which exhibit peak-to-valley current ratios of 14 to 1 with peak currents of 5 ma have been achieved. Representative measured values of junction capacitance and series resistance are 0.2 pf and 5 Ω, respectively. These parameters correspond to cutoff frequencies in the range of 40 to 50 Gc.

An experimental 55-Gc tunnel-diode detector is shown in Fig. 3. The detector voltage for such a detector can be shown to be

$$V_0 = \frac{P_i \frac{R}{2} \alpha(r_s G)}{r_s G + (r_s G)^2 + \omega^2 C^2 r_s^2}$$

where $P_i$ is the RF input power, $\omega$ is the angular frequency, $r_s$ is the diode series resistance and $C$ is the junction capacitance. $G$ $(=1/R)$ is the diode conductance and is equal to the slope of the I-V characteristic of the diode. $\alpha$ is a nonlinearity coefficient with the dimensions of $1/V$ and is equal to the ratio of the curvature to the slope of the I-V characteristic.

Fig. 4 shows the detector behavior for the case where $r_s G = 0.1$ $(Q_d = \omega C r_s,\ \beta = \alpha/R)$. The curve is marked by three special points: A) a tunnel diode biased near the peak current point, B) a backward diode, and C) an ordinary crystal diode. The circuit parameters of these diodes are

A) $R=50\ \Omega$, $r_s=5\ \Omega$, $L_s=0.5\times10^{-12}$ h, $C=10^{-12}$ f, $\alpha=200\ 1/V$

B) $R=100\ \Omega$, $r_s=10\ \Omega$, $L_s=10^{-9}$ h, $C=10^{-12}$ f, $\alpha=50\ 1/V$

C) $R=200\ \Omega$, $r_s=20\ \Omega$, $L_s=10^{-9}$ h, $C=10^{-12}$ f, $\alpha=25\ 1/V$.

The points indicate that the tunnel-diode detector yields the highest output voltage. The experimental tunnel-diode detectors did show an improvement in sensitivity of 15 to 22 db over the sensitivity of an ordinary 1N53 crystal.

With the addition of a pump source, a millimeter wave detector circuit can also be operated as a mixer. If the signal frequency differs from the pump frequency by only 100 Mc, the pump source can be coupled to the same input circuit through a directional coupler.

The noise-factor improvement of a tunnel-diode mixer over a crystal diode mixer has been demonstrated [2] at UHF and microwave frequencies. The diodes described above were operated in a 55 Gc to 100 Mc down converter. An improvement of about 10 db in the system noise figure was observed when the tunnel diode was used as the mixer compared to the same system with a 1N53 crystal as the mixer. A tangential sensitivity of −82 dbm was observed with the tunnel diode as compared to a tangential sensitivity of −71 dbm for a 1N53 crystal.

The crucial problem in the use of tunnel diodes at millimeter wave frequencies is one of technology, the fabrication of diodes with low junction capacitance and low series resistance. The present art seems capable of fabricating these diodes. There is reason to expect that future technology should increase the usefulness of tunnel diodes at millimeter wave frequencies and even allow them to be used at submillimeter wave frequencies.

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## Correction to "Group Delay and Dissipation Loss in Transmission-Line Filters"*

In the above Correspondence,[1] on page 216, in (17), the numerical factor should be 27.3, and not 2.73.

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* Received July 5, 1963.

[1] L. Young, "Group delay and dissipation loss in transmission-line filters," IEEE Trans. on Microwave Theory and Techniques (*Correspondence*), vol. MTT-11, pp. 215–217; May, 1963.

## Correction to "Direct-Coupled Cavity Filters for Wide and Narrow Bandwidths"*

In the above paper,[1] on page 170, the Δ symbols were omitted in (34) and (35), which should have read

$$\frac{\Delta f'}{\Delta f_1'} = \frac{\Delta f}{\Delta f_1} \qquad (34)$$

$$\frac{\Delta f'}{\Delta f_2'} = \frac{\Delta f}{\Delta f_2} \qquad (35)$$

On page 176, the caption to Fig. 24 should be: Characteristics in the stop band of the quarter-wave transformer prototype and the two filters (B and C in Fig. 23) derived from it.

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* Received July 5, 1963.

[1] L. Young, "Direct-coupled cavity filters for wide and narrow bandwidths," IEEE Trans. on Microwave Theory and Techniques, vol. MTT-11, pp. 162–178; May, 1963.