2.0 DISPLAY DEVICES

- Video display systems (CRT's)
  - Raster-scan displays (refresh)
  - Random-scan displays (vector refresh)
  - Color CRT monitors
- Flat-panel displays
  - Plasma panels
  - LCD's (Liquid Crystal Display)
  - Electroluminescent displays
  - Flat-panel characteristics
- 3D Viewing devices
  - VR-systems (Virtual Reality)

2.1 CRT principle

Fig. 3 below illustrates the basic operation of a CRT. A beam of electrons (cathode rays), emitted by an electron gun, passes through focusing and deflection systems that direct the beam towards specified position on the phosphor-coated screen. The phosphor then emits a small spot of light at each position 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 electron beam back over the same points. This type of display is called a **refresh CRT.**

The primary components of an electron gun in a CRT are the heated metal cathode and a control grid (Fig. 3). Heat is supplied to the cathode by directing a current through a coil of wire, called the filament, inside the cylindrical cathode structure. This causes electrons to be "boiled off" the hot cathode surface. In the vacuum inside the CRT envelope, negatively charged electrons are then accelerated toward the phosphor coating by a high positive voltage. The accelerating voltage can be generated with a positively charged metal coating on the in side of the CRT envelope near the phosphor screen, or an accelerating anode can be used, a in fig below . Sometimes the electron gun is built to contain the accelerating anode and focusing system within the same unit.

Spots of light are produced on the screen by the transfer of the CRT beam energy to the phosphor. When the electrons in the beam collide with the phosphor coating, they are stopped and there are stopped and their kinetic energy is absorbed by the phosphor. Part of the beam energy s converted by friction into heat energy, and the remainder causes electron in the phosphor atoms to move up to higher quantum-energy levels. After a short time, the “excited” phosphor electrons begin dropping back to their stable ground state, giving up their extra energy as small quantum of light energy. What we see on the screen is the combined effect of all the electrons light emissions: a glowing spot that quickly fades after all the excited phosphor electrons have returned to their ground energy level. The frequency (or color) of the light emitted by the phosphor is proportional to the energy difference between the excited quantum state and the ground state.

Different kinds of phosphor are available for use in a CRT. Besides color, a major difference between phosphors is their persistence: how long they continue to emit light (that is, have excited electrons returning to the ground state) after the CRT beam is removed. Persistence is defined as the time it takes the emitted light from the screen to decay to one-tenth of its original intensity. Lower-persistence phosphors require higher refresh rates to maintain a picture on the screen without flicker. A phosphor with low persistence is useful for animation; a high-persistence phosphor is useful for displaying highly complex, static pictures. Although some phosphor have a persistence greater than 1 second, graphics monitor are usually constructed with a persistence in the range from 10 to 60 microseconds

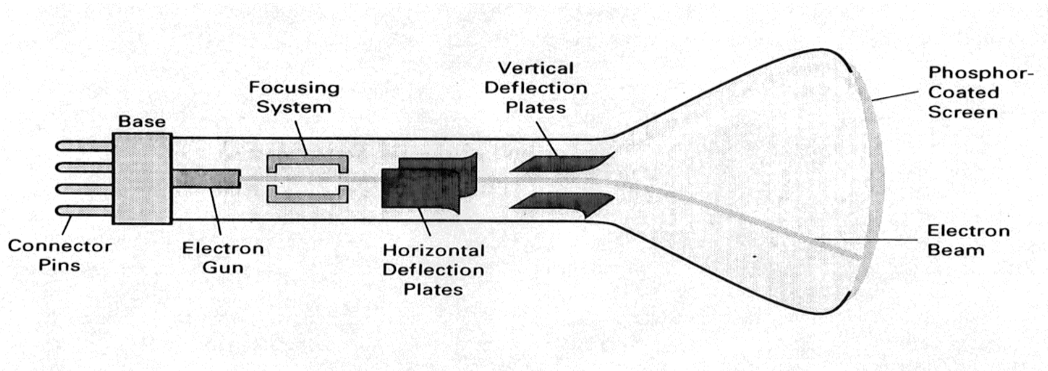

Figure 3 CRT screen

2.2 Raster-scan technique

In a raster- scan 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 definition is stored in memory area called the **refresh buffer** or **frame buffer**. This memory area holds the set of intensity values for all the screen points. Stored intensity values are then retrieved from the refresh buffer and “painted” on the screen one row (**scan line**) at a time (Fig. 4). Each screen point is referred to as a **pixel** or **pel** (shortened forms of **picture element**).

Refreshing on raster-scan displays is carried out at the rate of 60 to 80 frames per second, although some systems are designed for higher refresh rates. Sometimes, refresh rates are described in units of cycles per second, or Hertz (Hz), where a cycle corresponds to one frame. At the end of each scan line, the electron beam returns to the left side of the screen to begin displaying the next scan line. The return to the left of the screen, after refreshing each scan line, is called the **horizontal retrace** of the electron beam. And at the end of each frame (displayed in 1/80th to 1/60th of a second), the electron beam returns (**vertical retrace**) to the top left corner of the screen to begin the next frame.

On some raster-scan systems (and in TV sets), each frame is displayed in two passes using an interlaced refresh procedure. In the first pass, the beam sweeps across every other scan line from top to bottom. Then after the vertical retrace, the beam sweeps out the remaining scan lines (fig.below). Interlacing of the scan lines in this way allows us to see the entire screen displayed in one-half the time it would have taken to sweep across all the lines at once from top to bottom

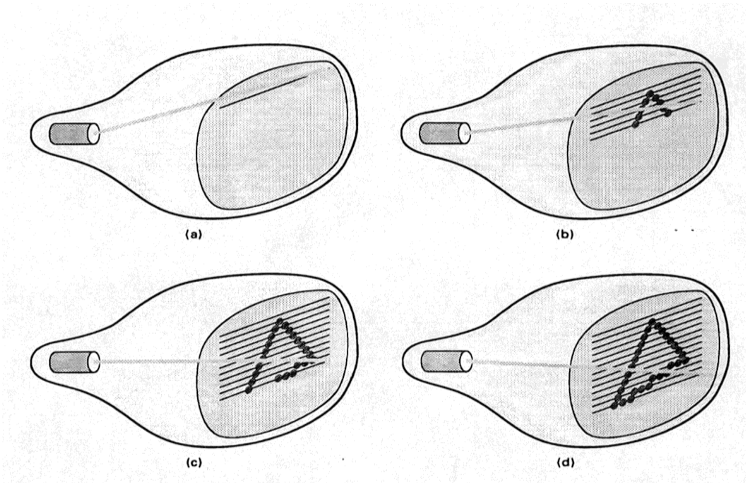

Figure 4 Raster Scan Technique

2.3 Random-scan technique

Random scan monitors draw a picture one line at a time and for this reason are also referred to as **vector** displays (or **stroke-writing** or **calligraphic** displays). The component lines of a picture can be drawn (Figure 5) and refreshed by a random-scan system in any specified order.

Refresh rate on a random-scan system depends on the number of lines to be displayed. Picture definition is now stored as a set of line-drawing commands in an area of memory referred to as the refresh display file. Sometimes the **refresh display file** is called the **display list, display program,** or simply the **refresh buffer**. To display a specified picture, the system cycles through the set of commands in the display file, drawing each component line in turn.

After all line- drawing commands have been processed, the system cycles back to the first line command in the list. Random-scan displays are designed to draw al the component lines of a picture 30 to 60times each second.

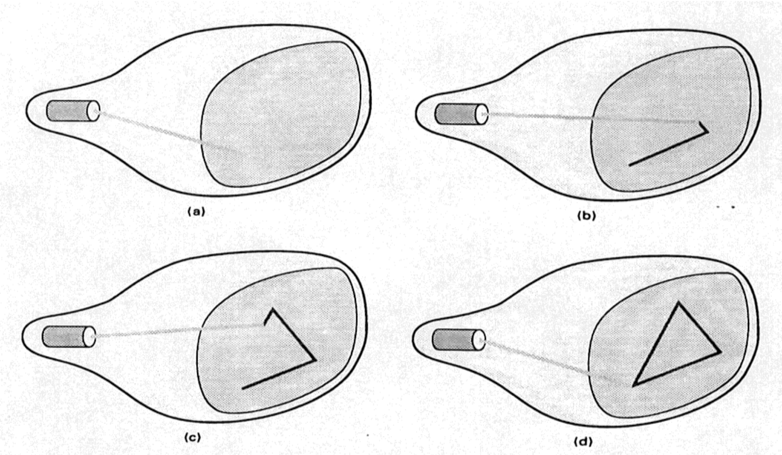

Figure 5 Random Scan Technique

2.4 Color CRT monitor

The beam penetration method for displaying color pictures has been used with random-scan monitors. Two layers of phosphor, usually red and green, are coated on to theinside of the CRT screen, and the displayed color depends on how far the electron beam penetrates into the phosphor layers.

2.5 Shadow-mask

Shadow-mask methods are commonly used in raster-scan systems (including color TV) because they produce a much wider range of color than the beam penetration method. A shadow-mask CRT has three phosphor color dots at each pixel position. One phosphor dot emits a red light, another emits a green light, and the third emits a blue light. This type of CRT has three electron guns, one for each color dot, and a shadow- mask grid just behind the phosphor –coated screen. Figure 6 below illustrates the delta-delta shadow-mask method, commonly used in color CRT systems. The three electron beam are deflected and focused as a group onto the shadow mask, which contains a series of holes aligned with the 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 color spot 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

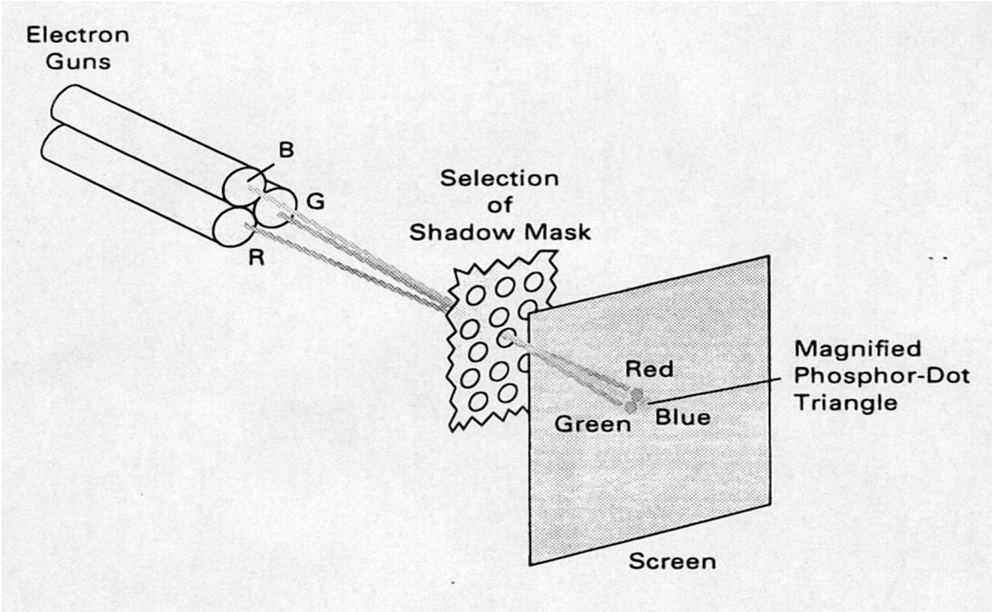

Figure 6 Shadow Mask Technique

2.6 Flat panel

The term **flat–panel displays** refers to a class of video devices that have reduced volume, weight, and power requirements compared to a CRT. A significant feature of flat-panel displayed is that they are thinner than CRTs, and we can hang them on walls or wear them on our wrists.

We can separate flat-panel displays into two categories: **emissive displays** and **non-emissive displays**. The emissive displays (or **emitters**) are devices that displays and light-emitting diodes are examples of emissive displays. Non-emissive displays (or **non-emitters**) use optical effects to convert sunlight or light from some other source into graphics patterns. The most important example of a non-emissive flat-panel display is a liquid- crystal device.

Plasma panels, also called **gas discharge displays**, are constructed by filling the region between two glass plates with a mixture of gases that usually include neon. A series of vertical conducting ribbons is placed on one glass panel, and a set of horizontal ribbons is built into the other glass panel. Firing voltages applied to a pair of horizontal and vertical conductors cause the gas at the intersection of two conductors to break down into glowing plasma of electrons and ions. Picture definition is stored in a refresh buffer, and the firing voltages are applied to refresh the pixel positions (at the intersections of the conductors) 60 times per second.

Another type of emissive device is the **light-emitting diode (LED)**. A matrix of diodes is arranged to form the pixel positions in the display, and picture definition is stored in refresh buffer. As in scan- line refreshing of a CRT, information is read from the refresh buffer and converted to voltage levels that are applied to the diodes to produce the light patterns in the display.

2.7 Liquid- crystal displays

Liquid- crystal displays (LCDs) are commonly used in systems, such as calculators (Figure 7) and portable, laptop computers. These non-emissive devices 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.

The term liquid crystal refers to the fact that these compounds have a crystalline arrangement of molecules, yet they flow like a liquid. Flat-panel displays commonly use nematic (threadlike) liquid-crystal compounds that tend to keep the long axes of the rod-shaped molecules aligned. A flat-panel display can then be constructed with a nematic liquid crystal, as demonstrated in fig. below. Two glass plates, each containing a light polarizer at right angles to the other palate, sandwich the liquid-crystal material. Rows of horizontal transparent conductors are built into one glass plate, and columns of vertical conductors are put into the other plate. The intersection of two conductors defines a pixel position. Normally, the molecules are aligned as shown in the "on state" of Figure 8. Polarized light passing through the material is twisted so that it will pass through the opposite polarizer. The light is reflected back to the viewer. To turn off the pixel, we apply 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 a **passive matrix** LCD. Picture definition is stored in a refresh buffer, and the screen is refreshed at the rate of 60 frames per second, as in the emissive devices. Back lighting is also commonly applied using solid-state electronic devices, so that the system is not completely dependent on outside light sources. Colors can be displayed by using different materials or dyes and 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, using thin-film transistor technology.

The transistors are used to control the voltage at pixel locations and to prevent charge from gradually leaking out of the liquid-crystal cells. These devices are called **active-matrix** displays

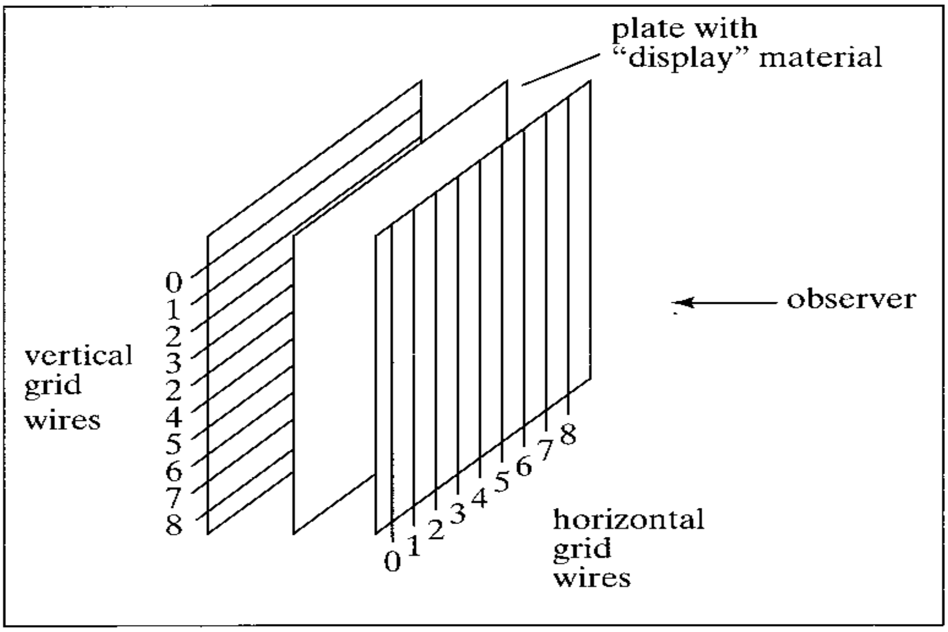

Figure 7 Flat panel Display