March 4, 1952 A. G. FOX 2,588,226

WAVE FILTER

Original Filed July 30, 1942

FIG. 1

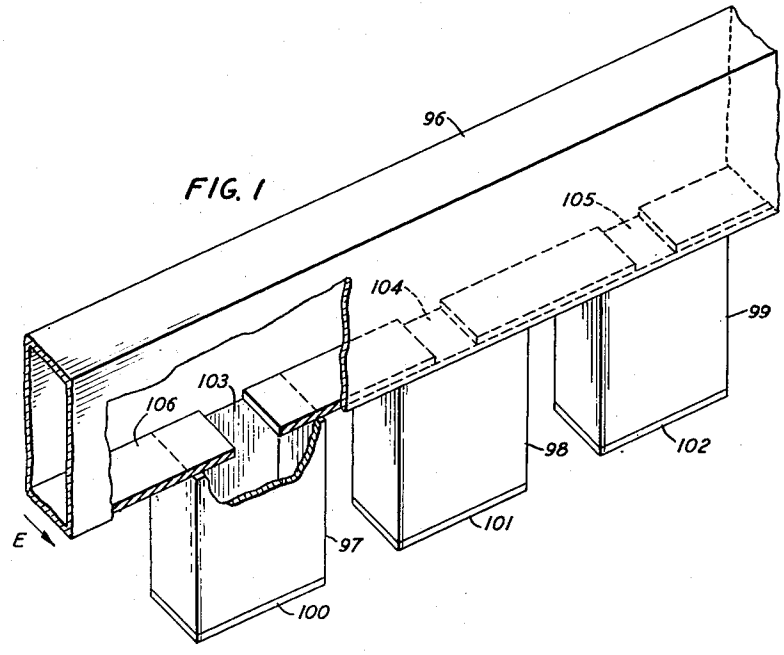
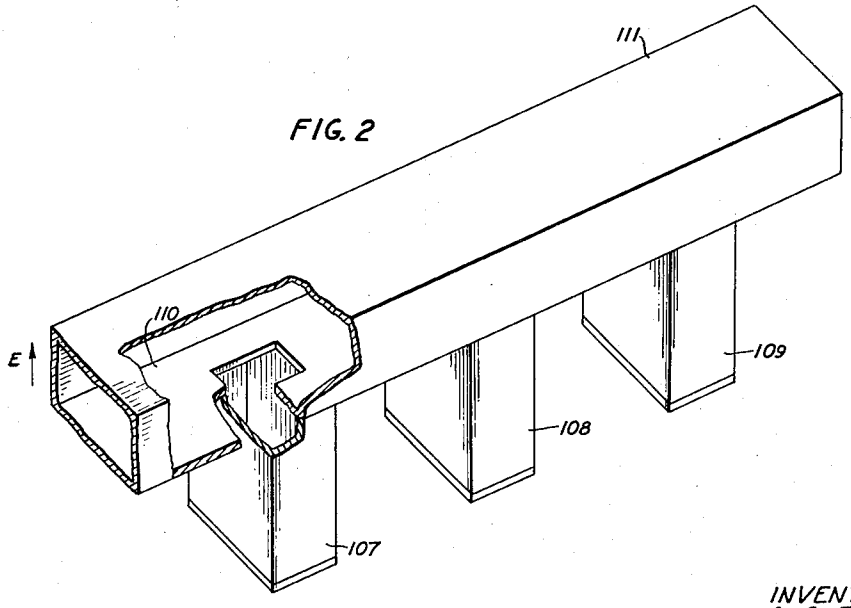


FIG. 2



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2,588,226

WAVE FILTER

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Original application July 30, 1942, Serial No. 452,851. Divided and this application December 5, 1947, Serial No. 789,811

5 Claims. (Cl. 178—44)

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This invention relates to wave transmission networks and more particularly to frequency selective networks for use in the transmission of guided electromagnetic waves.

The principal object of the invention is to transmit freely a band or bands of electromagnetic waves while effectively blocking waves falling outside of the band or bands. A further object is to improve the transmission characteristics of filters for use in wave guides.

A uniform metallic sheath with or without a dielectric filler will serve as a guide for suitable electromagnetic waves. In cross-section the sheath may be circular, rectangular, or of other shape. For all frequencies above a minimum, known as the cut-off frequency, the guide acts like a transmission line and has a specific propagation constant and characteristic impedance. For any particular frequency there are an infinite number of cross-sectional sizes and shapes of guide which will have the same characteristic impedance. Shunt reactive elements are obtained by placing partial obstructions across the wave guide. For example, a shunt reactive element for dominant transverse electric waves may be obtained by using a transverse metal partition having a slit therein which extends substantially from one side to the other. If the slit is perpendicular to the direction of polarization of the electric field the element is primarily capacitive, and if parallel with the field the element is primarily inductive. If the slot is replaced by a centrally located square or circular opening, the reactance will still be dominantly inductive.

In accordance with one embodiment of the present invention, a wave guide filter with improved transmission characteristics is formed by providing two or more branch chambers spaced along the wave guide. The chambers open into the guide through apertures the centers of which are spaced from each other approximately one quarter of a wavelength, or an odd integral multiple thereof, at the mid-band frequency. The chambers are tuned to resonate at or near the mid-band frequency and the resonance is made as sharp as desired by a proper choice of the width of the coupling aperture. If the wave guide is rectangular in cross-section, the chambers may branch from any of the four sides.

The three-branch filter disclosed may, for example, be designed to have a band-suppression characteristic with high attenuation at the mid-band frequency and, on each side thereof, a frequency of substantially perfect transmission, giving very sharp cut-offs. The chambers may be tuned to different resonant frequencies to increase the width of the band. For example, two chambers, tuned to slightly different frequencies, may be used to provide two peaks of attenuation with sustained attenuation between. A still wider band may be provided by using more complex side branches.

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This is a division of my copending application Serial No. 452,851, filed July 30, 1942, now Patent 2,432,093, issued December 9, 1947.

The nature of the invention will be more fully understood from the following detailed description and by reference to the accompanying drawing, in which like reference characters are used to designate similar parts and in which:

Fig. 1 is a perspective view, partly cut away, of a wave filter in accordance with the invention comprising three chambers branching from one of the narrower sides of a rectangular wave guide; and

Fig. 2 is a similar view of a modified form of the filter in which the chambers branch from one of the wider sides of the wave guide.

In the embodiment shown in Fig. 1, the filter comprises a rectangular wave guide **96** and three tuned side-branch chambers **97**, **98** and **99**. The chambers are closed at their outer ends by the end plates **100**, **101** and **102**, respectively, and open into one of the narrower sides **106** of the guide **96** through the apertures **103**, **104** and **105**. The centers of the apertures **103**, **104** and **105** are spaced from each other approximately one quarter of a wavelength, or an odd integral multiple thereof, at the mid-band frequency of the filter. The electric field E of the dominant transverse electric waves carried by the guide **96** is polarized in a direction parallel to the narrower side **106**, as indicated by the arrow. Each of the branch chambers **97**, **98** and **99** is tuned to resonate at the mid-band frequency by properly choosing its length, and the resonance is made as sharp as desired by a proper choice of the width of the associated aperture **103**, **104** or **105**. The three-branch filter shown may, for example, be designed to provide a band-suppression characteristic having high attenuation at the mid-band frequency and, on each side thereof, a frequency of substantially perfect transmission, giving very sharp cut-offs.

The chambers may be tuned to different resonant frequencies to increase the width of the suppression band. For example, two chambers, tuned to slightly different frequencies, may be used to provide two peaks of attenuation with sustained attenuation between. If a still wider band is desired, any one or all on the branches **97**, **98** and **99** may be replaced by more complex

side branches such, for example, as are disclosed in Fig. 21 of the above-identified parent application. As shown therein such a side branch comprises a resonant end chamber opening through an aperture into a side-branch section which connects the chamber with the main wave guide. At an intermediate point a reactive impedance branch, which may be either inductive or capacitive, is shunted across the side-branch section. As described therein, the side branch may be adjusted to provide either a band-pass or a band-suppression characteristic for the filter.

It will be understood, of course, that either more or less than three side-branch chambers may be used. Furthermore, the chambers may branch from any of the four sides of the wave guide 96. As shown, for example, in Fig. 2 all three of the side-branch chambers 107, 108 and 109 branch from one of the wider sides 110 of the rectangular wave guide 111. Otherwise the side-branch chambers 106, 107 and 108 are similar to the chambers 97, 98 and 99, and the main wave guide 111 is similar to the guide 96, shown in Fig. 1.

What is claimed is:

1. A filter for suppressing a band of guided electromagnetic waves comprising a tubular, single-conductor wave guide of rectangular cross-section and a plurality of cavity resonators, each of said resonators having an opening into said guide, the centers of said openings having a longitudinal spacing approximately equal to an odd integral multiple of a quarter wavelength at the mid-band frequency of said band and two of said resonators being resonant respectively at different frequencies within said band.

2. A filter in accordance with claim 1 in which said guide has unequal cross-sectional dimensions and one of said resonators opens into said guide through one of the narrower sides thereof.

3. A filter in accordance with claim 1 in which said guide has unequal cross-sectional dimensions and one of said resonators opens into said guide through one of the wider sides thereof.

4. An insertion piece for insertion in a signal transmission channel for effectively preventing transmission through said channel in a predetermined frequency band, said piece comprising a transmission line section having coupled thereto a plurality of cavity resonators, each tuned to a different frequency within said band, and separated one from another along the length of said line section by intervals corresponding to odd numbers of quarter wave-lengths at frequencies within said band.

5. An insertion piece for insertion in a signal transmission channel for effectively preventing transmission through said channel in a predetermined frequency band, said piece comprising a wave-guiding element having coupled thereto a plurality of cavity resonators, each tuned to a different frequency within said band, and separated one from another along the length of said wave guiding element by intervals corresponding to odd multiples of quarter wave lengths at frequencies within said band.

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REFERENCES CITED

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