United States Patent

Bastikar

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[54] MICROWAVE BALANCED EXTERNAL CAVITY REJECTION FILTER

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[52] **U.S. Cl.** .....**333/73 W,** 333/10

[51] **Int. Cl.**.....**H03h 7/10,** H03h 9/00

[58] **Field of Search**.....333/10, 73, 73 W

[56] **References Cited**

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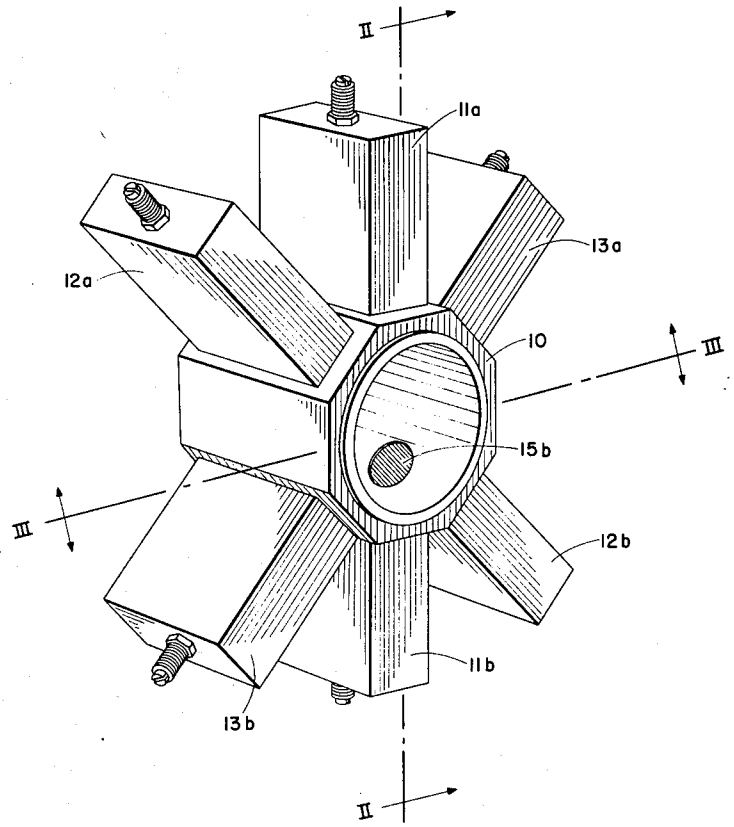
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[57] **ABSTRACT**

In an axially symmetrical waveguide, a balanced external cavity filter comprising a plurality of resonant cavity pairs coupled to the waveguide and disposed on the circumference of the same in a plane orthogonal to its axis, constitutes a novel mode-filter rejecting undesired polarizations in certain waveguide propagation-modes determined by the angular positions of the cavity pairs and their coupling to the waveguide at frequencies at which the cavity pairs are resonant.

2 Claims, 3 Drawing Figures



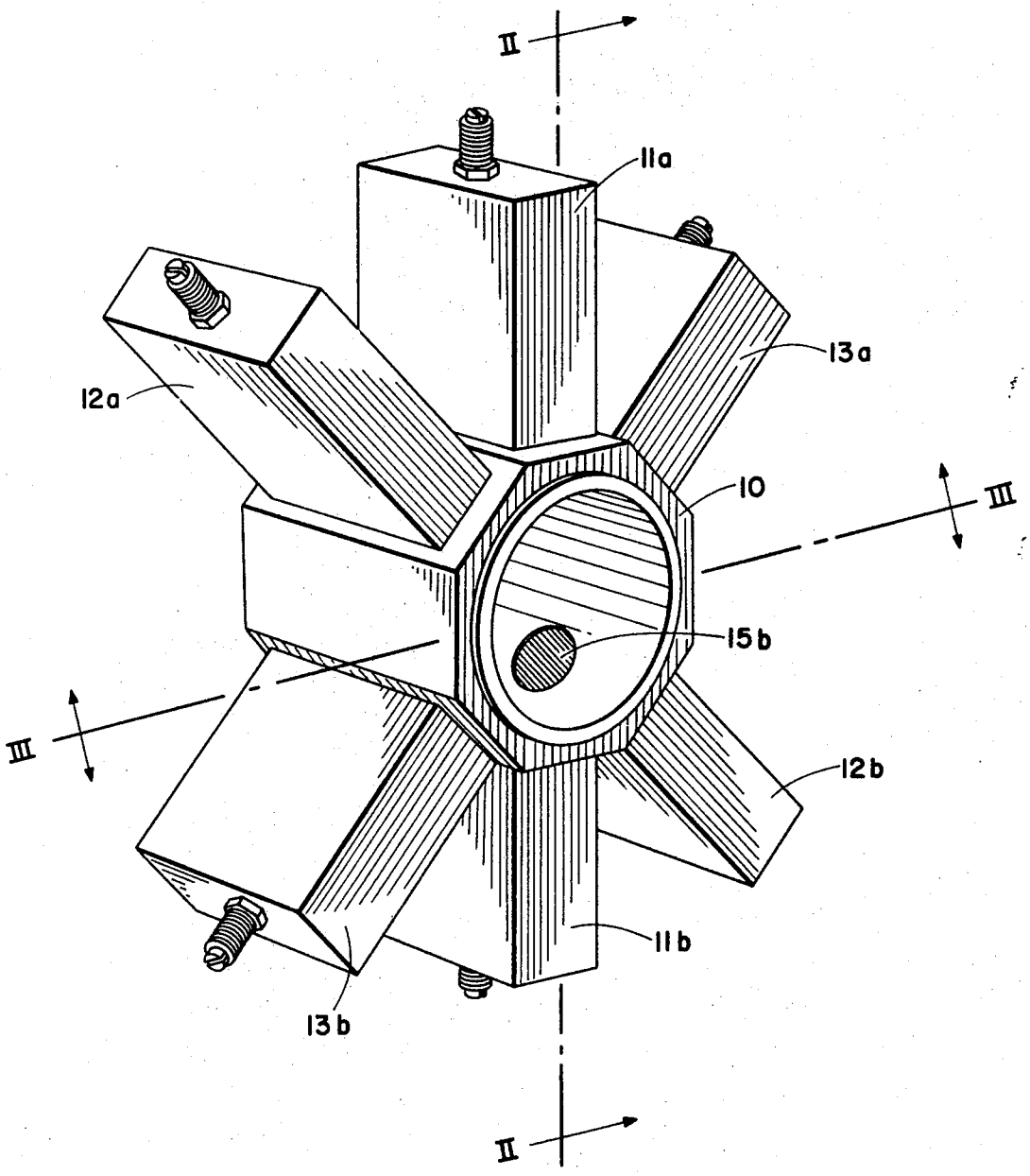


Fig. 1

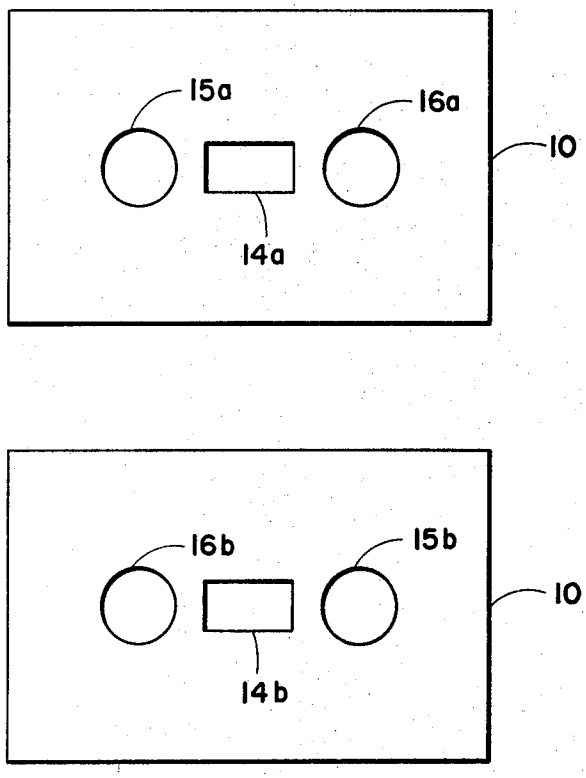


Fig. 3

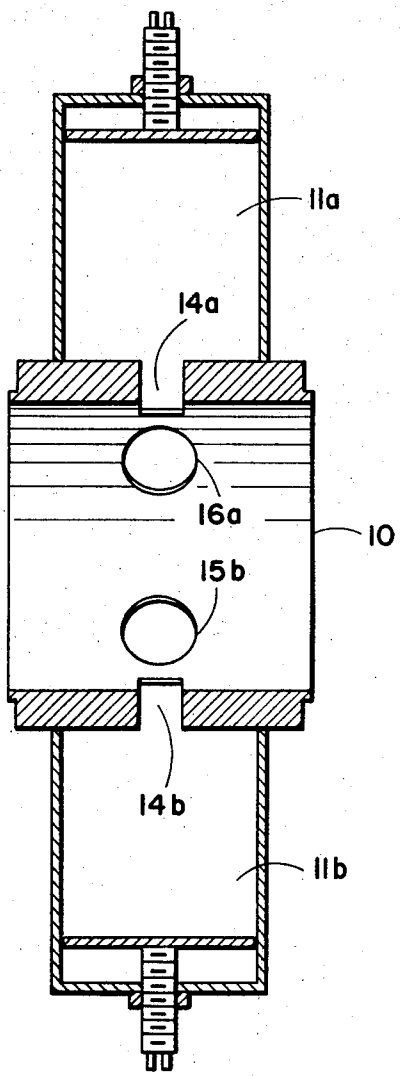


Fig. 2

MICROWAVE BALANCED EXTERNAL CAVITY REJECTION FILTER

FIELD OF THE INVENTION

This invention relates to microwave waveguide filters and more particularly to balanced external cavity rejection filters for axially symmetrical waveguides (referred to in the following disclosure simply as symmetrical waveguides).

BACKGROUND OF THE INVENTION

In the utilization of symmetrical waveguides, such as circular waveguides, for the transmission of signals or power at microwave frequencies, several problems arise. For example, because the cut-off frequency of the second mode of propagation TM_{01} in a circular waveguide is only approximately 31 percent higher than the cut-off frequency of the basic mode TE_{11}, the region of stable transmission in the basic mode is limited as compared to rectangular waveguide, where the second mode is approximately 100 percent higher than the basic mode. Also, the practical utilization of the TE_{11} basic mode is somewhat difficult. Slight irregularities in the waveguide, e.g., slight elipticity, cause the TE_{11} wave to have two different phase and group velocities for each of its circularly polarized components.

In the authoritative text book titled "Microwave Transmission Circuits," edited by George L. Ragan, Radiation Laboratories (MIT) Series, No. 9, published by McGraw-Hill Book Company, Inc., 1948, it is stated on page 54, section 2.10: "Round waveguide is seldom used as a transmission line because of difficulties arising from the fact that there is no unique direction of polarization of the fields. That is to say, the field pattern - - - may be rotated through any angle about the axis of the tube." [i.e., the waveguide]. "Imperfections in the tubing and bends required in installing it tend to introduce other components of polarization which then get out of phase, resulting in elliptical polarization of the waves."

One of the interesting modes of propagation is the TE_{01} mode. This mode possesses only axially and radially magnetic components; the absence of a tangential magnetic component causes attenuation to decrease with increasing frequency. In order to achieve sufficient reduction in attenuation, however, one must go much higher in frequency than the basic TE_{11} mode, leaving many other modes in between. To avoid the instabilities arising thereby, novel mode-filters would be necessary.

DESCRIPTION OF THE PRIOR ART

In a microwave antenna system, it is usually required that either a horizontally or vertically polarized signal be radiated, or eventually a circularly polarized signal. If the microwave antenna is fed by a symmetrical waveguide, means for suppressing the polarizations other than that to be radiated are necessary. To achieve this, the practice has been to place "-fins" inside the waveguide in certain known arrangements to attenuate unwanted modes and polarizations. These fins, however, cause losses in the wanted signals themselves and excite spurious modes, because of the sometimes severe discontinuities the fins create. They are imperfections in the waveguide leading to the complications mentioned by Ragan supra. Power losses in such cases, and these spurious modes and polarizations pose problems, especially since an antenna feed system usually carries high transmitter power. A restriction, therefore, was imposed on the number of such fins, and hence on the effective rejection of unwanted modes they provide.

SUMMARY OF THE INVENTION

This invention obviates the general difficulties inherent in the use of circular waveguides by introducing a filter which does not utilize internal fins, and therefore overcomes disadvantages of the prior art.

The novel filter is a balanced external cavity filter. The balanced pairs of resonant cavities are diametrically disposed on the circumference of the symmetrical waveguide at predetermined angles with respect to each other, and are all in the same orthogonal plane to the waveguide axis. Depending on what frequencies and modes must be rejected, each pair of cavities is made resonant in a well-known manner at the rejected frequency, and the means of coupling each pair of cavities to the waveguide are determined. In preferred embodiments, coupling irises in the wall of the waveguide, between the same and each resonant cavity, are employed. The shape and/or orientation of irises, i.e., circular, rectangular, etc., and the angular position of the resonant cavity pairs with respect to each other, determines the mode or modes rejected as shall be shown in describing the preferred embodiment of the invention.

This novel filter can be used with various types of symmetrical waveguides such as: circular, octagonal, hexagonal, or square. The resonant cavities can be cylindrical, rectangular, or such other forms of resonant cavities as may be expedient, and as are well known in the art.

The invention makes possible the simultaneous rejection of unwanted signals in the dominant mode and higher modes, as well as of harmonics, circularly polarized signals, and simultaneously, enables polarization discrimination of linearly polarized signals.

This type of filter can be used as a band-stop filter; in antenna feed systems as a higher mode rejection filter; or as a linear polarization discriminator.

In a preferred embodiment of the invention as a polarization and higher mode rejection filter, three pairs of resonant cavities are utilized. The first of said pairs being oriented either vertically, if the horizontal polarization is to be rejected and the vertical to be radiated, or it is oriented horizontally if the vertical polarization is to be rejected and the horizontal to be radiated. In general, the orientation is arbitrary if not specified by the application. This first pair of cavities is being coupled inductively to the waveguide by means of a pair of rectangular irises. The second and third pairs of resonant cavities are positioned one on each side of the first cavity pair and at 45° with respect to it. In order to couple more than one mode to the second and third cavity pairs, namely TM_{01}, TE_{01}, TM_{11} and TM_{21} at the same frequency, the coupling means may be circular irises. The positioning of these second and third cavity pairs at 45° angle with respect to the first pair enables the rejection of circularly polarized signals at the frequencies at which the cavities are resonant and that are in the above-mentioned modes.

In the above-described embodiment, three pairs of resonant cavities are efficiently utilized to offer a novel solution to the problem of polarization and higher mode rejection which may be used in an antenna feed system.

BRIEF DESCRIPTION THE DRAWINGS

An example embodiment of the invention will now be described with reference to the accompanying drawings in which:

FIG. **1** is a perspective view of a balanced external cavity filter with three cavity pairs disposed on a circular waveguide section;

FIG. **2** is a cross-section taken along the line II—II of the perspective view, FIG. **1**; and

FIG. **3** is a development along the line III—III in the perspective view, FIG. **1**.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to FIGS. **1**, **2** and **3**, the balanced external cavity filter comprises a section of an axially symmetrical waveguide **10**, first, second and third pairs of resonant cavities **11***a*–**11***b*, **12***a*–**12**and **13***a*–**13***b*, respectively, each pair being diametrically disposed on the waveguide **10** in a plane orthogonal to its axis. The second and third pairs of resonant cavities **12***a*–**12***b* and **13***a*–**13***b* respectively, being disposed at 45° with respect to the first pair of resonant cavities **11***a*–**11***b*, one on either

side thereof. The first pair of resonant cavities **11***a*–**11***b* being couple inductively to the waveguide **10** through rectangular irises **14***a*–**14***b*. The second and third pairs of resonant cavities **12***a*–**12** and **13***a*–**13***b*, respectively, being coupled to the waveguide **10** through circular irises **15***a*–**15***b* and **16***a* **16***b*, respectively. The first, second and third pairs of resonant cavities **11** *a*–**11***b*, **12***a*–**12***b* and **13***a*–**13***b*, respectively, being resonant at substantially the same frequency.

The use of the preferred embodiment as described herein, in an antenna feed system is particularly interesting. Assuming an axially symmetrical waveguide **10** feeding the microwave antenna (not shown) and carrying transmitted power at a frequency in the TE_{11} mode launched in a vertical polarization. Due to the lack of a unique direction of polarization in the waveguide as stated by Ragan supra, it is required to redefine the polarization originally launched. Therefore, the first pair of resonant cavities **11***a*–**11***b* is made resonant at the transmitted frequency, and is coupled inductively to the waveguide **10** through the rectangular iris pair **14***a*–**14***b* in a well known manner. The magnetic field of the undesired polarization which is perpendicular to the orientation of the resonant cavity pair **11***a*–**11***b* (i.e., horizontal) is coupled to the pair **11***a*–**11***b* and therefore rejected. The orientation of the resonant cavity pair **11***a*–**11***b*, then, is that parallel to the linear polarization direction of the transmitted signal.

The second and third resonant cavity pairs **12***a*–**12***b* and **13***a*–**13**, respectively, may also be resonant at the transmitted frequency but coupled to the waveguide **10** through circular iris pairs **15***a*–**15***b* and **16***a*–**16***b*, respectively, in order to couple and therefore reject a multiplicity of waveguide modes. This is required because spurious responses of the transmitted frequency in the dominant TE_{11} mode, caused by imperfections in the waveguide or existent in the signal at or prior to its launching, develop and propagate at higher modes, particularly TH_{01}, TE_{01}, TM_{11} and TM_{21}, if that frequency lies above the waveguide cut off frequency of these higher modes. The latter condition is common, since the next higher mode is only approximately 31 percent above the dominant mode. Spurious circular polarization in the dominant TE_{11} is also rejected, due to the positioning of the second and third resonant cavity pairs **12***a*–**12**, and **13***a*–**13***b*, respectively, at 45° angle with respect to the first resonant cavity pair **11***a*–**11***b*. Due to the simultaneous positioning of the second and third resonant cavity pairs **12***a*–**12** and **13***a*–**13***b*, respectively, at 45° angle with respect to the polarization of the transmitted frequency in the dominant mode TE_{11} any coupling of that frequency in that polarization, and in the latter mode is negligible.

If the rejection of such a filter as shown and described herein is not sufficient for any particular application, several such filters can be used in succession. The distance between such filters along the waveguide **10** axis may preferably be an odd multiple of a quarter wavelength of the frequency transmitted in the waveguide **10**.

What is claimed is:

1. A waveguide filter comprising:

an axially symmetrical waveguide;

at least three pairs of resonant cavities, diametrically disposed on said waveguide at angles which are integral multiplier of 45° with respect to each other, in a plane orthogonal to the waveguide axis;

each one pair of resonant cavities being resonant at substantially the same frequency; and

a plurality of irises in the wall of the waveguide for inductively coupling each of said pairs of resonant cavities to the waveguide to reject a plurality of predetermined modes of waveguide propagation.

2. A waveguide filter comprising:

an axially symmetrical waveguide;

first, second and third pairs of resonant cavities, each pair being diametrically disposed on said waveguide in a plane orthogonal to the waveguide axis, the second and the third pairs of resonant cavities being disposed at 45° with respect to the first pair of resonant cavities, one on either side thereof;

rectangular irises for inductively coupling said first pair of resonant cavities to the waveguide;

circular irises for coupling said second and third pairs of resonant cavities to the waveguide; and

said first, second and third pairs of resonant cavities being resonant at substantially the same frequency, whereby a plurality of predetermined modes of waveguide propagation are rejected by said filter.

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