waveguide, and the resulting value of β_1 was determined with the aid of a method described by the author elsewhere.[6] The thickness of the dielectric sheet to give the necessary value of $\beta_2=\beta_1$ was determined from the transverse resonance condition.[1a] Because of inaccuracies involved in this procedure, the design did not result in the desired situation in which $\beta_2=\beta_1$ at the design frequency. At this stage, use has been made of the fact that the group velocities in the coupled lines have different values, *i.e.*, $\partial\omega/\partial\beta_1 \neq \partial\omega/\partial\beta_2$, and by searching in the neighborhood of the design frequency, a particular frequency has been found for which $\beta_1=\beta_2$.

Copper-clad teflon, and later Rexolite, have been used in the construction of the reactive surface. The coupling aperture consisted of a row of 150 slots cut in the wide wall of a 0.4×0.9-in ID rectangular waveguide (see Fig. 2). The measurement of the field amplitude in the waveguide was performed by cutting in the opposite wide wall a longitudinal slot such as used in a slotted section and mounting the waveguide in a hp809B Universal Probe Carriage from which the original slotted section has been removed. The whole setup has been placed on a surface covered with microwave absorbing material.

In a few experiments conducted up to now, excitation efficiencies of between 92 and 95 per cent have been determined.

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Higher-Order Mode Resonances in Strip-Line *Y*-Junction Circulators*

Because of its small physical size, the *Y*-junction circulator has been the recipient of a great amount of investigation. Various theorists and experimentalists have devoted time to understanding the behavior of this device, both on the far and near side of ferrimagnetic resonance.[1–4]

In our laboratory, we have succeeded in developing units operating at the near side of resonance from 1.0–8.0 kMc. These units have instantaneous bandwidths providing 20 db of isolation in excess of 20 per cent; some units have bandwidths as high as 40 per cent. One of the limitations on bandwidth that we have discovered are resonances that occur in the insertion loss and isolation characteristics of the device at the HF end of the band. In narrow-band designs, these resonances might never be noticed. Because of their presence, it is necessary to limit the bandwidth specification to exclude them from the operating region. If resonance could be eliminated, we believe bandwidths of 50–60 per cent could be achieved.

Fig. 1 shows some experimental points relating the frequency at which the resonance occurs to the diameter of the ferrimagnetic material used in the design. Various materials were used, and they are labeled with their manufacturer's designation.

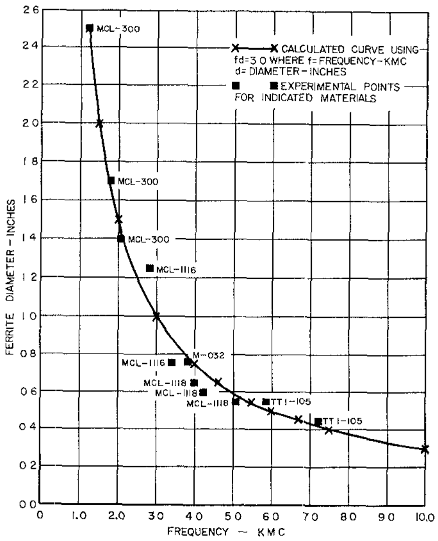

Fig. 1—Diameter at which higher-order mode resonance occurs for strip-line *Y*-junction circulators on the near side of resonance.

The frequency of these resonances depends upon the value of magnetic field. They occur at lower frequencies for smaller field values. The values of field used in the data presented were sufficient to saturate the disks.

A theoretical curve is plotted using the relationship

$$fd=3.0$$

where

f = frequency in kMc
d = diameter of material in inches.

This type of expression is typical of propagation in cylindrical waveguide where the mode cutoff frequency is related to the guide diameter and the proper-order Bessel function. It is felt, therefore, that these resonances can be explained by higher-order mode propagation in a direction parallel to the applied magnetic field, even though the dominant mode in the strip line is propagating perpendicular to this direction.

It is hoped that these resonances can be moved to higher frequencies without effecting the basic nonreciprocal scattering of the ferrimagnetic disks. Experiments to determine the feasibility of removing these resonances are now underway and, if successful, will be reported.

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* Received by the PGMTT, August 21, 1961.
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A Proposed Design to Enhance Microwave-Power-Limiter Characteristics*

A design is proposed for a device which would enhance the properties of presently available microwave power limiters, thereby making their use as crystal protectors in duplexing units of microwave systems more desirable. This design is a combination of a power-sensitive, nonlinear element with a traveling-wave ring resonator.

Several nonlinear elements, such as subsidiary resonance ferrite limiters,[1] and DeGrasse type of ferrimagnetic limiters,[2] and diode parametric limiters[3] have been devised which exhibit an attenuation vs power-level curve such as is depicted in the lower curve of Fig. 1. The nonlinear properties of ferroelectric materials indicate that these materials might also be used to produce limiting action.

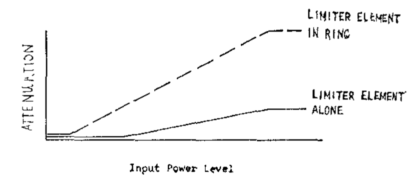

Fig. 1.

However, the referenced limiters are not completely usable as crystal protectors because either their threshold power levels are too high, or their maximum attenuations, slopes of attenuation vs power curve, or their power-handling capabilities are inadequate. Combining any one of the nonlinear elements with the traveling-wave ring resonator would improve upon all of these shortcomings, provided that the low-level insertion loss of the element is sufficiently small.

* Received by the PGMTT, August 21, 1961.
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