DEVICE FOR RADIATING CIRCULARLY POLARIZED WAVES

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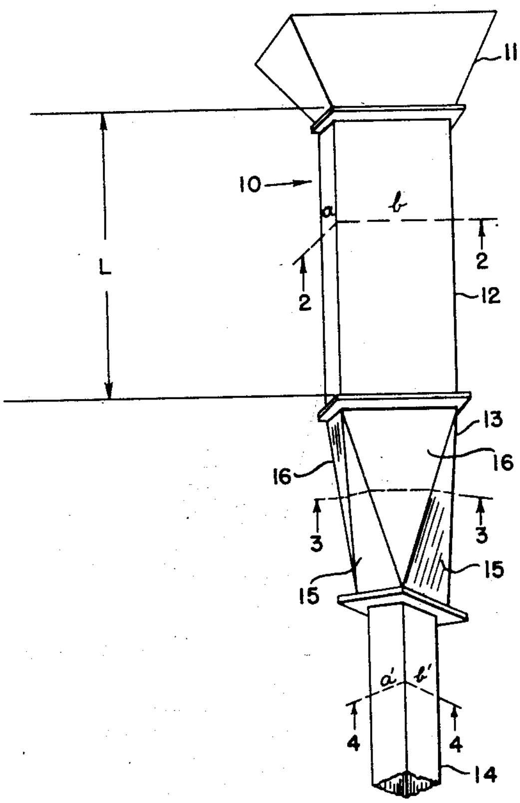


FIG. 1

FIG. 2

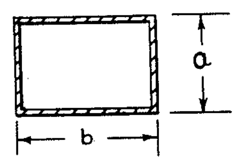


FIG. 3

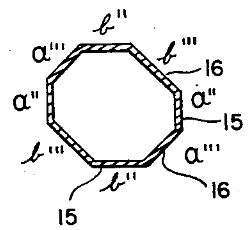
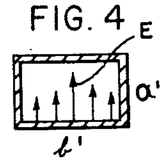


FIG. 4



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DEVICE FOR RADIATING CIRCULARLY POLARIZED WAVES

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6 Claims. (Cl. 250—33.63)

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This invention relates to the propagation of polarized waves of radio frequency electromagnetic energy and to means for producing circularly polarized waves. It is more particularly directed to a device wherein plane-polarized radio frequency energy from a hollow pipe wave guide is changed to circularly polarized energy for radiation.

As is well known, the phenomenon known as circular polarization is set up when two plane polarized waves of equal amplitude have their planes of polarization perpendicular to each other and are in time quadrature (polarization being defined in the sense used in the radio art rather than in the optical sense, and referring herein to the direction of the electric vector rather than that of the magnetic vector). This invention contemplates a simple and novel means of attaining circular polarization by means of suitable wave guide transition sections which will set up a difference in electrical path length between the two components of plane polarized waves.

It is one of the objects of the present invention to provide means for producing electromagnetic waves of circular polarization from linearly polarized plane waves.

It is another object of the invention to provide means for transition between plane and circularly polarized electromagnetic waves.

It is still another object of the invention to provide, in a wave guide transmission line, wave guide sections so dimensioned that a transition to circularly polarized waves from linearly polarized waves, is effected.

Another object of the invention is to provide a horn radiation system wherein a tapered section of wave guide is utilized to resolve the plane polarized wave from a conventional wave guide feed line into two mutually perpendicular components and wherein a section of rectangular wave guide is utilized to change the relative time phase of these components to 90° before radiation, from the flared portion of the horn, as a circularly polarized wave.

Other objects and advantages of the invention will become apparent from the following description with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of a horn radiating element having a wave guide feed and transition sections according to the invention;

Fig. 2 is a sectional view along the line 2—2 of Fig. 1;

Fig. 3 is a sectional view along the line 3—3 of Fig. 1; and

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Fig. 4 is a sectional view along the line 4—4 of Fig. 1.

In the drawings, the horn radiating element is generally designated 10 and comprises a flared portion 11, a rectangular wave guide portion 12 and a tapered wave guide portion 13 arranged for transmission of energy waves therethrough. Radio frequency energy, such as energy in the microwave range of frequencies (i. e., having wavelengths of the order of centimeters) is supplied to horn 10 by means of a conventional rectangular wave guide 14 communicating with one end (as shown, the lower end) of tapered portion 13.

It will be understood that the term "rectangular" as applied to the cross-section of wave guide portions 14 and wave guide 12 is intended to include an "effective rectangular section" such as an elliptically shaped section which may be produced by rounding the corners of a rectangularly shaped cross-section.

The cross-sectional dimensions of wave guide portion 12 are preferably larger than the corresponding dimensions of wave guide 14. Also portion 12 is angularly displaced about the longitudinal axis of horn 10 with reference to wave guide 14 so that the plane of the wider wall b or the major axis of its cross-section is at an angle of substantially 45° to the plane of wider wall b' or of the major axis of the cross-section of wave guide 14.

To effect the transition between portion 12 and wave guide 14, the tapered portion 13 preferably comprises eight triangularly shaped sections 15 and 16. The bases of the four sections 15 substantially form a rectangle at the lower end of portion 13 of substantially the same cross-sectional dimensions as that of wave guide 14, to the upper end of which the bases are adapted to be attached. Similarly, the bases of the four triangular sections 16 substantially form a rectangle at the upper end of tapered portion 13 having substantially the same dimensions as the lower end of wave guide portion 12 to which the portion 13 is adapted to be attached. The triangular sections 15 are joined along their sides to the sides of triangular sections 16 with the apices of sections 15 being at the corners of the rectangle formed by the bases of sections 16 and the apices of sections 16 meeting the corners of the rectangle formed by the bases of sections 15. Thus portion 13 affords a tapered transition, and permits energy to pass, from wave guide 14 to wave guide 12. It will be noted that the planes of sections 15 are preferably substantially at an angle of 45° to the planes of the corresponding sections **16** as indicated in Fig. 3 where the walls of sections **15** corresponding to the walls a' and b' of wave guide **14** are designated a'' and b'', and the walls of sections **16** corresponding to walls a and b of wave guide portion **12** are designated a''' and b'''.

The direction of electric vector E of the energy waves arriving at the bottom of tapered portion **13** are shown in Fig. 4. While traveling along the tapered portion **13**, the electric vector E is directed along the diagonal of the cross-section of wave guide portion **12**. By the time the wave arrives at the junction of tapered portion **13** and wave guide portion **12**, the electric vector is effectively resolved into two mutually perpendicular components. One component is parallel to side b and the other is parallel to side a of wave guide portion **12**. By making the cross-sectional dimensions a and b both greater than a half wavelength of the energy in space, it is possible for the two-component waves to propagate along the length of wave guide portion **12**.

Both component waves are of transverse electrical type and each behaves in much the same manner as a transverse electrical wave in a conventional wave guide. The phase velocities at which the two-component waves are propagating are different from one another when dimensions a and b are unequal. Because of this difference in velocities, there is a progressively increasing phase difference between the two electric vectors which are at right angles to each other in space. After the two-component waves have propagated over a suitable distance, L, the time phase distance between the two electric vectors becomes equal to 90° so that these vectors are not only in space quadrature but also in time quadrature thereby resulting in circularly polarized energy waves.

This is the case at the bottom of the flared portion **11**. The aperture of the flare **11** may be made approximately square and the flare itself is usually fairly short, so that the difference in phase does not continue to increase within the flare. The result is that the flared portion **11** acts merely as a transformer or as an impedance matching section between the rectangular guide and space, reducing the reflection at the end of the rectangular guide to a small value. When the flare is made gradual, further small phase differentiation may occur within the flare. This, however, may be allowed for by making the length of the main phasing section **12** somewhat shorter.

While the invention as hereinbefore described has been particularly directed to a horn radiating element, it will be understood that the invention is not limited thereto. It will be obvious that instead of terminating wave guide **12** in a horn, any other suitable termination may be utilized; also the portions **12** and **13** may form a transition portion in a transmission line wherein circular polarization is desired.

While there has been described what is at present considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention.

What is claimed is:

1. A device for radiating circularly polarized electromagnetic waves, comprising radiating means adapted to be fed by a wave guide, a first

rectangular wave guide coupled to said radiating means and having both of its cross-sectional dimensions greater than a half wavelength of the energy to be radiated, said cross-sectional dimensions being different from each other, a second rectangular wave guide for feeding said first wave guide, said first wave guide being oriented with its walls at substantially 45° with respect to the walls of said second wave guide, and a transition portion coupling and matching said wave guides together, whereby plane polarized waves in said second wave guide are divided in said first wave guide into a first component polarized perpendicularly to the narrow walls thereof and a second component polarized perpendicularly to the wide walls thereof, said first and second components having substantially equal amplitudes, said first wave guide having a length such that said first component of said waves is delayed substantially 90 electrical degrees relative to the second component of said waves.

2. A device for obtaining a pair of electromagnetic waves polarized perpendicularly to one another comprising a first rectangular wave guide having both of its cross-sectional dimensions greater than a half wavelength of the energy to be radiated, a second rectangular wave guide for feeding said first wave guide, said second wave guide having its walls oriented at an oblique angle with respect to the walls of said first wave guide, and a transition portion coupling and matching said wave guides together, whereby plane polarized waves in said second wave guide are divided in said first wave guide into a first component polarized perpendicularly to one pair of opposite walls thereof and a second component polarized perpendicularly to the other pair of opposite walls thereof.

3. A device for radiating circularly polarized electromagnetic waves comprising radiating means adapted to be fed by a wave guide, a first rectangular wave guide coupled to said radiating means and having both of its cross-sectional dimensions greater than a half wavelength of the energy to be radiated, said cross-sectional dimensions being different from each other, a second rectangular wave guide for feeding said first wave guide and oriented with its walls at 45° with respect to the walls of said first wave guide, and a transition portion coupling and matching said wave guides together, said transition portion including eight triangular portions four positioned with their bases coupled one to each of the walls of said first wave guide and with their apices coupled one to each of the corners of said second wave guide, the remaining four of said triangular portions having their bases coupled one to each of the walls of said second wave guide and their apices coupled one to each of the corners of said first wave guide, whereby plane polarized waves in said second wave guide are divided in said first wave guide into a first component polarized perpendicularly to the narrow walls thereof and a second component polarized perpendicularly to the wide walls thereof, said first and second components having substantially equal amplitudes, said first wave guide having a length such that said first component of said waves is delayed substantially 90 electrical degrees relative to said second component of said waves.

4. A device for obtaining a pair of electromagnetic waves polarized perpendicular to one another from a plane polarized wave comprising a

rectangular wave guide for propagating plane polarized waves and an additional wave guide coupled to said rectangular wave guide and including eight triangular portions four of which are positioned with their bases coupled one to each of the walls of said rectangular wave guide at an end thereof, the apices of said four triangular portions being positioned in a plane and defining the four corners of a rectangle both of whose cross-sectional dimensions are greater than a half wavelength of the electromagnetic waves and whose sides are oriented at 45° with respect to the walls of said wave guide, the remaining four of said triangular portions being positioned with their apices coupled one to each of the four corners of said rectangular wave guide and with their bases positioned each along one of the sides of said rectangle.

5. A device for producing elliptically polarized electromagnetic waves comprising a first rectangular wave guide having both of its cross-sectional dimensions greater than a half wavelength of the energy to be radiated, said cross-sectional dimensions being different from each other, a second rectangular wave guide for feeding said first wave guide, said second wave guide having its walls oriented at an oblique angle with respect to the walls of said first wave guide, and a transition portion coupling and matching said wave guides together, whereby plane polarized waves in said second wave guide are divided in said first wave guide into a first component polarized perpendicularly to the narrow walls thereof and a second component polarized perpendicularly to the wide walls thereof, said first wave guide having a length such that said first component of said waves is delayed substantially 90 electrical degrees relative to the second component of said waves, whereby the waves emanating from the end of said first wave guide are elliptically polarized.

6. A device according to claim 5, further including radiating means coupled to said end of said first wave guide for radiating the waves emanating therefrom.

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