A tapered-ridge K-band crystal mount

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A TAPERED-RIDGE K-BAND CRYSTAL MOUNT

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ABSTRACT

A broadband crystal mount operating in the band 10.5 to 20 kmc/s is described and some of the design problems are discussed. The mean tangential sensitivity in this band is -46.5 dbm into a video bandwidth of 0.5 mc/s and the voltage standing-wave ratio is less than 2.7:1 from 10.5 to 17.5 kmc/s.

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5. Tangential Sensitivity — K-Band Mount

A TAPERED-RIDGE K-BAND CRYSTAL MOUNT

- A. Staniforth -

INTRODUCTION

Laboratory measurements at microwave frequencies very often require the use of a sensitive detector with broadband characteristics. When these detectors are used in devices such as ratiometers or reflectometers, there may be a requirement that they "track" well across as wide a frequency band as possible; that is, that the response of two detectors should differ as little as possible.

This paper describes a crystal mount which operates as a low-level detector with fairly uniform response from 10.5 kmc/s to 20.0 kmc/s. A coaxial crystal is used, of the 1N26 or 1N78 type. Best over-all sensitivity is obtained with type 1N78A crystals, although the sensitivity of the type 1N26 crystals is higher from 17.0 to 20.0 kmc/s. During the development of this mount, two related factors were considered:

a) the mean tangential sensitivity of the mount with several types of crystals, and
b) the VSWR of the mount with crystals installed.

DESIGN OF MOUNT

Fig. 1 shows the mechanical details of the mount. It consists of a section of type RG-91/U waveguide containing a tapered-ridge guide-to-coaxial-line junction [1]. The original design matched the waveguide to a 65-ohm coaxial line, but because the impedance of the coaxial crystal is not 65 ohms, the dimensions had to be modified considerably to obtain maximum sensitivity across the frequency band. The video output cable is connected to the outer conductor of the crystal, through a spring loaded BNC connector. This connector is mounted in a crystal cap containing a block of radio-frequency absorbing material [2]. This material absorbs any energy that might be coupled from the waveguide into the cap. Low impedance is maintained between the crystal body and the mount by means of an insulated sleeve which forms a capacity of 50 $\mu\mu$f. As the video impedance of the crystal with bias is about 700 ohms, the pulse rise time will be less than 0.1 μs.

In the first models a sharp dip in sensitivity occurred at about 19.2 kmc/s, which appeared to be caused by the excitation of a resonance. A short investigation failed to locate any resonant structure, but reduction of the narrow dimension of waveguide from 0.311 inches to 0.281 inches at the coaxial line junction

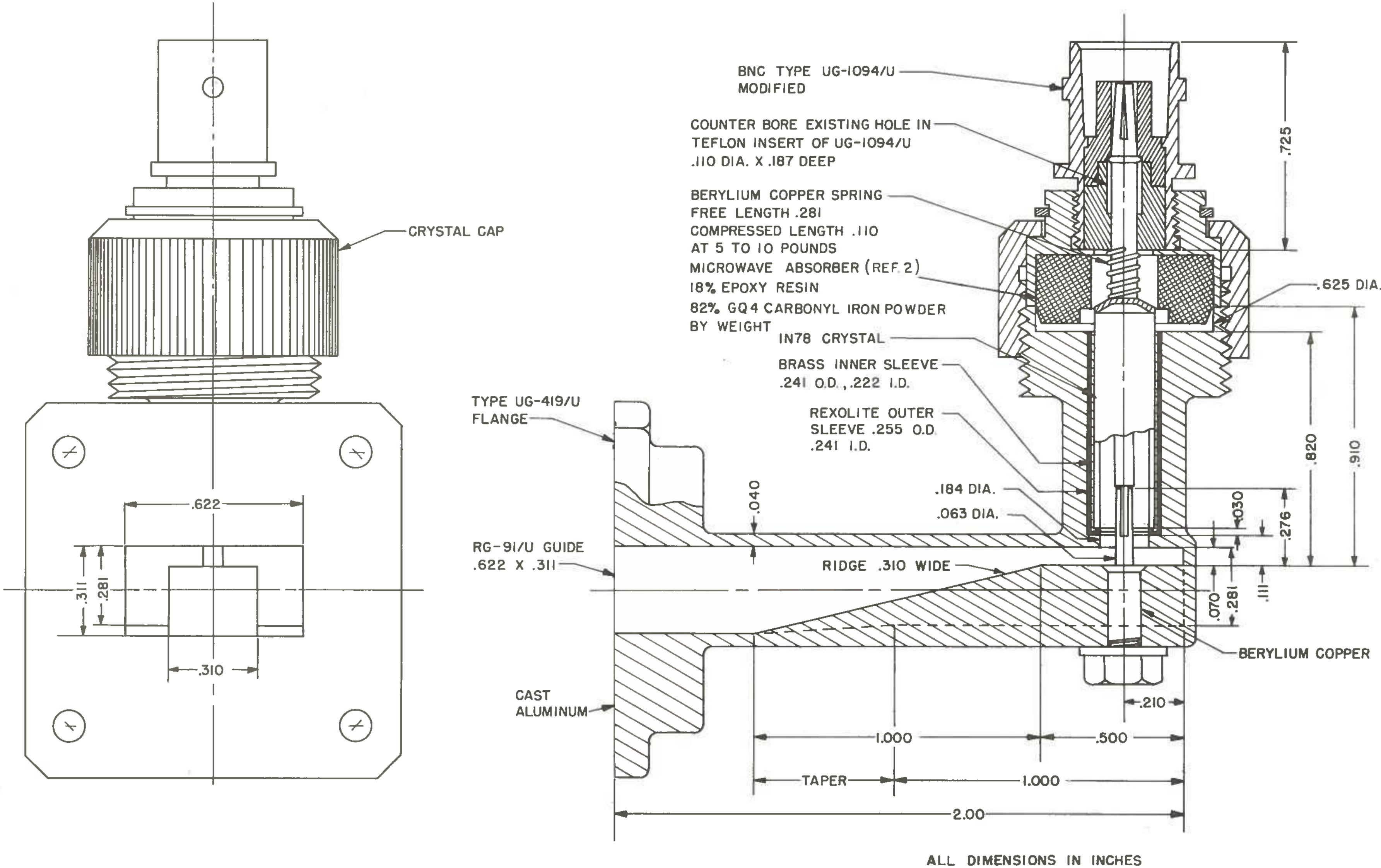

FIG. 1 K-BAND CRYSTAL MOUNT

eliminated the trouble. The position of the waveguide short circuit, with respect to the crystal, was varied to optimize the sensitivity over the band. This was found not to be critical, as the selected dimens on of 0.210 inches resulted in sensitivities averaging only 1 db better than 0.250 inches. The dimension from the top of the ridge to the top wall of the waveguide at the coaxial junction was more critical. A change in this dimension from 0.080 inches to 0.066 inches caused a variation in sensitivity of 6 db. A value of 0.070" ± 0.001" was chosen finally. The close tolerance was necessary to obtain equal performance from several crystal mounts across the frequency band. In the final model of this mount, the tapered ridge and the section which reduced the narrow dimension of the guide were machined from one piece of metal,and then inserted into the standard guide. Tests have shown that this method of fabrication makes the assembly less dependent on a good electrical contact at the joint, enabling the ridge to be held in place with only one screw, without affecting the performance. This construction was suggested by EMI-Cossor Electronics Ltd.

MEASUREMENTS

For comparison, VSWR and tangential sensitivity measurements were made with three different types of crystal mounts, using the coaxial crystal types 1N26, 1N78, and 1N78A.

Type A — A tapered waveguide mount requiring modified 1N26 crystals.
Type B — A good quality commercial mount using unmodified crystals.
Type C — The new NRC ridge-guide mount, also requiring unmodified crystals.

Modification of the type 1N26 crystals for the type A mount consists of shortening the skirt of the outer conductor.

In all measurements, the crystal was biased with 75 μa of forward current. This improved the detection efficiency and the radio-frequency impedance match of the complete mount. The video output resistance of the crystal was reduced by bias, providing a better match to the 50-ohm video load [3].

The voltage standing-wave ratios of the three mounts with type 1N26 and 1N78A crystals are shown in Fig. 2. These measurements were made at an input power level of -15 dbm using three crystals of each type. The voltage standing-wave ratio of the type C mount with type 1N78A crystals is uniformly low across most of the band, rising up to 3.6:1 at 20 kmc/s. With a type 1N26 crystal installed, the voltage standing-wave ratio is less than 2.6:1 from 14.0 to 20 kmc/s. The new mount appears to be a better impedance match to standard waveguide than either of the other two. Some voltage standing-wave ratio measurements were made at a much lower radio-frequency level (about -36 dbm) using a phase-shifting method [4]. The results shown in Fig. 3 indicate that, in general, there is not much

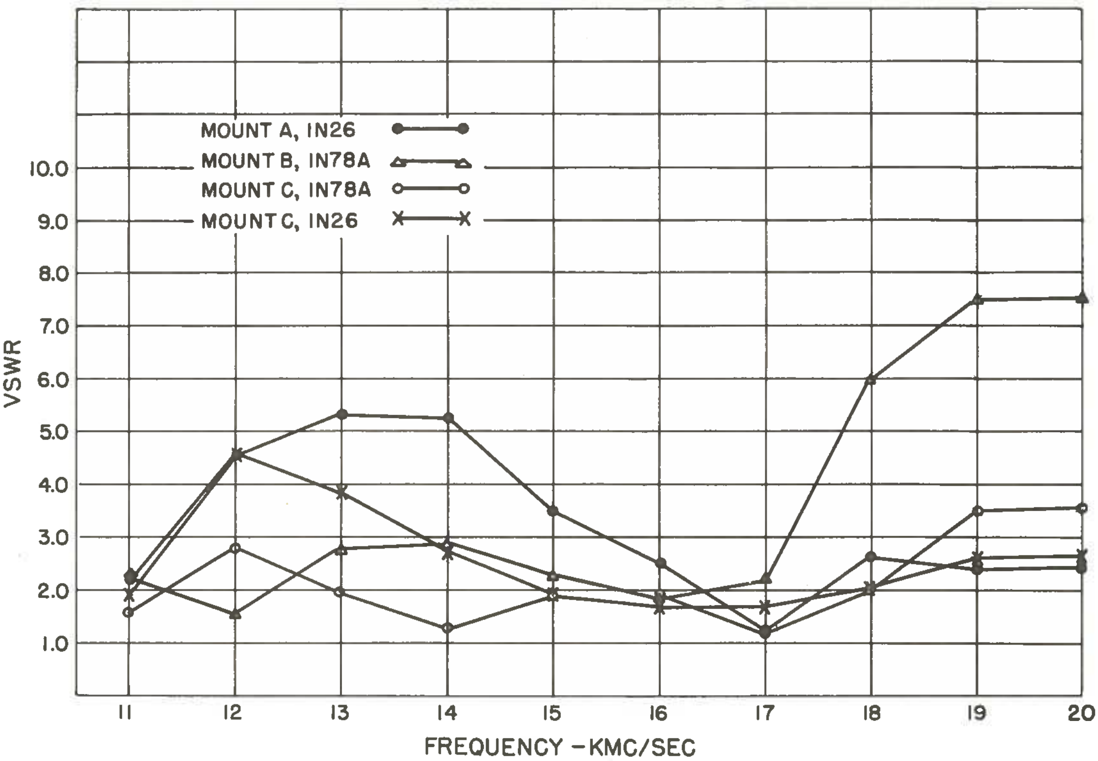

FIG. 2 VSWR AT -15 dbm - K-BAND MOUNT

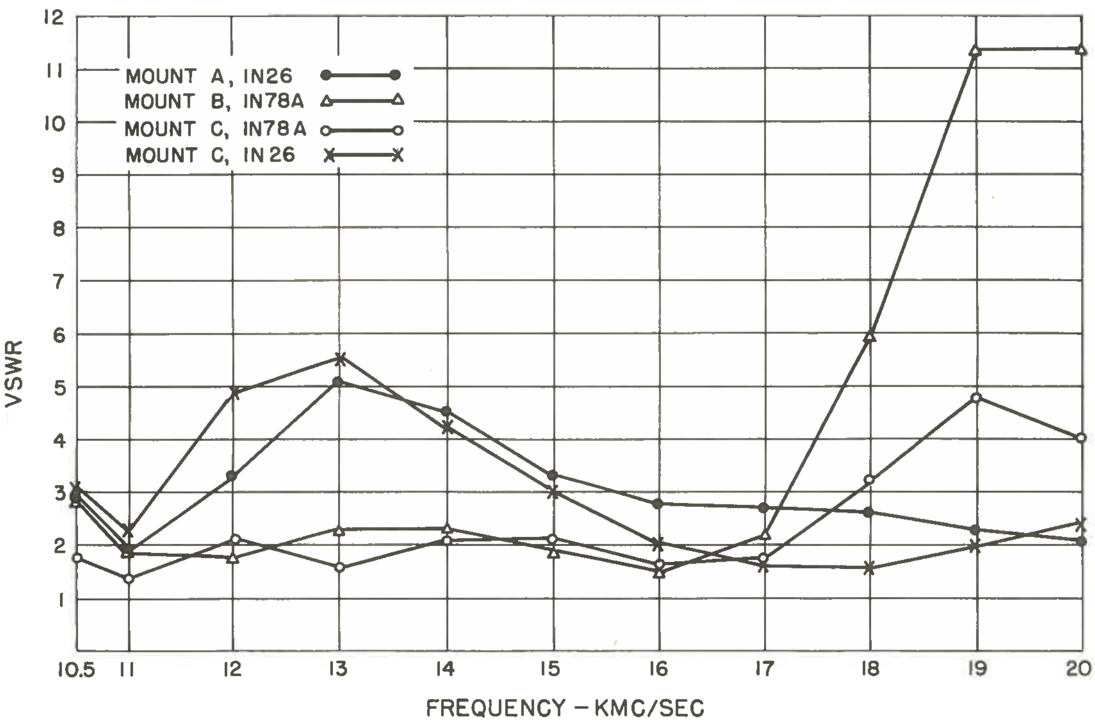

FIG. 3 VSWR AT -36 dbm - K-BAND MOUNT

change in crystal match with input power level, although there are a few instances where the change is as much as 50%.

The sensitivity measurements were made using five to ten crystals in each type of mount, and a mean value taken at each frequency. Fig. 4 shows the tangential sensitivities of mount A and mount C, with two different crystal types. Fig. 5 indicates the performance of mount B and mount C, both with 1N78 crystals. The results are summarized in Table I. The frequency band was divided into two parts and the arithmetic average of the tangential sensitivities calculated for each mount. The difference between the maximum and minimum of each curve of Figs. 4 and 5 is shown as "Total Variation".

TABLE I

MEAN TANGENTIAL SENSITIVITY (dbm)
(into 0.5 mc/s video bandwidth)

MOUNT	CRYSTAL	FREQUENCY BAND (kmc/s)			TOTAL VARIATION (db)
		10.5-15	15-20	10.5-20	
A	1N26 (Mod.)	-42	-45	-43.5	6.8
B	1N78	-45	-39	-42.0	14.8
C	1N26	-44	-45	-44.5	3.9
C	1N78	-47	-44	-45.5	7.2
C	1N78A	-48.5	-44.5	-46.5	6.7

A comparison of the curves of Fig. 4 and 5 and the results in Table I indicate that the mean sensitivity of the NRC crystal mount using type 1N78A crystals is 3 to 4 db better than that of the other mounts tested. Also, the sensitivity is a more linear function of frequency, with the total variation being less in this mount.

TRACKING

In certain applications, such as in ratiometers, it is desirable that the sensitivity curves be parallel. The departure from this condition, known as "tracking error", was estimated from the data. The results are shown in Table II with the frequency band divided into four parts. Mount C with 1N26 crystals produces the best over-all tracking, and mount A with the modified 1N26 crystals has the widest spread. The relatively low voltage standing-wave ratio and good tracking

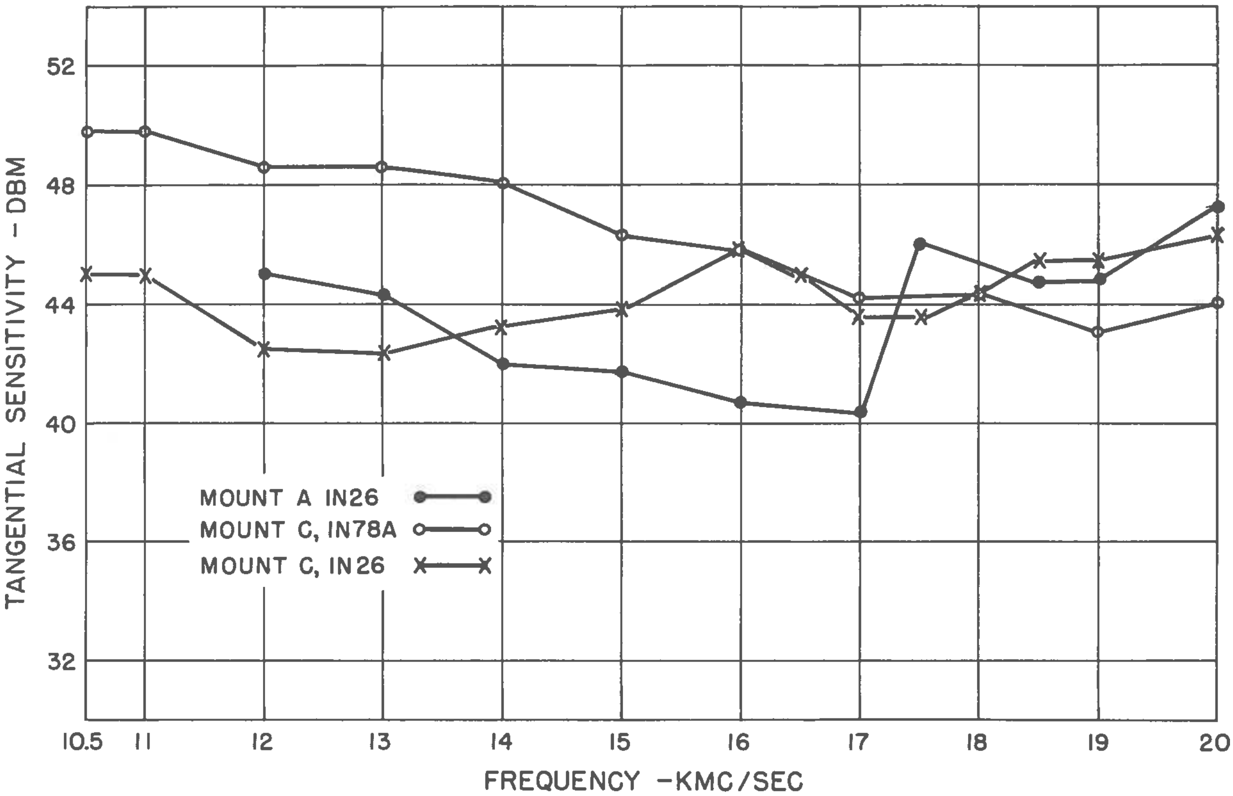

FIG. 4 TANGENTIAL SENSITIVITY— K-BAND MOUNT

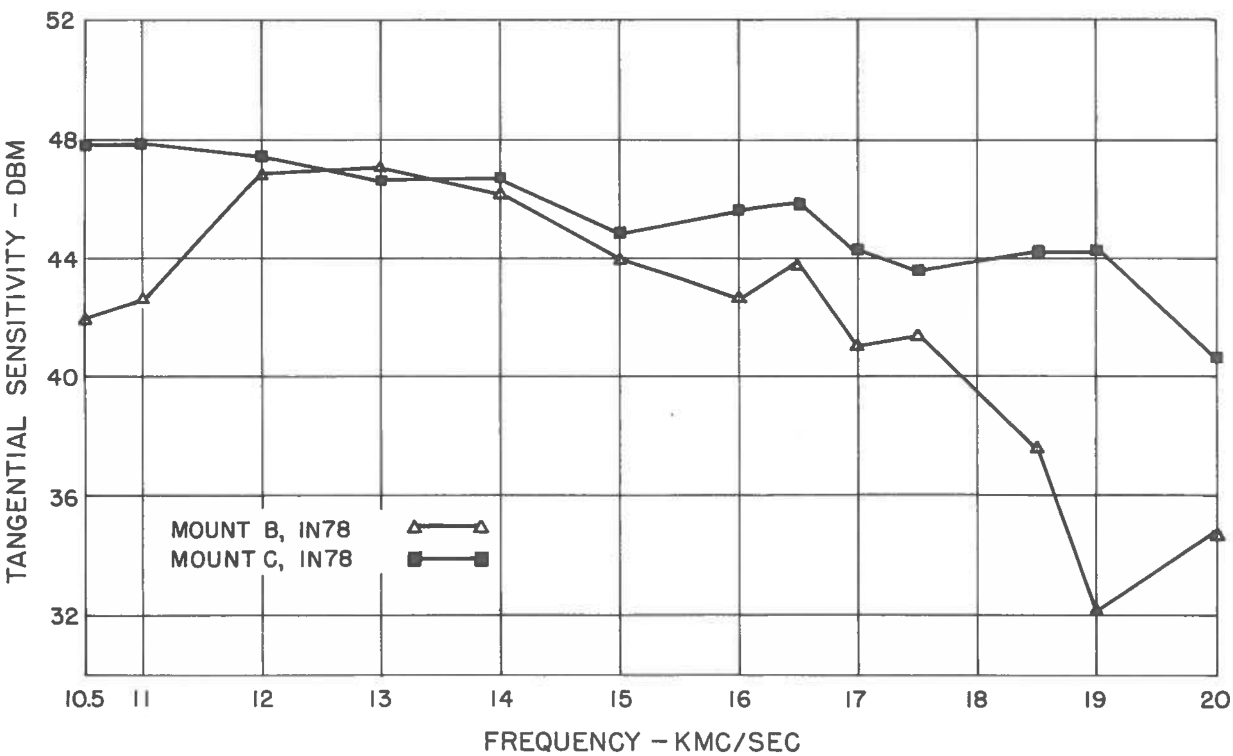

FIG. 5 TANGENTIAL SENSITIVITY— K-BAND MOUNT

characteristics of the type C mounts suggest their use in a balanced mixer, although no measurements were made on this application.

TABLE II

TRACKING OF TANGENTIAL SENSITIVITY (db)

MOUNT	CRYSTAL	TRACKING ERROR			
		10.5-12.5 (kmc/s)	12.6-15.0 (kmc/s)	15.1-17.5 (kmc/s)	17.6-20.0 (kmc/s)
A	1N26 (Mod.)	3.0	4.0	2.0	11.7
B	1N78	1.7	1.3	2.5	3.2
C	1N26	1.3	1.7	1.0	1.2
C	1N78	2.0	1.7	1.5	1.7
C	1N78A	2.0	2.0	2.0	3.3

SUMMARY

The choice of crystal type for use in the mount depends upon which frequency band is the more important. From 10.5 kmc/s to 17 kmc/s types 1N78A and 1N78 have higher sensitivities while from 17 kmc/s to 20.0 kmc/s type 1N26 is better. This is probably because the design frequency of the 1N78A's is 16 kmc/s and that of the 1N26's is 24 kmc/s.

The K-band crystal mount developed at the National Research Council laboratories is superior in performance to the other mounts tested. With type 1N78A crystals, the tangential sensitivity is about 3 db higher, with a more uniform response from 10.5 kmc/s to 20 kmc/s. The voltage standing-wave ratio is less than 2.7 from 10.5 to 18 kmc/s and less than 3.6 to 20 kmc/s.

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