KLYSTRON:

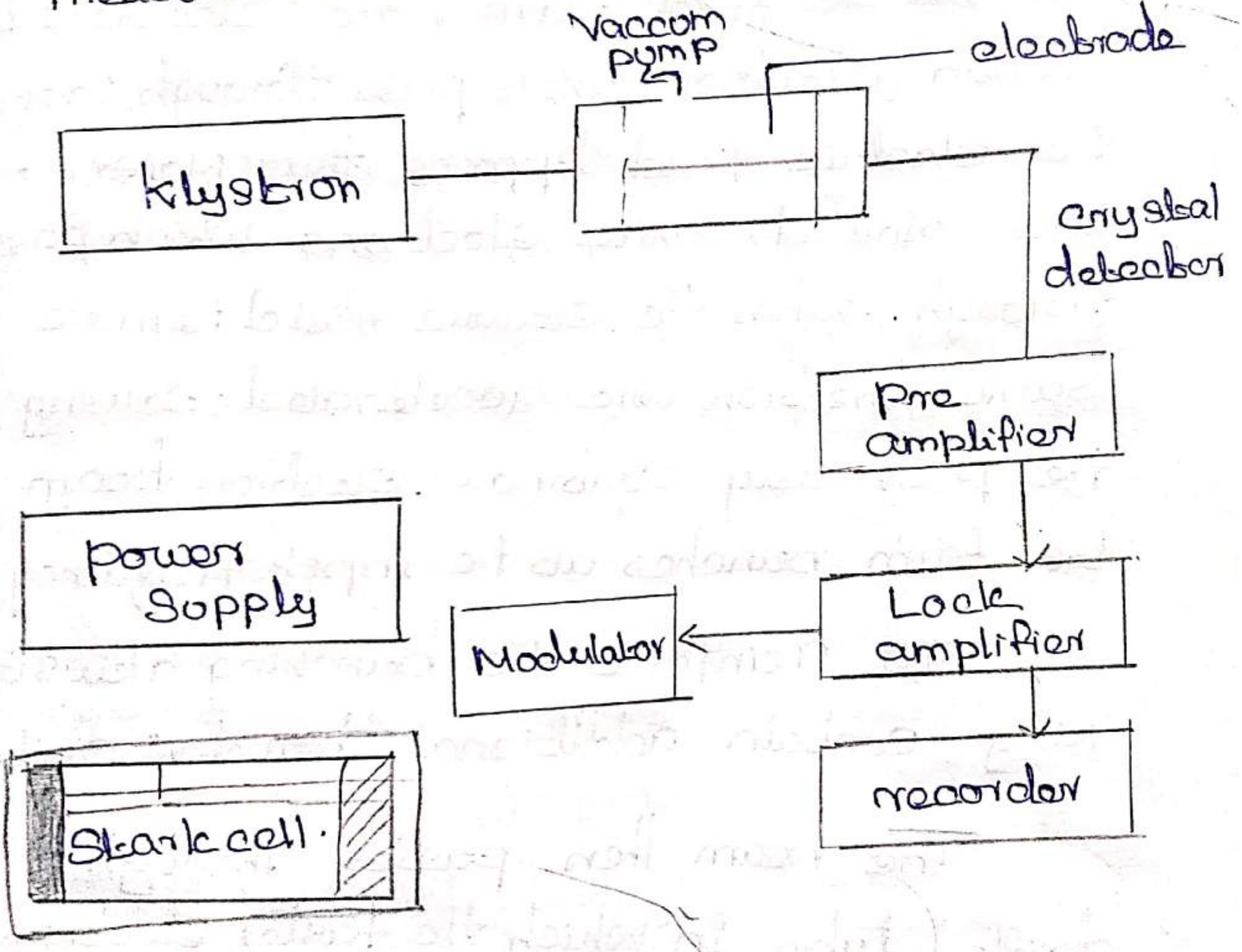
Klystron is a very high frequency radio value which provides a very stable Monochromatic source of radiation Reflex klystron is widely used as Microwave source, As the frequency of the emitted radiation depend on the supply voltage to the klystron value, the voltage is tuned over a suitable range to obtain the required region of Microwave radiation.

klystron at 70 and 140 GHz regions are commercially available and for high frequencies backward wave oscillator tubes are used klystron and backward wave oscillator tubes have certain drawbacks.

(i) The power output is very small and is of the order of ≃ 30 mW

(ii) They require 300 - 400V for this operation Since the energy radiated is concentrated into a very narrow frequency region the first drawback can be overcome by the use of Gun diode which requires only 20v input power.

Cavity wavemeters with accuracy between +1 and ± 5MHz can be employed to Measure. The frequency of the emitted microwave radiation. Frequency counters or beat technique are used for accurate and direct microwave frequency measurements.



Working :-

Klystron amplify RF Signals by coverting the kinetic energy in a DC electron beam into radio frequency power. In a vaccom beam of electron is emitted by a electron gun or thermionic cathode and accelerated by high - voltage electrodes.

The beam passes through an input cavity or resonator RF energy has been fed into the input cavity at or near its resonant frequency. Creating Standing waves which produce an oscillating voltage. which acts on the electron beam. The electric field causes the electrons to "bunch" electrons that pass through when the electric field opposes their motion, are slowed, while electrons which pass through. when the electric field is in the same direction are accelerated causing the previously continous electron beam to form bunches at the input frequency.

To reinforce the bunching a klystron may contain additional "buncher" cavities.

The beam then passes through a "drift" tube in which the faster electrons catch up to slower ones creating the "bunches". then through a "catcher" cavity

In the output "catcher" cavity each bunch enters the cavity at the time is the cycle when the electric field opposes the electrons motion

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deacelerating them. Thus the kinetic energy of the electron is converted to potential energy of the field increasing the amplitude of oscillations. The oscillation excited in the catcher cavity are coupled out through a co-axial cable or waveguide.

The spent electron beam with reduced energy is captured by a collector electrode.

To make an oscillator the output cavity can be coupled to the input cavity with a co-axial cable or waveguide. positive feedback excites spontaneous oscillations at the resonant frequency of the cavities.

Two cavity klystron:

The simplest klystron tube is the two cavity klystron. In this tube there are two microwave cavity resonators the "catcher" and the buncher when used as an amplifier the weak microwave signal to be amplified is applied to the "buncher cavity" through a co-axial cable or waveguide and the amplified signal is extracted from the catcher cavity.

At one end of the tube is the hot cathode which produces electrons when heated by a filament. The electrons are attracted to to and pass through an anode cylinder at a high positive potential the cathode and anode act as an electron gun to produce a high velocity stream of electrons.

An external electromagnet winding creates a longitudinal magnetic field along the beam axis which prevents the beam from spreading.

The beam first passes through the "buncher" cavity resonator through grids attached to each side. The buncher grids have an oscillating AC potential across them produced by standing waves oscillations within the cavity excited by the input signal at the cavity resonant frequency applied by a co-axial cable (or) waveguide.

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COLOUR PERCEPTION :-

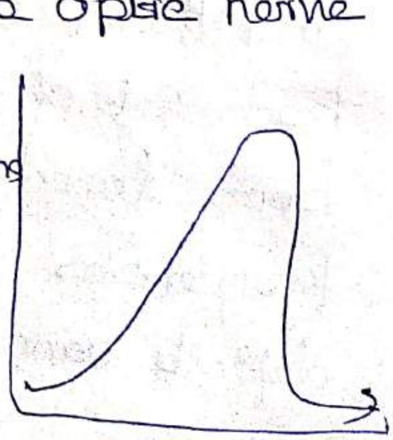
All objects that we observe are focused sharply by the lens system of the eye on its retina. The retina which is located at the back side of the eye has light sensitives visual sensations. organs which measure the The retina is connected with the optic nerve which conducts the light stimuli as sensed by the organs to the optical centre of the brain.

According to the theory formulated by Helmholtz the light sensitive organs are of two types rods and cones. The rods provide brightness sensation and thus perceive objects only in various shades of grey from black to white. The cones that are sensitive to colour are broadly in three different groups. One set of cones detects the presence of blue colour in the object focused on the retina, the second set perceives red colour and third is sensitive to the green range. Each set of cones may be thought of as being tuned to only a small band of frequencies and so absorb energy from a definite range of electromagnetic radiation.

to convey the sensation of corresponding colour or range of colour. The combined relative luminosity curve showing relative sensation of brightness produced by individual spectral colours radiated at a constant energy level is shown in fig 25.2. It will be seen from the plot that the sensitivity of the human eye is greatest for green light decreasing towards both the red and blue ends of the spectrum. In fact the maximum is located at about 550nm, a yellow green, where the spectral energy maximum of sunlight is also located.

THREE COLOUR THEORY

All light sensation to the eye are divided (provided there is an adequate brightness stimulus on the operative cones) into three main groups. The optic nerve system then integrates the different colour impressions in accordance with the curve as shown in fig. 25.2 to perceive the actual colour



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of the object being seen. This is known as additive mixing and forms the basis of any colour television system. A yellow colour, for example can be distinctly seen by the eye when the red and green groups of the cones are excited at the same time with corresponding intensity ratio. Similarly any colour other than red, green and blue will excite different sets of cones to generate the cummulative sensation of the colour. A white-colour is then perceived by the additive mixing of the sensation from all the three sets of cones.

MIXING OF COLOURS :

Mixing of colours can take place in two ways - subtractive mixing and additive mixing. In subtractive mixing reflecting properties of pigments are used which absorb all wavelength but for their characteristics colour wavelengths. When pigments of two or more colour are mixed they reflect wavelength which are common to both. Since the pigments are not quite saturated (pure in colour) They reflects a fairly wide band of wavelengths. This type of mixing takes place in painting and colour printing.

In additive mixing which forms the basis of colour television, light from two or more colour obtained either from independent source or through filters can create combined sensation of a different colour. These different colours are created by mixing pure colours and not by subtracting parts from white

The additive mixing of three primary colour red, green and blue in adjustable intensities can create most of the colours encountered in every-day life. The impression of white light can also be created by choosing suitable intensities of those colours.

Red, green and blue are primary colours. These are used as basic colours in television. By 'pairwise additive mixing of the primary colours the following complementary colour are produced.

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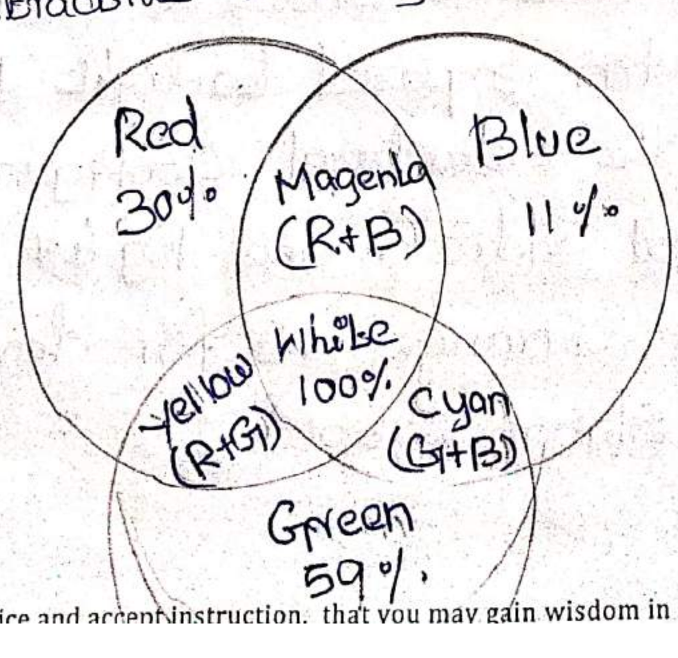
Red + Green = Yellow

Red + Blue = Magenta (purplish red shade)

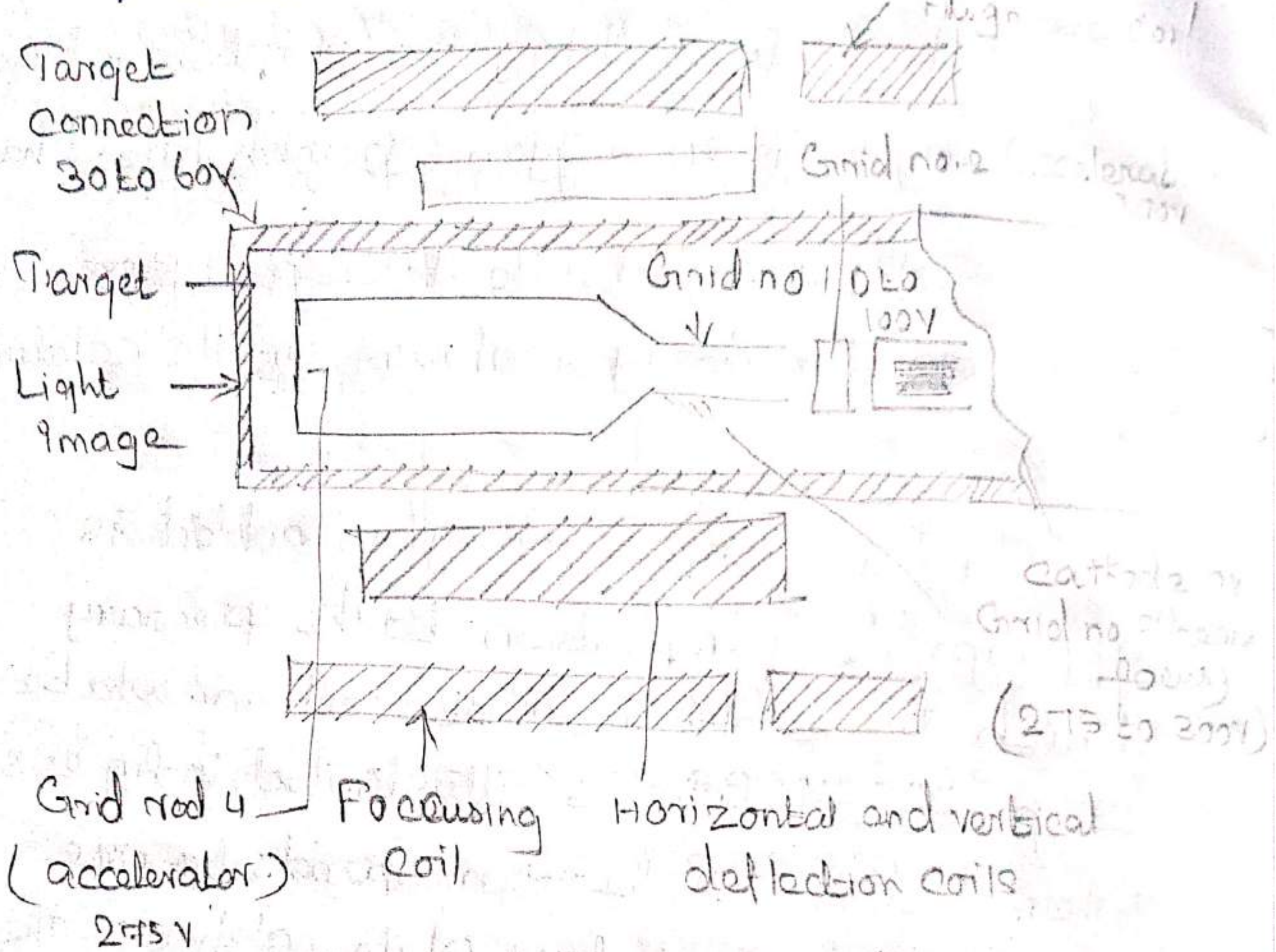
Blue + Green = Cyan (greenish blue shade)

colour plab 1 depicts the location of primary and complementary colours on the colour circle.

If a complementary is added is appropriate porepostion to the primary which it itself doesnot contain, white is produced. This is illustrated in fig 25.3(a) where each circle corresponds to one primary colour, colour plate 2 shows the effect of colour mining. Similarly Fig 25.3(b) illustrates the process of subtractive mining. Note thus as additive mining of the three primary colours produces white, their subsbractive mining result in black.



VIDICON :-



The Vidicon came into general use in the early 50's and gained immediate popularity because of its small size and ease of operation. It functions on the principle of photoconductivity where the resistance of the targets material shows a marked decrease when exposed to light. Fig. 6.6 illustrates the structural configuration of a typical Vidicon and Fig 6.7 shows the circuit arrangement for developing camera signal output.

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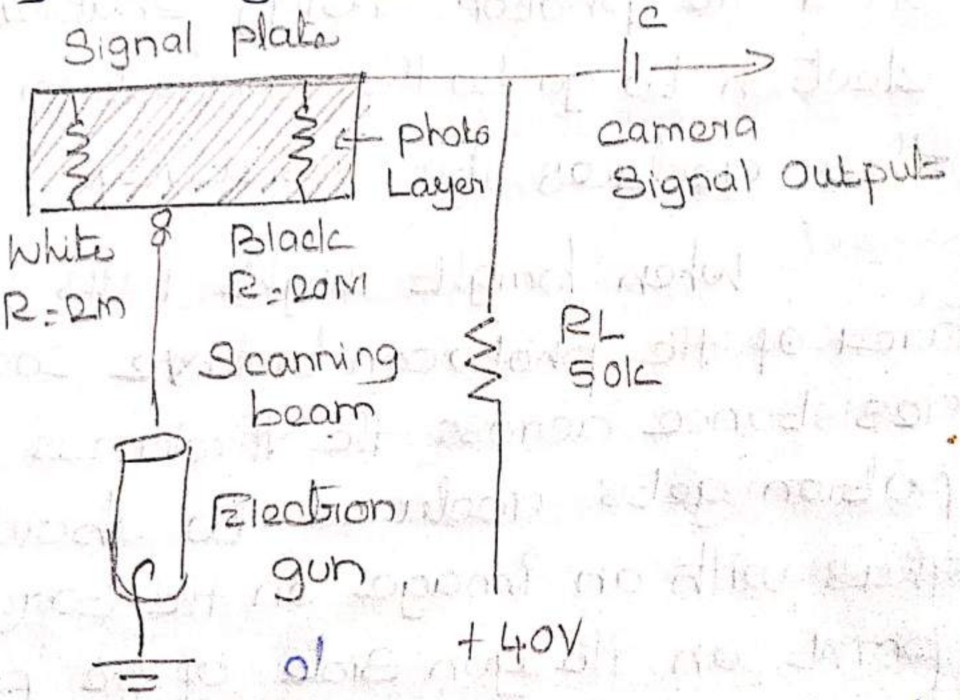
As shown there the target consist of a thin photo Conductive layer of enter selenium rantimony compound. This is deposited on a transparent conducting film coated on the inner Surface of the face plate. This conductive coating is known as Signal electrode or plate. Image Side of the photolayer, which is in contact with the Signal electrode is connected to DC supply through the load resistance RL



The beam that emerges from the electron gun is focussed on Surface of the photoconductive layer by Combined action of Uniformmagnetic field of an external coil and electrostatic field of grid No.3. Grid No.4 provides a Uniform deaccelerating field between itself and the photoconductive layer and the photoconductive layer. So that the electron beam approaches the layer with a low velocity to prevent any secondary emission. Deflection of the beam for scanning the target is obtained by vertical and horizontal deflecting coil placed around the tube.

The photolayer has a thickness of about 0.0001 cm and behaves like an insulator with a resistance of approximately 20 MΩ when in dark with light focussed on a the photon energy enables more electron to go to the conduction band and this reduces its resistivity.

When bright lights falls on any area of the photoconductive coating, resistance across the thickness of that potion gets reduced to about 2 MΩ. Thus with an image on the target each point on the gun side of the photolayer assumes a certain potential with respect to DC supply depending on its resistance to the signal plate.

For example with B+ source of 40V see Fig. 6.5 an area with high illumination may attain a potential of about +39V on the beam side

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Similarly dark area, an accout of high resistance of the photolayer may rise to only + 35 volts. Thus a pattern of positive potentials appears, on the gun Side of the photolayer, producing a charge image that corresponds to the incident optical image.

Though light from the scene fall continously on the target. each beam of the photoconducting is scanned intervals equal to the frame time. This results in storage action and the net change in resistance at any point or element on the photoconductive layer depend on the time, which elapses between two successive scannings and the intensity of incident light. Since storage time for all points on the target plate is same the net change is resistance of all elementary areas proportional to light intensity variation in the scene being televised.

Definition: A magnetron is a device that generates high power electromagnetic wave. It is basically considered as a self-excited microwave oscillator. And is also known as a *crossed-field device.*

The reason behind calling it so is that the electric and magnetic field produced inside the tube are mutually perpendicular to each other thus the two crosses each other.

Magnetron

1. Operating Principle
2. Construction
3. Working
4. Frequency Pushing and Pulling
5. Advantages
6. Disadvantages
7. Applications

Operating Principle

A magnetron is basically a vacuum tube of high power having multiple cavities. It is also known as **cavity magnetron** because of the presence of anode in the resonant cavity of the tube.

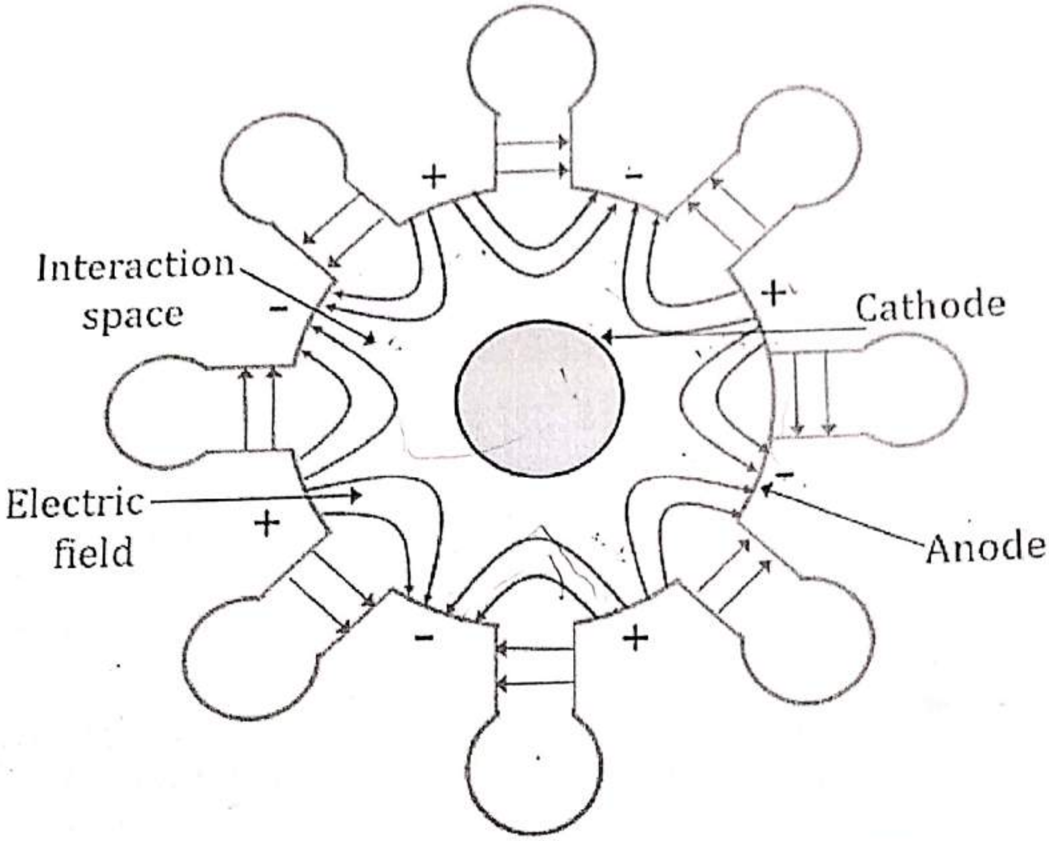
The operating principle of a magnetron is such that when electrons interact with electric and magnetic field in the cavity then high power oscillations get generated.

Magnetrons are majorly used in radar as being the only high power source of RF signal as a power oscillator despite a power amplifier. It was invented in the year **1921** by Albert Hull. However, an improved high power cavity magnetron was invented in **1940** by John Randall and Harry Boot.

Here in this article, we will discuss how a cavity magnetron works. But before that we must know how a magnetron is constructed.

Construction of Magnetrons

The figure here shows a magnetron with 8 cavities:



Structure of Magnetron

Electronics Desk A cylindrical magnetron has a cylindrical cathode of a certain length and radius present at the centre around which a cylindrical anode is present. The cavities are present at the circumference of the anode at equal spacing.

Also, the area existing between anode and cathode of the tube is known as *interaction space/region.*

It is to be noted here that there exists a phase difference of 180^0 between adjacent cavities. Therefore, cavities will transfer their excitation from one cavity to another with a phase shift of 180^0.

Thus we can say that if one plate is positive then automatically its adjacent plate will be negative. And this is clearly shown in the figure given above.

More specifically we can say that edges and cavities show 180^0 phase apart relationship.

As we have already discussed that here the electric and magnetic field are perpendicular to each other. And the magnetic field is generated by using a permanent magnet.

Working of Magnetron

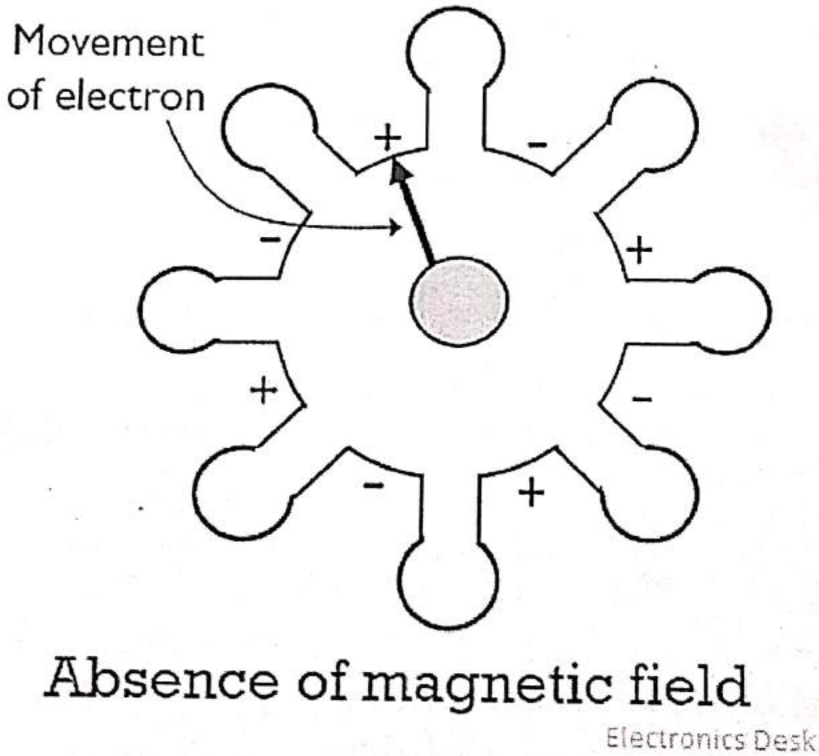
The excitation to the cathode of the magnetron is provided by a dc supply which causes the emergence of electrons from it.

Here in this section, we will discuss the working of magnetron under two categories. First without applying the RF input to the anode and the second one with the application of RF input.

1. When RF input is not present

Case I: When the magnetic field is 0 or absent

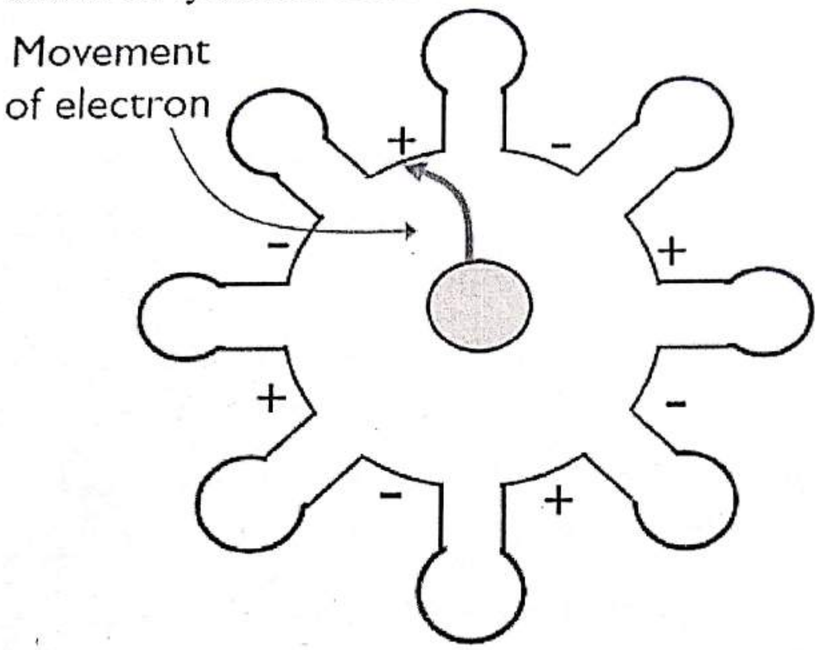
When the magnetic field is absent then the electron emerging from the cathode radially moves towards the anode. This is shown in the figure below:



This is so because the moving electron does not experience the effect of the magnetic field and moves in a straight path.

Case II: When a small magnetic field is present

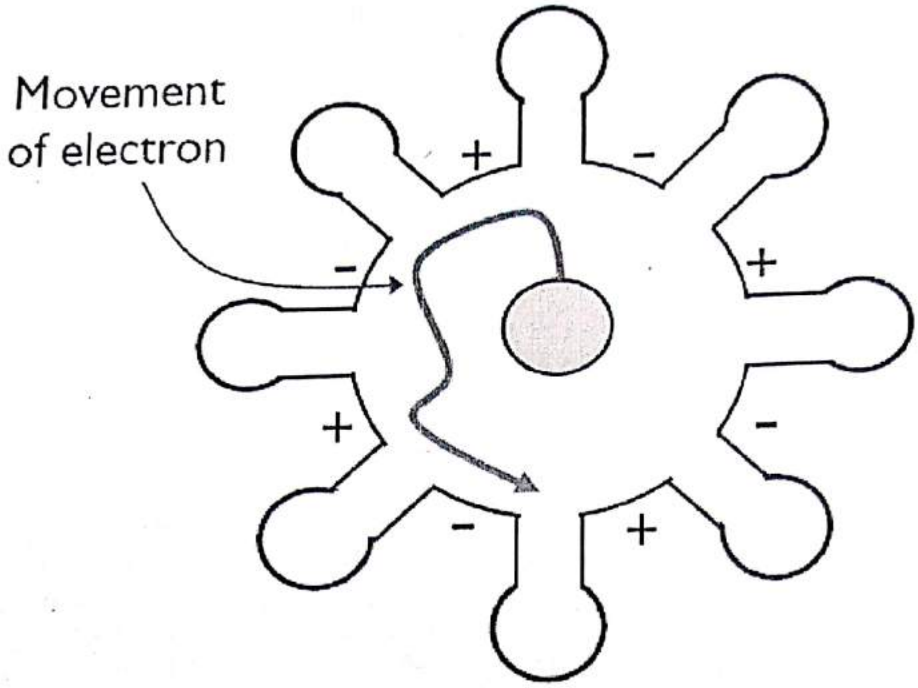
In case a small magnetic field exists inside the magnetron then the electron emerging from the cathode will slightly deviate from its straight path. And this will cause a curvy motion of the electron from cathode to anode as shown in the figure:



In presence of small magnetic field

Electronics Desk This motion of the electron is the result of the action of electric as well as magnetic force over it.

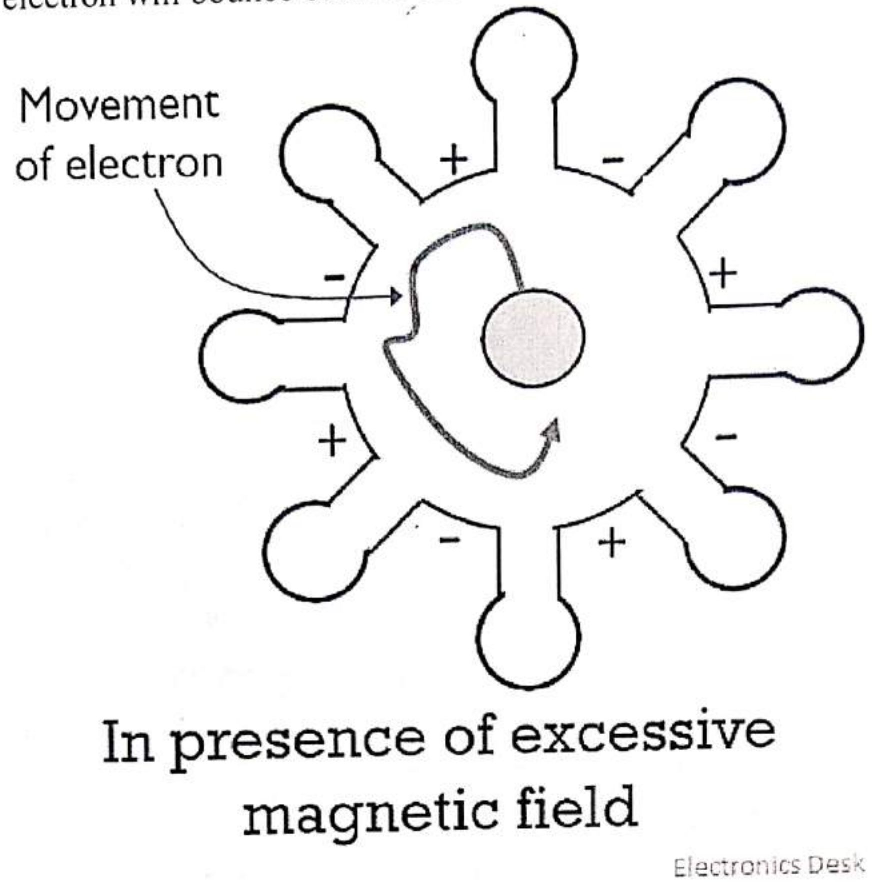
Case III: In case when the magnetic field is further increased then electrons emerging from the cathode gets highly deflected by the magnetic field. And graze along the surface of the cathode, as shown below:



In presence of large magnetic field

 This causes the anode current to be 0. The value of the magnetic field that causes the anode current to become 0 is known as the *critical magnetic field*.

If the magnetic field is increased beyond the critical magnetic field. Then the electron will bounce back to the cathode itself without reaching the anode.



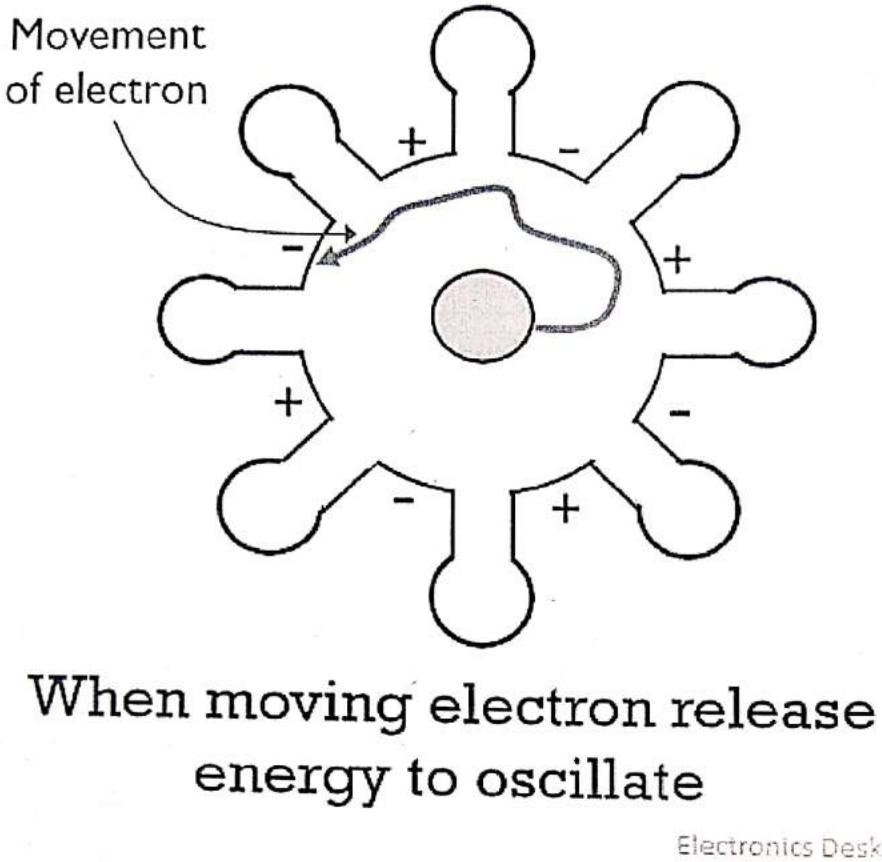
The reaching of the emitted electrons from the cathode back to it is known as **back heating**. So to avoid this the electric supply provided to the cathode must be cut-off after oscillations have been set up in the tube.

2. When the RF field is present

Case I: In case an active RF input is provided to the anode of the magnetron then oscillations are set up in the interaction space of the magnetron. So, when an electron is emitted from the cathode to anode then it transfers its energy in order to oscillate.

Such electrons are called **favoured electrons**. In this condition, the electrons will have a low velocity and thus will take a considerably high amount of time to reach from cathode to anode.

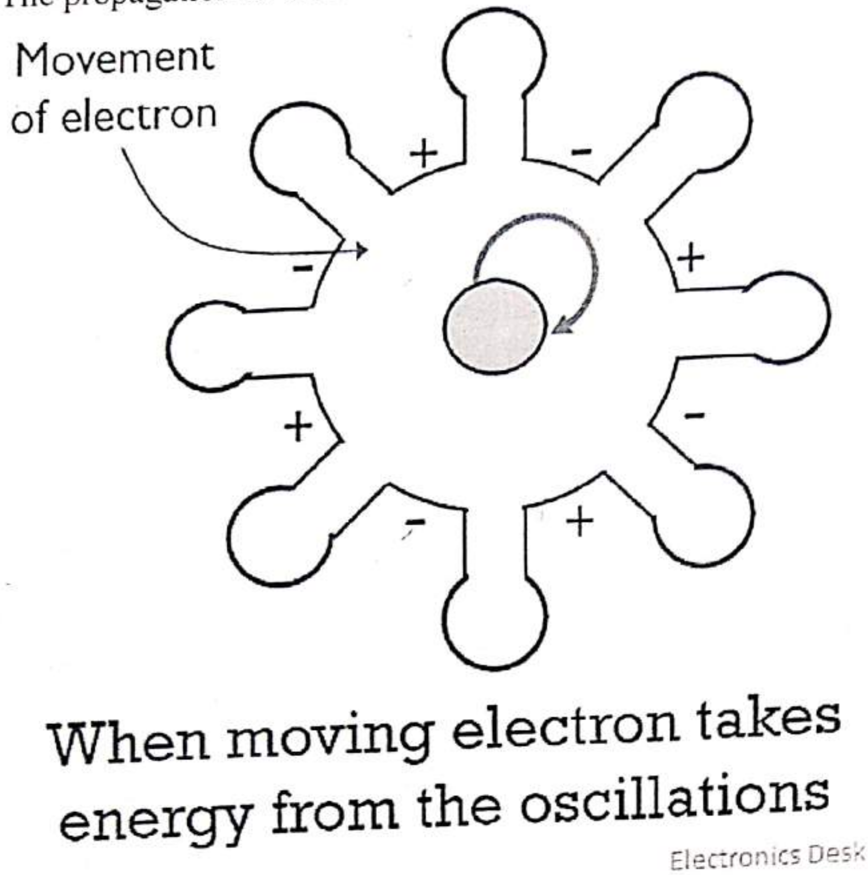
This is given in the figure below:



Case II: Another condition arises in the presence of RF input. In this case, the emitted electron from the cathode while travelling takes energy from the oscillations thereby resultantly increasing its velocity.

So despite reaching the anode, the electrons will bounce back to the cathode and these electrons are known as **unfavoured electrons**.

The propagation of unfavoured electrons is shown below:



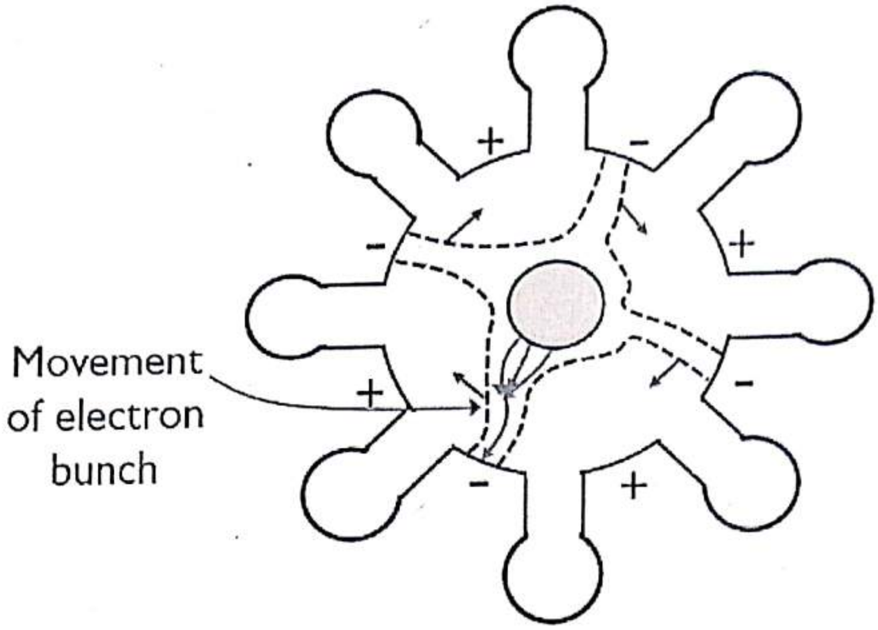
Case III: When the RF input is further increased then the electron emitted while travelling increases its velocity in order to catch up the electron emitted earlier with comparatively lower velocity.

So, all those electrons that do not take energy from the oscillations for their movement are known as favoured electrons. And these favoured electrons form **electron bunch** or **electron cloud** and reaches anode from the cathode.

The formation of electron bunch inside the tube is known as **phase focusing effect.**

Due to this, the orbit of the electron gets confined into spokes. These spokes rotate according to some fractional value of electron emitted by the cathode until it reaches anode while delivering their energy to oscillations.

However, the electrons released from the region of cathode between spokes, will take the energy of the field and get back to the cathode very quickly. But this energy is very small in comparison to the energy delivered to the oscillations. This is shown in the figure below:



Path of electron cloud according to the rotation of spokes

Electronics Desk

The movement of these favoured electrons inside the tube enhances the field existing between the gaps in the cavity. This leads to sustained oscillations inside the magnetron thereby providing high power at the output.

Frequency Pushing and Pulling

The variation in the oscillating frequency of the magnetron give rise to the term *frequency pushing and pulling.*

When the voltage applied at the anode of the magnetron is varied then this causes the variation in the velocity of the electrons moving from cathode to anode. This resultantly changes the frequency of oscillations.

Therefore, we can say when the resonant frequency of the magnetron shows variation due to the change in the anode voltage then it is known as **frequency pushing.**

The change in resonant frequency is sometimes a result of the change in the load impedance of the magnetron. The load impedance varies when the change is purely resistive or reactive. This frequency variation is known as **frequency pulling**. A steady power supply can provide a reduction in this frequency variation.

Advantages

- Magnetrons are a highly efficient device used for generation of the high power microwave signal.
- The use of magnetrons in radar can produce radar system of better quality for tracking purpose.
- It is usually small in size thus less bulky.

Disadvantages

- It is quite expensive.
- Despite producing a wide range of frequency, there exists a drawback in controllability of the generated frequency.
- It offers average power of around 1 to 2 kilowatts.
- Magnetrons are quite noisy.

Applications of Magnetron

- A major application of magnetron is present in a pulsed radar system in order to produce a high-power microwave signal.
- Magnetrons are also used in heating appliances likes microwave ovens so as to produce fixed frequency oscillations.
- Tunable magnetrons find their applications in sweep oscillators.

It is noteworthy here that this mode of operation of the magnetron is also known as π mode. This is so because a proper phase shift of 180^0 is maintained between two adjacent plates. Also, it is to be noted that oscillations are only built-up in π mode.