This invention relates to waveguides, and more particularly to waveguides employing a solid dielectric substance as the propagating medium. Consequently, waveguides of the hollow pipe variety have consisted of rugged metallic walls containing air as the propagating medium, but these are bulky, difficult to construct, and are not easily adapted to the problem of feeding properly phased energy to the radiating elements of an antenna array.

An object of the present invention is to provide a small and simply constructed waveguide for carrying electromagnetic waves without serious energy loss.

Another object is to provide a waveguide utilizing a solid dielectric substance as the propagating medium. Another object is to provide a waveguide which is readily adaptable for use as a slot type radiator.

A still further object is to provide a waveguide whose physical dimensions are not appreciably affected by variations in temperature.

To achieve the above objects, a form of waveguide is constructed which comprises a solid dielectric rod, commonly of rectangular or circular cross-section, which is plated on its outer surface with a good conducting material such as copper or silver.

The invention is fully described in the following specification and the drawings of which:

Fig. 1 is a perspective view of a rectangular waveguide constructed in accordance with the invention;

Fig. 2 is a perspective view of a circular wave guide constructed in accordance with the invention;

Fig. 2A is a perspective view of the waveguide of Fig. 2 adapted to become a coaxial line;

Fig. 3 is a view of an antenna utilizing the waveguide of this invention as a feed;

Fig. 4 is a view of the waveguide of this invention used as a radiator.

Referring specifically to Figs. 1 and 2, the waveguides shown are formed from a solid strip or rod 10 of a low-loss dielectric material such as polystyrene. The outer surface of strip or rod 10 is coated or plated with a good conducting material such as copper or silver to form a covering 11. This conducting material may be applied by a known process such as electroplating. Electromagnetic energy is propagated through the dielectric rod or strip 10 and is confined therein by the conducting material coated or plated thereon.

By the use of a dielectric propagating medium, the wave length of energy in rectangular waveguide is lessened in accordance with the well known equation

$$\lambda_e = \frac{\lambda_a}{\sqrt{\epsilon_r}}$$

where \(\lambda_e\) is cutoff wave length, \(\lambda_a\) and \(\epsilon_r\) are wave length and dielectric constant in the guide. As a result, the required physical dimensions of the guide are lessened, thus providing desired compactness.

It will be obvious to those skilled in the art that the circular wave guide of Fig. 2 may be adapted, as in Fig. 2A, to use as a coaxial line by disposing a conducting rod 12 in the dielectric material 10 along the axis of the outer conducting sheath 11. The well known coaxial line wave length equation

$$\lambda_c = \frac{\lambda_a}{\sqrt{\epsilon_r}}$$

where \(\lambda_c\) is wave length in air, \(\epsilon_r\) and \(\epsilon_a\) are dielectric constant and wave length in the guide. As a result, the required physical dimensions of the guide are lessened, thus providing desired compactness.

The electrical length of a solid dielectric wave guide or coaxial line depends on dielectric constant, and in number of applications, this type of phase control is advantageous. Fig. 3 illustrates an example of such a circuit and shows a linear antenna array having a reflector 15 and dielectric guide waves 16 feeding an array of dipoles 17. Such an array is designed for broadband radiation (i.e., outward in a direction perpendicular to the plane of the reflector) and this requires that all the dipoles be excited in phase but that they be geometrically arranged so that their side radiation is cancelled. By the use of dielectric wave guide 16 or dielectric coaxial line to feed the radiating elements 17, these conditions are easily achieved and without the need for driving alternate dipoles in phase opposition.

Dielectric wave guide is also used to advantage in endfire antenna arrays wherein it is desired that the wave length of energy in the wave guide feeding the dipoles be the same as that in free space.

Wave guides having radiating apertures such as slots are easily constructed from the guides of Figs. 1 and 2 by either selective plating or by scraping away plating where it is not needed. Such a radiator, having radiating slots 18, is shown in Fig. 4.

For situations where it is desired to keep the temperature expansions and contractions of a wave guide at a minimum, a low expansion dielectric material is used in the wave guide of this invention. The metallic plating on the dielectric is very thin and its dimensional variations with temperature are thus negligible.

The invention described in the foregoing specification need not be limited to the details shown, which are considered to be illustrative of certain forms of the invention that may take. What we desire to be secured by Letters Patent and claimed is:

1. The method of fabricating a wave guide component for electromagnetic energy which comprises the steps of forming from a low loss solid dielectric material a member having a shape and cross section corresponding to the wave guide component desired, plating the surface of said dielectric member with a metallic coating sufficiently thick to confine electromagnetic energy within said medium and without radiation loss and removing predetermined areas of said metallic coating through which electromagnetic energy is to pass.

2. The method of fabricating an antenna for the radiation of electromagnetic energy which includes the steps of forming from a low loss solid dielectric material a member having the shape and cross section corresponding to that of the antenna desired, electroplating to the outer surface of said member a layer of conductive material...
having a thickness sufficient to confine electromagnetic
energy within said member without radiation loss yet
thin enough to be substantially unaffected dimensionally
by normal temperature variations and removing portions
of said conducting layer at predetermined locations to
permit radiation therethrough, the shape of said portions
removed determining the beam characteristics of the
antenna.

3. A wave guide member for the propagation of elec-
tromagnetic energy comprising a solid, low-loss dielec-
tric member having a shape and cross-section correspond-
ing to that of the waveguide component desired, said
member having selected areas of its outer surface coated
with a metallic deposit of a thickness sufficient to con-
fine electromagnetic energy within said dielectric member
without radiation loss therethrough and of a thickness
sufficient to be substantially unaffected dimensionally by
normal temperature variations.

References Cited in the file of this patent

UNITED STATES PATENTS

2,066,511 Arlt ------------------------------- Jan. 5, 1937
2,072,262 Herzog ----------------------------- Mar. 2, 1937
2,129,711 Southworth -------------------- Sept. 13, 1938
2,129,712 Southworth -------------------- Sept. 13, 1938
2,134,794 Muth et al. ------------------------ Nov. 1, 1938
2,206,923 Southworth -------------------- July 9, 1940
2,210,415 Kellogg ----------------------------- Aug. 6, 1940
2,376,783 Krasik ----------------------------- May 22, 1945
2,411,534 Fox ------------------------------- Nov. 26, 1946
2,412,249 Brown et al. ----------------------- Dec. 10, 1946
2,455,224 Buchwalter et al. ------------------ Nov. 30, 1948