- Types of Graphic Devices – Interactive Graphic inputs – Raster Scan and Random Scan Displays.

- Phosphorous electrons get excited when electron beams fall on them
- Drops 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 electron 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 phosphors 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 phosphors have a persistence greater than 1 second, graphics monitors are usually constructed with a persistence in the range from 10 to 60 microseconds.

- **Resolution**
  - **The maximum number of points that can be displayed without overlap on a CRT is referred to as the resolution.**
  - The number of points per centimeter that can be plotted horizontally and vertically
  - Simply stated as the total number of points in each direction.

- Thus, resolution of a CRT is dependent on the type of phosphor, the intensity to be displayed, and the focusing and deflection systems.
- Typical resolution on high-quality systems is **1280 by 1024, with higher resolutions available on many systems.**
- **High resolution** systems are often referred to as ***high-definition systems***.
- ***The physical*** size of a graphics monitor is given as the length of the screen diagonal, with sizes varying from about **12 inches to 27 inches or more.**

- Another property of video monitors is **aspect ratio.**
  - The **ratio of vertical points to horizontal points necessary to produce equal-length lines in both directions on the screen**

- An aspect ratio of 3/4 means that a vertical line plotted with three points has the same length as a horizontal line plotted with four points.

Raster-Scan Displays

- The most common type of graphics monitor
- Based on television technology
- 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 a 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. **2-7).**
- Each screen point is referred to as a pixel or pel (shortened forms of picture element).
- The capability of a raster-scan system to store intensity information for each screen point makes it well suited for the realistic display of scenes containing subtle shading and color patterns.
- Home television sets and printers are examples of other systems using raster-scan methods.

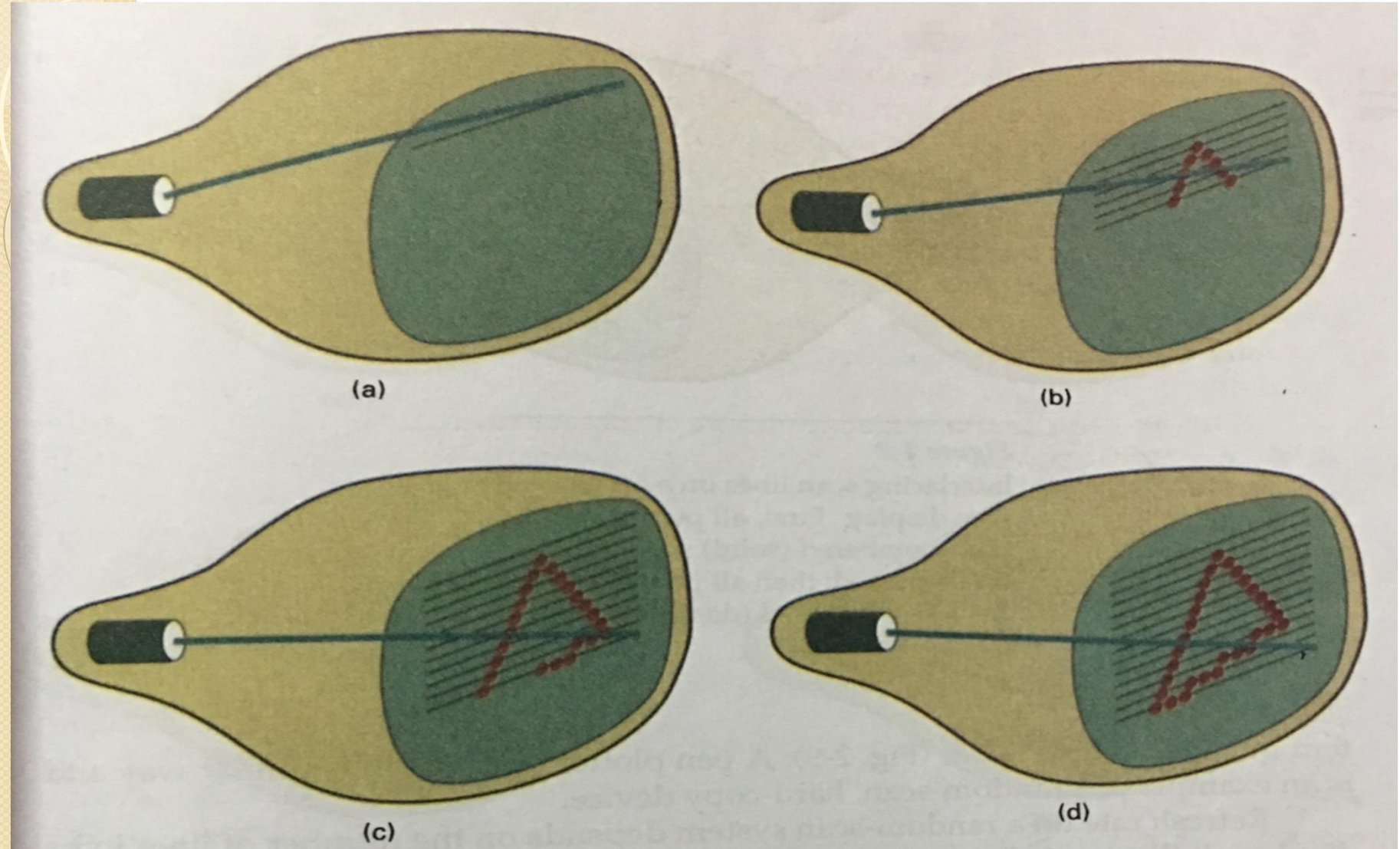

Figure 2-7
A raster-scan system displays an object as a set of discrete points across each scan line.

- The intensity range for pixel positions depends on the capability of the raster system.
- In a simple black-and-white system, each screen point is either on or off, so only one bit per pixel is needed to control the intensity of screen positions.
- For a bi-level system, a bit value of 1 indicates that the electron beam is to be turned on at that position, and a value of **0 indicates that the beam intensity is to be off.**
- Additional bits are needed when color and intensity variations can be displayed.
- Up to **24 bits per pixel are included in high-quality systems, which can require** several megabytes of storage for the frame buffer, depending on the resolution of the system.

- 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. 2-8).

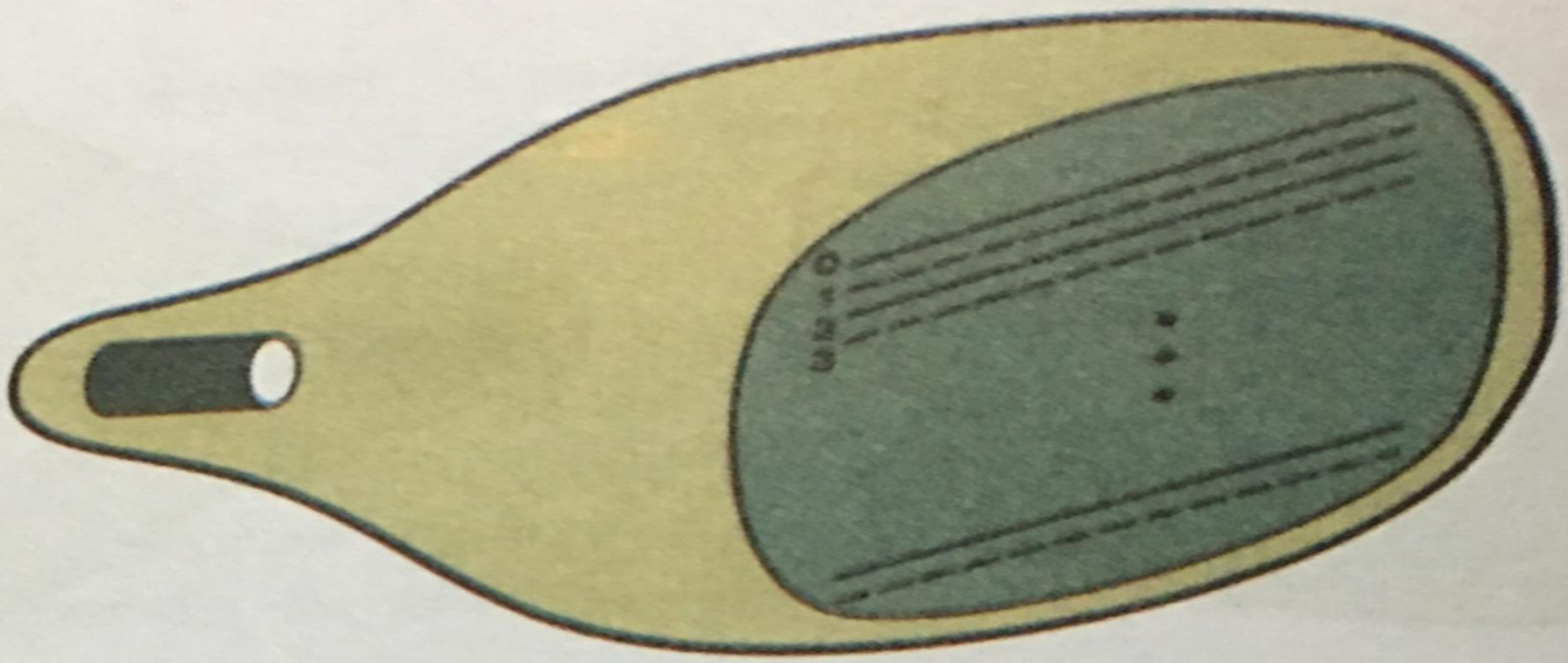

Figure 2-8

Interlacing scan lines on a raster-scan display. First, all points on the even-numbered (solid) scan lines are displayed; then all points along the odd-numbered (dashed) lines are displayed.

Random-Scan Displays

- When operated as a random-scan display unit, a CRT has the electron beam directed only to the parts of the screen where a picture is to be drawn.
- Random scan monitors draw a picture one line at a time 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 and refreshed by a random-scan system in any specified order (Fig. ***2-9)***.
- A pen plotter operates in a similar way and is an example of a random-scan, hard-copy device.

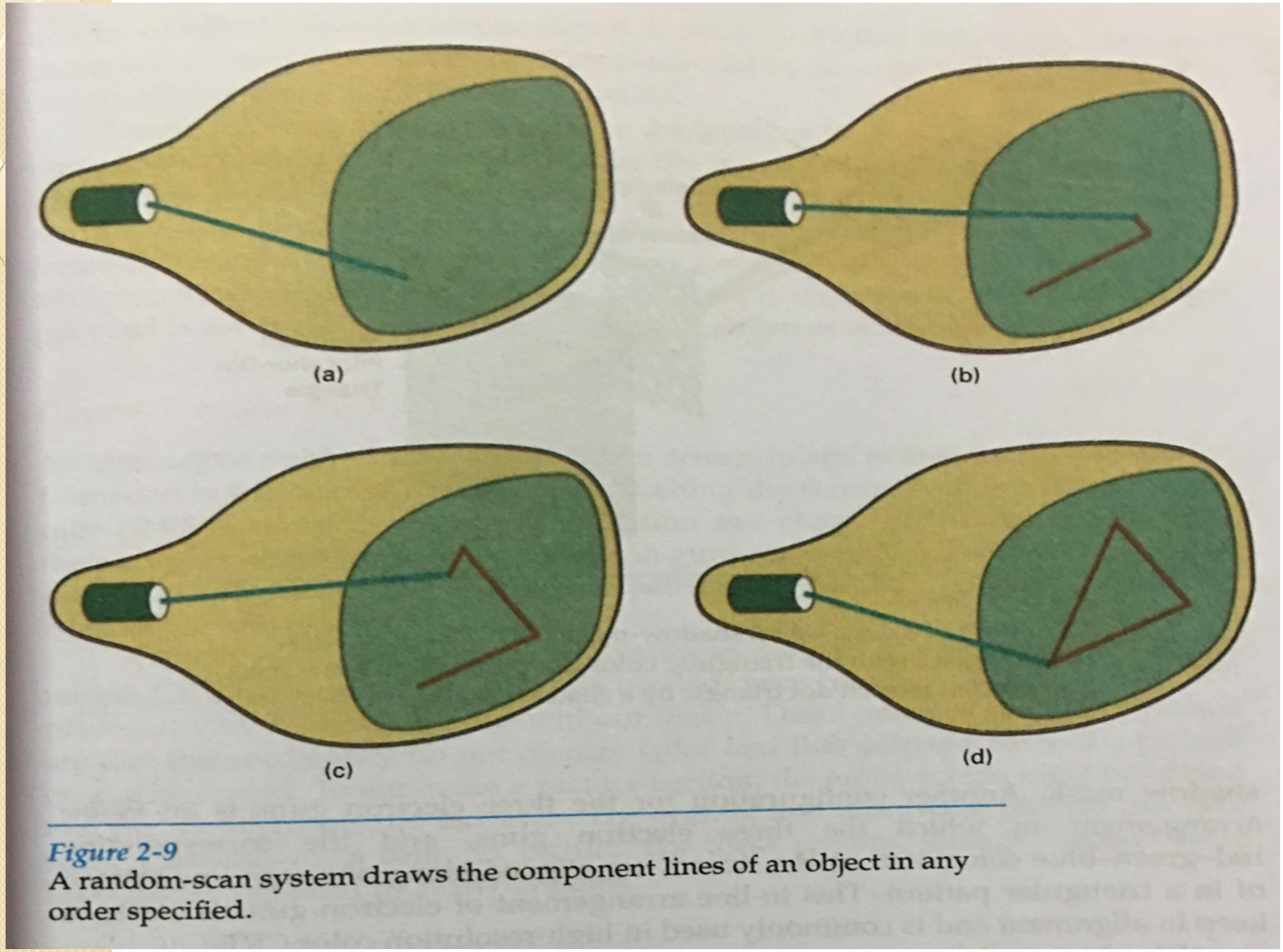

Figure 2-9
A random-scan system draws the component lines of an object in any order specified.

- 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 systems are designed for line drawing applications and cannot display realistic shaded scenes.
- Since picture definition is stored as a set of line drawing instructions and not as a set of intensity values for all screen points, vector displays generally have higher resolution than raster systems.
- Also, vector displays produce smooth line drawings because the CRT beam directly follows the line path.
- A raster system, in contrast, produces jagged lines that are plotted as the point sets.

Raster Scan Vs Random Scan

PROPERTY	RANDOM SCAN	RASTER SCAN
RESOLUTION	Higher	Lesser
Cost	High	Lesser
Ease of Alteration	Easy	Not so easy
Interweaving	Not used	Used
Picture definition	Stored as combination of Intensity values	Stored as a group of line drawing instructions
Method used	Mathematical functions	Used pixels
Applications	Polygon drawings	Realistic scenes

Color CRT Monitors

- 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 color displays with a CRT are the beam-penetration method and the shadow-mask method.

- The beam-penetration method for displaying color pictures has been used with random-scan monitors.
- Two layers of phosphor, usually red and green, are how far the electron beam penetrates into the phosphor layers.
- A beam of slow electrons excites only the outer red layer.
- A beam of very fast electrons penetrates through the red layer and excites the inner green layer.
- At intermediate beam speeds, combinations of red and green light are emitted to show two additional colors, orange and yellow.

- The speed of the electrons, and hence the screen color at any point, is controlled by the beam-acceleration voltage.
- Beam penetration has been an inexpensive way to produce color in random-scan monitors, but only four colors are possible, and the quality of pictures is not as good as with other methods.

- Shadow-mask methods are commonly used in raster scan systems (including color TV) because they produce a much wider range of colors 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 2-10 illustrates the delta-delta shadow-mask method, commonly used in color CRT systems.
- The three electron beams 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 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

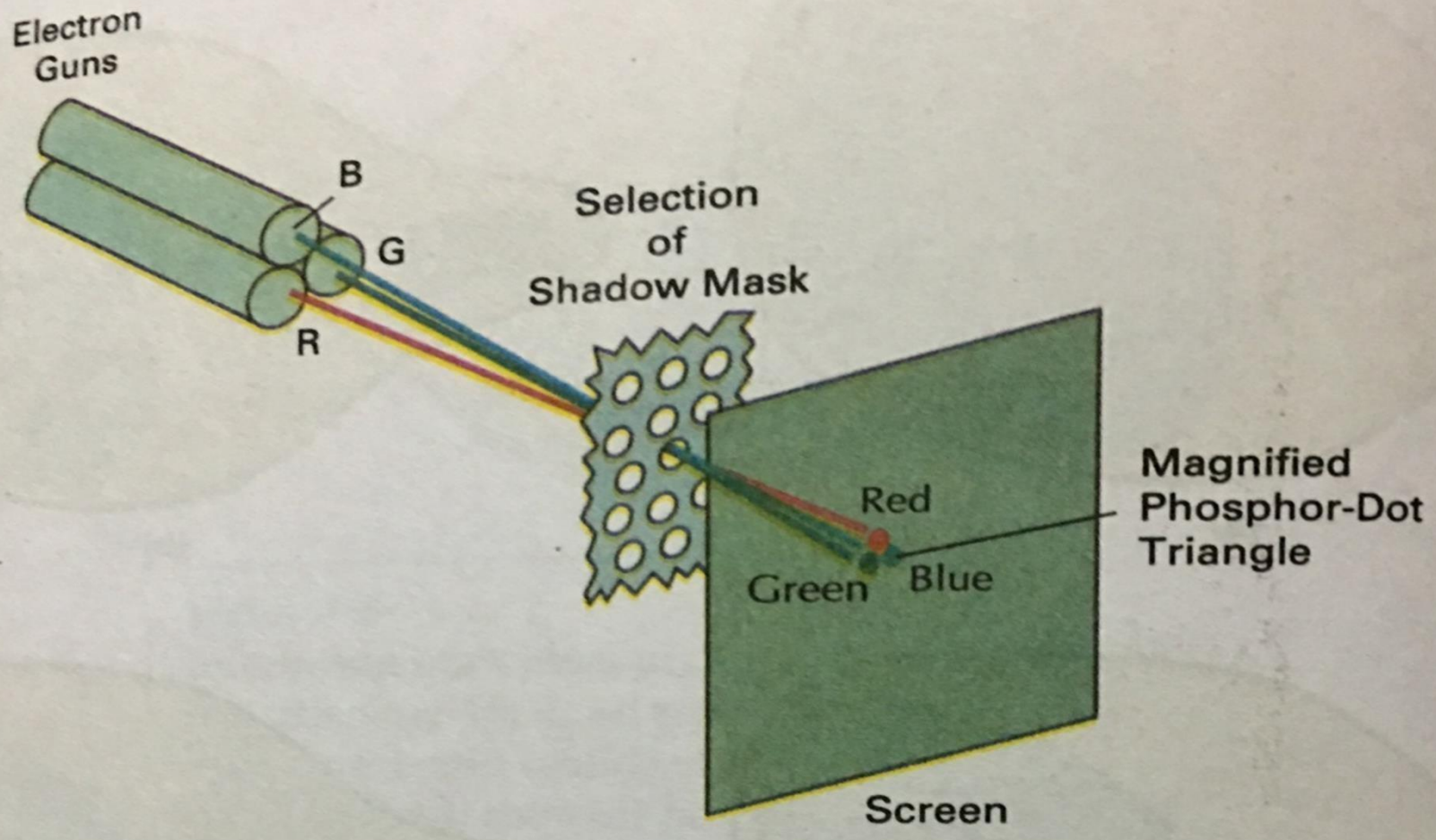

Figure 2-10
Operation of a delta-delta, shadow-mask CRT. Three electron guns, aligned with the triangular color-dot patterns on the screen, are directed to each dot triangle by a shadow mask.

Direct-View Storage Tubes

- An alternative method for maintaining a screen image is to store the picture information inside the CRT instead of refreshing the screen.
- A direct-view storage tube (DVST) stores the picture information as a charge distribution just behind the phosphor-coated screen.
- Two electron guns are used in a DVST.
- One, the primary gun, is used to store the picture pattern; the second, the flood gun, maintains the picture display.

- A DVST monitor has both disadvantages and advantages compared to the refresh CRT.
- Because no refreshing is needed, very complex pictures can be displayed at very high without flicker. resolutions
- Disadvantages of DVST systems are that they ordinarily do not display color and that selected parts of a picture cannot be erased.
- To eliminate a picture section, the entire screen must be erased and the modified picture redrawn.
- The erasing and redrawing process can take several seconds for a complex picture.
- For these reasons, storage displays have been largely replaced by raster systems.

Flat-Panel Displays

- Flat-panel display 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 displays is that they are thinner than CRTs, and we can hang them on walls or wear them on our wrists.
- Current uses for flat-panel displays include small TV monitors, calculators, pocket video games, laptop computers, armrest viewing of movies on airlines, as advertisement boards in elevators, and as graphics displays in applications requiring rugged, portable monitors

- We can separate flat-panel displays into two categories: emissive displays and non-emissive displays.
- The emissive displays (or emitters) are devices that convert electrical energy into light.
- Plasma panels, thin-film electroluminescent displays, and Light-emitting diodes are examples of emissive displays.
- Flat CRTs have also been devised, in which electron beams arts accelerated parallel to the screen, then deflected 90' to the screen.
- But flat CRTs have not proved to be as successful as other emissive devices.

- 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 includes neon

- **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 a 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

Input devices

- Keyboards
- Mouse
- Track ball and Space ball
- Joysticks
- Data Glove
- Digitizers
- Image Scanners
- Touch Panels
- Light Pens
- Voice Systems