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Mason et al.

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[54] **DIELECTRICALLY LOADED WAVEGUIDE ASSEMBLY**

[75] Inventors: **Robert Jean Mason**, Medford; **Norman Richard Landry**, Willingboro, both of N.J.

[73] Assignee: **RCA Corporation**, New York, N.Y.

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[52] **U.S. Cl.** ..... **333/95 R**, 333/24.1, 333/98 R

[51] **Int. Cl.** **H01p 3/12**, H01p 1/00

[58] **Field of Search** ..... 333/24.1, 24.2, 95 R, 333/95 A, 98 R, 81 B; 138/108; 174/12

[56] **References Cited**

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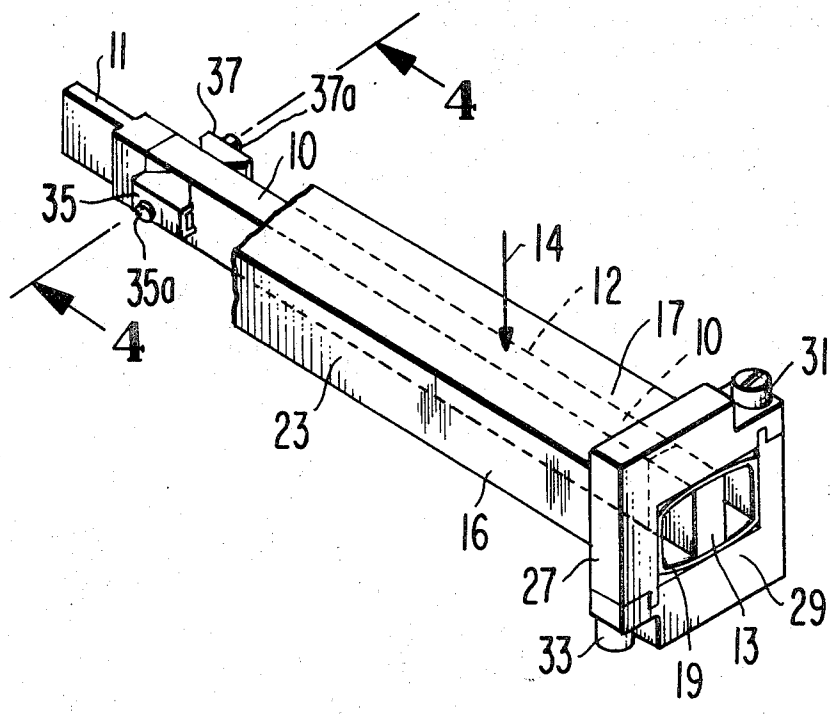
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Primary Examiner—Rudolph V. Rolinec
Assistant Examiner—Wm. H. Punter
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[57] **ABSTRACT**

A body of gyromagnetic material closely fitted within a flexible waveguide is supported by means of an external clamp and a pair of dielectric guides.

8 Claims, 4 Drawing Figures



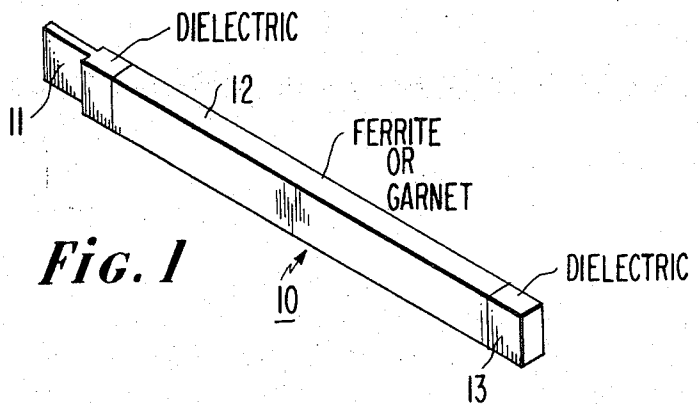


FIG. 1

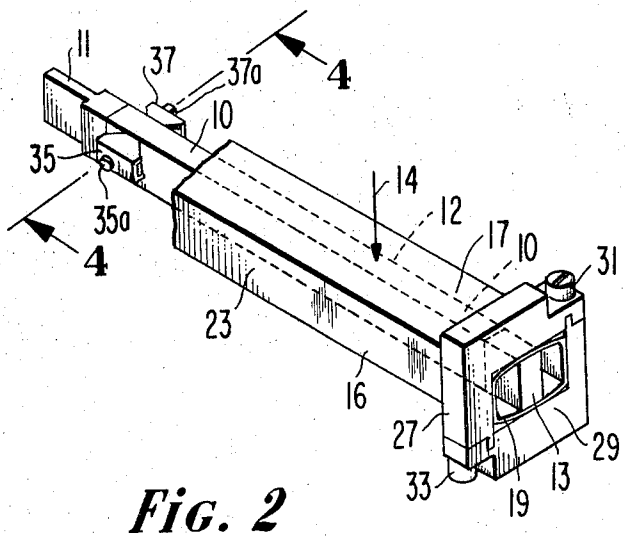


FIG. 2

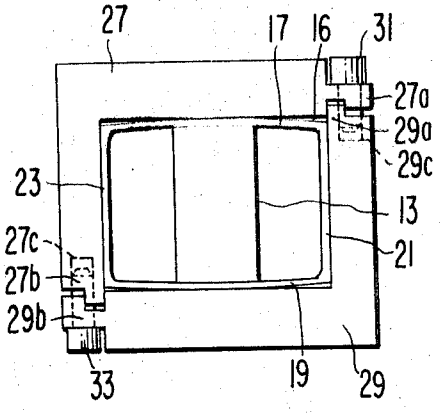


FIG. 3

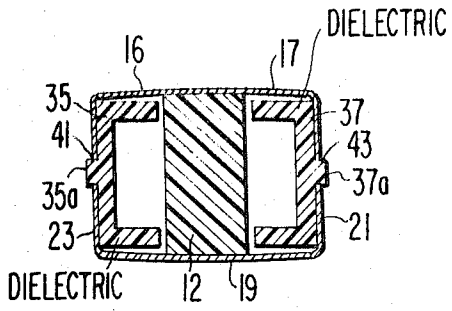


FIG. 4

DIELECTRICALLY LOADED WAVEGUIDE ASSEMBLY

This invention relates to a waveguide assembly and more particularly to waveguide structures which include a dielectric body of "gyromagnetic" material such as ferrite or garnet material. This term "gyromagnetic" material is a name applied to both of these materials due to their common characteristic which in the presence of a D.C. magnetic field and an R.F. magnetic field is similar to that in a mechanical gyroscope. When the dielectric body is ferrite or garnet material and is properly biased such such as by a D.C. magnetic field, the waveguide assembly may provide the functions of phase shifting, isolating and limiting of radio frequency signal waves applied to the waveguide section.

The waveguides are conventionally made by extruding, machining, or casting tubes to a required cross sectional dimension. This dimension is dependent on the frequency and the modes of the propagating wave. A dielectric body of ferrite or garnet material is dimensioned so as to properly fit within the waveguide. The ferrite or garnet materials are generally fragile and have a different thermal expansion coefficient from that of the waveguides. This can cause fracture of these materials if they are simply bonded to the waveguide. In addition, the garnet materials are magnetostrictive. The stresses on the garnet material caused by differences in thermal expansion or contraction between the garnet and the waveguide as when these materials and the waveguide are bonded or are otherwise fixed to each other along their length can drastically effect the magnetic field within the garnet. Consequently, changes in the D.C. bias cause unpredictable changes in the amount of phase shift, for example, effected by the waveguide section. Although ferrite material has no appreciable magnetostrictive effect, at certain frequencies such as at S-band, the remanent level changes rather drastically with substantial change in temperature rendering this ferrite material impractical for many applications at S-band. It is therefore desirable that a means be provided by which ferrite and garnet material particularly may be attached to and supported in a waveguide section such that the forces of magnetostriction and thermal expansion are minimized to prevent fracture of the material or large changes in the magnetic field.

Briefly, the present invention provides a waveguide assembly, for example, a rectangular tube of flexible conductive material. A body of dielectric material having at least a portion of gyromagnetic material is spaced between the opposed broad walls of the rectangular tube. An external clamp is placed above the dielectric body at one end of the body of material so as to force the opposed walls of the rectangular tube against a portion of the body. A pair of dielectric guides placed within the rectangular tube at a point remote from the external clamp prevents transverse movement of the body but permits longitudinal motion of the body in the waveguide tube.

A further description follows in conjunction with the following drawings wherein:

FIG. 1 is a perspective view of a dielectric body including a gyromagnetic material member and dielectric matching members.

FIG. 2 is a perspective drawing of an assembled microwave phase shifter with a portion of the waveguide removed for illustration.

FIG. 3 is an end view of the waveguide assembly of FIG. 2.

FIg. 4 is a cross section of the waveguide assembly of FIG. 2 taken in the 4—4 plane.

Referring to FIG. 1, there is illustrated a dielectric body 10. At the center portion of the body 10 is a member 12 of gyromagnetic material. The term "gyromagnetic" material refers to those materials, both garnets and ferrites, which exhibit a gyromagnetic effect when a D.C. and an R.F. magnetic field are applied thereacross. At either end of the member 12 of gyromagnetic material are bonded high dielectric non-magnetic transformer members 11 and 13 to form the total dielectric body 10. These dielectric transformer bodies 11 and 13 act, when the body 10 is placed within a rectangular waveguide, as matching elements for the input and output ends of the waveguide assembly.

Referring to FIGS. 2, 3 and 4, the body 10 is placed within a hollow rectangular waveguide 16 such that the body 10 including the dielectric transformer members 11 and 13 and the center member 12 is centered between the narrow walls 21 and 23 of the waveguide 16 and extends between the broad walls 17 and 19 of the waveguide 16. The pair of dielectric transformer bodies 11 and 13 are at the opposite ends of the rectangular waveguide 16. The hollow rectangular waveguide 16 is made up of electrically conductive material. The pair of opposing broad walls 17 and 19 of the waveguide 16 are separated by a distance which is normally slightly less than the heighth dimension of the dielectric body 10 which is gripped between the opposing broad walls 17 and 19 of the waveguide 16. The waveguide walls are made of a material of such thickness and elastic properties to allow the body to be placed within the waveguide with the walls imposing a force on the body 10 which neither exceeds an acceptable value nor is less than sufficient to provide a close fit of the gyromagnetic body 10 between the waveguide walls 17 and 19. The waveguide walls 17, 19, 21 and 23 are thin enough to follow the contour of the body 10 but yet be fairly rugged. For example, this waveguide 16 can be formed by drawing a tube through a die to a thickness of 0.014 inch. The particular material used, for example, may be 6061–T3 aluminum as sold by Aluminum Co. of America.

A pair of L-shaped members 27 and 29 with interlocking portions 27*a*, 27b, 29a and 29b are fitted to the outside of walls 17, 19, 21 and 23 of the waveguide 16 near the dielectric end 13. See detail in FIG. 3. The members 27 and 29 are attached to each other by means of a pair of screws 31 and 33 extending through members 27 and 29 respectively and being tightened against threads 29*c* and 27*c* located in members 29 and 27 respectively. As the L-shaped members 27 and 29 are fitted closer by tightening the screws 31 and 33, the broad walls 17 and 19 of the tube are brought in closer contact with dielectric member 13 of body 10 so as to clamp the dielectric member 13 between the broad walls 17 and 19 at one end of the waveguide 16. Since the member 12 of gyromagnetic material is bonded to the dielectric body 13 and dielectric member 11 is bonded to member 12 the whole body 10 is fixed at one end to waveguide 16.

Remote from the clamping end of the body **10** at the dielectric member **13** is located a pair of dielectric spacers **35** and **37**. See FIGS. **2** and **4**. These spacers **35** and **37** fit on either side of the gyromagnetic member **12** and inside the waveguide **16** in such a way to prevent lateral displacement (toward or away from narrow walls **21** and **23**) of the gyromagnetic member **12** and body **10** within the waveguide **16**. Referring to FIG. **4**, the spacers **35** and **37** are configured with small protrusions **35***a* and **37***a* which may fit to small holes **41** and **43** in the side walls **23** and **21** respectively of the waveguide **16** to thus lock these spacers into position. By making these spacers **35** and **37** U-shaped with the free end against the body and the middle portion against the narrow waveguide wall, air can flow through the waveguide **16** to permit cooling.

In the operation of the device as a phase shifter, for example, changes in the amount of phase shift for waves propagating along the waveguide assembly can be provided by changing the amount of D.C. magnetic field bias applied in the direction of arrow **14** in FIg. **2**. This D.C. magnetic field bias is applied perpendicular to broad wall **17**. The D.C. magnetic field bias can be achieved by a magnet located above the wall **17** or below wall **19** or can be achieved by making the member **12** a toroid. When the member **12** of body **10** is a toroid, a biasing wire, not shown, extends along the length of the member **12** within the center of the member **12** and a D.C. current pulse is coupled to the wire.

What is claimed is:

1. A waveguide assembly comprising:

a waveguide of flexible conductive material and having a pair of opposite walls,

a body of dielectric material spaced between the opposed walls of the waveguide,

an external clamp coupled to the outside of the waveguide near one end of the body and the waveguide so as to force the opposed walls of the waveguide against a portion of the body and hold the body, and

dielectric means coupled between the waveguide walls and a point along said body remote from the clamping portion for preventing transverse movement of said body within said waveguide but permitting longitudinal movement of said body.

2. The combination claimed in claim **1** wherein said dielectric means includes a pair of dielectric spacers wherein one of said spacers is located in the region between a third wall of said waveguide and said body and the second spacer is located in the region between a fourth wall of said waveguide and said body.

3. The combination claimed in claim **2** wherein said spacer is U-shaped with the free ends against the body and the middle portion against the waveguide wall.

4. The combination claimed in claim **3** wherein said spacers include means for locking said spacers within said waveguide.

5. The combination claimed in claim **1** wherein said dielectric body includes a portion of gyromagnetic material and a portion of non-magnetic dielectric material.

6. The combination claimed in claim **5** wherein said gyromagnetic material is garnet.

7. The combination claimed in claim **6** wherein only said non-magnetic dielectric material portion of said body is clamped between said waveguide walls.

8. The combination claimed in claim **1** wherein said waveguide is rectangular and is made of thin walled aluminum tubing, said third and fourth walls being the opposite narrow walls of said waveguide, said clamp arranged to force the opposite broad walls of said waveguide against said body to hold said body.

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