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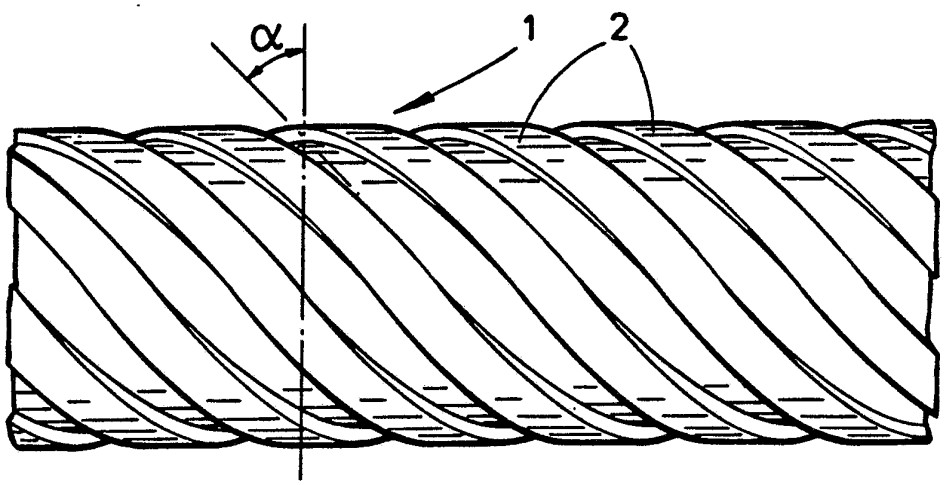
(54) Title: FLEXIBLE WAVEGUIDES



(57) Abstract

A flexible waveguide (1) has corrugated seamless walls (2) the corrugations of which are inclined to the transverse planes of the waveguide, that is, planes perpendicular to the longitudinal axis of the waveguide, at an angle of substantially 45°. The inclined corrugations, which may be annular or helical, permit both flexing and twisting of the waveguide.

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Flexible Waveguides

This invention relates to flexible waveguides.

A known construction of flexible waveguide has walls which have a corrugated or bellows-like conformation, the corrugations lying in planes transverse the longitudinal axis of the waveguide. The corrugations may be formed by winding a conductive metal strip such as brass and sealing adjacent windings together by solder. Such a waveguide is flexible by virtue of the flexibility of the strip forming the individual corrugations, but is not in general capable of being twisted. In order to sustain an angular deformation or twist about its longitudinal axis a corrugated waveguide has to be formed with interlocking corrugations which overlap, for example, around a wire core which is wrapped around the waveguide; sliding movement of the individual corrugations or "turns" relative to the wire core permits a degree of twist in the waveguide.

The present invention seeks to provide, in a simple construction, a corrugated waveguide which is capable of sustaining both bending and twisting movements.

According to the invention there is provided a flexible waveguide having corrugated walls the corrugations of which are inclined to the transverse planes of the waveguide, that is, planes perpendicular to the longitudinal axis of the waveguide at an angle of substantially 45°. Such a corrugation angle has been found in practice to permit combined bending and twisting of the waveguide.

Upon flexing of the waveguide according to the invention the waveguide can exhibit both bending and twisting deformation. Such deformation can be useful for certain interfacing applications. In some cases the degree of twist imparted to a length of the flexible waveguide will be a result of a bending of the waveguide and will depend on the exact angle of the inclined corrugations, the length of the waveguide and the degree of bending imparted thereto. In other cases, bending and twisting deformations of the waveguide will be independent of each other.

The corrugations in the waveguide may be rectangular in cross sectional profile. Alternatively the corrugations may have a substantially sinusoidal cross sectional profile, applicable more particularly to the larger sizes of waveguide.

The waveguide according to the invention is preferably seamless. The corrugations may be obtained by, for example, an hydraulic cold-forming process or an electro-forming process.

The seamless flexible waveguide according to preferred embodiments of the invention, in contrast with previously known twistable waveguides, does not have any discontinuity between adjacent corrugations, for permitting relative sliding movement between these corrugations. Since the corrugations are formed in a single piece of sheet metal without discontinuity the degree of radio frequency leakage exhibited by the flexible

waveguide according to the invention is potentially less than that exhibited by flexible waveguides of the traditional construction referred to previously.

The invention will be further described, by way of example only, with reference to the accompanying purely diagrammatic drawings, in which:

Figures 1 to 4 are respective scrap plan views of sections of flexible waveguide according to four different embodiments of the invention, and

Figure 5 is a perspective view of part of the flexible waveguide illustrated in Figure 3, illustrating its flexing and twisting characteristics.

Figures 1 to 4 illustrate sections of flexible waveguide 1 the walls of which are continuous, that is, seamless, and formed with corrugations 2 which are inclined at an angle α of substantially 45° to the longitudinal axis of the waveguide 1. In other words, the corrugations 2 are inclined at 45° to the transverse planes in which the corrugations of a conventional flexible waveguide would normally lie.

The corrugations 2 in the waveguide are preferably of helical or spiral configuration, as illustrated diagrammatically in Figures 1 and 2, with a pitch angle α of 45°. Alternatively, the corrugations 2 may be fully annular, as illustrated in Figures 3 and 4. Where the corrugations 2 are of helical form the requisite corrugation pitch is achieved by conforming the corrugations to a multi-start helical configuration.

The individual corrugations, whether of spiral or annular form, may have a rectangular cross sectional profile, as illustrated in Figures 1 and 3. Such corrugations are particularly applicable to the smaller sizes of waveguide down to millimetric sizes and are readily formed by electroforming techniques, that is, by electrolytic deposition of the waveguide upon a former or arbor, which is subsequently dissolved.

The corrugations 2 of the waveguide may alternatively have a generally curved cross sectional profile, for example the sinusoidal profile illustrated diagrammatically in Figures 2 and 4. Corrugations of this profile are readily formed by hydraulic deformation of an initially smooth wall waveguide to conform to a profile determined by an external die or mould, the waveguide walls being deformed by the application of an internal hydraulic pressure. Corrugations of this profile are suitable for waveguides of larger sizes up to 26 GHz.

It will be understood that in practice the electroforming process may also be used for the production of waveguides of the kind illustrated in Figures 2 and 4, and the hydraulic forming method may be used for waveguides of the kind illustrated in Figures 1 and 3.

The inclined corrugations 2 of the flexible waveguide according to the invention permit flexing and twisting deformation of a section of waveguide, as illustrated schematically in Figure 5. The

inclined corrugations allow normal flexing of the waveguide perpendicular to its major face, as indicated in broken outline in Figure 5, and also a twisting deformation of the waveguide, as shown in full outline.

In the illustrated embodiment, the flexing of the section of waveguide 1 is indicated by the arrow F and is accompanied by a twisting deformation indicated by the arrow T. It will be seen that as a result of the bending and twisting of the waveguide the opposite ends of the flexed section of waveguide, as well as lying in different planes as a result of the bending of the waveguide, are also angularly displaced relative to each other about the longitudinal axis of the waveguide.

The degree of twisting may be predetermined, for a given length of waveguide, by the degree of bending imparted to the waveguide, or may be completely independent of the flexing of the waveguide.

The invention has been described in its particular application to flexible waveguides of rectangular cross section; it will be understood, however, that the invention is also applicable to flexible waveguides of circular and other cross-sectional profiles.

CLAIMS

1. A flexible waveguide (1) having corrugated walls the corrugations (2) of which are inclined at an angle (α) to the transverse planes of the waveguide, that is, planes perpendicular to the longitudinal axis of the waveguide, characterised in that the angle of inclination (α) of the corrugations (2) is substantially 45°, allowing both bending and twisting of the waveguide.

2. A flexible waveguide according to Claim 1, characterised in that the corrugations (2) have a rectangular cross-sectional profile.

3. A flexible waveguide according to Claim 1, characterised in that the corrugations (2) have a substantially sinusoidal cross-sectional profile.

4. A flexible waveguide according to any one of Claims 1 to 3, characterised in that the corrugations are fully annular.

5. A flexible waveguide according to any one of Claims 1 to 3, characterised in that the corrugations are helical.

6. A flexible waveguide according to any one of the preceding claims, characterised in that the waveguide (1) has continuous, that is, seamless, walls.

FIG 1

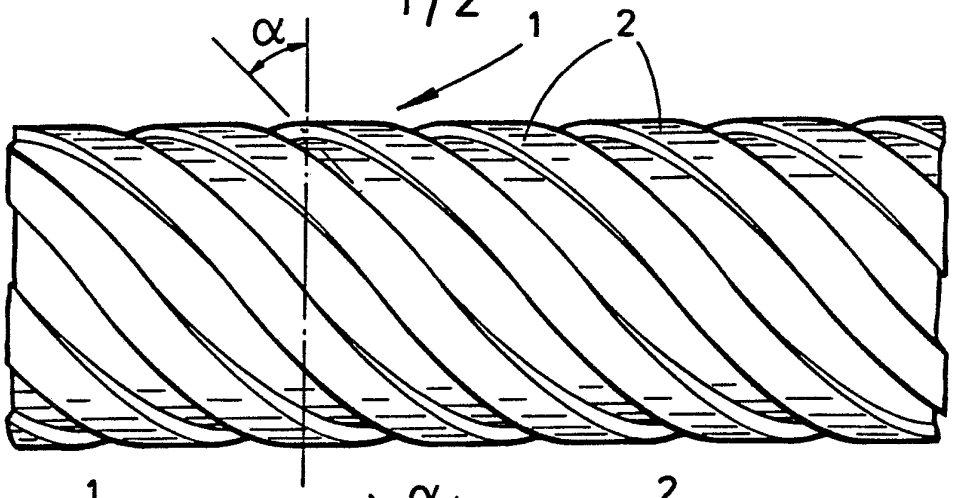


FIG 2

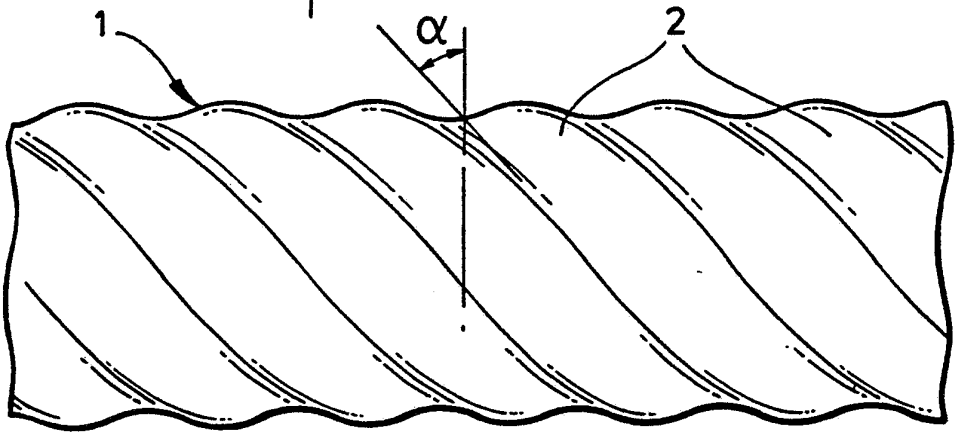


FIG 3

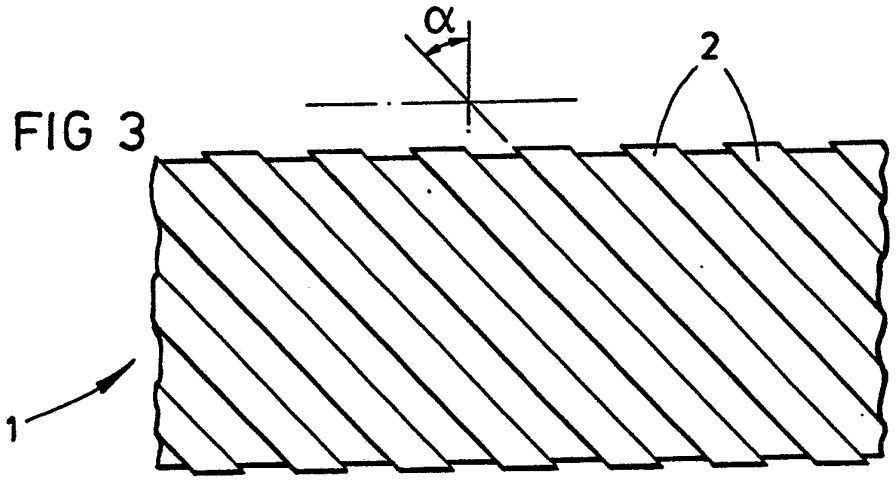


FIG 4

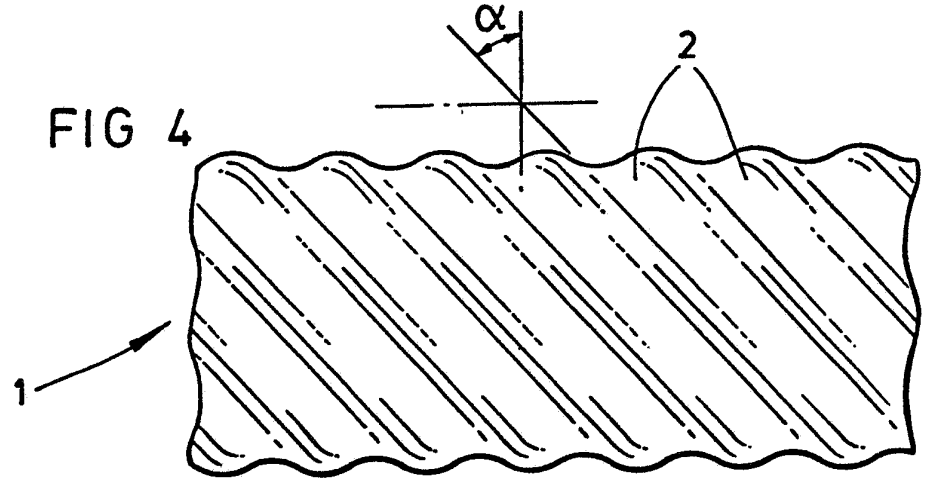
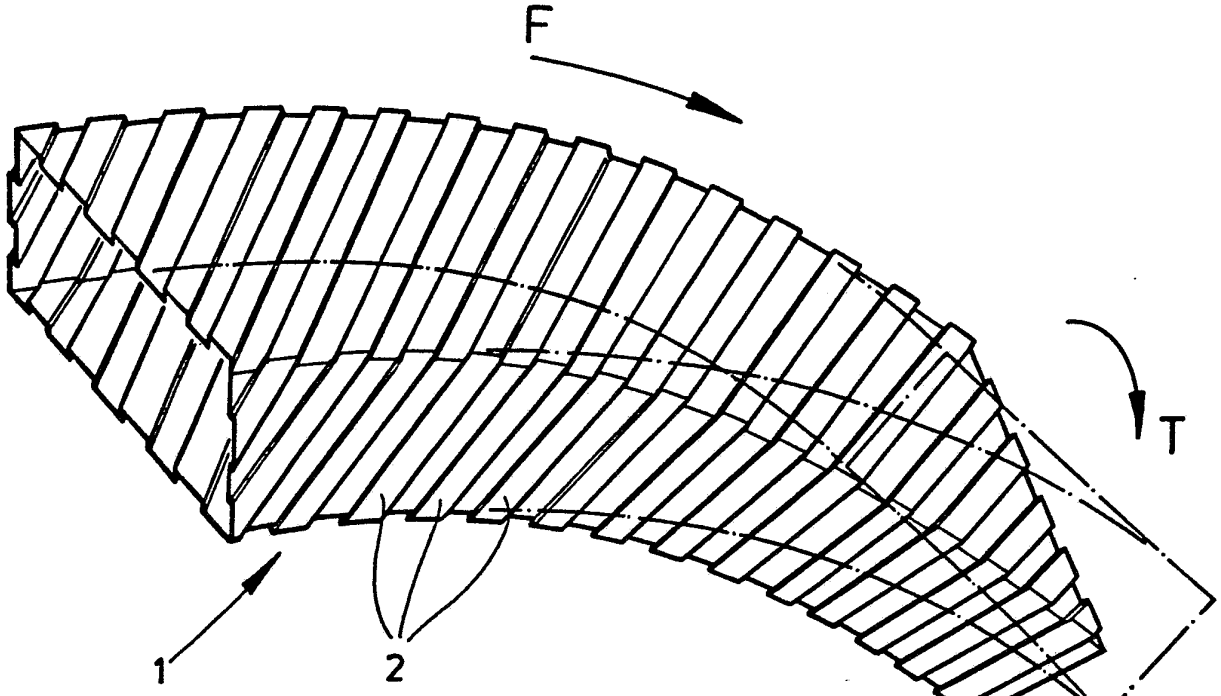


FIG 5



INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 84/00241

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[4] : H 01 P 3/14

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC[4]	H 01 P

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	Patents Abstracts of Japan, vol. 1, no. 92, 25 August 1977 & JP, A, 52-26478 (Nippon Denshin Denwa Kosha)	1
A	DE, B, 1048970 (SIEMENS) 22 January 1959	1
A	GB, A, 1160942 (TELEFUNKEN) 6 August 1969	1
A	FR, A, 2176089 (ANDREW CORP.) 26 October 1973	1
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IV. CERTIFICATION

Date of the Actual Completion of the International Search [3]	Date of Mailing of this International Search Report [3]
4th October 1984	25 OCT. 1984
International Searching Authority [1]	**Signature of Authorized Officer [20]**
EUROPEAN PATENT OFFICE	G.L.M. Kruydenberg

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No [18]
A	US, A, 3201723 (H. MARTIN et al.) 17 August 1965 --	1
A	US, A, 3345590 (W. KRANK et al.) 3 October 1967 --	1
A	US, A, 3372352 (W. KRANK et al.) 5 March 1968 ------	1

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/GB 84/00241 (SA 7498)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 16/10/84

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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
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GB-A- 1160942	06/08/69	DE-A-	1690246	06/05/71
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		AU-B-	471974	13/05/76
US-A- 2556187		None		
US-A- 3016503		None		
US-A- 3201723		None		
US-A- 3345590		None		
US-A- 3372352		None		