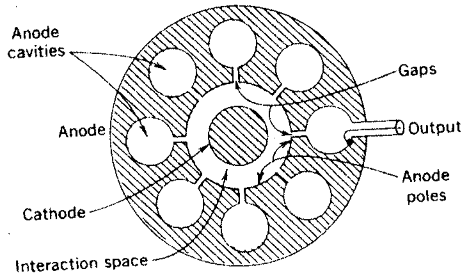
MAGNETRON

The "cavity magnetron" is a high power microwave oscillator was invented by Randall and Boot. It uses both electric and magnetic fields.

CONSTRUCTION :-

The shape of the magnetron is cylinderical. The crosssection is shown in the diagram.



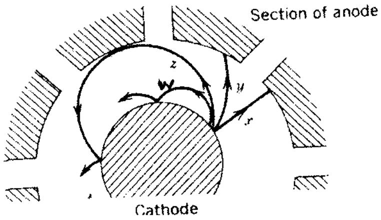
It employs a radial "electric field" and an axial "Magnetic field" and an anode structure with permanent cavities. The cylindrical cathode is surrounded by the anode with cavities and thus a radial electric field exist. The magnet is placed at the top and Bottom a the cylinderical construct and so axial magnetic field is applied and the line are thus at right angle to the cross section, So MF and EF are perpendicular to each other it is also known as "CROSS FIELD" device.

The smallest practical phase between two cavities is 45° or π/4, but π-mode is preffered. In this mode of operation, the phase difference between adjacent anode poles is π rad or 180°.

EFFECT OF MAGNETIC AND ELECTRIC FIELD

When magnetic and electric fields act simultaneously upon the electron, its path can have any of a number of shapes dedicated by relative strength of magnetic field and electric field.

When the MF is zero, the electron goes straight from cathode to the anode as indicated by 'x' electron in diagram. When the magnetic field has a small but definite strength, it will

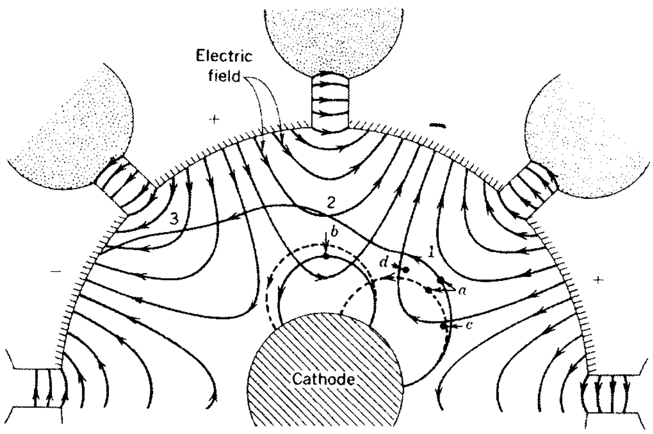


exert lateral force of electrons as shown by electron 'y'. As the MF increases the electrons are accelerated velocity increases and more bending of electrons takes place. It is possible to make the M.F so strong that electrons will not reach the anode at all. The Magnetic field required to return electrons to the cathode after they have just ('Z') "GRAZED" the Anode is called "Cutt off field" or "CRITICAL M.F". If more M.F is increased than cutt off field its will return to cathode even sooner as "W" electron.

Operation of MAGNETRON

The π-mode is used commonly between adjacent poles. The formula

$$\phi = \frac{2\pi n}{N}$$



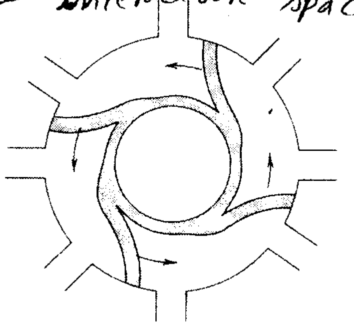
where
ϕ = phase
n = integer
N = no of cavity

Normally $N = 8$

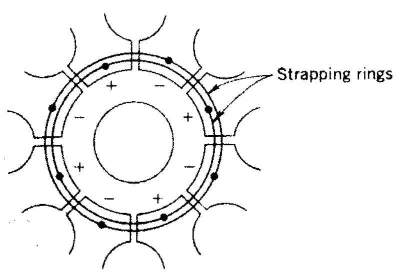
$$\phi = \frac{2\pi n}{8}$$ so for π-mode the value of $n = 4$.

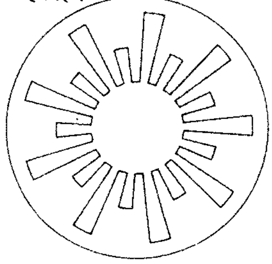
In the absence of the R.F field electrons 'a' and 'b' would have followed the path shown by dotted lines 'a' and 'b' respectively.

The presence of oscillations in the magnetron brings in a tangential R.F component of electric field. Each gap corresponds to maximum voltage point in the resulting standing wave pattern. When electron 'a' is situated at point 1, the tangential component of RF. retards, then it gives energy to RF. If the condition is arranged so that when electron 'a' reaches at point 2 the polarity is reversed and it is deaccelerated and the the effect of magnetic force is decrease because it is equal to BeV and it is moving towards the anode spend considerable time in anode interaction space. This is called "favourable Electrons"



But Electron 'b' is so placed that it absorbs equal amount of energy from the R.F field but spend much less time in interaction space are "UNFAVORABLE" produces "Back heating". The Bunching occurs is known as "phase focusing effect". The wheel-spoke bunches in the cavity magnetron. The is called the "TRAVELING WAVE MAGNETRON".





(b) RISING SUN

The Mode Jumping is prevented by either "STRAPPING or RISING SUN Cavity. In strapping the copper rings are used to connect alternate rings. But in high power losses in copper rings becomes significant so in high power "RISING SUN".

Frequency PULLING & PUSHING

FREQUENCY PUSHING :- The change in frequency of oscillations by changing the Anode voltage because change in Anode Voltage changes the orbital velocity of Electron cloud which change the rate of energy given to resonator is called Frequency pushing

FREQUENCY PULLING :- The frequency variations caused by the changes in the load variations is called Frequency pulling.

Types of Magnetrons

1) FREQUENCY-Agile (Dither-turned):- The volume of cavity is changed in order to vary the frequency with help of Piston. The piston is operated by a processor-controlled servometer, permitting very large frequency changes to be made quickly. This is of advantage to the radar from jamming.

2) Voltage tunable magnetron (VTM) → The frequency is adjust with the help anode voltage and . The use low-Q cavities, cold cathodes and an extra injection electrode.

PERFORMANCE CHARACTERISTICS

1) Power Output : 250 kW (pulsed Mode)
   8 kW (at 95 GHz)

2) Frequency : 500 MHz to 12 GHz

3) Duty Cycle : 0.1%

4) Efficiency : 40% to 70%

Applications

1) Pulsed Radar is single most important application with large pulse power

2) VTM are used in sweep oscillators in telemetry and in missile applications.

3) Fixed frequency : CW is used in microwave ovens around 2.5 GHz with 50% η.