CHAPTER 1

DISPLAY DEVICES , RANDOM AND RASTER SCAN SYSTEMS

History

- A cathode-ray tube, often called a CRT, is an electronic display device in which a beam of electrons can be focused on a phosphorescent viewing screen and rapidly varied in position and intensity to produce an image.
- Probably the best-known application of a cathode-ray tube is as the picture tube in a television.
- Other applications include use in oscilloscopes, radar screens, computer monitors, and flight simulators.

- The cathode-ray tube was developed in 1897 by Ferdinand Braun of Strasbourg in what was then the French-German region of Alsace-Lorraine.
- It was first used as an oscilloscope to view and measure electrical signals. In 1908, A.A. Campbell-Swinton of England proposed using a CRT to send and receive images electronically.
- It wasn't until the 1920s, however, that the first practical television system was developed.
- The concept for a color cathode-ray tube was proposed in 1938 and successfully developed in 1949.

- Although General Electric introduced their first television set for home use in 1928, commercial television broadcasting remained an experimental technology with only limited range and audience.
- It took until the late-1940s before television net-works had established themselves sufficiently to start a boom in consumer sales.
- Black-and-white television sets gave way to the first color sets in the 1960s. In the following decades cathode-ray tubes for televisions got both larger and smaller as manufacturers sought to satisfy consumer wants

Overview

- **Display Hardware**
  - How are images displayed?

Overview (Display Devices)

- Raster Scan Displays
- Random Scan Displays
- Color CRT Monitors
- Direct View Storage Tube
- Flat panel Displays
- Three Dimensional Viewing Devices
- Stereoscopic and Virtual Reality System

Overview (Display Devices)

- The display systems are often referred to as **Video Monitor** or **Video Display Unit** **(VDU)**.

Display Hardware

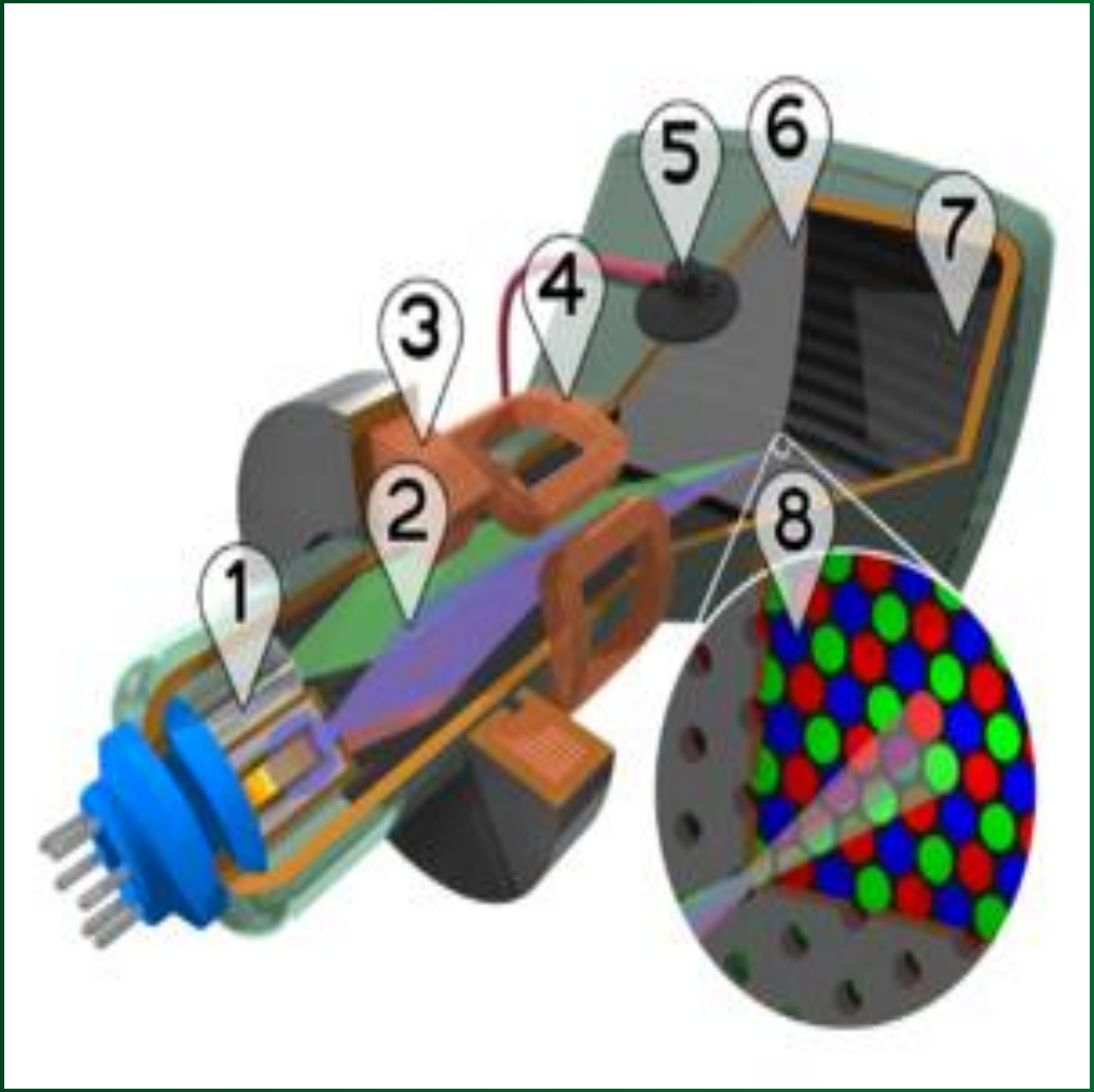
- **Video Display Devices**
- The primary output device in a graphics system is a monitor.
- The operation of video monitors are based on standard **Cathode Ray Tube design (CRT).**

Video Monitor

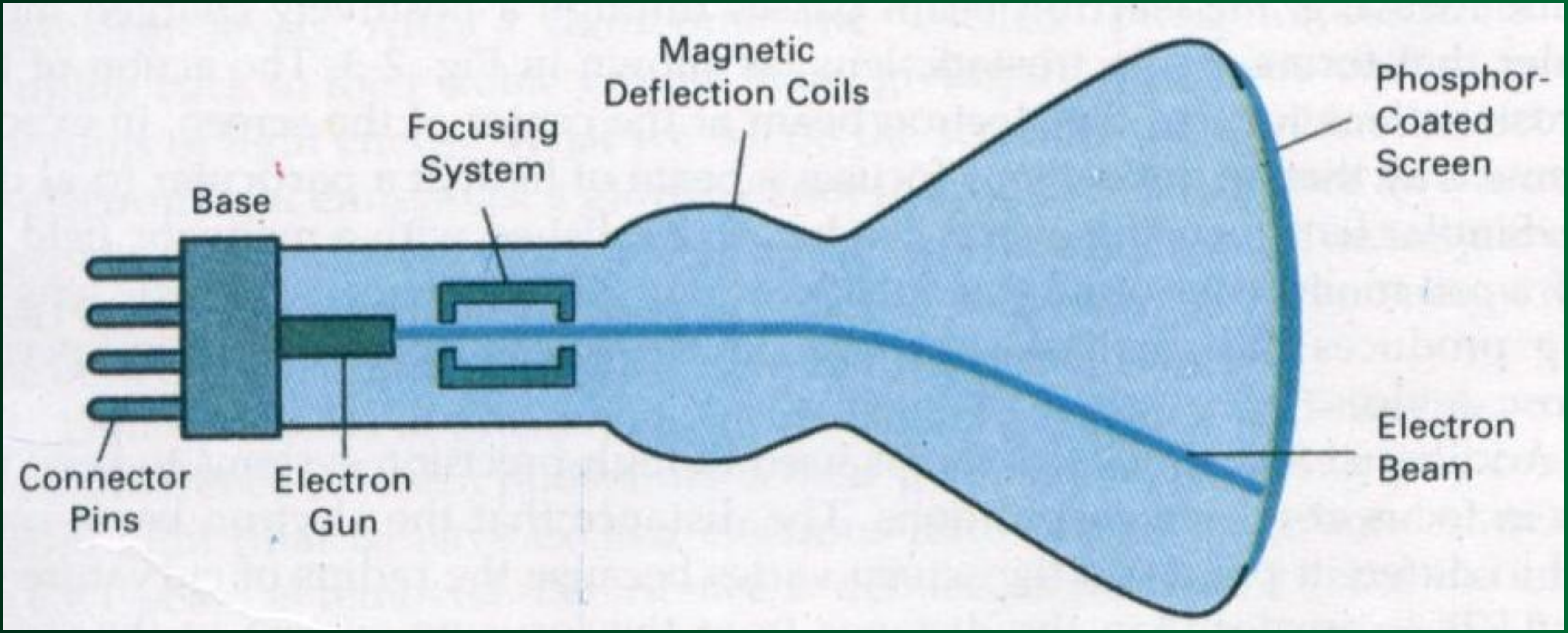
Cathode **R**ay **T**ube

(**CRT**)

1. Electron Guns
2. Electron Beams
3. Focusing Coils
4. Deflection Coils
5. Anode Connection
6. Shadow Mask
7. Phosphor layer
8. Close-up of the phosphor coated inner side of the screen



Cathode Ray Tube (CRT)



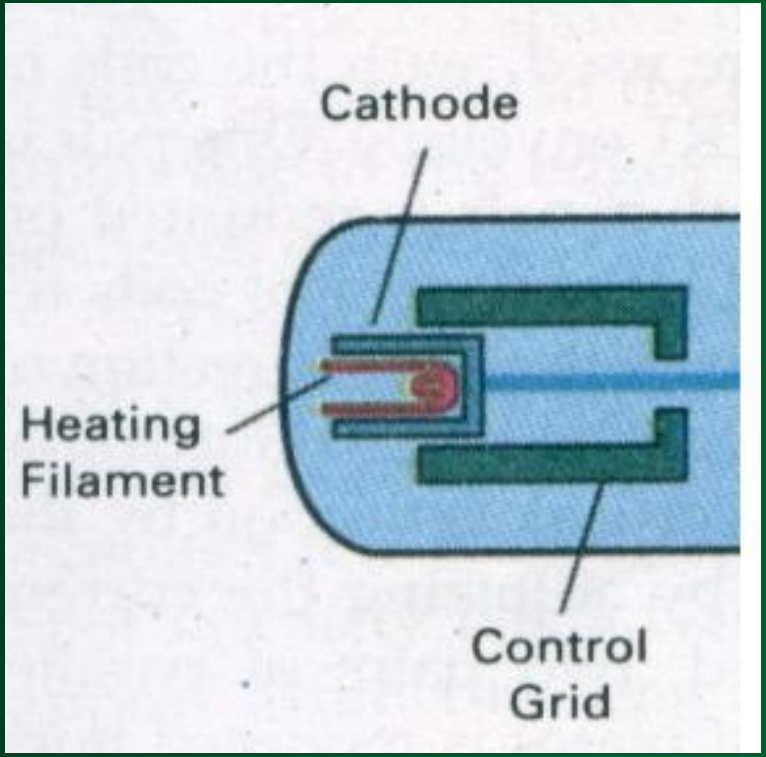
Refresh CRT

- Light emitted by the Phosphor fades very rapidly.
- **Refresh CRT:** One way to keep the phosphor glowing is to redraw the picture repeatedly by quickly directing the electron beam back over the same points.

Electron Gun

Electron Gun

- Heat is supplied to the cathode by the **filament**.

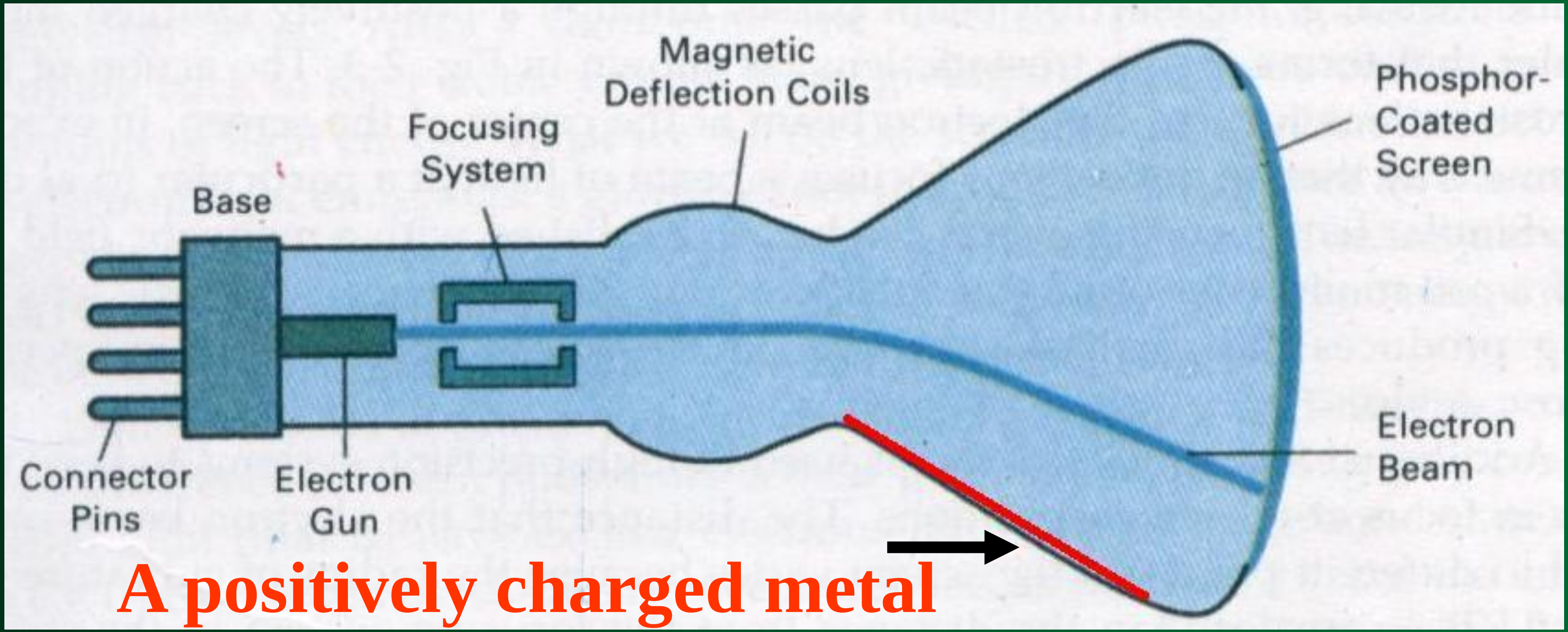


Electron Gun

- The free electrons are then accelerated toward the phosphor coating by a **high positive voltage or the accelerating anode is used.**

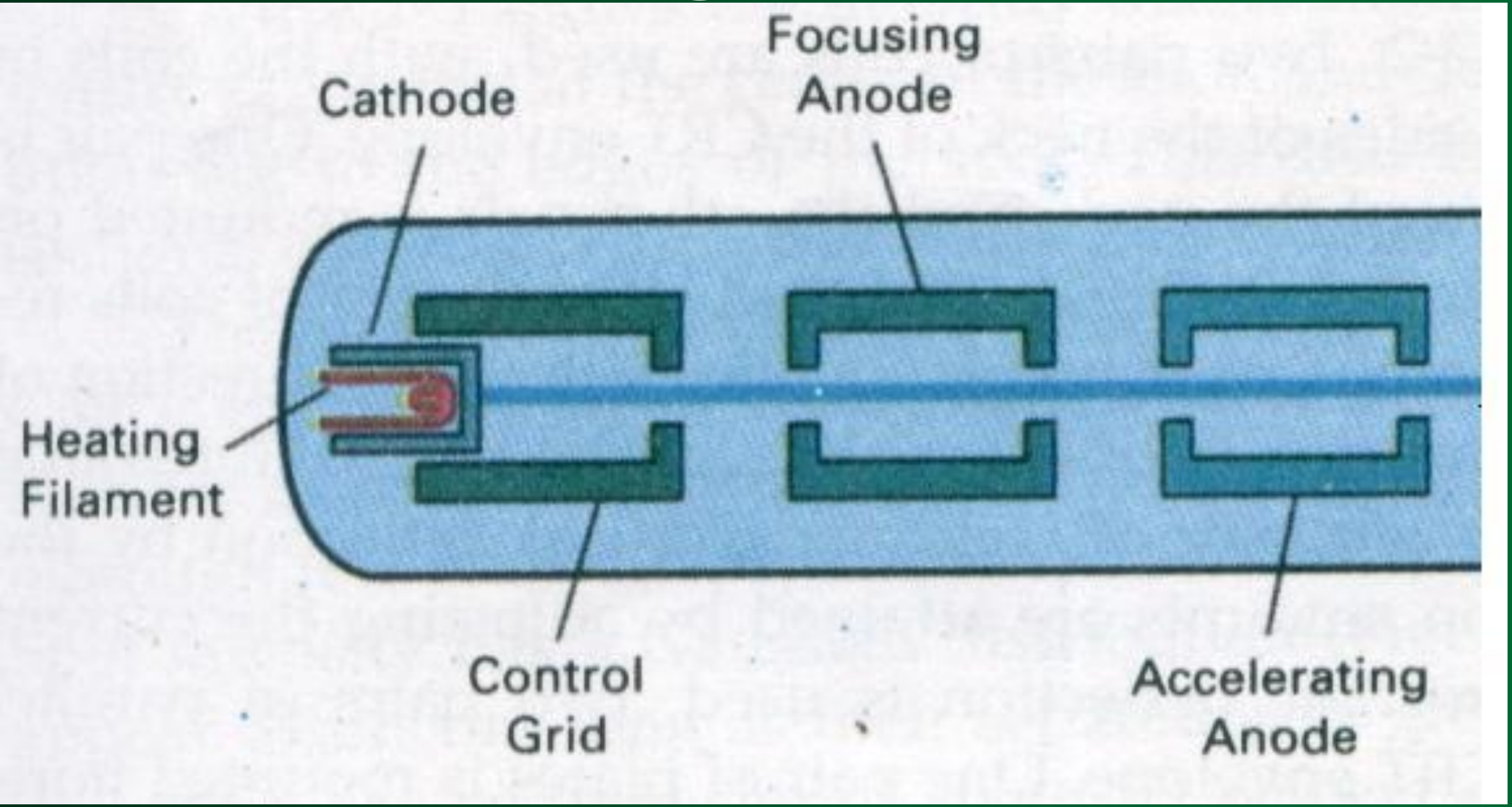
High Positive Voltage

- **A positively charged metal coating** on the inside of the CRT envelope near the phosphor screen.



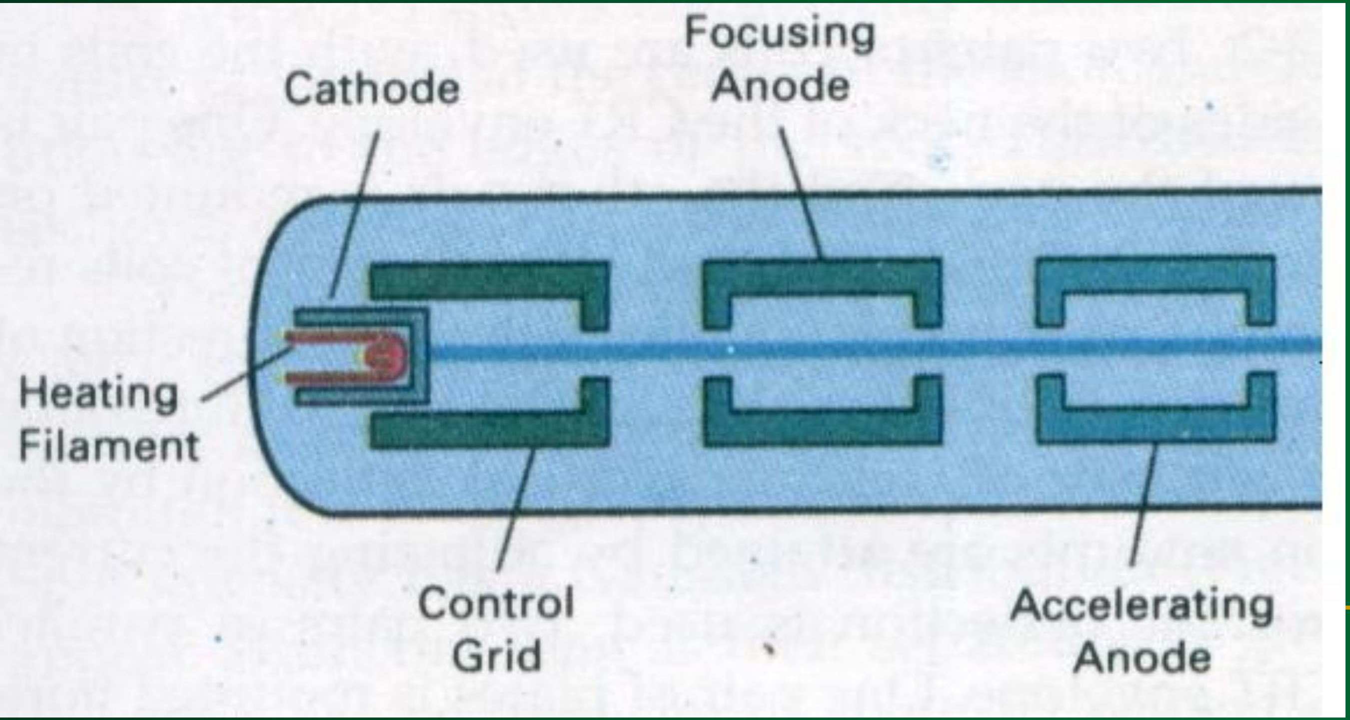
High Positive Voltage

- An accelerating **anode** .



Electron Gun

- **Intensity** of the electron beam is controlled by setting voltage level on the control grid.



Electron Gun

- **A smaller negative voltage** on the control grid simply decrease the number of electrons passing through.

Focusing System

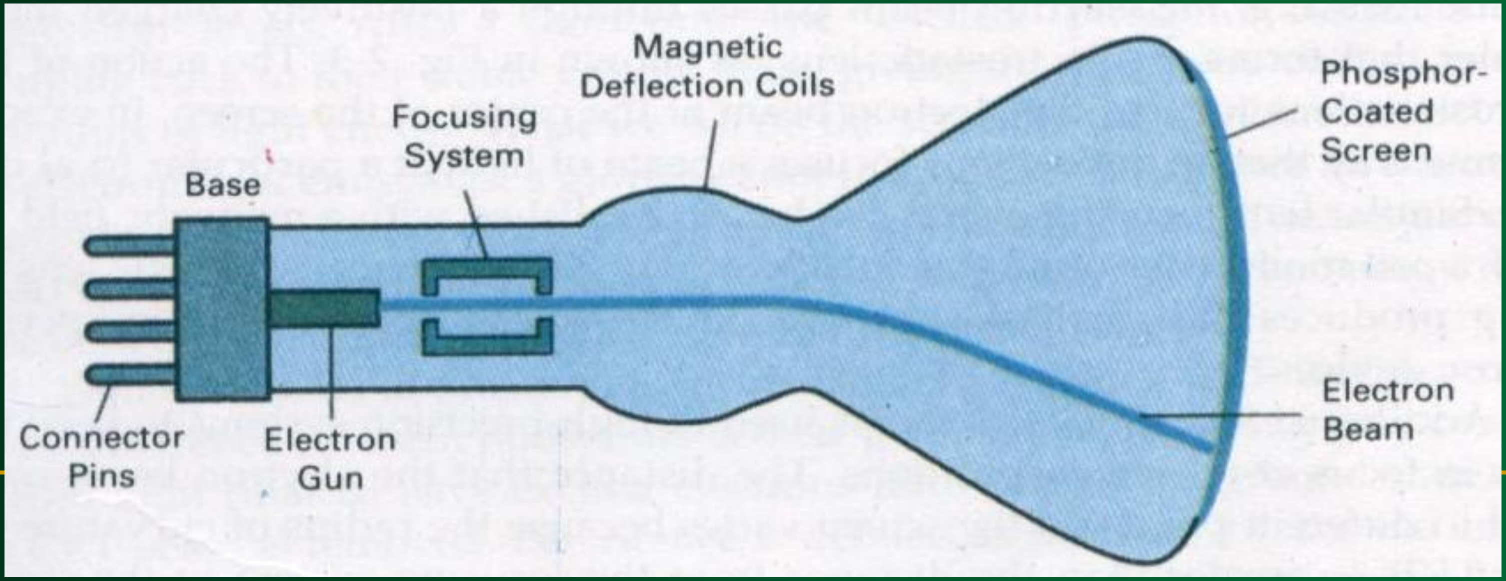
Focusing System

- The **focusing system** is needed to force the electron beam to converge into a small spot as it strikes the phosphor.

- **Electrostatic focusing** is commonly used in computer graphics monitor.

Focusing System

- With electrostatic focusing, the electron beam passes through a positively charged metal cylinder that forms an **electrostatic lens**.



Focusing System

- Similar lens focusing effects can be accomplished with a **magnetic field** set up by a coil mounted around the outside of the CRT envelope.

Focusing System

- The **distance** that the electron beam must travel to different points on the screen **varies** because the **radius of curvature** for most CRTs is ***greater*** than the distance from the focusing system to the screen center.

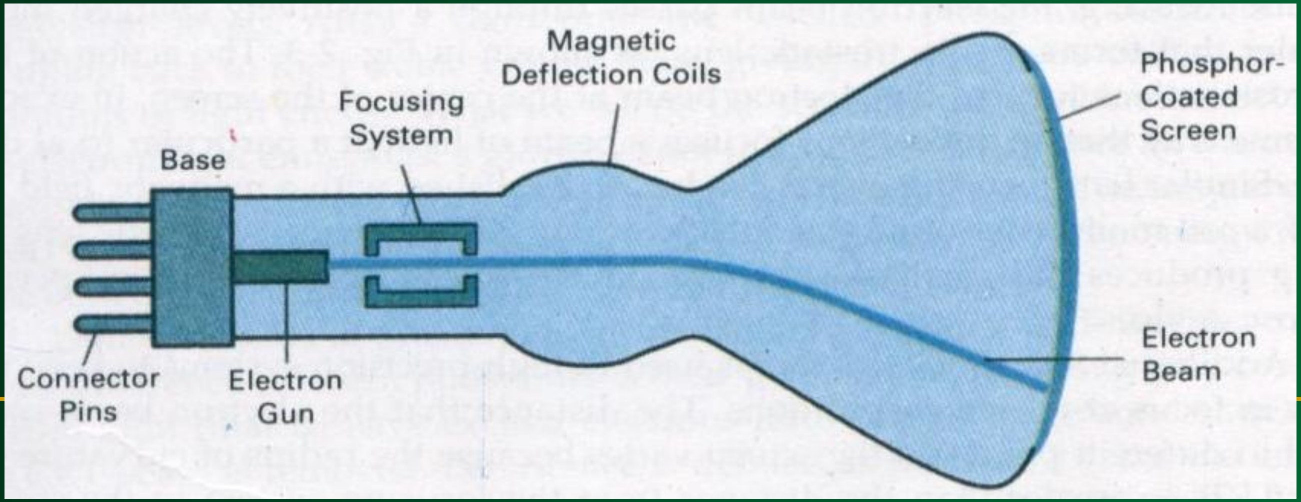
Focusing System

- The electron beam will be focused properly only at the **center** of the screen.
- As the beam moves to the **outer edges** of the screen, displayed images become ***blurred***.
- **Dynamically focusing lens** work based on beam position.

Deflection Systems

Deflection Systems

- Deflection of the electron beam can be controlled either with **electric fields** or with **magnetic fields**.
- The magnetic deflection coils mounted on the outside of the CRT envelope.

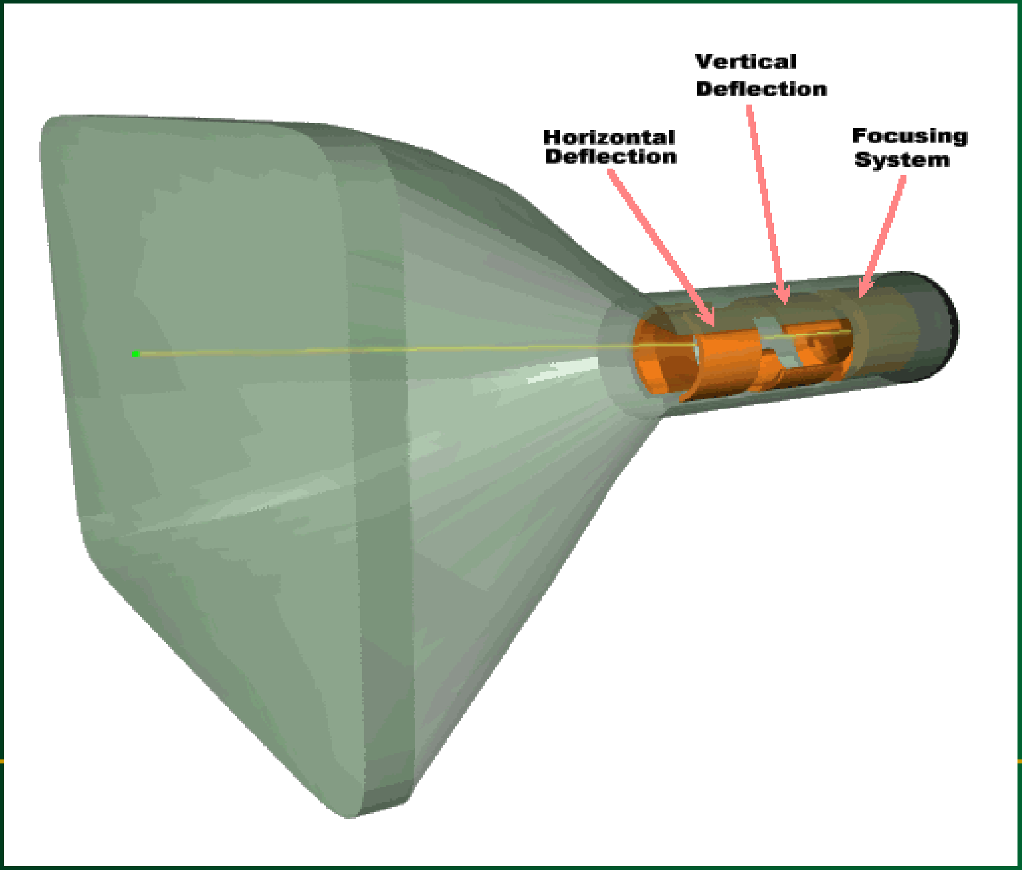


Deflection Systems

- **Two pairs of coils** are used, with the coils in each pair mounted on opposite sides of the neck of the CRT envelope.

Deflection Systems

- One pair is mounted on the top and bottom of the neck, and the other pair is mounted on opposite sides of the neck.



Deflection Systems

- **Horizontal deflection** is accomplished with one pair of coils, and **vertical deflection** by the other pairs.

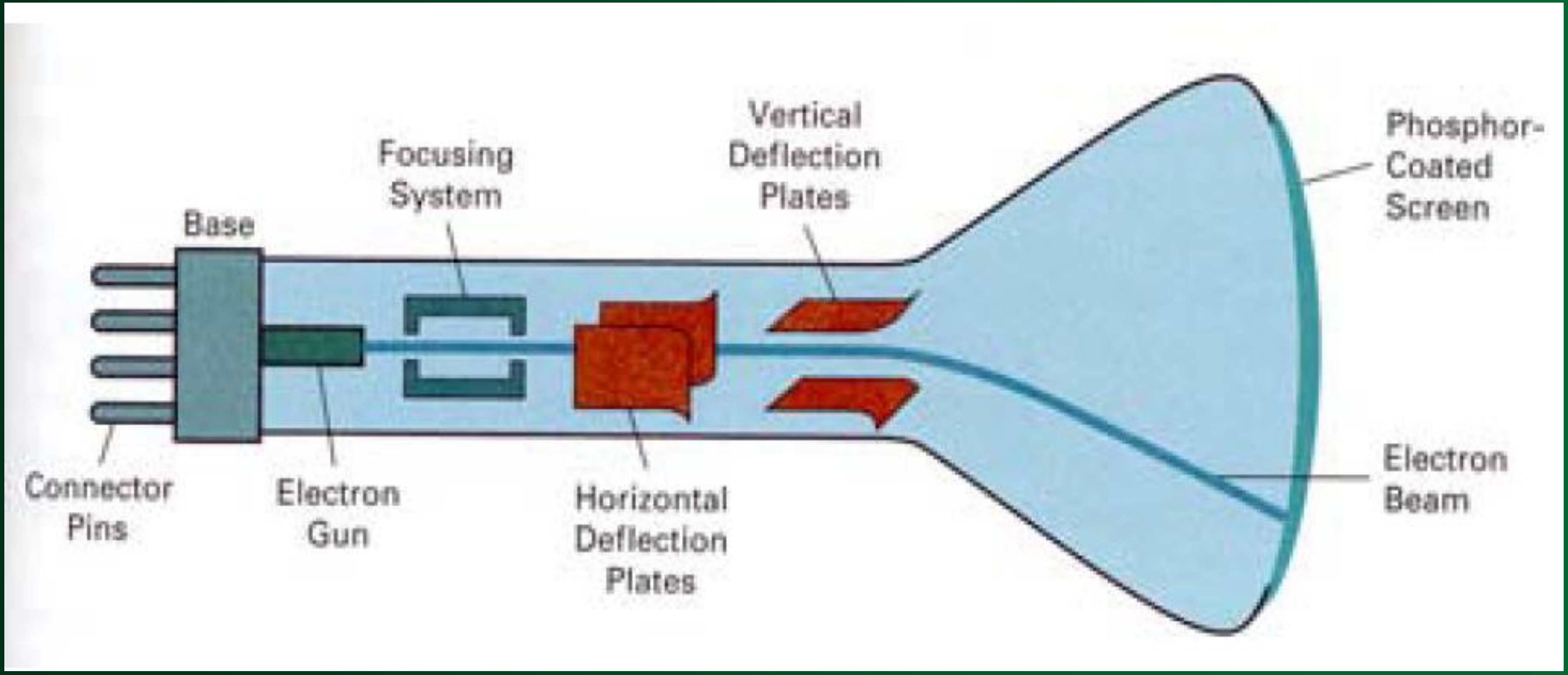
- The proper deflection amounts are attained by adjusting the **current** through the coil.

Deflection Systems

- **Electrostatic deflection:** Two pairs of parallel plates are mounted inside the CRT envelope.

Deflection Systems

- One pair of plates is mounted horizontally to control the **vertical deflection**, and the other pair is mounted vertically to control **horizontal deflection**.



Spots of Light

Spots of Light

- **Spots of lights** are produces on the screen by the transfer of the CRT beam energy to the phosphor.
- Part of the beam energy is converted into heat energy.

Spots of Light

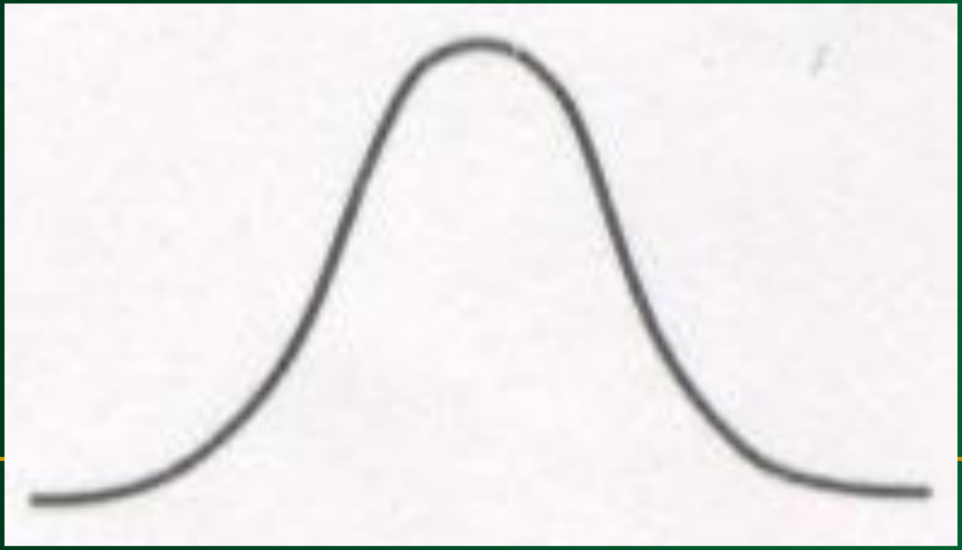
- The **excited** phosphor electrons begin dropping back to their stable ground state, giving up their extra energy as small quantums of **light energy**.

Persistence

- **Persistence** :The time it takes the emitted light from the screen to decay to one-tenth of its original intensity.

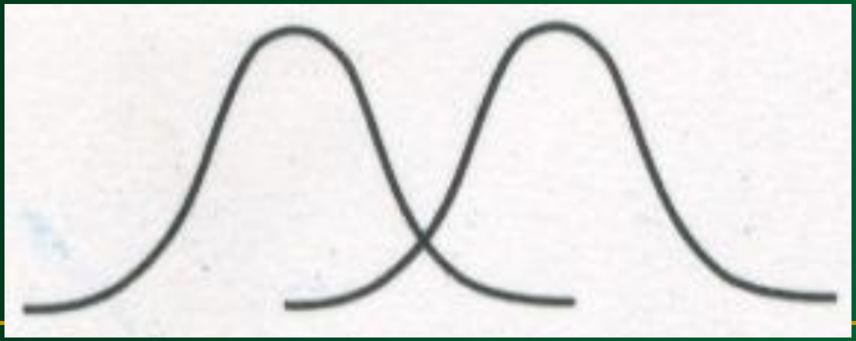
Intensity Distribution

- The intensity is greatest at the center of the spot, and decrease with Gaussian distribution out to the edges of the spot.



Resolution (Spots of Light)

- **Resolution:** The maximum number of points that can be displayed without overlap on a CRT.



Overlap

Resolution (Spots of Light)

- Resolution of a CRT is dependent on:
- **The type of phosphor**
- **The intensity to be displayed**
- **The focusing and deflection systems.**

Typical resolution: 1280 by 1024

Aspect Ratio

- **Aspect Ratio:** This numbers gives the ratio of vertical points to horizontal points necessary to produce equal length lines in both directions on the screen.

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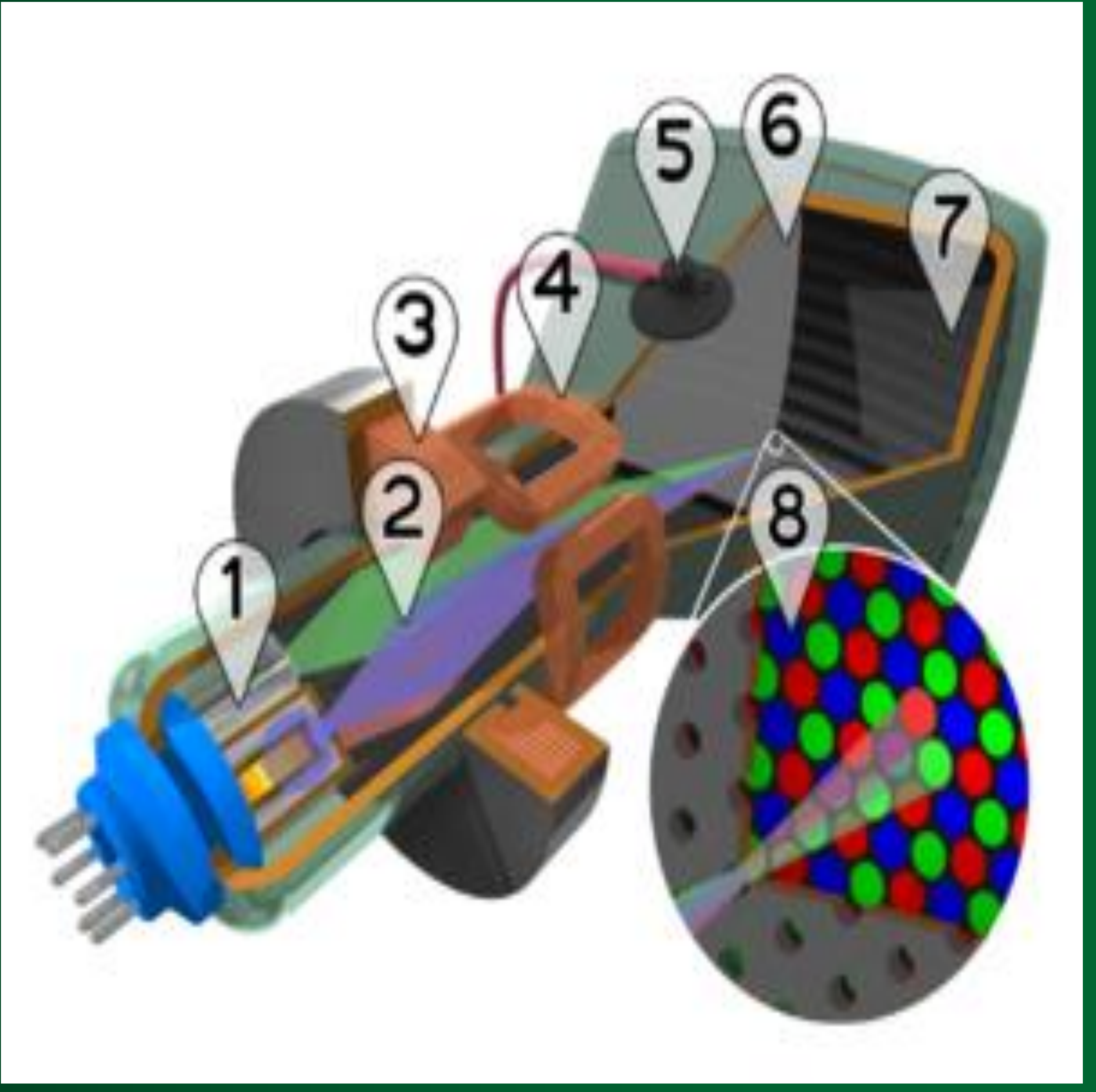
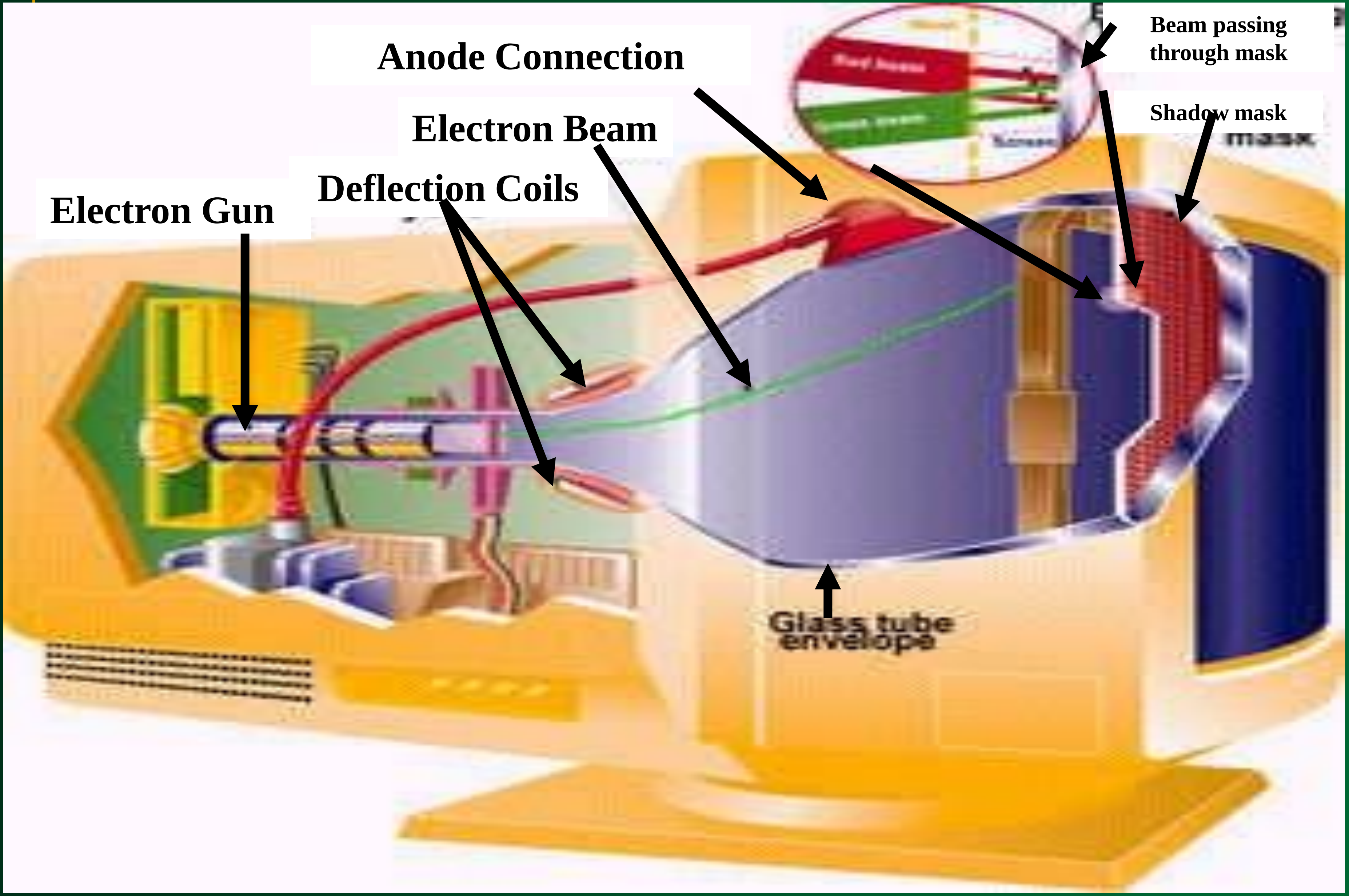


Cathode Ray Tube (CRT)



Entire Working of CRT

- A CRT consists of three basic parts: the electron gun assembly, the phosphor viewing surface, and the glass envelope. The electron gun assembly consists of a heated metal cathode surrounded by a metal anode.
- The cathode is given a negative electrical voltage and the anode a positive voltage. Electrons from the cathode flow through a small hole in the anode to produce a beam of electrons.
- The electron gun also contains electrical coils or plates which accelerate, focus, and deflect the electron beam to strike the phosphor viewing surface in a rapid side-to-side scanning motion starting at the top of the surface and working down.

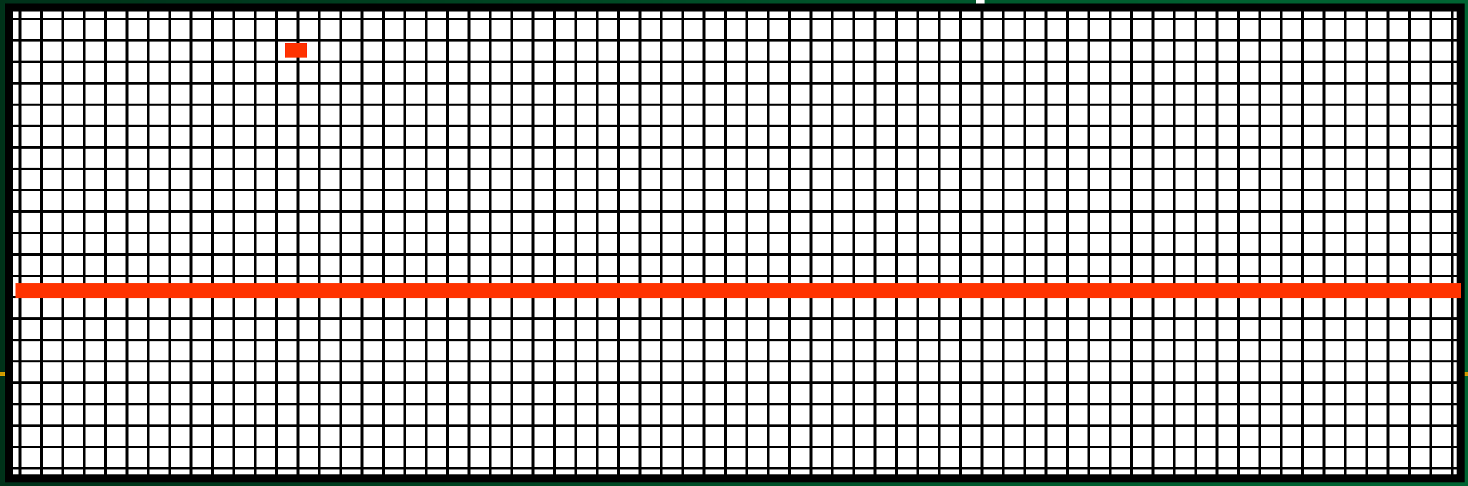
- The phosphor viewing surface is a thin layer of material which emits visible light when struck by the electron beam.
- The chemical composition of the phosphor can be altered to produce the colors white, blue, yellow, green, or red.
- The glass envelope consists of a relatively flat face plate, a funnel section, and a neck section.
- The phosphor viewing surface is deposited on the inside of the glass face plate, and the electron gun assembly is sealed into the glass neck at the opposite end.
- The purpose of the funnel is to space the electron gun at the proper distance from the face plate and to hold the glass envelope together so that a vacuum can be achieved inside the finished tube.

Refresh Rate

- Alternatively referred to as frame rate, horizontal scan rate, vertical frequency, or frequency.
- Refresh rate is a CRT monitor measurement in Hz that indicates how many times per second a monitor screen image is renewed. For example, a monitor with a refresh rate to 75 Hz means the screen is going to redraw 75 times per second.
- Refresh rates below 75 Hz can produce an often-imperceptible flicker that can cause eyestrain after long viewing.
- While some cards can support as high as 120 Hz, sometimes even higher, it is recommended you run 85-90 Hz; rates beyond 90 Hz add an unnecessary processing burden to the eyes.

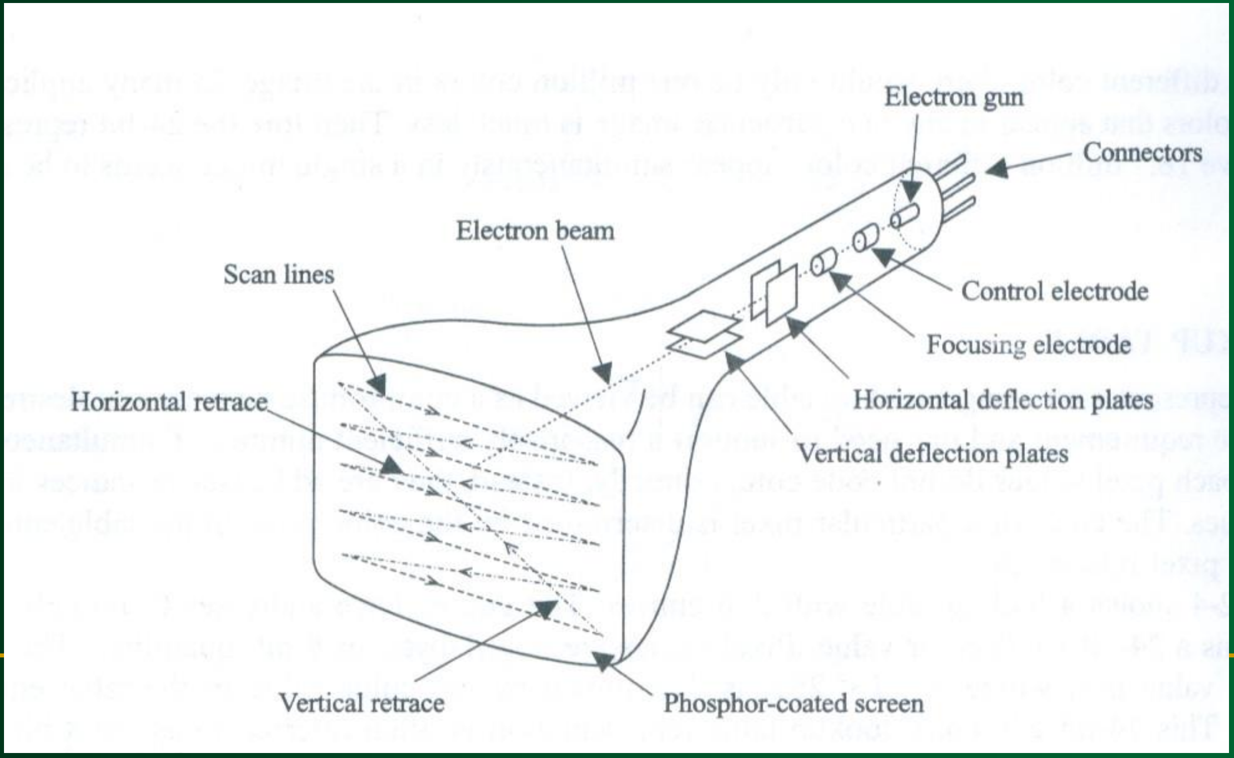
Raster Scan Displays

- **Raster:** A rectangular array of points or dots
- **Pixel:** One dot or picture element of the raster
- **Scan Line:** A row of pixels



Raster Scan Displays

- In a raster scan system, the electron beam is swept across the screen, one row at a time from top to bottom.

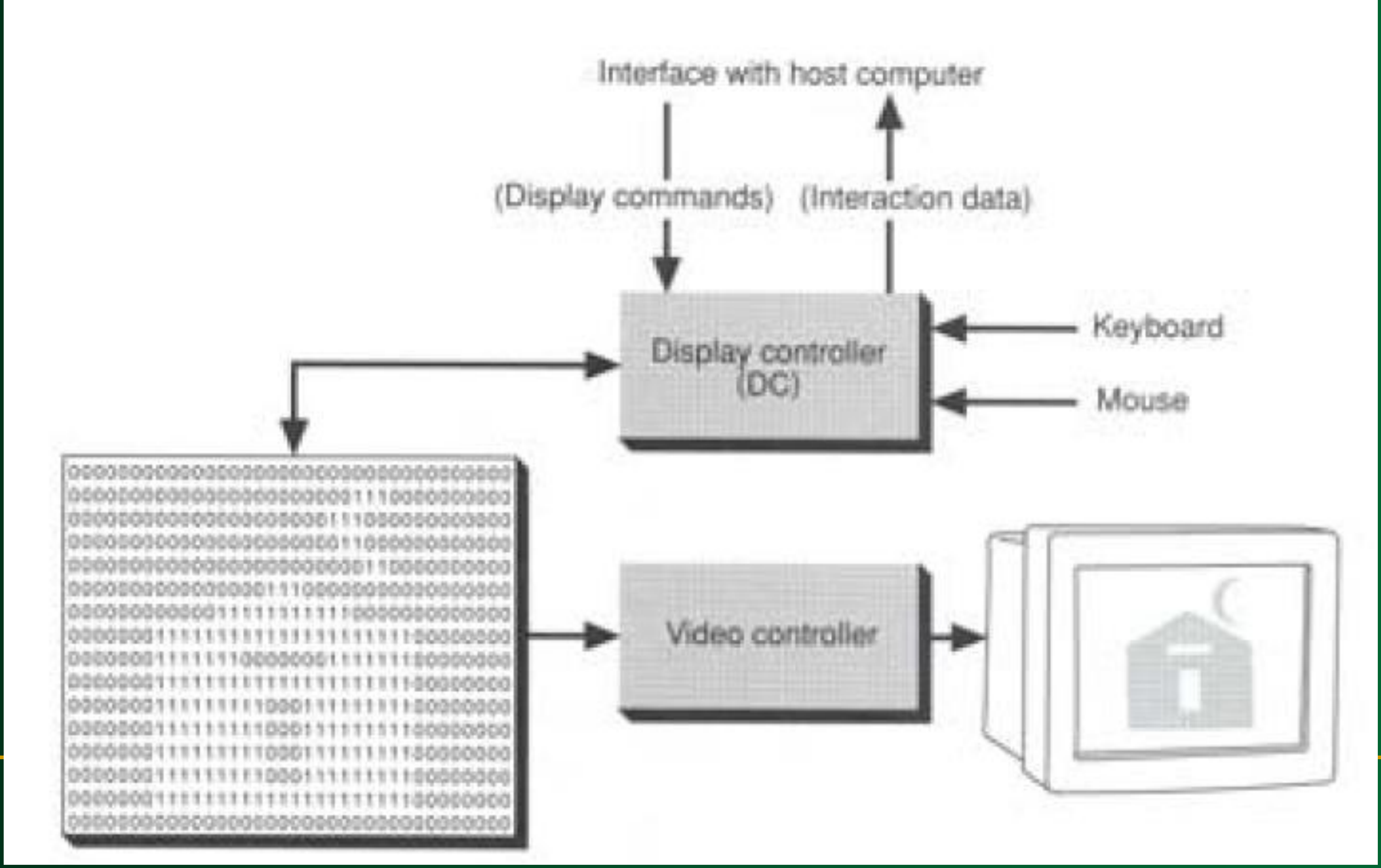


Raster Scan Displays

- As the electron beam moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots.

Raster Scan Displays

- Picture definition is stored in a memory area called the **refresh buffer** or **frame buffer**.

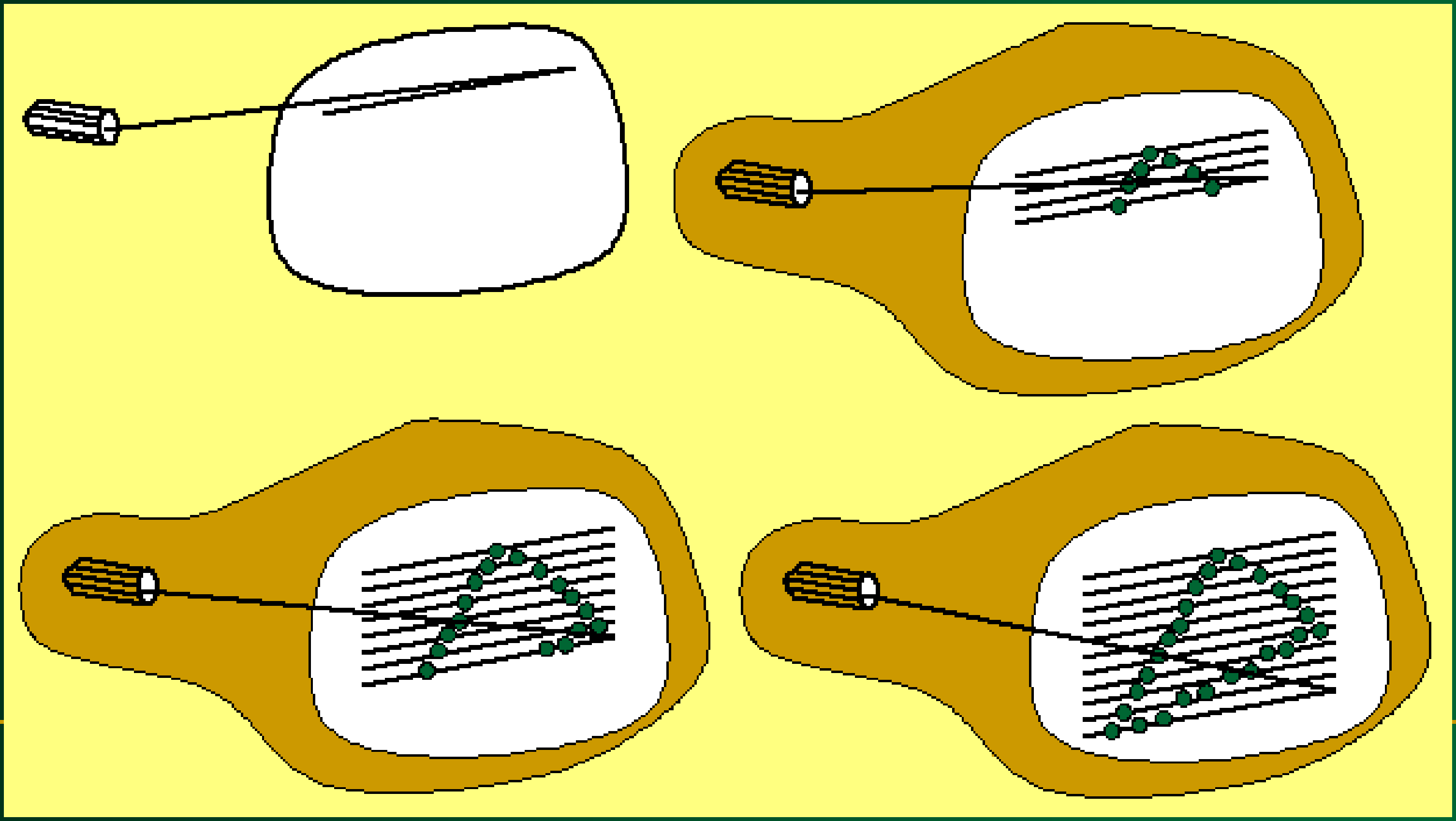


Raster Scan Displays

- **Refresh buffer** or **frame buffer:** This memory area holds the set of intensity values for all the screen points.

Raster Scan Displays

- Stored intensity values then retrieved from refresh buffer and "**painted**" on the screen one row (**scan line**) at a time.



Raster Scan Displays

- Intensity range for pixel positions depends on the capability of the raster system.

- A black-and-white system: each screen point is either on or off, so only **one bit** per pixel is needed to control the intensity of screen positions.

Raster Scan Displays

- On a black-and-white system with one bit per pixel, the frame buffer is called **bitmap**.
- For system with multiple bits per pixel, the frame buffer is called **pixmap**.

Raster Scan Displays

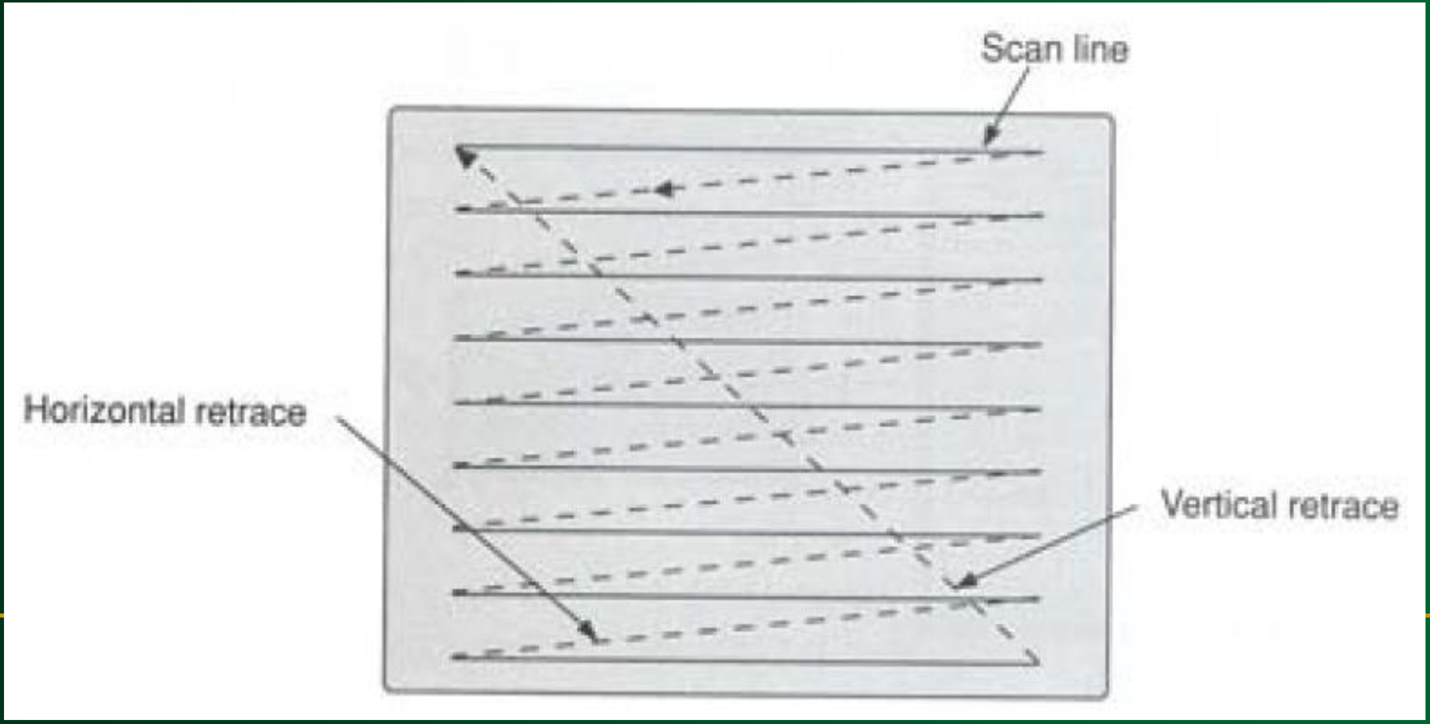
- Sometimes, refresh rates are described in unit of cycles per second, or Hertz (**HZ**)

Raster Scan Displays

- Refreshing on raster scan displays is carried out at the rate 60 to 80 frame per second.

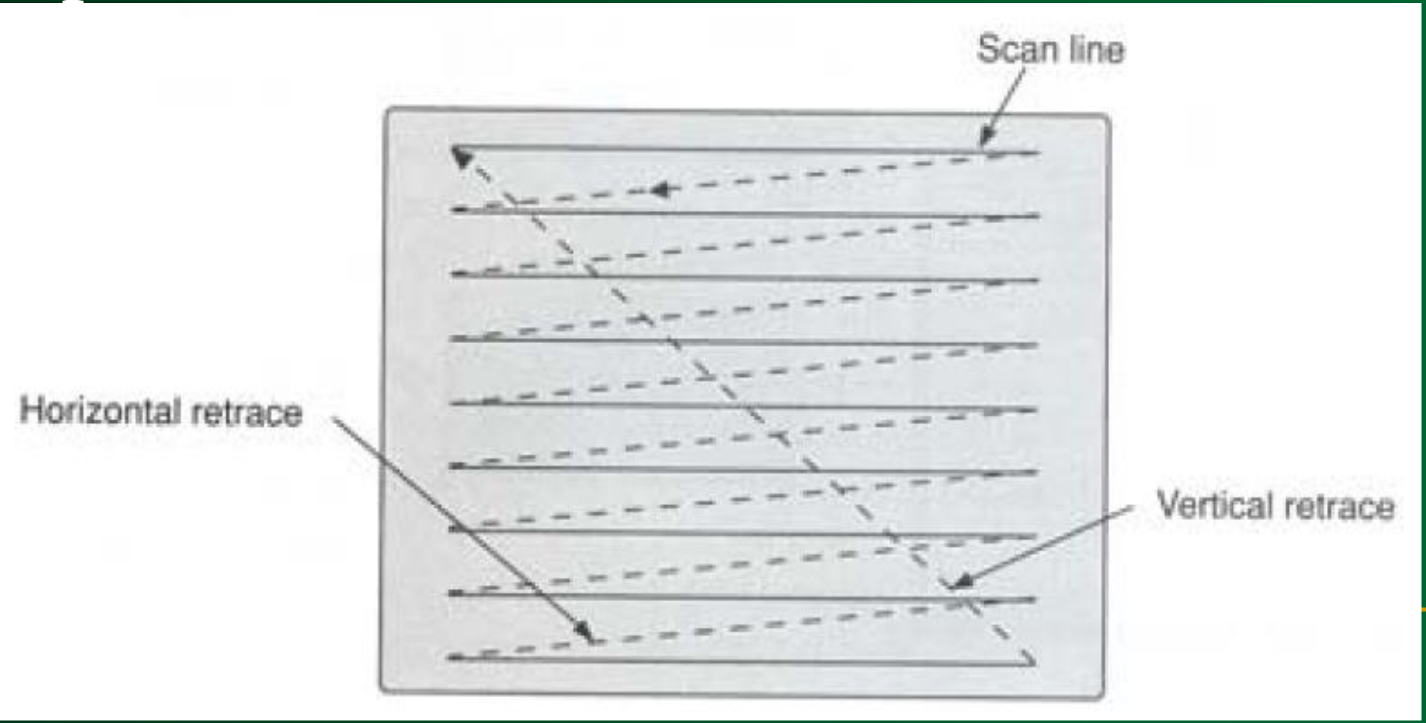
Raster Scan Displays

- **Horizontal retrace**: The return to the left of the screen, after refreshing each scan line.



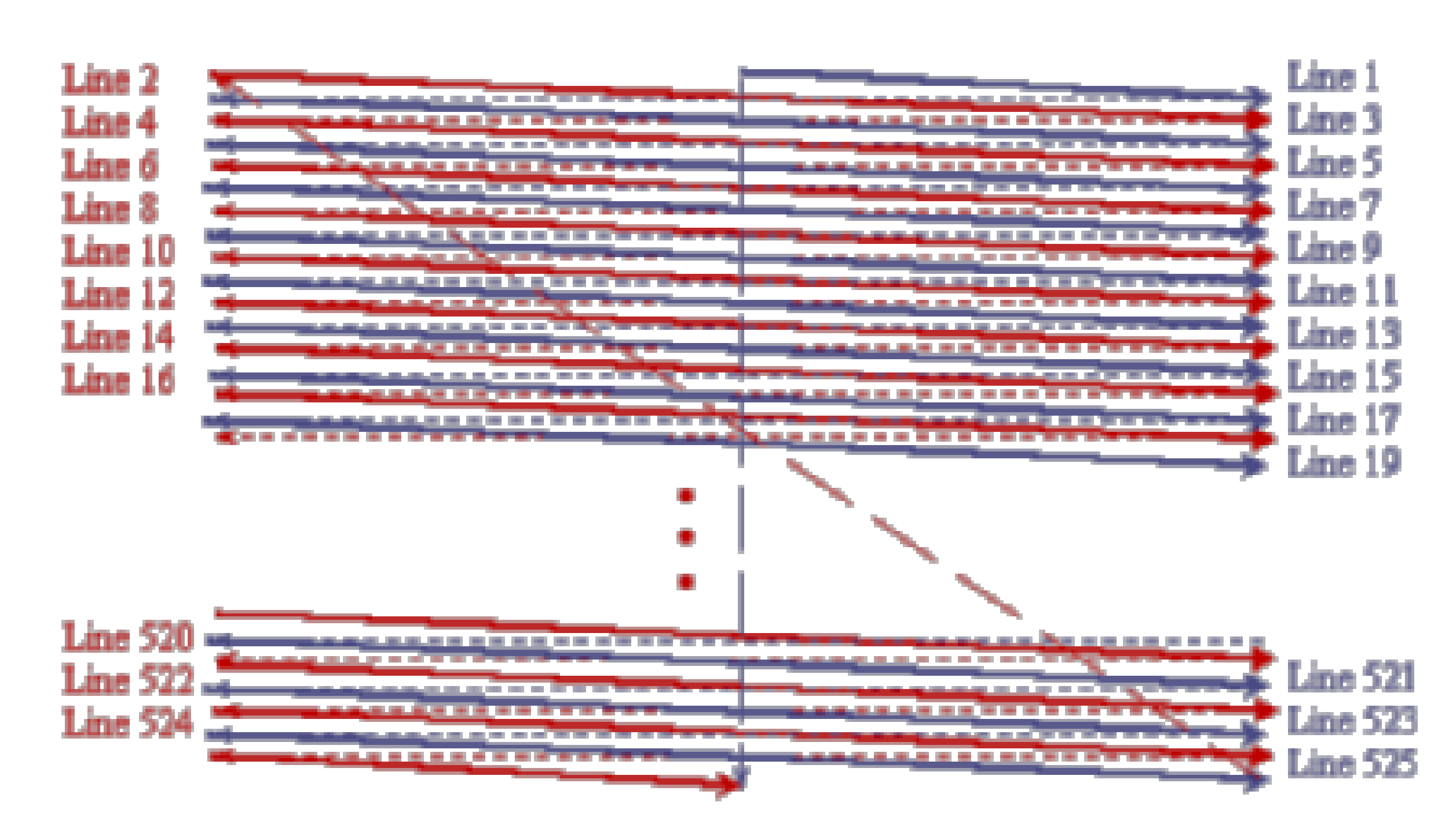
Raster Scan Displays

- **Vertical retrace**: At the end of each frame (displayed in 1/80th to 1/60th of a second) the electron beam returns to the top left corner of the screen.



Interlacing

- On some raster systems (TV), each frame is displays in two passes using an **interlaced refresh procedure**.



Interlacing

- On an older, 30 frame per-second, noninterlaced display, some flicker is noticeable.
- With interlacing, each of the two passes can be accomplished in $1/60^{th}$ of a second.

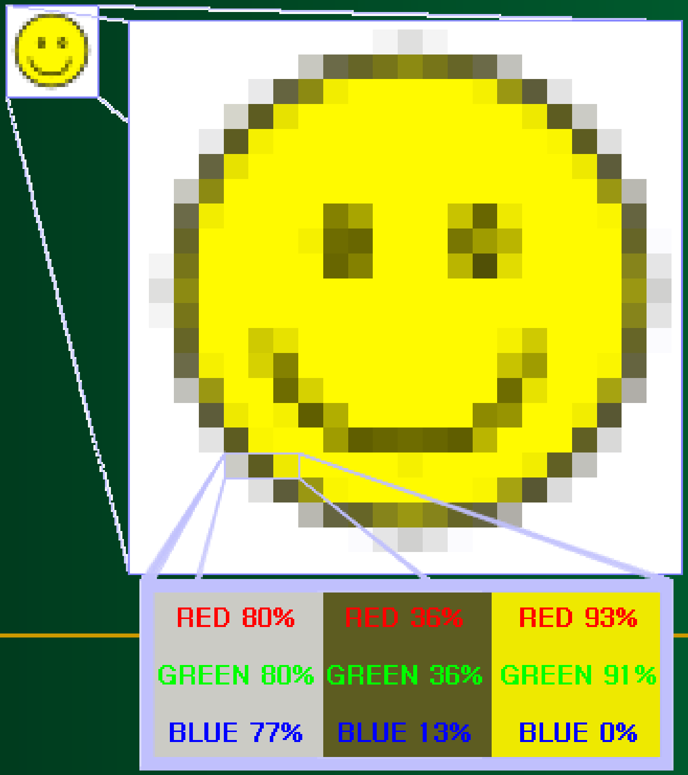
An effective technique for avoiding flicker

Raster image

- The **quality** of a raster image is determined by the total number pixels (**resolution**), and the amount of information in each pixel (**color depth**)

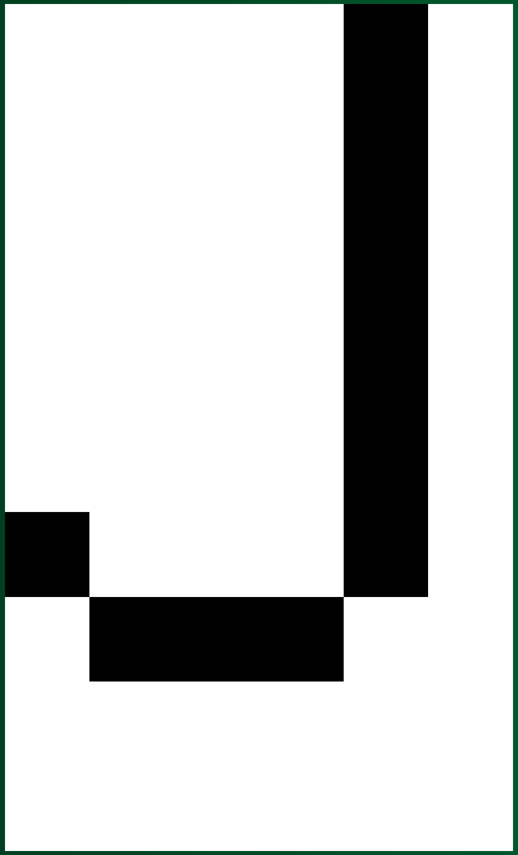
Raster image

- Raster graphics cannot be **scaled** to a higher resolution without loss of apparent quality.



Raster image

Brightness and color @ each x, y on screen



Random Scan Displays

Random Scan Displays

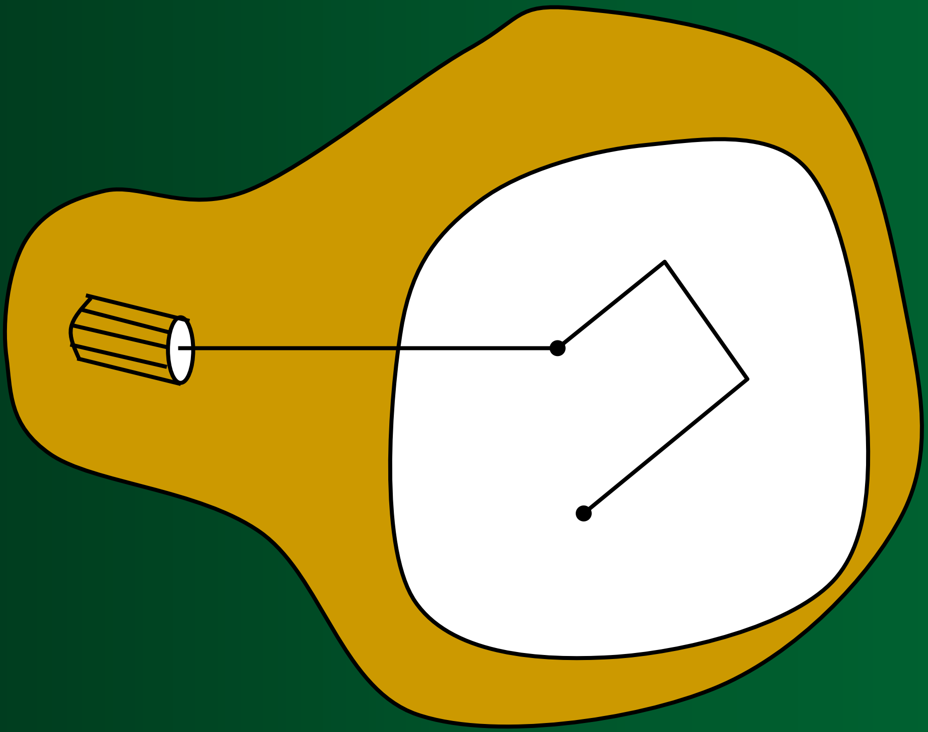
- Random scan display is the use of geometrical primitives such as points, lines, curves, and polygons, which are all based upon **mathematical equation**.
- Raster Scan is the representation of images as a collection of **pixels** (dots)

Random Scan Displays

- In a random scan display, a CRT has the electron beam directed only to the **parts of the screen** where a picture is to be drawn.
- Random scan monitors draw a picture one line at a time (**Vector** display, **Stroke –writing** or **calligraphic** displays).

Random Scan Displays

- The component lines of a picture can be drawn and refreshed.



Random Scan Displays

- **Refresh rate** depends on the number of lines to be displayed.

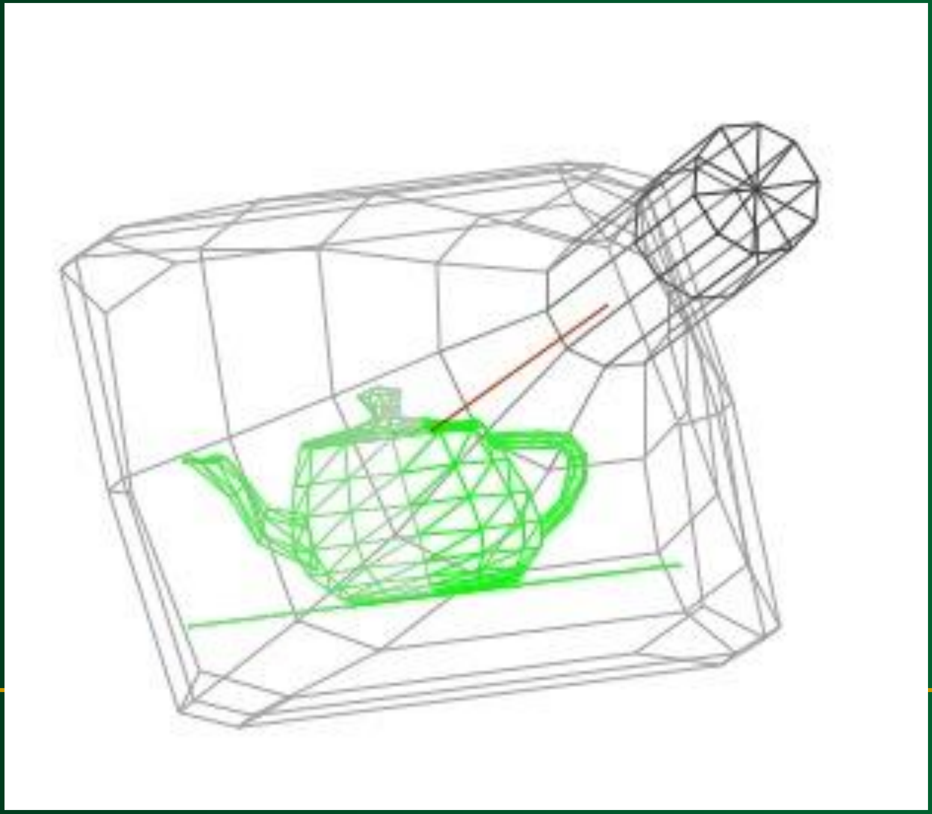
- Picture definition is now stored as a line-drawing commands an area of memory referred to as **refresh display file** (**display list**).

Random Scan Displays

- To display a picture, the system cycle through the **set of commands** in the display file, drawing each component line in turn.

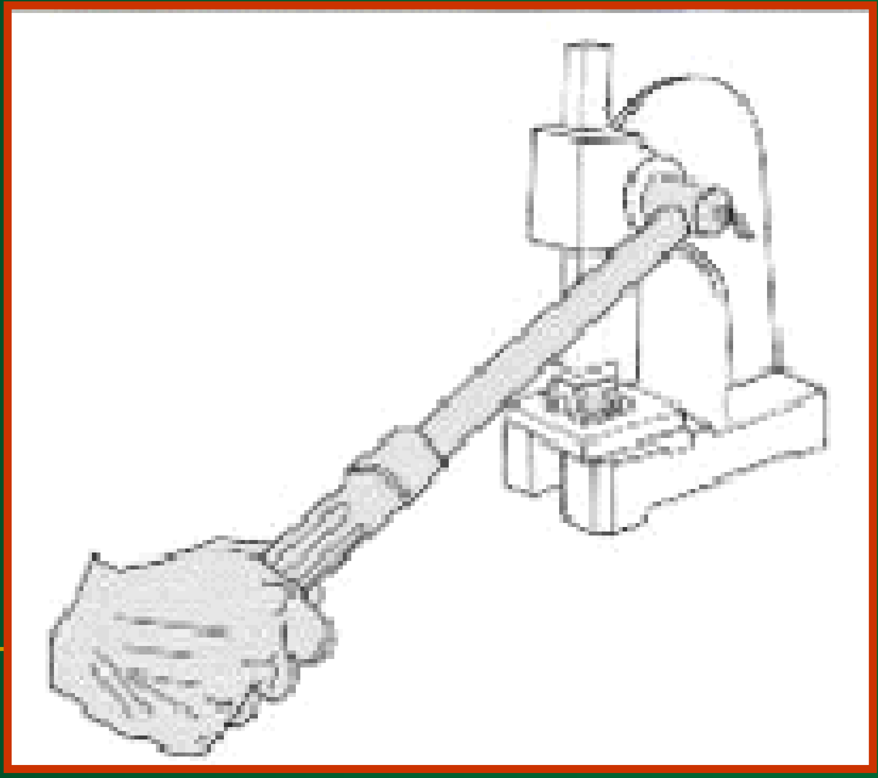
Random Scan Displays

- Random scan displays are designed to draw all the component lines of a picture 30 to 60 times each second.



Random Scan Displays

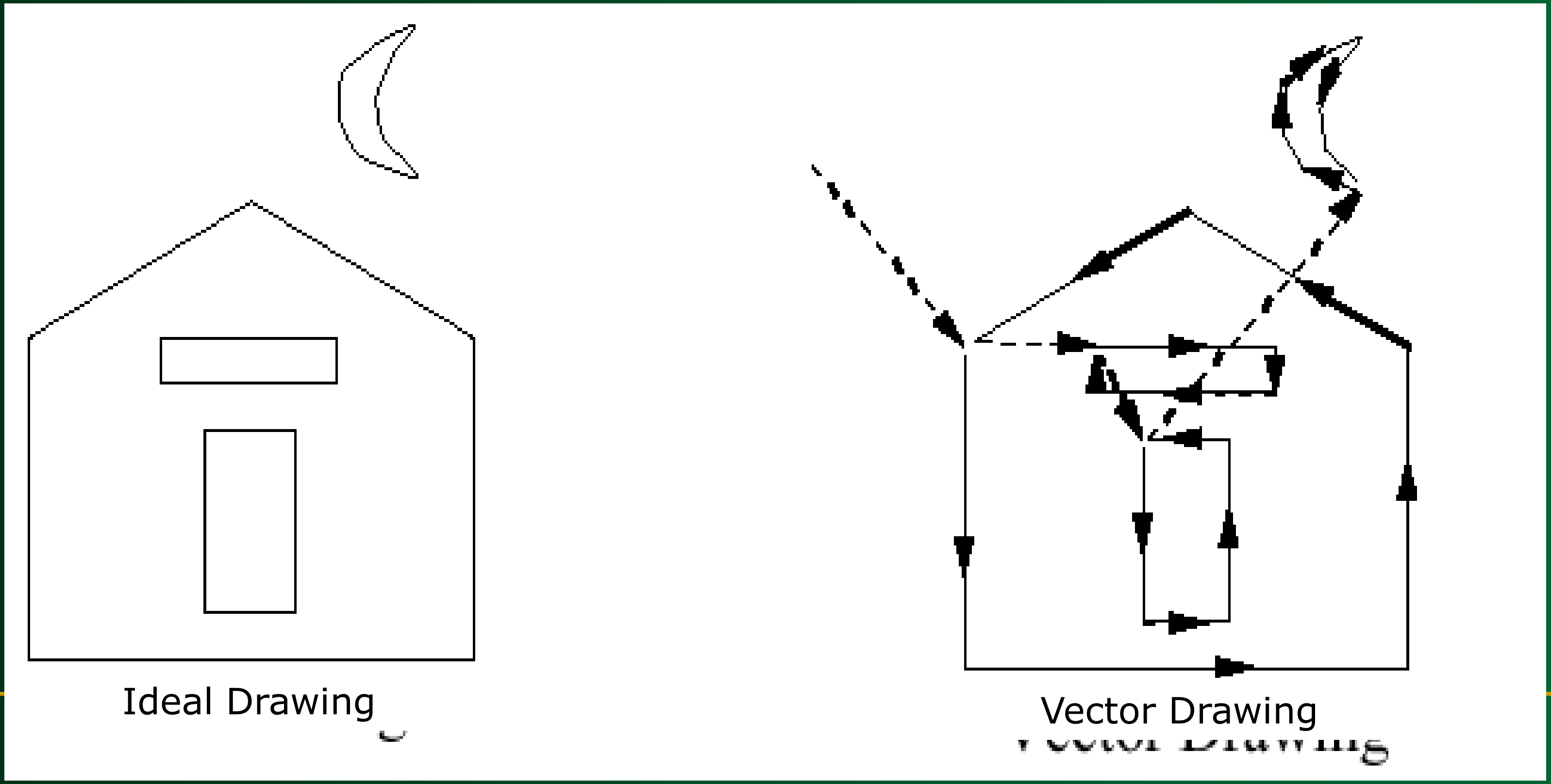
- Random scan displays are designed for **line-drawing applications** and can not display realistic shaded scenes.



Random Scan Displays

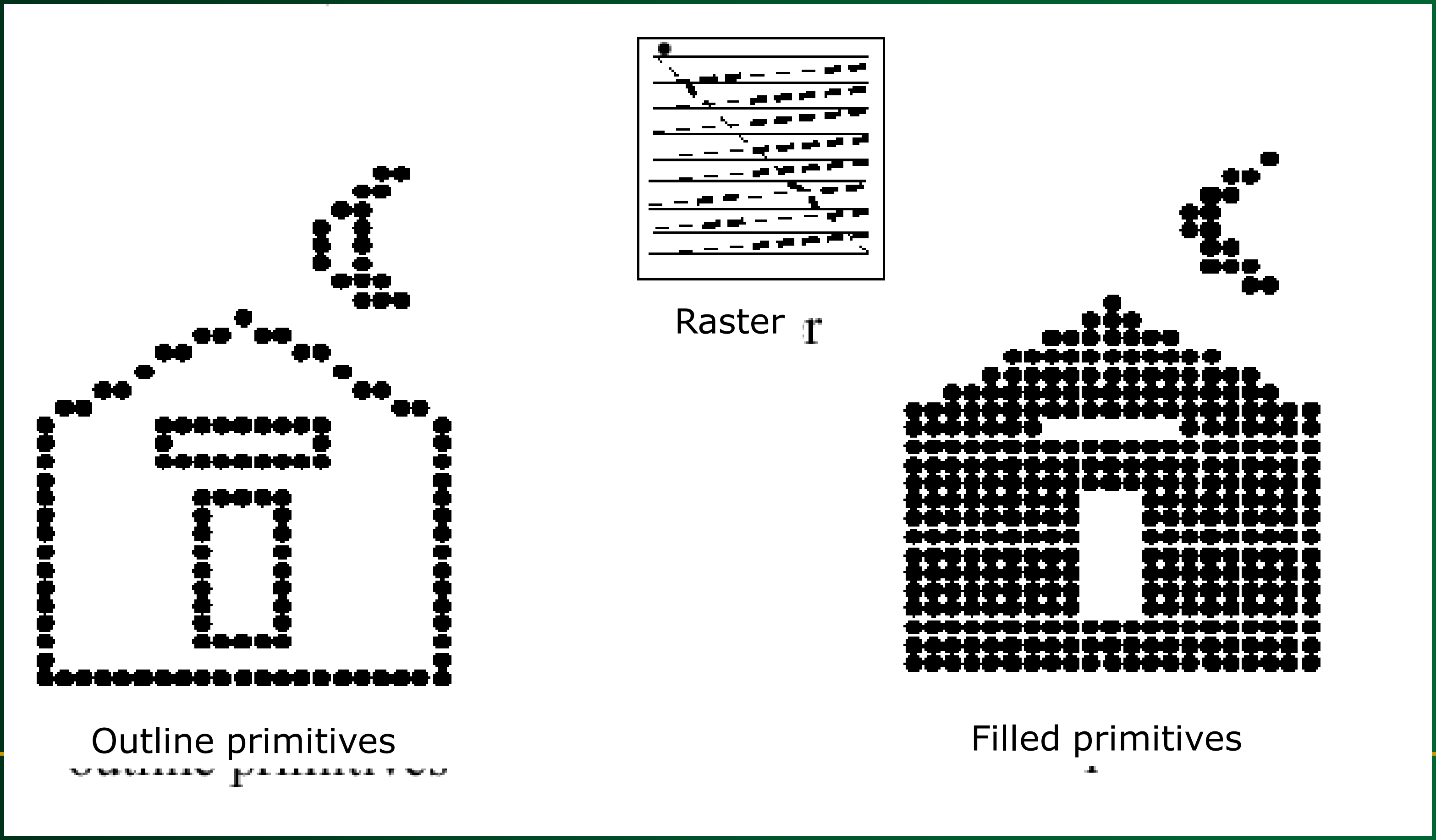
Random Scan Displays

- Random scan displays have higher resolution than raster systems.
- Vector displays product smooth line drawing.



Random Scan Displays

- A raster system produces jagged lines that are plotted as discrete points sets.



Random Scan Example

Data are describing a circle:

- the radius r
- The location of the center point of the circle
- Stroke line style and color
- Fill style and color

Random Scan Example

- **Advantages:**
- This minimal amount of information translates to a much smaller file size. (file size compared to large raster images)
- On zooming in, and it remains smooth
- The parameters of objects are stored and can be later modified (transformation).

Color CRT Monitors

Color CRT Monitors

- A CRT monitor displays color pictures by using a combination of phosphors that emit different ***color*** lights.

Methods

1. **Beam Penetration**

2. **Shadow Mask**

Beam Penetration Method

Beam Penetration Method

- Two layers of ***phosphor*** (**red** and **green**) are coated onto the inside of the CRT screen.
- The display color depends on haw far the electron beam **penetrates** into the phosphor layers.

Beam Penetration Method

- The speed of the electrons, and the screen color at any point, is controlled by the beam **acceleration voltage.**

Beam Penetration Method

The beam penetration method:

- Used with random scan monitors
- Only four colors are possible (**red**, **green**, **orange**, and **yellow**).
- Quality of pictures is not as good as with other methods.

Shadow Mask Method

Shadow Mask Method

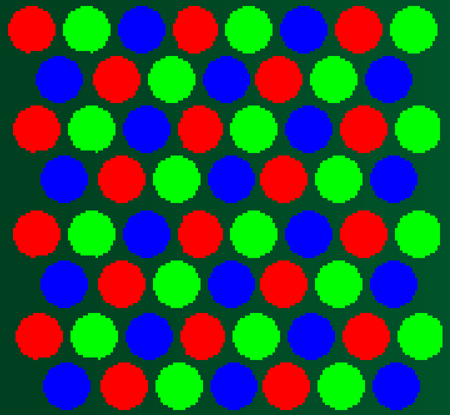
The color CRT has:

- Three color ***phosphor*** dots (**red**, **green** and **blue**) at each point on the screen

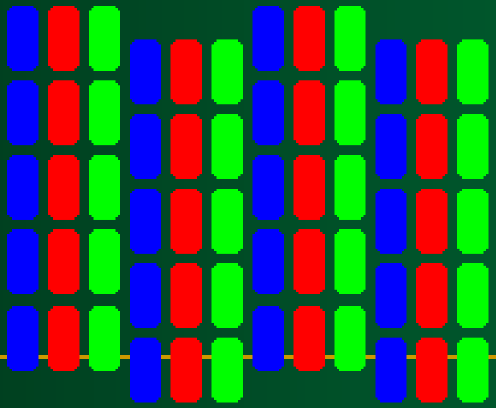
- Three ***electron guns***, each controlling the display of red, green and blue light.

Shadow Mask Method

Delta Method:

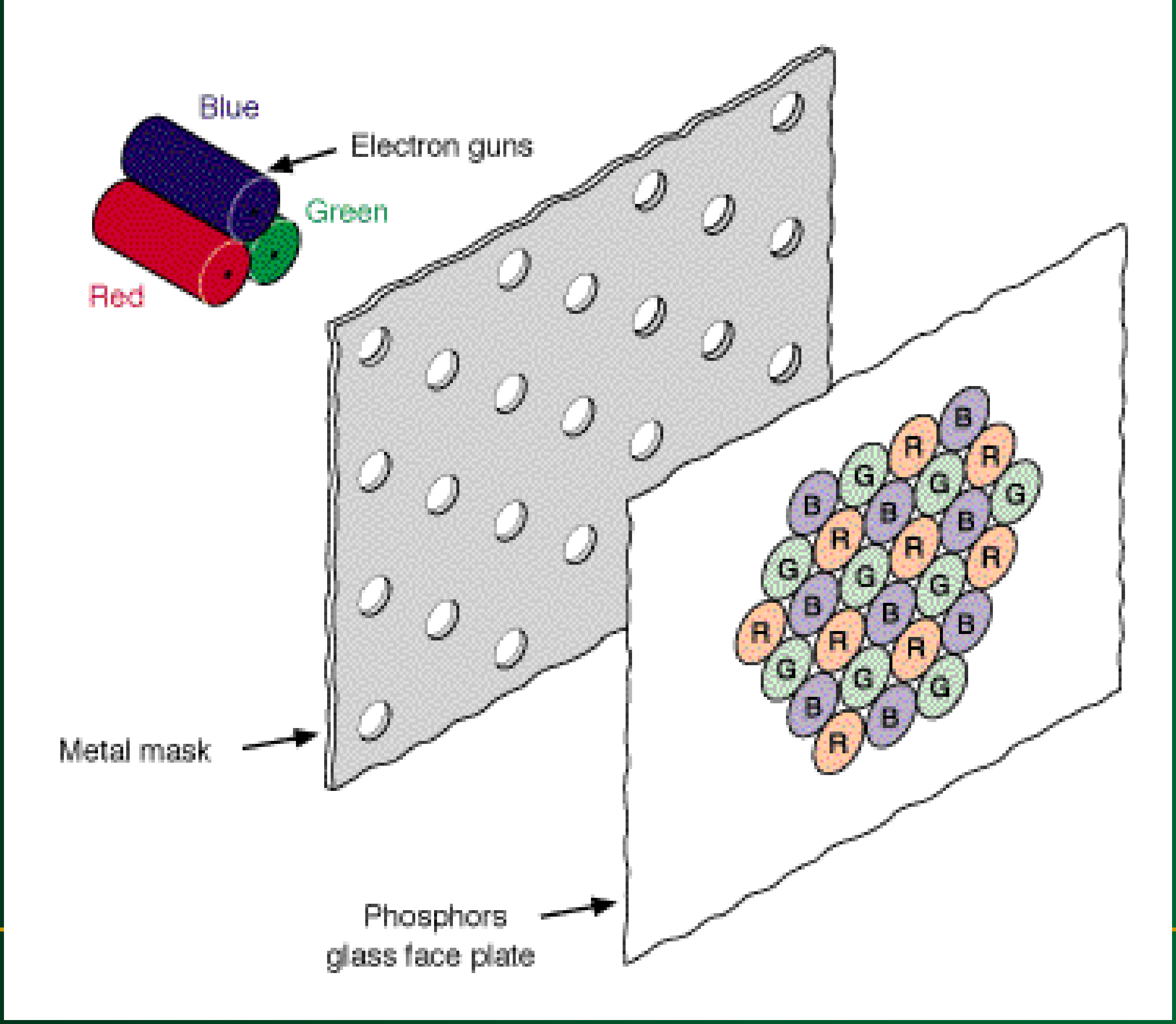


In-line Method:



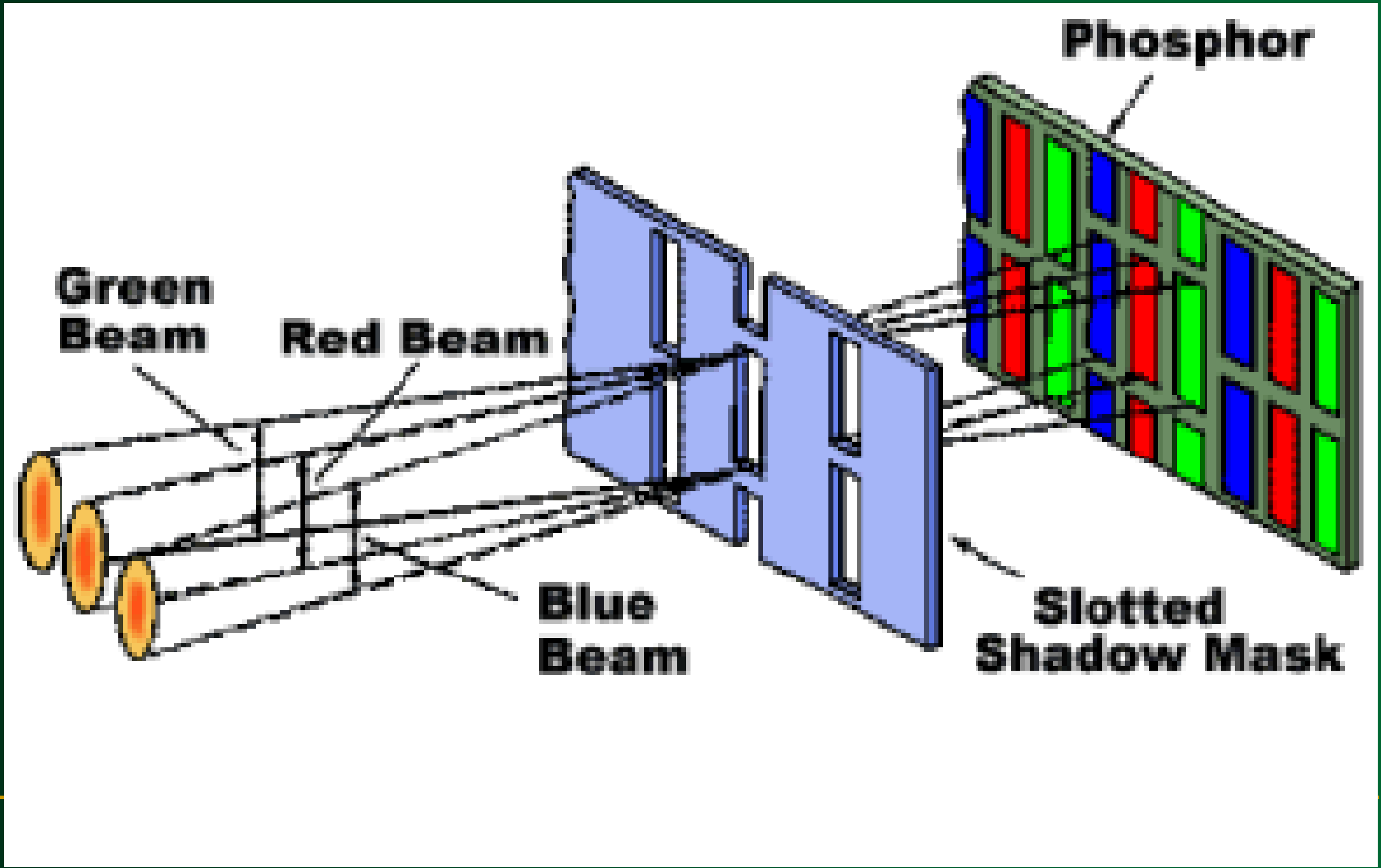
Shadow Mask Method

The delta-delta method:



Shadow Mask Method

The in-line method:



Shadow Mask Method

- We obtain color variations by varying the **intensity** levels of the three electron beam.

Shadow Mask Method

Shadow mask methods are:

- Used in raster scan system (including color TV)

- Designed as ***RGB*** monitors.

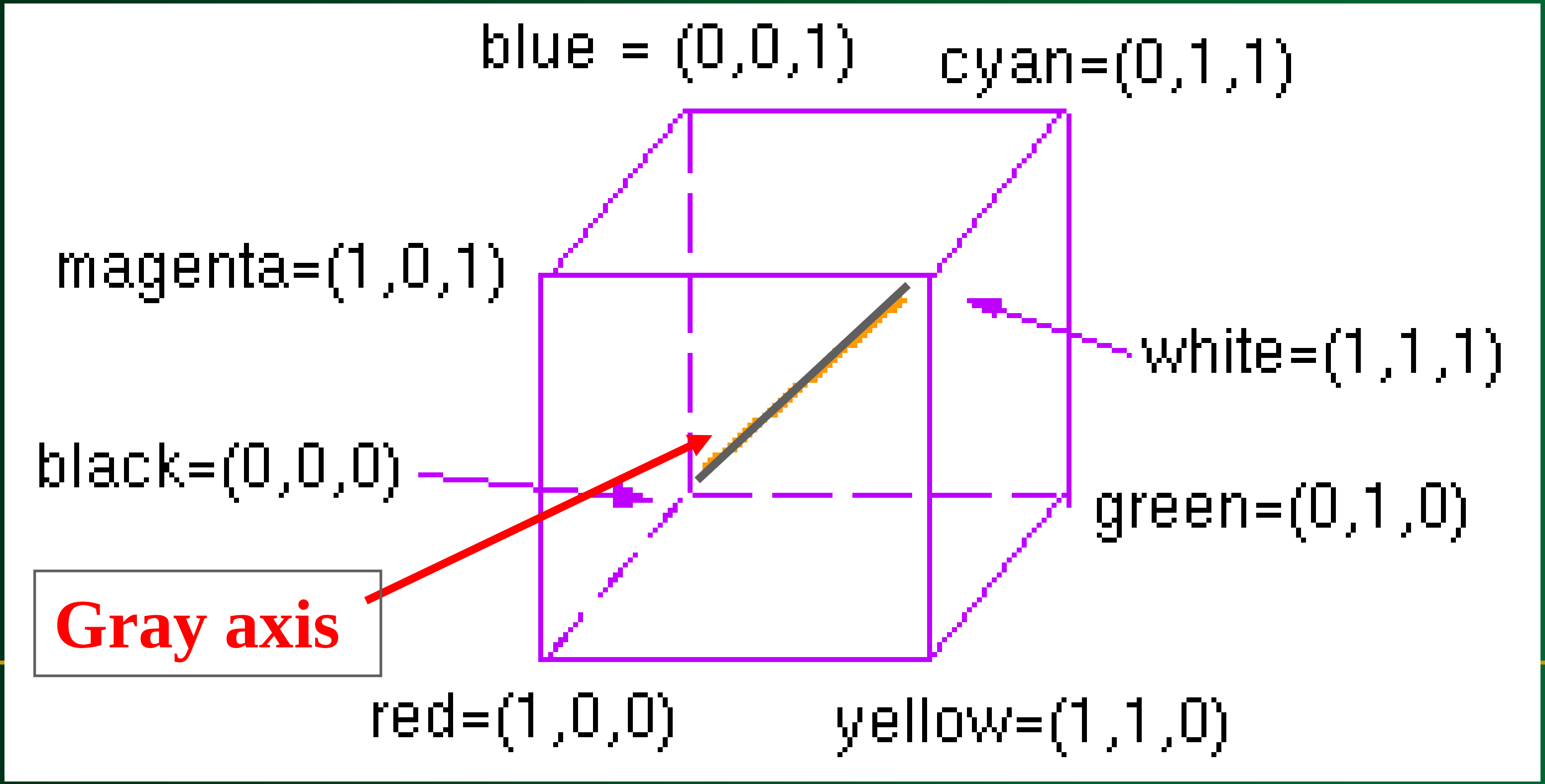
Shadow Mask Method

- High quality raster graphics system have **24** bits per pixel in the frame buffer (a **full color** system or a **true color** system)

Color Models

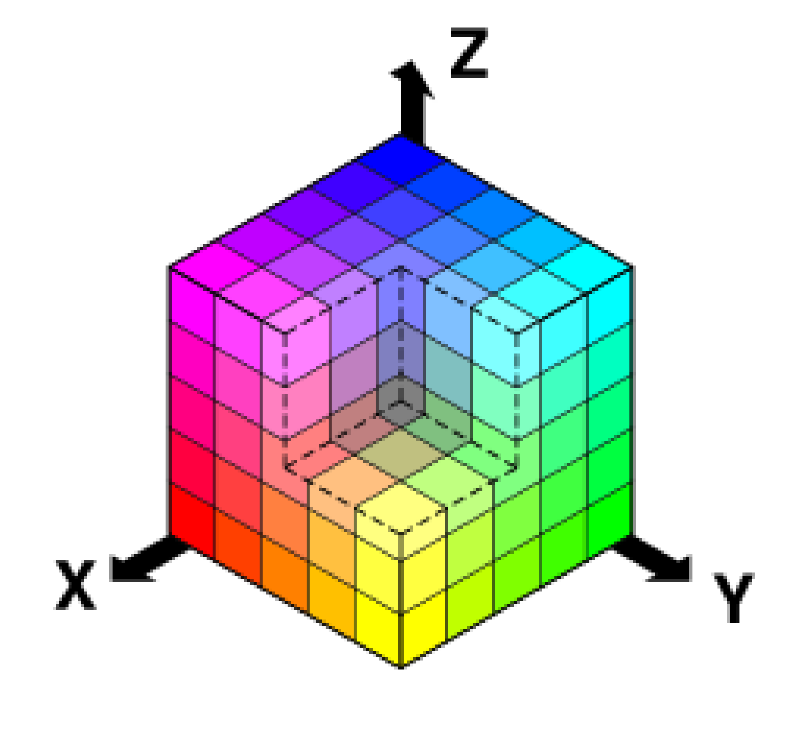
The RGB Color Model

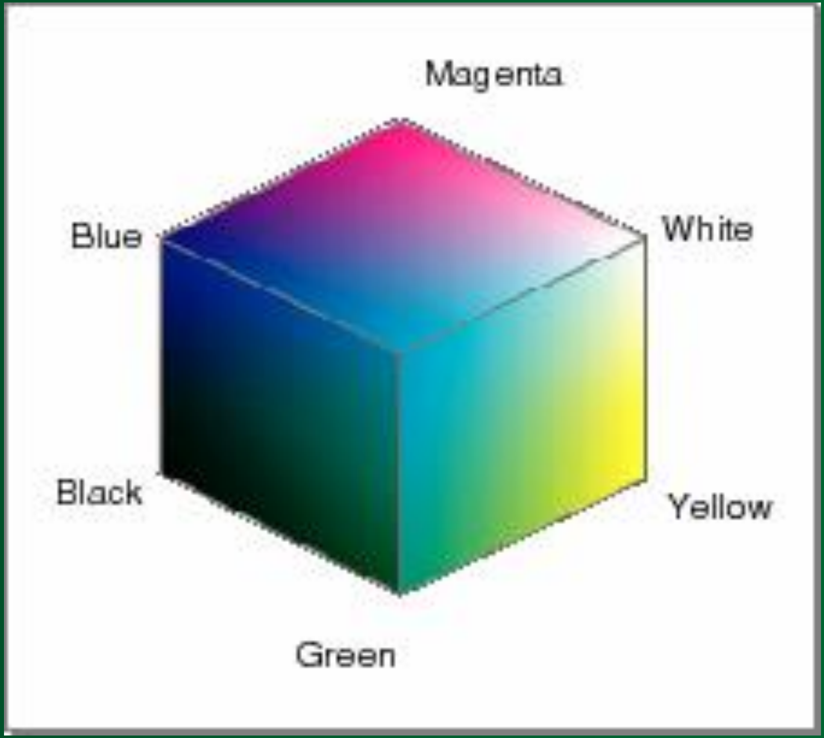
- ***R***, ***G***, and ***B*** represent the colors produced by ***red***, ***green*** and ***blue*** phosphors, respectively.



RGB Color Model

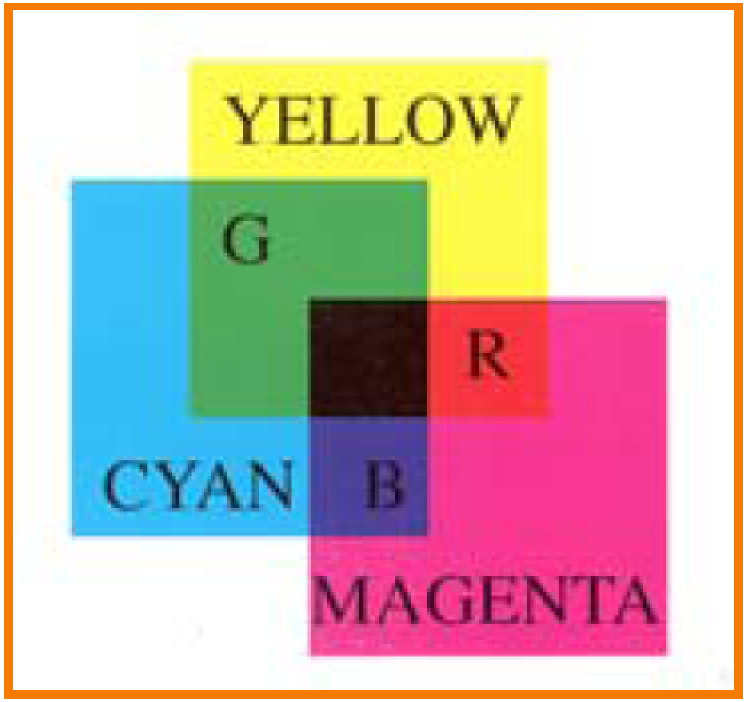
RGB color space





CMY Color Model

CMY (short for Cyan, Magenta, Yellow, and key) is a subtractive color model.

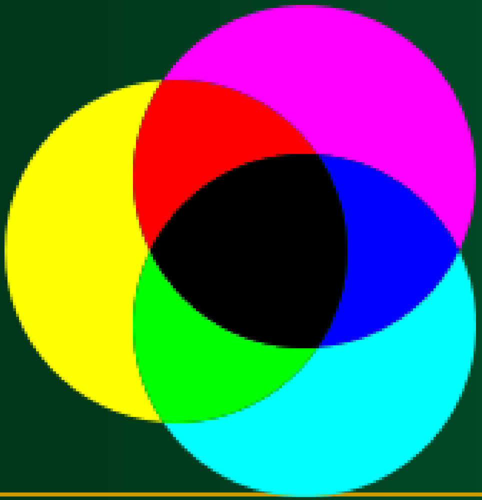


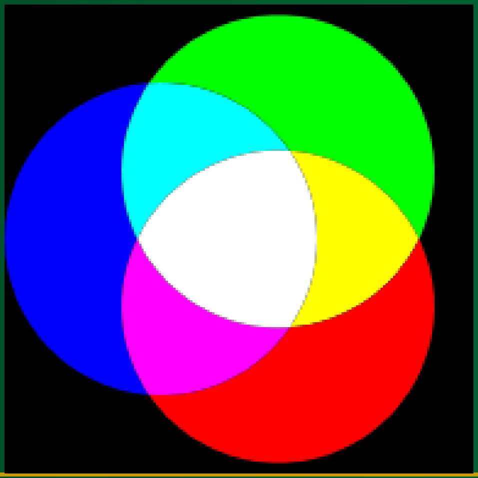
Colors are subtractive

C	M	Y	Color
0.0	0.0	0.0	White
1.0	0.0	0.0	Cyan
0.0	1.0	0.0	Magenta
0.0	0.0	1.0	Yellow
1.0	1.0	0.0	Blue
1.0	0.0	1.0	Green
0.0	1.0	1.0	Red
1.0	1.0	1.0	Black
0.5	0.0	0.0	
1.0	0.5	0.5	
1.0	0.5	0.0	

CMY Color Model

$$\begin{pmatrix} C \\ M \\ Y \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} - \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$





Color Depth, Bit Depth

- The number of discrete intensities that the video card is capable of generating for each color determines the maximum number of colors that can be displayed.
- The number of memory bits required to store color information (intensity values for all three primary color components) about a pixel is called **color depth** or **bit depth**.

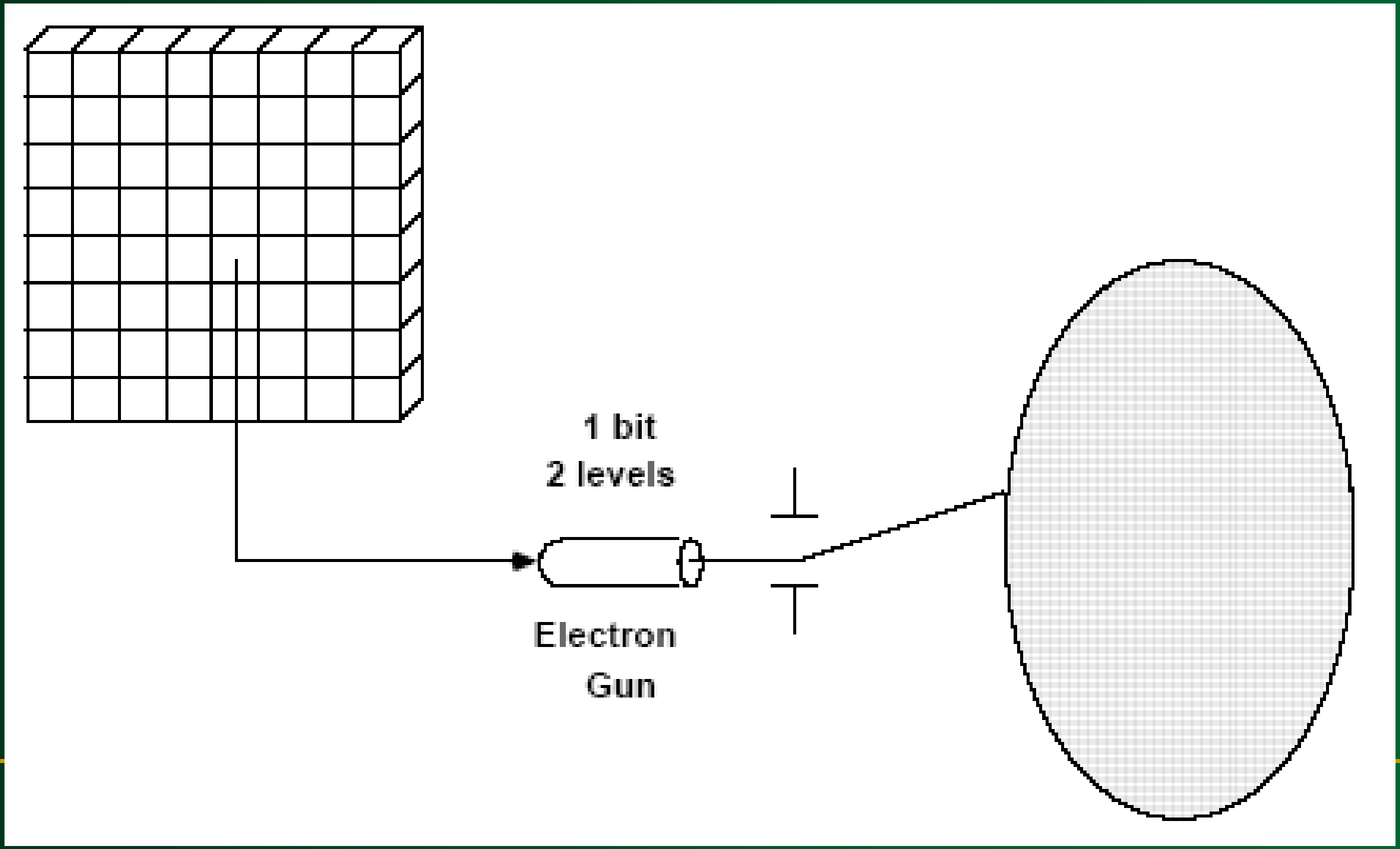
Color Depth, Bit Depth

- A minimum of one memory bit (color depth=1) is required to store intensity value either 0 or 1 for every screen pixel.

- If there are n pixels in an image a total of n bits memory used for storing intensity values (in a pure black & white image)

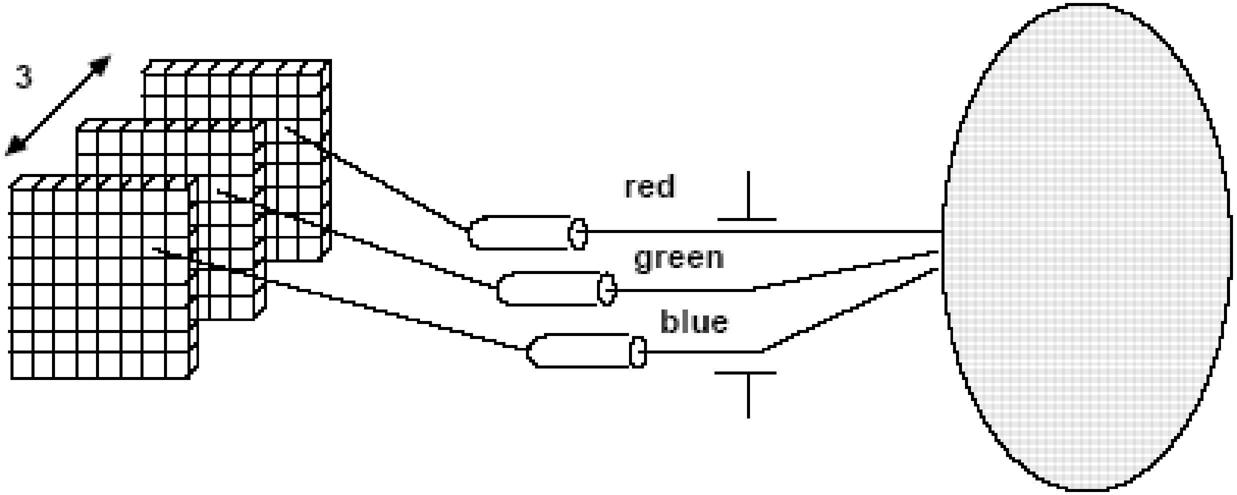
Bit Plane

- The block of memory which stores (or is mapped with) intensity values for each pixel (B& W image) is called a **bit plane** or **bitmap**.



3Bit color display

- Color or gray levels can be achieved in the display using additional bit planes.



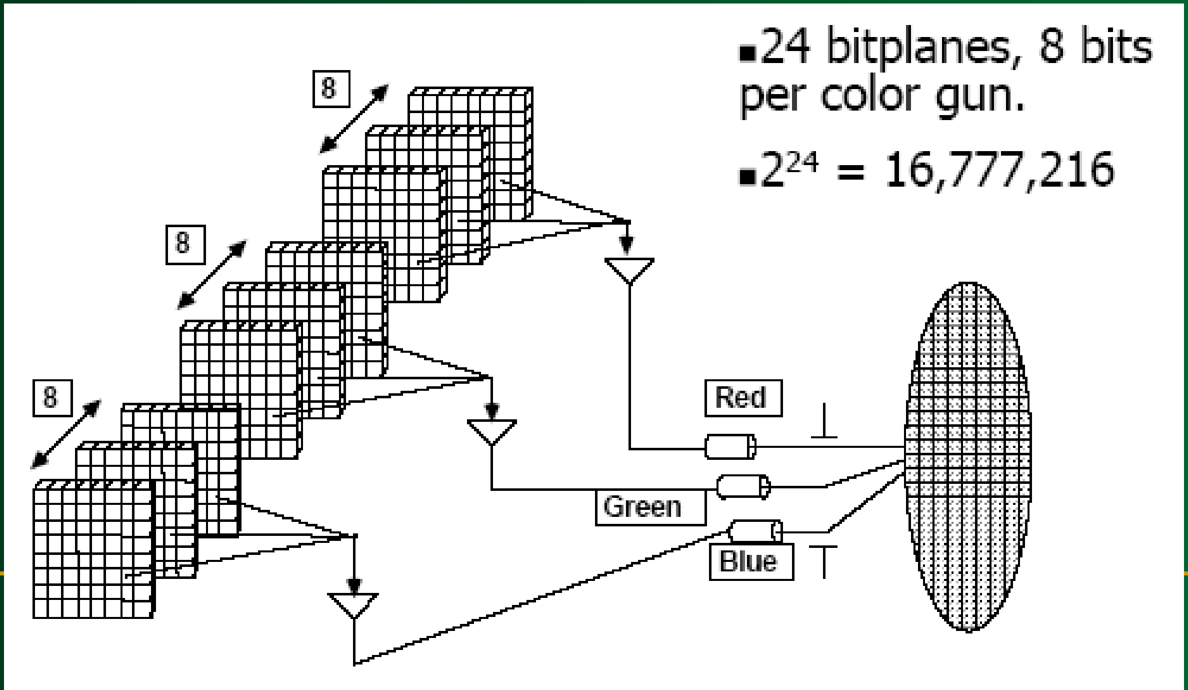
COLOR:	black	red	green	blue	yellow	cyan	magenta	white
R	0	1	0	0	1	0	1	1
G	0	0	1	0	1	1	0	1
B	0	0	0	1	0	1	1	1

N Bit Planes

- The result for n bits per pixel (color depth=n) is a collection of n bit planes (2^n colors or gray shades at every pixel)

True Color

- For **true Color three bytes** of information are used, one for each of the red, blue and green signals that make a pixel.
- A byte can hold 256 different values and so 256 intensities setting are possible for each electron gun which mean each primary color can have 256 intensities (**256*256* 256 color possible**)



High Color

- For **high Color two bytes** of information are used, to store the intensity values for all three color. This is done by dividing 16 bits into 5 bits for blue, 5 bits for red and 6 bits for green. This means 32($=2^5$) intensities for blue, 32 ($=2^5$) for red, and 64 ($=2^6$) for green.

- Loss of visible image quality.

256 color mode

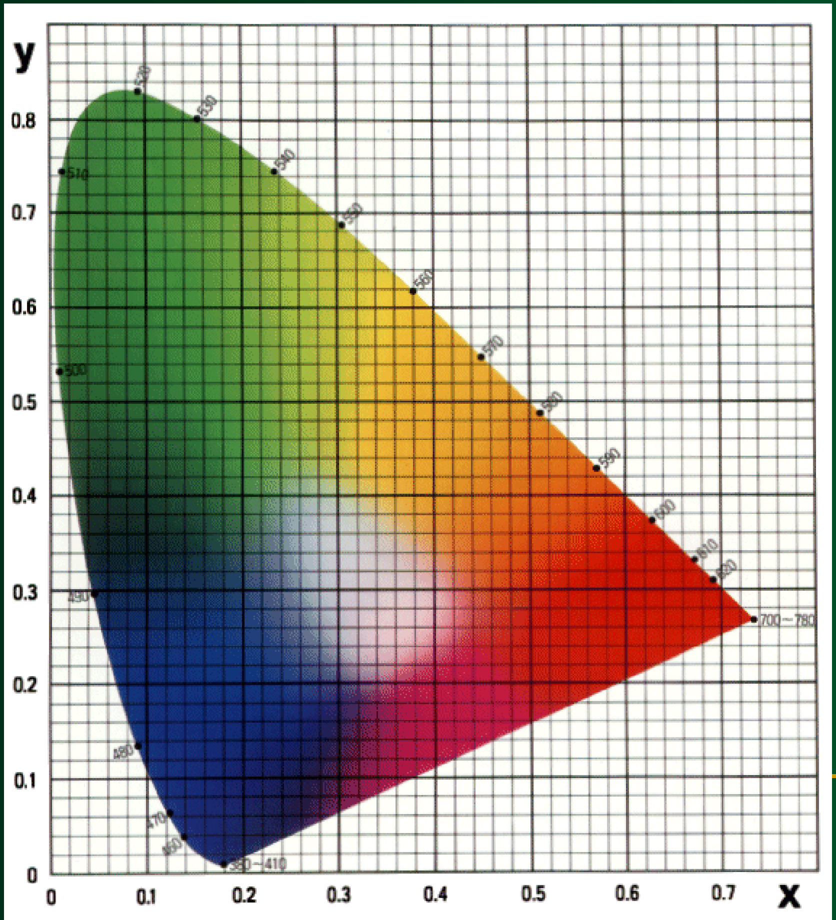
- The PC uses only 8 bits, 2 bits for blue and 3 each for green and red.
- Most of the colors of a given picture are not available.
- A ***palette*** or ***look-up table*** is used here.

Color Palette

- A palette is a separate memory block (in addition to the 8 bit plane) created 256 different colors.
- Each color is defined using the standard 3 byte color definition that is used in true color.
- The intensity values for each of the three primary color component can be anything between 0 and 255 in each of the table entries.

Color Palette

- The intensity values for each of the three primary color component can be anything between 0 and 255 in each of the table entries.

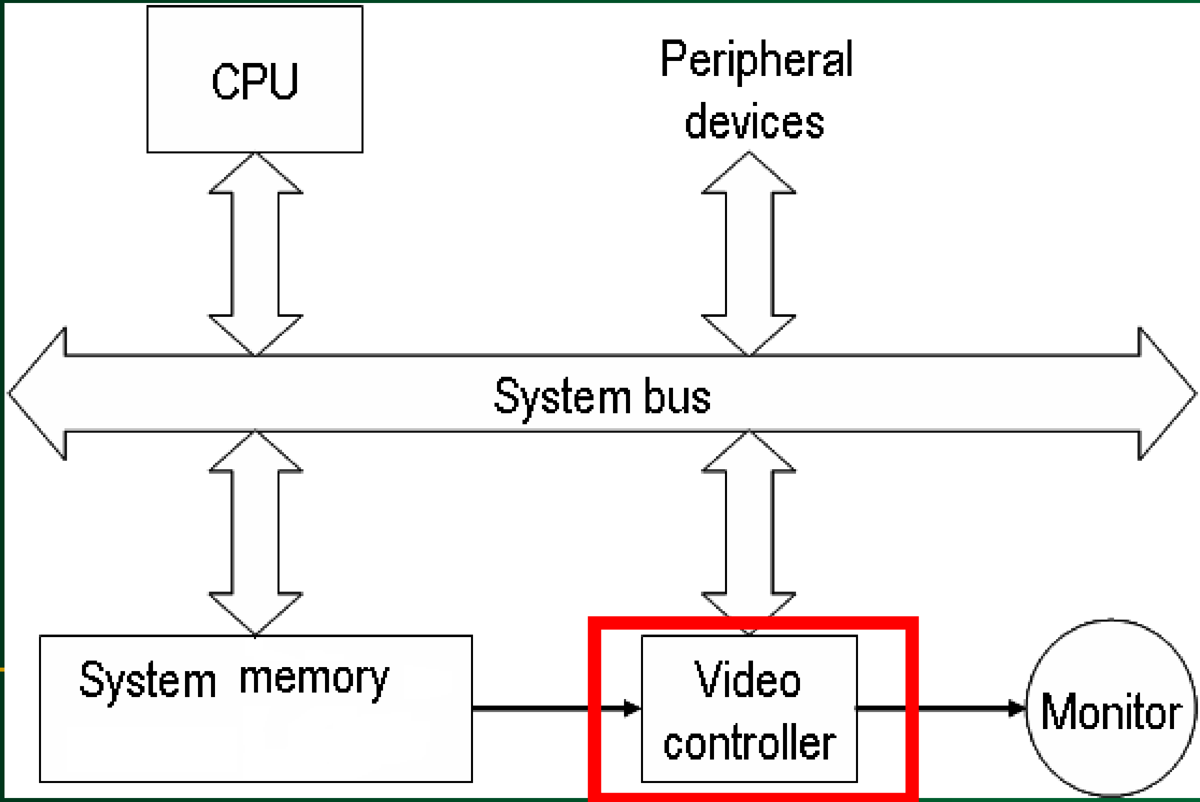


Total number of colors available called **color palette**.

Raster Scan Systems

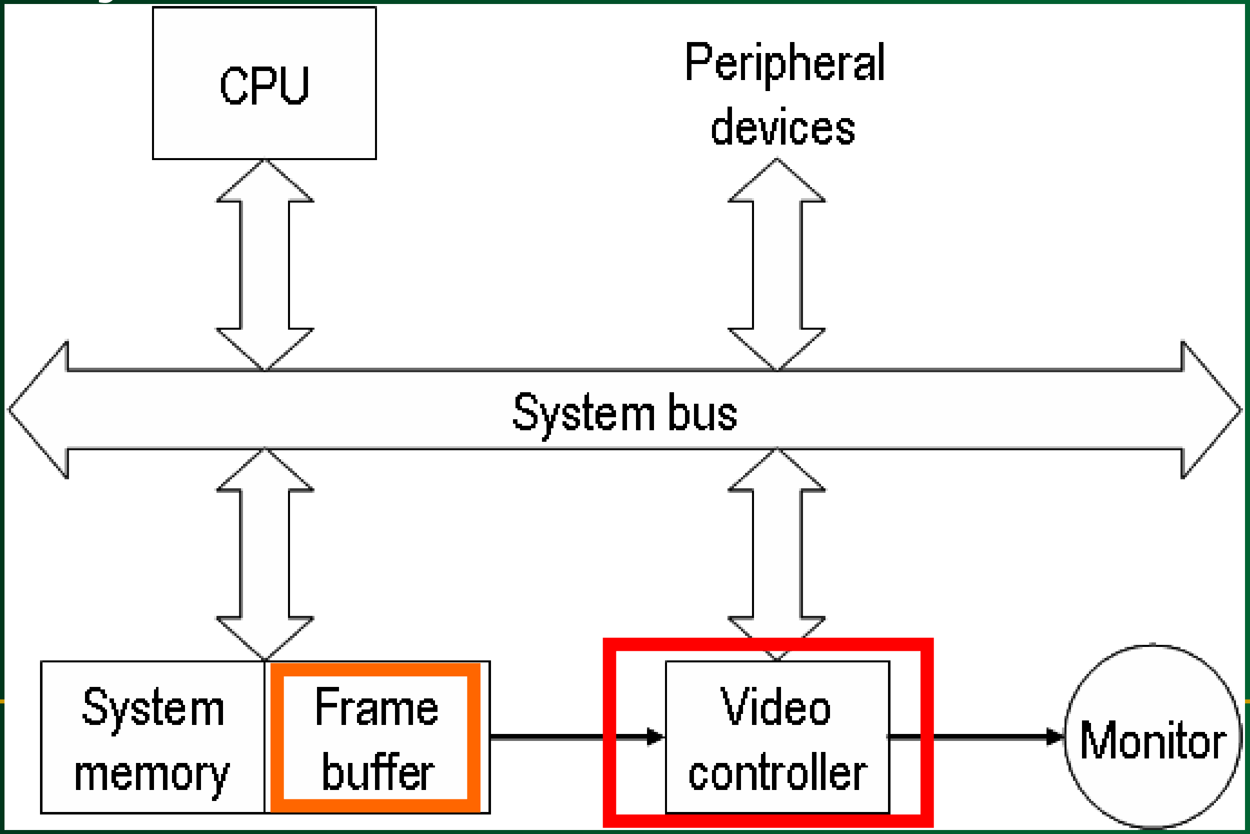
Raster Scan Systems

- In addition to the central processing unit (CPU), a special processor, called the **video controller** or **display controller**, is used to control the operation of the display device.



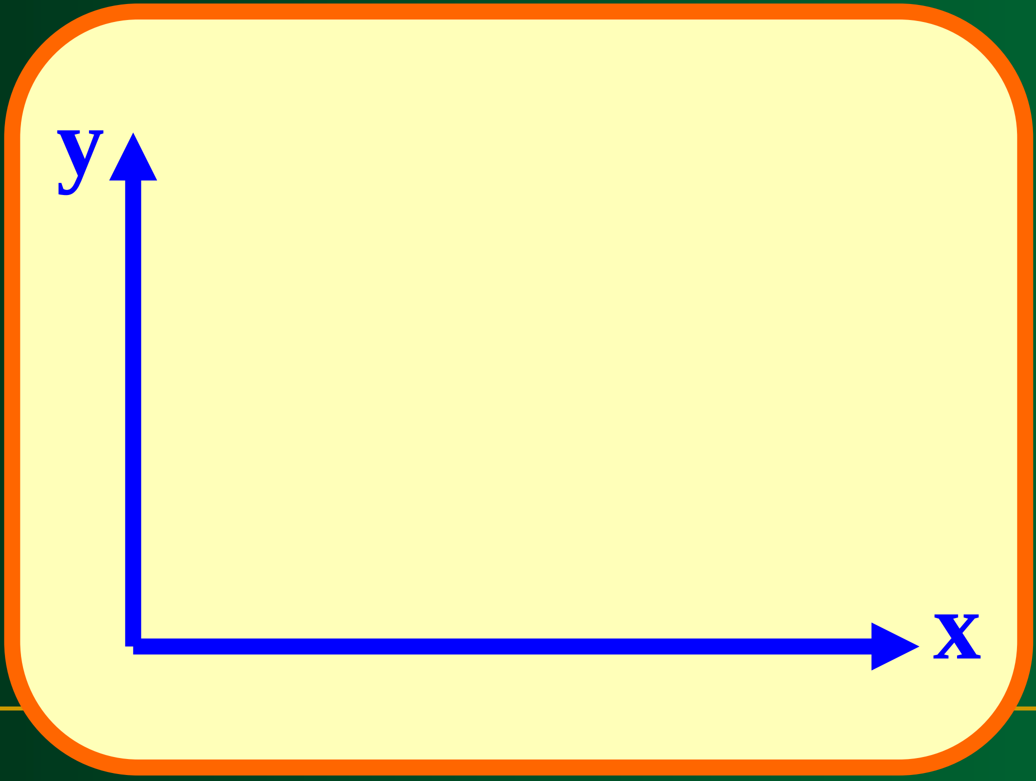
Video Controller

- A fixed area of the system memory is reserved for the frame buffer, and the video controller is given direct access to the frame buffer memory.



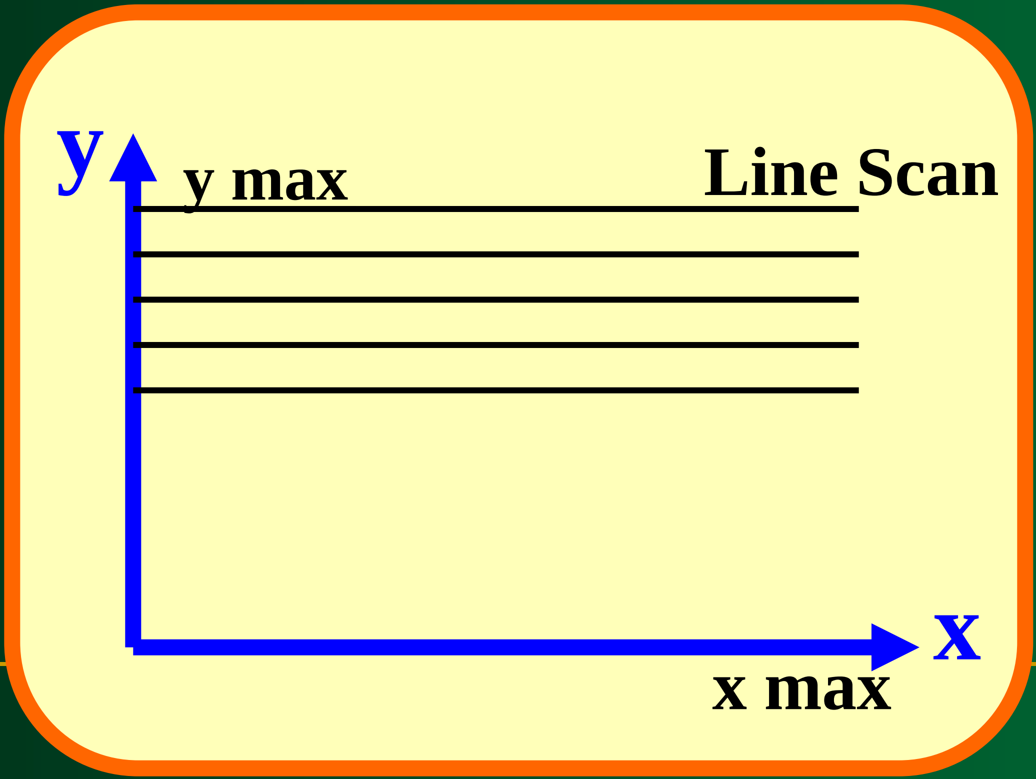
Video Controller

- **Frame buffer** location, and the corresponding screen positions, are referenced in Cartesian coordinates.



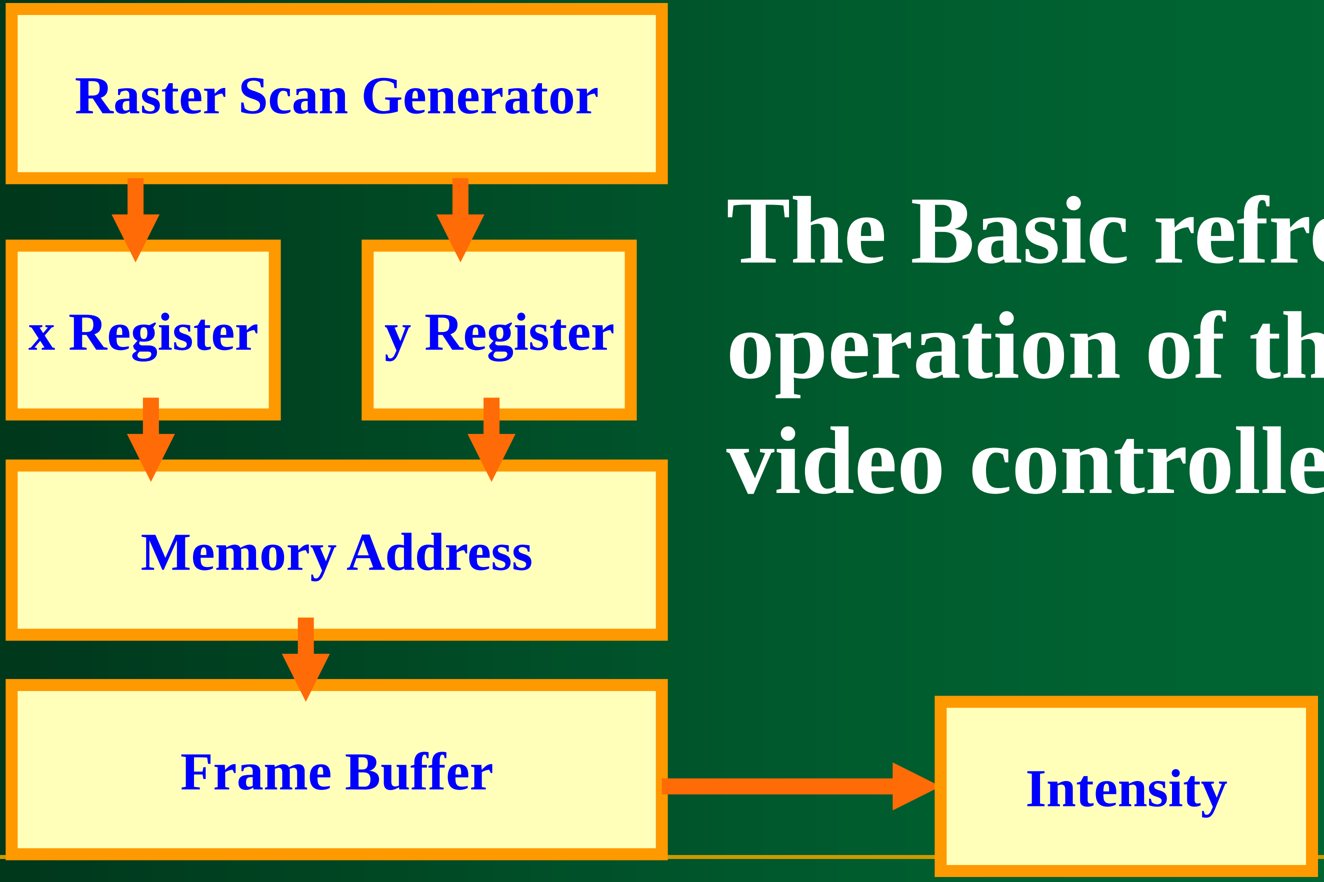
Video Controller

- **Scan lines** are then labeled from y_{max} at the top of the screen to 0 at the bottom. Along each scan line, screen **pixel** positions are labeled from 0 to x_{max}.



Video Controller

- Two registers are used to store the coordinates of the screen pixels.



The Basic refresh operation of the video controller.

Video Controller

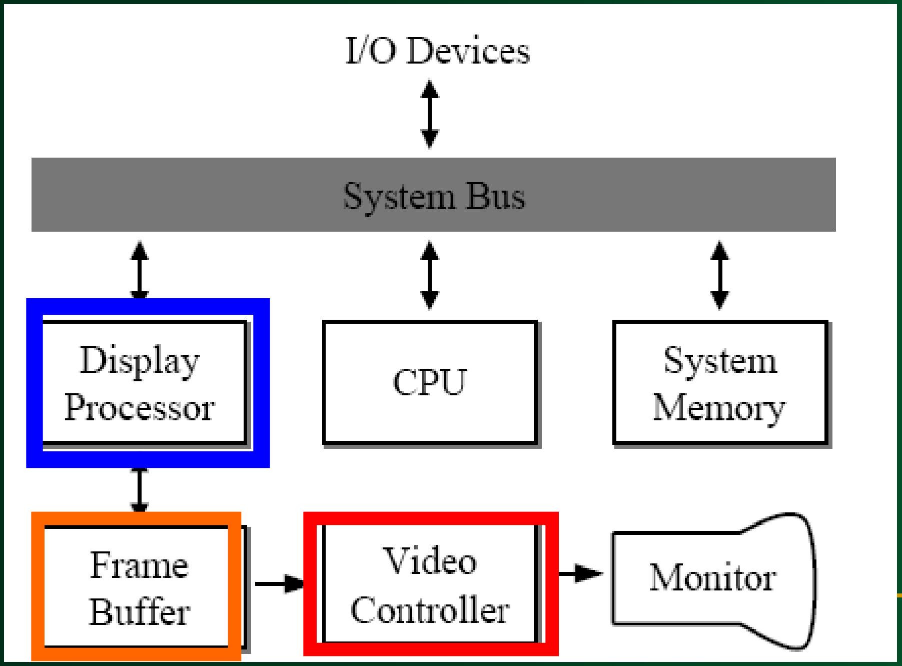
Some of operations can be performed by the Video Controller:

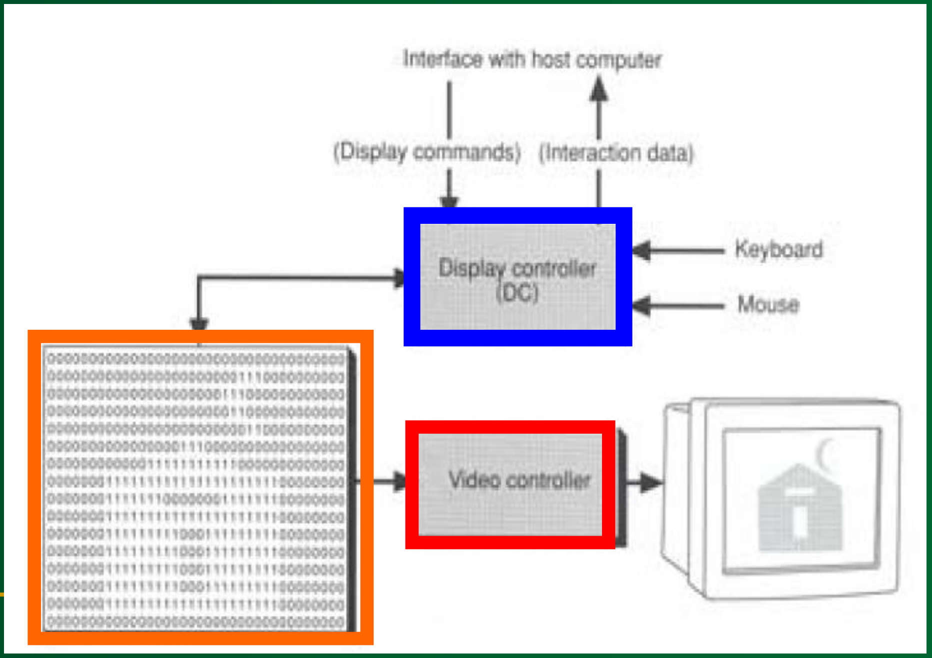
- Refreshing operation
- Transformation (Areas of the screen can be enlarged, reduces, or moved during the refresh cycles)

Raster Scan Display Processor

Raster Scan Display Processor

- A raster system containing a separate **display processor** (graphics controller, display coprocessor)
- The purpose of the **DP** is to free the CPU from the graphics chores.





DP

- A major task of the display processor is **Scan Conversion.**

- **Scan Conversion: is digitizing a picture definition given in an application program into a set of pixel intensity values for storage in the frame buffer**.(scan conversion straight line segment, Character)

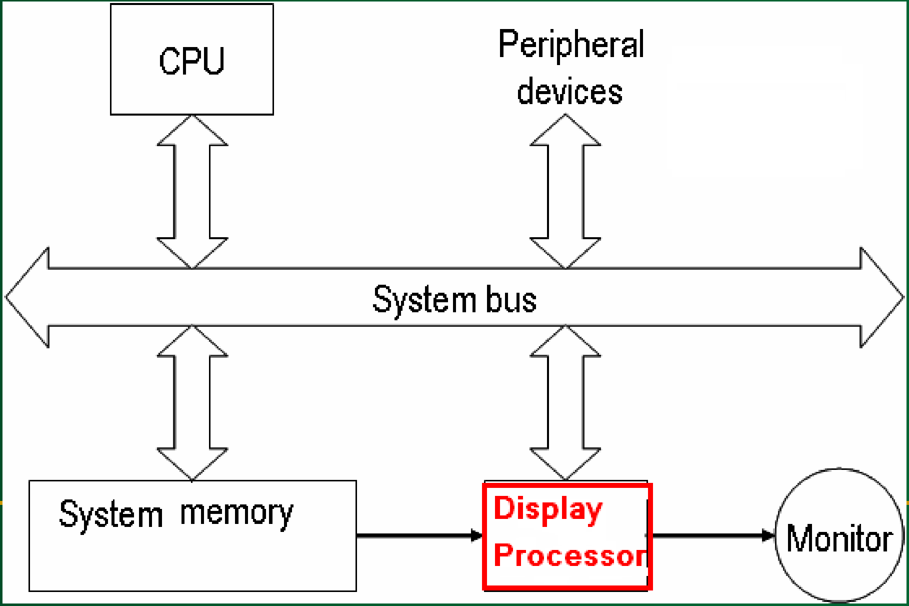
DP

- Generation various line styles (dashed, dotted, or solid)
- Displaying color areas
- Performing certain transformation and manipulation on display objects.

Random Scan Systems

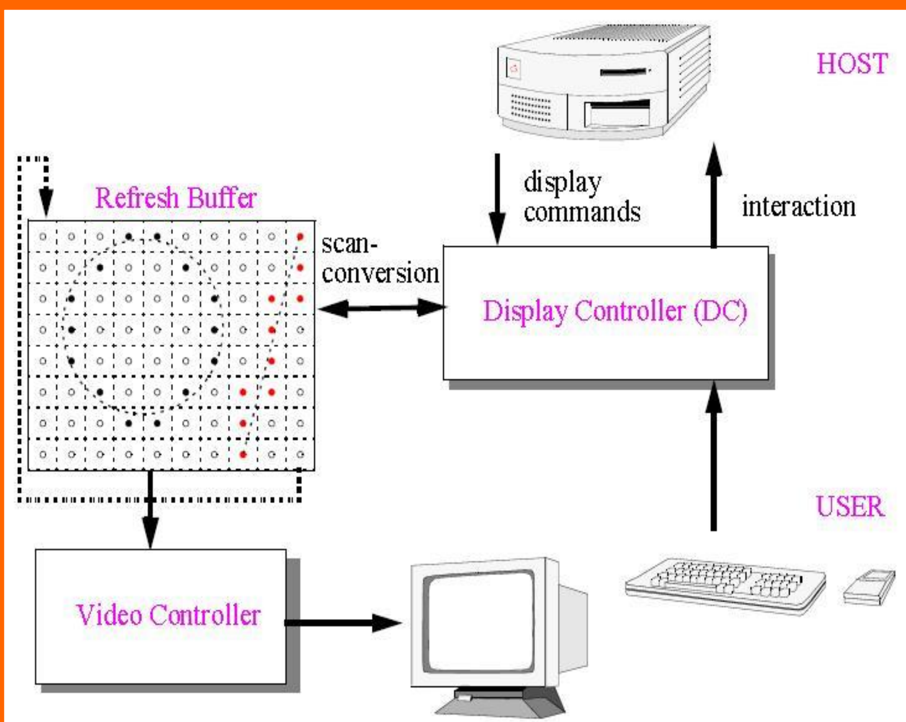
Random Scan System

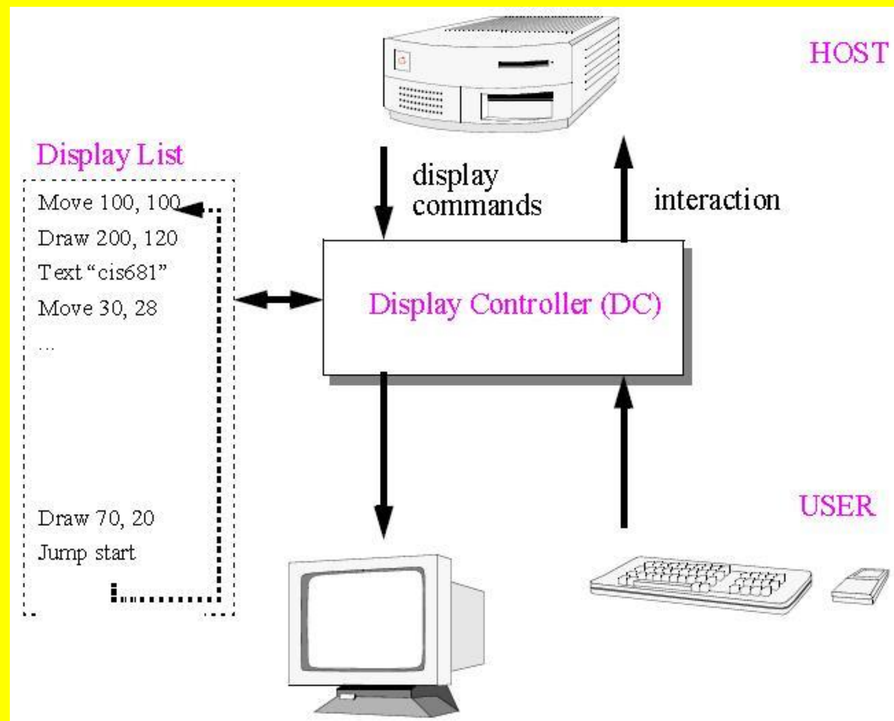
- Graphic commands are translated by the graphics package into a display file stored in the system memory.
- This file is then accessed by the **display processor unit** (**DPU**)(graphic controller) to refresh the screen.



Raster Scan System

Random Scan System





Flat Panel Displays

Flat Panel Displays

- A class of video devices that have reduce volume and weight compared to a CRT.

- A significant feature of flat panel displays is that they are **thinner** than CRTs.

Flat Panel Displays

Current uses for flat panel displays:

- Small TV monitors
- Calculators
- Pocket video games
- Laptop computers
- Advertisement boars in elevators

Flat Panel Displays

Flat panel displays:

- **Emissive** or **Emitters** Displays

- **Non-emissive** or **Non-emitters** Displays

Emissive (or Emitters) Displays

- Emissive displays convert **electrical energy** into light.
- Examples: Plasma panel, thin-film electroluminescent displays, Light-Emitting Diodes (LED) and flat CRT.

Non-Emissive (or Non-Emitters) Displays

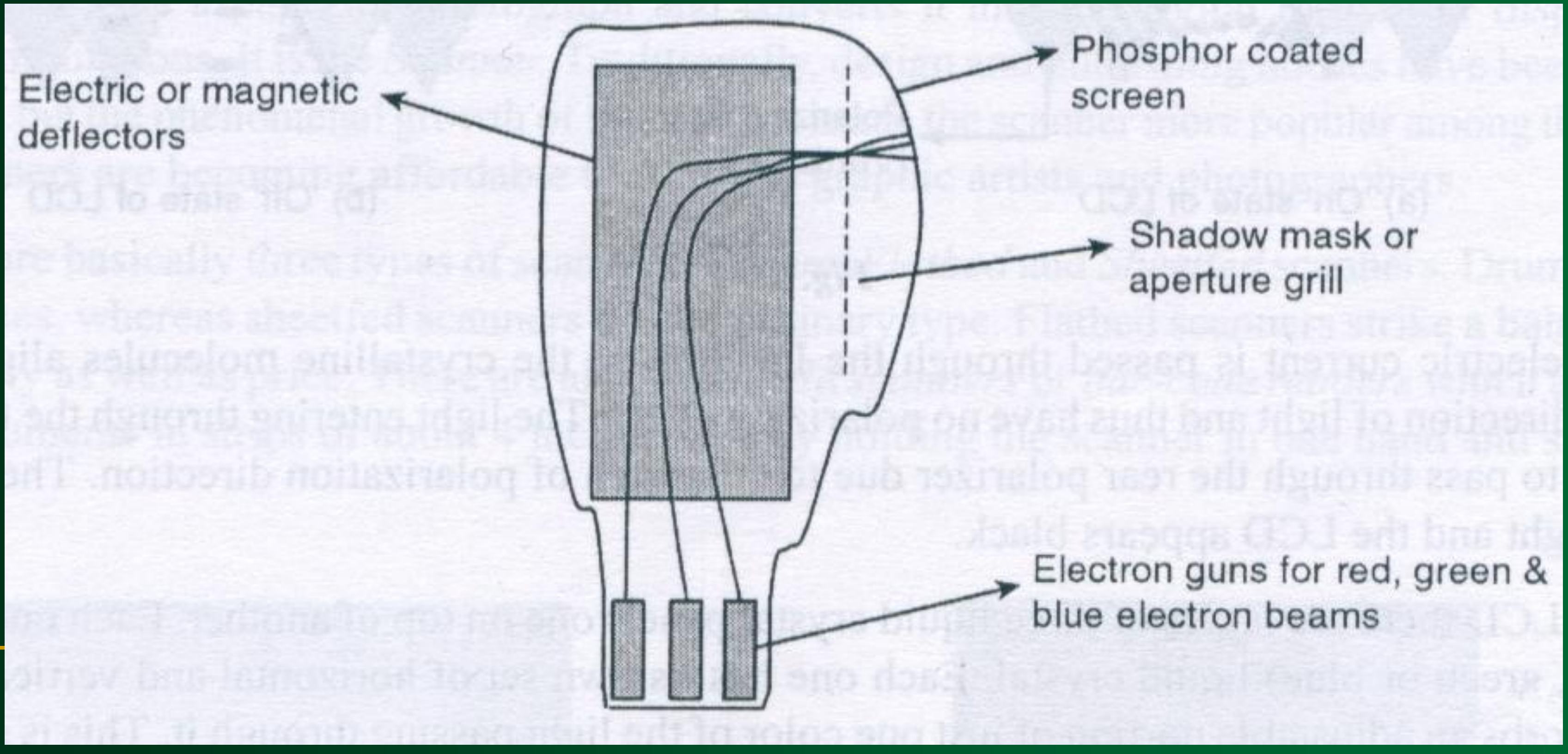
- Use **optical effects** to convert sunlight or light from some other source into graphics pattern.

- Example: **L**iquid-**C**rystal **D**evice (**LCD**)

Flat CRT

Flat CRT

- Electron beams are accelerated parallel to the screen, then deflected 90° to the screen.



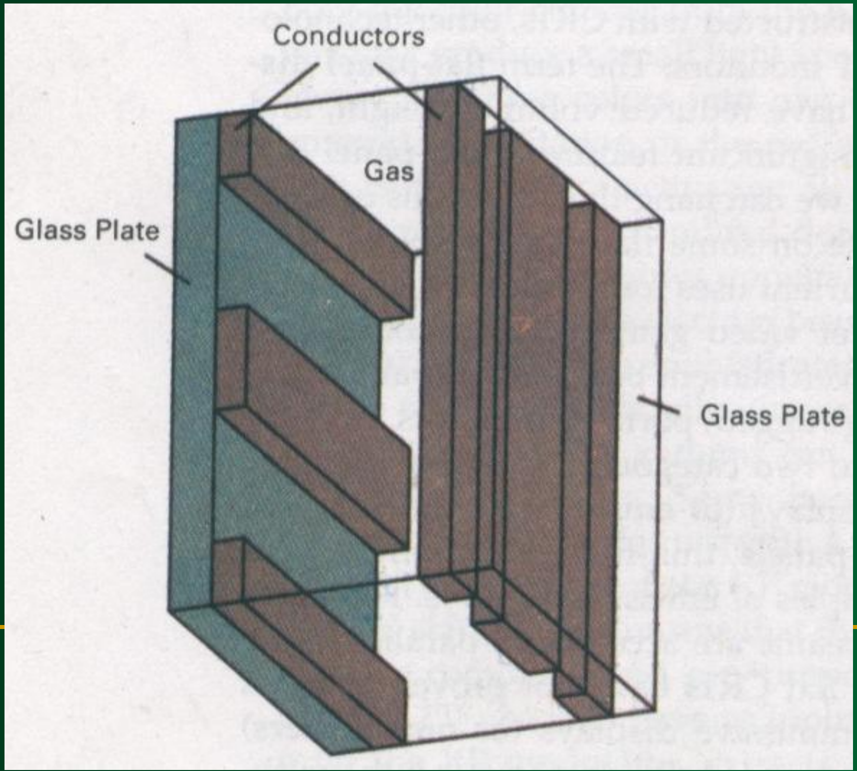
Plasma Panel

Plasma Panel

- A **layer of gas** (usually neon) is sandwiched between two glass plates.

Plasma Panel

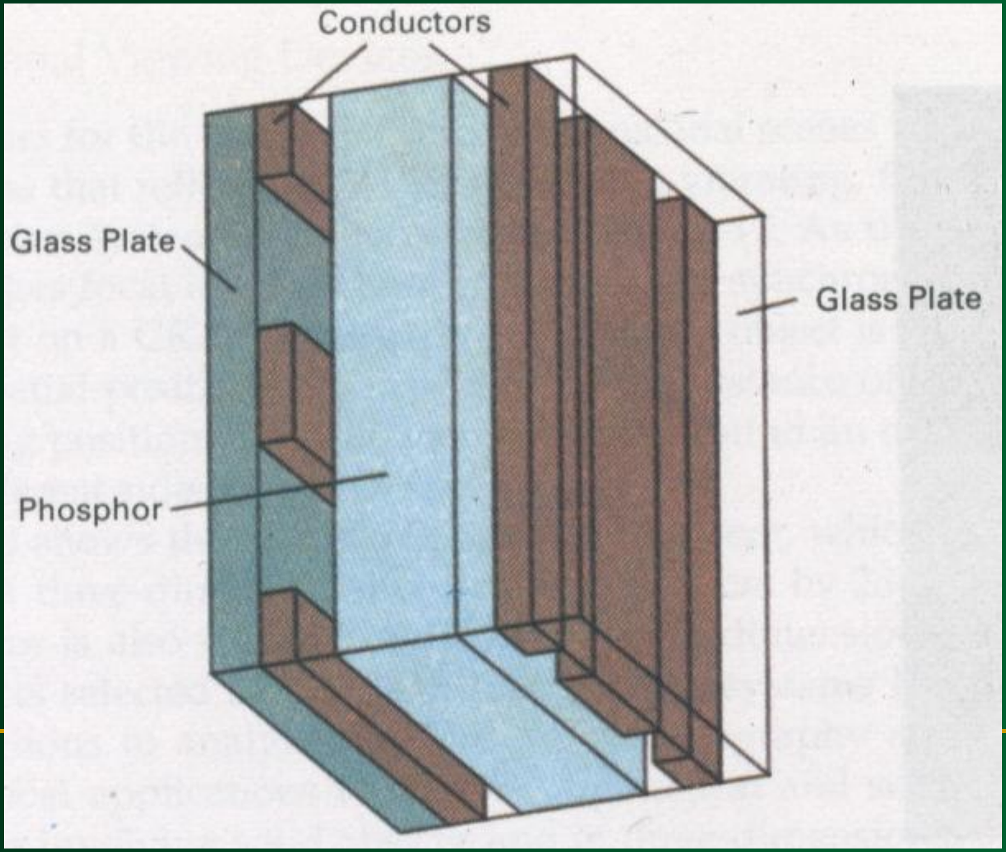
- By applying high voltage to a pair of horizontal and vertical conductors, a small section of the gas (tiny neon bulb) at the intersection of the conductors break down into glowing plasma of electrons and ions.



Thin Film Electroluminescent

Thin Film Electroluminescent

- The region between the glass plates is filled with a phosphor, such as zinc sulfide doped with manganese.



Light Emitting Diode (LED)

Light Emitting Diode (LED)

- A matrix of **diodes** is arranged to form the pixel positions in the display, and picture definition is stored in a refresh buffer.
- Information is read from the refreshed buffer and converted to voltage levels that are applied to the diodes to produce the light patterns in the display.

Liquid Crystal Displays (LCD)

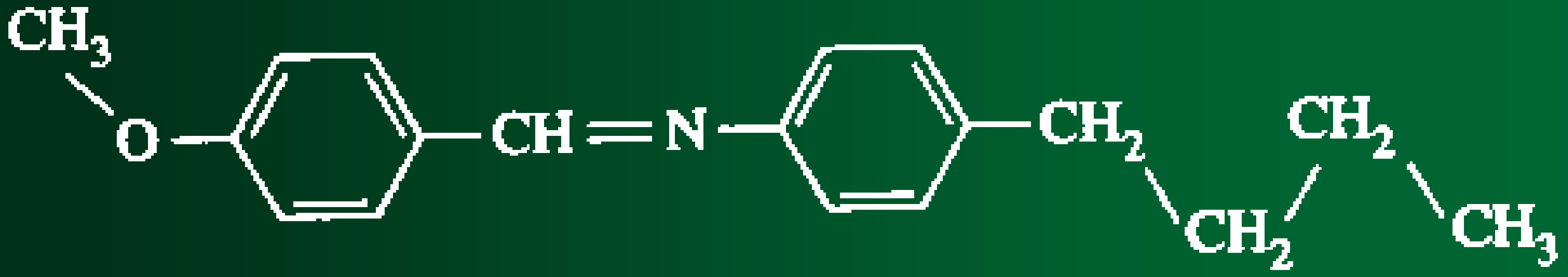
Liquid Crystal Displays (LCD)

- Used in small systems, such as calculators, laptop computers.

- Produce a picture by passing polarized light (from the surrounding or from an internal light source) through a liquid-crystal material that can be aligned to either block or transmit the light.

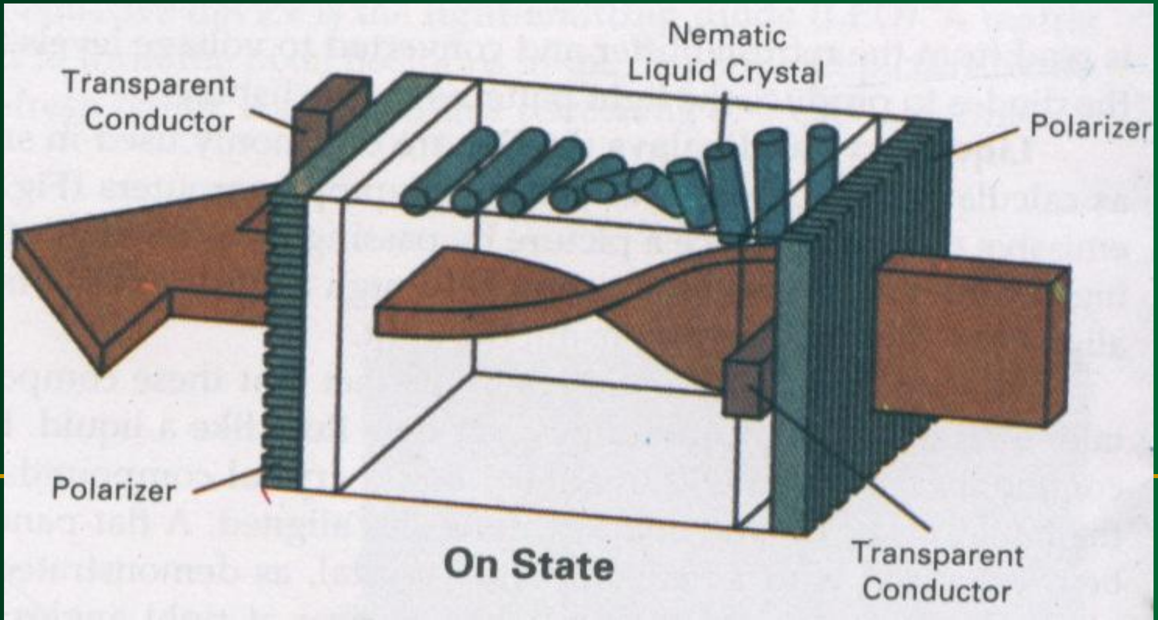
Liquid Crystal Displays (LCD)

- **Liquid crystal:** These compounds have a crystalline arrangement of molecules, yet they flow like a liquid.



Liquid Crystal Displays (LCD)

- Two glass plates, each containing a light polarizer at right angles to the other plate, sandwich the liquid crystal materials.
- Rows of horizontal transparent conductor & columns of vertical conductors (put into glass plates)

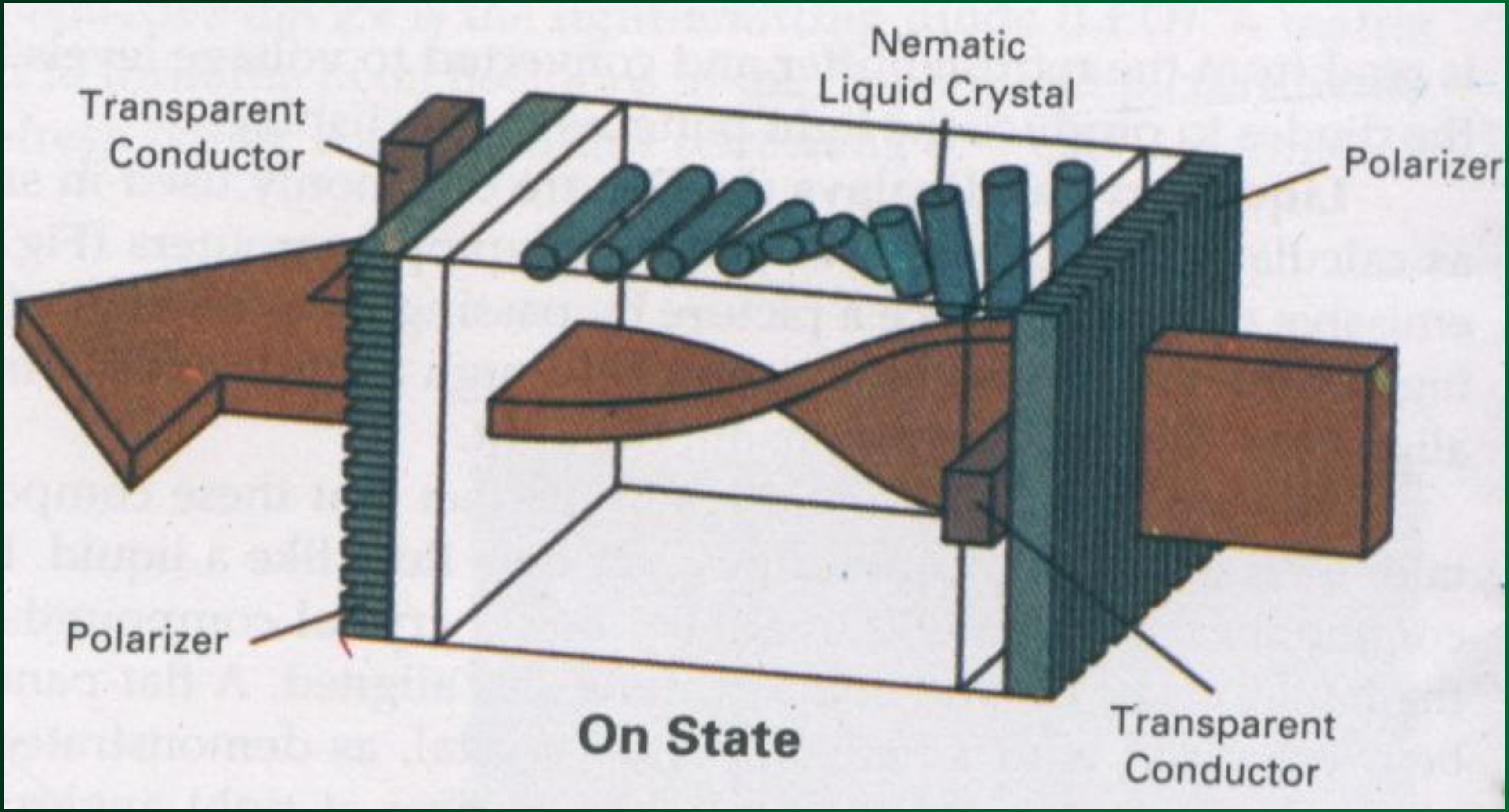


Liquid Crystal Displays (LCD)

- Polarized light passing through the material is ***twisted*** so that it will pass through the opposite polarizer.

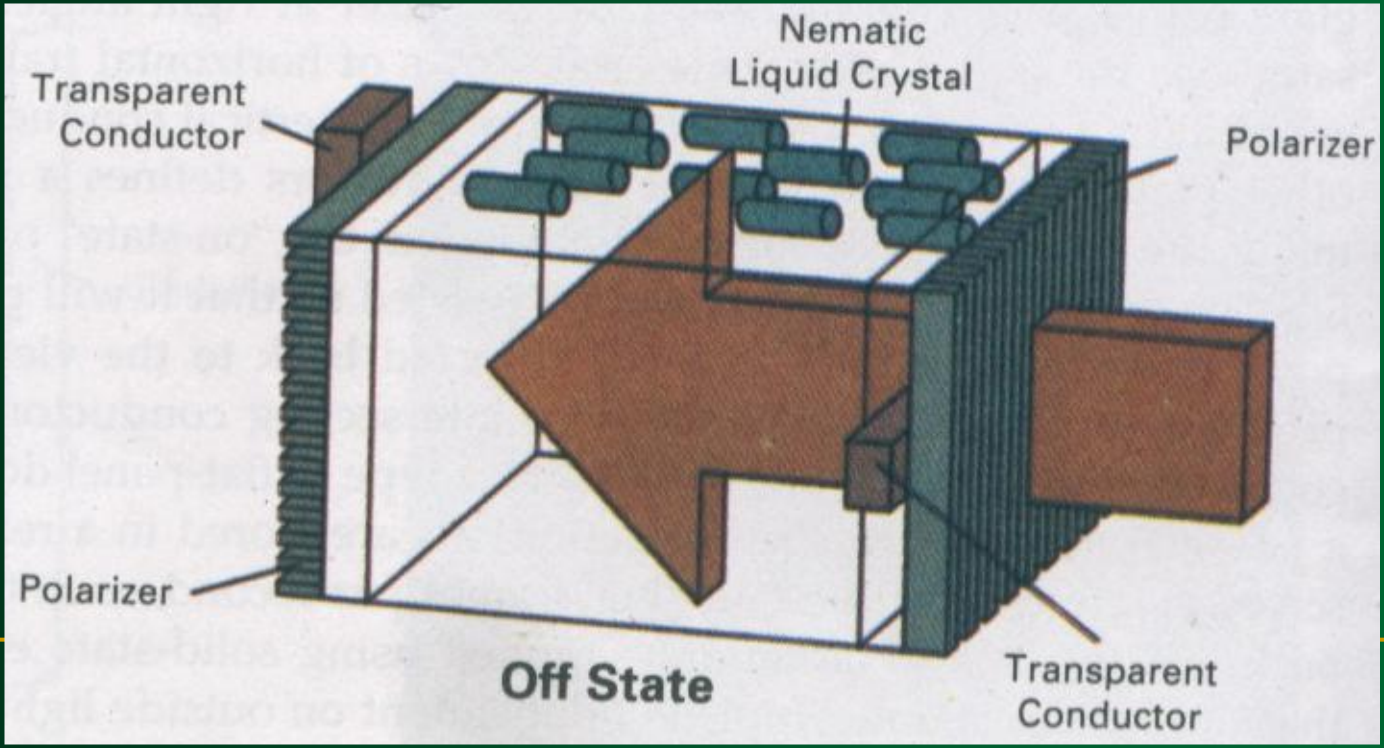
- The light is then reflected back t the viewer.

Liquid Crystal Displays (LCD)

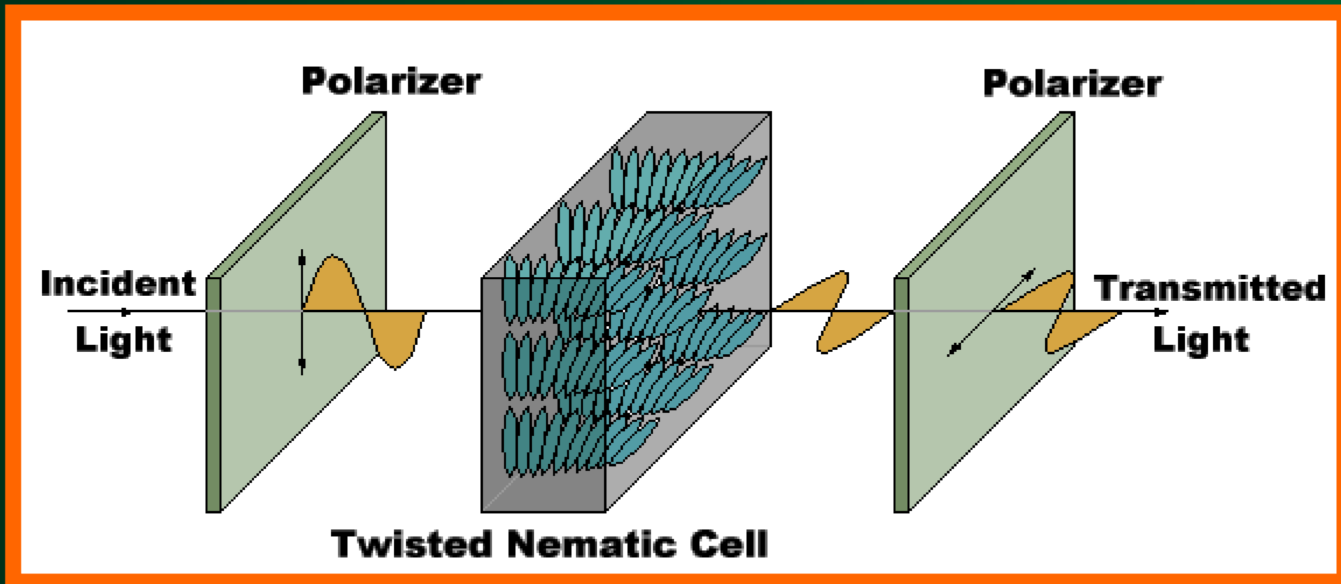


Liquid Crystal Displays (LCD)

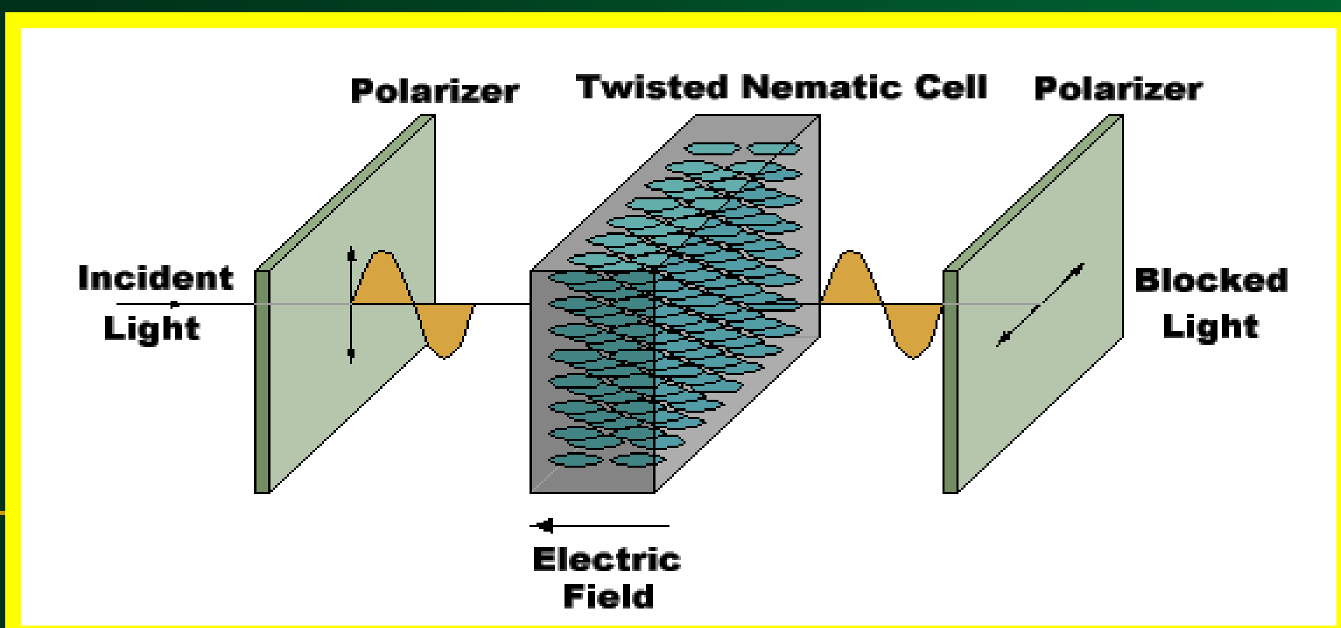
- To turn off the pixel, we apply a voltage to the two intersecting conductor to align the molecules so that the light is not twisted.



Liquid Crystal Displays (LCD)



On State



Off State

THANK YOU