DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF TORONTO

CSC318S

# THE DESIGN OF INTERACTIVE COMPUTATIONAL MEDIA

Lecture 9 — 9 Feb. 1998

## INTERACTIVE SYSTEMS TECHNOLOGY



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## 9.1 Graphical output technology

Goal: Generation of a picture (image) on a display surface
- Surfaces are (almost always) two-dimensional
- Pictures may be two-dimensional, or representations of three-dimensional objects or scenes mapped to 2D

Three key issues:
- The medium
  - *Soft copy*: screen or
  - *Hard copy*: paper
- Method of generating the image
  - *Refreshed*: dynamic, continuously regenerating
  - *Stored*: Static, must be erased or must start afresh
- Method of tracing out the image
  - *Random scan*: “Connect the dots”
  - *Raster scan*: “Like a TV”

| **SCREEN** | **Refreshed** | **Storage** |
|---|---|---|
| **Random scan** | Vector displays | Direct view storage tube |
| **Raster scan** | Digital video display | Liquid crystal displays<br>Electroluminescent displays<br>Plasma panels |

Toy examples of random scan, storage (see 9.10)
- Etch a Sketch
- Skedoodle

Toy example of raster scan, storage
- Lights Alive

| **PAPER** | **Refreshed** | **Storage** |
|---|---|---|
| **Random scan** | ——— | Pen plotter |
| **Raster scan** | ——— | Laser printer<br>Ink jet plotter<br>Dot matrix printer |

## 9.2 CRT raster scan displays, frame buffers

Cathode ray tube (CRT) (Fig. 9.1)
- Deflects electron beam
- Beam strikes phosphor on face of tube
- Phosphor gives off light for brief period of time (*persistence*)
- Refresh rate and the problem of *flicker*
  - Typical for raster displays: 30 frames/second
  - *Interlaced* vs, non-interlaced display (Fig. 9.2)
  - *Fields* versus *frames:* 60 fields/second
- Shadow mask CRT for colour (Fig. 9.3)

*Figure 9.1 Cross section of a CRT (not to scale)*
*(Foley, van Dam, Feiner, Hughes, 1990, p. 155)*

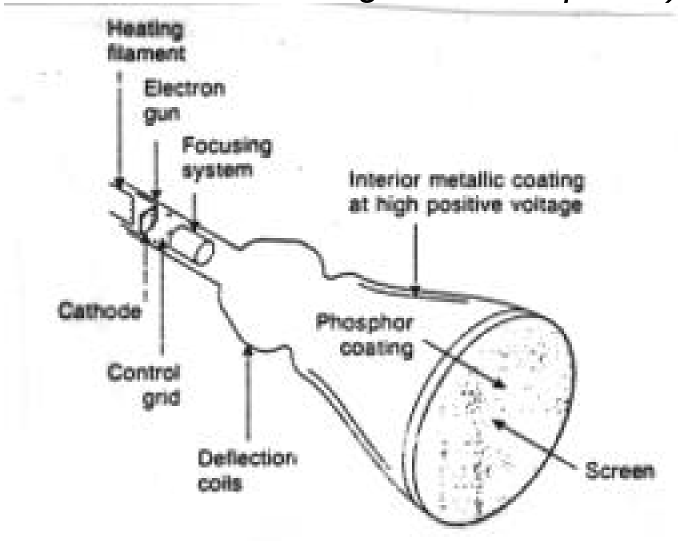



**Fig. 4.12** Cross-section of a CRT (not to scale).

*Figure 9.2 Non interlaced display (left) and interlaced display (right)*

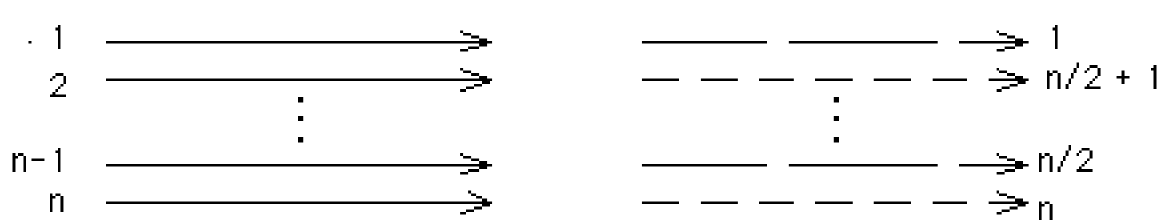
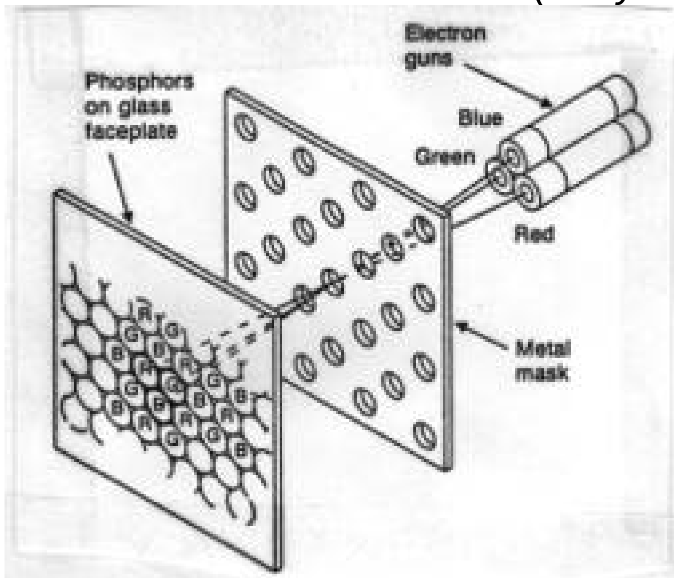


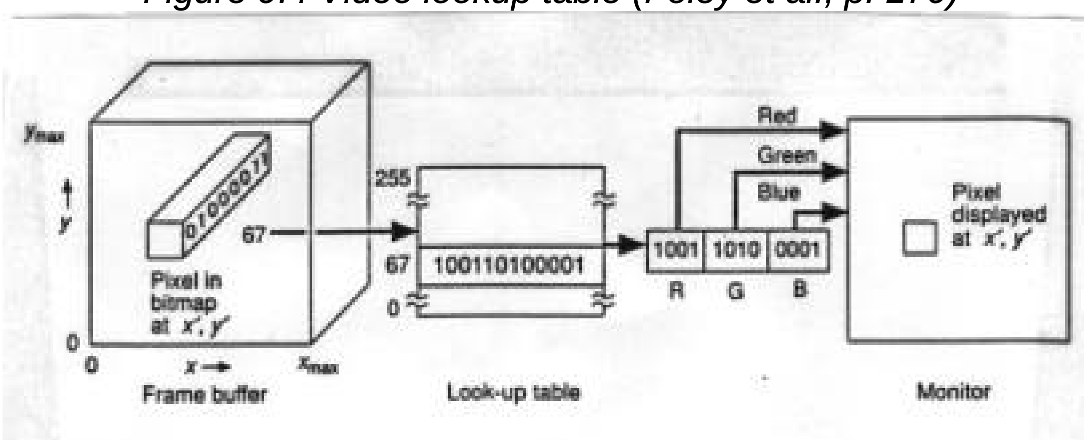
*Figure 9. 3 Delta-delta shadow mask CRT (Foley et al., p. 159)*




CRT driven by *display controller (video controller)*

- Display organized into rectangular grid of pixels
  - Picture elements at each horizontal and vertical position
- Display controller determines value/colour at each pixel
- Most flexible and common method
  - Display controller reads a *frame buffer*
  - Memory has direct representation of value of each pixel
- Can map values into specific colours: (R,G,B) components through a *colour map (video lookup table)* (Fig. 9.4)

*Figure 9.4 Video lookup table (Foley et al., p. 170)*



Parameters of Raster Displays
    Capacity (horizontal X vertical) in number of pixels
        Typically, 512 x 384 640 x 480
            768 x 1024 1024 x 1024
    Resolution (horizontal and vertical)
        Measure of the smallest object that can be discerned
            (resolved), e.g., 120 line pairs/inch, 67 pixels/inch
            Typical shadow mask triad spacing .24 mm
        For purposes of comparison, photography and
            typesetting: 300–2000 lines/inch
Colour Capacity
    Number of different colours, e.g., 1, 16, 256
    Precision in specifying R,G,B components, e.g., 1, 12, 24 bits
    The first is the number of rows in the colour map
    The second is the width of the colour map

## 9.3 Important modern display technologies

Electroluminescent displays
    Material that emits light when in electric field
Liquid crystal displays
    Crystalline molecules control light transmission through
    polarization mechanisms (reflected or active matrix)
Plasma panels
    Cells of neon gas fire and glow under application of voltage

*Figure 9.5 Comparison of display technology pragmatics, esp. cost, size, weight, brightness, colour, and power consumption (Foley et al., p. 165)*

**TABLE 4.3 COMPARISON OF DISPLAY TECHNOLOGIES**

| | CRT | Electro-luminescent | Liquid crystal | Plasma panel |
|---|---|---|---|---|
| power consumption | fair | fair–good | excellent | fair |
| screen size | excellent | good | fair | excellent |
| depth | poor | excellent | excellent | good |
| weight | poor | excellent | excellent | excellent |
| ruggedness | fair–good | good–excellent | excellent | excellent |
| brightness | excellent | excellent | fair–good | excellent |
| addressability | good–excellent | good | fair–good | good |
| contrast | good–excellent | good | fair | good |
| intensity levels per dot | excellent | fair | fair | fair |
| viewing angle | excellent | good | poor | good–excellent |
| color capability | excellent | good | good | fair |
| relative cost range | low | medium–high | low | high |

## 9.4 A novel display — the electronic whiteboard

Xerox LiveBoard
- Rear-projection of LCD display onto a large screen, monochrome, 4 foot by 3 foot, 25 lines per inch
- Pen that emits a beam of optical radiation which is imaged onto a detector module located behind the screen near the LCD, accuracy of better than 1 mm

Smart Technologies SmartBoard
- Large pressure-sensitive whiteboard with front- or rear-projection displays
- Multiple coloured magic markers as input devices

Software for managing WIMP, gestures, freehand sketching

## 9.5 Raster display system architecture

Architectural alternatives
- Simple raster display system architecture (Fig. 9.6)
- Common raster display system architecture (Fig. 9.7)
- Display processor concept (Fig. 9.8)

*Fig. 9.6 Simple raster display system architecture (Foley et al., p. 167)*

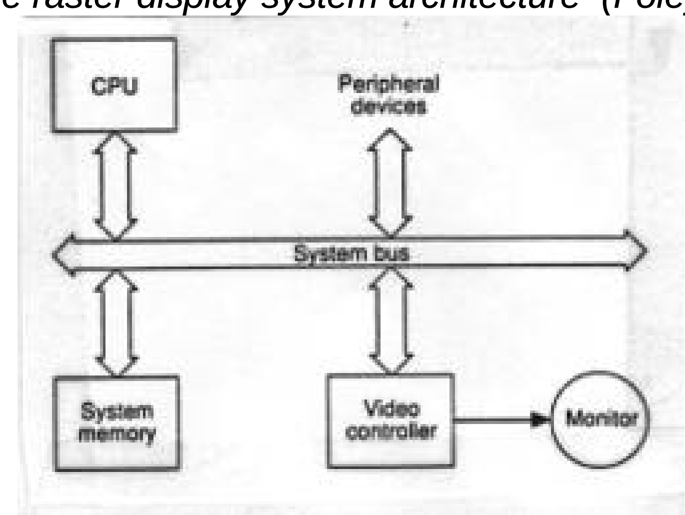


*Fig. 9.7 Common raster display system architecture (Foley et al., p. 166)*

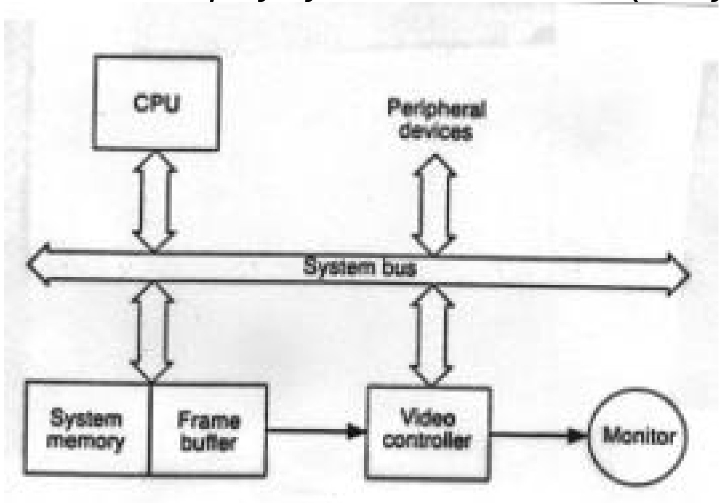
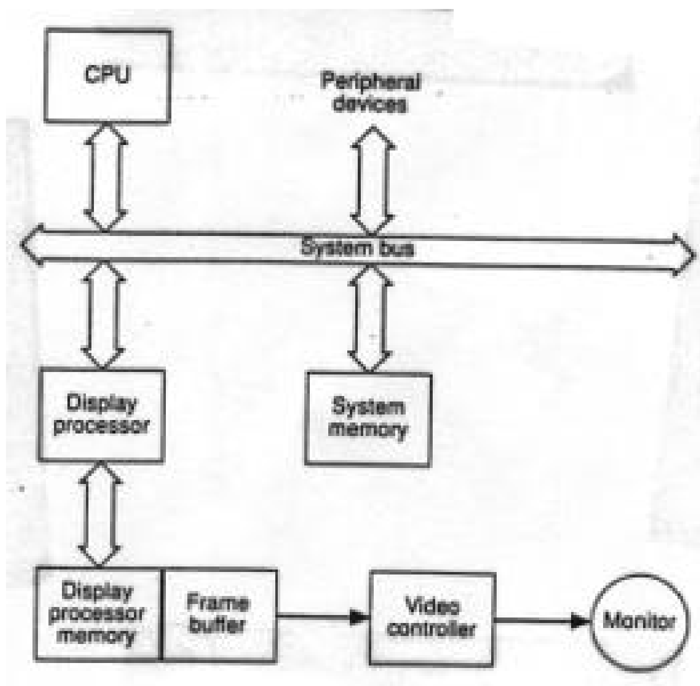



*Fig. 9.8 The display processor concept, as used, e.g., in SGI 3D workstations (Foley et al., p. 171)*



Typical tasks of display processors
- Line drawing and other scan conversion
- Area filling
- Generation of typography
- Geometric transformations
- 3D graphics computations, e.g., shading
- Conversion from high level primitives to low level ones

Architectural tradeoffs
- Cost
- Flexibility in memory utilization
- Bus utilization

## 9.6 Graphics hard copy technology

Pen Plotter
- Flatbed – pen moves in 2D
- Drum – pen moves in 1D, paper moves in 1D

Dot matrix printer
- Key factor is number of pins
- Spacing of pins: 50-100 dots/inch

Ink jet printer
- Spray stream of ink in thin jet: 100-200 dots/inch

Laser printer
- Computer drives laser
- Scan is imaged onto Xerographic drum: 300 dots/inch
- Good typography

These are binary devices — Grey scale via *spatial halftoning*

Colour once a problem for last three, now affordable

## 9.7 Input device technology

Goal: Facilitation of user control of and input to the program
- Control: Start, stop, carry out specific actions, ...
- Input: Data, parameters, drawings, sketches, gestures, ...

Five key issues:
- The medium
  - *The user*: touch, speech, body movements
  - *Devices* held by the user (e.g., mouse)
- Relationship of medium to display
  - *On the display* (e.g., touch panel)
  - *Separate from the display* (e.g., touch pad)
- *Dimensionality* of devices
  - 1D versus 2D versus 3D
- Type of device data
  - *Discrete*
  - *Continuous*
- Device *pragmatics*
  - Size, weight, shape, feel, etc.

Distinction between input device and *cursor* (tracking symbol)

| | **Discrete** | **Continuous** |
|---|---|---|
| **0 Dimensions** | Push button<br>Toggle switch<br>Function keys | ———————————— |
| **1 Dimensions** | Keyboard | Thumbwheel<br>Slider |
| **2 Dimensions** | Touch panel | Touch pad<br>Joystick<br>Trackball<br>Mouse<br>Data tablet<br>Light pen |

## 9.8 Mice, tablets, and other 2D devices

Joystick

Position-sensitive (Fig. 9.9, left)

Pressure-sensitive (Fig. 9.9, right)

*Fig. 9.9 Position-sensitive joystick with 3 degrees of freedom (left) and pressure-sensitive (isometric) joystick (Foley et al., p. 192)*

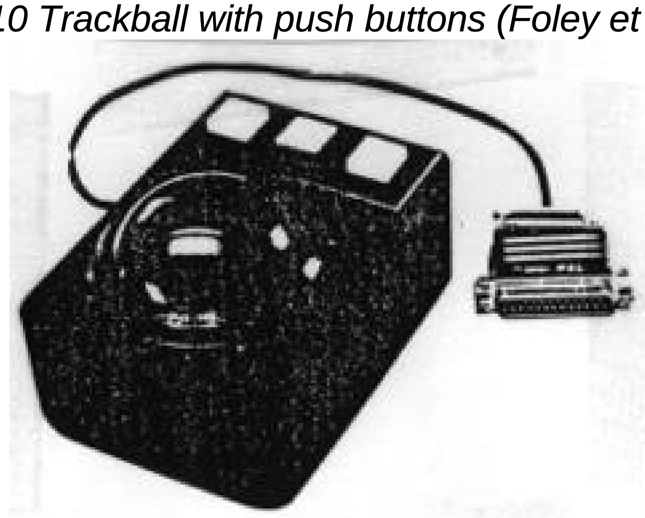
Trackball (Fig. 9.10)

“Upside-down mechanical mouse”

Rotation sensed by potentiometers or shaft encoders

Can be 2D or 3D

*Figure 9.10 Trackball with push buttons (Foley et al., p. 191)*



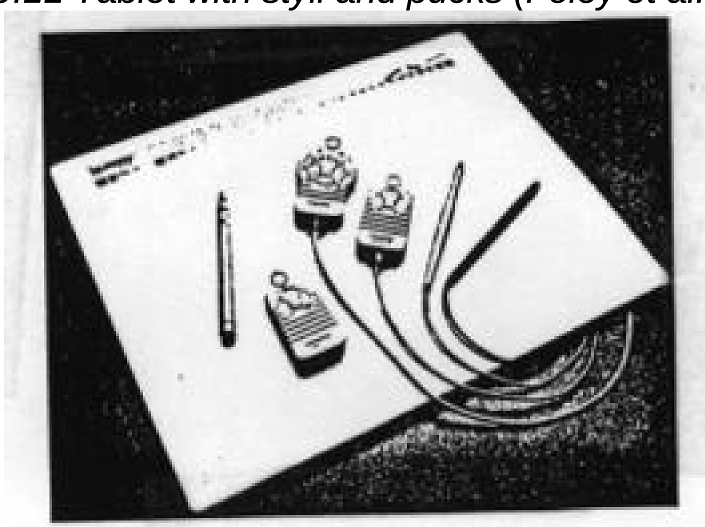
Mouse

- Electro-mechanical versus electro-optical
- Pragmatics
  - Size
  - Feel
  - Gear ratio

Data tablet (Fig. 9.11)

- Puck or stylus and tablet
- Typical resolution: 100 points/inch

*Figure 9.11 Tablet with styli and pucks (Foley et al., p. 190)*



Tablets versus mice

- Position-sensing versus motion-sensing
- Spring-loaded switch in tip of stylus versus 1-3 buttons
- Special surface for tablet and optical mouse versus
  - no special surface for mechanical mouse

## 9.9 Touch devices

Touch panels
- Technologies
  - LED units (“electric eye” effect)
  - Resistance across “plate”
  - Acoustic sound wave
- Resolution: Typically, to 1/4", but can be better
- Advantages
  - Panel on top of screen, no apparent additional device
  - Therefore point directly to commands, objects:
    - Very natural
- Disadvantages
  - Low resolution
  - Hand tires out
  - Hand obscures vision of screen

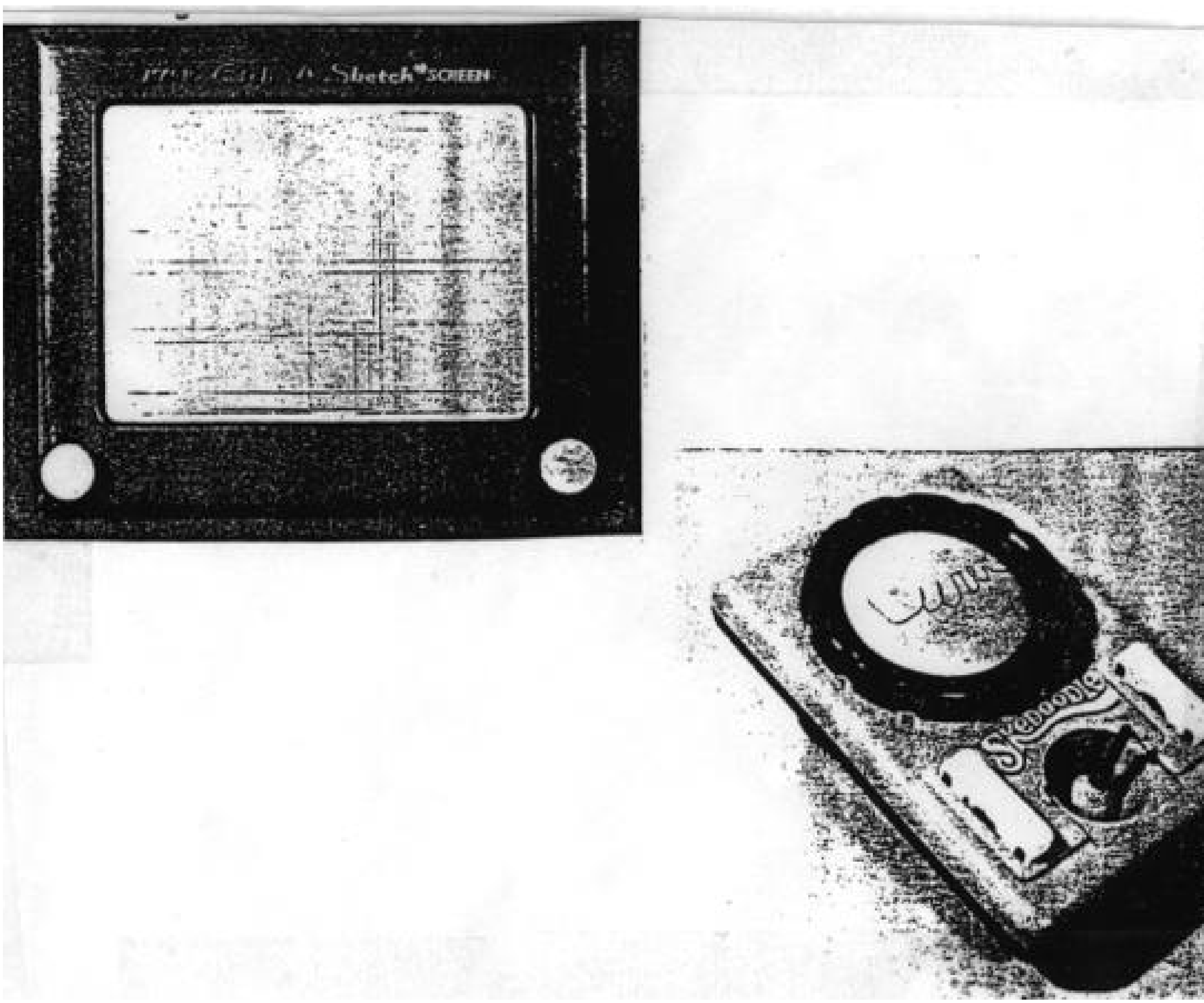
Touch tablets
- Technologies
  - Resistance across “plate”
  - Acoustic sound wave
- Resolution: From 1/20" to 1/100 "
- Advantages
  - Simple technology for hand gestures without devices
  - Pressure-sensitive tablets
- Disadvantages
  - Coarse resolution
  - Difficult to achieve smooth motion
- Now widely in use in Personal Digital Assistants, e.g.,
  - Newton and Pilot

## 9.10 Importance of device pragmatics

The “feel” of the device
- Size
- Weight
- Responsiveness
- What it transduces (e.g., position or pressure)
  - e.g., position- versus pressure-sensitive joystick

Consider drawing with Etch a Sketch vs. Skedoodle (Fig. 9.12)

*Figure 9.12 Two “semantically identical” drawing toys*
*(Norman & Draper, p. 327, also in Baecker and Buxton, p. 370)*



## 9.11 Leading edge technologies

Speech I/O, no-speech audio output (later in class)

Ubiquitous computing hardware (badges, tabs)

Wall-sized displays

Desks as I/O devices
*VIDEO, Wellner, Xerox EuroPARC, SGVR #79*

Stereo displays

3D displays

Head-mounted displays

Pointing stick
*VIDEO, Rutledge and Selker, IBM, SGVR #55*

Two-handed input
*VIDEO, Bier et al., Xerox PARC, SGVR #97*

3D input devices

Video, body suits, or other body movement sensors

Eye tracking hardware