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(54) Hybrid mode waveguiding member and hybrid mode feedhorn antenna.

(57) The waveguiding member transforming the TE_{11} mode into the HE_{11} mode, comprises a waveguide body (12), including a tubular section (12) at the TE_{11} mode entrance port, and a spiro-helical projection (18) bonded to the interior surface of the waveguide body. In a first arrangement, the spiro-helical projection comprises a closely spaced helically wound wire structure (18) formed of dielectrically coated wires which decrease in gauge size in small adjacent portions thereof as the helix progresses away from the TE_{11} mode entrance port and in the remainder of the helical projection, the same or decreasing gauge wire in adjacent portions can be used. In another arrangement, the spiro-helical projection comprises an initially flattened dielectrically coated wire that gradually returns to a rounded configuration in closely spaced helical turns after which the spacings between turns gradually increase linearly in the tubular section. In a further arrangement, multiple layers of closely-wound helically wound dielectrically coated wires, which layers gradually taper down to a single layer, can replace the closely spaced flattened-to-round wire section of other arrangement.

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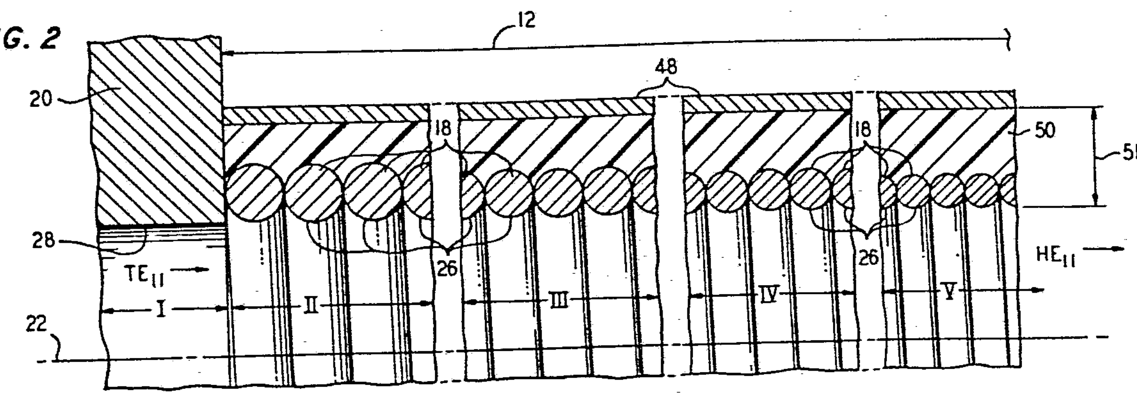
FIG. 2



The present invention relates to a hybrid mode waveguiding member comprising a waveguide body including an inner surface.

Hybrid mode corrugated horn antennas have been in use in the microwave field for a number of years. Various techniques for forming the corrugated horn antennas have been used to provide certain advantages. For example, U. S. Patent 3,732,571 discloses a microwave horn aerial which is corrugated on its inner surface, defining a tapered waveguide mouth area, with at least one spiro-helical projection which can be produced by a screw cutting operation with a single start spiro-helical groove or by molding on a mandrel which can be withdrawn by unscrewing it.

In U. S. Patent 3,754,273, a circular waveguide feedhorn is disclosed which includes corrugated slots on the inner wall surface, the width of the slots abruptly changing from a smaller value in the portion near the axis of the waveguide to a larger value in the remaining portion of the slot.

In U. S. Patent 4,106,026, a corrugated horn of the exponential type is disclosed with corrugations whose depth decreases exponentially from the throat of the horn towards its mouth.

In the typical prior art arrangements, construction is generally complicated and expensive and coupling to a dominate mode waveguide is difficult and limited in bandwidth.

The problem remaining in the prior art is to provide a hybrid-mode waveguiding member of a design which is inexpensive to fabricate, provides simplified mode coupling of the TE_{11} mode to the HE_{11} mode, and is operative over a very wide frequency bandwidth.

The foregoing problem is solved in accordance with the present invention by a helically wound wire structure bonded to the inner surface of the waveguide body with a dielectric layer and comprising a mode conversion section (II-V) including a plurality of subsections capable of converting a TE_{11} mode signal at an entrance port of the waveguiding member into a HE_{11} mode signal, the wire structure being formed of closely-spaced helical turns of dielectrically coated wires whereby the outer diameter of the helical structure in contact with the dielectric layer gradually decreases in the direction away from the TE_{11} mode entrance port of the waveguiding member thereby substantially reducing the coupling per wavelength of the propagating signal into the dielectric layer.

In accordance with one embodiment of the present invention, the helically wound dielectrically coated wire structure changes gauge in each of a plurality of sequential portions thereof to the next smaller gauge as the structure progresses away from the entrance port of the waveguide. A second section of the waveguiding member can comprise helical turns of uniform gauge wire or helical turns of decreasing gauge sections as the structure progresses from the first section to the other end of the waveguide.

In accordance with another embodiment of the invention, the spiro-helical structure is formed from at least one helically wound dielectrically coated wire which has closely spaced turns for a portion of its length and then has the spacings between turns gradually increased as the helix progresses in the waveguide to convert the TE_{11} mode to the HE_{11} mode and then proceeds towards the other end of the waveguide with a uniform pitch.

In one aspect of the present invention, the spiro-helical structure can be formed from a single dielectrically coated wire that is initially flattened and formed in closely spaced edge-wound turns for a portion of its length and then gradually changes to a rounded configuration before continuing with increased spacing between the turns in the mode converting waveguide section and then in a uniform pitch as the helix progresses towards the other end of the waveguide.

In another aspect of the present invention, the spiro-helical structure is formed from multiple layers of helically wound dielectrically coated wires in closely spaced turns which gradually reduce to one layer before the spacings between the turns is gradually increased in a linear manner in the waveguide section and then proceed with a uniform pitch as the projection progresses to the other end of the waveguide.

In the drawings, like numerals represent like parts in the several views:

FIG. 1 illustrates a helical hybrid mode feedhorn antenna in accordance with an embodiment of the present invention;

FIG. 2 illustrates an exploded view in cross-section of a portion of the first section of the waveguide body of the feedhorn antenna of FIG. 1 or the waveguide of FIG. 6 showing the spiro-helical projection or structure in accordance with one embodiment the present invention.

FIG. 3 illustrates an exploded view in cross-section of a portion of the flared section of the feedhorn antenna of FIG. 1 showing the projection or structure comprising only helical turns of uniform gauge wire;

FIG. 4 illustrates an exploded view in cross-section of a portion of the flared section of the feedhorn antenna of FIG. 1 showing the projection or structure comprising helical turns of wire which decrease in gauge in adjacent portions as the projection progresses towards the mouth of the feedhorn;

FIG. 5 illustrates a helical hybrid mode feedhorn antenna similar to FIG. 1 wherein the helical wire structure is supported in the center and bonded to the conductive sheath with a foam dielectric;

FIG. 6 illustrates a helical waveguide similar to the feedhorn antenna of FIG. 1 capable of converting the TE_{11} mode to the HE_{11} mode and supporting the latter mode in accordance with one embodiment of the present invention;

FIG. 7 illustrates a helical hybrid mode feedhorn antenna in accordance with another embodiment of the present invention;

FIG. 8 illustrates an exploded view in cross-section of a portion of the circular waveguide section of the feedhorn antenna of FIG. 7 or waveguide of FIG. 11, respectively, showing one arrangement of the spiro-helical projection in accordance with the other embodiment of the present invention;

FIG. 9 illustrates an exploded view in cross-section of a portion of the feedhorn antenna of FIG. 7 where the circular section converts into the conical section;

FIG. 10 illustrates an exploded view in cross-section of a portion of the circular waveguide section of the feedhorn antenna of FIG. 7 or waveguide of FIG. 12 respectively, showing an alternative arrangement of the spiro-helical projection of FIG. 8 in accordance with a further embodiment of the present invention; and

FIG. 11 illustrates a helical hybrid mode waveguide in accordance with the other embodiment of the present invention.

FIG. 1 illustrates a helical hybrid-mode feedhorn antenna 10 formed in accordance with an embodiment of the present invention comprising a first waveguide mode transducer section 12 of uniform cross-section which converts to a tapered waveguide section 14 which is flared outward to form the mouth 16 of feedhorn antenna 10. A spiro-helical projection 18 is formed from a helically wound, dielectrically coated, wire structure, which is shown in greater detail in FIGS. 2-4, that is bonded to the wire surface of sections 12 and 14 with a dielectric layer 50. Feedhorn antenna 10 is shown coupled to a smooth-walled waveguide section 20, which is of a size that is capable of propagating the TE_{11} mode in the frequency band of interest, in a manner that the longitudinal axis 22 of waveguide section 20 and feedhorn antenna 10 correspond.

In accordance with one embodiment of the present invention, a suitable transition from the TE_{11} mode to the HE_{11} mode is obtained in section 12, and as shown in greater detail in FIG. 2, by starting the helical projection 18 adjacent waveguide 20, which is at the TE_{11} mode end of section 12, with closely spaced helical turns of a dielectrically coated wire of a first gauge as, for example, 18 gauge. As shown in FIG. 2, after a number of turns of the exemplary 18 gauge wire in portion II, a number of closely spaced helical turns of a dielectrically coated wire of a second gauge smaller than the first gauge as, for example, a 20 gauge wire continue helical projection 18 in portion III. Portions IV and V of FIG. 2 illustrate that helical projection 18 in section 12 continues with closely spaced helical turns formed from dielectrically coated wire which reduce in gauge in each adjacent portion as, for example, 22 and 24 gauge wire, respectively. In essence, the outer diameter of the spiral structure is tapered as the helix progresses away from the TE_{11} mode signal entrance port.

The overall length of portions II to V in FIG. 2 is an arbitrary value and merely of sufficient length to provide a smooth transition area for continuity of the TE_{11} mode between portion I in waveguide 20 and portion II in section 12 of feedhorn antenna 10, and mode conversion to the HE_{11} mode in portions III to V. The edges 26 of the helical turns 18 should also be an extension of the inner wall 28 of waveguide 20 to avoid reflective surfaces for the propagating TE_{11} mode signal. Once the mode conversion from the TE_{11} mode to the HE_{11} mode has been achieved in portions III to V of section 12 by the gradual reduction of wire gauge in the closely spaced helical turns of projection 18, the remaining closely spaced helical turns of projection 18 in section 12 can be formed from a wire of the smaller gauge used in, for example, portion V or the last portion of the mode conversion area.

The use of a large gauge wire to form the helical turns in portion II of FIG. 2 substantially increases the capacitance between adjacent turns and, therefore, substantially reduces the coupling per wavelength of the propagating signal into the resonant chamber formed by the dielectric layer 50. The reduction in gauge of the wires in portions III to V alters the capacitance between adjacent turns in the successive portions in a manner to cause the mode conversion from the TE_{11} mode to the HE_{11} mode. The remaining portion in sections 12 and 14 provides primarily the proper conductive path for the HE_{11} mode and the impedance match for launching the converted mode from mouth 16 of feedhorn antenna 16 into space.

One method for forming the projection 18 in section 14 is shown in FIG. 3 where projection 18 is formed from a single gauge dielectrically coated wire with uniform pitch, closely spaced, helical turns. An alternative method for forming projection 18 in section 14 is shown in FIG. 4 where projection 18 can comprise portions, in section 14, which comprise dielectrically coated wire of a different gauge in each subsection which reduce in gauge between subsections as the helix progresses towards mouth 16. For example, in FIG. 4, portion VI may be formed from, for example, 26 gauge dielectrically coated wire and adjacent portion VII may be formed from 28 gauge dielectrically coated wire. A reason for providing an occasional reduction in wire gauge as the helix progresses towards the mouth 16 of the feedhorn antenna 10 is to achieve a smooth transition to obtain an ideal taper of the energy distribution at the mouth 16 of antenna feedhorn 10 in all planes in order to reduce wall currents that radiate sidelobe energy to a minimal value at the mouth 16 of feedhorn antenna 10.

Construction of the helical arrangement of FIGS. 1-4 can be accomplished by winding the different gauge wires on a suitable mandrel. When the helical turns have been completely formed, a uniform thickness homogenous layer of dielectric material 50 is bonded to the wires and then enclosed in a conductive sheath 48. The combined thickness 51 of dielectric layer 50 and helix wires 18 capacitive loading should be approximately an electrical quarter wavelength at some intermediate frequency in the operating frequency band. The outer sheath wall 48 can comprise any suitable conductive material. The final feedhorn antenna 10 structure can then be coupled to waveguide 20 by any suitable means as, for example, a flange (not shown).

FIG. 5 illustrates an alternative method for constructing antenna feedhorn 10. In FIG. 5, the helical structure is formed of different gauge dielectrically coated wires as described hereinbefore for FIGS. 1-4. A layer 50 of foam dielectric is next deposited on the wire structure and the wire and foam layer 50 enclosed in a conductive sheath 48. To ensure the positioning of the helical wire structure once the mandrel has been removed, the central portion of feedhorn antenna 10 between the inner edges of the helical turns is filled with a dielectric foam 55 which has a permittivity which approximates the permittivity of the propagation medium in waveguide 20. For example, if air is the medium in waveguide 20 with a permittivity of 1.0, then the dielectric foam 55 should have a permittivity as close to 1.0 as possible.

FIG. 6 illustrates a hybrid mode waveguide 70 formed in the same manner as shown in FIGS. 1-4 and described hereinbefore for feedhorn antenna 10 except that waveguide section 12 continues with the same uniform cross-section in section 72 as found in section 12 instead of converting to a flared section 14 as found in antenna 10. The waveguide 70, when completed in a manner similar to feedhorn antenna 10, is coupled between an entrance waveguide 20 and a utilization means (not shown).

Effecting a smooth transition between the TE_{11} mode and the HE_{11} mode requires that the boundary conditions on the inner wall of the waveguide be matched at the interface of the smooth walled waveguide 20 and the hybrid mode structure. These boundary conditions are best described by considering the normalized anisotropic wall susceptance defined below.

$$\left.\begin{aligned} Y_\phi &= jZ_0H_z/E_\phi \\ Y_z &= jZ_0H_\phi/E_z \end{aligned}\right\} \text{ at } r = a \qquad (1)$$

In equations (1) the cylindrical coordinate system is used where z is the direction of propagation, r = a is the radius at the inner wall of the waveguide, E_ϕ and H_ϕ are respectively the electric and magnetic components of the field polarized in the ϕ direction, and E_z and H_z are the field components polarized in the z direction. Those field components are functions of r, ϕ and z, and Z_o is the free space impedance of approximately 377 ohms. In the smooth walled waveguide 20, the tangential electric fields are identically zero at the conducting surface, r = a, implying that in the TE_{11} mode, $y_\phi = y_z = \infty$. In order that the pure hybrid mode, the HE_{11} mode, propagate, the susceptance values required are $y_\phi = \infty$ but $y_z = o$. Therefore, a matching section is required such that y_z gradually changes from a very large value $y_z > 1$ to a very small value $y_z < 1$ for a larger band of frequencies.

In the prior art corrugated feedhorns, the requirement on y_z is met at the interface between the smooth walled waveguide and the corrugated horn matching section by standing waves in the slots. However, the bandwidth over which a good match is obtained is limited by the fact that the resonance in the slots is frequency sensitive. Ring-loading the corrugations as found in the

Takeichi patent cited in the present Prior Art description adds a capacitance to the wall susceptance y_z such that the condition that y_z be large for a good match to the TE_{11} mode is met for a much larger bandwidth. Since E_ϕ is required to go to zero at the teeth edges at r = a, $y_o = \infty$.

Using a helical winding in place of the teeth edges will also require E_ϕ to go to zero at r = a. However, the windings have been found to add a capacitance to y_z much like ring-loading the teeth in a corrugated horn. A standing wave is set up in the space between the wires 18 and the conducting wall 48 as in the slots of a corrugated horn.

The wires are supported off the conducting wall by a dielectric material such as epoxy and the susceptance y_z is directly proportional to the dielectric constant of the medium that supports the helical wires inside the conducting wall. While this fact helps to increase the bandwidth over which y_z is large at the input to the hybrid mode matching section, it has the opposite affect at the output where it is desired that y_z be small. As a consequence, the helical horn would have to have a larger aperture at the output than the corresponding corrugated horn. The feedhorn antenna 10 design of FIG. 5, however, would eliminate this problem by using a dielectric foam with a very small relative permittivity to support the windings. This feedhorn antenna would then permit the same size aperture as a corrugated feedhorn.

FIG. 7 illustrates a helical hybrid-mode feedhorn antenna 10 formed in accordance with another embodiment of the present invention comprising a circular waveguide mode transducer section 12 of uniform diameter which converts to a conical waveguide horn section 14 which is flared outward to form the mouth 16 of feedhorn antenna 10. A spiro-helical projection 18 is formed from a helically wound dielectrically coated wire, which is shown in greater detail in FIGS. 8 and 9, which is bonded to the inner surface of sections 12 and 14 with dielectric layer 50. Feedhorn antenna 10 is shown coupled to a circular waveguide section 20, which is of a size that is capable of propagating the TE_{11} mode in the frequency band of interest, in a manner that the longitudinal axis 22 of waveguide section 20 and feedhorn antenna 10 correspond.

In accordance with the present invention, a suitable transistion from the TE_{11} mode to the HE_{11} mode is obtained in such embodiment by starting with a round dielectrically coated wire which is partially flattened in a rolling mill and then edge-wound in closely spaced helical turns in the area adjacent to circular waveguide 20 which is at the TE_{11} mode end of circular waveguide section 12. Flattening of this wire to produce the helical turns substantially increases the capacitance between adjacent turns and, therefore, substantially reduces the leakage per wavelength of the propagating signal into dielectric layer 50.

As shown in FIG. 8, the flattening of the wire, as depicted in portions II to IV of FIG. 8, is gradually reduced starting at the intput TE_{11} mode end adjacent waveguide 20 to a round cross-section of closely spaced turns. For example, if a No. 15 guage Formex copper wire 18 is used to form the helical turns of portions II to IV of FIG. 8, the wire may initially be flattened to dimensions of, for example, approximately 0.74 by 1.96 millimeters which changes gradually to a round cross-section of approximately 1.55 millimeters. In essence, the outer diameter of the spiral structure of FIG. 8 is tapered as the helix progresses away from the TE_{11} mode signal entrance port. The overall length of portions II to IV in FIG. 8 is an arbitrary value and is merely of sufficient length to provide a smooth transition area for continuity of the TE_{11} modes between waveguide 20 and portion II, and mode conversion to the HE_{11} mode in portions III to V. The edges 26 of the helical turns 18 should also be an extension of the inner wall 28 of circular waveguide 20 to avoid reflective surfaces for the propagating signal.

The next portion of section 12 shown by portions IV and V of FIG. 8 includes a helical winding with a tapered pitch which starts with a zero spacing and gradually has the spacings between turns increased in a linear manner. The remainder of the helical turns in section 12 and in section 14 are of uniform pitch of, for example, approximately 3 wire diameters center-to-center as shown in FIG. 9. Therefore, in portions II to V of FIG. 8, the continuity of the TE_{11} mode is preserved in a smooth transition between waveguide 20 and horn antenna 10 and the TE_{11} mode is converted to the HE_{11} mode by the gradually increased spacing between the helical turns while the conical section 14 provides a proper impedance match with its uniform tapered helical turns for launching the converted mode from the mouth 16 of feedhorn antenna 10 into space.

An alternative and preferred method for forming the feedhorn antenna 10 in accordance with the present invention is shown in FIG. 10. There a multi-layer helical wire structure is formed in the area 30 which is equivalent to portions II to IV of FIG. 8. In forming the helical projection of FIG. 10, a round dielectrically coated wire is first formed in a helix of closely spaced turns for the length of area 30 and then in area 32 the spacings between the helical turns are gradually increased in a linear manner. Wire 38 continues its helical spiral for the remainder of section 12 and in section 14, in the manner shown in FIG. 9, with a uniform pitch. Once wire 38 has been formed as described for traversing the entire length of the inside surface of feedhorn 10, a second layer of helical turns of dielectrically coated wire 40 is superimposed on top of the helical turns of wire 38 starting at waveguide 20 and extending for most of the length of transition area 30. Additional layers of helical turns of dielectrically coated wire are then superimposed on top of wires 38 and 40 with each layer extending for a lesser distance along area 30 so as to effectively form a taper 44 along the ends of the layers. In accordance with the present invention, the number of layers of wire in transition area 30 is arbitrary and should be of a sufficient number to provide a low enough surface impedance for propagating the TE_{11} mode. In forming the arrangement of FIG. 10 it was found that preferably at least four layers should be used and that each additional layer of wire improved the performance substantially by providing less leakage per wavelength.

Construction of the helical arrangements of FIGS. 7-10 can be accomplished by winding the wire 18 or 38 on a suitable mandrel and securing both ends. Additional layers of wire can be wound on the initial turns for forming the structure of FIG. 10. When the helical structure is completely formed, a uniform thickness homogenious layer of dielectric material 50 is bonded to the wire 18 or 38 and then enclosed in a conductive sheath 48. The combined thickness 51 of dielectric layer 50 and helix wire 18 capacitive loading should be approximately an electrical quarter wavelength at the lowest operating frequency. The outer shield wall 48 can comprise any suitable conductive material. The final feedhorn 10 structure can then be coupled to waveguide 20 by any suitable means as, for example, a flange (not shown).

FIG. 11 illustrates a circular hybrid mode waveguide 70 formed in the same manner as that shown in FIGS. 7-10 and described hereinbefore for feedhorn antenna 10 except that circular waveguide section 10 continues with the same uniform diameter in section 72 as found in section 12 instead of converting to a conical section 14 as found in feedhorn antenna 10.

It is to be understood that the

above-described embodiments are simply illustrative of the principles of the invention. Various other modifications and changes may be made by those skilled in the art which will embody the principles of the invention and fall within the spirit and scope thereof as, for example, substituting a rectangular or square waveguide body for circular waveguide body 48 of FIGS. 1-11.

Claims

1. A hybrid mode waveguiding member comprising a waveguide body (48) including an inner surface

CHARACTERIZED BY

a helically wound wire structure (18) bonded to the inner surface of the waveguide body (48) with a dielectric layer (50) and comprising a mode conversion section (II-V) including a plurality of subsections capable of converting a TE_{11} mode signal at an entrance port of the waveguiding member into a HE_{11} mode signal, the wire structure being formed of closely-spaced helical turns of dielectrically coated wires whereby the outer diameter of the helical structure in contact with the dielectric layer (50) gradually decreases in the direction away from the TE_{11} mode entrance port of the waveguiding member thereby substantially reducing the coupling per wavelength of the propagating signal into the dielectric layer (50).

2. A hybrid mode waveguiding member according to claim 1,

CHARACTERIZED IN THAT

each subsection of said mode conversion section comprises a different cross-sectional sized wire, the wire size between the subsections of the mode conversion section gradually decreasing as the helix progresses away from the TE_{11} mode entrance port of the waveguiding member.

3. A hybrid mode waveguiding member according to claim 2

CHARACTERIZED IN THAT

any remaining section (72, FIG. 6) of the waveguide body following the mode conversion section comprises a layer of closely-spaced helical turns of dielectrically coated wire comprising a cross-sectional size which is no greater than the smallest cross-sectional size wire in the mode conversion means.

4, A hybrid mode waveguiding member according to claim 1 or 2

CHARACTERIZED IN THAT

the combined thickness of the wire layer (18) and the dielectric layer (50) bonding the wire structure to the inner surface of the waveguide being an approximate quarter wavelength at some intermediate frequency in the operating frequency band of the waveguiding member.

5. A hybrid mode waveguiding member according to claim 2

CHARACTERIZED BY

a second section (14) that flares outward from the mode conversion section to form the mouth of a feedhorn antenna, said second section comprising

a remaining portion of the wire structure including closely-spaced helical turns of a dielectrically coated wire of a cross-sectional size no larger than the smallest size wire in said mode conversion section.

6. A hybrid mode waveguiding member according to claim 5

CHARACTERIZED IN THAT

the remaining portion of the wire structure further comprising at least two subsections, each subsection including a different cross-sectional sized wire with the wire size between subsections decreasing as the helix progresses towards the mouth of the feedhorn antenna.

7. A hybrid mode waveguiding member according to claim 1,

CHARACTERIZED BY

the wire being helically wound in closely spaced turn which abut one another starting at one end of the waveguide body and covering a first portion of the inner surface of the waveguide body in a manner capable of providing a smooth transition for a TE_{11} mode signal propagating therethrough, the helical windings continuing in a second portion of the waveguide body adjacent said first portion with turns which gradually have the spacing therebetween increased in a linear manner which is capable of converting the TE_{11} mode signal into a HE_{11} mode signal, and the helical windings continuing in the remaining portion of the waveguide body with a uniform pitch.

8. A hybrid mode waveguiding member according to claim 7,

CHARACTERIZED IN THAT

the helical structure (18) in the first portion of the waveguide body is formed from the dielectrically coated wire which is initially flattened on two opposing surfaces and edge wound in abutting helical turns, the wire gradually changing to a rounded cross-section as the helix approaches said second portion of the waveguide body.

9. A hybrid mode waveguiding member according to claim 7,

CHARACTERIZED IN THAT

the helical structure (18) in the first portion of the waveguide body further includes multiple abutting layers of helically wound dielectrically coated wires disposed on the surface of the first helically wound wire nearest the inner surface of the waveguide body, the successive layers of helically wound wires forming said multiple layers having lengths, which progress inwards from the one end of the waveguide, to effect an edge on said multiple layers which slopes inward to the first helically wound wire in the direction of the second portion of the waveguide body.

10. A hybrid mode waveguiding member according to claim 7, 8 or 9,

CHARACTERIZED IN THAT

the thickness of the wire and the dielectric layer being an approximate quarter wavelength at the lowest operating frequency of the waveguiding member.

11. A hybrid mode waveguiding member according to claim 7 or 9,

CHARACTERIZED BY

a second section that flares outward from the mode conversion section to form the mouth of a feedhorn antenna, the helical windings continuing in said second section of the feedhorn antenna with a uniform pitch.

12. A hybrid mode feedhorn antenna according to claim 11,

CHARACTERIZED IN THAT

the thickness of the wire and the dielectric layer being an approximate quarter wavelength at the lowest operating frequency of the feedhorn antenna.

13. A hybrid mode waveguiding member according to any one of the preceding claims

CHARACTERIZED IN THAT

the dielectric layer (50) bonding the wire structure, to the inner surface of the waveguide body comprises a dielectric foamed materia; and the waveguiding member further comprises a core of dielectric foamed material filling the area between the opposing inner edges of the helical turns of the wire structure, the dielectric foamed material having a permittivity which substantially corresponds to the permittivity of the medium adjacent the TE_{11} mode entrance port of the waveguiding member.

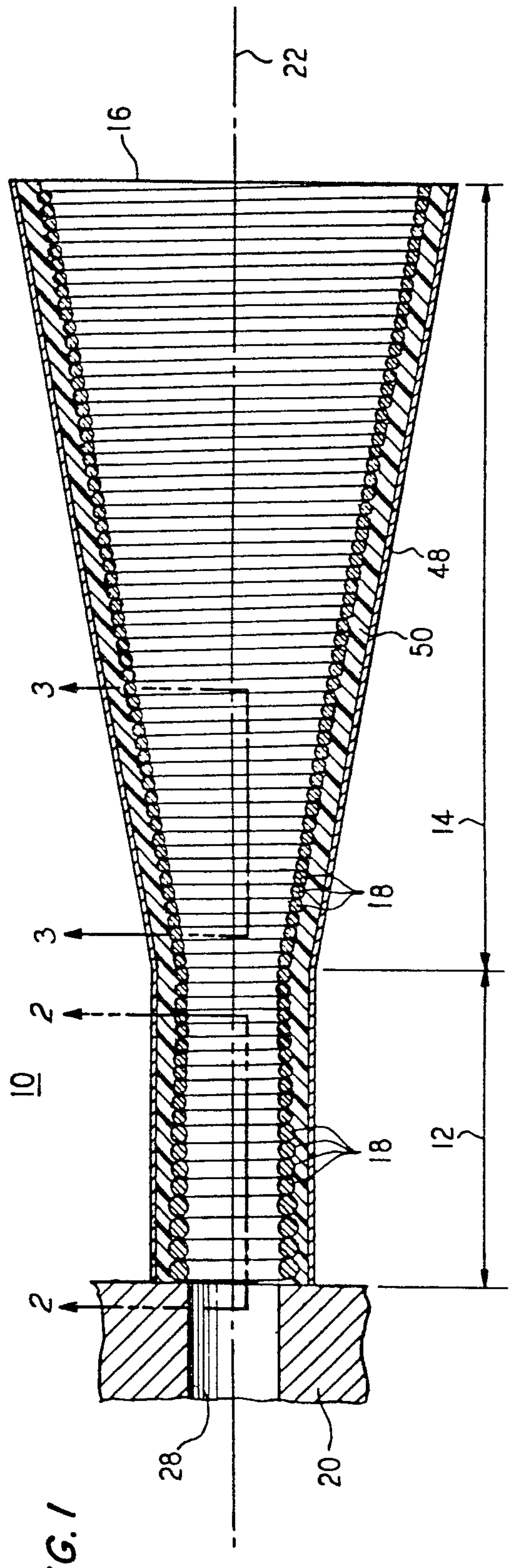

10
2
2
3
3
12
14
16
18
18
20
22
28
48
50

FIG. 1

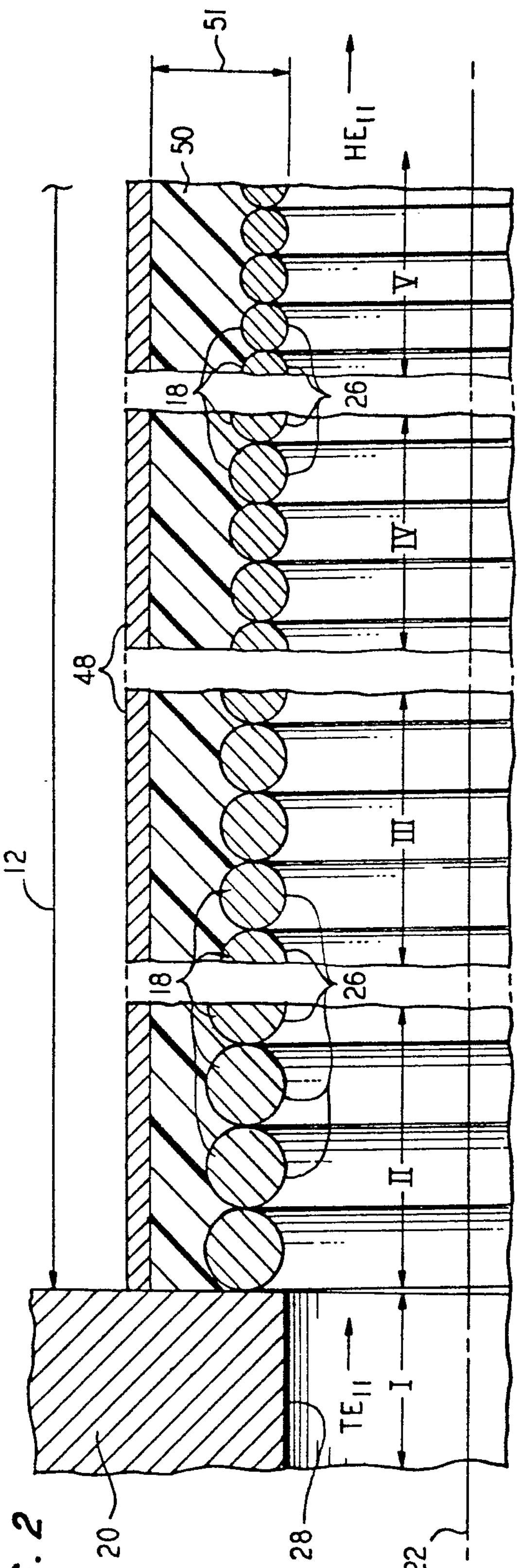

12
18
18
20
22
26
26
28
48
50
51
I
II
III
IV
V
TE11
HE11

FIG. 2

FIG. 3

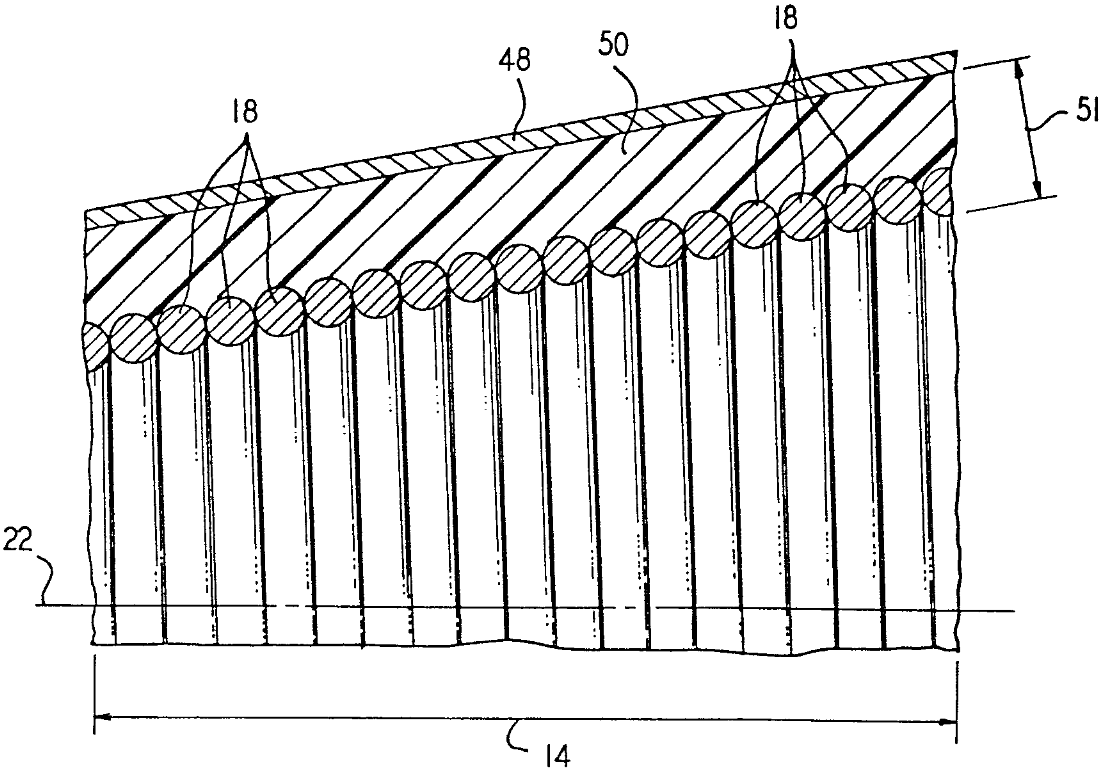
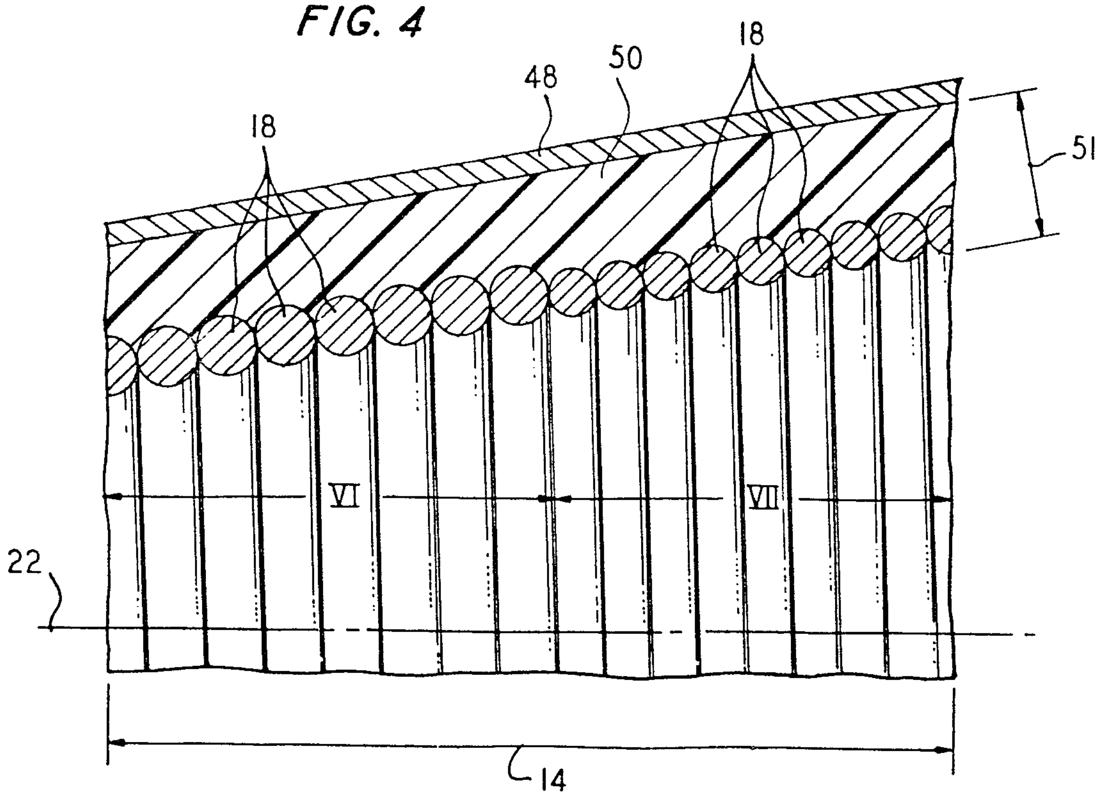
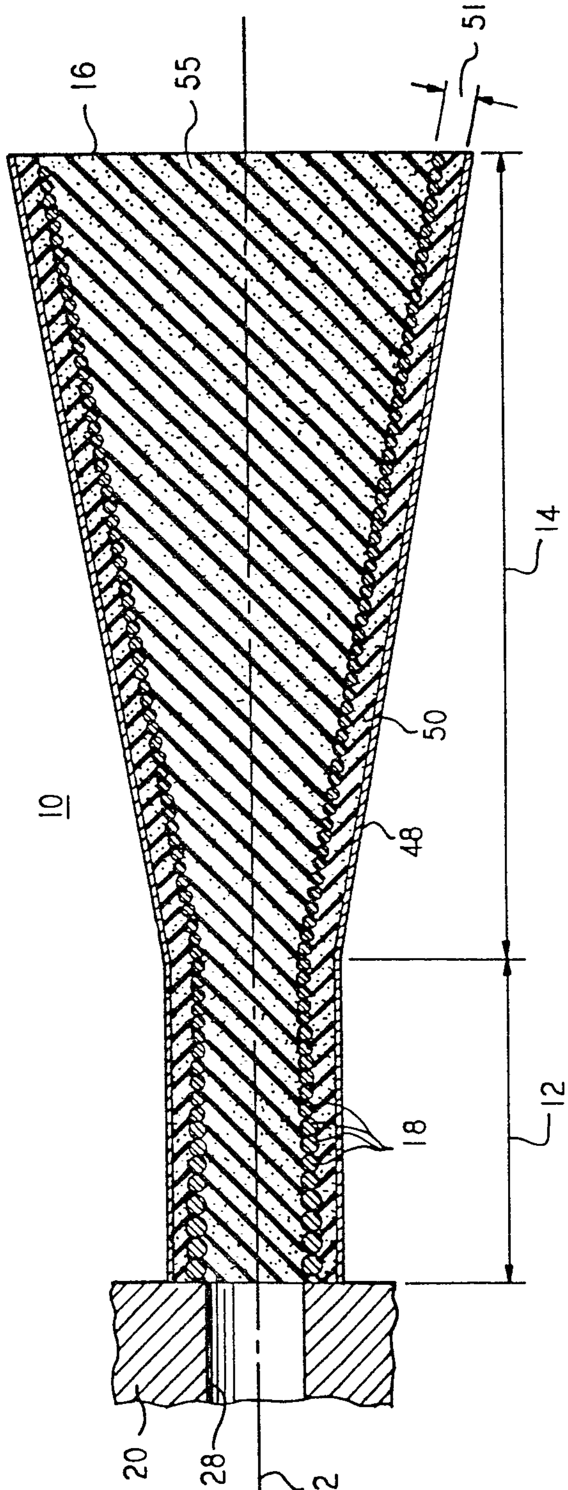


FIG. 4

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18
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22

FIG. 5

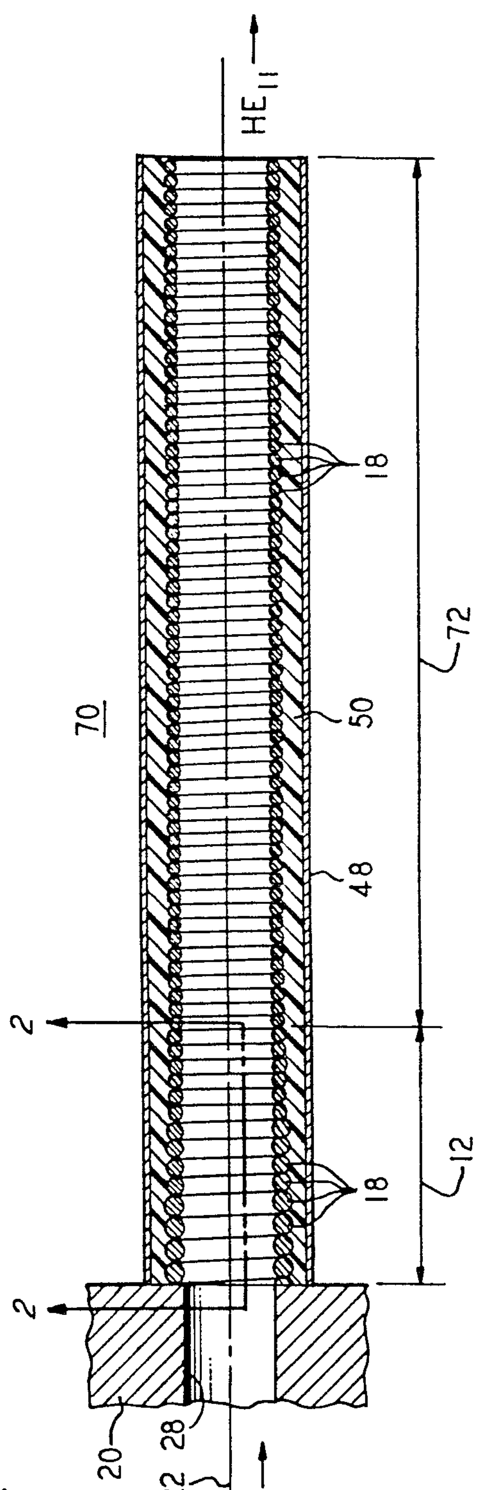
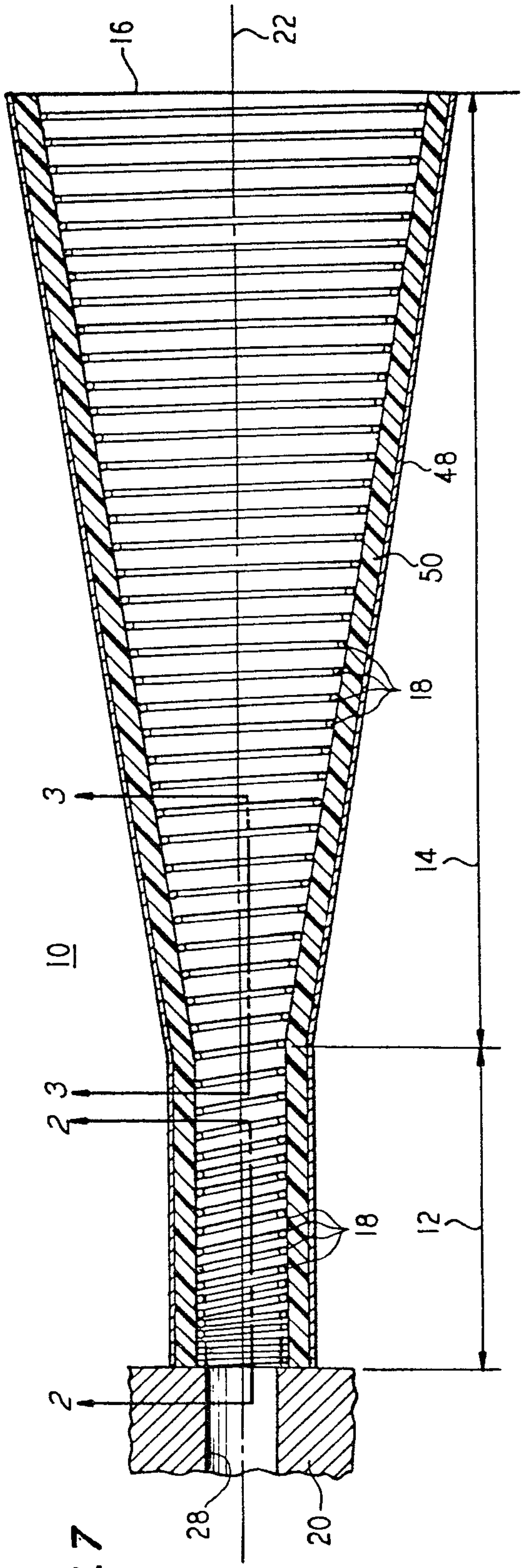

HE11
18
72
70
50
48
2
12
18
2
20
28
22
TE11

FIG. 6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50
18
3
10
14
3
2
18
12
2
28
20

FIG.7

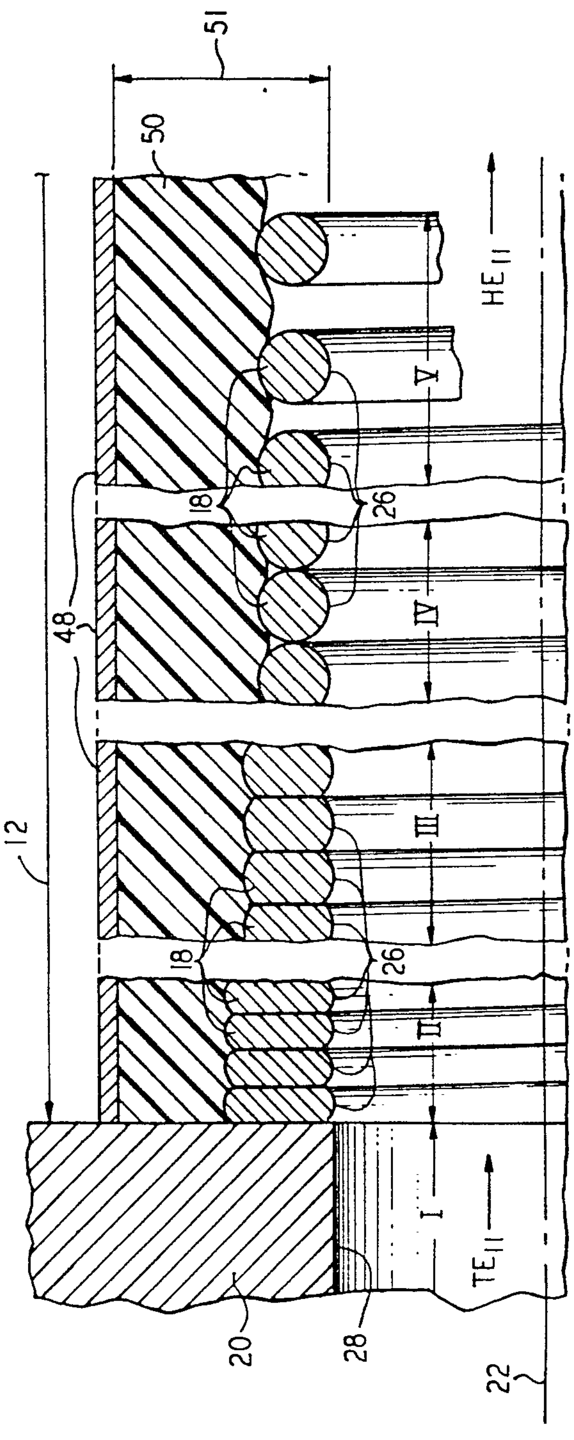
51
50
HE_{11}
V
18
26
48
IV
III
12
18
26
II
I
TE_{11}
20
28
22

FIG. 8

FIG. 9

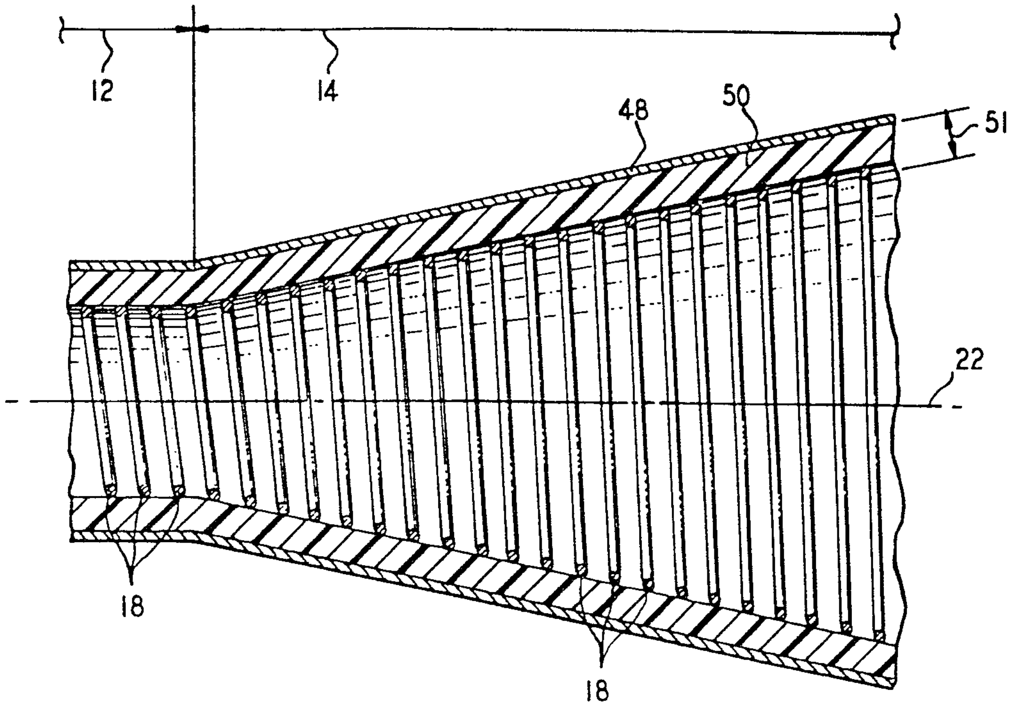

FIG. 10

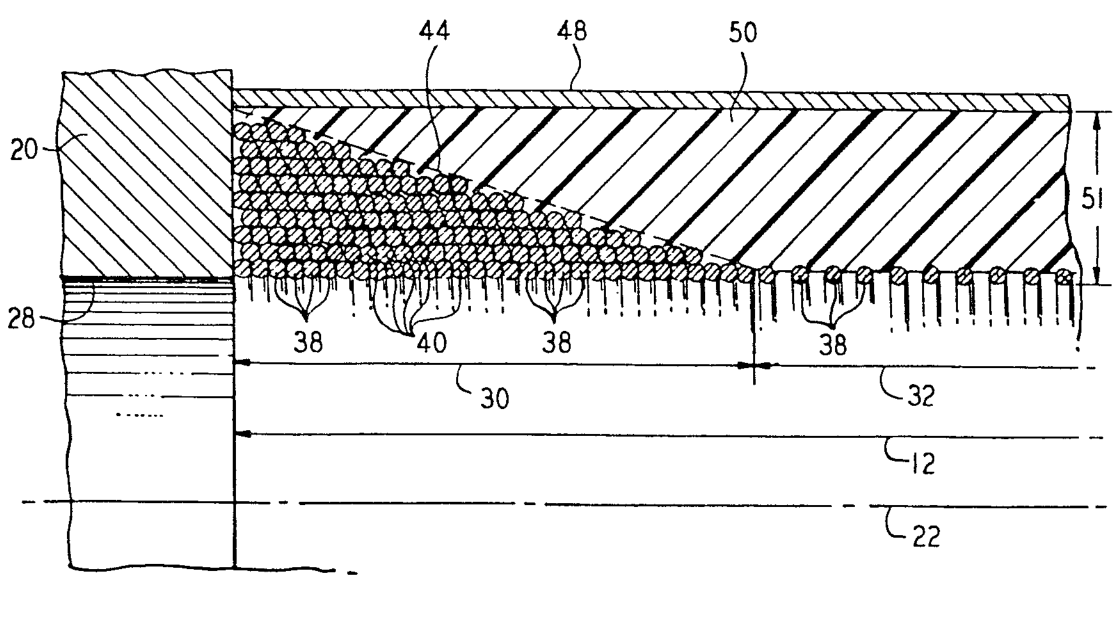

FIG. 11

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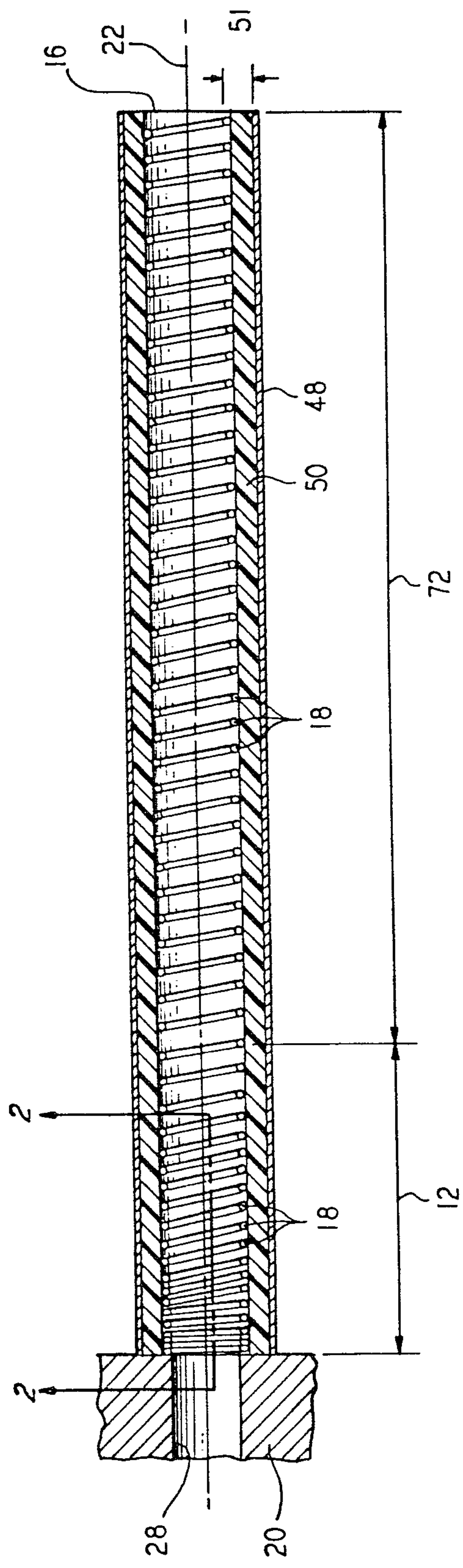

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Application number
EP 80 10 4951

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
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CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

H 01 P 1/16
3/127
H 01 Q 13/02

TECHNICAL FIELDS SEARCHED (Int Cl.³)

H 01 P
H 01 J 23/32
H 01 Q

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	02-12-1980	LAUGEL

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
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			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)