Sub :→ INTERACTIVE COMPUTER GRAPHICS (ICG)

UNIT – 1

~~Interactive Computer graphics~~

Display Devices

COMPUTER GRAPHICS (CG) :→ Creation and Manipulation of pictures with the aid of computers.

It is of two types :-

1) **NON - INTERACTIVE** :→ The observer has no control over the images. Also called passive computer graphics.
   e.g. titles on TV

2) **INTERACTIVE CG** :→ we can give some control to the observer over the images by providing him the I/P device like levers of ping pong game so that observer can signal his request to the computer

Interactive Computer Graphics :-

- It involves two - way commn b/w computer & user.
- The computer, upon receiving signals from the I/P device, can modify the displayed picture appropriately.
- To the user, it appears that the picture is changing instantaneously in response to his commands.

→ He can give the series of commands, → each one generating a graphical response from the computer

In this way, he maintains a conversation or dialogue with the computer.

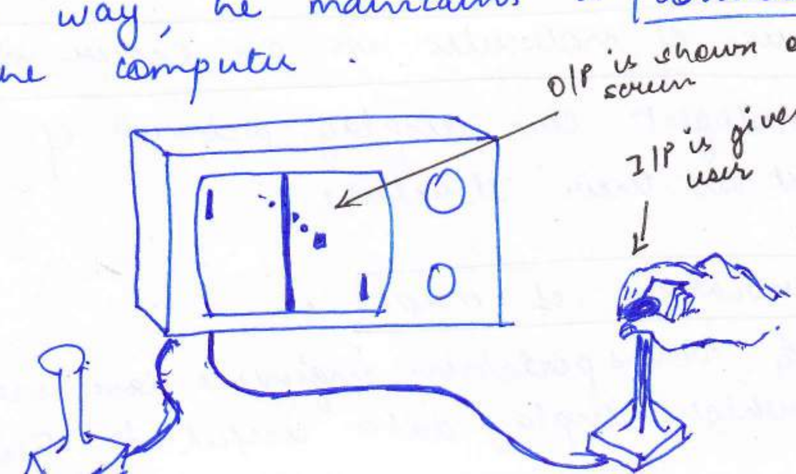


Fig 1:- Computer graphics in the home : a video game based on ping pong

By → JASMINE BE

USES :→

(1) It helps to train the pilots of our airplanes :→

Pilots spend much of their training not in a real aircraft but on the ground at the controls of a flight simulator. It contains all the usual controls & It is surrounded by screens on which are projected computer generated views of the terrain visible on takeoff & landing.

As the trainee pilot maneuvers his "aircraft", these views changes so as to maintain an accurate impression of the plane's motion.

(2) The electronics industry is also dependent on use of ICG :→

A typical integrated electronic circuit of the kind used in a computer is so complex that it would take an engineer weeks to draw by hand & equally long time to redraw in case of major modification.

Using an interactive graphics system, engineer can draw the circuit in a much shorter time. and can make modifications to the design in a matter of minutes.

(3) Great Help to architects to carry out tasks that would otherwise expensive to perform :→

Architects can explore alternative solutions to design problems at an interactive graphics terminal. In this way, they can test many more solutions that would not be possible w/o computer.

(4) Display pictures of molecules in an easier way :→

The molecular biologist can display pictures of molecules & gain insight into their structure.

(5) Use in the generation of maps :-

Town planners & transportation engineers can use computer generated maps which display data useful to them in their

The main reason for the effectiveness of interactive computer graphics is

Speed with which the user of the computer can assimilate the displayed information.

WORKING OF INTERACTIVE GRAPHICS DISPLAY :→

The interactive Graphics Display consists of 3 components

- **Digital Memory or frame buffer** :- in which the displayed image is stored as a matrix of intensity values.
- **A television monitor** :- i.e a home TV set w/o the tuning & receiving electronics.
- **A simple interface** :- called display controller, that passes the contents of frame buffer to the monitor.

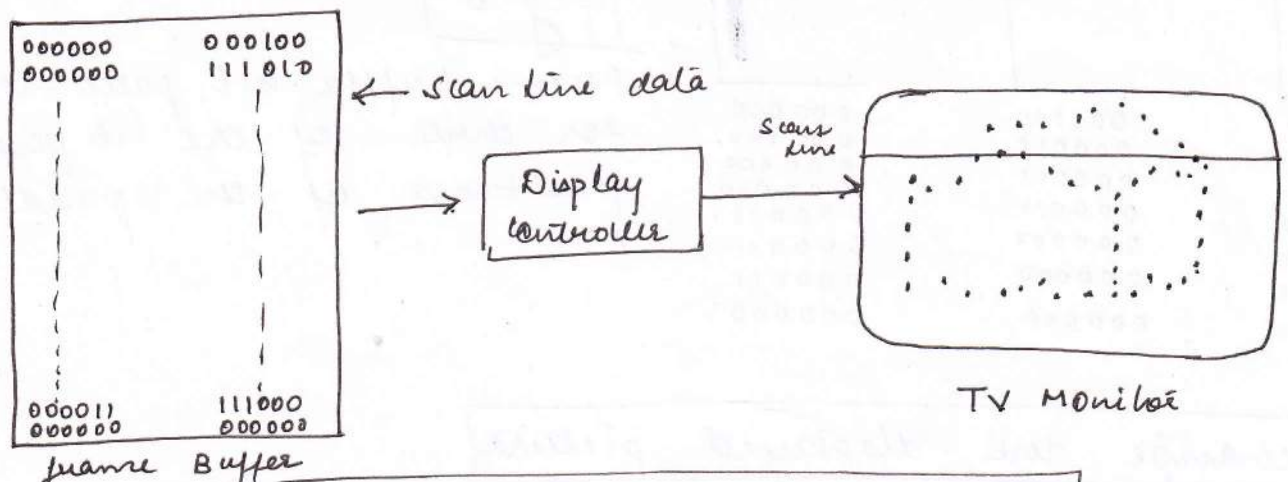


fig 2 | The frame Buffer display

→ Inside the frame Buffer, the image is stored as a pattern of binary digital numbers → which represents a rectangular array of picture elements or pixels

e.g. → we wish to store only black - and - white images.

- ★ we can represent black pixels by 1s in frame buffer
- ★ white pixels by 0s

Thus a 16X16 array of black & white pixels would be represented by the binary values stored in a 32 8-bit bytes shown in fig 2.

→ The display controller simply reads each successive byte of data from the frame buffer & converts its 0s & 1s into the corresponding video signal

→ The signal is then fed to the TV monitor producing a black & white pattern on the scre

Note :→ The display controller repeats this operation 30 times a second & thus maintains a steady picture on the TV screen.

How to change the displayed picture :-

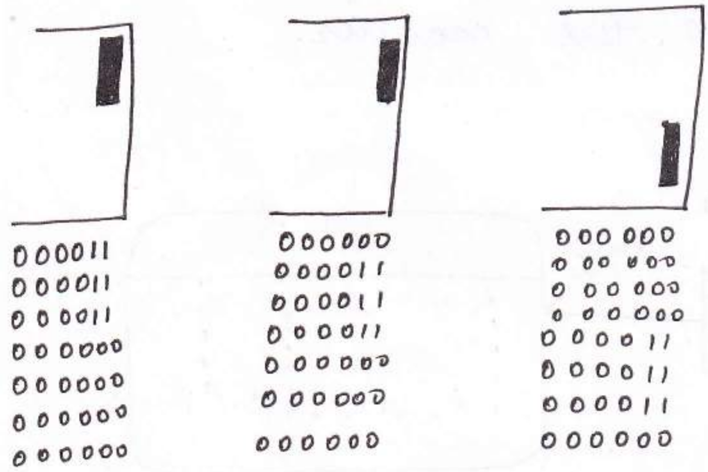


fig 3

Frame buffer bit patterns for three of the 16 possib positions of the paddle

To change the displayed picture

→ All we need do is modify the frame buffer's contents to represent the new patte of pixels.

Some concepts about interactive graphics :→

★ **How do we display straight lines? How are curves Drawn on the display :→**

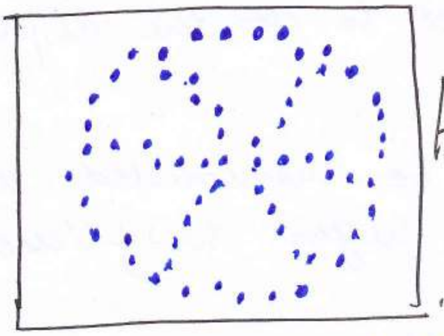


fig . 4 Raster image of a wheel showing staircase - like Quantization effects

The wheel picture in fig 4 illustrates two of the problems in drawing curved & straight lines on a graphic image.

→ we must choose which pixels should be black & which should be white . The choice is not always straightforward .

→ Slanting lines & curves in our image is not smooth & showing unpleasant "staircase" effects .

Soln to the above problem :-

✓ The first problem is solved by using an algo that computes which pixels should be black from the eqn of the line or curve .

✓ The second problem of staircase like quantization effects is much more difficult to solve .

The most common soln is to use a different sort of display called a line drawing display which plots continuous lines & curves rather than separate pixels

With a line drawing display , it is possible to draw lines that appear completely smooth to the

* Why speed is so important in Displaying pictures

Any display based on the CRT must be refreshed by repeatedly passing to it the image to be displayed.

The image must be transmitted to ~~this~~ the display point by point.

Unless the entire image can be transmitted at least 25 times a second, it will begin to flicker in an unpleasant way.

- The longer it takes to transmit each element of the picture
  - The fewer elements can be transmitted
  - The less information can be displayed.

* How are pictures made to Grow, shrink & Rotate?

Our knowledge of how to apply changes in size & orientation or transformations to pictures is based on standard mathematical techniques: -

- coordinate geometry
- trignometry
- matrix methods.

These techniques tell us how to compute the coordinates of a line segment's end pts. after scaling or rotating it.

It is therefore relatively easy to apply the appropriate computation & to plot the line segment that results from the transformation.

* What Happens to Pictures that are too large to fit on the screen :->

Display screens are relatively small, & the pictures we wish to display on them are often too big to be shown in their entirety.

e.g. If we were to enlarge the wheel of fig. 4, it would no longer fit in the frame buffer

In this case, we would probably like to show as much of it as we could.

A technique called ~~clipping~~ clipping can be used to select those parts of the picture that lie on the screen & to discard the rest.

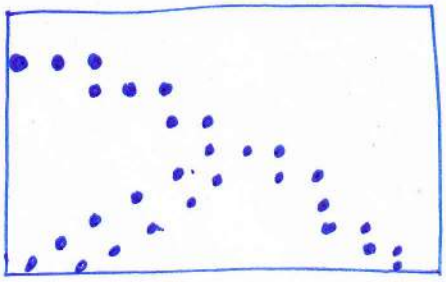


fig 5 Use of clipping to select part of an enlarged image of a wheel

★ **How can the user of the Display Draw on the screen :-**

A no. of different I/P devices — light pen, tablet, mouse have been inverted to make this kind of interaction more convenient.

When we draw with these devices, we have the impression of making marks directly on the display screen. In fact, the computer is following every movement of the I/P device & is changing the picture in response to these movements.

It is the speed of the computer in changing the picture that creates the ~~picture that~~ impression of drawing directly on the screen.

X

Abbreviations

I/P → Input
w/o → without

Book Referred :-

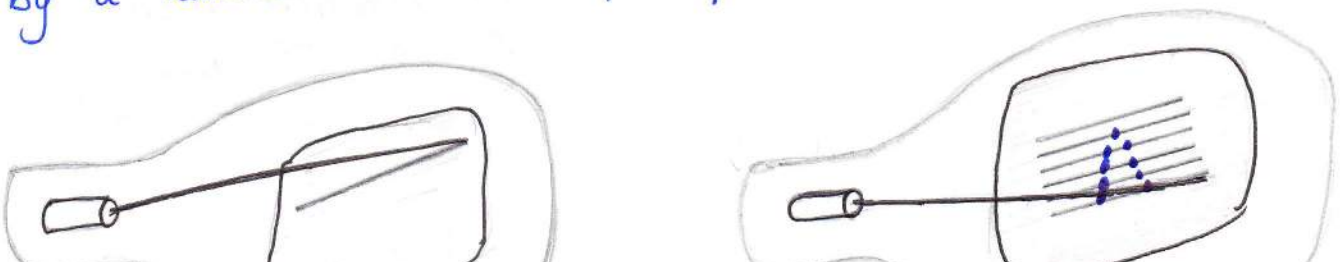
Principles of Interactive Computer Graphics
by
William M. Newman
Robert F. Sproull

DISPLAY DEVICES :-

LINE AND POINT PLOTTING SYSTEM :-

Raster → In this system, the electron beam is swept across the screen one row at a time from top to bottom. As the electron beam moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots. Picture defn is stored in a m/m area called refresh buffer or frame buffer. This m/m area holds the set of intensity values for all screen points. Stored intensity values are then retrieved from the refresh buffer & "painted" on the screen one row at a time. (fig 1)

Vectors → In this system, the picture is drawn one line at a time and for this reason they are referred to as vector displays.
In this a CRT has the electron beam directed only to the parts of the screen where a picture is to be drawn.
The component lines of a picture can be drawn & refreshed by a random - scan ~~displ~~ system in any specified order.



(a) (b)

fig 1 | A raster system displays an object as a set of discrete points across each scan line

(a) (b)

[pixel] →

In raster system, Picture defn is stored in a m/m area called [refresh buffer] or [frame buffer]

This m/m area holds the set of intensity values for all screen points.

Each screen point is referred to as [pixel] or [pel]

(shortened forms of picture element)

On a black-and white system with one bit per pixel the frame buffer is commonly called a [bit map]

For system with multiple bits per pixel, the frame buffer is often referred to as [pixmap]

Book Referred

Computer Graphics

by Donald Hearn & [Baker]

✻ CONTINUAL REFRESH & STORAGE DISPLAY :→

★ Continual Refresh Display :→

A beam of electrons emitted by an electron gun, passes through focussing and deflection system that direct the beam toward specified positions on the phosphor coated screen. The phosphor then emits a small spot of light at each posⁿ contacted by the electron beam. Because the light emitted by the phosphor fades very rapidly, some method is needed for maintaining the screen picture.

One way to keep the phosphor glowing is to redraw the picture repeatedly by quickly directing the ē beam back over the same points. This type of display is called Refresh CRT

The basic arrangement of the CRT is shown in fig 1
At the narrow end of a sealed conical glass tube is an ELECTRON-GUN – that emits a high-velocity, finely focused beam of electrons.

The other end, the face of the CRT, is more or less flat & is coated on the inside with PHOSPHOR – which glows when the ē beam strikes it.

The energy of the beam can be controlled so as to vary the intensity of light output, & when necessary, to cut off the light altogether.

The FOCUSING SYSTEM → in a CRT is needed to force the ē beam to converge into a small spot as it strikes the phosphor.

MAGNETIC DEFLECTION COILS – Deflection of the ē beam can be controlled either with electric field or with magnetic ~~def~~ field provided by Magnetic Deflection coils.

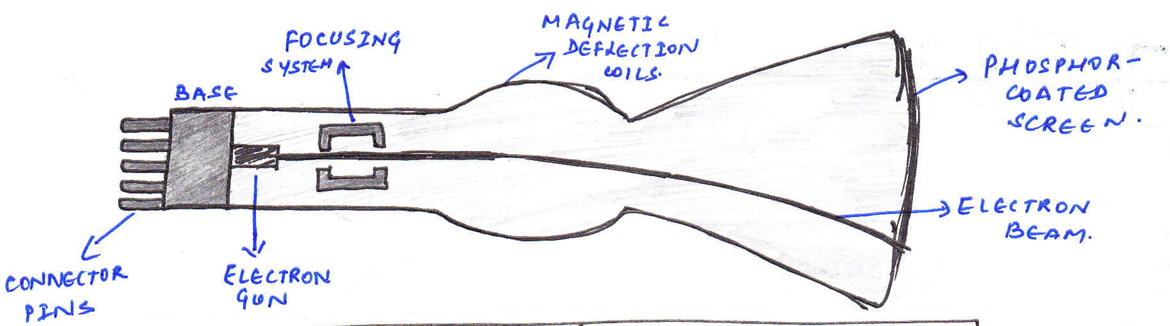


Fig 1 → Basic Design of a CRT

The light output of the CRT's phosphor falls off rapidly after the ē beam has passed by, & a steady picture is maintained by tracing it out rapidly and repeatedly; generally this REFRESH process is performed at least 30 times a second.

(A) ELECTRON GUN :→ The electron gun makes use of electrostatic fields to focus & accelerate the ē beam.

The purpose of ē ~~beam~~ gun in the CRT is to produce an ē beam with the following properties :→

- → It must be accurately focused so that it produces a sharp spot of light where it strikes the phosphor.
- → It must have high velocity, since the brightness of the image depends on the velocity of the ē beam.
- → Means must be provided to control the flow of ē so that the intensity of trace of the beam can be controlled.

COMPONENTS OF ELECTRON GUN :-

1) CATHODE :- Heat is supplied to the cathode by directing a current through filament. This causes ē to be "boiled off" the hot cathode surface. In the vacuum inside the CRT, the free, negatively charged ē are then accelerated towards the phosphor coating by a high +ve voltage.

2) CONTROL GRID :- Intensity of ē beam is controlled by setting voltage level on the control grid, fits over the cathode. A high -ve voltage is applied to the control grid that will shut off the beam by repelling ē & stopping them from passing through the small hole at the end of control grid structure.
We can control the brightness of a display, by varying a voltage on the control grid.

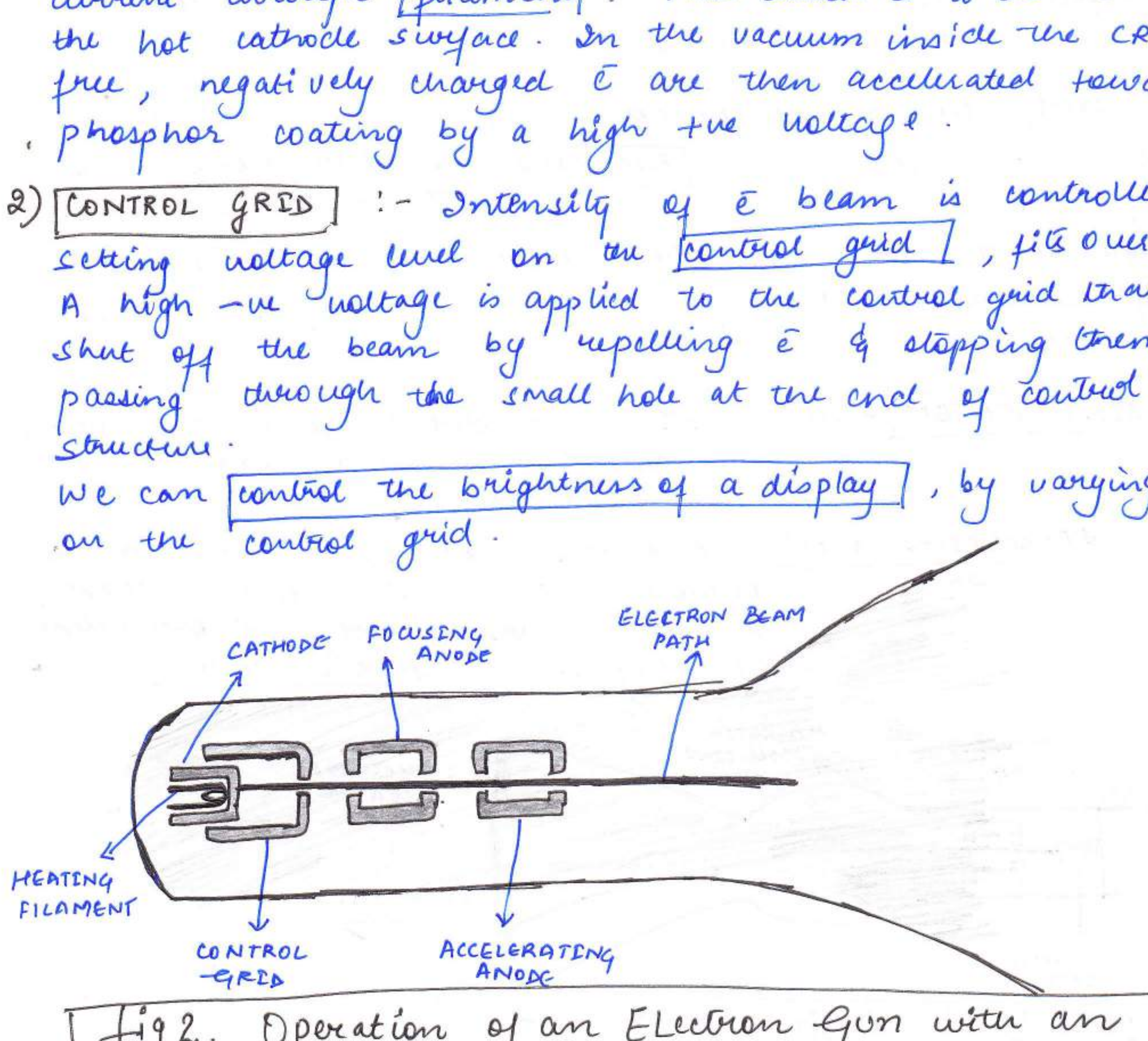


fig 2. Operation of an Electron Gun with an accelerating anode.

BY JASMINE

(3) **FOCUSING ANODE** :- It is containing two or more cylindrical metal plates at different potentials. These set up a **toroidal electrostatic field** that effectively catches straying electrons & deflects them back towards the axis of the beam.

The **result** is a **beam** that is extremely finely focused & highly concentrated at the precise moment at which it strikes the phosphor.

4) **ACCELERATING ANODE** :- It consists of 2 metal plates mounted perpendicular to the beam axis with holes at their centers through which the beam can pass. The two plates are maintained at a sufficiently high relative potential to accelerate the beam to the necessary velocity.

(B) DEFLECTION SYSTEM :→

CRT are now commonly constructed with magnetic deflection coils mounted on the outside of the CRT envelope.

Two pairs of coils are used. One to control **horizontal deflection**, the other **vertical**.

A **primary requirement of the deflection system** that **it deflect rapidly** since speed of deflection determines → how much inf can be displayed w/o flicker.

To **achieve fast deflection**, we must use large amplitude currents in the coils.

(C) PHOSPHORS :→

The phosphor used in a graphic display are normally chosen for their color characteristics & persistence.

How spot of light are produced on the screen

- When the ē in the beam collide with the phosphor coating, they are stopped & their kinetic energy is absorbed by phosphor.
- Part of the beam energy is converted by friction into heat energy and the remainder causes ē in the phosphor atoms to move up to higher - quantum energy levels.
- After a short time, the "excited" phosphor ē begin dropping back to their stable ground, giving up their extra energy as small quantums of light energy.

What we see on the screen is the combined effect of all ē light emissions: a glowing spot that quickly fades after all the excited phosphor ē have returned to their ground energy level. (4)

Note :- The frequency of the light emitted by the phosphor is proportional to the energy difference b/w the excited quantum state & the ground state.

TERMS :-

PERSISTENCE :- is defined as the time it takes the emitted light from the screen to decay to one-tenth of its original intensity.

OR

How long they continue to emit light (i.e. have excited ē returning to the ground state) after the CRT is removed.

Lower persistence phosphors require **higher refresh rates** to maintain a picture on the screen.

A **phosphor with low persistence** is useful for **animation**

A **high-persistence phosphor** is useful for **displaying highly complex static pictures**

RESOLUTION :- The max. no. of points that can be displayed w/o overlap on a CRT is referred to as the **Resolution**.

ASPECT RATIO :- This gives the ratio of $\frac{\text{vertical pts.}}{\text{horizontal pts.}}$ necessary to produce equal length lines in both directions on the screen.

e.g. An aspect ratio of $\frac{3}{4}$ means

vertical line plotted with 3 pts. has the same length as **Horizontal line plotted with 4 pts.**

Disadvantages of CRT :→

- High cost
- Tendency to flicker when the displayed picture is complex.

Books Referred

- Computer Graphics by D. Hearn & Baker.
- Principles of ICG by Newman

★ Storage Display :-

The most widely used device is (Direct-view storage tube)

Direct-view Storage Tube (DVST) :-

- It behaves like a CRT with an extremely long-persistence phosphor.
- A line written on the screen will remain visible for up to an hour before it fades from sight.
- The DVST resembles the CRT, since it uses a similar ē gun and a somewhat similar phosphor coated screen. The beam is designed not to write directly on the phosphor but on the fine mesh wire grid — coated with dielectric and mounted just behind the screen.
- A pattern of the charge is deposited on the grid, and this pattern is transferred to the phosphor by a continuous flood of electrons issuing from a separate flood gun

The general arrangement of the DVST is shown in detail in fig. 3.

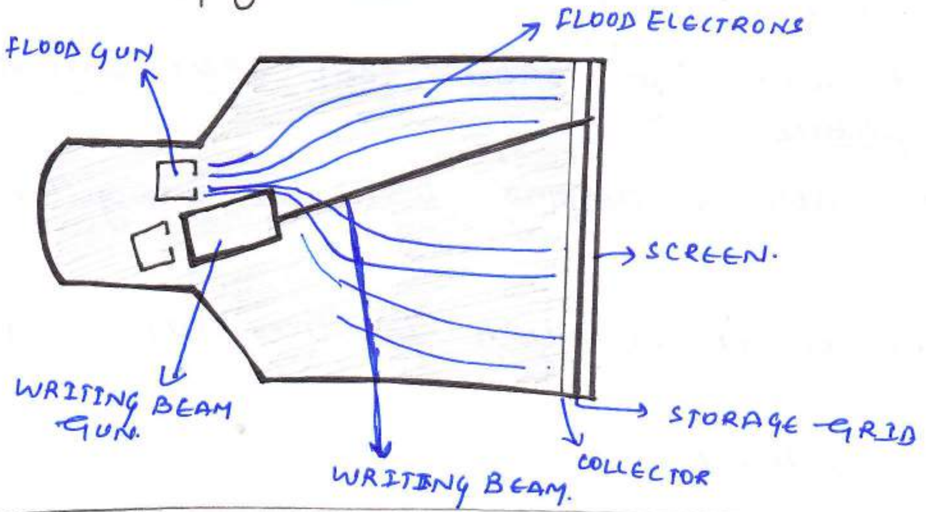


fig. 3. The direct-view storage tube

- Just behind the storage mesh is a second grid, the collector whose main purpose is to smooth out the flow of flood electrons.

These electrons pass through the collector at a low velocity, and are attracted to the positively charged portions of the storage mesh but repelled by the rest.

- The electrons not repelled by the storage mesh pass right through it and strike the phosphor.

- In order to increase the energy of these relatively ~~small~~ slow moving electrons and thus create a bright picture, the screen is maintained at a high +ve potential by means of a voltage applied to a thin aluminium coating b/w the tube face and the phosphor.
- Until they pass through the mesh, the flood ē are still moving fairly slowly and therefore hardly affect the charge on the mesh.

Advantages :→

→ The storage tube retains the image generated until it is erased. Thus no refreshing is necessary & the image is absolutely flicker free.

→ Very complex pictures can be displayed at very ~~very~~ high resolution.

Disadvantages :→

→ Inability to selectively erase parts of an image from the screen. To erase a line segment from the displayed image, one has to first erase the complete image and then redraw it by omitting that line segment.
The erasing and redrawing process can take several seconds for a complex picture.
For these reasons, storage displays have been largely replaced by raster system.

→ It prevents the use of the device for the dynamic graphics appⁿ.

→ Relatively poor contrast.

→ In terms of performance, the DVST is somewhat inferior to the refresh CRT

X

Books Referred: –

– Principles of Interactive Computer Graphics by William M. Newman

– Introduction to Computer Graphics

DIGITAL FRAME BUFFER

The most common method of implementing a [raster CR[T]] graphics device uses a [Digital frame Buffer].

A [digital frame buffer] is a large, contiguous piece of computer memory used to hold or map the image displayed on the screen.

→ At a minimum, there is [1 m/m bit → for each pixel in the raster]

This amt of m/m is called a [bit plane]

→ A 1024 x 1024 element sq. raster —requires→ 2^{20} ($2^{10} = 1024$; $2^{20} = 1024 \times 1024$) or 1,048,576 m/m bits in a single bit plane.

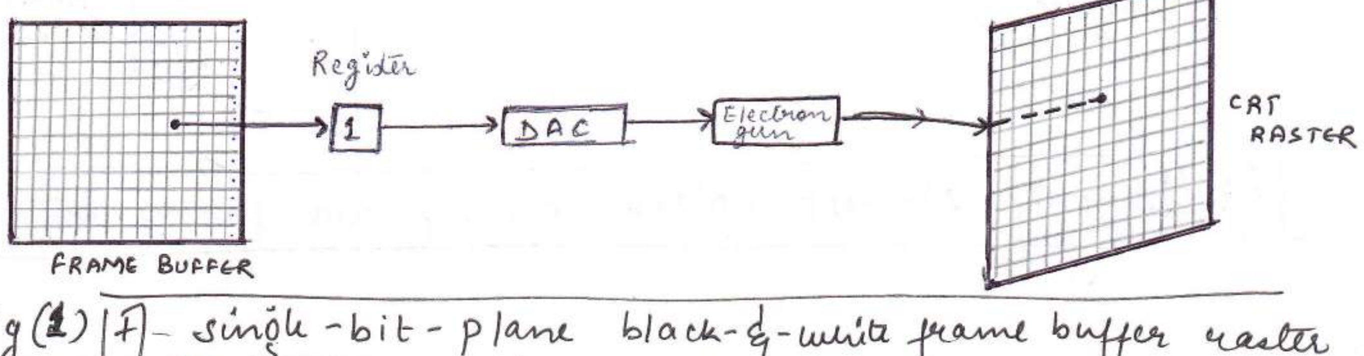
→ The picture is built up in the frame buffer one bit at a time.

→ ∵ a m/m bit has only two states [(binary 0 or 1)], a [single bit plane] yields a [black-&-white (monochrome) display].

→ F/s frame buffer is a digital device while raster CRT is an analog device

Digital-to-analog converter (DAC) is used to convert digital representation to an analog signal, when inf. is read from the frame buffer & displayed on the raster CRT graphics device.

OR Each pixel in the frame buffer must be accessed & converted before it is visible on the raster CRT.



fig(1) [F] - single-bit-plane black-&-white frame buffer raster

Color or Gray Level Frame Buffer :-

Color or gray levels are incorporated into a frame buffer raster graphics device by using additional bit planes

An N-bit plane gray level frame buffer

- The intensity of each pixel on the CRT is controlled by a corresponding pixel location in each of the N-bit planes.
- The binary value (0 or 1) from each of the N-bit plane is loaded into the corresponding positions in a register.
- The resulting binary number is interpreted as an intensity level b/w 0 (dark) & 2^N-1 (full intensity)
- This is converted into analog voltage b/w 0 & the max voltage of the electron gun by the DAC.
- A total of 2^N intensity levels are possible.
- fig (2) illustrates a system with 3 bit planes for a total of $8(2^3)$ intensity levels.
- a 3-bit-plane frame buffer for a 1024x1024 raster

↓ requires

3,145,728 (3x1024x1024) m/m bits

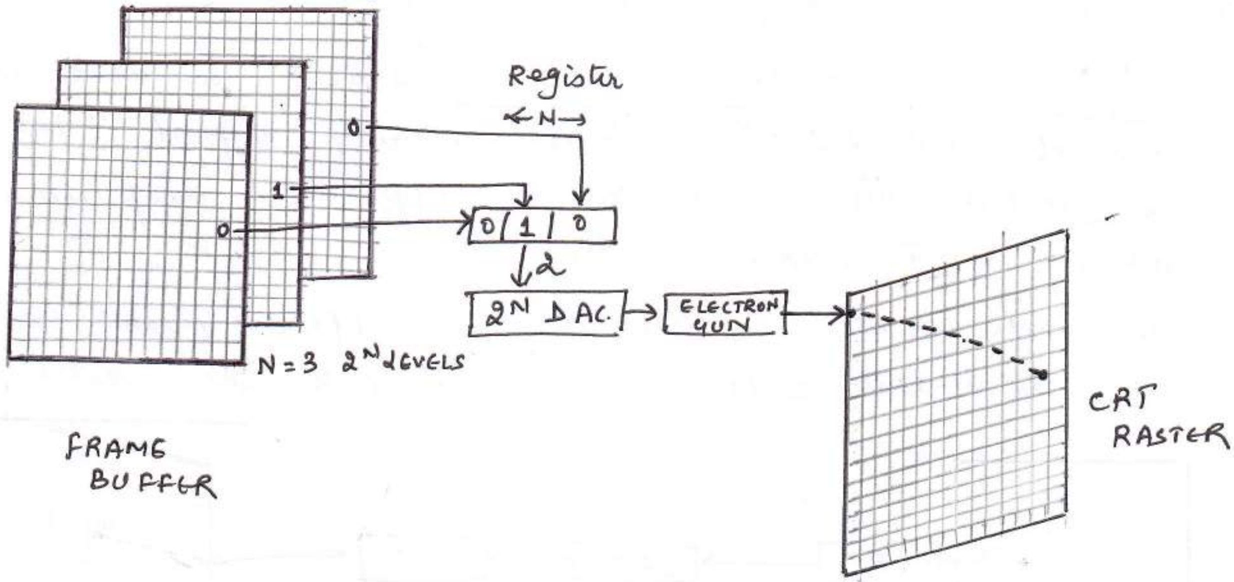


fig. (2) An N-bit-plane Gray level frame buffer

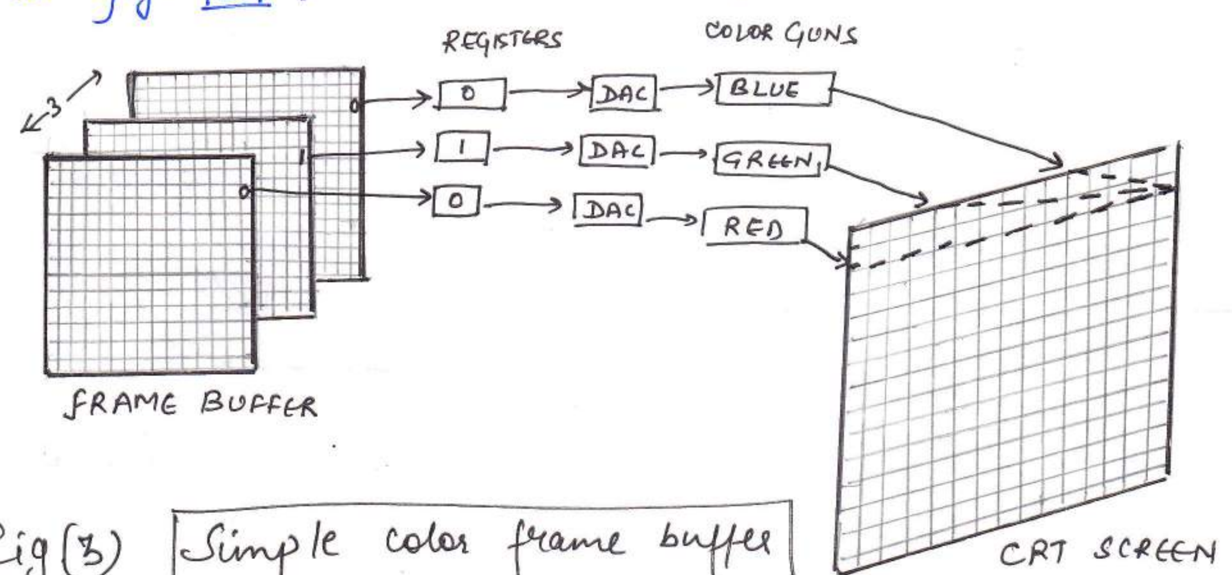
Colour frame buffer

- Because there are three primary colors, a simple color frame buffer is implemented with 3 bit ~~patt~~ planes, one for each primary color.
- Each bit plane drives an individual color gun for each of the three primary colors used in color video.
- These 3 primaries (red, green, blue) are combined at the CRT to yield eight colors as shown in Table 1.

Table 1. Simple 3-bit plane frame buffer color combinations

	Red	Green	Blue
Black	0	0	0
Red	1	0	0
Green	0	1	0
Blue	0	0	1
Yellow	1	1	0
Cyan	0	1	1
Magenta	1	0	1
White	1	1	1

- Additional bit planes can be used for each of the 3 color guns. ~~A schematic of a multiple-bit-plane color frame buffer,~~ A simple color raster frame buffer is shown schematically in fig. [3].



fig(3) Simple color frame buffer

Books Referred :-
Procedural Elements for Computer Graphics
by → David F. Rogers

BY-JASMINE BEDI

PLASMA PANEL DISPLAY :→

The plasma panel is an unorthodox display device.

~~The term of~~

Plasma panels are also called glass - discharge displays

Images can be written onto the display surface point-by point, each point remains bright after it has been intensified. This makes the plasma panel functionally very similar to the DVST even though its construction is very different.

Construction of Plasma Panel :→

It consists of two sheets of glass with thin, closely spaced gold electrodes attached to the inner faces & covered with a dielectric material.

The two sheets of glass are spaced a few thousandths of an inch apart, and the intervening space is filled with a neon- based gas & sealed.

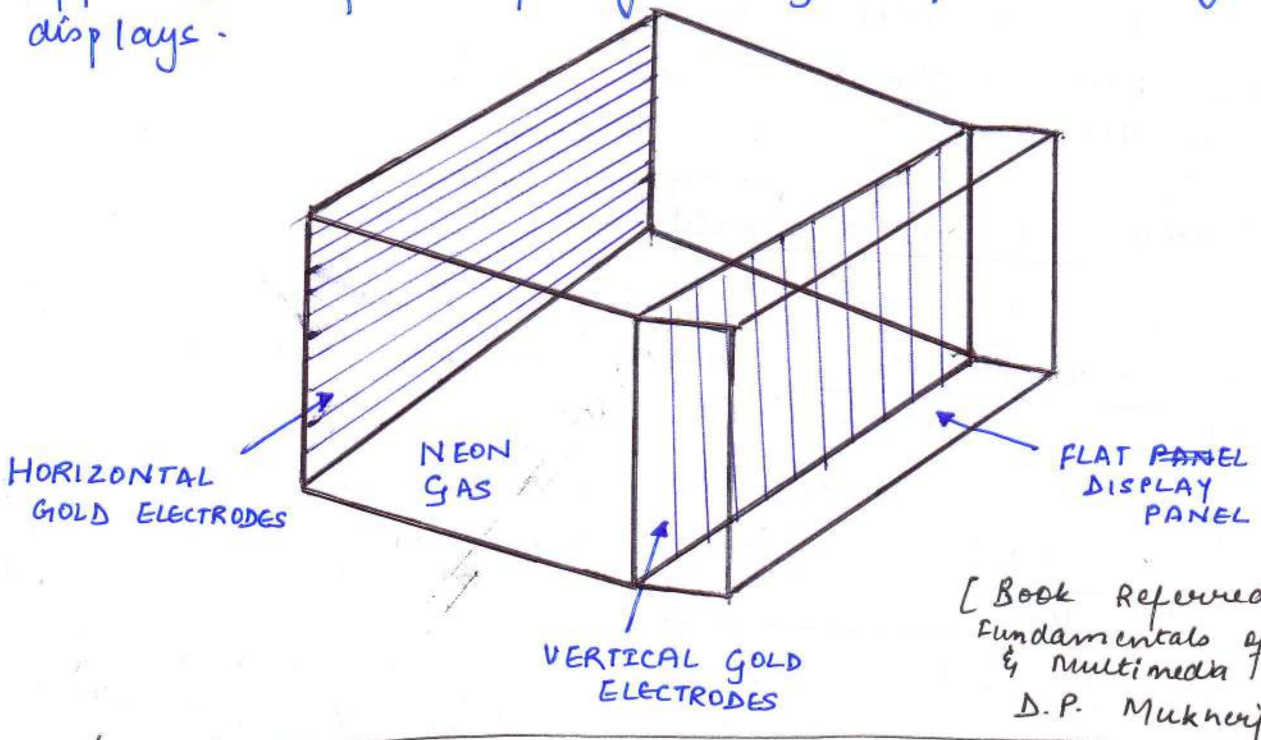
A series of vertical gold electrodes are placed on one glass panel, and a set of horizontal gold electrodes ~~as pl~~ are built on other glass panel

Appropriate voltages is applied to a pair of horizontal and vertical ~~con~~ electrodes cause the gas at the intersection of the two conductors to break down into a glowing plasma of electrons and ions.

Working of Plasma Panel Display :→

- The voltage is applied between the electrodes the gas within the panel is made to behave as if it were divided into tiny cells, each one independent of its neighbours
- By an ingenious mechanism certain cells can be made to glow, and thus a picture is generated.
- A cell is made to glow by placing a firing voltage across it by means of the electrodes.
- The gas within the cell begins to discharge, and this develops very rapidly into a glow.

- The glow can be sustained by maintaining a high-freq alternating voltage across the cell. (2)
- Picture definition is stored in a refresh buffer & the firing voltages are applied to refresh the pixel pos^ns 60 times / second.
- Alternating current methods are used to provide faster application of the firing voltages & thus brighter displays.



[Book Referred → Fundamentals of CG & Multimedia by D.P. Mukherjee]

fig (1) CONSTRUCTION OF A PLASMA PANEL

- Each cell is bistable, i.e it has two stable states
- Cells can be switched on by momentarily increasing the sustaining voltage; this can be done selectively by modifying the signal only in the two conductors that intersect at the desired cell
- Similarly, if the sustaining signal is lowered, the glow is removed
- Thus the plasma panel allows both selective writing & selective erasure, at speeds of about 20 μs / cell
- This speed can be increased by writing or erasing several cells in parallel

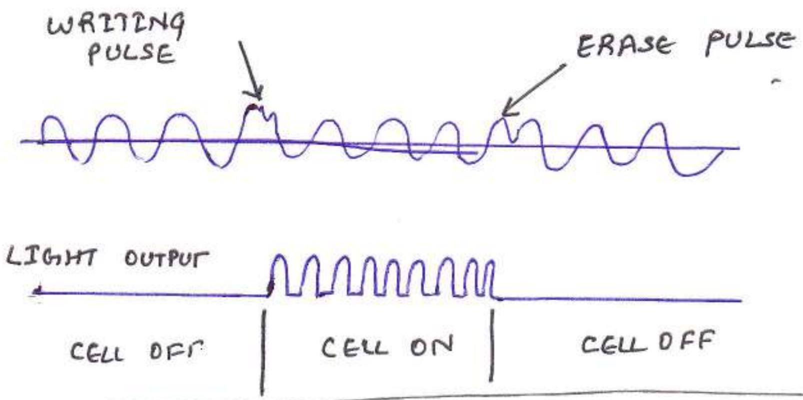


fig. (2) Plasma Panel sustaining signal (above) and corresponding cell light output (below)

Advantages :→

- → It produces a very steady image, totally free of flicker.
- → Less bulky device than a CRT of comparable screen size.
- → Because of its excellent brightness, contrast & scalability to larger sizes, plasma panel is attractive.

Disadvantages :→

- → Its main disadvantages are its relatively poor resolution of about 60 dots / inch.
- → Addressing and wiring requirements are complex.
- → Its inherent m/m is useful but is not as flexible as a frame buffer m/m.
- → They were strictly monochromatic devices.
- → Due to inexpensive digital m/m.s that are used in raster scan display, plasma panels are not used in very many of today's displays.

X

Books Referred :-

→ Principals of ICG by Newmann

VERY HIGH RESOLUTION DEVICES :→

LIQUID CRYSTAL DISPLAY -(LCDs) is one of the very high resolution display.

- They are commonly used in small systems, such as calculators and portable, laptop computers
- These non emissive devices produce a picture by passing polarized light from the surroundings or from an internal light source through a liquid crystal material that can be aligned to either block or transmit the light.
- The term liquid crystals refers to the fact that these compounds have a talline arrangement of molecules yet they flow like a liquid.

CONSTRUCTION :-

- The front panel is a vertical polarizer followed by vertical grid lines liquid crystal layer, horizontal grid wires, horizontal polarizer, & finally the reflective layer all in order shown in fig. 1.

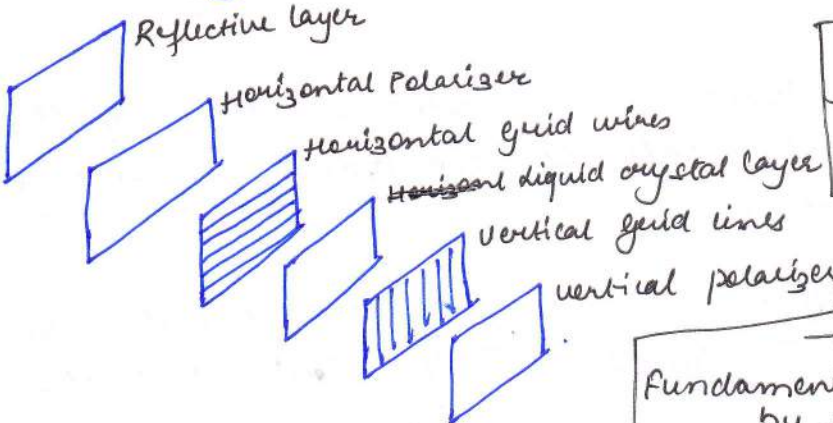


Fig 1. Different Layers of Liquid crystal Display

→ Book Referred
Fundamentals of computer Graphics & Multimedia
by → D. P. Mukherju

- The LCD displays are addressed in a matrix fashion. Rows of matrix are defined by a thin layer of horizontal transparent conductors, while columns are defined by another thin layer of vertical transparent conductors. The intersection of the two conductors defines a pixel position.

This means that an individual LCD element is required for each display pixel, unlike a CRT which may have several dot triads for each pixel.

- The liquid crystal is made up of long - rod - shaped crystalline molecules containing cyanobiphenyl unit

The individual polar molecules in a nematic (spiral) LC layer are normally arranged in a spiral fashion such that the direction of polarization of polarized light passing through it is rotated by 90°

WORKING :→

Light from an internal source enters the first polarizer (say horizontal) & is polarized according. As the light passes through the LC layer, it is twisted 90°, (to align with the vertical) that it is allowed to pass through the real polarizer (vertical) & then reflect from the reflector behind the rear polarizer.

The reflected light when reaches the viewers eye travelling in the reverse direction, the LCD appears bright

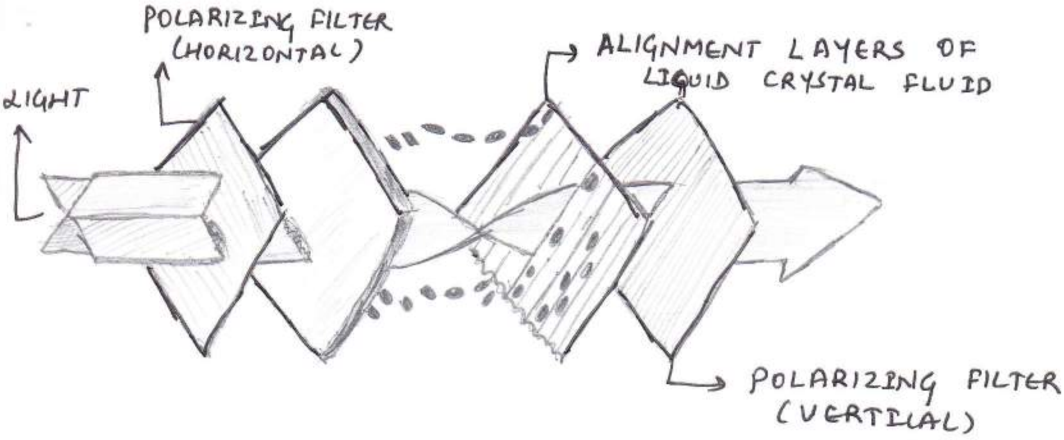
To turn off the pixel, we apply a voltage to the two intersecting conductors to align the molecules so that the light is not twisted.

This type of flat - panel device is referred to as passive - matrix LCD.

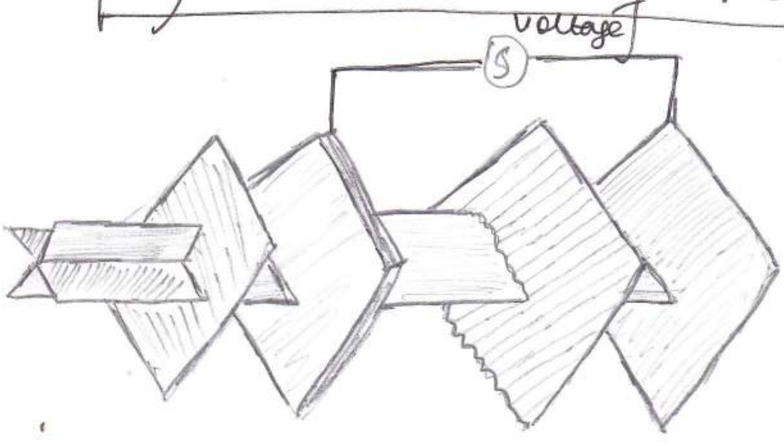
Picture definitions are stored in a refresh buffer & the screen is refreshed at the rate of 60 frame per seconds as in the emissive devices.

* Colors can be displayed by using different materials or dyes & by placing a triad of color pixels at each screen location.

* Another method for constructing LCDs is to place a transistor at each pixel location, the transistors are used to control the voltage at pixel location & to prevent charge from gradually leaking out of the liquid crystal cells. These devices are called active - matrix LCD



a) 'On' state of LCD.



b) 'Off' state of LCD

→ Book Referred
Intro to CG by Mukhopadhyay.

X

Books Referred

- Introduction to CG by Mukhopadhyay
- Computer Graphics by D. Hearn & Bakers

DISPLAY PROCESSORS :→

- The display adapter circuitry (on video card or motherboa[rd]) in a raster graphics system typically employs a special purpose processor called

  Display Processor or Graphics Controller or Display Coprocessor

  which is connected as an I/O peripheral to the CPU.

- Such processors assist the CPU in scan converting the output primitive (line, circle, arc etc)

  ↓ into

  bitmaps in frame buffer

  & also perform raster operations of moving, copyin[g] and modifying pixels or block of pixels

- The output circuitry also includes another specialized H/w called Video controller which actually drives the CRT & produces the display on the screen.

- The purpose of the display processor is to free the CPU from the graphics chores

CONSTRUCTION :→ Refer fig (1)

The monitor is connected to the display adapter circuitry throu[gh] a cable with 15-pin connectors. Inside the cable, are 3 analog signals carrying brightness information in parallel for the 3 color components of each pixel. The cable also contains two digital signal lines for vertical & horizontal drive signals and three signal lines which carry specific information about the monitor to the display adapter. In addition the system ~~monitor~~ m/m, a separate display processor m/m area can also be provided

WORKING :→

* The video controller in the output circuitry generates the horizontal and vertical drive signals so that the monitor can sweep its beam across the screen during raster scan.

to control the CRT beam intensity or color.

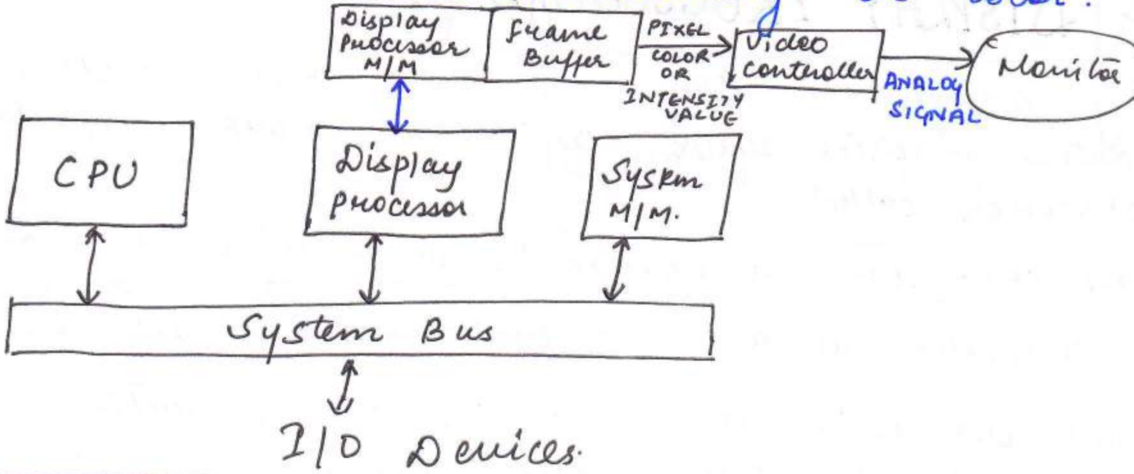


fig (1) Architecture of a Raster ~~Scan~~ Display System with a display processor

* As fig (3) is showing that 2 register (X register & Y register) are used to store the coordinates of the screen pixels.
* Assume that the y values of the adjacent scan lines increase by 1 in upward dirⁿ starting from 0 at the bottom of the screen to y_{max} at the top

∴ & Along each ~~line~~ scan line the screen pixel positions or x values are incremented by 1 from 0 at the leftmost position to X_{max} at the rightmost position.

* The origin is at the lower left corner of the screen as in a standard cartesian coordinate system. (fig 2).

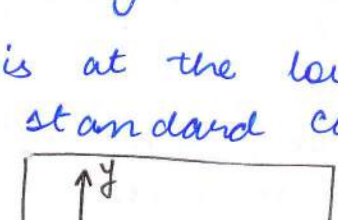


fig (2) The origin of the coordinate system for identifying screen posⁿ's is usually specified in the lower - left corner.

* At a start of a REFRESH CYCLE :-

X register is set to 0 & Y register is set to y_{max}

This (x, y) address is translated into a m/m address of frame buffer where the color value for this pixel posⁿ is stored.

* The controller receives this color value (a binary no.) from the frame buffer, breaks it up into three parts & sends

each part to a separate digital - to - analog converter (DAC)

* These voltages in turn controls the intensity of 3 ē beam that are focussed at the (x, y) screen position by the horizontal & vertical drive signals.

* This process is repeated for each pixel along the top scan line, each time incrementing the X register by 1.
  As pixels on the first scan line are generated, the X register is incremented through x_{max}

* Then X register is reset to 0, & Y register is decremented by 1 to access the next scan line.

* Pixels along each scan line are then processed & the procedure is repeated for each successive scan line until pixels on the last scan line (y=0) are generated.

* For a display system employing a color look-up table frame buffer value is not directly used to control the CRT beam intensity.
  It is used as an index to find the true pixel-color value from the look-up table. This look up operation is done for each pixel on each display cycle.

* As the time available to display or refresh a single pixel in the screen is too less, accessing the frame buffer every time for reading each pixel intensity value would consume more time than what is allowed.

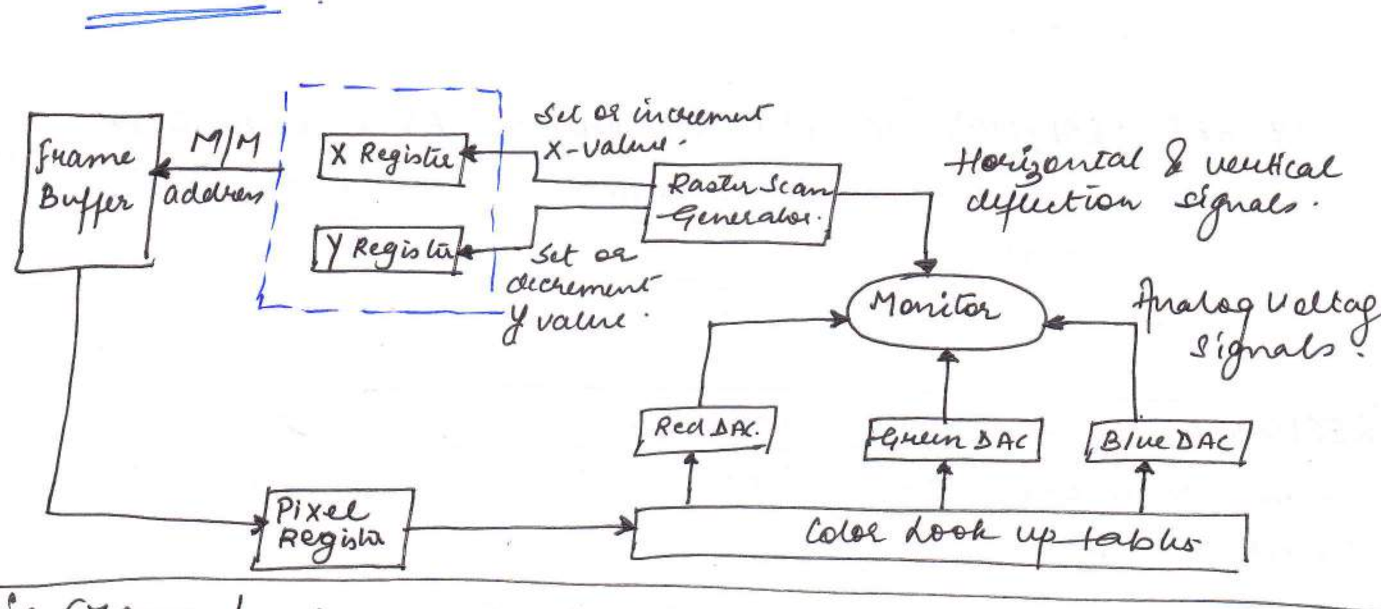


Fig (3) Logical operations of the video controller

∴ multiple ~~data~~ adjacent pixel values are fetched to the frame buffer in a single access & stored in the register

* After every allowable-time gap, one pixel value is shifted out from register to control the beam intensity for that pixel.

* The procedure is repeated with the next block of pixels & so on, thus the whole group of pixels will be processed.

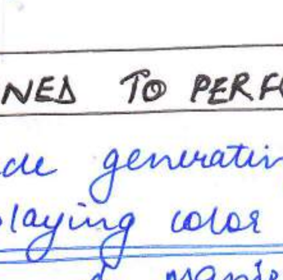
APPLICATIONS →

1) **MAJOR TASK OF THE DISPLAY PROCESSOR** :→ is digitizing a picture defn given in an appn program into a set of pixel-intensity values for storage in the frame buffer.
This digitation process is called **Scan conversion**

e.g. Scan converting a **straight line segment** like
we have to locate the pixel posns closest to the line path & store the intensity for each posn in the frame buffer.
Mr methods are used for scan converting **curved lines** & **polygon outlines**

* **characters** can be defined with the **rectangular grids** as in fig 4.

The array size for character grids can vary from abt **5 by 7** to **9 by 12** or more higher quality displays.



fig(4.) A character defined as a rectangular grid of pixel positions.

2) **THEY ARE DESIGNED TO PERFORM NO. OF ADDITIONAL OPERns.**
These fns include generating various line styles (dashed, dotted, or solid) displaying color areas & performing certain transformations & manipulations on displayed objects.

3) **DESIGNED TO INTERFACE WITH INPUT DEVICES** :-
Display processors are typically designed to interface with interactive I/P devices, such as mouse.

X

Books Referred:-
- CG by - D. Hearn & Baker
- Intro to CG by - Mukhopadhyay & Arup Chattopadhyay.

CHARACTER GENERATOR (CG)

When you have a lot of printed information to air, such as sports scores or closing credits, you should use a character generator (CG).

The character generator is computer graphics system used widely in closed circuit and broadcast television.

- It creates letters and numbers in a variety of sizes, & fonts
- Requires no special skill for the user to make flawless letters.

- A character generator has a solid-state keyboard similar in appearance to a microcomputer keyboard, except it contains additional keys for specific CG functions.
- As you create text, you may store it in RAM and recall it as needed.
- Most CGs uses a floppy or hard disk system for permanent text storage

Some of the more CGs features :-

* 14 to 16 lines of 32 characters within the full-screen scanning area line-by line m/m recall
* automatic centering
* word flash
* word or line underline
* stand alone titling
* titling over video
* two speed roll through all or part of the m/m
* You may even program the letters in certain color arrangement by using a colorizer.

→ The overall design style for a set of characters is called Typeface or fonts

Typefaces can be divided into 2 broad gps -

(a) Serif :→ It has small lines or accents at the ends of the main character strokes

(b) Sans-serif :→ It does not have accents.

Two different representations are used for storing computer fonts :

(a) BitMap font :→ A simple method for representing the character shapes in a particular typeface is to use rectangular grid patterns

The set of characters are then referred to as **Bitmap font** (2)

(b) Outline font :- More flexible scheme is to describe character shapes using straight-line and curve-sections, as in PostScript. The set of characters is called an **outline font**.

(a) (b)

The letter B represented in
(a) with an 8 by 8 bilevel bitmap pattern
(b) with an outline shape defined with straight line & curve segments

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COLOUR DISPLAY TECHNIQUES

* SHADOW MASK & PENETRATION TECHNIQUES

A CRT monitor displays color pictures by using a combination of phosphors that emit different colored light.

By combining the emitted light from the different phosphors, a range of colors can be generated.

The Two basic techniques for producing colour displays with a CRT are the

→ Beam penetration method.
→ Shadow Mask method

The Beam-Penetration CRT :-

- The normal CRT can generate images of only a single color, due to the limitations of its phosphor.
- A color CRT device for line drawing displays has been developed.
- It uses a multilayer phosphor & achieves color control by modulating a normal constant parameter, namely the beam accelerating potential.

The arrangement of the beam-penetration CRT is similar to that of normal CRTs; the only unusual component is the multilayer phosphors usually Red & Green

→ Layer of Red phosphor is deposited behind the initial layer of Green phosphor

→ the displayed color depends on how far the electron beam penetrates into the phosphors layers

Process :-

- If A beam of slow potential electron beam strikes the tube face, it excites only the red phosphor & therefore produces a **Red** trace
- When the accelerating potential is increased, the velocity of the beam striking the phosphor is greater, & as a result, the beam penetrates into **green** phosphor, increasing the green component of light O/P.
- At **intermediate beam speeds**, combination of Red & Green light are emitted to show two additional colors **Orange** & **Yellow**.

Note :- The **speed** of the electrons & hence the screen color at any point, is controlled by the **beam-acceleration voltage**

Advantages

→ This method is an inexpensive way to produce color in random scan monitors.

Disadvantages

→ Only 4 colors are possible
→ Quality of pictures is not as good as with other.
→ Problem with Beam penetration CRT is the need to change beam accelerating potential by significant amt in order to switch colors.
The H/w or s/w must be designed to introduce adequate delays b/w changes in color, so that there is time for voltage to settle

Note :- Beam penetration CRT are commonly used in **random - scan monitors**

— Books Referred

- Newmann

Shadow – Mask CRT :→

- Shadow - mask methods are commonly used in raster scan system because they produce a much wider range of colors than the beam penetration method
- It is used in the majority of color TV sets & monitors.

Construction :→

A shadow mask CRT has 3 phosphor color dots at each pixel position.

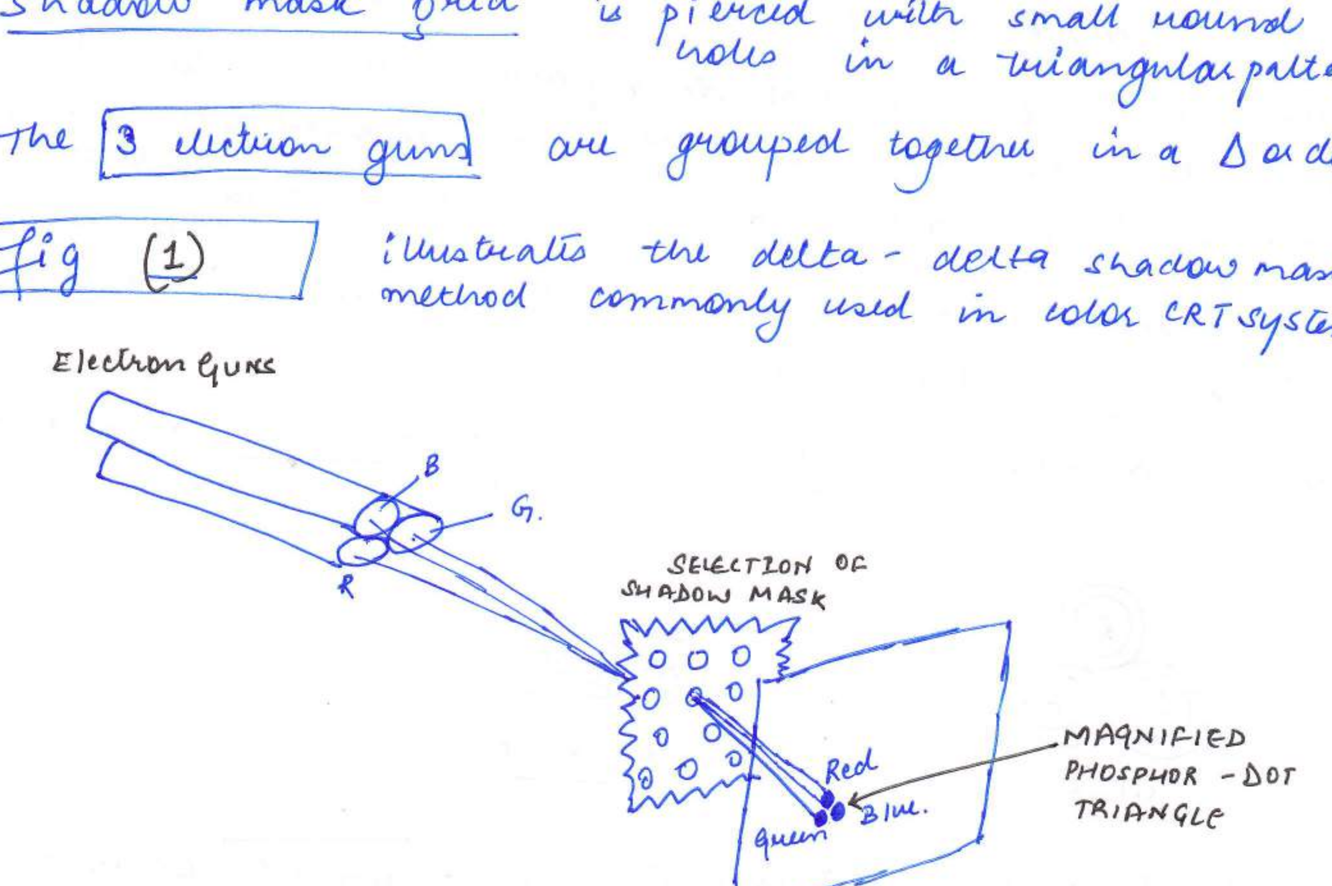
One phosphor dot emits – red light
another emits – green light
third emits – blue light

This type of CRT has 3 electron guns, one for each color dot and a shadow mask grid just behind the phosphor coated screen

Shadow mask grid is pierced with small round holes in a triangular pattern.

The 3 electron guns are grouped together in a Δ or delta

Fig (1) illustrates the delta - delta shadow mask method commonly used in color CRT system



fig(1) Operation of delta - delta, shadow mask CRT. Three electron guns, aligned with the triangular color dot patterns on the screen, are directed to each dot triangle by a shadow mask

WORKING :→ Triad arrangement of Red, green, Blue e guns

The deflection system of the CRT operates on all 3 electron beams simultaneously, the 3 electron beams are deflected and focused as a group onto the shadow mask, which contains a series of holes aligned with the g phosphor - dot patterns.

When the three beams pass through a hole in the shadow mask, they activate a dot triangle, which appears as a small colour spot on the screen.

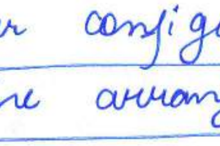
The phosphor dots in the triangles are arranged so that each electron beam can activate only its corresponding color dot when it passes through the shadow mask.

Inline arrangement

Another configuration for the 3 electron guns is an In-line arrangement in which the 3 electron guns and the corresponding red - green - blue color dots on the screen, are aligned along one scan line instead of in a triangular pattern

→ This inline arrangement of electron guns is easier to keep in alignment

→ & is commonly used in high resolution color CRTs.



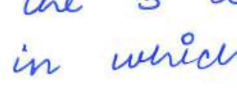


fig 2 Triad - and in-line arrangements of red, green & blue electron guns of CRT for colour monitors.
↓
Book Referred for above fig

- Fundamentals of Computer graphics & Multimedia

COLOUR VARIATIONS IN SHADOW - MASK CRT

we obtain color variations in a shadow mask CRT by varying the intensity level of the 3 electron beams

By turning off the red and green guns, we get only the color coming from the blue phosphor.

Other combinations of beam intensities produce a small light spot for each pixel position, since our eyes tend to merge the three colors into one composite.

*NOTE: The color we see depend on the amt of Excitation of the Red, green & blue phosphors

- white (or Gray) - is the result of activating all 3 dots with equal intensity.
- Yellow - is produced with Green & Red dots only
- Magenta - is produced with blue & Red dots only
- Cyan - shows up when blue & green are activated equally.

In some low-cost system, the electron beam can only be set to on or off, limiting displays to eight colors

More sophisticated systems can set intermediate intensity levels for the electron beams, allowing several million different colors to be generated.

Advantages :-

→ Produce much wider range of colors.

Disadvantages :-

→ Relatively poor performance in all respects except color range
→ Remained relatively expensive compared with the monochrome CRT
→ Relatively poor resolution
→ Reducing total brightness → Mask tends to block a large proportion of the available beam energy, reducing the total brightness

BY JASMINE REDDY

→ Unique problem with shadow-mask tube is that of CONVERGENCE

It is ~~diff~~ extremely difficult to adjust the 3 guns and the deflection system, so that the electron beams are deflected exactly together, all 3 converging on the same hole in a shadow mask where they fail to converge, the 3 component color appear to spread in a manner reminiscent of a poorly-aligned color printing process. Often it is possible to achieve adequate convergence over only a limited area of the screen.

Note — • The convergence problem
• Relatively poor resolution
& • Light O/P of shadow-mask CRT

have tended to discourage its use in inkin drawing displays.

X

Books Referred :-

→ Computer Graphics by Donald Hearn & Baker.

→ Principles of Interactive computer graphics by. Newman.

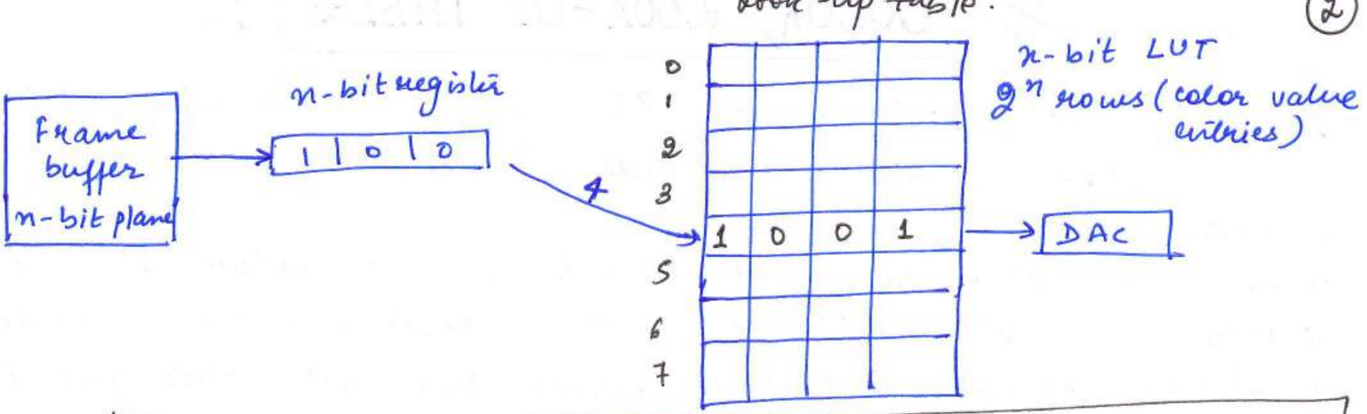


fig (1) The n-bit register holds the row number of the look-up table; the particular row pointed contains the actual pixel intensity value which is a x-bit number ($x > n$)

Advantages :→

→ An Excellent compromise at the cost of moderate increase in M/m. It allows only 8 bits of the frame buffer to be used to specify each color in an image & allows the creator of the image to decide what the 256 colors in the image should be.

→ Look-up table can be reloaded :→
The look up table can be reloaded any time with diff. combination of 256 colors out of 16 million w/o changing the frame buffer values.

→ Allows for more precision in an image :→
Since virtually, no image contain an even distribution of colors, this allows for more precision in an image by using more colors than would be possible by assigning each pixel a 2-bit value for blue & 3-bit value for green and red.

e.g. an image of the sky with clouds (like the windows 95 standard background) would have diff shades of blue, white & gray & virtually no red, green, yellow & the like.

X

Book Referred :-
Introduction to Computer Graphics
by Anirban Mukhopadhyay

HARD COPY COLOUR PRINTERS

There is a large selection of hardcopy printer e.g. electrostatic, ink jet, pen & ink, thermal & dye sublimation plotter /printers; laser printers, phototypesetters etc.

★ **ELECTROSTATIC PLOTTERS** :- It is a raster scan device.
Basically, it operates by depositing small particles of toner onto electrostatically charged areas of a special paper.
High resolution devices attempts to minimize the effects of aliasing by overlapping the individual dots.
Typical dot overlap is 30 to 50 percent.
The three ~~subsattra~~ subtractive primary colors (cyan, magenta, yellow (CMY) and black are applied to the medium in either a single pass or in four passes.
The no. of available colors depends on both
- → size of the pattern used e.g 2x2, 3x3 or 4x4
- → resolution of the plotter.

★ **INK-JET PLOTTERS** :- They are particularly suited for generating low cost color output.
The basic idea is to shoot tiny droplets of ink onto a medium. 2 types of ink jet printers → continuous flow & drop on demand

→ **continuous flow ink-jet** → produces a stream of droplets by spraying ink out of a nozzle.

→ **Drop-on-demand technology** → The ink is fired on demand by applying an electric voltage to a piezoelectric crystal.

Advantage → Ability to blend colors.

★ **THERMAL PLOTTERS** :- There are basically two thermal printing or plotting techniques.

Direct Thermal transfer → It is uses a temperature sensitive paper that changes color when heated.

Indirect Thermal transfer → It uses a thin film or paper ribbon coated with a wax-based ink.

Typically, **seven** colors are obtained directly by combining the CMY primaries from the ribbon, plus black.

Patterning & **dither** are used to expand the color palette.

Since the inks are not absorbed by the paper, quite brilliant colors are obtained.

★ **DYE SUBLIMATION PRINTERS** :- Imp

They provide the highest quality color printer output. Dye sublimation is sometimes called dye diffusion, dye transfer or sublimable dye technology.

(Working of the same is given in Book (Rogers) Pg. 30)

★ **PEN AND INK PLOTTERS** :- Digital pen & ink plotters are of 3 basic types, flatbed, drum & pinch roller

→ **Flatbed** → In moving-arm flatbed plotter - the medium is fixd in posn on the bed of the plotter. 2 dimensional motion of the plotting head is obtained by movement of an arm suspended across the width of plotter bed.

In moving head flat bed plotter - uses a plotting tool carriage suspended above the bed by magnetic forces that are counterbalanced by an air bearing.

Large flatbed plotters usually fix the medium to the plotters bed using vacuum.

→ **Drum plotters** → are mechanically more complex than flatbed plotters.

→ **Pinch rollers plotters** - is a hybrid of the flatbed & drum plotters.

★ **LASER PRINTERS** :→ They are used extensively for computer graphics output.

- These systems are capable of combining near-typeset-quality text, line art & halftone pictures on a single page.
- They are currently available with resolutions from **300 x 300 dpi** upto **1200 x 1200 dpi** with a **600x600dpi** resolution typical.
- Laser printing is a continuous process.

X

Books Referred :-

→ Procedural elements for Computer Graphics by David F. Rogers