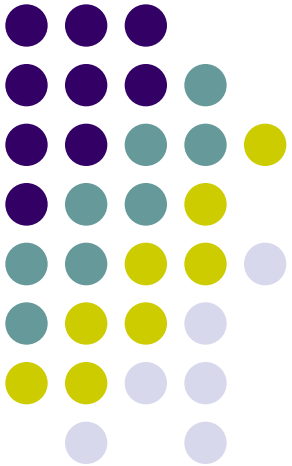
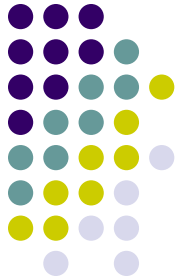
CSE 301
History of Computing

World War II and the
Advent of Modern Computing



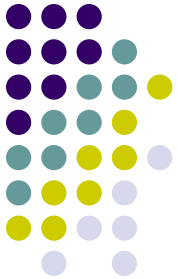
George Stibitz



- Electrical Engineer at Bell Labs
- Constructed digital electronic calculator out of odds and ends in his Kitchen (1937)
  - called it the “Model-K”
  - did binary arithmetic
  - used lights to display result
- Bell Labs saw the potential
  - Completed Stibitz Complex Number Calculator in 1939
- Would be the foundation for most digital computers

- http://ei.cs.vt.edu/~history/Stibitz.html

Who invented the computer?



- The Candidates:
  - Zuse? (Z1-Z4)
  - Flowers/Turing? (COLOSSUS)
  - Atanasoff/Berry? (ABC Computer)
  - Eckert/Mauchly? (ENIAC/EDVAC)
  - Von Neumann? (EDVAC)
  - Newman/Williams? (Manchester Baby)
  - Wilkes? (EDSAC)

WW II

- At start of WW II (1939)
  - US Military was much smaller than Axis powers
  - German military had best technology
    - particularly by the time US entered war in 1941
  - US had great industrial *potential*
    - twice the steel production as any other nation

- A military and scientific war
  - Outcome was determined by technological developments
    - atomic bomb, advances in aircraft, radar, code-breaking computers, and many other technologies

Konrad Zuse

- German Engineer
- Z1 – built prototype 1936-1938 in his parents living room
  - did binary arithmetic
  - had 64 word memory
- Z2
  - called by some first fully functioning electro-mechanical calculator/computer
- Z3 (1941)
  - used by German's Aircraft Institute
  - Z3 was a stored-program computer
- Z1 – Z3 were electromechanical computers
  - destroyed in WWII, not rebuilt until years later

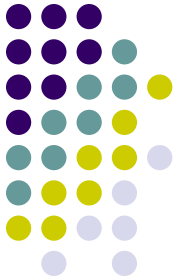
The Z4

- A digital, electronic computer
- A stored program computer
- Never could convince the Nazis to put it computer to good use
- Smuggled to Switzerland in a military truck
- Not completed until years after the War
- A forgotten computer.
- After the War, Zuse was left behind. Why?
  - the accelerated pace of American/English technological advances
  - the destruction of German infrastructure

English Code-breaking

- Alan Turing works at Bletchley Park on breaking the German Enigma Code
- Made up of a set of rotors to translate and a reflector.
- Input letter using keys
- Output letter shown with lights

Enigma Example

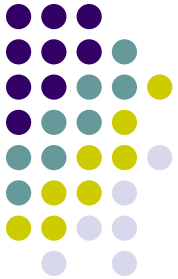


ABCDEFGHIJKLMNOPQRSTUVWXYZ	
BDFHJLCPRTXVZNYEIWGAKMUSQO	rotor1
AJDKSIRUXBLHWTMCQGZNPYFVOE	rotor2
EKMFLGDQVZNTOWYHXUSPAIBRCJ	rotor3
YRUHQSLDPXNGOKMIEBFZCWVJAT	reflector

After one letter is encoded, the first rotor rotates one position.

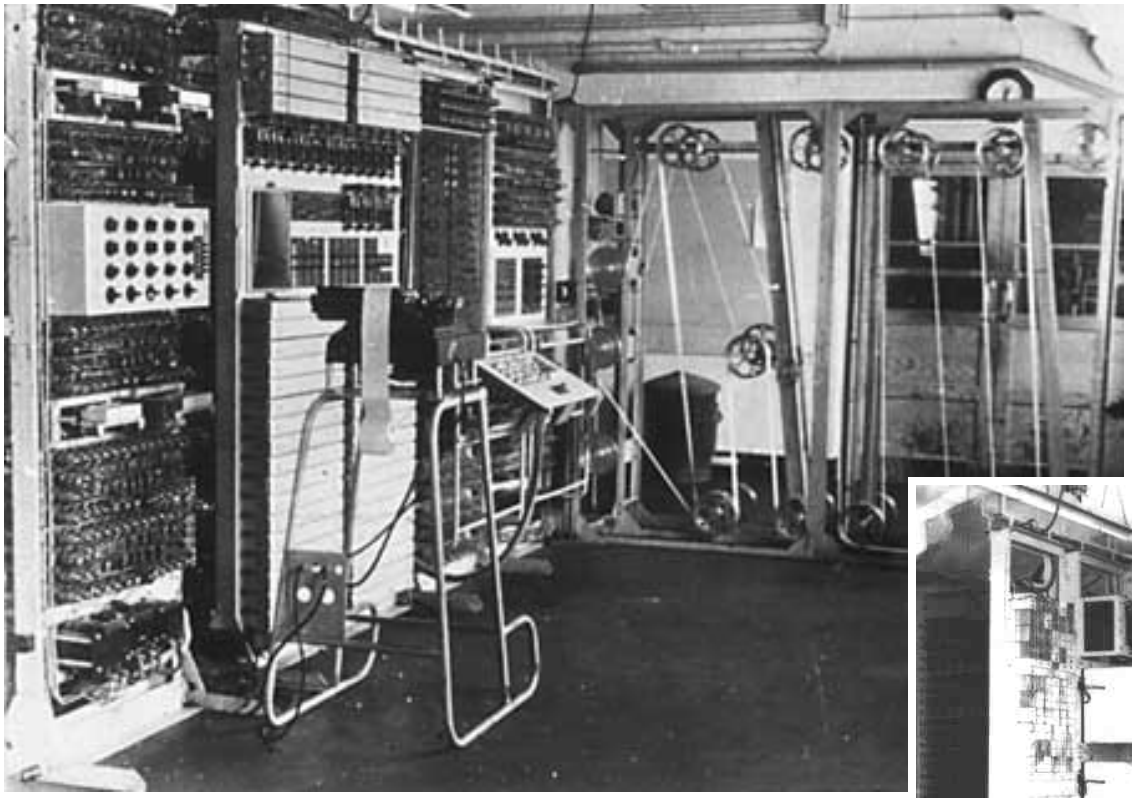
Once the first rotor rotates one whole turn, the second rotor rotates one position, ...

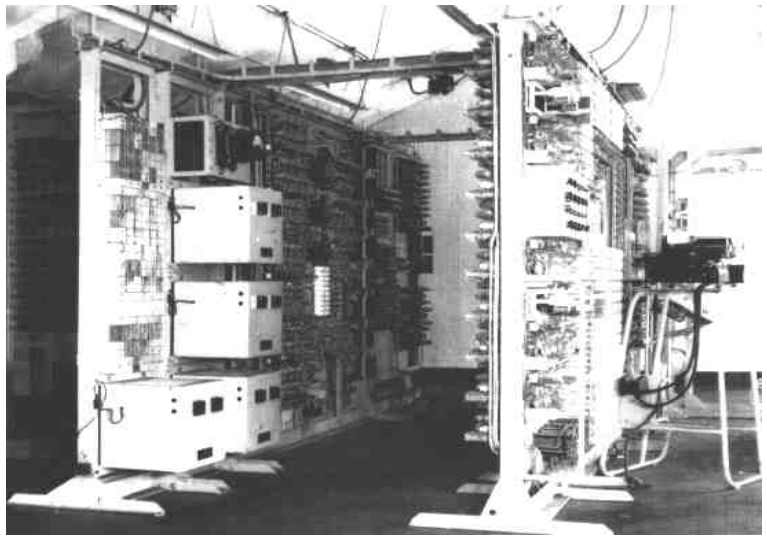
COLOSSUS



- Germans had another cipher for ultra-top-secret communications called *Geheimfernschreiber* (secret telegraph)
  - The allies called this the “Fish”
- Designed a machine called COLOSSUS that could break the Fish code in 1943
- A digital electronic computer
  - 1800 vacuum tubes
- Theoretical design by Alan Turing
- Practical design by Tommy Flowers

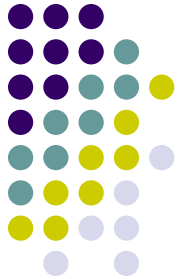
Colossus





from Tony Sale,
original curator of the
Bletchley Park Museum

The Atanasoff-Berry Computer (ABC)



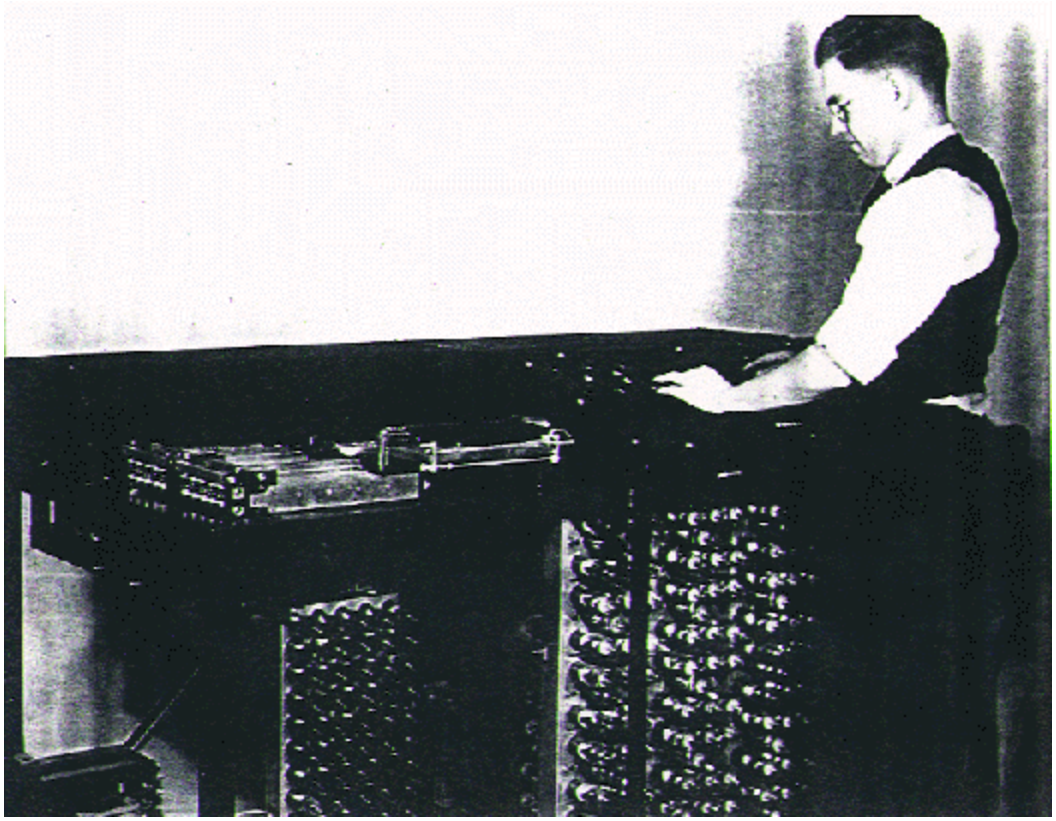
- By John Vincent Atanasoff (designer) and Clifford Berry (his grad student, the builder) at Iowa State University during 1937-42
  - the first US *electronic* digital computer?
  - used binary arithmetic
  - parallel processing
  - separation of memory and computing functions

- How did Atanasoff get the idea?
  - Iowa was a dry state, so he drove 189 miles to Illinois and got a drink of bourbon at a roadhouse
  - neon lights sparked the idea

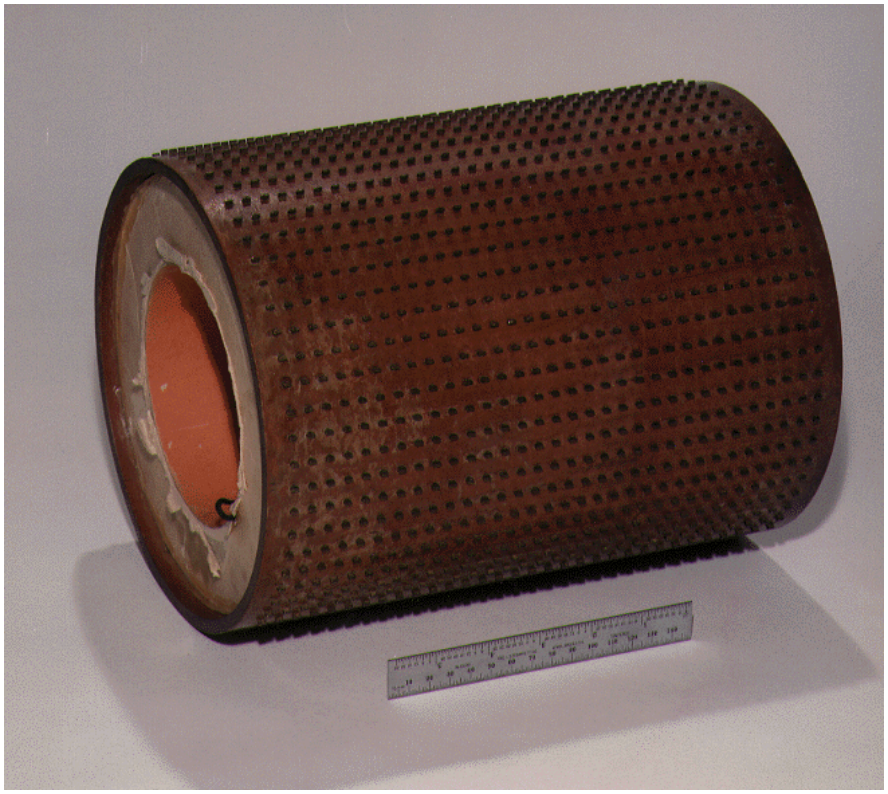
John Vincent Atanasoff

- 1903-1995
- Given $650 to start work on his ideas of an electronic computer in 1937.
- Was called to war effort at the Naval Ordinance Lab in Washington DC
  - had to give up ABC
- Returns in 1948 to Iowa State to find the ABC dismantled.
- Receives the National Medal of Technology from President George Bush in 1990

ABC



Clifford Berry with the ABC (Ames Laboratory, DOE)



The only surviving fragment of the original ABC built in 1939.
(Ames Laboratory, DOE)

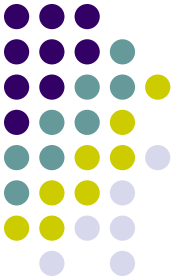
Mauchly and Eckert

Mauchley

Eckert

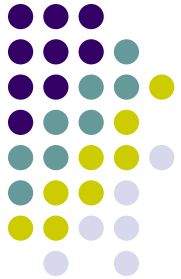
from
www.computer.org

The Birth of ENIAC



- Collaboration between Moore School of Electrical Engineering at the University of Pennsylvania and the Ballistic Research Laboratory in Aberdeen, MD
- Both sites had Bush Differential Analyzers
- UPenn's DA was faster but not fast enough for the amount of computation needed to compute trajectory tables
- Dr. John W. Mauchley of the Moore School visits Atanasoff at Iowa State to learn about his research in electronic computing in 1941

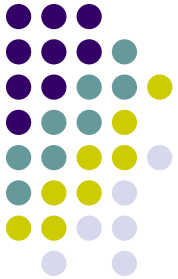
Mauchly and Eckert create ENIAC



- Mauchly returns and works with Dr. J. Presper Eckert on creating an electronic computer to solve differential equations for the Ordinance Dept.
- In 1943, the Ordinance Dept. signs a contract for UPenn to develop an electronic computer based on the plans of Mauchly and Eckert
  - Eckert – chief engineer
  - Mauchley – principal consultant
  - presented by Lt. Herman H. Goldstein, mathematician
- Constructed completed in the fall of 1945 after WWII ends, and dedicated in February 1946.

ENIAC

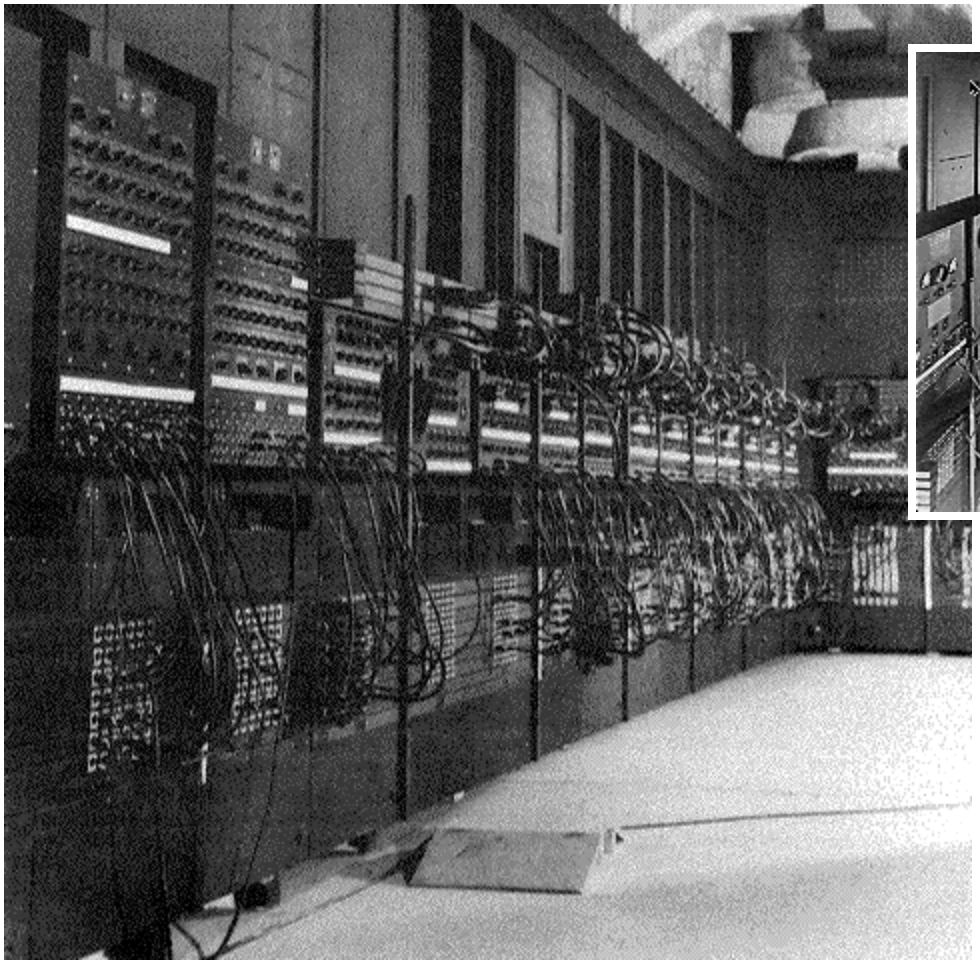
Electronic Numerical Integrator and Computer

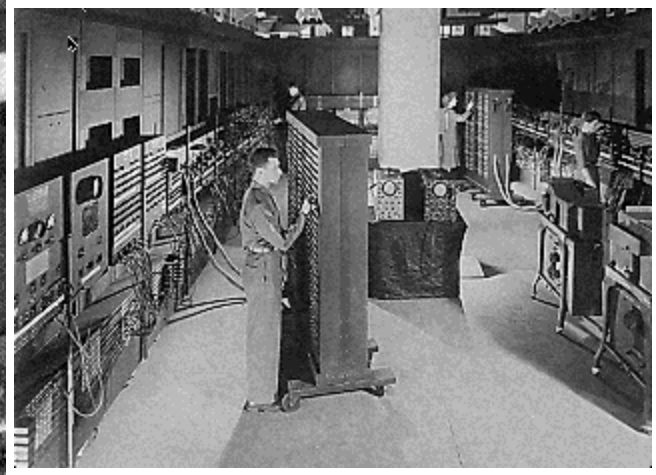


- This is the most important computer we've discussed so far
  - It's creation commonly called the birth of modern computers
  - Speed left Mark I behind
    - 5000 vs. 3 calculations per second
  - it is the first true ancestor of all computers used today
  - In it's lifetime, it will do more computing than than the entire human race had done before 1945
- Filled an entire room
  - 42 panels, each 9' X 2' X 1', three on wheels
  - organized in a U shaped around the perimeter of a room with forced air cooling
- Weighed 30 tons
- Reportedly consumed 150-200 kW of power
- Contained a huge amount of parts:
  - approx. 19,000 vacuum tubes
  - 1500 relays
  - over 100,000 resistors, capacitors and inductors
- Input and output via an IBM card reader and card punch

ENIAC

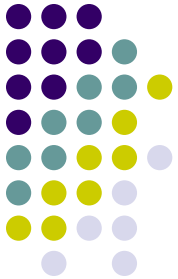
Electronic Numerical Integrator and Computer





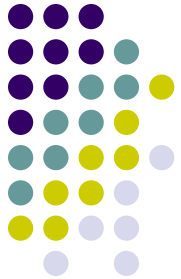
(Virginia Tech –
History of Computing)

Advantages and Disadvantages of ENIAC



- Advantage:
  - Speed in calculation of ballistic trajectories:
    - Human with hand calculator: 20 hours
    - Bush Differential Analyzer: 15 minutes
    - ENIAC: 30 seconds
      - "could calculate the trajectory of a speeding shell faster than the shell could fly"
- Disadvantages:
  - Programming took very long
    - plugging in patch cables and setting 3000 switches
  - Vacuum tubes would burn out quickly
    - In 1952, 19,000 tubes were replaced → ~50 per day!
  - Small memory limited the types of problems ENIAC could solve – used mercury delay lines
  - Used decimal system

Who created the first electronic computer?

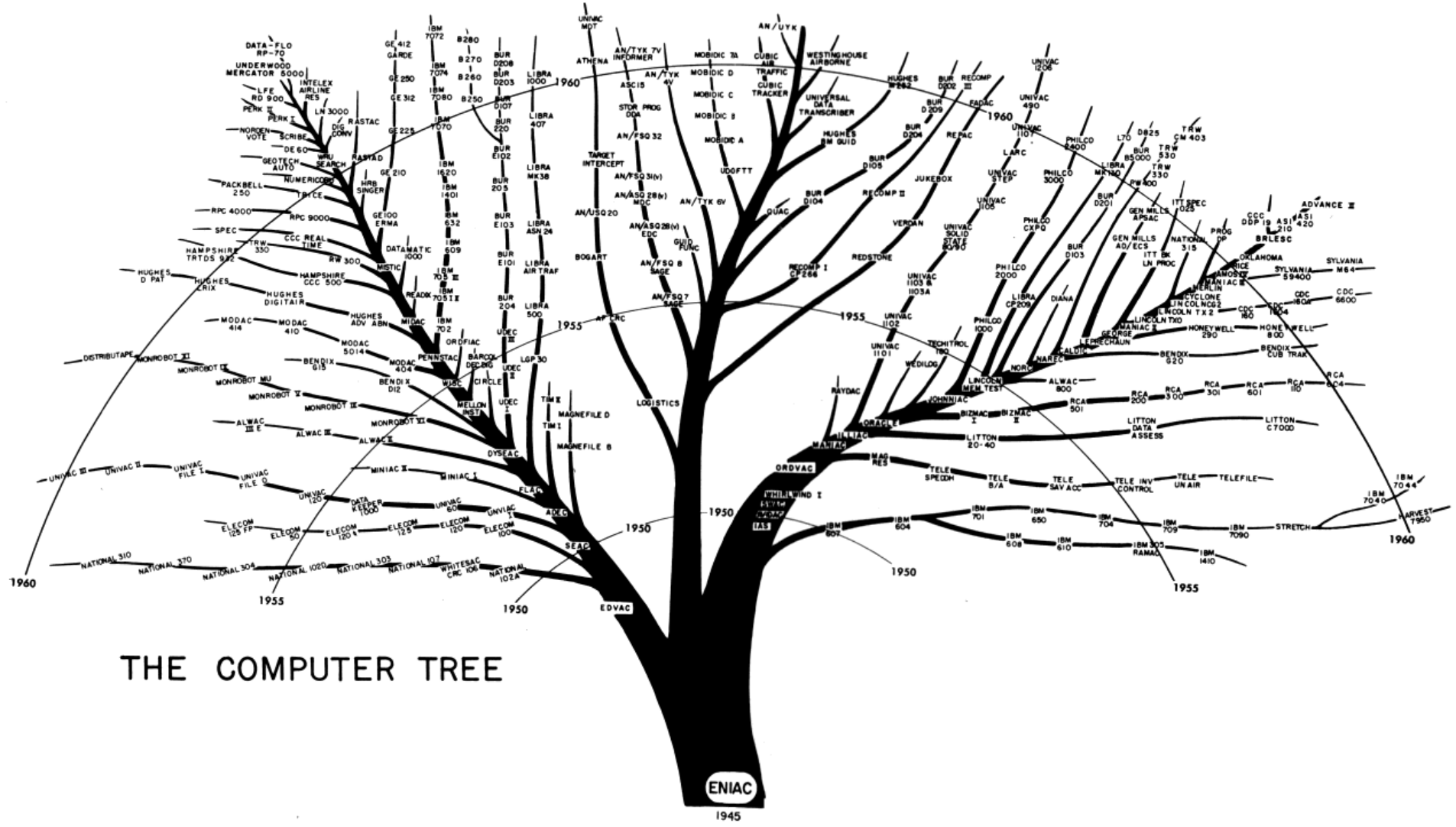


- *"...With the advent of everyday use of elaborate calculations, speed has become paramount to such a high degree that there is no machine on the market today capable of satisfying the full demand of modern computational methods. The most advanced machines have greatly reduced the time required for arriving at solutions to problems which might have required months or days by older procedures. This advance, however, is not adequate for many problems encountered in modern scientific work and the present invention is intended to reduce to seconds such lengthy computations..."* - from the ENIAC patent (No. 3,120,606), filed 6/26/47.

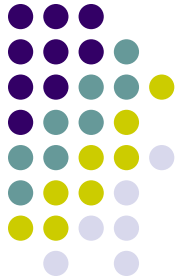
- On October 19, 1973, US Federal Judge Earl R. Larson signed his decision following a lengthy court trial which declared the ENIAC patent of Mauchly and Eckert invalid and named Atanasoff the inventor of the electronic digital computer -- the Atanasoff-Berry Computer or the ABC.

The Computer Tree

http://ftp.arl.mil/~mike/comphist/61ordnance/chap7.html



Eniac's Spawn

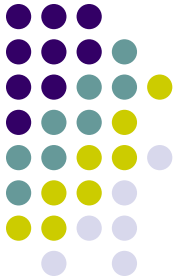


- Computer experts from America & Britain attended lectures on ENIAC/EDVAC
  - Britain was one of the only European nations not ravaged by war
  - Attendees spawned constructions
  - Manchester Baby Computer (1948)
  - Cambridge University's EDSAC (1948)
- Von Neumann's IAS Computers
- Eckert & Mauchly's BINAC & UNIVAC
- The Moore School's EDVAC (completed in 1952)
- IBM & Columbia's Selective Sequence Electronic Calculator
- Lots of others
  - JONNIAC, MANIAC, ILLIAC, SILLIAC

John von Neumann

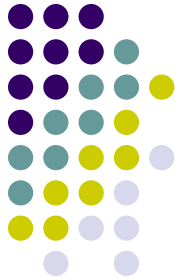
- 1903-1957
- born in Budapest, Hungary
- a child prodigy
  - at age 6, could divide 8-digit numbers in his head
- fled persecution of Jews in Hungary
- renowned mathematician at Princeton

John von Neumann



- During WWII, he served as a consultant to the armed forces.
- Contributions:
  - proposal of the implosion method for bringing nuclear fuel to explosion
  - participation in the development of the hydrogen bomb
  - guess what? more calculating necessary
- Member of the Navy Bureau of Ordinance 1941-1955
  - chance meeting with Herman Goldstine, introducing him to the ENIAC project
  - visited ENIAC team and observed its use, including its deficiencies
  - Interested in project, he became an advisor to the group to help develop a new design
    - new design was the “stored-program” computer

The stored-program concept



- Instructions and data were to be stored together in the same memory unit
  - Example: ADD #100, R1

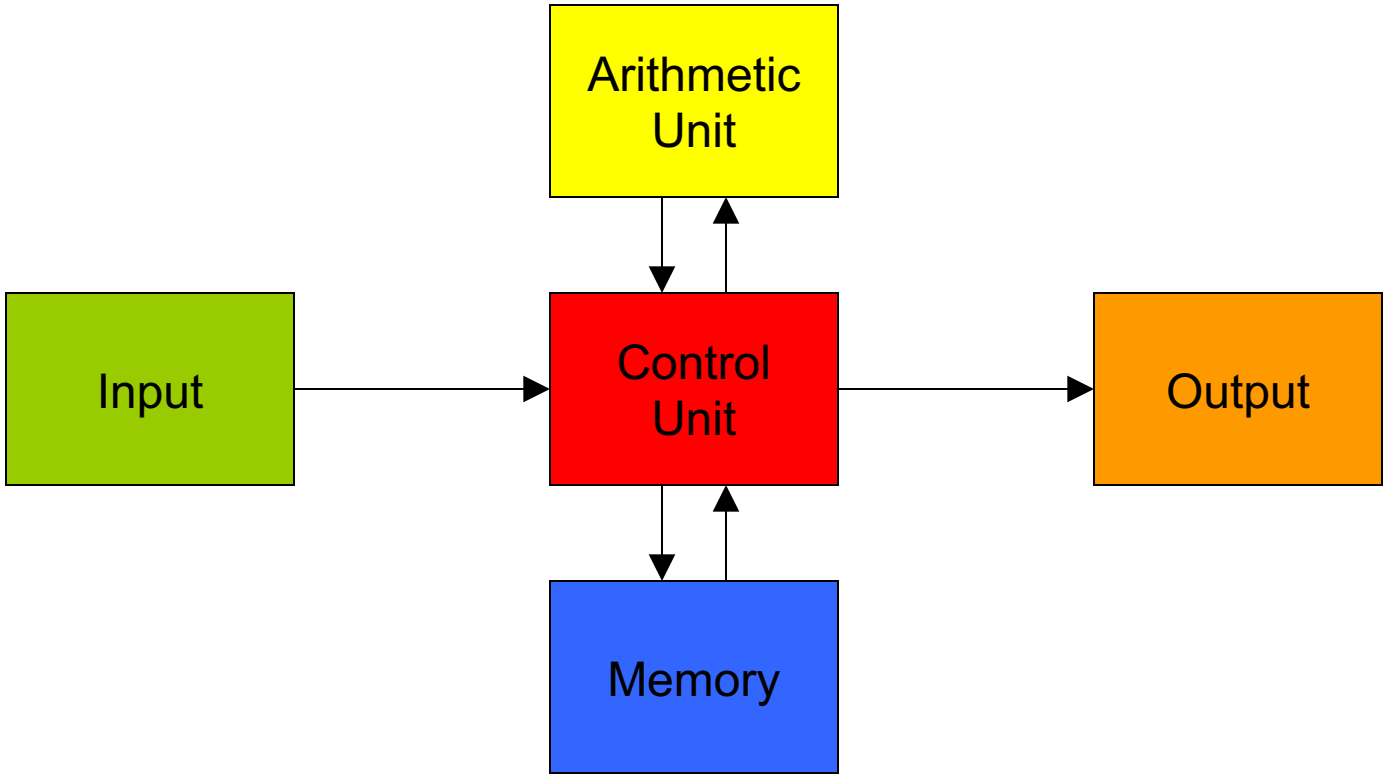
    1000 0001 ADD to R1

    0110 0110 data 100
  - Example: ADD @100, R1

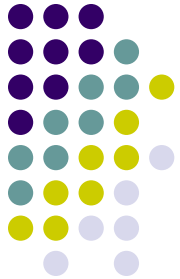
    1001 0001 ADD to R1

    0110 0110 data at address 100
- Instructions were stored in memory sequentially with their data
- Instructions were executed sequentially except where a conditional instruction would cause a jump to an instruction someplace
- Fetch-Decode-Execute
- Binary switching circuits for computation and control
- This is how all modern-day computers work
  - Called the von-Neumann machine
  - Eckert & Mauchly were furious it was not named after them
    - They claimed it was their idea first, but could not implement it during the war due to time constraints

The stored-program concept

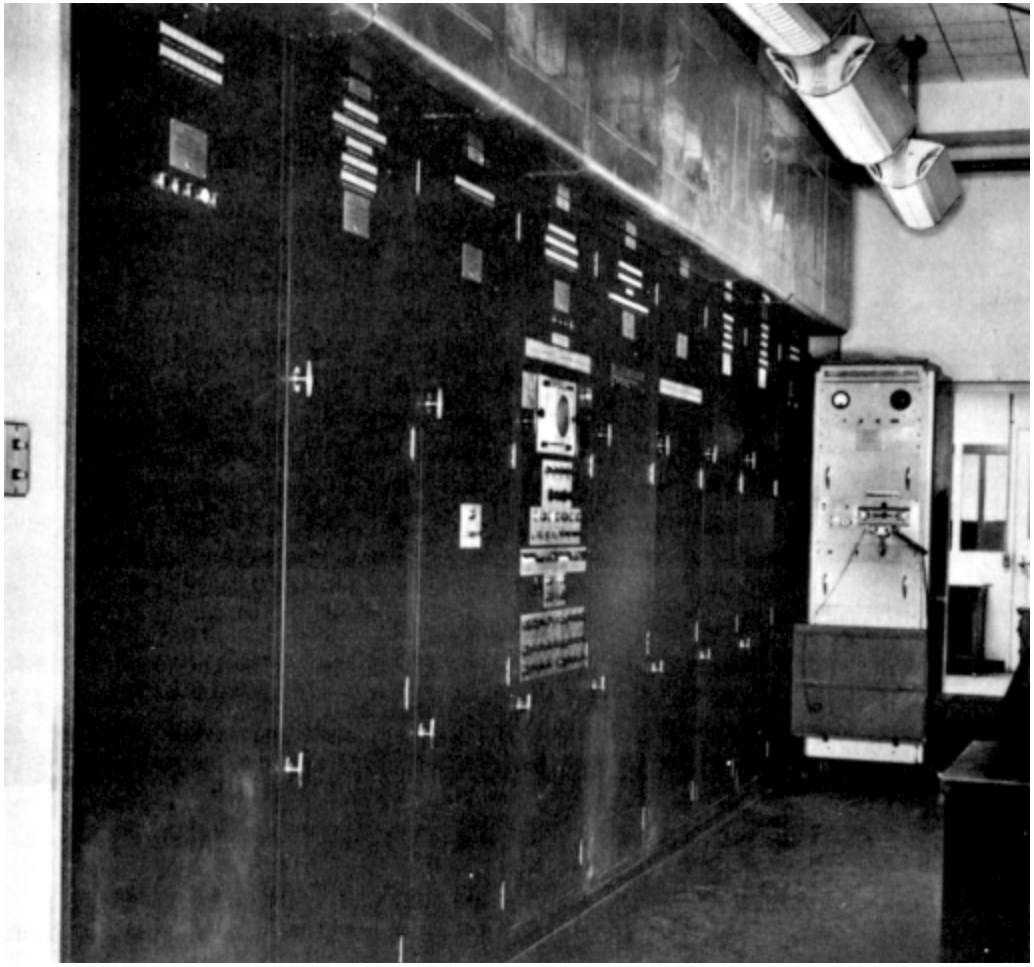


The EDVAC Report



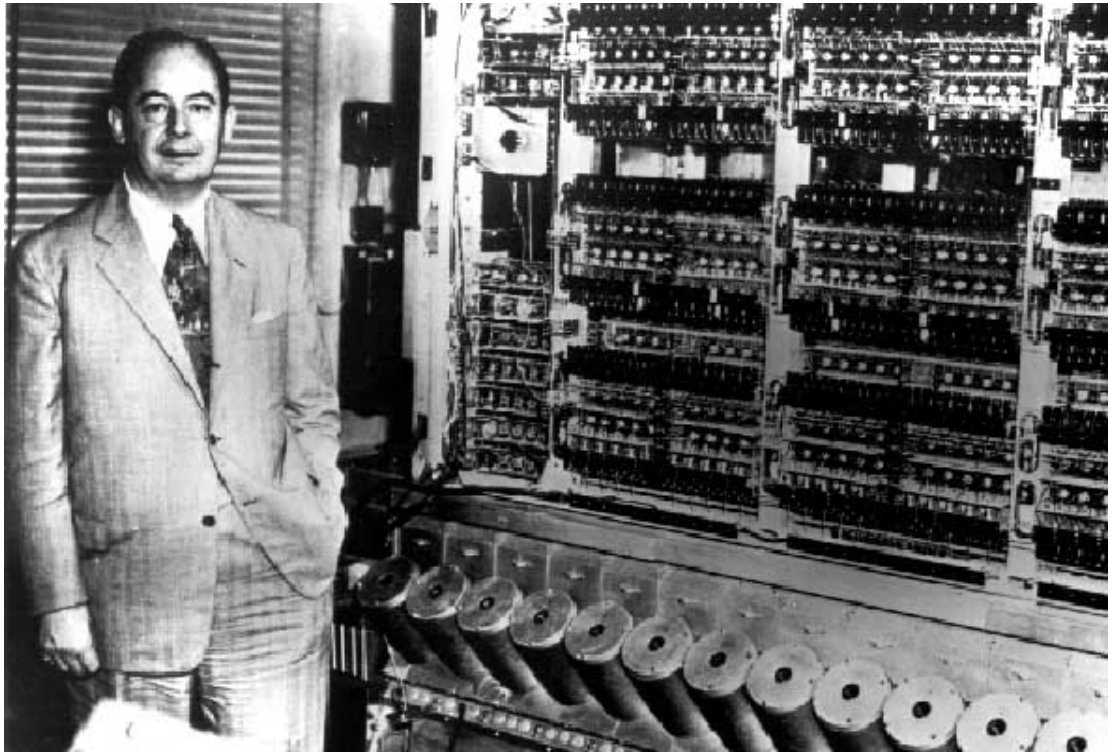
- Stored-program concept is the fundamental principle of the EDVAC (Electronic Discrete Variable Automatic Computer)
- Although Mauchly and Eckert are generally credited with the idea of the stored-program, von Neumann publishes a draft report that describes the concept and earns the recognition as the inventor of the concept
  - “von Neumann architecture”
    - some Germans might say Zuse had this idea first
  - *A First Draft of a Report of the EDVAC* published in 1945
  - http://www.wps.com/projects/EDVAC/

EDVAC



from U.S. Army
Research Laboratory
ftp.arl.army.mil

John von Neumann



Hungarian stamp
in his honor

von Neumann with his first IAS computer

from the Archives of the Institute for Advanced Study

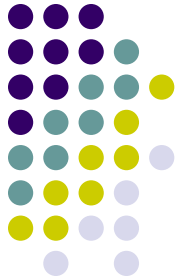
John von Neumann's death

... his mind, the amulet on which he had always been able to rely, was becoming less dependable. Then came complete psychological breakdown; panic, screams of uncontrollable terror every night. His friend Edward Teller said, "I think that von Neumann suffered more when his mind would no longer function, than I have ever seen any human being suffer."

Von Neumann's sense of invulnerability, or simply the desire to live, was struggling with unalterable facts. He seemed to have a great fear of death until the last... No achievements and no amount of influence could save him now, as they always had in the past. Johnny von Neumann, who knew how to live so fully, did not know how to die.

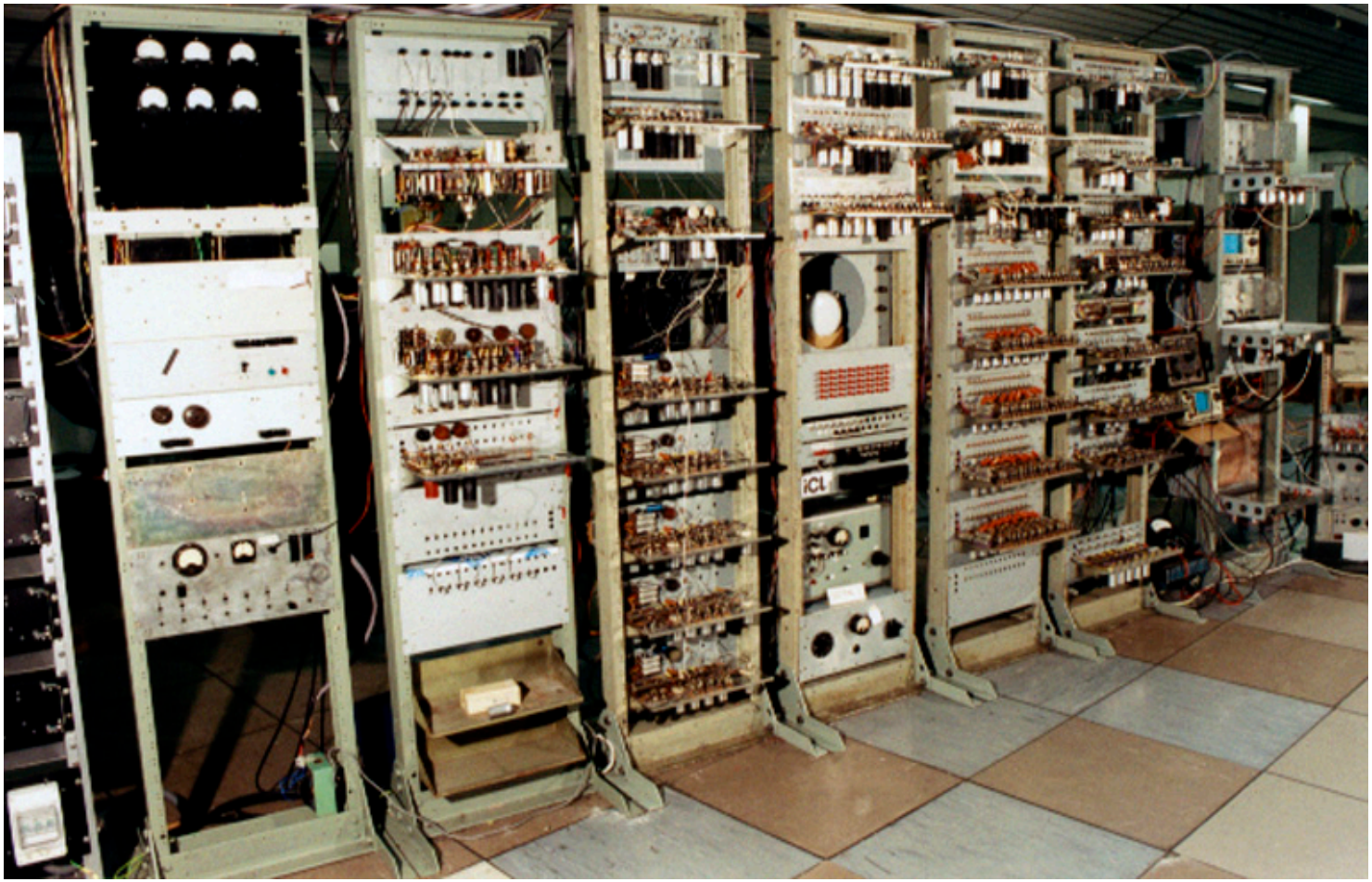
S J Heims, *John von Neumann and Norbert Wiener: From mathematics to the technologies of life and death* (Cambridge,MA, 1980).

Back in England



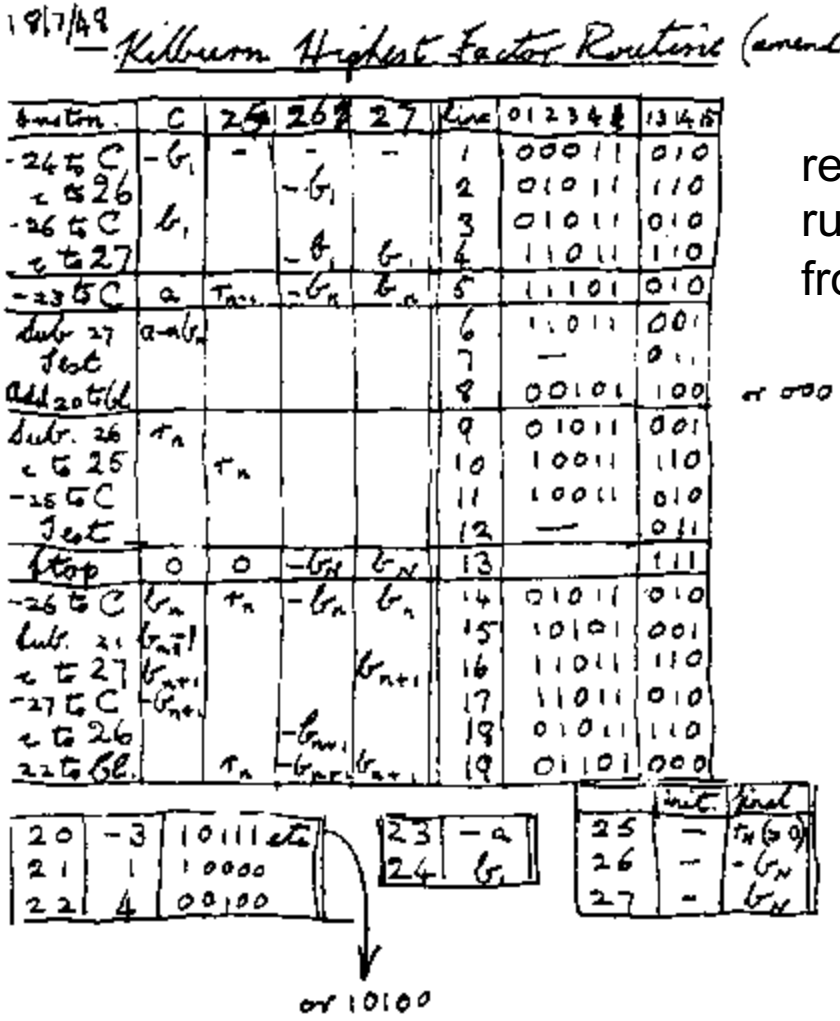
- Max Newman and F.C. Williams build the Manchester Baby Computer in 1948 and demonstrate the feasibility of the stored-program concept.
  - first von Neumann computer to become operational
- Maurice Wilkes attends the Moore School Lectures in 1946 and builds EDSAC at Cambridge University
  - first practical stored-program computer
  - 32 memory delay lines
  - 3000 vacuum tubes (1/6 of ENIAC)
  - 30 kW of electric power

Manchester Baby Computer

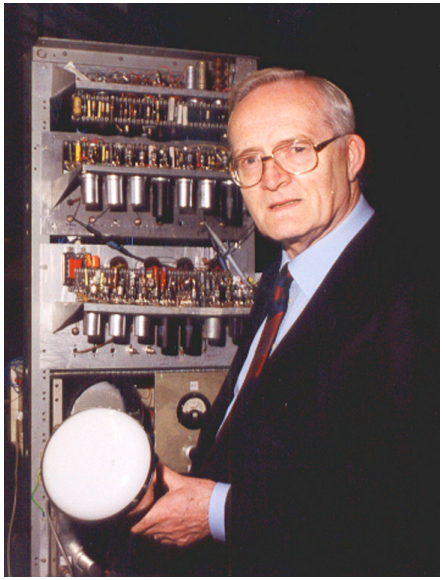


Replica of “Baby” from 1998, from University of Manchester

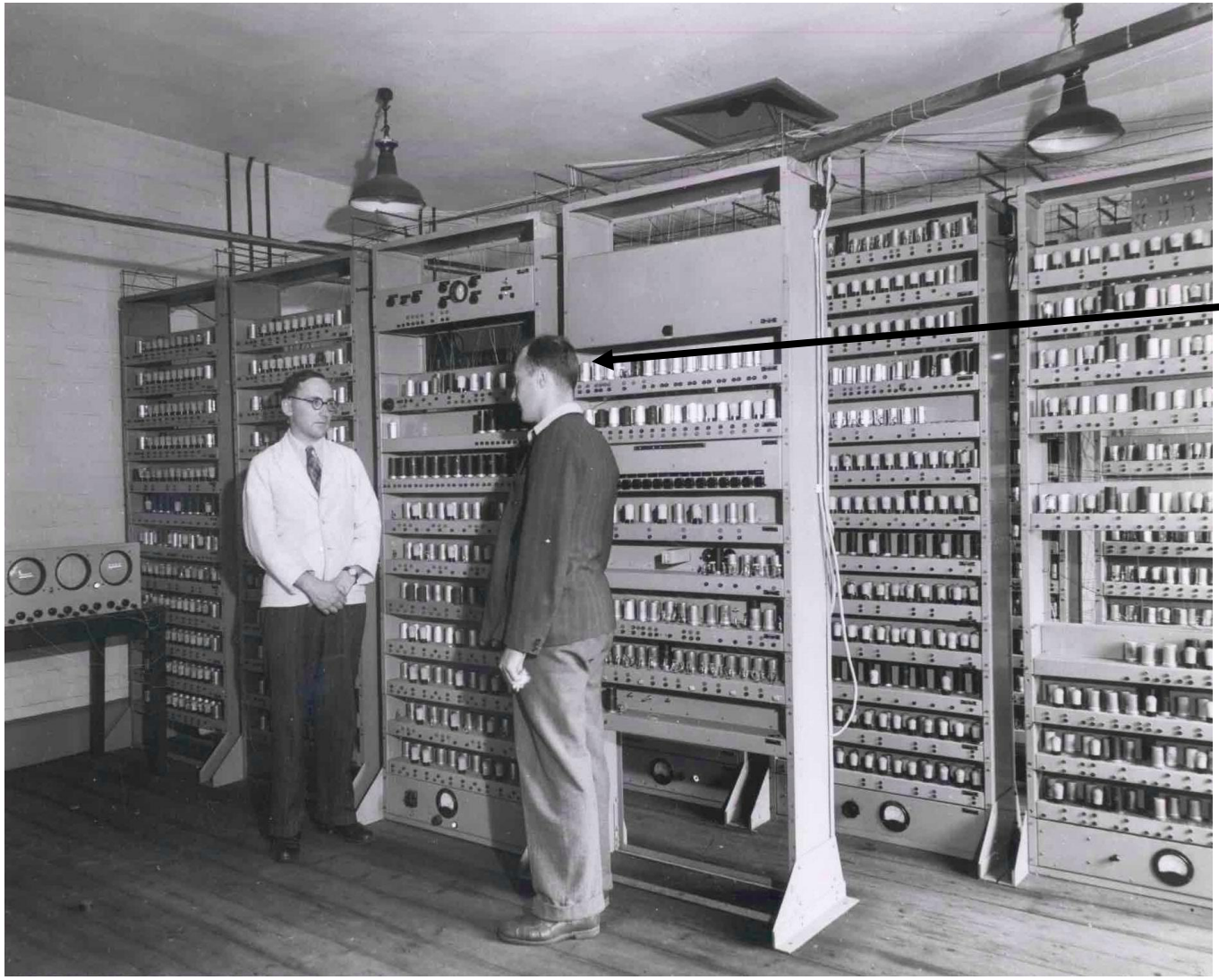
Manchester Baby Computer



revised version of the first program run on the Baby, written by Tom Kilburn, from University of Manchester



EDSAC



EDSAC I, from University of Cambridge