not a threat to them. The permanency of a depository at the Library of Congress in effect guarantees an eternal availability of reprints at no added cost to the society or its publications.

There are many other aspects of this ADI Auxiliary Publications Program which come to mind and could be explored once the use of the service, as here outlined, to meet the present acute need is widely accepted. I believe they would naturally follow with experience in using the service as presently constituted, but it would be premature to speculate in this correspondence.

I urge the Editor of the IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES to consider using this ADI program immediately and bring it to the attention of the IEEE Editorial Board for discussion.

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Editor's Note: It is recommended that authors who wish to take advantage of this form of dissemination of their results proceed as follows.

The author submits his paper or correspondence item and auxiliary documents (such as tables) to the Editor of these TRANSACTIONS with the understanding that, if accepted,

1) He will send check to the Editor for $2.00 payable to American Documentation Institute for cost of accessioning and handling of his auxiliary document, and
2) The Editor will then forward the check, deposit the tables, and include a notice as a footnote to the paper or correspondence item concerning the availability, document number, and cost for a photoreproduction of the auxiliary document.

Calibration of Coaxial Bolometer Units

The Radio Standards Laboratory of the Institute for Basic Standards (National Bureau of Standards, U. S. Department of Commerce) announces that services are now available for the measurement of calibration factor of nominal 50-Ω coaxial bolometer units and coaxial bolometer-coupler units. These devices have proved useful in the accurate measurement of CW RF power in coaxial systems over a range of 1 mW to 10 watts. At present the service is offered for bolometer units at two frequencies only, 100 MHz and 1 GHz; for bolometer-coupler units the service is offered at 30, 100, 200, 300, 400, 500 MHz, and 1 GHz. Plans call for extension of the frequency range to at least 10 GHz and for essentially continuous frequency coverage.

A bolometer unit includes both the bolometer element and the bolometer mount in which the element is supported. The element may be of the barretter type, consisting of a short length of silver wire of approximately 0.0001-inch diameter (Wollaston wire); or it may be the thermistor type, in the form of a bead of semiconductor material. As a metallic conductor the element has a positive temperature coefficient of resistance, as a semiconductor the coefficient is negative. The element is designed to have a resistance in the range of 50 to 200 Ω and is made a part of a bridge circuit. The bridge provides a means of measuring the RF power absorbed by the element in terms of accurately known dc power which is substituted for the RF power in order to restore bridge balance when the RF power is withdrawn. This dc power is known as the substituted dc power.

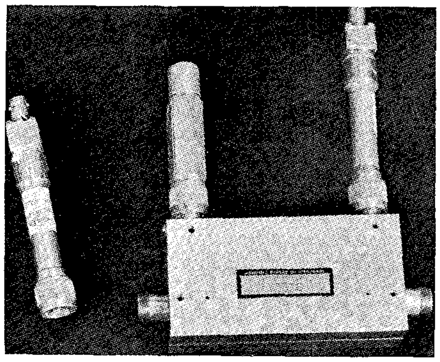

Fig. 1. The Radio Standards Laboratory calibrates coaxial bolometer units used for the accurate measurement of HF power. Left: a bolometer unit for measuring HF power up to 10 mW. Right: Bolometer-coupler unit for measuring HF power up to 10 watts. The present frequency range extends to 1 GHz (1000 million c/s).

The element is supported in the bolometer mount at a position where it absorbs a maximum amount of the RF power fed into the bolometer unit. In one form a single element is used; in another, two elements are used in a symmetrical arrangement between the inner and outer coaxial conductors. It is common practice to use a type *N* connector to join the bolometer unit into the measurement system. However, several types of precision connectors are being developed by industry which will provide for greater precision in performing the calibration.

The calibration factor for bolometer units is defined as the ratio of the substituted dc power in the bolometer unit to the RF power incident upon the bolometer unit. The calibration factor of a bolometer unit combined with a coaxial directional coupler is defined as the ratio of the substituted dc power in the bolometer unit on the side arm of the coupler to the RF incident upon a nonreflecting load attached to the output port of the main arm.

Bolometer units are calibrated at power levels of 1 and 10 mW only. Bolometer-coupler combinations are calibrated for coupling ratios in the range of 3 to 30 dB. Bolometer units should be of the fixed tuned or untuned broadband type and permanently attached to the coupler. The directional coupler should have good design features, with a directivity of at least 30 dB, and a VSWR no greater than 1.10 for the input and output ports of the main arm of the coupler.

Limits of uncertainty in determining the calibration factor of a well-designed bolometer unit or bolometer-coupler unit are within one per cent; although somewhat wider limits in the uncertainty of measurement may result for bolometer units and for bolometer-coupler units having a VSWR above 1.05.

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Manuscript received August 11, 1965.

Discrepancies in Dielectric Waveguide Mode Cutoff Conditions

The rederivation of the characteristics of modes of propagation along a dielectric rod by Biernson and Kinsley [1] kindled renewed interest in work we published in 1960 on the same topic [2]. Whereas our interest in the dielectric rod waveguide was as a surface wave transmitting structure at microwave frequencies, Biernson and Kinsley analyze this configuration mainly as a model of retinal cones, sensitive to optical frequencies. Since the electromagnetic field equations are, of course, identical in both regimes, a direct comparison is possible.

The comparison is somewhat hampered by the fact that Biernson and Kinsley, being interested in dielectric rods whose permittivity is only slightly higher than that of the surrounding medium, derive and present their results mainly in the limit of the permittivity ratio approaching unity. Our results, which are exact for all values of the permittivity ratio ϵ, agree with theirs in the limit $\epsilon=1$, but not always for higher, realistic values of ϵ. In particular, there is disagreement in the equation for the cutoff frequencies of the higher-order hybrid HE modes of propagation. Biernson and Kinsley give two expressions for this cutoff condition, which contradict each other. Although this at first suggests merely some typographical error, comparison with our results shows that neither one of their expressions is correct.

Biernson and Kinsley give the cutoff condition for HE modes for $n \geq 2$, once in their (91) as

$$J_{n-2}(v) = -[\delta/(2+\delta)]J_n(v) \qquad (1)$$

and again in their summary Table I as

$$J_{n-2}(v) = [\delta/(2+\delta)]J_n(v) \qquad (2)$$

where v is a normalized frequency variable and $\delta=(\epsilon-1)/\epsilon$. The correct result, when translated into their notation, is

$$J_{n-2}(v) = -[\delta/(2-\delta)]J_n(v). \qquad (3)$$

Manuscript received July 28, 1965.

Unfortunately, Biernson and Kinsley derive the cutoff condition only in the limit $\delta=0$, whereupon all three expressions agree. They content themselves with the statement that "It can be shown that the cutoff frequency . . . is given by" (1). The correct result is derived in [2] in the form

$$J^{-} = 1/[(n-1)(\epsilon+1)] \tag{4}$$

where $J^{-}=J_{n-1}(v)/vJ_n(v)$; this is equivalent to (3).

Biernson and Kinsley also state that Snitzer [3] "gives an approximation in this value, which is slightly different. Equation (91) is exact." In fact, Snitzer's expression for this cutoff condition is not approximate but exact, and is equivalent to (4) and (3).

As Biernson and Kinsley's conclusions concerning the dielectric characteristics of retinal cones appear to be based on the cutoff frequencies of observed mode patterns and as their estimate of δ as 0.25 leads to a substantial discrepancy between the numerical factors appearing in (1) and (3), a reassessment of some of their results may be warranted.

Microwave applications of dielectric waveguide mode theory were reported by the present authors [4], [5] with no restrictions on the permittivity ratio, in conjunction with the V-line, a surface waveguiding structure which supports the higher-order hybrid modes of a dielectric rod.

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References

[1] G. Biernson and D. J. Kinsley, "Generalized plots of mode patterns in a cylindrical dielectric waveguide applied to retinal cones," *IEEE Trans. on Microwave Theory and Techniques*, vol. MTT-13, pp. 345–356, May 1965.
[2] S. P. Schlesinger, P. Diament, and A. Vigants, "On higher-order hybrid modes of dielectric cylinders," *IRE Trans. on Microwave Theory and Techniques (Correspondence)*, vol. MTT-8, pp. 252–253, March 1960.
[3] E. Snitzer, "Cylindrical dielectric waveguide modes," *J. Opt. Soc. Am.*, vol. 51, pp. 491–498, May 1961.
[4] P. Diament, S. P. Schlesinger, and A. Vigants, "A dielectric surface-wave structure: the V-line," *IRE Trans. on Microwave Theory and Techniques*, vol. MTT-9, pp. 332–337, July 1961.
[5] P. Diament, S. P. Schlesinger, and A. Vigants, "A dielectric surface wave structure: the V-line," Dept. Elect. Engrg., Columbia University, New York, N. Y., Tech. Rept. 3, Contract AF 19(604)-3879, July 1960.

Authors' Comment[1]

We are thankful to Diament and Schlesinger for correcting the errors in our paper. The equation they corrected was never used directly in our calculations, and so the mistake was not caught. We obtained the value of cutoff frequency for each of these modes by determining the value of v at which the $u-v$ curve for the mode intersects the $u=v$ line (indicated in our plots by a dashed line). These values of cutoff frequency are represented in the $u-v$ plots as the terminating points of the curves. Since these values of cutoff frequency are correct, the errors in the equation did not affect our results.

[1] Manuscript received August 6, 1965.

Although we were interested in the case of relatively small difference in dielectric constant, the approach that we chose of starting with the $\delta=0$ case and perturbing from that curve also appears to be a good way of attacking the problem for reasonably large values of dielectric constant. As the figures show, the $u=v$ plots do not vary very much from $\delta=0$ to $\delta=0.5$. Although the method may not be practical for very large differences in dielectric constant, it certainly is not limited to very small differences.

A problem with which we were faced is that our assumed values of dielectric constants of the retinal receptors could be in error, and therefore we needed an extensive family of curves. The approach we employed provided this result very conveniently.

It should be pointed out, also, that the theoretical value of cutoff frequency for a mode can sometimes be misleading. As our paper shows, the mode efficiencies for the HE_{11} and HE_{12} modes are essentially zero at frequencies significantly greater than the theoretical cutoff frequencies, and therefore these modes should be considered as having practical cutoff frequencies higher than the theoretical values. Thus the plots of mode efficiency provide better criteria for whether a mode is capable of propagation in a practical sense than do the cutoff frequencies.

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