A (very) brief history of Computing

Lecture 01.02

By Marina Barsky

With what purpose was writing invented?

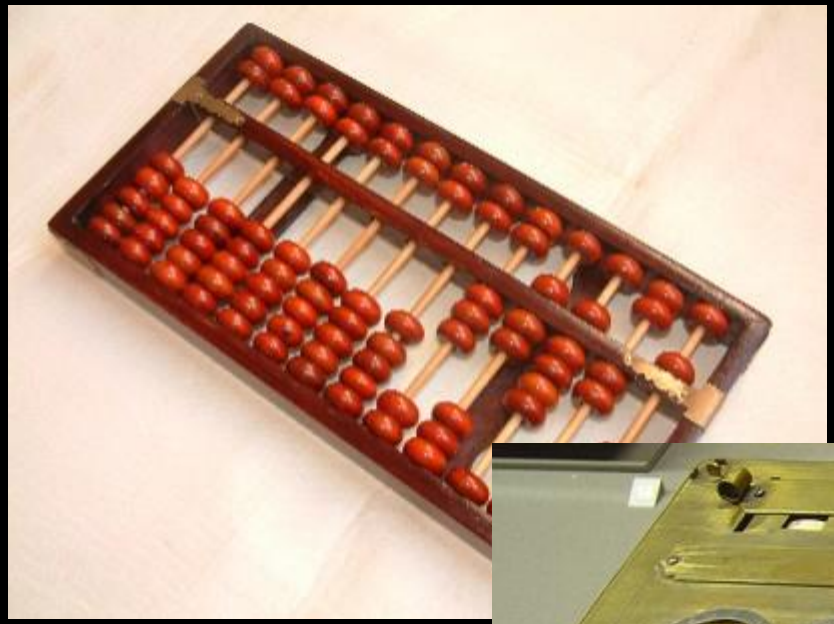
Writing was invented for manipulating numeric data

- Writing numbers for the purpose of record-keeping began long before the writing of language
- All advances of math and science began after inventing writing
- This is because human brain is not good for abstract manipulation of numbers in memory

We always wanted to automate calculations

- Precise values of square roots and logarithms were produced with known *algorithms* by human “computers” and published as tables
- People invented some mechanical devises to facilitate this process
- The practical calculations in astronomy, sea navigation etc. were performed by using these manually computed tables

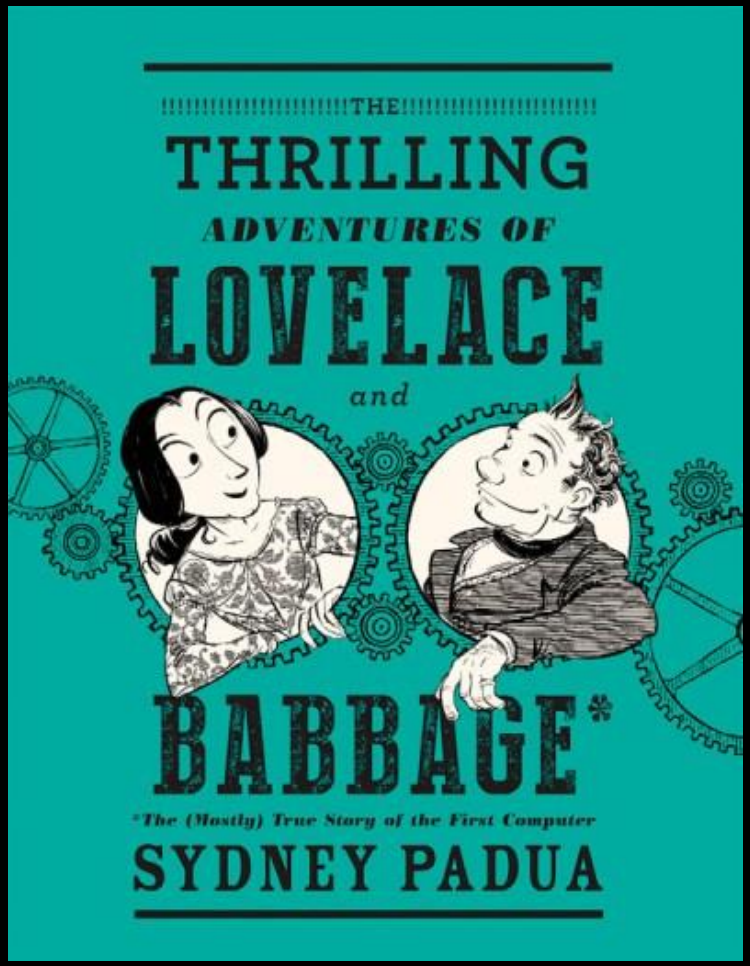
Computing machines



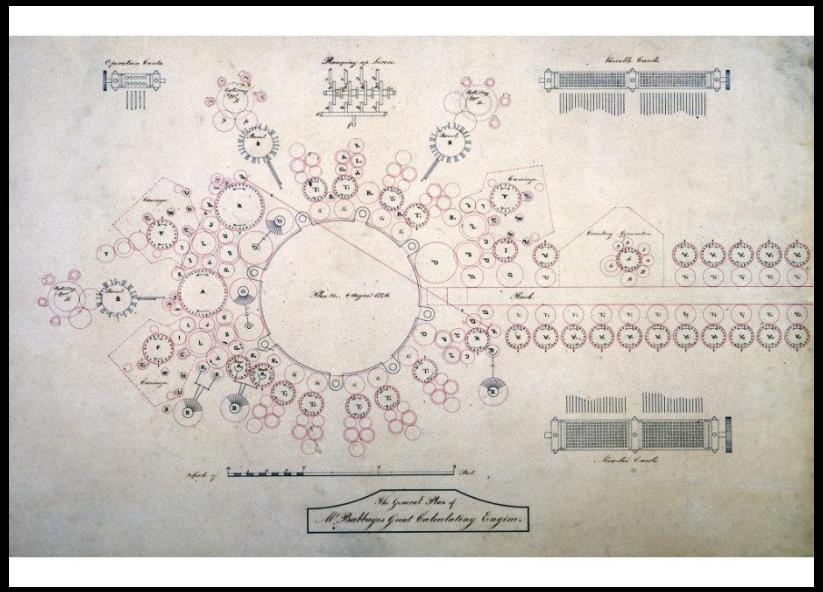
The Chinese Abacus
'Suan Pan'

Pascaline

Imaginary Engines

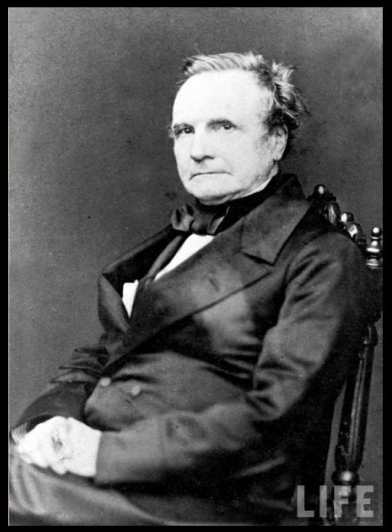


Idea of a general-purpose computer - ***Analytical Engine***



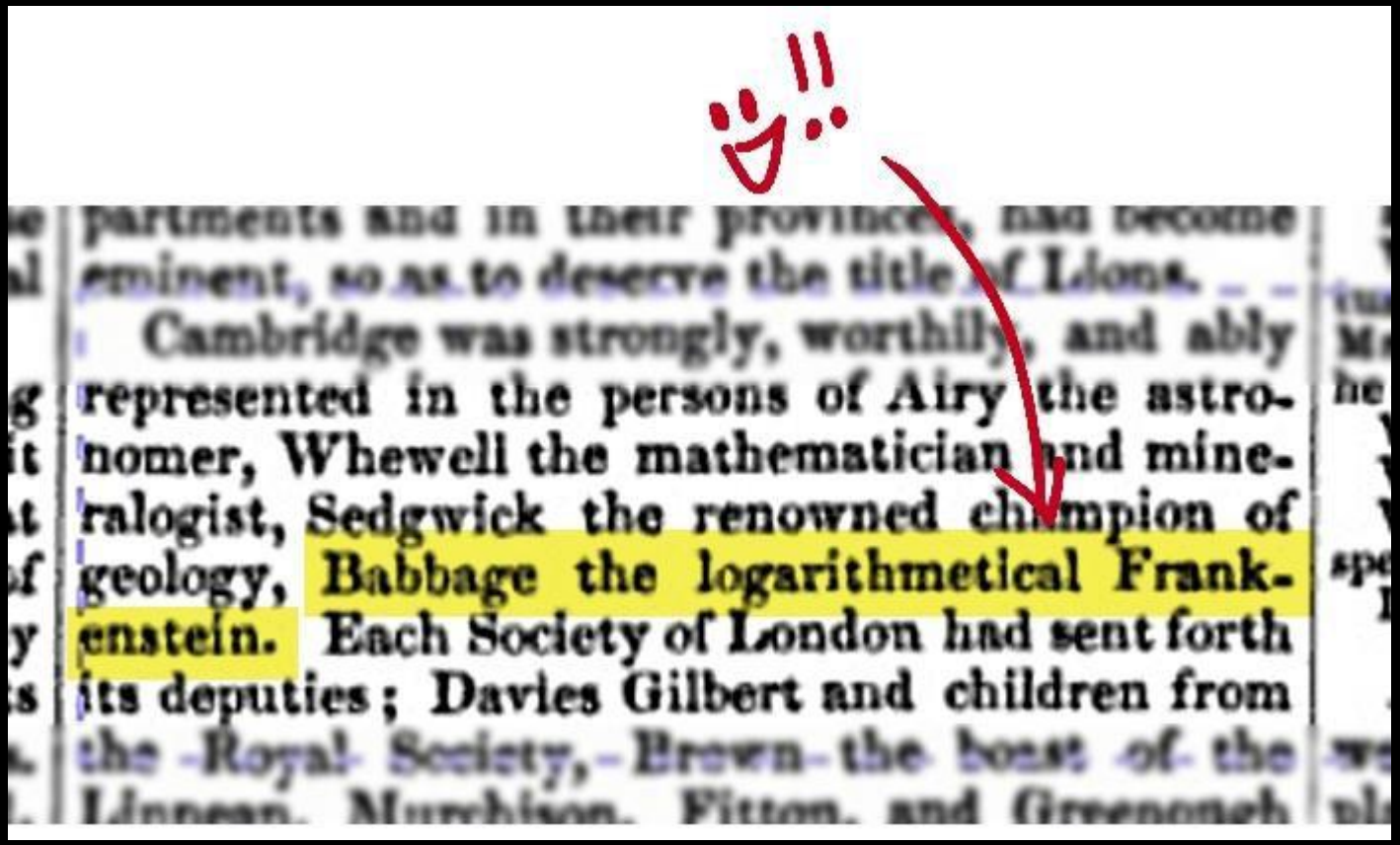
Purely theoretical layout of a mechanical computer

Charles Babbage 1822



https://www.youtube.com/watch?v=_fyUtU6LVNY

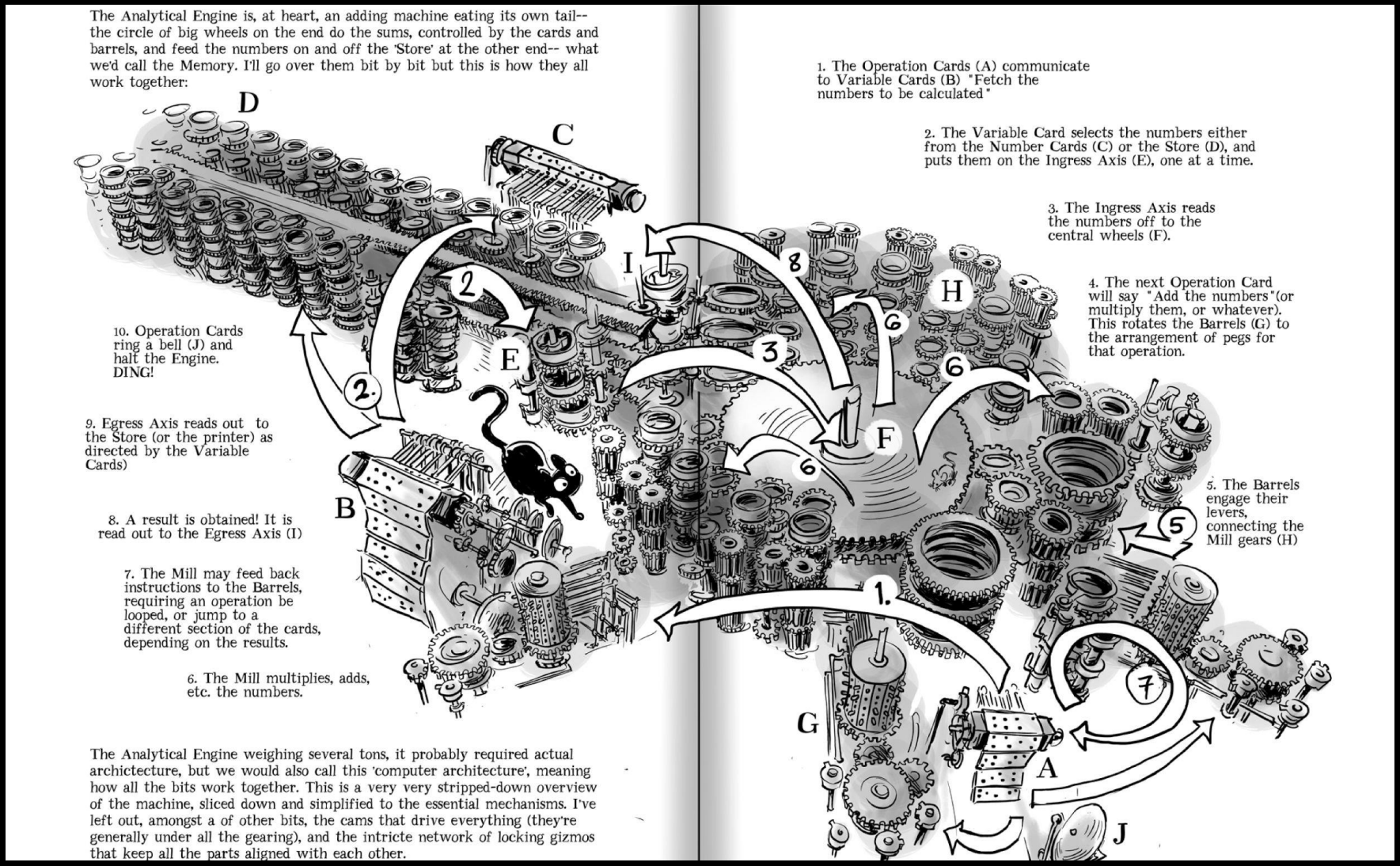
Babbage was a famous mathematician



partments and in their provinces, had become
eminent, so as to deserve the title of Lions.

Cambridge was strongly, worthily, and ably represented in the persons of Airy the astronomer, Whewell the mathematician and mineralogist, Sedgwick the renowned champion of geology, Babbage the logarithmetical Frankenstein. Each Society of London had sent forth its deputies; Davies Gilbert and children from the Royal Society, Brown the boast of the
Linnean, Murchison, Fitton, and Greenough

Analytical engine version 25



the same process would be repeated. If, however, any mistake had been made by the attendant, and a wrong logarithm had been accidentally given to the engine, it would have discovered the mistake, and have rung a louder bell to call the attention of its guide, who on looking at the proper place, would see a plate above the logarithm he had just put in with the word "*wrong*" engraven upon it.

By such means it would be perfectly possible to make all calculations requiring tabular numbers, without the chance of error.

...mputed and punched by itself.
...ine first computes and punches on
...ers. These are brought to it by
...led. But the engine itself takes
...s brought to it by verifying the *number* of that card by the number of the card which it demanded. The Engine will always reject a wrong card by continually ringing a loud bell and stopping itself until supplied with the precise intellectual food it demands.

It will be an interesting question, which time only can solve.


WRONG
WRONG
#5@%*!!
KLANG!
KLANG!
KLANG!

Ada Lovelace meets Babbage
(Software meets hardware)

- Lady Byron described seeing the working prototype of the difference engine in 1833:

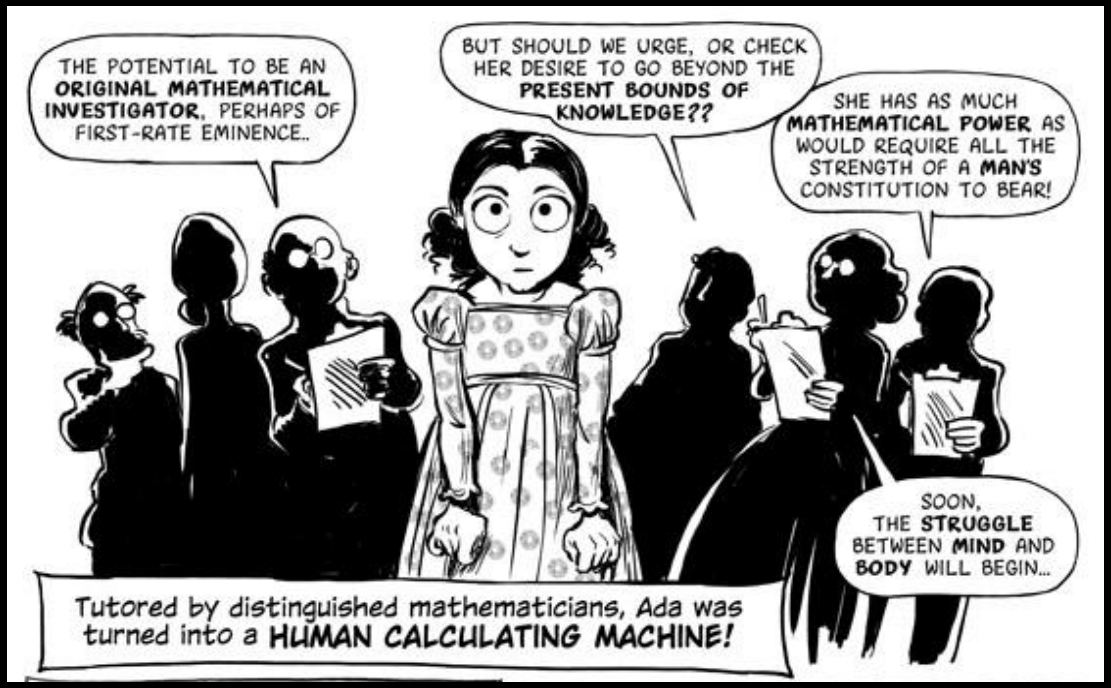
- "*We both went to see the **thinking** machine (for so it seems) last Monday. It raised several Nos. to the 2nd and 3rd powers, and extracted the root of a Quadratic equation…*"

Ada Lovelace?

The disease of imagination

And the cure


E
A
N
G
Q
B
F
C
NOTHING BUT A VERY CLOSE AND INTENSE APPLICATION TO SUBJECTS OF A SCIENTIFIC NATURE NOW SEEMS AT ALL TO KEEP MY IMAGINATION FROM RUNNING WILD...
...OR TO STOP THE VOID WHICH SEEMS TO BE LEFT IN MY MIND!
I SHALL BE A GREATER MATHEMATICIAN THAN MY FATHER EVER WAS A POET!
IT IS MY DUTY TO MAKE A COMPENSATION TO MANKIND FOR HIS MISUSED GENIUS...
I WISH TO LEARN THE WAYS OF HIGHER MATHEMATICS, AND REDEEM MY FATHER'S IRRATIONAL LEGACY!!
TEACH ME, MASTER!



perhaps (I speak doubtfully) Maria Agnesi, has wrestled with difficulties and shown a man's strength in getting over them. The reason is obvious: the very great tension of mind which they require is beyond the strength of a woman's physical power of application. Lady L. has unquestionably as much power as would require all the strength of a man's constitution to bear the fatigue of thought to which it will unquestionably lead her. It is very well now, when the subject has not entirely engrossed her attention; by-and-bye when, as always happens, the whole of the thoughts are continually and entirely concentrated upon them, the struggle between the mind and body will begin.

Perhaps you think that Lady L. will, like Mrs. Somerville, go on


IT CAN TABULATE ACCURATELY AND TO AN **UNLIMITED EXTENT**, ALL **SERIES** WHOSE GENERAL TERM IS COMPRISED BY THE FORMULA $\Delta^7 U_x = 0$!!!
INDEED, **ALL** OTHER SERIES WHICH ARE CAPABLE OF TABULATION BY THE **METHOD OF DIFFERENCES**!!
EXACTLY!

De Morgan – mathematical logic

and A in which B is the subject. Thus neither of the four following lines is inconsistent with itself.

Some A is not B and Every B is A
Some A is not B and No B is A
Some A is not B and Some B is A
Some A is not B and Some B is not A.

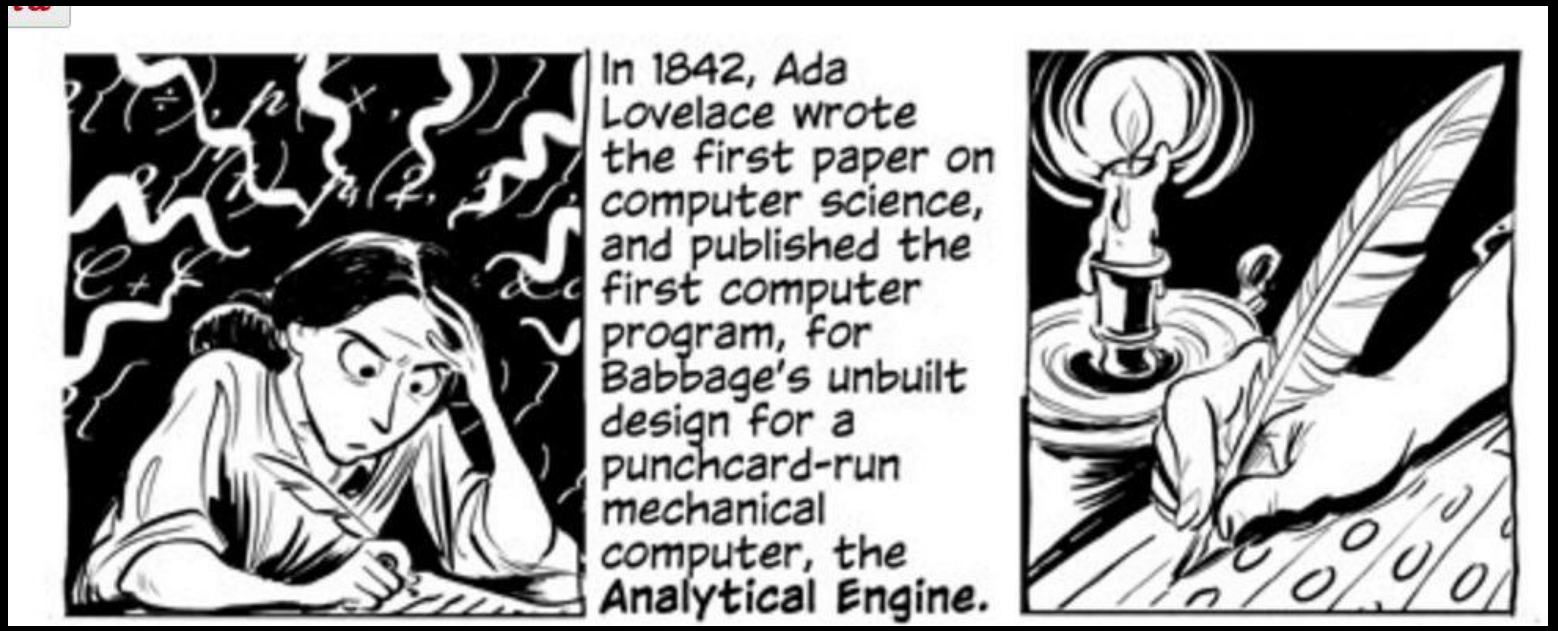
We find then, including converses, which are not identical with their direct propositions, *six* different ways of asserting or denying, with respect to agreement or non-agreement, total or partial, between A and, say X: these we write down, designating the additional assertions by U and Y.

A	Every A is X	Identical. E { No A is X / No X is A }		Identical. I { Some A is X / Some X is A }	O Some A is not X
U	Every X is A				Y Some X is not A

We shall now repeat and extend the table of page 8 (A), &c., meaning, as before, the denial of A, &c.

From A or (O) follow A, (E), I (O)
From E or (I) ..... (A), E, (I), O, (U), Y
From I or (E) ..... (E) I
From O or (A) ..... (A), O
From U or (Y) ..... (E) I, U (Y)
From Y or (U) ..... (U) Y

Having thus discussed the principal points connected with the simple



Variables
Conditionals
Loops

Sheet 1

Trains on "F and I during Operations in Mill

Addition Not. 132 N° 1

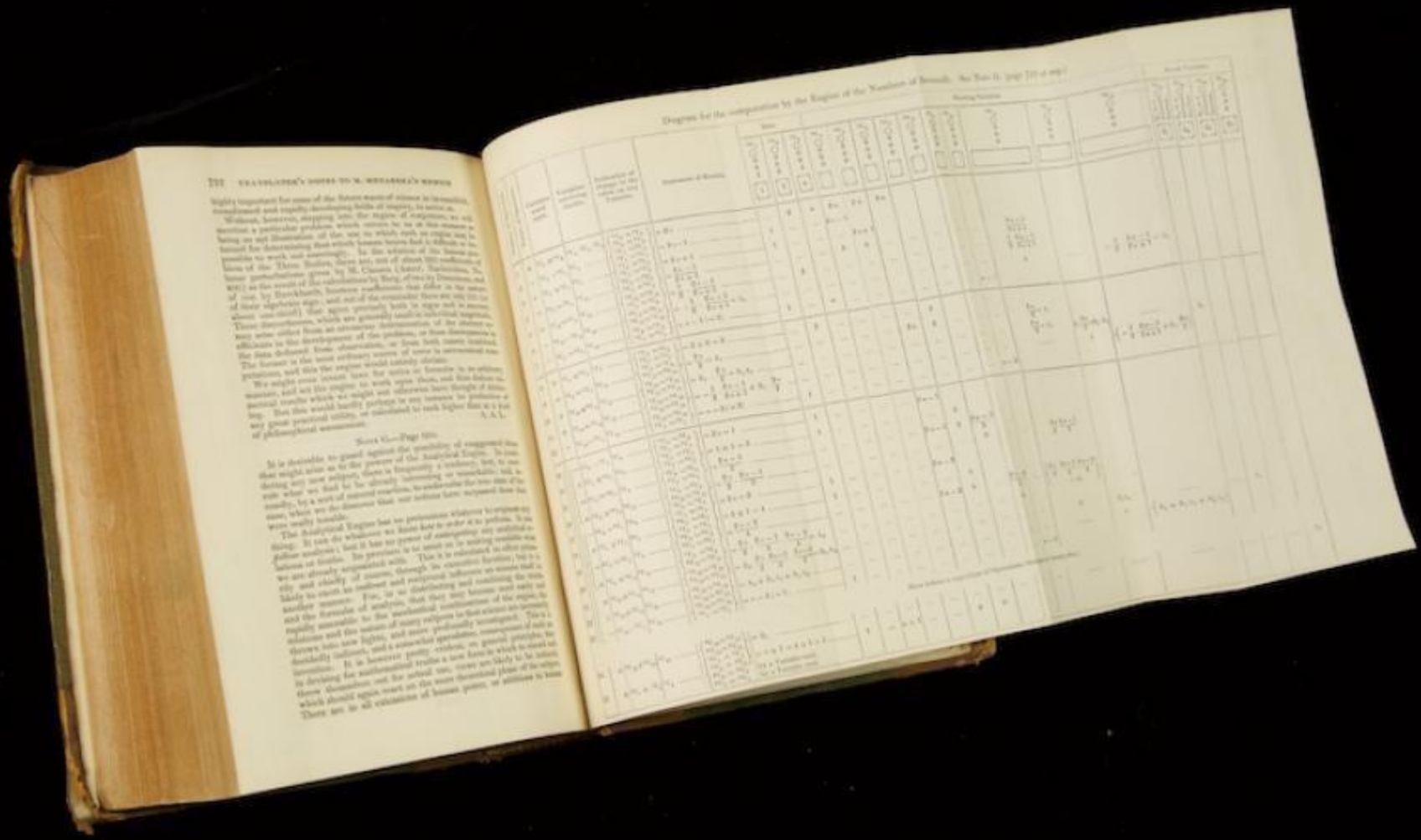
Operation		Trains	Note
Give P from Store to Ingrep wh. 1 Card puts Alg. sign on sign wh. of "F Transfer sign of P to sign wh. of "F	A	Rk $\breve{Q}$ $\hat{I}$ "$\breve{O}$ "S "L "I "F "C "L "I "F	Card puts ± on "F
Give Q from Store to Ingrep wh. 2 Card puts Alg. sign on sign wh. of "F Transf. P from Ingrep wh. 1 to Central. Transf. sign of Q to sign wh. of "F	B	Rk $\breve{Q}$ $\hat{I}$ $\hat{I}$ "G "S "O C "$\breve{O}$ "S "L "I "F "C "L "I "F	Card puts ± on "F
Transf. Q from Ingrep wheel 2 to Central	C	$\hat{I}$ G S O C	
Reduce I to zero	D	$\hat{I} = 0$	
Reduce "F to minus zero	E	"F = −0	
Subtract W which is on A from "F Reduce Ingrep wh. 1 to zero			
Reduce "F to minus zero	Dᵒ	C "O "S "L "I, "I "F "C "L "S "O C "L "I, "I "F	$\hat{I} = 0$

The above trains include all recurring in the six standard cases of Addⁿ

All the Trains in Not. 135 Addⁿ are included in Not. 132

Multiplication (Standard)

The first program: state machine




THESE MECHANISMS REMIND ME OF MR. DE MORGAN'S STRIVINGS TOWARD A MATHEMATICAL LOGIC...
INDEED... WE MAY CONSIDER THE ENGINE AS THE MATERIAL AND MECHANICAL REPRESENTATIVE OF ANALYSIS!
(IF I MAY RISK A POTENTIALLY POETICAL METAPHOR...)
SUCH A SCIENCE OF OPERATIONS HAS ITS OWN TRUTH AND LOGIC...
A PROCESS WHICH ALTERS THE MUTUAL RELATION OF TWO OR MORE THINGS—
IF the pep is interposded AND the lever is enaged THEN the OR else
ANY PROCESS... IT MIGHT ACT UPON OTHER THINGS BESIDES NUMBER...
THE BOUNDS OF ARITHMETIC HAVE BEEN OVERSTEPPED!!

idea of applying the cards had occurred; and the Analytical Engine does not occupy common ground with mere "calculating machines." It holds a position wholly its own; and the considerations it suggests are most interesting in their nature. In enabling mechanism to combine together *general* symbols, in successions of unlimited variety and extent, a uniting link is established between the operations of matter and the abstract mental processes of the *most abstract* branch of mathematical science. A new, a vast, and a powerful language is developed for the future use of analysis, in which to wield its truths so that these may become of more speedy and accurate practical application for the purposes of mankind than the means hitherto in our possession have rendered possible. Thus not only the mental and the material, but the theoretical and the practical in the mathematical world, are brought into more intimate and effective connexion with each other. We are not aware of its being on record that anything partaking in the nature of what is so well designated the *Analytical* Engine has been hitherto proposed, or even thought of, as a practical possibility, any more than the idea of a thinking or of a reasoning machine.

We will touch on another point which constitutes an important distinction in the modes of operating of the Difference and Analy-

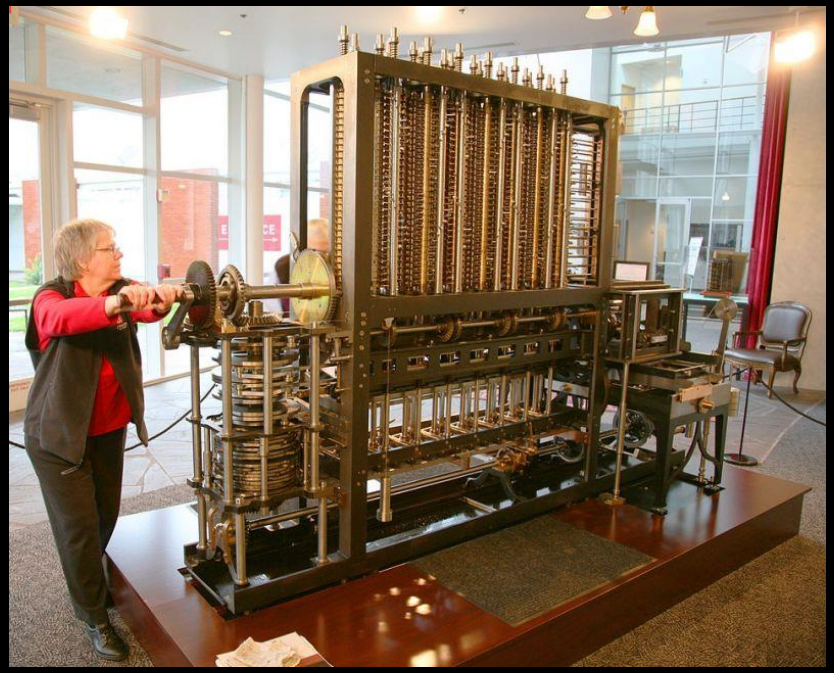

Then, at a party on June 5th, 1833...
NOBODY UNDERSTANDS ME..
ASTOUNDING!! IN ENABLING MECHANSIM TO COMBINE TOGETHER GENERAL SYMBOLS IN SUCCESSIONS OF UNLIMITED VARIETY AND EXTENT, A UNITING LINK IS ESTABLISHED BETWEEN THE OPERATIONS OF MATTER--
EH?
--AND THE ABSTRACT MENTAL PROCESSES OF THE MOST ABSTRACT BRANCH OF MATHEMATICAL SCIENCE!!!
A NEW, VAST, AND POWERFUL LANGUAGE IS DEVELOPED FOR THE FUTURE USE OF ANALYSIS, SO IT MAY BECOME OF MORE SPEEDY AND ACCURATE PRACTICAL APPLICATION FOR THE PURPOSES OF MANKIND THAN THE MEANS HITHERTO IN OUR POSSESSION HAVE RENDERED POSSIBLE!!
YES, YES, EXACTLY!
HEY LOOK-- WE'RE PRESENT FOR THE INVENTION OF THE GEEK!
THIS MUST BE TWITTERED!
WAIT, THIS IS A FAN.
SUDDENLY THERE IS A GAPING HOLE IN MY LIFE OF WHICH I WAS HITHERTO UNAWARE.

Ada's Vision

- Mechanism to combine general symbols in successions of unlimited variety and extent
- Uniting link between operations of matter and the most abstract mental processes
- Theoretical and practical are brought together

- Thinking machine, can do more than computing with numbers

The greatest machine that never was



Difference Engine built in 2010

https://www.ted.com/talks/john_graham_cumming_the_greatest_machine_that_never_was

What if …


Ugh, that's a terrible ending! Actually what happened was, Lovelace and Babbage lived on and built a giant calculating Engine and used it to
FIGHT CRIME and HAVE ADVENTURES!


UNLESS...
YES.
I KNOW.
YOU'VE BEEN USING THE DIFFERENCE ENGINE TO COMPOSE MUSIC!!
I.. UH...
HOW COULD YOU?? I THOUGHT YOU WERE A MATHEMATICIAN?
BUT MUSIC IS MATHEMATICS! WHY CAN'T YOU SEE THAT??!
MY GOD, WHOSE SIDE ARE YOU ON??


LET'S SEE HOW LADY LOVELACE IS GETTING ON!
%**@#!!!
Lady Lovelace speaks so many languages-- We are not familiar with that one!
THAT'S AN.. ER.. SPECIAL LANGUAGE WE'RE DEVELOPING JUST FOR THE ENGINE!
Fascinating!

No cure from the disease of imagination: “The engine could analyze all subjects in the universe!”

Main breakthrough ideas

- Every problem can be expressed as a combination of basic primitive operations (tape – reading instructions and writing them back – Turing machine – 1936)
- Program - sequence of instructions built out of primitives

- The program itself is no different than the data (stored-program computer – von Neuman 1945)

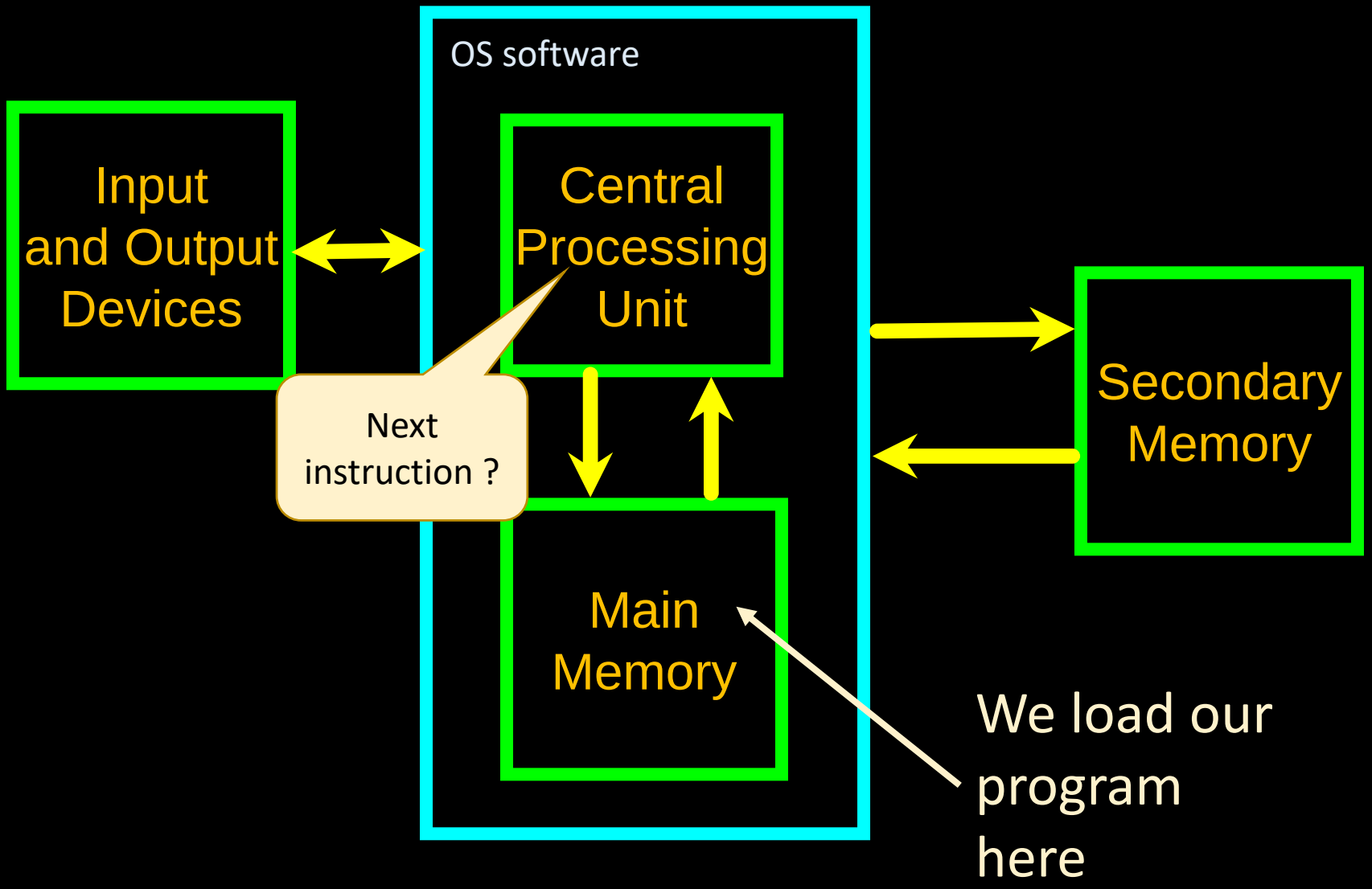
Play with Turing

Implementation: modern computers

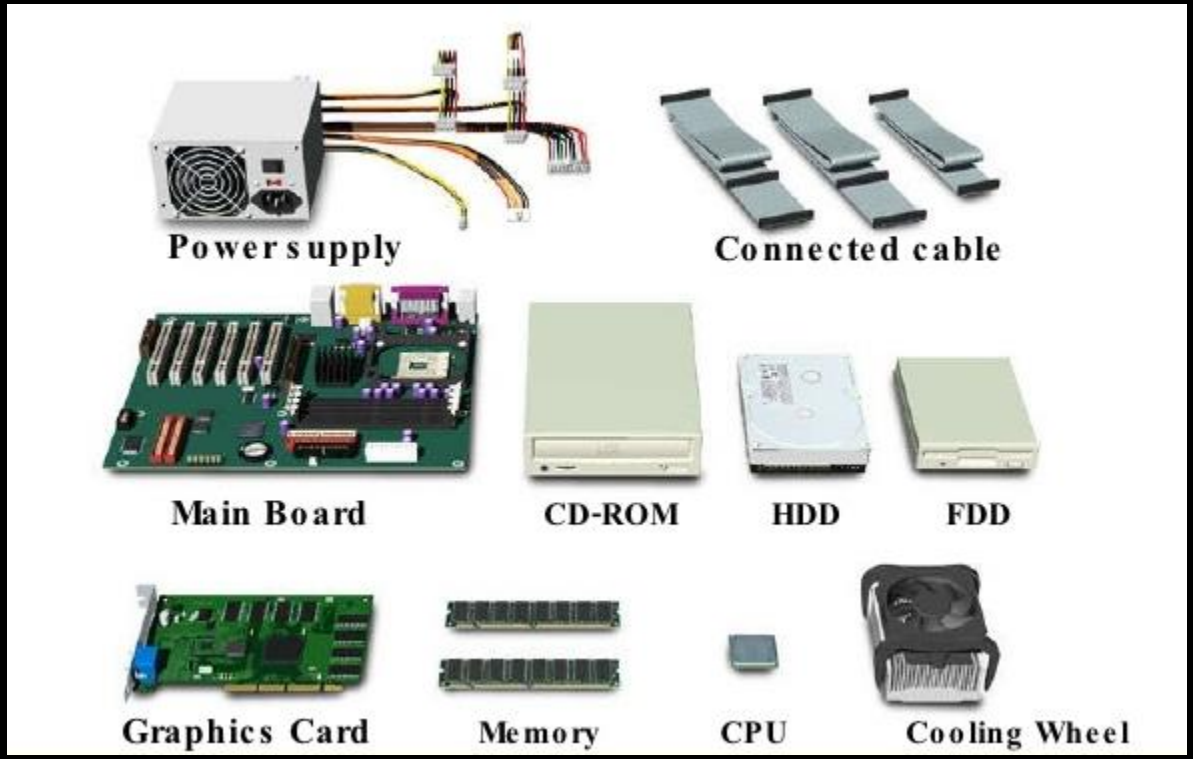
- The basic set of primitive operations is implemented using digital circuits
- We have digital memory where we load the data and the instructions
- There is a processing unit which executes these instructions one at a time

- All the work of a computing machine is in reading next instruction from a known place in memory and sticking the result into another place

Stored-program computer



Physical parts (hardware)



Raspberry Pi

Motherboard