Overview of Graphics Systems

Agenda

- Video display devices
- Raster-scan systems
- Graphics workstations and viewing systems
- Input devices

Learning Objectives

- Understand which are the important display devices and input devices.
- Understand how the important output devices for computer graphics work.
- Understand how the important input devices for computer graphics work.

Video Display Devices

- Cathode-ray tubes
- Raster-scan displays
- Random-scan displays
- Color CRT displays

Cathode-Ray Tubes

- Classical output device is a monitor.
- Cathode-Ray Tube (CRT)
  - Invented by Karl Ferdinand Braun (1897)
  - Beam of electrons directed from cathode (-)to phosphor-coated (fluorescent) screen (anode (+))
  - Directed by magnetic focusing and deflection coils (anodes) in vacuum filled tube
  - Phosphor emits photon of light, when hit by an electron, of varied persistence (long 15-20 ms for texts / short < 1ms for animation)
  - Refresh rate (50-60 Hz / 72-76 Hz) to avoid flicker / trail
  - Phosphors are organic compounds characterized by their persistence and their color (blue, red, green).

Cathode-Ray Tubes

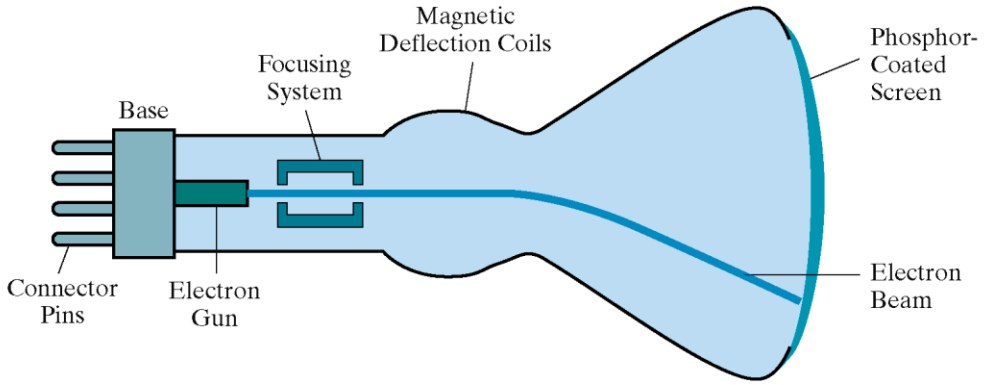


Figure 2-2

Basic design of a magnetic-deflection CRT.

(from Donald Hearn and Pauline Baker)

Cathode-Ray Tubes

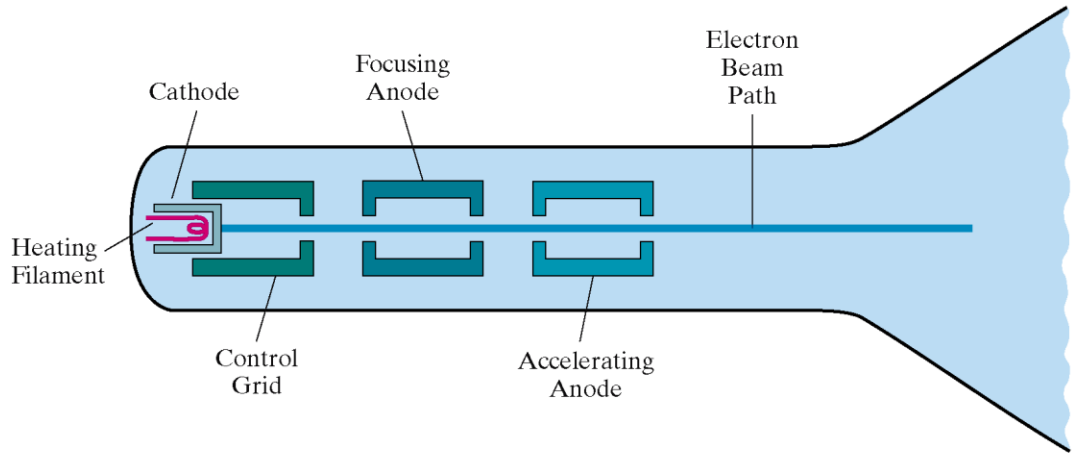


Figure 2-3

Operation of an electron gun with an accelerating anode.

(from Donald Hearn and Pauline Baker)

Cathode-Ray Tubes

- Cathode-Ray Tube (CRT)
  - Horizontal deflection and vertical deflection direct the electron beam to any point on the screen
  - Intensity knob: regulates the flow of electrons by controlling the voltage at the control grid (high voltage reduces the electron density and thus brightness)
  - Accelerating voltage from positive coating inside screen (anode screen) or an accelerating anode
- Image maintenance
  - Charge distribution to store picture information OR
  - Refresh CRT: refreshes the display constantly to maintain phosphor glow.

Cathode-Ray Tubes

- Characteristics of Cathode-Ray Tube (CRT)
  - ***Intensity*** is proportional to the number of electrons repelled in beam per second (***brightness***)
  - ***Resolution*** is the maximum number of points that can be displayed without overlap; is expressed as number of horizontal points by number of vertical points; points are called pixels (picture elements); example: resolution 1024 x 768 pixels. Typical resolution is 1280 x 1024 pixels.
- High-definition systems: high resolution systems.

Cathode-Ray Tubes

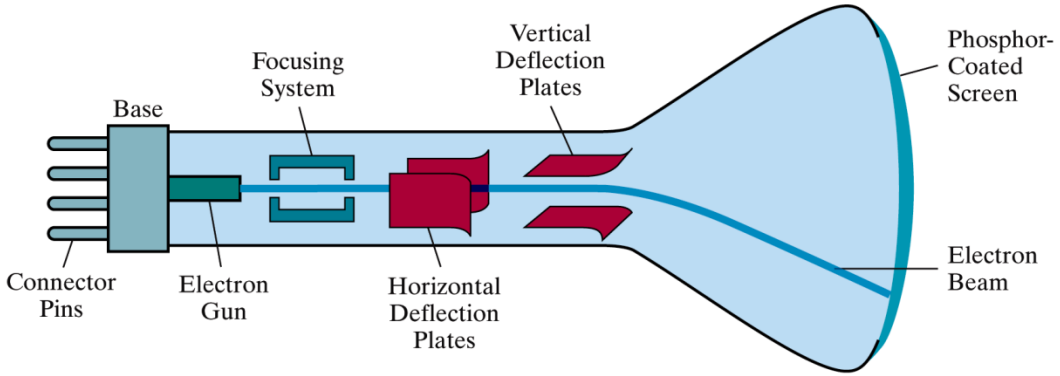


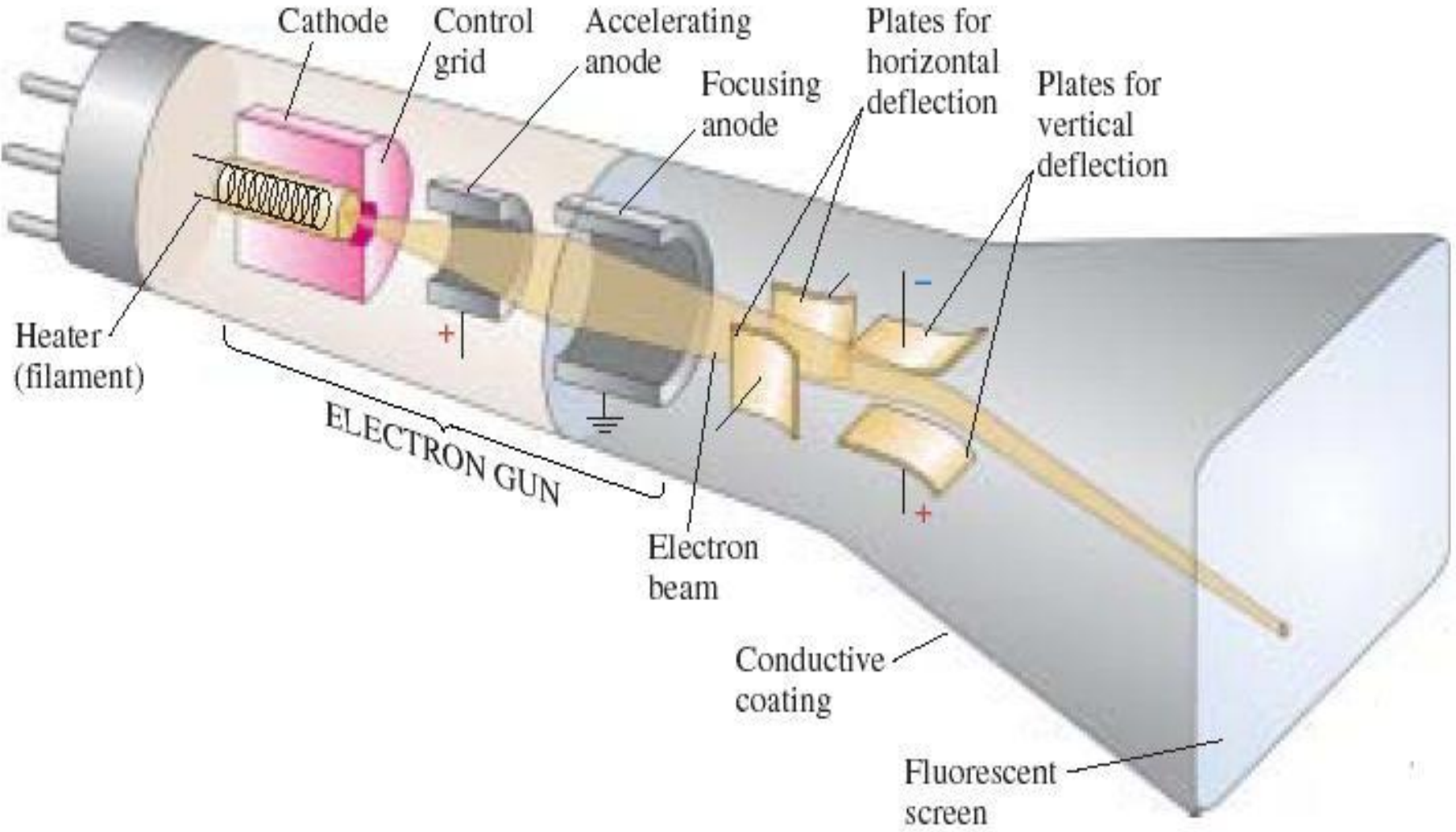
Figure 2-4

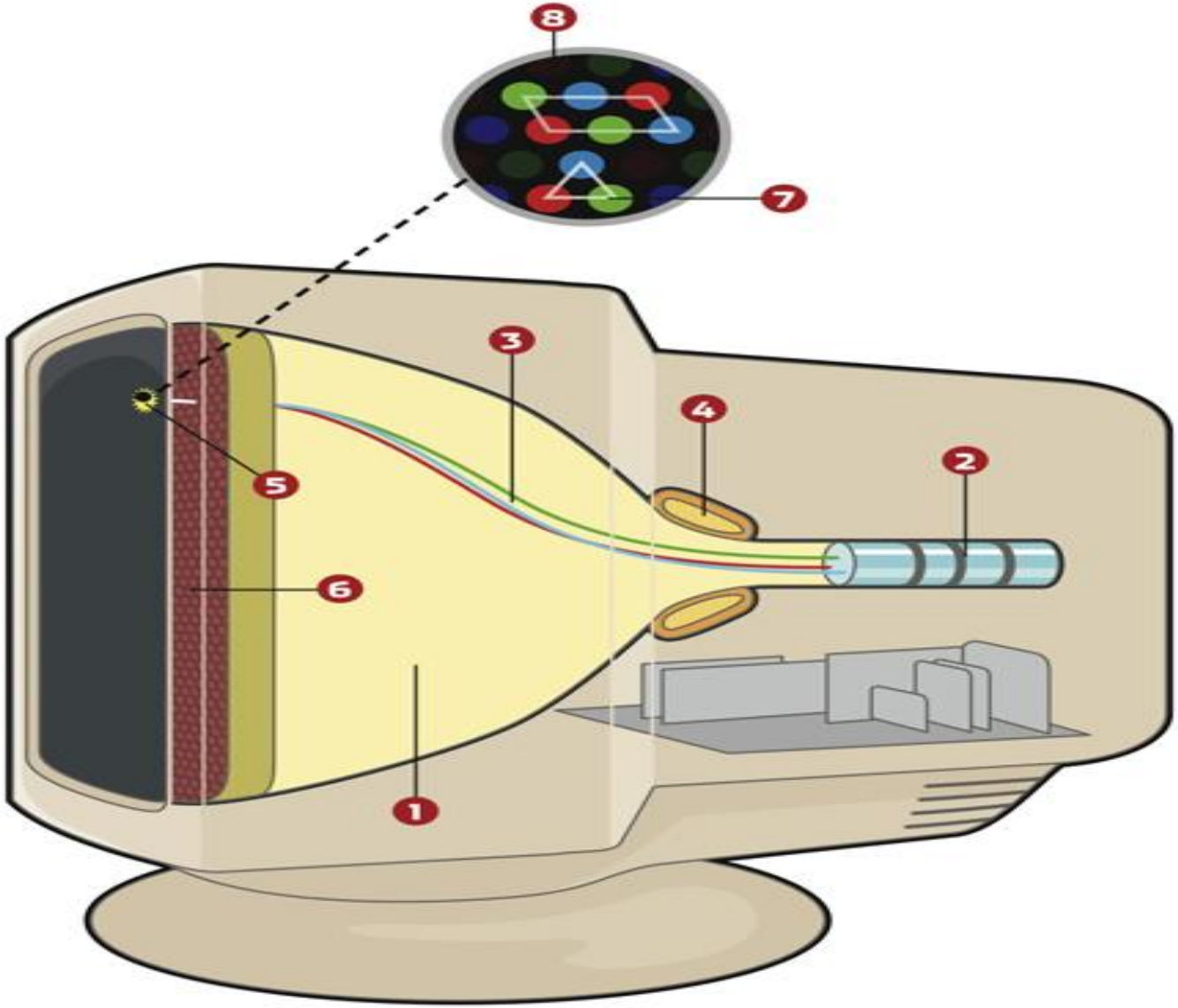
Electrostatic deflection of the electron beam in a CRT.

(from Donald Hearn and Pauline Baker)

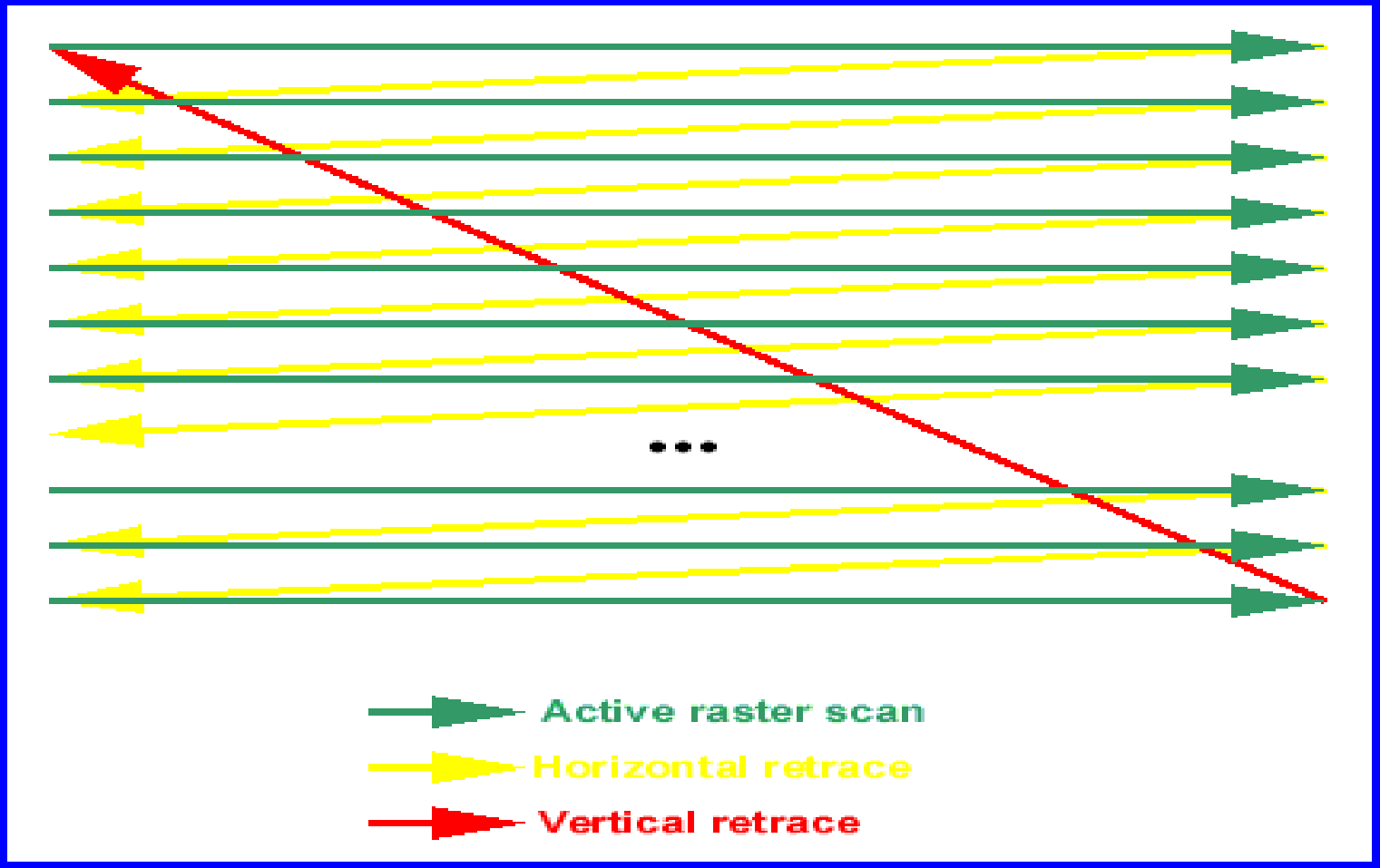
Cathode-Ray Tubes

- Focusing
  - ***Focusing*** forces the electron beam to converge to a point on the monitor screen
  - Can be electrostatic (lens) or magnetic (field)
- Deflection
  - ***Deflection*** directs the electron beam horizontally and/or vertically to any point on the screen
  - Can be controlled by electric (deflection plates) or magnetic fields (deflection coils)
  - Magnetic coils: two pairs (top/bottom, left/right) of tube neck
  - Electric plates: two pairs (horizontal, vertical)


Cathode
Control grid
Accelerating anode
Focusing anode
Plates for horizontal deflection
Plates for vertical deflection
Heater (filament)
ELECTRON GUN
Electron beam
Conductive coating
Fluorescent screen
+
−
+


8
7
3
4
2
5
6
1

Raster-scan Displays



Raster-scan Displays

- The image is stored in a ***frame buffer*** containing the total screen area and where each memory location corresponds to a pixel.
- In a monochrome system, each bit is 1 or 0 for the corresponding pixel to be on or off (bitmap).
- The display processor scans the frame buffer to turn electron beam on/off depending if the bit is 1 or 0.
- For color monitors, the frame buffer also contains the color of each pixel (color buffer) as well as other characteristics of the image (gray scale, …). 8 bits/pixel → 0..255 (pixmap).
- Depth of the buffer area is the number of bits per pixel (bit planes), up to 24.
- Examples: television panels, printers, PC monitors (99% of raster-scan)...

Raster-scan Displays

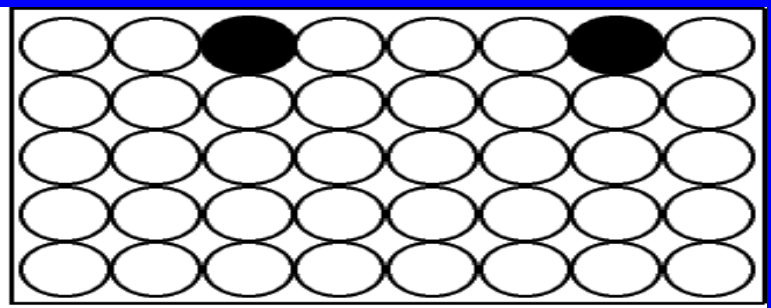
- Refresh rate: 24 is a minimum to avoid flicker, corresponding to 24 Hz (1 Hz = 1 refresh per second)
- Current raster-scan displays have a refresh rate of at least 60 frames (60 Hz) per second, up to 120 (120 Hz).
- Uses large memory: 640x480 → 307200 bits → 38 kB
- Refresh procedure:
  - Horizontal retrace – beam returns to left of screen
  - Vertical retrace – bean returns to top left corner of screen
  - Interlaced refresh – display first even-numbered lines, then odd-numbered lines
    permits to see the image in half the time
    useful for slow refresh rates (30 Hz shows as 60 Hz).

Move(2,0)
Line(4,4)
Move(-4,0)
Line(4,-4)

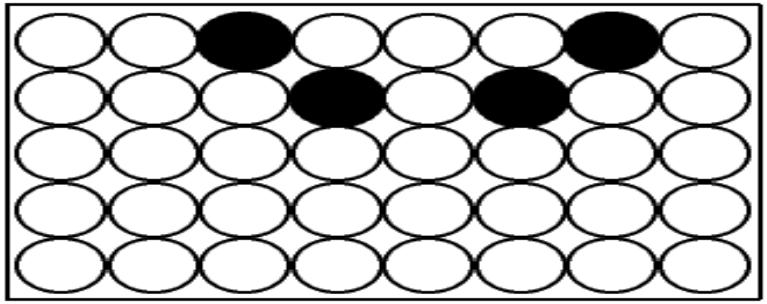
commands in display list

00100010
00010100
00001000
00010100
00100010

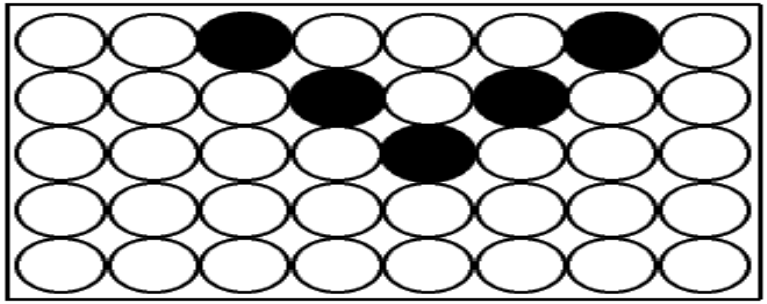
frame buffer



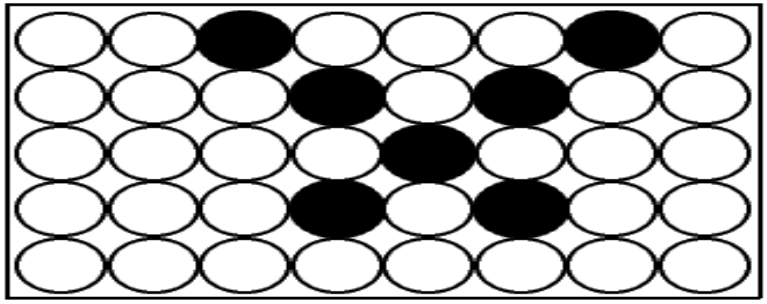
screen after 1 scan lines



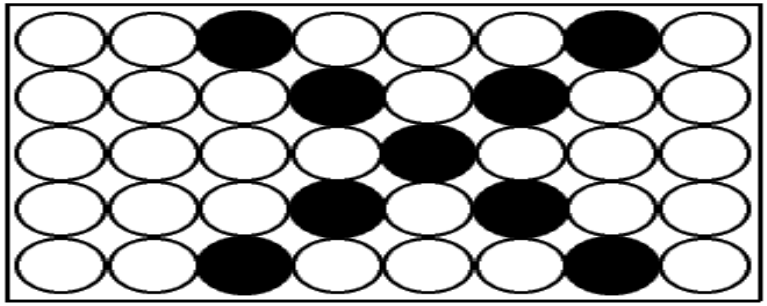
screen after 2 scan lines



screen after 3 scan lines

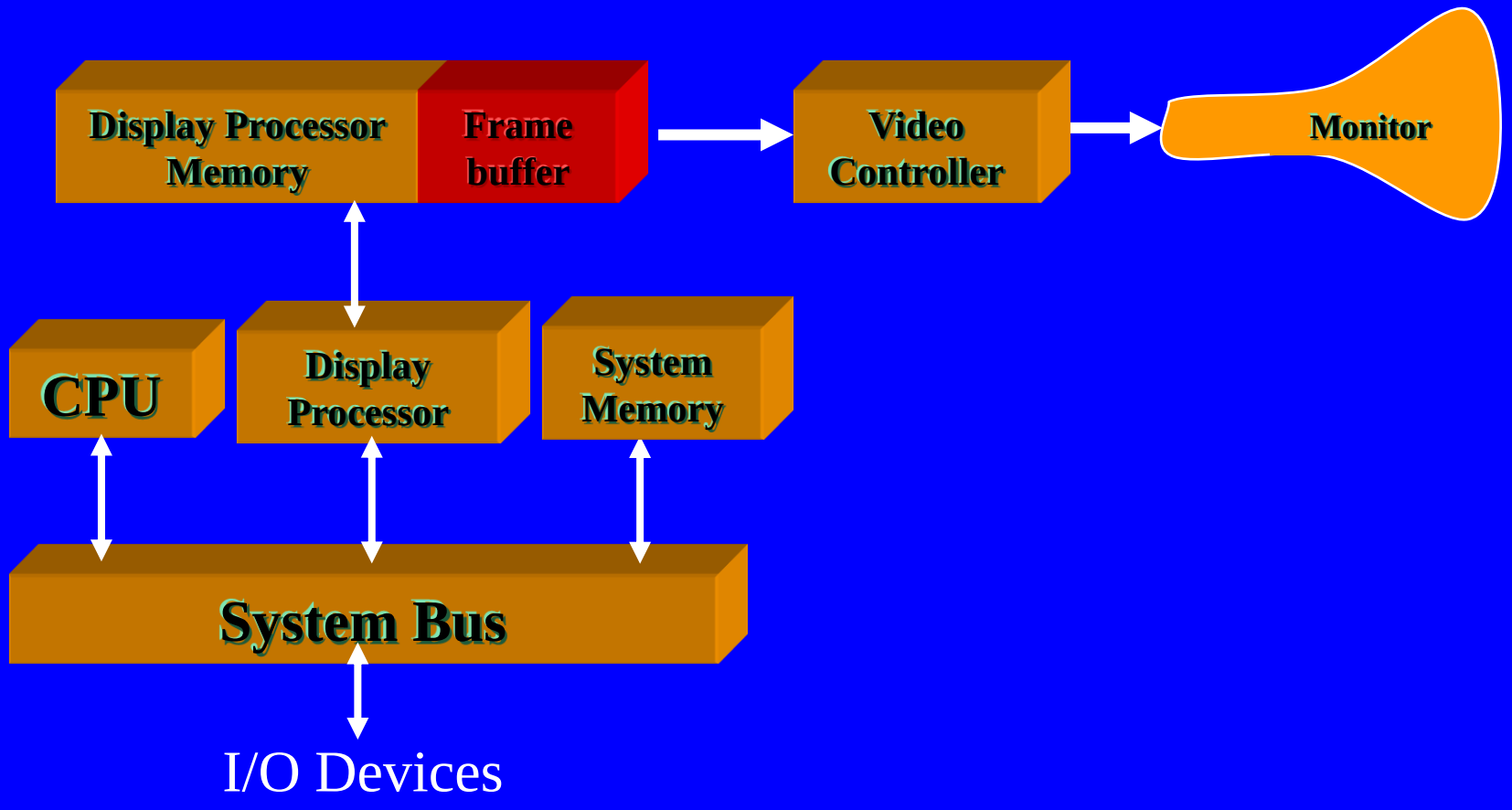


screen after 4 scan lines

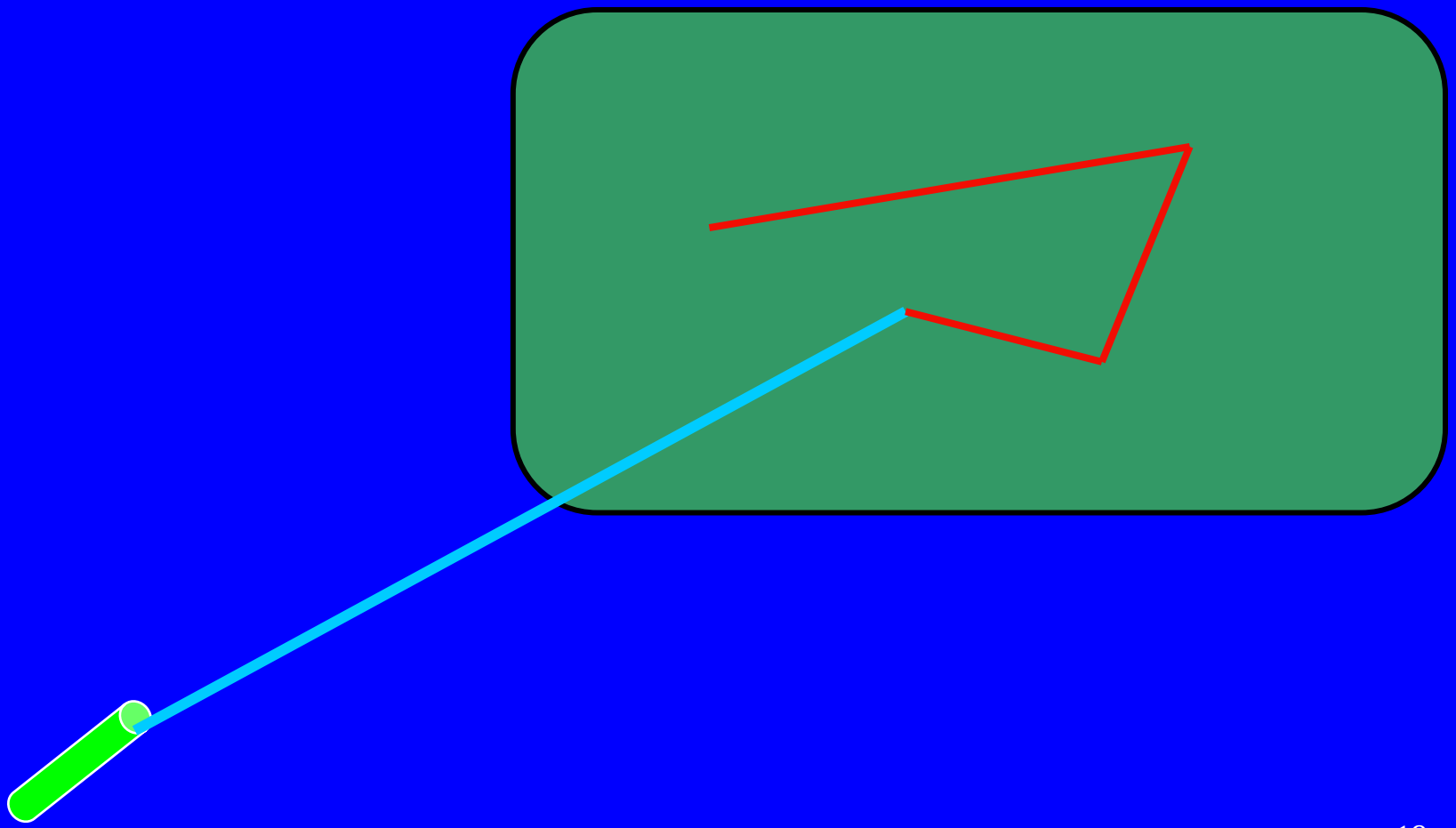


screen after 5 scan lines

Raster-scan Displays - Architecture



Random-scan Displays



Random-scan Displays

- Random scan systems are also called vector, stroke-writing, or calligraphic displays.
- The electron beam directly draws the picture in any specified order.
- A pen plotter is an example of such a system.
- Picture is stored in a display list, refresh display file, vector file, or display program as a set of line drawing commands.
- Refreshes by scanning the list 30 to 60 times per second.
- More suited for line-drawing applications such as architecture and manufacturing.

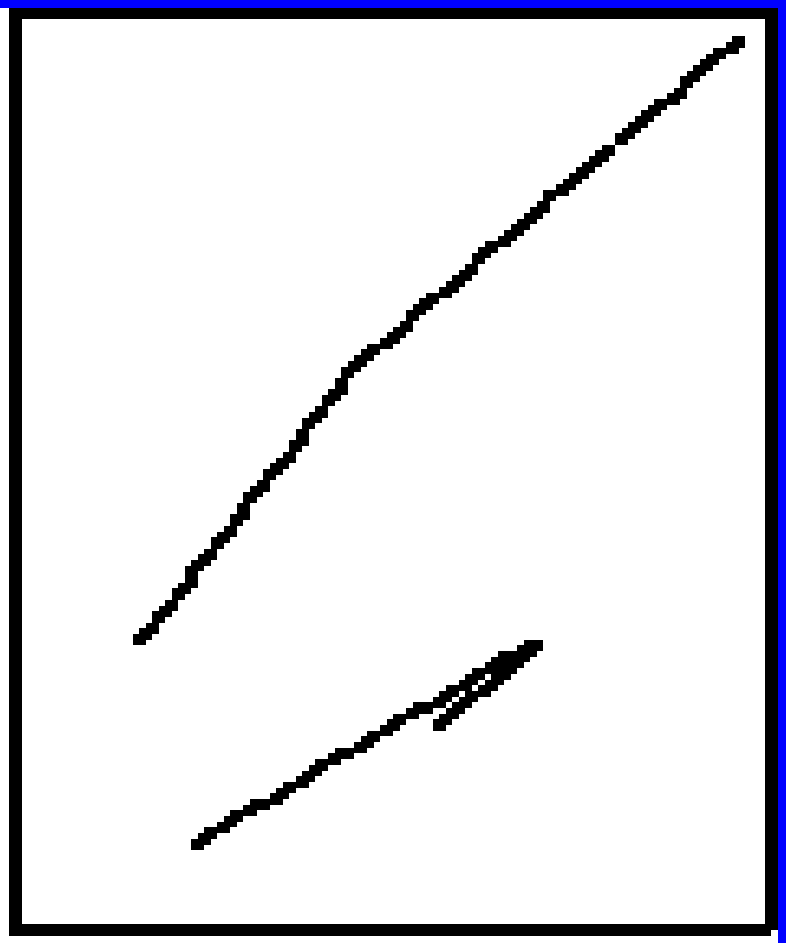
Random-scan Displays

- Advantages:
  - High resolution
  - Easy animation
  - Requires little memory
- Disadvantages:
  - Requires intelligent electron beam (processor controlled)
  - Limited screen density, limited to simple, line-based images
  - Limited color capability.
- Improved in the 1960's by the Direct View Storage Tube (DVST) from Tektronix.

Images are described in terms of line segments rather than pixels

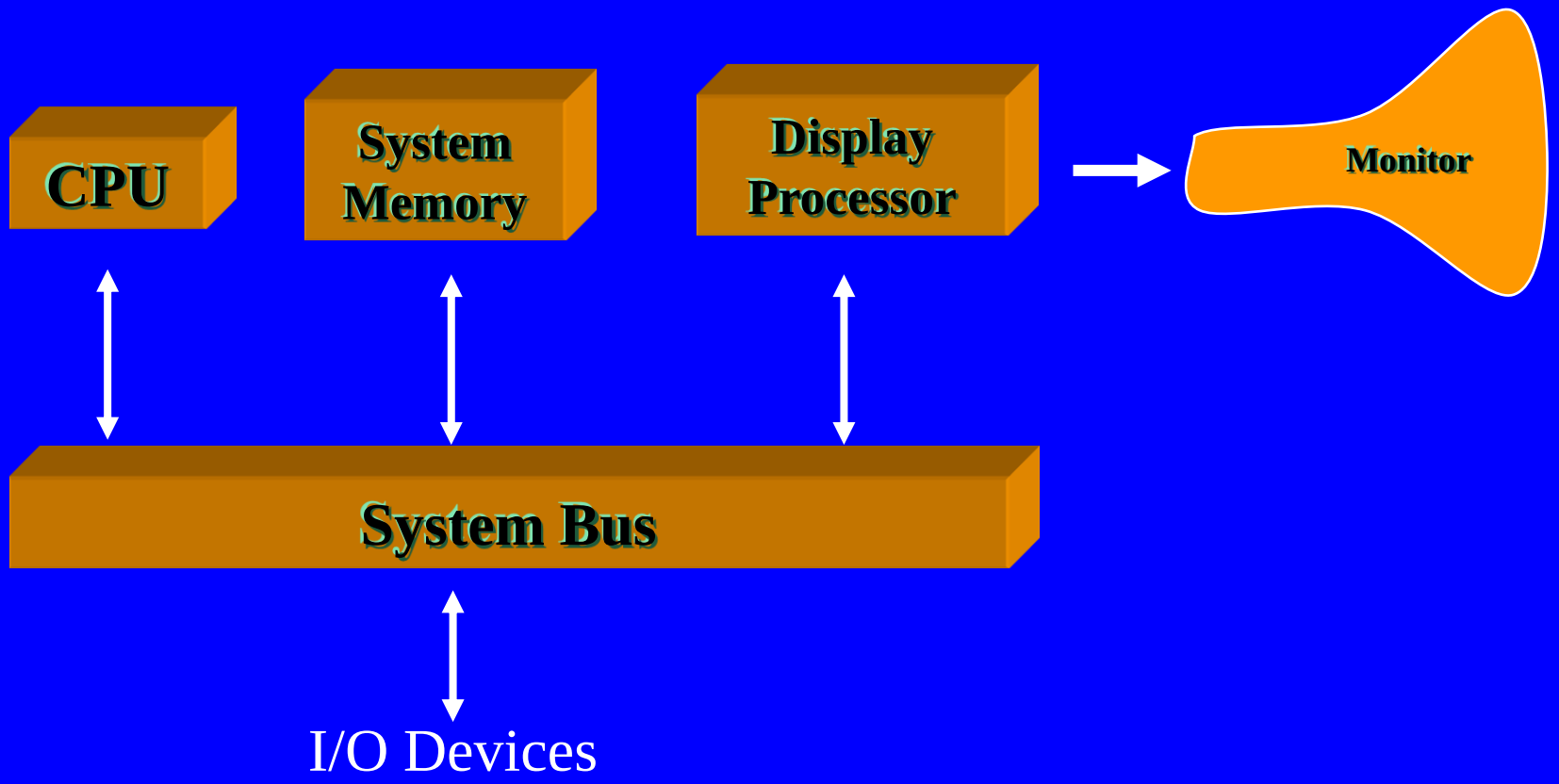
```
moveto(10,30)
lineto(30,60)
lineto(70,100)
moveto(40,20)
lineto(50,30)
lineto(15,7)
```

display file

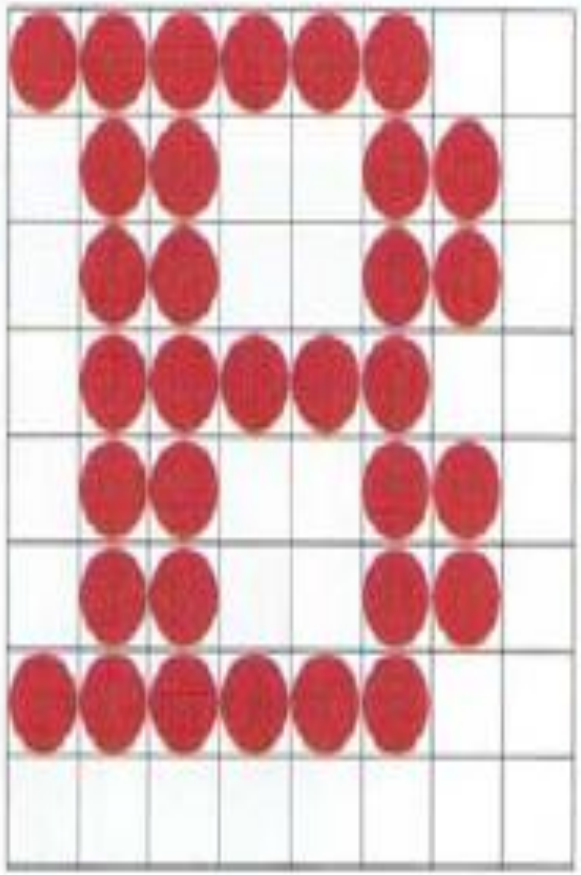


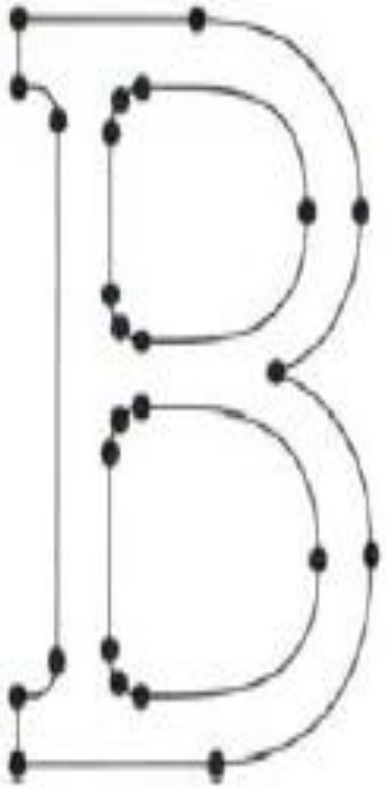
screen

Random-scan Displays - Architecture



Raster-scan vs. random-scan

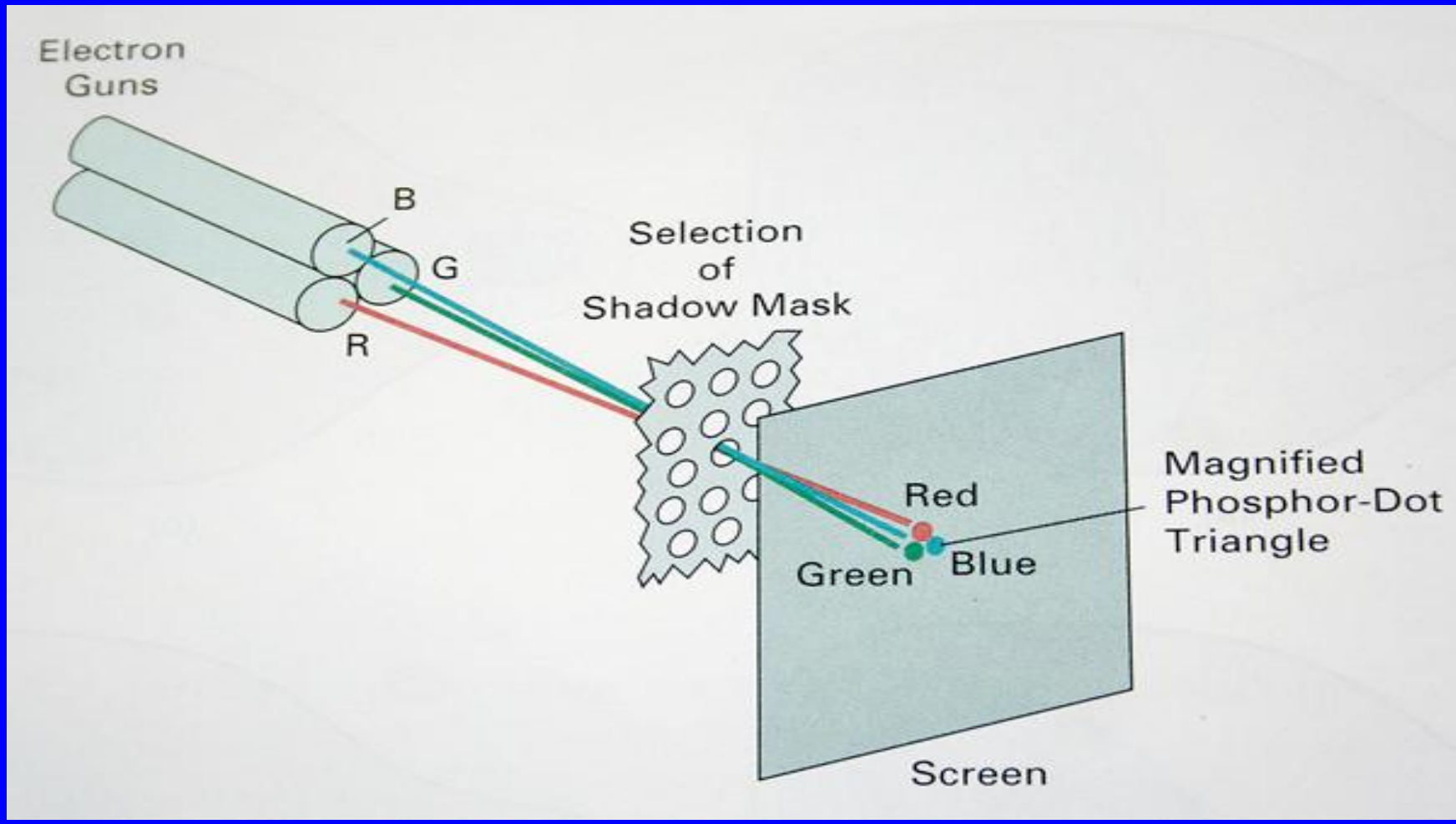




Color CRT Monitor

- Color CRT's are designed as RGB monitors also called full-color system or true-color system.
- Use shadow-mask methods with intensity from each electron gun (red, green, blue) to produce any color directly on the screen without preprocessing.
- Frame buffer contains 24 bits per pixel, for 256 voltage settings to adjust the intensity of each electron beam, thus producing a choice of up to 17 million colors for each pixel (256^3).

Color CRT Monitor



(from Donald Hearn and Pauline Baker)

Work Station

A **workstation** is a computer designed for technical or scientific applications. Intended primarily to be used by one person at a time, they are commonly connected to a local area network and run multi-user operating systems.

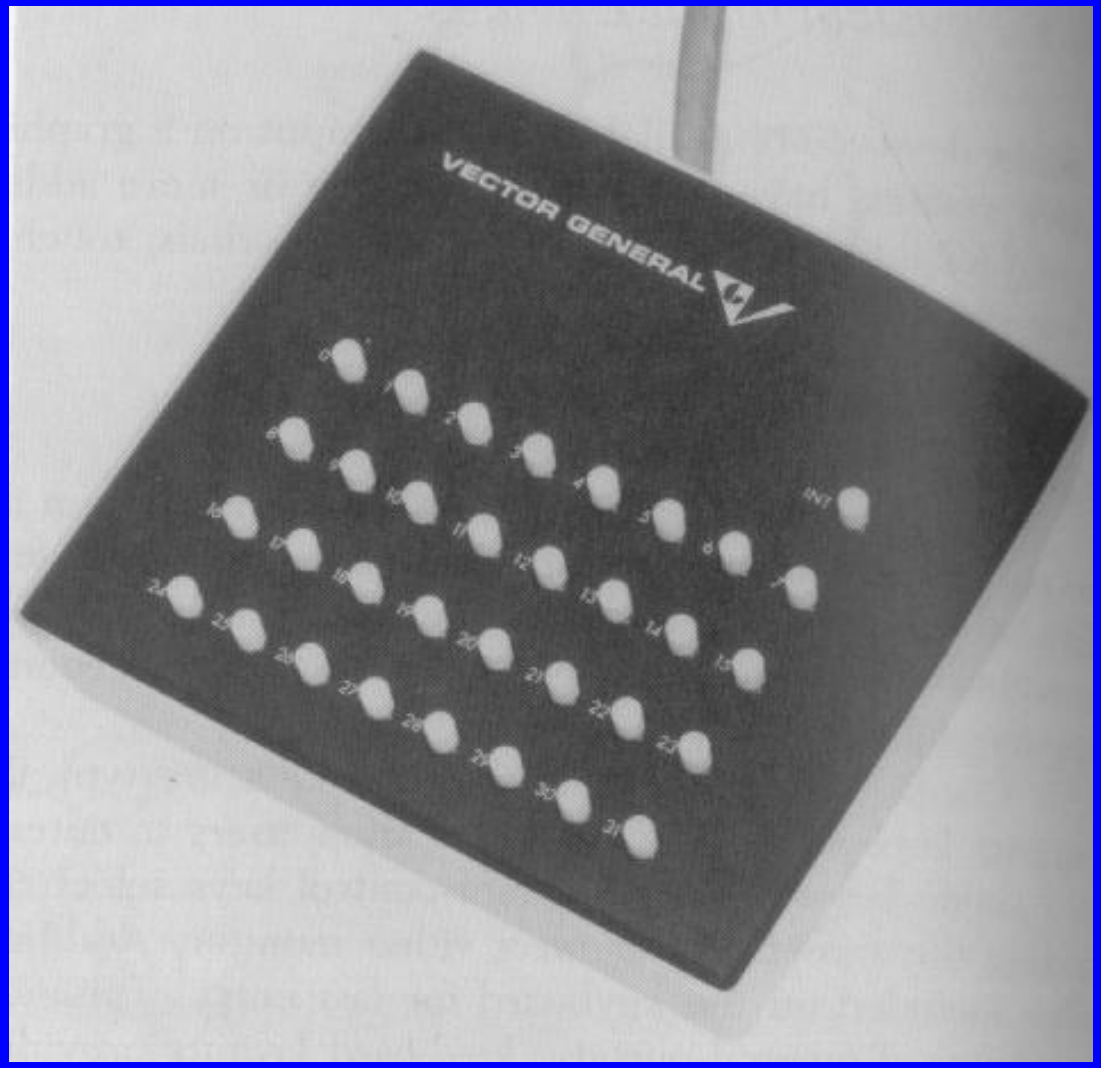
INPUT DEVICES

The key matrix

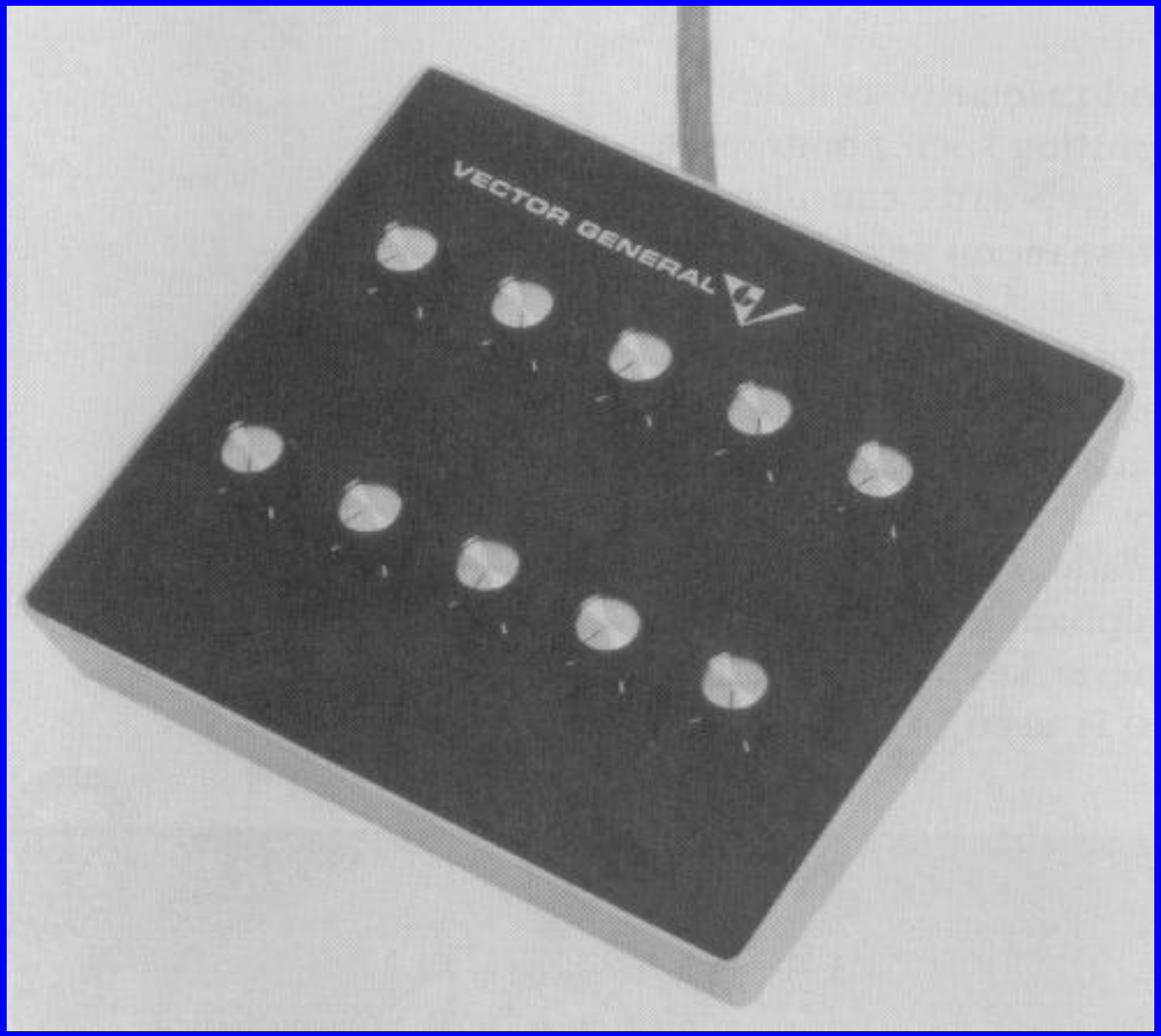
This keyboard uses rubber dome switches.

Optimus keyboard programmable hot keys

Buttons



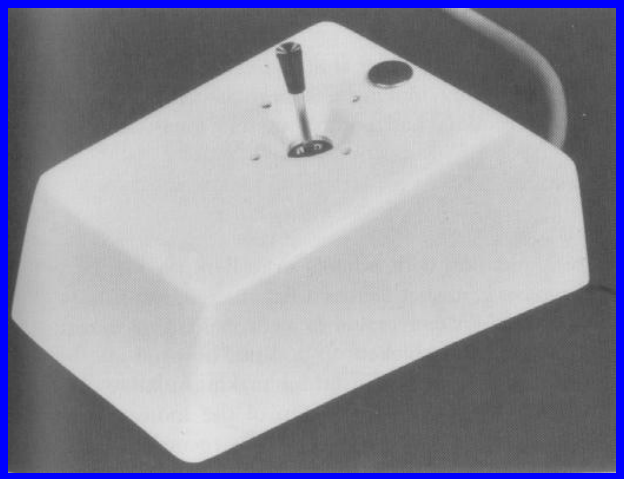
Dials

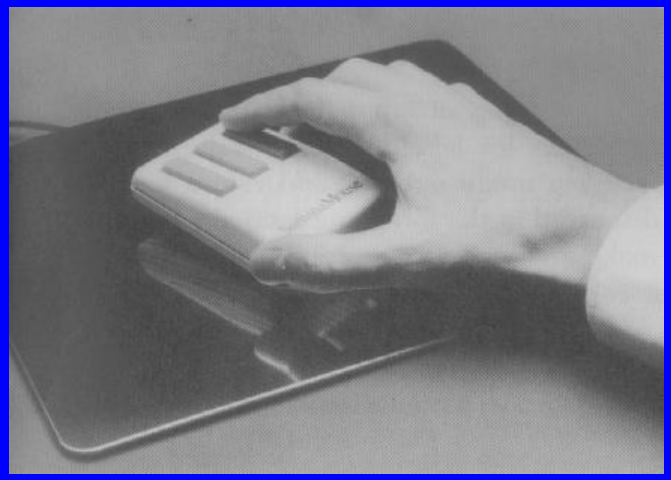


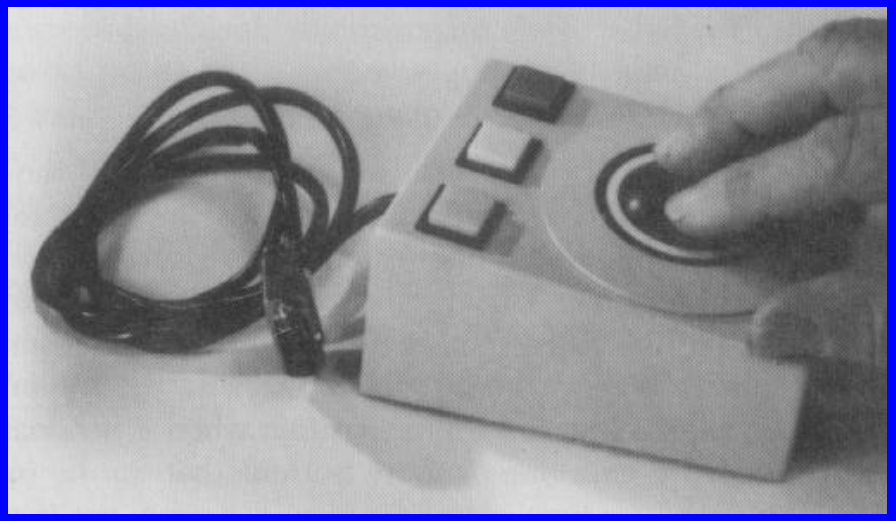
Trackball

Spaceball

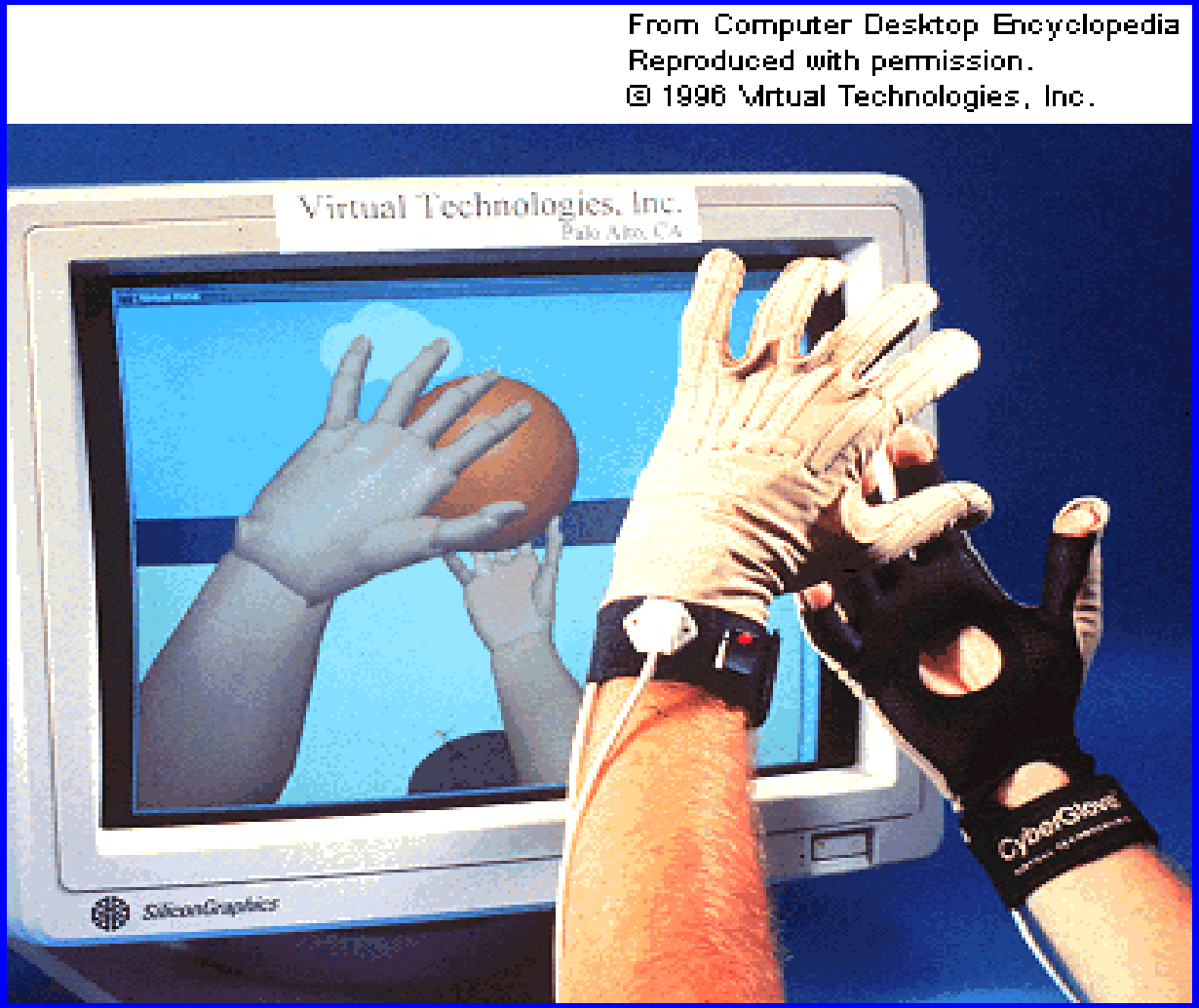
Joysticks / Mice / Trackballs







Data Glove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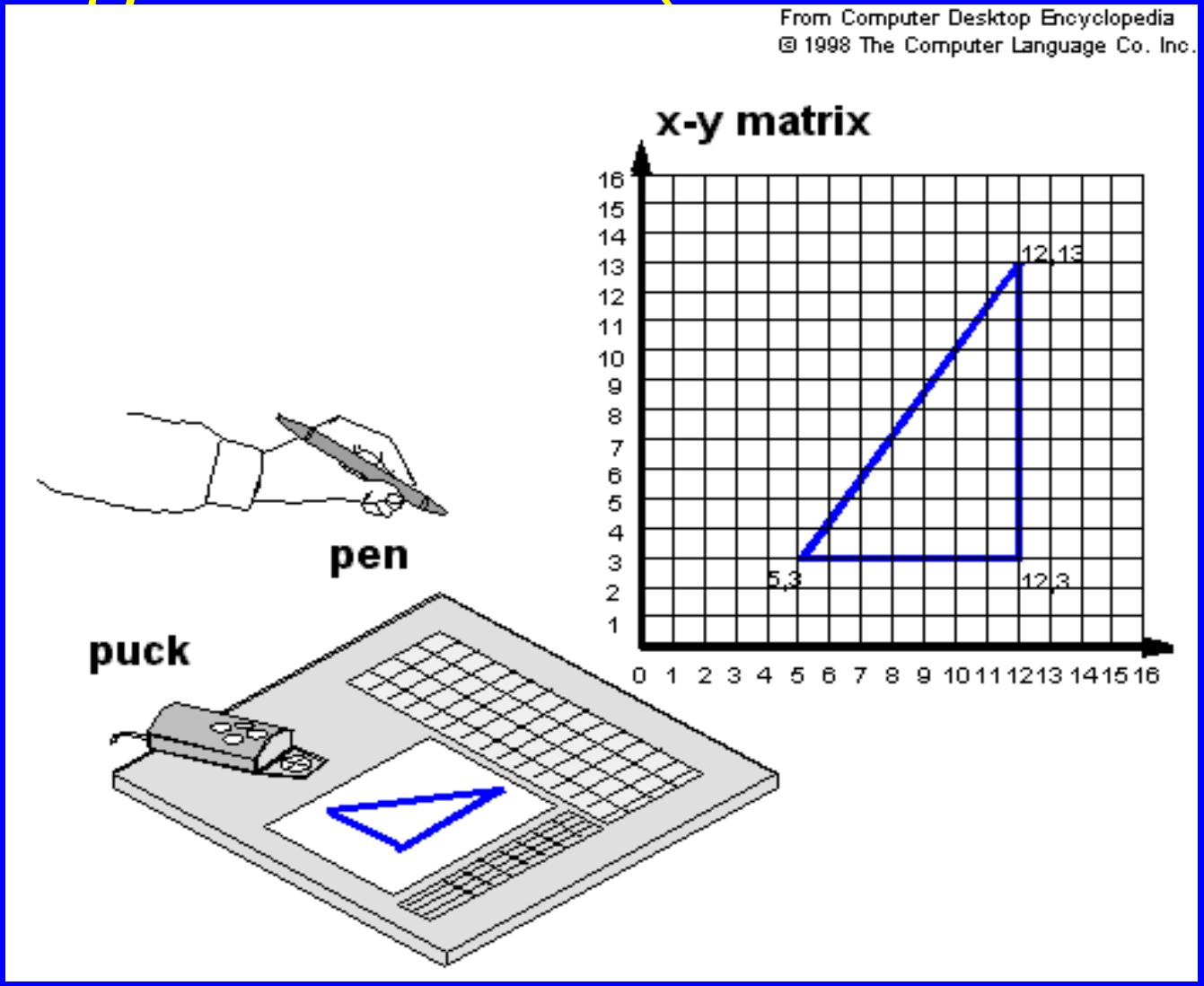
Digitizer Tablet(Data Tablet)



Digitizer used for drawing larger Images

Voice Systems