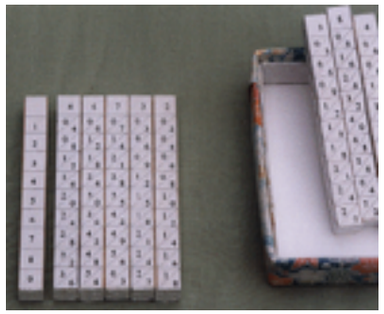
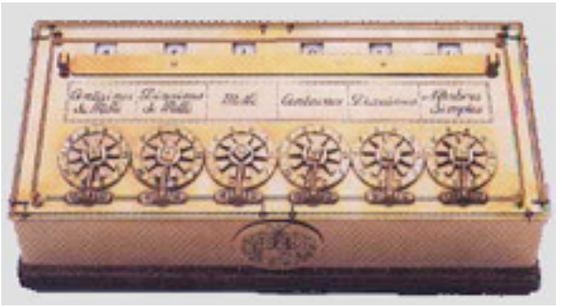
Episodes in Computing History (a 30-minute tour)

Zero

Quipu

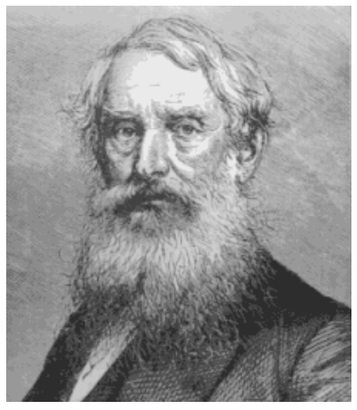


Rabdology



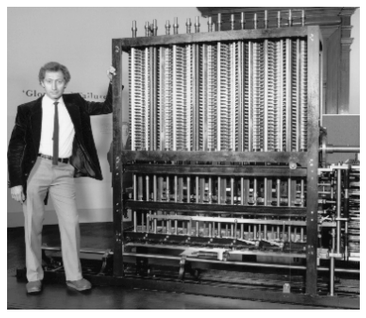
Calculators

Pigeon Post

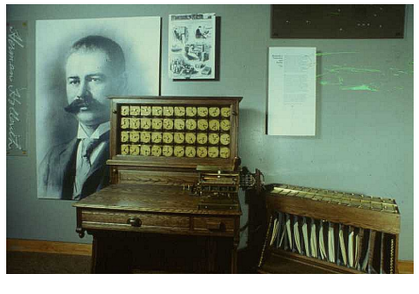


Morse

Jacquard Loom



Babbage



Hollerith

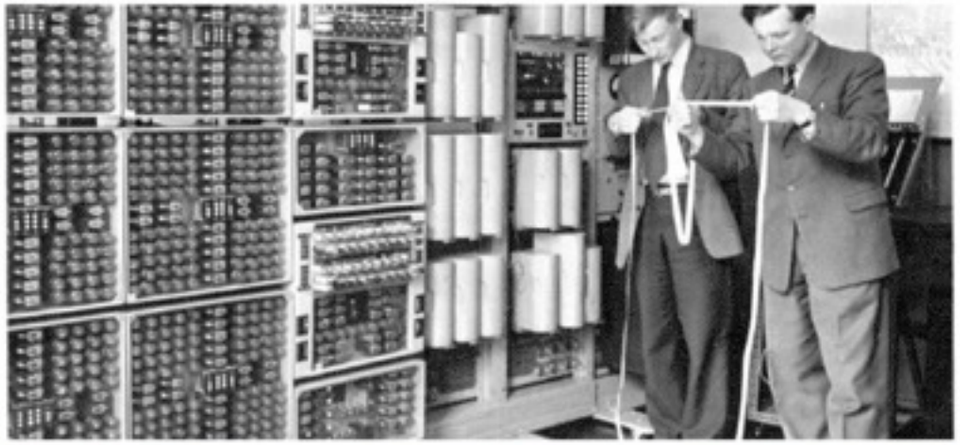
Enigma

Electronic Era

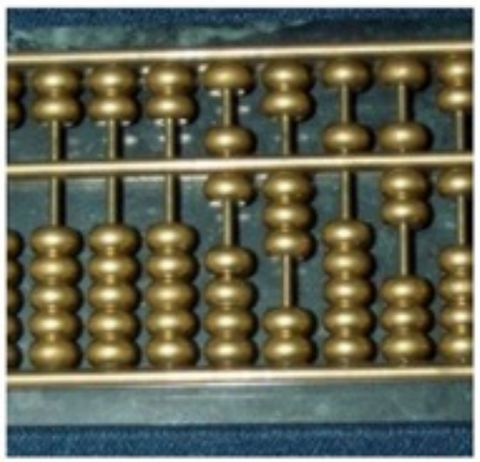
Memex

Episodes in the History of Computing
George K. Thiruvathukal, PhD



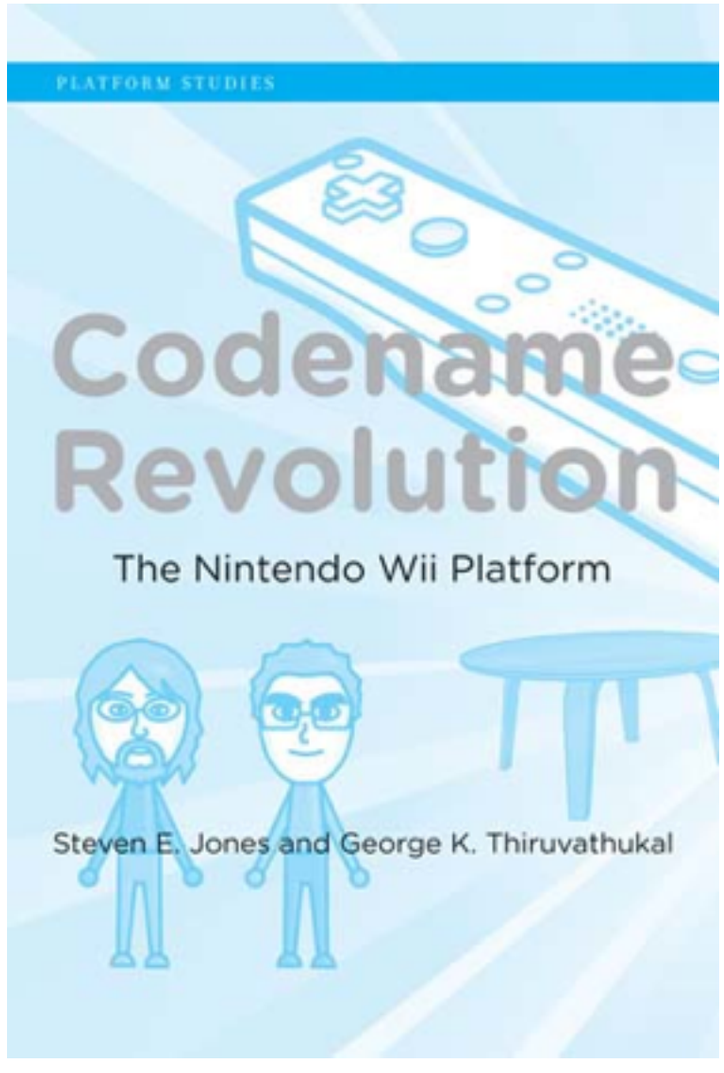







About Me (or Mii in Nintendo Parlance)

- Professor of Computer Science at Loyola University Chicago, since 2001
- PhD, IIT, 1995; Postdoctoral Scientist at Argonne/University of Chicago, 1996-1998
- Co-director (with Steve Jones), Center for Textual Studies and Digital Humanities
- Lead Fellow of new Center for Interdisciplinary Thinking, 2013-
- Editor in Chief, Computing in Science and Engineering (http://computer.org/cise)
- Co-author of recent book in MIT Press Platform Studies Series (on Kindle, too)



Outline

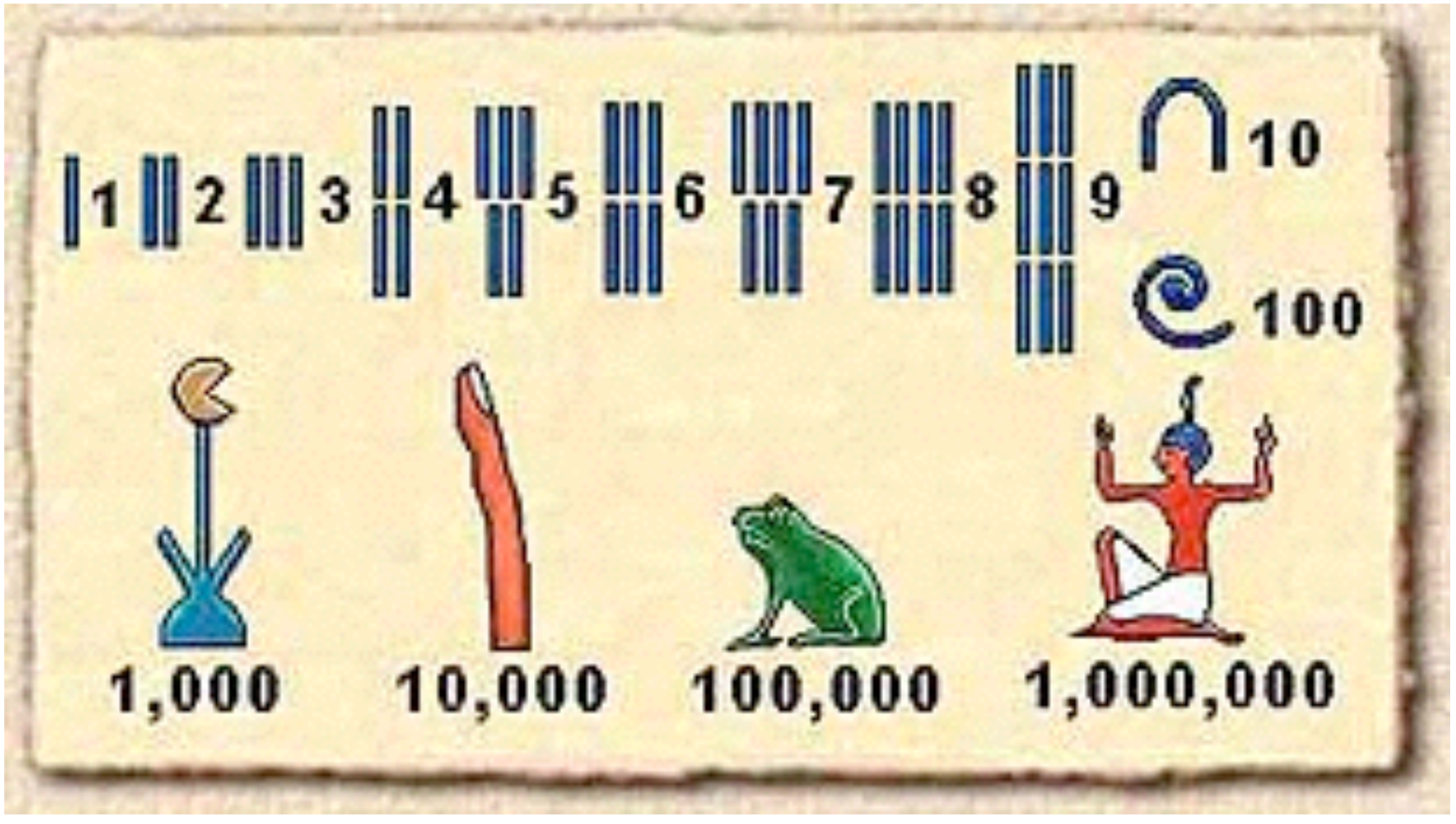
- Numbers and Calculation
- Nascent Computing Attempts
- Communication and the Information Age
- Jacquard Loom and the Mechanical Computing
- Stored Program Computing and the Advent of Electronic Computing
- “As We May Think” by Vannevar Bush
- Turing and von Neumann
- The Future?

Numbers and Calculation

Tally Stick/Tallies

- Around 4000 BC, traders in Uruk 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:
  - these tallies were regrouped at a hundred,
  - and regrouped again at one thousand.

Hieroglyphic Numbers, ~3200 BCE - AD 400



Source: http://www.eyelid.co.uk/numbers.htm
Used with Permission

Egyptians and Use of Pictographic Symbols

- 1 = Stick
- 10 = Arch
- 100 = Coiled Rope
- 1000 = Lotus Flower
- 10,000 = Finger (pointing to sky)
- 100,000 = Tadpole (from the Nile)
- 1,000,000 = Man (arms reaching to heaven)

Roman Numerals

- Theories
  - Descended from tally sticks.
  - Related to hand signals (finger reckoning?) Stopping at IIII lends credence to this possibility.
- Notable for absence of the number 0.
- The Greeks adapted their alphabet for numerals; others followed their example.
- Roman numerals are also alphabetical, but they did not originate as such. Early artifacts show that the X for ten, originated from the way in which scribes drew a slanted line through the number for four:
- ///// + / became X; one half of X was V, and the habit of putting a ci around the tenth X to indicate one hundred became C

Hindu-Arabic Notation

- The Indians used horizontal tallies (/) for one, two and three, and special symbols for four through nine.
- Around 600 CE, the Indians started using place values, i.e., instead of writing the equivalent of 100 + 80 + 7, they wrote 187
- Only nine digits were used along with a symbol for zero, probably derived from astronomer's marking empty places.
- A stone inscription dated 876 CE contains the first undisputed use of written zero (Chaturbhuj Temple, Orchha, Madhya Pradesh, India).
- See http://en.wikipedia.org/wiki/History_of_the_Hindu-Arabic_numeral_system.
- This, combined with George Boole's boolean logic (T and F) of 1854, provide the mathematical tools for all of computing as we know it toda

Place Values and Zero

- Ancient Hindus understood the importance of 0.
- Aids in using place values **and** decimal system (base 10)
    - Others recognized zero as a concept earlier but not the all-important notion of placeholder for an unused power of 10.
- An unused position needs a zero multiple.
- Positional Notation: 4408
    - 4000 + 400 + 00 + 8
    - 4x1000 + 4x100 + 0x10 + 8
- Arab traders brought the system to Europe, where it became known as Arabic numerals (more properly, the Hindu-Arabic numerals)

House of Wisdom / Bayt al-Hikmah

- Caliph Al-Mamun established 800 AD in Baghdad
    - dispatched scholars to Baghdad to translate the works of Greek scientists (stored in libraries at Constantinople) into Arabic at *Bayt al-Hikmah.*
- Prophet Mohammed: “Seek Learning Though It Be In China” or “Seek knowledge even in the land of China...”
    - Astronomical tables - Feast of Ramadan (and other religious holidays)
    - Mecca (geography and geometry)
- http://www.islamicity.com/mosque/ihame/Sec12.htm
- http://prophetmohammadquotes.com/prophet-muhammad-quotes-on-knowledge/

Abu Jafar Mohammed Ibn Musa Al-Khowarizmi

- born 780 AD in Khiva (Uzbekistan)
- His *Algebra* was the first book on the systematic solution of linear and quadratic equations (father of algebra)
- Used Hindu numerals and decimal system
- Spread throughout Europe
- “business” problems: inheritance of estates
- modern words: algorithm from “Al-Khowarizmi” and algebra from “Al Jabr”
- wrote 2 additional books on the Astrolabe

Mesopotamians, ~3000 BCE

- Number system based on sixty: 60 (sexagesimal)
- Through the ages this system has been used by astronomers
  - 60 seconds/minute (time), 60 minutes/hour
  - 360 degrees/circle (geometry and spherical/polar coordinates)
- Note: This system is useful not only for keeping time but also for measuring distance.
- Ptolomy's Almagest (a 2nd Century CE mathematical and astronomy treatise) draws significant inspiration from this system.

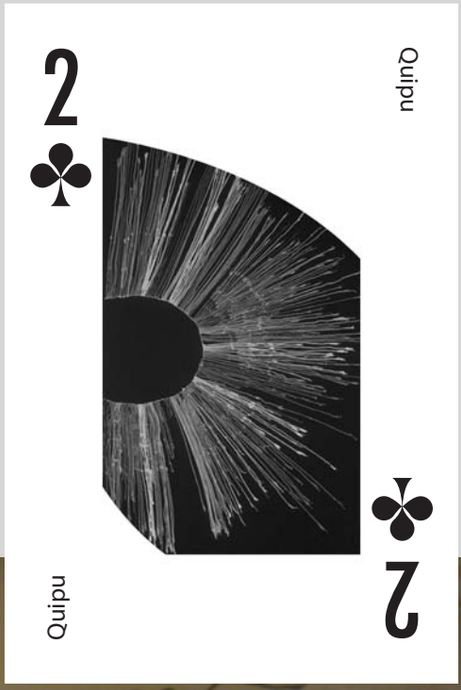
Early European

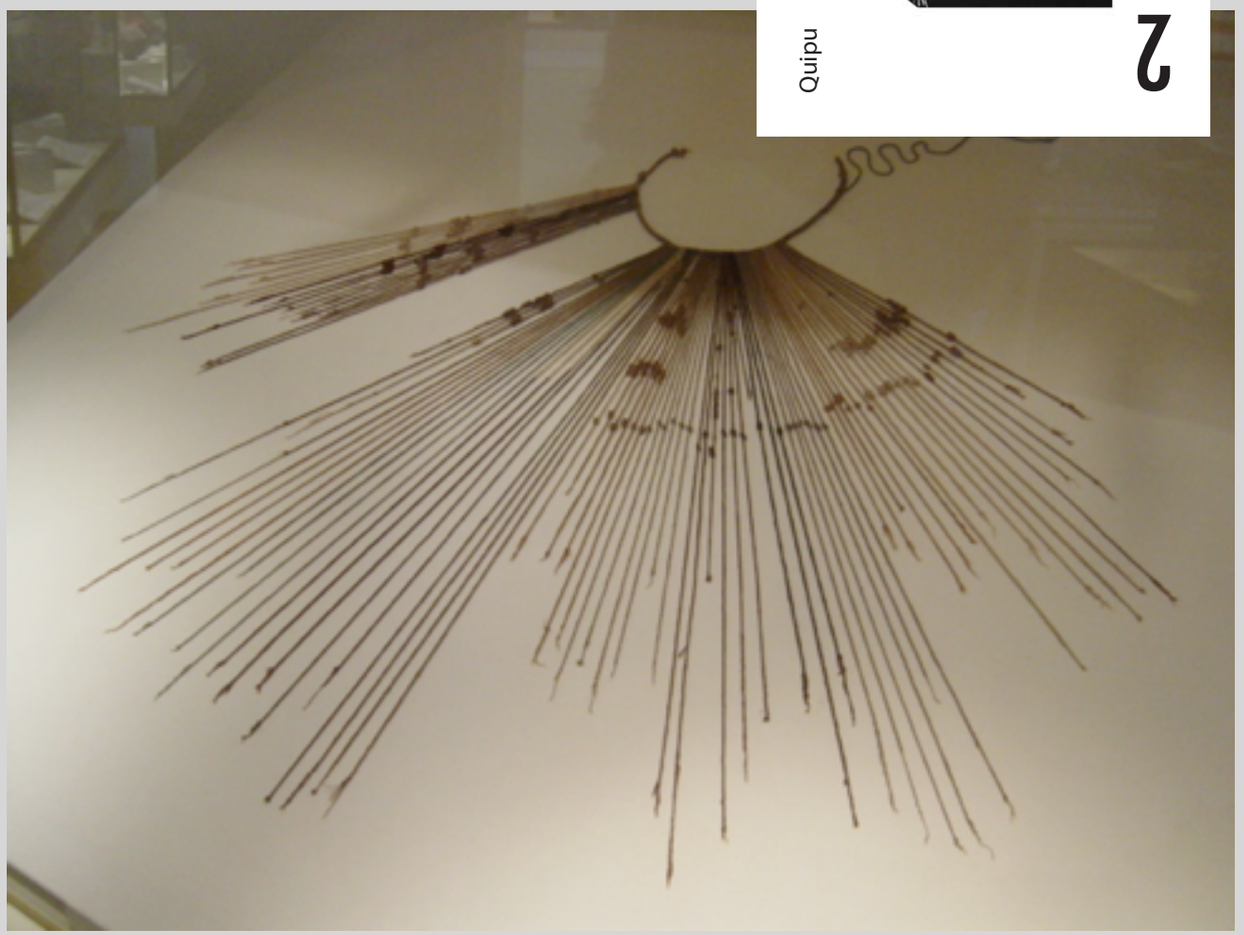
- Hero of Alexandria: multiplication by factoring
  - 13 times 18 = (10 + 3) x (10 + 8) =
  - 100 + 80 + 30 + 24 = 234
- Ptolemy (The Almagest)
  - Used Babylonian number system
  - Base 60, our source of 60 minutes, 60 seconds, and 360º angular measurements
- Mathematical Operations
  - Addition, Subtraction, Multiplication, Division,
  - Duplation (doubling), and Mediation (halving)

Nascent Computing Attempts

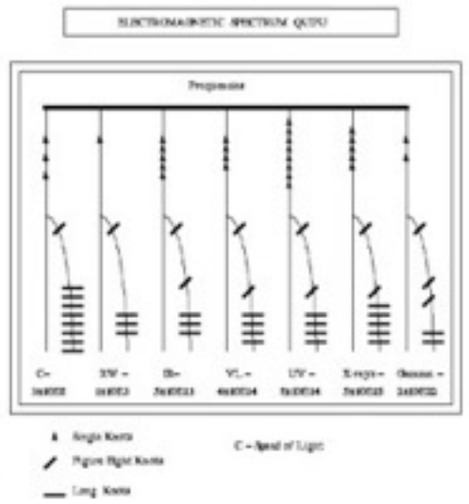
Quipu

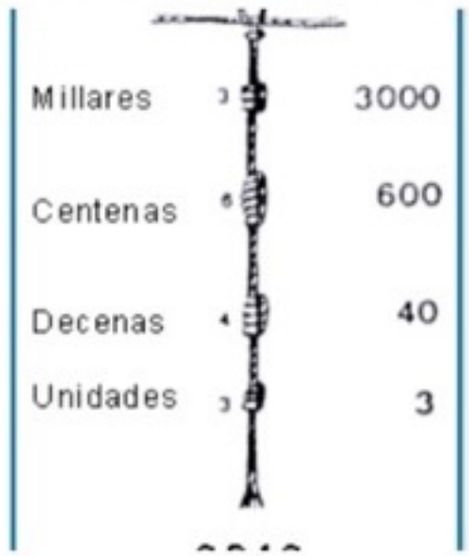
- Quipu or khipu were recording devices used in the Inca Empire and its predecessor societies in the Andean region.
- colored spun and plied thread from llama or alpaca hair or cotton cords with numeric and other values encoded by knots in a base 10 positional system
- Uses: census counts, tax accounting

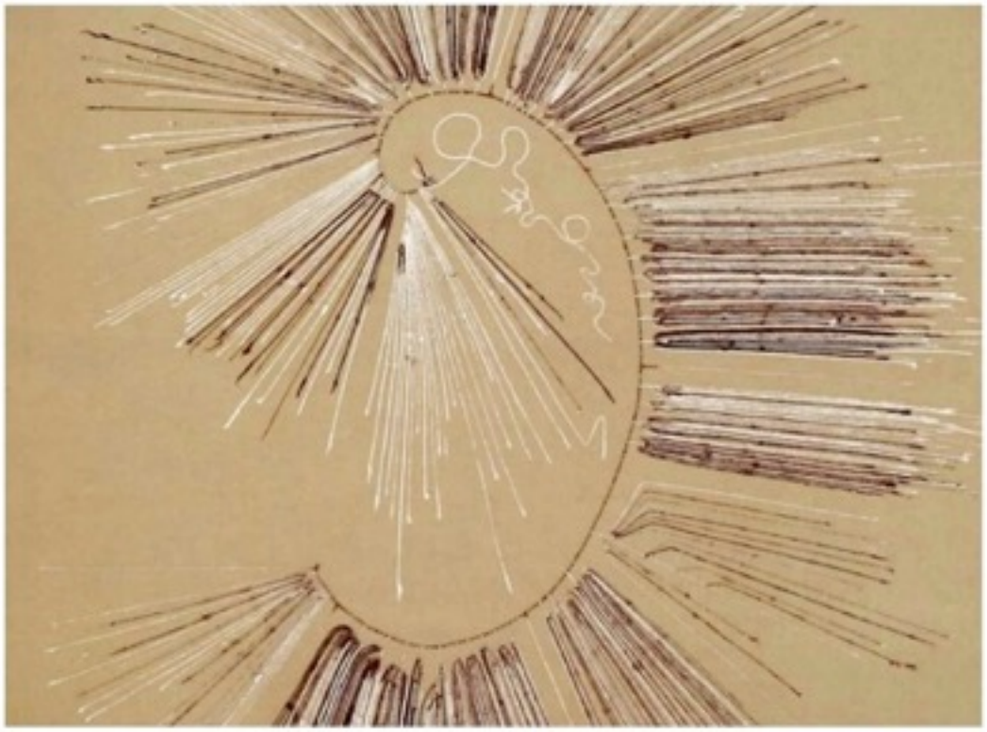


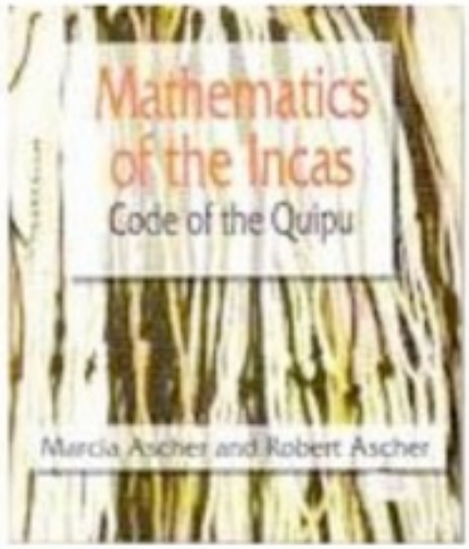


Museo de la Nación in Lima
(photo courtesy of Victor Tutiven)









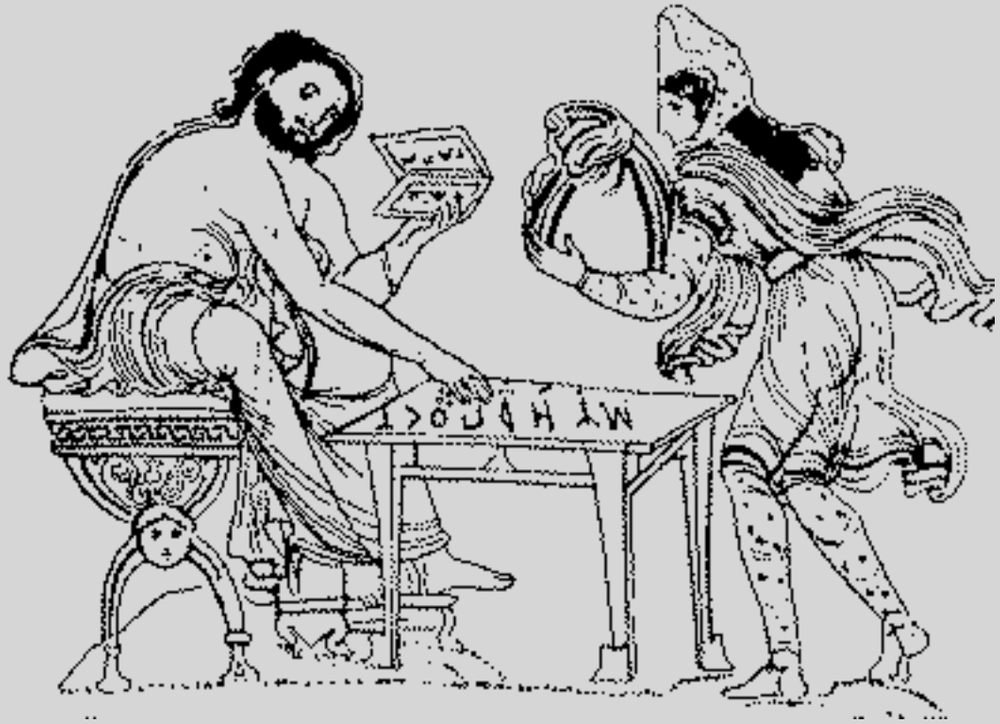
Mined using Google Images - Collage Prepared on Android via Photo Grid

Calculus Etymology

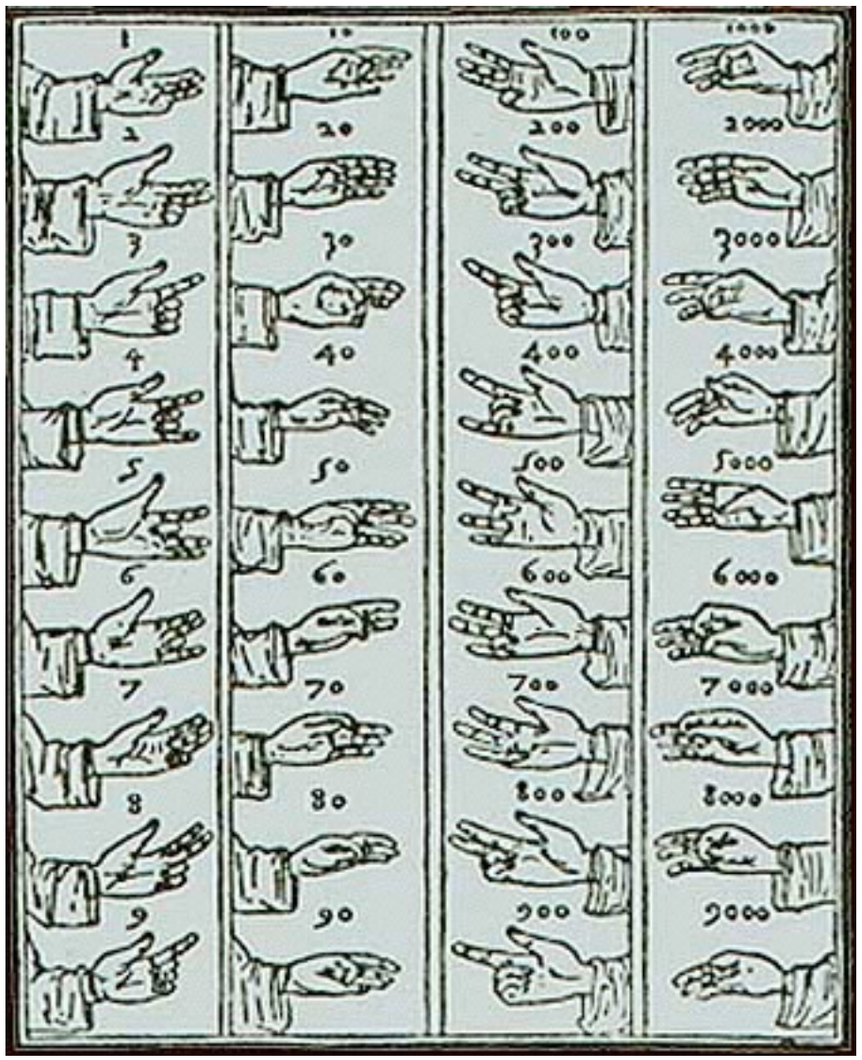
- Latin, calculus, *a small stone or pebble used in reckoning*; diminutive of calx, calcis -- a stone.
- A small stone or pebble
- Any hard, solid concentration or deposit or any part of the body… (*calcium* shares this etymology)
- In higher mathematics, (a) a method of calculation; (b) the use of symbols: (c) a method of analysis; …

Abacus

- 3000 BCE, early form of beads on wires, used in China
- From semitic abaq, meaning dust.



Finger Reckoning



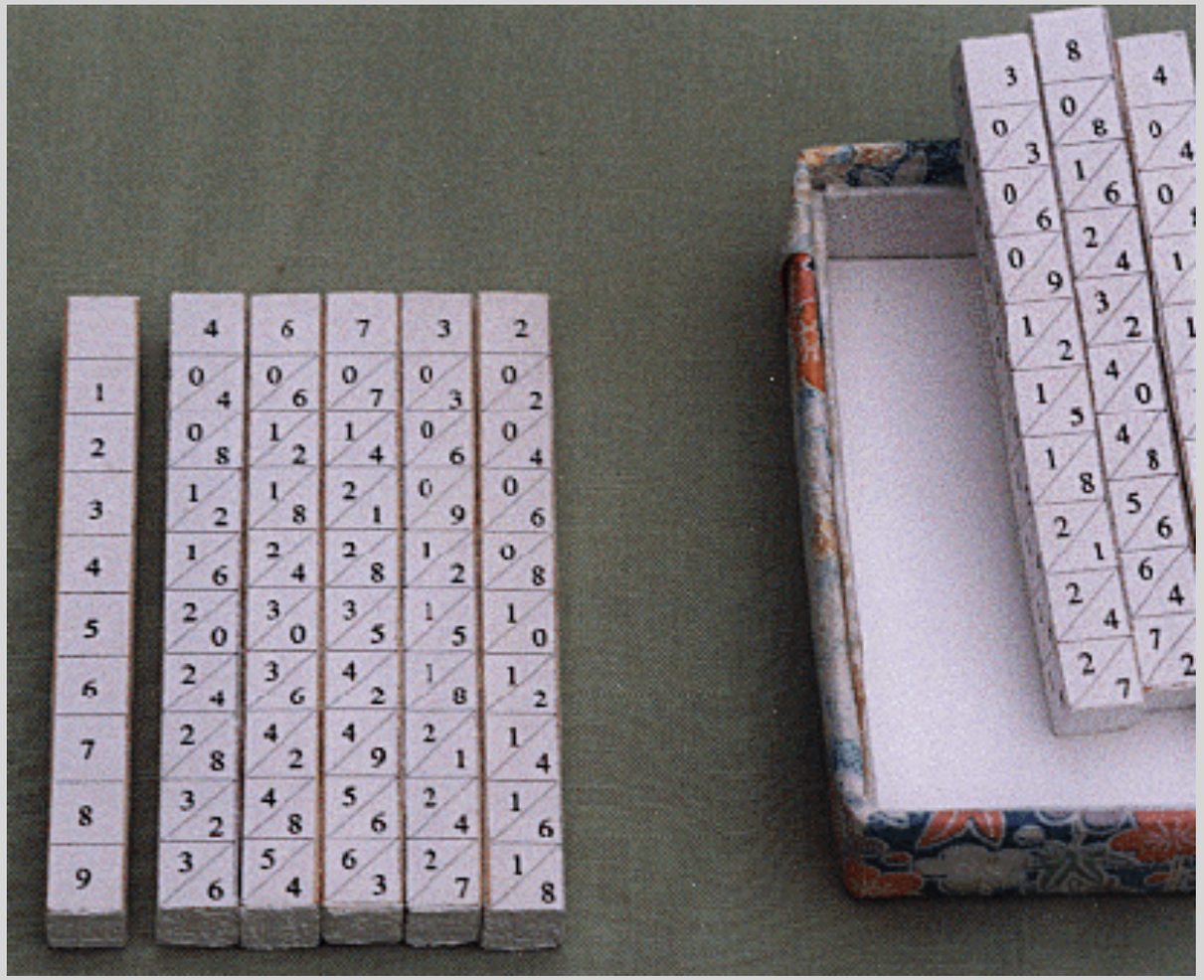
digit (n.)
late 14c., "numeral below 10," from Latin *digitus* "finger or toe" (also with secondary meanings dealing in counting and numerals), related to *dicere*"tell, say, point out" (see ***diction***). **Numerical sense is because numerals under 10 were counted on fingers.** The "finger or toe" sense in English is attested from 1640s.

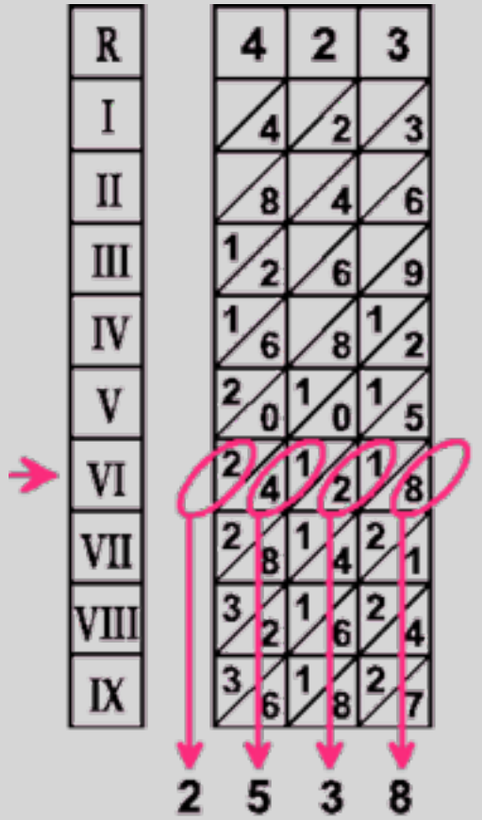
Basic Idea of Finger Reckoning/Calculation

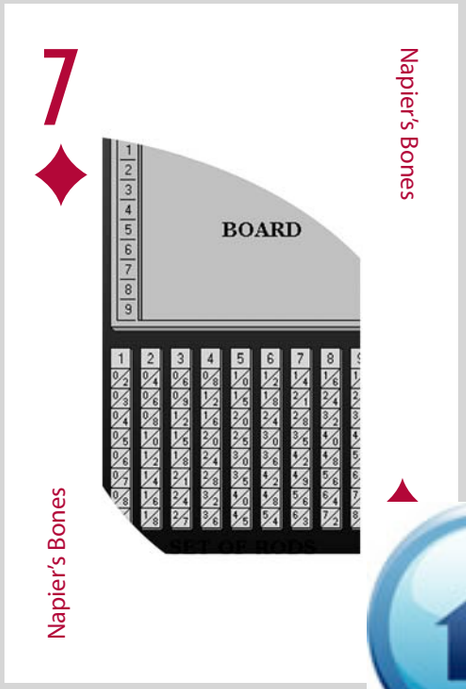
- “Educated” people memorized up to 5 times 5
- Assume fingers = 5 + number extended:
  - e.g., 7 = 3 folded, 2 extended
  - 8 = 2 folded, 3 extended
- Add the extended fingers and multiply the folded fingers!
  - 7 x 8 = 56, which is 10*(3 + 2) + 2 * 3
  - 8 x 9 = 72, which is 10*(3 + 4) + 2 * 1
- Looks simple but don’t be fooled! It gets harder as you try to multiply larger numbers. (Uses ideas of modular arithmetic.)
  - e.g. 12 x 14 = 10(2 + 4) + 2 * 4 + 100 = 168

Napier's Rabdologia "Bones", 1617 CE

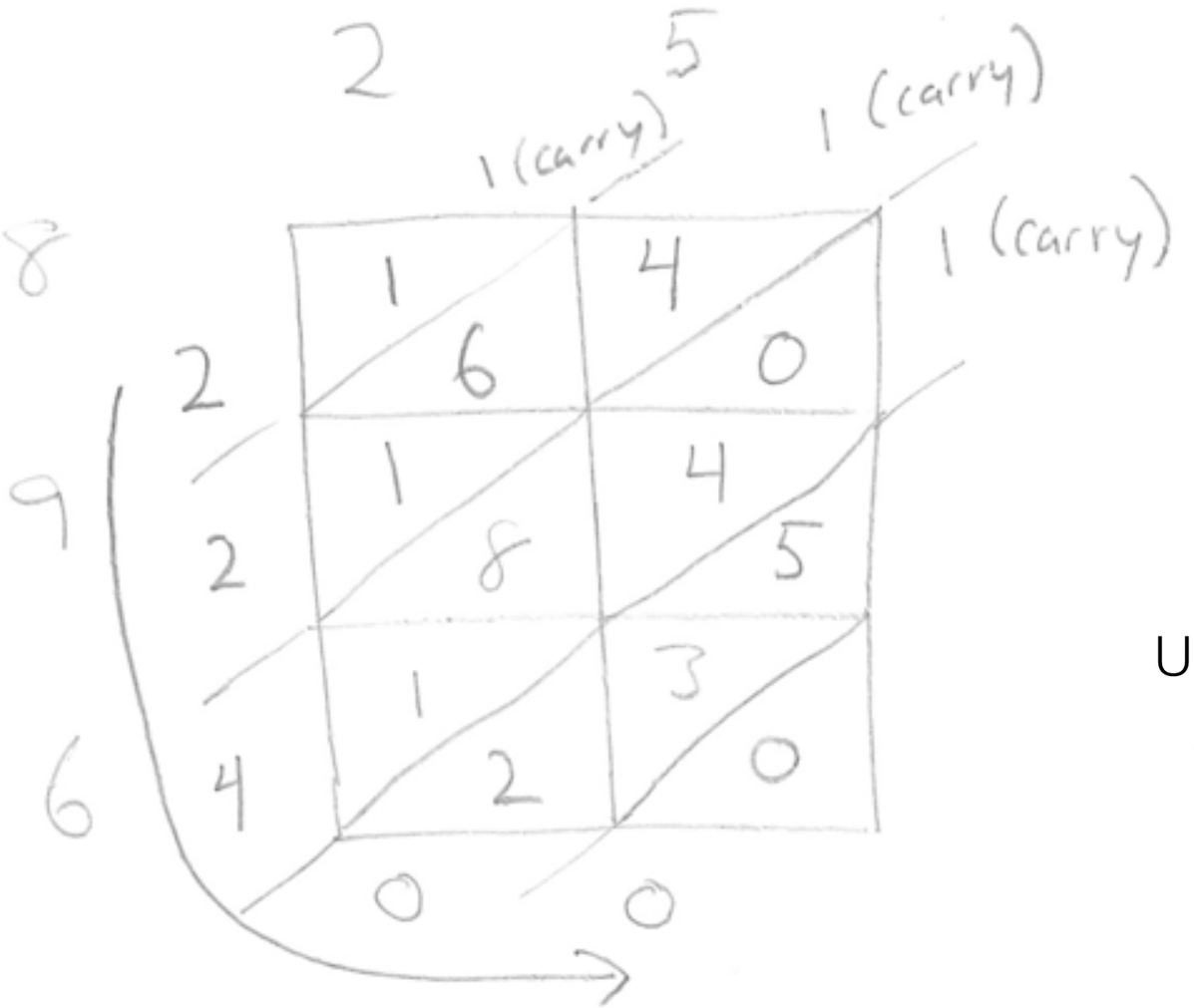
- Find the 7th multiple of 423 (multiplicand)
- Align bones for 4, 2 & 3
- Add values on the diagonal
- Be careful of carries!
- Write down resultant
- Genaille-Lucas rulers made it easier to deal with carries.







Napier Multiplication - 25 x 896

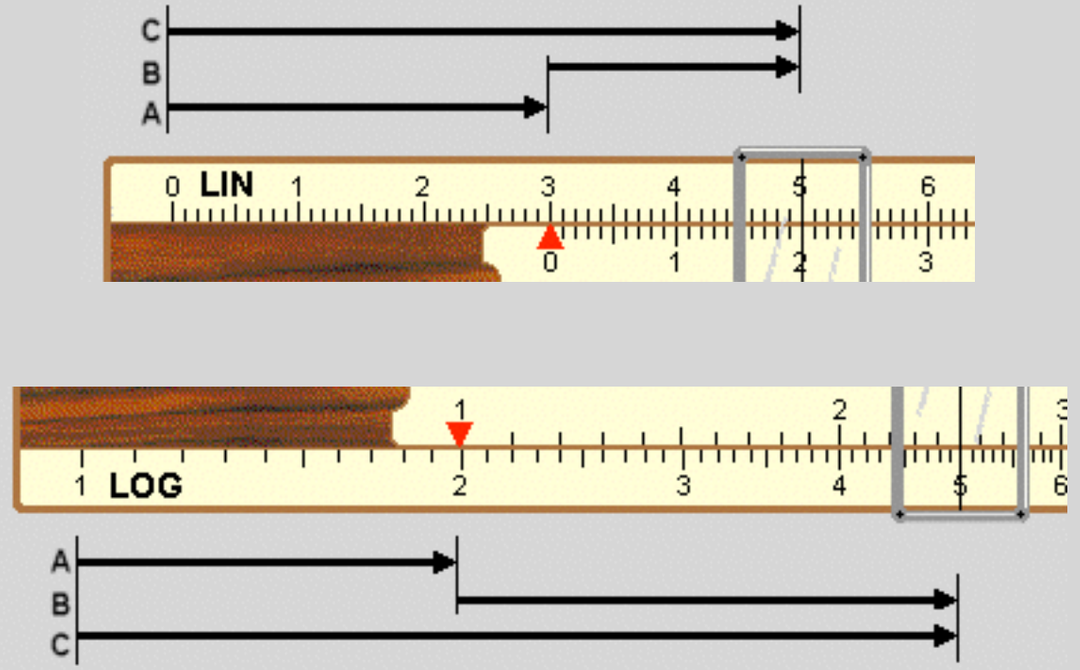


25 x 896 = 22,400

U of C Everyday Math Curriculum,
www.everydaymathonline.com
Used in CPS at Skinner North Elementary

Slide Rule

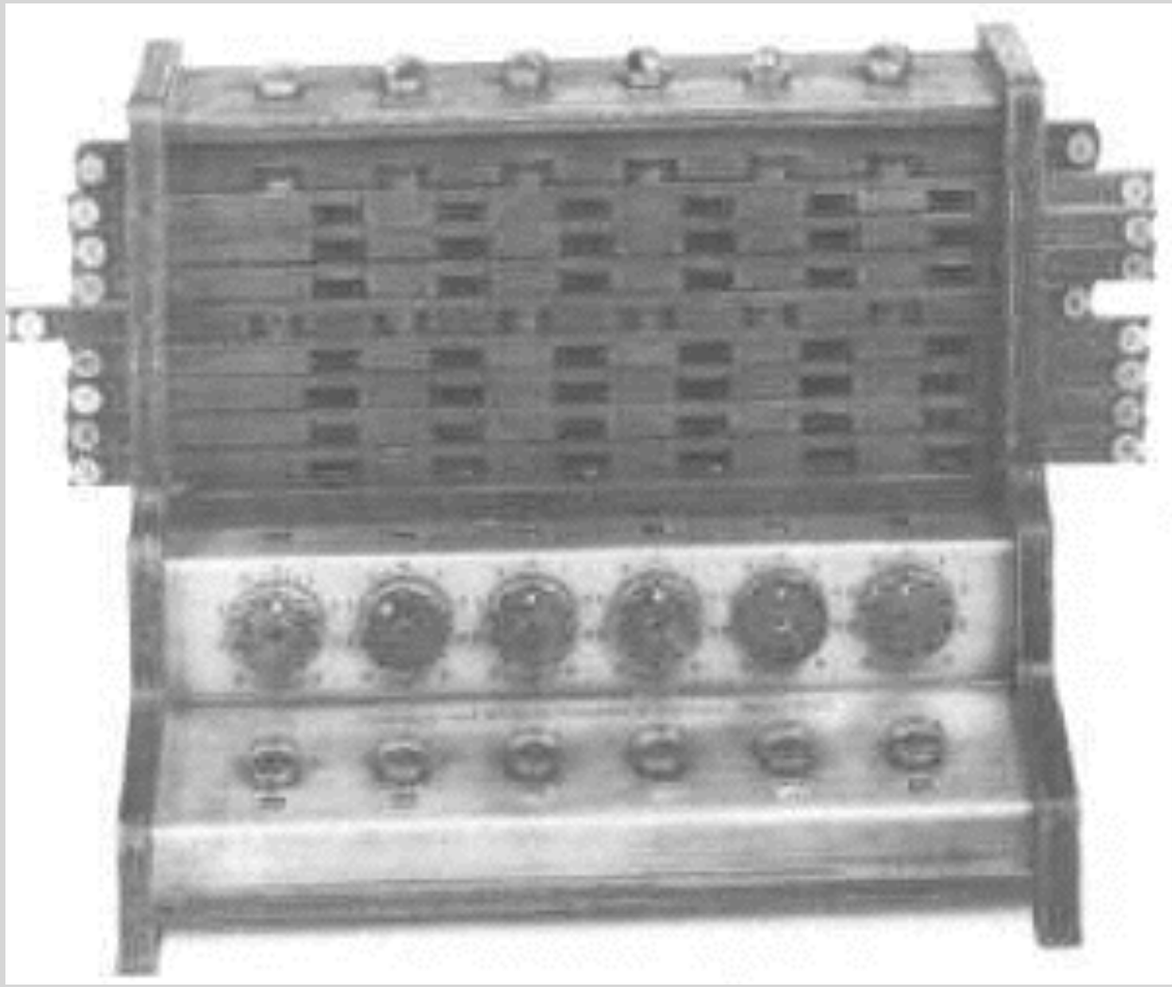
- Napier's Logarithms
- Edmund Gunter: Gunter's Line of Numbers (1620)
- William Oughtred (right)
- (1574? to 1660)
- invented the slide rule by putting Line of Numbers on top of each other
- Circles of Proportion, as circular slide rules (1622)



Wilhelm Schickard
1592-1635

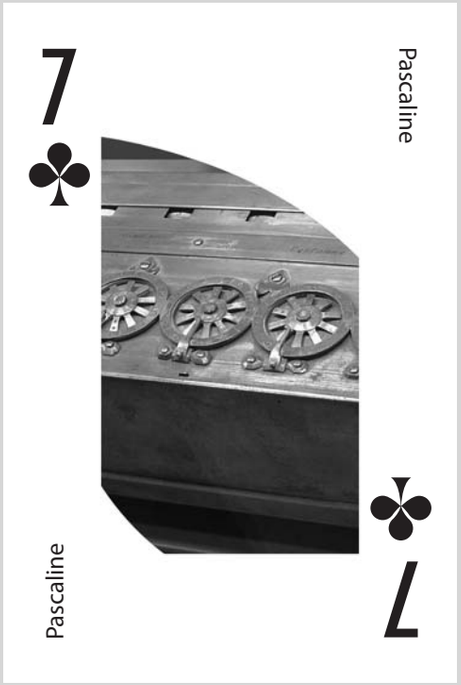
- Napier’s bones on cylinders for multiplicand
- movable sliders to expose multiples (multiplier)
- gears with carry mechanism

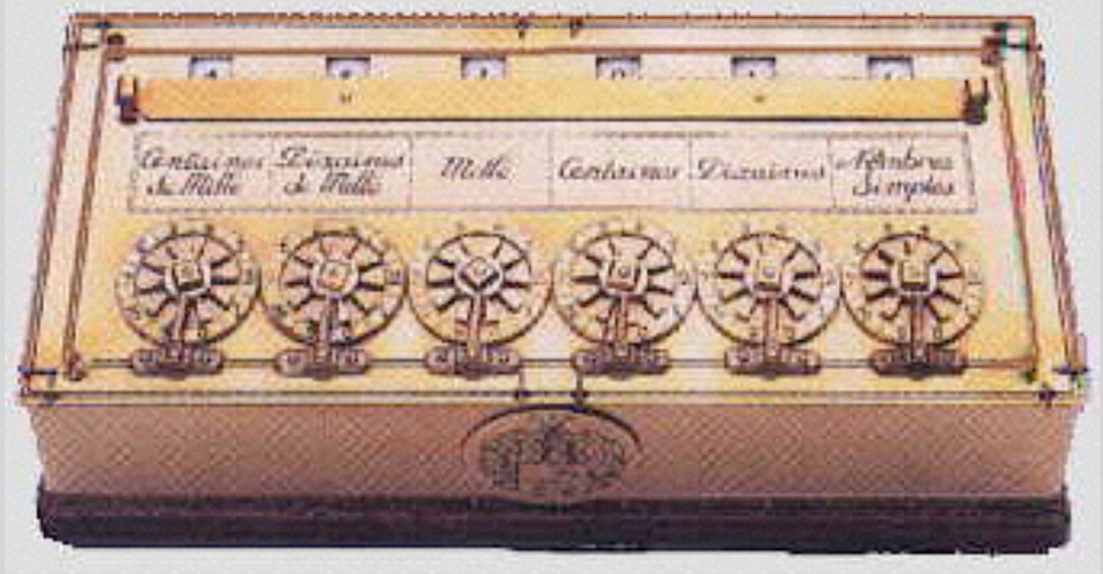
- none exist; only known from drawing
- recreation by Dutch machinist @ 1992



Blaise Pascal's Pascaline

- Father was a tax collector in Rouen, France
- Pascaline (19 years old)
- Carry mechanism
- problems: carry propagation and inability to do subtraction (see trick on next page)
- Made 50 Pascalines
- Provides early example of relying on complementary arithmetic.





Subtraction via Addition: Still used today!!!

```
  294736                  294736
-217485  ---------->     +782514
--------                --------
                        1077250
                             +1
                        --------
                        1077251
```

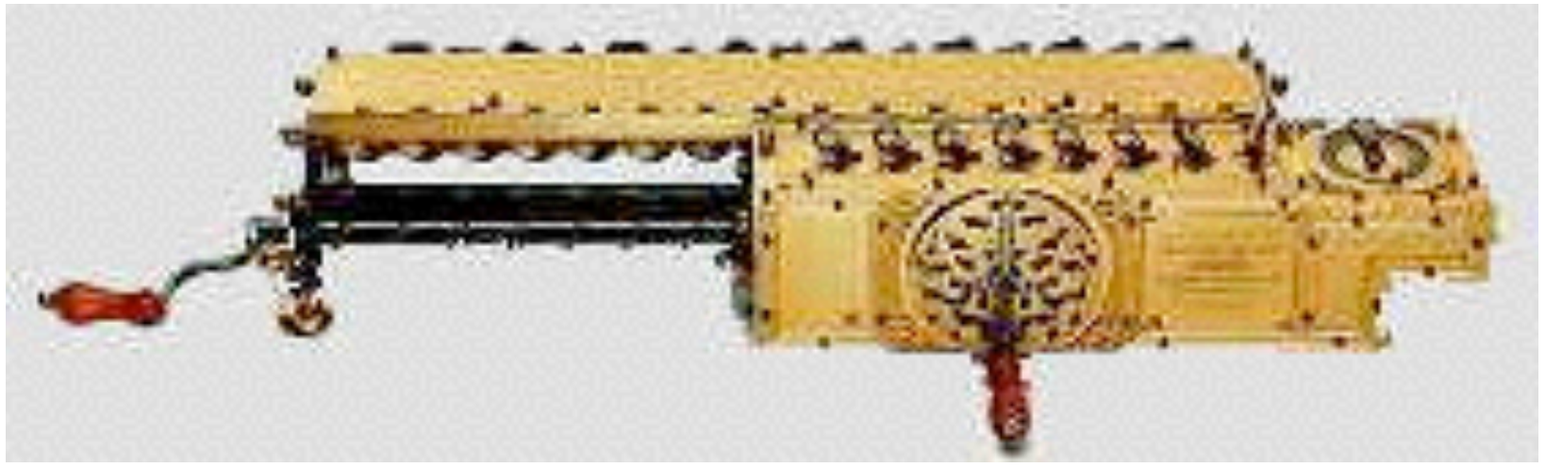
Check:

```
  294736
- 217485
--------
   77251
```

All digits d_i in the subtrahend are changed to $9-d_i$

Leibniz Stepped Drum Calculator

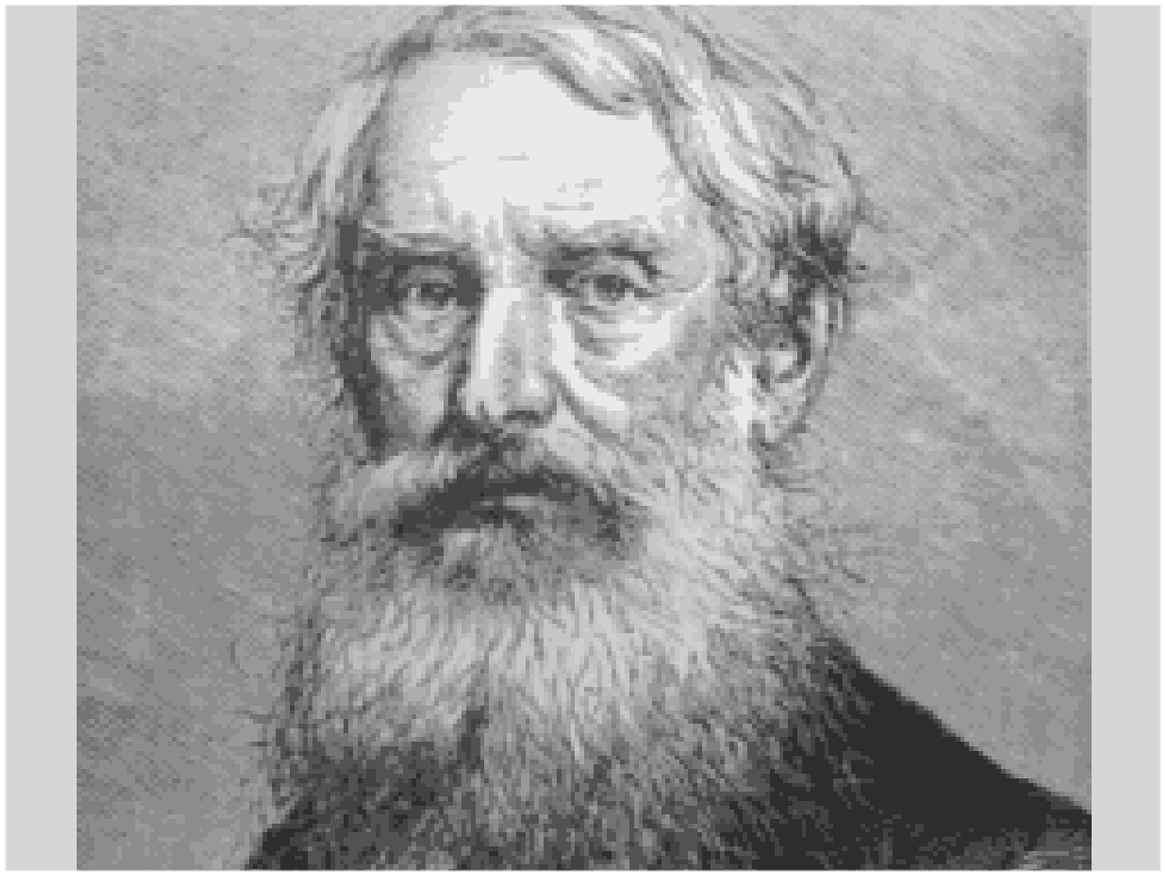
8 Leibnitz Calculator

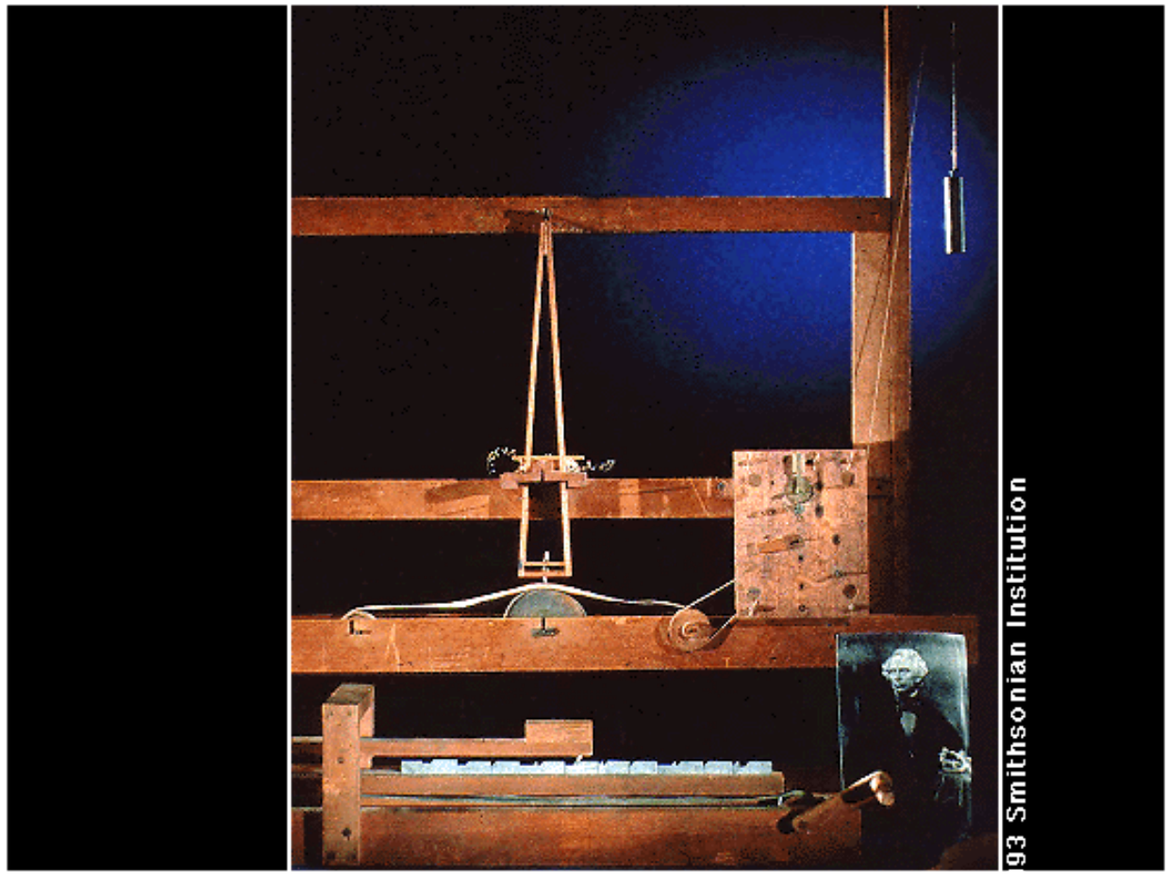


Communications and the Information Age

Homing Pigeons

- Pioneered by Persians, who specialized in training them.
- Used by Greeks to conveyed the names of the victors at the Olympic Games to their various (home) cities by this means
- Used in siege of Paris (1870-71) beginning of use for military purposes; beginning of a “Pigeon Post”
- Discontinued by 1910.





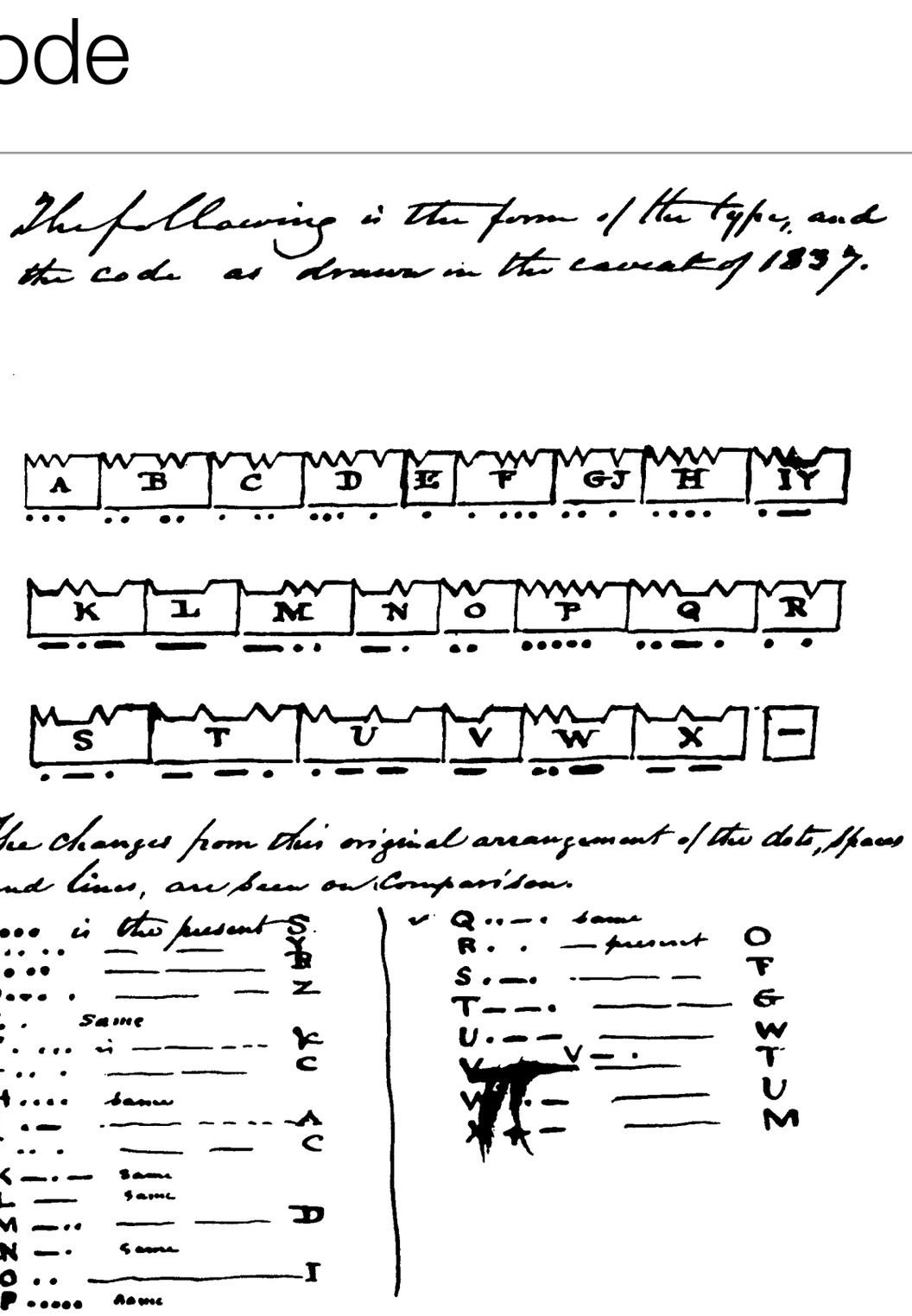
Samuel F. B. Morse and his telegraph built from an artist's frame.

Samuel F. B. Morse (1791-1872) and his most excellent adventure

- graduated from Yale
- moved to NYC in 1823 and became one of the foremost artists of his day
- appointed first professor of art in US

“If this be so, and the presence of electricity can be made visible in any desired part of the circuit, I see no reason why intelligence might not be instantaneously transmitted by electricity to any distance.”

The Morse Code



A notebook page shows Morse's 1837 code (with 1844 modification) and its relationship to the sawtooth type.

Impacts

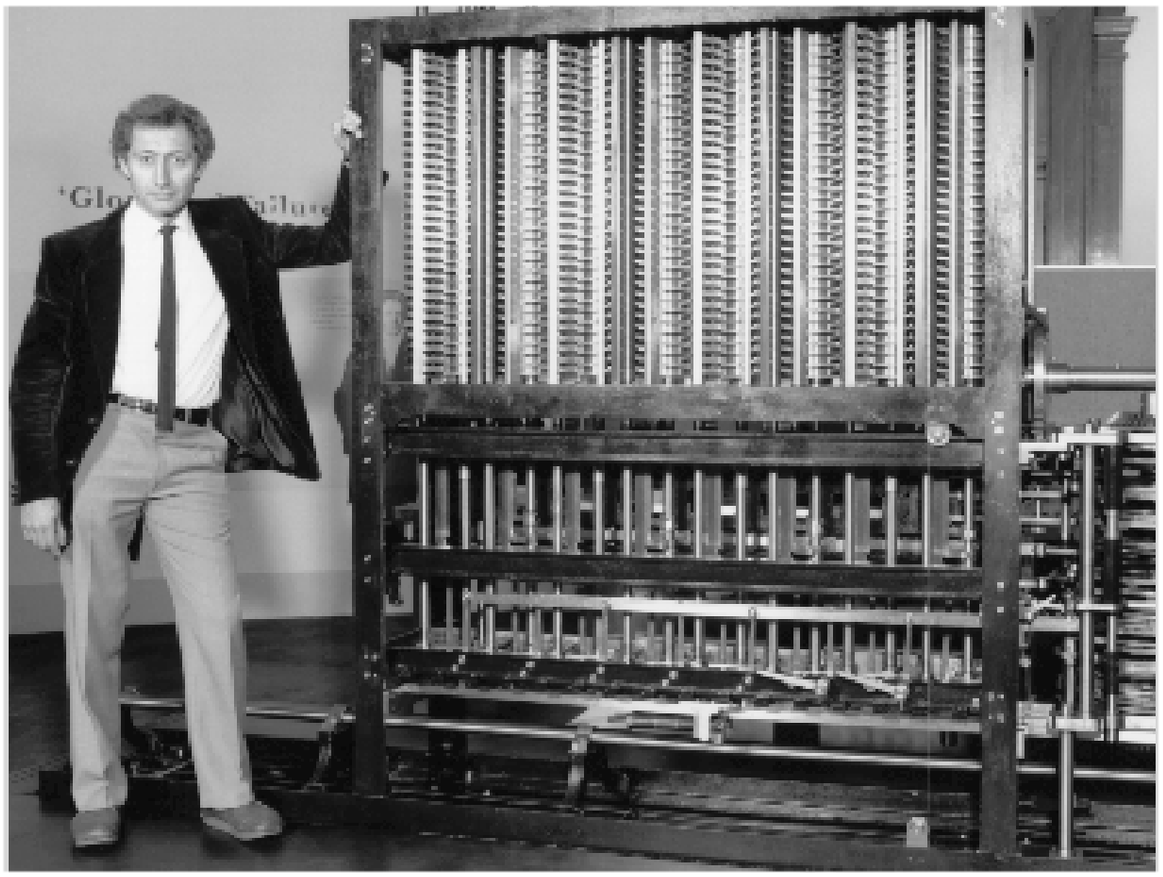
- 1846: Mexican War
- 1848: Associated Press: 6 New York newspapers
- 1850s: Erie railroad: messages about tracks, switches, location, freight, passengers, personnel, rolling stock, etc. Creates a system for control and management of a widely dispersed enterprise
- 1858: First transatlantic cable: 26 hours for first message to cross
- 1864: Union Army advantage during Civil War

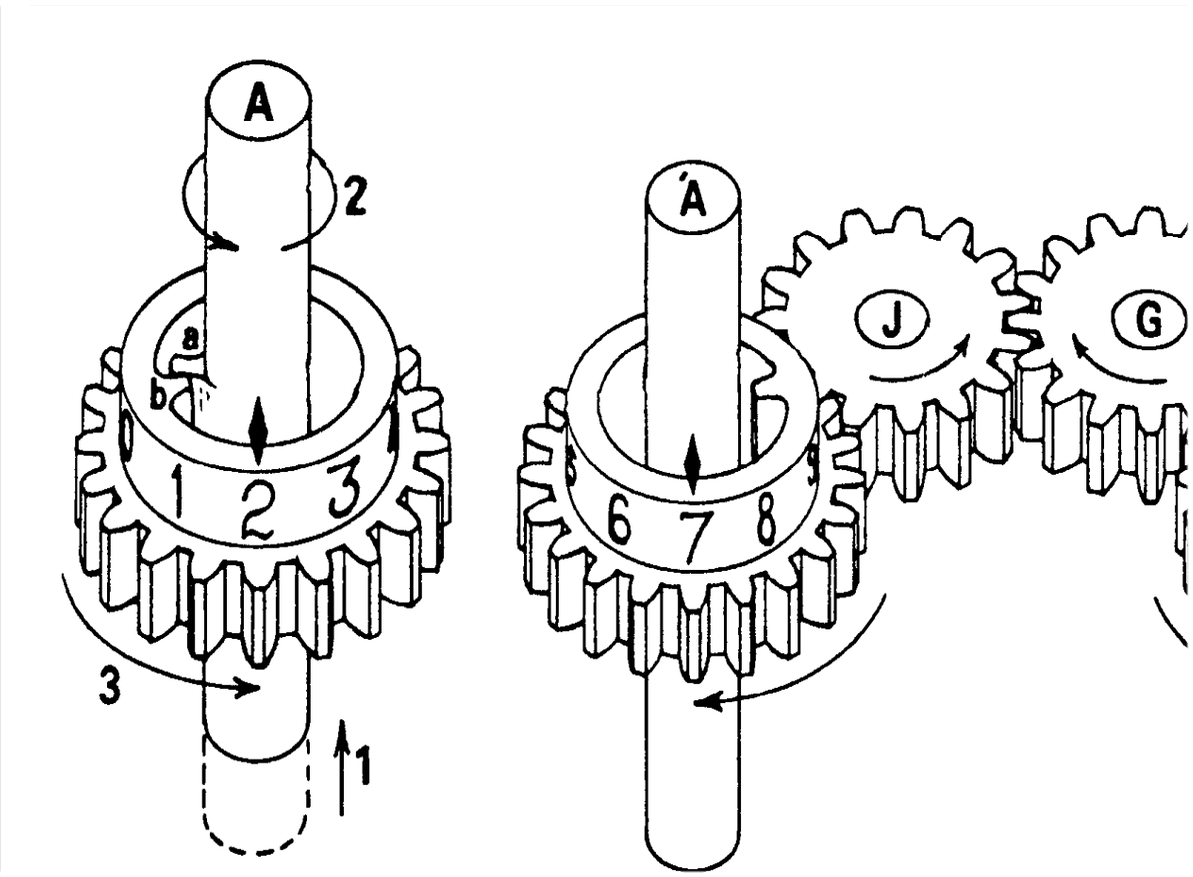
Transatlantic Cable 1858 (and later in 1866)

And to think we were in a Civil War just a few years later!

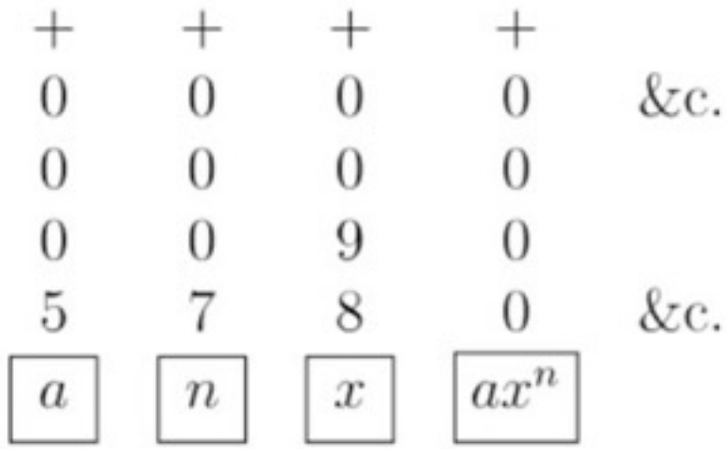
Looms and Mechanical Computing

Jacquard Loom and Punch Card System
Source: Wikipedia

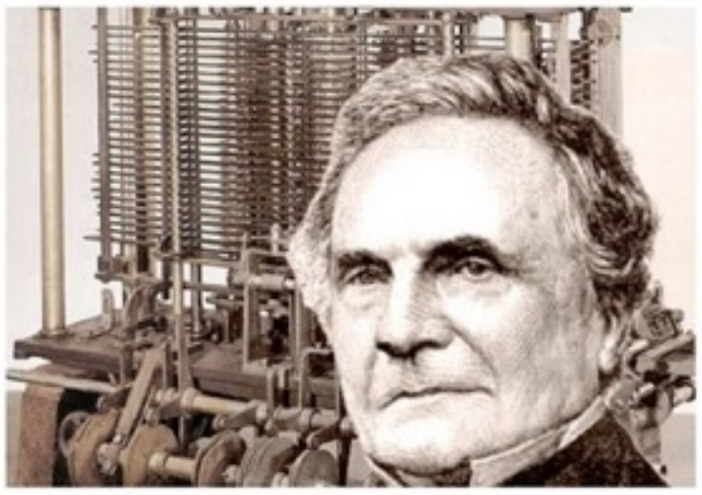


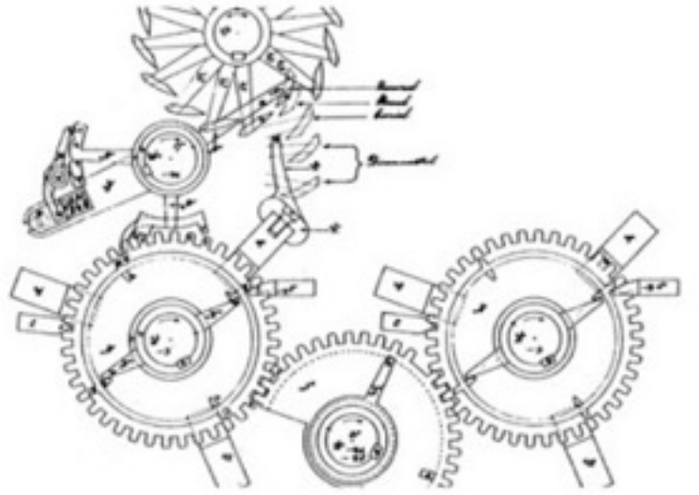


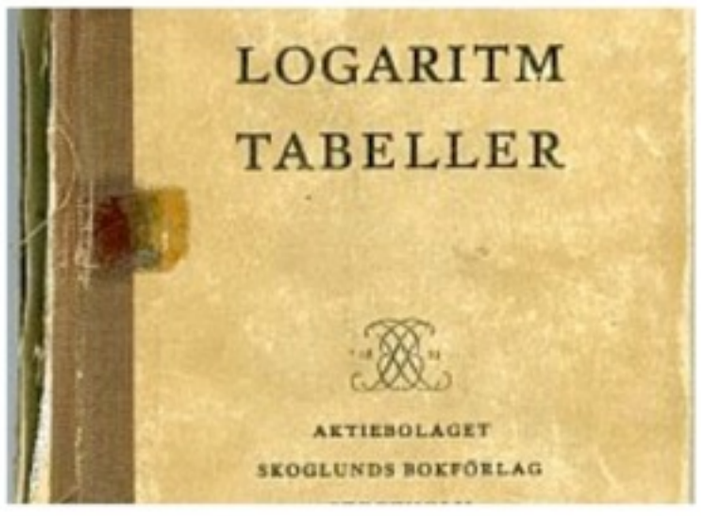
Difference Engine and “Display” Mechanism

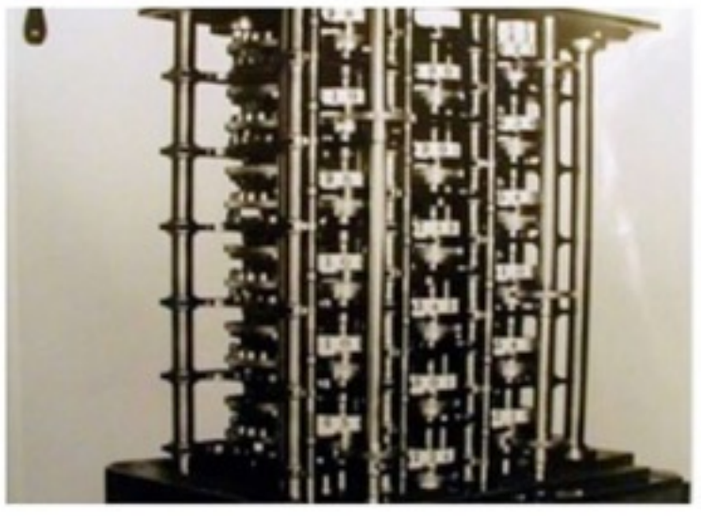


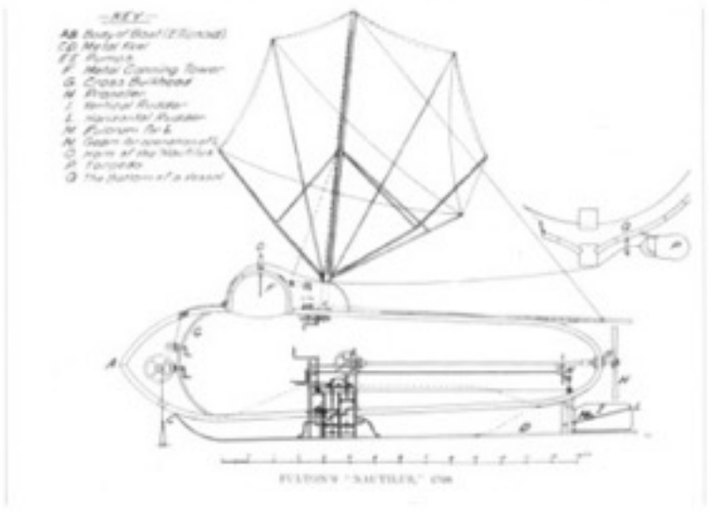
+	+	+	+	
0	0	0	0	&c.
0	0	0	0	
0	0	9	0	
5	7	8	0	&c.
a	n	x	ax^n	











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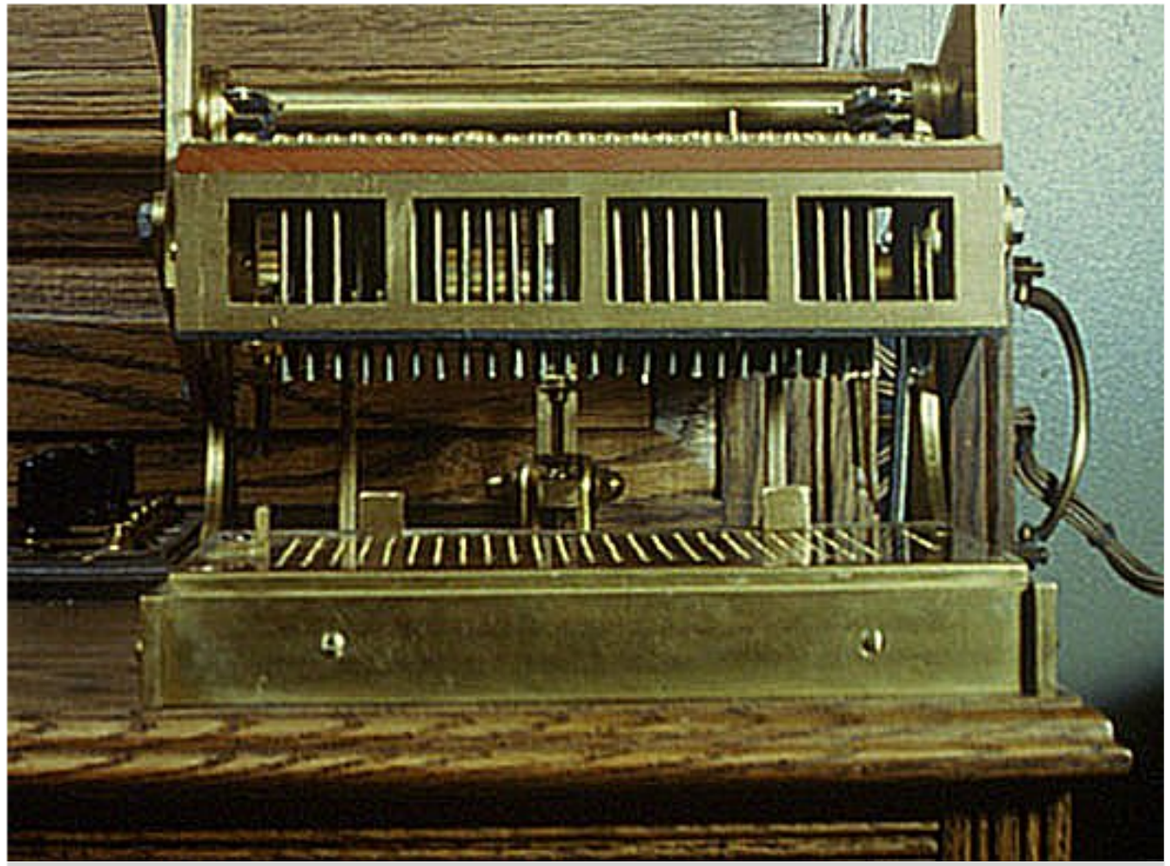
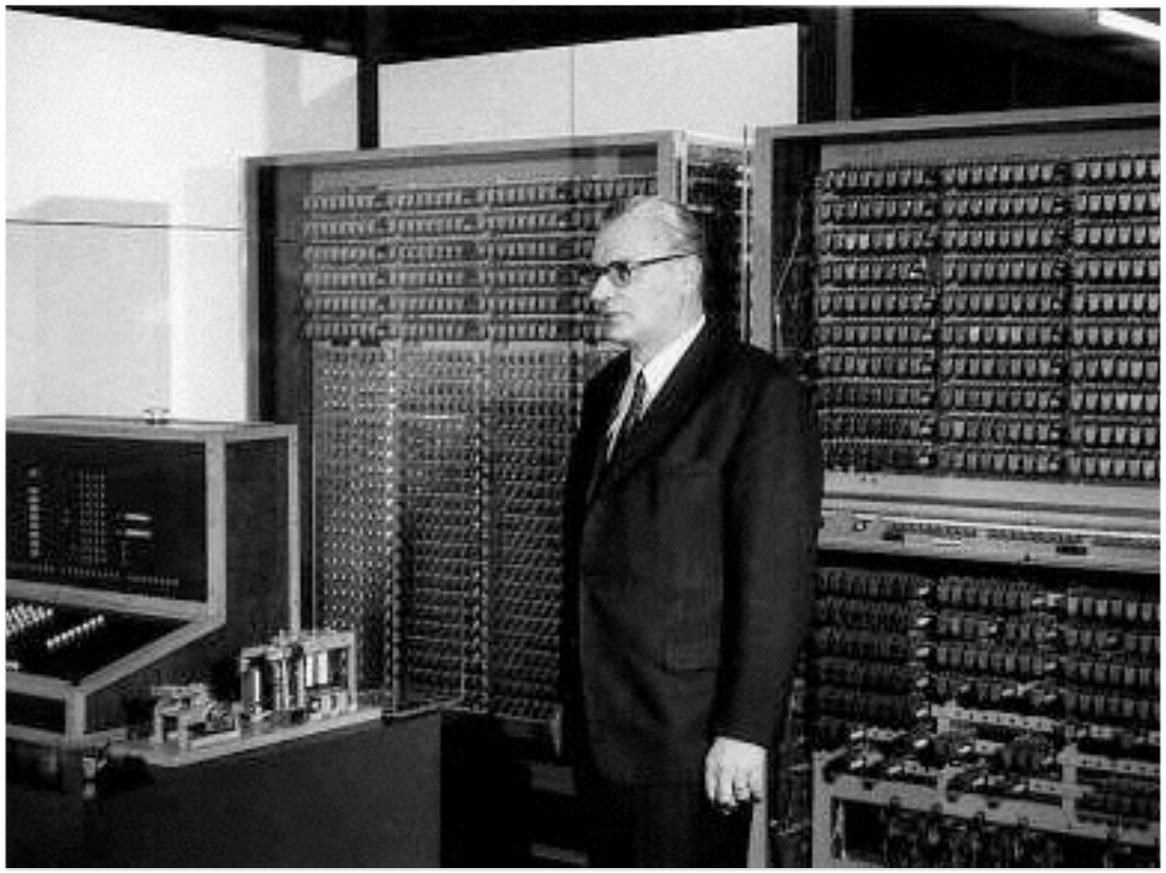
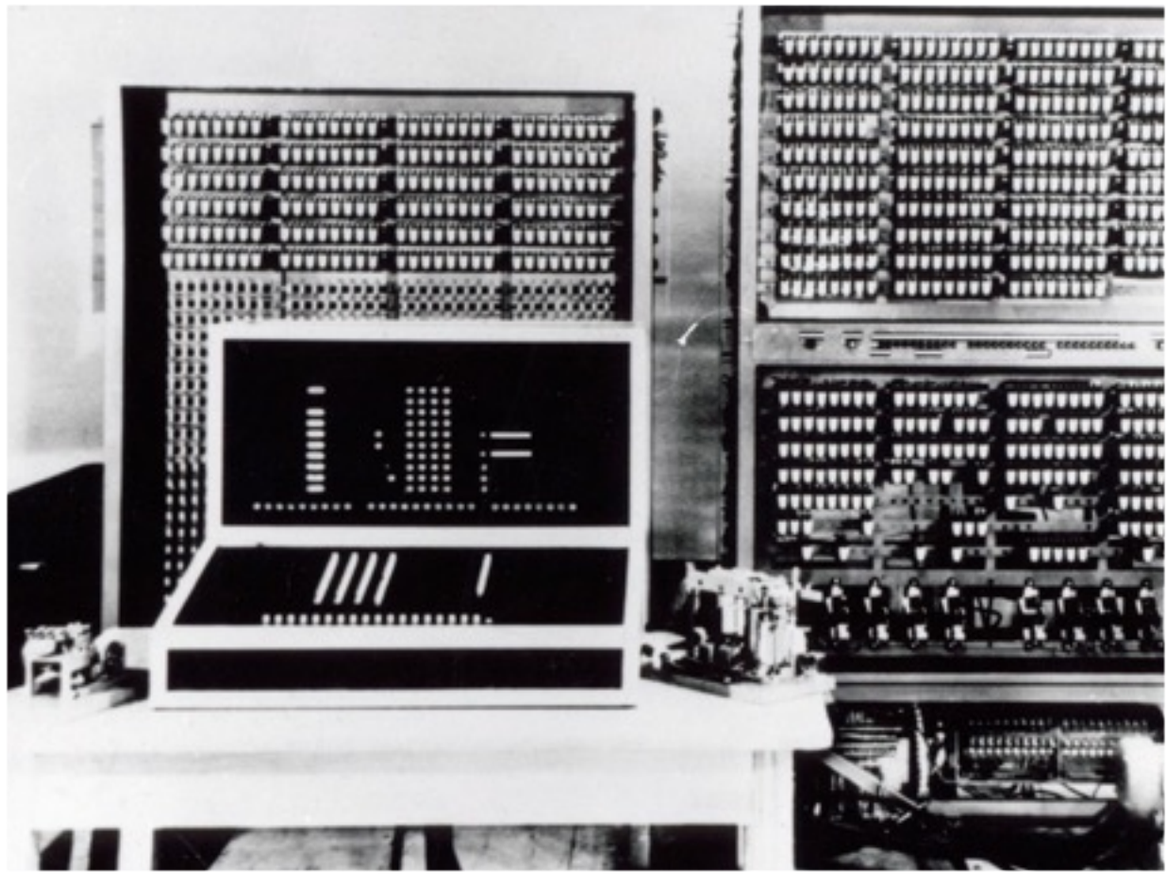


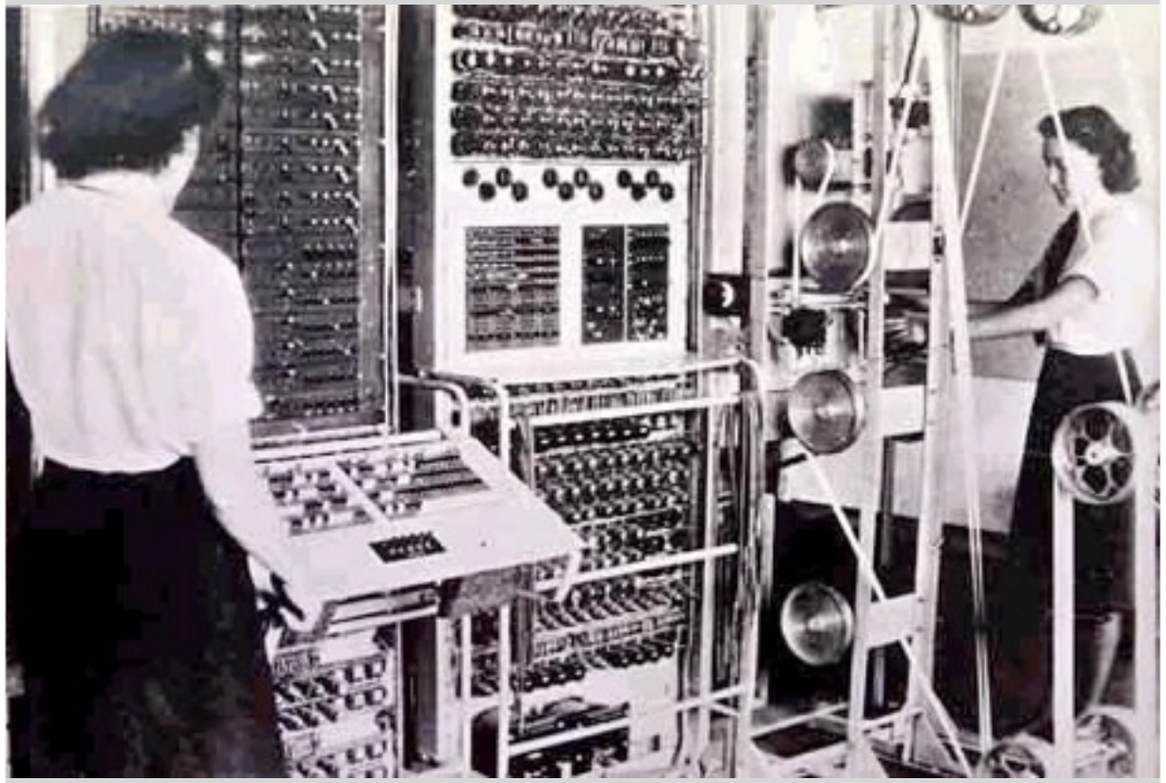
Hollerith, the Hollerith Machine, and Close-up of the tabulator (counter) used to determine the 1890 Census

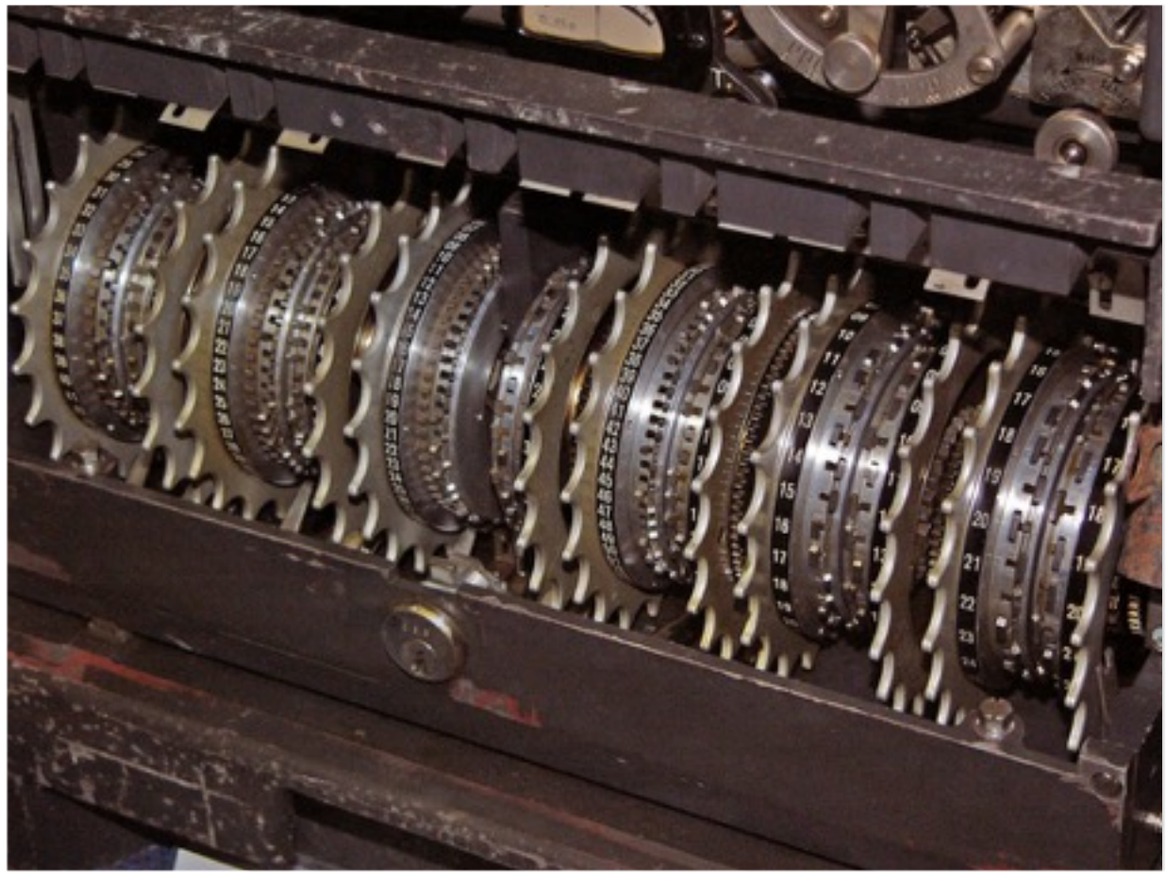
Early Electronic Computing



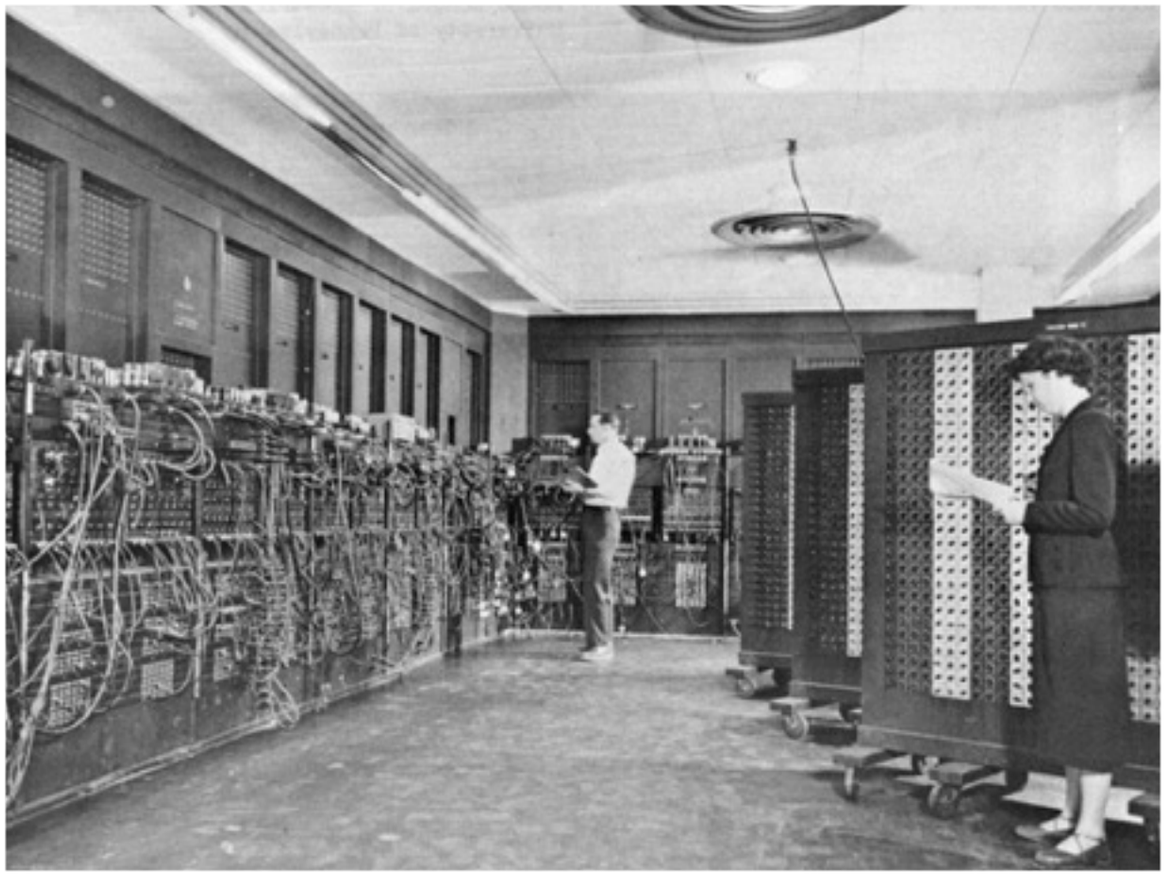


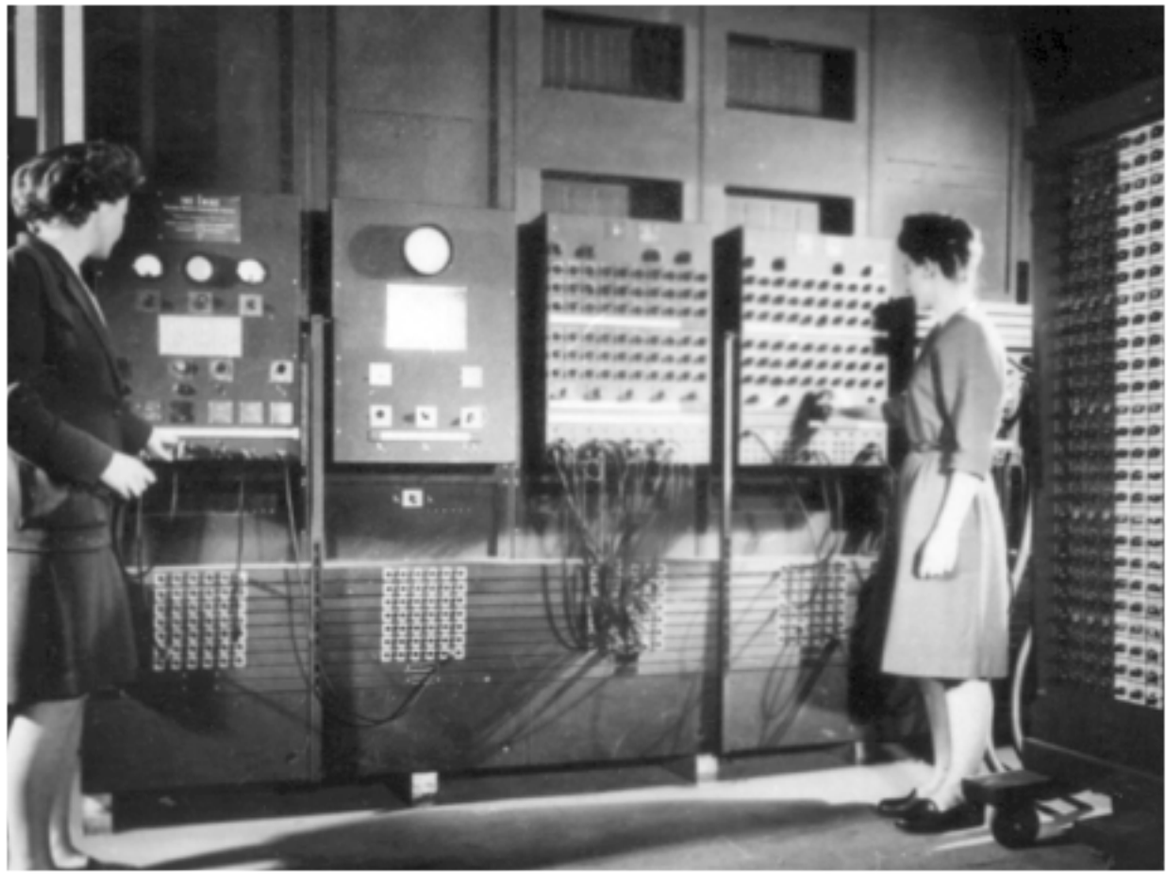
Konrad Zuse with his programmable Z3 Computer, the first Turing complete programmable computer.





Colossus computer from Bletchley Park, England. Lorenz encryption teleprinter used by Germans. Colossus was used to “crack the code”.

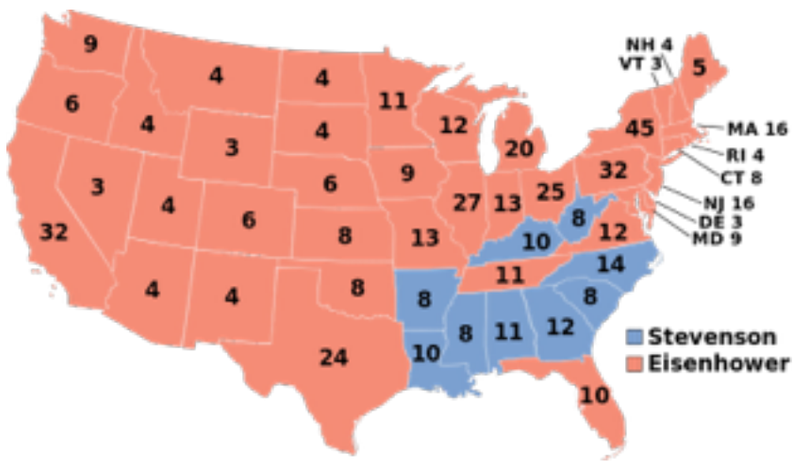




The ENIAC of Eckhert and Mauchly. The “programming” or “wiring” of computations was done by six women!

Univac II used by CBS to Predict 1952 Presidential Election

Source: Wikimedia Commons



“As We May Think” and WWW

“As We May Think”
Vanevar Bush, *The Atlantic Monthly*, 1945

- Director of Office of Scienific Research and Development (precursor to NSF/ARPA)
- Editor’s note: “men of science should then turn to the massive task of making more accessible our bewildering store of knowledge”
- Remarkably prescient: The memex looks a lot like today’s web and search technology, but much work remains to achieve Bush’s

*Consider a future device for individual use, which is a sort of mechanized private file and library. It needs a name, and, to coin one at random, "memex" (**mem**ory **ex**tender) will do. A memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory.*

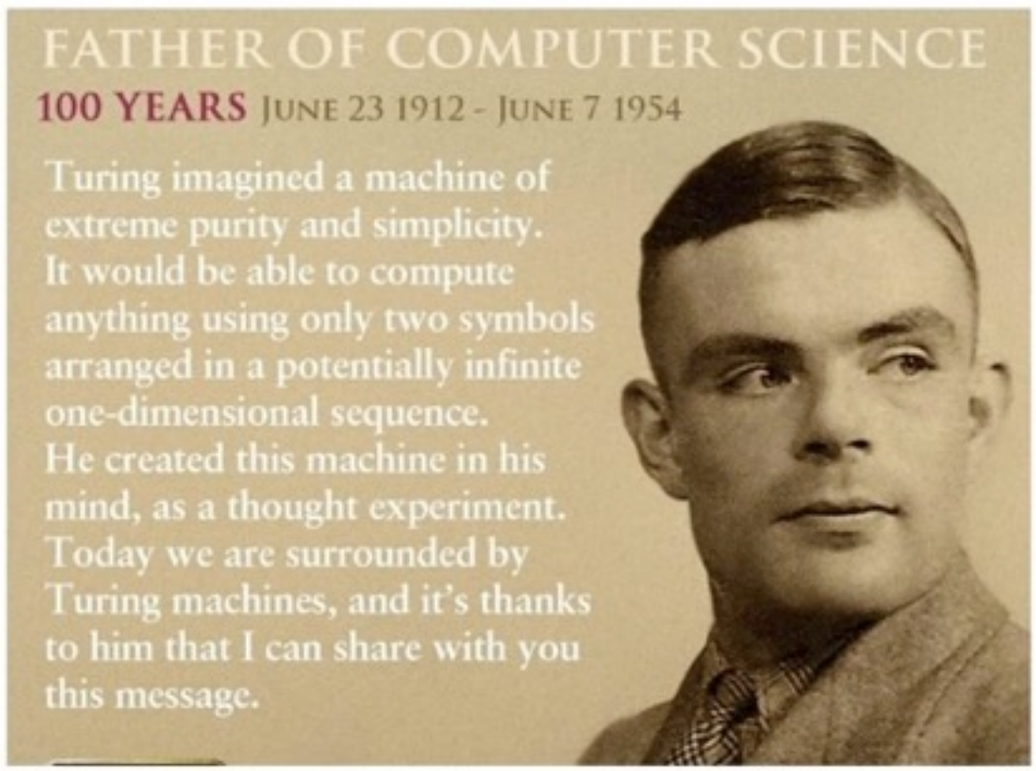
...

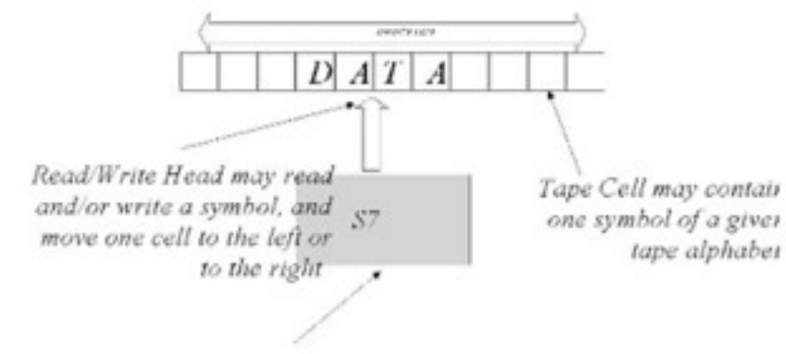
Most of the memex contents are purchased on microfilm ready for insertion. Books of all sorts, pictures, current periodicals, newspapers, are thus obtained and dropped into place. Business correspondence takes the same path. And there is provision for direct entry.

Stored Program and Universal Computing

The (Universal) Turing Machine, 1936

- Alan Turing's "abstract machine" that predates modern programmable computers.
- A **tape** which is divided into cells, one next to the other.
- A **head** that can read and write symbols on the tape and move the tape left and right one (and only one) cell at a time.
- A table of **instructions**:
  (s_i, symbol at current position, s_j, replacement symbol, L or R)
- A **state register** that stores the state of the Turing table.
- All programming languages today are said to be *Turing-equivalent*, because they can all be reduced to the Turing machine as defined here.
- Compare these concepts to the ideas of von Neumann.





Mined using Google Images

John von Neumann (draft report on EDVAC), 1945

- Von Neumann was influential in many endeavors (mathematics, physics, game theory, and computing)
- Involved in the Manhattan project and design of EDVAC (successor to the ENIAC of Eckhert and Mauchly).
- Three ideas that have shaped modern computer engineering:
  - "First: since the device is a computor (sic), it will have to perform the elementary **operations of arithmetics**…."
  - "Second: the logical control of the device is the proper **sequencing** of its operations (by…a control organ)."
  - "Third: Any device which is to carry out long and complicated sequences of operations…must have a **considerable memory**."

References and Reading List

- Thomas J. Bergin, American University Computing History Museum
- Vanevar Bush, “As We May Think”, The Atlantic Monthly, July 1945
- Paul E. Ceruzzi, *A History of Modern Computing*, 2nd Edition
- Gareth Cook, Untangling the Mystery of the Inca, *Wired*, January 2007
- Gerald Holzmann and Björn Pehrson, *The Early History of Data Networks*
- Georges Ifrah, *Universal History of Computing: From Abacus to Quantum Computer*
- Howard Rheingold, *Tools for Thought: The History and Future of Mind-Expanding Technology*
- Simon Singh, The Code Book: The Science of Secrecy from Ancient Egypt to Quantum Cryptography
- Wikipedia (Yes, it’s bad for you, but it’s fun. Make sure to inhale.)