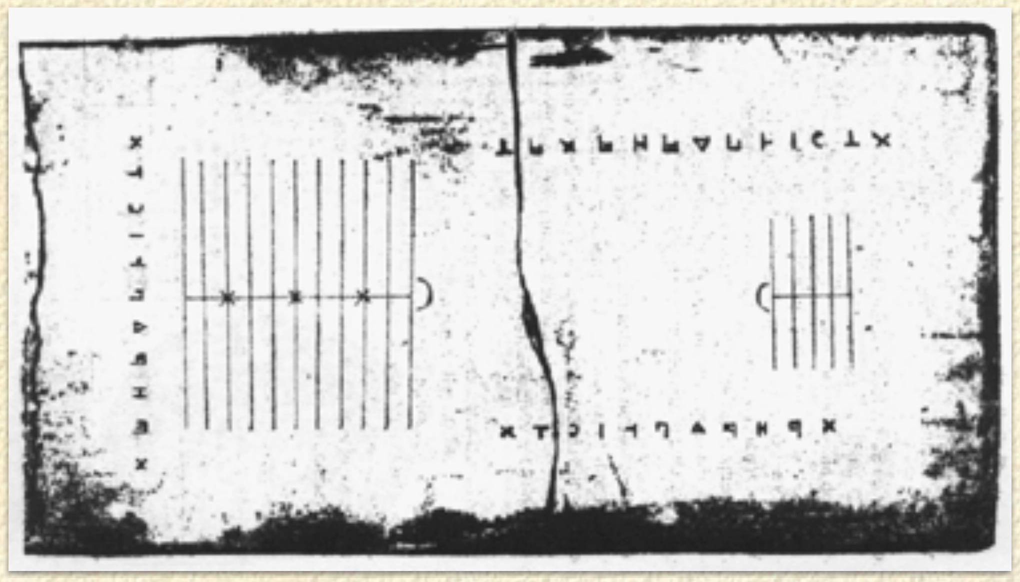
A Little History...

CS 202 - Spring 2016

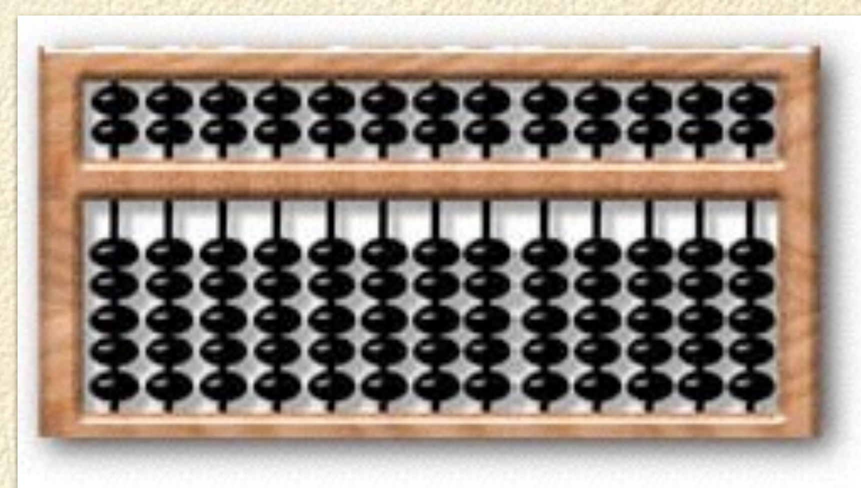
Professor Christopher Andrews

In the beginning…

- 300 B.C. - The Salamis Tablet

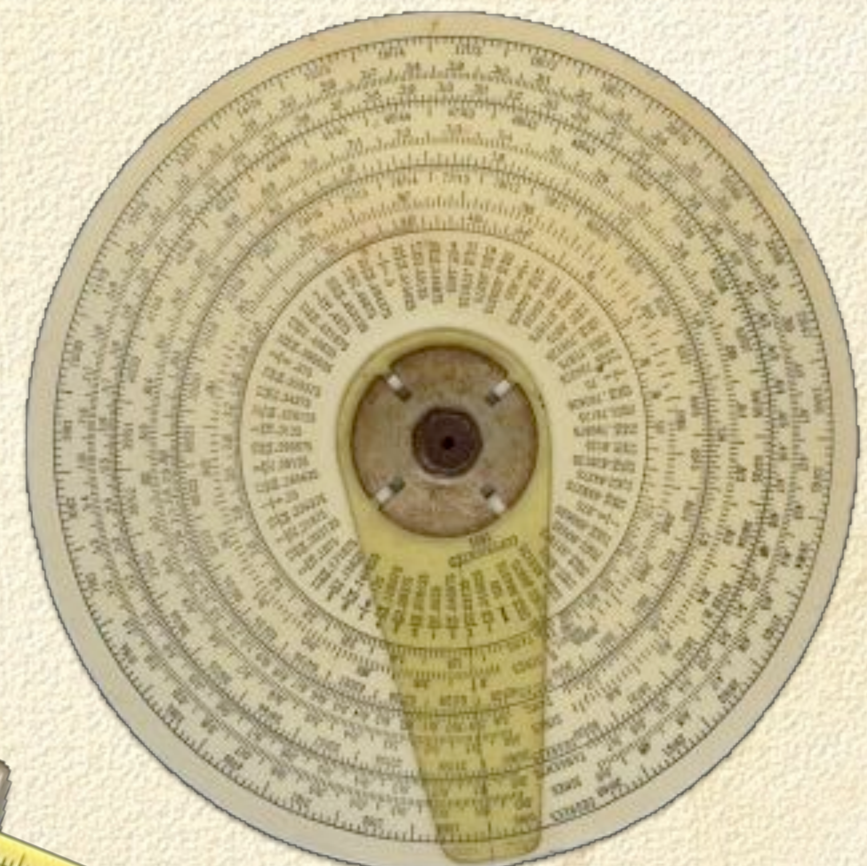


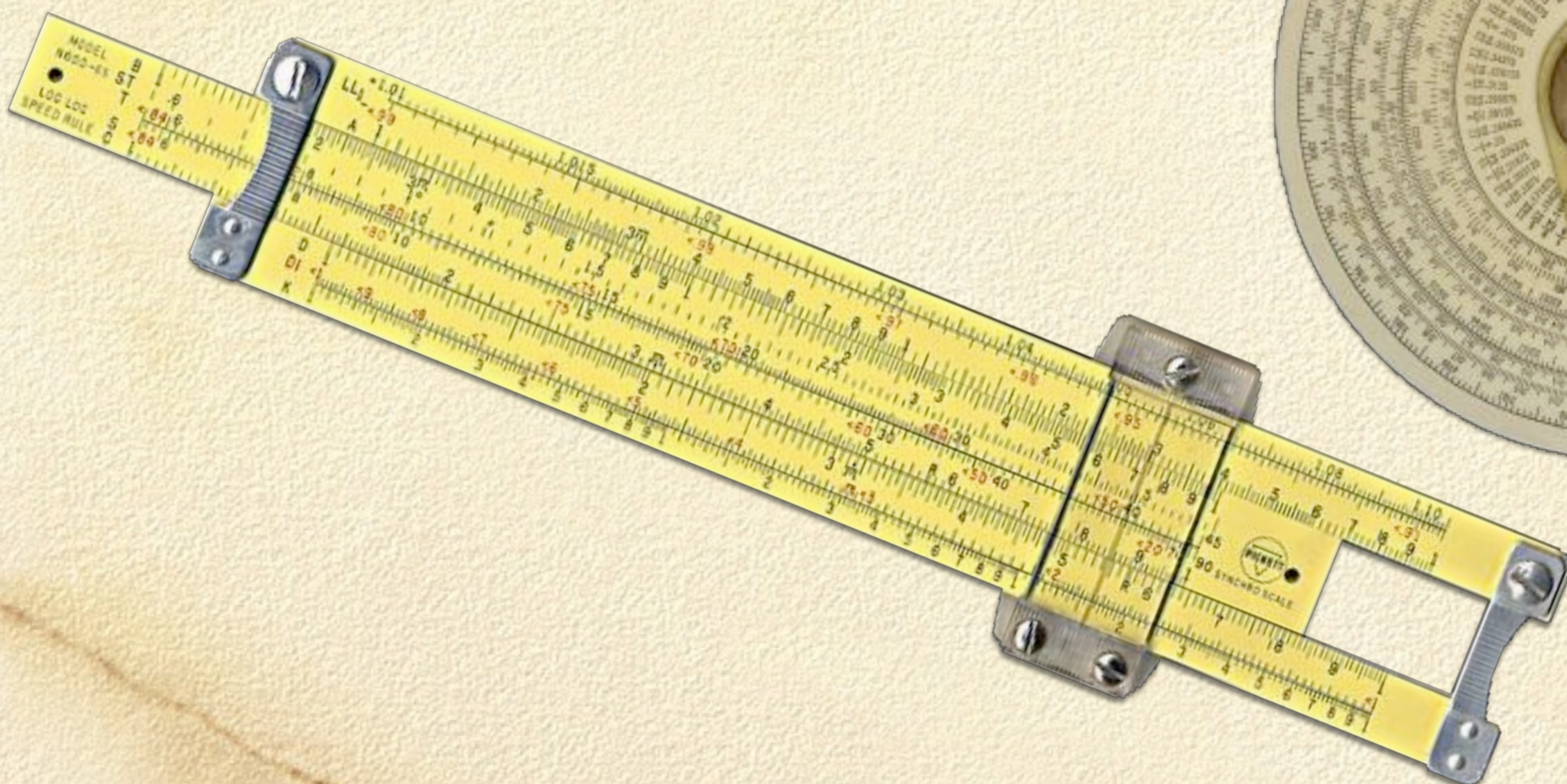
- 1200 A.D. - the abacus appears



An idea is born…

- 1630 - William Oughtred develops the **slide rule**





An idea is born…

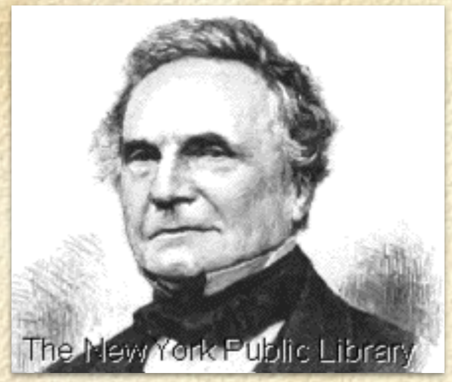
- 1624 - **Blaise Pascal** and the **Pascaline**
  - a geared device that can add & subtract
  - multiplication and division are added in the next two centuries

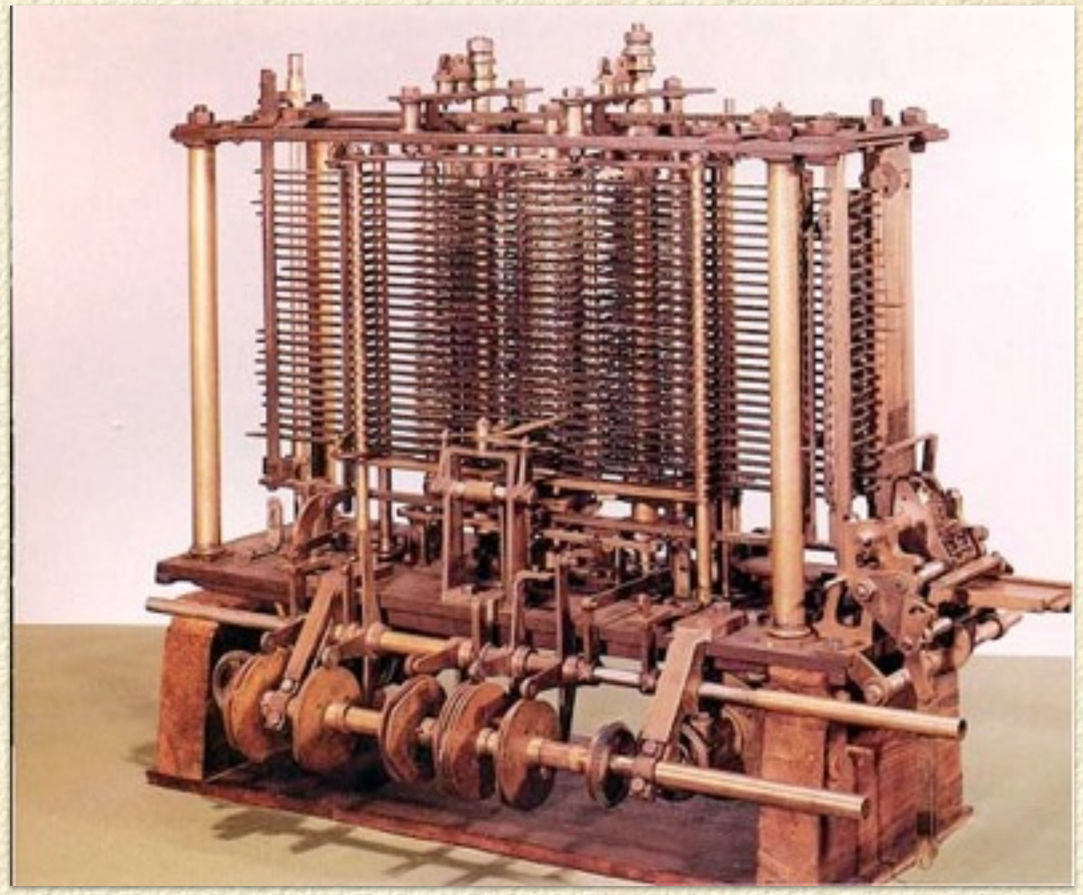
Punch cards

- 1800 - Joseph Jacquard develops the Jacquard Loom

Industrial Revolution

- Charles Babbage
  - The Difference Engine (1820) - steam powered device for generating mathematical tables
  - The Analytical Engine (1834) - essentially the first computer



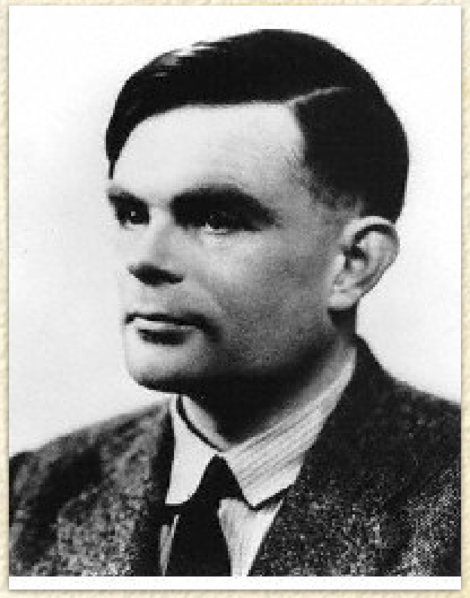


Industrial Revolution

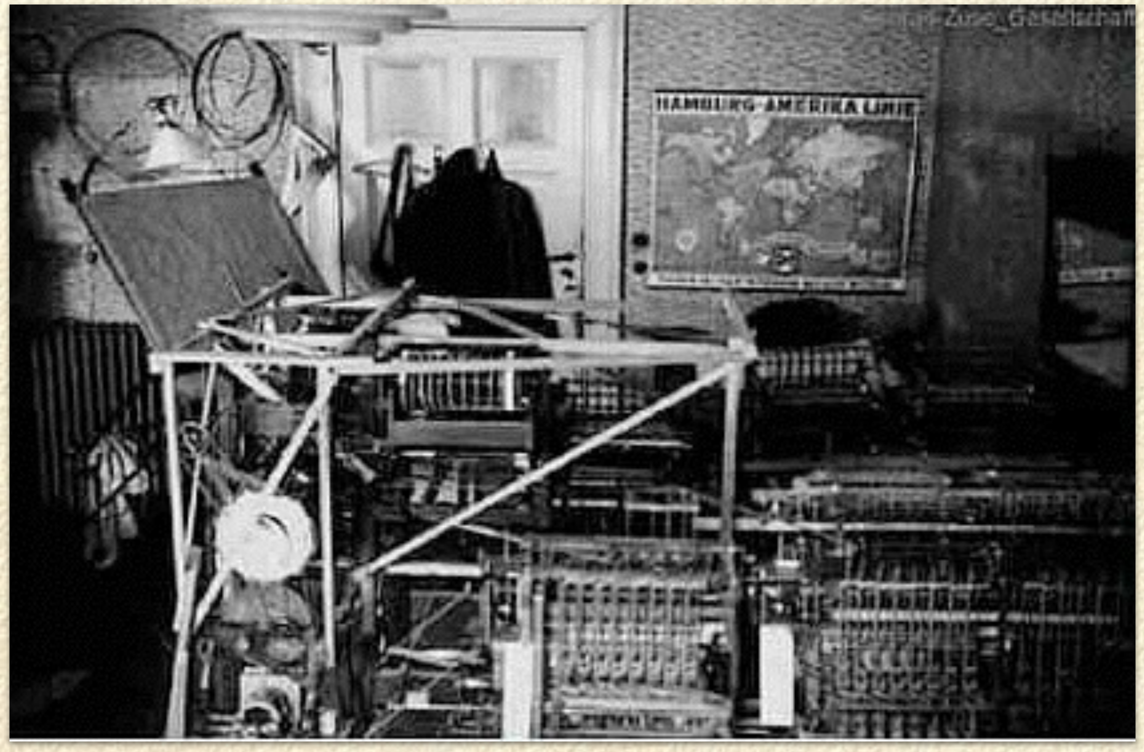
- Lady Ada Lovelace
  - Considered to be the first programmer
  - The concept of the loop is credited to her

The Dawn of Computers

- 1936 – **Alan Turing**
  - Writes a critical essay describing the **Turing Machine**



- 1938 – **Konrad Zuse** develops the Z1

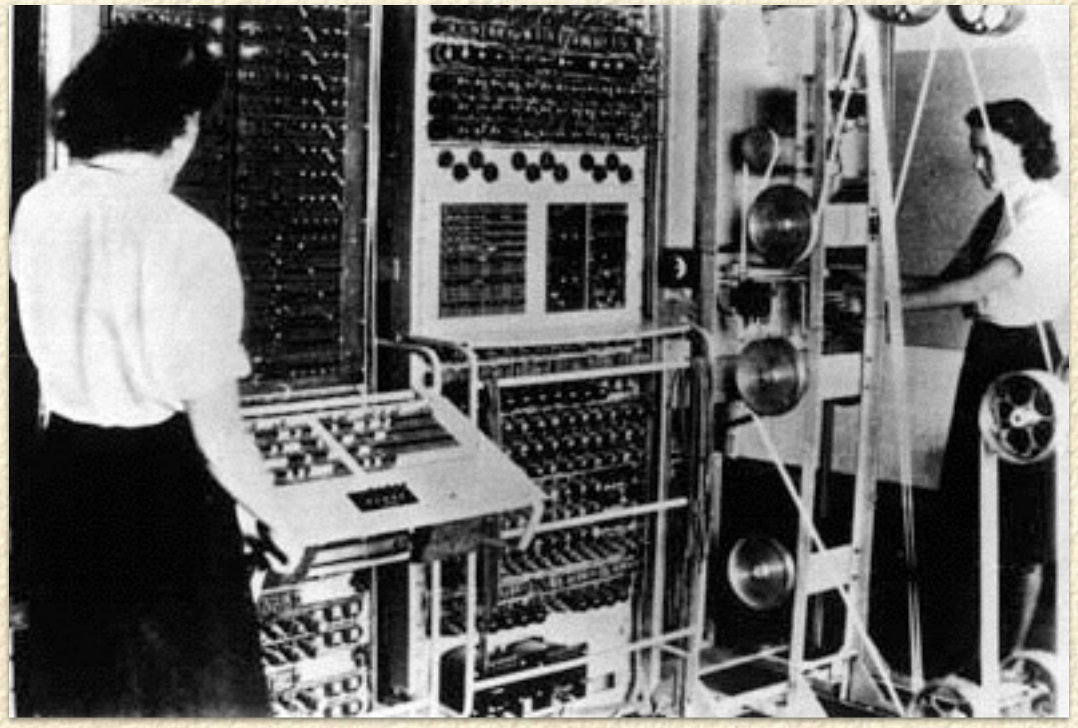


World War II

- The Allies form a team of code breakers at Bletchley Park to crack the Enigma code

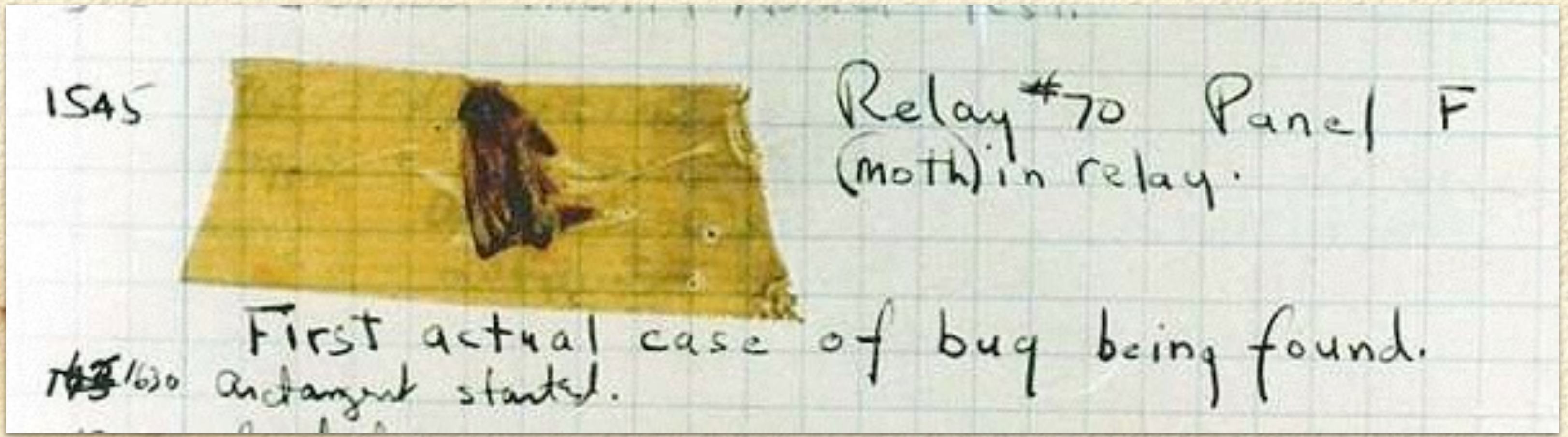
FOUR-ROTOR ENIGMA (GVG / PD)

- **Tommy Flowers** designs the **Colossus** computer



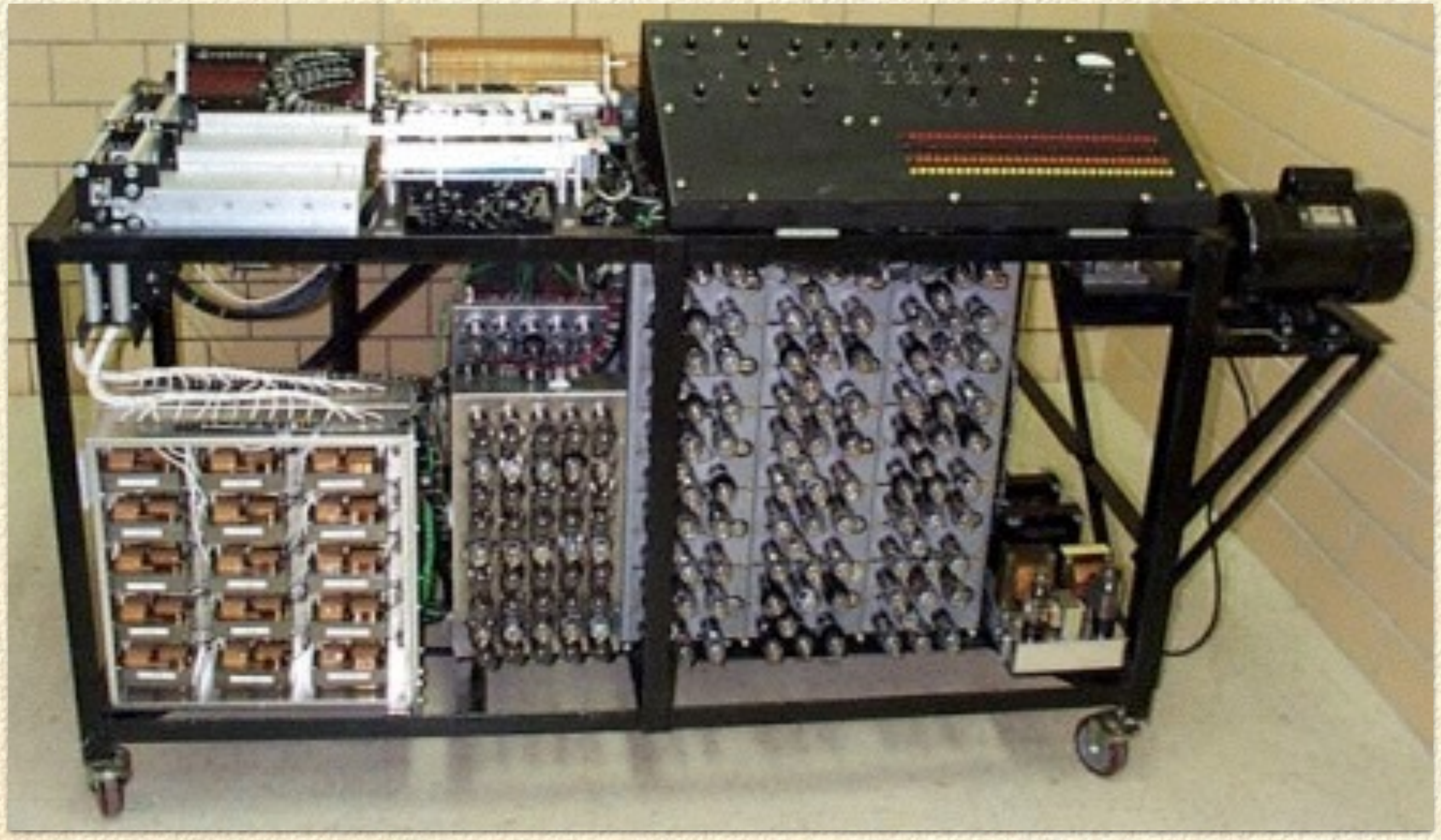
The Mark I

- 1944 - **Howard Aiken** develops the **Mark I**
  - the first all electronic calculator
- The Mark I is half as long as a football field and contains *500 miles* of wire
- Used electro-mechanical relays
  - calculations took 3-5 seconds *apiece*
- 1945 - The first actual computer bug is identified…



The ABC

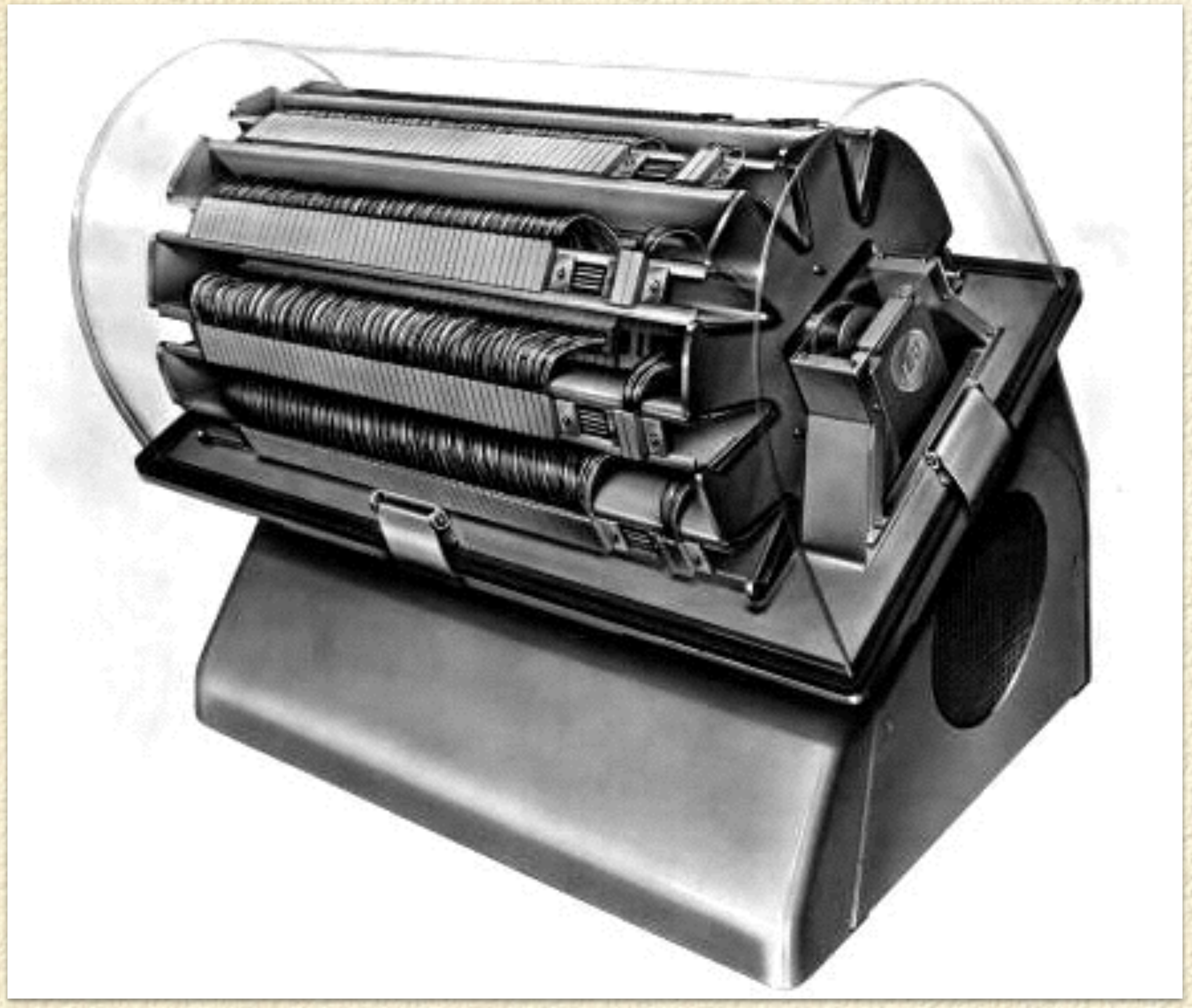
- 1937 – **John Atanasoff** builds the **Atanasoff-Berry Computer** (ABC) at Iowa State



The First Generation (1946 - 1959)

- Vacuum Tubes
  - large, generated a lot of heat and not terribly reliable

The First Generation (1946 - 1959)



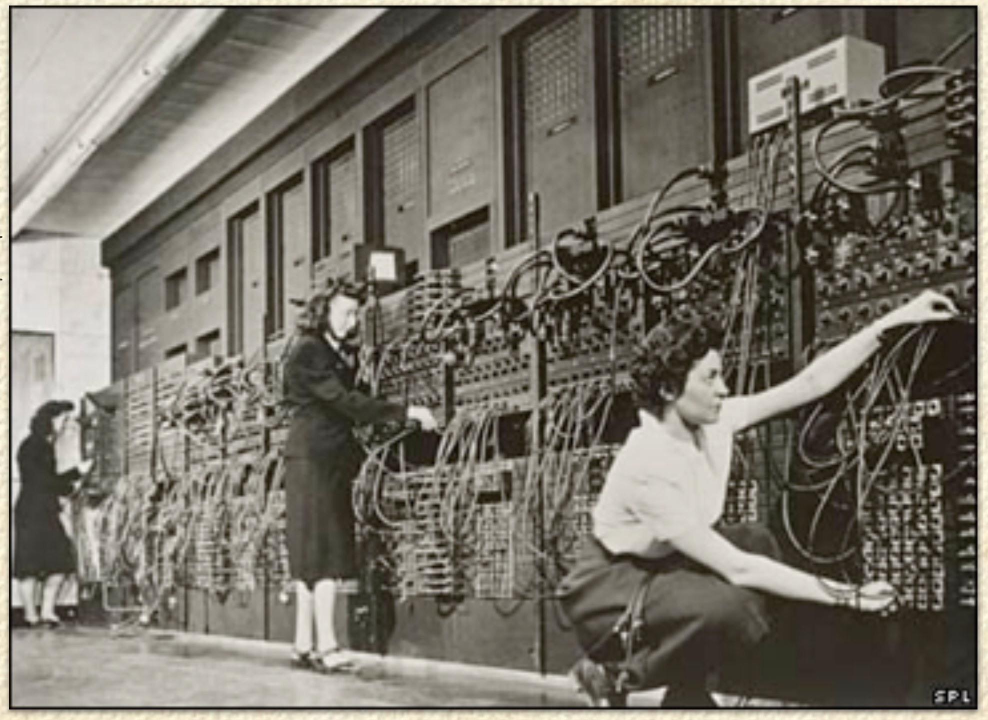
- Magnetic Drum
  - memory device that rotated under a magnetic head

The ENIAC

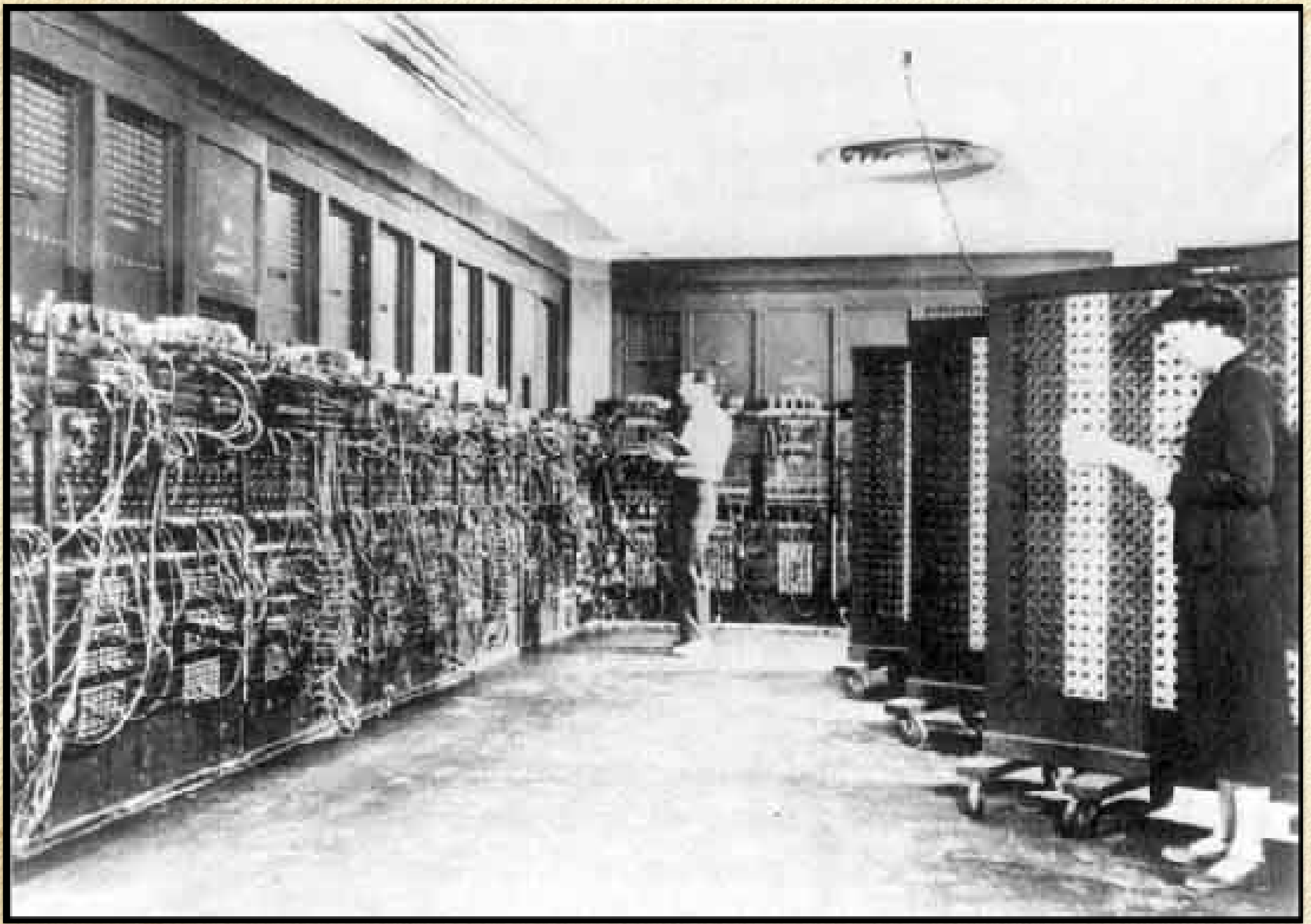
- **E**lectronic **N**umerical **I**ntegrator **A**nd **C**omputer
- Was developed to calculate trajectory tables for the military
  - work began in 1943 and finished in 1946 - too late for the war
  - in use until 1955
- Eckert and Mauchly working at UPenn
- Considered the first fully functional, *all electric, programable computer*

ENIAC Facts

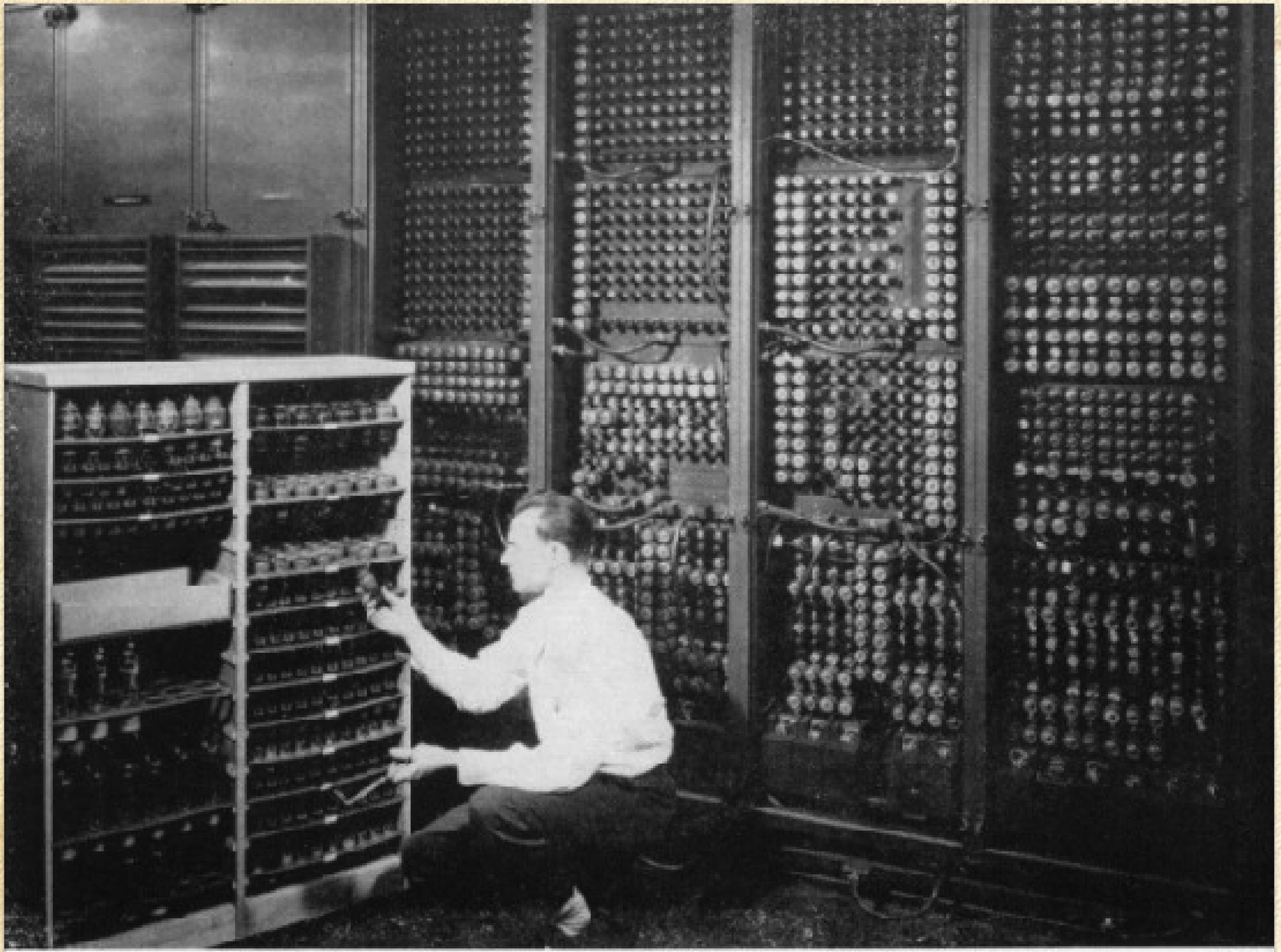
- Worked on *decimal* numbers - not binary
- Programed manually using switches
  - think old time telephone operators...
- Used *vacuum tubes* rather than relays
- Contained 18,000 vacuum tubes, 70,000 resistors and over 5 million soldered joints
- Consumed 140 kW of power
- 5,000 operations a second
  - about 20000 times faster than the Mark I



The ENIAC at Work



Repairing the ENIAC



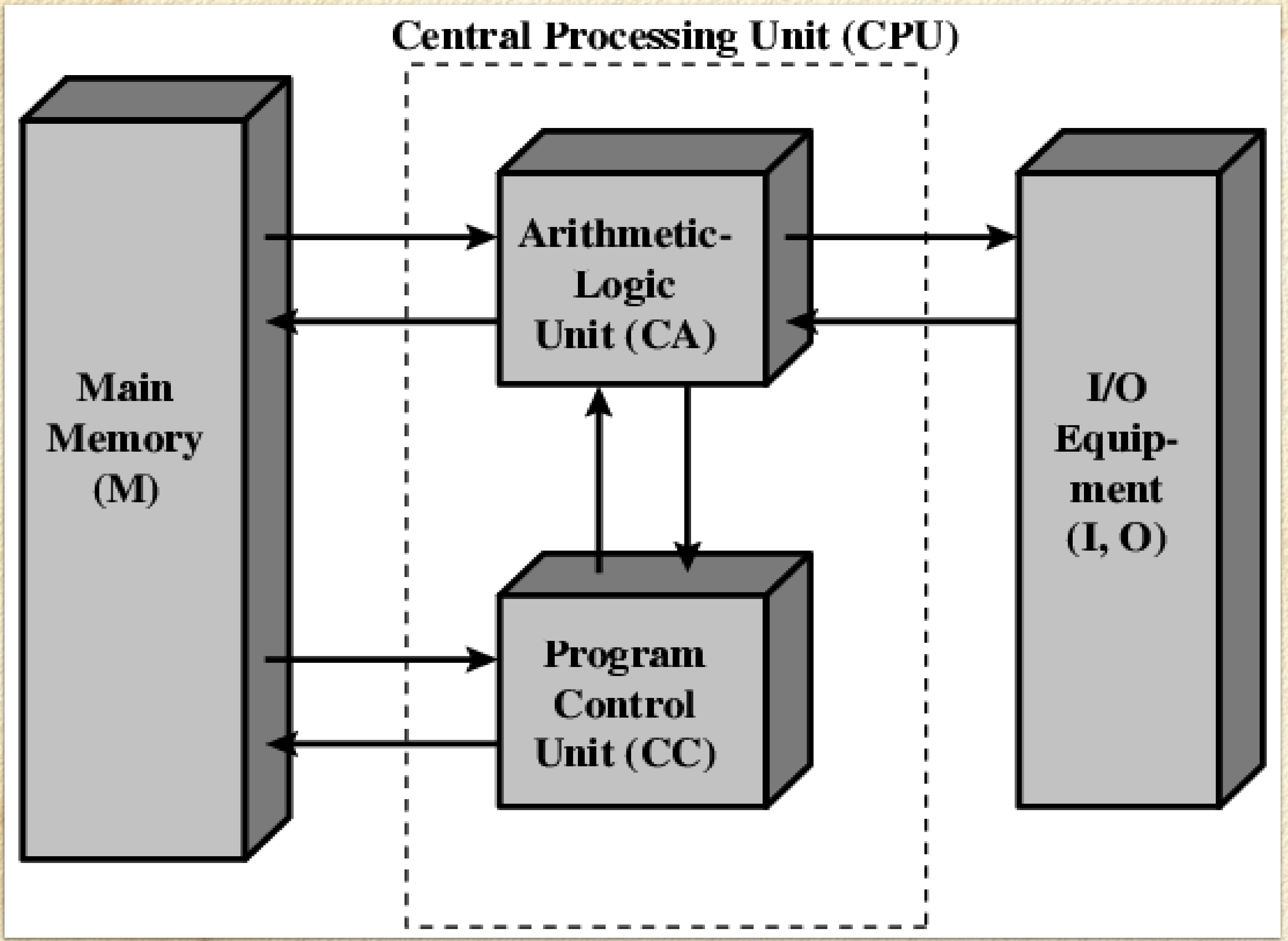
Replacing a bad tube meant checking among ENIAC's 19,000 possibilities.

von Neumann Architecture

- 1945 - **John von Neumann**
  - Realized that there was **no** real difference between program instructions and data - it is all just bits (*stored-program concept*)

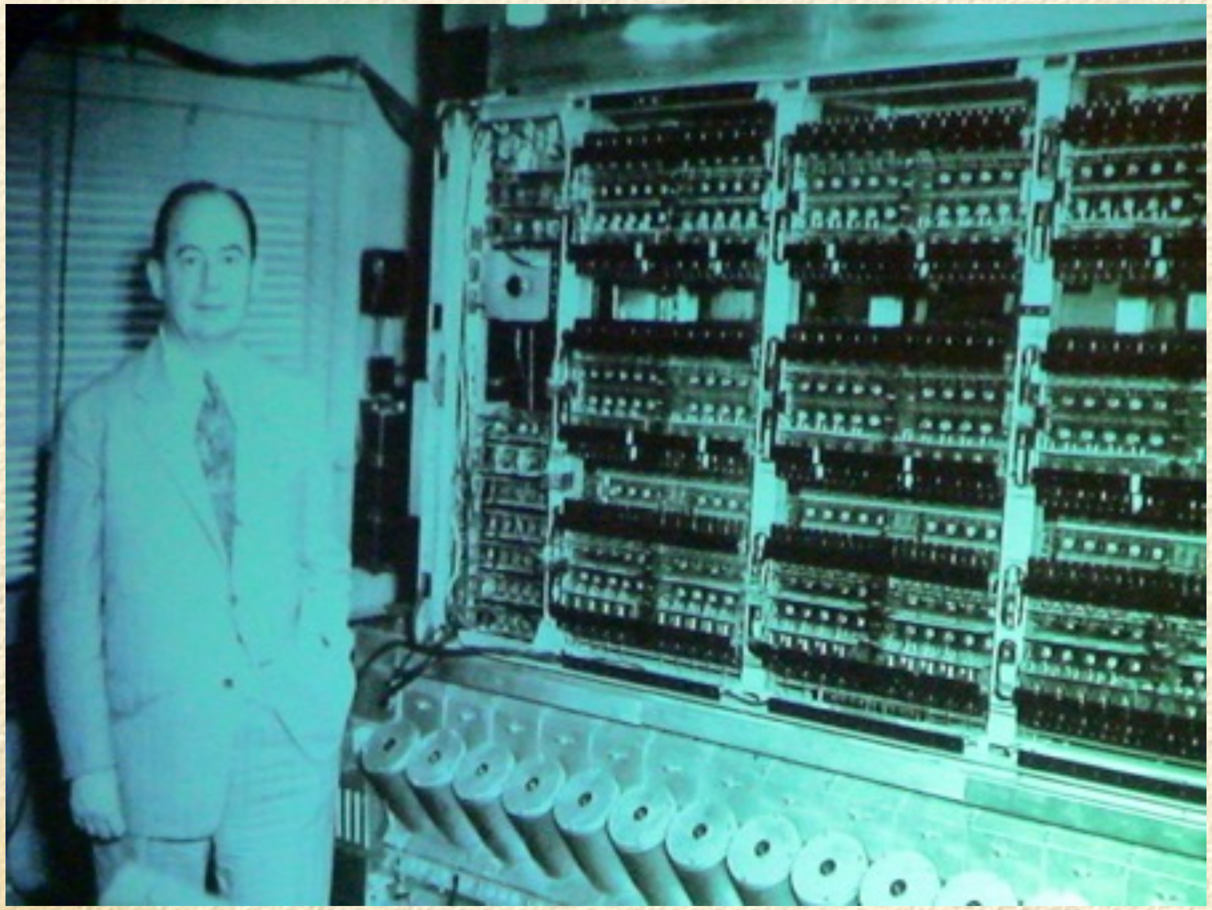
- The Architecture
  - I/O devices
  - Main memory (short term)
  - Secondary memory (long term)
  - Central Processing Unit (the brains)

The Architecture

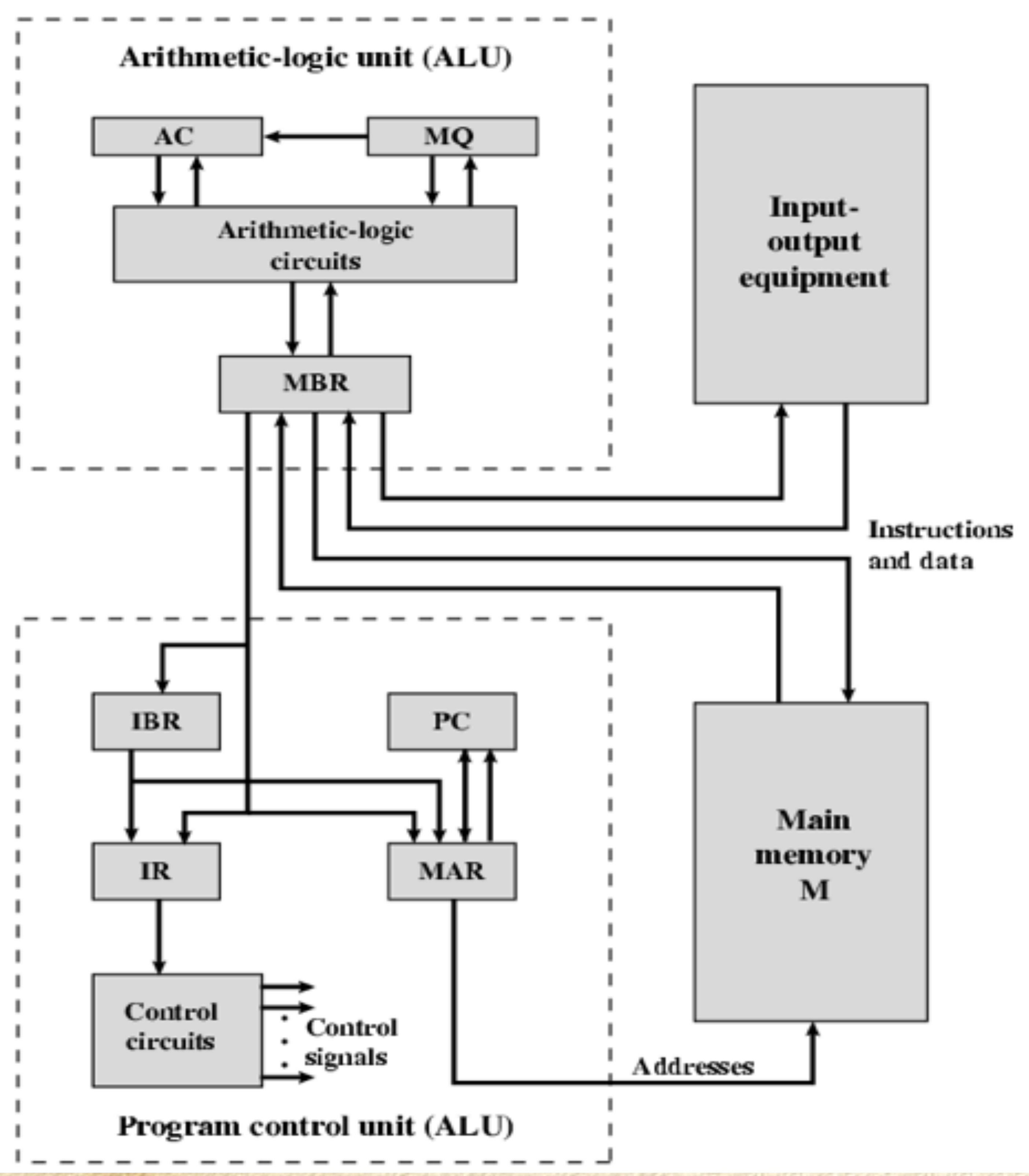


IAS computer

- Developed at Princeton's Institute for Advanced Studies in 1946
  - Completed in 1952
- We can consider it to be a prototype of all subsequent general purpose computers



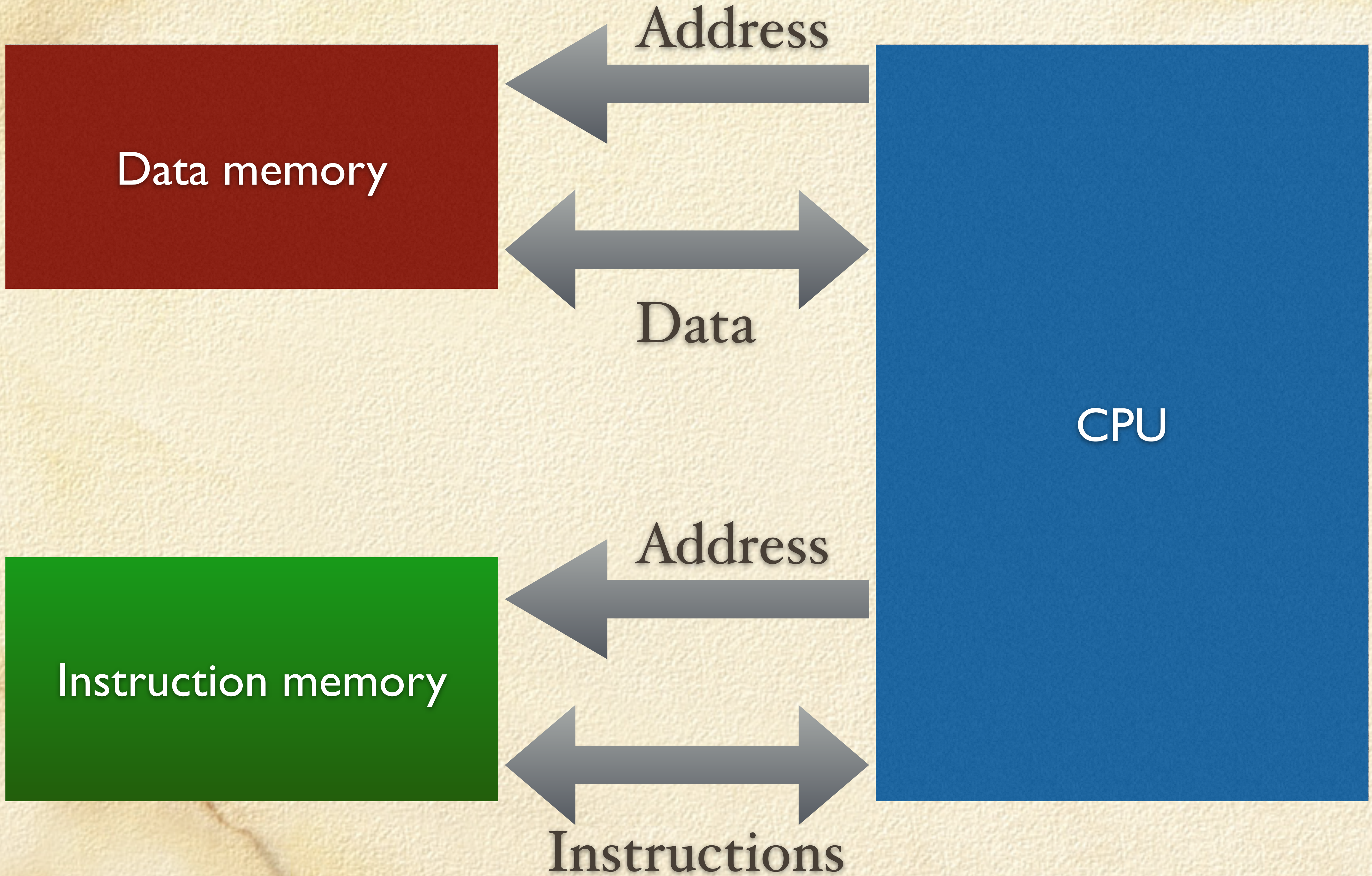
Structure of the IAS



ISA Instruction Set

Instruction Type	Opcode	Symbolic Representation	Description
Data transfer	00001010	LOAD MQ	Transfer contents of register MQ to the accumulator AC
	00001001	LOAD MQ,M(X)	Transfer contents of memory location X to MQ
	00100001	STOR M(X)	Transfer contents of accumulator to memory location X
	00000001	LOAD M(X)	Transfer M(X) to the accumulator
	00000010	LOAD –M(X)	Transfer –M(X) to the accumulator
	00000011	LOAD |M(X)|	Transfer absolute value of M(X) to the accumulator
	00000100	LOAD –|M(X)|	Transfer –|M(X)| to the accumulator
Unconditional branch	00001101	JUMP M(X,0:19)	Take next instruction from left half of M(X)
	00001110	JUMP M(X,20:39)	Take next instruction from right half of M(X)
Conditional branch	00001111	JUMP+ M(X,0:19)	If number in the accumulator is nonnegative, take next instruction from left half of M(X)
	00010000	JUMP+ M(X,20:39)	If number in the accumulator is nonnegative, take next instruction from right half of M(X)
Arithmetic	00000101	ADD M(X)	Add M(X) to AC; put the result in AC
	00000111	ADD |M(X)|	Add |M(X)| to AC; put the result in AC
	00000110	SUB M(X)	Subtract M(X) from AC; put the result in AC
	00001000	SUB |M(X)|	Subtract |M(X)| from AC; put the remainder in AC
	00001011	MUL M(X)	Multiply M(X) by MQ; put most significant bits of result in AC, put least significant bits in MQ
	00001100	DIV M(X)	Divide AC by M(X); put the quotient in MQ and the remainder in AC
	00010100	LSH	Multiply accumulator by 2, i.e., shift left one bit position
	00010101	RSH	Divide accumulator by 2, i.e., shift right one position
Address modify	00010010	STOR M(X,8:19)	Replace left address field at M(X) by 12 rightmost bits of AC
	00010011	STOR M(X,28:39)	Replace right address field at M(X) by 12 rightmost bits of AC

Harvard architecture



The UNIVAC

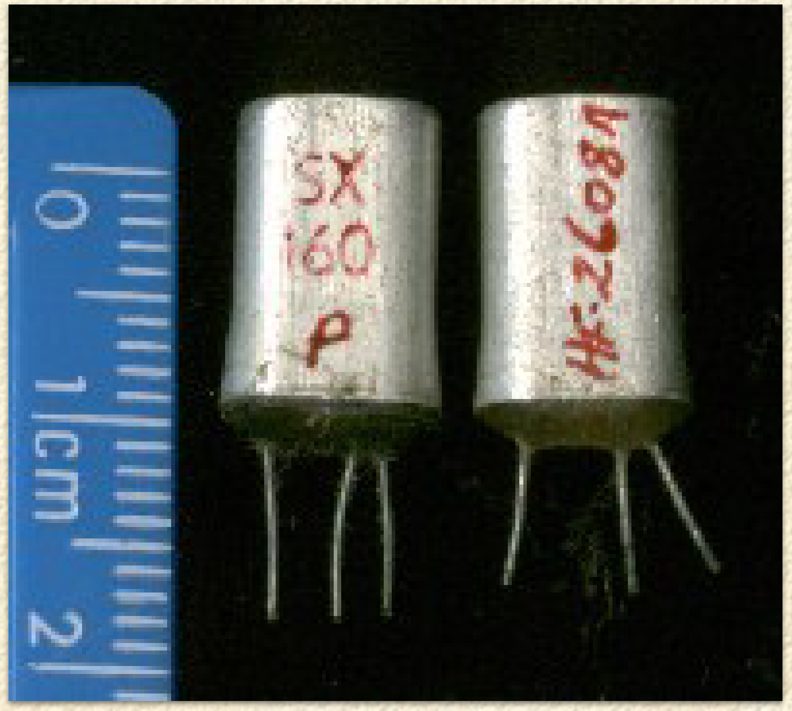
- **UNIV**ersal **A**utomatic **C**omputer
  - First commercial computer, released in 1951
- Based upon the von Neumann architecture
- Product of the Eckert-Mauchly Computer Corporation
- Many generations of the UNIVAC
  - around for thirty years or so

The Second Generation (1959-1965)

- The Transistor
  - smaller, faster, cheaper and more reliable than the vacuum tube
- Magnetic Core Memory
  - instant access to items in memory

Transistors

- Invented in 1947 by Bardeen, Brattain and Shockley
- Solid State (no moving parts)
- Silicon
- low heat dissipation
- just a switch...



Transistors

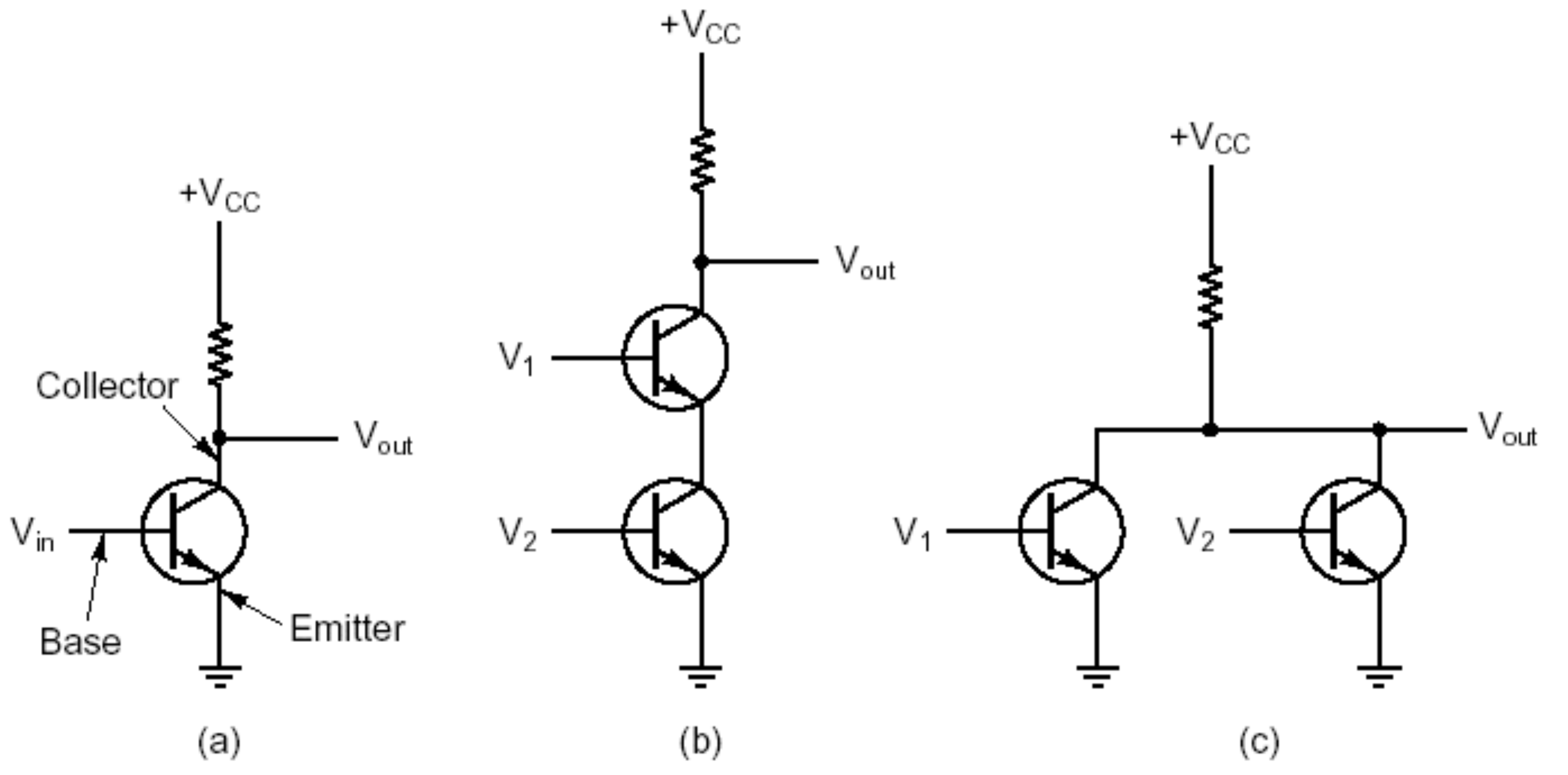
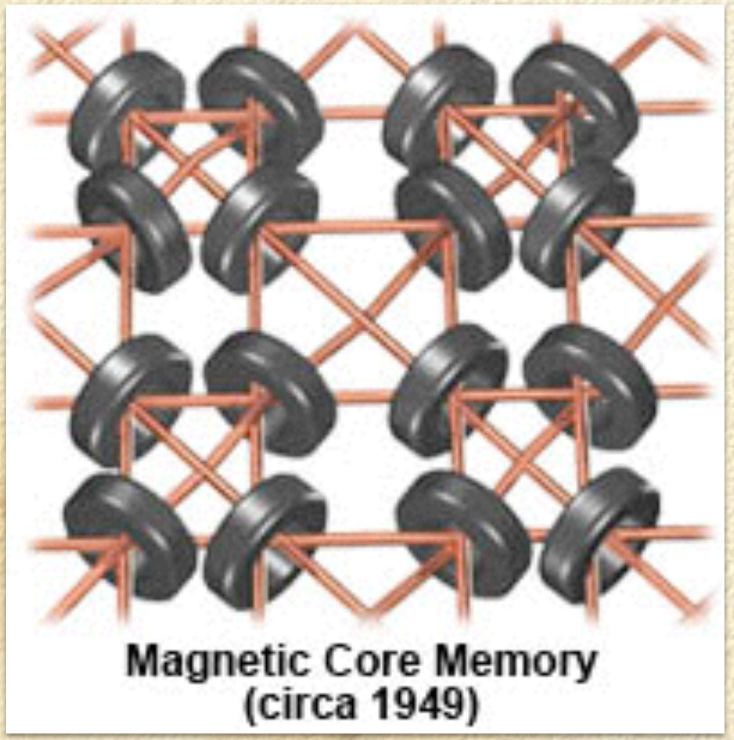
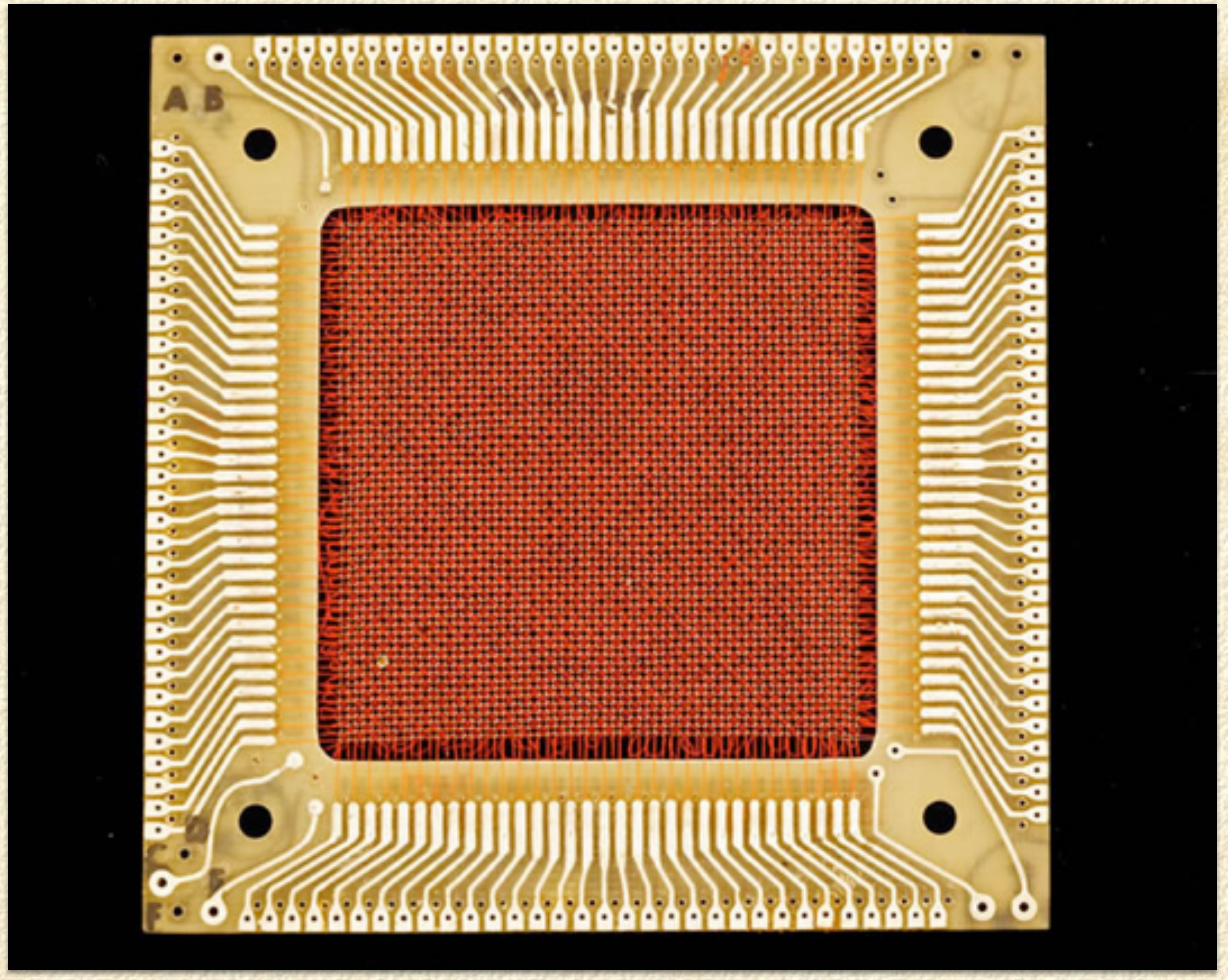


Figure 3-1. (a) A transistor inverter. (b) A NAND gate. (c) A NOR gate.

Magnetic Core Memory

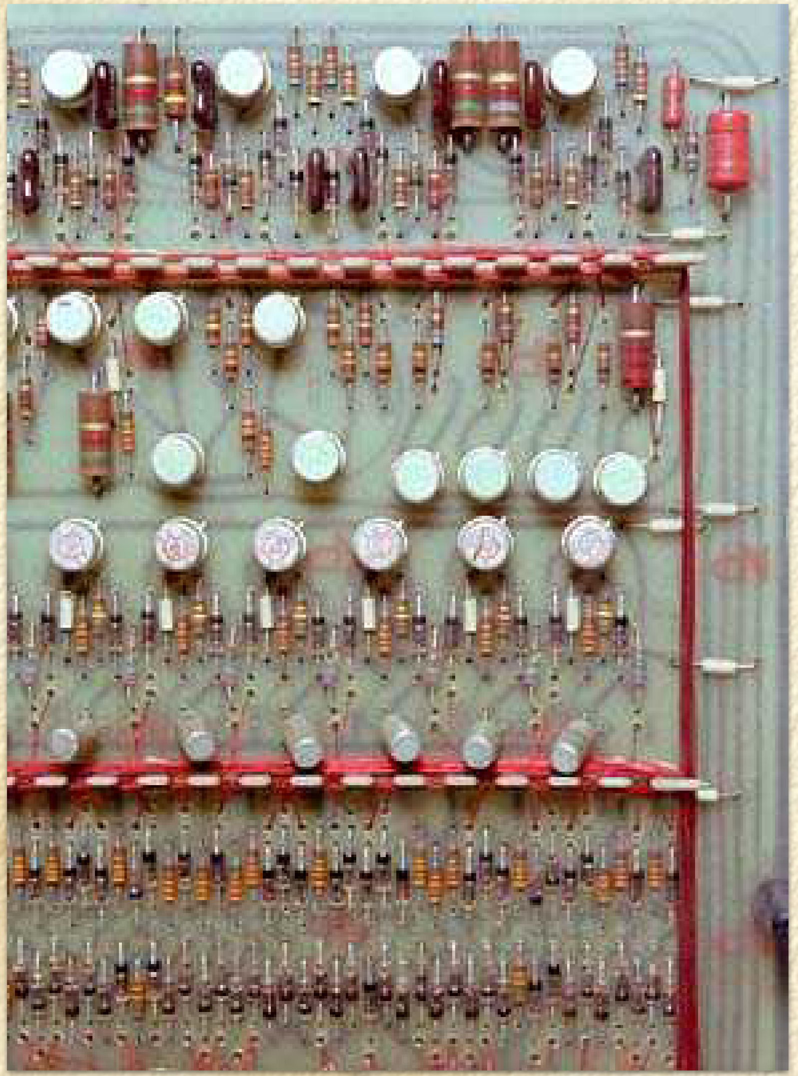
- Used tiny, doughnut shaped devices
  - one per bit
- Always available
  - i.e. instant access to data
- No moving parts

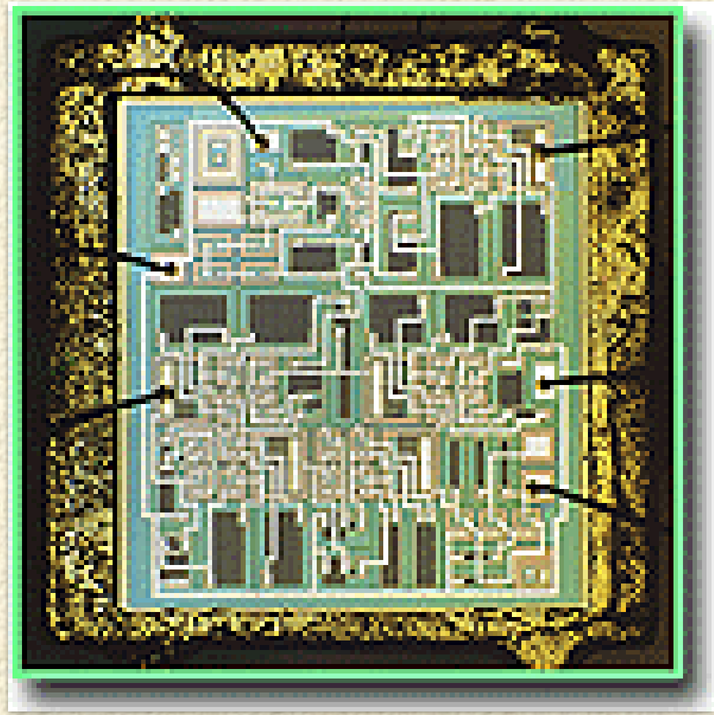


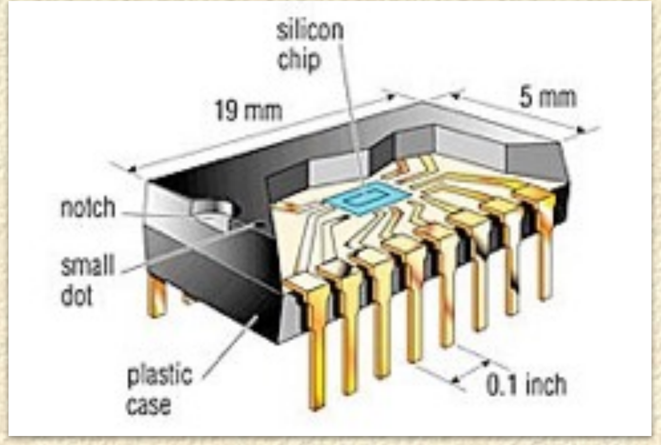


The Third Generation (1965-1971)

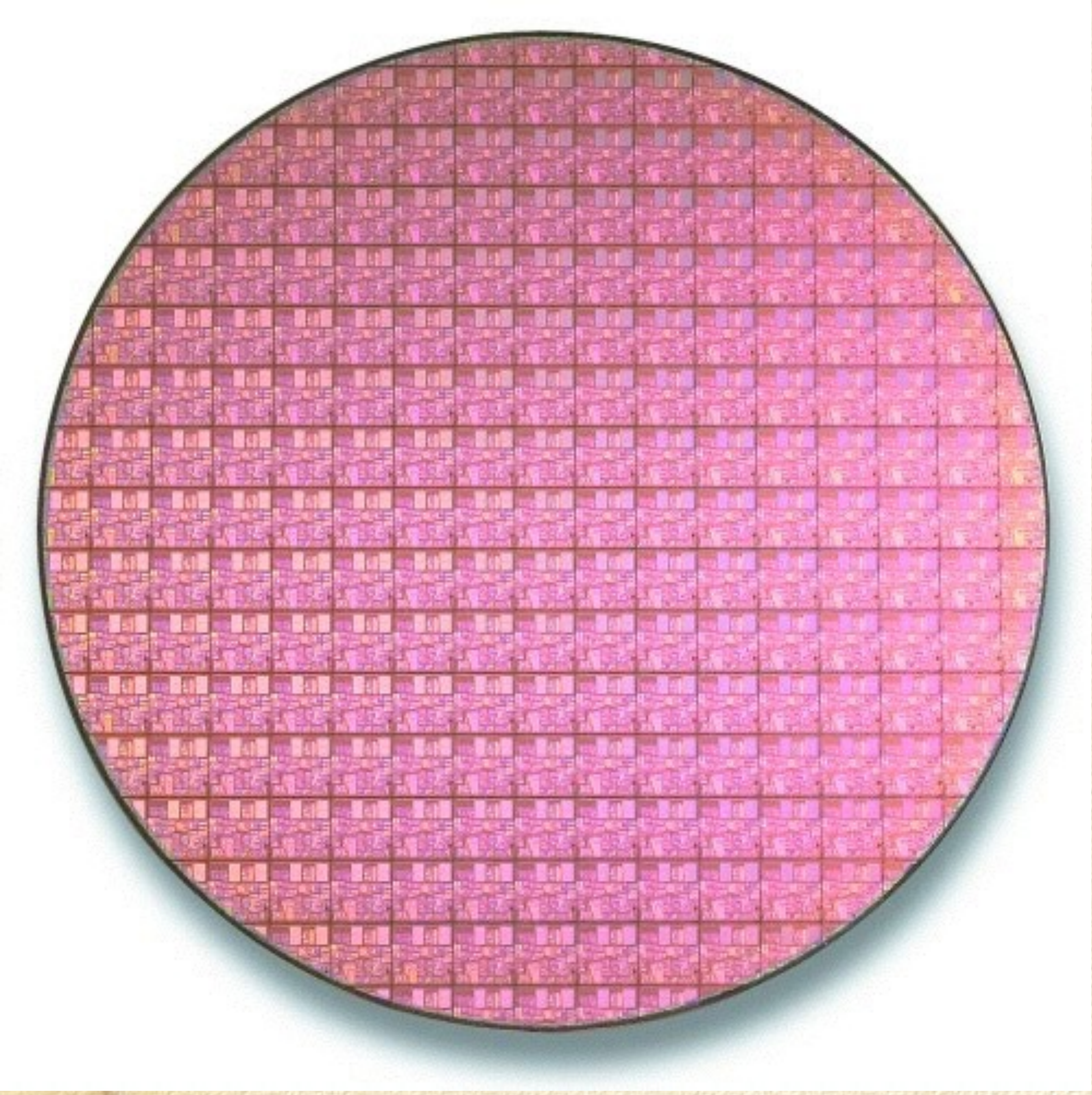
- Integrated Circuits
  - solid pieces of silicon containing multiple components
  - much smaller, faster cheaper and more reliable than printed circuit boards

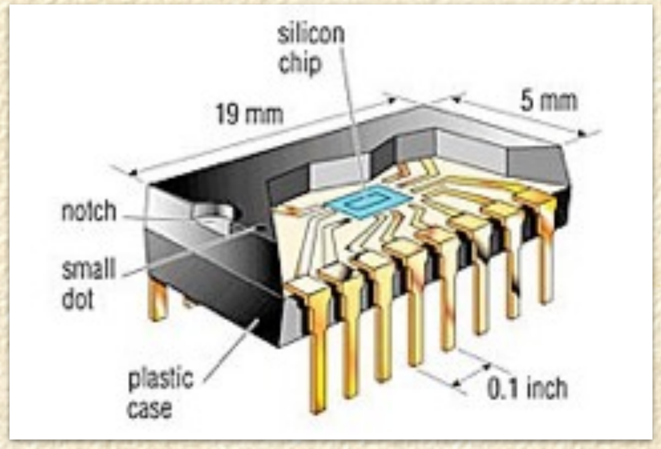






Silicon Wafer



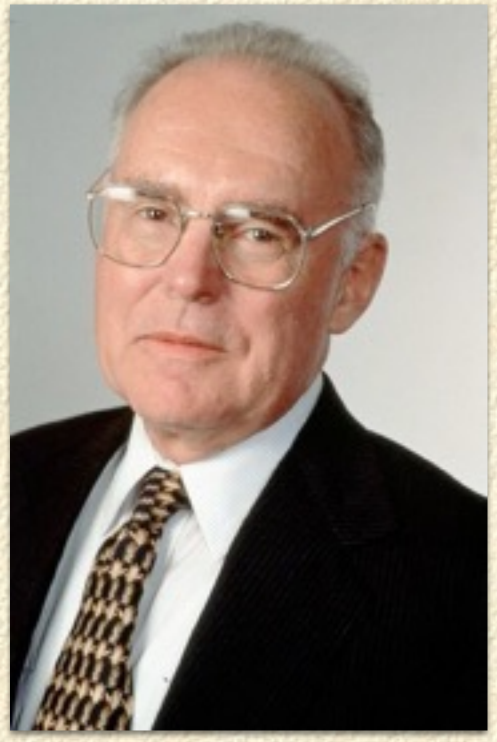


IC Memory

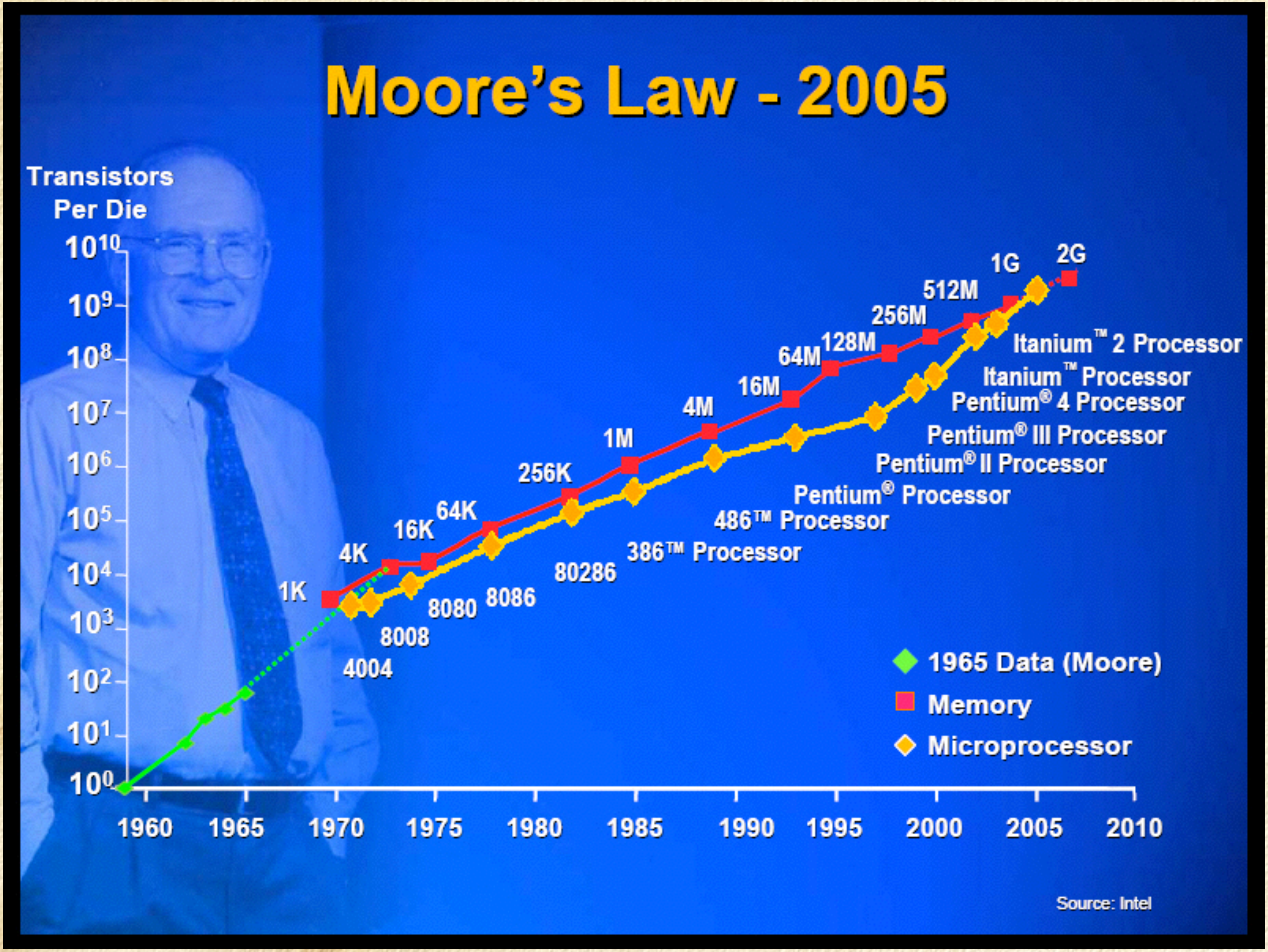
- Memory moved from cores to ICs as well
  - replace a single core (1 bit) with 256 bit IC
- Non-destructive read
  - unlike core memory
- Much faster
- Still volatile
  - i.e. goes away when the power is turned off

Moore's Law

- 1965 - **Gordon Moore**
  - Co-founder of Intel
- Predicted that the number of circuits that could be placed on a single IC would double each year
  - or 18 months… or 10 months, or every few years
- Chip cost has stayed the same
- Tighter packing means shorter interconnects
  - faster
  - more reliable
  - reduced power and cooling requirements



Moore’s Law



Moore’s Law - 2005
Transistors
Per Die
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
1K
4K
16K
64K
256K
1M
4M
16M
64M
128M
256M
512M
1G
2G
4004
8008
8080
8086
80286
386™ Processor
486™ Processor
Pentium® Processor
Pentium® II Processor
Pentium® III Processor
Pentium® 4 Processor
Itanium™ Processor
Itanium™ 2 Processor
1965 Data (Moore)
Memory
Microprocessor
Source: Intel

Moore’s Law

ars technica

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TECHNOLOGY LAB / INFORMATION TECHNOLOGY

Moore’s law really is dead this time

The chip industry is no longer going to treat Gordon Moore's law as the target to aim for.

by **Peter Bright** - Feb 10, 2016 8:22pm EST

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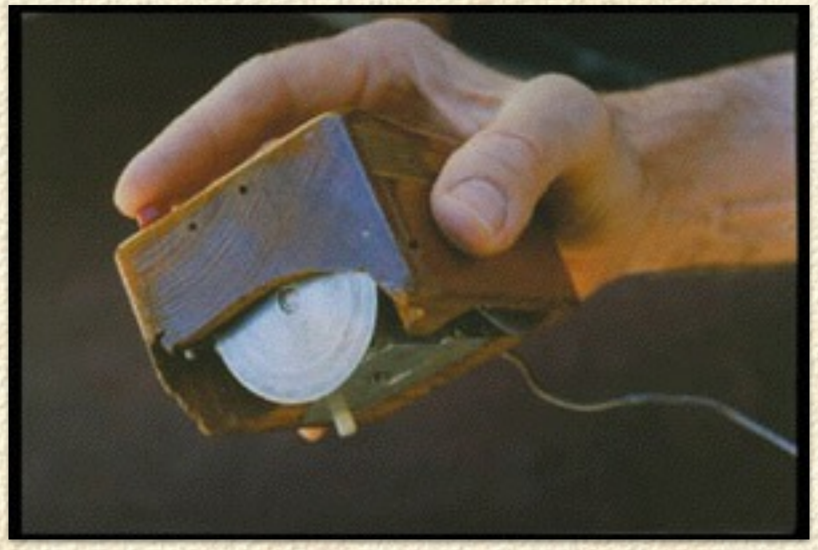
http://arstechnica.com/information-technology/2016/02/moores-law-really-is-dead-this-time/#p3

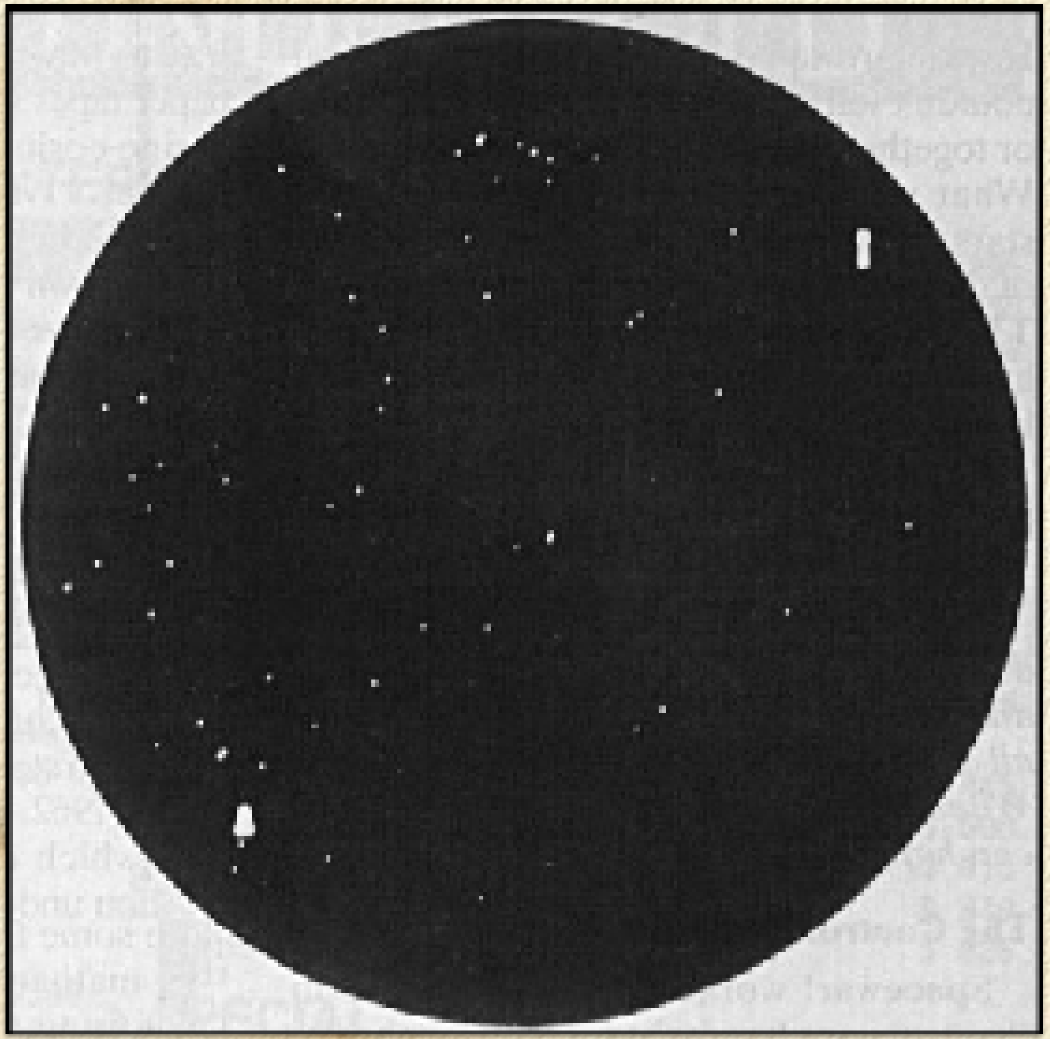
Other Advancements

- 1960 - DEC developed the first **terminal**
  - keyboard and screen for direct interaction with computer
- 1962 - Stanford and Purdue open the first CS departments
- 1962 - The first computer game is created at MIT
- 1964 - Doug Englebart develops the mouse
- 1968 - The birth of *Arpanet*



SpaceWar

- Developed by Steve Russell, MIT grad student



PDP 8

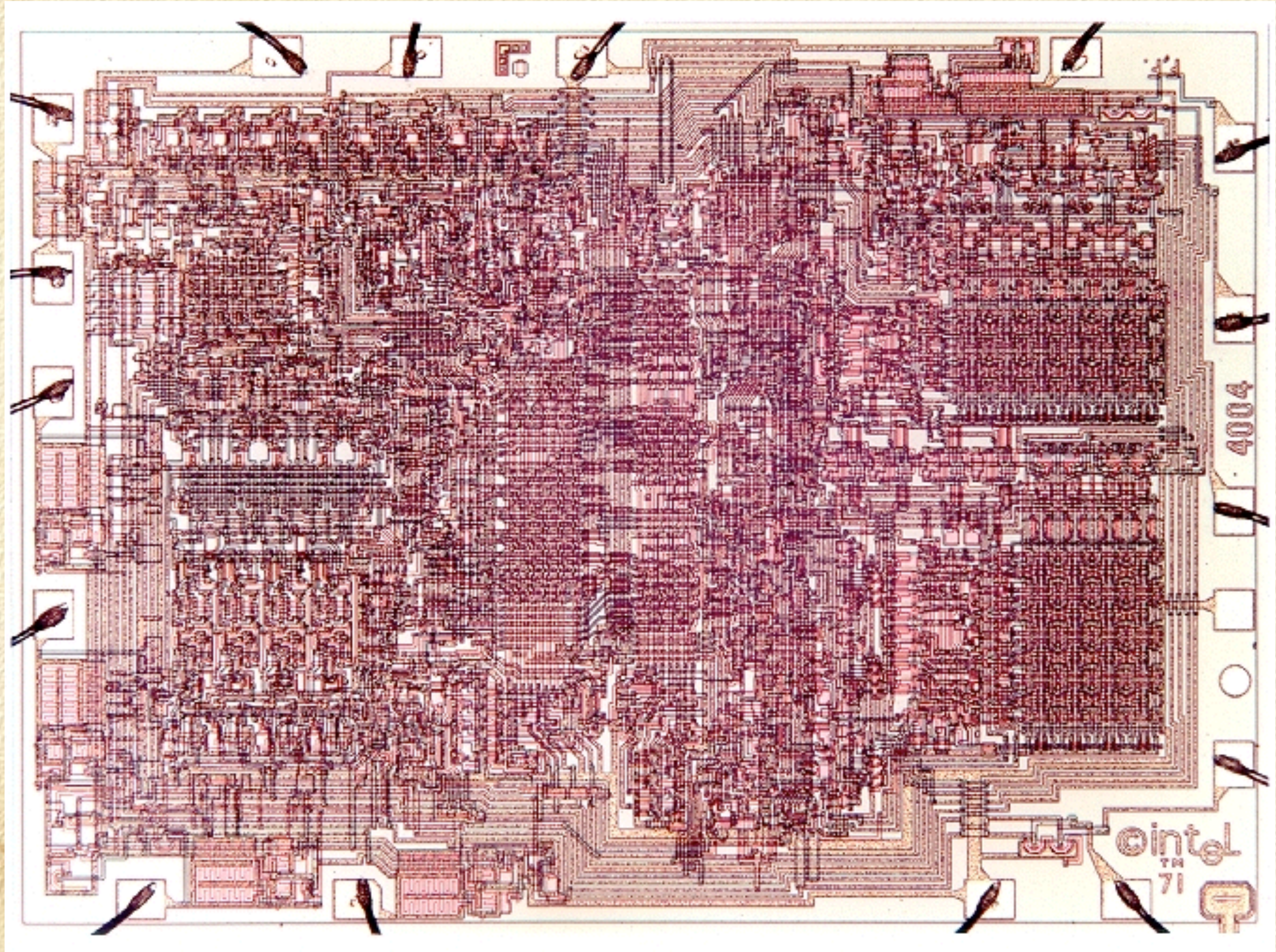
- The first of the *minicomputers*

The Fourth Generation (1971- ...)

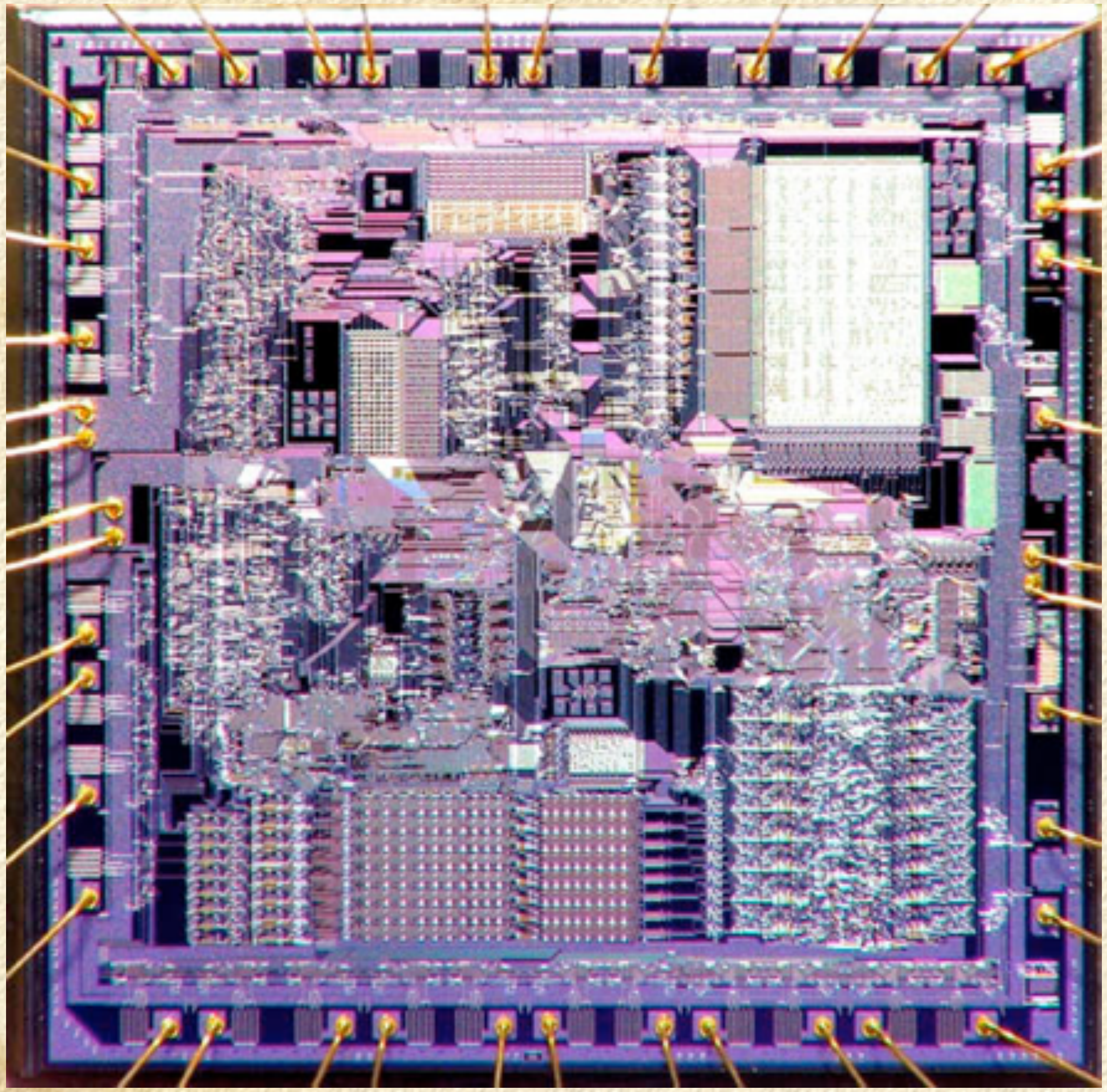
- **Large Scale Integrated Circuits**
  - able to put a whole microcomputer on a single chip

- Brought about the PC revolution
  - chips were now small enough and cheap enough to create *personal computers*
- Innovations come fast and furious

Enter the Microprocessor...



Ascendancy of Intel



Model Number	First Delivery	Clock rate	Bus width	Addressable memory	Number of Transistors
4004	11/15/71	740 kHz	4 bits	640 bytes	2,300
8008	4/1/72	0.5-0.8 MHz	8 bits	16 KB	3,500
8080	4/1/72	2 MHz	8 bits	16 KB	6,000
8086 / 8088	6/8/78	5-10 MHz	16 bits	1 MB	29,000

The first personal computer

- 1975 - The first PC, the Altair 8800 is released on the public

An innovation… that vanished

- 1973 - Xerox PARC develops the Alto
  - uses ethernet connection, a mouse and the first GUI

Birth of Apple

- 1977 - **Steve Jobs** and **Steve Wozniak** form Apple Computers
  - the Apple II is released from their garage

The IBM PC

- 1981 - Release of the first IBM Personal Computer

The GUI hits the mainstream

- 1984 - The Macintosh Computer says hello

Hitting the power wall

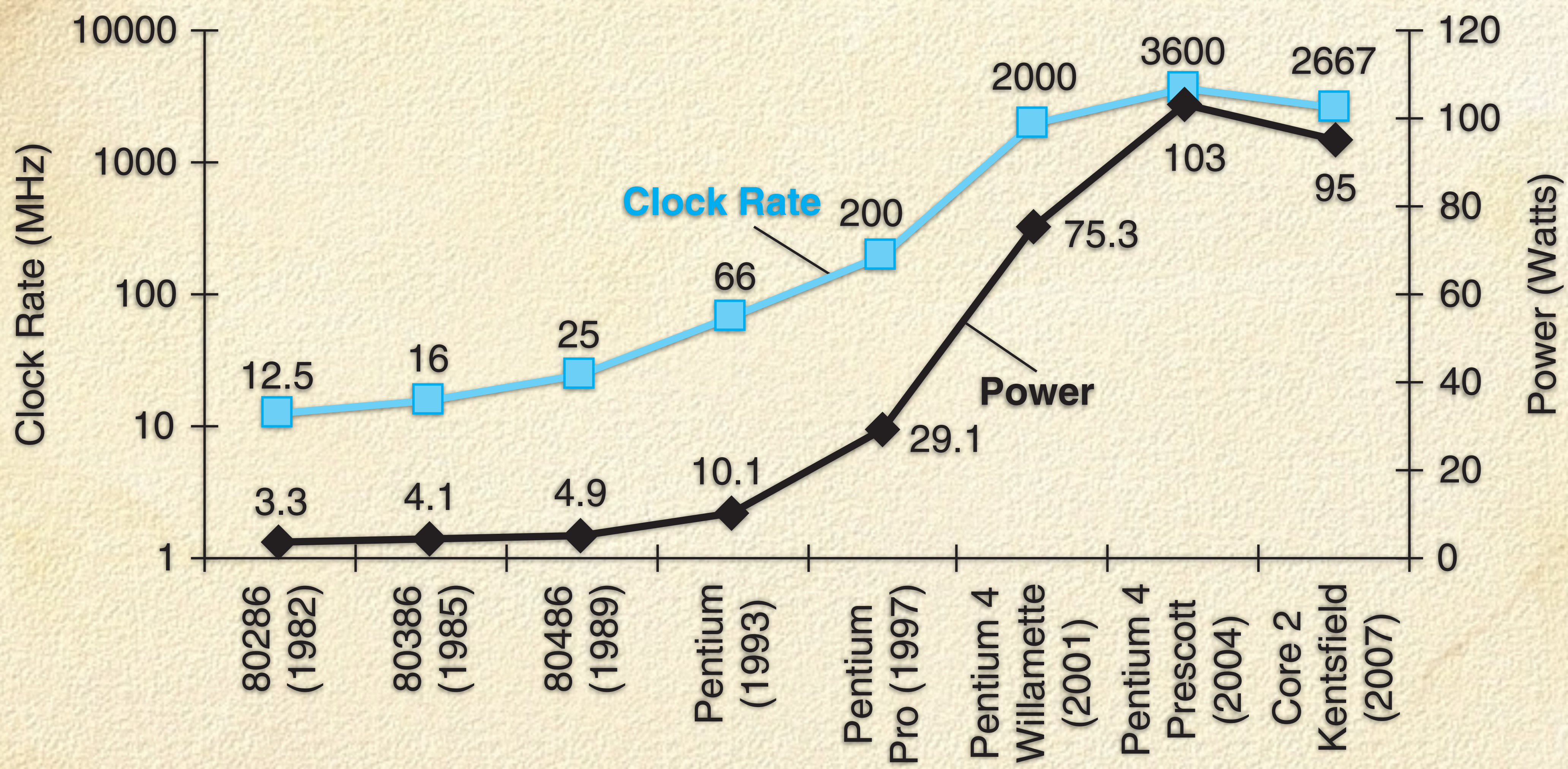


FIGURE 1.15 Clock rate and Power for Intel x86 microprocessors over eight generations and 25 years. The Pentium 4 made a dramatic jump in clock rate and power but less so in performance. The Prescott thermal problems led to the abandonment of the Pentium 4 line. The Core 2 line reverts to a simpler pipeline with lower clock rates and multiple processors per chip.

Processor performance

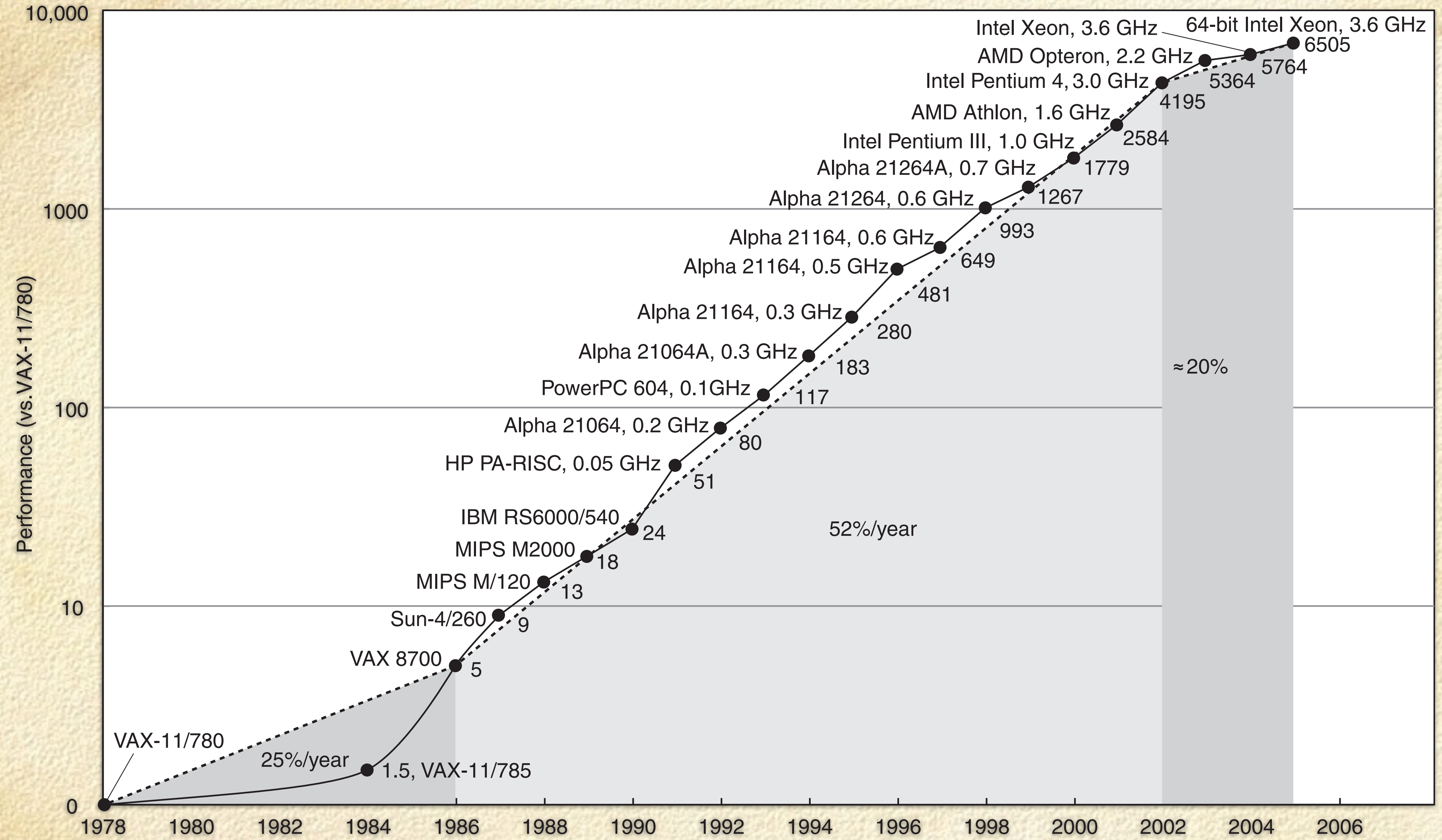
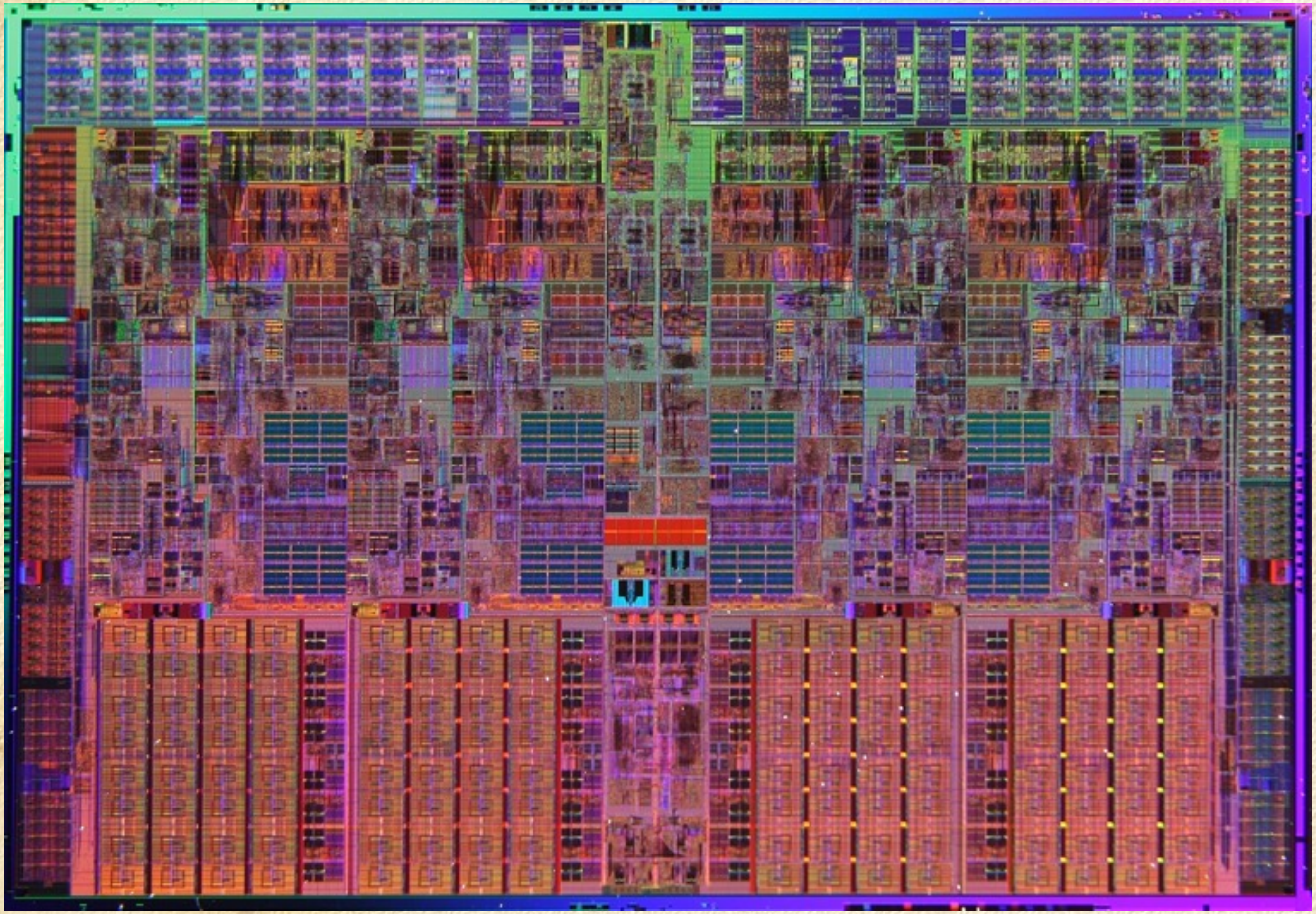


FIGURE 1.16 Growth in processor performance since the mid-1980s. This chart plots performance relative to the VAX 11/780 as measured by the SPECint benchmarks (see Section 1.8). Prior to the mid-1980s, processor performance growth was largely technology-driven and averaged about 25% per year. The increase in growth to about 52% since then is attributable to more advanced architectural and organizational ideas. By 2002, this growth led to a difference in performance of about a factor of seven. Performance for floating-point-oriented calculations has increased even faster. Since 2002, the limits of power, available instruction-level parallelism, and long memory latency have slowed uniprocessor performance recently, to about 20% per year.

Multiprocessors...



GPGPU computing