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WAVE GUIDE FILTER HAVING RESONANT CAVITIES MADE OF JOINED PARTS

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FIG. 1

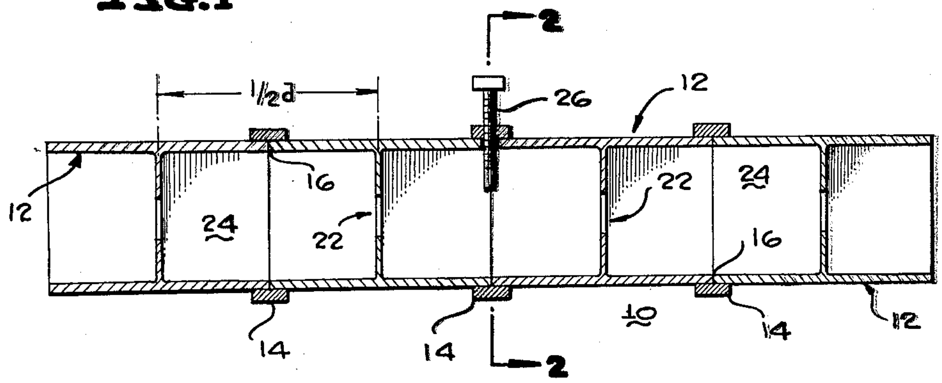


FIG. 2

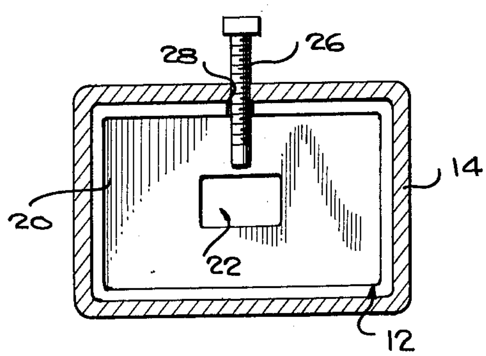


FIG. 4

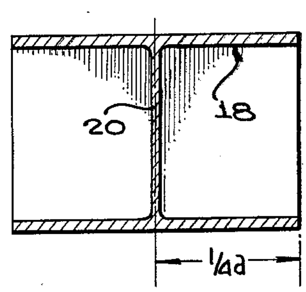


FIG. 3

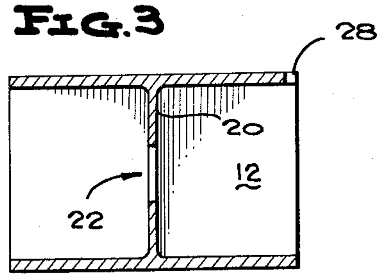
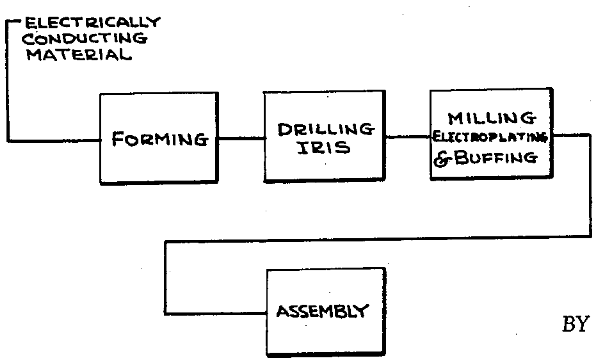


FIG. 5



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WAVE GUIDE FILTER HAVING RESONANT CAVITIES MADE OF JOINED PARTS

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The present invention relates generally to wave guide filters, and more particularly to wave guide filters consisting of discrete sections.

In the construction of high-Q direct-coupled microwave filters having two or more cavities in series, post susceptances or inductive irises inserted in a section of waveguide are commonly used. This type of construction is mechanically troublesome in that critical soldered or brazed joints are required at points which are relatively inaccessible within the guide. Also, the soldered connections fall in regions where the current in the filter is relatively large so that the connections are electrically critical as well.

The fabrication technique according to the present invention makes electrically critical portions of the filter completely accessible to machining, to special surface treatment such as silver plating, and to inspection prior to assembly of the filter. Also, the mechanical joint (soldered, bonded, or merely clamped), occurs at places where the electrical performance of the joint is especially non-critical. Finally, the technique permits use of a circular-hole-in-iris type of coupling susceptance capable of providing a wide range of susceptance values (merely by varying hole diameter) and amenable to close control of tolerances.

A filter according to the invention is assembled from a number of standard preformed sections having the form of a short length of waveguide with a centered transverse wall as an integral part of the guide section. These sections might be cast or possibly drawn, and for critical applications could be plated and buffed on the interior surfaces. With a large number of such standard sections on hand, fabrication of the filter would involve milling down the ends of the sections to a length appropriate to the center frequency of the filter, and drilling a centered hole in the transverse wall appropriate to the bandwidth of the filter in accordance with standard filter synthesis procedures. Each resulting section can then be pictured as consisting electrically of a shunt susceptance centered between quarter-wave lengths of guide. Thus, when a number of these sections are connected together, the joints occur at points of low current and high voltage so that poor electrical contact at the joint will have little effect on filter performance.

This type of fabrication is not only simpler than that conventionally used, but will produce electrically superior results as well, especially in the case of narrow-band high-Q filters where dissipation becomes critical.

Secondary advantages include the following:

(1) In experimental filter design, various values of shunt susceptance can be easily substituted.

(2) For special applications, the sections can incorporate ridge loading so as to reduce the cut-off frequency of the prototype guide structure. This would permit a reduction in the size of filters designed for, say the S and C frequency bands.

Finally, special short sleeves or bushings incorporating

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tuning screws could be used to connect the sections together.

It is well known that in waveguide components for very high frequencies, such as filters, structural discontinuities in the interior surfaces generate standing waves which involve losses and undesired phase shifts. Elimination of such discontinuities in waveguide filters during manufacture in an economical and effective manner is therefore highly desirable. However, in prior art waveguide filters the elimination of such discontinuities is extremely difficult because the interiors of the filters are inaccessible.

It may also be desirable to have the capability of changing the electrical characteristics of waveguide filters after they have been fabricated. In conventional filters wherein there are a pluarity of resonant chambers each of ½ wavelength in length and separated by shunt susceptances of the apertured wall type, once the filter is fabricated, the size of the apertures and the size of interior chambers cannot be changed. Thus in prior art practice the resonant frequency and the bandwidth of a waveguide filter cannot be varied, and an entire new filter possessing the desired electrical characteristics must be substituted.

According to the present invention there is provided a waveguide filter assembly comprising a plurality of tandem connected discrete waveguide filter sections, each section being in the form of a tube having an apertured transverse wall in the center thereof. Each of the discrete filter sections is made by forming electrically conducting material into a tube having a transverse wall in the center thereof. An aperture is drilled in the transverse wall to provide a desired susceptance, and the ends of the tubular body are milled to a desired wavelength. The discrete filter sections are then joined end to end by bushings to form a filter assembly having resonant chambers each ½ wavelength long with joints in the center of each chamber. The bushings may have variable tuning elements such as screws or stubs located thereon. The exactness of the fit of the discrete filter sections at their joints is not critical because, as is well known, the current is low and the voltage is high at points in the center of a ½ wavelength resonant chamber, and thus, at the joints of the filter assembly of the invention. If desired, each discrete section may be electroplated and buffed prior to assembly.

One object and advantage of the waveguide filter assembly according to the invention is that the electrical characteristics at the joints connecting the discrete filter element are not critical.

Another object and advantage is that any of the discrete filter sections of the waveguide filter assembly may be replaced by other discrete filter section having different electrical characteristics such as, for example, different values of shunt susceptance.

A further advantage and object of the invention is that interior areas of the waveguide filter assembly are readily accessible for repairs, or for finishing during fabrication.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a view in longitudinal section of a waveguide filter assembly according to the invention;

FIGURE 2 is a cross section of the filter of FIGURE 1 taken along line 2—2;

FIGURE 3 is a view in longitudinal section of a discrete filter section according to the invention;

FIGURE 4 is an integral tubular body having a transverse wall in the center thereof, from which a discrete filter section may be fabricated; and

FIGURE 5 is a self-explanatory flow sheet indicating a method of fabricating discrete filter sections and assembly thereof.

Referring to FIGURE 1, a longitudinal section of the waveguide filter assembly of the invention is generally illustrated at **10**. The particular type of filter shown at **10** is a waveguide bandpass filter of well-known design having shunt susceptances of the apertured transverse wall type. However, other types of waveguide filters of the resonant cavity type may be constructed according to the invention, the type shown in FIGURE 1 constituting an illustrative example only. Filter assembly **10** includes a plurality of discrete waveguide filter sections **12** tandemly connected in a stack by bushings or short sleeves **14** located at abutting joints **16**.

A typical discrete filter section is shown at **12** in FIGURE 3. Referring to the flow sheet of FIGURE 5 and to FIGURES 3 and 4, a discrete filter section **12** is fabricated by forming electrically conductive material, such as copper or brass, into a unitary tubular body **18** shown in FIGURE 4, having an integral transverse wall **20** therein. The forming of bodies **18** may be carried out by conventional methods of extrusion or casting. An aperture **22** of a size appropriate to the bandwidth desiderd in a filter section is drilled through wall **20**. The distance of wall **20** to each open end of the tubular body **18** is ¼ the wavelength of the center frequency λ of a filter in which the discrete section **12** is intended for use. If a more critical tolerance is desired, the ends of each of the discrete sections **12** may be milled and the interior surfaces thereof electroplated with highly conductive material such as silver and buffed in a conventional manner as indicated on the flow sheet of FIGURE 5.

As indicated in FIGURE 1, a plurality of discrete filter sections **12** is tandemly stacked and suitably secured by bushings **14** to form the filter assembly **10** of the invention. Since each apertured transverse wall **20** of each discrete section **12** is ¼λ from its ends, the filter assembly **10** includes a plurality of resonant chambers indicated at **24**, each chamber being ½λ in length and coupled by apertures **22** as shunt susceptances according to well known principles. The joints **16** formed by the open ends of the discrete sections **12** abut at the center of each resonant chamber **24**. Since the center of a ½λ resonant chamber has high voltage but low current, the phase shift and losses due to irregularities or discontinuities at each joint **16** are relatively small. On the other hand, and according to the invention there are no discontinuities such as may be caused by bonding or welding at the junction of each transverse wall **20** with the inside periphery of tubular body **18** because wall **20** is formed integrally with body **18**.

Referring to FIGURES 1 and 2, it may be desirable to provide one or more tuning elements in filter assembly **10** to vary the center frequency thereof. To accomplish this, one or more of the short sleeves or bushings **14** may be provided with a conventional tuning element **26** shown as being of the screw type but which may be of the rod or rotary type as well. Such tuning elements are well known and are described by in chapter 28 of "Very High Frequency Techniques," vol. II, published by McGraw-Hill in New York and London in 1947. In order to receive the tuning element **26** a small notch **28** may be drilled at one or both ends of a discrete filter section **12** at a location in corresponding register with a notch **28** of another discrete filter section so that when the two discrete sections are brought together in abutting relationship, an opening is formed.

It is understood that each of the discrete filter sections **12** of the invention may have varying shunt susceptances in a given filter assembly. An example of a filter having sections of varying apertures or slots is described in the patent to W. D. Lewis, 2,585,563, issued on February 12, 1952.

In operation, the filter assembly **10** of the invention is inserted in a conventional very high frequency line such as a waveguide or a coaxial line having suitable translation elements. Discrete filter sections **12** are selected for assembly according to the center frequency λ and bandwidth desired to be filtered. The assembly **10** is conveniently connected to the line by sleeves or bushings **14** in the manner described for connecting the filter sections **12**. If it is desired to change the operating characteristics of the inserted assembly **10**, one or more of the discrete sections **12** may be replaced by other discrete sections without removing the entire assembly **10** from the line. Because the sections **12** are independently replaceable, the filter assembly according to the invention is particularly advantageous for testing purposes.

Should there be an occurrence of losses or phase shifts after placing the filter assembly **10** in a line, the interior surfaces of each discrete filter section **12** may be separately inspected, tested, and modified.

As an example of a discrete filter section **12** constructed as rectangular in cross section according to the invention, the following measurements in inches and limits of tolerance thereof were found to give satisfactory results:

Length of body **18**	1.500±.010
Distance from a side of wall **20** to an end of body **18**	0.734±.005
Thickness of wall **20**	.030±.001
Radius at junction of wall **20** with inside periphery of body **18**	1/16"
Outside width of body **18**	1.000±.003
Inside width of body **18**	.900±.002
Thickness of tube wall of body **18**	.050±.003
Inside radius of corners of body **18**	.031±.005
Outside radius of corners of body **18**	1/16"
Outside depth of body **18**	.500±.003
Inside depth of body **18**	.400±.003
Thickness of electroplating on inside surfaces of body **18**	1/32"

What we claim is:

1. A waveguide filter assembly comprising a plurality of discrete filter sections, each of said discrete filter sections being of unitary construction and being in the form of a tube having an apertured central transverse integral member, and coupling means for joining said filter sections end to end for electrical contact therebetween, said coupling means including at least one tuning means mounted on said connecting means.

2. A waveguide filter assembly for passing a band of wavelengths having a central wavelength λ and having a plurality of electrically coupled resonant chambers each of a length equal to $\lambda/2$ comprising a plurality of unitary bodies of electrically conductive material each in the form of a tube having an intgeral transverse apertured wall in the center thereof, the distance from each wall to the open ends of each said body being equal to $\lambda/4$, means for separably joining said unitary bodies at their open ends for electrical contact therebetween to form a stack thereof, and at least one variable tuning mounted on said joining means.

3. A waveguide filter of the type having a stack of resonant chambers electrically coupled in tandem by shunt susceptances of the apertured transverse wall type comprising a plurality of electrically conducting tubular bodies each having an apertured integral transverse wall in the center thereof, means to separably join said bodies end to end for electrical contacts at joints therebetween, said joined plurality of tubular bodies thereby forming a stack of chambers, each chamber having a central joint, and variable tuning means mounted on at least one of said means to join.

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