United States Patent

[11] **3,605,101**

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[21] Appl. No. **862,352**
[22] Filed **Sept. 30, 1969**
[45] Patented **Sept. 14, 1971**

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[54] **DUAL MODE CONICAL HORN ANTENNA**
2 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **343/783,** 343/786
[51] **Int. Cl.** **H01q 13/00**
[50] **Field of Search** 343/783, 786, 854

[56] **References Cited**
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ABSTRACT: A circular rod having tapered ends is coaxially mounted within a conical horn antenna. When energy in the TE°_{11} mode is fed into the throat of the antenna, it transforms smoothly over the length of the rod into the hybrid HE°_{11} mode. At the antenna aperture, the energy again transforms and this time appears in correctly phased TE°_{11} and TM°_{11} modes.

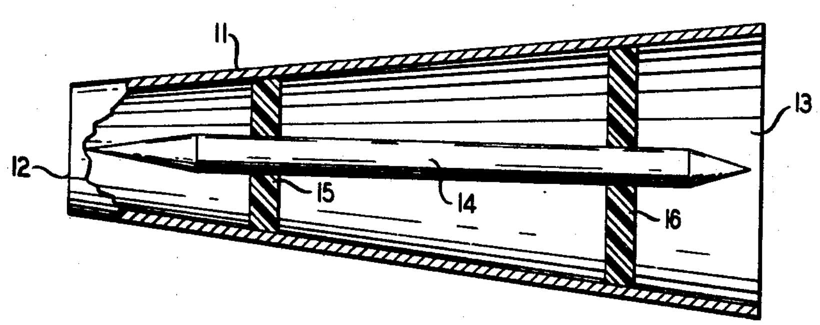

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FIG. 1

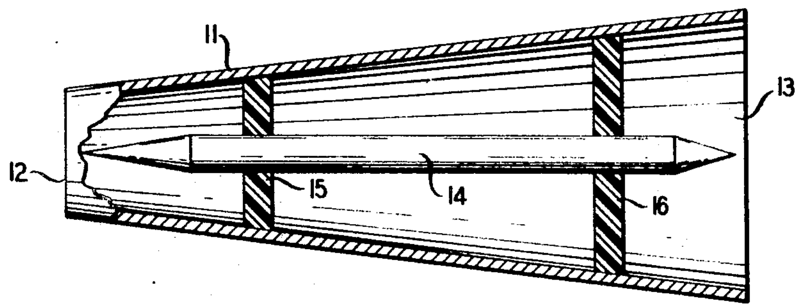
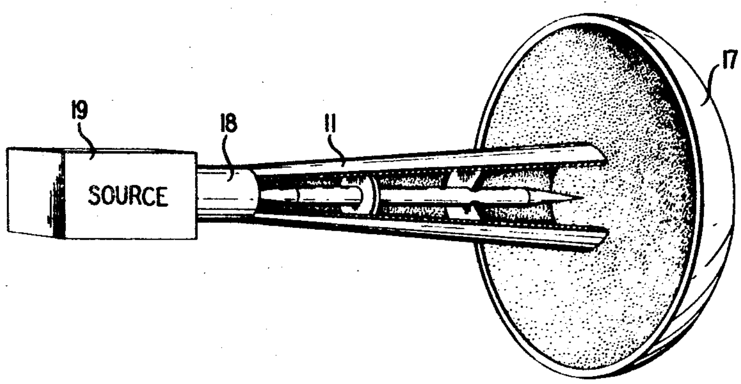


FIG. 2



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DUAL MODE CONICAL HORN ANTENNA

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to conical horn antennas for radiating electromagnetic energy simultaneously in the TE°_{11} and TM°_{11} modes.

2. Description of the Prior Art

A conical horn antenna radiating an appropriate mixture of energy in the TE°_{11} and TM°_{11} modes offers several advantages over a conical horn antenna radiating energy in a single mode only. Lower sidelobe levels with resulting higher directivity, for example, are achieved with such dual mode radiation. Furthermore, better beamwidth equalization with resulting improved circular symmetry is achieved. These advantages are discussed in detail in "A New Horn Antenna with Suppressed Sidelobes and Equal Beamwidths," by P. D. Potter, beginning on p. 71 of the June 1963 issue of *the microwave journal* and also in "The Open Cassegrain Antenna: Part I, Electromagnetic Design and Analysis" by J. S. Cook, E. M. Elam and H. Zucker, beginning on p. 1255 of the Sept. 1965 issue of *The Bell System Technical Journal.*

Dual mode radiation is achieved in the prior art through the use of a conical horn antenna preceded by a mode converter which converts a portion of energy in the TE°_{11} mode into the TM°_{11} mode. For satisfactory dual mode radiation, this TM°_{11} mode energy and the remaining TE°_{11} mode energy must combine with appropriate amplitudes and phases over the aperture of the horn antenna. These requirements become a problem, however, because of two frequency dependent characteristics of the configuration. First, the two modes exist independently and are nondegenerate (possess different phase velocities) so that their phase difference over the antenna aperture depends, for a given horn length, upon the operating frequency. Second, the phase and amplitude of the mode generated by the converter also depend upon the operating frequency. Because of these frequency-dependent characteristics, the widest bandwidth over which the arrangement performs effectively has been limited to less than 25 percent.

SUMMARY OF THE INVENTION

An object of the invention is to broaden the frequency bandwidth over which a dual mode conical antenna performs effectively.

This and other objects are achieved in accordance with the invention by converting energy from the TE°_{11} mode into the hybrid HE°_{11} mode as the energy traverses from the throat to the aperture of a conical horn antenna. The hybrid mode is a unique mode. For purposes of explanation, however, it may be viewed as a linear superposition of the TE°_{11} and TM°_{11} modes where the modes are phase locked at a unique phase difference which is independent of antenna length and frequency. At the antenna aperture, the energy is converted from the hybrid mode into the TE°_{11} and TM°_{11} modes. Because of the uniqueness of the phase difference of the hybrid mode, the resulting TE°_{11} and TM°_{11} modes as they appear at the antenna aperture also have a unique phase difference which is substantially independent of antenna length and frequency. Fortuitously, the latter phase difference is that required for effective dual mode radiation. Furthermore, because this phase difference is substantially independent of antenna dimensions, the antenna dimensions may be readily selected to achieve the desired mode amplitudes.

One feature of the invention, therefore, is the production at the antenna aperture of the two modes with the desired phase difference. Another feature of the invention is a substantial reduction of the effects of frequency and antenna dimensions on the phase difference between the two modes. Still another feature is the ability to readily select the antenna dimensions so as to achieve the desired mode amplitude relationship. These and other features result in an antenna with an effective bandwidth at least twice that of the best known prior art arrangement.

A conical horn antenna constructed in accordance with the invention comprises a tapered circular waveguide having a minimum inside diameter equal to that of a cylindrical waveguide in which TE°_{11} mode energy can be supported and a maximum inside diameter equal to that of a cylindrical waveguide in which TE°_{11} and TM°_{11} mode energy can be supported. Within the tapered waveguide is a circular rod having tapered ends, a dielectric constant greater than that of air and a length no greater than that of the tapered waveguide. Several dielectric rings having dielectric constants substantially equal to that of air coaxially mount the rod completely within the tapered waveguide.

Other objects and features of the invention will become apparent from a study of the following detailed description of an embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a pictorial view, partially broken away, of an embodiment of the invention; and

FIG. 2 is a pictorial view, partially broken away, of the embodiment of FIG. 1 utilized as a primary feed in a parabolic reflector.

DESCRIPTION OF THE DISCLOSED EMBODIMENT

The embodiment of the invention shown in FIG. 1 comprises a tapered circular waveguide **11** having a throat **12** at its smaller end and an aperture **13** at its larger end. The inside diameter of throat **12** is equal to that of a cylindrical waveguide in which energy in the TE°_{11} mode can be supported while aperture **13** has an inside diameter equal to that of a cylindrical waveguide in which energy in the TE°_{11} and TM°_{11} modes can be supported.

A circular rod **14** is coaxially mounted in waveguide **11** by a pair of spacers **15** and **16** so as to be completely within the waveguide. Rod **14** has tapered (pencil-pointed) ends, a dielectric constant greater than that of air and a length not exceeding that of the waveguide. In practice, it has been made out of polystyrene material. The spacers **15** and **16**, on the other hand, have dielectric constants substantially equal to that of air.

FIG. 2 shows the conical horn antenna of FIG. 1 used as a primary feed for a parabolic reflector **17**. Circular waveguide **11** is coaxially aligned with the centerline of the reflector. A circular waveguide **18** connects throat **12** of waveguide **11** to a source **19** of energy in the TE°_{11} mode. For purposes of simplicity, supporting structure for elements **11**, **17**, **18** and **19** have not been shown but are readily understood and realizable by those skilled in the art.

In operation, energy in the TE°_{11} mode is coupled from source **19** to waveguide **11** by waveguide **18**. As this energy is transversing waveguide **11**, it is transformed into the HE°_{11} mode as a result of the cooperative action between waveguide **11** and rod **14**. At aperture **13**, the energy transforms to the TE°_{11} and TM°_{11} modes. As earlier discussed in greater detail, the latter modes have a unique phase relationship with respect to one another because the energy was just previously in the HE°_{11} mode. This phase relationship is that required for effective dual mode transmission and, furthermore, is substantially independent of antenna length and frequency. Because it is independent of antenna length, the lengths of waveguide **11** and rod **14** may be selected to achieve the relative mode amplitudes necessary for effective dual mode transmission. These features result in an antenna with an effective bandwidth at least twice that of known prior art dual mode antennas.

What is claimed is:

1. An antenna for operation over a particular frequency band, said antenna comprising,

a tapered waveguide of circular cross section having an interior wall void of any irises for mode conversion within said frequency band, a minimum inside diameter equal to that of a cylindrical waveguide in which energy in the TE°_{11} mode can be supported and a maximum inside diameter equal to that of a cylindrical waveguide in which energy in the TE°_{11} and TM°_{11} modes can be supported,

a dielectric rod having a circular cross section, a continuous external surface void of any openings, a length no greater than the length of said tapered waveguide, a dielectric constant greater than that of air and, furthermore, both ends tapered to substantial points with the remainder of said rod having a substantially constant circular cross section, and

means coaxially mounting said rod completely within said tapered waveguide.

2. An antenna for operation over a particular frequency band, said antenna comprising,

a waveguide of circular cross section having an interior wall void of any irises for mode conversion within said frequency band, an input end with an inside diameter to support energy in the TE°_{11} mode, an output end with an inside diameter to support energy in the TE°_{11} and TM°_{11} modes and a substantially uniform taper between said ends,

a dielectric rod having a circular cross section, a continuous external surface void of any openings, a length no greater than the length of said tapered waveguide a dielectric constant greater than that of air and, furthermore, both ends tapered to substantial points with the remainder of said rod having a substantially constant circular cross section, and

means coaxially mounting said rod completely within said tapered waveguide.