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A. G. FOX

2,740,094

WAVE-GUIDE IMPEDANCE ELEMENTS

Original Filed July 30, 1942

FIG. 1

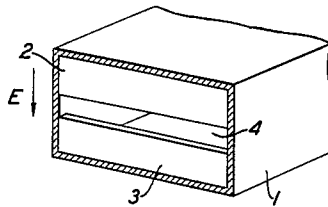


FIG. 2

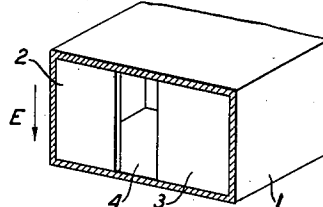


FIG. 3

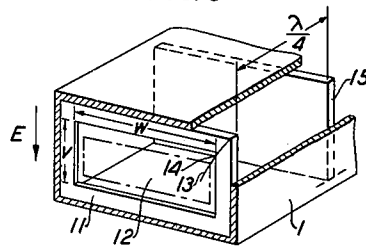


FIG. 4

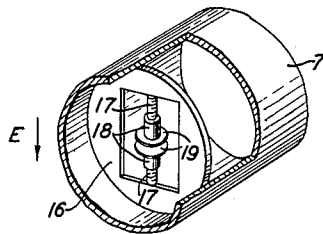


FIG. 5

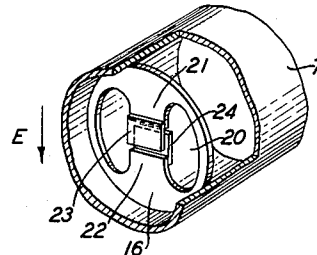
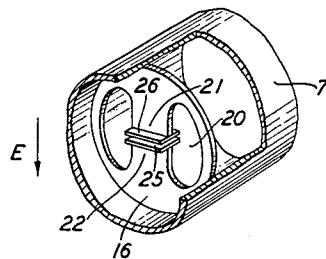


FIG. 6



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WAVE-GUIDE IMPEDANCE ELEMENTS

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Original application July 30, 1942, Serial No. 452,851, now Patent No. 2,432,093, dated December 9, 1947. Divided and this application January 12, 1952, Serial No. 266,179

24 Claims. (Cl. 333—73)

This invention relates to guided electromagnetic wave transmission and more particularly to impedance elements for wave guides. This application is a division of application Serial No. 610,956, filed August 17, 1945, now Patent 2,607,850, issued August 19, 1952, which, in turn, is a division of application Serial No. 452,851, filed July 30, 1942, now Patent 2,432,093, issued December 9, 1947.

An object of the invention is to provide series-resonant impedance branches and parallel-resonant impedance branches for use in wave guides.

Another object of the invention is to provide means for tuning such resonant impedance branches.

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 dominant transverse electric waves a shunt reactive element may be provided by 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.

In accordance with the present invention an aperture in a transverse partition in a wave guide is proportioned to provide both inductive and capacitive components in the right amounts to resonate at a particular frequency. Depending upon the shape of the aperture the resonance thus produced may be either of the parallel type, offering a high shunt impedance across the guide, or of the series type, offering a low shunt impedance. For example, a rectangular aperture may be proportioned for parallel resonance or, if made sufficiently narrow, for series resonance. The resonance may be sharpened by providing inwardly extending projections on opposite sides of the opening. A wider opening may be used if the opposed edges of the aperture are made thicker, or if the two halves of the partition are made to overlap. The resonant frequency may be controlled by adjusting an effective dimension of the aperture or by controlling its effective configuration.

The nature of the invention will be more fully understood from the following detailed description and by reference to the accompanying drawings, in which like reference characters refer to like parts and in which:

Figs. 1 and 2 are perspective views of wave guides having therein partitions with apertures which provide reactive elements;

Fig. 3 shows a wave-guide termination employing a parallel-resonant element;

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Fig. 4 shows an impedance element in accordance with the invention that may be adjusted for either parallel or series resonance; and

Figs. 5 and 6 show series-resonant elements in accordance with the invention.

Taking up the figures in more detail, Fig. 1 is a perspective view of a section of a metallic wave guide 1 in the form of a rectangular sheath which has been cross-sectioned just ahead of the transverse metallic partition comprising an upper portion 2 and a lower portion 3 with an aperture 4 therebetween extending from one side of the guide to the other. If the guide 1 is carrying dominant transverse electric waves with the electric field E polarized in a direction perpendicular to the length of the aperture 4, as indicated by the arrow, the partition will provide a shunt capacitive reactance. The magnitude of this reactance depends upon the width of the aperture 4 in the direction of the electric field E and decreases as the width is decreased.

Fig. 2 is similar to Fig. 1 except that the aperture 4 extends from the top to the bottom of the guide 1 and has its length parallel to the direction of the electric field E. A partition of this type provides a shunt inductive reactance, the magnitude of which also decreases as the width of the aperture 4 decreases.

By properly proportioning the aperture, a partition in a wave guide may be made to provide both inductive and capacitive components in the right amounts to resonate at a particular frequency. This may be either a parallel resonance or a series resonance. For example, Fig. 3 shows a parallel-resonant element, that is, one providing a high shunt impedance, in a rectangular wave guide 1. The partition 11 has a symmetrically placed aperture 12 having a height V in a direction parallel to the electric field E and a width W perpendicular thereto. There are an infinite number of different apertures which will produce parallel resonance but, once either the height V or the width W has been chosen, the other dimension is thereby determined. The line 13 gives the locus of the upper right-hand corner 14 of all possible rectangular apertures that will provide parallel resonance in the wave guide 1. Such an element placed in the guide and followed by a solid metallic partition such as 15 placed one-quarter of a wavelength behind the element 11 will serve as a reflectionless termination for the guide 1.

Fig. 4 shows a circular guide 7 having therein an impedance element which may be adjusted for either parallel resonance or series resonance. The partition 16 has a rectangular aperture into which project a pair of threaded studs 17 having their axes along a diameter of the guide 7 and parallel to the electric field E. The two internally threaded sleeves 18, each with a circular metal plate 19 fastened to one end, may be screwed onto the studs 17. The separation between the plates 19, and therefore the resonant frequency of the element, may thus be adjusted as desired. For series resonance, only a small separation is required. For parallel resonance the spacing will be greater, and in this case the plates 19 may not be required. An advantage of using an aperture with one or more inwardly extending projections, as shown in Fig. 4, is that sharper resonances may be obtained.

Fig. 5 shows an element more particularly adapted for series resonance, providing a low shunt impedance. The partition 16 has a symmetrical aperture 20 having its length perpendicular to the electric field E and its width constricted toward the center by means of the inwardly extending projections 21 and 22, to which are attached, on opposite sides of the partition 16, two overlapping metal flaps 23 and 24. These flaps 23 and 24 may be bent toward or away from each other to adjust the spacing therebetween and thereby the resonant frequency of the element.

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Fig. 6 shows a modification of the series-resonant element of Fig. 5 in which the flaps 23 and 24 are replaced by two opposing metallic plates 25 and 26 which are perpendicular to the partition 16 and attached to the ends of the projections 21 and 22.

Since a metallic obstruction in a wave guide usually produces a point of low potential and high current, it is preferable that the partitions be secured to the walls of the guide by soldering, welding, or in some other appropriate manner such that a good electrical contact is obtained. It should also be noted that thinner partitions than those shown in the drawings will, under some circumstances, produce more satisfactory results. The partitions have been shown thicker in the drawings only in the interest of clarity. In Figs. 3, 4, 5 and 6 a portion of the wave guide has been cut away to show the partitions more clearly.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. In combination, a conductively sheathed wave guide, means for establishing electromagnetic waves therein, a transverse partition within said guide, said partition having an aperture which is resonant at the frequency of said waves, two opposite projections and opposed plates at the inner ends thereof which constrict the width of said aperture and form a comparatively narrow central opening and a wider opening at each end thereof, and means for adjusting the spacing between said plates.

2. The combination in accordance with claim 1 in which said projections extend in a direction parallel to the electric field of said waves.

3. The combination in accordance with claim 1 in which said aperture is series resonant at said frequency.

4. In combination, a hollow-pipe wave guide, a conductive transverse partition therein, said partition containing an aperture which is dimensioned for resonance at a frequency freely transmissible by said guide, a pair of opposed projections extending from opposite sides of said aperture to form a comparatively narrow central opening and a wider opening at each end thereof, means for increasing the capacitance between the inner ends of said projections, and means for adjusting an effective dimension of said aperture to control the frequency at which said aperture is resonant.

5. The combination in accordance with claim 4 in which said aperture is series resonant at said frequency.

6. In combination, a conductively sheathed guide for the transmission of electromagnetic waves, a partition transversely disposed at a point in said guide, said partition containing an aperture dimensioned to provide at said point a shunt impedance which is resonant at a frequency transmissible by said guide, a pair of opposed projections extending from opposite sides of said aperture in a direction parallel to the electric field of said waves to form a comparatively narrow central opening and a wider opening at each end thereof, means for increasing the capacitance between the inner ends of said projections, and means for adjusting the effective configuration of said aperture to adjust said resonant frequency.

7. The combination in accordance with claim 6 in which said aperture is series resonant at said frequency.

8. In combination, a conductively sheathed guide for the transmission of electromagnetic waves and a partition transversely disposed in said guide, said partition having an aperture which is resonant at a frequency transmissible by said guide, and said aperture comprising a comparatively narrow, adjustable central opening and a wider opening at each end thereof.

9. The combination in accordance with claim 8 in which said aperture is series resonant at said frequency.

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10. In combination, a metallic pipe-shaped wave guide, means for establishing electromagnetic waves therein, a partition substantially perpendicular to the direction of propagation of said waves, said partition being provided with an aperture which is resonant at the frequency of said waves, a pair of opposite projections and opposed plates at the inner ends thereof which constrict the width of said aperture in a direction parallel to the electric field of said waves and form a comparatively narrow central opening and a wider opening at each end thereof, and means for adjusting the spacing between said plates.

11. The combination in accordance with claim 10 in which said aperture is series resonant at said frequency.

12. In combination, a hollow-pipe wave guide, means for establishing electromagnetic waves therein, a metallic wall member associated with said guide, said member being positioned transversely to the direction of wave propagation through said guide and having an opening which is resonant at the frequency of said waves, a pair of opposed projections extending into said opening from opposite sides thereof in a direction parallel to the electric field of said waves to form a comparatively narrow central opening and a wider opening at each end thereof, means at the inner ends of said projections for increasing the capacitance therebetween, and means for adjusting said capacitance to adjust said resonant frequency.

13. The combination in accordance with claim 12 in which said opening is series resonant at said frequency.

14. In combination, a pipe-like wave guide, means for establishing electromagnetic waves therein, a wall member substantially perpendicular to the longitudinal axis of said guide, said member having an aperture dimensioned to be resonant at the frequency of said waves, a pair of opposed projections extending into said aperture from opposite sides thereof in a direction parallel to the electric field of said waves to form a comparatively narrow central opening and a wider opening at each end thereof, a pair of opposed plates connected, respectively, to the inner ends of said projections, and means for controlling an effective dimension of said aperture to control said resonant frequency.

15. The combination in accordance with claim 14 in which said aperture is series resonant at said frequency.

16. In combination, a wave guide of the hollow-pipe type, exciting means for establishing electromagnetic waves therein, a metallic wall positioned in said guide, said wall lying in a plane substantially transverse to the direction of propagation of said waves and being provided with an aperture which is resonant at the frequency of said exciting means, a pair of opposed projections extending into said aperture from opposite sides thereof in a direction parallel to the electric field of said waves to form a comparatively narrow central opening and a wider opening at each end thereof, means at the inner ends of said projections for increasing the capacitance therebetween, and means for adjusting said capacitance to adjust said resonant frequency.

17. The combination in accordance with claim 16 in which said aperture is series resonant at said frequency.

18. In combination, a metallic pipe-shaped wave guide, means for establishing electromagnetic waves therein, a radiative wall substantially perpendicular to the direction of propagation of said waves, said wall being provided with an aperture which is resonant at the frequency of said waves, a pair of opposed projections extending into said aperture from opposite sides thereof in a direction parallel to the electric field of said waves to form a comparatively narrow central opening and a wider opening at each end thereof, a pair of opposed plates connected, respectively, to the inner ends of said projections, and means for adjusting the spacing between said plates to adjust said resonant frequency.

19. The combination in accordance with claim 18 in which said aperture is series resonant at said frequency.

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20. In combination, a hollow-pipe wave guide, a transverse partition therein, said partition having an aperture, and adjustable means for constricting the width of said aperture near its center, said means comprising a pair of oppositely disposed threaded studs projecting into said aperture and a pair of internally threaded sleeves screwed onto said studs.

21. In combination, a hollow-pipe wave guide, a transverse partition therein, said partition having an aperture, and adjustable means for constricting the width of said aperture near its center comprising a pair of oppositely disposed threaded studs projecting into said aperture, a pair of internally threaded sleeves screwed onto said studs, and a pair of metal plates fastened to the opposed ends of said sleeves.

22. In combination, a hollow-pipe wave guide, a transverse partition therein, said partition having an aperture, and adjustable means for constricting the width of said aperture near its center, said means comprising a pair of overlapping metallic flaps.

23. The combination in accordance with claim 22 in

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which the spacing between said flaps and the area of overlap are selected to make said aperture series resonant at a frequency freely transmissible by said guide.

24. In combination, a conductively sheathed wave guide, means for establishing electromagnetic waves therein, a transverse partition within said guide, said partition having an aperture which is series resonant at the frequency of said waves, two opposite projections and opposed plates at the inner ends thereof which constrict the width of said aperture, and means for adjusting the spacing between said plates.

References Cited in the file of this patent

UNITED STATES PATENTS

2,106,771	Southworth	Feb. 1, 1938
2,210,636	Schelkunoff	Aug. 6, 1940
2,270,416	Cork	Jan. 20, 1942
2,368,031	Llewellyn	Jan. 23, 1945
2,408,435	Mason	Oct. 1, 1946