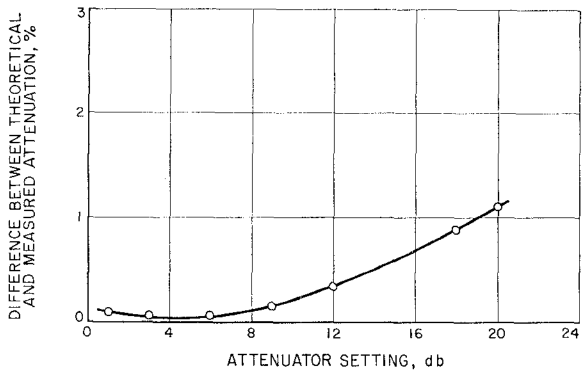

Fig. 4—Linearity test of the insertion loss test set.

TABLE II
ACCURACY TOLERANCES OF INSERTION LOSS MEASUREMENTS

Insertion loss measurement range, db	Accuracy of measured value, db
0 to 6	±0.001 ±0.1 per cent
6 to 18	1 per cent
18 to 25	±3 per cent

TABLE III
INSERTION LOSS OF VARIOUS *H*-BAND WAVEGUIDE COMPONENTS

Description of test item	Date	VSWR	Insertion loss db	Average difference db
6-in straight waveguide (Narda type 341)	7-11-63	1.005	0.014	0.0006
Mica window (RG-51/U) (Microwave Associates)	7-12-63	1.01	0.012	0.0007
20 db directional coupler-matched loads on two unused faces (Hewlett-Packard H 750D)	—	—	0.0640	0.0010
3.4-inch straight stainless steel waveguide (RG-51/U) plated inside with 0.00015 inch Cu, 0.00001 inch Au	8- 6-63	—	0.0120	0.0004
24-inch straight stainless steel waveguide (no plating)	8- 9-63	—	0.389	0.0005

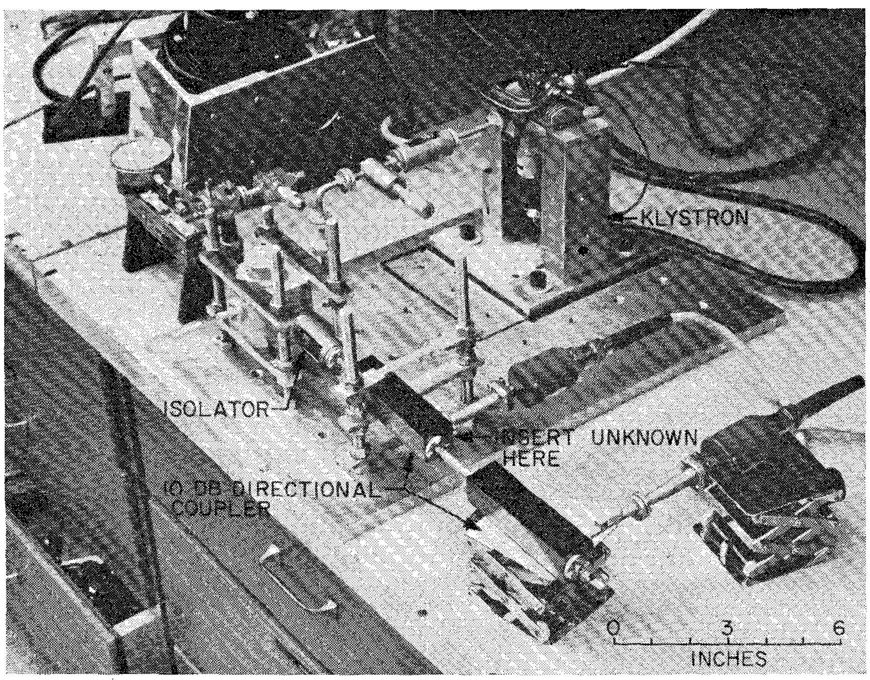

Fig. 5—Stability recording of insertion loss test-set instrumentation.

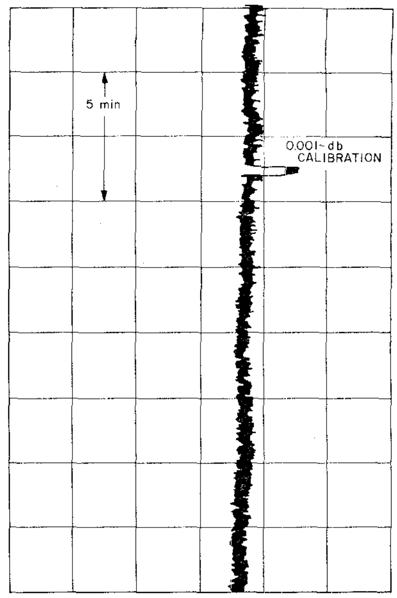

Fig. 6—Insertion loss test-set application at 90 Gc.

The test set has recently been used at 90 Gc (Fig. 6) for component evaluation of a millimeter radiometer. Commercially available power meter detectors rated to 40 Gc were used with transitions. The performance was somewhat degraded from that otherwise obtained at lower frequencies.

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Circular Polarization at Millimeter Waves by Total Internal Reflection

A plane wave traveling from a dielectric medium with dielectric constant ϵ_1 into a dielectric medium with dielectric constant ϵ_2, for which $\epsilon_1 > \epsilon_2$, is totally reflected at an angle of incidence θ_i greater than the critical angle of incidence θ_c, defined by

$$\sin^2 \theta_c = \frac{\epsilon_1}{\epsilon_2} \cdot$$

When this phenomenon of total reflection occurs, a plane incident wave polarized in the plane of incidence is reflected[1,2] with a phase change δ_p, where

$$\delta_p = 2 \tan^{-1} \frac{\epsilon\sqrt{\epsilon \sin^2 \theta_i - 1}}{\cos \theta_i \sqrt{\epsilon}} \cdot$$

Manuscript received April 6, 1964. This work was partly supported by the Air Force Systems Command, United States Air Force.

[1] J. A. Stratton, "Electromagnetic Theory," McGraw-Hill Book Company, Inc., New York, N. Y., pp. 497–500; 1941.

[2] F. A. Jenkins and H. E. White, "Fundamentals of Optics," McGraw-Hill Book Company, Inc., New York, N. Y., pp. 512–518; 1957.

Similarly a plane incident wave polarized normal to the plane of incidence is reflected with a phase change δ_n, where

$$\delta_n = 2 \tan^{-1} \frac{\sqrt{\epsilon \sin^2 \theta_i - 1}}{\cos \theta_i \sqrt{\epsilon}}.$$

It is evident that when the incident wave is polarized in an arbitrary direction, the reflected wave will be in general elliptically polarized. The phase δ between the two components into which the arbitrary wave can be resolved is

$$\delta = \delta_p - \delta_n = 2 \tan^{-1} \frac{\cos \theta_i \sqrt{\epsilon \sin^2 \theta_i - 1}}{\sin^2 \theta_i \sqrt{\epsilon}}.$$

Fig. 1 gives the relation between the various phase changes with angle of incidence for a dielectric with dielectric constant $\epsilon=2.55$. At θ_c, δ_p and δ_n are both zero, while at $\theta_i=90°$ they are both 180°. The difference in phase between the two rectangular components δ, has a maximum of 51°46′ at $\theta_i=48°38'$.

It will be obvious from the formulas that circular polarization can be obtained by an incident wave linearly polarized at 45° with the plane of incidence utilizing a dielectric with dielectric constant $>3+2\sqrt{2}$. Unfortunately dielectrics with such high dielectric constants are either dispersive and/or lossy at millimeter wavelengths. An alternative solution can be found using more than one internal reflection, so that nondispersive and low loss dielectrics may be used. An elegant example is the Fresnel rhomb depicted in Fig. 2. The incident wave polarized at 45° with the plane of incidence is twice totally reflected, each reflection contributing a phase change of 45° between the two components into which the wave can be resolved, resulting in a circularly polarized wave emerging from the rhomb. In general, two angles of incidence may be used in order to obtain circular polarization (see Fig. 1). Since the only dependence on frequency is the dielectric constant, the Fresnel rhomb is essentially a broad-band device.

Fig. 3 shows a picture of a Fresnel rhomb that was constructed from 3-inch thick Rexolite 1422 (dielectric constant 2.55). Although an angle of incidence of 58°39′ is less critical, as $|d\delta/d\theta_i|$ is smaller, an angle of incidence of 42°40′ was chosen to minimize the absorption losses in the medium as the rhomb can be made shorter for the latter angle. Measurements on this device at 75 Gc indicated that the axial ratio was better than 1 db. The device could be further improved by correcting the end faces of the rhomb to minimize reflection losses.

An immediate application for the circular polarizer described above is a rotating joint, using two circular polarizers when linear polarization at both input and output is desired.

A dielectric circular polarizer duplexer is described in Fig. 4. It consists of a Fresnel rhomb and a parallel wire grid as a polarizing filter. In the picture the transmitter radiates a plane wave with its polarization in the plane of the paper. As the wires of the polarization filter are normal to the electric field, this wave passes the grid unmolested and emerges from the Fresnel rhomb, which is rotated 45° around its axis, as a circular polarized wave. This wave is then guided to an antenna. The return wave received by the antenna may be either the reflection from a target or the transmitted signal from another similar communication station with the opposite circular polarization. In either case the return wave has a circular polarization opposite from that of the transmitter. As a consequence, this wave when guided through the polarizer emerges at the transmitter end as a linear polarized wave with its polarization normal to the polarization of the transmitter and so parallel to the wires of the polarization filter. When the distance between the grid wires is properly chosen, the received wave is totally reflected and guided to the detector.

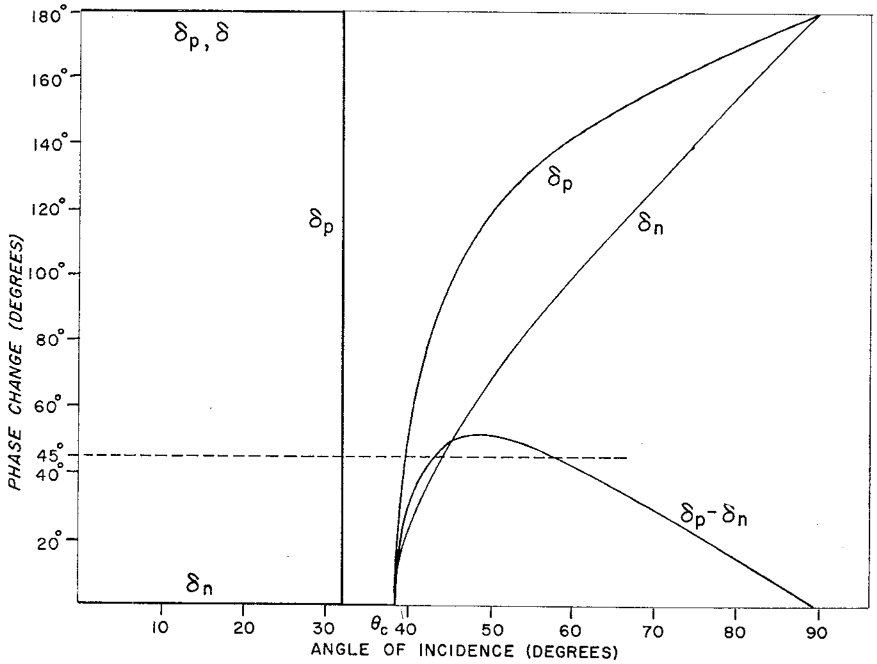

Fig. 1—Dependence of phase shifts δ_p, δ_n and $\delta_p-\delta_n$ on angle of incidence θ_i for a dielectric with $\epsilon=2.25$.

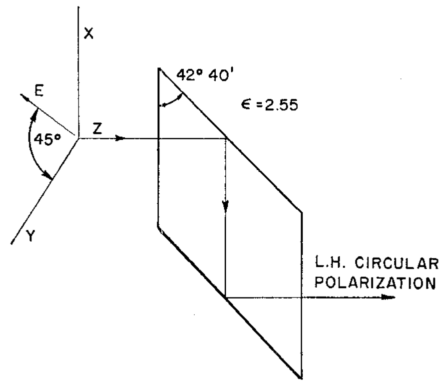

Fig. 2—Fresnel rhomb giving rise to circular polarization.

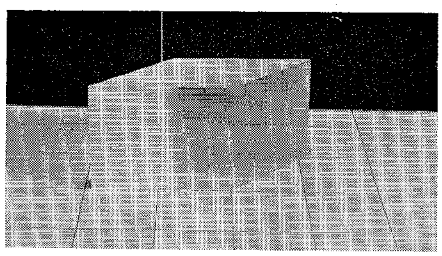

Fig. 3—Photograph of Fresnel rhomb made of Rexolite 1422. Heavy divisions are 5 cm apart.

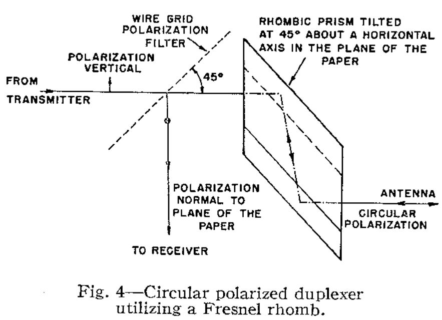

Fig. 4—Circular polarized duplexer utilizing a Fresnel rhomb.

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Microwave Measurements on Semiconductor Filled Symmetrical Strip Transmission Line

A number of microwave techniques for studying semiconductor properties have recently been reported [1]. In many of the techniques for measuring semiconductor conductivity, the guided wave approach has been utilized. The usual procedure is to mount a semiconductor sample of known dimensions in a waveguiding structure. Then a convenient microwave quantity, such

Manuscript received April 6, 1964.