detector. Experiments at S band have shown that errors of as much as 10 db in amplitude and 4 to 5 degrees in phase can be produced in an otherwise perfect system when the crystal detector is carefully tuned. It is possible to evaluate such errors directly. However, experimentally, it is far simpler to eliminate the undesirable second-harmonic component by placing a low-pass filter ahead of the crystal detector.

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A High-Capacitance Parametric Diode for Use at Low Frequencies*

For operation of parametric amplifiers at low frequencies and at low-impedance levels a parametric diode of very large capacitance is necessary. In general a capacitance which has an impedance of the same order as the source impedance is required, so that for a 600-ohm system at a frequency of 5 kc the static capacitance C_0 should be

$$C_0 \simeq \frac{1}{\omega_s R_g} \simeq 0.05\ \mu\text{f}.$$

The capacitance variation with bias should also be large.

A capacitance for this purpose may be assembled from a number of silicon rectifiers of the type used in TV receiver power supplies. The capacitance as a function of voltage for a typical 0.5 ampere silicon rectifier (such as the 1N1763, 1N2094, OA210, etc.) measured at $1/\pi$ Mc and with an applied RF level of 10 mv (rms) is as follows:

Bias (volts)	0	−1	−2	−3	−6	−12
Capacitance ($\mu\mu$f)	74.7	45.8	38.3	30.8	26.3	20.0

An assembly of 220 silicon rectifier wafers of this type, connected in parallel, and measured under the same conditions, gave a C-V curve as in Fig. 1. The cutoff frequency of this diode, measured at −3 volts, was 10 Mc.

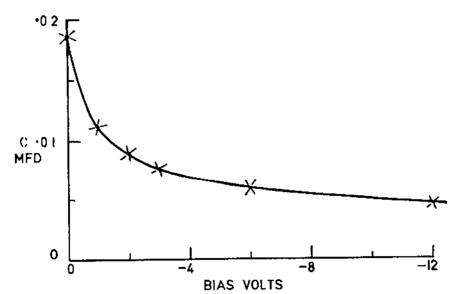

Fig. 1.

This diode, when used in an appropriate 3-frequency parametric amplifier using high Q inductors ($f_p \simeq 50$ kc $f_s \simeq 5$ kc), shows all of the classical characteristics of parametric amplifiers, both qualitatively and quantitatively.

This note is intended primarily to draw the attention of microwave engineers to the possibility of using such diodes in a low-frequency electrical parametric amplifier for demonstration and teaching purposes.

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A Nonreflective Hybrid Stop-Band Filter*

A novel waveguide stop-band filter employing a four terminal hybrid circuit and two lossy cavity resonators has been developed. With this circuit, adjustable frequency sensitive loss can be accomplished with very little reflection similar to directional filter type operation. The circuit utilizes the diplexing characteristics of two adjacent ports of a standard 3-db short slot forward-wave directional coupler. Two identical cavities, each filled with lossy dielectric material, produce the necessary loss. Fig. 1 shows a schematic diagram of the device.

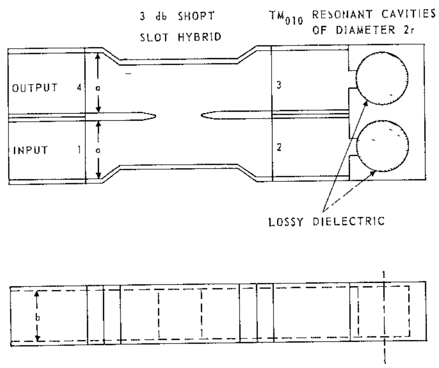

Fig. 1—Stop-band waveguide filter.

For explanatory purposes, first consider a short circuit placed across terminals 2 and 3 of the hybrid in place of the cavities, each short being equidistant from the hybrid. Energy entering port 1 of the hybrid will split equally in power to terminals 2 and 3, and the phase of the signal at terminal 3 will lag terminal 2 by 90 degrees. Upon reflection from the short circuit, energy from port 2 will phase add at port 4 with the reflected energy from port 3. At port 1, destructive interference will occur between the reflected energies from ports 2 and 3. Thus, within the relatively broad passband of the hybrid, all the input energy at port 1 will appear at port 4, with a minimum of loss; and no mismatch will be exhibited at port 1. By replacing the shorts with two identical cavities filled with a lossy dielectric material, the amount of transmitted power from terminals 1 to 4 can be made frequency sensitive again with no reflection appearing at the input terminal. The cavities were designed to resonate in the TM_{010} cylindrical cavity mode. Within a few per cent, this resonant frequency may be stated as follows:

$$f_0 = \frac{4.521}{r\sqrt{\epsilon_r}}\ \text{kMc},$$

where r is the cavity radius in inches and ϵ_r is the relative dielectric constant of the lossy dielectric material.

A typical transmission and reflection coefficient plot as a function of frequency is shown in Fig. 2. The dielectric material used

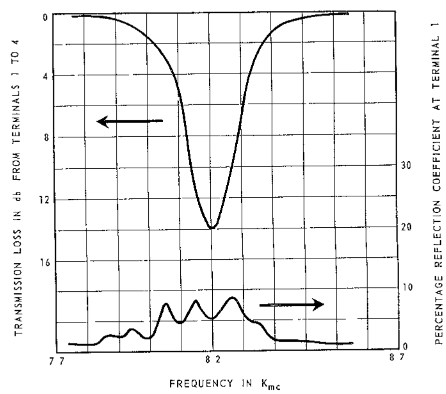

Fig. 2—Transmission and reflection characteristics of a typical stop-band filter.

was a forsterite compound. The loss was 14 db at the filter center frequency of 8.2 kMc. The loaded Q of this filter was about 75 and the reflection coefficient less than 10 per cent over the frequency band of the large X-band hybrid employed. The amount of loss at the center frequency at which the cavities are tuned can easily be controlled by varying the amount of coupling between the waveguide and cavity by adjustment of the cavity iris geometry or by varying the composition of the dielectric material. With this circuit technique, stop-band waveguide filters exhibiting up to 20-db loss at the center frequency can be realized simultaneously with very little mismatch, *i.e.*, with less than a 10 per cent reflection coefficient.

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