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M. D. BRILL

2,530,679

RESONANT IMPEDANCE BRANCH

Filed Dec. 23, 1948

FIG. 1

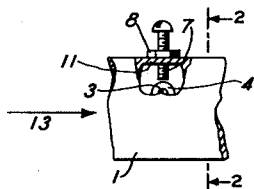


FIG. 3

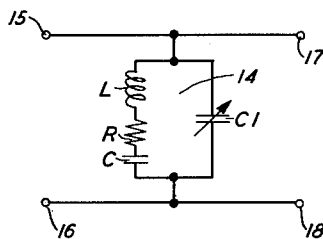


FIG. 2

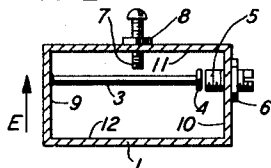
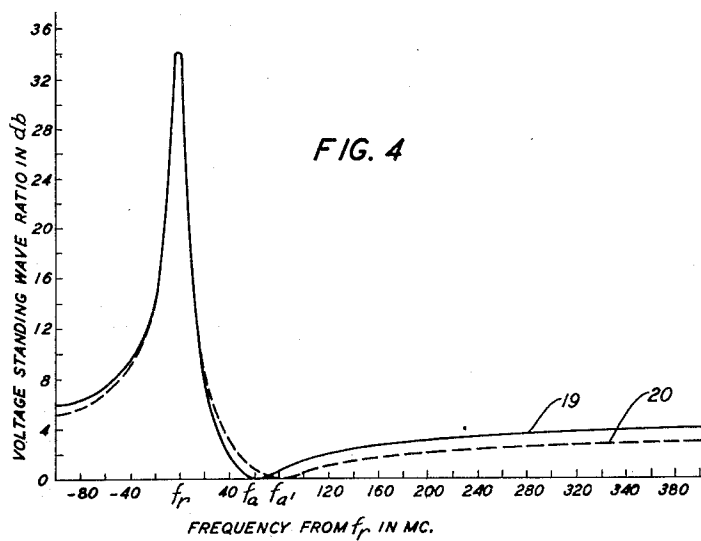


FIG. 4



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RESONANT IMPEDANCE BRANCH

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1 Claim. (Cl. 178—44)

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This invention relates to wave transmission and more particularly to a resonant impedance branch for use in a wave guide.

The principal object of the invention is to reduce the inherent shunt capacitance associated with a resonant impedance branch for use in a metallic wave guide of the hollow pipe type.

A resonant shunt impedance branch for use in a rectangular metallic wave guide of the hollow pipe type having unequal cross-sectional dimensions may be constituted by a rod extending perpendicularly from the inner side of one of the narrower walls of the guide, a tuning screw extending through the other narrower wall toward the end of the rod, and a coupling screw extending through a third wall toward the rod. The gap between the rod and the tuning screw is preferably located near one of the narrower walls. The coupling screw is preferably positioned transversely in one of the wider walls at the point of the maximum electric field of the electromagnetic waves within the guide. The rod and the tuning screw are preferably made of highly conductive material, or coated with such material, and the coupling screw is preferably made of metal. The resonant frequency of the branch may be adjusted by means of the tuning screw. The impedance level, or stiffness, of the circuit is dependent upon the penetration of the coupling screw. It is assumed that the guide is transmitting a transverse electric (TE) wave having an electric field parallel to the narrower walls, with no longitudinal component. An impedance branch of this type is disclosed in a United States application of W. D. Lewis and L. C. Tillotson, Serial No. 789,986, filed December 5, 1947, now Patent No. 2,510,288, issued June 6, 1950.

Associated with a resonant branch of this type is a shunt capacitance which, in some applications, may be undesirable. For example, when the impedance branch is used as a component part of a wave filter to provide a suppression band centered at the resonant frequency, this shunt capacitance introduces undesirable standing waves at frequencies outside of the band. When the rod is centered in the guide, as has been the practice heretofore, this shunt capacitance and the resultant standing waves outside of the suppression band are a maximum.

It has been found that this undesired shunt capacitance is proportional to the penetration of the coupling screw and, in accordance with the present invention, may be materially reduced by decreasing this penetration. However, if the same impedance level is to be maintained, the rod must be moved off center, toward the coupling screw, by a greater distance than the length by which the coupling screw is shortened. In other words, as the penetration of the coupling screw is decreased the spacing between this screw and

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the rod must be reduced. The limit is reached when this spacing is reduced to the smallest distance consistent with the mechanical tolerances and the vibratory motions of the component parts. When this point has been reached the undesired shunt capacitance has been reduced to a minimum.

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 or corresponding parts and of which:

Fig. 1 is a side view, partly cut away, of a section of rectangular metallic wave guide having therein an impedance branch in accordance with the invention;

Fig. 2 is a cross-sectional view of the structure of Fig. 1, taken at the line 2—2;

Fig. 3 is an approximately equivalent circuit representing the section of line and impedance branch shown in Figs. 1 and 2; and

Fig. 4 presents typical voltage standing wave ratio-frequency characteristics, curve 19 being for a rod which is centrally positioned in accordance with prior practice and curve 20 for the off-center rod of the present invention.

Figs. 1 and 2 show a portion of a rectangular metallic wave guide 1 with which there is associated an off-center, resonant-rod impedance branch in accordance with the invention comprising a metallic rod 3, a metallic tuning screw 5 and a coupling screw 7. The guide 1 has unequal cross-sectional dimensions, with narrower walls 9, 10 and wider walls 11, 12. Electromagnetic waves of the TE type having an electric field E parallel to the narrower walls 9, 10 as indicated by the arrow in Fig. 2 are supplied to the guide 1 as indicated by the arrow 13 in Fig. 1.

The rod 3 is conductively secured at one end to the inner side of one of the narrower walls 9 and is perpendicular thereto. The other end of the rod 3 is capacitively coupled to the other narrower wall 10 by means of the tuning screw 5 which is threaded through the wall 10 and extends toward the end of the rod 3. In order to increase this capacitive coupling, the tuning screw 5 has a larger diameter than that of the rod 3 and a metallic disc 4 of approximately the same diameter as the screw 5 is secured to the free end of the rod 3. The resonant frequency f_r of the impedance branch is adjusted by turning the screw 5, which is held in the properly adjusted position by the lock nut 6. As the screw 5 is inserted into the guide 1 the separation between the screw 5 and the disc 4 is decreased and the resonant frequency thereby lowered. An opposite adjustment increases the frequency. In order to reduce energy dissipation, the elements comprising the resonant-rod assembly 3, 4, 5 are

preferably made of highly conductive material such as copper or silver, or coated with such material to a depth well in excess of the skin depth at the resonant frequency. The gap between the disc 4 and the screw 5 should be as far as possible from the coupling screw 7 in order not to interfere with the action of the latter. This gap is, therefore, preferably located near one of the narrower walls 10 by making the tuning screw 5 considerably shorter than the rod 3.

In the absence of the coupling screw 7, the impedance of the resonant-rod assembly 3, 4, 5 is substantially infinite because there is no component of the electric field E along the longitudinal axis of the rod 3, and therefore no coupling. The required coupling is, however, provided by the coupling screw 7 which is threaded through one of the wider walls 11 at a point near the rod 3 and extends toward the rod 3. The screw 7 serves to distort the electromagnetic wave in the vicinity of the rod 3 and provide a component of the field E along the longitudinal axis of the rod. The impedance level, or stiffness, of the resonant branch is thus controlled by the penetration of the coupling screw 7, decreasing as the screw is inserted and increasing as it is withdrawn. The lock nut 8 holds the screw 7 in its adjusted position. The screw 7 may be made of dielectric material, but a metal screw is preferred as it is easier to fabricate, less expensive, less subject to cold flow, and more stable with atmospheric changes.

The coupling screw 7 is preferably located at the point of the maximum electric field E of the electromagnetic waves within the guide 1 because, when so positioned, it has maximum effect in distorting the field. If the screw 7 is not located at this point, the separation between the screw 7 and the rod 3 must be reduced, to provide the same degree of coupling, and this is undesirable from the standpoints of mechanical tolerance and vibration of the parts. If the waves are the dominant, or lowest frequency, TE type, the coupling screw 7 is, therefore, preferably centered transversely in the wall 11, as shown in Fig. 2, because the maximum electric field E occurs at that point.

Fig. 3 is an approximately equivalent circuit representing the section of wave guide 1 and associated structure shown in Figs. 1 and 2. The circuit comprises a shunt impedance 14 connected across a section of line having input terminals 15, 16 and output terminals 17, 18. The branch 14 is made up of a capacitance C_1 in parallel with a resonant arm comprising an inductance L , a resistance R and a second capacitance C connected in series. The inductance L is furnished by the rod 3 and the tuning screw 5, the capacitance C is that effective between the elements 4 and 5, and the resistance R represents the energy dissipation in the elements.

The shunt capacitance C_1 is that associated with the coupling screw 7 and increases as the penetration of this screw into the guide 1 is increased. In some applications it is desirable to reduce or minimize this capacitance. For example, when the branch 14 is used as a component part of a wave filter having a suppression band centered at the resonant frequency f_r of the branch 14, the presence of the capacitance C_1 causes undesired standing waves at frequencies outside of the suppression band.

In the prior art the rod 3 is centrally located transversely in the guide 1, that is, it is positioned equidistant from the wider walls 11 and

12. Under these circumstances the penetration of the coupling screw 7 is a maximum and therefore the value of the undesired shunt capacitance C_1 is also a maximum. In accordance with the present invention, however, this capacitance is considerably reduced by moving the rod 3 off center, toward the coupling screw 7, thus reducing the required penetration of the screw 7. However, if the same impedance level is to be maintained, the rod 3 must be moved off center by a greater distance than the decrease in penetration of the screw 7. The capacitance C_1 will, therefore, reach its minimum value when the rod 3 has been moved off center a distance such that the separation between the rod 3 and the screw 7 is as small as the mechanical tolerances and the vibratory motions of the component elements will permit.

In Fig. 4 the solid line curve 19 shows the voltage standing wave ratio in decibels plotted against frequency in megacycles for a typical shunt branch 14 of the type shown in Fig. 3 when the resonant-rod assembly 3, 4, 5 is centered in the guide 1 in accordance with the prior art. The curve has a maximum at the resonant frequency f_r of the branch 14 and a minimum at the antiresonant frequency f_a , above which it again rises. The resonant frequency f_r may be adjusted, as explained above, by means of the tuning screw 5. The broken line curve 20 shows, for comparison, the characteristic obtainable by moving the rod 3 and tuning screw 5 off center toward the coupling screw 7, shortening the penetration of coupling screw 7, and decreasing the separation between the screw 7 and the rod 3 to maintain the same impedance level. It is seen that the resonant frequency f_r is not changed but the antiresonant frequency f_a has been moved up to f_a' . However, the most important point to observe is that the standing wave ratio at frequencies well removed from the resonant frequency f_r has been materially reduced.

What is claimed is:

In combination, a rectangular wave guide with unequal cross-sectional dimensions and a series-resonant shunt impedance branch of preselected impedance level associated therewith, said impedance branch comprising a conductive rod extending perpendicularly from the inner side of one of the narrower walls of said guide, a tuning screw shorter than said rod extending through the other narrower wall of said guide toward the free end of said rod, and a transversely centered coupling screw extending through a third wall of said guide toward said rod, and said rod being positioned off center toward said coupling screw to permit said coupling screw to be withdrawn by a sufficient amount to reduce the undesired capacitance to a minimum while maintaining said impedance level substantially unchanged.

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REFERENCES CITED

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