United States Patent

Wagele

[15] **3,692,063**

[45] **Sept. 19, 1972**

[54] **FLEXIBLE WAVEGUIDE AND METHOD OF PRODUCING**

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[22] Filed: **March 15, 1971**

[21] Appl. No.: **124,024**

[30] **Foreign Application Priority Data**

March 17, 1970 Germany..........P 20 12 572.8

[52] **U.S. Cl.**..................................**138/139,** 138/171

[51] **Int. Cl.**..**F16l 11/00**

[58] **Field of Search**......138/171, 141, 145, 146, 128, 138/137, 139; 174/107

[56] **References Cited**

UNITED STATES PATENTS

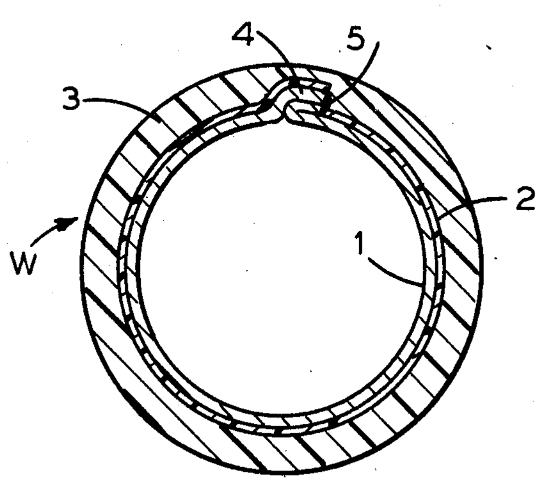
1,952,955	3/1934	Trageser et al.	138/171
2,511,916	6/1950	Hollingsworth et al	138/139 X
2,886,691	5/1959	Rudd	138/171 X
3,459,877	8/1969	Bullock et al	174/107

Primary Examiner—William R. Cline
Attorney—Philip G. Hilbert

[57] **ABSTRACT**

A method of forming a waveguide for the transmission of electromagnetic waves, having a construction particularly adapted for transmission of high frequency waves and which is capable of sufficient flexure to allow the same to be wound on drums. The waveguide is formed from a thin metal tape converted to tubular form having a longitudinal tab seam portion which is welded and folded over against an outer surface portion of the tubing. An adherent coating of thermoplastic polymer and an outer sheath of synthetic resin are applied over the tubing.

9 Claims, 4 Drawing Figures



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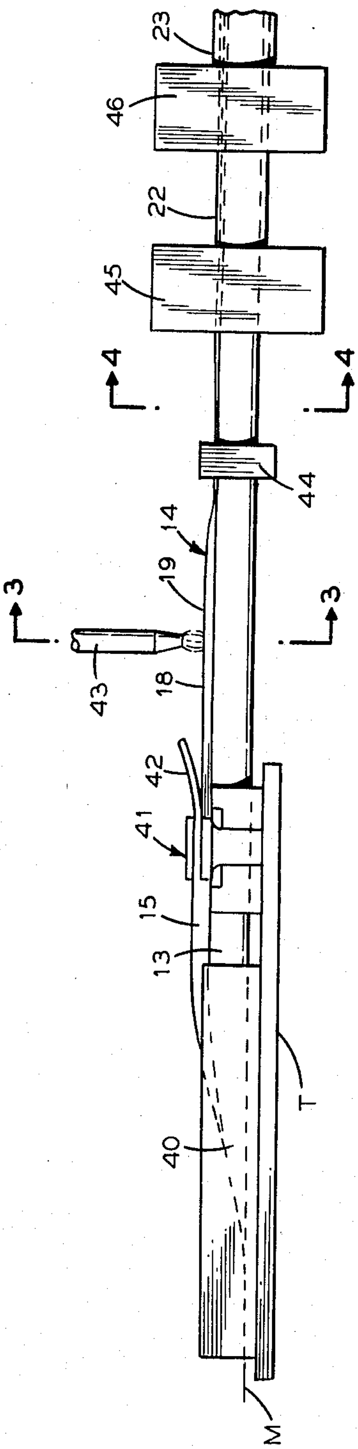

FIG. 2

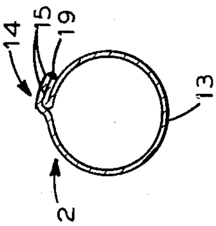

FIG. 4

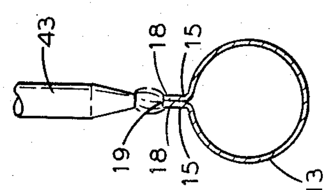

FIG. 3

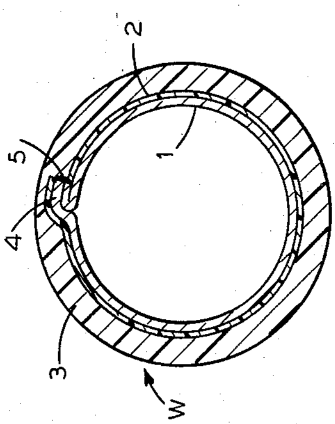

FIG. 1

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FLEXIBLE WAVEGUIDE AND METHOD OF PRODUCING

BACKGROUND OF THE INVENTION

The use of waveguides or coaxial cables for the transmission of microwaves, as for example, from a receiver or transmitter to an antenna, is well known in the art. When such transmission means must be flexible so as to allow the same to be wound on drums; coaxial cables have been the preferred form of such transmission means.

Such coaxial cables, however, are limited in their application to the transmission of frequencies which under modern understanding of the pertinent technology, are relatively low. If used for transmitting high frequencies, e.g., in the giga-hertz region, their damping is too large with economically and spatially tolerable parameters. To increase the dimensions thereof is not feasible for technical reasons, since with such increased dimensions, the limiting frequency falls off. Further, there is a possibility of the occurrence of interfering modes, which again would increase the damping excessively and intolerably.

Thus, for economical and technical reasons, one must use waveguides as transmission elements between a transmitter or receiver and the antenna. Attempts have been made to use flexible waveguides of circular cross section, which can be wound on drums, for the transmission of microwaves. In such cases, the corrugated outer conductor of a coaxial cable has been used, omitting the inner conductor thereof and its supporting means.

In order to achieve sufficient flexibility, such known waveguides must have corrugations of an optimum depth. These corrugations may cause the excitation of certain oscillation modes, or the injected, linearly polarized wave can be split into two components. This results in a rotation of the direction of polarization which is length and curvature dependent and acts in a strongly damping fashion. Further, the aforesaid splitting phenomena and the rotation of polarization are strongly frequency dependent. Thus, when a broad band of frequencies is to be transmitted over such an element, it is almost impossible to avoid large losses upon a coupling of the supplied energy.

To avoid these disadvantages, it has been suggested to employ corrugated waveguides having an elliptical cross section; such cross section stabilizing the plane of polarization by exact matching to that of the wave-modes to be transmitted. Such elliptical, corrugated waveguides are quite expensive to produce and their use is limited for economic reasons.

Accordingly, an object of this invention is to provide an improved waveguide and a method of making the same, which is economical to produce, has a simple cross section, is flexible so as to be readily wound on drums, and which does not inject any unfavorable influences on the waves to be transmitted.

Another object of this invention is to provide an improved waveguide construction which is formed from a thin metal tape converted to tubular form and having a tab seam portion extending longitudinally thereof, the seam portion being folded over against an outer surface portion of the tubing; an adherent coating of thermoplastic polymer and an outer sheath of synthetic resin being applied over the freshly formed tubing.

A further object of this invention is to provide an improved waveguide of the character described, which has a mirror-like inner surface adapted to optimize the propagation of high frequency waves.

Yet another object of this invention is to provide a waveguide of the character described and including a tubular member formed of thin metal tape; the tubular member being strengthened in a mechanical sense by the synthetic resin sheath which is in tight adherence to the thin tubular member by way of the intermediate adherent polymer coating; thereby allowing for mechanical loading without deformation as when the waveguide is wound on or off a drum or when the waveguide is bent during installation.

Still another object of this invention is to provide a waveguide of the character described, which may have any one of several geometric cross sections, including circular, elliptical, square or rectangular, made in accordance with the method of the invention.

Other objects of this invention will in part be obvious and in part hereinafter pointed out.

DESCRIPTION OF THE DRAWING

FIG. 1 is a cross sectional view of a waveguide embodying the invention;

FIG. 2 is a schematic showing of the process embodying the invention;

FIGS. 3 and 4 are sectional views taken on the lines 3—3 and 4—4 respectively of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS.

As shown in FIG. 1, W designates a waveguide embodying the invention. The same comprises a tubular member 1 formed from a thin metal tape such as copper or aluminum and having a longitudinally extending folded tab seam 4 with a longitudinally extending weldment 5 securing the outer edges of the seam together. The metal tape has a thickness of not more than 0.3 mm. and preferably a thickness of not more than 0.2 mm.

A sheath 3 of a polymeric resin such as polyethylene is secured to the outer surface of tubular member 1 by an intermediate layer 2 of a synthetic polymer which is tightly adherent to metal, as well as to the sheath 3. Such layer 2 may be derived from copolymers of polyethylene and selected monomers, as set forth in U.S. Pat. Nos. 2,987,501 and 3,027,346.

It has been found that the inner mirror surface of tubular member 1 is highly effective in the transmission of high frequency waves. Also, it has been found that the groove formed by the turned over tab seam 4 does not disturb the transmission of high frequency energy as the transmitted waves are already polarized. Such groove can be used as a directrix for the waves to be transmitted.

The waveguide W show good stability and resistance to deformation during transport and installation thereof, and further may be bent through selected radii without permanent deformation. The flexibility of the waveguide facilitates the formation in situ of bends and curves dictated by the installation; thus materially reducing costs.

While the waveguide W is shown as being of circular cross section; it is understood that the same may be of elliptical, rectangular or other cross sections.

The waveguide W is made by the process set forth in FIGS. 2–4. Thus, a thin metal tape M is moved along a forming table T and is converted to tubular form **13** by known tube forming means **40**. The tape M has a width greater then the circumference of the tubular member **13**, so that marginal side portions thereof form upstanding, radially disposed tab portions **15** in face to face relation. The member **13** moves along table T to a trimming device generally indicated at **41**, and shown in greater detail in copending application Ser. No. 864,984, filed Oct. 9, 1969, **now U.S. Pat. No.** 3,576,939; where the tab portions **15** are cut to a determined tab height, bringing the freshly cut edges **18** into true alignment.

The tubing continues its movement past trimming device **41**, the trimmed portion **42** of tab portions **15** being suitably removed and bringing the freshly cut, oxide free edges **18** thereof into precise alignment with suitable welding means **43**, preferably operated under a protective atmosphere of argon or the like, whereby to weld and metallically integrate the tab edges **18** by way of a continuous, longitudinally extending weldment **19**.

The resultant tab seam **14** may have a selected height and is folded over from its radial position to a circumferential position, as by a suitable folding die **44**. The coating **22** of metal adherent polymer is applied over the outer surface of member **13** by an extruder **45**. The thicker sheath **23** of polyethylene or the like, as applied by a second extruder **46**.

Thus, the waveguide W may be formed in indefinite lengths, and in a continuous manner so as to materially reduce production costs.

I claim:

1. A waveguide comprising a tubular metal member, an outer sheathing of polymeric resin, and a synthetic polymer coating bonding said sheathing to the outer surface of said member, said tubular member being formed of a metal tape having a thickness of not more then **0.3** mm., said tape being converted to tubular shape with a longitudinal seam comprising tab portions in face to face relation, weldment means securing said tab portions, said secured tab portions being disposed circumferentially throughout the length thereof in contact with an outer surface portion of said member.

2. A waveguide as in claim **1**, wherein said metal tape has a thickness of less than 0.2 mm.

3. A waveguide as in claim **1**, wherein said metal tape is aluminum.

4. A waveguide as in claim **1**, wherein said synthetic polymer coating is a copolymer of polyethylene and monomers.

5. A waveguide as in claim **4**, wherein said sheathing is polyethylene.

6. A method of making a waveguide comprising converting a thin metal tape into tubular form with a longitudinal seam comprising radially extending tab portions in contacting relation, welding said tab portions, bending the welded tab portions into contact with an outer surface portion of said tubular member, continuously applying a coating of metal adherent synthetic polymer to the outer surface of said tubular member, and continuously applying a sheathing of synthetic polymer resin over said metal adherent synthetic polymer.

7. A method as in claim **6** wherein said metal tape has a thickness of not more than 0.3 mm.

8. A method as in claim **6**, wherein said metal adherent synthetic polymer is a copolymer of polyethylene and monomers.

9. A method as in claim **8** wherein said sheathing is polyethylene.

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