Computing System I

Fisica dell'Energia - a.a. 2018/2019

2020/2021

Computing

"*It is unworthy of excellent men to lose hours like slaves in the labour of calculation which could safely be relegated to anyone else if machines were used*".

(Describing, in 1685, the value to astronomers of the hand-cranked calculating machine he had invented in 1673.)

- Gottfried Wilhelm Leibniz

Che cos'è un computer?

Computer = Calcolatore (dal latino *computare*)

Un computer è una macchina che esegue automaticamente dei calcoli

Differenza tra computer e calcolatrice

un computer è un dispositivo che elabora informazione, immessa sotto forma di dati numerici al fine di conseguire un risultato il cui raggiungimento viene ottenuto mediante una sequenza di operazioni preordinate.

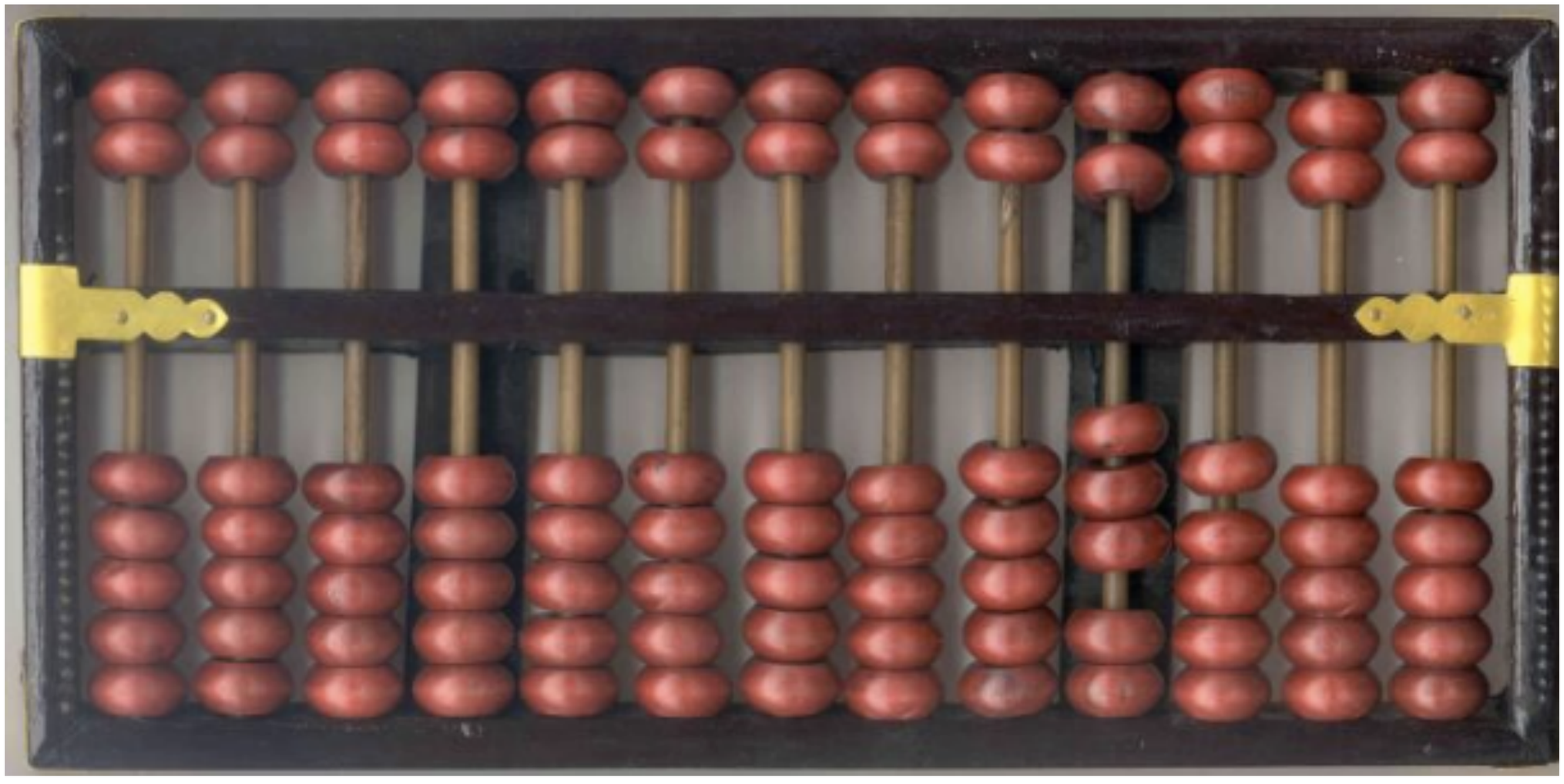
Algorithm

- The program P should have finite length
- A computing agent C should exist and should be able to exec the instructions
- The computing agent C can use a memory in witch store intermediate results
- The computation is done by discrete steps
- The computation is deterministic
- No limits on input length
- No limits on available memory

Diverse tipologie di computer

Nome	**Dimensioni fisiche**	**costo**
Supercomputer	10 m	10^6 €
Mainframe	2 m	10^5 €
Workstation	1 m	10^4 €
PC	$3\ 10^{-1}$ m	10^3 €
Palmare	10^{-1} m	10^2 €
Embedded Computer	10^{-2} m	10 €
Wireless sensors	$10^{-4} - 10^{-3}$ m	10^{-1} €

Abacus 2700–2300 BC



multiplication, division, addition, subtraction, square root and cube root

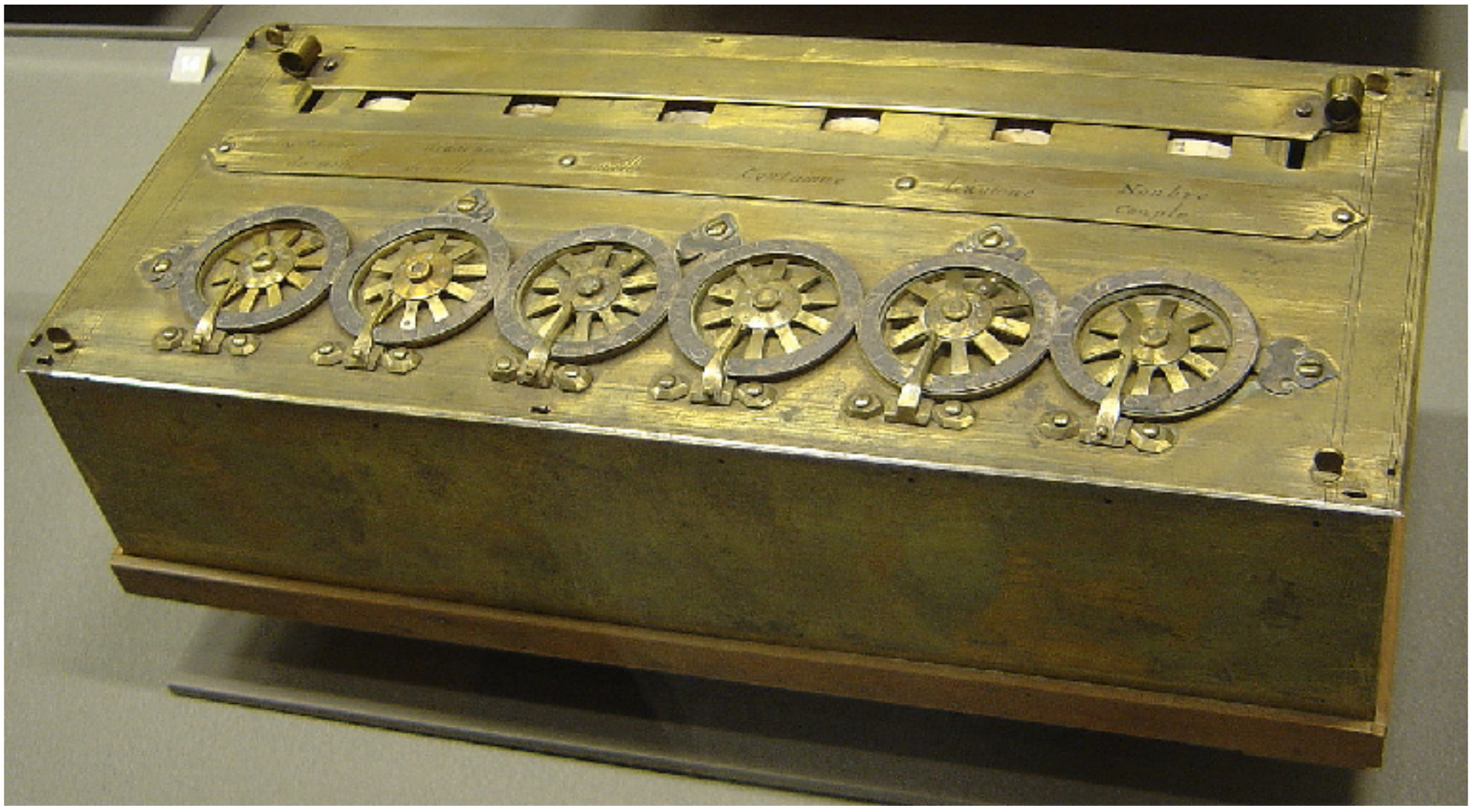
Antikythera mechanism

- Designed to predict astronomical positions and eclipses.

- Recovered in 1900–01 from the Antikythera wreck, a shipwreck off the Greek island of Antikythera

- Designed and constructed by Greek scientists and has been dated between 150 to 100 BC

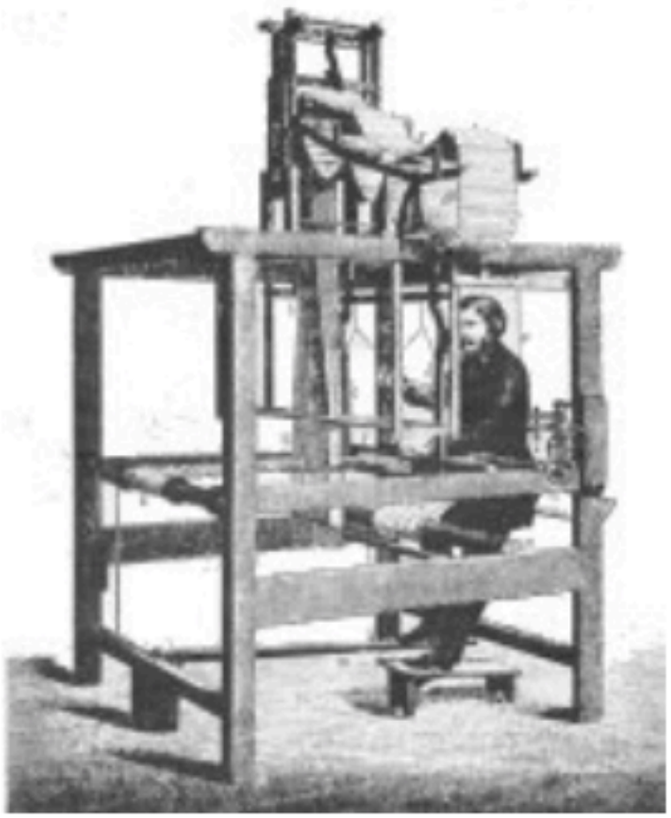
Pascal's calculator

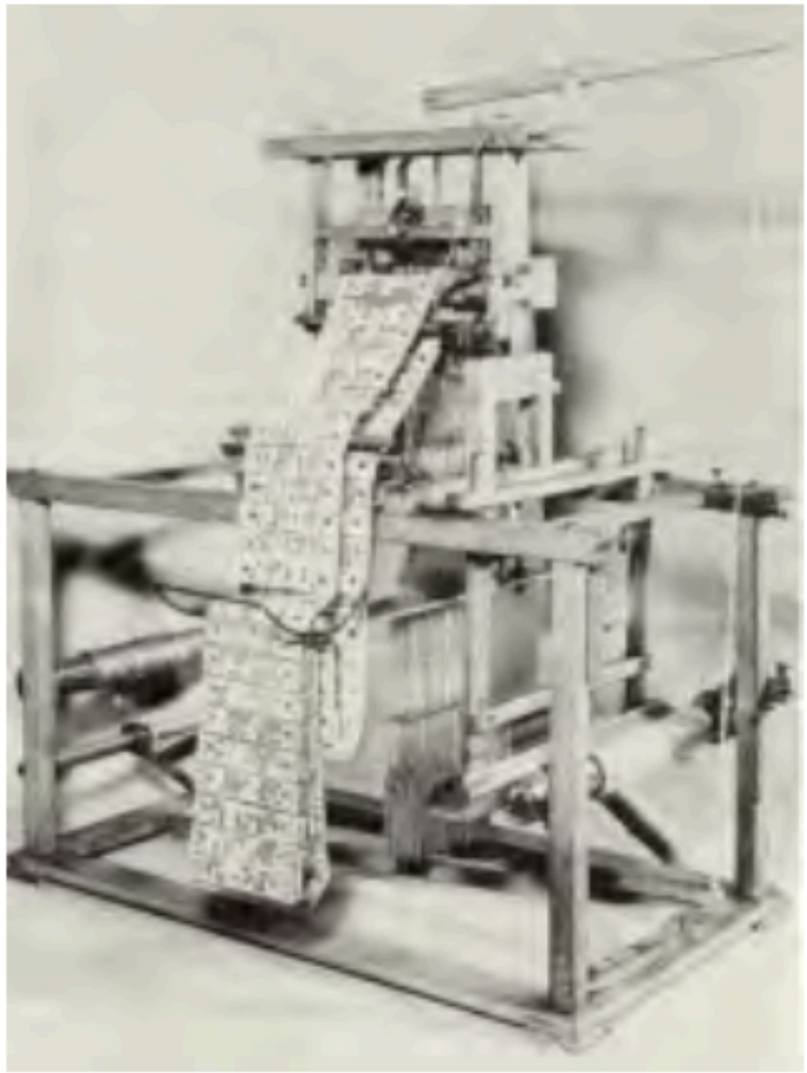


Adding machine designed by Pascal on 1642

Jaquard (1800)

1801 il Telaio automatico





Babbage differential engine

- Automatic mechanical calculator designed to tabulate functions
- Functions commonly used by both navigators and scientists, can be approximated by polynomials
- Interpolate functions by using a small set of polynomial coefficients

Babbage analytical engine

- The Analytical Engine marks the transition from mechanised arithmetic to fully-fledged general purpose computation

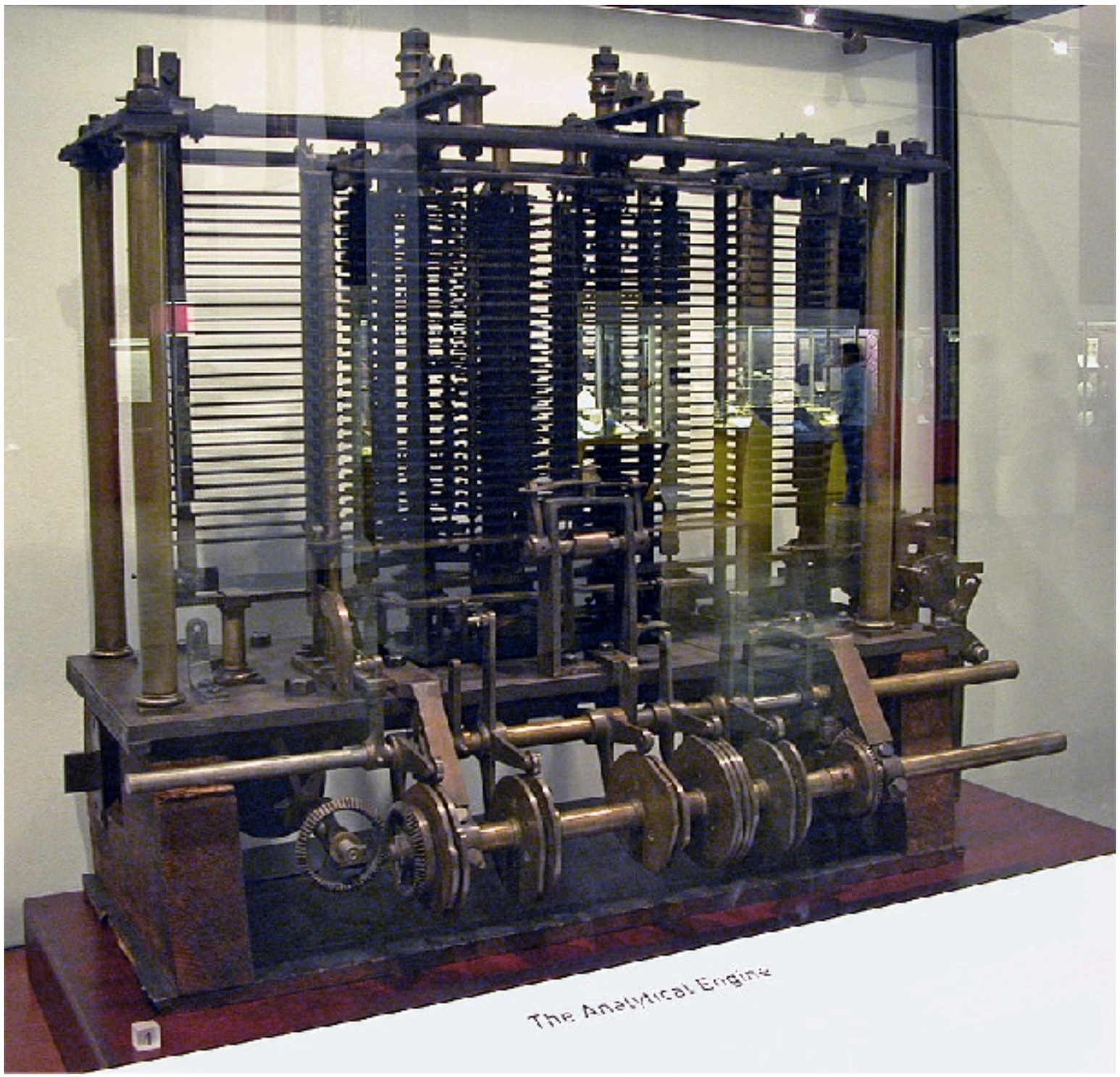
- The major innovation was that the Analytical Engine was to be programmed using punched cards

  - sequential control

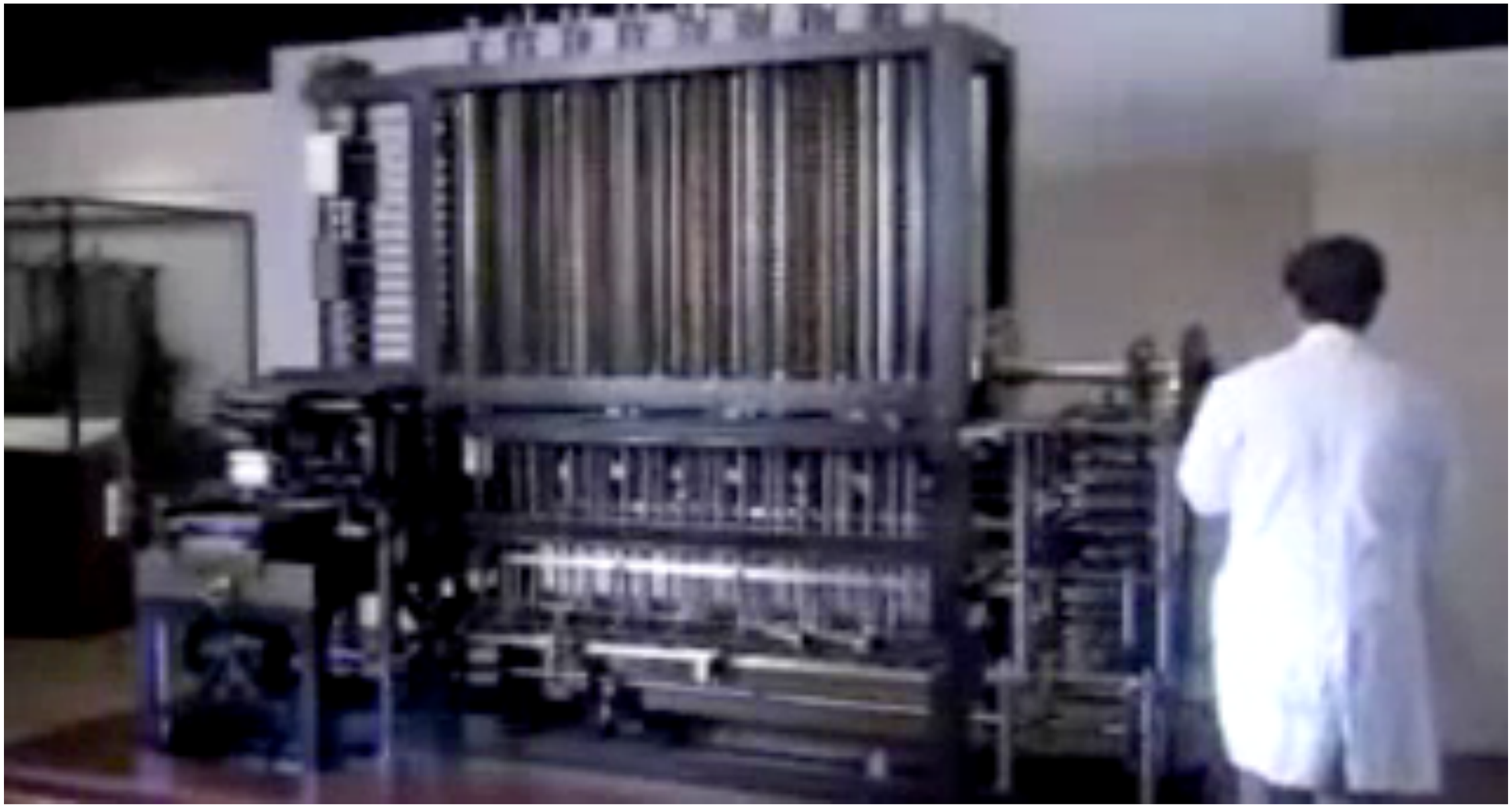
  - branching

  - looping

Babbage analytical engine



Babbage analytical engine



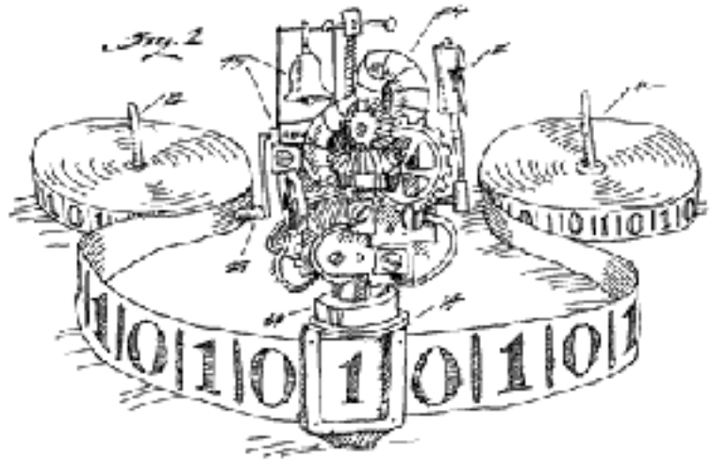
Ada Lovelace

- She corresponded Babbage during his development of the Analytical Engine
- She is credited with developing an algorithm for the Analytical Engine to calculate a sequence of Bernoulli numbers
- She is often described as the first computer programmer
- She goes a step further suggesting that a machine can create music or drawing
- She gave first hint of artificial intelligence

Alan Turing

- Mathematician
- Logician
- Cryptanalyst
- Philosopher
- Pioneering computer scientist
- Mathematical biologist
- Marathon and ultra distance runner

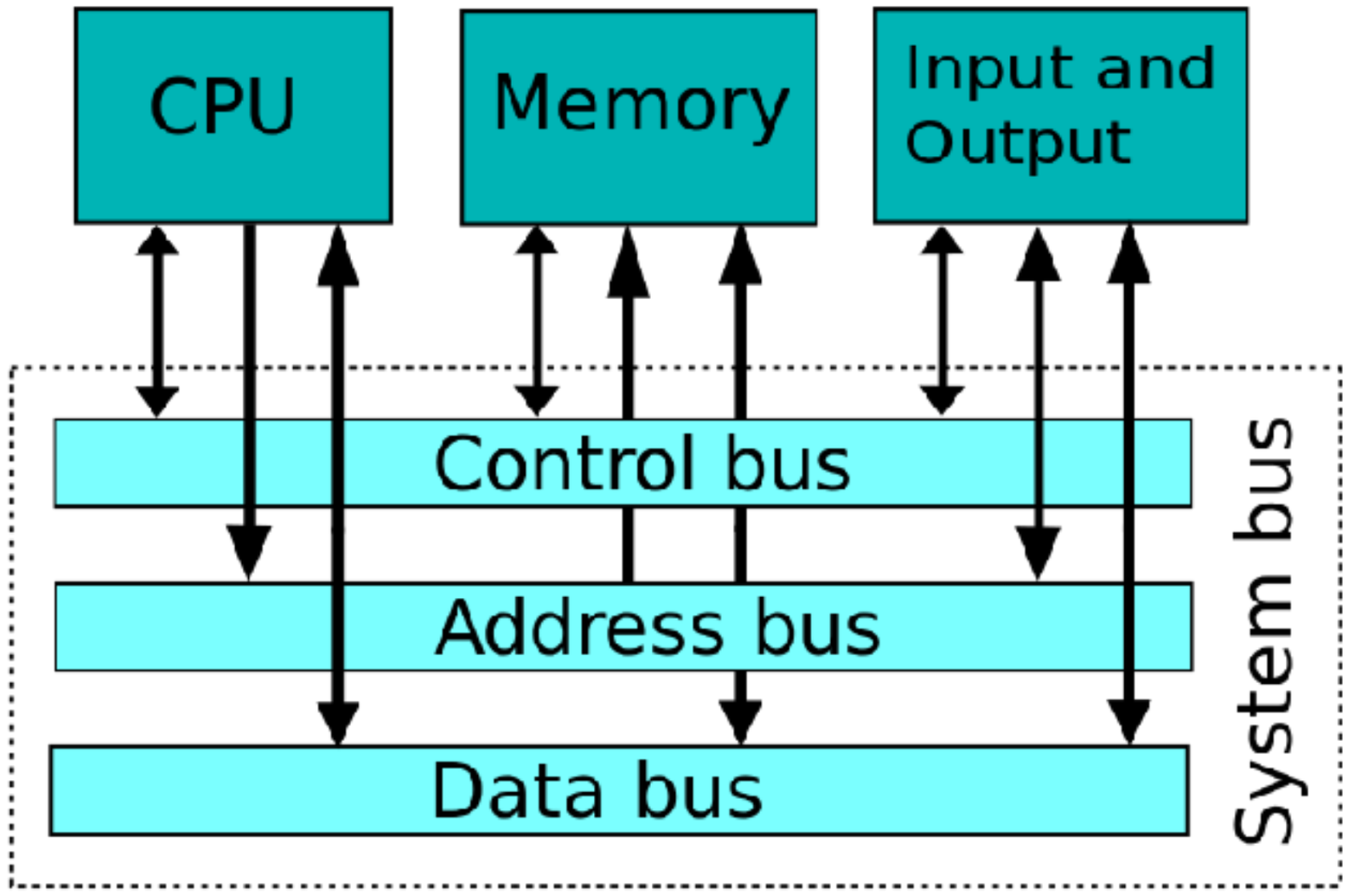
Turing machine



- Invented by Alan Turing in 1936.
- A simple mathematical model of a general purpose computer.
- It is capable of performing any calculation which can be performed by any computing machine.

Regulus

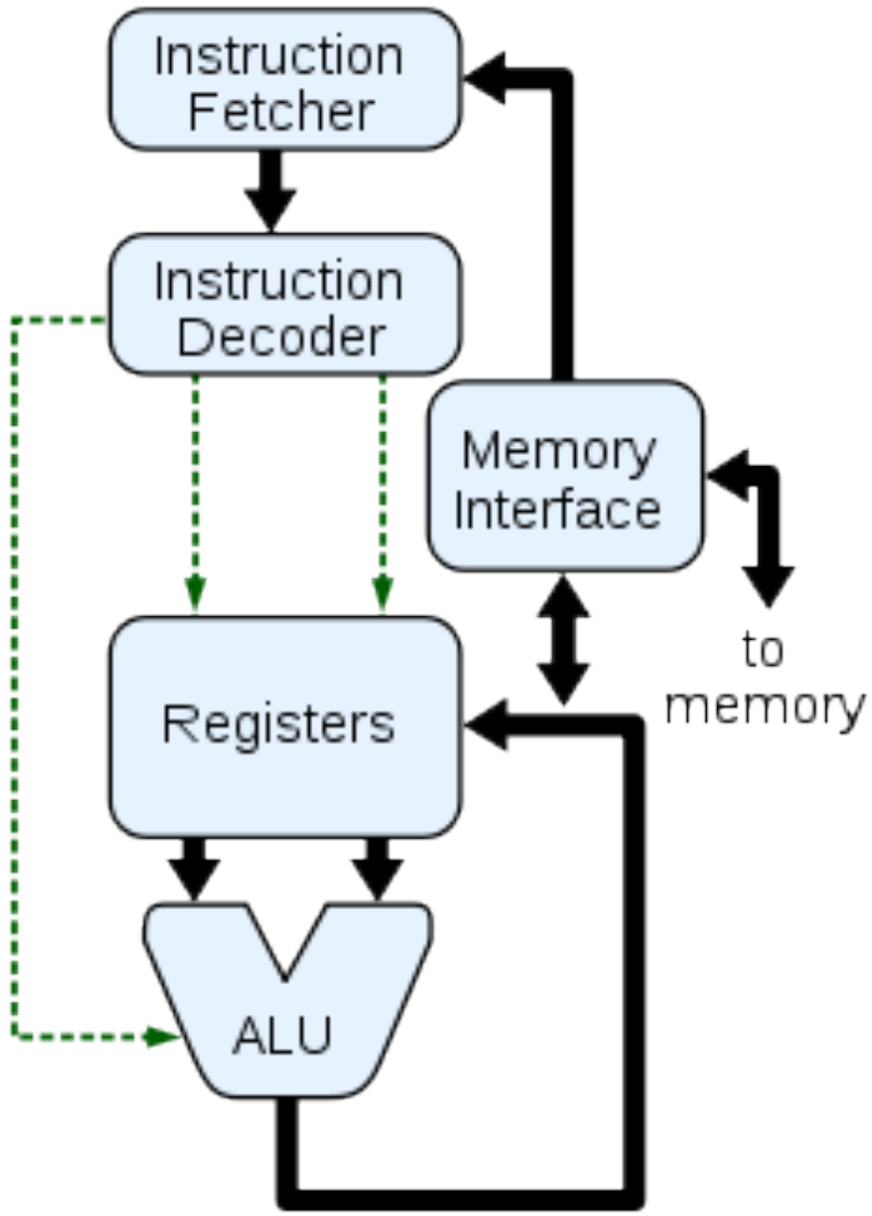
John Von Neumann (EDVAC 1945)



Electronic Discrete Variable Automatic Computer

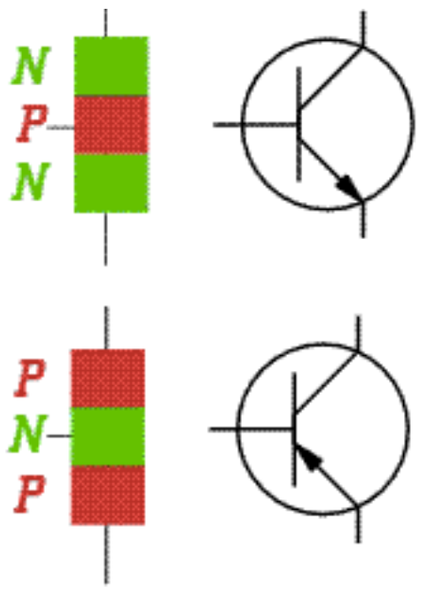
Central Processing Unit (CPU)

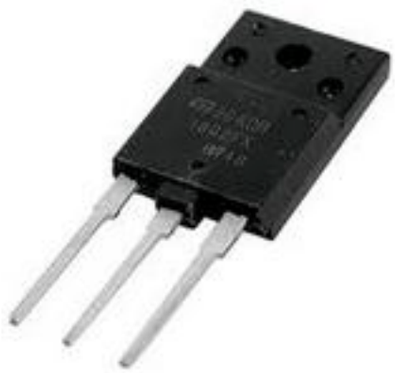
- Control Unit
- Arithmetic Logic Unit (ALU)
- Registers



Transistor

- 1944 (Bardeen, Brattley e Shotky)

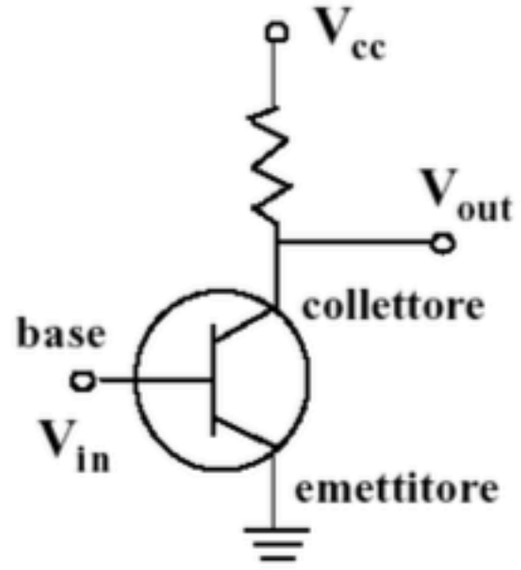




Il transistor come elemento base

1944 (Bardeen, Brattley e Shotky)

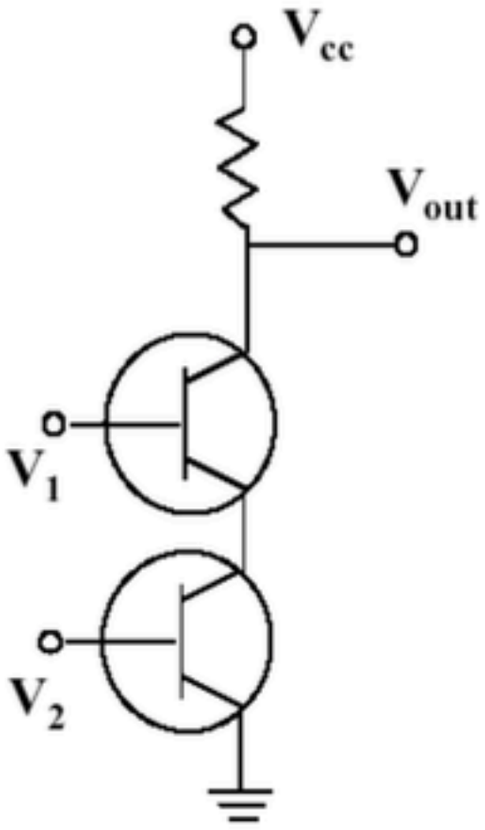
Se $V_{in} > 0.5V$ allora $V_{out} = 0$ V
Se $V_{in} < 0.5V$ allora $V_{out} = 5$ V



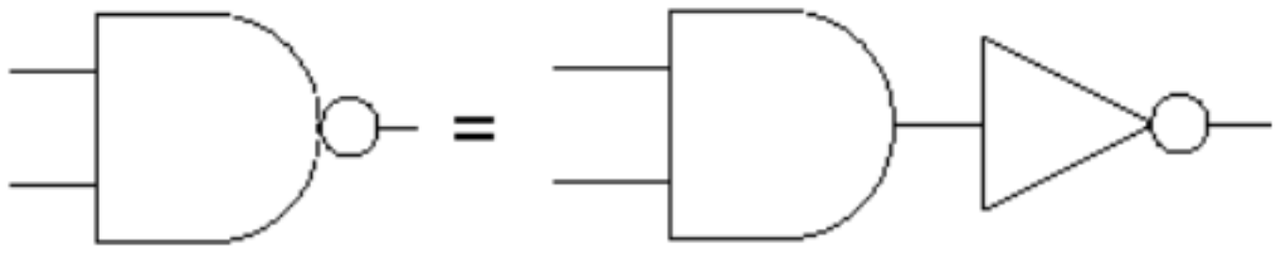
NOT gate:

Se $V_{in} > 0.5V$ (stato di Input=1) allora $V_{out} = 0$ V (stato di Output=0)
Se $V_{in} < 0.5V$ (stato di Input=0) allora $V_{out} = 5$ V (stato di Output=1)

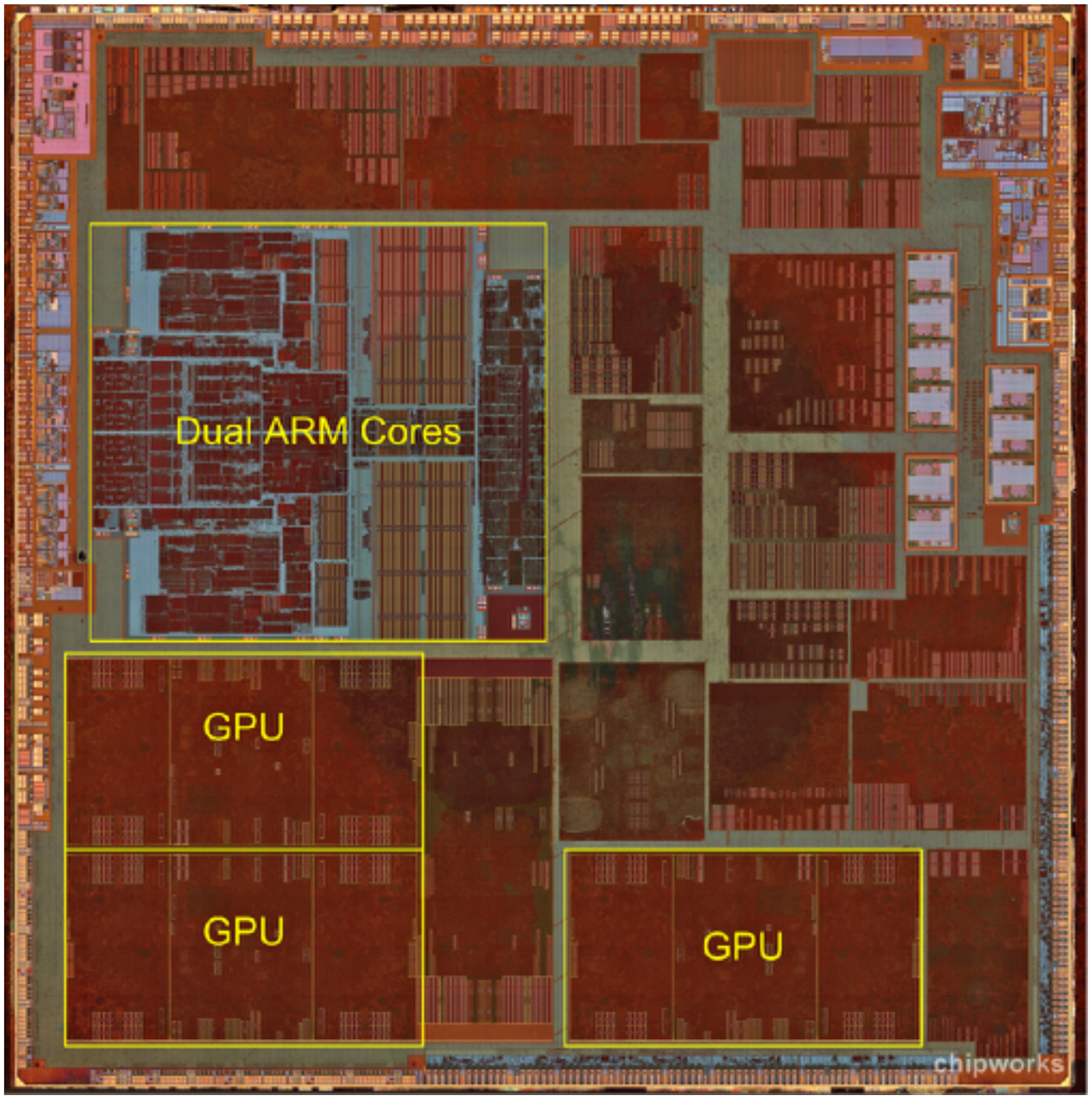
NAND gate:



V_1	V_2	V_{out}
0	0	1
0	1	1
1	0	1
1	1	0



Modern CPU



Transistor count

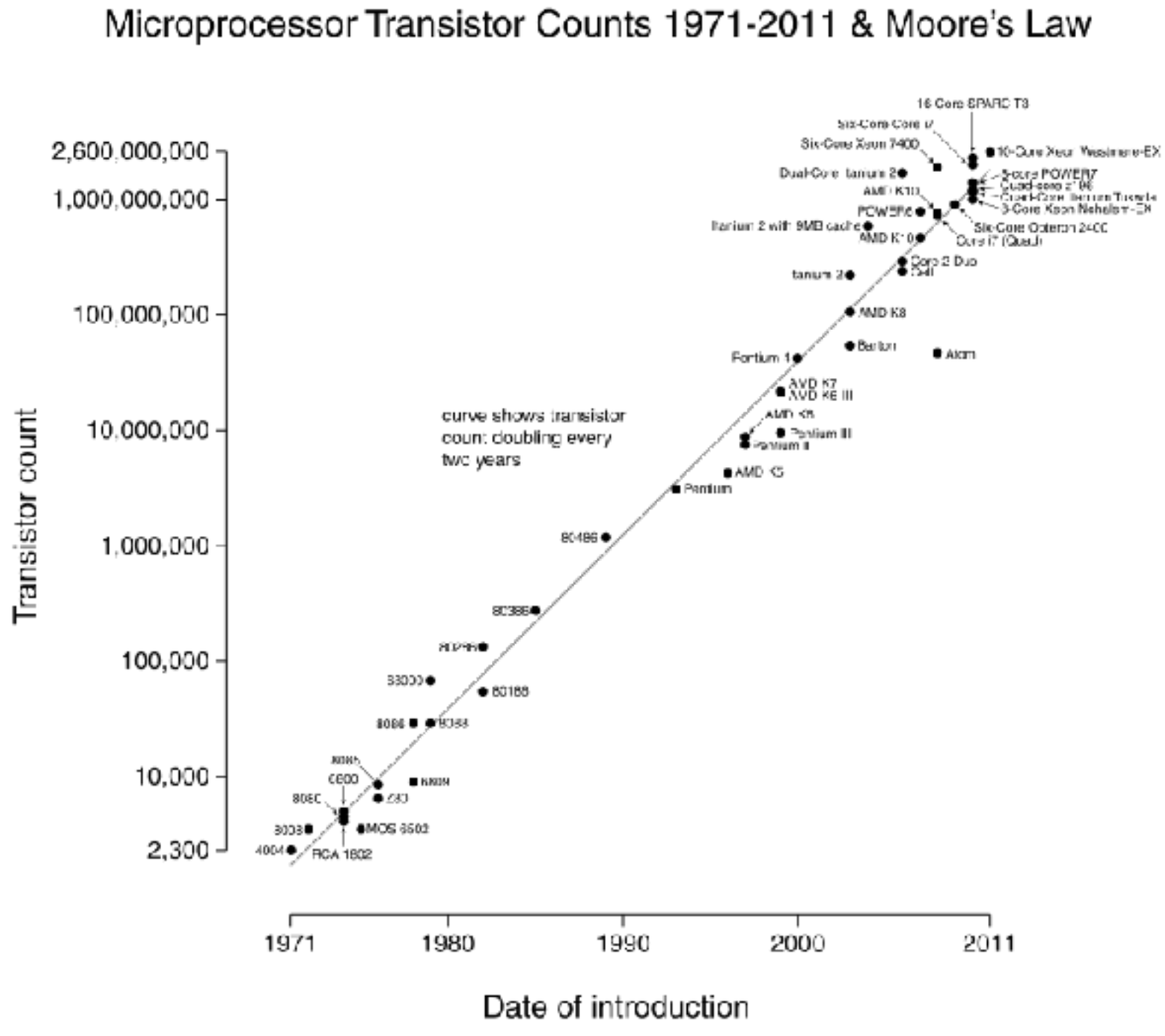
Processor	Transistor count	Date of introduction	Manufacturer	Process	Area
SPARC M7	>10,000,000,000	2014	Oracle	20 nm	
Intel 4004	2,300	1971	Intel	10 μm	12 mm²
Intel 8008	3,500	1972	Intel	10 μm	14 mm²
MOS Technology 6502	3,510[1]	1975	MOS Technology	8 µm	21 mm²
Motorola 6800	4,100	1974	Motorola	6 µm	16 mm²
Intel 8080	4,500	1974	Intel	6 µm	20 mm²
RCA 1802	5,000	1974	RCA	5 µm	27 mm²

...

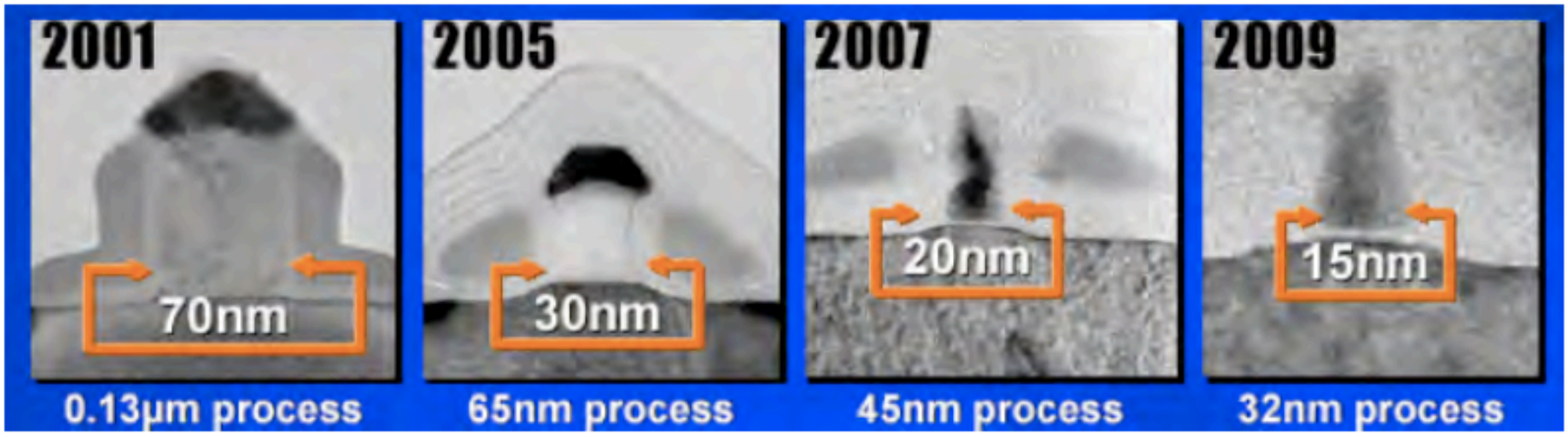
8-core Xeon Nehalem-EX	2,300,000,000[19]	2010	Intel	45 nm	684 mm²
10-core Xeon Westmere-EX	2,600,000,000	2011	Intel	32 nm	512 mm²
Six-core zEC12	2,750,000,000	2012	IBM	32 nm	597 mm²
Apple A8X (tri-core ARM64 "mobile SoC")	3,000,000,000	2014	Apple	20 nm	
8-core Itanium Poulson	3,100,000,000	2012	Intel	32 nm	544 mm²
12-core POWER8	4,200,000,000	2013	IBM	22 nm	650 mm²
15-core Xeon Ivy Bridge-EX	4,310,000,000[20]	2014	Intel	22 nm	541 mm²
62-core Xeon Phi	5,000,000,000	2012	Intel	22 nm	
Xbox One main SoC	5,000,000,000	2013	Microsoft/AMD	28 nm	363 mm²

Moore’s law - 1965

Moore's law is the observation that, over the history of computing hardware, the number of transistors in a dense integrated circuit doubles approximately every two years



Transistors dal vero



Da “Alcune riflessioni sulla legge di Moore”, Roberto Saracco, Future Center, TILAB

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Physical limits of silicon transistors and circuits

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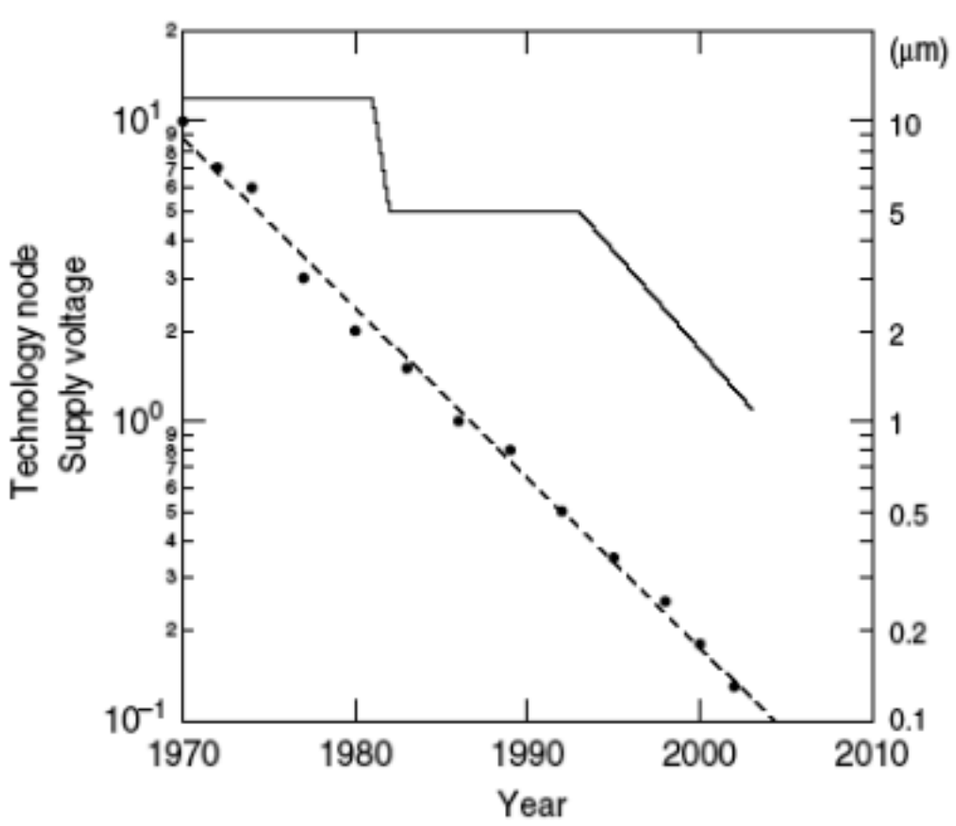
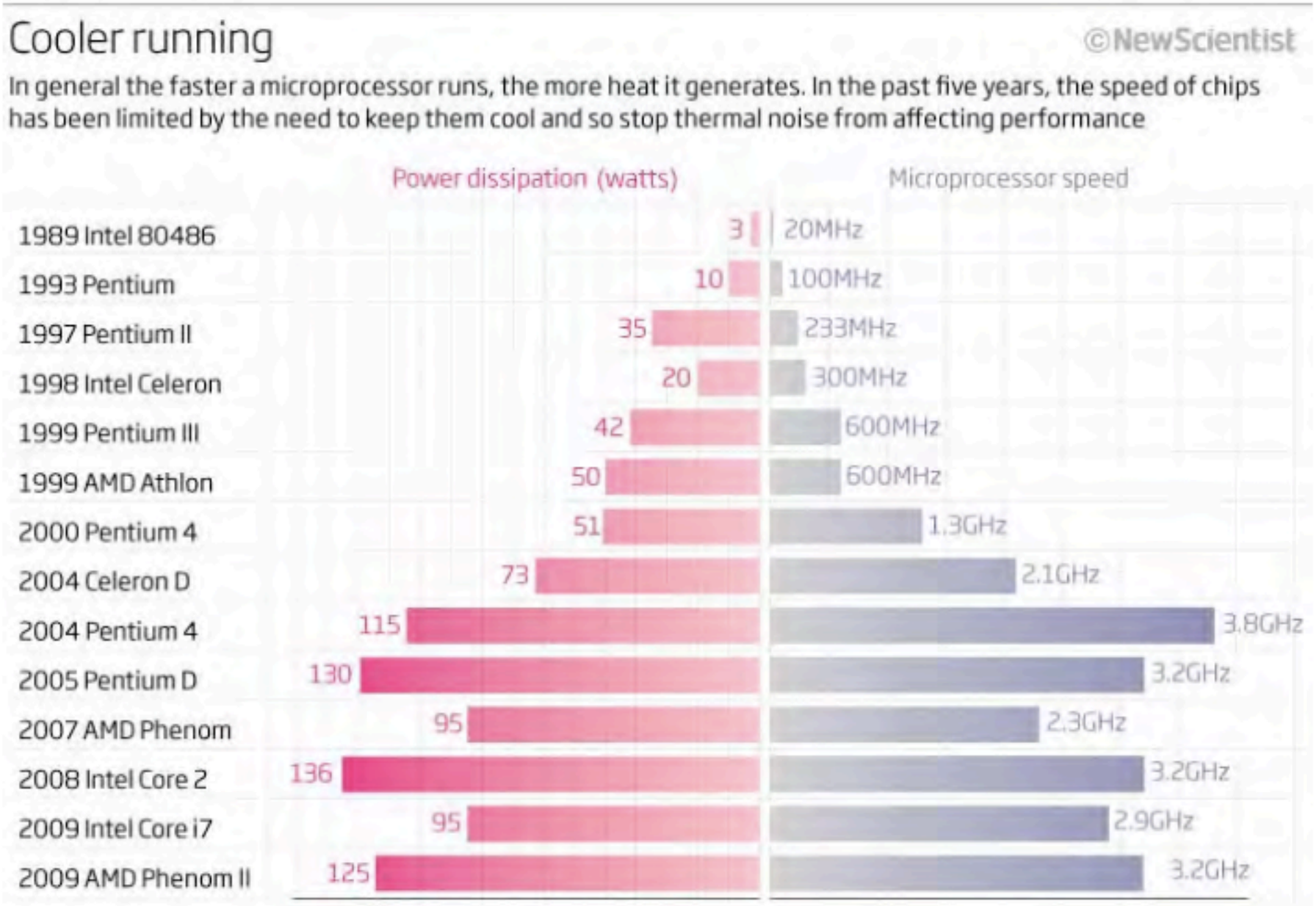


Il problema del calore



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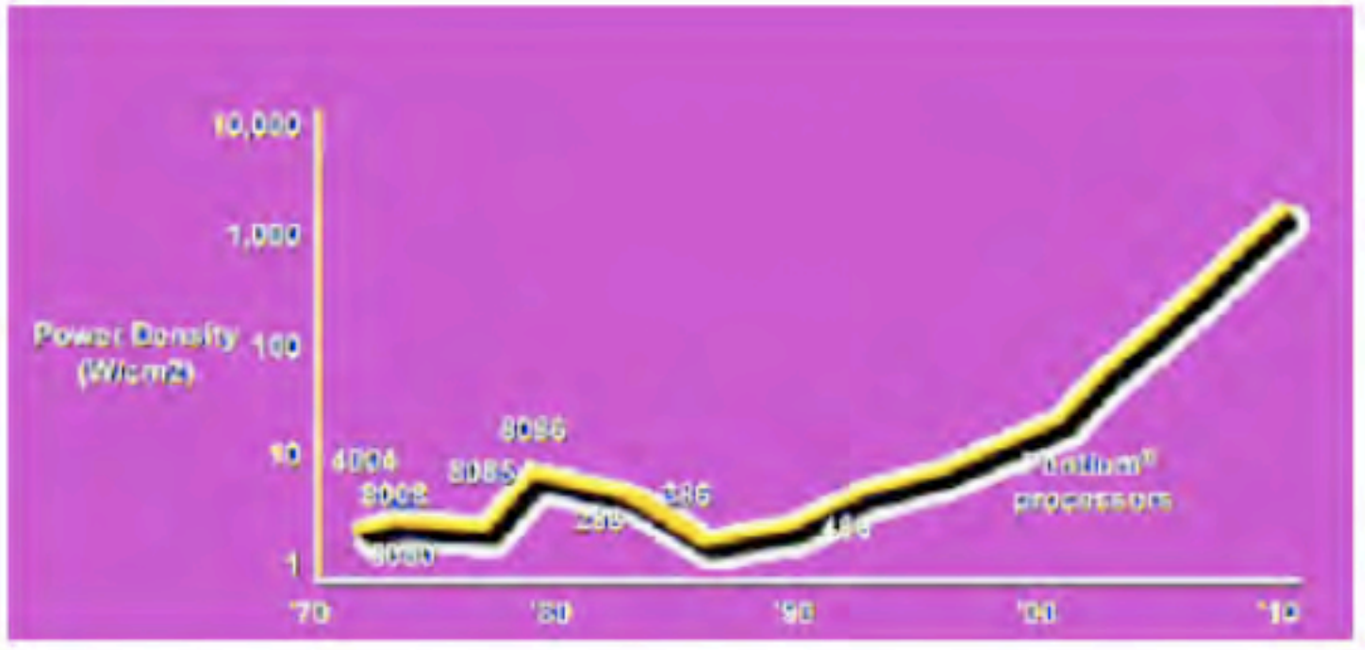

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