Chapter-2

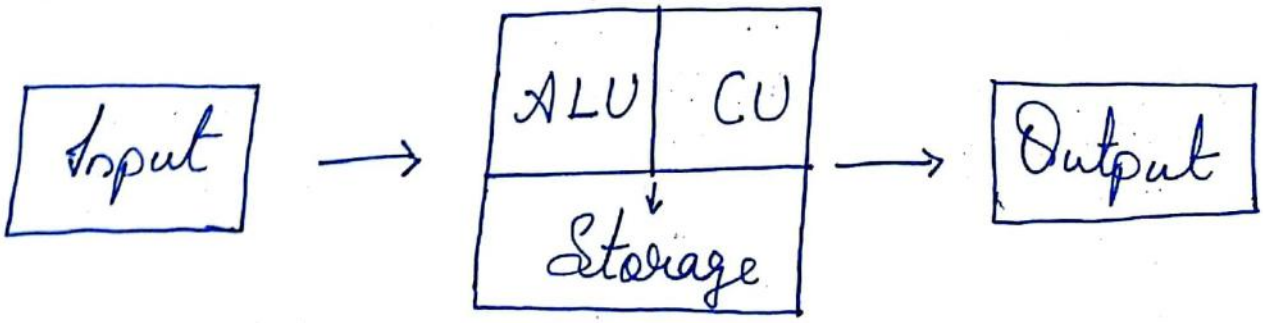
Computer Graphics - I

The components or tools of a computer system are grouped into one of two categories:

- Hardware, and
- Software

All the physical components that compose a computer system are known as Hardware. The hardware includes all electrical, mechanical, electronics, and magnetic devices within the computer system (CPU) and all peripheral devices such as printers, magnetic tape units, disk drive units etc.

All the set of instructions which are encoded to perform some specific function is known as Software.



As shown in the above diagram a computer system is mainly composed of:

1. Input Devices
2. Central Processing Unit → ALU, CU
3. Storage
4. Output Devices.

↳ Graphics Input Devices :

Input devices in a CAD system allows the user to interface with the computer system. Graphics i/p devices are provided at the CAD system to facilitate convenient communication between the user and the system. Two types of information that can be put into the graphics system include

1. Text
2. Graphics.

Text i/p devices are alphanumeric keyboards

Graphics i/p devices are of three types:

a) Cursor Control Devices
b) Digitizers
c) Image i/p devices / Image Scanners.

- Text, and
- Graphics

Text-input devices are the alphanumeric keyboards.

Graphic input devices are of basically three types:

- Cursor control devices or locating devices.
- Digitizers.
- Image-input devices/Image scanners.

2.4.1. Cursor Control Devices

Cursor control devices in a graphics system are also called locating devices. These devices are used for two types of interaction in a CAD system:

- To create and position new items on the computer graphics screen.
- To point at or otherwise identifying location on the screen, usually associated with existing images.

The various cursor control devices in a CAD system are discussed below.

1. Mouse: The mouse was invented in the late 1960s. This device is popular due to its convenient use with icons and pop-up and pull-down menus in a Computer Graphics system. There are two types of mice, which are used:

- mechanical and
- optical

The mechanical mouse is a box with two metal wheels or rollers on the bottom, the axes of these rollers axes are orthogonal in order to record the mouse motion in the X and Y directions. The movement of the mouse on any flat surface causes the rotation of the wheel which is ultimately controls the movement of the cursor on the screen. Press or click the mouse buttons to access functions or commands. Figure 2.6 shows a mechanical mouse on a mouse pad.

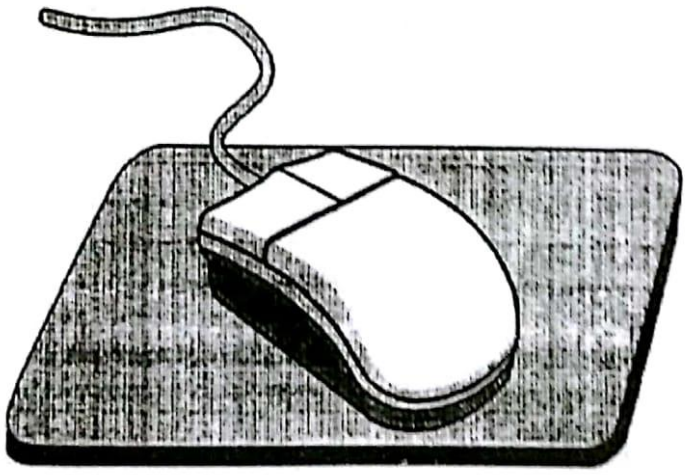


Fig. 2.6. A mechanical mouse

The optical mouse also moves the cursor, but it uses a beam of light on a reflective mouse pad, the optical mouse is shown in Fig. 2.7. Push-buttons are mounted on the top of the mouse and programmed to various functions.

2. Light Pen: It is a pointing or picking device that enables the designer to select a displayed graphics items on a screen by directly touching the icon of the item on the screen. The light pen does not project light, but it is a detector of light on the CRT screen and uses a light sensor. The light pen can only be used with refresh-type CRT but not with a storage tube. This is because the image on the refresh tube is being generated in time sequence, and this time sequence is so short that the image appears continuous to the human eye. But the computer is capable of reading this time sequence and the computer coordinates this timing with the position of the pen against the screen. Figure 2.8 shows a schematic diagram of light pen. Figure 2.9 shows use of light pen on a computer graphics screen.

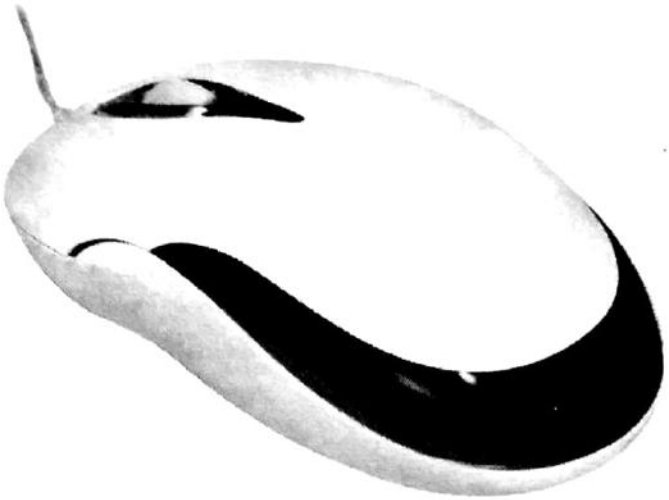


Fig. 2.7. An optical mouse

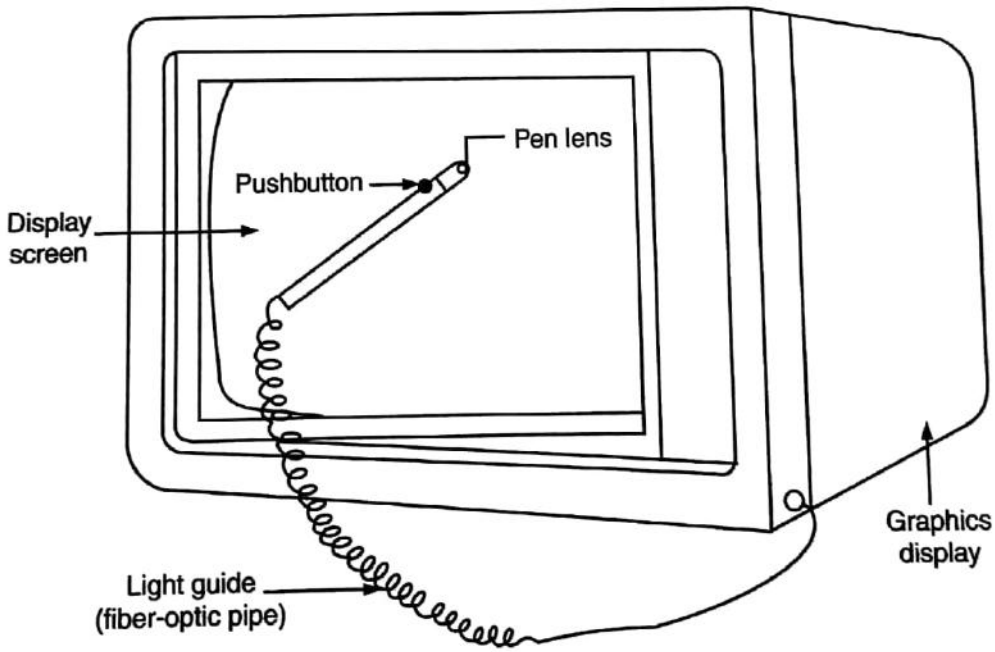


Fig. 2.8. A schematic view of light pen

Advantages of light pens are:

- Using a light pen is more direct and precise than using a mouse.
- Light pen is also convenient for applications with limited desktop space.

Disadvantage of light pens are:

- Light pens normally require a specially designed monitor.

3. Joystick: A joystick is a cursor control or pointing device with a vertical lever mounted on a base. The modern joystick levers also contain buttons called triggers, which activate certain commands when pressed. Joysticks are mainly used for computer games. Figures 2.10, and 2.11 show a line diagram of joystick and a modern joystick used these days respectively.

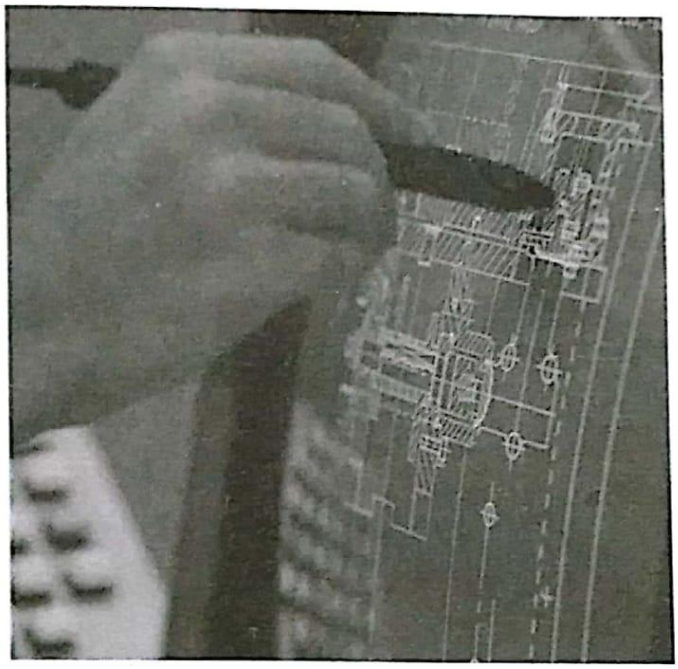


Fig. 2.9. Use of light pen on computer graphics screen

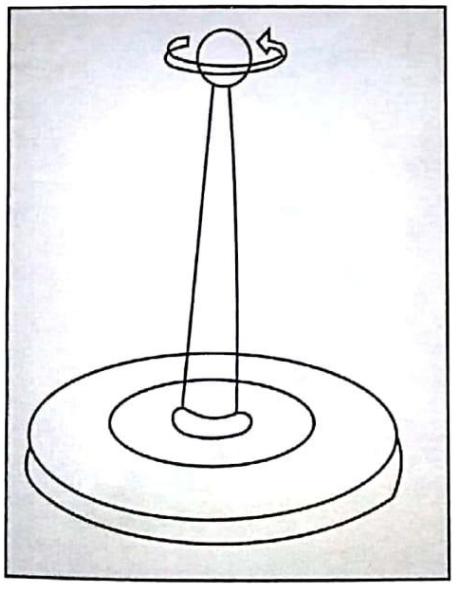


Fig. 2.10. A joystick line diagram

Fig. 2.11. A modern joystick

Advantages of using a joystick are:

- A joystick allows fast interactions with the computer system.

Disadvantages of using a joystick are:

- It is difficult to use a joystick to select objects accurately on the screen.

4. Thumb Wheel: Two thumb wheels are required to control the screen cursor as shown in Fig. 2.12. One thumb wheel controls the horizontal position and the other controls its vertical position. This type of device is often mounted as an integral part of the CRT terminal. The cursor position is indicated by the intersection of a vertical line and a horizontal line on the CRT screen. The two lines are like cross-hair. Figure 2.12 shows two thumbwheels used in a graphics hardware.

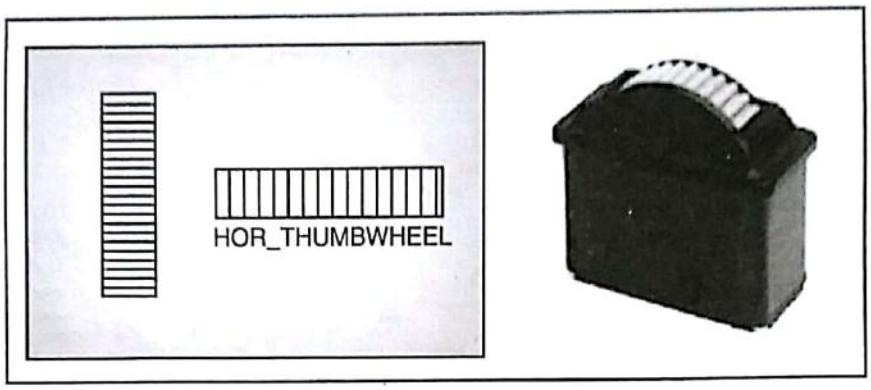


Fig. 2.12. Two thumb wheels used to control X and Y movement of cursor

5. Trackball: A trackball is a stationary pointing device which is having a ball that can be rotated with the fingers or palm of the hand to produce screen-cursor movement. Figure 2.13 shows the diagram of a trackball.

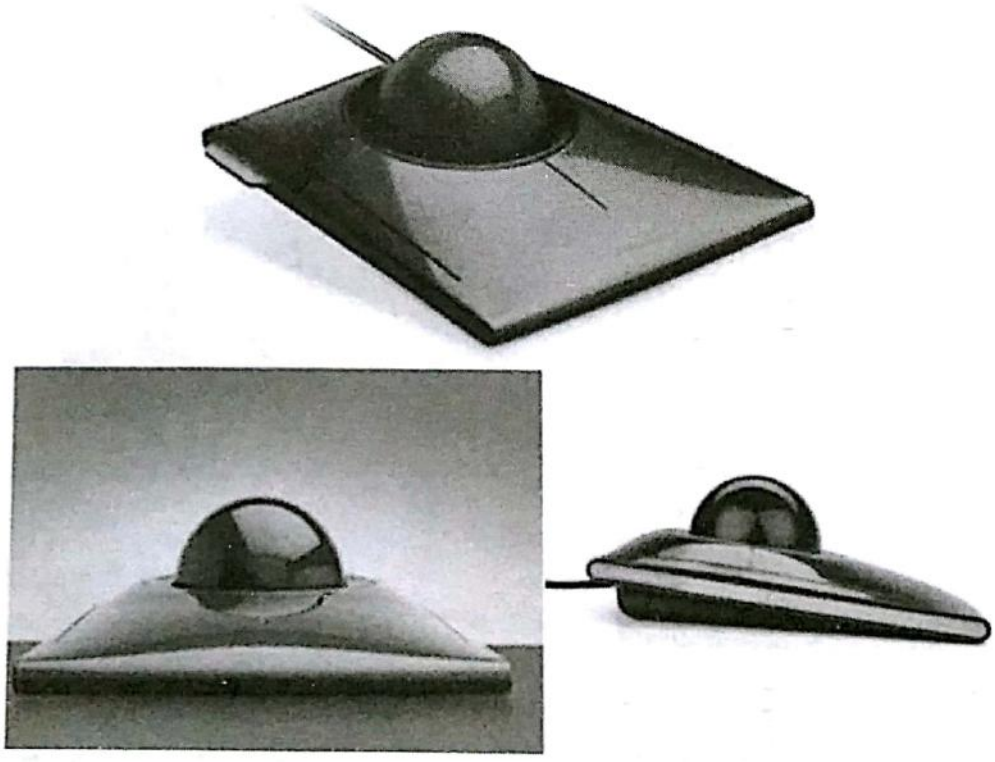


Fig. 2.13. Trackball

Advantages

- A trackball is good for limited desk space because the user does not have to move the entire device.

Disadvantages

- A trackball is less accurate than a mouse.
- The ball mechanism of requires more frequent cleaning than a mouse.

6. Electronic Tablet/Pen: The tablet and pen in computer graphics is an electronically sensitive tablet used with an electronic stylus. The tablet is a flat surface, separate from the CRT screen, on which the designer draws with the pen like stylus to input instructions or to control the cursor. It is mainly used for computer-aided design and drafting by architects, and designers. Each location on the graphics tablet corresponds to a specific location on the screen. A graphics tablet can be used to digitise drawing with great accuracy. Figure 2.14 shows a typical electronic tablet.

Fig. 2.14. An Electronic tablet with pen

Fig. 2.15. A touch panel

7. Touch Panels: A touch panel allows the displayed objects or the screen positions to be selected with touch of finger. The graphical icons or graphical commands of a CAD software can be selected with the touch of finger. These panels use various types of touch sensing techniques such as optical or electrical sensing techniques. The cursor moves to the location on the screen where finger is touched. Figure 2.15 shows a touch panel.

2.4.2. Digitizers

The digitizer tablet is also known as the graphic tablet. It is used for graphic input into the computer and is very important in the interactive graphical operation of CAD. A typical digitizer is shown in Fig. 2.16. This is having a small (280 × 280 mm is typical) flat plates which may be used for various purposes. This device is used for entering drawings directly into the system.

Digitizers can accurately measure the position of the hand cursor or the stylus with reference to the x and y axes located on the tablet and to input the position to the CPU directly for further processing. The coil in the digitizers generates voltages in the wires of the grid and the position of the puck or stylus can be found after analysis of the voltage. Some tablets are provided with a digital read-out showing the coordinate. Figure 2.16 shows a digitizer.

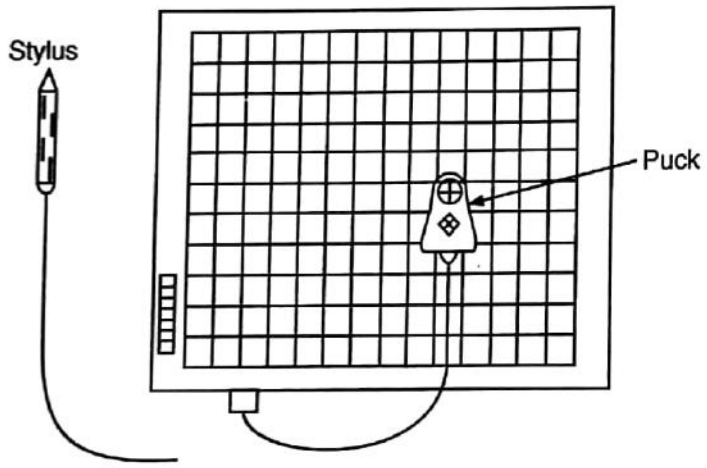


Fig. 2.16. A digitizer

Graphic tablets (Digitizers) can be used in following ways:

- To drive the screen cursor with the movement of the puck or stylus
- To support a menu card from for selecting options
- To input shapes from drawings
- To provide a natural means of sketching for designers

Digitizers are specified by board size, resolution of the screen and number of grid.

Advantages

- A stylus can be pointed to different positions on the tablet quickly.

Disadvantages

- A stylus and a graphics tablet normally have to work together, and cannot work separately.

2.4.3. Image Input Devices

1. Image Scanners: A scanner is a light-sensing input device that converts printed text and graphics into a digital form that can be further processed by the computer. The gradations of gray scale or colour are then recorded and stored in an array. This image can be then processes to apply transformations such as scale, rotate or crop the picture, or modify the array representation of the picture.

Two popular types of scanners are:

A flatbed scanner works like a copy machine except that it creates a file of the document rather than a paper copy, as shown in Fig. 2.17.

Fig. 2.17. The Image Scanner used in CAD systems

The second type of image scanner is a handheld scanner that can be manually passed over the image to be scanned. Hand-held scanners are ideal for capturing small images, such as signatures and logos. A hand-held scanner is smaller, less expensive, and more portable than a flatbed scanner. Figure 2.18 shows a hand held image scanner.

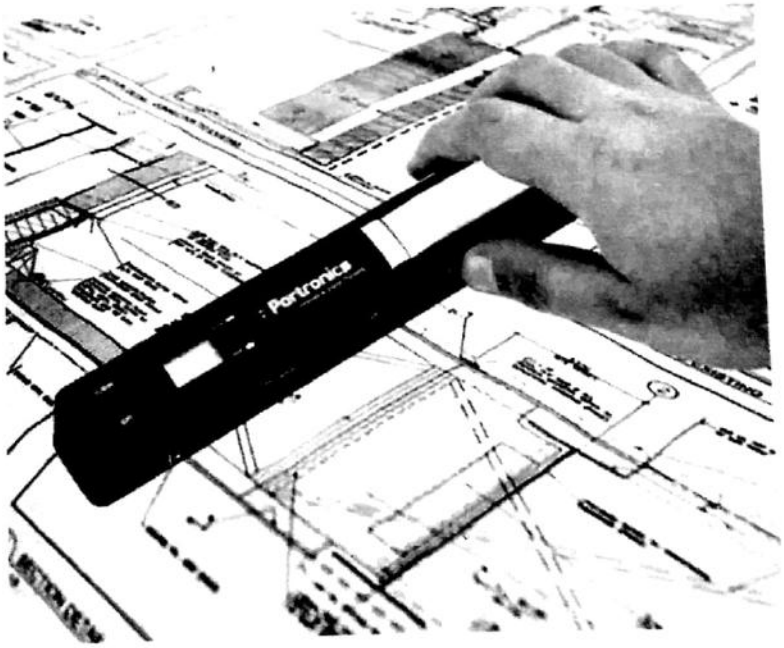


Fig. 2.18. A hand held image scanner (Image Thanks : Portronics)

searches the dictionary for a frequency-pattern match. Usually microphones are used to give voice input.

If the same system has to be used by different operator, then the speech training should be done again with that operator's voice. A typical speech recognition system is shown in Fig. 2.20.

2.6. GRAPHICS DISPLAY DEVICES

Various types of display devices are used in CAD system. These display devices are primarily output devices. These devices display graphical output on the computer screen, which has better visualization in the real world. Alongwith displaying the image, these devices are also used to modify or editing the graphical entities of the image.

The Graphics display devices can be classified as follows:

1. Cathode Ray Tube (CRT)
   - Raster scan
   - Random scan
2. Direct View Storage Tubes
3. Colour CRT Monitors
4. Flat Panel Displays (Solid State Monitors)
   - Plasma display
   - LCD (Liquid Crystal Display)
   - LED (Light Emitting Diode)

2.6.1. Cathode Ray Tube (CRT)

Cathode-ray tubes are referred as CRTs. Cathode ray tube (CRT) has produced a wide range of extremely effective graphics displays. Figure 2.21 shows a schematic diagram of a cathode ray tube (CRT).

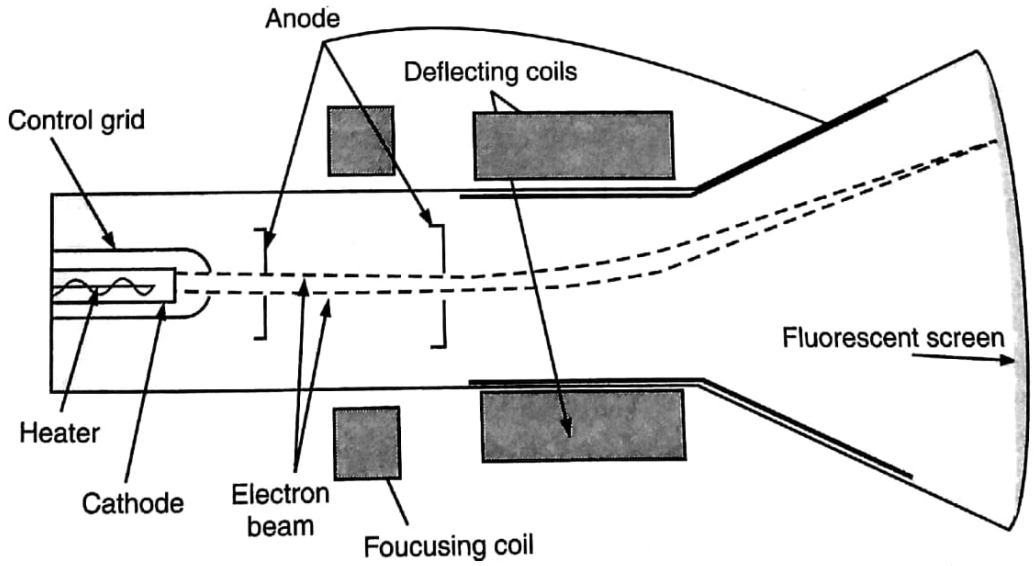


Fig. 2.21. A Cathode Ray Tube

There is vacuum inside the tube with pressure around 0.01 Pa or even less. The working principle of the CRT is based on the principle of energizing a beam of electrons

which strikes the phosphor coated fluorescent screen at very high speed. An electron gun is used to generate the electron beam, which contains the cathode, as shown in Fig. 2.21 on left side of the CRT. These electrons are focused into a beam with the help of a focusing unit. By focusing and changing the intensity of electron beam, the point of contact of the beam with phosphor coated fluorescent screen is controlled with the help of a deflector system. With the contact on the screen, the beam is made to generate a picture on CRT screen. The assembly of cathode, control grid, focusing anode, and accelerating electrode is called the electron gun.

The X and Y, horizontal and vertical positions of the beam are controlled by the deflection system of the CRT, which is related to graphics information through display controller. The controller with the information from computer converts it into signals which are acceptable to the CRT.

There are two basic techniques used in computer graphics terminals for displaying the image on the CRT screen. They are:

- Random scan display
- Raster scan display

2.6.1.1. Random scan display CRTs

In random scan display system a CRT has the electron beam directed only to those parts of the screen where a picture is to be drawn. These display draw one line at a time, therefore these are also called vector displays, or stroke writing, or calligraphic displays. The lines of a picture are drawn and refreshed in any specified order. Figure 2.22 shows a random scan display.

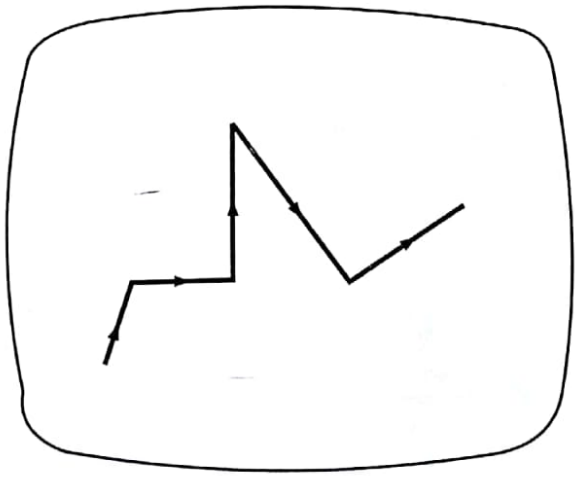


Fig. 2.22. A random scan display: combination of lines

This refresh rate depends upon the number of lines to be displayed. Picture definition is stored as a set of line-drawing commands in the memory referred to as the refresh display file, display program, or simply the refresh buffer. To a display a picture, the system recalls the program from memory and draws each component line one by one. After processing all line commands the system goes back to first line command in the program.

Random-scan displays are designed to draw all the component lines of a picture 30 to 60 times each second. Random scan systems can not display realistic shaded images because these are designed for only line drawing applications.

2.6.1.2. Raster scans display CRTs

Raster scans display CRTs (tv scan video monitors or display monitors) are used extensively in the display of alphanumeric data and graphics. The **raster** is a series of horizontal lines crossing the face of the CRT screen as shown in Fig. 2.23. Each horizontal line is made up of one trace of the electron beam from left to right. The raster starts at the top left corner of the CRT screen. As each horizontal line is completed, the blanked electron beam is rapidly returned to the left of the screen.

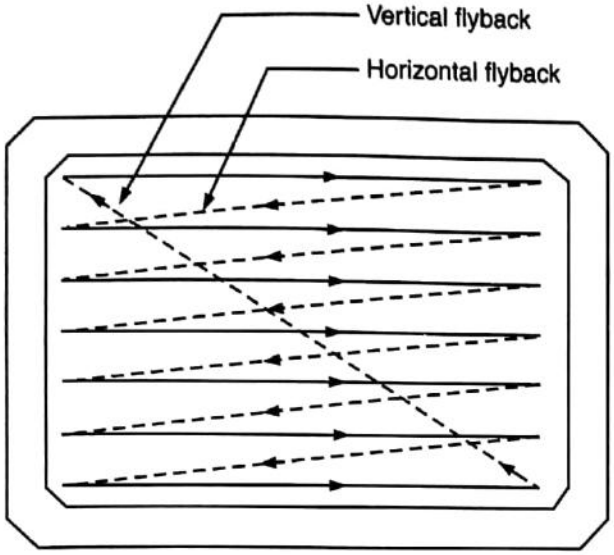


Fig. 2.23. A raster scan display

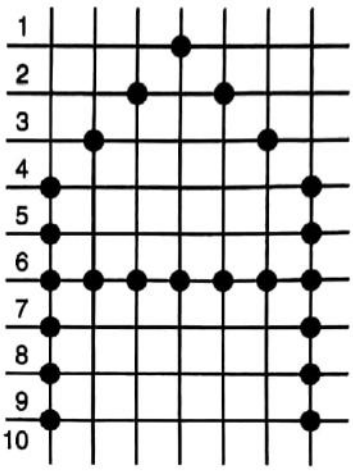


Fig. 2.24. Pixel elements displaying character A on raster scan display

The vertical deflection moves the beam downwards, and the horizontal sweep repeats. When the vertical sweep reaches the bottom line of the raster, the system takes back the beam to the starting position of the raster, and the process is repeated.

The picture elements are used to display actual data, which are called pixels. A pixel is a variable dot of light which is illuminated with video signals input to monitor. The pixels are contained in horizontal scan lines on the CRT screen. The pictures can be generated and displayed by varying the intensity of pixels. It takes several horizontal lines and picture elements on each line to create a character. Figure 2.24 shows the generation of the character A, which is built using a 7 by 9 pixel matrix.

In a black and white display, each pixel is either on or off, therefore only one bit per pixel is needed to control the intensity of screen positions. In a binary system, a bit value of 1 means the electron beam is to be turned on at that position, 0 means that the beam intensity is off. If colour and intensity variations are to be displayed, then additional bits are needed. For example, 24 bits per pixel is a system of high quality resolution. But this requires high memory storage capacity.

Raster scan displays are repetitive in nature. The raster frame is refreshed approximately 30 times a second.

2.6.2. Direct View Storage Tubes

We can store the image information inside the CRT instead of refreshing the screen. The Direct View Storage Tubes (DVST) use this principle and store the information of

image in form of charge distribution just behind the phosphor coated fluorescent screen. Figure 2.25 shows the diagram of a DVST.

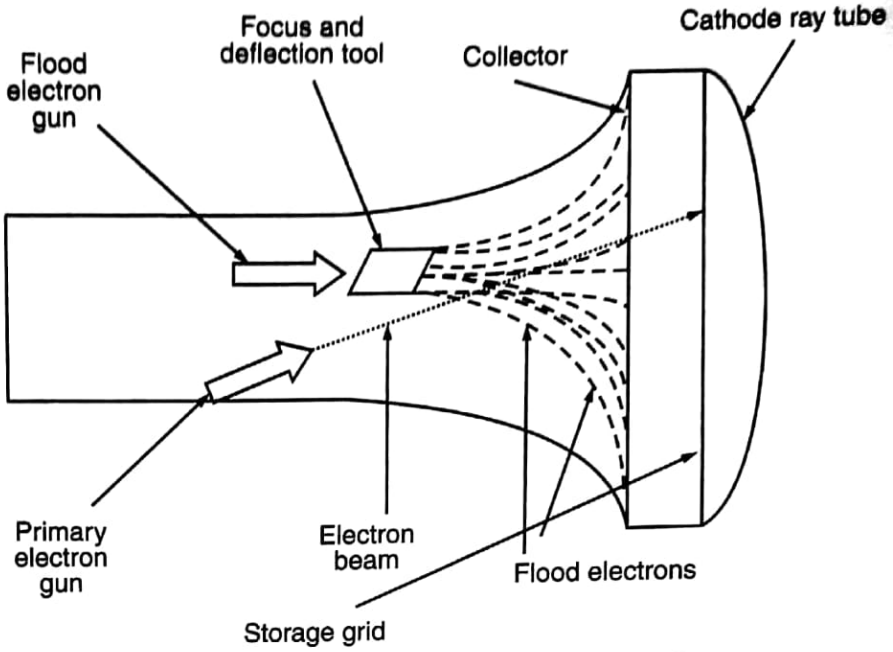


Fig. 2.25. A Direct view storage tube

In these, two electron guns are used, as shown in Fig. 2.25. First electron gun is used to store the picture information and second electron gun is used to maintain the picture display on the screen. First gun is known as primary electron gun, and second gun is known as flood gun. We can display complex pictures at very high resolution because no refreshing is needed in this case. The drawback of DVST is that colours can not be displayed and picture can not be edited. Because to edit the picture, entire screen has to be erased and then picture has to be redrawn.

2.6.3. Colour CRT Display

In the colour display CRTs a coating of phosphors of different compounds is used, which can produce a colour image. The basic principle is that by combining three basic colours that is red, blue and green, we can produce picture of any colour. These three colours are combined in different ratios.

There are two popular techniques for producing color displays with a CRT are:

- Beam-penetration method
- Shadow-mask method

2.6.3.1. Beam Penetration Method

In this case three layers of red, green and blue phosphorus are coated on the screen. The displayed colour depends on the intensity of penetration of electron beam in the phosphorus layer. For example, if a low speed electron beam strikes CRT, it only activates the red colour phosphors; a slightly accelerated electron beam activates red and green colour phosphors, whereas a highly accelerated electron beam strikes all the three colour phosphorus. The problem of this method is to accelerate the electron beam to a required level to get the exact colours. Therefore, only a limited range of colours can be easily produced using this method.

2.6.3.2. The Shadow-Mask method

This method is also based on the principle of combining three basic colours to get a desired colour. In this case, 3 different electron guns are used, which are placed to form a triangle or a Delta as shown in Fig. 2.26. Each pixel is made up of 3 types of phosphorus to produce three basic colours that is red, blue and green. A metal shadow mask is used just before the phosphors screen.

The shadow mask CRT, instead of using one electron gun, uses 3 different guns placed one by the side of the other to form a triangle or a "Delta" as shown. Each pixel point on the screen is also made up of 3 types of phosphors to produce red, blue and green colors. Just before the phosphor screen is a metal screen, called a "shadow mask".

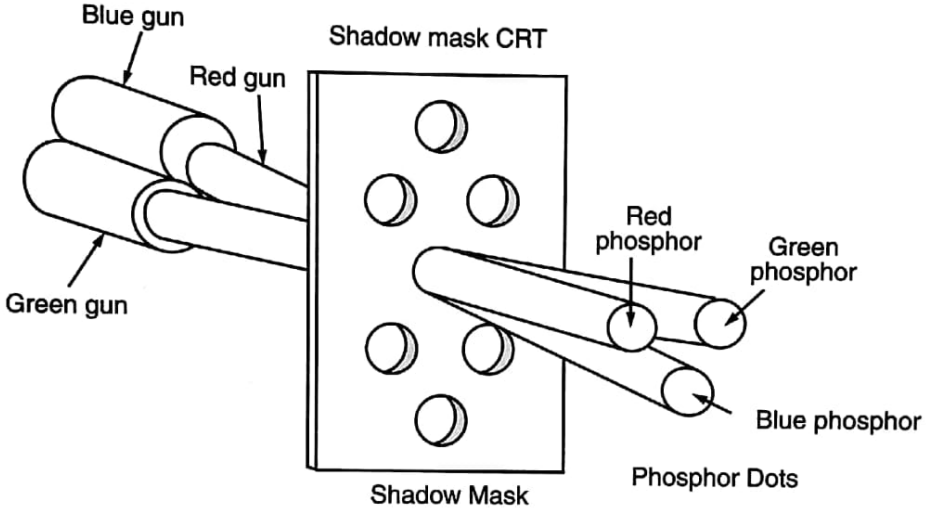


Fig. 2.26. Colour CRT display using shadow mask method

The shadow mask has holes, when beam from three electron guns are focused on a pixel, they are focused on particular colour pixel only. And electron beam activates only its corresponding pixel or dot. In this case, the intensity of all three beams can be controlled simultaneously and independent to each other. Therefore it is easy to get a desired ratio of a particular colour in the mixture. Therefore, we can have a matrix of combinations to produce a wide variety of colours in this method.

2.6.4. Flat Panel Displays

The major disadvantage of using CRTs is their length and size. Therefore, a number of other display methods are in use these days to reduce the size of CRTs display. These devices are known as flat panel displays. The common three types of flat panel displays are liquid crystal displays (LCDs), gas plasma displays (GPDs), and light emitting diode display (LEDs). The screens of these flat panel displays are made up of pairs of electrodes and each pair of electrodes is used to generate one picture element.

2.6.4.1. Liquid Crystal Display (LCD)

The liquid crystal display (LCD) does not generate its own light for the picture elements, and it requires a source of external light. This external source is called backlight. The liquid crystal material is used between the electrodes. And when voltage is applied, the electrodes get charged and this causes this crystal material becomes translucent

and allows the backlight to shine through as a picture element. Figure 2.27 shows working of of a LCD display.

2.6.4.2. Plasma Display

In case of plasma display tiny cells filled with gas like xenon or neon are placed between two glass plates. The electrodes are placed inside glass plates such that they are positioned in front and behind each cell. The address electrodes are behind the cells, and front glass plate has transparent display electrodes which are surrounded by a layer of magnesium oxide layer and a dielectric material. The Fig. 2.28 shows the working principle of a plasma display.

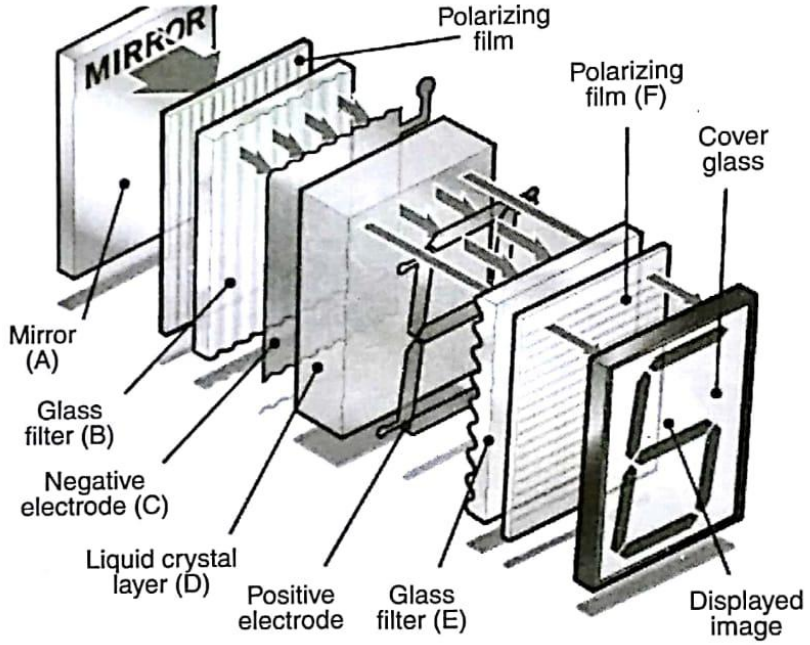


Fig. 2.27. The working of a LCD display

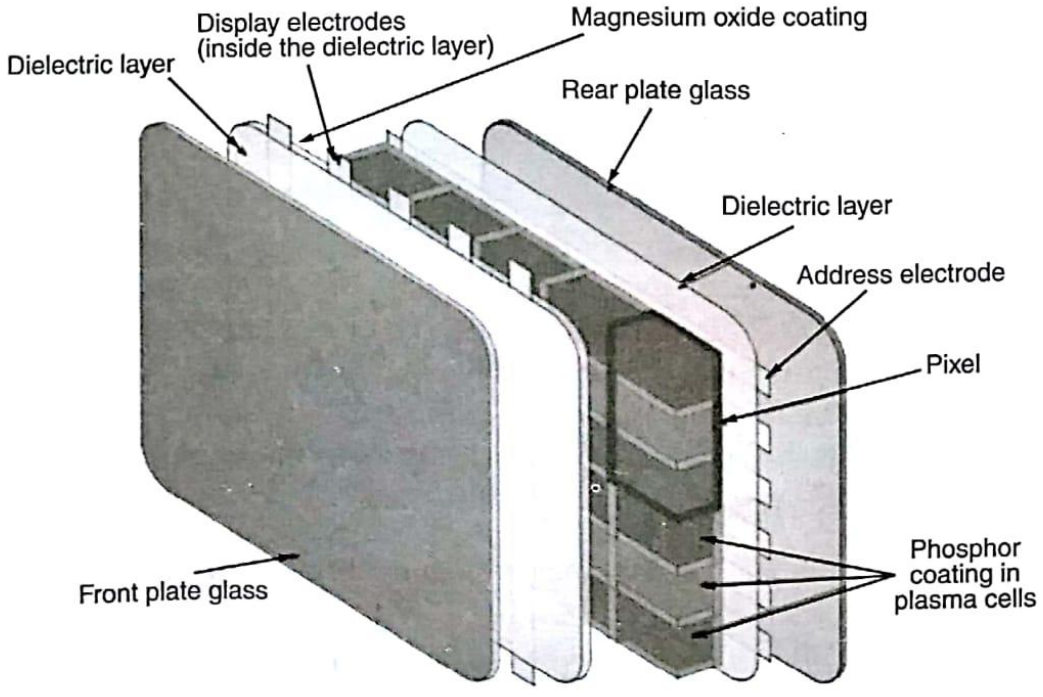


Fig. 2.28. A plasma display

When a voltage is applied, the electrodes are charged which causes the ionization of the gas resulting in plasma. Due to collision between ions and electrons, photons of light are emitted. For getting colour plasma, phosphor is coated on the back of each cell. The photons are ultraviolet and these ultraviolet photos react with phosphor to give coloured light.

The major advantages of flat panel displays is that small voltages are required than CRTs.

2.7. PRINTERS AND PLOTTERS

2.7.1. Printers

Printers are widely used output devices that express coded characters on hard copy or paper. The output is in form of numbers, letters, symbols, graphics or drawings. Printers range from electronic typewriters to high-speed printers.

Daisy-wheel printers: Daisy-wheel printer is impact printer. In this printer a round disk is used, which is embossed with characters located at end of each petal like projections. Figure 2.29 shows a daisy wheel printer. The wheel is rotated at high speed. The print hammers strike when the desired character spins to the correct position causing it to be printed on paper.

Fig. 2.29. A Daisy wheel printer

Dot-matrix printers: Dot-matrix printers use an arrangement of tiny pins called dot matrix to generate one dot at a time. In this the printed character is made up of a number of dots.

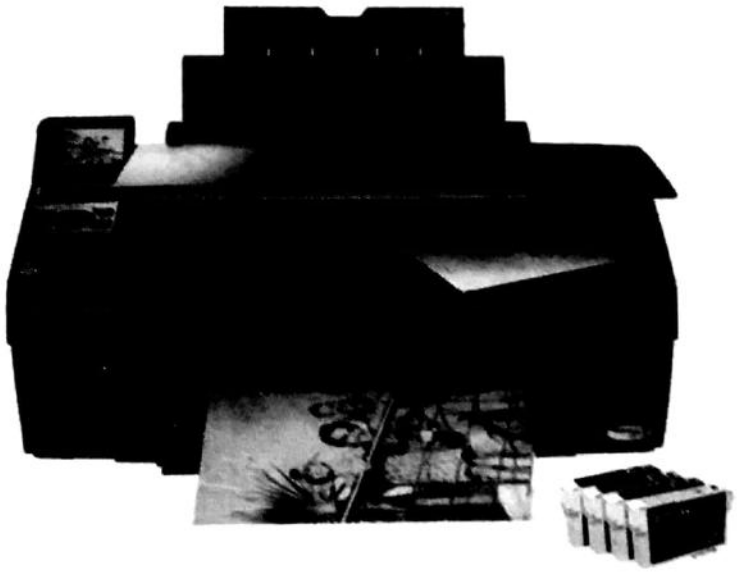


Fig. 2.30. An ink jet printer

Ink jet printers: Ink jet printers use the technique of spraying the paint. The ink is electrically charged and under pressure it is shot towards the paper. This sprayed ink is passed through an electrical field which forms the letter in a matrix form. Figure 2.30 shows an ink jet printer.

Laser Printers: The laser printers direct a beam of light through a rotating disk. This rotating disk contains full range of print characters. The appropriate character image is directed to the paper, is passed through a toner and is developed and then gave impression on the paper. This printer gives sharp and clean images, and is very fast in speed. Figure 2.31 shows working of a laser printer.

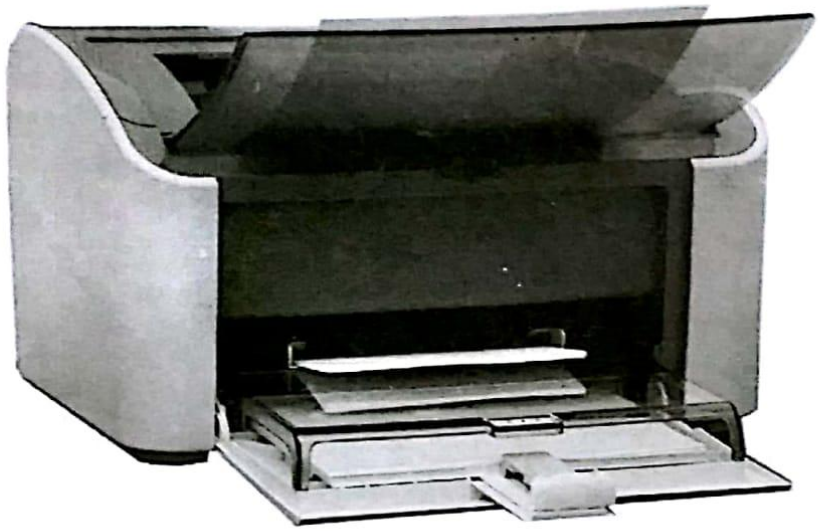


Fig. 2.31. Laser jet printer

2.7.2. Plotter

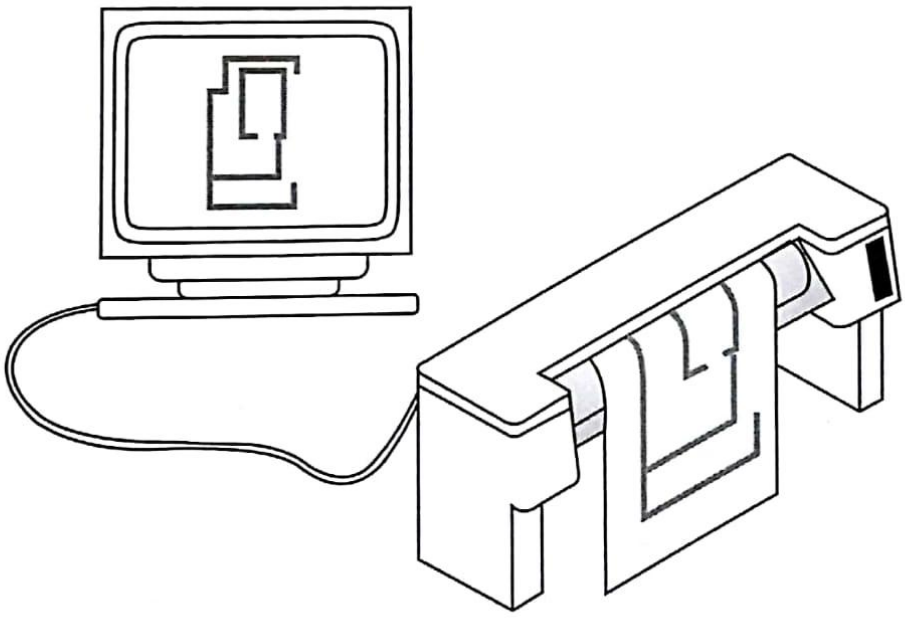


Fig. 2.32. A plotter connected to a computer system

A plotter is used to plot an image or drawing from the computer screen to some form of drawing paper. A line type digital plottter is electormechanical graphics output

device, and is capable of giving two dimensional movements between a pen and drawing paper. The ink pens are used to generate a permanent copy of a drawing. The drawings produced are of high quality, precise and uniform, but expensive. Most of the CAD drawings are plotted on plotters only. Figure 2.32 shows a plotter connected to a computer system to plot drawings. Figure 2.33 shows a colour plotter.

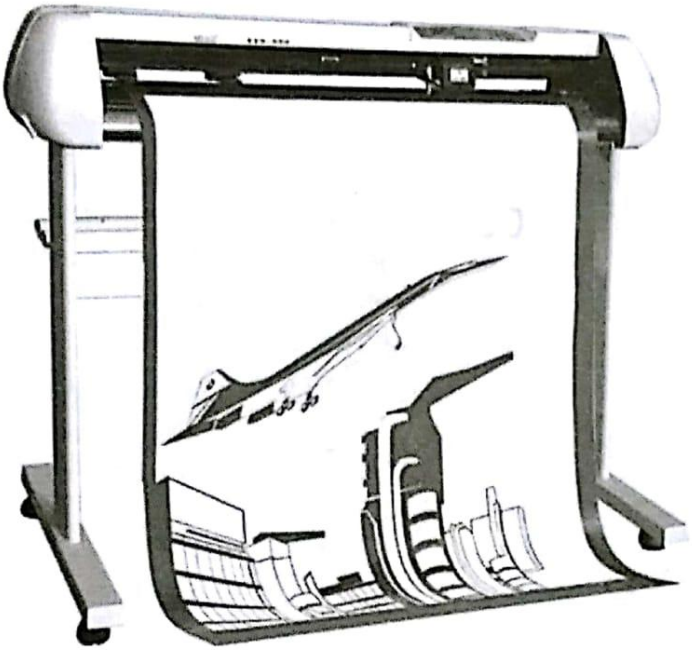


Fig. 2.33. A colour plotter

➠ 2.8. OTHER INPUT DEVICES

The various input devices used in computer aided design system or computer graphics system are discussed in article 2.4 above. There are other text input devices, which are being used these days in computer systems. These are explained as follows.

2.8.1. Bar Code Reader

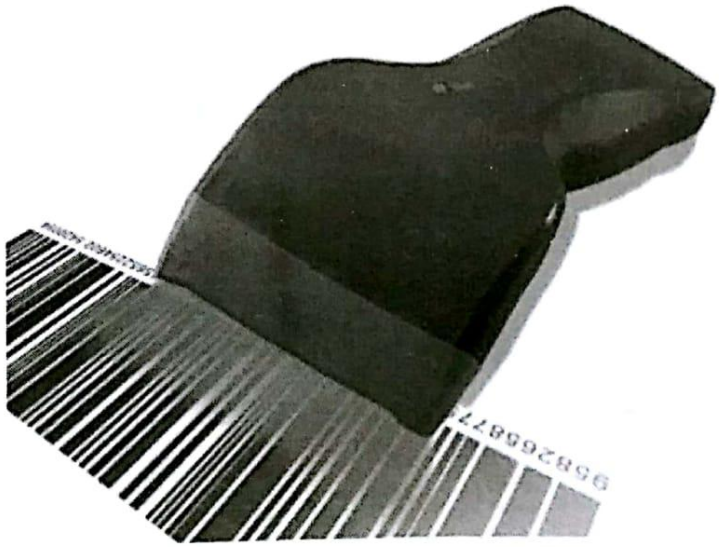


Fig. 2.34. A bar code reader

A bar code reader reads bar codes using laser beams. A bar code reader reads a specific bar code by using light patterns that pass through the bar code lines. These types of readers are widely used in a point of sales for example supermarkets, department stores etc. Figure 2.34 shows a bar code reader.

The advantages of using a bar code reader are that the process of data is very fast and accurate; also any detail of information about item can be coded in the bar codes. The disadvantage is that only numbers can be coded into such system.

2.8.2. Magnetic Ink Character Reader

A magnetic ink character recognition (MICR) reader can read the text printed with special type of magnetized ink. Magnetic ink character recognition is used most exclusively by the banking industry for processing of checks. The characters represent the check number, the bank branch details, and the account number of customers. Figure 2.35 shows a bank check coded with the information.

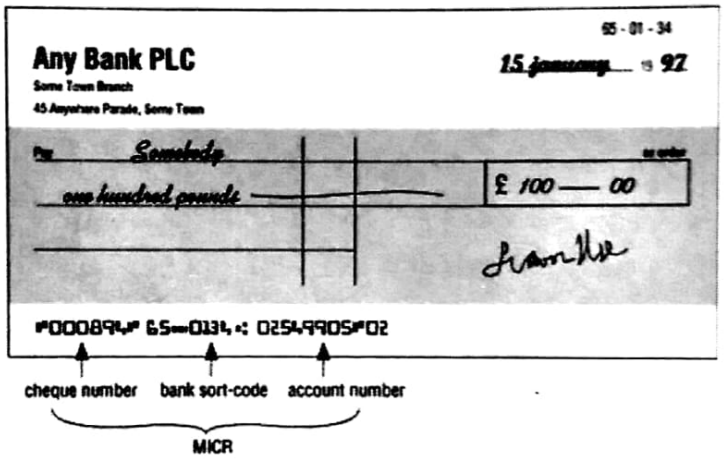


Fig. 2.35. A MICR check

2.8.3. Optical Character Recognition (OCR)

Optical character recognition is a technology that is used to convert different types of documents, such as scanned paper documents, PDF files or images captured by a digital camera into editable and searchable data. We can edit this data after the conversion. A scanner is not enough to make this information available for editing. An OCR software singles out letters on the image, put them into words and then words into sentences, therefore enabling a user to access and edit the document. Figure 2.36 shows the data flow in optical character recognition technique with an OCR software.

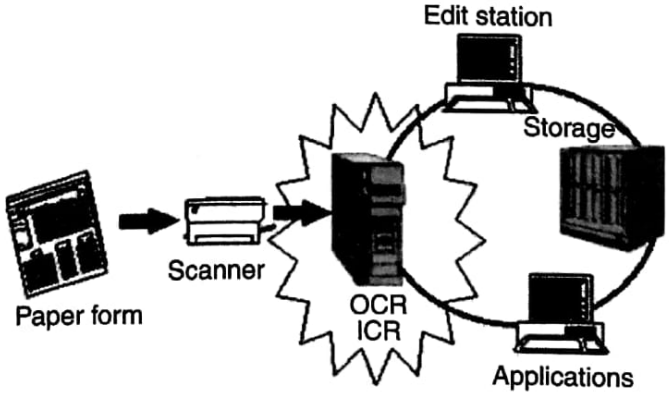


Fig. 2.36. Data flow in OCR technique