CIRCULARLY POLARIZING HORN ANTENNA HAVING DIELECTRIC INSERT WHICH PROVIDES REDUCED AXIAL RATIO OVER WIDE BAND

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Our invention relates to a horn antenna for use in radiating electromagnetic energy, and is especially concerned with a horn-type antenna which develops and emits a circularly polarized electromagnetic field in space that is characterized by a reduced axial ratio as between the orthogonal components of such field over a comparatively wide operating frequency bandwidth.

An important object of this invention is to provide a horn antenna that may be employed to develop and radiate an electromagnetic energy radiation field which is circularly polarized and which has an axial ratio of approximately 2:1 or less over a comparatively wide operating frequency bandwidth.

Another object of our invention is to provide a circularly polarizing horn antenna, having ridged phase-shifter and horn sections, with an insert means which improves the operating frequency bandwidth capability of the horn antenna in terms of radiated circularly polarized energy fields having an axial ratio of approximately 2:1 or less and which further improves the impedance match of such sections to each other.

A still further object of our invention is to provide a ridged circularly polarizing horn antenna, coupled to a ridged waveguide feed, with an insert means which improves the operating frequency bandwidth capability of the horn antenna as to radiated circularly polarized fields having an axial ratio of approximately 2:1 or less and which further improves the impedance match of the horn antenna and the waveguide feed to each other.

Another object of our invention is to provide a means for improving the operating frequency bandwidth capability of a circularly polarizing horn antenna, as to radiated fields of reduced axial ratio, with an insert means which is not complex, which may be readily fabricated and installed in the horn antenna, and which is economical to manufacture.

The horn antenna of this invention is essentially comprised of a 4-ridged metal transition section, a 4-ridged metal phase-shifter section, and a 4-ridged metal radiator section, joined to each other and coupled to a 2-ridged waveguide feed. In addition, our invention employs a diamond-shaped dielectric insert means installed in the antenna in the region of said phase-shifter and radiator sections to obtain the before-received objects.

Additional details regarding our invention are set forth in the drawings and specification. Also, other objects and advantages of this invention will become apparent during consideration of such details.

In the drawings:

FIG. 1 is a perspective view of a circularly polarizing horn antenna having the features of our invention;

FIG. 2 is an elevational view, partially in section, of the horn antenna illustrated in FIG. 1;

FIG. 3 is a perspective view of the insert means employed in our invention to improve the operating frequency bandwidth capability of the basic horn assembly as to radiated circularly polarized fields having a reduced axial ratio;

FIGS. 4, 5, and 6 are sectional views taken at lines 4—4, 5—5, and 6—6 of FIG. 2;

FIG. 7 illustrates the relation of the phase-shift developed between orthogonal components of an electromagnetic energy field radiated by the horn antenna of FIGS. 1 through 6 in comparison to the radiated field components phase-shift developed in the horn antenna assembly without the insert means of our invention, each measured over a wide range of operating frequencies; and

FIG. 8 illustrates the relation of the axial ratio of the orthogonal components of the circularly polarized field radiated by the horn antenna of FIGS. 1 through 5 in comparison to the axial ratio of the circularly polarized field emitted by the antenna without the insert means of our invention, each measured over a wide range of operating frequencies.

The horn antenna assembly 10 illustrated in FIG. 1 incorporates the features of our invention and essentially consists of transition section 11, phase-shifting section 12, radiator section 13, and an insert means 40 (FIG. 6).

Such horn antenna assembly conforms to the circularly polarizing horn antenna assembly 10 disclosed and described in U.S. Letters Patent No. 2,942,261, except as to insert means 40, and is illustrated in combination with the waveguide feed assembly referenced generally as 14, Sections 11 through 13 are fabricated and assembled as a unit through the use of threaded fastener means 15 (FIG. 2). As shown in FIGS. 1 and 2, assembled horn antenna 10 is attached to flange portion 18 of waveguide assembly 14 by means of the threaded fasteners designated 19.

Waveguide component 21 of waveguide feed assembly 14, in the form shown, conducts electromagnetic energy from a generating device (not shown) to antenna assembly 10 in the TE_{10} mode at least throughout the frequency bandwidth referenced in FIGS. 7 and 8.

The requirements for launching a circularly polarized electromagnetic field require that three distinct parameters be closely controlled. Such parameters relate to division of the single orthogonal electric field configuration of the energy transmitted by waveguide assembly 14 into two orthogonal electric field configurations of near-equal amplitude and at right angles to each other, establishing a time phase difference of approximately 90° (1/4 cycle) as between such two orthogonal electric field configurations, and radiating the resulting circularly polarized electromagnetic field into free space by a suitable horn device. Such parameter controls are associated with the horn antenna sections designated 11, 12, and 13, respectively.

However, although the electromagnetic field radiated from section 13 is essentially circularly polarized, an improved operating bandwidth capability may be developed as to horn antenna assembly 10 for radiated circularly polarized fields having an axial ratio of approximately 2:1 or less through use of the hereinafter-described insert means of FIG. 4.

As suggested by the previously-referenced patent, transition section 11 is provided with four ridge portions arranged in a particular manner for effecting field division. Similarly, phase-shifter section 12 is provided with four ridge portions for effecting a time phase difference between the two electric field configurations developed by transition section 11. Such ridge portions are referenced by the numerals 28 through 31 of FIG. 4. Ridge portions 30 and 31 are of greater depth (or height) than are ridge portions 28 and 29.

Details regarding specific depths of each ridge portion for a frequency bandwidth of from 6 kmc. to 15 kmc. may be obtained from U.S. Letters Patent No. 2,942,261. Horn radiator section 13 launches the circularly polarized electromagnetic energy field developed by section 12 into space, and has a 4-ridge arrange-
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The improved operating bandwidth capability which has previously been referred to in terms of radiated circularly polarized fields having an axial ratio of approximately 2:1 or less is developed by use of insert means 40. Such insert means is positioned within horn assembly 10 in the region of phase-shifter section 12 and horn radiator section 13. We have employed an insert means 40 made of a dielectric material having a dielectric constant of 6.5 and a loss tangent of 0.001 for the purposes of our invention. A material such as "Micalex" has the required properties and in addition has excellent machinability. Insert means 40 may be properly positioned in horn antenna assembly 10 by use of a suitable adhesive.

Referring to the specific dimensions of the horn antenna assembly 10 detailed in U.S. Letters Patent No. 2,942,261, we have employed an insert means 40 which is generally diamond-shaped and which measures approximately 1½" in overall length by ¾" thick. Such insert means 40 is positioned so that it is generally parallel to and positioned between the ridge portions of phase-shifter section 12 and radiator section 13 which are of least depth. See FIGS. 5 through 6. Insert means 40 may be positioned so that approximately ¾" of the length thereof extends into the region of radiator section 13. This dimension is represented by the distance D of FIG. 4. The height of insert means 40 is such that it may be properly secured to ridge portions 34 and 35.

Data pertaining to horn antenna assembly 10 of this invention was obtained in an evaluation effort and is presented in FIGS. 7 through 9. Curve 41 and 42 show the performance of horn assembly 10 with insert means 40 and without insert means 40, respectively. It will be noted that the phase-shift relation illustrated in connection with curve 41 is maintained at a higher level of magnitude throughout the range from approximately 8 kmc. to approximately 18 kmc. by use of insert means 40.

In FIG. 8, curves 43 and 44 are employed to show the relation between the axial ratio of the radiated circularly polarized electromagnetic energy field and the operating frequency of the horn antenna. Curve 43 relates to a circularly polarizing horn assembly 10 having the features of this invention; curve 44 relates to a horn antenna assembly corresponding to assembly 10 except without an insert means 40. From FIG. 8 it will be observed that an axial ratio of less than approximately 2:1, which often is accepted as a limit for a properly circularly polarized field for aircraft microwave equipment applications, is essentially maintained throughout the bandwidth of from approximately 6 kmc. to approximately 17.5 kmc. The bandwidth is approximately 2:9:1 in comparison to an operating frequency bandwidth of approximately 1:8 for curve 44 for circularly polarized fields having an axial ratio of approximately 2:1 or less.

It is to be understood that the form of the invention herewith shown and described is to be taken as a preferred embodiment of the same, but that various changes in the shape, size, and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

We claim:

1. A microwave horn antenna assembly which radiates a circularly polarized field and which includes: a hollow metallic phase-shifter section having interior symmetrically-positioned ridge members projected inwardly and arranged in opposed pairs which each have a different projected depth, a hollow metallic radiator section located adjacent said phase-shifter section and having interior symmetrically-positioned ridge members projected inwardly and arranged in opposed pairs which each have a different projected depth, and dielectric insert means located within said phase-shifter section and within said radiator section, said insert means providing a reduced axial ratio in the circularly polarized field radiated by said horn antenna assembly.

2. The invention defined in claim 1, wherein said insert means is located in said phase-shifter section and in said radiator section in parallel relation to one pair of opposed ridge members in each of said sections, said one pair of opposed ridge members in each of said sections being an opposed pair of ridge members of least projected depth.

3. The invention defined in claim 1, wherein said insert means is generally diamond-shaped, said diamond-shaped insert means providing an improved impedance match between said phase-shifter section and said radiator section.

4. The invention defined in claim 1, wherein said horn antenna assembly is coupled to a waveguide feed, said insert means providing an improved impedance match between said waveguide feed and said horn antenna assembly.

5. In a circularly polarizing microwave horn antenna assembly having a ridged phase-shifter section and having a flared ridged radiator section coupled to said phase-shifter section, diamond-shaped dielectric means positioned within said phase-shifter and radiator sections to improve the operating frequency bandwidth capability of said assembly as to circularly polarized energy fields radiated with an axial ratio of approximately 2:1 or less.

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