United States Patent

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[54] **WAVEGUIDE PARTIALLY FORMED OF A FLEXIBLE MEMBER FOR OBTAINING UNIFORM MINIMAL PRESSURE CONTACT WITH A LOAD THEREIN**

7 Claims, 2 Drawing Figs.

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[51] Int. Cl. H01p 3/12, H01p 1/30
[50] Field of Search .... 333/95, 95 A, 98, 82 BT, 83 T

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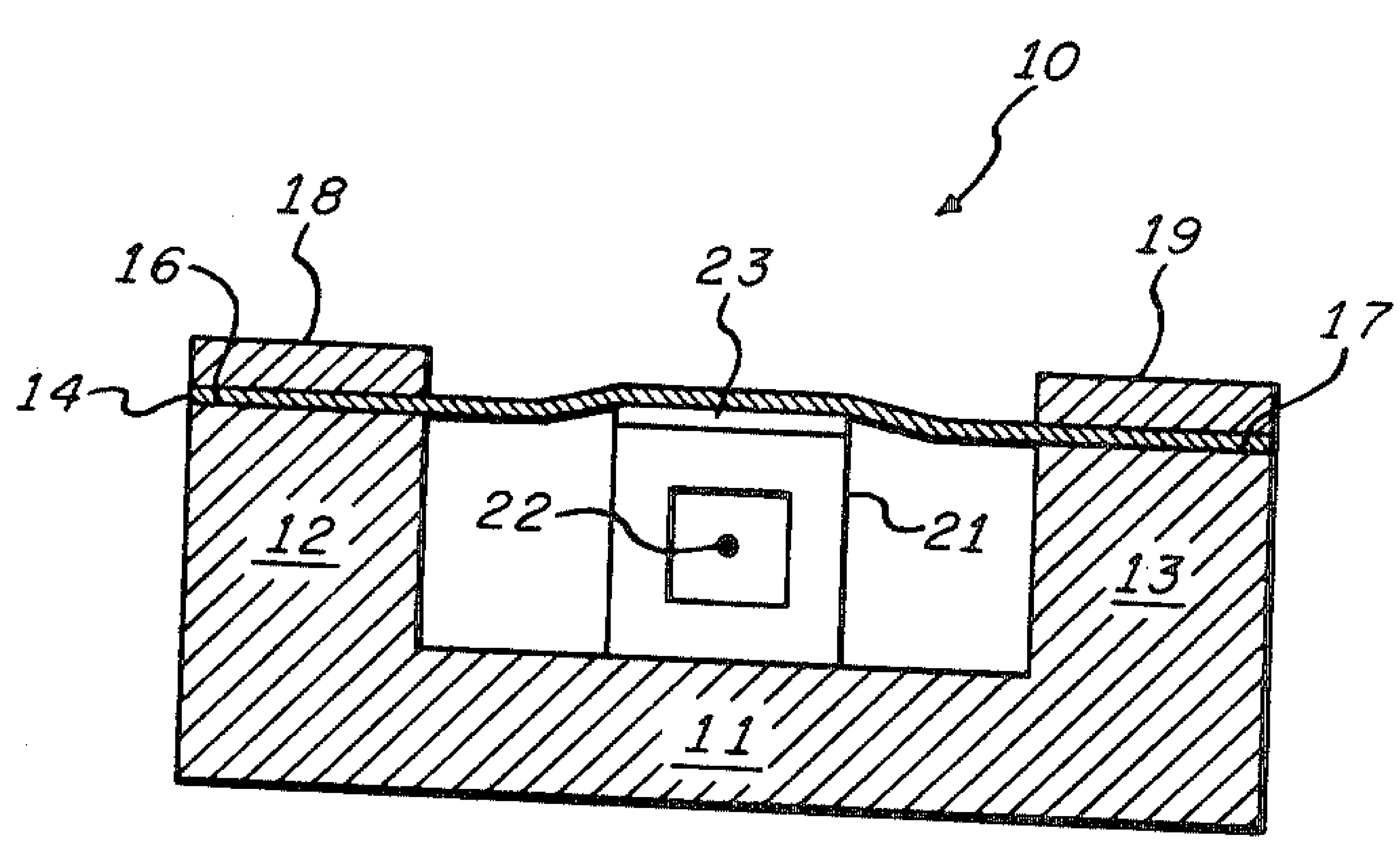
ABSTRACT: A microwave device comprising a waveguide having part of its periphery constructed of a flexible member held in contact at substantially zero pressure with a load positioned in the guide.



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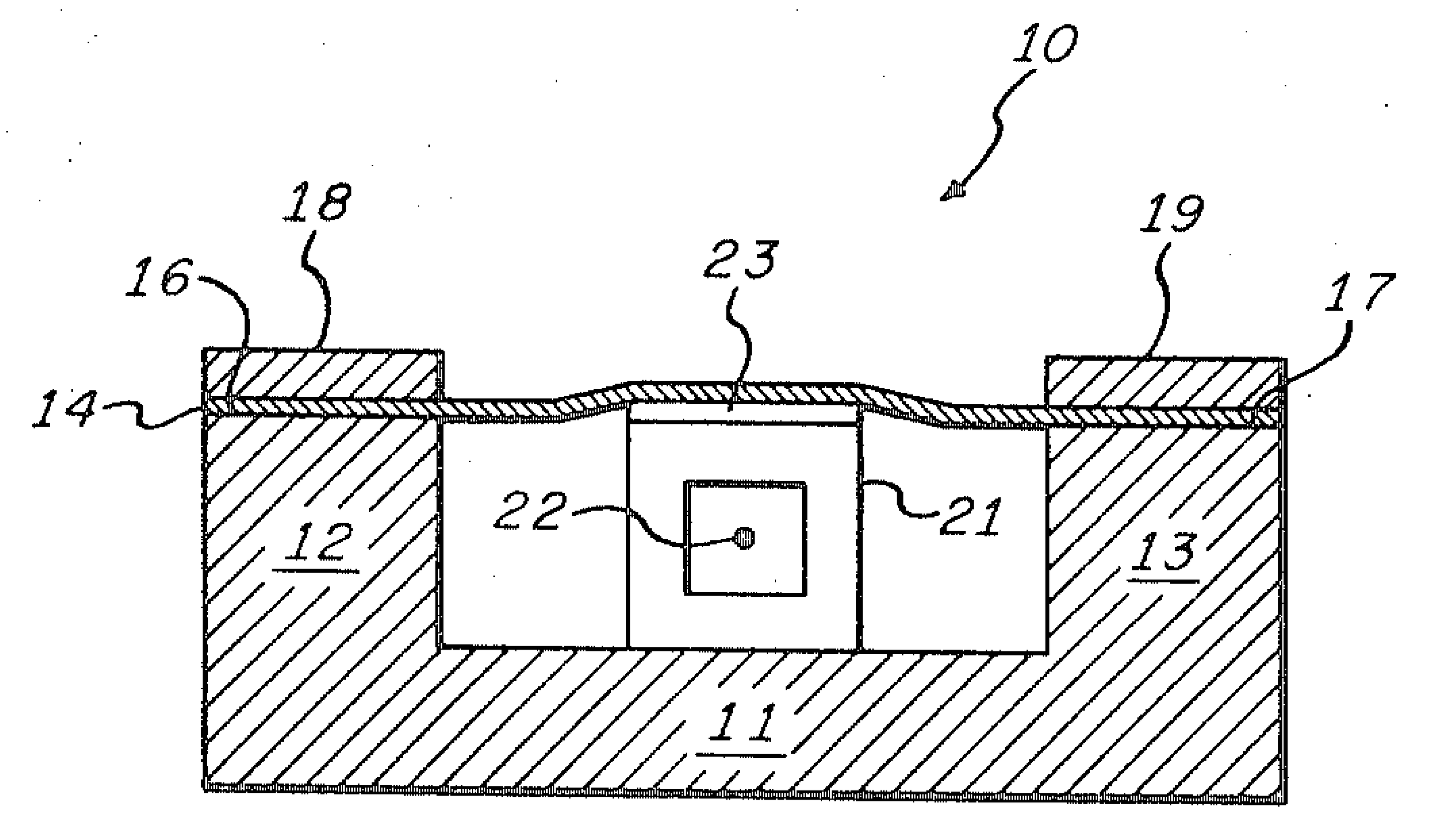

FIG. 1.

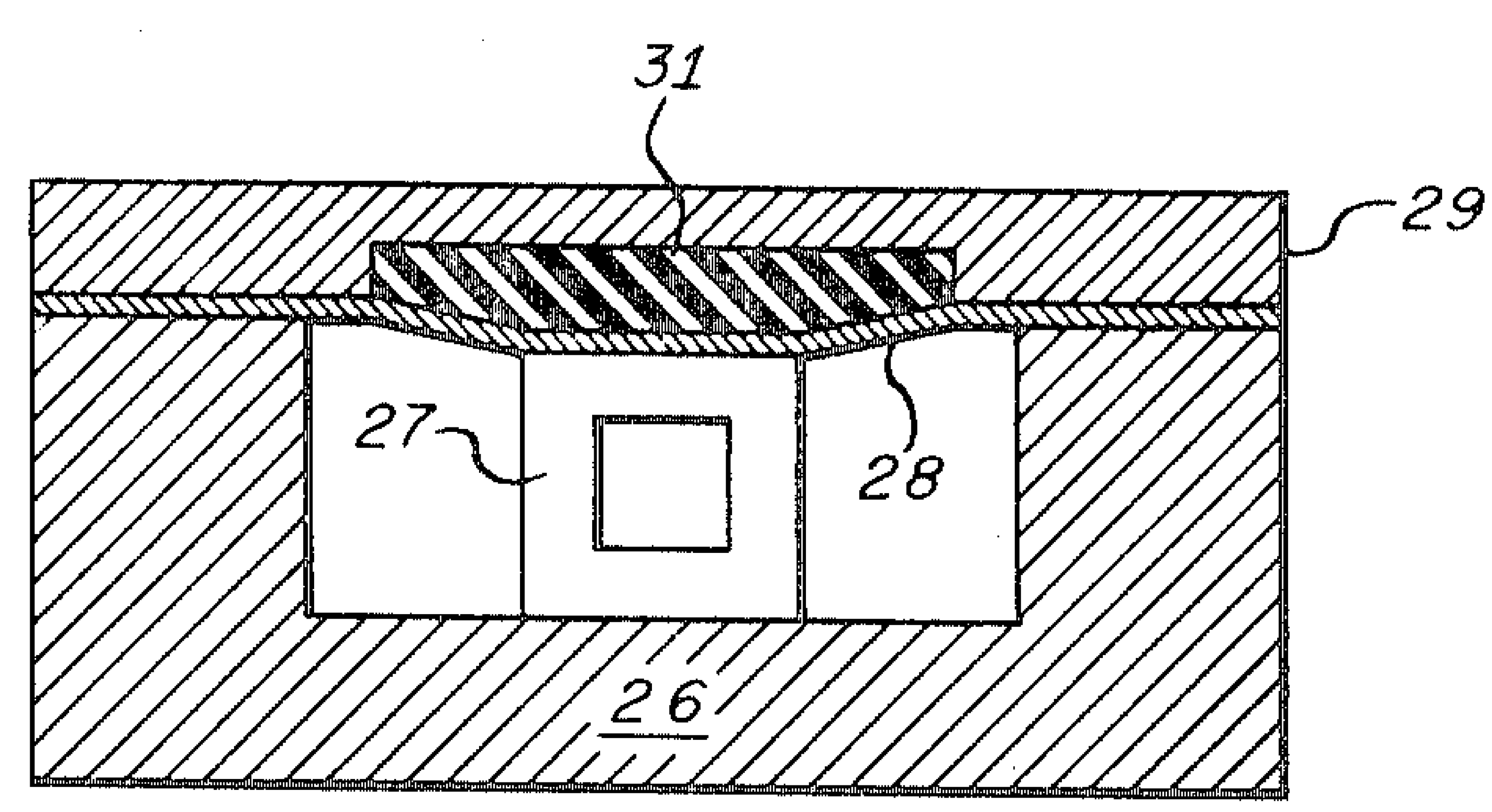

FIG. 2.

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WAVEGUIDE PARTIALLY FORMED OF A FLEXIBLE MEMBER FOR OBTAINING UNIFORM MINIMAL PRESSURE CONTACT WITH A LOAD THEREIN

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to microwave devices and more particularly to waveguide structures arranged and constructed in a manner to provide a close tolerance fit between the guide and a load inserted therein such that minimum pressure is exerted therebetween.

2. Description of the Prior Art

Heretofore, microwave devices such as phase shifters and circulators comprising one or more ceramic load elements disposed in a waveguide have generally been constructed with rigid waveguide structures. In such devices it is highly desirable, if not essential, for zero or close-fitting tolerances to be provided between the load and waveguide to assure proper electrical performance. As a result of the rigidity of the waveguide, however, taper of either the load or guide or differences in the size of individual load elements in the case of devices comprising a plurality of such elements invariably precludes the attainment of close-fitting tolerances without the necessity for machining or grinding some or all of the various components. Hence, per unit costs have customarily been rather high owing to the complexity of the fabrication and assembly processes.

In the interest of overcoming these problems there has recently been disclosed in the art a microwave phase shifter comprising a plurality of ferrite members positioned along the propagational axis of a rectangular waveguide having one broad wall constructed of a resilient member. This device simplifies assembly procedures, thereby reducing costs, and improves electrical performance to some extent as a consequence of all the ferrite members being in close contact with the broad walls of the waveguide. The latter feature is provided in this prior art device by means of the resilient wall being flexed such that it continuously exerts pressure against the ferrite members and is held in contact therewith as a result of attempting to resume the unflexed state. It will be readily appreciated that in this device a close tolerance fit between the guide and ferrite members will be obtained only under appropriate conditions relating to the size and taper of the various components as well as the width of the ferrite surface in contact with the resilient wall. For instance, ferrite members having a broad surface adjacent to the resilient wall will be in substantial contact with the wall only along two edges even in the absence of taper or differences in size of the individual ferrite members.

As previously mentioned, electrical performance of the microwave devices is a primary consideration relevant to the matter of providing a close tolerance fit between the guide and load elements. It is known that operation is impaired when gaps exist between the load elements and certain walls of the waveguide. These gaps enable undesired electromagnetic modes to propagate in the guide and are also responsible for increases in insertion loss and erratic changes of voltage standing wave ratios. In addition, it has been found that the existence of pressure on the load elements is similarly detrimental to optimum performance particularly in the case of devices constructed with load elements made of garnet material which is magnetostrictive and therefore subject to having its magnetic remanence altered upon having pressure applied thereto. The prior art device previously alluded to is therefore unsuitable when minimum or zero pressure must be maintained between the waveguide and load elements.

Additional problems arise in those applications where the devices are required to operate under extreme temperature ranges. Under such conditions, even though proper tolerances are effected in the course of manufacture, differential temperature coefficients of expansion of the respective parts will tend to produce gaps or pressures therebetween, as the temperature changes, with a concomitant degradation of electrical performance.

SUMMARY OF THE INVENTION

The present invention overcomes the aforementioned limitations of the prior art by the provision of a waveguide constructed in part of a thin flexible easily deformable plate arranged in a manner to assure contact between the plate and load elements disposed in the guide. More specifically, in one embodiment of the invention a rigid U-shaped member forms the two narrow walls and one broad wall of a rectangular waveguide. The other broad wall of the guide is formed by the thin flexible plate which is secured to the extending edges of the U-shaped member. A ceramic load disposed along the propagational axis of the waveguide is supported therein with one of its surfaces resting on the broad wall section of the U-shaped member while its opposite surface is held in contact with the flexible plate by means of an adhesive material intermediate the load and plate.

An alternative rectangular waveguide embodiment of the invention is constructed in substantially the same manner except that a rigid backing plate coextensive with the flexible plate is also secured to the extending edges of the U-shaped member and a compressible member is disposed intermediate the rigid and flexible plates. The rigid backing plate operates to exert pressure against the compressible member thereby urging the flexible plate into contact with the load at substantially zero pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a rectangular waveguide embodiment of the present invention observed along the propagational axis of the guide.

FIG. 2 is a cross-sectional view along the propagational axis of an alternate rectangular waveguide embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, rectangular waveguide **10** comprises a rigid U-shaped member having a base **11** and two sides **12** and **13** respectively forming one broad wall and the two narrow walls of the waveguide. The U-shaped member is typically constructed of a material such as aluminum in accordance with conventional microwave practice. It can be made in a single piece or of multiple pieces, if desired, to aid in fabrication. A thin foil plate **14** constructed of aluminum or other material, which is conductive and suitably pliable or permanently deformable, forms the other broad wall of the guide. The foil plate is typically secured to the extending edges **16** and **17** of the U-shaped member by means of screws (not shown) feeding through backing plates **18** and **19** into the foil and terminating in sidewalls **12** and **13**. A ceramic load in the form of a toroid **21** is disposed along the longitudinal axis **22** of the guide. A symmetrically disposed toroid is illustratively depicted as the load element since many common microwave components such as phase shifters and circulators are usually constructed in this manner, but it should be understood that the invention also has utility with asymmetrically disposed loads of varying configuration. Moreover, as explained heretofore it is particularly adapted to devices having a plurality of load elements. The essential point is that irrespective of the number, size, shape, and position of the load elements in the guide, close contact will be maintained between the entire top surface of the load and the flexible wall of the guide. Moreover, by virtue of the foil plate being sufficiently pliable or permanently deformable, it is able to be held in uniform close proximity with the load at minimal or substantially zero pressure. This is achieved in the illustrated embodiment by means of adhesive layer **23** located between foil plate **14** and the top surface of toroid **21**. Scotch brand commercial spray adhesive sold under the name Spra-ment (item number 6060) by 3M Company has been found satisfactory for this purpose. In any case, the adhesive used should have minimum film thickness, preferably less than 0.001 inch, to assure satisfactory RF coupling through the adhesive. Thickness on the order of several thousandths of an inch is suitable, however, at lower operating frequencies in the VHF and UHF ranges.

The embodiment shown in FIG. 2 is similar to the embodiment of FIG. 1 except as to the manner of holding the flexible broad wall of the guide in contact with the load. Thus, the FIG. 2 embodiment comprises a U-shaped member 26 with a toroid 27 supported therein. Foil plate 28 forming the upper broad wall of the guide is held in contact with the top surface of the toroid by means of backing plate 29 forcing against compressible foam rubber member 31 which is located between the foil and backing plate. Scotch brand commercial quality, adhesive backed polyurethane foam manufactured by 3M Company is suitable for this purpose. To assure that contact is maintained between the foil and the entire top surface of the load, the compressible member is made coextensive therewith or larger, if desired, as indicated in the drawing. As in the FIG. 1 embodiment, the foil is held in contact with the toroid at substantially zero pressure. This obtains because the foil deforms in response to force transmitted through the foam member from the backing plating only until the foil contacts the toroid and thereafter the foam member compresses as additional force is applied to it. It should be noted that an adhesive material can also be used in the FIG. 2 embodiment, the adhesive being positioned between the foil and top surface of the toroid, as in the FIG. 1 embodiment, to aid the foam member in maintaining contact between the foil and toroid.

Once contact has been established between the guide and load elements as described in the foregoing paragraphs, it should be readily apparent that such contact will be maintained at minimal pressure even in the presence of different changes in size of the various parts, which may result, for example, from ambient temperature variations as previously mentioned.

I claim:

1. A microwave device comprising,
- a waveguide,
- a deformable member forming at least part of the periphery of said waveguide,
- a load disposed in said waveguide,
- said deformable member being characterized by sufficient pliability and deformation retentivity to enable an area of the surface of said deformable member to be held in close proximity at substantially zero pressure at a predetermined temperature with a coextensive surface area of said load, and
- means for holding the coextensive areas of said deformable member and said load in close proximity with one another.

2. The apparatus of claim 1 wherein said holding means comprises an adhesive material disposed between the coextensive areas of said load and said deformable member.

3. The apparatus of claim 1 wherein said holding means comprises a rigid backing plate and a compressible member disposed intermediate said deformable member and said backing plate, said compressible member being at least coextensive with said load and said backing plate being operative to hold said compressible member in contact with said deformable member such that the latter is held in contact with said load.

4. The apparatus of claim 1 wherein the waveguide is formed by a U-shaped member having a base and two sides, the latter being secured at the extending edges thereof to said deformable member.

5. The apparatus of claim 4 wherein the surface of said load opposite the surface containing said coextensive area is set on the interior surface of the base of said U-shaped member and further including an adhesive material disposed between the coextensive areas of said deformable member and said load.

6. The apparatus of claim 4 further including a compressible member disposed in contact with said deformable member and means for exerting pressure on said compressible member so as to hold said deformable member in contact with said load.

7. The apparatus of claim 6 further including an adhesive material disposed between said deformable member and said load to aid said compressible member and said pressure exerting means in holding said deformable member in contact with said load.

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