

# United States Patent

Gissel

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## [54] PLASTIC COVERED FLEXIBLE WAVEGUIDE FORMED FROM A METAL COATED DIELECTRIC LAYER

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[58] Field of Search .....333/95, 95 A; 174/109; 29/600, 29/601

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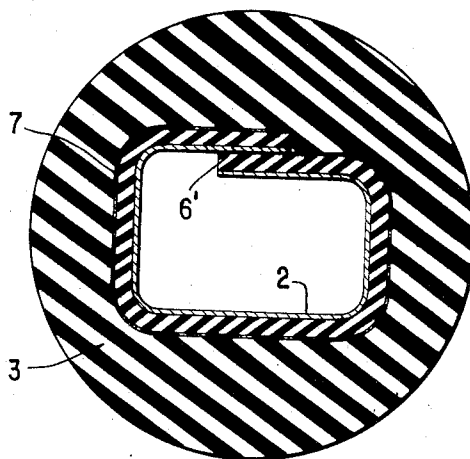
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### [57] ABSTRACT

A flexible waveguide composed of a tube of noncircular cross section formed by overlapping opposite edges of a sheet, the sheet being a laminate formed of metal foil covered on one surface by a layer of flexible dielectric. The exterior of the tube is covered with additional flexible dielectric material which forms a relatively thick protective coating.

11 Claims, 3 Drawing Figures



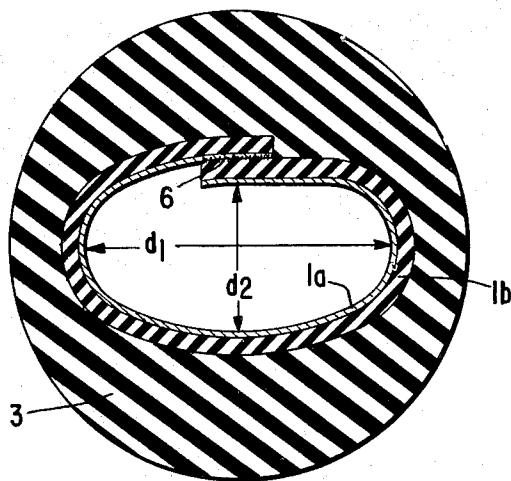


FIG. 1

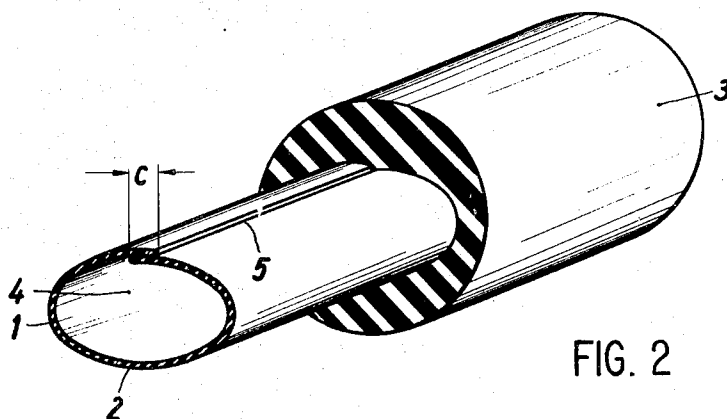


FIG. 2

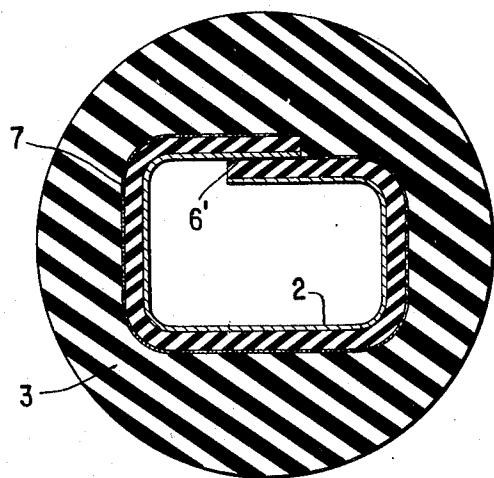


FIG. 3

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# PLASTIC COVERED FLEXIBLE WAVEGUIDE FORMED FROM A METAL COATED DIELECTRIC LAYER

## BACKGROUND OF THE INVENTION

This invention relates to waveguides, and more particularly to a flexible dielectric tube having a metallized layer on its interior surface to permit its use as a waveguide.

Prior art flexible waveguides have been made of corrugated metal tubes covered with an additional protective coating of a dielectric material such as a plastic. These presented certain disadvantages. The corrugated metal tube was subject to corrosion and the waveguide was relatively heavy. Moreover, the manufacturing expense for forming such a corrugated tube was relatively great. In addition the corrugations impaired the transmission properties of the waveguide.

## SUMMARY OF THE INVENTION

Among the objects of the present invention is the provision of a waveguide which is free of the above-noted drawbacks in that it is inexpensive to manufacture, light in weight and has a structure which does not adversely affect the transmission properties of the waveguide.

Briefly stated, these and other objects of the present invention are achieved by forming a tube from a laminated sheet formed of a metal foil covered with a dielectric layer. The opposite edges of the sheet are overlapped with the metal foil forming the tube interior. The sheet is glued or welded at the points of overlap and the entire tube is then covered with an additional protective coating of dielectric material, such as plastic. The internal cross section of the tube is noncircular.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view through a waveguide according to the present invention.

FIG. 2 is a perspective view, partly in section and partly broken away, of the waveguide of FIG. 1.

FIG. 3 is a cross-sectional view of a waveguide according to another embodiment of the invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, a waveguide according to the present invention is formed with a sheet 1 having opposite edges bent back upon itself to form a tube 2 having an approximately elliptical inner cross section 4. The tube interior has a major diameter  $d_1$  and a minor diameter  $d_2$ . The edges are overlapped through a region C whose width is approximately one-quarter of the wavelength of the waves to be transmitted over the waveguide. The longitudinal seam 5 of the overlapped region is secured by a welded or glued joint 6.

Sheet 1 is formed of a metal foil layer 1a and a layer of dielectric material 1b. The metal foil may be of copper or aluminum and the dielectric material may be of polyethylene or polyisobutylene mixed with carbon black or graphite. The relative thickness of the sheet layers is somewhat exaggerated in the drawing to more clearly show the structure. The exterior of the tube is covered with a protective coating 3 of polyvinyl chloride.

The protective coating 3 is secured to the tube 2 by gluing or welding. In the preferred embodiment the polyvinyl chloride may be sprayed on. The heat released as the polyvinyl chloride mass hardens may be used to weld the dielectric layer of the tube 2 and its metal foil in the region of the seam 5. The exterior surface of coating 3 is of circular cross section.

During fabrication, the sheet 1 is placed over a suitably shaped core to produce the desired inner cross section for the waveguide and the desired overlap. The waveguide can be easily manufactured in any desired length with the aid of conventional cable sheathing machines.

The thickness of the metal foil and of the other materials involved are primarily selected so that the waveguide can be bent about desired radii or through desired torsion angles without undesirable buckling or other distortion when the

guide is installed. From an electrical point of view the layer thickness of the foil should be a multiple of the penetration depth of the electromagnetic waves to be transmitted. This will suffice for externally shielding the waveguide. For reasons of stability the thickness of the metal foil is always a multiple of the above-mentioned penetration depth.

Unintended escape of electromagnetic energy from the interior of the waveguide in the region of the overlap may be avoided by making the overlap width C equal to approximately a quarter wavelength of the wave to be transmitted. Preferably the overlapping zone extends parallel to the longitudinal axis of the waveguide and is arranged that it extends approximately perpendicular with the Hy vector of the guided waves. The dielectric material 1b may be enriched with a material which strongly damps electromagnetic waves in order to prevent the escape of electromagnetic energy in this region.

Preferably this additive is concentrated in the region of the overlap. For this purpose graphite is added to the dielectric material 1b with a percentage by volume of about 10-30 percent.

Referring now to FIG. 3, another embodiment of the invention is seen in which the inner cross section of the waveguide is rectangular with sharply rounded corners. This shape, or any other noncircular cross section, may be formed by using an appropriately formed core during fabrication. Such shapes are useful for clear transmission of plane polarized waves.

This embodiment has a glued joint 6' securing the overlapped regions together and another glued joint 7 securing the protective coating 3 to the tube 2.

In both embodiments of the invention the circular exterior of coating 3 is particularly advantageous for attachment of the required fittings to the waveguide. The waveguide according to either embodiment of the present invention is particularly suited for use in mobile stations where fast setup and take-down time for the antenna is required.

It will be apparent that there has been provided a waveguide which is inexpensive to manufacture, relatively light in weight and which is flexible and convenient to use.

For a particular embodiment of the invention intended to transmit waves of a length of 5.9-6.5 MHz, a waveguide might have the following dimensions:

Thickness of aluminum metal foil 1a 0.1 mm.,  
thickness of sheet dielectric layer 1b 3.5 mm.,  
exterior diameter of coating 3 70 mm.,  
major diameter  $d_1$  of interior of tube 2 43.6 mm.,  
minor diameter  $d_2$  of tube 2 25.9 mm.

The metal foil thickness is a multiple of the penetration depth of the waves.

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

I claim:

1. A waveguide comprising, in combination:

a. a tube of noncircular cross section formed of a laminated sheet of a metal foil layer which covers one surface of a layer of flexible dielectric material, said sheet extending back upon itself so that opposite edge regions overlap for approximately one-quarter wavelength with the metal foil layer facing the interior of said tube, said overlapped regions of said laminated sheet being secured together, and extending parallel to the longitudinal axis of the waveguide and approximately perpendicular to the Hy vector of the wave to be transmitted through said waveguide, said dielectric material containing means for damping transmitted electromagnetic waves at least in the area between said overlapped regions; and  
b. a flexible dielectric coating covering the exterior of said tube and secured thereto.

2. The combination defined in claim 1 wherein the inner cross section of said tube is approximately elliptical.

3. The combination defined in claim 1 wherein said inner cross section is rectangular with rounded corners.

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4. The combination defined in claim 1 wherein the outer cross section of said flexible dielectric coating is of circular cross section.

5. The combination defined in claim 1 wherein said overlapped regions are secured together and said flexible dielectric coating is secured to said tube by respective welded joints.

6. The combination defined in claim 1 wherein said tube further comprises a glue joint securing said overlapped regions together and a glue joint securing said flexible dielectric coating to the exterior of said tube.

7. The combination defined in claim 1 wherein said dielectric material in said laminated sheet is a plastic mixed with carbon.

8. The combination defined in claim 7 wherein said plastic

material is polyethylene.

9. The combination defined in claim 7 wherein said plastic material is polyisobutylene.

10. The combination defined in claim 1 wherein said dielectric coating is of polyvinyl chloride.

11. The combination defined in claim 1 wherein: said inner cross section of said tube is elliptical and the outer cross section of said flexible dielectric coating is circular; said overlapped regions are secured together and said flexible dielectric material is secured to the exterior of said tube by respective welded joints; said metal foil is aluminum; said dielectric material is a polyethylene mixed with carbon; and said flexible dielectric coating is of polyvinyl chloride.

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