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ELECTROMAGNETIC HORN ANTENNA

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Fig. 1.

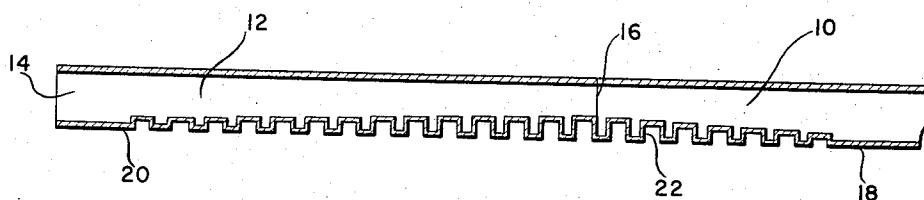
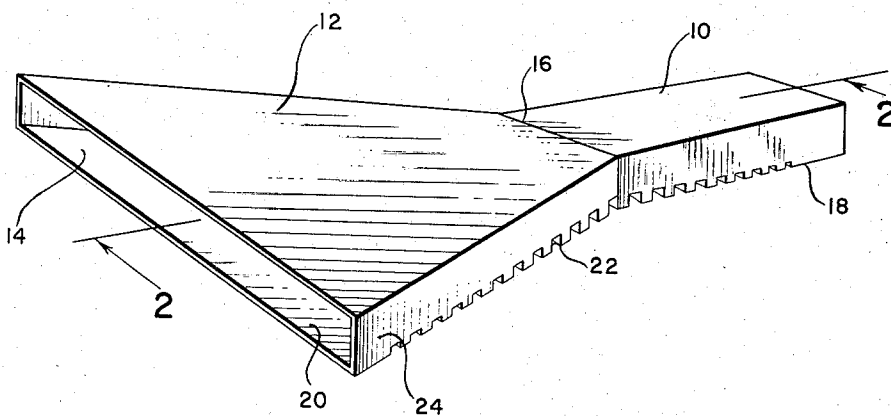
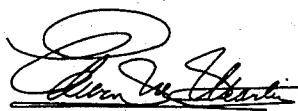


Fig. 2.

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ELECTROMAGNETIC HORN ANTENNA

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6 Claims. (Cl. 343-786)

This invention relates to electromagnetic radiators and more particularly to a combination of a waveguide and a sectoral horn.

An H-plane sectoral horn is a horn in which the flaring increases the aperture in a plane perpendicular to the electric vector. Such horns often are employed to terminate a rectangular electromagnetic waveguide propagating wave energy in the TE_{01} mode to facilitate radiation therefrom. The radiation pattern from such a horn terminated waveguide depends, among other things, on the flare angle and the length of the side walls of the horn. The phase front of the wave energy radiated by the H-plane sectoral horn is cylindrical in a plane perpendicular to the electric vector and somewhat spherical in a plane parallel to the electric vector.

It often has been found desirable to correct or to modify the cylindrical phase wave front in order to obtain a colinear phase front. Even though the curvature of the cylindrical phase front may be reduced by increasing the length of the horn, such a solution has been unsatisfactory. Heretofore modification of the wave front has been accomplished by inserting a dielectric convergent lens of the proper curvature into the aperture of the horn. As it is well known to those skilled in the art, a dielectric lens varies in thickness over the plane of its surface and thereby produces the necessary phase retardation of wave energy passing therethrough to modify the phase front in a predetermined manner. Such a dielectric lens, however, has the disadvantage of giving rise to reflections by virtue of the discontinuity of the interface presented to the wave energy passing therethrough. Furthermore, the transmission of wave energy through the lens generates heat inside the lens, raising problems of cooling and causing changes in the transmission characteristics.

It is therefore an object of this invention to provide an H-plane sectoral horn affixed to a waveguide, which combination is capable of radiating wave energy having a substantially planar phase front without the use of a dielectric lens.

It is a further object of this invention to provide a waveguide terminated with a short H-plane sectoral horn capable of radiating wave energy having a substantially colinear phase front.

It is a still further object of this invention to provide a colinear phase front from an H-plane sectoral horn which is rugged in construction and which provides an impedance match with free space superior to that achieved with dielectric lenses.

In accordance with this invention, an H-plane sectoral horn terminated waveguide is adapted to radiate wave energy with a substantially colinear wave front. A sectoral horn is affixed to a waveguide and wave energy trapping means are provided across the throat of the combination. Wave energy propagated by the waveguide in the dominant TE_{01} mode towards the throat of the horn is transformed by the trapping means into a TM surface wave before reaching the throat, and passed across the throat as a surface wave. Thereafter, the trapping means

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re-transforms the surface wave in the dominant TE_{01} mode before reaching the aperture of the horn. In this manner, the effect of the flaring side walls is minimized and the phase front of the wave energy radiated remains colinear.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawing in which an embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawing is for the purpose of illustration and description only, and is not intended as a definition of the limits of the invention.

Fig. 1 is a perspective view of an embodiment of a corrugated wall horn antenna provided in accordance with this invention; and

Fig. 2 is a cross-sectional view taken along line 2-2 of the antenna of Fig. 1.

Referring now to the drawing and particularly to Fig. 1, there is shown a rectangular waveguide 10 and an H-plane sectoral horn 12. The horn has an aperture 14 and is affixed to the waveguide 10 at its throat 16. The waveguide wall 18 and the horn wall 20 are provided with a plurality of corrugations 22 which are perpendicular to the direction of propagation of the wave energy. The length of the horn, usually measured as the length of the flared horn wall 24, is substantially longer than the working wavelength of the wave energy propagated through the rectangular waveguide 10.

Fig. 2 shows with greater particularity the dimension and position of the corrugations 22. The corrugations 22 have their maximum depth at the throat 16 which depth may be up to one-quarter of the working wavelength of the wave energy propagated. On either side of the throat, the depth of the corrugations is incrementally reduced or tapered so that the depth decreases slowly to zero. The degree of taper required determines the length of the corrugated portion and is usually not critical. The length of the corrugated portion in the horn depends on the length of the horn and the flare angle of the side walls. It is usually good practice to continue the corrugations well towards the aperture 14 of horn 12 to obtain a good colinear phase front. Also, the length of the tapered corrugated portion extending into the waveguide 10 determines the degree of conversion of the wave energy from the TE_{01} mode to the TM mode. The distance between adjacent corrugations should be small relative to the working wavelength. This may be accomplished, for example, by providing at least five corrugations per working wavelength.

The operation of this embodiment of the present invention may best be explained by tracing the different modes of transmission of energy from one end of the waveguide 10 to the horn aperture 14. The waveguide propagates the wave energy in the dominant or TE_{01} mode to the point within the waveguide where the corrugations begin. Upon encountering the tapered corrugations, the dominant mode is gradually converted into the TM mode, also called a trapped surface wave. Thereafter the trapped surface wave is passed through the throat 16 by the corrugations. Upon encountering the tapered corrugations in the horn 12, the decrease of depth of the corrugations causes a gradual leaking off of the wave energy. The wave energy so released from the trapping surface again assumes the dominant TE_{01} mode. In this manner the effect of the flared portion following the throat 16 of the horn 12 is almost completely eliminated and radiation from the aperture has been found to have a substantially colinear wave front in a plane normal to the electric vector of the dominant waveguide mode.

Even though the trapping agent employed in this invention has been shown and described in terms of parallel corrugations, such corrugations are but an example of one preferred embodiment. As is well known to those skilled in the art, a tapered dielectric slab such as polystyrene may also be employed to convert wave energy from the dominant waveguide mode to the surface wave. A dielectric slab of constant thickness attached to a metallic surface provides a good surface wave transmission line. In the case of dielectric trapping agents, a tapered portion of the dielectric material is bonded to the antenna surface perpendicular to the electric vector of the dominant mode over the junction section at the throat. Even though corrugated trapping agents have the advantage of superior ruggedness, dielectric trapping agents are able to capture and support surface waves which are cross-polarized. As a consequence, a dielectric trapping agent may be bonded to any wall of a waveguide horn combination to facilitate transfer of wave energy across a horn throat and prevent distortion or curving of the phase front.

There has been described an improved transition between an electromagnetic horn and a feed waveguide which provides a substantially colinear phase front at the mouth of the horn.

What is claimed is:

1. An electromagnetic horn antenna comprising, a waveguide whose axis defines an antenna axis, an H-plane sectoral horn having a throat coupled to one end of said waveguide, said waveguide and said horn each including a corresponding broad wall having trapping means adapted to transform the dominant waveguide mode traveling toward said throat into a surface wave and to transform said surface wave traveling away from said throat into the dominant mode of the mouth of said horn, said trapping means terminating short of the mouth of said horn.

2. An electromagnetic horn antenna comprising, a waveguide whose axis defines an antenna axis, an H-plane sectoral horn having a throat coupled to one end of said waveguide, said horn and said waveguide each having a corresponding broad wall including a trapping means, said trapping means being disposed within said waveguide and said horn and adapted to trap wave energy as its thickness increases and to release wave energy as its thickness decreases.

3. An electromagnetic horn antenna comprising, a waveguide including a broad wall whose axis defines an

antenna axis, an H-plane sectoral horn having a throat coupled to one end of said waveguide and including a broad wall, each of said broadwalls being provided with parallel corrugations whose direction of elongation is perpendicular to the axis of said antenna, said corrugations having a maximum depth at the throat of the horn and tapering to zero depth along either direction parallel to said antenna axis.

4. A wave energy horn antenna adapted to provide a wave energy beam having a substantially colinear phase front and comprising, a waveguide including a first trapping member, said first trapping member adapted to convert wave energy propagated in the dominant mode by said waveguide into a trapped surface wave, and a wave energy horn coupled to said waveguide and including a second trapping member adapted to receive and to reconvert said surface wave into the dominant mode of said horn, said second trapping member terminating short of the mouth of said horn.

5. A wave energy horn antenna adapted to provide a wave energy beam having a substantially colinear phase front and comprising: a waveguide including a first trapping member; and a wave energy horn coupled to said waveguide and including a second trapping member, said first and second trapping members being arranged to mode transform wave energy into a trapped surface wave across the junction formed by said waveguide and said horn, said second trapping member being disposed adjacent said first trapping member and arranged within said horn to reconvert said surface wave at the throat of the horn into a dominant mode at the aperture of the horn.

6. A wave energy horn antenna adapted to provide a wave energy beam having a substantially colinear wave front and comprising, a waveguide having one broad wall including transverse corrugations, and a wave energy horn coupled to said waveguide and having one broad wall including transverse corrugations, said corrugations having a maximum depth across a junction formed by said waveguide and said horn, the depth of said corrugations being tapered to zero depth in the direction normal to the corrugations for mode transforming wave energy into a trapped surface wave across said junction.

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