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ELECTROMAGNETIC WAVEGUIDES

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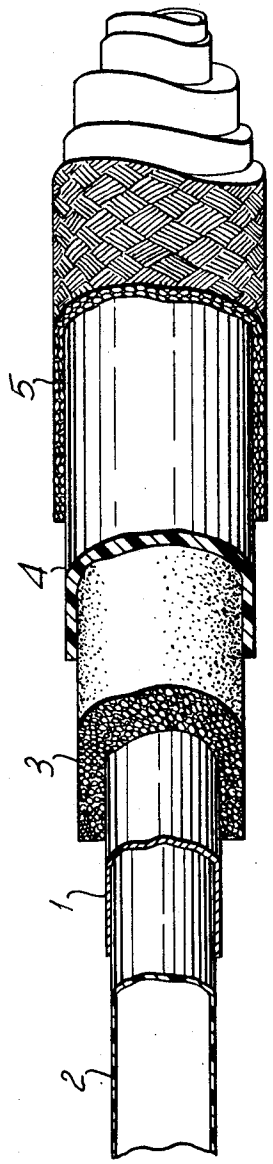


FIG. 1.

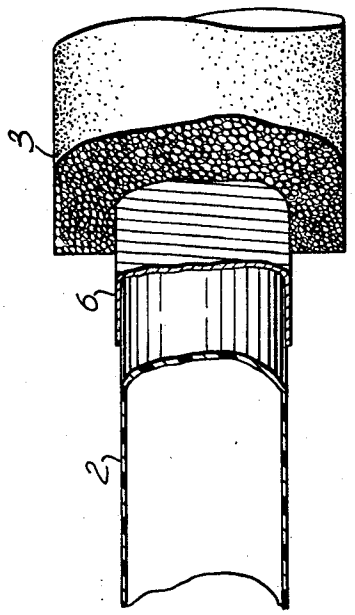


FIG. 2.

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ELECTROMAGNETIC WAVEGUIDES

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ABSTRACT OF THE DISCLOSURE

A flexible waveguide structure suitable for fabrication in long stretches which can be stored, transported, and installed in a similar manner to conventional cables. The waveguide proper is constituted by conductive material formed around the exterior of an insulating tube to constitute a composite gas-tight tubular member which may be maintained accurately circular in cross section by pressurizing its interior, the tubular member being sheathed by a layer of resilient material which is, in turn, surrounded by a protective covering.

It has been proposed to effect communication over a long distance by conveying microwave signals along electromagnetic waveguide of circular cross-section extending continuously along an appropriate transmission path. The forms of waveguide currently available are however not very suitable for this purpose, and it is accordingly an object of the invention to provide a form of electromagnetic waveguide particularly adapted for such a use.

According to the invention, a waveguide structure comprises a long composite tubular member which includes a tube of insulating material and at least one layer of conductive material formed around the exterior of the tube so as to constitute an electromagnetic waveguide, the tubular member having a thin and flexible wall such that its cross-section may be maintained accurately circular by pressurizing its interior, a layer of resilient material sheathing the tubular member, and a protective covering surrounding the layer of resilient material and having sufficient flexibility to permit the whole structure to be coiled.

It will be appreciated that a waveguide structure of this form may be conveniently fabricated in long unjointed stretches, which may be stored, transported and installed in a similar manner to conventional cables. The intended mode of propagation in the waveguide is the H_{01} mode, and the presence of the insulating material within the waveguide proper serves in known manner to reduce the risk of excessive attenuation occurring due to unwanted coupling between the H_{01} and E_{11} modes.

Some embodiments of the invention will now be described by way of example with reference to the accompanying drawings, in which:

FIGURE 1 is a partly sectional elevation, partly cut away, of a structure incorporating a waveguide suitable for conveying signals having a frequency of the order of 35,000 mc./s.; and

FIGURE 2 is a partly sectional view showing a detail of a modified form of the structure shown in FIGURE 1.

Referring to FIGURE 1, the waveguide is constituted by a continuous layer of copper **1**, which may suitably have a thickness of 0.0005–0.001 inch, formed on the outside of a polypropylene tube **2** having a uniform circular cross-section of diameter two inches and a wall thickness in the range 0.004–0.01 inch. The tube **2** may for example be formed by extrusion or by seamless welding together of the edges of a strip, and the layer **1** is preferably produced by a continuous process carried out in conjunction

with the formation of the tube **2**, for example by evaporation, spraying or electroless deposition. The tubular member constituted by the tube **2** and the layer is sheathed in a layer **3** of resilient material, for example a foamed thermoplastic resin, which may suitably have a thickness in the range ¼–½ inch; the layer **3** is in turn surrounded by a protective covering comprising a layer **4** of polythene of suitable thickness (say ⅛ inch) to form a homogeneous tube and an outer sheath **5** of metal braiding, the protective covering having a sufficient flexibility to enable the whole structure to be coiled on a drum or reel of the kind used for storing or transporting conventional cables. Preferably, the formation of the parts **3**, **4** and **5** is carried out by continuous processes similar to those used in cable making.

The structure shown in FIGURE 1 may be conveniently fabricated in unjointed stretches of length 1,000 feet, which may be coiled on a drum of 8 feet diameter. With stretches of this length it will normally be desirable to provide one or more mode filters at an intermediate point or points. Such a mode filter may conveniently be incorporated in the structure by removing parts of the layer **1** to leave, over a length of about three feet, a structure constituted by discrete copper bands 0.010 inch wide separated by gaps of width 0.001–0.002 inch.

During the handling of the structure prior to its installation some distortion of the tube **2** will normally occur. After the structure has been installed the tube **2** may be restored to its original cross-section by filling its interior with gas at superatmospheric pressure, so that the tube **2** is forced outwards uniformly against the layer **3** to maintain the cross-section of the waveguide accurately circular. For this purpose, lengths of the structure may be arranged to be jointed together by rigid waveguide sections (not shown) provided with valves suitable for the admission of compressed gas. The pressurising of the tube **2** will allow the structure to be laid along moderately curved paths without any appreciable distortion of the cross-section of the waveguide occurring.

In alternative embodiments of the invention, various modifications may be made in the form of the protective covering and the central tubular member as compared with the structure shown in FIGURE 1. For example, in appropriate circumstances the sheath **5** may be omitted, leaving the protective covering consisting solely of the layer **4**.

As is shown in FIGURE 2, in one modification of the form of the central tubular member the layer **1** may be replaced by a layer **6** formed by wrapping a strip of copper foil around the tube **2** in the form of a spiral with overlapping adjacent turns. The foil may suitably have a thickness of 0.001–0.003 inch and a width of 0.17 inch, and be wound in a spiral having 11 turns per inch; preferably the foil is secured to the tube **2** by means of an adhesive. In fabricating this structure the tube **2** may conveniently be drawn continuously over a mandrel as it is formed, the wrapping being carried out by rotating a reel of the foil around the portion of the tube **2** supported on the mandrel; any adhesive required may be applied to the tube **2** continuously as it is drawn onto the mandrel.

In other modifications of the form of the central tubular member, the waveguide itself need not be constituted by a single conductive layer; for example the waveguide may be constituted by two similar conductive coatings each formed as a regular series of discrete bands, one coating being formed directly on the exterior of the tube of insulating material, and the other being formed on a thin layer of lossy insulating material superimposed on the first coating, the bands of the outer conductive coating overlaying the gaps between the bands of the inner; the bands could for example have a width of 0.01 inch and

be spaced 0.002–0.003 inch apart, the insulating layer between the two coatings having a thickness of 0.02 inch. In this case the risk of damage to the waveguide occurring during handling of the structure prior to its installation should be lessened.

Further, it may be desirable in some cases for the outermost part of the central tubular member to be constituted by a thin layer of insulating material superimposed on the conductive material constituting the waveguide so as to avoid direct contact between the latter and the layer of resilient material.

I claim:

1. A waveguide structure comprising a long composite tubular member which includes a tube of insulating material and at least one layer of conductive material formed around the exterior of the tube so as to constitute an electromagnetic waveguide, the tubular member being gas-tight and having a thin and flexible wall such that its cross-section may be maintained accurately circular by pressurizing its interior, a layer of spongy material sheathing the tubular member, and a protective covering surrounding the layer of spongy material and having sufficient flexibility to permit the whole structure to be coiled.

2. A waveguide structure as claimed in claim 1 wherein said layer of spongy material includes a foamed material.

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