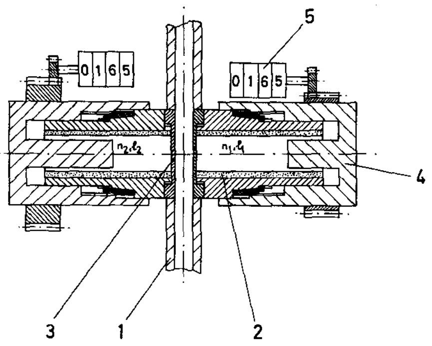

Fig. 1. Schematic drawing of the wavemeter: 1) 2 mm waveguide, 2) helix waveguide, 3) coupling hole, 4) tuning piston, and 5) mechanical counter driven by a toothed-wheel gear.

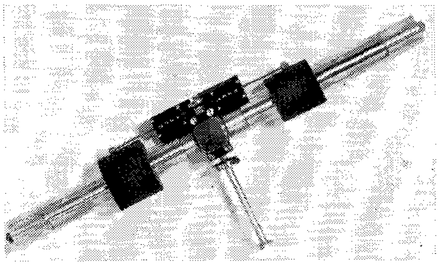

Fig. 2. Photo of the wavemeter.

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Broadband Hybrids

Marcatili and Ring [1] have shown that using two 3 dB directional couplers with a $\pi/2$ phase shifter between them a broader band 3 dB directional coupler can be realized.

We have built such a device to operate in the X-band frequency region, using two multibranch directional couplers described by Reed [2] and a dielectric phase shifter in one of the interconnecting arms as shown in Fig. 1. In our work, we have chosen Reed's multibranch couplers which are easy to realize; their geometry enables us to make many at a time, so they are perfectly identical, a property we have assumed in the theory. The distance L must be one quarter wavelength for the central frequency (here 10.1 GHz), so $L=9.76$ mm. Using Reed's computations [2], we have for a fourteen branch coupler

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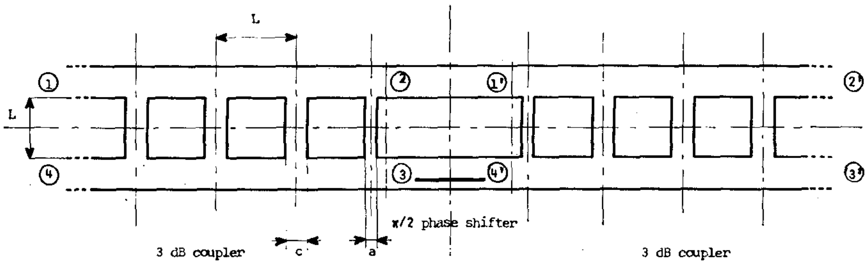

Fig. 1. The broadband hybrid. A $\pi/2$ dielectric phase shifter is placed in the lower interconnecting arm between two 3 dB couplers.

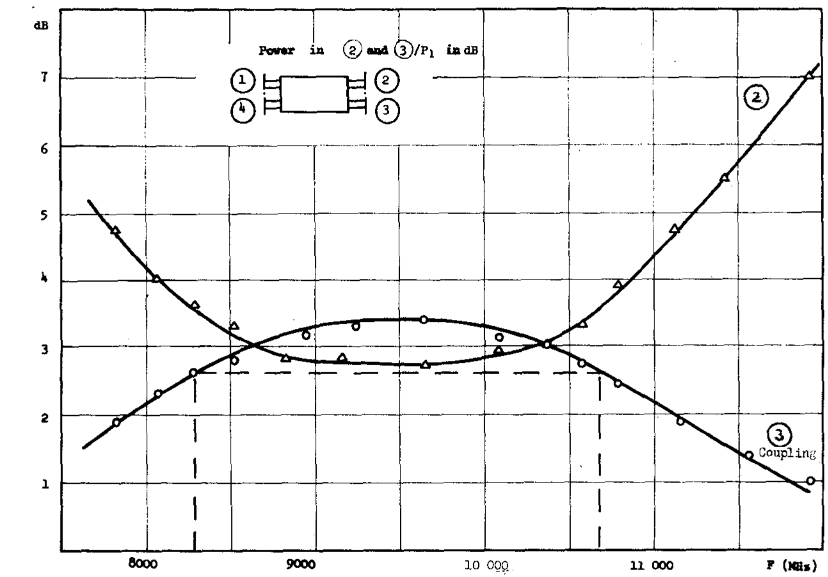

Fig. 2. Characteristics of the fourteen-slot couplers: transmitted power versus frequency.

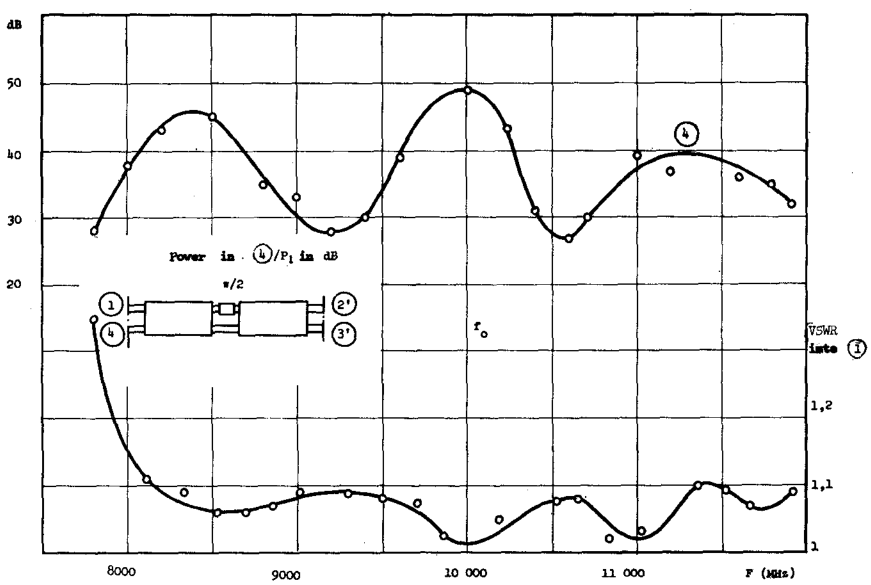

Fig. 3. Directivity and VSWR of the broadband hybrid.

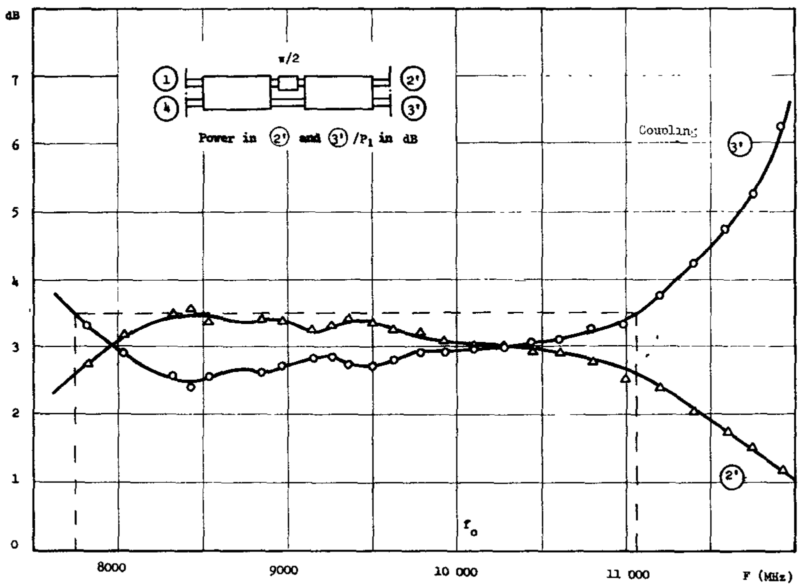

Fig. 4. Coupling of the whole hybrid versus frequency.

$a=0.6$ mm and $c=1.23$ mm. The characteristics of the fourteen-slot couplers used are shown in Fig. 2. The couplers used have a coupling higher than 2.6 dB over 2350 MHz (bandwidth of 23 percent). The VSWR measured at one port when all the others are matched is less than 1.08 between 8 and 12 GHz and the directivity is better than 30 dB. The quadrature phase shifter is constructed by inserting, in the waveguide (RG 52/U), a dielectric slab tapered at both ends to minimize reflections.

The dimensions of this slab have been calculated from the theory described by Halford [3] and Altmann [4].

The whole junction we built [5] is realized with two fourteen-slot couplers and one $\pi/2$ phase shifter designed as above. For this whole junction we measured the directivity, the coupling, and the VSWR at one port when all the others were matched. The results are shown in Fig. 3 and Fig. 4. The VSWR is less than 1.1 between 8.3 and 12 GHz. The most interesting property remains the decoupling between the input 1 and the output 4 when arms 2′ and 3′ are terminated by two identical impedances (here short circuits). This decoupling is higher than 40 dB for the two frequencies where the coupling of each coupler is exactly 3 dB. We have shown that a junction endowed with the magic tee properties over a range wider than 3 GHz in the X band could be obtained.

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Normal Incidence on Semi-Infinite Longitudinally Drifting Magneto-Plasma: The Nonrelativistic Solution

The purpose of this correspondence is to present a nonrelativistic solution to the problem of normal incidence of electromagnetic waves on a semi-infinite longitudinally drifting homogeneous cold magnetoplasma. Reflected and transmitted waves from the drifting boundary are found and the results are identical with a relativistic solution presented by Chawla and Unz [1].

Let a linearly polarized plane electromagnetic wave in free space be normally incident in the positive z direction on the drifting boundary of a semi-infinite cold magnetoplasma which is drifting with a constant velocity $\bar{v}_0=v_0\hat{z}$ with a superimposed static magnetic field $\bar{H}_0=H_0\hat{z}$; the incident wave will be given by

$$\bar{E}_I = E_x^I\hat{x}e^{i(\omega_I t-k_I z)};$$

$$\bar{H}_I = \frac{1}{\eta}E_x^I\hat{y}e^{i(\omega_I t-k_I z)} \quad (1)$$

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where E_x^I is a constant, ω_I is the circular frequency of the incident wave,

$$k_I = \frac{\omega_I}{c} = \omega_I\sqrt{\mu_0\epsilon_0},$$

$\eta=\sqrt{\mu_0/\epsilon_0}$, and μ_0, ϵ_0 are the free space permeability and permittivity, and $\hat{x}$, $\hat{y}$, $\hat{z}$ being the corresponding unit vectors.

The drifting gyrotropic plasma boundary, assumed to be located at $z=v_0t$, will produce in general two reflected waves in free space

$$\bar{E}_{R1} = E_x^R\hat{x}e^{i(\omega_R t+k_R z)};$$

$$\bar{H}_{R1} = -\frac{1}{\eta}E_x^R\hat{y}e^{i(\omega_R t+k_R z)} \quad (2a)$$

$$\bar{E}_{R2} = E_y^R\hat{y}e^{i(\omega_R t+k_R z)};$$

$$\bar{H}_{R2} = \frac{1}{\eta}E_y^R\hat{x}e^{i(\omega_R t+k_R t)} \quad (2b)$$

where E_x^R, and E_y^R are constants, ω_R is the circular frequency of the reflected wave, and

$$k_R = \frac{\omega_R}{c} = \omega_R\sqrt{\mu_0\epsilon_0}.$$

In addition, one will have transmitted waves in the drifting magnetoplasma of the type $e^{i(\omega_T t-k_T z)}$. From Maxwell's equations one obtains for the plasma waves [2]

$$H_x = -\frac{k_T}{\mu_0\omega_T}E_y = -\frac{n}{\eta}E;$$

$$H_y = \frac{k_T}{\mu_0\omega_T}E_x = \frac{n}{\eta}E_x \quad (3a)$$

$$\epsilon_0(n^2-1)E_x = sP_x;$$

$$\epsilon_0(n^2-1)E_y = sP_y \quad (3b)$$

where $s=1-n\beta_L$, ω_T is the circular frequency of the transmitted electromagnetic plasma waves, k_T is the corresponding wavenumber, P_x, P_y are the space polarization components,

$$\beta_L = \frac{v_0}{c}, \qquad n = \frac{ck_T}{\omega_T} = \frac{c}{u_p},$$

is the refractive index, and u_p is the phase velocity of the wave in the drifting magnetoplasma. From the constitutive relations, one has for the plasma waves [3]

$$\epsilon_0X_TE_x = -U_TP_x - iY_TP_y \quad (4a)$$

$$\epsilon_0X_TE_y = -U_TP_y + iY_TP_x \quad (4b)$$

where the notation by Budden [4] has been used taking

$$X_T = \frac{\omega_p^2}{\omega_T^2}, \quad Y_T = \frac{\omega_{HL}}{\omega_T}, \quad Z_T = \frac{\nu}{\omega_T},$$

$$U_T = s - iZ_T = 1 - n\beta_L - iZ_T,$$

ω_p being the plasma frequency, ω_{HL} the longitudinal gyromagnetic frequency, and ν the collision frequency of the plasma. Substituting (3b) into (4), one obtains

$$[U_T(n^2-1)+sX_T]E_x = -iY_T(n^2-1)E_y \quad (5a)$$

$$[U_T(n^2-1)+sX_T]E_y = +iY_T(n^2-1)E_x. \quad (5b)$$

By equating the determinant of the homogeneous equations (5) to zero one may obtain for a nontrivial solution

$$(n^2-1)[1-n\beta_L-iZ_T\mp Y_T] + (1-n\beta_L)X_T = 0 \quad (6)$$