version loss is a conventional single-ended mixer at an IF of 45 Mc were found to be 2.2 and 5.0 db, respectively.

Conclusions

It has been shown that it is possible to achieve decoupling between the RF signal and the IF circuit of a microwave mixer by using two crystals in a symmetrical "bar-and-post" circuit, avoiding the necessity for filters. A mixer has been constructed using this principle, and conversion losses in the range 6.5–8.5 db have been observed at an RF of 15 Gc and an IF of 2 Gc.

A parametric amplifier[2] has also been constructed which uses this principle to isolate the pump and idler from the signal circuit.

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[2] British Patent Application No. 9651/61.

A High-Power S-Band Filter*

This note describes the measured performance of a high-power *S*-band "waffle-iron" filter. Techniques for designing varying-impedance corrugated waveguide filters in rectangular waveguide have been available for some time [1]. If propagation is restricted to the dominant TE_{10} mode, these filters have wide well-matched pass bands and wide high-attenuation stop bands. Unfortunately, the filters may have spurious transmissions in the stop band when power is incident upon them in other modes, such as TE_{20} or TE_{30}, if the guide wavelength of these modes at the stop-band frequencies is equal to the guide wavelength of the TE_{10} mode at the pass-band frequencies of the filter.

A technique for suppressing these higher-order TE_{m0} modes in the stop band was devised by Cohn [2], [3], which consists of cutting longitudinal slots through the corrugated filter. If the center-to-center spacings of the bosses formed by milling the longitudinal slots is less than one-half of the free-space wavelength at the highest operating frequency, the characteristics of the modified filter depend almost exclusively on frequency rather than on the reciprocal guide wavelength. Hence, higher-order TE_{m0} modes are almost completely suppressed in the stop band.

The wide stop band of these filters makes them particularly attractive for use in suppressing the spurious harmonic emissions from high-power transmitters. However, early versions of these filters (which have sharp edges) are susceptible to breakdown. Weber [4] has shown that in the vicinity of the sharp edges, the electric-field intensity approaches infinity. Therefore, components with sharp corners, such as the earlier filters, are inherently low-power devices. The present filter was designed to determine the power-handling capacity of these filters when the sharp edges are rounded to minimize electric gradients within the filter.

The *S*-band filter designed for power testing is shown in Fig. 1. Fabricated of oxygen-free high-conductivity copper, the filter consists of two pairs of identical parts that can be relatively easily machined. A sketch of the interior of the filter is shown in Fig. 2. The stepped transformers with rounded corners which match the filter to the standard *S*-band waveguide are also shown in Fig. 2. These transformers are not slotted; they prevent modes with horizontal components of electric field from passing through the longitudinal slots in the filter.

This type of filter is designed by initially neglecting the presence of the longitudinal slots and by using as the frequency variable the reciprocal of free-space wavelength instead of the reciprocal guide wavelength. At the pass-band frequencies, the principal effect of the longitudinal slots is to reduce the capacitance between the filter bosses. This is compensated for by reducing the spacing between the bosses until the capacitance is approximately the same as that between the transverse ridges in the filter with no longitudinal slots. When the gap spacing is correct, the pass-band frequency characteristics of the longitudinally slotted filter are essentially the same as those of the unslotted prototype, while the stop band is free of spurious responses which might otherwise be caused by propagation of the TE_{20}, TE_{30} $\cdots$ TE_{m0} modes.

The VSWR of the high-power filter in the 2.7–4.1-Gc pass band is less than 1.6. It is judged that the VSWR of the pass band of the high-power filter can be reduced by increasing the length of the 90° transforming end sections at each end of the waffle-iron filter.

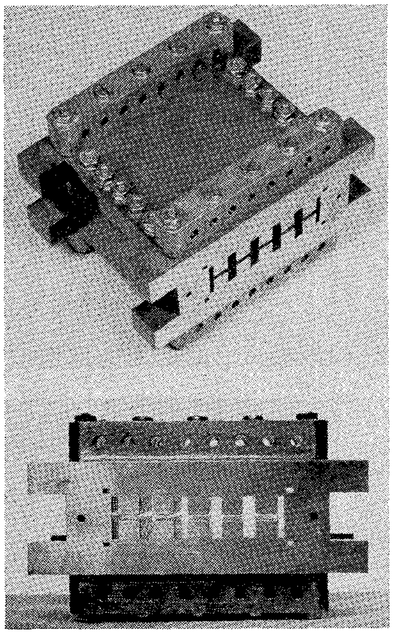

Fig. 1—High-power *S*-band waffle-iron filter.

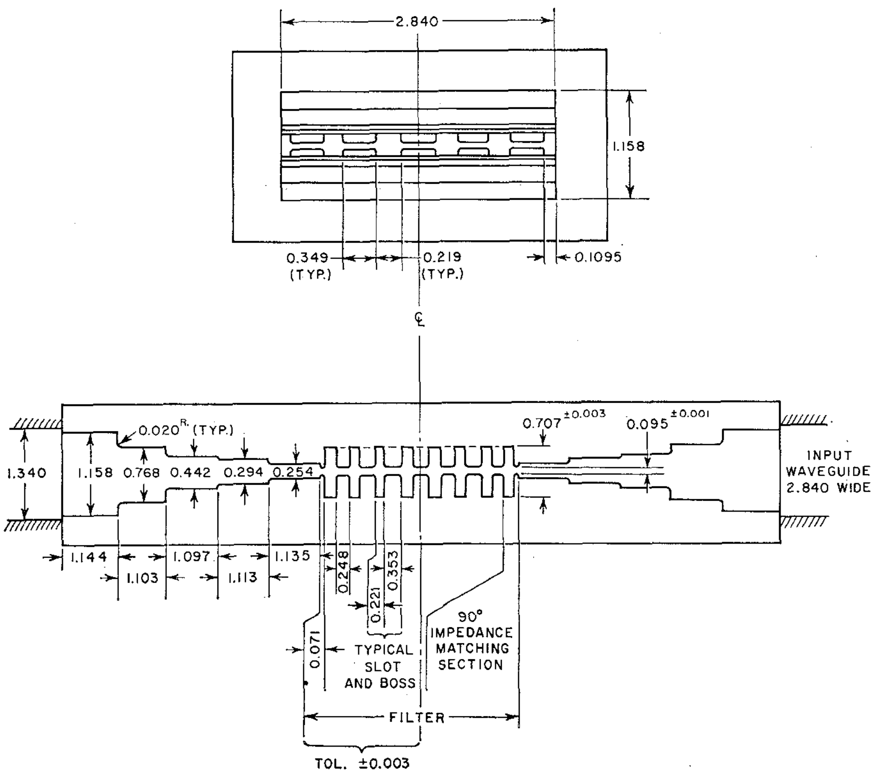

Fig. 2—Sketch of high-power waffle-iron filter giving internal dimensions.

* Received by the PGMTT, July 24, 1961; revised manuscript received, November 1, 1961.

Measurements of the dominant mode insertion loss of the filter reveal that the filter suppresses this mode by more than 45 db throughout the 5.3–12.4-Gc stop band. The spurious mode insertion loss was measured to be greater than 50 db throughout the stop band. Of course, greater attenuation can be achieved by increasing the number of waffle-iron sections.

The measurements of the power capacity of the waffle-iron filter with rounded edges were conducted at the General Electric Microwave Laboratory, Palo Alto, Calif., under the direction of V. Price. The measurements were conducted at a frequency of 2.78 Gc, using a pulsed transmitter. The pulses were 2 μsec long and occurred at a rate of 300 pps. All the experiments were conducted a cobalt-60 radioisotope to irradiate the filter.

Table I gives the experimental results of the tests as a function of pressure.[1] The filter is said to be arcing or suffering voltage breakdown when a pulse incident on the filter is not transmitted—*i.e.*, the pulse is totally reflected. The "sputtering power" is defined as the power level for which there is at least one arc within a 5-minute interval. The "all-clear power" is that power for which there is no arc within a 5-minute interval. It is seen from Table I that the filter will transmit 2-Mw peak power without the incidence of voltage breakdown if the filter is operated at an air pressure of 30 psi (gage). A further increase in the power-handling capability is to be expected if the filter is pressurized with sulfur hexafluoride.

TABLE I
MEASURED POWER CAPACITY OF THE HIGH-POWER WAFFLE-IRON FILTER

Pressure (psi gage)	Sputter Power (kw peak)	All-Clear Power (kw peak)
0	293 250	272 231
15	1260 952	1050 935
30	2200	2090

[1] Windows having a relatively large mismatch were employed at either end of the filter during the tests of the pressurized filter. The combination of the windows and the stepped transformers was found to produce an input VSWR s of 3.0. Thus only $4s/(s+1)^2 = 0.75$ of the incident power was transmitted. Within the waffle-iron filter proper, the VSWR s' was 2.5. The standing waves within the filter allowed it to transmit to the load only $1/s'$ of the power that it could transmit when it had no standing waves within it. The values of power capacity of the filter listed in Table I are $4s' s/(1+s)^2 = 1.88$ times the experimentally measured values, and represent the power handling capacity of a matched filter.

The authors extend their thanks to V. Price, now with the Electromagnetic Technology Corporation, Palo Alto, Calif., for making the facilities and staff of the General Electric Microwave Laboratory available for the power tests, and to Dr. W. Wilson of Stanford Research Institute in making the cobalt-60 radioisotope available for the high-power measurements.

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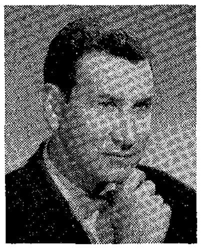

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