

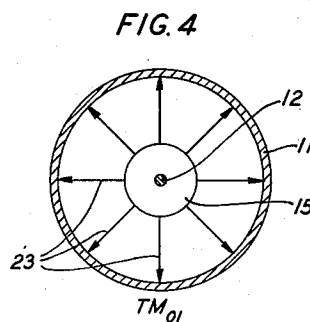
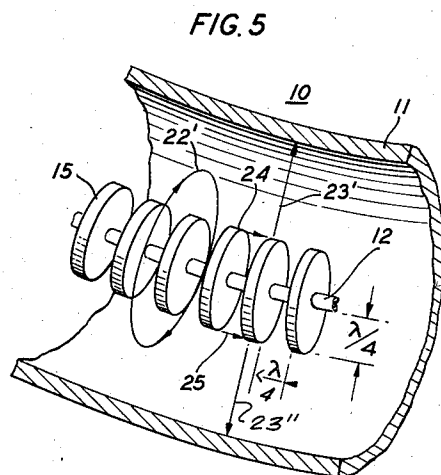
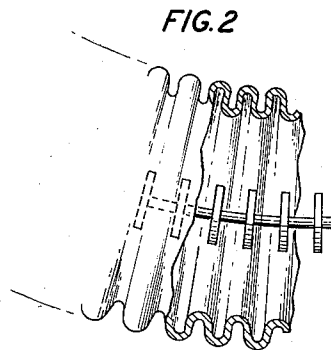
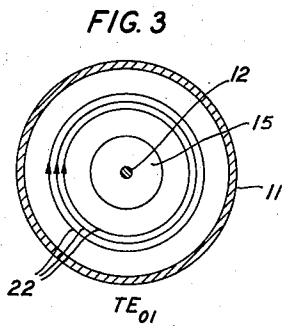
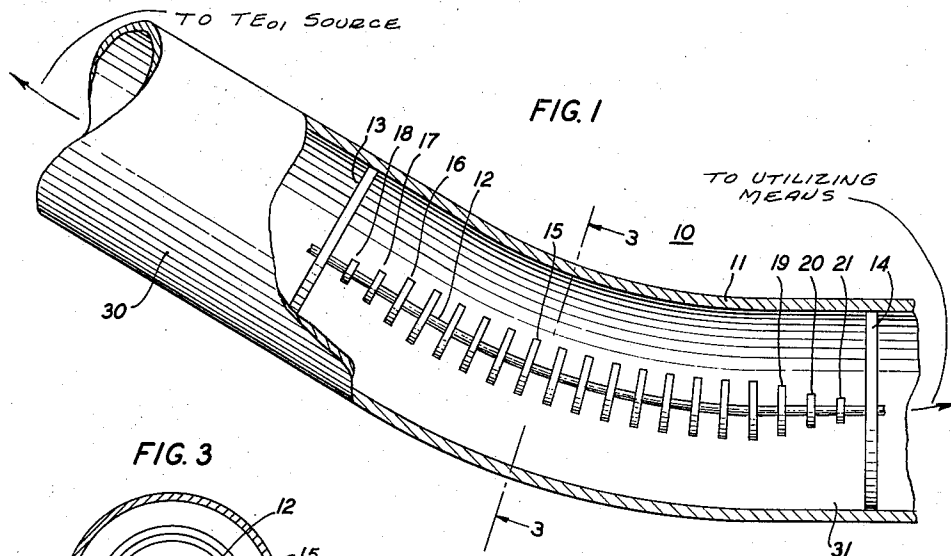
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WAVE GUIDE ELBOWS

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WAVE GUIDE ELBOWS

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2 Claims. (Cl. 333-98)

This invention relates to hollow-pipe wave guides for the transmission of electromagnetic waves and more particularly to structures for curved lengths or elbows of such wave guides.

An object of the invention is to attenuate and substantially suppress waves of undesired modes which may be generated in curved lengths of wave guide.

A further object of the invention is to reduce the cost and facilitate the manufacture of curved lengths of wave guide which will reduce the propagation of undesired modes of transmission while freely transmitting a desired mode.

A feature of the invention is the use of a coaxial elbow with a corrugated central conductive structure such as a rod or wire supported by insulating bushings or spiders and in turn supporting a plurality of conductive discs that are centrally apertured and strung upon the rod or wire at intervals less than a quarter of a wavelength.

The outer conductor or sheath of the wave guide may be smooth or corrugated as desired, but for lower cost of construction a smooth wall is preferable. No inner conductor is required in straight portions of the wave guide.

In accordance with the invention, the corrugated inner conductor does not interfere with the transmission of the circular electric type of waves. These are freely transmitted through the curved portions containing the corrugated inner conductor as well as through the straight portions. Waves of the circular magnetic type tend to be generated wherever the wave guide is curved but are attenuated by the presence of the corrugated inner conductor.

Since the principal circular electric mode, in a wave guide of circular cross-section, also called TE_{01} mode, has advantages of low inherent attenuation it is likely to come into more extensive use in the future. When a wave guide carrying the TE_{01} mode has material curvature, the TM_{01} mode tends to be generated and tends to take power away from the TE_{01} mode. It is desirable, therefore, to have some economical means for suppressing the TM_{01} mode in curved portions of the wave guide. It has been proposed to use a wave guide with corrugated outer wall to suppress the TM_{01} mode but such a wave guide is expensive to fabricate. In accordance with the invention a relatively simple corrugated central conductor is used, the depth of corrugation being a quarter wavelength to suppress the TM_{01} mode and the width of corrugation being less than a quarter wavelength in order not to materially effect the transmission of the TE_{01} mode. In those places where bends in the wave guide are required the structure may consist of a curved length of wave guide carrying the TE_{01} mode on a corrugated central conductor which is tapered at both ends to reduce wave reflections. In all straight portions of the wave guide the central conductor is not necessary and is omitted. It is feasible also to use a corrugated outer conductor in the curved portions, if desired. While this adds to the expense of fabrication, it has an advantage

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in permitting the use of larger diameter wave guides without introducing trouble from higher order modes of transmission that may be generated.

In the drawings,

Fig. 1 is a plan view, partly broken away, of a curved length of wave guide between two straight portions, showing a centrally supported conductive structure in accordance with the invention;

Fig. 2 is a plan view, partly broken away, of a curved portion of wave guide with a corrugated outer conductor and in inner conductor structure like that shown in Fig. 1;

Fig. 3 is a cross-sectional view of the structure of Fig. 1 at the plane 3-3, with a diagrammatical representation of a few of the electric field lines of a circular electric wave of TE_{01} mode;

Fig. 4 is a cross-sectional view of the structure of Fig. 1 at the plane 3-3 with a few of the electric field lines of a circular magnetic wave of TM_{01} mode shown diagrammatically; and

Fig. 5 is an enlarged perspective view of a portion of the structure of Fig. 1 with diagrammatical representations of electric field lines of circular electric and circular magnetic waves.

Referring to Fig. 1, a curved portion 10 of hollow-pipe wave guide between straight portions 30 and 31 is shown having an outer conductor 11 with a smooth inner wall. Centrally mounted in the curved portion 10 is a rod or wire 12 which may or may not be conductive and which is supported on the central axis of the wave guide as by means of bushings 13 and 14. Supported upon the rod or wire 12 are a plurality of conductive discs 15. The discs 15 may each be provided with a central aperture to fit the rod or wire 12 upon which the discs are strung and suitably fixed at regular intervals. The space between adjacent discs should be less than a quarter of a wavelength of the waves of desired mode in the wave guide. The radial dimension of the disc from the surface of the rod 12 out to the circumference of the disc should be effective exactly a quarter wavelength for best suppression of the undesired mode. This wavelength will be substantially the same for the waves of desired mode in the curved portion in the presence of the discs as in the straight portions where no central structure is used. A lower limit to the spacing will be imposed by considerations such as clearance between adjacent discs on the inside of the curve, breakdown voltage between discs, and tendency for dust and dirt to collect between discs. Spacings from one-sixteenth to three-sixteenths of a wavelength, more or less, will generally be satisfactory.

The inside diameter of the hollow-pipe wave guide will be governed by the usual practice, a commonly used size being at least three half-wavelengths in diameter.

In straight lengths of the wave guide no central conductive structure is needed and should be omitted.

To reduce reflection of the wave upon entering and leaving the region of the center conductor, however, the diameters of the discs at both ends of the rod 12 may be gradually reduced to provide tapered transitions as indicated by discs 16, 17, 18 and 19, 20, 21. The tapered portions of the inner conductive structure will preferably extend into the adjacent straight portions of the wave guide.

The use of a corrugated outer conductor with no inner conductor has been suggested for attenuating undesired modes of transmission in curved lengths of wave guide, but such corrugated conductors are relatively difficult and costly to manufacture, as will be evident in comparison with the rod, disc and bushing structure of the present invention. It is possible, however, to combine the structure of the present invention with the corrugated outer conductor of the prior art and thereby obtain the combined effects of both structures in attenuating the

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circular magnetic waves. Such a combined structure is shown in Fig. 2. The corrugated outer conductor has the added advantage of suppressing higher order modes, thereby enabling larger size wave guides to be used where desired.

Fig. 3 is a sectional view of the curved wave guide 10 at the plane 3—3 as indicated in Fig. 1. A portion of the pattern of the circular electric field of the TE_{01} mode excited from a suitable source connected to guide 11 is indicated diagrammatically in Fig. 3 by circles 22 with arrows to show the instantaneous direction of the electric force. This mode is referred to herein as the desired mode to be delivered by guide 11 to the required utilizing means.

Fig. 4 is a sectional view similar to that shown in Fig. 3, except that it shows some of the field lines 23 of the transverse component of the electric field of the circular magnetic mode TM_{01} , the mode referred to herein as the undesired mode.

Fig. 5 shows an enlarged perspective view of a portion of the curved wave guide 10 of Fig. 1. It will be evident from a consideration of this figure that the TE_{01} mode is propagated through the curved wave guide in the presence of the central conductive structure without deleterious effects whereas the TM_{01} mode will be attenuated or suppressed.

One of the electric field lines 22' of the TE_{01} mode is shown in Fig. 5 as a circle concentric with the axis of the wave guide. The circle 22' is free to move longitudinally parallel to the axis of the wave guide, but movement of the circle 22' in the radial direction is greatly impeded due to the narrow spacing between adjacent discs. Inspection of Fig. 5 shows that each two adjacent discs form a wave guide the width of which is the distance between the discs. For the electric field parallel to the disc surfaces as in the case of the circle 22', cut-off occurs when the spacing is reduced to a half wavelength. As the discs are spaced less than a quarter wavelength apart, the TE_{01} mode cannot appreciably enter into the space between the discs. Wave transmission proceeds substantially unhindered in the space between the inner wall 11 and the outer edges of the discs 15 and does not differ essentially from the TE_{01} mode in a hollow cylindrical wave guide. It is immaterial that the wave does not extend to the axis of the wave guide, particularly as the tapered end portions provide a smooth transition into and out of the curved wave guide.

For the TM_{01} mode, however, the conditions are different. The radial components of electric field 23' and 23'' of Fig. 5 in propagating longitudinally along the axis of the wave guide tend to be bent into the axial direction upon contact with the discs as at 24 and 25 and these axial components break off, so to speak, and are freely transmitted radially between the opposed surfaces of two adjacent discs 15. The axial component of the electric field, not shown, is also parallel to the axial components shown at 24 and 25 and is freely transmitted

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radially. No limiting width of wave guide arises in this case. The discs form a parallel plate transmission line, having no cut-off frequency. Due to the radial depth of the corrugation formed by two discs being a quarter wavelength, the wave traveling to the central rod and back to the periphery of the disc is delayed one-half period and the wave emerges from the corrugation exactly or substantially 180 degrees out of phase with the next succeeding wave. Thus a partial or complete suppression occurs and as a result the TM_{01} mode is attenuated. Accordingly, the central conductive structure shown, is effective to suppress the TM_{01} mode while freely propagating the TE_{01} mode.

It is to be understood that the above-described arrangements are illustrative of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A high frequency electromagnetic wave transmission system including a source of wave energy in the circular electric mode, means for utilizing said circular electric mode energy, and means for selectively transmitting said energy around a bend in a guiding path connecting said source to said utilizing means, said transmitting means comprising a curved section of conductively bounded wave guide of circular cross section and a cylindrical conductive member extending coaxially within and substantially coextensive with said guide, said member having a plurality of transverse circumferential grooves each having an axial dimension less than a quarter-wavelength of said waves.

2. A high frequency electromagnetic wave transmission system including a source of wave energy in the circular electric mode, means for utilizing said circular electric mode energy, and means for selectively transmitting said energy around a bend in a guiding path connecting said source to said utilizing means, said transmitting means comprising a curved section of conductively bounded wave guide of circular cross section and a cylindrical conductive member extending coaxially within and substantially coextensive with said guide, said member having a plurality of transverse circumferential grooves each having a radial depth substantially equal to a quarter-wavelength of said waves.

References Cited in the file of this patent

UNITED STATES PATENTS

2,231,602	Southworth	Feb. 11, 1941
2,567,718	Larson	Sept. 11, 1951
2,567,748	White	Sept. 11, 1951
2,688,732	Kock	Sept. 7, 1954
2,751,561	King	June 19, 1956

FOREIGN PATENTS

890,924	France	Nov. 19, 1943
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