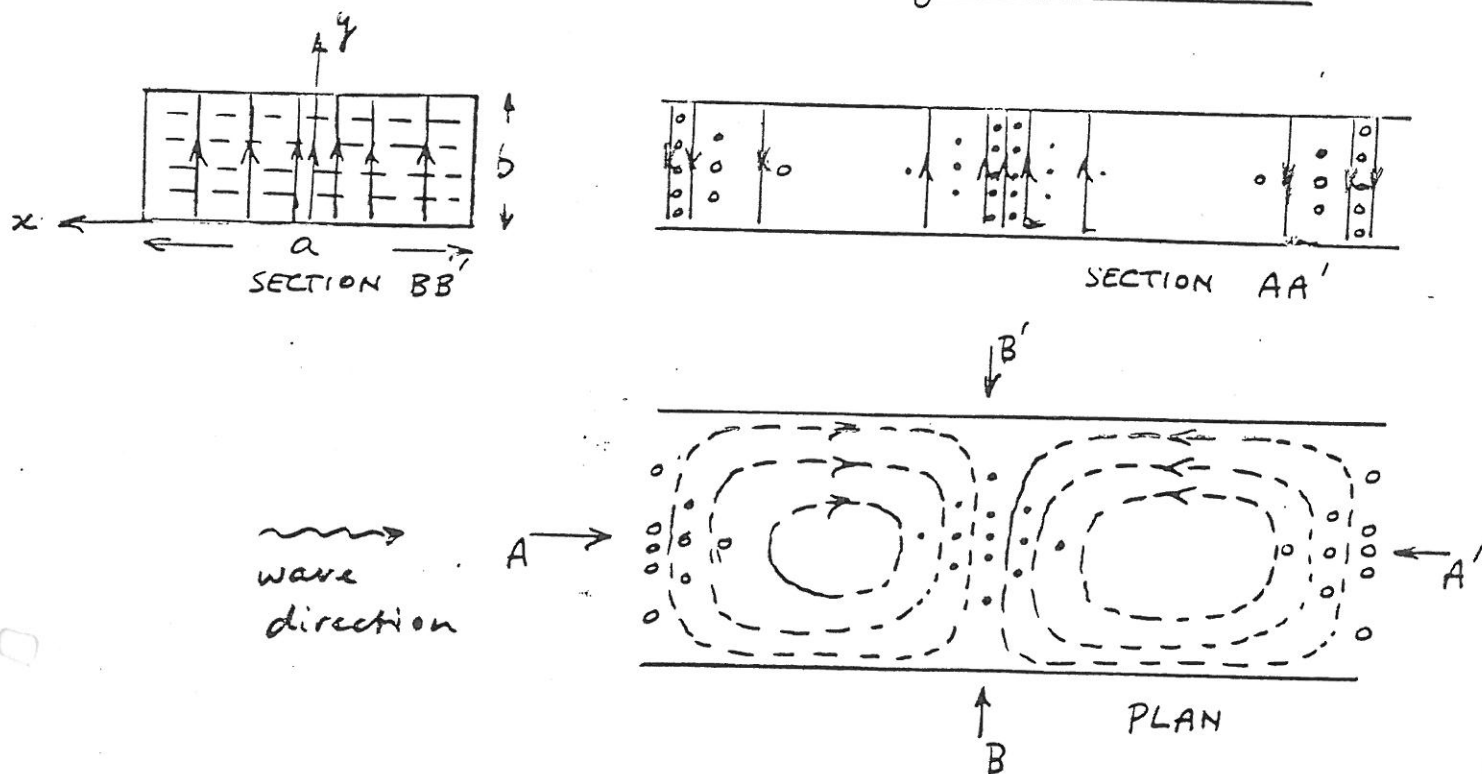


# TE<sub>10</sub> Mode in a Rectangular Guide



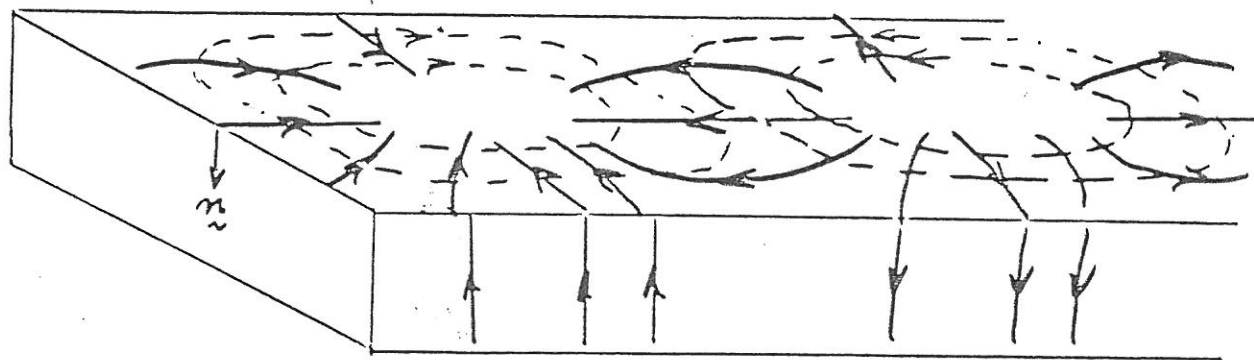
$$E_y(x, y, z) = E_0 \cos\left(\frac{\pi x}{a}\right) e^{-j\beta z}$$

$$H_x(x, y, z) = -\frac{E_0}{Z_{TE}} \cos\left(\frac{\pi x}{a}\right) e^{-j\beta z}$$

$$H_z(x, y, z) = -j \frac{E_0}{Z} \frac{\lambda}{2a} \sin\left(\frac{\pi x}{a}\right) e^{-j\beta z}$$

all uniform with  $y$

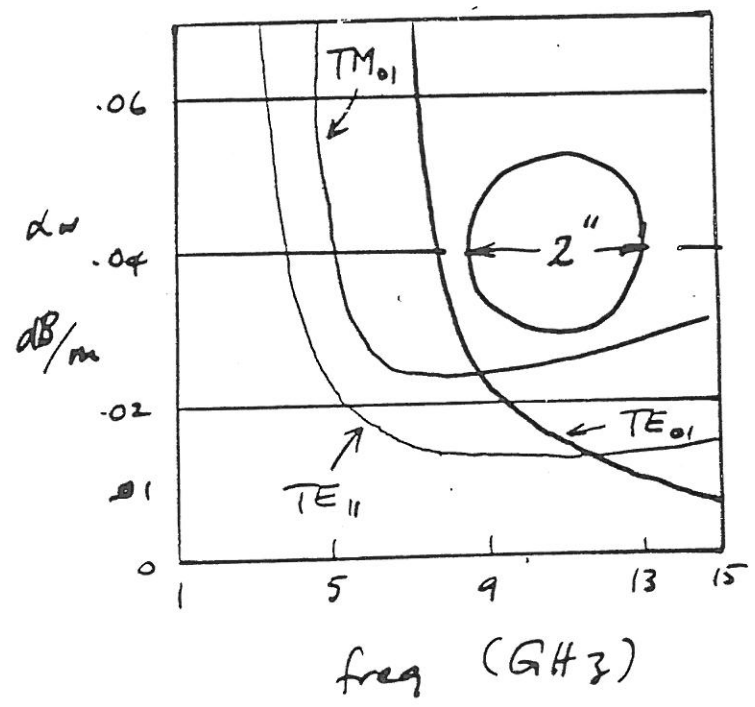
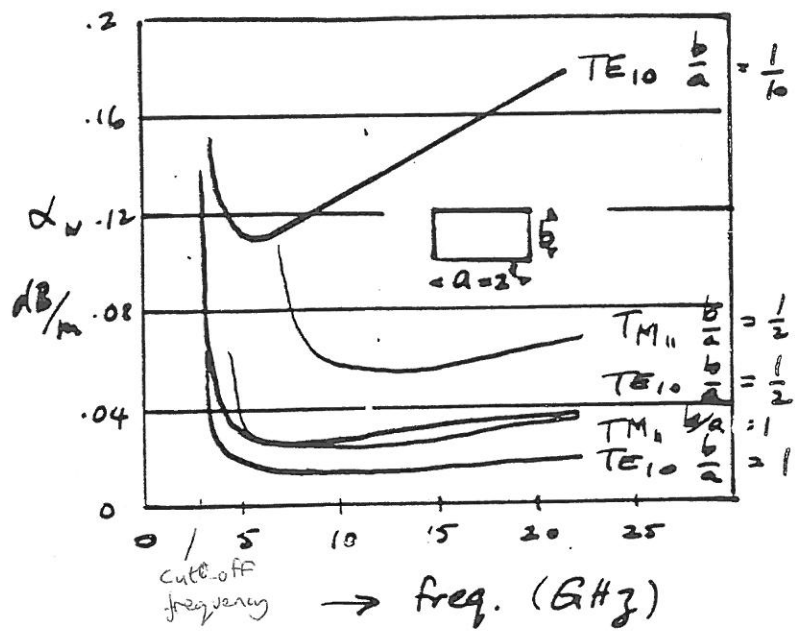
all zero outside  $x$ -section  $a \times b$



Currents in the Walls

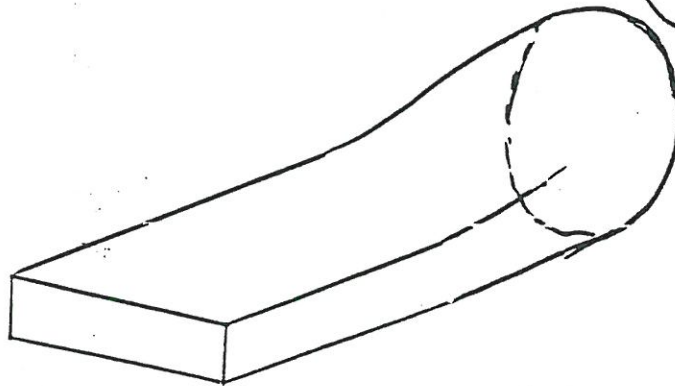
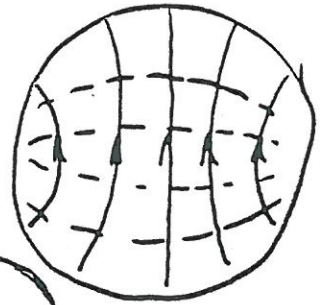
$$\vec{J}_s = \vec{n} \times \vec{H}_t$$

\*G+L = glazier + Laurent

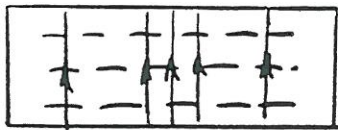


# Circular Waveguides

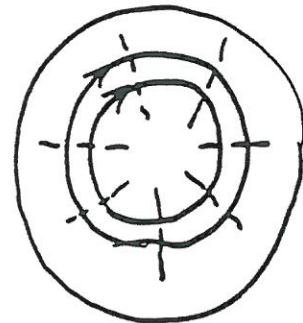
$TE_{11}$   
circ.



$TE_{10}$  rect.

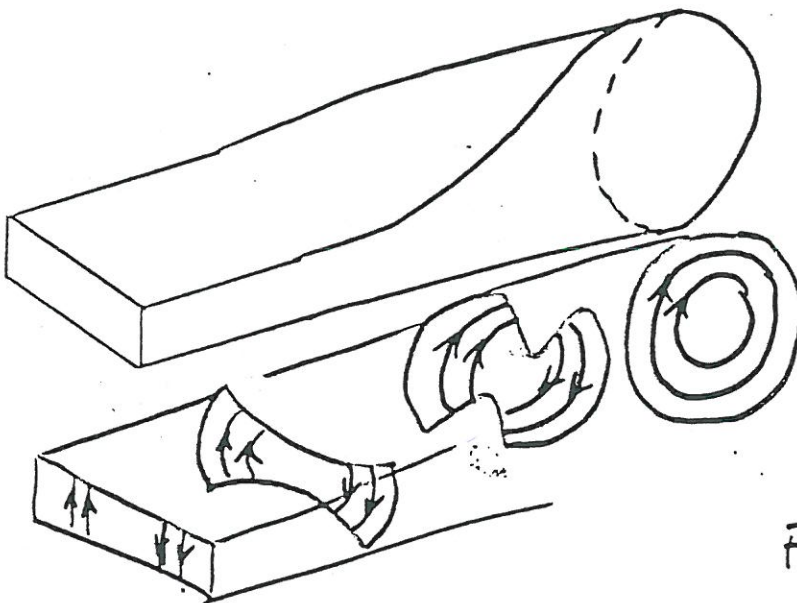


Note: tapers over a few wavelengths have negligible reflection.



$TE_{01}$  Circ.

very low loss  
(low skin penetration)



$TE_{20}$   
rect

$TE_{20}$   
rectangular

For:

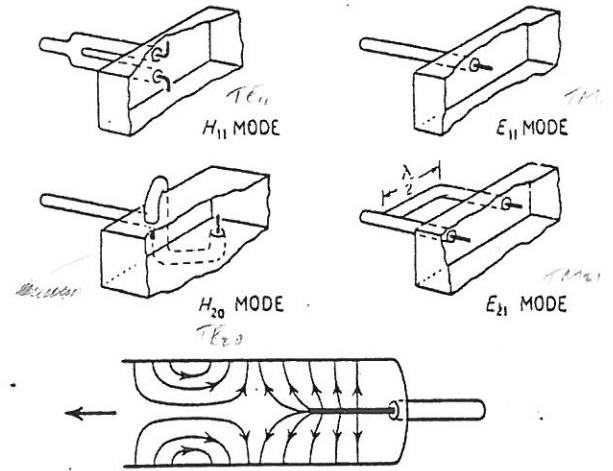
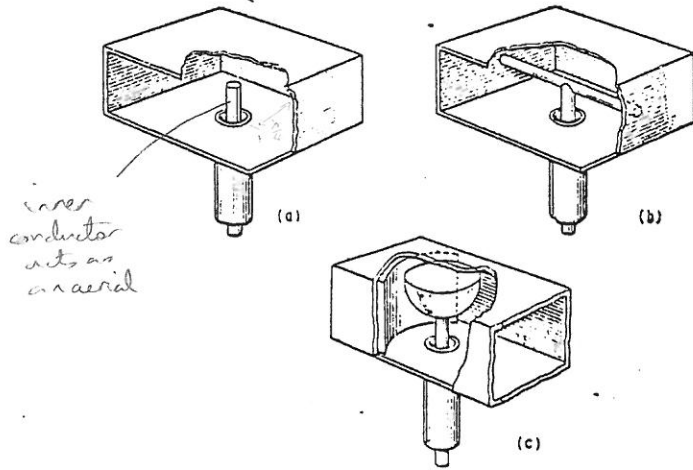
low loss waveguides

rotating joints

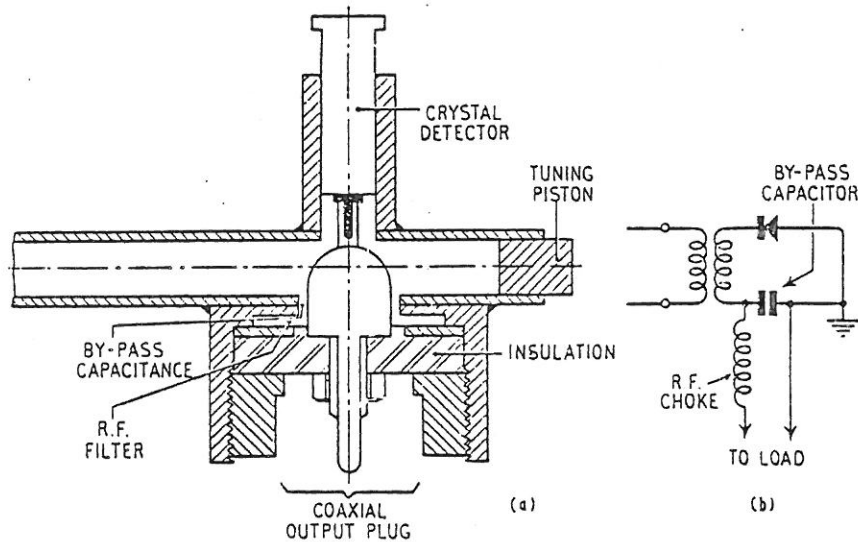
some devices

(e.g., cavity waveguide)

# Coaxial / Waveguide Junctions

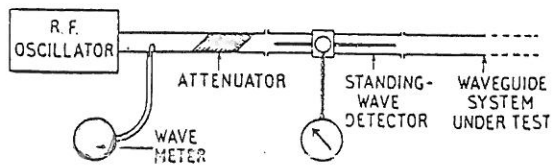


## Crystal - Detector Waveguide Mount

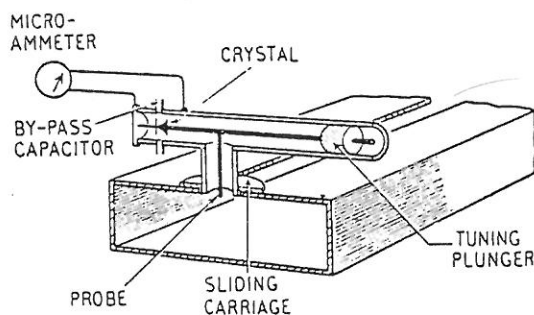


## Standing - Wave Indicator

Very important measurement for a system



Measurement of standing-wave ratio.

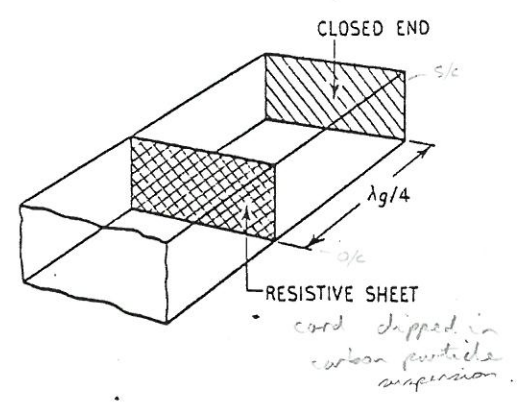


Direction of slot (down centre of waveguide) effectively leaves everything undisturbed. As long as current flow is not cut, no radiation occurs.



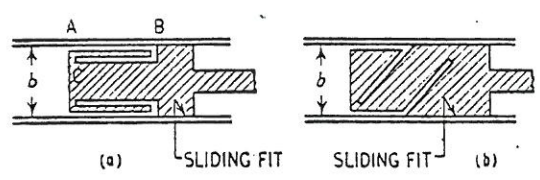
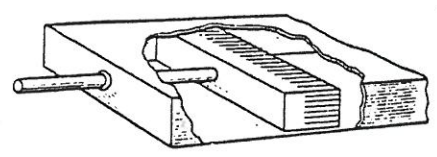
# Closed and Open-Ended Wave Guides.

## Matched Termination:

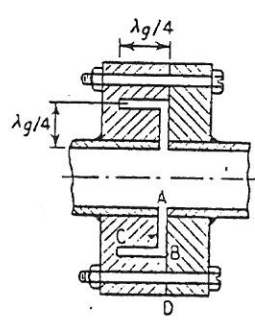


## Movable Short Circuits:

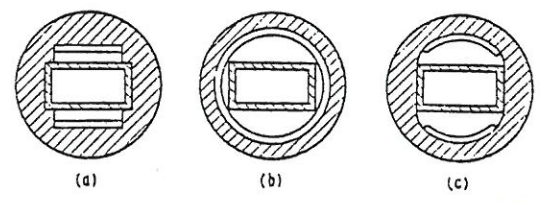
at s/c, mag field is a max,  
∴ lots of current, need a good wall contact



## Couplings.

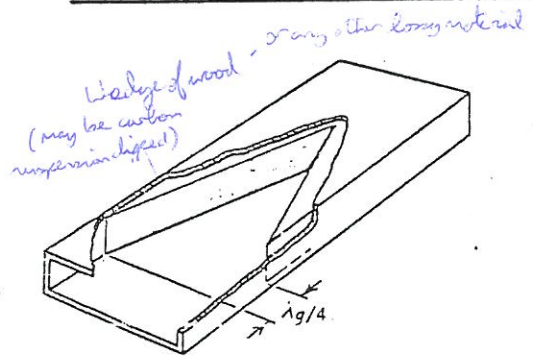


$CSA = \lambda_g/2$  presents equivalent s/c at A  
 $BA = \lambda_g/4$  presents o/c, so low current into wall

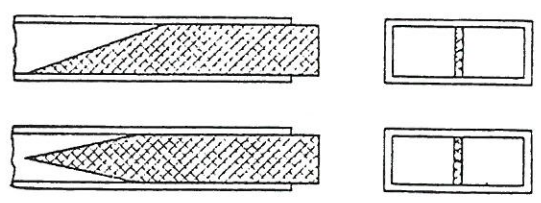


Many get a rubber seal for gas tight fit, so can use inert gas

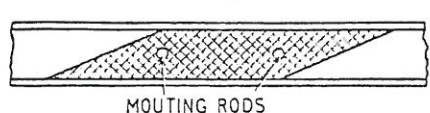
## Matched Terminations.



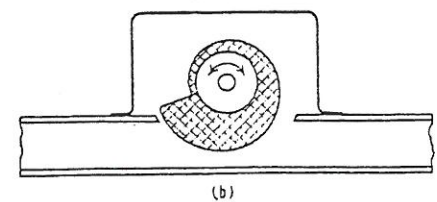
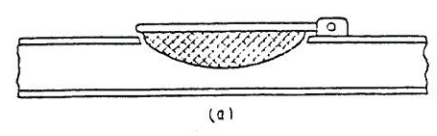
wedge shaped to eliminate reflections



## Variable Attenuators (and Phase Shifters)

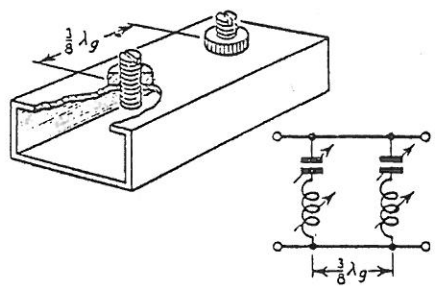
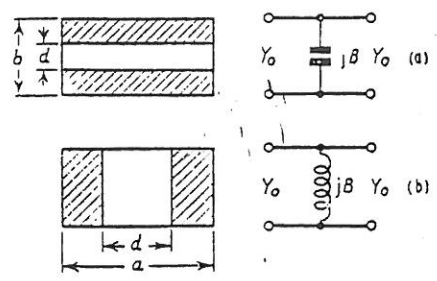


Tapered vane variable attenuator.

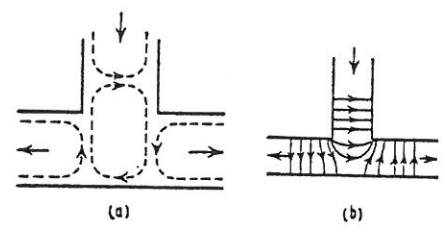
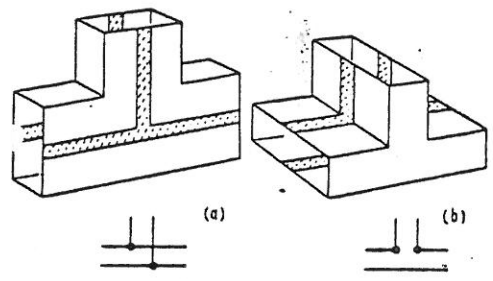


Two forms of variable attenuator using resistive strip.

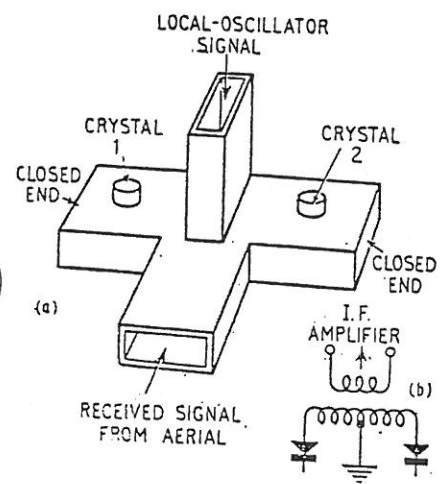
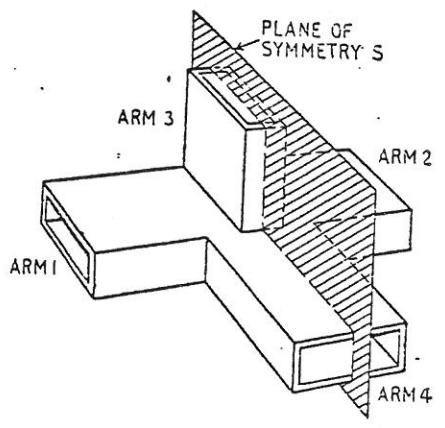
# Irises and Posts : matching elements.



## T-Junctions

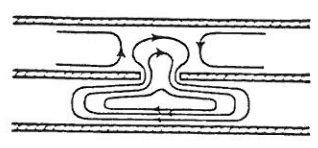


## Hybrid-T J.

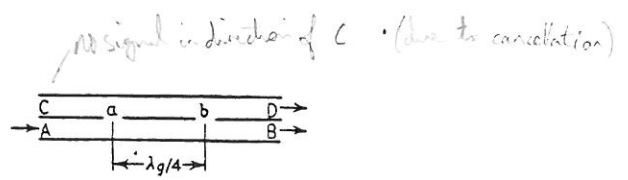


(a) Hybrid T balanced mixer; (b) connections to i.f. amplifier.

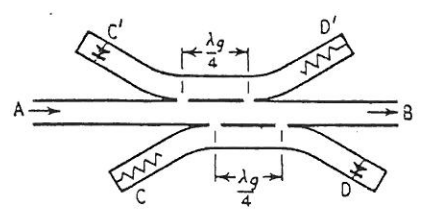
## Directional Couplers.



Coupling of guides through small hole.



Layout of two-hole directional coupler.



Double directional coupler.

Can use directional coupler to measure standing wave reflection coefficient in continuous operation

# Waveguides

TEM

pair of wires



co-ax



sandwich line



strip line

non-TEM



waveguide  $\times$  rects  $\rightarrow$



dielectric rod

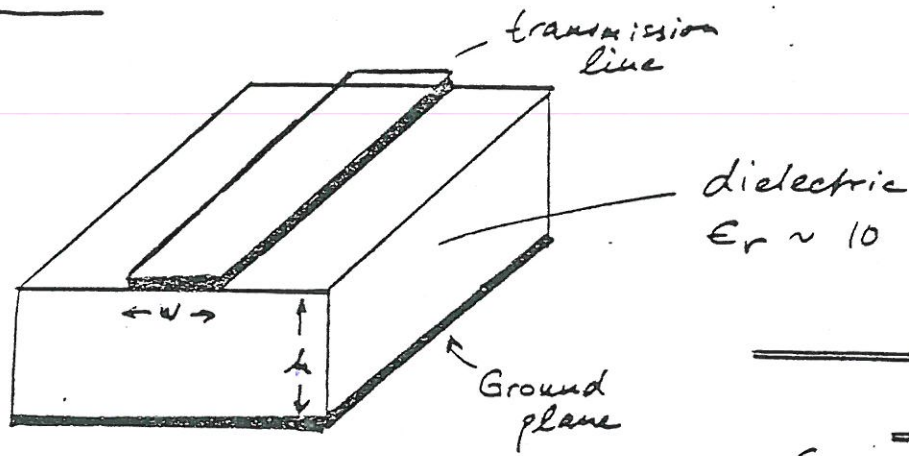


layer of dielectric

metal boundary

surface wave structure

# TEM Lines



aluminum, quartz, fused silica.

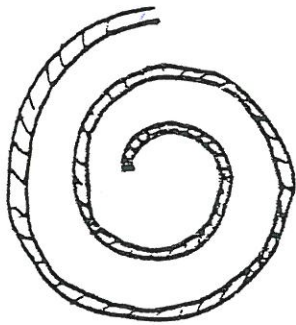
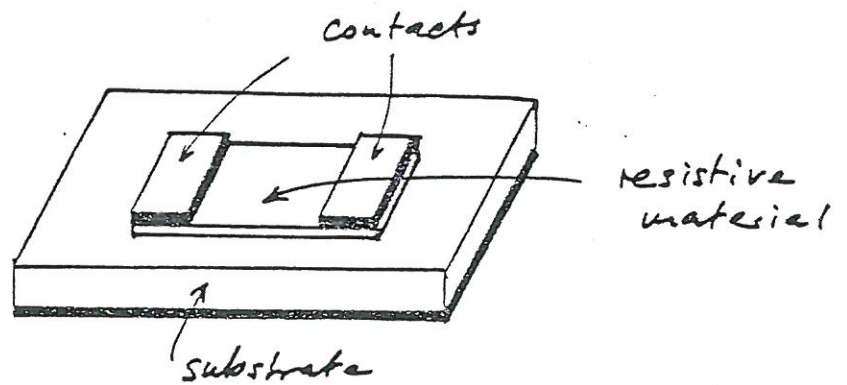
Microstrip Line



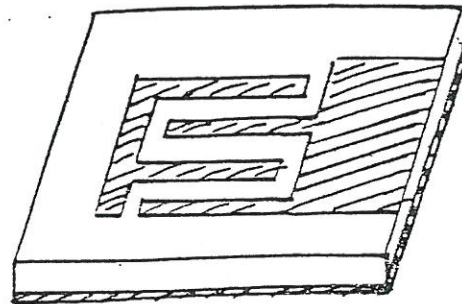
Stripline (Triplate)  
give better shielding

## Lumped Elements

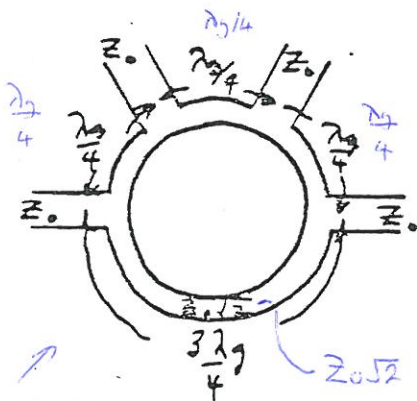
thin-film resistor



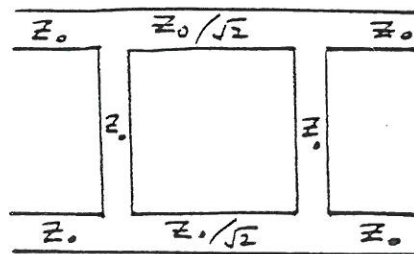
spiral inductor



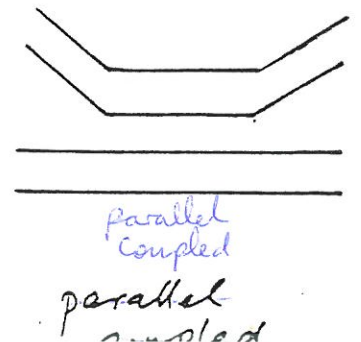
## Hybrid Ring (Rat race)



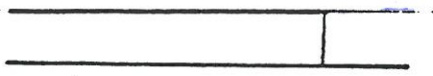
## Directional Couplers



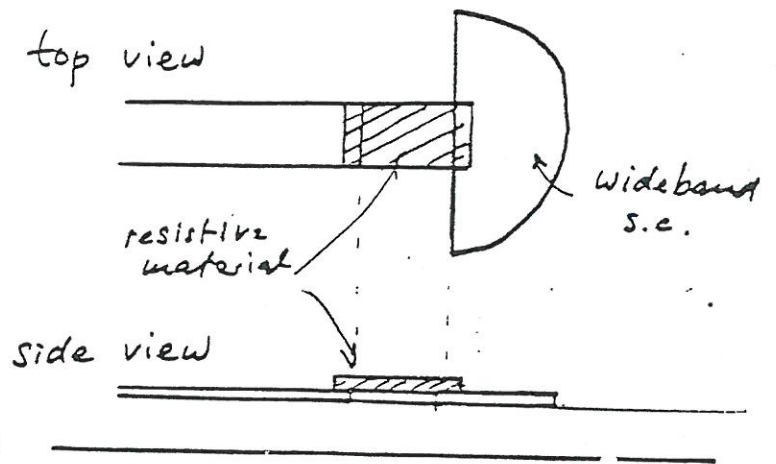
branched line (3dB)  
branched line 3-dB



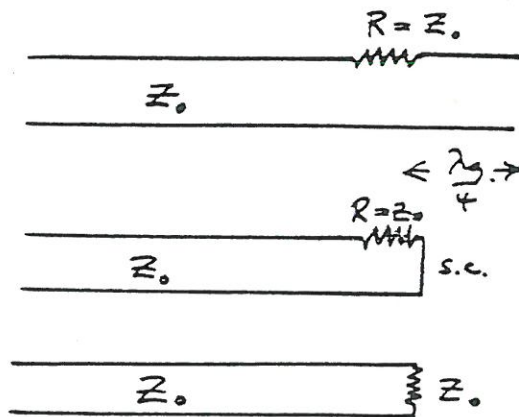
# Wideband Short Circuit + Matched Load



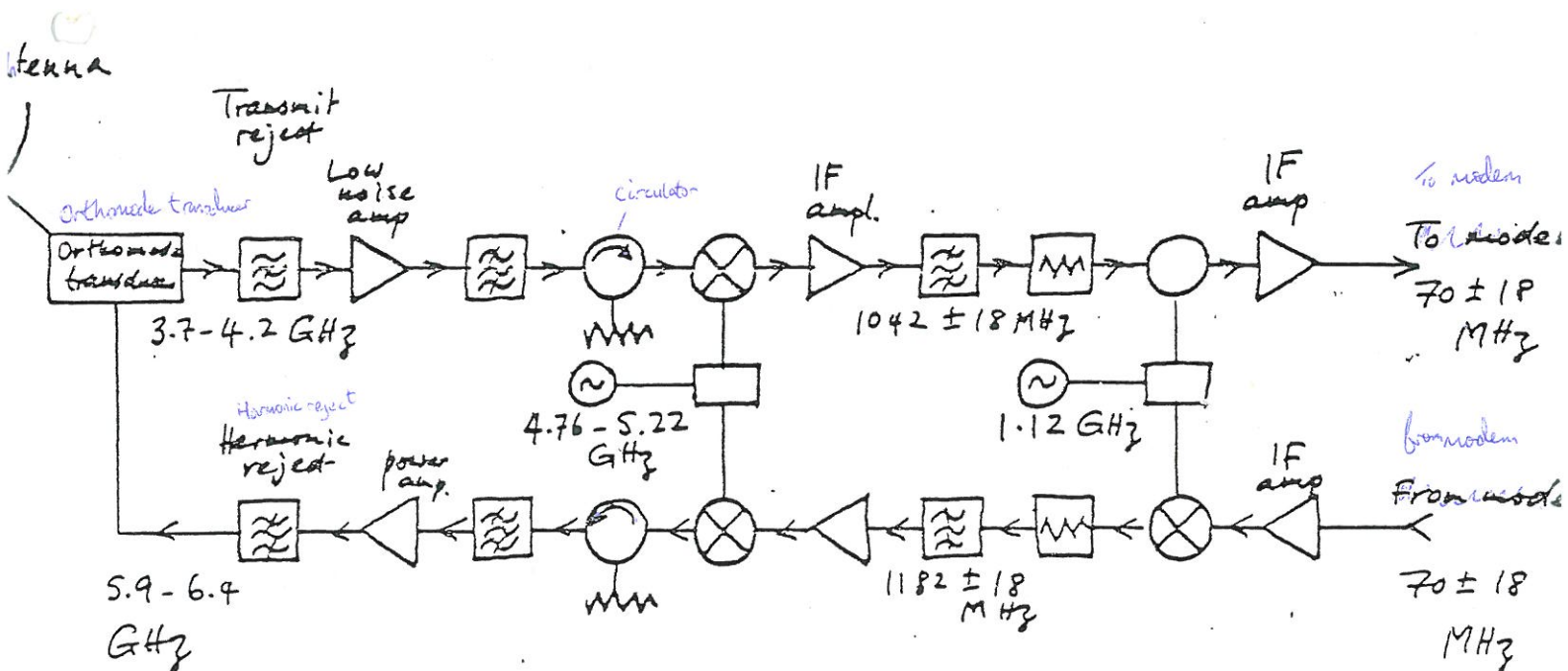
punch-through S.C.  
has inductance



transmission-line equivalent



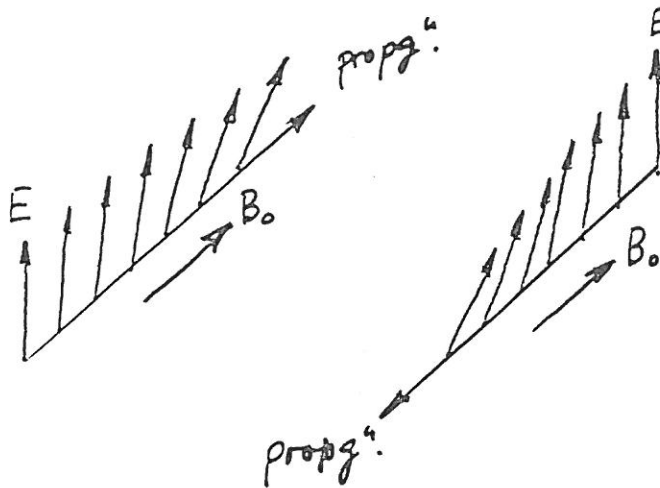
O.C. not perfect  
in microstrip,  
but better  
than S.C.



C-band earth terminal

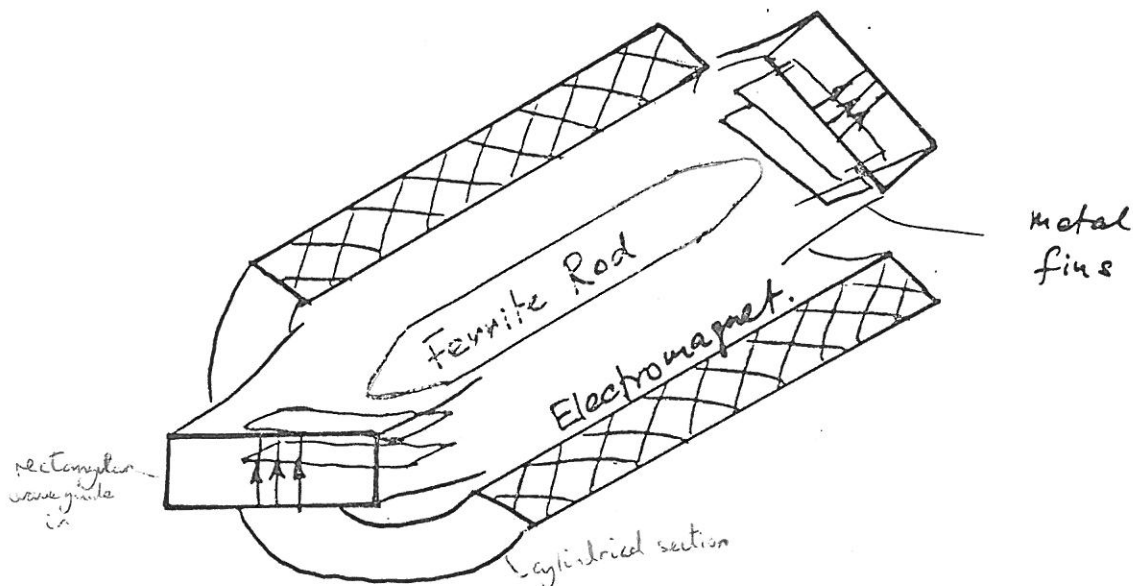
# Non - Reciprocal Devices

Faraday rotation:



Occurs in gyro-magnetic media, such as ferrites and the ionosphere, in the presence of a constant magnetic field  $B_0$ .

Faraday isolator:



Schematically :

