A short history of computing

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Calculation

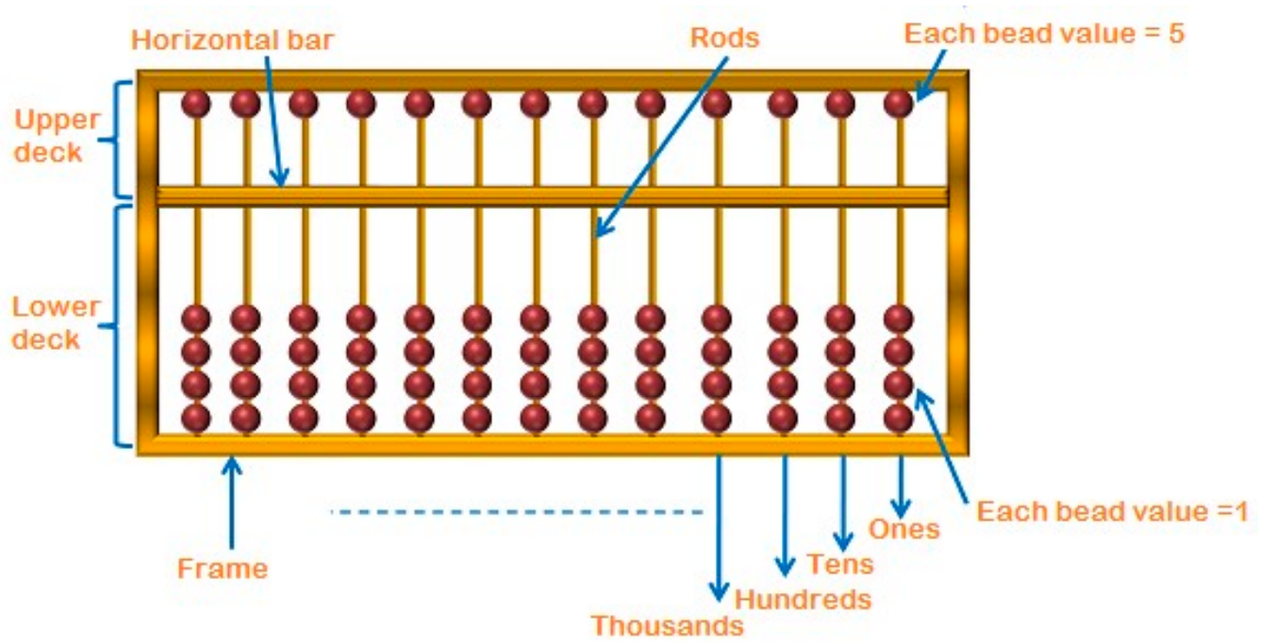
- Calculation stands at the beginning of civilization
  - Sumerian Cuneiform: 3400 BC
    - developed to keep accounts and records of business transactions

Standard of Ur, side B: top banquet, bottom men driving cattle and sheep

Bill of sales in cuneiform

Abacus: First Calculators

- Abacus or Counting board
  - Known from Mesopatamia 2700 BC
  - Current type invented in China 200 BC
- Used by babylonians, romans, greeks, medieval times
- Still used in Japan
- Can be used for all four basic arithmetic operations



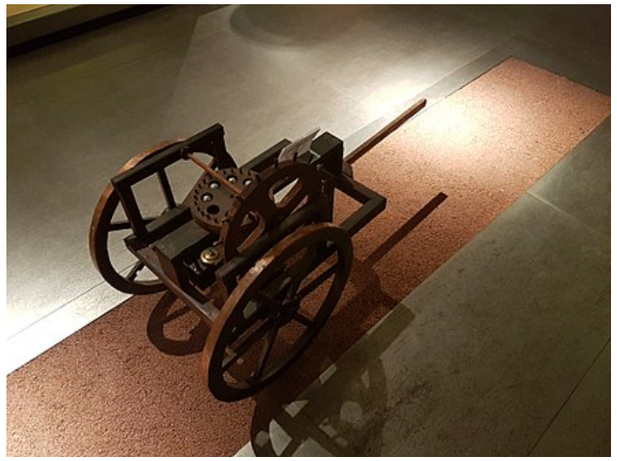
What do we not know

- Antikythera mechanism, detected in a wreck under the Mediterranean sea 1901
- Analog computing device
  - Maybe for astronomy
  - From 2nd century BC to first century BC

Napier's Bones

- 1617 John Napier: Numbering rods using logarithmic scale
- Precursor to the slide rule

Calculators



- Odometers:
  - Pliny / Strabo: Distances of routes traveled by Alexander the great measured by odometers
  - 635: Jin Shu: records use of odometer in the Han period of China
    - Also: south-pointing chariot

Calculators

- 17th century: mechanical calculators
  - 1632 Wilhelm Schickard calculating clock
  - 1642 Blaise Pascal
  - 1672 Gottfried Leibniz: direct multiplication

Calculators

- 1709; Giovanni Poleni: calculator that can multiply automatically
- 1727: Antonius Braun: fully functional four operations machine
- 1851 Thomas de Colmar: Arithmometer: suitable to an office environment
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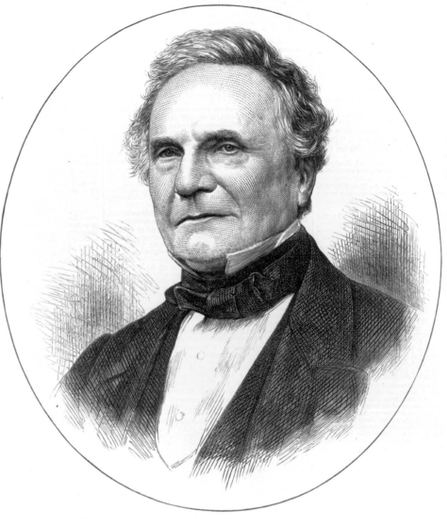


Charles Babbage

- (1791-1871) Founding member of the Royal Astronomical Society
    - Well aware of faulty logarithm tables
        - Which were used for navigation
            - And navigation was the backbone of the British Empire
- Saw potential in the *method of the differences*

Method of the Differences

- Calculate the values of a polynomial for $x = 0,\ x = 1,\ x = 2,\ \ldots$
  - $f(x) = x^4 - x^2 + 2$
- First calculate $D_1(n) = f(n+1) - f(n)$

- This is helpful because $D_1(n)$ is a polynomial of degree ≤ 3
- $D_1[n] = (n+1)^4 - (n+1)^2 + 2 - n^4 + n^2 - 2$
  $= n^4 + 4n^3 + 6n^2 + 4n + 2 - n^2 - 2n - 1 + 2 - n^4 + n^2 - 2$
  $= 4n^3 + 6n^2 + 2n$

Method of Differences

- Now use a table:
- Example:
- $f(2) = f(1) + f(2) - f(1)$

n	f(n)	D1(n)
0	2	0
1	2+0=2	12
2	2+12=14	60
3	14+60=74	168
4	74+168=242	360
5	242+360=602	660

Method of Differences

- We can use the same method in order to calculate $D_1(n)$
- $D_2(n) = D_1(n+1) - D_1(n) = 12n^2 + 24n + 12$
- $D_3(n) = D_2(n+1) - D_2(n) = 24n + 36$
- $D_4(n) = 24$

Method of Differences

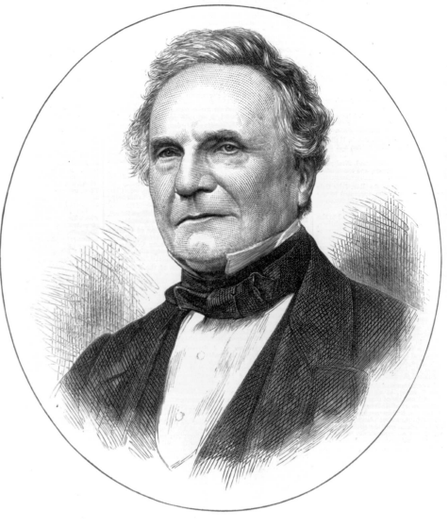
- Now we have a bigger table:

n	f(n)	D1(n)	D2(n)	D3(n)	D4(n)	D5(n)
0	2	0	12	36	24	0
1	2	12	48	60	24	0
2	14	60	108	84	24	0
3	74	168	192	108	24	0
4	242	**360**	300	132	24	0
5	602	660	432	156	24	0

Method of Differences

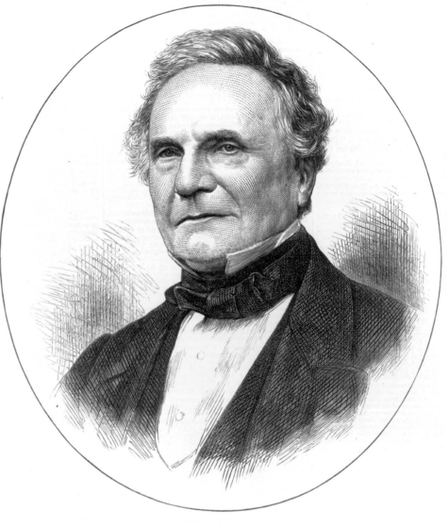
- Why is this cool:
  - All tables are calculated in exactly the same way
  - To get different functions:
    - Change the values of the first row

n	f(n)	D1(n)	D2(n)	D3(n)	D4(n)	D5(n)
0	**2**	**0**	**12**	**36**	**24**	**0**
1	2	12	48	60	24	0
2	14	60	108	84	24	0
3	74	168	192	108	24	0
4	242	360	300	132	24	0
5	602	660	432	156	24	0



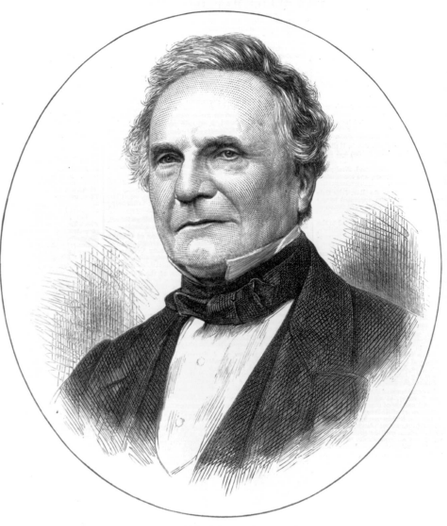
Charles Babbage

- Babbage insight:
  - One can mechanize the calculations of the difference table
- 1832: government funding for a difference engine
  - Digits are represented as positions of wheels
  - 20 decimal positions
  - Was at the boundary of what precision tools can provide
  - Still room sized and needed steam energy



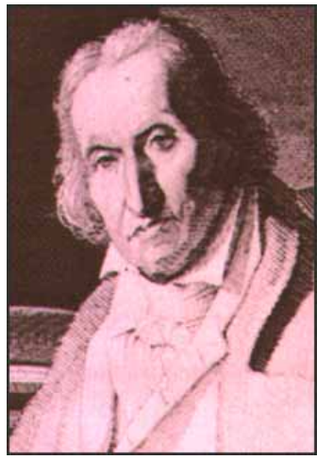
Charles Babbage

- Why did he receive support?
  - Mechanical calculation allows
  - Tables without mistakes
  - Better navigation
  - Less losses of ships
  - Cheaper insurance rates, less lives lost, and lower navy spending
  - And the government is interested
- It helps to eventually become the Lucasian professor of Mathematics at Cambridge



Charles Babbage

- Why did he not finish it?
  - Ran out of funds for paying his workmen
  - Had an idea for a much more versatile machine
- Machine that could react to instructions
- Instructions given by a punch card

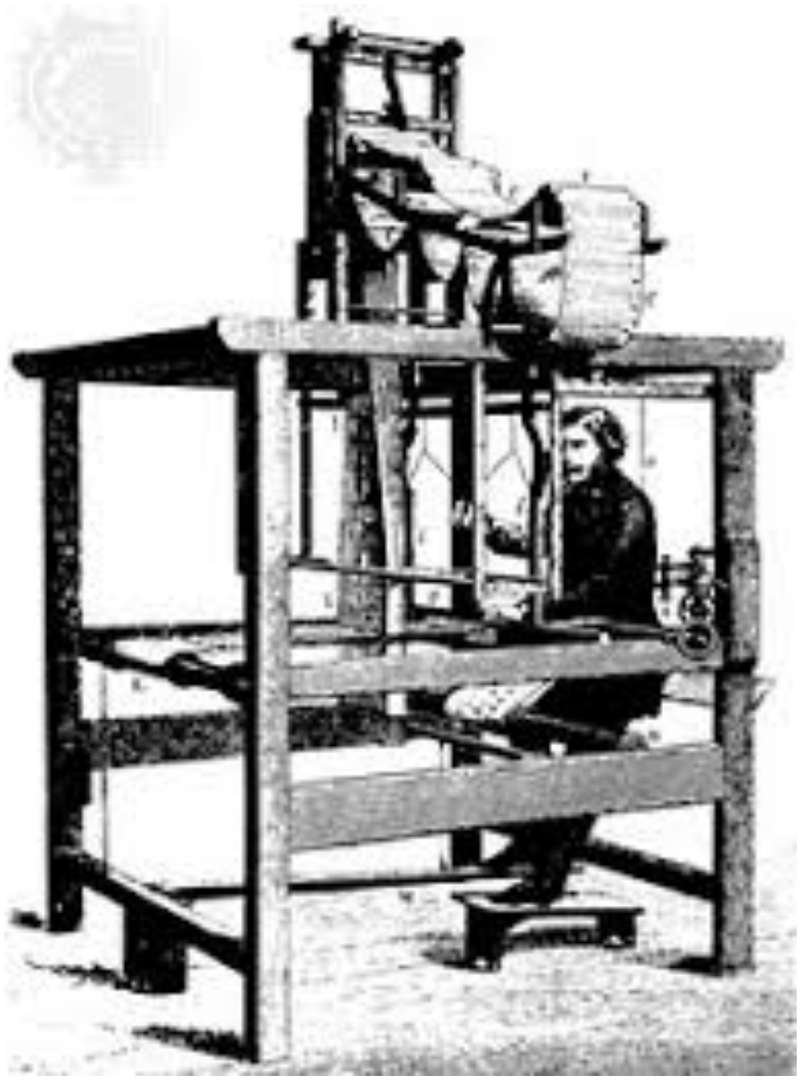


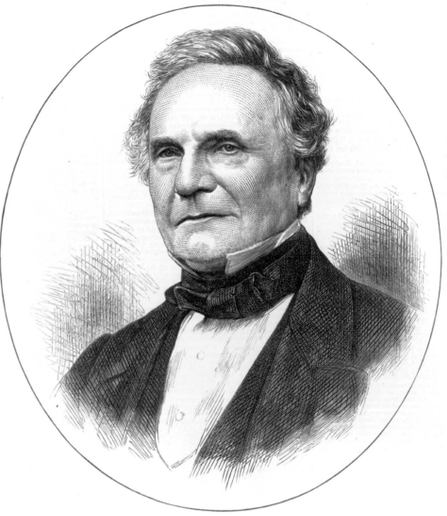
Jacquard Loom

- A loom that can weave very intricate patterns (1800)
- Previously:
  - Draw loom was controlled by a master weaver
    - Master weaver commands a draw boy to raise hooks that controlled harnesses
    - Generates intricate floral patterns
- Jacquard loom:
  - Skill of a master weaver codified in punch cards

Jacquard Loom

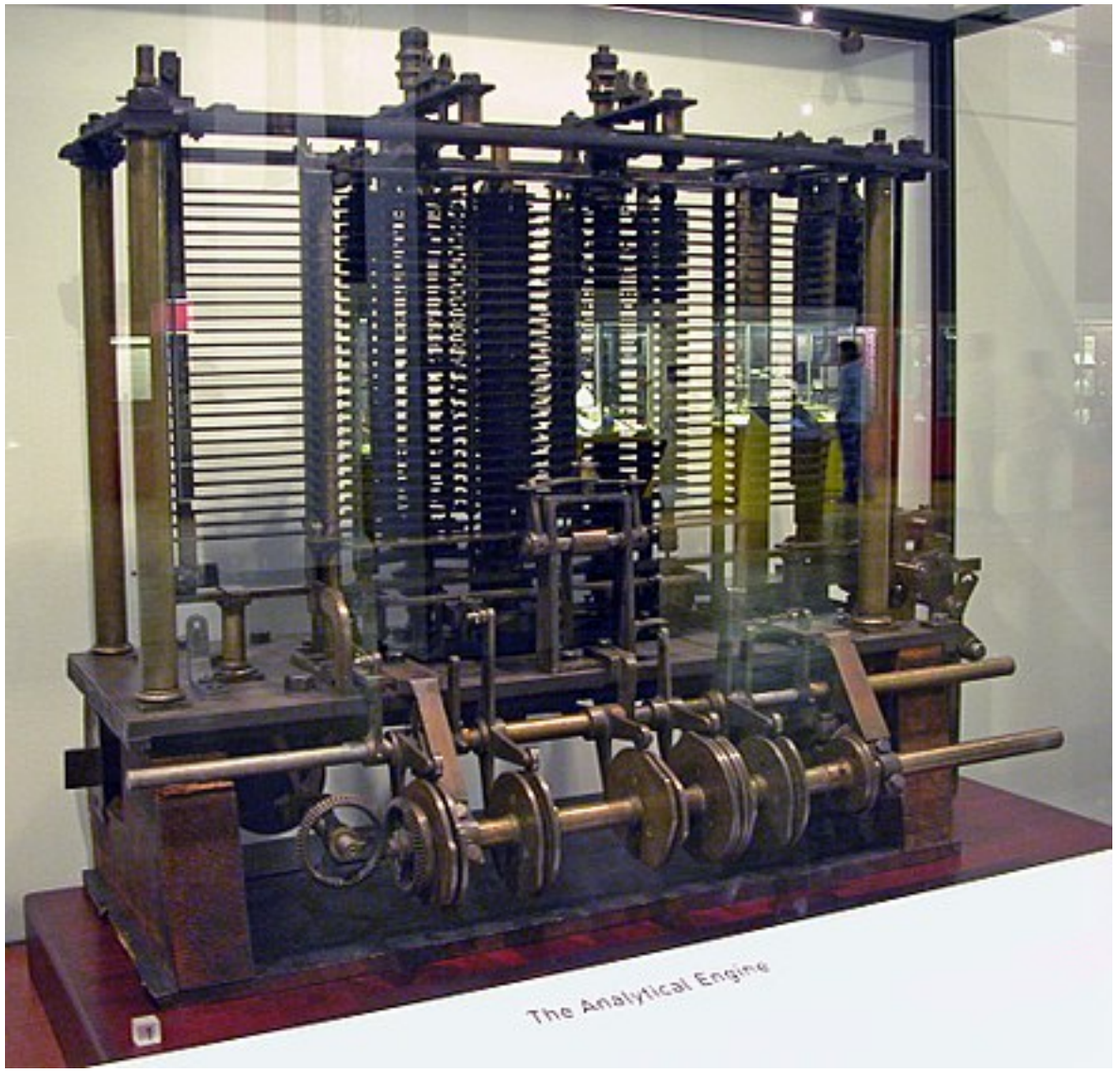
- Consequences of using the Jacquard Loom
  - Introduced in Britain in 1820
  - Lower skilled weavers can now produce better quality products for a fraction of the costs
  - First effect: Move monies from employees (the master weavers) to mill owners
  - Helps create the Luddite movement
  - Second effect: A new class of skilled workers replaces the master weavers: the ones that create the punch cards and keep the loom working



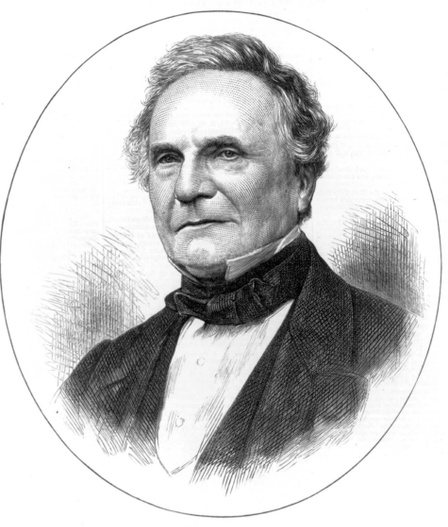


Charles Babbage

- First described in 1837
  - Has an arithmetic logic unit
  - conditional branching
  - integrated memory
  - And too difficult to build without hindsight



Trial version of Analytical Engine, Science Museum, London



Charles Babbage

- 1842 Luigi Frederico Menabrea publishes a description based on a lecture by Babbage
- 1843 **Ada Lovelace** translate this memoir into English
- Adds ways of how this machine could be used to make useful calculations
- Considered the "first computer programmer" and has a programming language named after her
- And after all, their work was unknown to the pioneers of computing

Predecessor to Computing

- Bombe (1939, 1940, 1943) / Poland, UK, US:
  - Specialized electro-mechanical machine to break ciphers
  - Part of the war-effort to break German codes, especially enigma

Predecessor to Computing

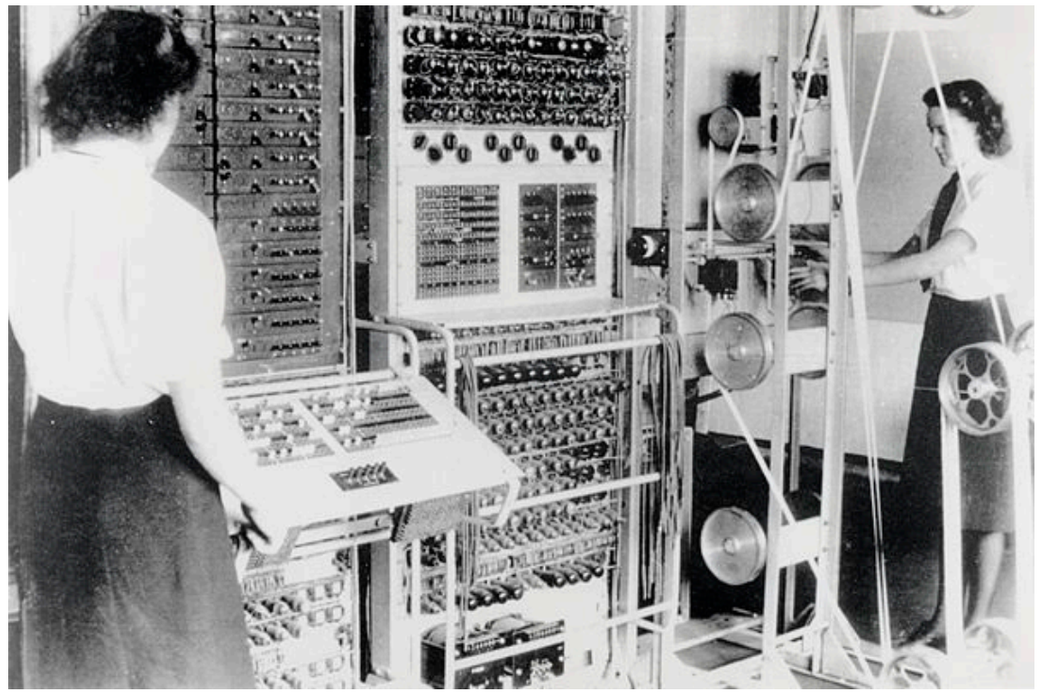
- Zuse Z3 (1941/Germany)
  - Electro-mechanical
    - Used relays to store data
    - Use 35 mm film to program
  - To study airflow over wings in airplane design (and to keep its inventor from being drafted)
  - In principle: first programmable computer

Predecessor to Computing

- Atanasoff-Berry Computer (1942, US)
  - Solves large linear system, entered by punched cards
  - Electronic, uses capacitor memory

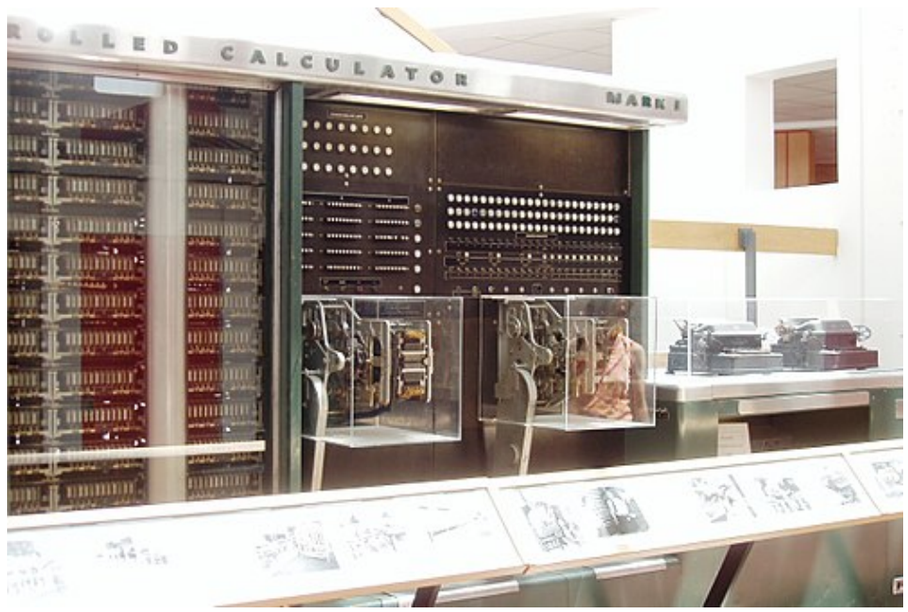
Predecessor to Computing

- Colossus Mark 1
  - Follow up on the Bombe
  - Uses vacuum tubes
  - Special purpose machine to solve a problem posed at Bletchley Park
- Subsequentially improved
  - End of WW2: 10 Mark 2 in commission for code breaking



Predecessor to Computing

- Harvard Mark 1 - IBM ASCC (1944 US)
  - Electro-mechanical computer for war effort
  - Also used in the Manhattan project
  - Conceived by Aiken and built by IBM
  - Data entry by punched paper tape
  - Division took 15.3 sec



Aiken-IBM Automatic Sequence Controlled Calculator Mark I"

Predecessor to Computing

- ENIAC - Electronic Numerical Integrator and Computer (1945)
  - First programmable, electronic, general-purpose computer
  - Primarily used to calculate artillery firing tables
  - Also used to study feasibility of thermonuclear weapons
  - Calculated a trajectory in 30 seconds vs. 20 hours
    - Speed-up of 2400 : 1

Predecessor to Computing

- Manchester Baby -- Small-Scale Experimental Machine (UK, 1948)
  - Test-bed for the Willams tube
  - General purpose computer
- Predecessor to the Manchester Mark 1, which was the prototype to the Ferranti Mark 1
  - The world's first commercially available general-purpose computer