range of 1 to 4 GHz. The tuner was checked for tuning range with a slotted line and actually has the capacity to tune out a 2 to 1 VSWR down to 0.5 GHz. The tuner was tested for reflectometer applications in a combined waveguide-coaxial reflectometer system. The directional coupler of the reflectometer could easily be tuned for directivities of greater than 60 db.

The leakage from the tuner was checked with a sensitive receiver and the leakage to the outside was down by more than 85 db from the coaxial line power level.

W. E. Little
E. Niesen
Radio Standards Engrg. Div.
National Bureau of Standards
Boulder, Colo.

Orientation of YIG Spheres for Minimum Temperature Dependence

Due to magnetocrystalline anisotropy energy, YIG spheres display a resonant frequency shift with temperature variation. By orienting the sphere along certain directions relative to the applied dc magnetic field, this frequency shift with temperature can be minimized. Clark, Brown, and Tribby [1] have analyzed this problem, and resorted to X-ray alignment using the Laue back reflection pattern to obtain the temperature-stable orientation. They have pointed out the difficulty in maintaining the accuracy of alignment in transferring the sphere from the X-ray apparatus to the RF structure.

It is possible to do away with the costly and time consuming X-ray orientation method, and align the YIG spheres directly in the RF structure intended for use. Between the limits of 1680 and 3360 Mc, a YIG sphere operates in the coincidence limiting region and saturates at input power levels in excess of −10 dbm [2]. If the garnet sphere is not temperature aligned, applied power levels above the limiting threshold will result in heating of the sphere and hence in a resonant frequency shift.

Fig. 1 shows the laboratory setup. The sweep frequency generator is adjusted to cover a range of a few hundred megacycles above and below the resonant frequency, at a power level well below the limiting threshold. The high power CW signal generator is adjusted for the resonant frequency. A coaxial switch allows for rapid connection of the signal generator or sweep-frequency generator to the garnet sphere.

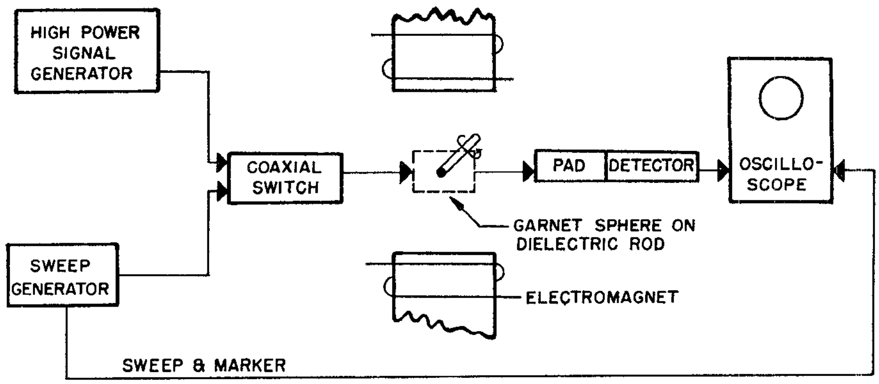

Fig. 1—Test setup.

Initially, the sweep-frequency generator is connected and the resonant frequency f_0 is noted on the oscilloscope. Then the high power signal is applied for a few seconds and the sweep generator is reconnected. If the sphere is not oriented for minimum temperature dependence, the resonant point will appear displaced, and then will slowly drift back to its original position. The entire procedure can be repeated rapidly, since only the sphere is heated, and its mass is small. By rotating the post to which the garnet sphere is attached, an orientation can be located such that the resonant frequency is not displaced after high powers are applied. Because of the anisotropy, the magnetic field must be adjusted to establish resonance at f_0 after any change in orientation of the garnet. Otherwise, the high power generator will not be tuned to the resonant frequency of the garnet sphere.

The above technique can be extended to multiple-stage YIG devices. By means of an RF probe, the first stage is temperature aligned. The following stages are then synchronously tuned with the first.

E. J. Wrobel
Solid State Div.
Lavoie Labs., Inc.
Hackensack, N. J.

Manuscript received April 20, 1964, revised June 18, 1954.

References

[1] J. Clark, J. Brown, and D. E. Tribby, "Temperature stabilization of gyromagnetic couplers," IEEE Trans on Microwave Theory and Techniques (*Correspondence*), vol. MTT-11, pp. 447–449, September, 1963.
[2] B. Lax and K. J. Button, "Microwave Ferrites and Ferrimagnetics," McGraw-Hill Book Co., Inc., New York, N. Y., p. 679; 1962.

An Empirical Formula for the Design of Radial Line Filters

The present wide interest in varactor parametric amplifiers and frequency multipliers has led to renewed interest in band-pass and band-stop filters suitable for microwave frequencies. In negative resistance amplifiers it is essential to prevent leakage of pump and idler frequencies into the signal circuit and in multipliers it is necessary to prevent outputs at unwanted higher harmonic frequencies. In many such instances simple radial-line band rejection filters are adequate, combining high reflection within the rejection band with low insertion loss at other frequencies.

Manuscript received June 18, 1964.

A great deal of useful information for the design of such filters is given by de Loach[1] and the present note reports a simple extension of his work. All measurements were carried out using standard $\frac{3}{8}$-inch air-filled coaxial line (50 ohms) with dimensions

Inner Conductor O/diameter
0.120 inch ($=2a$)
Outer Conductor I/diameter
0.276 inch ($=2b$).

A cross section through a typical radial line cavity is shown in Fig. 1. From de Loach[1] (and intuitively), it is expected that for a fixed cavity height h the cavity diameter d will be inversely proportional to frequency. Measurements were carried out on cavities of fixed height (0.125 inch), but varying diameters, having rejection frequencies in the K-band region (12–18 Gc), and the results were graphed against reciprocal/linear scales. As expected, the points were scattered about a straight line, and the line of best fit was obtained by the method of least squares. The equation of this line, relating cavity diameter to resonant (rejection) frequency, is

$$d = 0.18\left(1 + \frac{46.51}{f_0}\right). \qquad (1)$$

where d is the cavity diameter in inches and f_0 is the rejection frequency in Gc.

It must be emphasized that this is a purely empirical relationship and as such is valid only for air-filled cavities of height 0.125 inch, with input lines as specified above. Further work is being carried out to determine the relationship between h and for fixed d.

Eq. (1) has been tested at frequencies below K band, and is accurate, giving diameters to within ±0.003 inch down to 8 Gc. With less accuracy (±0.006 inch) it is useable down to 5 Gc: below this frequency air-filled cavities become inconveniently large, and dielectric filling, as described by de Loach, should be adopted.

At high frequencies, application of (1) is limited by the onset of multimode propagation, which for the coaxial line dimensions quoted occurs above 19 Gc: up to this limit (1) may be used with confidence.

All cavities used in these experiments

[1] B. C. de Loach, "Radial line coaxial filters in the microwave region," IEEE Trans. on Microwave Theory and Techniques, vol. MTT-11, pp. 50–55; January, 1963.

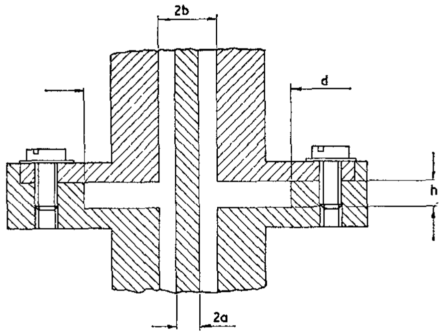

Fig. 1—Radial line cavity assembly.

were constructed of brass to the configuration of Fig. 1. Center-of-band rejection was at least 25 db in all cases: this was adequate for our purposes. For greater rejection, electro-formed cavities are described by de Loach should be adopted, and to broaden the rejection band a number of cavities can be coupled in series.

The author is indebted to the Managing Director of G. and E. Bradley, Ltd. for permission to publish this communication. He also wishes to thank R. G. Amos and J. A. Dodson for making the necessary measurements.

M. A. R. Gunston
G. and E. Bradley, Ltd.
London, England

Correction to "Electrolytic Pointing of Fine Wire"

In the above correspondence,[1] the final line should have read 0.0002 inch instead of 0.002 inch.

J. W. Dozier
Advanced Technology Corp.
Timonium, Md.

Manuscript received July 9, 1964.
[1] J. W. Dozier and J. D. Rodgers, IEEE Trans. on Microwave Theory and Techniques, vol. MTT-12, p. 360; May, 1964.

Microwave and High-Frequency Calibration Services of the National Bureau of Standards—Part II

Introduction

Following the series of presentations on microwave and high-frequency calibration services of the National Bureau of Standards which began in the July, 1964 issue of these Transactions, the services for the measure-

Manuscript received June 19, 1964.

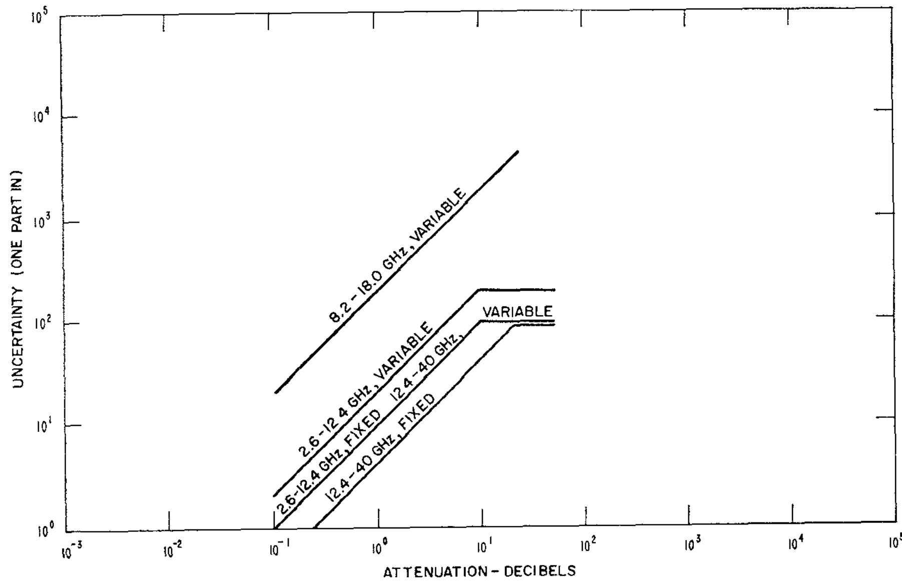

Fig. 1—Microwave attenuation calibrations (rectangular waveguide).

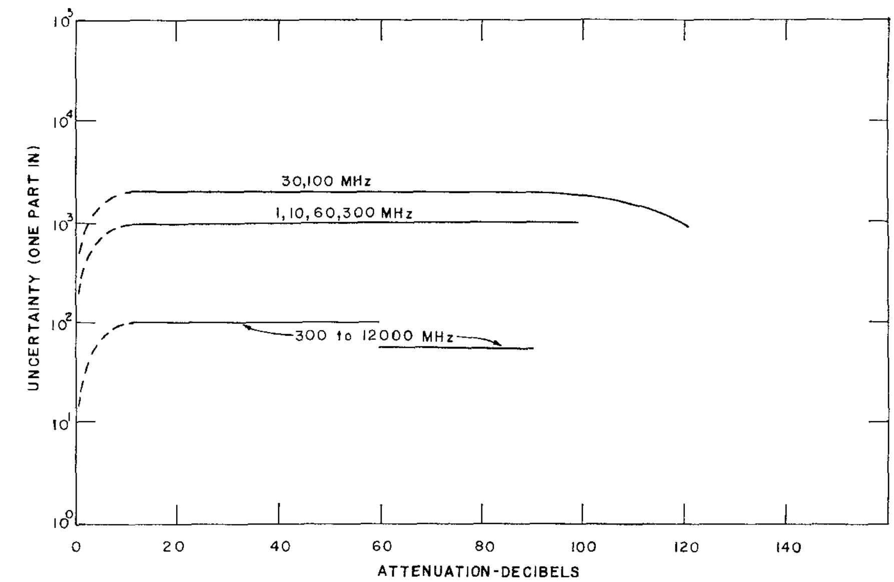

Fig. 2—High-frequency attenuation calibrations (coaxial).