

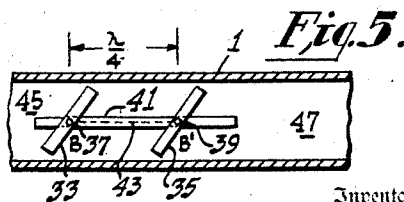
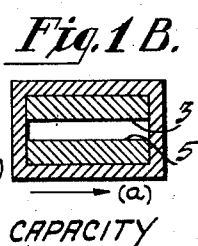
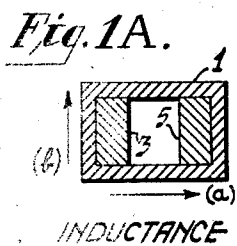
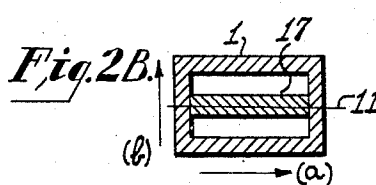
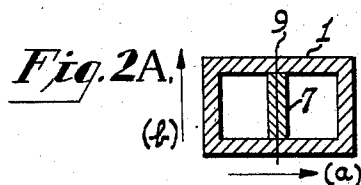
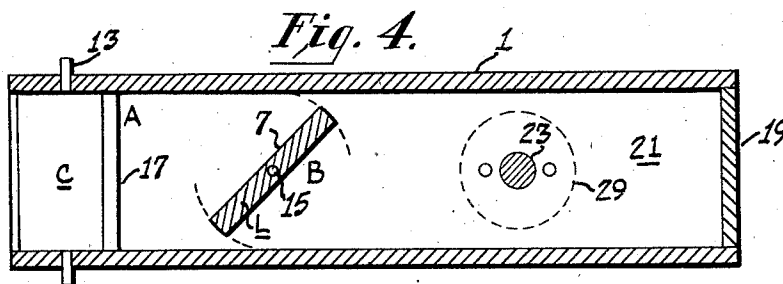
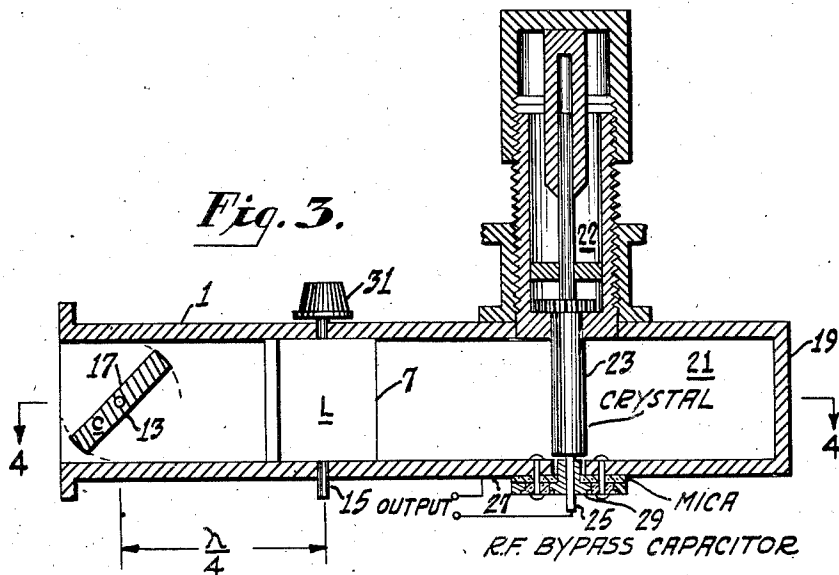
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MICROWAVE VARIABLE REACTANCES

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MICROWAVE VARIABLE REACTANCES

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This invention relates generally to microwave apparatus and more particularly to an improved method of and means for introducing adjustable reactance into a waveguide transmission system and for adjustably coupling separate sections of a waveguide system.

Heretofore, various types of apparatus including tuning stubs, tuning screws, adjustable irises and fixed projections from the inside surfaces of the waveguide faces have been employed for introducing reactance into waveguide transmission systems at predetermined points therein for the purpose of tuning or coupling adjacent waveguide sections. The instant invention contemplates the use of rotatable vanes for introducing either capacitive or inductive reactance at predetermined points in a waveguide transmission system.

Among the objects of the invention are to provide an improved method of and means for tuning a waveguide transmission system. Another object of the invention is to provide an improved method of and means for selectively introducing reactance into a waveguide. A further object of the invention is to provide an improved method of and means for adjustably coupling adjacent sections of a waveguide transmission system. Another object of the invention is to provide an improved means for adjustably coupling adjacent sections of a waveguide transmission system without introducing objectionable tuning effects therein.

The invention will be described in further detail by reference to the accompanying drawing of which Figure 1A and 1B are cross-sectional views of a waveguide including reactive elements known in the art, Figures 2A and 2B are cross-sectional views of a pair of waveguides including comparable reactive elements in accordance with the instant invention, Figure 3 is an elevational cross-sectional view of a preferred embodiment of the invention, Figure 4 is a plan cross-sectional view of the device of Figure 3 taken along the section line 4-4, and Figure 5 is a cross-sectional view of a second embodiment of the invention. Similar reference characters are applied to similar elements throughout the drawing.

Figures 1A and 1B are illustrative of a known system for selectively introducing either inductive or capacitive reactances into a waveguide transmission system. Figure 1A comprises a waveguide 1 having conductive projections 3, 5 extending transversely from the short side walls of the waveguide to shorten effectively the magnetic axis a of the waveguide for a predetermined dis-

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tance along the longitudinal axis of the guide. It will be seen that the electrical axis b of the guide is unchanged, while the magnetic axis a is shortened in the region of the transverse projecting elements 3, 5. The effect of introducing such transverse conductive elements, is to introduce inductance effectively in parallel with the surge impedance of the waveguide system.

In the waveguide illustrated in Figs. 1 and 2, when using a TE_{01} wave the characteristic impedance is given by

$$Z_0 = \sqrt{\frac{\mu}{\epsilon}} \frac{1}{\sqrt{1 - \left(\frac{\lambda}{2a}\right)^2}} \frac{b}{a}$$

("Microwave Transmission" by J. C. Slater, page 185, published 1942 by McGraw-Hill Book Co., New York).

Therefore, if a is decreased by increasing the sizes of the conductive projections 3, 5, or in any other manner, Z_0 is increased. Likewise, if b is decreased by closing off the top and bottom of the guide, or in any other manner, Z_0 is decreased.

In Figure 1B the transverse projections 3, 5 extend from the wide inner faces of the guide. It will be seen that the magnetic axis a of the guide is unchanged, while the electrical axis b is shortened appreciably. The effect of shortening the electric field does not appreciably change the cut-off condition of the section of the waveguide including the transverse projections, but has the effect of introducing capacitance in parallel with the line surge impedance. It has been calculated that the effective reactance, either positive or negative, introduced by transverse projections of the type described is equal to

$$X = \frac{Z_1}{\beta_1 L [(Z_1/Z_0)^2 - 1]}$$

where Z_0 is the characteristic impedance of the waveguide, Z_1 is the characteristic impedance of the waveguide in the region of the transverse projecting elements, L is the longitudinal length of the guide in the region of the projecting elements and β_1 is the propagation constant of the microwaves in the region of the projecting elements, being dependent upon the particular dielectric employed. ("Microwave Transmission" by J. C. Slater, page 187.) It is evident that if $Z_1 > Z_0$, then X is positive or equivalent to an inductance. If $Z_1 < Z_0$, then X is negative and equivalent to a capacitance.

Figure 2A comprises a waveguide 1 having a transverse conductive vane 7 rotatable around the

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central electrical axis 9 of the waveguide 1. As the vane 7 is rotated about the axis 9, the effective capacitance introduced into the waveguide effectively in parallel with the waveguide characteristic impedance may be adjusted from substantially zero to some maximum value as the plane of the vane is rotated from zero to 90° with respect to the longitudinal axis of the waveguide. It will be seen that when the plane of the vane 7 is normal to the longitudinal waveguide axis, the guide is substantially cut-off thereby since the vane 7 will extend entirely across the magnetic axis H of the waveguide.

Figure 2B is similar to Figure 2A except that the vane 7 is rotatable upon the central magnetic axis 11 of the waveguide. The dimensions of the vane are such that, when it is rotated to a plane normal to the longitudinal axis of the waveguide, the vane substantially interrupts all wave propagation along the guide. Rotation of the plane of the vane 17 from zero to 90° with respect to the longitudinal axis of the waveguide varies the effective inductance introduced in parallel with the waveguide characteristic impedance from substantially zero to some predetermined maximum value.

Referring to Figures 3 and 4, the vane 17 is rotated by means of a shaft 13 disposed on the central magnetic axis of the rectangular waveguide 1. Similarly, the vane 7 is secured to a shaft 15 disposed on the central electrical axis of the rectangular waveguide 1. The shafts 13 and 15 are separated at distances of $\frac{1}{4}$ wavelength along the longitudinal axis of the waveguide 1. For the purpose of illustration, the waveguide is terminated by means of a fixed conductive section 19 to define a cavity 21 enclosing a crystal detector 23. The particular structure of the crystal detector, and the mounting thereof, does not comprise a part of the instant invention. The particular structure illustrated is well known in the art and comprises suitable clamping and contact means for supporting a cartridge type crystal detector in a position substantially coinciding with the central electrical axis of the guide at a point of the order of $\frac{1}{4}$ wavelength from the terminating conductive element 19 of the waveguide 1. An adjustable series resonant coaxial line 22 is illustrated for tuning out reactance introduced by the detector structure. Output from the crystal detector 23 is obtained from one output terminal 25 thereof and from the adjacent waveguide face 27. Radio frequency energy is bypassed across the output terminals 25, 27 by means of a relatively large capacitor 29.

Rotation of the horizontal shaft 13 and hence the vane 17 will provide variable capacitive reactance for tuning the crystal cavity 21. Similarly, rotation of the vertical shaft 15 and hence the vane 7 will provide variable inductive reactance for tuning the crystal cavity 21. The shafts 13, 15 may be rotated manually. For example, one suitable manual control is the control knob 31 secured to one end of the vertical shaft 15 which extends through suitable bearings in the face of the waveguide 1. If desired, the control shafts 13, 15 may be ganged by any suitable linkage mechanism.

Figure 5 is illustrative of the means whereby the coupling between adjacent sections of a waveguide may be varied continuously without introducing objectionable reactive characteristics. The conductive vanes 33, 35 are secured to two horizontal shafts 37, 39 respectively, which are

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longitudinally adjustable in a slot 41 along the central magnetic axis of the waveguide 1 at distances of the order of $\frac{1}{4}$ wavelength along the longitudinal waveguide axis. Preferably, the control shafts 37, 39 are ganged together by any suitable gear or linkage means, not shown, but indicated by the dash line 43. After preliminary adjustment of the relative positions of the vanes 33, 35, and the shafts 37, 39, they may be rotated in unison by means of the coupling means 43 to provide a continuous coupling adjustment for microwave energy transmitted between the input section 45 and the output section 47 of the waveguide 1.

Thus the invention described comprises several modifications of a system wherein rotatable vanes are disposed within a waveguide transmission system for adjusting selectively the effective capacitive and inductive reactance introduced into the system in parallel with the waveguide characteristic impedance. Means for separately adjusting both tuning and coupling have been described for a typical rectangular waveguide system.

I claim as my invention:

1. Microwave apparatus including a waveguide transmission system, a first adjustable reactive element comprising a first conductive vane coextensive in cross-section and disposed transversely within said waveguide and centrally hinged to rotate on one of the principal transverse axes of said waveguide to introduce inductive reactance into said waveguide, and a second adjustable reactive element comprising a second conductive vane coextensive in cross-section and disposed transversely within said waveguide and centrally hinged at a point substantially of the order of any odd multiple of one-quarter wavelength from the hinge axis of said first element to rotate on another of the transverse axes of said waveguide to introduce capacitive reactance into said waveguide.

2. Apparatus of the type described in claim 1 including means external of said waveguide for adjusting the angular positions of said elements.

3. Microwave apparatus including a waveguide transmission system, a first adjustable reactive element comprising a conductive closure-member disposed transversely within said waveguide and hinged to rotate on one of the principal transverse axes of said waveguide to introduce inductive reactance into said waveguide, and a second adjustable reactive element comprising a second conductive closure-member disposed transversely within said waveguide and hinged at a point substantially any odd multiple of one-quarter wavelength from the hinge axis of said first element to rotate on another of the transverse axes of said waveguide to introduce capacitive reactance into said waveguide.

4. Microwave apparatus including a waveguide transmission system, a first adjustable reactive element disposed transversely within said waveguide and hinged to rotate on one of the principal transverse axes of said waveguide, a second adjustable reactive element disposed transversely within said waveguide at a point substantially any odd multiple of one quarter wavelength from the hinge axis of said first element and hinged to rotate on said same one of said transverse waveguide axes as said first element, and means for adjusting the angular positions of said elements with respect to said waveguide to vary the attenuation provided in said guide by said elements.

5. Microwave apparatus including a wave-

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guide transmission system, a first adjustable reactive element comprising a conductive closure member disposed transversely within said waveguide and hinged to rotate on one of the principal transverse axes of said waveguide, a second adjustable reactive element comprising a second conductive closure member disposed transversely within said waveguide at a point substantially any odd multiple of one quarter wavelength from the hinge axis of said first element and hinged to rotate on said same one of said transverse waveguide axes as said first element, and means for adjusting the angular positions of said elements with respect to said waveguide to vary the attenuation provided in said guide by said elements.

6. Microwave apparatus including a waveguide transmission system, conductive means terminating said system, microwave signal responsive means interposed in said system adjacent said terminating means, a first adjustable reactive element comprising a conductive closure member disposed transversely within said waveguide and hinged to rotate on one of the principal transverse axes of said waveguide to introduce inductive reactance into said waveguide, and a second adjustable reactive element comprising a second conductive closure member disposed transversely with said waveguide and hinged at a point substantially any odd multiple of one-quarter wavelength from the hinge axis of said first element to rotate on another of the transverse axes of said waveguide to introduce capacitive reactance into said waveguide, said reactive means and said terminating means defining a tunable cavity resonator in said system enclosing said signal responsive means.

7. Microwave apparatus including a waveguide transmission system, conductive means terminating said system, microwave signal response means interposed in said system adjacent said terminating means, a first adjustable

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reactive element comprising a conductive closure member disposed transversely within said waveguide and hinged to rotate on one of the principal transverse axes of said waveguide, a second adjustable reactive element comprising a second conductive closure member disposed transversely within said waveguide at a point substantially any odd multiple of one-quarter wavelength from the hinge axis of said first element and hinged to rotate on said same one of said transverse waveguide axes as said first element, and means for adjusting the angular positions of said elements with respect to said waveguide to vary the attenuation provided in said guide by said elements, said reactive means and said terminating means defining a tunable cavity resonator in said system enclosing said signal responsive means.

8. Microwave apparatus including a waveguide connecting a microwave source to a load, a pair of adjustable reactive elements each comprising conductive vanes coextensive in cross-section and disposed transversely within said waveguide and each being centrally hinged to rotate on one of the principal transverse axes of said waveguide, said vanes being spaced an odd number of quarter wavelengths along said waveguide between said source and said load, whereby said vanes cooperate to provide adjustable microwave attenuation in said waveguide.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,129,712	Southworth	Sept. 13, 1938
2,180,950	Bowen	Nov. 21, 1939
2,206,923	Southworth	July 9, 1940