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G. SCHICKLE ET AL

3,364,446

WAVEGUIDE

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2 Sheets-Sheet 1

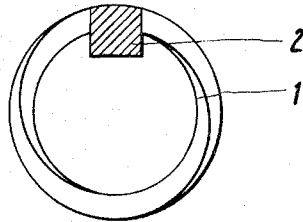


Fig. 1

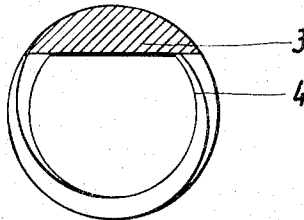


Fig. 2

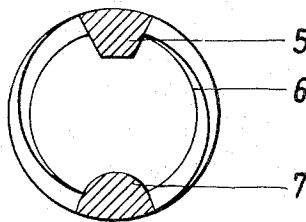


Fig. 3

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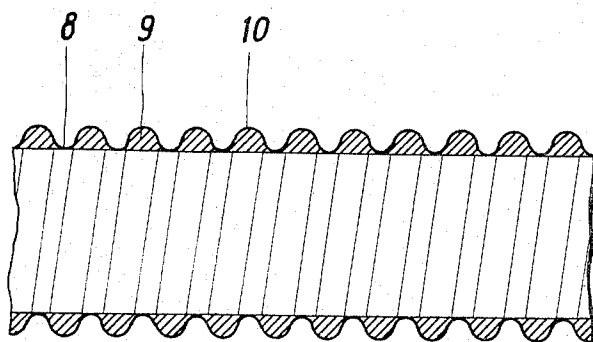


Fig. 4

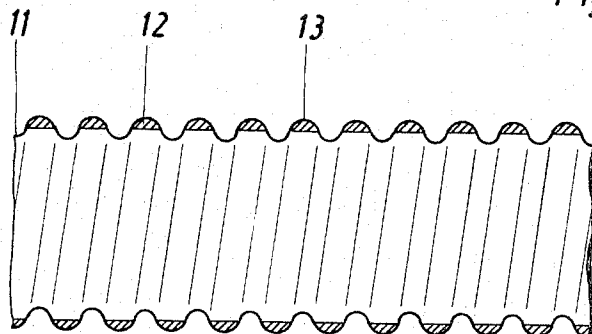


Fig. 5

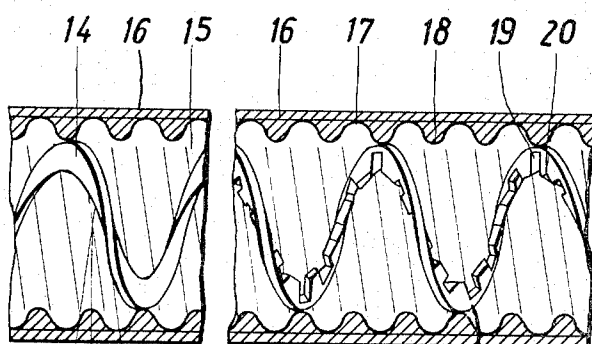


Fig. 6

Fig. 6a

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WAVEGUIDE

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11 Claims. (Cl. 333-95)

ABSTRACT OF THE DISCLOSURE

A corrugated waveguide having a circular cross section and within which is provided a body of dielectric material which acts to suppress undesired rotation of the plane of polarization of a linearly polarized wave propagated in the waveguide.

The present invention relates to a waveguide, and particularly to a corrugated waveguide having a circular cross section.

It is well known that the presence of unavoidable irregularities in the wall of a circular waveguide normally produces an undesired rotation of the polarization plane during the transmission of linearly polarized waves there-through.

A linearly polarized, electromagnetic wave propagated along a flexible circular waveguide having a continuous helical corrugation undergoes a rotation which causes its polarization plane to have an indeterminate orientation when the wave leaves the guide. It has already been suggested that this undesired rotation can be eliminated by giving the waveguide a non-circular cross section, such as an elliptical cross section for example. Such a form presents several drawbacks, however, particularly because relatively complicated coupling elements are required between elliptical waveguide sections and waveguide sections having other configurations.

In circular waveguides having a helically corrugated wall, the rotation of the polarization plane, which can be indicated in degrees per meter of waveguide length, has an additive component which is frequency dependent and which is also a function of the pitch and shape of the helical corrugation. It has been discovered that the sense of rotation of the polarization plane corresponds with the sense of the corrugation pitch. As a result, it has previously been attempted to cancel out the net rotation of the polarization plane by connecting together several waveguide sections each having the same cross section, but each having its helical corrugation wound in the opposite sense with respect to the helical corrugations of the adjacent sections. A waveguide constructed in this manner, however, has not proved satisfactory in practice because an intolerable degree of reflection occurs at the discontinuities existing along the joints between adjacent sections, even when these discontinuities are extremely small.

It is a primary object of the present invention to overcome these disadvantages.

It is a more specific object of the present invention to provide a continuous circular waveguide having helically corrugated walls in which rotation of the polarization plane of linearly polarized waves is suppressed.

Broadly stated, the present invention is based on the discovery that the undesired rotation of the polarized plane of a linearly polarized wave propagated in a circular waveguide having a helically corrugated wall can be suppressed by providing a body of dielectric material within the waveguide.

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More specifically, the present invention involves a device for conveying high frequency, linearly polarized electromagnetic waves, which device is composed of a flexible waveguide having a substantially circular cross section and a helically corrugated wall, and a dielectric loading disposed within the waveguide, the dimensions and dielectric constant of the loading being chosen in such a way that the loading compensates for rotation which the helical corrugation of the waveguide wall tends to induce in the polarization plane of the linearly polarized waves. According to one preferred form of construction, this dielectric loading is in the form of at least one longitudinal strip of dielectric material disposed on the inner surface of the waveguide wall. According to another form of construction, the loading is in the form of a helical strip which is wrapped so that the sense of its pitch is opposite from that of the corrugation of the waveguide wall.

Additional objects and advantages of the present invention will become apparent upon consideration of the following description when taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a transverse, cross-sectional view showing one embodiment of the present invention.

FIGURES 2 and 3 are views similar to that of FIGURE 1 showing two other embodiments of the present invention.

FIGURES 4, 5, 6 and 6a are longitudinal, cross-sectional views showing still further embodiments of the present invention.

FIGURE 1 shows a cross section of a circular, helically corrugated waveguide 1 within which is disposed a longitudinal dielectric strip 2 constituting the loading for the waveguide. In the embodiment shown, this strip has substantially a square cross section.

FIGURE 2 shows a cross section of a waveguide 4, which is identical with the waveguide 1 of FIGURE 1, and in which the dielectric loading strip 3 has the form of a segment of the circle defined by the interior circumference of the waveguide.

Turning now to FIGURE 3, there is shown a waveguide 6, which is similar to the waveguides 1 and 4 of FIGURES 1 and 2, respectively, having a pair of diametrically opposed dielectric loading strips 5 and 7. Each of these strips has a different cross section, the strip 5 having a trapezoidal cross section and the strip 7 having substantially a semicircular cross section, these forms being chosen, primarily, in order to indicate the wide variety of cross sections which can be given to the strips according to the present invention.

The dielectric strips shown in FIGURES 1 to 3 are preferably made of a foamed dielectric material exhibiting a low loss characteristic, because such material is highly flexible and thus does not adversely influence the flexibility of the waveguide itself. Furthermore, such a material can be readily applied in a continuous manner during the production of the waveguide itself by spraying the foamed dielectric material on the internal face of the waveguide with the aid of suitable spraying jets. The ability to apply the dielectric strips in this manner is highly important because it permits the assemblies shown in FIGURES 1 through 3 to be fabricated in an economical and rapid manner. The use of such material and method of application also permits the flexible dielectric strip to be applied to the flat, corrugated metal sheet from which the waveguide is to be made before this sheet is bent into its cylindrical form. If this procedure is followed, it is advantageous to protect the dielectric strip from the heat generated by the subsequent seam welding process by applying it along the centerline of the metal sheet so that it will be as far away from the seam as possible.

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In order to prevent an unnecessary increase in attenuation, the loading strip is preferably applied in such a way that it fills the internal grooves of the corrugated waveguide and protrudes only slightly beyond these grooves. Such an arrangement is shown in FIGURE 4, in which the material of dielectric strips 9 is disposed almost entirely within the grooves 10 on the internal wall of the waveguide 8.

It is also possible to apply the dielectric loading to the waveguide in the form of a series of isolated bodies of dielectric material which are spaced from one another and dimensioned in such a way that the undesired rotation of the polarization plane of the electromagnetic waves is suppressed. In this case, each of the bodies is disposed in one of the grooves on the internal wall of the waveguide and may extend slightly beyond their grooves. FIGURE 5 shows a waveguide 11 in which bodies 12 of dielectric material are disposed in this way in the grooves 13. In the embodiment shown, each of the bodies 12 is disposed entirely within its respective groove. When the dielectric loading is applied in the form of two diametrically opposed series of isolated bodies, as shown in FIGURE 5, it is also possible to space these bodies at greater distances from one another by leaving some of the grooves empty.

The presence, in a circular waveguide, of a dielectric having the form described above causes the waveguide to behave in a manner similar to that of a so-called "ridge waveguide" and therefore has an advantageous influence on the dimensions of, and the signal bandwidth which can be transmitted by the waveguide.

According to another embodiment of the present invention, the loading can be present in the form of a helix which is disposed in the waveguide and which is concentric with the cylindrical waveguide wall. The helix described by this loading has a winding sense which is opposite from that of the helix formed by the corrugation in the waveguide wall. The dimensions and dielectric constant of the loading are chosen in such a way that the loading acts to compensate for the rotation of the wave which would otherwise be produced by the waveguide corrugations.

According to the simplest form of construction of this loading, it is made in the form of a helical dielectric strip having a uniform cross section, the strip being mounted in the waveguide in the same manner as the plastic helices used for holding the inner conductors in coaxial cables. In the present case, the dielectric strip must have a certain degree of flexibility.

In order to maintain the attenuation and the reflection factors as small as possible, the helical loading can be effectively formed, in accordance with another feature of the present invention, of a series of regularly spaced dielectric bodies. This is achieved, according to a preferred embodiment, by forming the helical strip with a series of notches extending partially through the dielectric strip and disposed along its length. The desired rotation compensation can be obtained by varying the dimensions and the dielectric constant of the loading. Generally, however, it is preferable to give the dielectric strip a uniform dielectric constant and to form the strip so that its pitch angle is equal to the pitch angle of the helical corrugation in the waveguide wall. If these dielectric bodies extend inwardly substantially beyond the edges of the corrugation grooves on the internal waveguide wall, it is possible to improve the fitting of the necessary connection pieces at the ends of each waveguide section by a suitable choice of the dimensions of the dielectric strip.

FIGURE 6 shows one embodiment of a loading of this type in which the waveguide 15 is provided with a dielectric strip in the form of a helix 14. The pitch angle of the corrugation in the waveguide wall is designated by β . The strip 14 has a pitch angle α whose value is different from β . The sense of the pitch of strip 14 is opposite from that of the grooves 17. The corrugation ridges

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on the inner waveguide wall are designated by 18. The helical loading 14 has a uniform cross section.

The helical strip 14' of FIGURE 6a differs from the strip 14 of FIGURE 6 only in that it is provided with a spaced series of notches 19 which cause the loading to be effectively constituted by a spaced series of tooth-shaped dielectric bodies 20. Such an arrangement serves to increase the elasticity of the helix 14, so that the insertion of the loading in the waveguide is facilitated.

In order to protect the waveguide against damage, both during fabrication and use, there is provided a wear-resistant plastic coating 16 which is sprayed on in a conventional manner and which fills in the grooves formed in the outer wall of the waveguide.

It may thus be seen that the present invention makes it possible to use circular metal tubes having helical corrugations, which shape has previously been employed only for shielding coaxial high frequency cables, as waveguides for the transmission of linearly polarized microwaves without requiring an alteration of the cross section of the tube, and, consequently, without requiring the provision of complicated connection pieces between adjacent waveguide sections. The waveguide can thus be fabricated by a continuous process so as to have any desired length and can be wound on a drum in the same manner as a cable.

The fabricated waveguide can thus be easily transported and, because couplings, elbow joints and twists are eliminated, can be readily mounted in any configuration. The ease with which the waveguide can be mounted for operation is enhanced by the fact that a circular, corrugated waveguide can be bent equally well in any direction without having to be twisted.

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.

What is claimed is:

1. A device for transmitting high-frequency, linearly polarized electromagnetic waves, comprising, in combination:
 - (a) a flexible waveguide having a substantially circular cross section and a helically corrugated wall; and
 - (b) dielectric loading means disposed within said waveguide for compensating for rotation which the helical corrugation of said waveguide wall tends to induce in the polarization plane of the linearly polarized waves.
2. An arrangement as defined in claim 1 wherein said loading means is in the form of at least one dielectric strip disposed parallel to the length of said waveguide on the inner surface of said waveguide wall, said strip being made of a foamed dielectric having a low loss characteristic.
3. An arrangement as defined in claim 2 wherein said strip is disposed in the grooves formed on the inner surface of the waveguide wall by the corrugation thereof and extends inwardly slightly beyond these grooves.
4. An arrangement as defined in claim 1 wherein said loading means is constituted by at least one series of longitudinally aligned bodies of dielectric material disposed in the grooves on the inner surface of said helically corrugated wall.
5. An arrangement as defined in claim 1 wherein said loading means is composed of two diametrically-opposed, longitudinal loading members disposed on the inner surface of said waveguide wall.
6. An arrangement as defined in claim 1 wherein said loading means is composed of a dielectric body in the form of a helix having a pitch sense which is opposite from that of the waveguide wall corrugation.
7. An arrangement as defined in claim 6 wherein said body has a uniform cross section along its entire length.

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8. An arrangement as defined in claim 6 wherein said body is formed with a series of notches spaced at regular intervals along its length.

9. An arrangement as defined in claim 6 wherein said body has a uniform dielectric constant along its entire length. 5

10. An arrangement as defined in claim 6 wherein the helix defined by said body is concentric with said waveguide wall.

11. An arrangement as defined in claim 1 further comprising a layer of wear-resistant plastic covering the outer 10

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surface of said waveguide wall and filling the grooves formed in said outer surface by the corrugation of said wall.

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