The over-all mount efficiency was measured at 5.4 millimeters and 2 millimeters using the above arrangement. The measured efficiency at these wavelengths was found to be 50 per cent and 25 per cent, respectively.

This bolometer provided a means of measuring peak powers as low as 20 microwatts. As it is a device that measures the RF energy converted into heat, its response is proportional to the RF power. This bolometer provided a detector of known response law, which is essential to accurately perform impedance measurements.

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Injection Phase Locking of Two-Cavity Klystron Oscillators*

Injection phase locking of reflex klystron oscillators was recently reported by Mackey in these Transactions.[1] Two-cavity klystron oscillators may be phase locked in a similar manner. Injection locking affords a means of two-cavity oscillator stabilization that obviates the necessity for elaborate beam voltage and temperature control. Excellent frequency stability may be obtained by locking the two-cavity oscillator to a signal derived from either a crystal oscillator or a frequency standard. Fig. 1 shows a two-cavity oscillator injection locking system.

An estimate of the locking bandwidth can be made by adapting the low-frequency theory of Adler[2] to the two-cavity oscillator. Since only a fraction of the output power is fed back to the input cavity to sustain oscillation, the input cavity is lightly coupled to the load. The input cavity typically receives 30 per cent of the injected locking power. The total locking bandwidth $2\Delta f$ may be expressed as

$$2\Delta f = \frac{f_o}{Q_L}\left(\frac{0.3\,P_1}{P_o}\right)^{1/2},$$

where f_o = oscillator frequency, Q_L = total loaded Q of input cavity, P_1 = locking power, P_o = output power.

Locking measurements were made on a Sperry SOU-293, two-cavity oscillator at 17.5 Gc. A calibrated spectrum analyzer was used to observe the locking range. Fig. 2

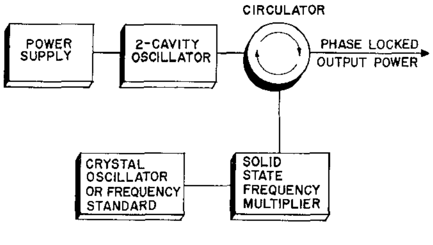

Fig 1—Injection phase-locking system for two-cavity oscillators.

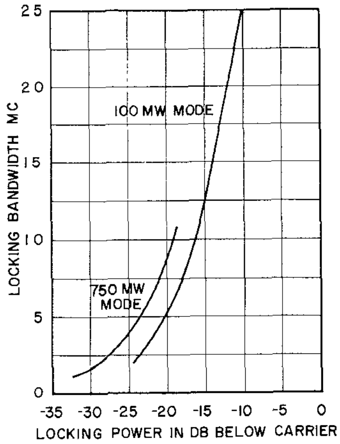

Fig. 2—Phase-locked bandwidth vs injected-locking power for SOU-293, 17.5 Gc.

shows the locking bandwidth vs locking power for the two modes of the SOU-293. The curves differ because the increased electron beam loading at the higher power mode produces a lower value of loaded Q.

Two-cavity oscillators require higher values of locking power than reflex klystrons for a given locking bandwidth since their loaded Q's are higher and only about 30 per cent of the locking power enters the input cavity. One compensating factor is that the higher inherent stability of the two-cavity oscillator requires less locking bandwidth and thus less locking power in many applications.

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[1] R. C. Mackey, "Injection locking of klystron oscillators," IRE Trans. on Microwave Theory and Techniques, vol. MTT-10, pp. 228–235; July, 1962.

[2] R. Adler, "A study of locking phenomena in oscillators," Proc. IRE, vol. 34, pp. 351–357; June, 1946.

TEM Mode in a Parallel-Plate Waveguide Filled with a Gyrotropic Dielectric*

The purpose of this communication is to point out that a parallel-plate waveguide filled with a gyrotropic dielectric, can support a TEM mode which has special characteristics.

* Received March 28, 1963; revised manuscript received May 6, 1963.

Consider a waveguide formed by two perfectly conducting plane parallel plates. The lower and the upper plates occupy, respectively, the regions $-\infty<x<\infty$, $-\infty<y<\infty$, $z=0$ and $-\infty<x<\infty$, $-\infty<y<\infty$, $z=a$, where x, y and z form a right-hand rectangular coordinate system (Fig. 1). The space between the parallel plates is filled uniformly with a homogeneous plasma, which for the sake of simplicity is assumed to be an incompressible, loss-free electron fluid, with stationary ions that neutralize the electrons, on the average. A line source given by

$$E_x(x, 0) = E_0\delta(x) \tag{1}$$

is assumed to be present inside the waveguide, along the y axis. Only the linear, time-harmonic problem is considered. The harmonic time dependence $e^{-i\omega t}$ is implied for all the field components. An external magnetic field is assumed to be impressed throughout the plasma in the y direction.

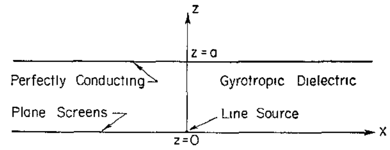

Fig. 1—Geometry of the problem.

Under these assumptions, the plasma becomes equivalent to an anisotropic dielectric. The line source excites only the E mode, for which the magnetic field has only a single component, namely, $H_y(x, z)$. It can be shown [1] that $H_y(x, z)$ satisfies the wave equation

$$\left[\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial z^2} + k^2\right] H_y(x, z) = 0, \tag{2}$$

where

$$k^2 = \omega^2\mu_0\epsilon_0\frac{\epsilon}{\epsilon_1} = k_0{}^2\frac{\epsilon}{\epsilon_1} = \frac{k_0{}^2(\epsilon_1{}^2 - \epsilon_2{}^2)}{\epsilon_1} \tag{3}$$

$$\epsilon_1 = \frac{\Omega^2 - R^2 - 1}{\Omega^2 - R^2}; \quad \epsilon_2 = \frac{R}{\Omega(\Omega^2 - R^2)}$$

$$\epsilon = \epsilon_1{}^2 - \epsilon_2{}^2 = \frac{(\Omega^2 - \Omega_1{}^2)(\Omega^2 - \Omega_3{}^2)}{\Omega^2(\Omega^2 - \Omega_2{}^2)}; \tag{4}$$

and

$$\Omega_{1,3} = \frac{\mp R + \sqrt{R^2 + 4}}{2}; \quad \Omega_2 = \sqrt{1 + R^2} \quad (5)^1$$

$$\Omega = \frac{\omega}{\omega_p}, \qquad R = \frac{\omega_c}{\omega_p}. \quad (6)^1$$

Also μ_0 and ϵ_0 are the permeability and dielectric constant pertaining to vacuum; ω_p and ω_c are, respectively, the plasma and the gyromagnetic frequency of an electron.

The nonvanishing components $E_x(x, z)$ and $E_z(x, z)$ of the electric field are obtained

[1] The notation used in (5) and (6), though frequently used in the literature, is different from the URSI notation as given in J. A. Ratcliffe, "The Magneto-Ionic Theory," Cambridge University Press, Cambridge, England; 1959.