A history of early computers

With an emphasis on the “compute” part (1640 to the 1950s)

What's next?

- A timeline of inventions that lead to the design of computers that used the stored-program concept
- A brief look at the University of Toronto's place in the history of computing[1]
- A comparison of general-purpose computers built in the 1940s and 1950s

1. And the founding of this department

Mechanical devices

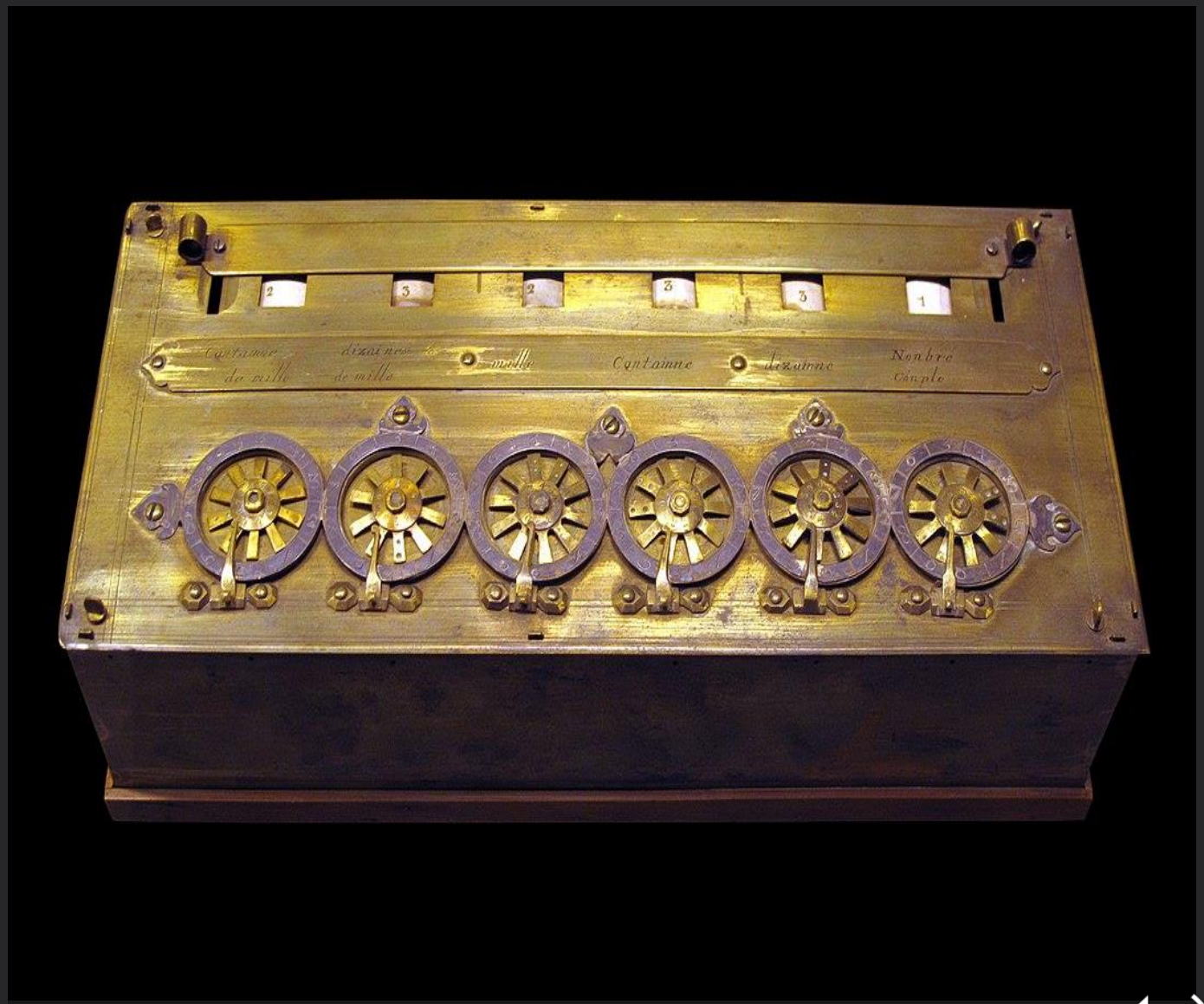
- Computers made of cranks and gears.

1642
Pascal's calculator

A *mechanical* calculator used to help with tax-related arithmetic and included an innovative carry mechanism.

Each operation (e.g., add) changed the state of the *accumulator*. To subtract numbers, *nine's complement* was used.

The device supported multiplication and division through repeated addition/subtraction.



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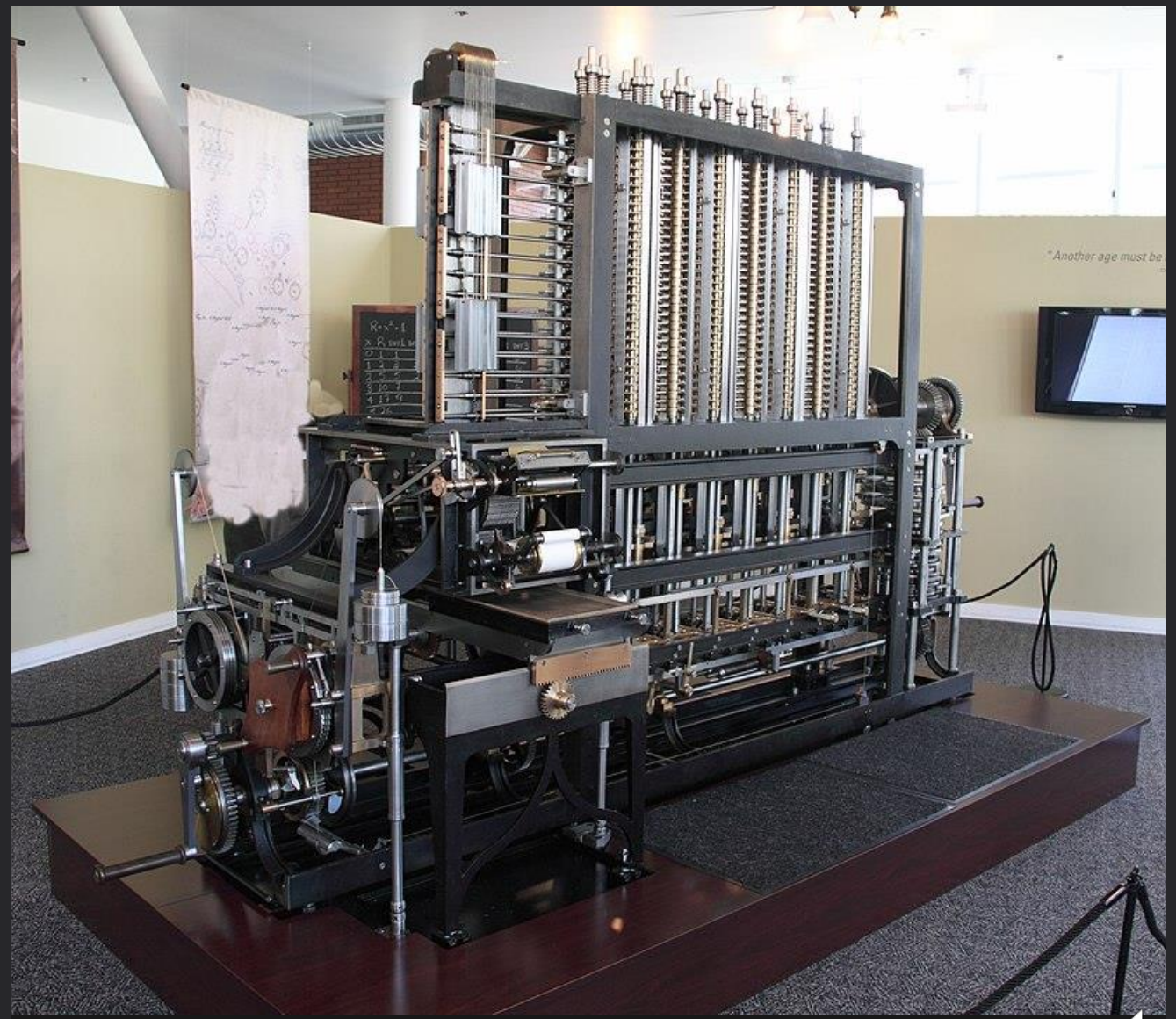
1791 – 1871
Charles Babbage

1820s: The difference engine is an *automatic* mechanical calculator used to tabulate 6th degree polynomials.

1830s: The analytical engine is a *general-purpose computer* with input (punched cards), output (printer, curve plotter, bell), an arithmetic unit, and a control unit (e.g., for conditional branching, looping).

To subtract numbers, the analytical engine used *ten's complement*.



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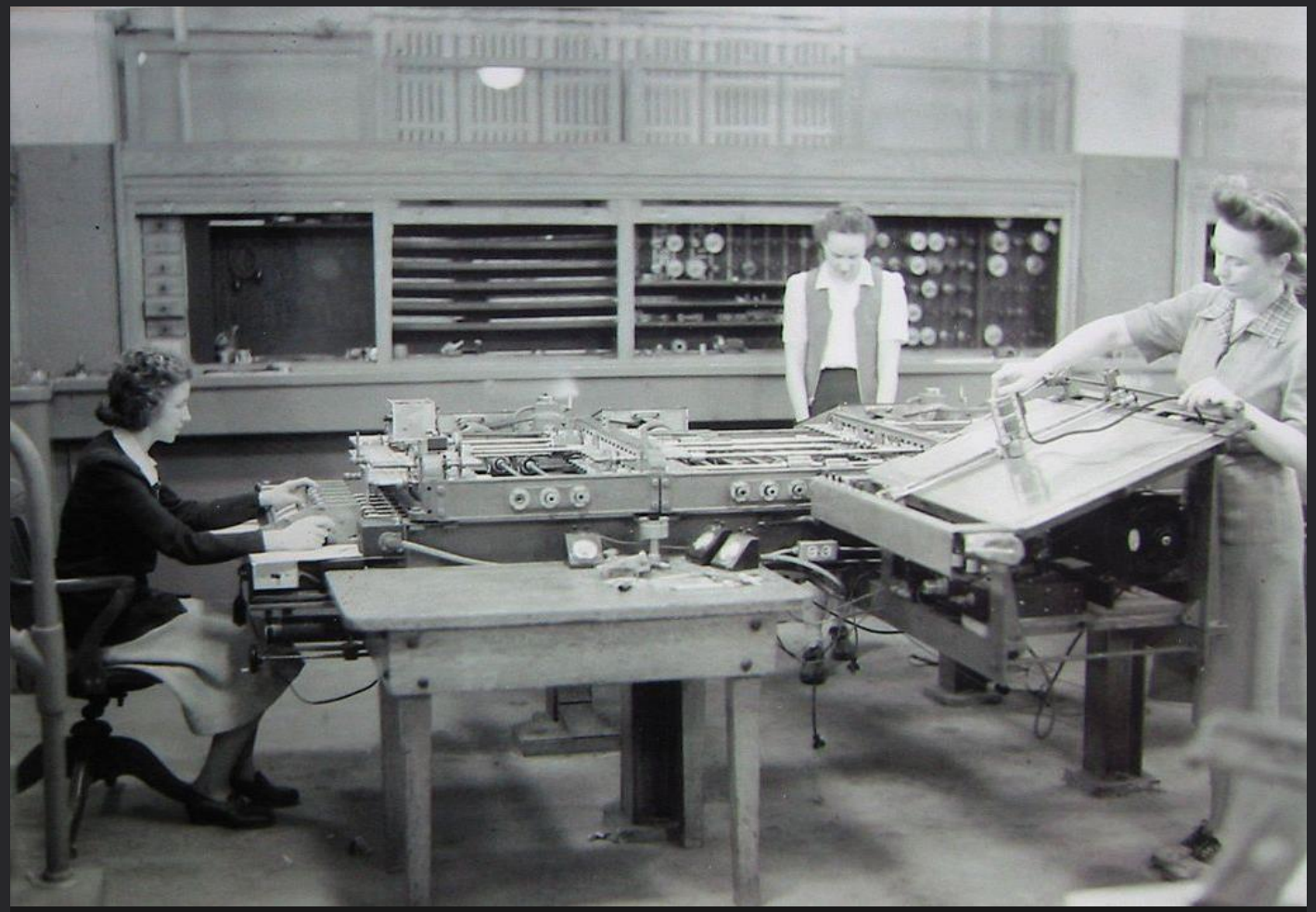
1931
Differential analyser

A *mechanical analog device* used to solve differential equations by integration.

Aside: Differential analysers were described and built earlier in the 19th century.

During World War II, several differential analysers were built and used at the *Ballistic Research Laboratory (BRL)* to compute artillery firing tables.



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Electronic devices

The birth of electronics and the rapid evolution of computers.

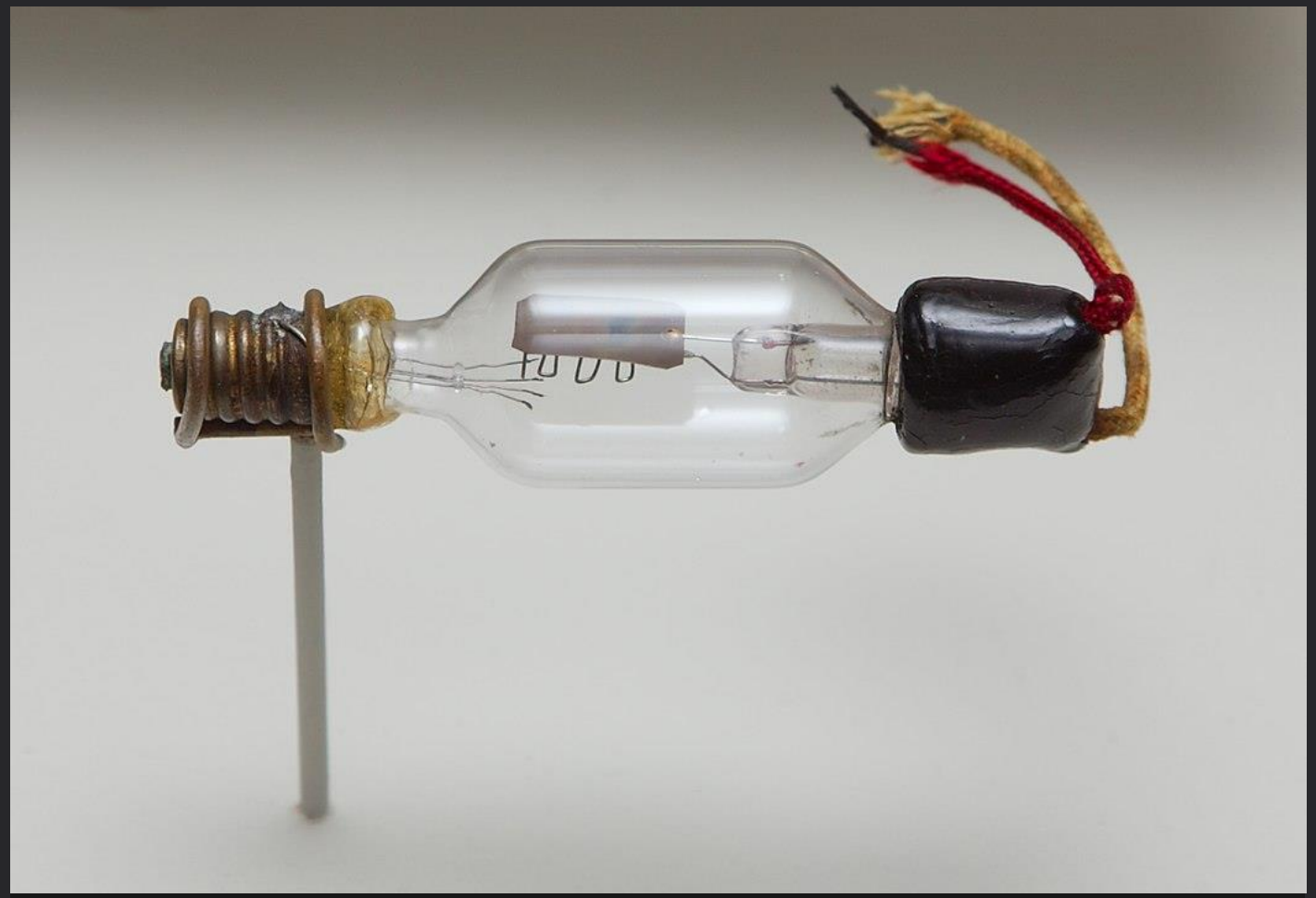
1904 – 1942
Vacuum tubes

An *electronic* (i.e., uses electricity) device that controls current. Created the discipline of electronics.

In 1918, vacuum tubes were used to create a *latch* (a circuit that can store 1 bit of data).

In 1939, Atanasoff and Berry use vacuum tubes to create a 16-bit adder.

In 1942, Atanasoff and Berry use vacuum tubes to create a *special-purpose* digital computer for solving systems of simultaneous linear equations.



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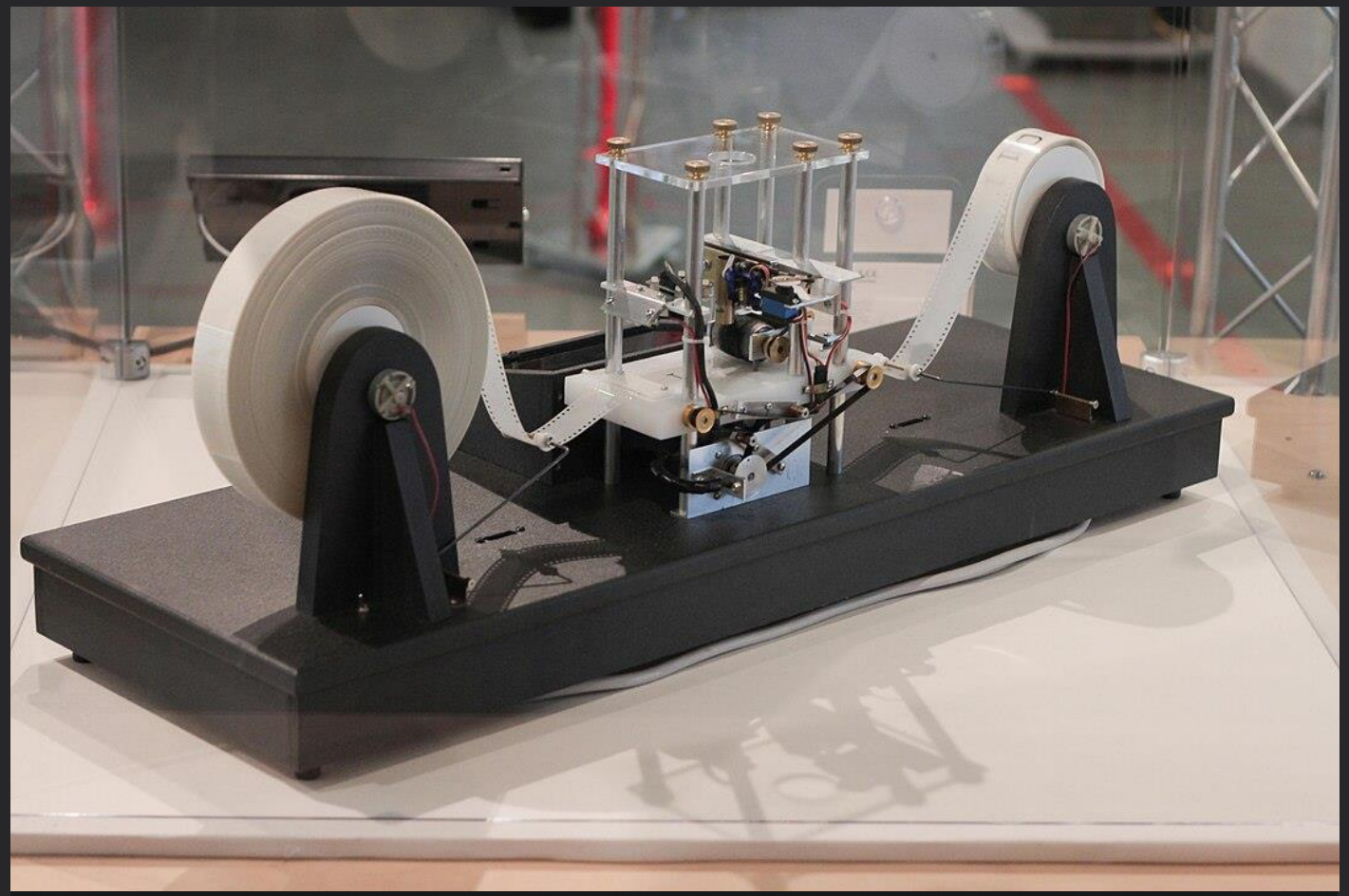
1936
The Turing machine

An abstract machine (later called the Turing machine) that can implement any computer algorithm.

The machine reads symbols from an infinite tape (memory) and, based on the symbol and its current state, updates the symbol before moving.

A programming language is *Turing complete* if it can simulate a Turing machine.



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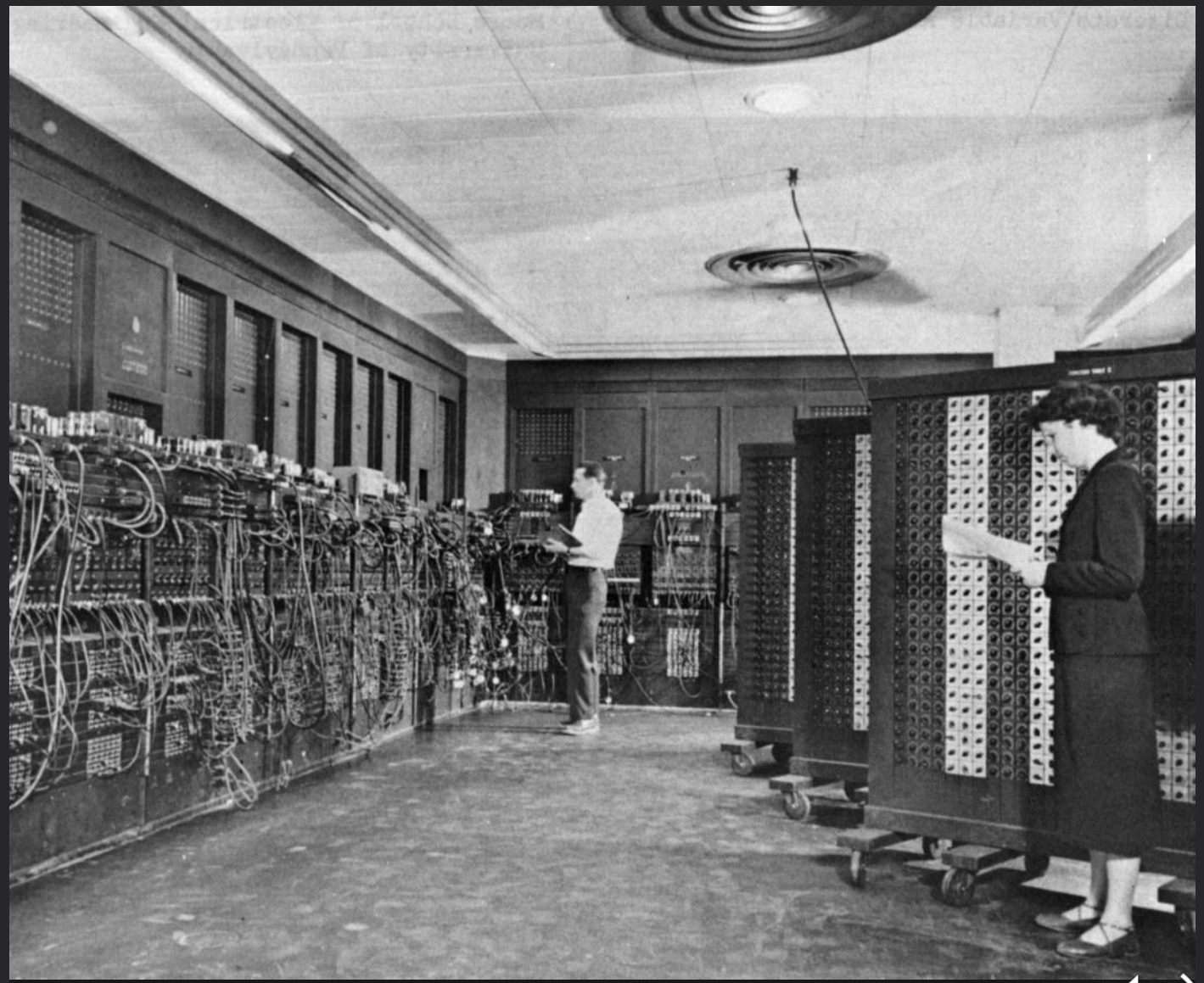
1943-1946
The ENIAC

An electronic general-purpose computer (Turing-complete) made of thousands of vacuum tubes.

Had 20 accumulators and used the decimal number system.

Designed by John P. Eckert Jr. and John W. Mauchly for the BRL to quickly and accurately calculate artillery firing tables.

Significant “behind-the-scenes” contributions made by women, especially in programming.



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1947
Delay-line memory

Analog delay line technology existed since the 1920s.

Eckert patents a method to use delay lines for computer memory in the in 1947.

Delay-line memory is “sequential-access” (not random-access).

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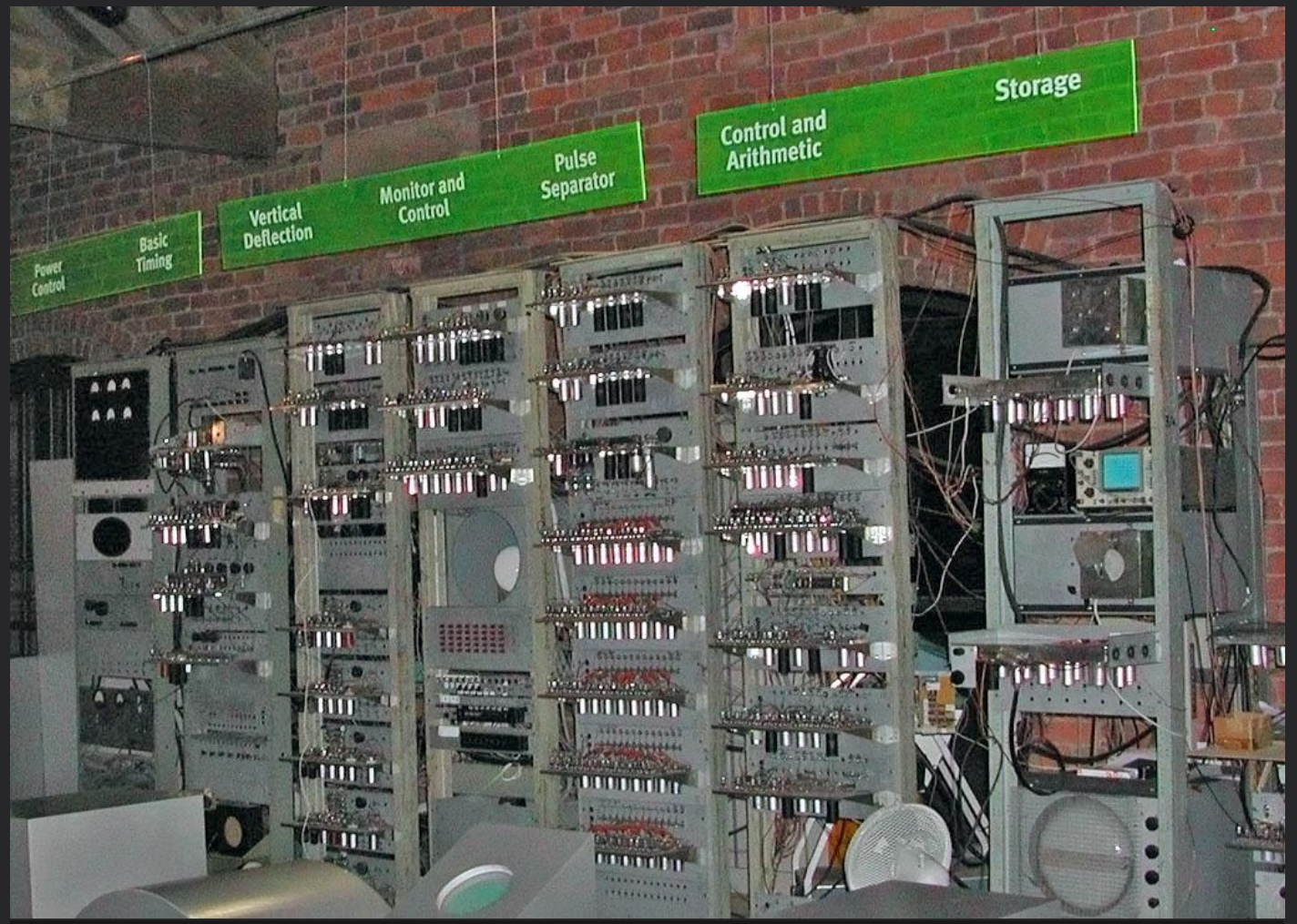
1945-1948
The stored program

Building off the Turing machine paper published earlier…

1945: John von Neumann authors a report describing the design of a stored-program computer (the EDVAC).

1946: Turing presents on the detailed design of a stored-program computer.

1948: The University of Manchester's "Baby", an electronic computer proof-of-concept, runs a stored program.



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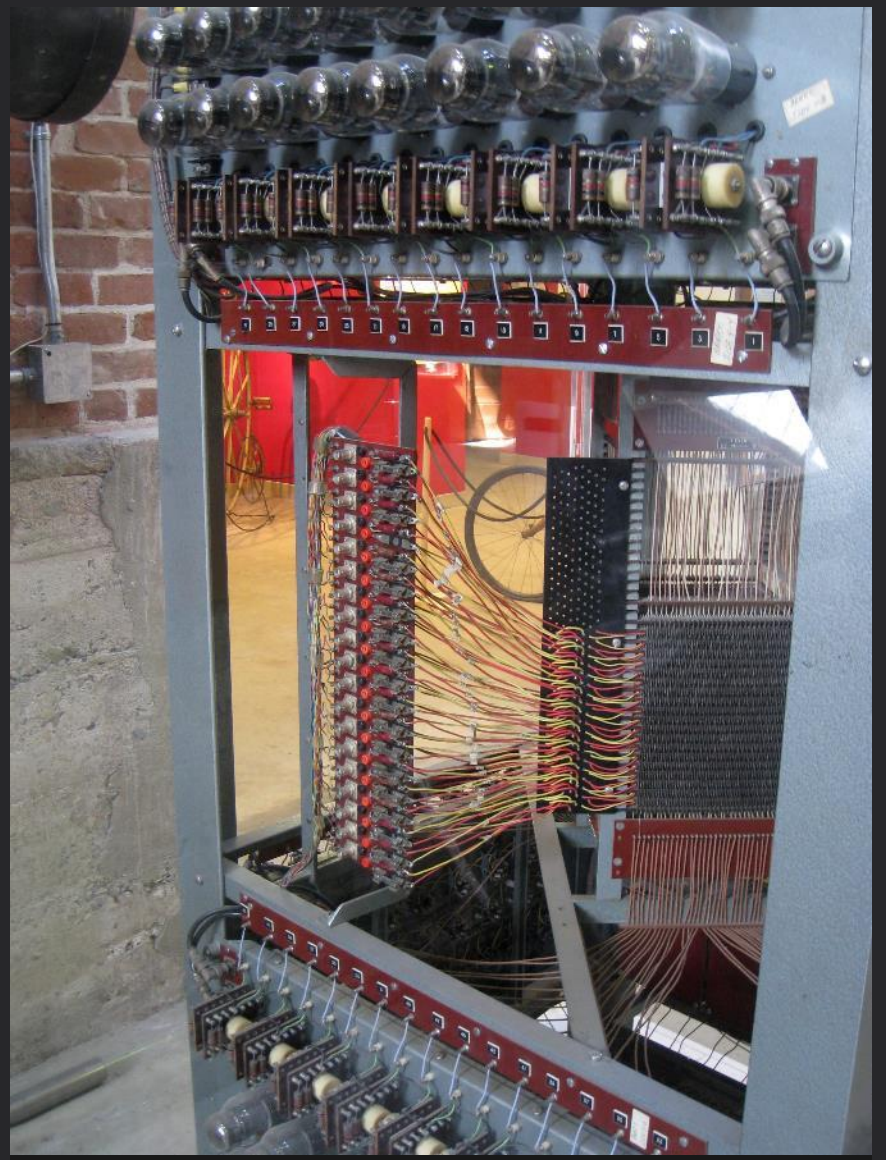
1951
Core memory

Uses magnetism to store a 1 or a 0. The value can be measured based on the direction of the magnetic field (clockwise or counter-clockwise).

Magnetic-core memory was random access.

Magnetic-core memory was the dominant technology between 1955 and 1975, and the cost-per-bit became cheaper over time.



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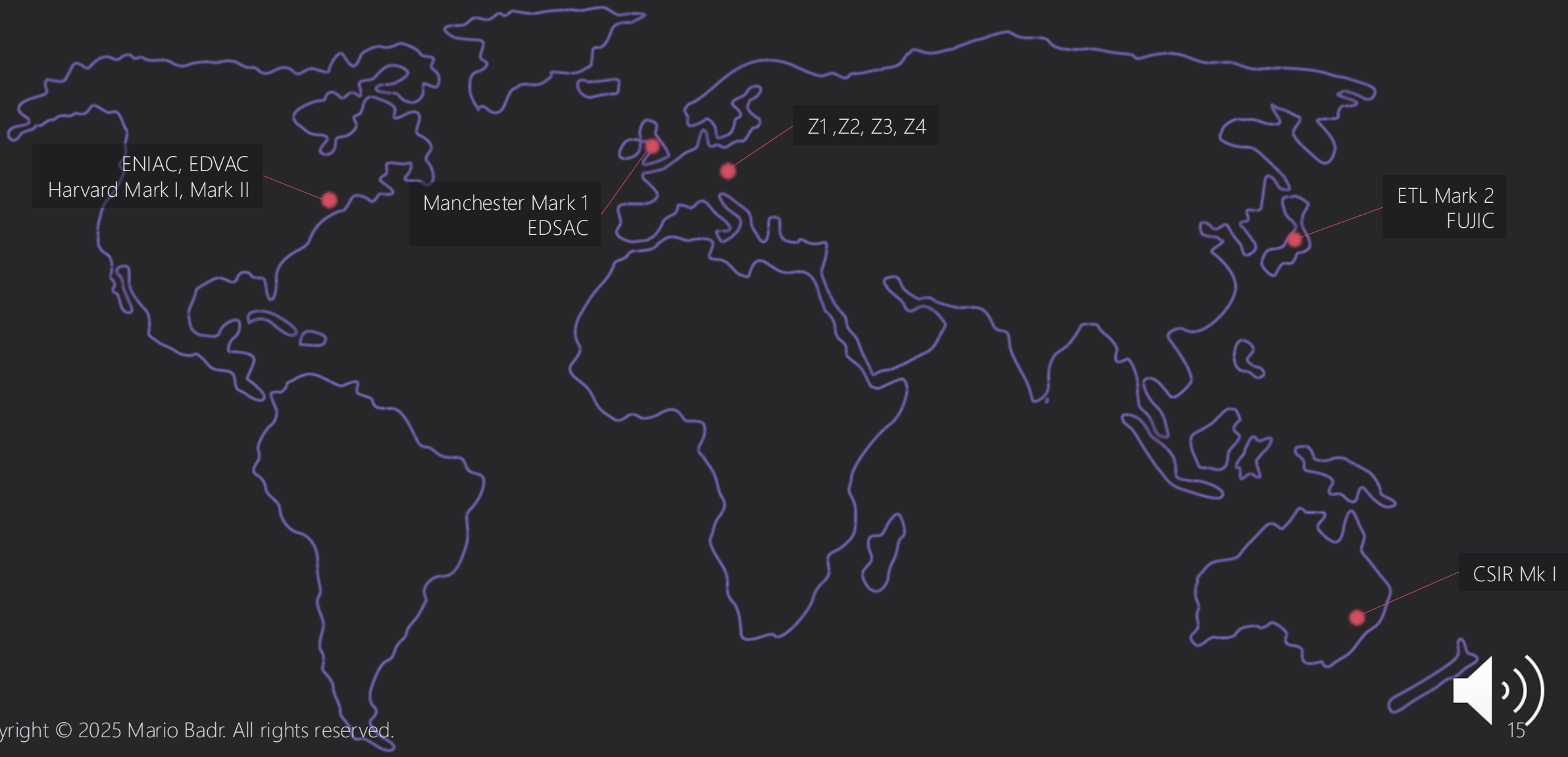
Conclusion

- The implications and trends

Computing machines evolved all over the world



The University of Toronto's DCS

1950-1951

First courses in computing are offered

1952-1953

Ferranti Mark I is delivered (called "FERUT")

Ontario Hydro needs to determine the route of the Saint Lawrence Seaway

FERUT produces the result in hours (instead of 20 years)

1955

The programming language "Transcode" (for FERUT) is published by Worsley and Hume

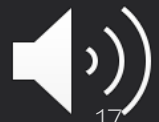
1964



Graduate department of computer science founded

Some electronic computers (technology)

Computer	Built in	Category	Memory	Programming
Harvard Mark I	1944	Electro-mechanical	Electro-mechanical counters	Punched paper tape
ENIAC	1946	Electronic	Vacuum tube registers	“Direct programming”
Harvard Mark II	1947	Electro-mechanical	Electro-magnetic relays	Punched paper tape
Harvard Mark III	1949	Hybrid	Magnetic drum	Stored-program
EDSAC	1949	Electronic	Mercury delay lines	Stored-program
Manchester Mark 1	1949	Electronic	Williams tubes	Stored-program
Harvard Mark IV	1952	Electronic	Magnetic drum and magnetic-core	Stored-program
EDVAC	1952	Electronic	Mercury delay lines	Stored-program



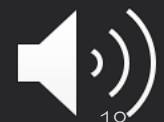
Characteristics of early (up to 1950s) computers

Hardware

- Very large (physically)
- Expensive
- Strongly influenced by technology
  - Vacuum tubes for compute
  - Various technologies for (very small) memory
  - Accessing memory was much slower than computation

Controlling the hardware

- In other words: “programming”
- Programmers needed to know and understand how the hardware worked
  - i.e., no clearly defined separation between software and hardware (yet)



Some IBM computers (instruction sets)

Model	Year(s)	Domain	Notes on instruction set
IBM 701	1952	Scientific computing	• Instructions: 18-bit length • Data: 18- or 36-bit sign-magnitude, fixed-point numbers • Two programmable registers
IBM 702	1953-1955	Business data processing	• Instructions: 5-character length • Data: Variable-length character strings • Two programmable registers (512 characters each)
IBM 704	1954	Scientific computing	• Instructions: 36-bit length • Data: Support for floating point • Several programmable registers, with different lengths • The high-level languages FORTRAN and LISP first developed for this machine