Early Calculating Tools

- **Abacus**

  - At least 5,000 years old

  - Memory aid for making calculations

  - Cannot perform actual computations

  - Eventually replaced by pencil and paper

Early Calculating Tools

- **Pascalene**

  - Invented by Blaise Pascal around 1645

  - One of the earliest true mechanical calculators
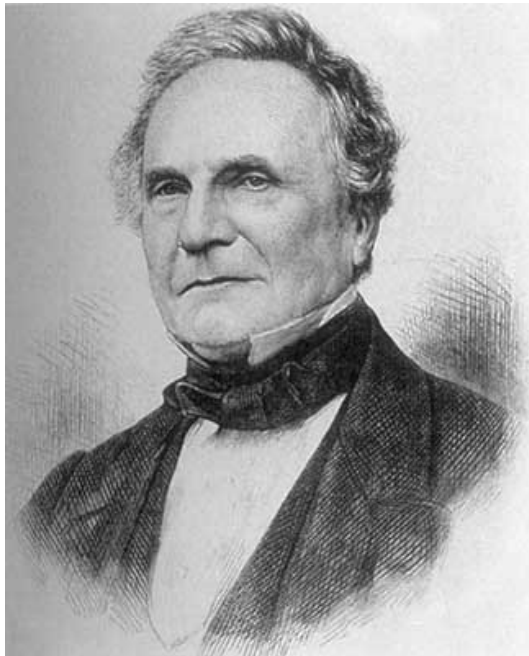
  - Capable of addition and subtraction

The Jacquard Loom

- Invented by Joseph Jacquard in 1801

- Controlled fabric patterns by punched cards

- Could produce fabrics faster and more accurately than any human

- Knowledge encoded in cards could be easily stored and shared

- Caused riots in 1811 by skilled craftsmen fearing for their jobs (the Luddites)

Charles Babbage

1791-1871

Difference Engine

- English mathematician and inventor

- Originated the concept of a programmable computer

- Steam-powered design programmed by punched cards, called the **Analytical Engine**

- Inspired by Jacquard's loom

- Never built

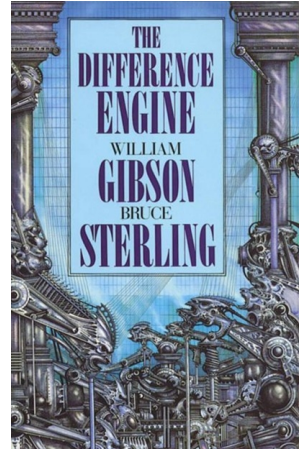- Also designed the Difference Engine

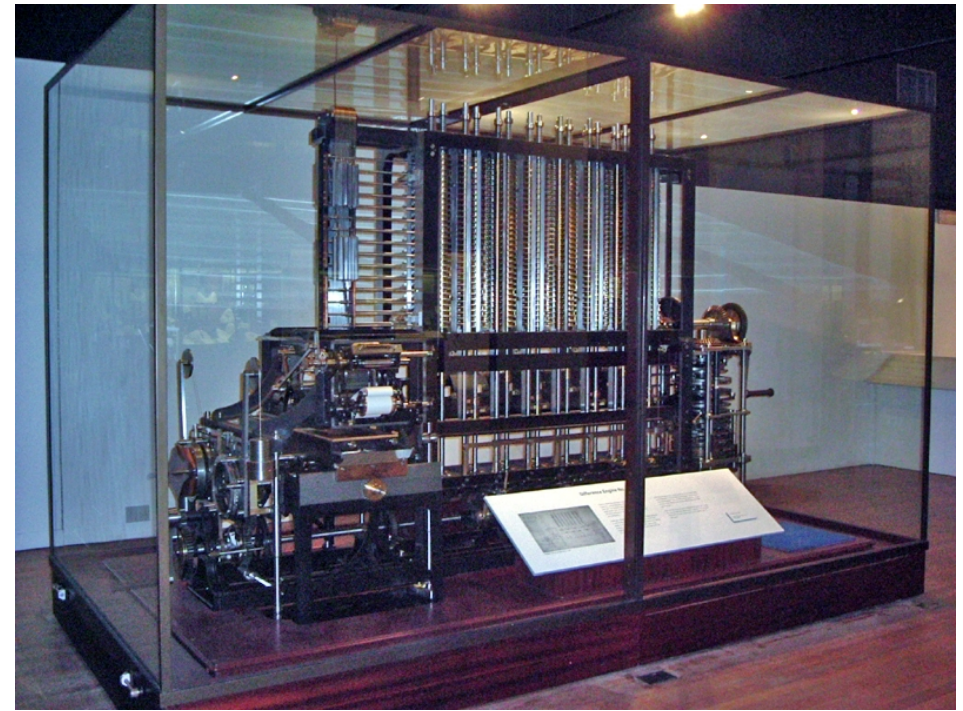Jacquard loom

Charles Babbage

The Difference Engine

- Special-purpose mechanical calculator designed to compute tables of polynomial functions

- Powered by cranking a handle

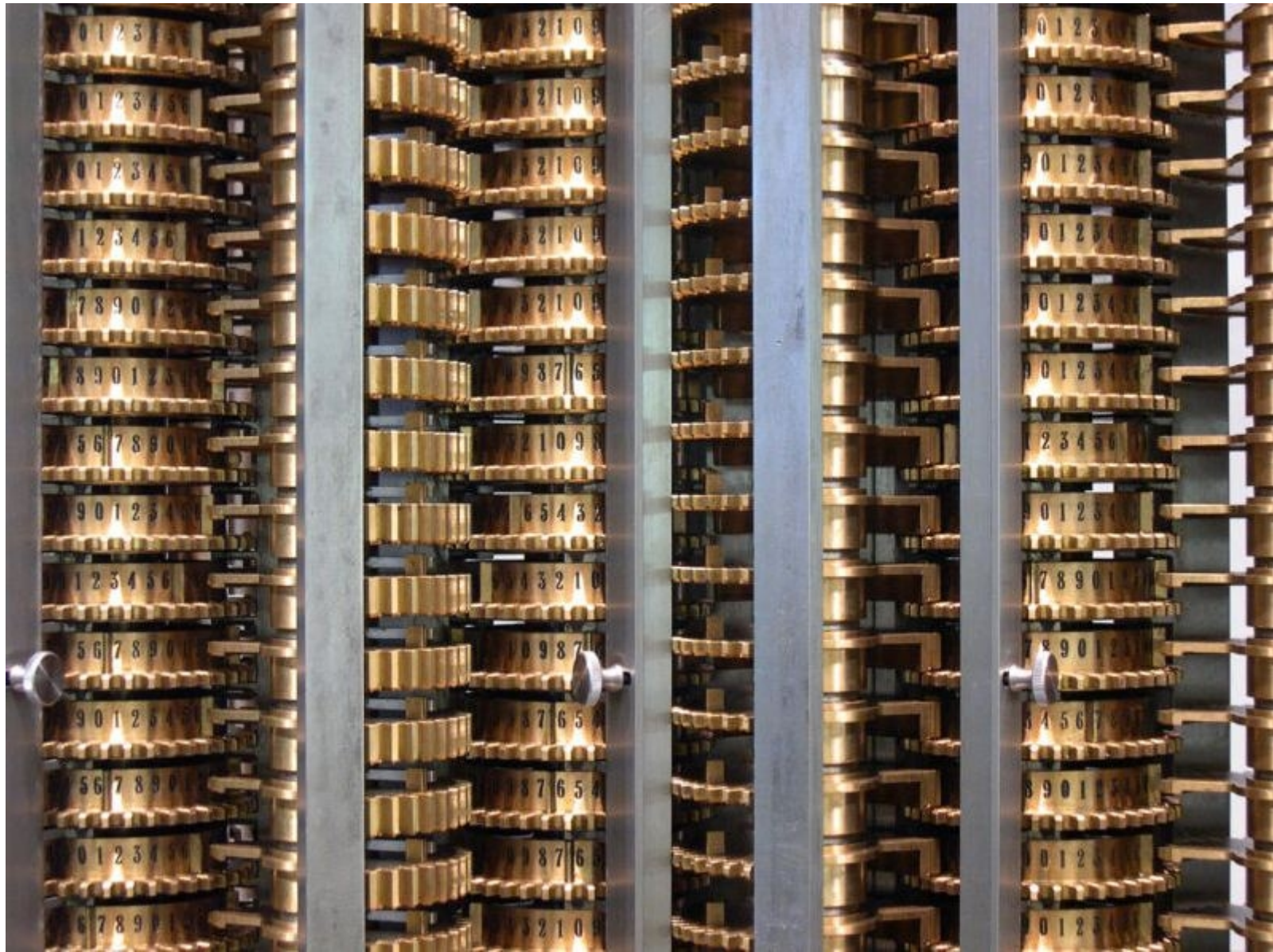- In 1991 the London Science Museum built a working Difference Engine and printer from Babbage's designs

1879 (Babbage's son, Henry Provost Babbage)

1991 (Doron Swade, London Science Museum)

The Difference Engine

Close-up view of the gears of the museum's Difference Engine

Augusta Ada King
# Countess of Lovelace

1815-1852

> *"The Analytical Engine weaves algebraic patterns just as the Jacquard loom weaves flowers and leaves"*

- Charles Babbage's patron, assistant, and chronicler

- An accomplished mathematician in her own right

- Daughter of Lord Byron, the poet

- Wrote sets of instructions for the Analytical Engine

- World's first true computer programmer

- U.S. Department of Defense named its programming language Ada after her
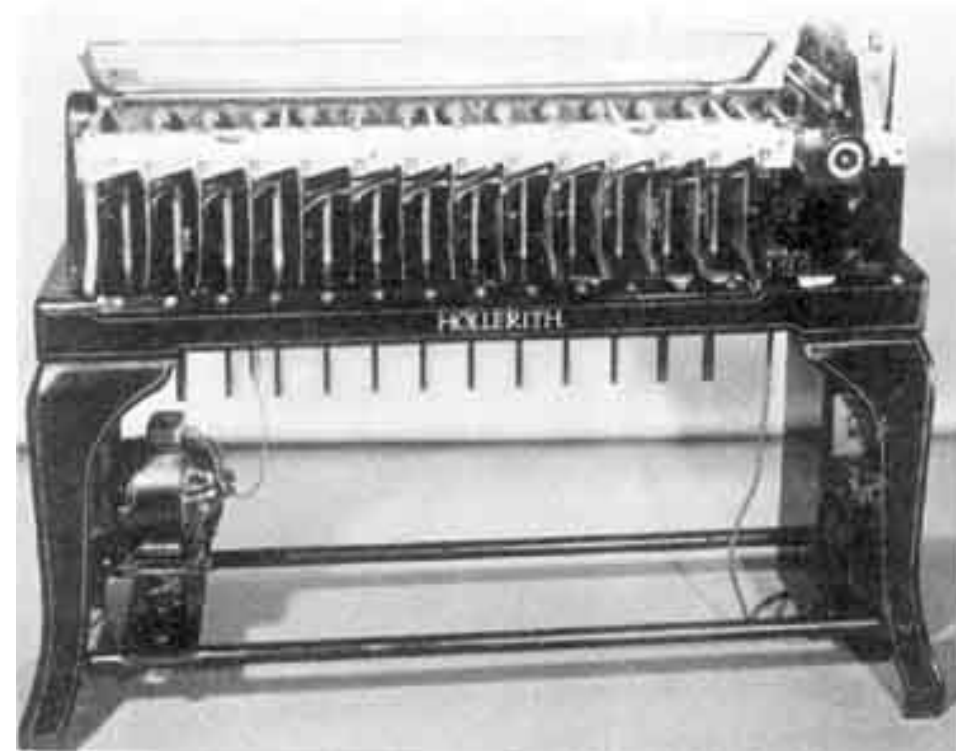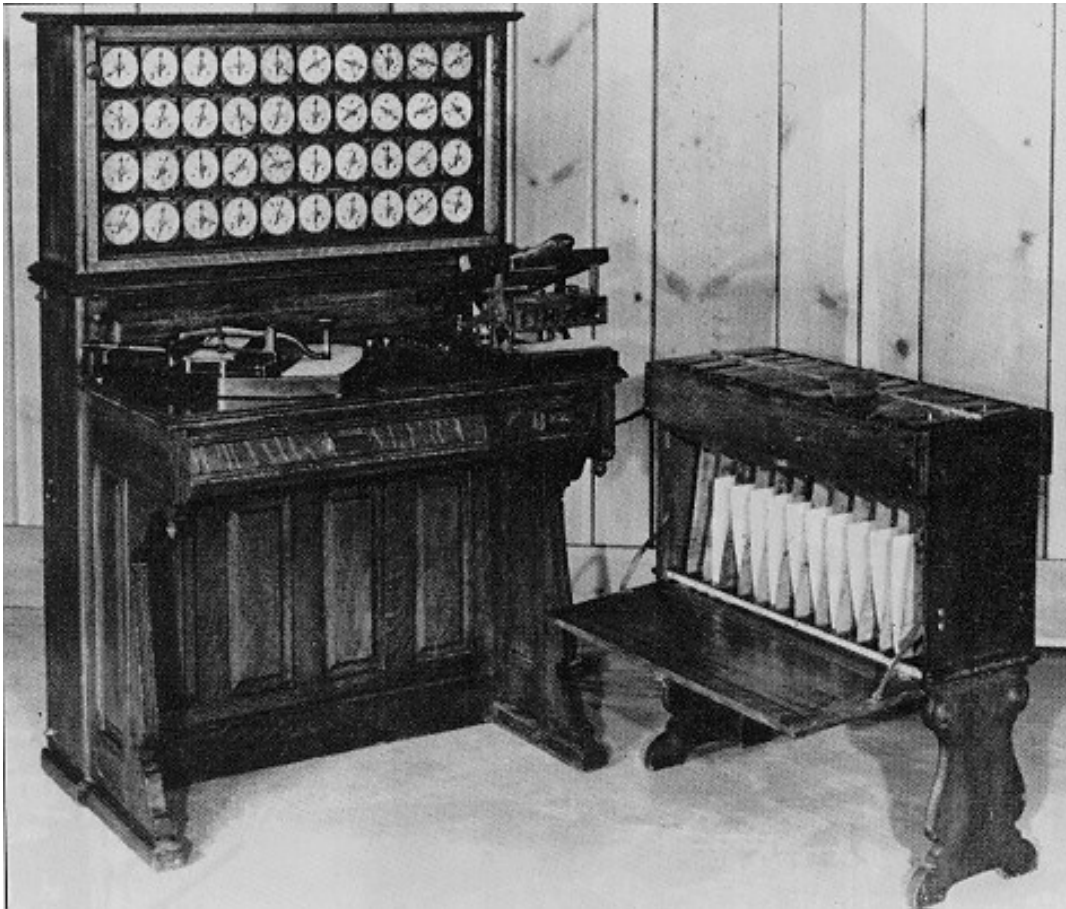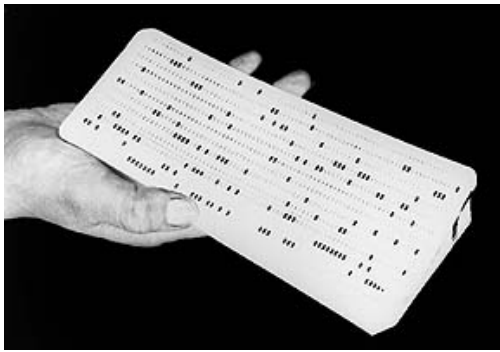
Herman Hollerith
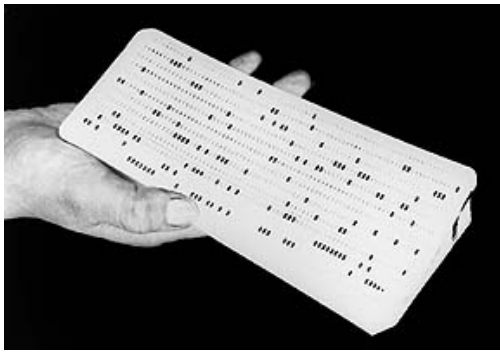
- Developed a tabulating machine for the U.S. census of 1890

- Stacks of punched cards served as a permanent memory

- Cut census time from 10+ years to 6 weeks

- Not programmable

- Started a company to market his machine which merged with others to form the Computing-Tabulating-Recording Company (eventually known as... **IBM**)
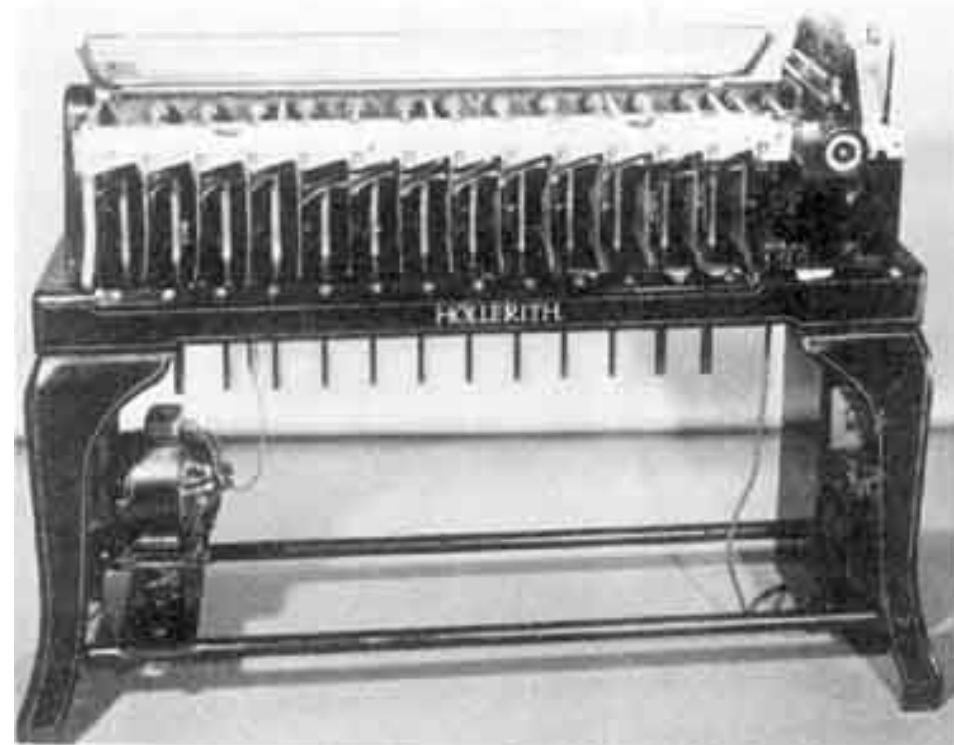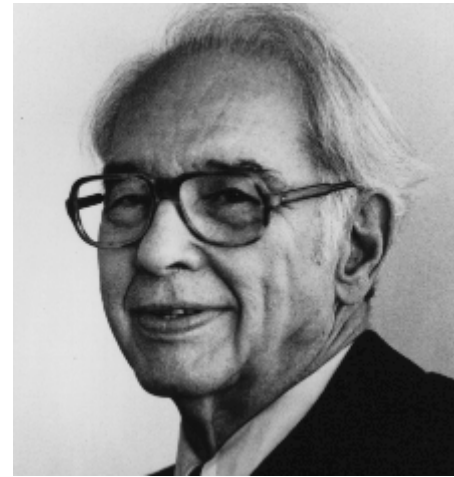
Herman Hollerith

John Atanasoff and Clifford Berry

- American physicists at Iowa State College

- Berry was Atanasoff's grad student

- Built ABC machine in late 1930s

- Special-purpose calculator for finding solutions to systems of equations

- All-electronic design using **vacuum tubes** for switching elements

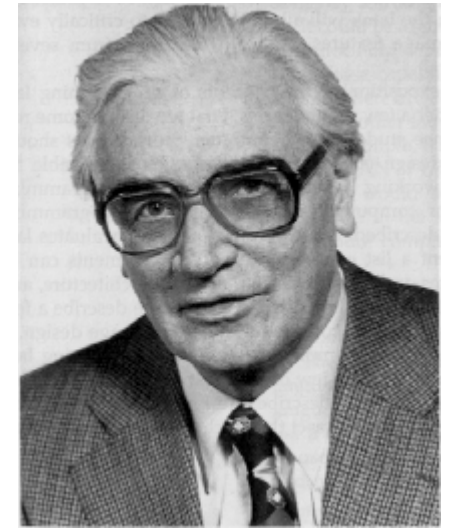- Never completed, due to insufficient funding

# The Atanasoff-Berry Computer (replica)

Konrad Zuse

- German engineer under the Third Reich

- Built Z1, Z2, Z3, and Z4 in late 1930s and early 1940s with Helmut Schreyer

- Electromechanical design with relays for switching elements

- General-purpose computing device

- Controlled by perforated celluloid strips (like punched cards)

- First machine to use **binary number system**

- Never completed, due to insufficient funding from the Nazi government

110010101
100010001101
11110
0001011
001001011
1101010

Howard Aiken

- American physicist and applied mathematician

- Built **Mark I** at Harvard in collaboration with Grace Hopper and IBM engineers in 1944

- Inspired by Babbage's Analytical Engine

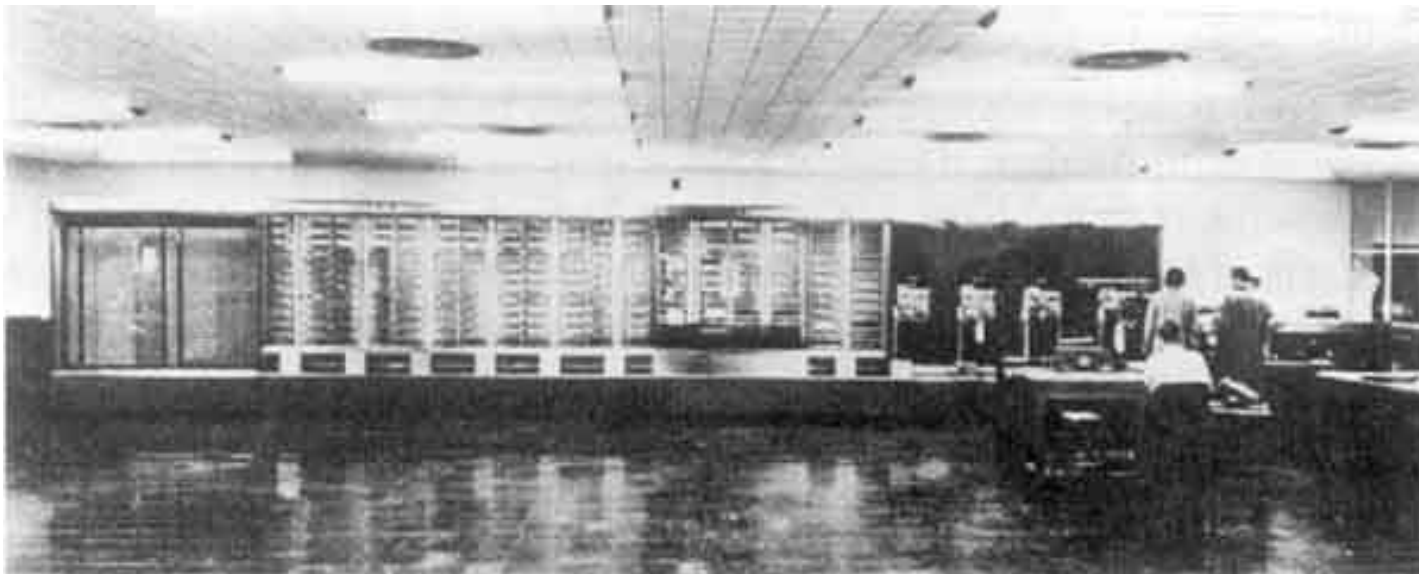- Electromechanical design with relays for switching elements
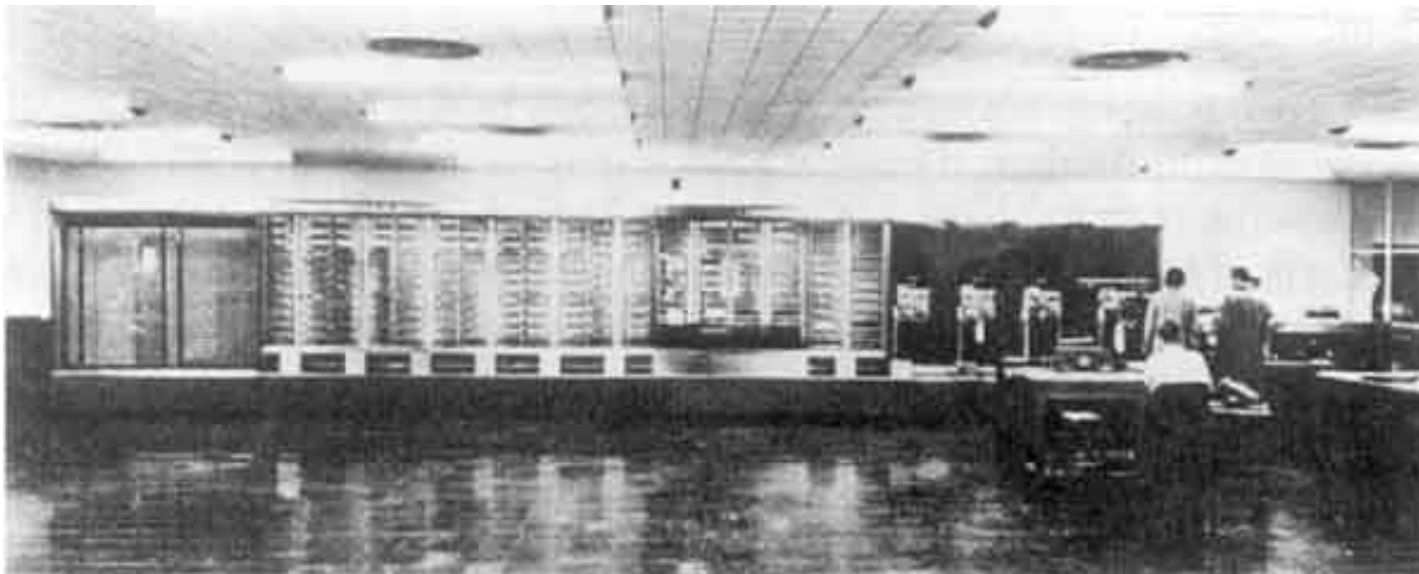
Rear Admiral Grace Hopper

Howard Aiken

- Handled 23-digit numbers, logarithms, trigonometric functions

- Controlled by punched paper tape

- Fully automatic but slow
(3-5 seconds per multiplication)

- Remained in use at Harvard until 1959

Rear Admiral Grace Hopper

The First Bug

- Grace Hopper found the first **actual computer bug** while working on the Mark II in 1945

Alan Turing

- English mathematician and first true computer scientist

- Invented a mathematical model of a computer called a **Turing Machine**

- Proved fundamental theorems about the limitations of computers

- Wrote groundbreaking papers in many different fields

  – Theory of computation (1936)

  – Artificial intelligence (1950)

  – Self-organizing chemical reactions (1952)

Alan Turing

- During World War II, he secretly worked for the British government to crack German Enigma codes

- Helped develop the British electronic code-breaking computer called Colossus

- Enabled Allies to read German military transmissions from 1942 on

- Persecuted by British government after the war for being homosexual

- Forced to undergo hormone "therapy"

- Committed suicide in 1954 at the age of 41

Alan Turing

- Published *Computing Machinery and Intelligence* in 1950

- The Turing Test

- Language allows for in-depth probing of intelligence and consciousness

```
Q: In the first line of your sonnet which reads "Shall I compare thee
   to a summer's day," would not "a spring day" do as well or better?

A: It wouldn't scan.

Q: How about "a winter's day?"  That would scan all right.

A: Yes, but nobody wants to be compared to a winter's day.

Q: Would you say Mr. Pickwick reminded you of Christmas?

A: In a way.

Q: Yet Christmas is a winter's day, and I do not think Mr. Pickwick
   would mind the comparison.

A: I don't think you're serious.  By a winter's day one means a
   typical winter's day, rather than a special one like Christmas.
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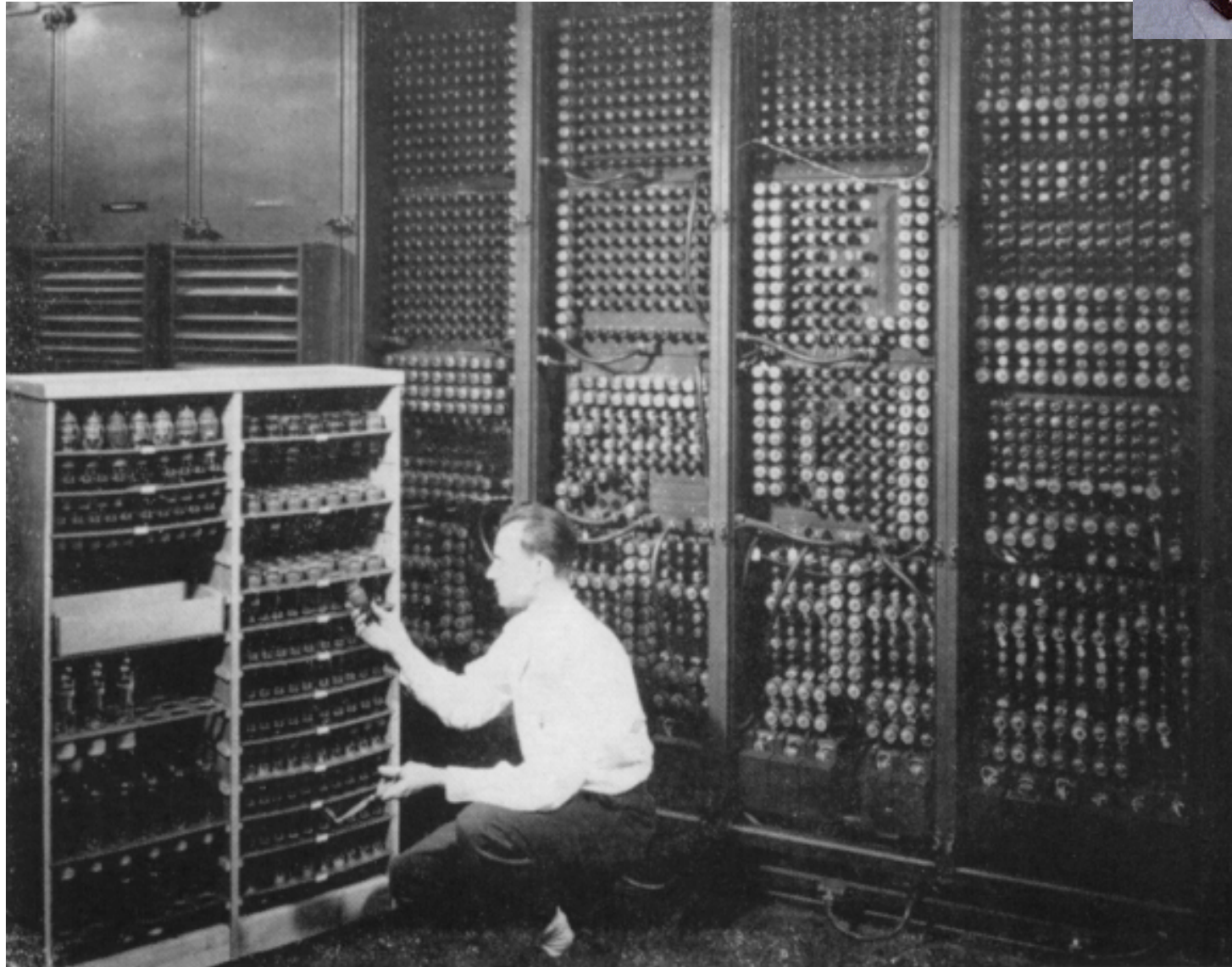
ENIAC

- **E**lectronic **N**umerical **I**ntegrator **A**nd **C**alculator

- Developed by John Mauchly and J. Presper Eckert at the University of Pennsylvania in 1945

- First general-purpose all-electronic digital computer

- Filled a 30 x 50 ft. room

- Weighed 30 tons

- Dissipated 150,000 watts of energy

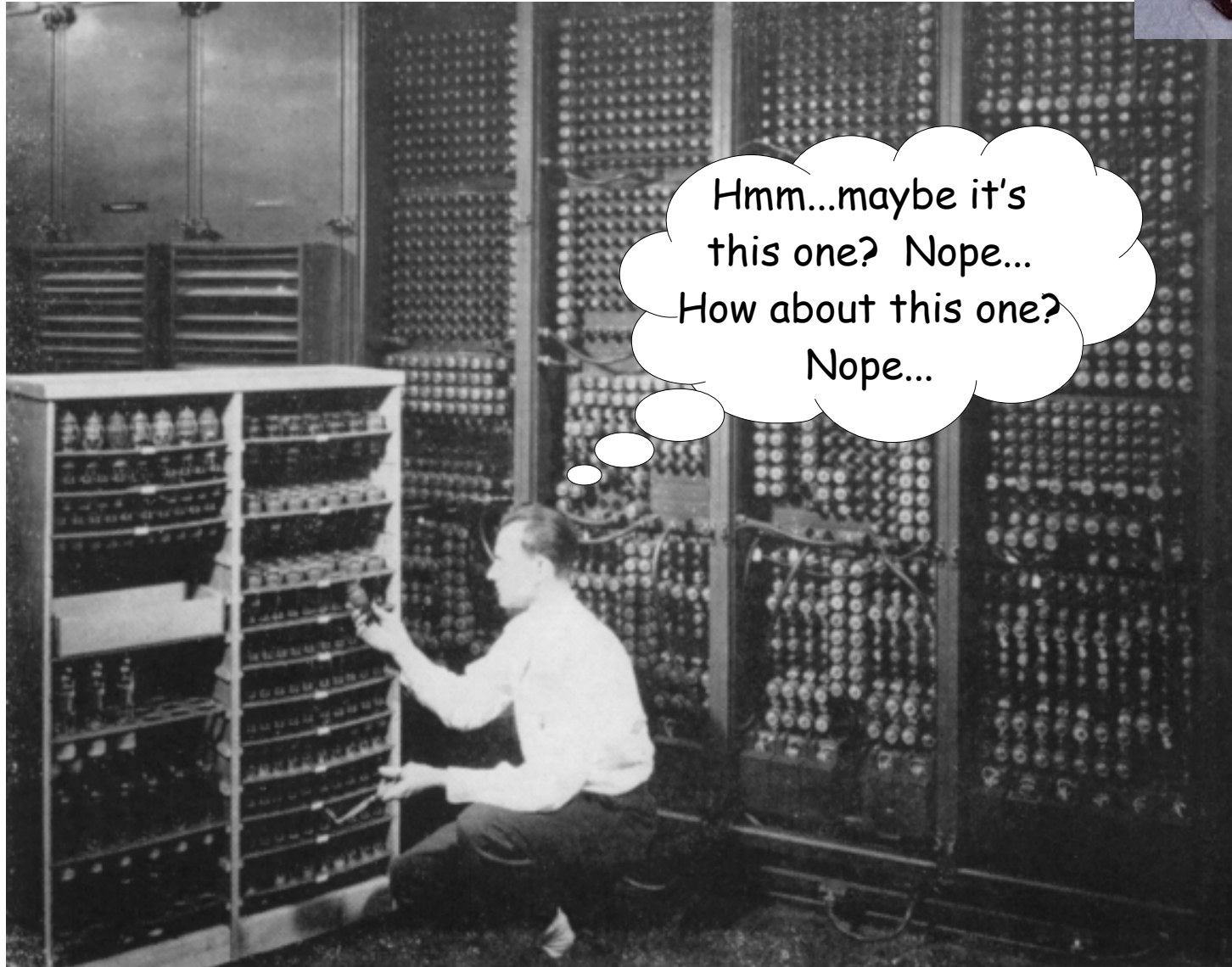- Performed calculations for the atomic bomb project at Los Alamos

ENIAC

- Used 19,000 vacuum tubes

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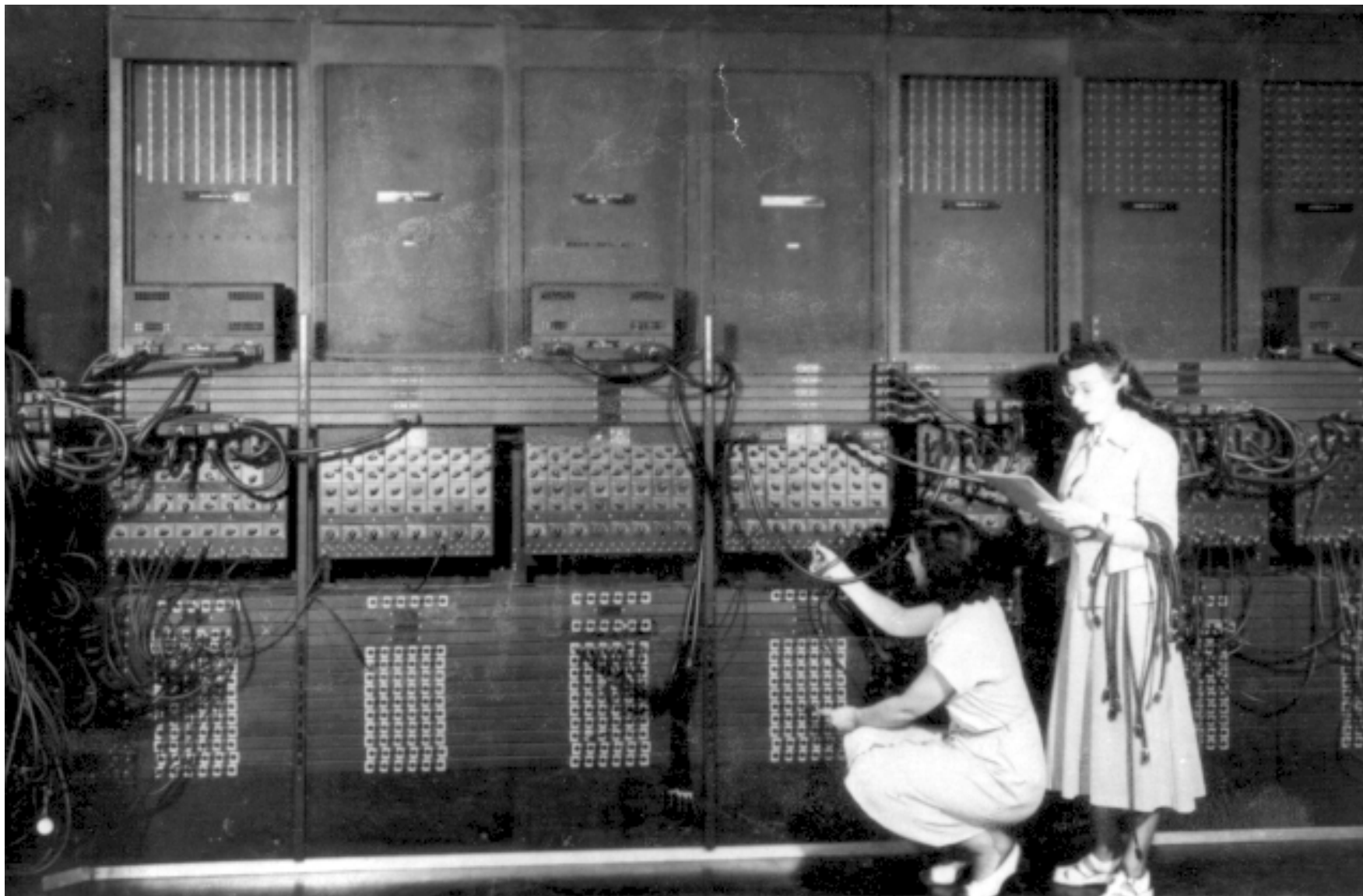
ENIAC

- …which tended to burn out frequently

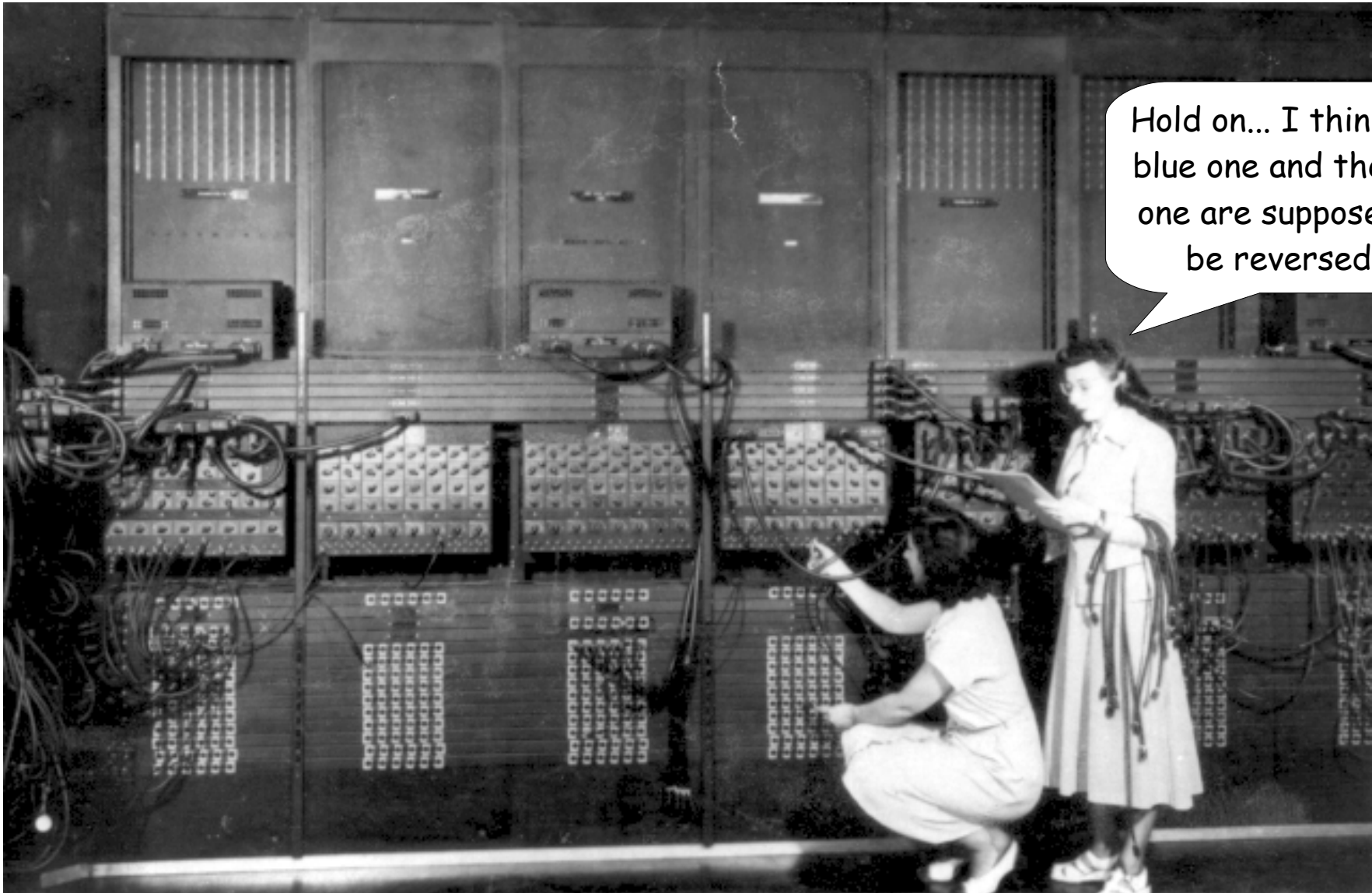Replacing a bad tube meant checking among ENIAC's 19,000 possibilities.

ENIAC

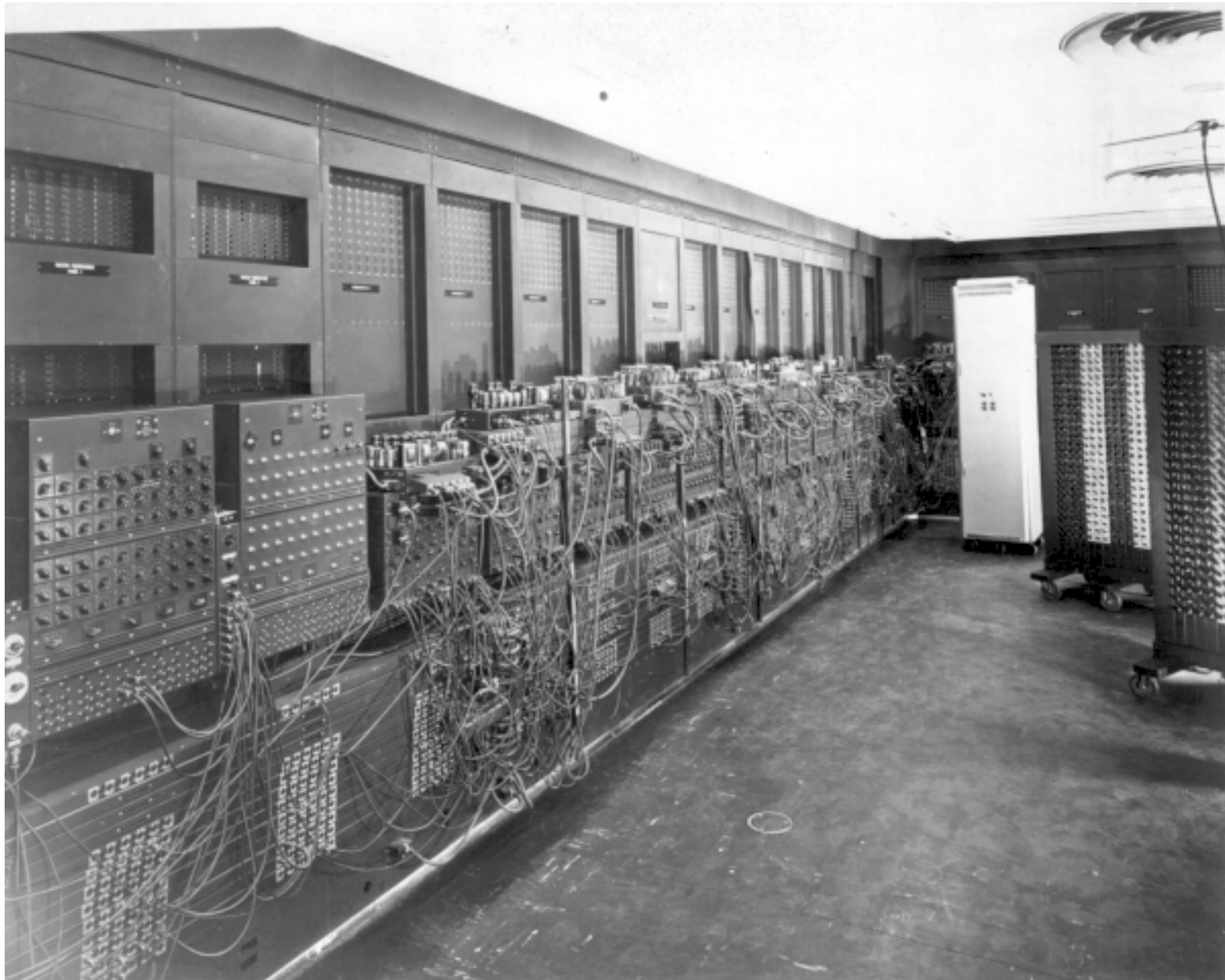- Reprogramming required physically rewiring the machine

ENIAC

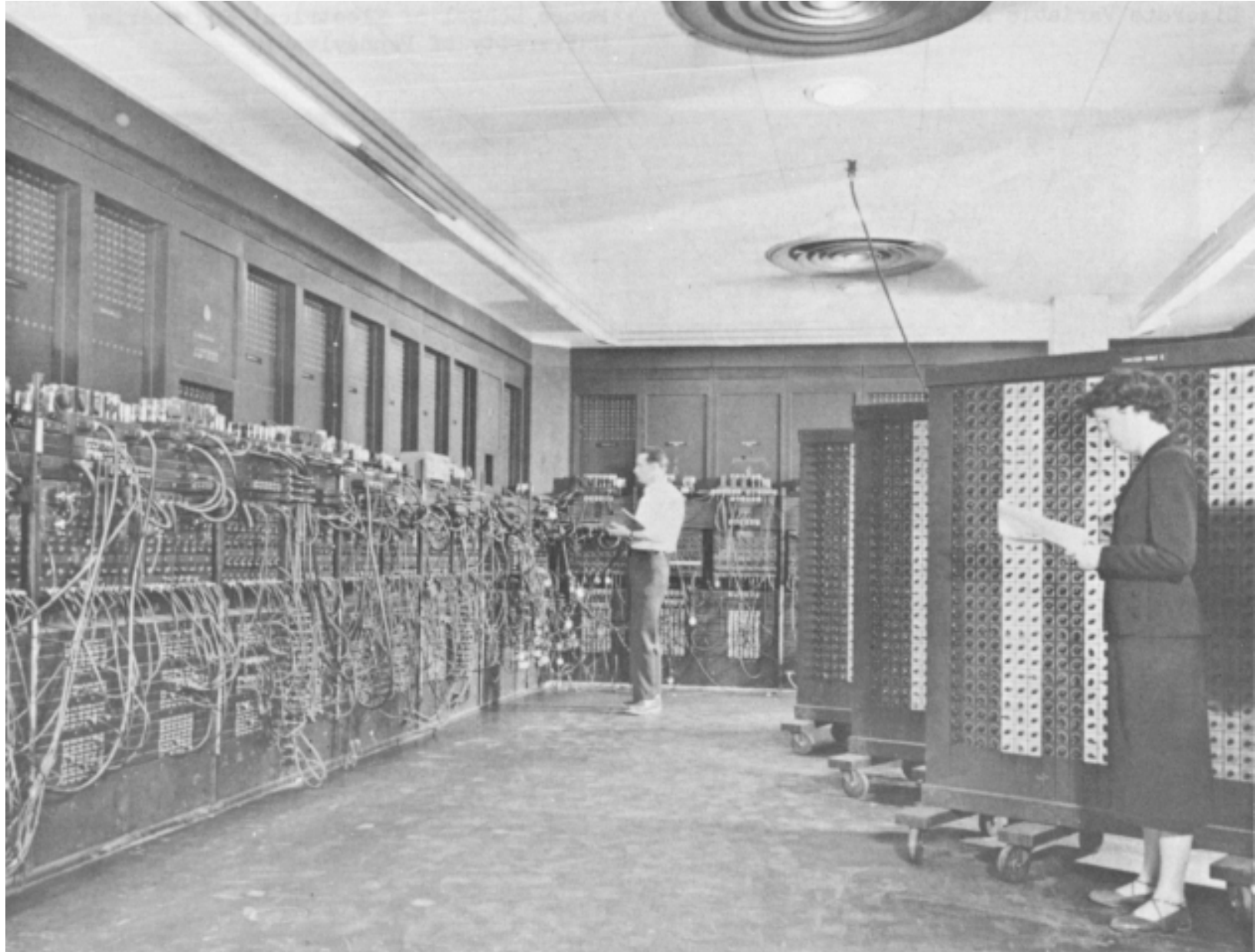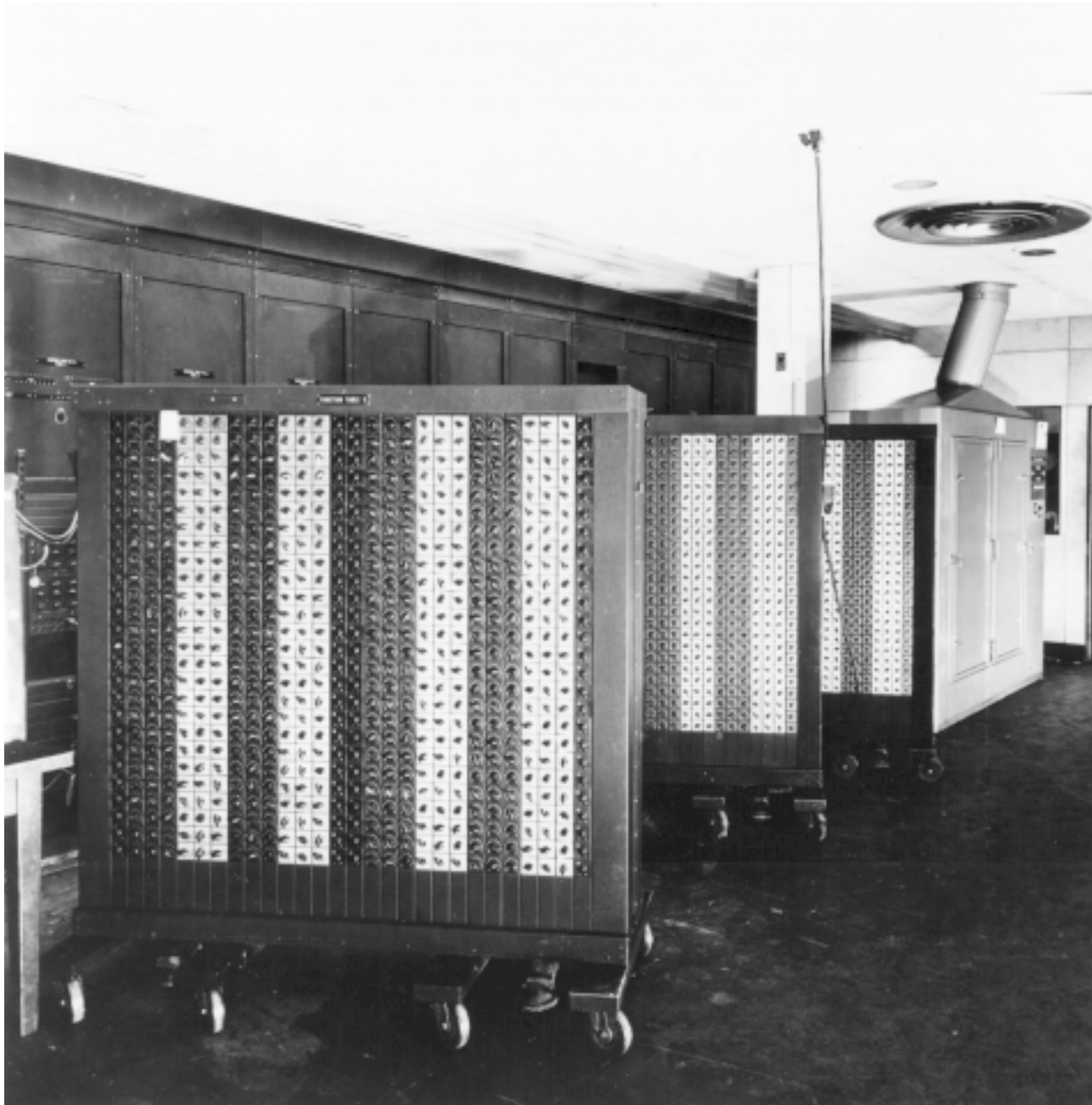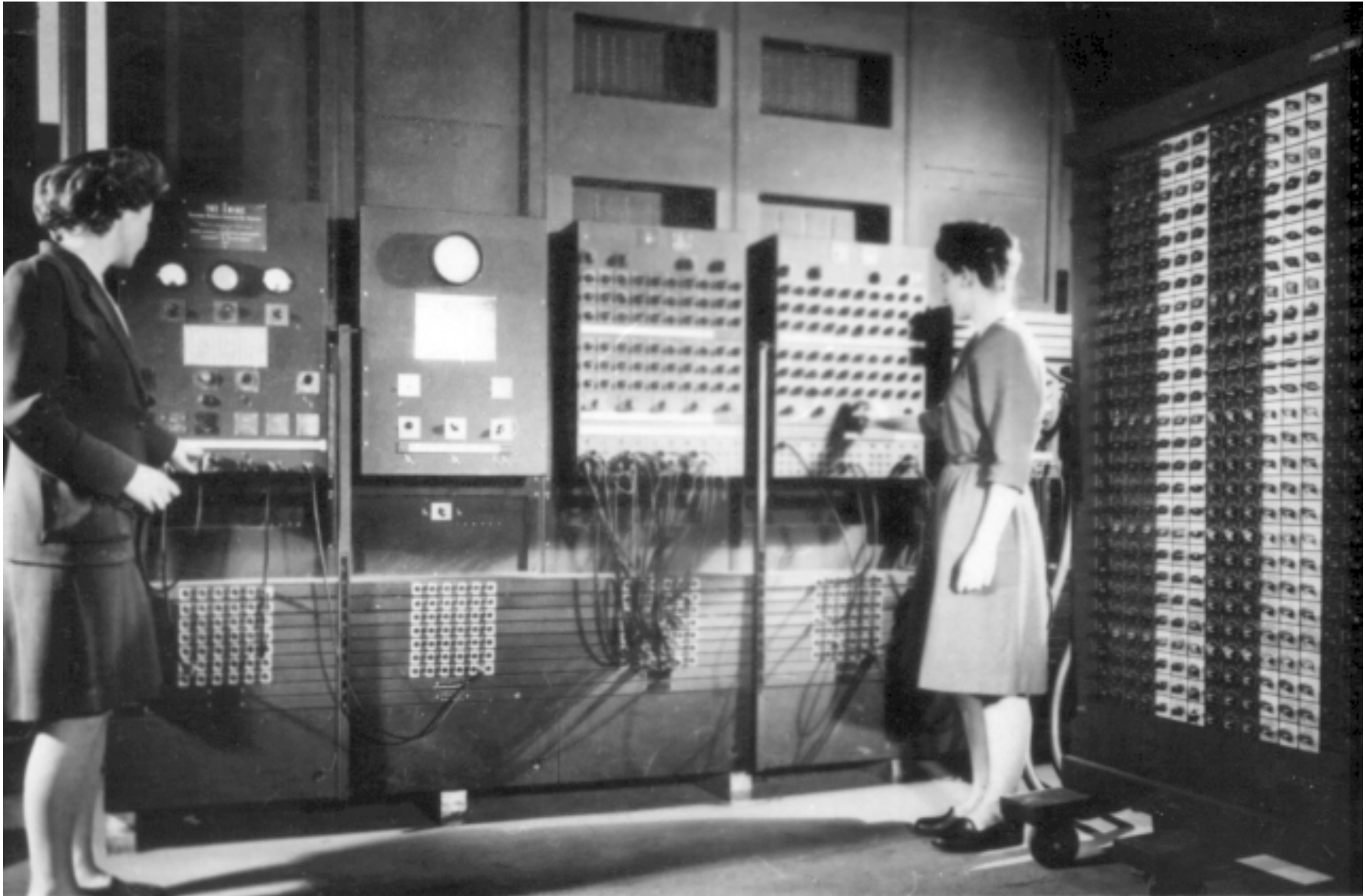- …which was a tedious and error-prone process

ENIAC

ENIAC

ENIAC

ENIAC

John von Neumann

- Hungarian mathematician, computer scientist, cyberneticist, all-around genius

- Worked on atomic bomb project in WW II

- Invented game theory and developed theory of self-replicating automata

- Originated key concept of **stored-program computer** in 1945

- Program instructions = data

- Easily reprogrammable

- **Von Neumann architecture** is still the universal standard