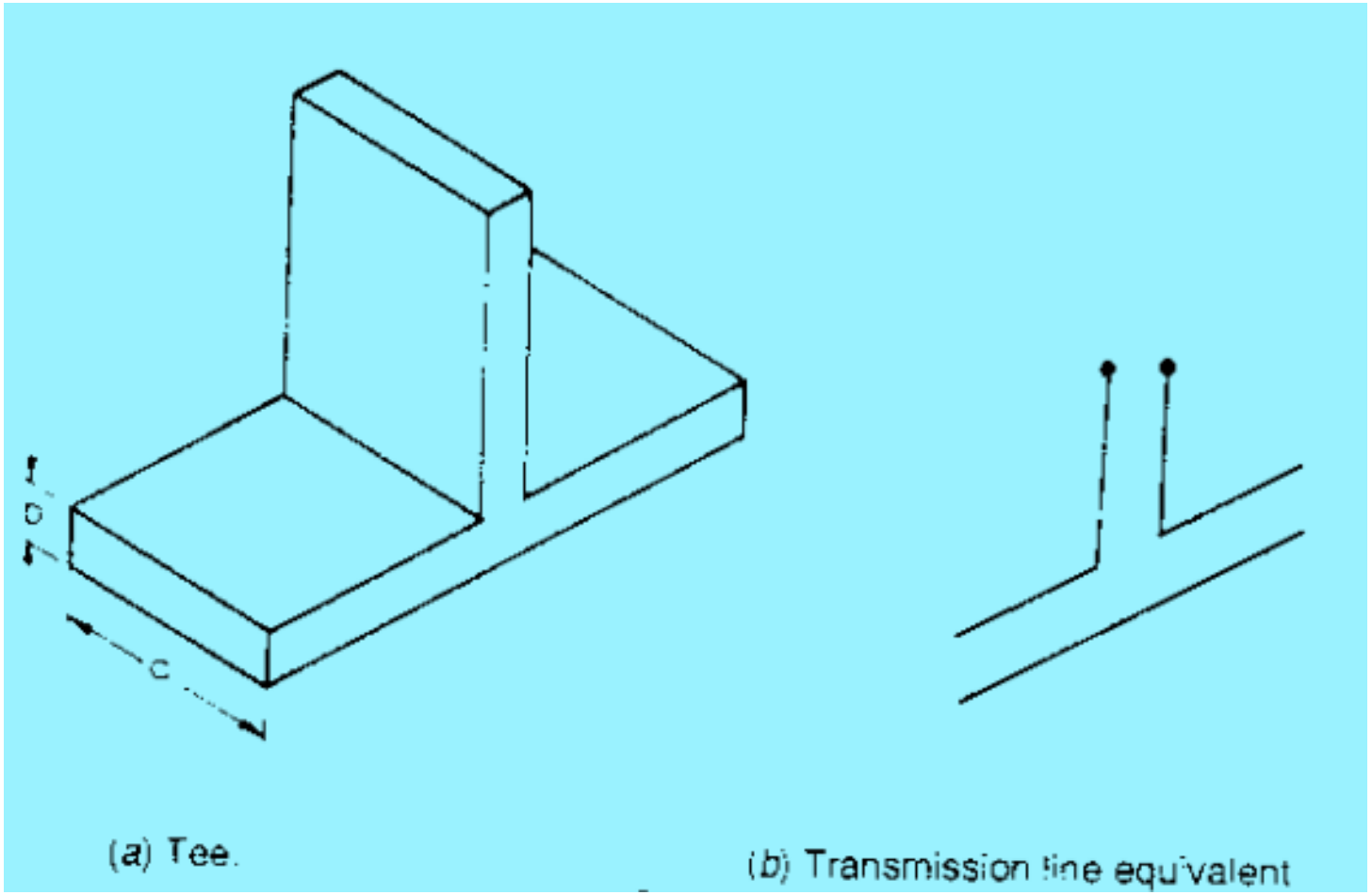
Microwave Components and Measurements

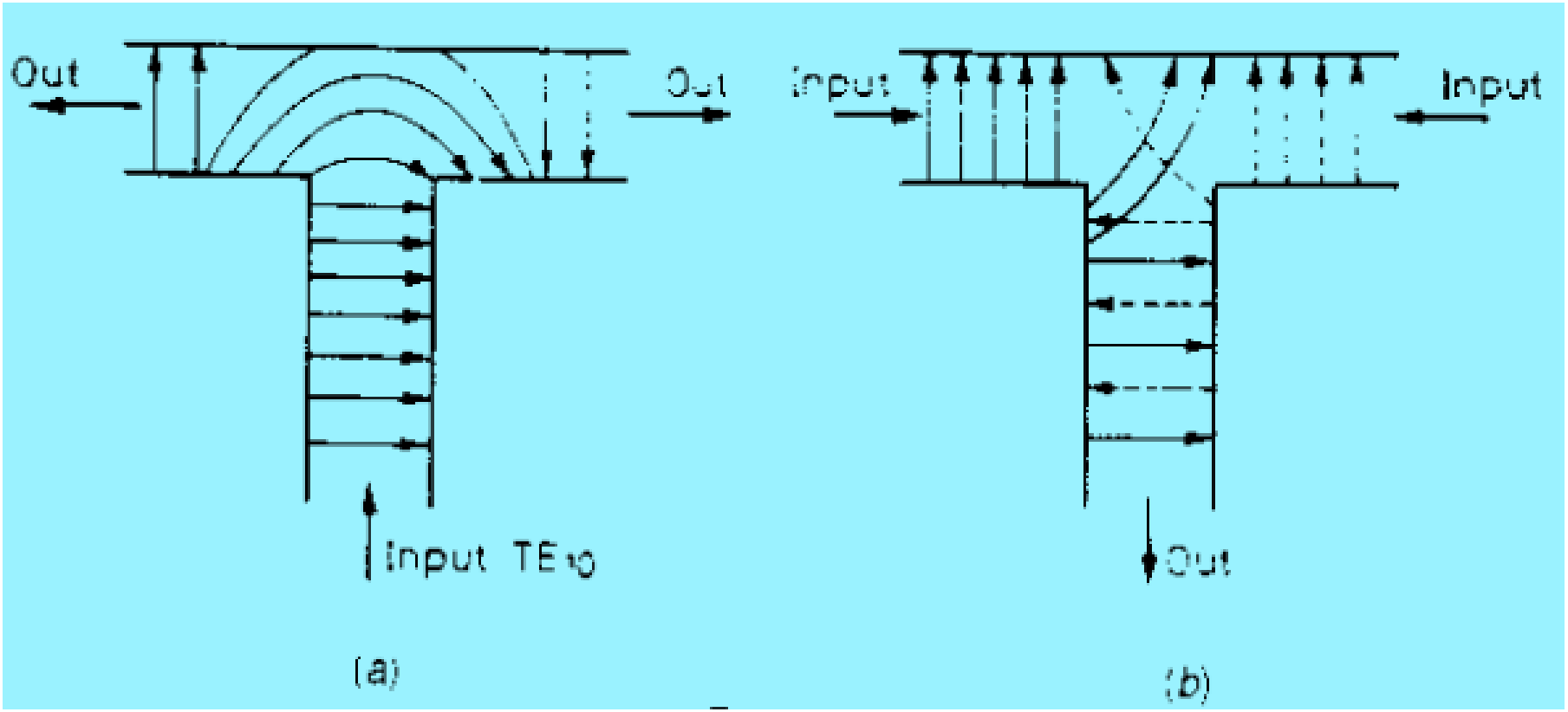
S.M. Riazul Islam, PhD

Wave guide Tees

- E-plane Tee: Series Type; voltage junction



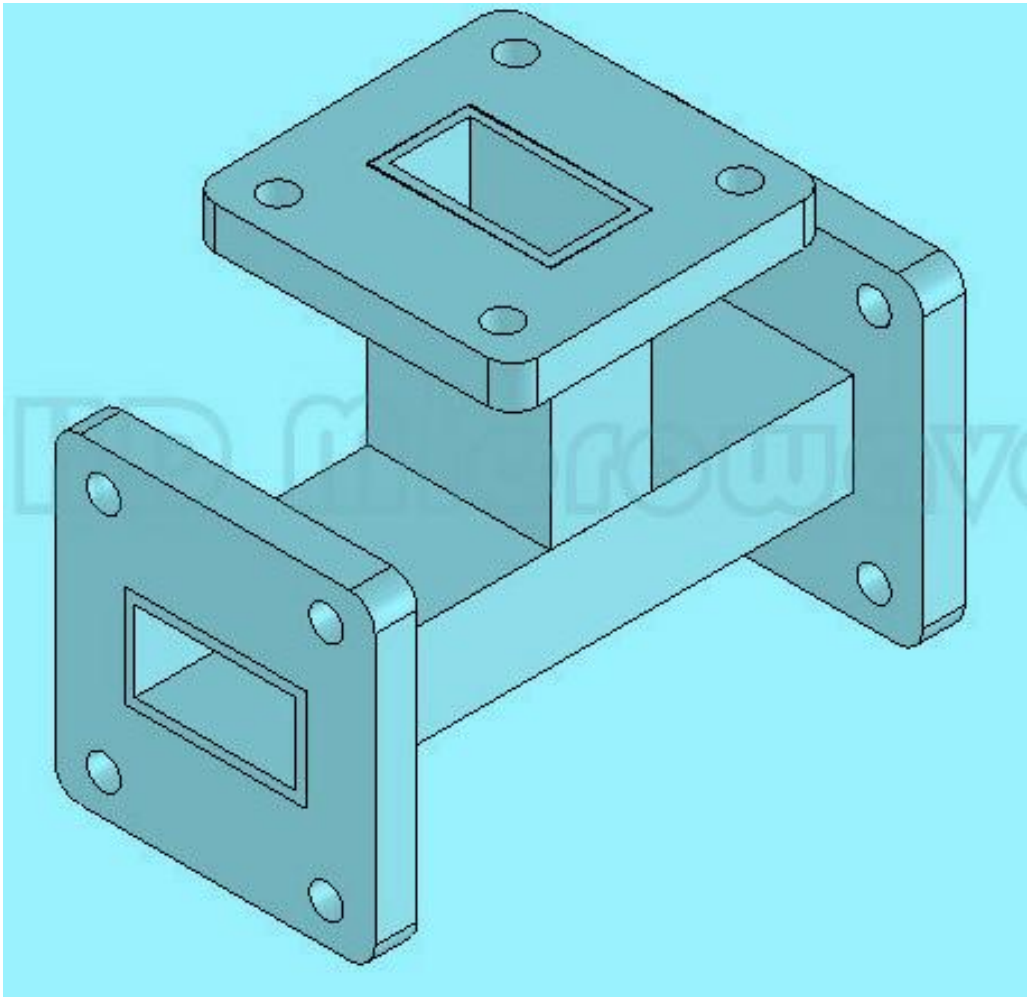
Wave guide Tees



- Max energy leaves the side arm when waves entering the junction through main arms are in phase opposition.

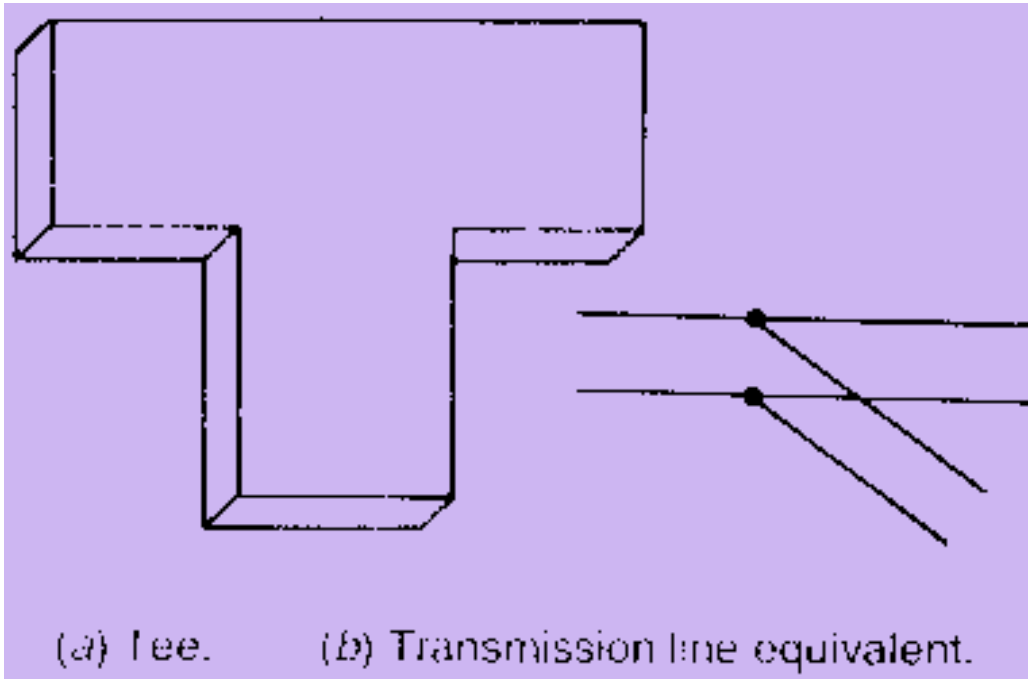
Wave guide Tees

- E-plane Tee



Wave guide Tees

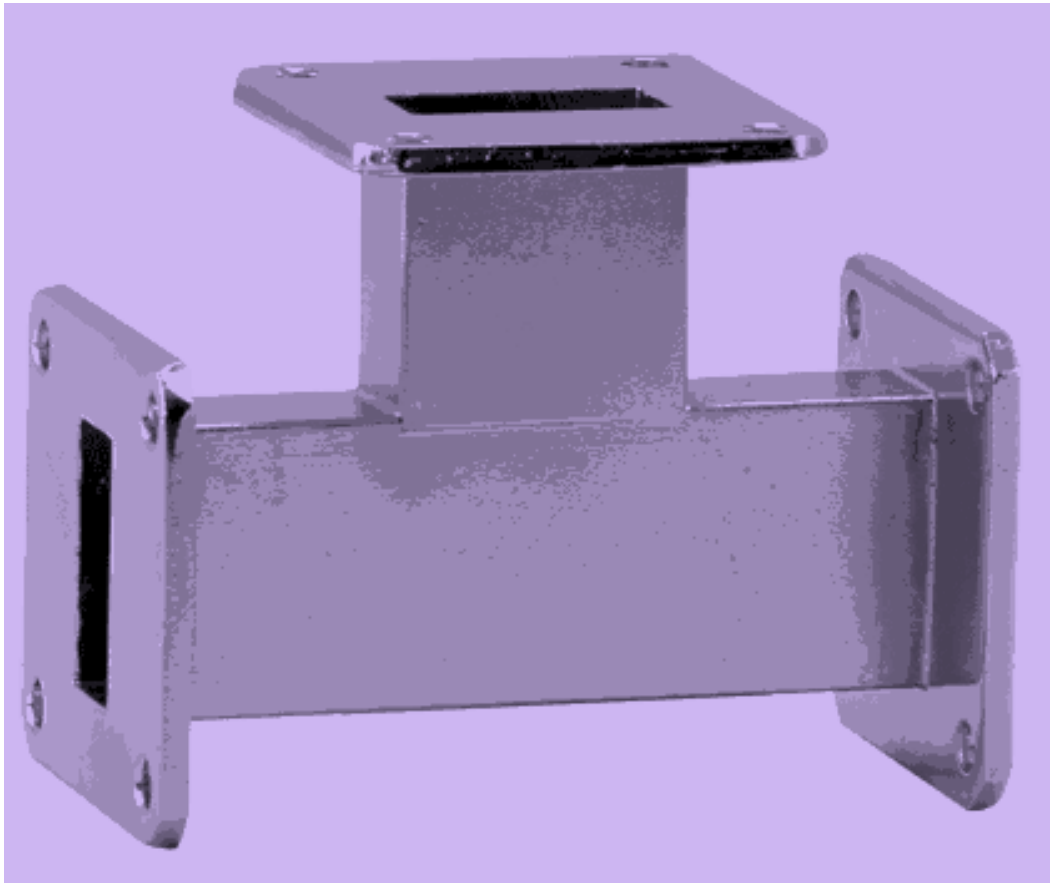
- H-plane tee: Shunt type; current junction



- Max energy delivers to side arms occurs when waves entering the junction through main arms in phase.

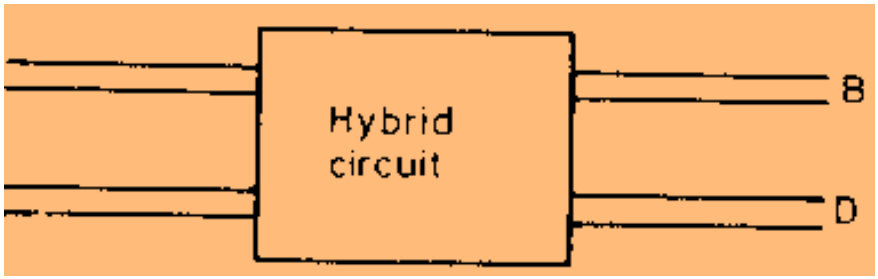
Wave guide Tees

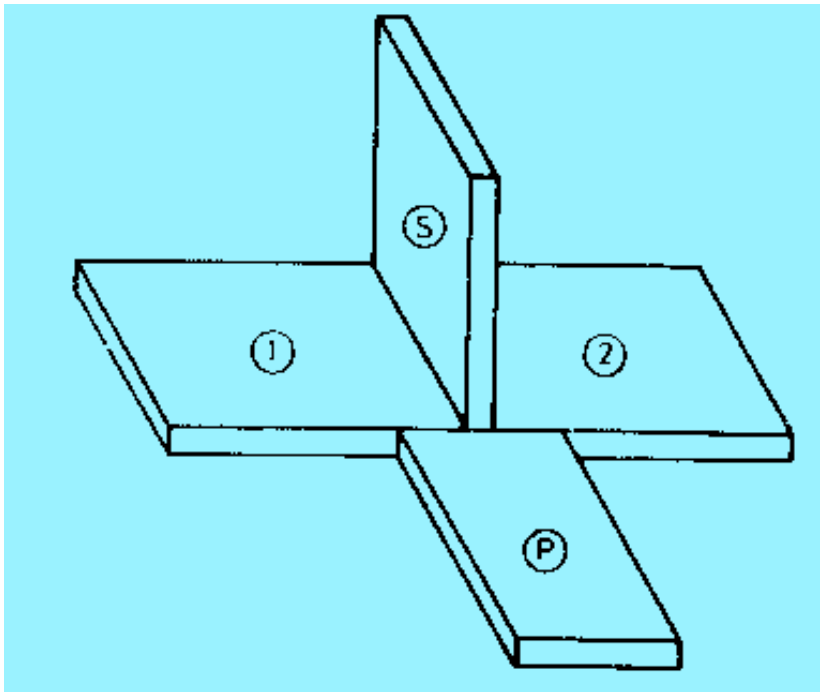
- H-plane Tee

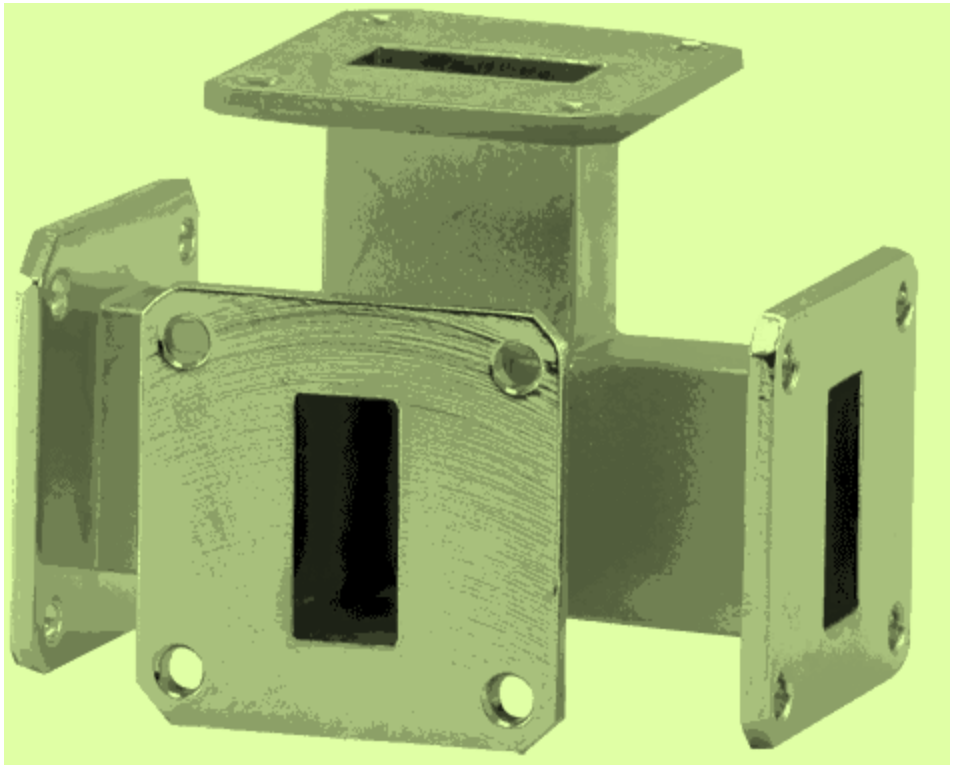


Wave guide Tees

- Magic Tee: 4-port hybrid circuit

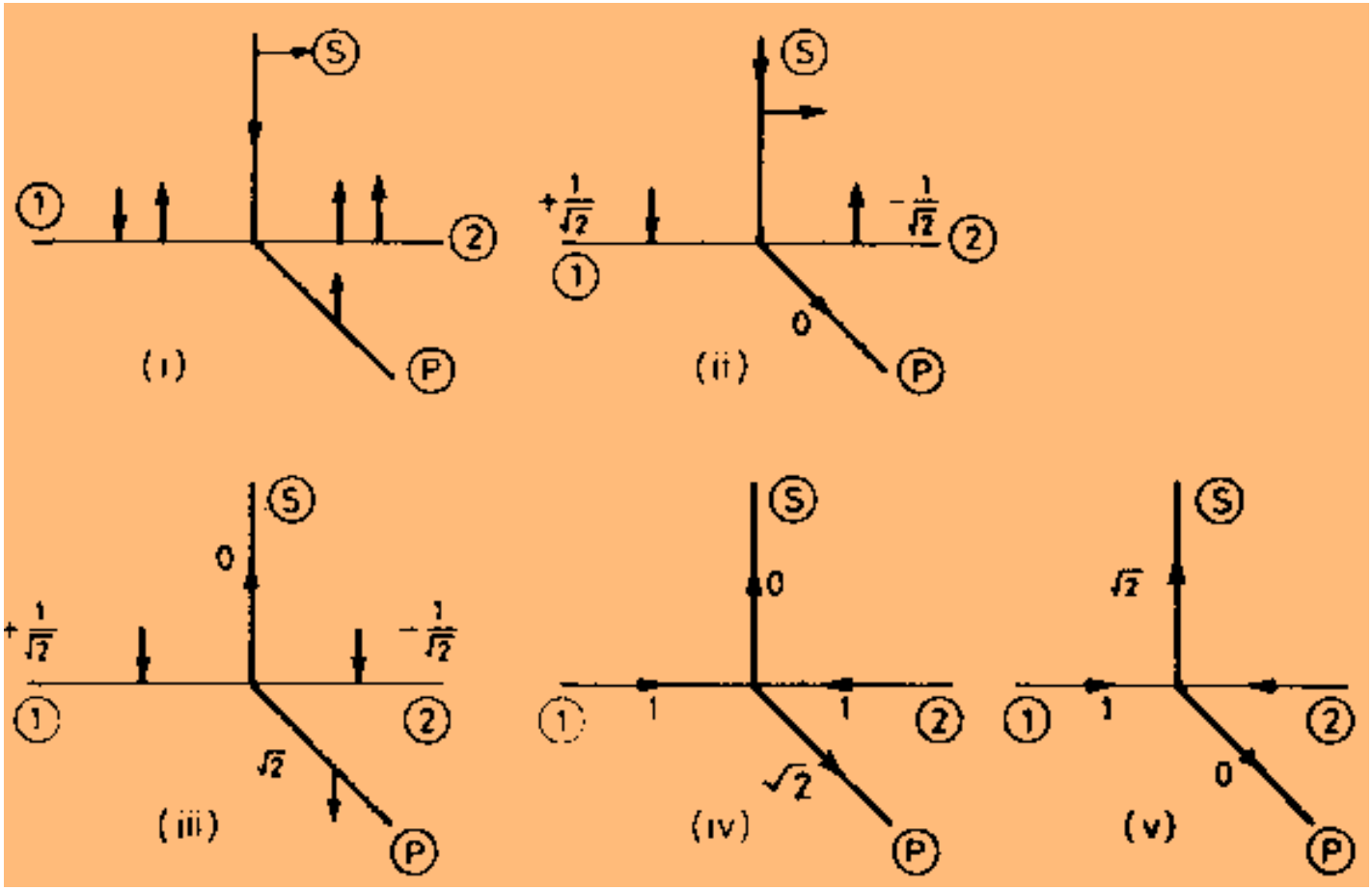






Wave guide Tees

- When waves of equal amplitude and phase enter the P and S arms, the E-fields cancel in one of the side arms and add in the other (i).



Wave guide Tees

- When power enters through 1 and 2, the fields leaving the P arm are proportional to the phasor sum of the two I/P fields (iv).
- While the fields leaving arms S are proportional to phasor difference of two input fields (v).

- If 1 and 2 are terminated in matched load, no reflection inside the junction
  - entrance of power through either S or P results in equal power delivery to 1 and 2.
- Reflections may take place due to severe discontinuity in the junction--

Wave guide Tees

- Effect of Reflection:
  - Only a portion of power is delivered to 1 and 2
  - Not Equal power delivery
  - Balance does not exist! (some power transmits directly from 1 to 2 or from 2 to 1)
    - ?Avoidance: Isolator, Matching device, phase shifter

Directional Couplers

- Used for unidirectional power measurement, SWR measurement, and unidirectional wave launching.

- 4 pairs of terminals
  - Power transfer from C to D w/o reflection
  - No transfer of power bet A and C or B and D
  - Degree of coupling: A and D; B and C

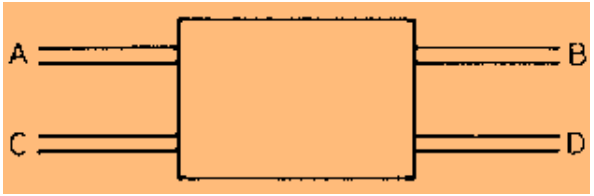
- Performance: Coupling factor and Directivity

Directional Couplers

- Coupling: ratio of the I/P power to coupled power in dB.
- If power out of B is 1/100 of the power into C, the component is a 20 dB coupler.
- As the coupling becomes tighter, the reduction in power at arm D becomes greater.
- 10 dB coupler: 90%; 3 dB coupler: 50%
- Above: Perfect coupler; no power out of A ➔ directivity

Directional Couplers

- Directivity: power out of coupling arm to the unwanted signal in A.
  - Directivity can be more or less than the coupling
    - 10 dB coupler with 30 dB directivity!!



In general, coupling factor

$$= -10 \log_{10} \frac{P_B}{P_C} \text{ dB}$$

Directional Couplers

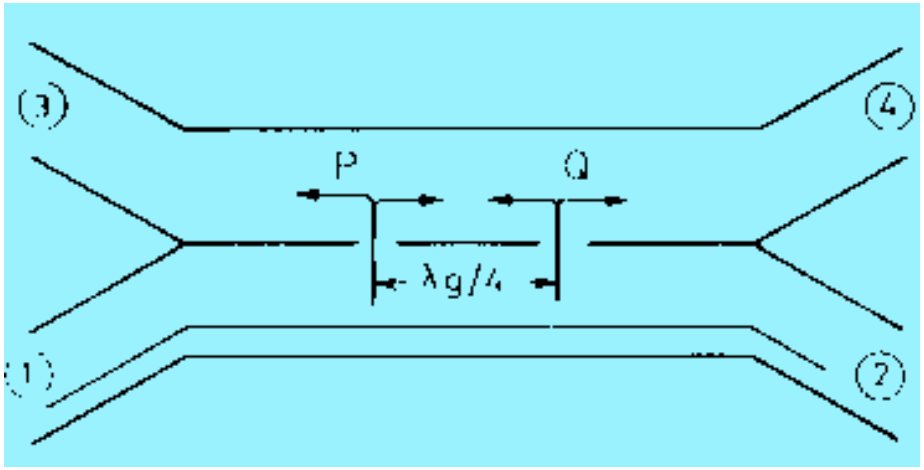
$$directivity = 10 \log \frac{P_C}{P_A}$$

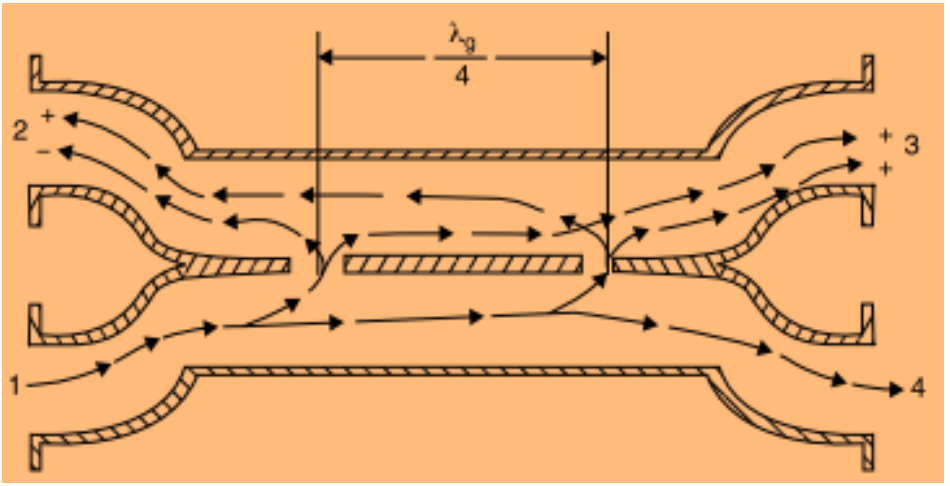
- Coupling factor: measure of energy levels in primary and secondary wave guides.
- Directivity: how well the forward travelling wave in primary guide couples only to desired terminals of secondary wave guide.

- Only three out of four ports are used. The unwanted port usually being terminated by a matched load built into it.

Directional Couplers

- Two hole directional coupler:

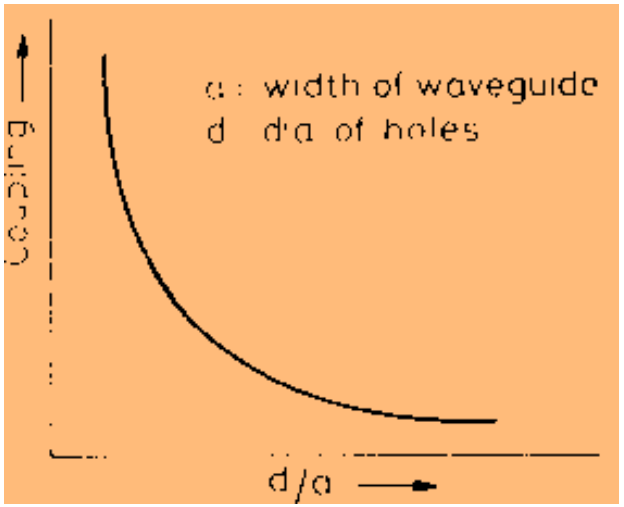


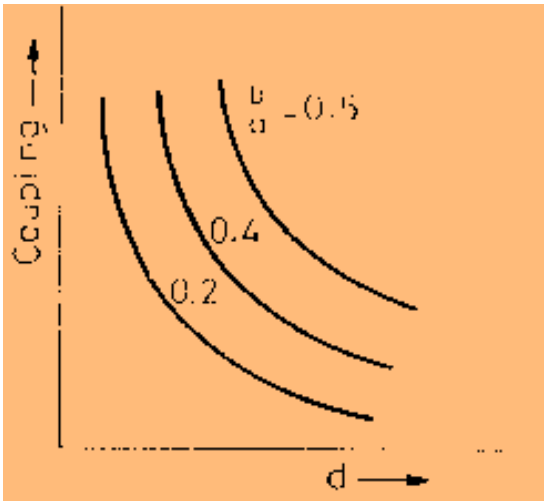


$$\frac{2\pi}{\lambda g} \times 2 \times PQ = \frac{4\pi}{\lambda g} \times \frac{\lambda g}{4} \therefore \pi \text{ radians.}$$

Directional Couplers

- Two whole directional Coupler

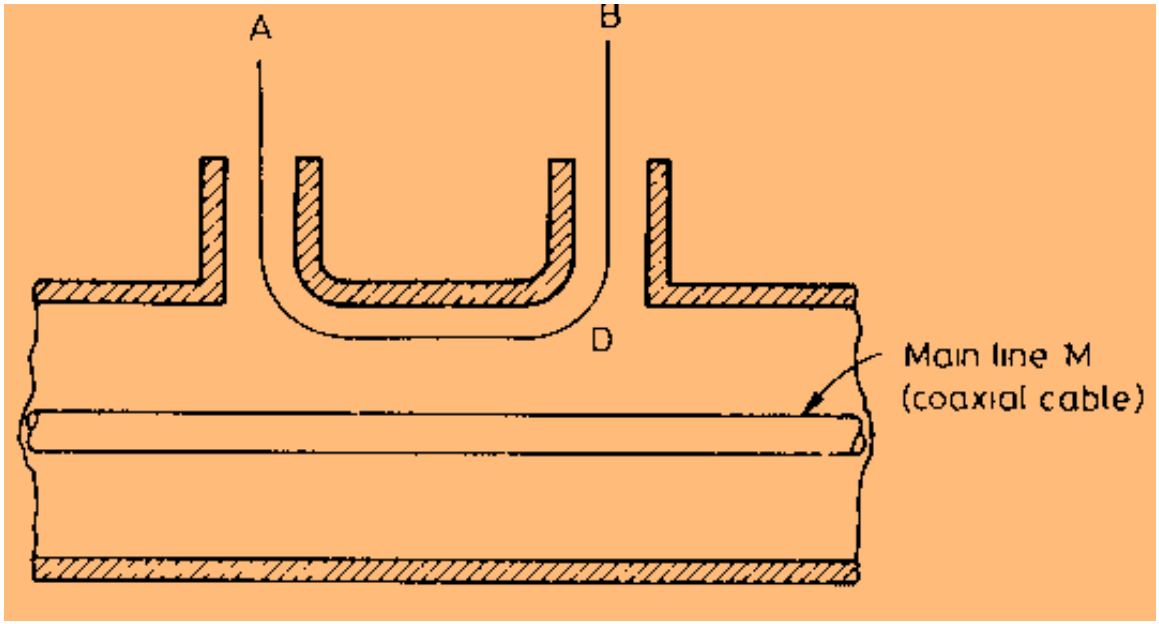




- Sample power appearing at port (4) is uitilized for a) measurement purpose b) feedback purpose too.

Directional Couplers

- Loop directional coupler:



Microwave Power Mes

- Bolometer Methods:

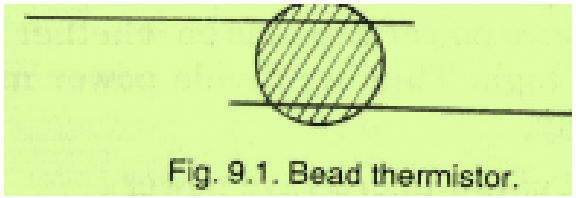


Fig. 9.1. Bead thermistor.

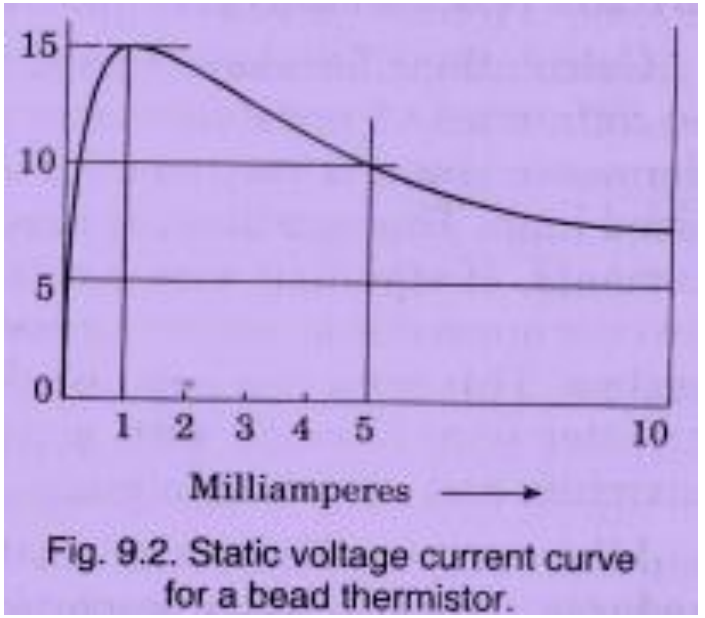


Fig. 9.2. Static voltage current curve for a bead thermistor.

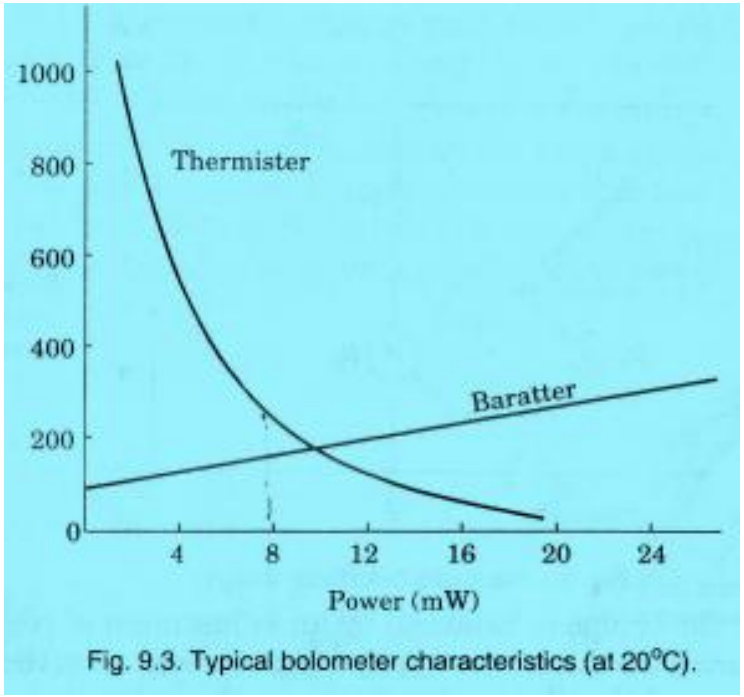


Fig. 9.3. Typical bolometer characteristics (at 20°C).

MW Power Mes

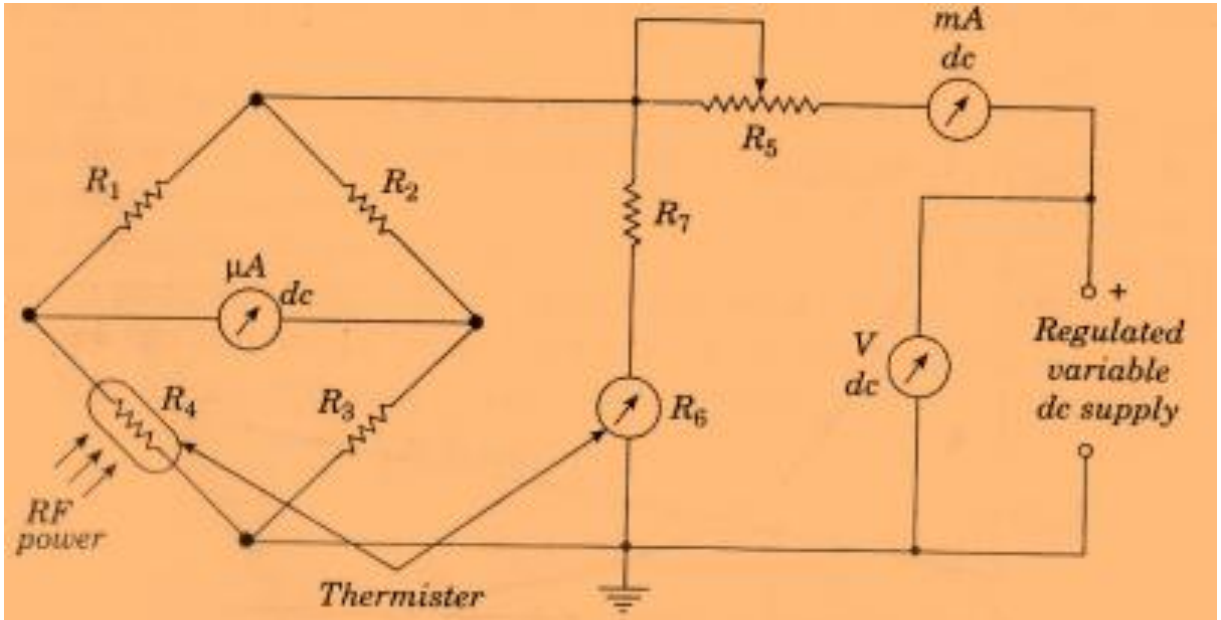


Fig. 9.4. Balanced bolometer bridge.

Initially the bridge is balanced [illegible]

MW Power Mesurements

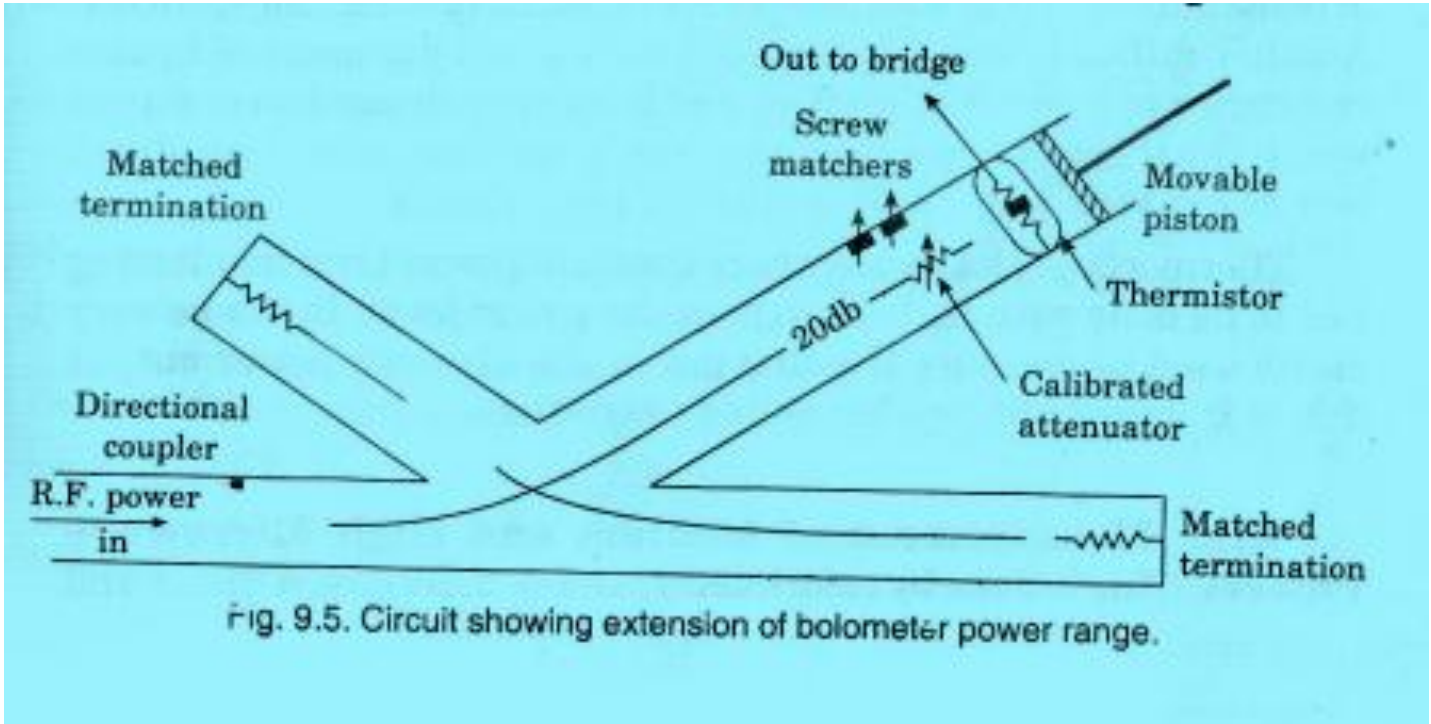


Fig. 9.5. Circuit showing extension of bolometer power range.

MW Power Mesurements

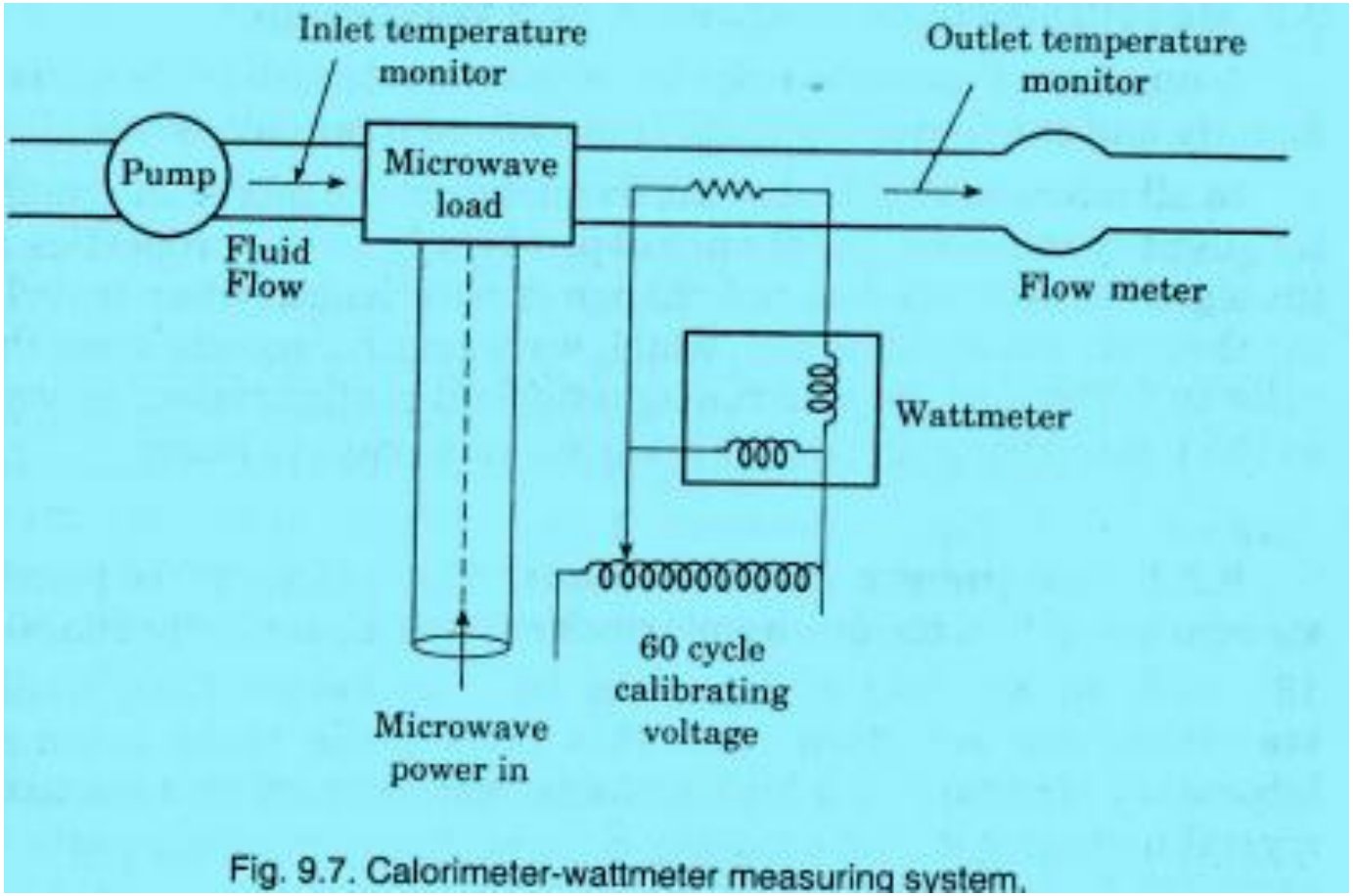


Fig. 9.7. Calorimeter-wattmeter measuring system.

Klystrons

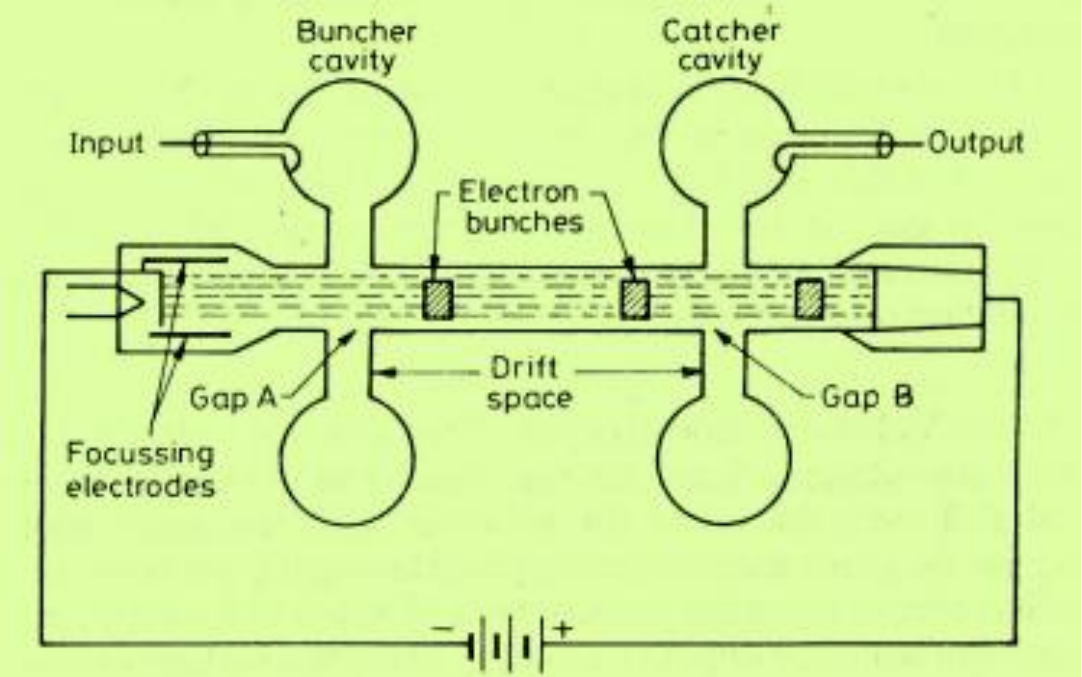


Fig. 7.1. Schematic diagram of a klystron amplifier.

Klystrons

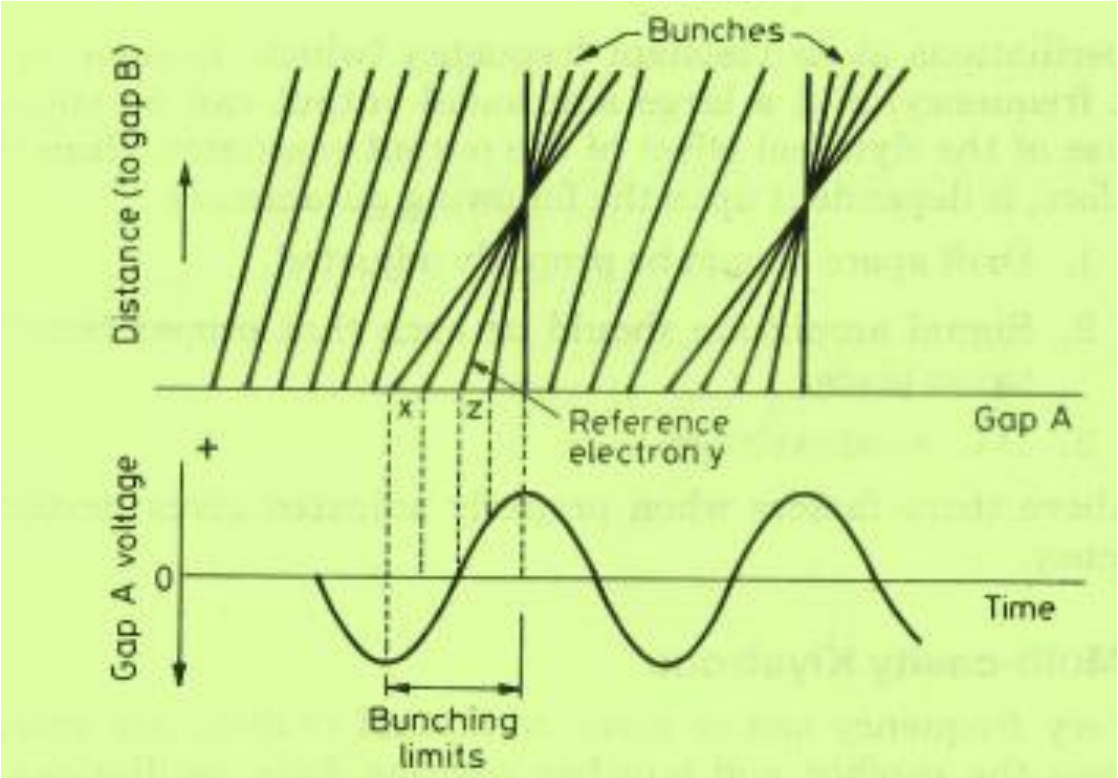


Fig. 7.2. Applegate diagram for klystron amplifier.

Klystrons

- Multi-cavity Klys

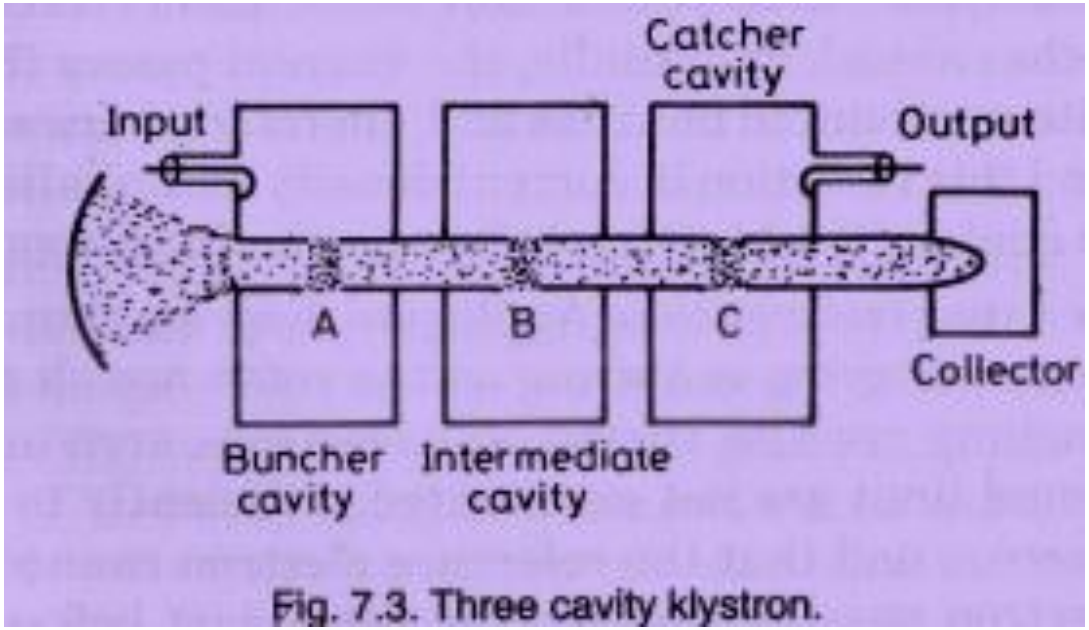


Fig. 7.3. Three cavity klystron.

Klystrons

- Reflex Klys

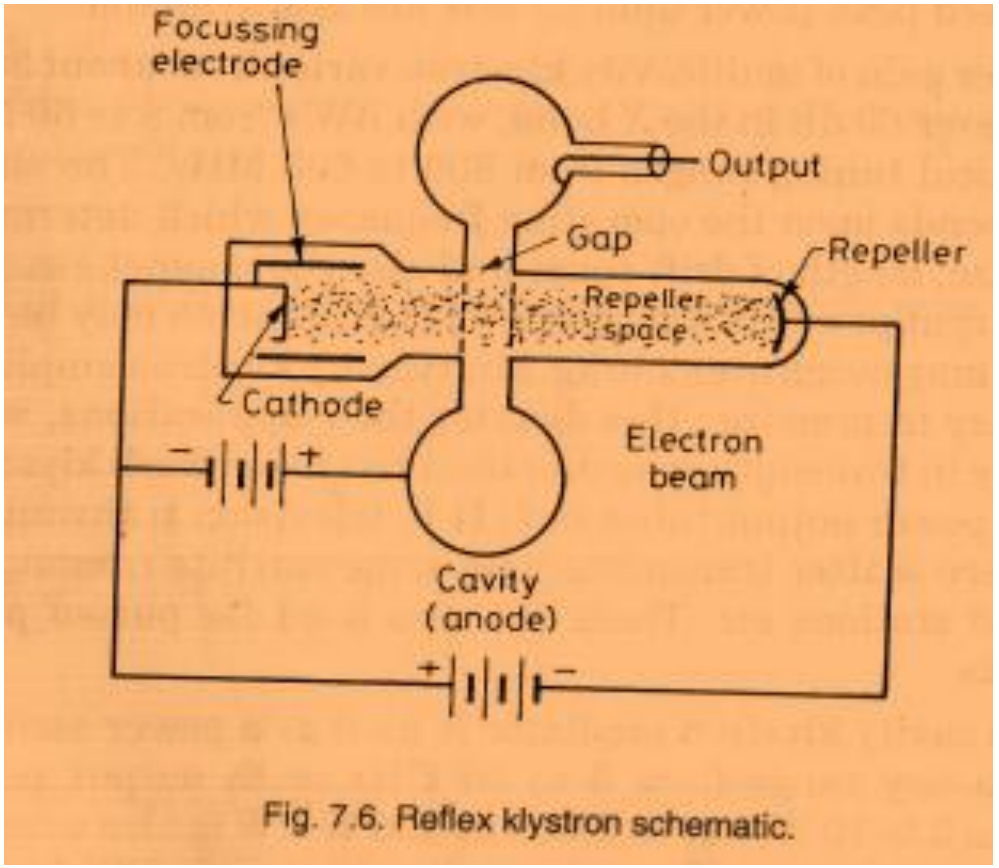


Fig. 7.6. Reflex klystron schematic.