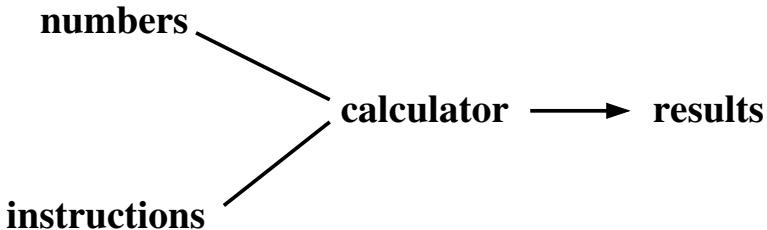# Computer Science 1400: Part #2:

Getting Here:
The First Computers (1940–1950)

THE FIRST ELECTRONIC COMPUTERS

THE FIRST COMPUTER COMPANIES

What *is* a Computer? (Take II)

numbers

instructions

calculator ⟶ **results**

Overall speed of calculation can only increase if input, calculation, and output operations **all** undergo **same** increase in speed.

Computing in the 1930's: The State of the Art

- Human computers (business / scientific / government)
- IBM tabulators (business / government)
- Differential analyzer (scientific)

New Frontiers in Computing: Mechanical
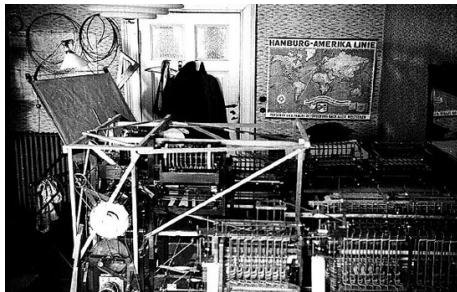

Howard Aiken
(1900–1973)

Harvard Mark I
(1944)

- Inspired by nonlinear equations in Aiken's PhD thesis.
- Done in collaboration with IBM starting in 1938.

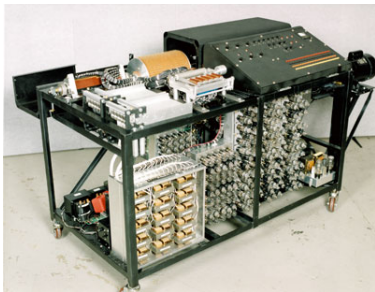# New Frontiers in Computing: Electromechanical

Konrad Zuse
(1910–1995)

Zuse Z1
(1938)

- Inspired by aircraft design calculations at Zuse's job.
- Done between 1935 and 1938 in parent's apartment.

New Frontiers in Computing: Electronic
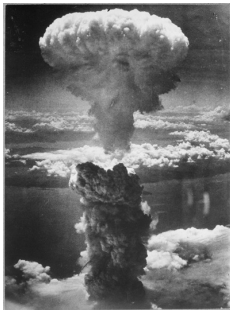

John Atanasoff
(1904–1995)

Atanasoff-Berry Computer
(1941)

- Inspired by statistical analyses at Iowa State U.
- Done with Clifford Berry starting in 1939.

The Driving Forces Behind Electronic Computers

Adolf Hitler
(1889–1945)

Atomic Bomb
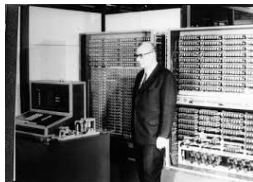(August 6, 1945)

Joseph Stalin
(1878–1953)

Computing During World War II: Applications

- Weapons design and use:
  - Artillery tables
  - Automated firing control
  - Atomic bomb design
- Decrypting encoded military messages

Computing During World War II: Machines

Harvard Mark I
(1944
Mechanical
Artillery Tables)

Zuse Z3
(1941
Electromechanical
Aircraft Design)

Colossus
(1944
Electromechanical
Codebreaking
(Lorentz Cipher))

Electronic Computing During World War II

Presper Eckert
(1919-1995)
and
John Mauchley
(1907-1980)

- Mauchley writes electronic computer memo in 1942.
- Eckert and Mauchley collaborate in 1943 at Moore School of Electrical Engineering, U. Penn, on ENIAC (Electronic Numerical Integrator and Computer).
- Focused on electronic implementation of computer.

Electronic Computing During World War II (Cont'd)
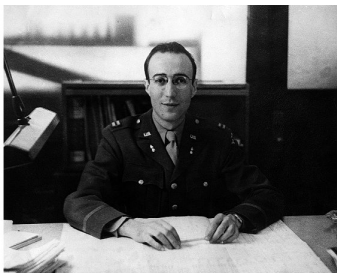
Herman Goldstine
(1913-2004)

John von Neumann
(1903-1957)

- Goldstine collaborates with Mauchley in 1943 (after reading 1942 memo) and with von Neumann in 1944 (after meeting on a train).
- Focused on logical organization of computer.

# Electronic Computing During World War II (Cont'd)

ENIAC (1945)

- Performs 5000 calculations / sec; programmed by wiring.

ENIAC: The Forgotten Fathers?

- After meeting at AAAS in Philadelphia in December 1940, Atanasoff (for legal patent reasons) declines to discuss Mauchley technical details of ABC; however, Atanasoff invites Mauchley to visit Iowa and see ABC.

- Mauchley visits Iowa for 4 days in June 1941; sees ABC, chats with Atanasoff and Berry about design of ABC, and reads (but is not given copy of) ABC documentation.

- Atanasoff and Berry leave Iowa and ABC for war work after attack on Pearl Harbor in December 1941; Mauchley writes electronic computer memo in August 1942.

- Extent to which ABC influenced ENIAC still hotly debated; however, in 1973, evidence of influence was considered legally sufficient to overturn ENIAC patents filed by Eckert and Mauchley in 1947.
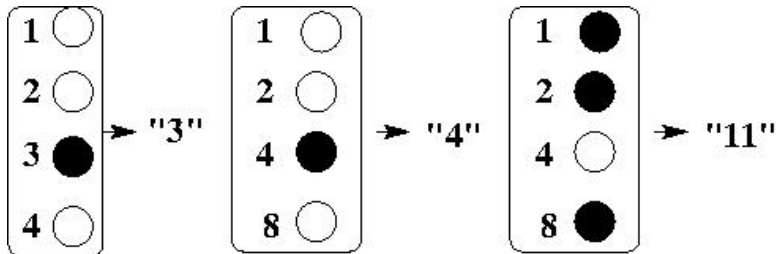
What *is* a Computer? (Take III)
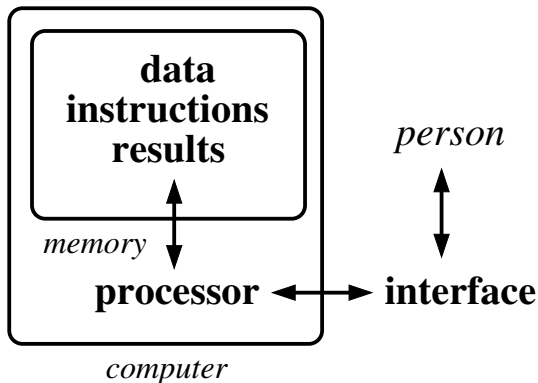
- Proposed by von Neumann and collaborators in 1945's
  EDVAC Report as the stored program computer.

Interlude: Digital Computer Organization

- A **bit** is a 0/1 memory element; a **word** is a set of bits.
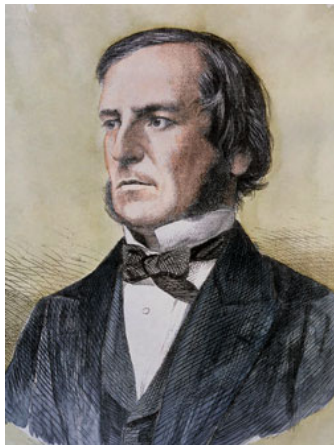- Store numbers compactly in words using binary encoding.

Interlude: Digital Computer Organization (Cont'd)

- Computer memory consists of a set of words, each with its own unique numerical address.

1	2	3	4	5	6	7	8
9	10	11	12 **15**	13	14	15	16
17	18	19	20	21 **X**	22 **Y**	23 **Z**	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40

George Boole
(1815-1864)

Boolean logic

Claude Shannon
(1916-2001)
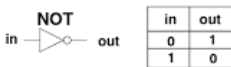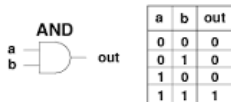
Boolean logic gates
(Shannon MSc (1937))

- Combine logic gates to construct circuits that manipulate numbers encoded in binary, *e.g.*, a one-bit (half-)adder:
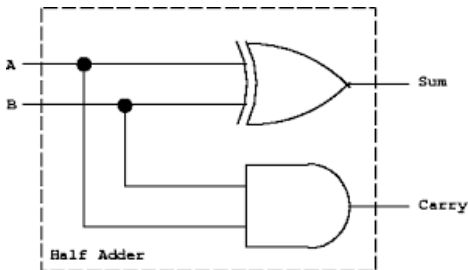
- All processing and memory components of a digital computer can be specified by logic-gate circuits.

Computing After World War II: Applications

- Weapons design and use:
    - Atomic and hydrogen bomb design
    - Bomber defense / offense systems
    - Missile guidance systems
- Government (recordkeeping / planning)
- Business (recordkeeping / planning)
- Science (numerical calculation)

Computing After World War II: Overview

- ENIAC team splits up in 1946 – work continues at Moore School on EDVAC (Electronic Discrete-Variable Automatic Computer), von Neumann and Goldstine develop their own stored-program computer in collaboration with RCA at Princeton, and Eckert and Mauchley form Electronic Control Corporation (ECC) to commercialize UNIVAC (Universal Automatic Computer).

- In wake of Aiken's error at Mark I (IBM Sequence Controlled Calculator) ceremony in 1944, Watson Sr. steered IBM R&D to create Selective Sequence Electronic Calculator (SSEC) and Card Programmed Calculator (CPC) ("evolution, not revolution").

Computing Technology: Processor

Vacuum tube
(1904)
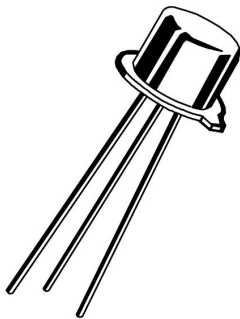
Transistor
(1947)

- Transistor invented by William Shockley (1910-1989).

Computing Technology: Memory

Punch card / tape
(1940s)

Mercury delay line
(1940s)

CRT display
(1940s)

Computing Technology: I/O Interface

Punch card / tape
(1940s)

Teletype
(1940s)

CRT Display
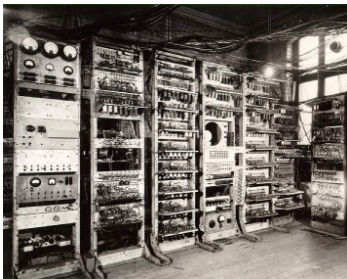(1940s)

British Computing After World War II

Leslie Comrie
(1893–1950)

Maurice Wilkes
(1913–2010)

- Comrie spread *EDVAC Report* in England; Wilkes built
  EDSAC (Electronic Delay Storage Automatic Calculator).

British Computing After World War II (Cont'd)

SSEM ("Baby")
(1948, U. Manchester)

EDSAC
(1949, U. Cambridge)

- SSEM and EDSAC were world's first (non-German) operational stored-program electronic computers.
- SSEM developed into commercial computer by Ferranti.

Human Computing After World War II

- Towards end of WWII, human computing groups dominated by women ("kilogirl" = 1000 human-computing hours); several speed and accuracy comparisons also run between human computing groups and prototype electromechanical and electronic computers.

- After WWII, many human computer groups dismantled and formation of new ones discouraged by electronic computing groups. Human computing survived in niches (e.g., Blanch's Institute for Numerical Analysis at UCLA, Jet Propulsion Laboratory (JPL), NACA / NASA).

- Some women computers become computer programmers (e.g., under Mauchley on the UNIVAC, at JPL / NACA / NASA).