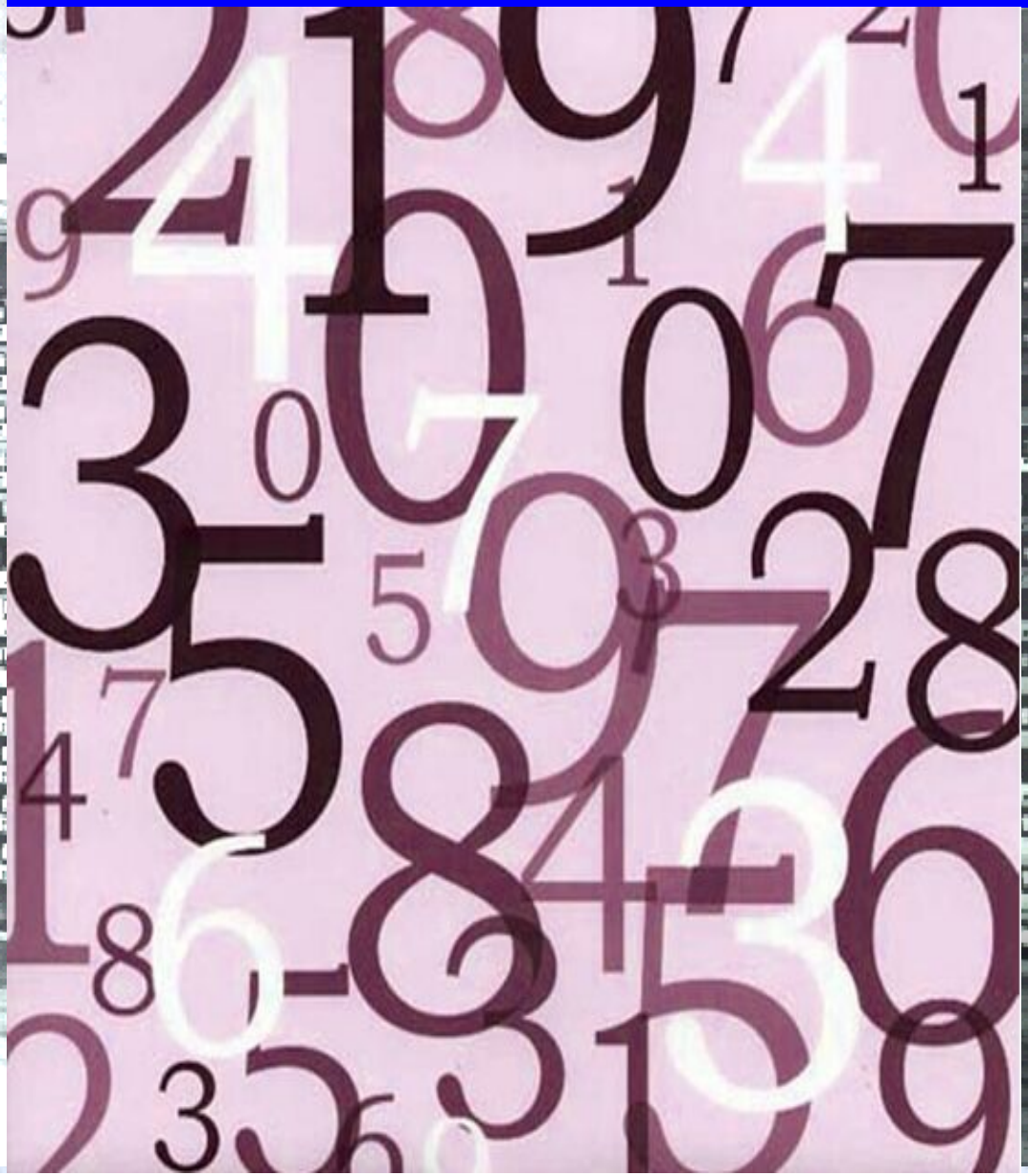
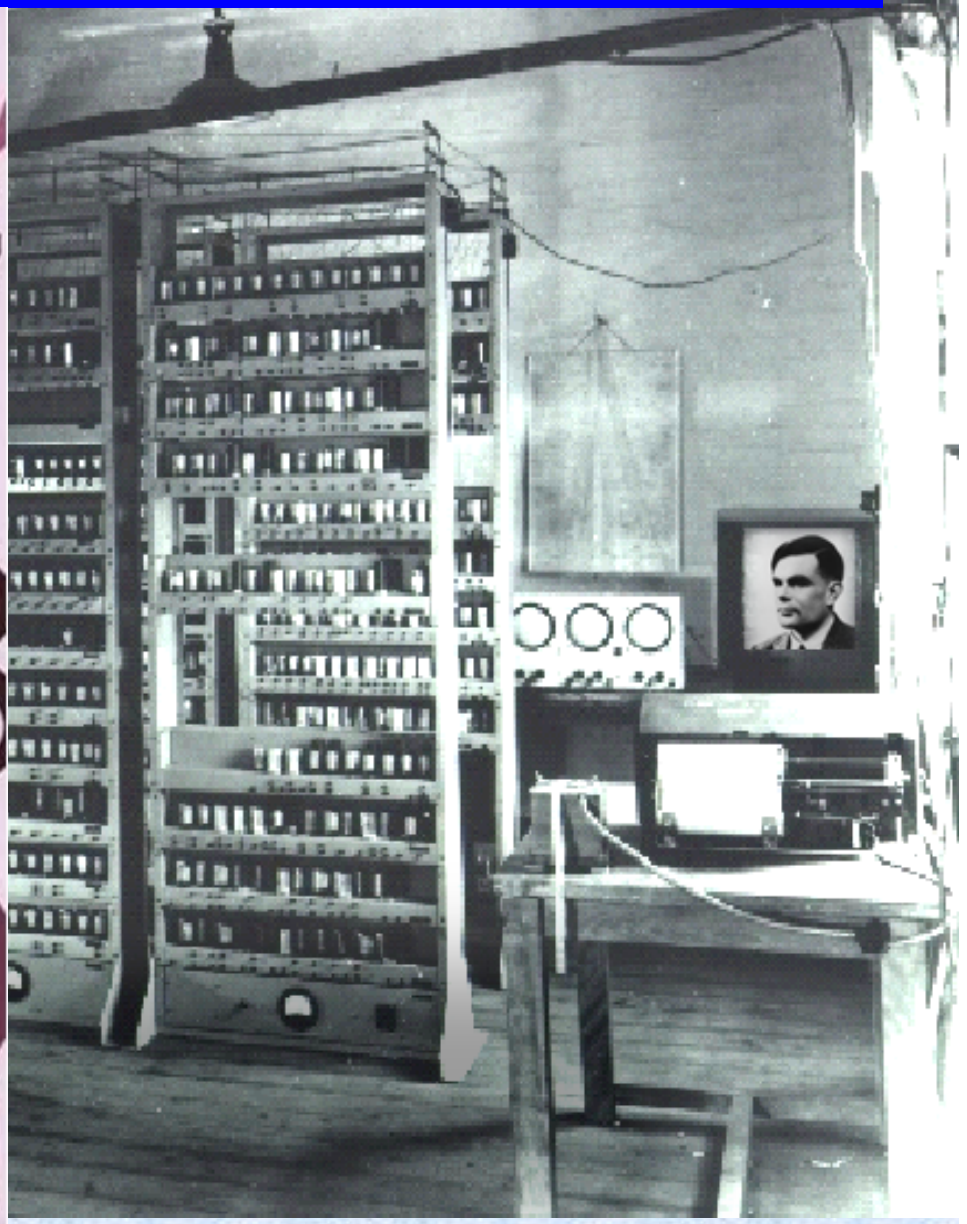
A BRIEF HISTORY OF COMPUTING





A *brief* History of Computing

- Computers are both *abstract logical machines* and *physical realizations* of such machines

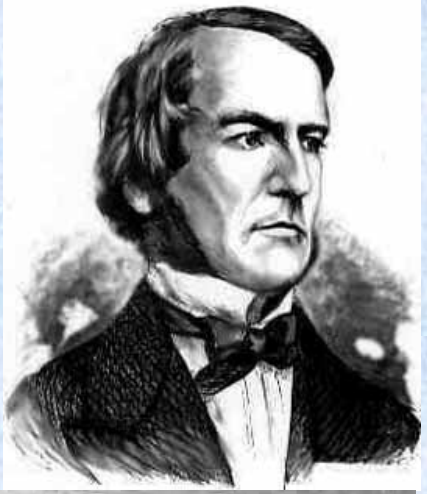
- The concepts on which computers are based have a long history
  - Same logic underlying room-sized computers, mainframes, PCs,, cellphones, iPods, etc.

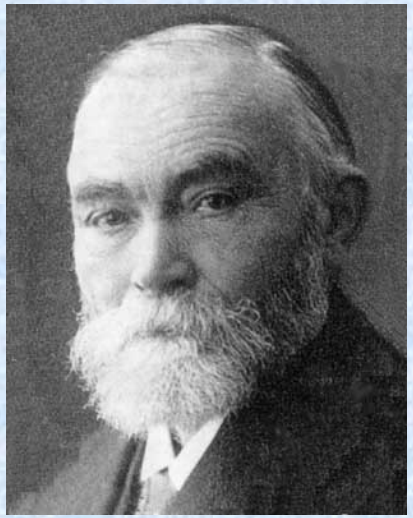
- Many individuals contributed to the development of computing machines, which is a testament to the value of *vision* and *abstract thought:*

Ideas have consequences!

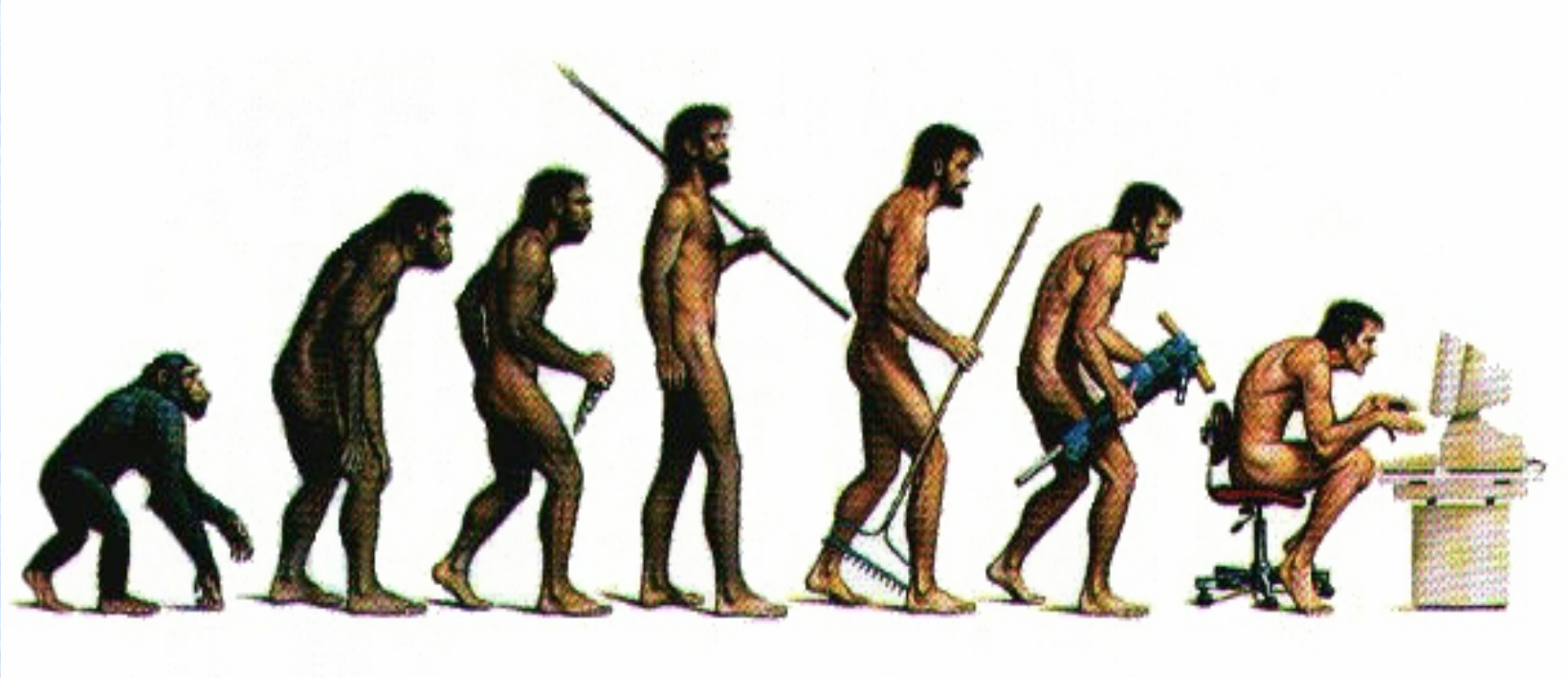
Main heroes

Gottfried Leibniz	1646-1716
George Boole	1815-1864
Gottlob Frege	1848-1925
Georg Cantor	1845-1918
David Hilbert	1862-1943
Kurt Gödel	1906-1978
Alan Turing	1912-1954





A *pre*-history of Computing



Symbols, numbers, counting and arithmetic

Most basic units: Symbols

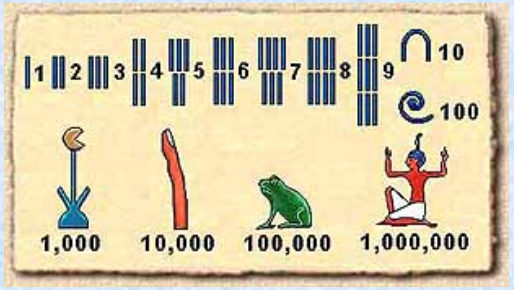
- Symbols are a means of communicating facts and ideas
  - Symbols can not only represent objects, but also properties of objects and quantities of objects.

- Clay tablets were used by Sumerians in 4000-1200 BC for keeping records of commercial transactions
- Egyptians use hieroglyphic signs on pottery and papyrus, 3000+ BC
- Numeration: Counting using strokes, tallies
  - Evidence on bone fragments from 15,000 BC

- Early societies developed tokens to represent quantities

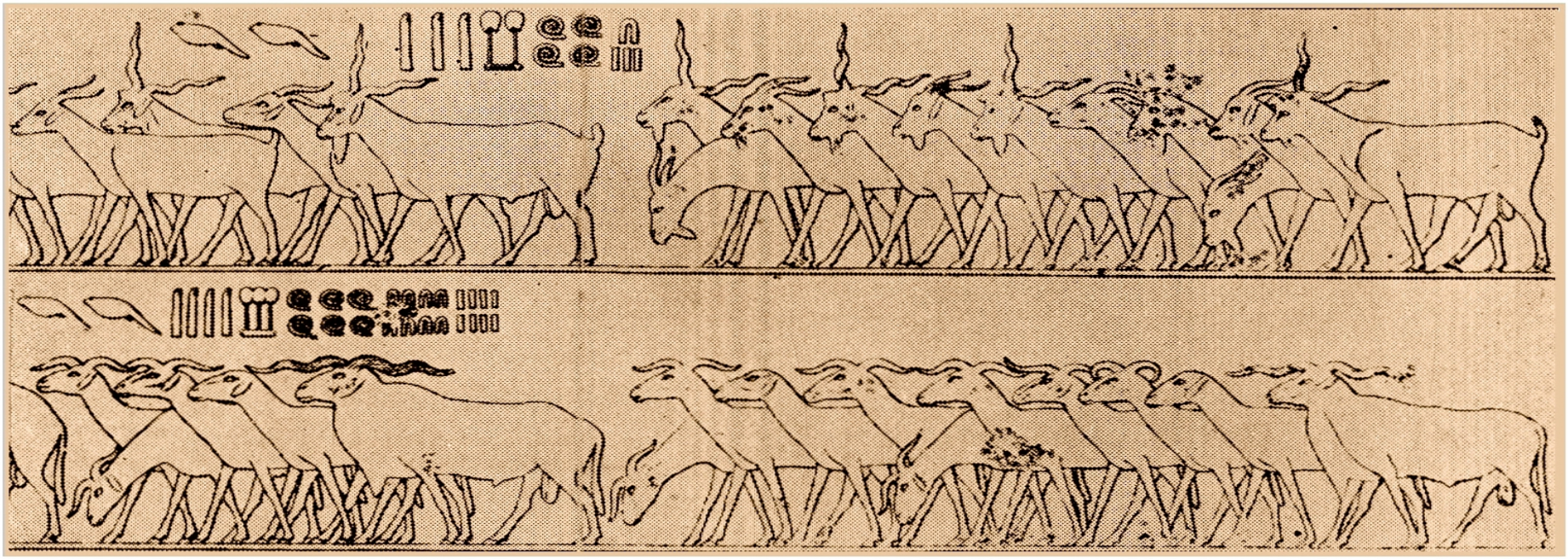
Concept of *Number*

- Around 4000 BC, traders in Uruk (present day Warka/Iraq) were discovering that the same number could be used to mean ten sheep, ten bags of grain, or ten talents of copper.
- About 3000 BC, Egyptian tallies show items grouped at ten, one hundred, one thousand
- Number systems
  - Egyptian hieroglyphics
  - Sumerian number system
  - Roman numerals (I, II, III, IV, V, …, IX, X, …, C, M)
  - Hindu-Arabic notation – a place-value system



- The "discovery" of zero was a key event in the history of computing! (First known inscription: 870 AD)

Egyptian hieroglyphic numerals

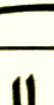
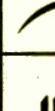


polywog	100,000
finger	10,000
lotus flower	1000
coiled rope	100
arch	10
single stroke	1

232,413 goats

243,688 sheep

Egyptian hieratic numerals

	1	2	3	4	5	6	7	8	9
1s									
10s									
100s									
1000s									
10,000s									
100,000s									
4367 =									

Kahun papyri, Twelfth Dynasty

Egyptian multiplication

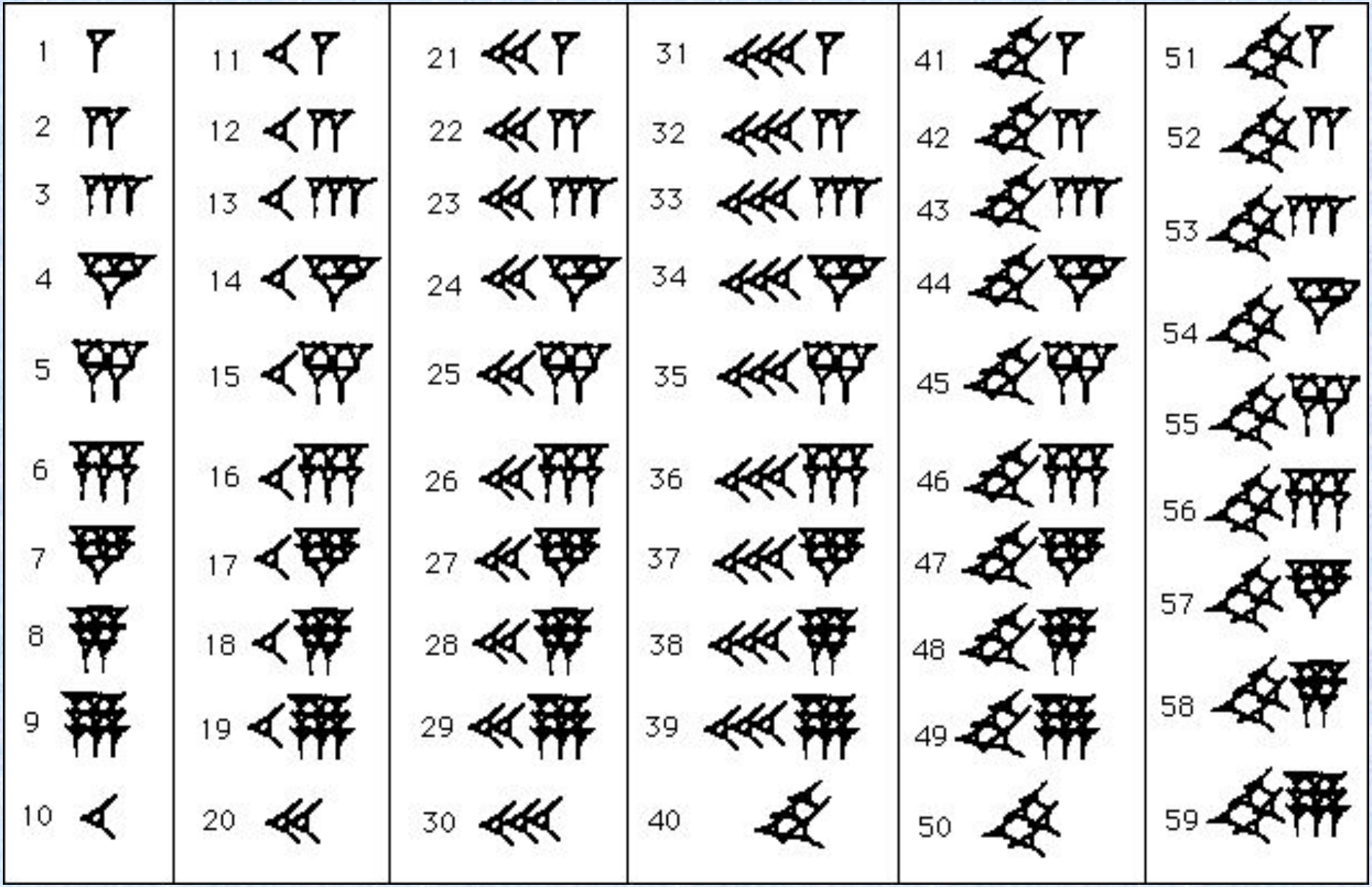
37 x 11 = 407 by doubling

	37	1'	1
	74	2'	1
	148	4	0
+	296	8'	1
	407		

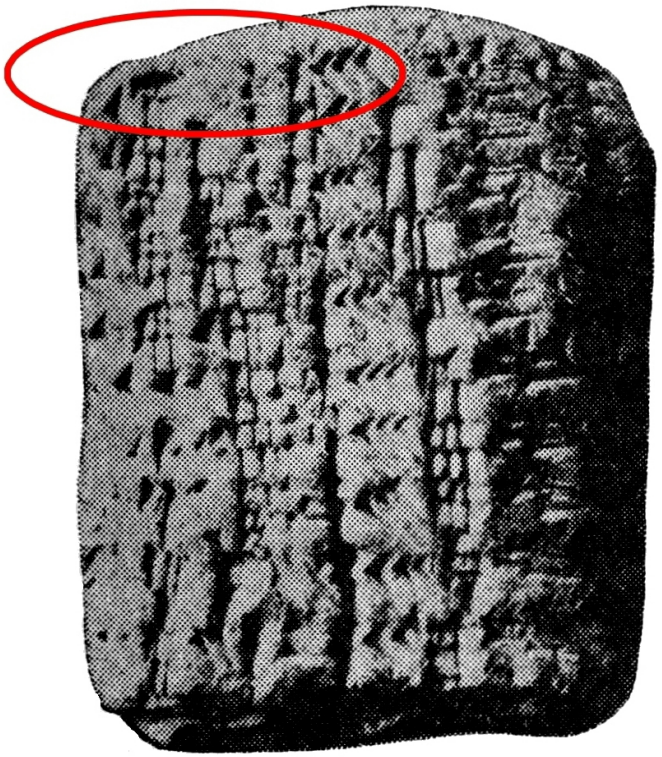
0's and 1's:

BINARY ARITHMETIC

Babylonian sexagesimal numerals



Babylonian tablet of squares



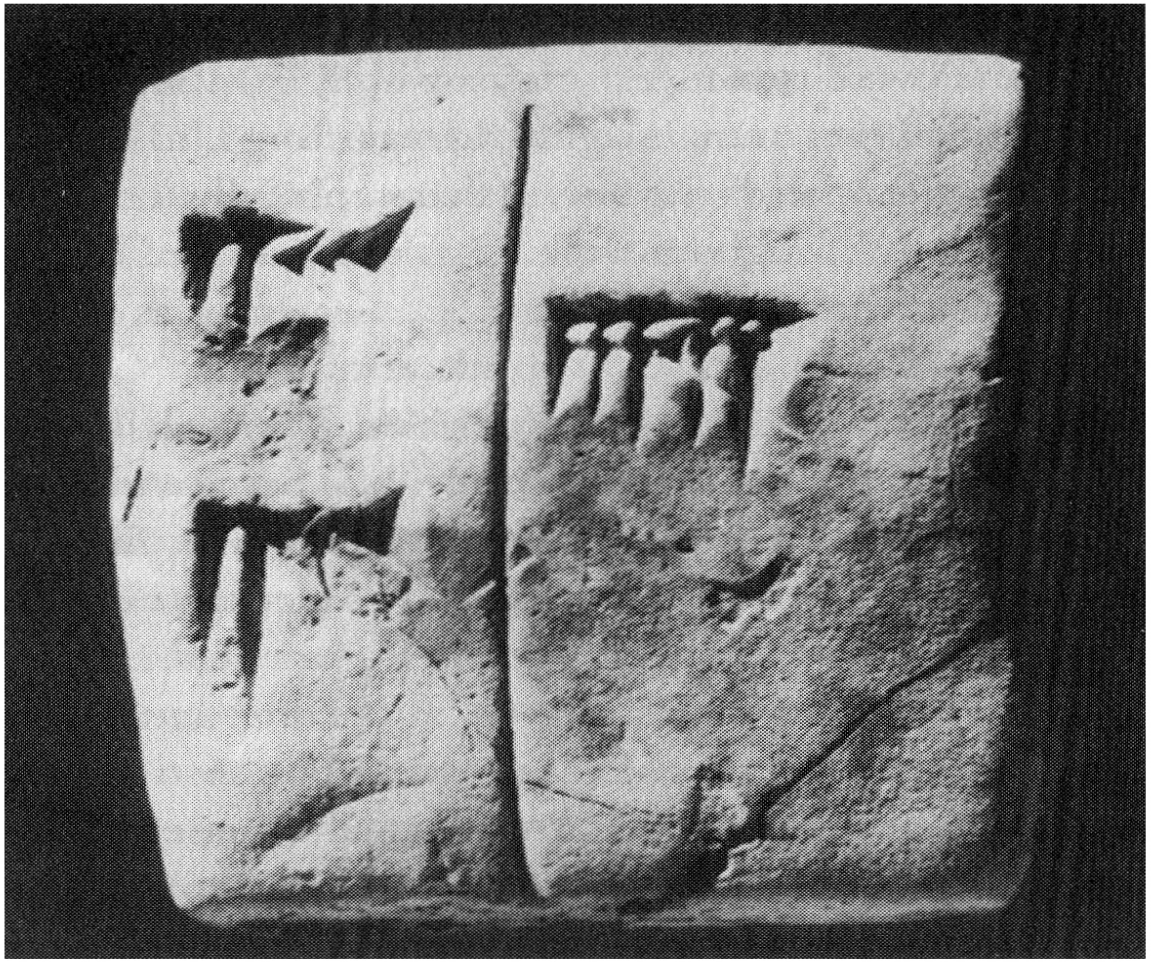
$15 = (15 \times 60)$ 30

$900 = 30^2$

900	30
961	31
⋮	⋮
1521	39

Table of squares, c. 2200 BC

Babylonian multiplication



Yale Babylonian Collection.

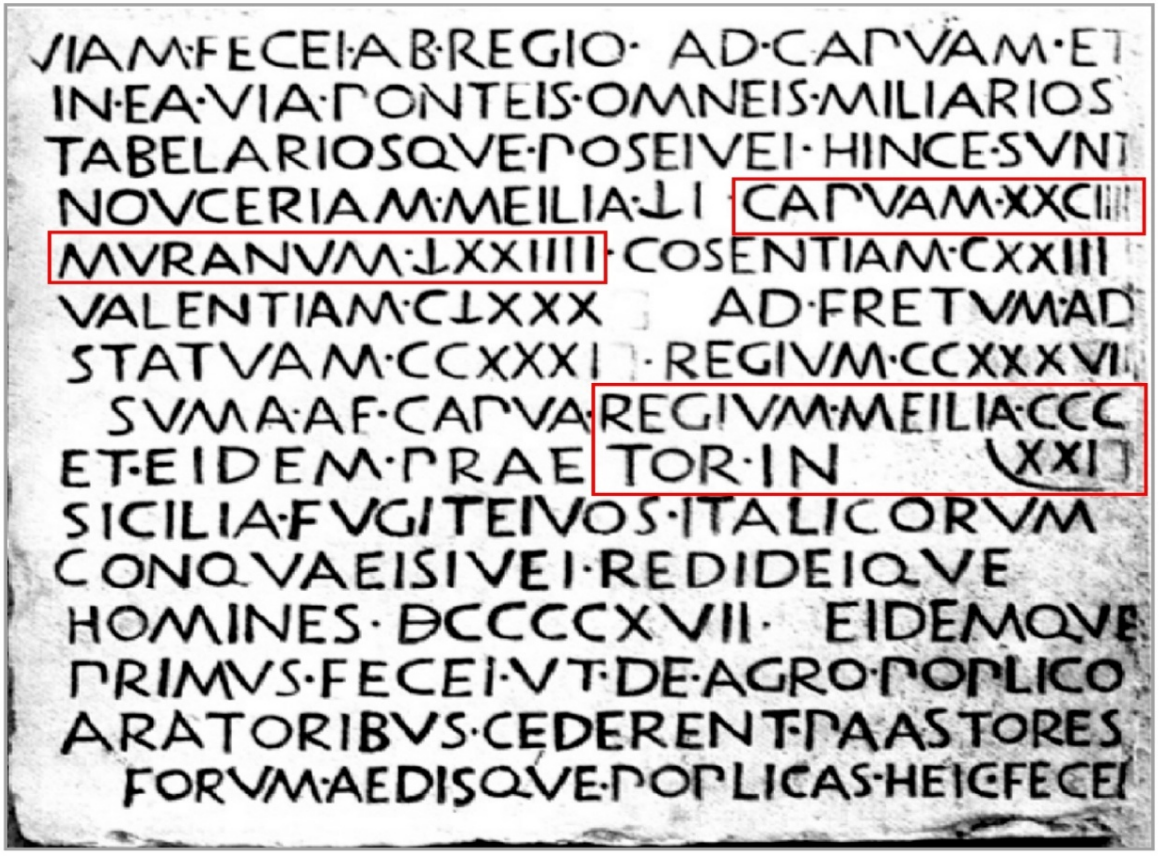
150 (2 × 60 + 3 × 10)
150 (2 × 60 + 3 × 10)

product 22,500

Mileage sign, 21st century AD

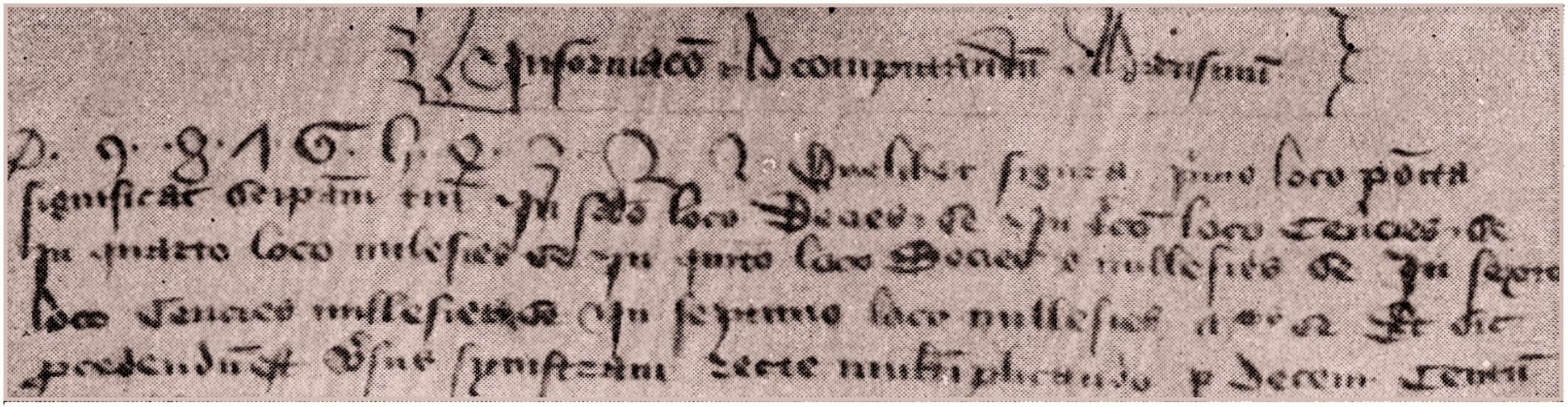
Mileage sign, 2nd century BC

Roman "Polla" Milestone, 130 BC.



In the fourth line is our word "miles" in the ancient spelling *meilia*, followed by 51. The numeral at the end of this line is 83, written in the subtractive form because there was not room for LXXXIII.

Latin manuscript on "Algorisms"



British Museum, Add. MS. 24059 fol. 22b.

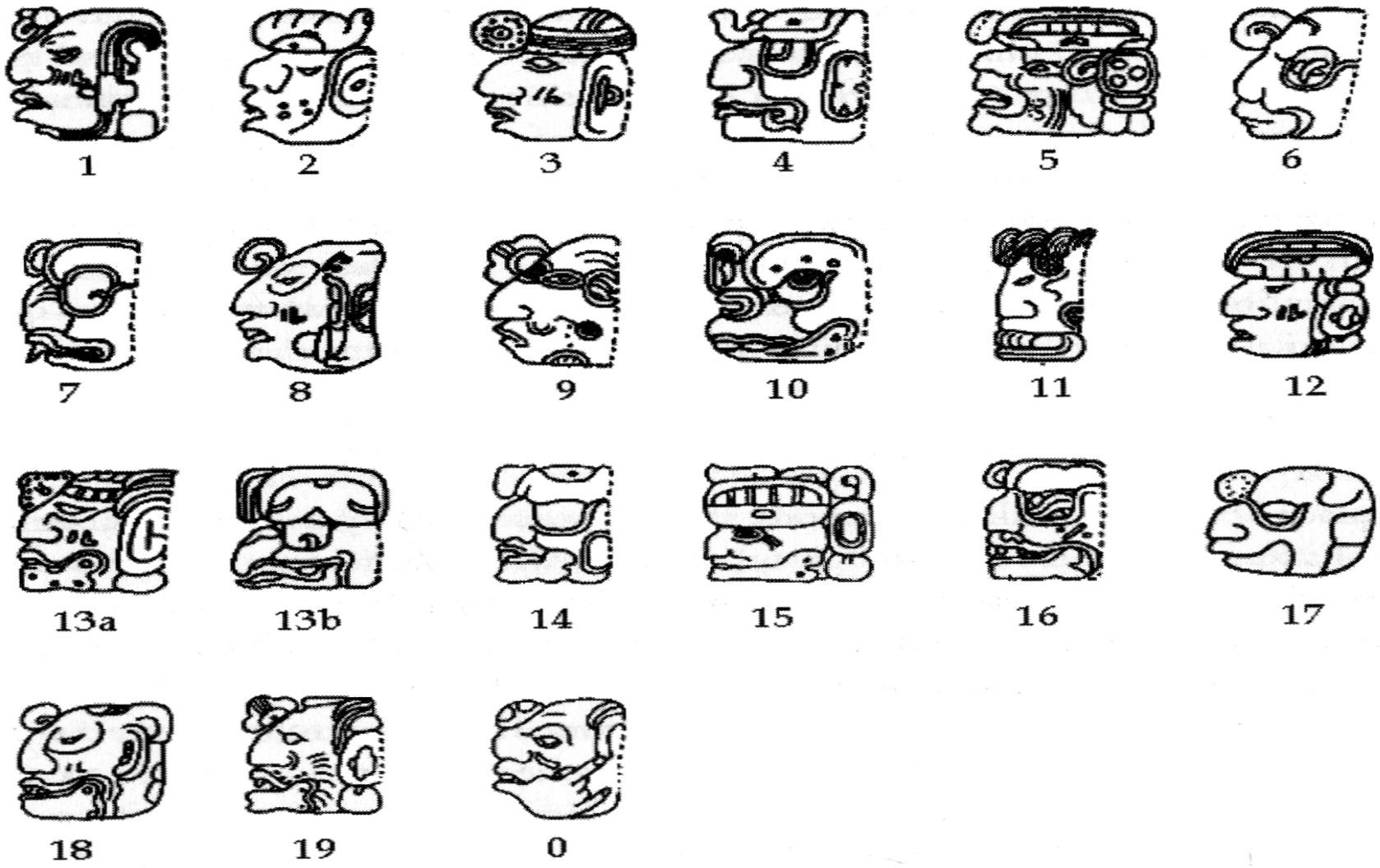
"Quelibet figura primo loco posita significat seipsam, tamen in secundo loco Decies seipsam . . . "

"Any digit in the first or units' place signifies so many units, in the second place so many tens, and so on . . . "

The title is **"Informacio ad computandum Algorismi,"**
"Information concerning the Computation by Algorism."

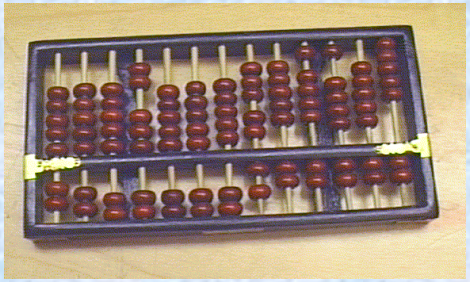
Numeration in a 15th Century Manuscript

Mesoamerican systems



Maya head-variant glyphs

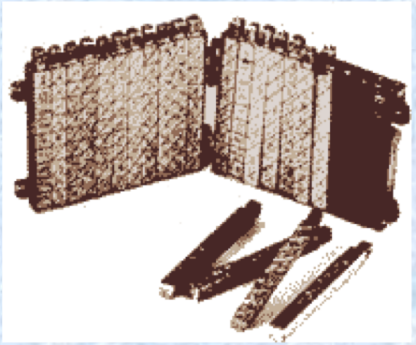
Aids to Counting and Manipulating Numbers



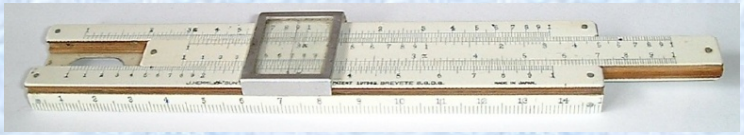
- Fingers (digit/decimal)
- Stones, pebbles, sticks, etc.
- Abacus, 3000 BC – 1300 BC
- Quipa (Incas) and Quipu (Peruvians), 1500 AD
  - Making knots in tiny ropes with various colors and lengths

- Logarithm tables, ~1600
  - Scotsman John Napier

Napier's bones ➔



- Slide rule, 1622
  - Invented by Englishman William Oughtred



Heading out of pre-history

- Why did people need to compute?
  - Commerce
  - Astronomy
  - Navigation
  - Warfare
  - Science
  - Taxes
- What is a “computer”?
  - Originally, a job description: ***"a person who computes"***
  - The earliest known reference to “computers”: in 1398 from a writer called Trevisa, who wrote about people who occupied themselves with calculations of time:

"compotystes . . . departed by twelve mones, in sixe even and sixe odde,"

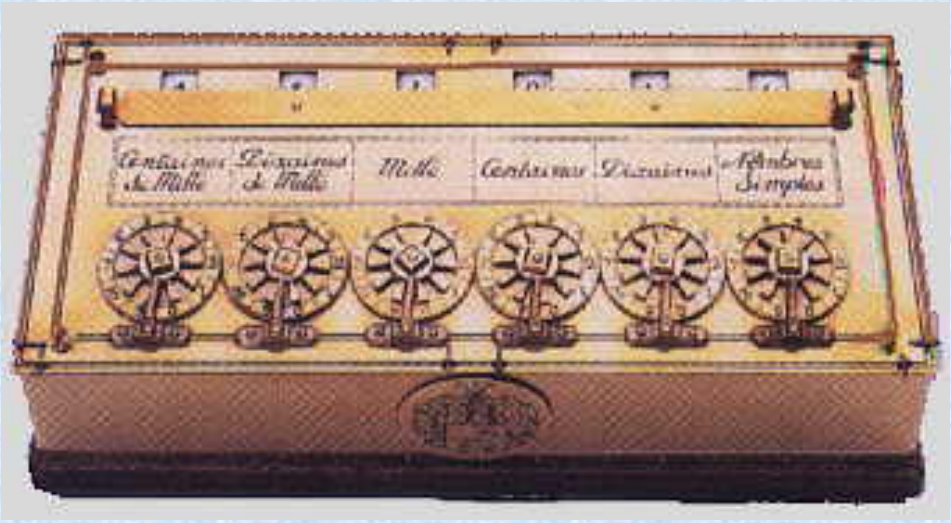
  - Boring, repetitive, error-prone calculation of tables!

Climate of the 1600s in Europe

- The middle ages are over
  - Ideas of the ancient Greeks are discussed once again (Thales, Pythagoras, Socrates, Plato, Aristotle)

- The Renaissance had been going on for 200 years
  - Revival of art, literature, and learning
- The Enlightenment is about to get going
  - René Descartes, Blaise Pascal, John Locke, Isaac Newton
- The industrial revolution is yet to come
- By the 1600s, computing was quite entrenched, and some people were pursuing the idea of ***mechanizing*** computation

Blaise Pascal (1623-1662) French



1643 – Mechanical adding machine (the "Pascaline")

Gottfried Wilhelm Leibniz (1646-1716) German

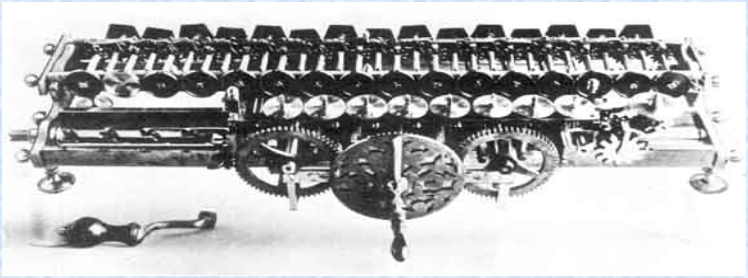
- Co-inventor of the calculus
- Dreamed of a universal mathematical language to encode knowledge, and rules to embody logic

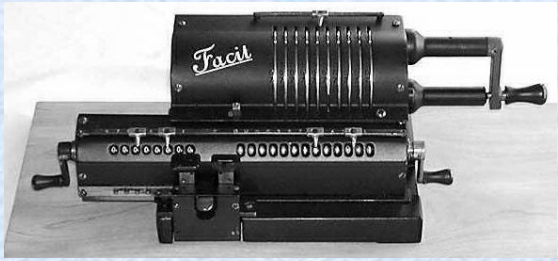
"For it is unworthy of excellent men to lose hours like slaves in the labor of calculation which could safely be relegated to anyone else if the machine were used."

Leibniz

- Leibniz built a calculating machine that could add and subtract.
  - Part of it, the "Leibniz wheel," was used into the 20th century

1673

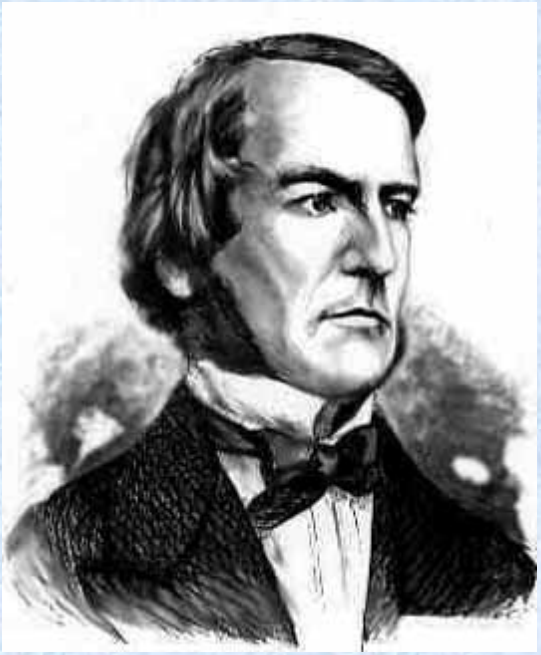




1950

- But his dream was much grander – to reduce human reasoning to a kind of calculation and to ultimately build a machine capable of carrying out such calculations
  - Symbols – an alphabet of human thought
- Leibniz' ***universal characteristic*** would encode ***all knowledge*** and reduce all reasoning and discovery to a combination of basic elements such as numbers, letters, sounds and colors.

George Boole (1815-1864) BRITISH

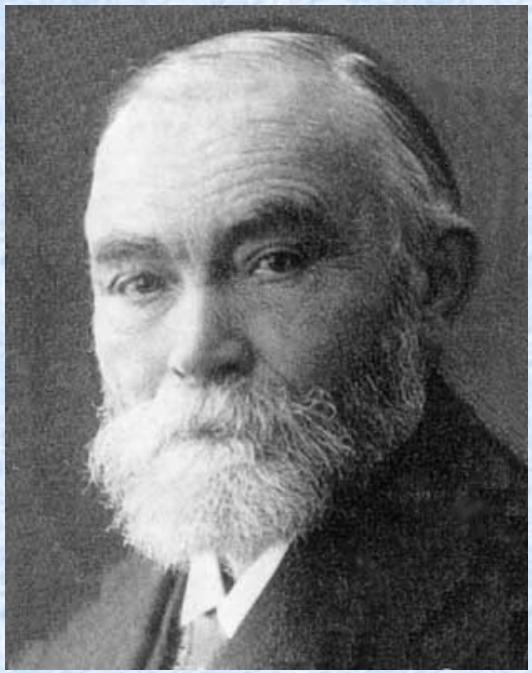


- Boole's insight: Logical relationships are expressible as a kind of algebra
- Published ***The Laws of Thought***

- Boole extended Aristotle's simple 3-term *syllogisms* to a broader range of reasoning
  - Syllogism:

    All B's are C's , All A's are B's → All A's are C's

Gottlob Frege (1848-1925) GERMAN



- Frege provided the first fully developed system of logic.
- *All of mathematics* could be based on, and derived from, logic.
- In 1879 he published ***Begriffsschrift***, subtitled "*A formula language, modeled upon that of arithmetic, for pure thought*"

As such, the ***Begriffsschrift*** can be considered the ancestor of all current computer programming languages

Georg Cantor (1845-1918) RUSSIAN/GERMAN

LEIBNIZ
BOOLE
FREGE
CANTOR

- Cantor – against the conventional wisdom of the day, and against significant opposition –created a coherent mathematical theory of the infinite.

- The ensuing debate and disputes over this would eventually lead to key insights into the development of all-purpose digital computers

David Hilbert (1862-1943) GERMAN

LEIBNIZ
BOOLE
FREGE
CANTOR
HILBERT

- A brilliant mathematician profoundly interested in the foundations of mathematics
- In 1900, he presented mathematicians with a grand challenge for the new century: 23 fundamental unsolved problems in mathematics
  - #1 Cantor's Continuum Hypothesis (Cohen)
  - #2 the problem of the consistency of arithmetic and logic (Gödel)
  - #10 universal solution of Diophantine equations (Matiyasevitch)

- More than a collection of problems – Hilbert's philosophy of mathematics

Kurt Gödel (1906-1978)

AUSTRIAN

LEIBNIZ
BOOLE
FREGE
CANTOR
HILBERT
GÖDEL

- An important goal of philosophy is to develop and study symbolic systems of logic, encompassing mathematics and empirical science

- Gödel chose Hilbert's question of completeness for his doctoral dissertation.

Gödel revolutionized the way we think about the power and properties of formal systems.

Alan Turing (1912-1954)

BRITISH

LEIBNIZ
BOOLE
FREGE
CANTOR
HILBERT
GÖDEL
TURING

- Leibniz, Boole, Frege
  - Calculation as reasoning; foundations of logic
- Cantor, Hilbert, Gödel
  - Foundations of mathematics and logic
- John von Neumann
  - The renaissance man of computing
- Babbage, Ada, Burroughs, Hollerith, Bush, Zuse, Aiken, Atanasoff, Eckert, Mauchly, Wilkes, Hopper, Shannon…
  - Computing pioneers

- Alan Turing is at the intersection of the "thinkers" and the "builders", where the rubber meets the road.
  - The real hero of computing

Turing

- Turing constructed a mathematical model of an

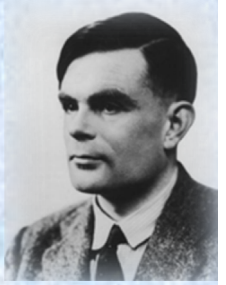
  all-purpose computing machine.

- What does this mean?

¿

?

Turing



- Howard Aiken quote (1956):

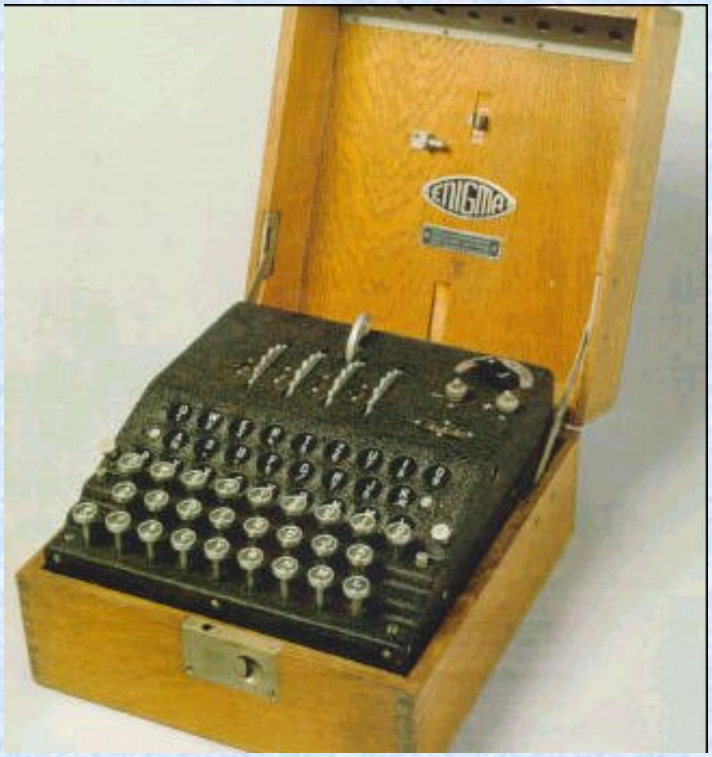
  – *"If it should turn out that the basic logics of a machine designed for the numerical solution of differential equations coincide with the logics of a machine intended to make bills for a department store, I would regard this as the most amazing coincidence that I have ever encountered."*

Turing

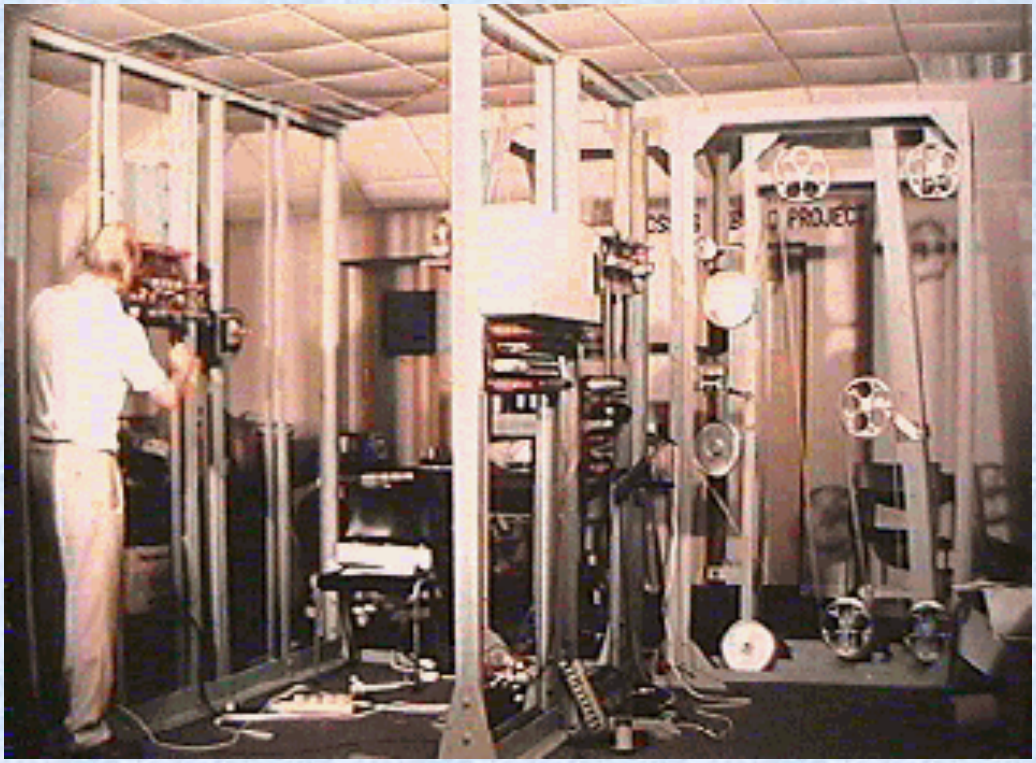
- Once the idea of such a machine (called the **Universal Turing Machine**) was understood, the challenge to ***build it*** began
  - –How to design and build such a device?
  - –Not just a device to do particular computations,
- **–Turn from ideas to devices**
  - –Mechanical gears to electromechanical relays to vacuum tubes
  - –Going from "underlying logic" to actual device
  - –Memory: Mercury delay line to cathode-ray tube to metal core

OBE, marathon runner

- What were the immediate practical needs for computers in the late 1930s and early 1940s?



The Enigma Machine



The Colossus

The Race to Build a Computer: Who was first?

- **1834-1871: Analytical Engine (Babbage)**
  - Design of a mechanical computer that possessed all the essential logical features of the modern general-purpose computer
- **1930: Differential Analyzer (Bush)**
  - First large-scale automatic general-purpose mechanical analog computer
- **1941: Z3 (Zuse)**
  - First fully-functional program-controlled electromechanical digital computer
- **1942: Atanasoff-Berry Computer (ABC)**
  - Small, special-purpose digital computer (300 vacuum tubes)
- **1943: Colossus (Bletchley Park team, Turing)**
  - First fully functioning electronic digital computer; classified until 1983 (2400 vacuum tubes)

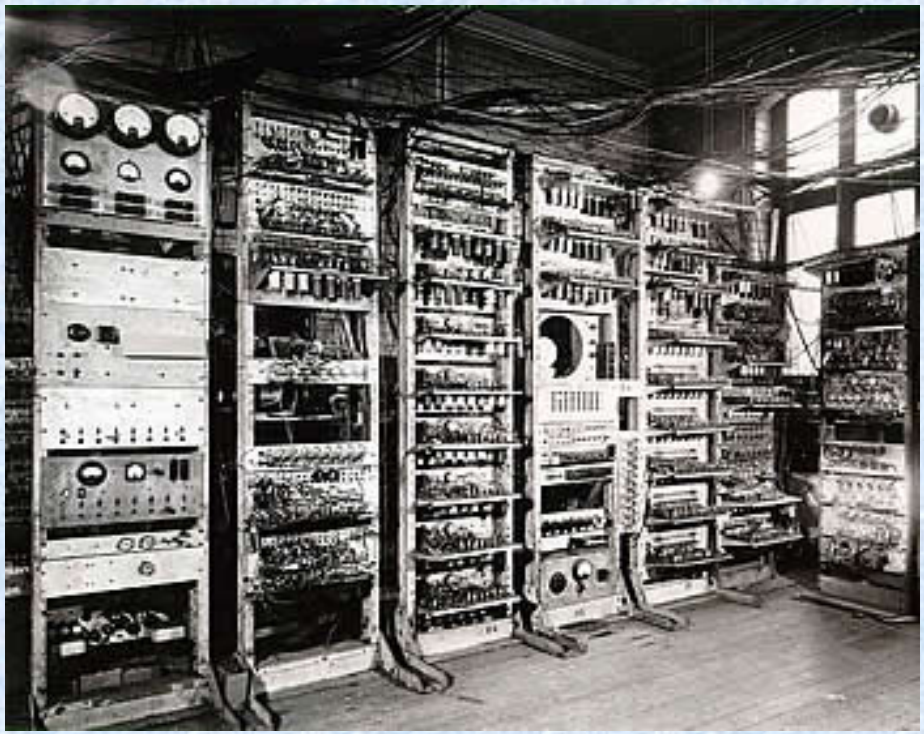
The Race to Build a Computer (cont.)

- **1944: Harvard Mark I (Howard Aiken)**
  - First practical digital computer with programmed instructions
- **1946: ENIAC (Eckert and Mauchly)**
  - First large-scale electronic digital computer (calculator)
- **1948: Manchester Mark I / "Baby" (Williams and Kilburn)**
  - First working general-purpose stored-program electronic digital computer
- **1949: Whirlwind (MIT)**
  - First real-time computer
- … and many many other firsts…

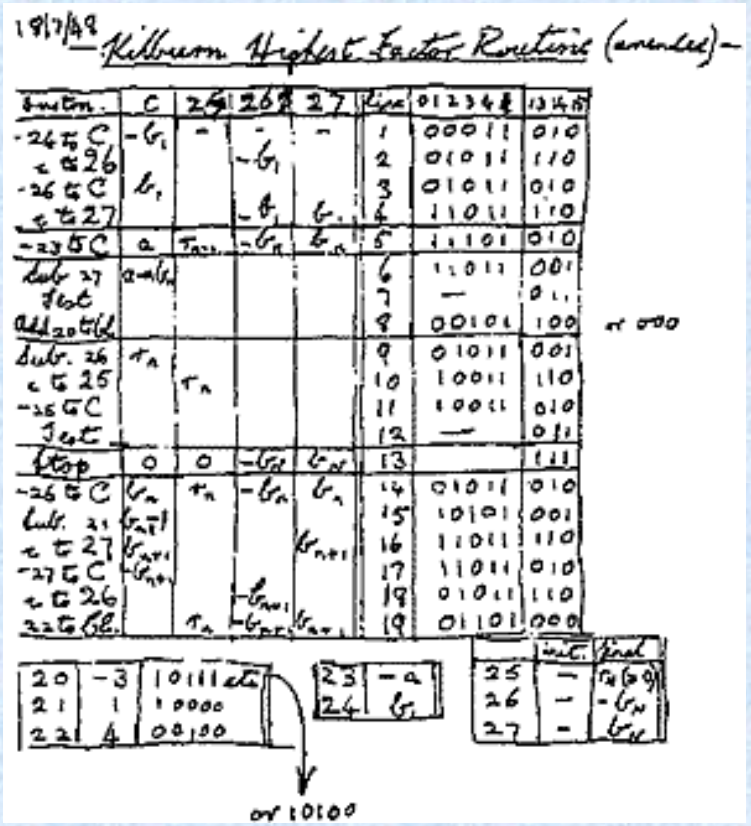
➔ let's take a look at a few:

The Race to Build a Computer (cont.)

- 1948: Manchester Mark I / "Baby" (Williams and Kilburn)
  - –First working general-purpose stored-program electronic digital computer



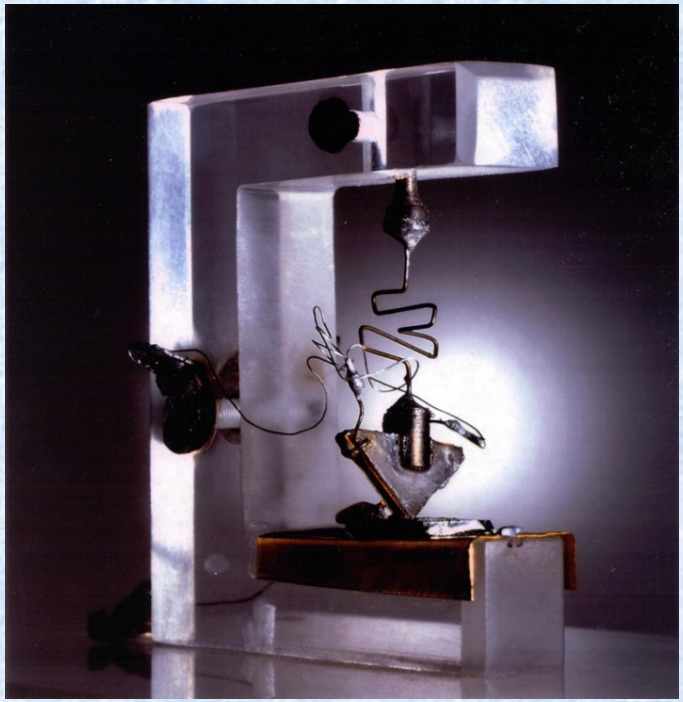
Manchester Mark I



First computer program by Tom Kilburn

Highlights

- 1947 – Invention of the TRANSISTOR [TRANsfer reSISTOR] Walter H. Brattain, William Shockley and John Bardeen of AT&T - Bell laboratories

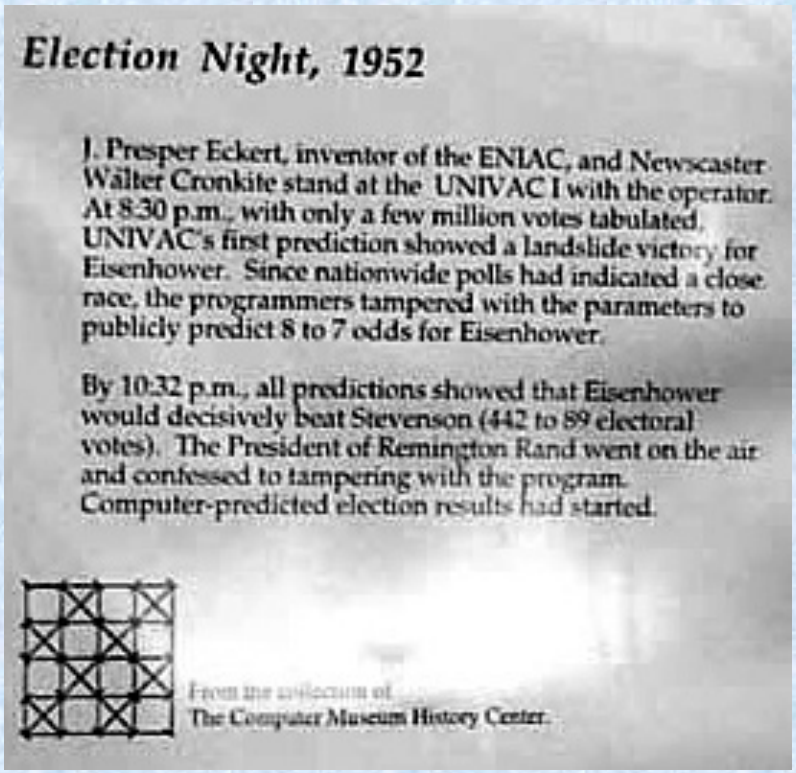


Nobel prize in 1956.

Highlights (cont.)

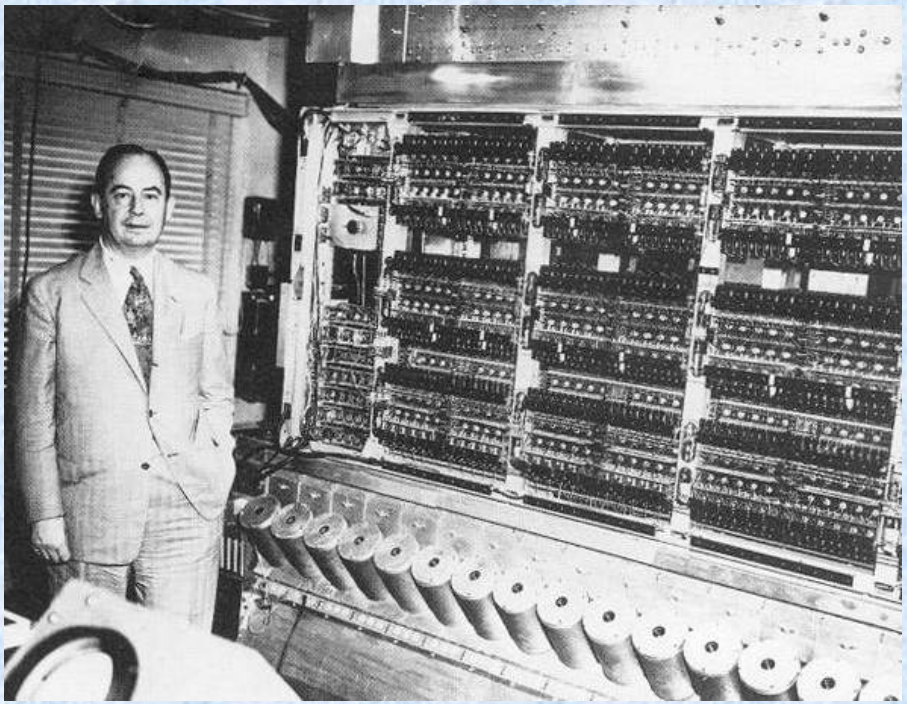
- 1950 – Turing's "Computing Machinery and Intelligence"
- 1952 – Univac I computer predicts the outcome of the presidential election on television (contrary to the pundits)

Univac I, 1952 presidential elections

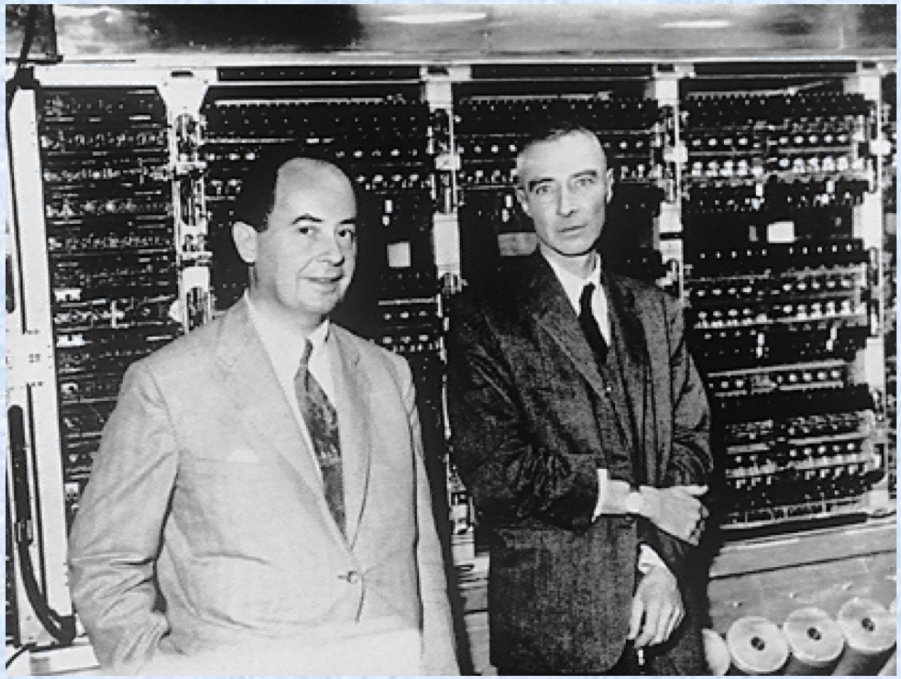


Highlights (cont.)

- 1952 John Von Neumann and ENIAC at Princeton



- Weather prediction a reality

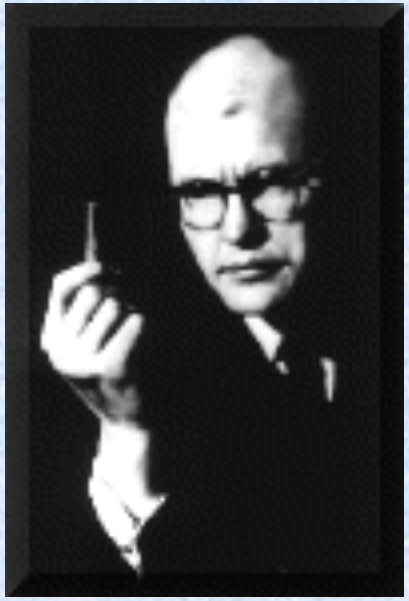


- Von Neumann & Robert Oppenheimer

Highlights (cont.)

1958 – Fairchild laboratories and Texas Instruments (Jack Kilby) develop the IC

- Beginning of third generation computers

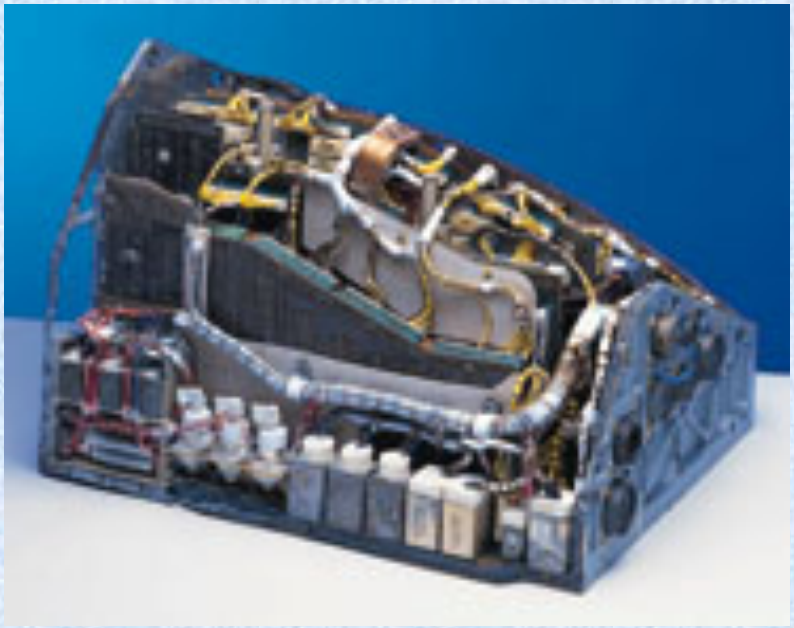


Jack Kilby

Five components on a piece of germanium measuring half an inch long ... and thinner than a toothpick

Highlights (cont.)

Spaceborne computers of the Mercury/Gemini projects through late 1960s.



Grissom/Young splashdown

1963

1966 Gemini 8 lift-off

- SIZE
  Big as a loaf of bread - 19 inches long
- WEIGHT
  58 pounds
- MEMORY
  159,744 bit core memory (about 20K)

Athena Orbital randezvous

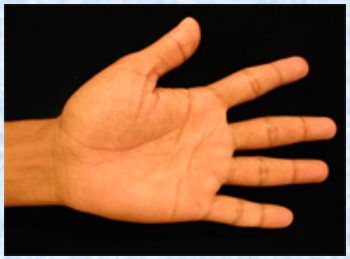
Neil Armstrong in Gemini 8

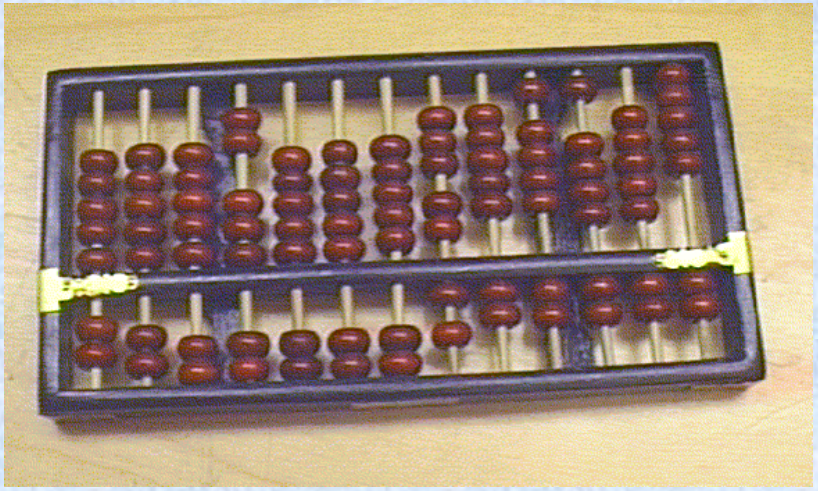
Wrap-up

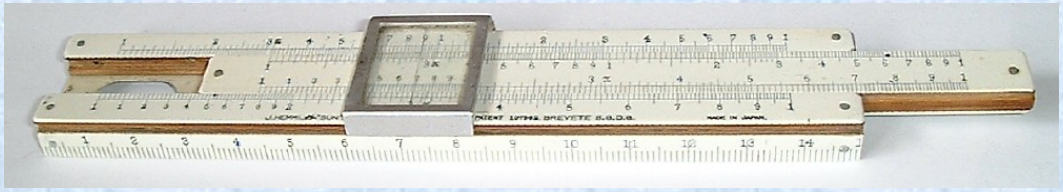
- The history of computers is, in large part, a history of ideas
  - Visionaries in logic and mathematics
- Some of the main players are
  - Leibniz, Boole, Frege, Cantor, Hilbert, Gödel, Turing
- And don't forget
  - Pascal, Babbage, Russell, von Neumann, Shannon, Bush….
- But also
  - Ada, Burroughs, Hollerith, Zuse, Aiken, Atanasoff, Eckert, Mauchly, Wilkes, Hopper, Kirby, Backus, Moore, Engelbart, Licklider, Roberts, Cray, Sutherland, Wozniak, Jobs, Gates, Allen, Metcalfe, Berners-Lee…. and a cast of thousands

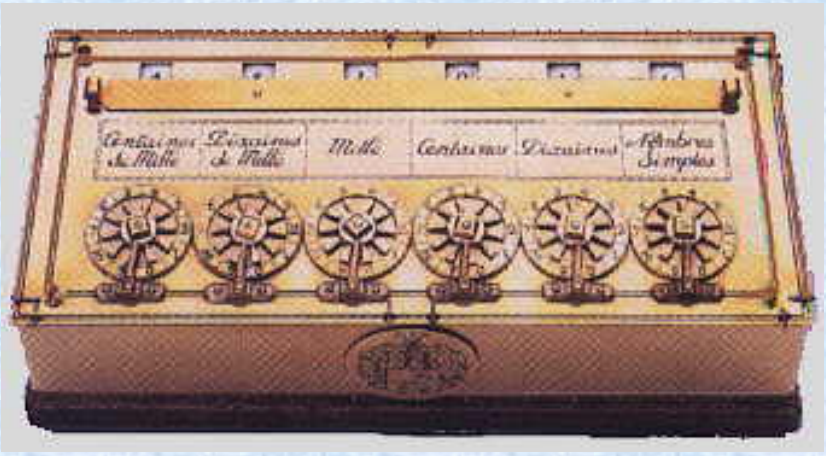
The Future of Computing

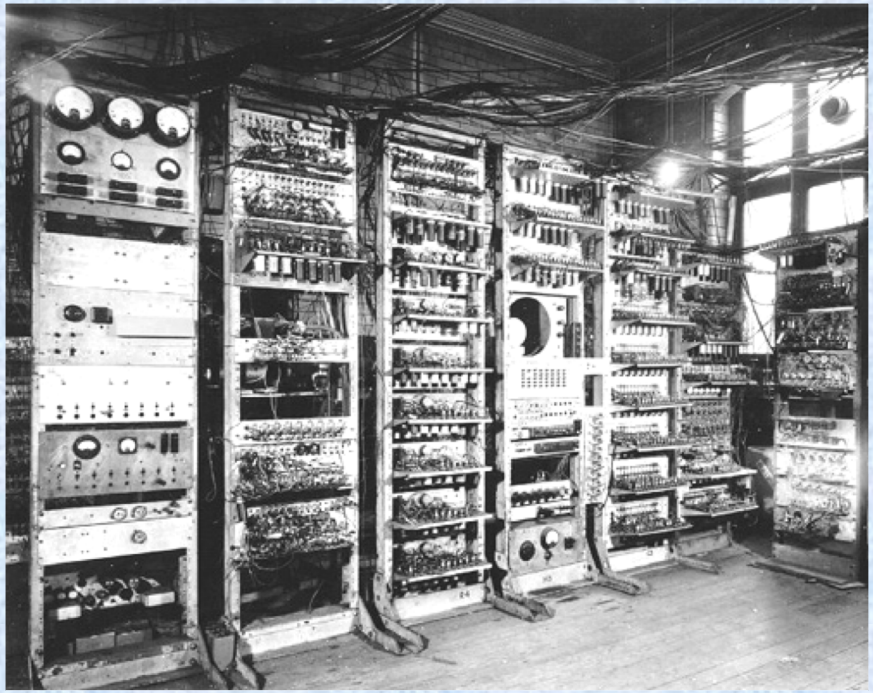
- All the great thinkers were motivated not just by current needs and problems, but by vision – ***what could be***
- Leibniz' dream is still alive
- What will computing/computers be like in 20 years? 100 years?
  - Not like today

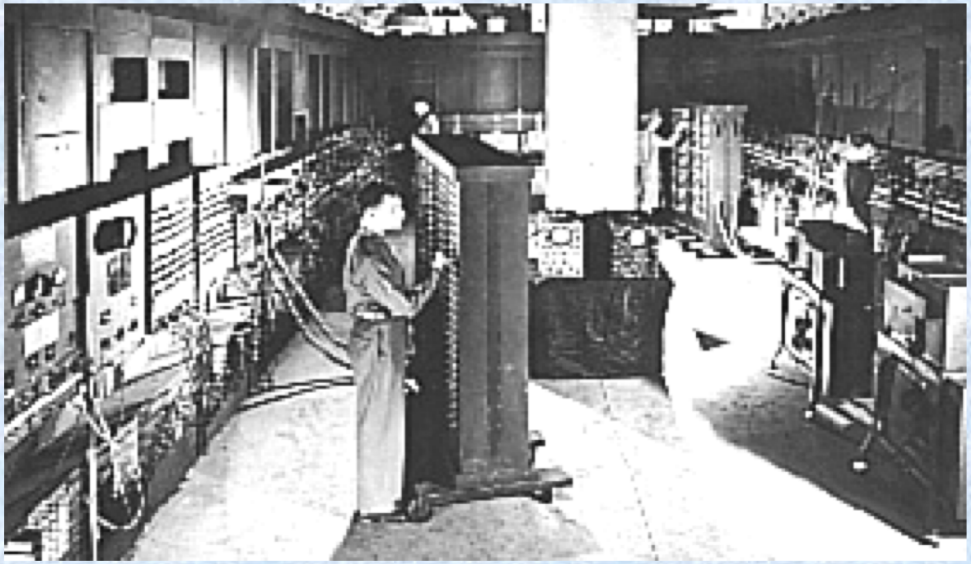


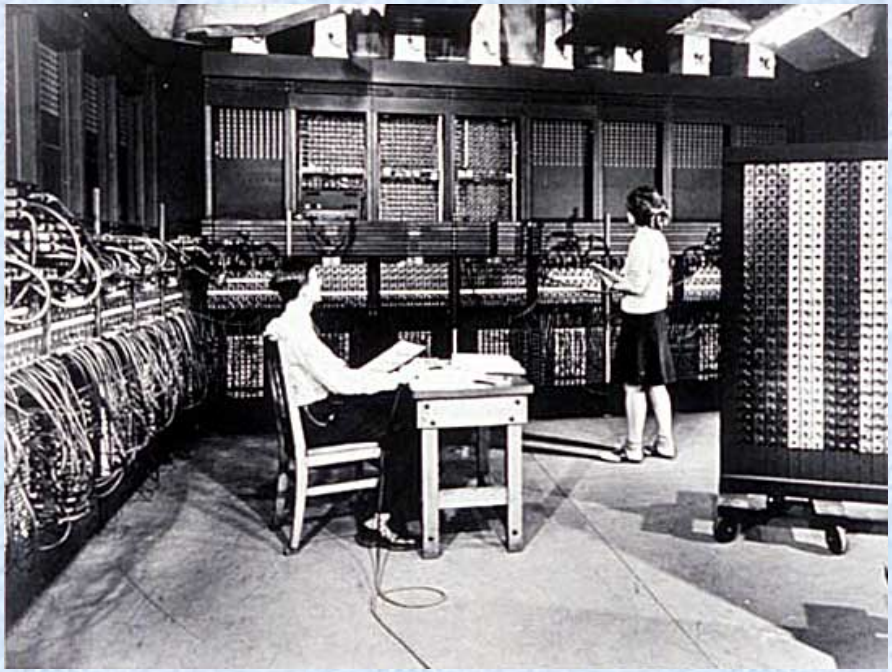


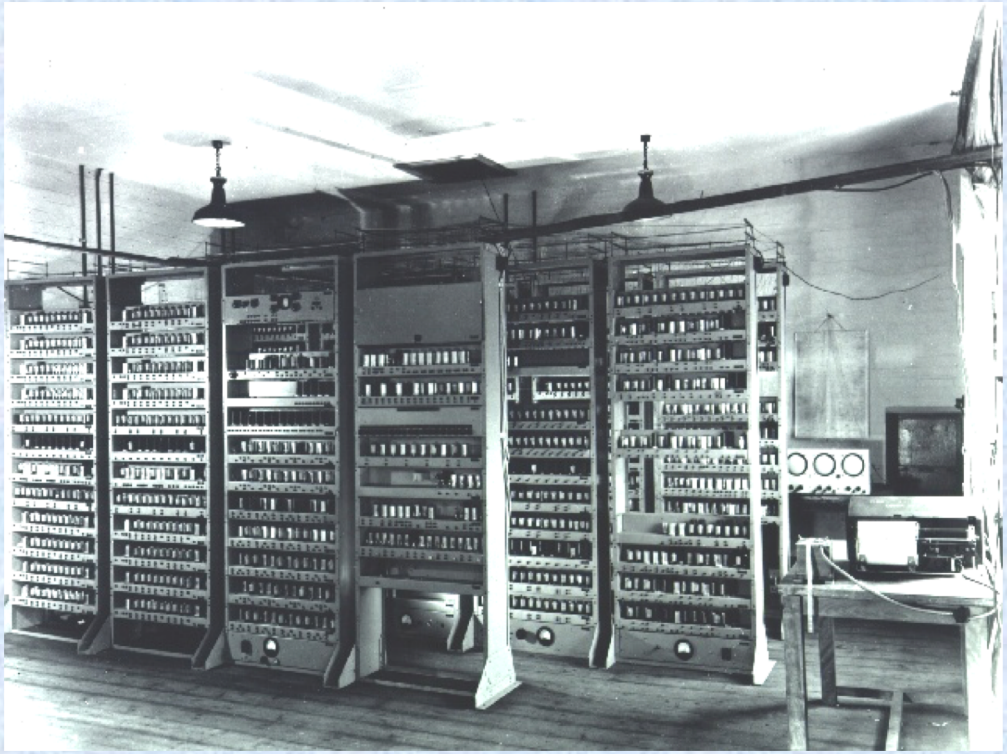


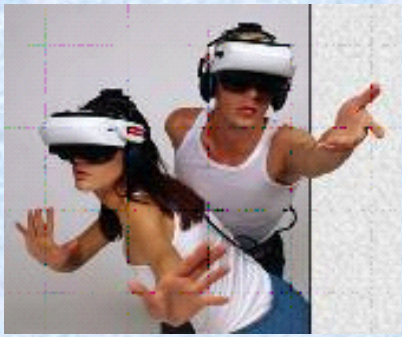

Centaines de Mille
Dizaines de Mille
Mille
Centaines
Dizaines
Unités Simples












MicroOptical display
anchor
anchor
IR tag reader
802.11 bridge
CerfBoard
body bus junction
body network hub
batteries
BSEV core


Zire