

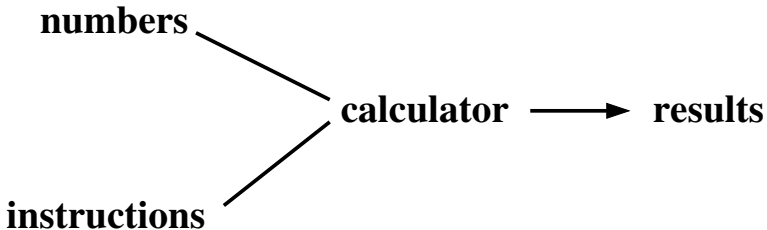
## Computer Science 1400: Part #2:

### Getting Here: The First Computers (1940–1950)

THE FIRST ELECTRONIC COMPUTERS

THE FIRST COMPUTER COMPANIES

## What is a Computer? (Take II)



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)



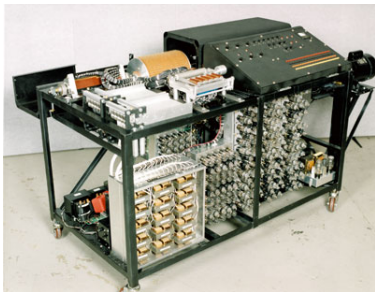
Harvard Mark I  
(1944)

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

## New Frontiers in Computing: Electronic



John Atanasoff  
(1904-1995)



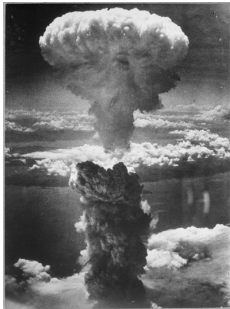
Atanasoff-Berry Computer  
(1941)

- 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)

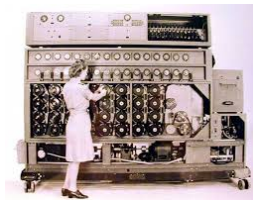
## Computing During World War II: Applications

- 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)



Bombe  
(1940  
Electromechanical  
Codebreaking  
(Enigma Cipher))



Colossus  
(1944  
Electromechanical  
Codebreaking  
(Lorentz Cipher))



## Electronic Computing During World War II

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



- Started collaborating in 1942 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)

- Started working together in 1944 after meeting on train; collaborated with Eckert and Mauchley on ENIAC.
- Focused on logical organization of computer.

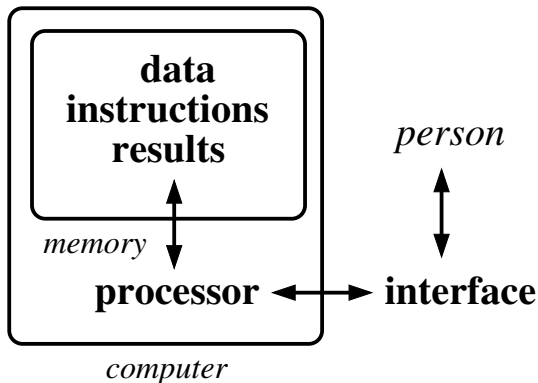
# Electronic Computing During World War II (Cont'd)



ENIAC (1945)

- Performs 5000 calculations / sec; programmed by wiring.

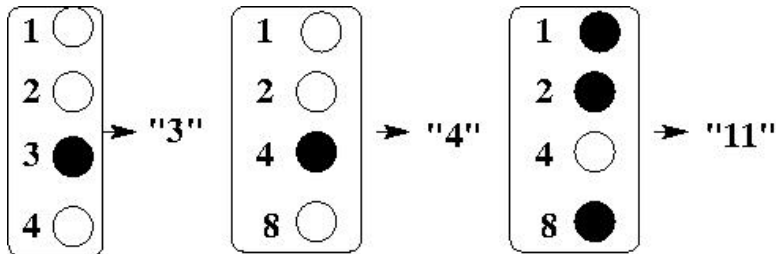
## What *is* a Computer? (Take III)



- 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.

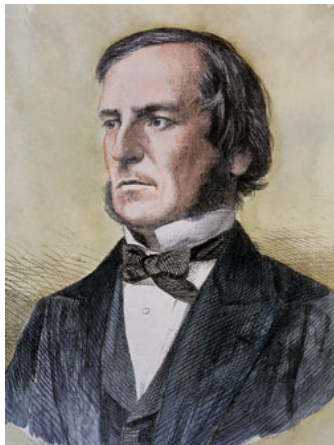


## Interlude: Digital Computer Organization (Cont'd)

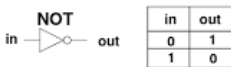
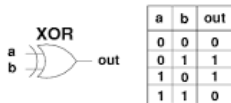
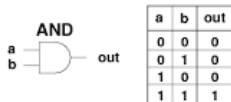
- Computer memory consists of a set of words, each with its own unique numerical address.

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

## Interlude: Digital Computer Organization (Cont'd)



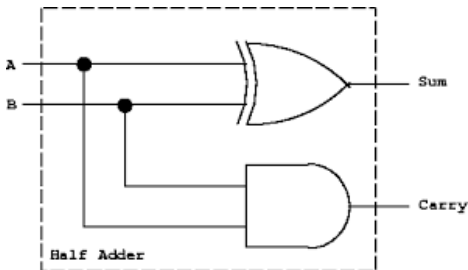
George Boole  
(1815–1864)



Boolean logic gates

## Interlude: Digital Computer Organization (Cont'd)

- 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)

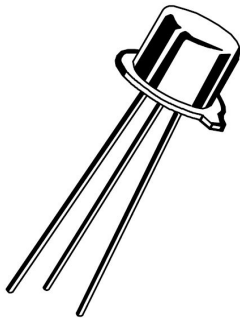
## Computing After World War II: Overview

- 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



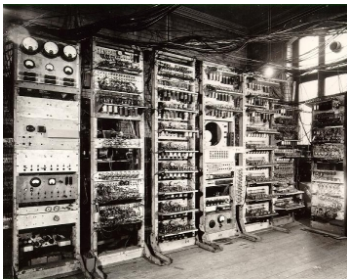
Leslie Comrie  
(1893-1950)



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 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 (Blanch’s Institute for Numerical Analysis at UCLA).
- Some women computers become computer programmers (particularly under John Mauchley on the UNIVAC).