

MPSM311
Electronic Projects for Artists SP17

*Processing, Max/MSP/Jitter, pd (puredata),
Arduino and (maybe) Raspberry Pi*

1. Electricity

Electricity is the movement of electrical charge through a circuit (usually, flowing electrons.)

*The Greek word for “amber”
is “elektron”*



Women in ancient Greece noticed that rubbing their amber jewelry against silk caused it to accumulate a charge -which they used to shock small frogs at parties.





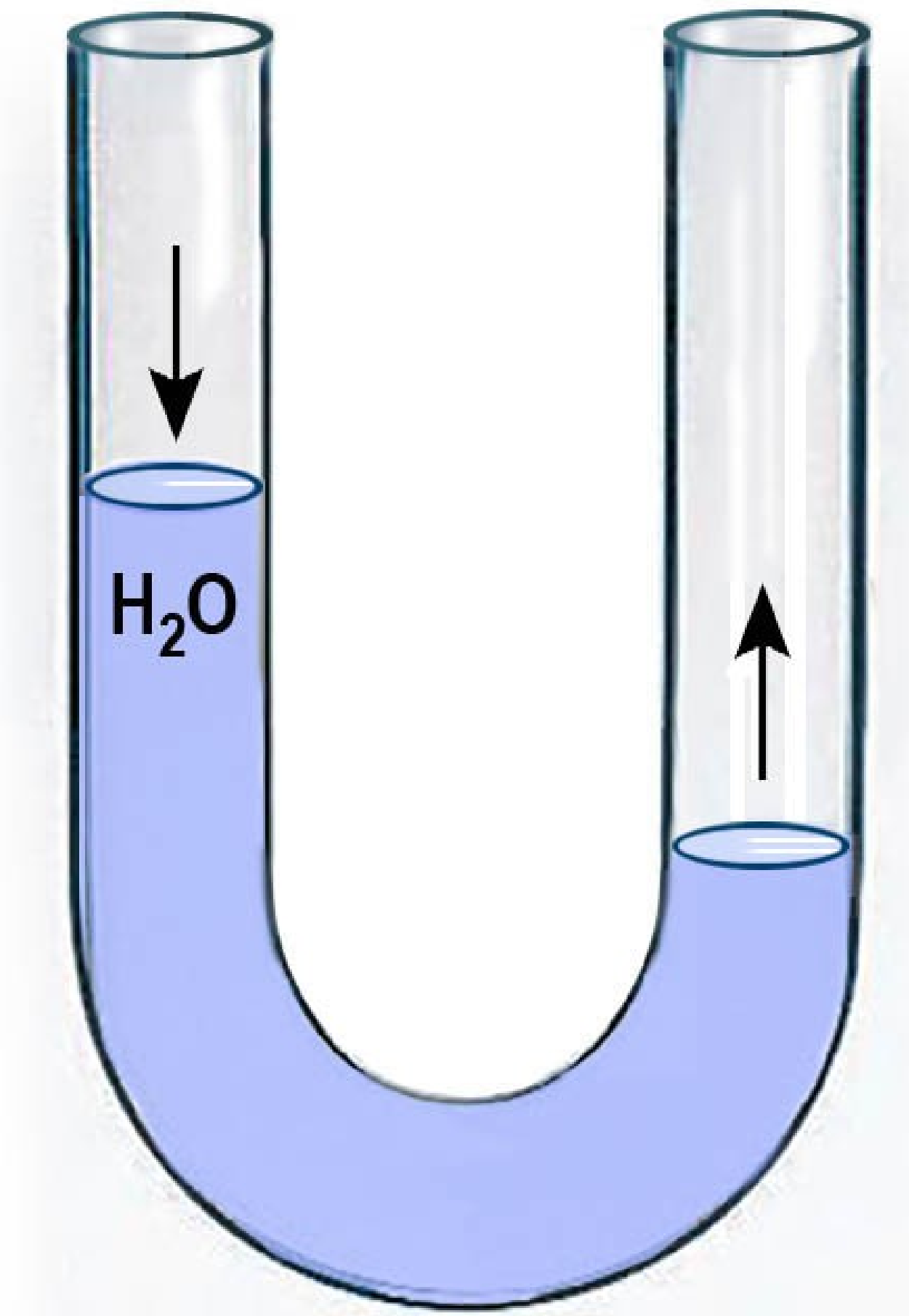
Benjamin Franklin (1705-1790) had ideas about electricity:

1. That Lightning was electricity.
2. The two types of electrical charge (at the time, referred to as two "fluids": "resinous" and "vitreous") were in fact the result of the relative presence or absence of a "single fluid".

We can make this intuitive generalization:

- Electrical current
(like electrons from a voltage source)
tries to flow taking the *path of least
resistance*, to ground." (-From “+” to “-”.)

“Volts” is a unit of measure of the difference in *electrical potential* between 2 points in a circuit.



Here is a water metaphor...

Some Definitions:

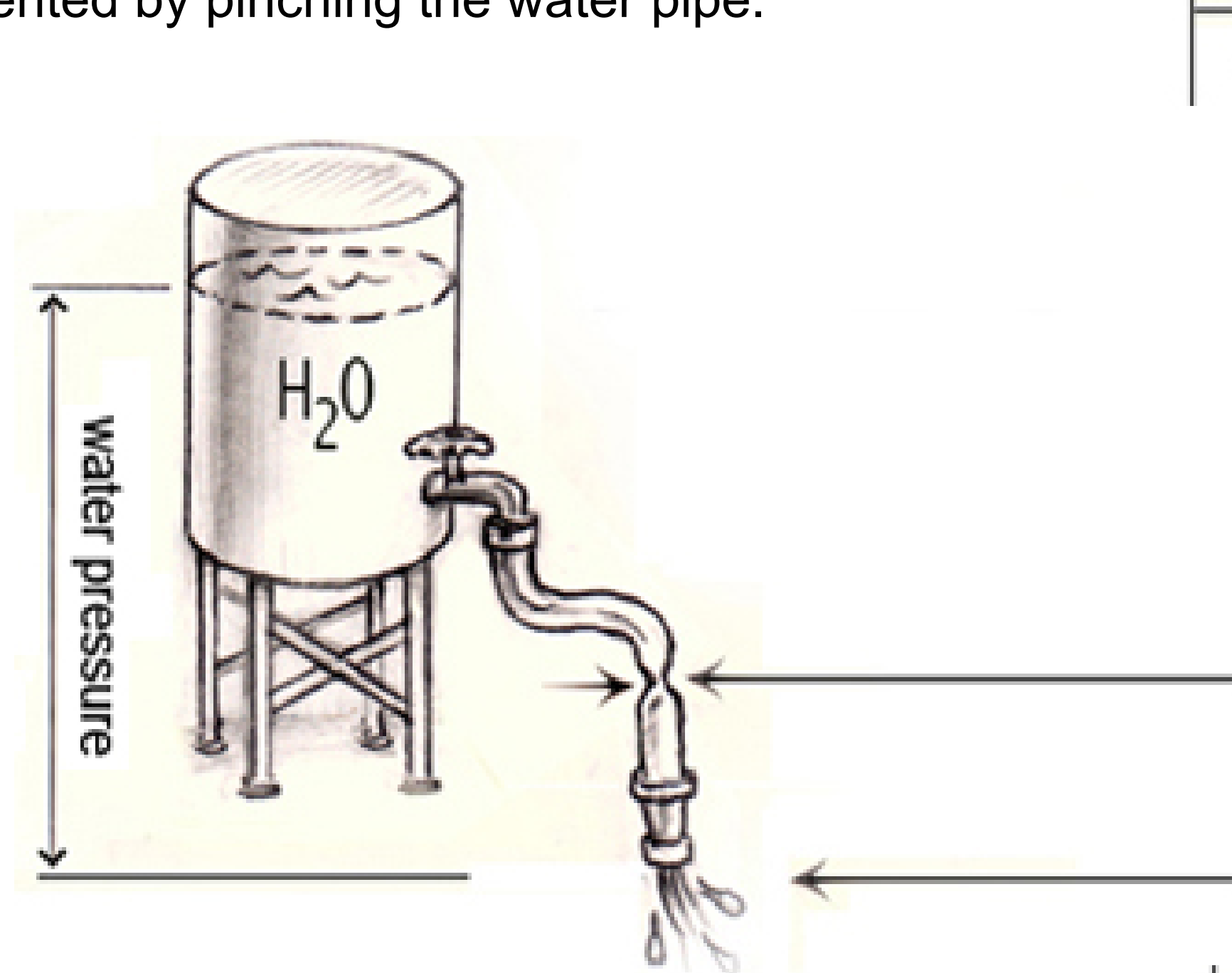
- Electricity (electrons flowing through a circuit) has two principle properties: voltage and current.
- **Electromotive potential** (*symbol: V , or sometimes the more archaic E*) is the difference in potential energy between two points in a circuit. It is measured in units called **volts** (after Alessandro Volta, inventor of the battery.) In the metaphor of water and plumbing often used to visualize electrical charge flowing in a circuit, voltage would be thought of as water pressure.
- **Current:** (*symbol: I for “intensité”*) Current is the rate of flow, or volume of electrical charge through a circuit. The unit of measure is the **ampere**, usually shortened to “**amp**” (after French physicist André-Marie Ampère.) It's a measure of how many electrons go past a given point in a circuit per second. (In the water metaphor, current can be thought of as the diameter of the pipe.)
- **Power** (*symbol: W*) Volts and amps multiplied together equals the total amount of electrical power in the circuit, measured in units called **watts** (after James Watt, Scottish inventor and engineer.)
- **Resistance** (*symbol: Ω -Greek letter for omega*) Also called **impedance**, is measured in units called **ohms** (after German physicist, Georg Ohm.)

Thinking about current:

The famous “water metaphor”

Electrical components called “resistors” slow down the flow of electrons, and are essential for controlling the flow of electricity in a circuit. The electrical energy lost when current goes through a resistor is transformed into heat. The property of ***impedance (resistance)*** in a resistor is measured in units called ***ohms***. In the metaphor, it's represented by pinching the water pipe.

The water pressure (measured between two points) is a metaphor for ***electromotive potential***, measured in units called ***volts***.

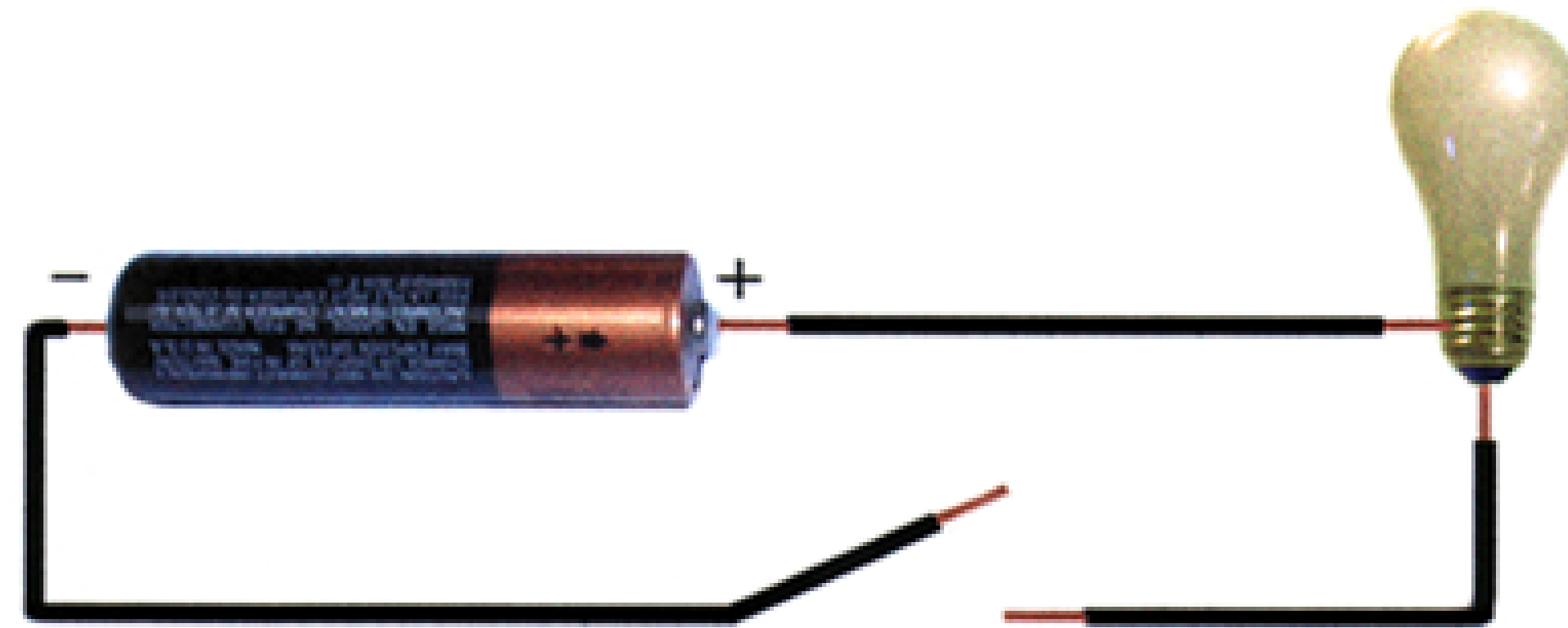


The diameter of the pipe (or volume of water flowing) is a metaphor for ***current***. It is measured in units called ***amperes (amps.)***

One ampere = a volume of one coulomb per second.

-A *coulomb* is a measure of charge equal to 6.24×10^{18} electrons.

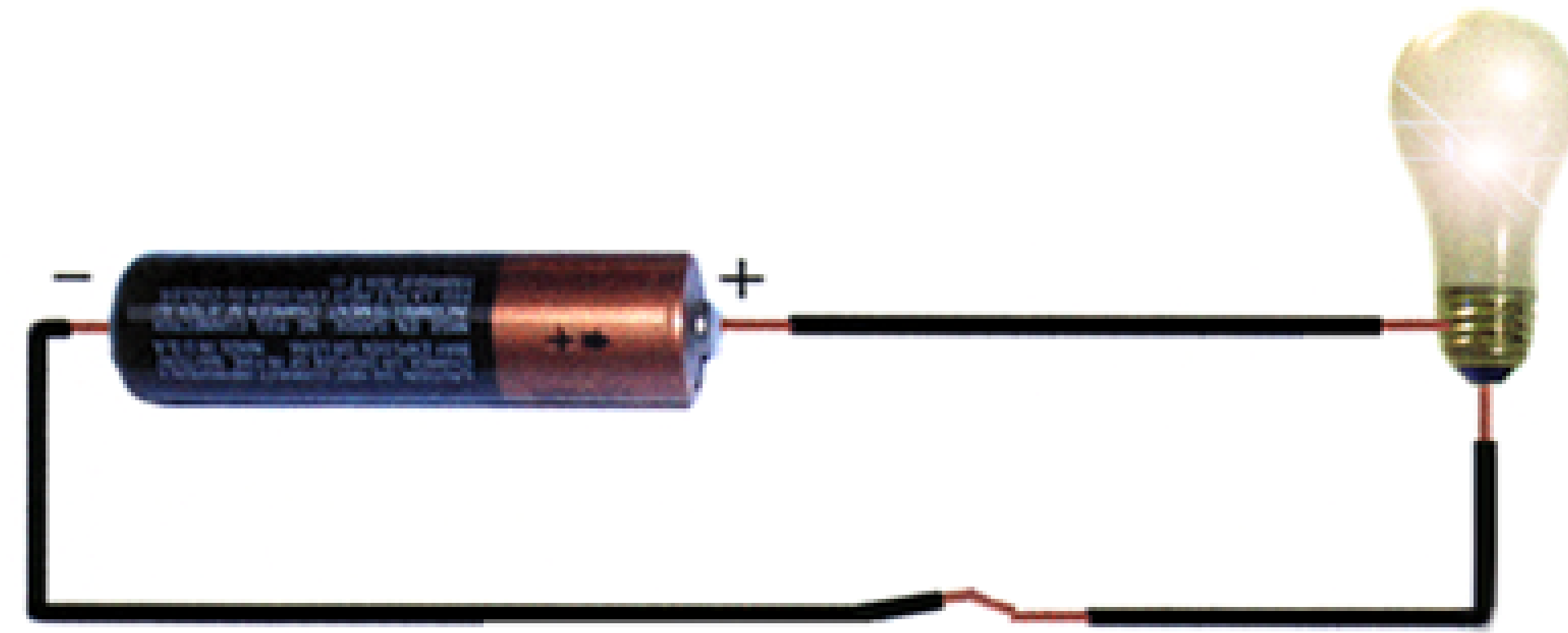
Simple DC Circuit (open):



Here is perhaps the simplest circuit we could build. In this case the light bulb is the “load” in the circuit, controlled by a “single pole, single throw” (SPST) switch. (More on switches later.)

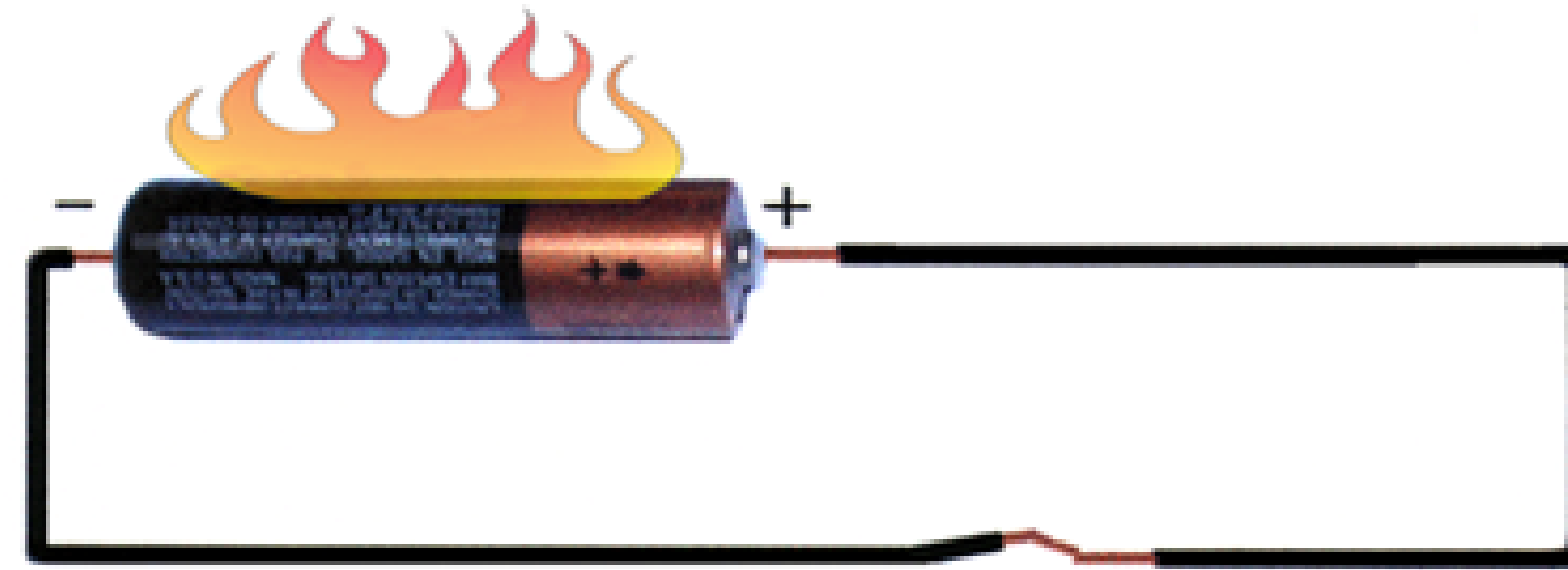
Materials that have lots of “free electrons” in their atomic structure that move easily from and between their valence shells are referred to as **conductors** (e.g. copper, gold.) Conversely, materials with relatively few free electrons are called **insulators** (e.g. wood, rubber.) If the electromotive potential is great enough, just about anything can become a conductor, even the air in the sky (in the case of lightning.)

Simple DC Circuit (closed):



DC (Direct Current) circuits harness the power of the electrical current flowing from a positive source, energizing a load of some kind as it passes through it to ground.

Simple DC Circuit (short!):



- Always make sure there is a load of some kind on the circuit. A path through a conductor directly from source to ground is called a ***short circuit*** (very bad.) It will cause the power source to over-heat and die. In this case it would cause the battery to get very hot and die. If this happens with AC current in your home it can cause catastrophic fires.

Series and Parallel:



Batteries in series.

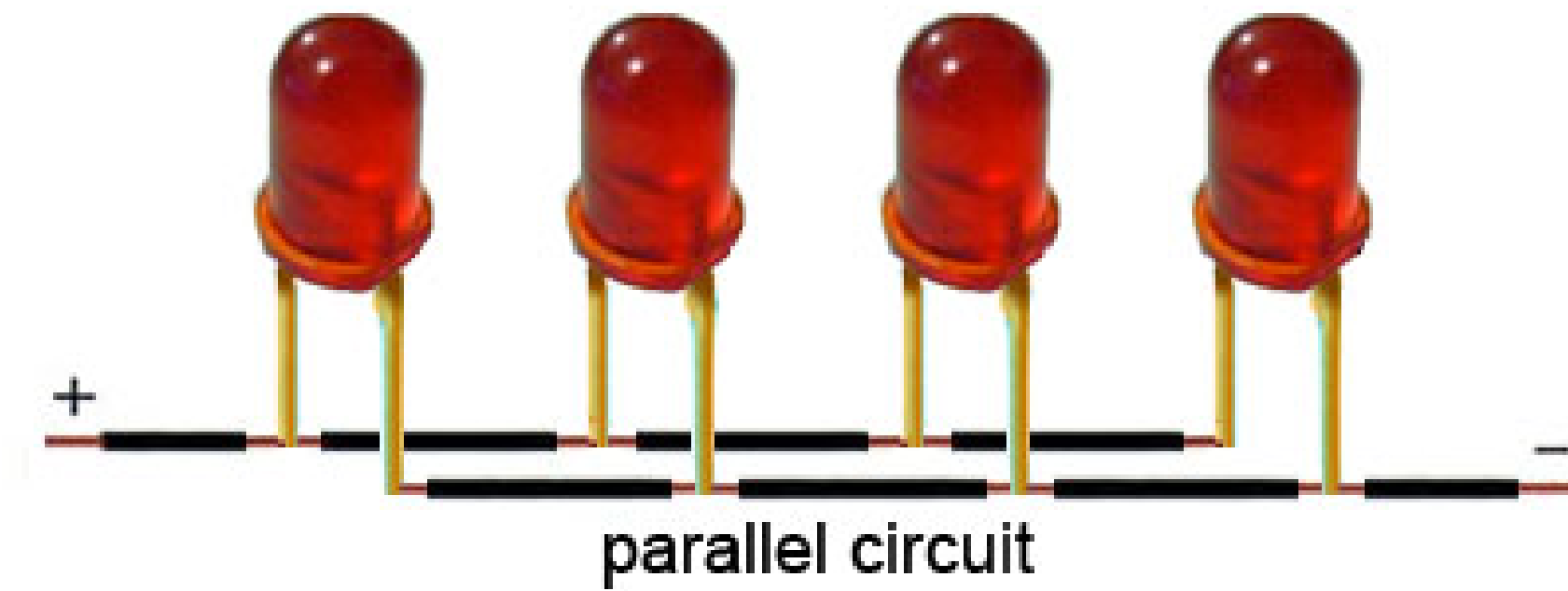
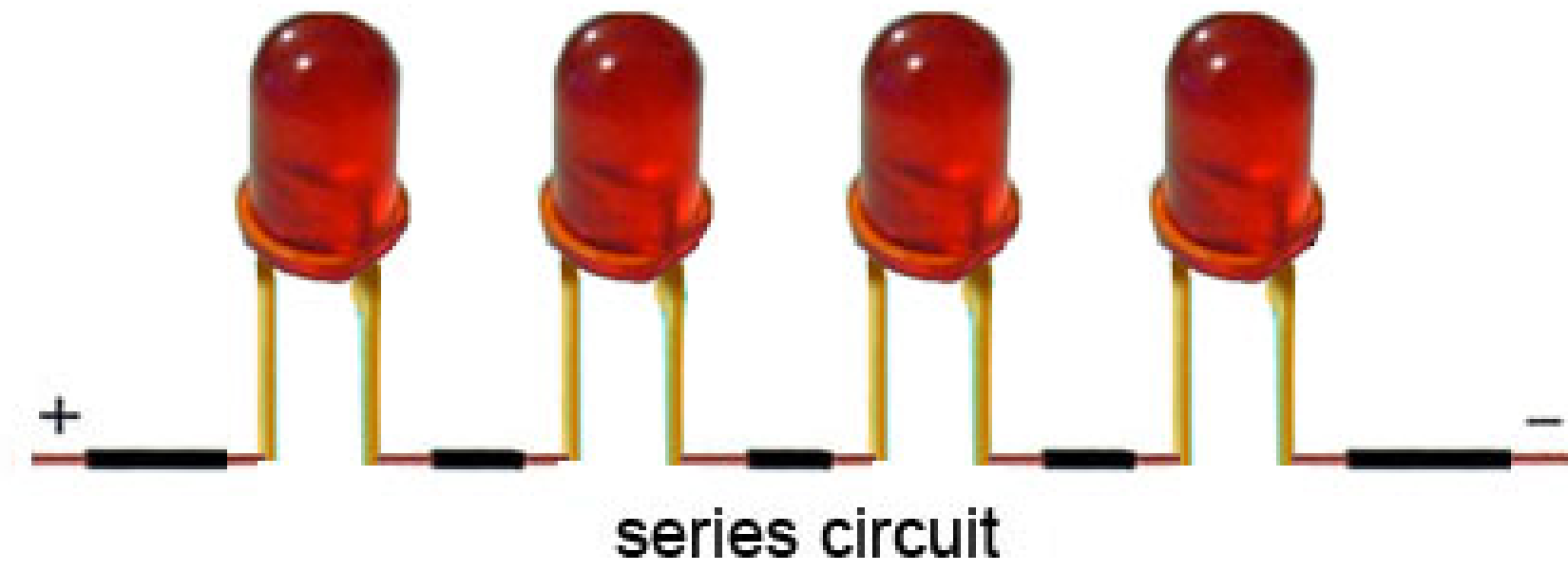
When connected “in series”, DC voltage sources are added. In the above example, two AA batteries (1.5 volts each) wired in series supply 3 volts to the circuit. ($1.5 + 1.5 = 3$.)



Batteries in parallel.

When connected “in parallel”, batteries' voltages are unaffected, but the current (measured in *amperes*) is increased. In the above example, two AA batteries (1.5 volts each) wired in parallel supply 1.5 volts to the circuit, but can do so for a longer time than a single battery alone.

Series and Parallel load:



The concept of being “in series” or “parallel” also applies to electrical components which are wired as the load of the circuit.

Prefixes:

These prefixes are universally used to scale units in science and engineering:

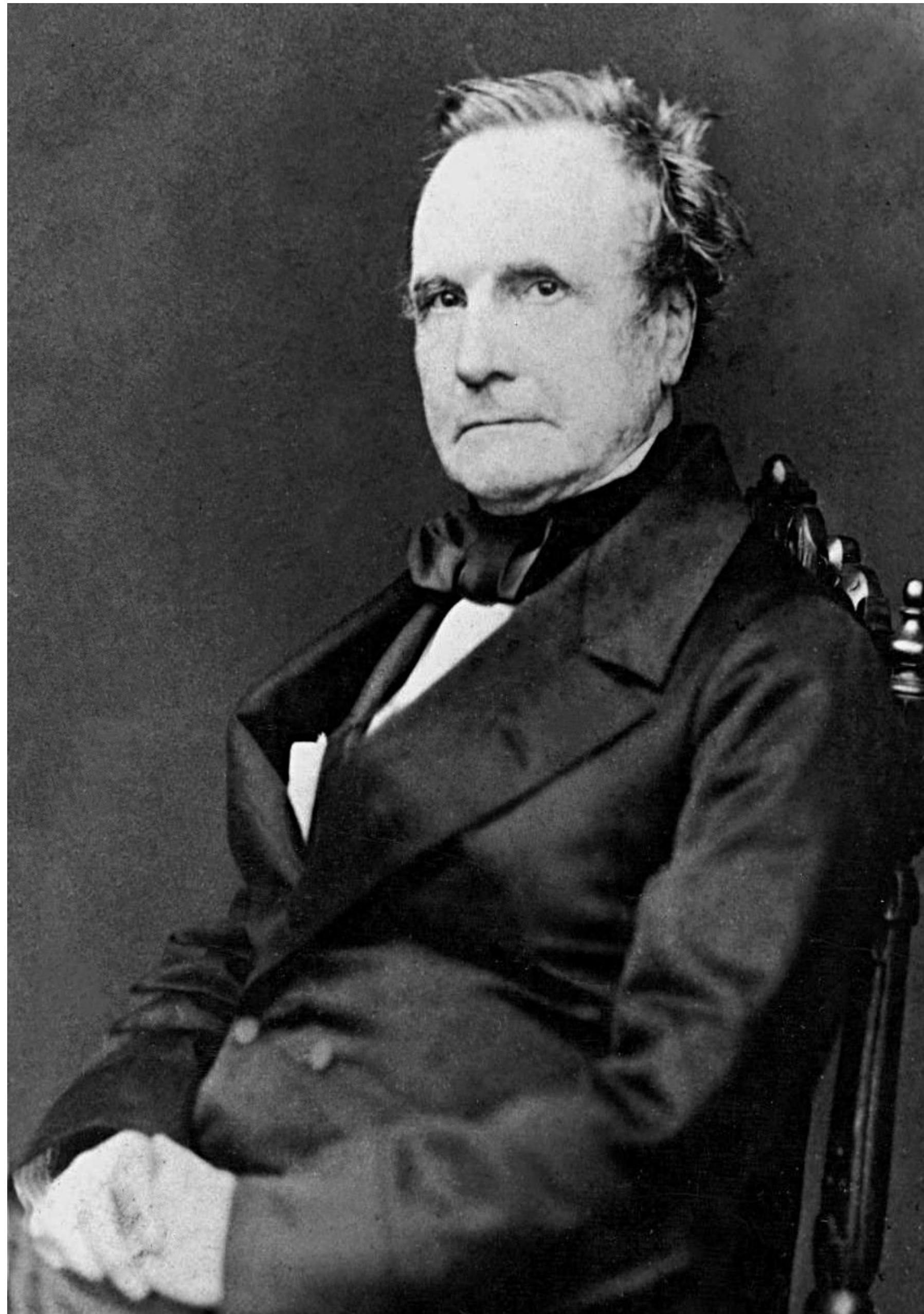
<i>Prefix</i>	<i>Abbreviation</i>	<i>Multiplier</i>
tera	T	10^{12} (= 1,000,000,000,000)
giga	G	10^9 (= 1,000,000,000)
mega	M	10^6 (= 1,000,000)
kilo	k	10^3 (= 1,000)
(none)	(none)	10^0 (= 1)
centi	c	10^{-2} (= 0.01)
milli	m	10^{-3} (= 0.001)
micro	μ	10^{-6} (= 0.000 001)
nano	n	10^{-9} (= 0.000 000 001)
pico	p	10^{-12} (= 0.000 000 000 001)
femto	f	10^{-15} (= 0.000000000000001)

When abbreviating a unit with a prefix, the symbol for the unit follows the prefix without space. Be careful about upper-case and lower-case letters (especially m and M.) 1mW is a milliwatt, or one-thousandth of a watt, but 1MW is a megawatt (one million watts.) The unit name is only capitalized when it is abbreviated. For example, in describing cycles-per-second we use hertz and kilohertz, but Hz and kHz.

2. Calculating Machines



Blaise Pascal, noted mathematician, thinker, and scientist, built perhaps the first mechanical adding machine in 1642 based on a design described by Hero of Alexandria in the year 2. The basic principle of his calculator is still used today in modern-day odometers.



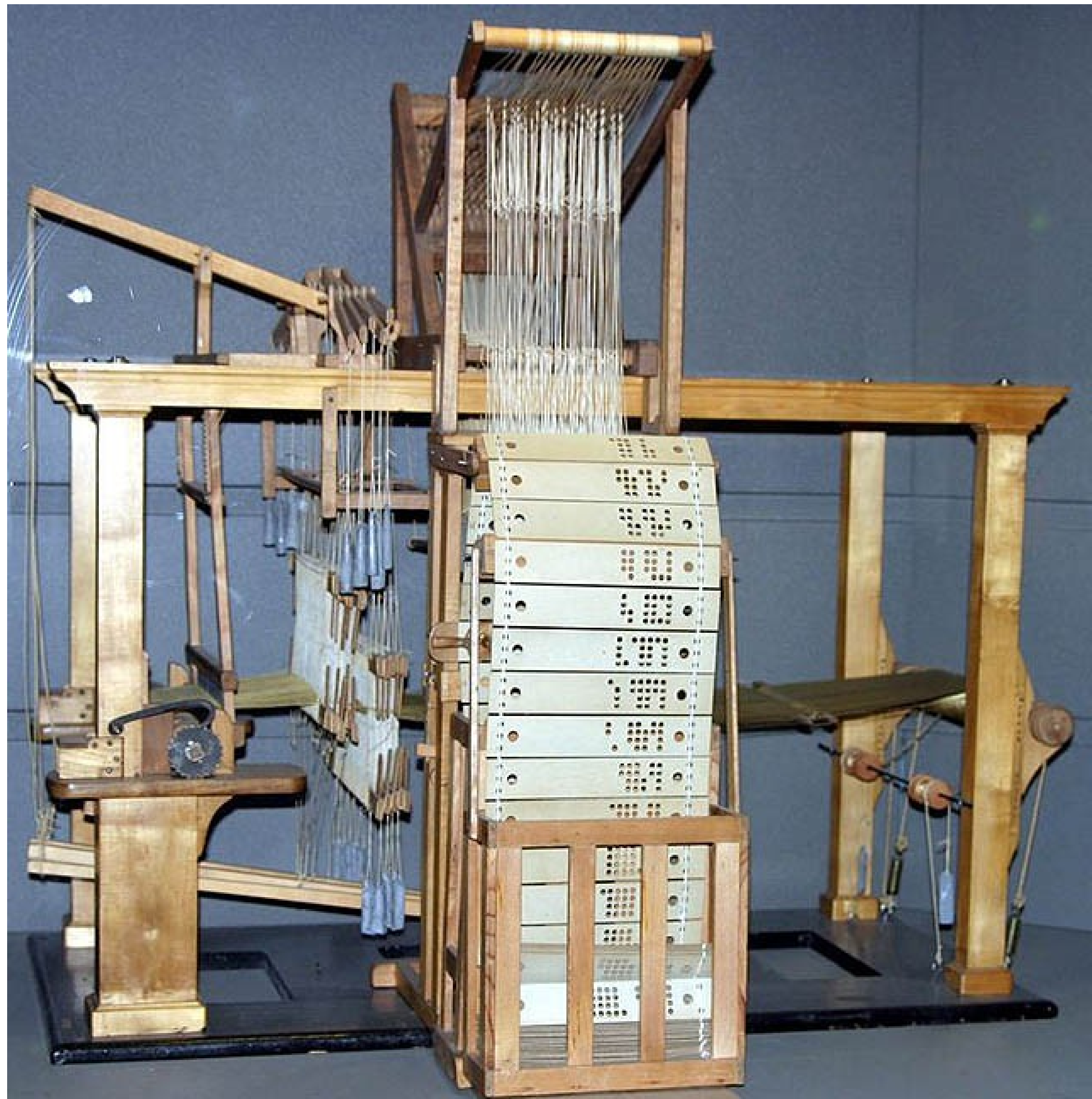
*Charles
Babbage*

1860

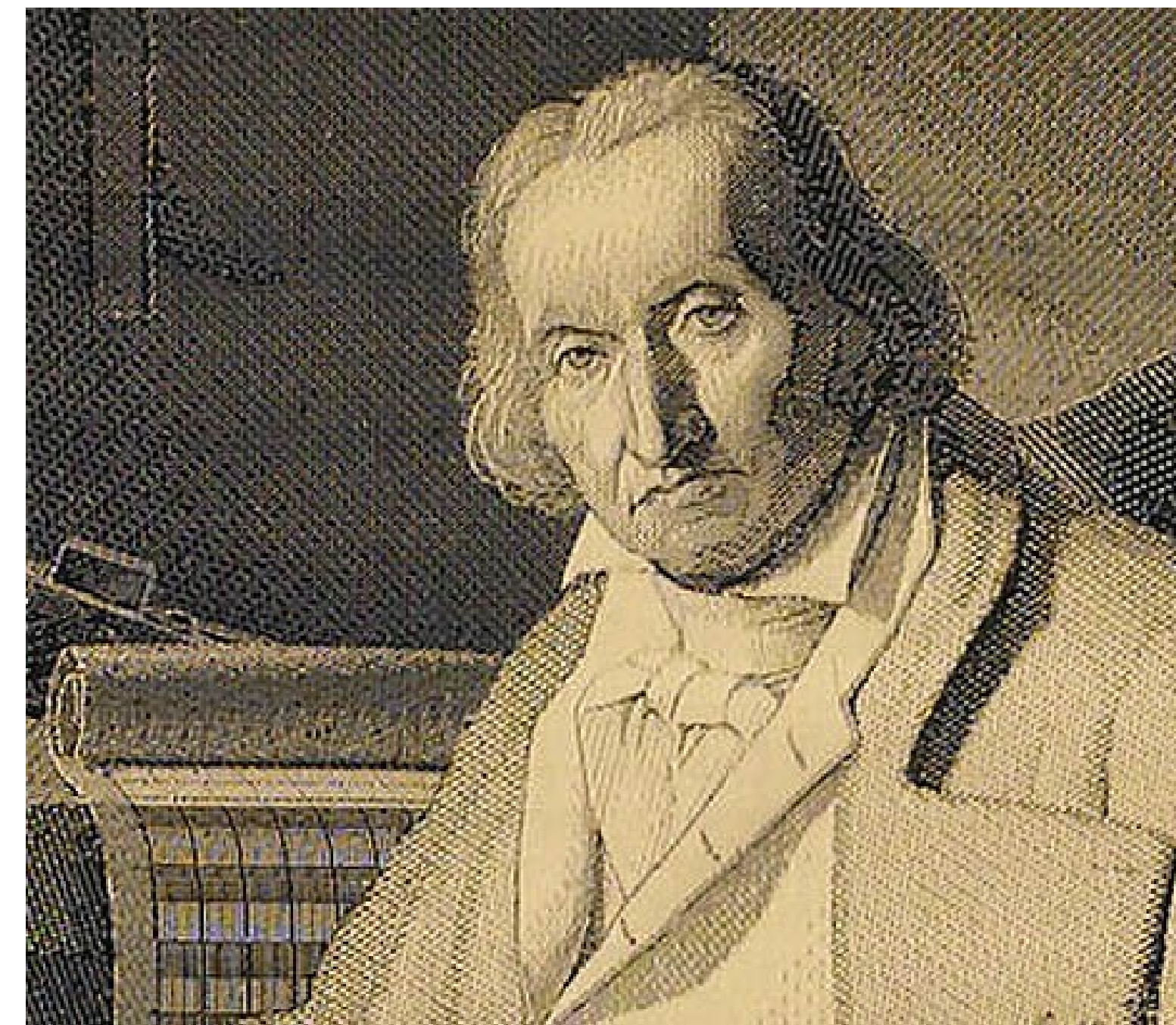
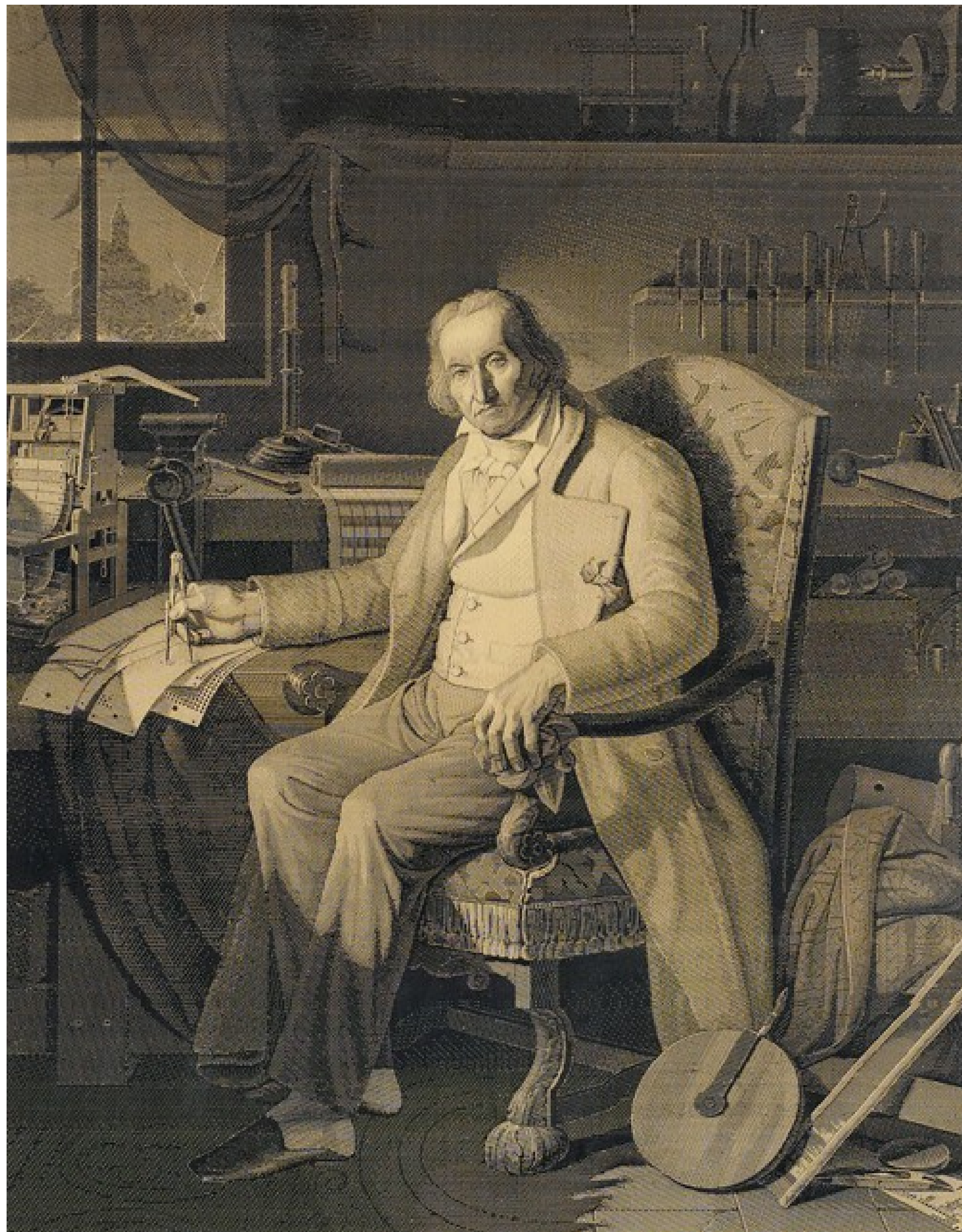


*Lady Ada
Lovelace*

1860



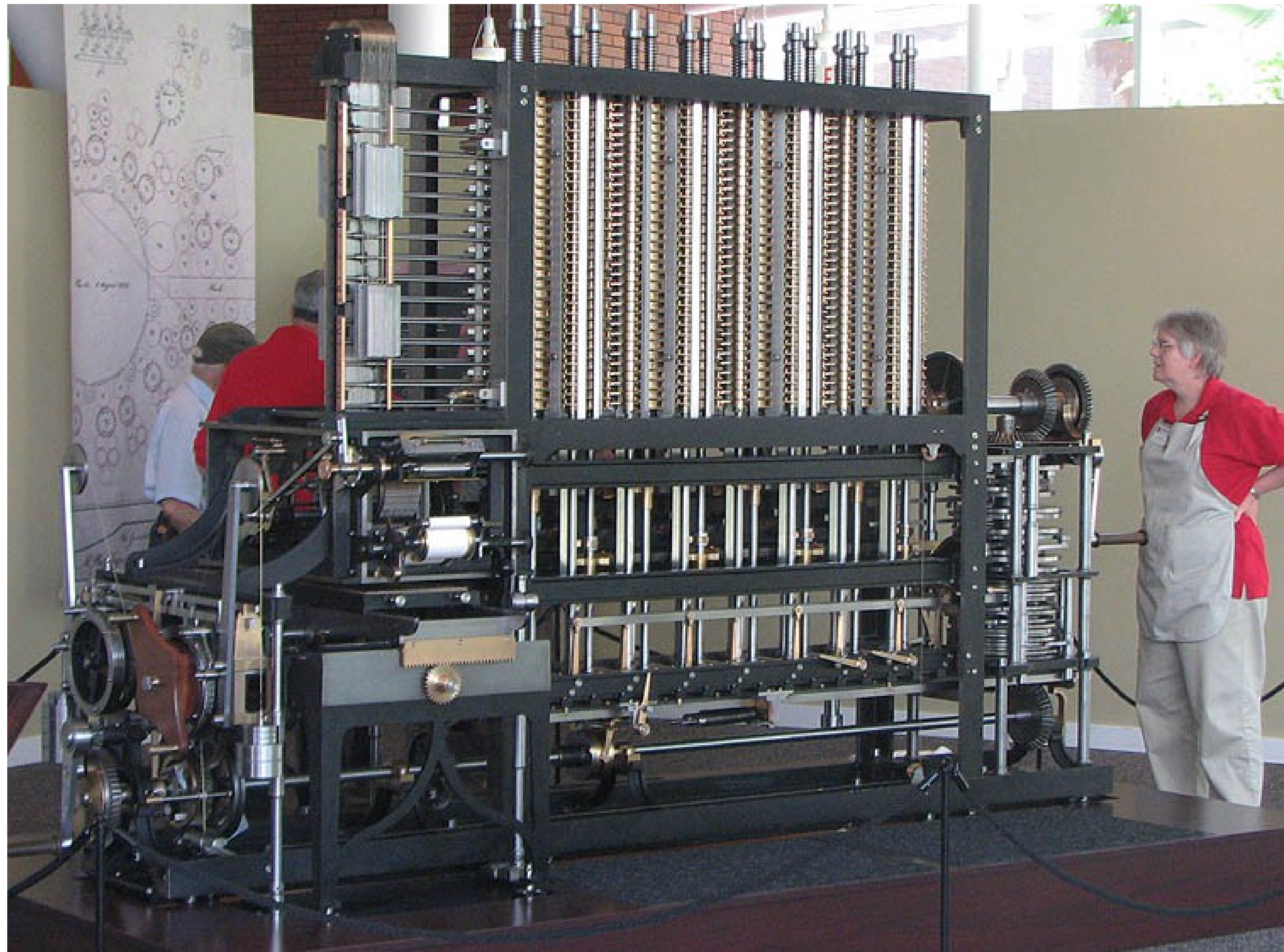
Joseph-Marie Jacquard,
a contemporary of
Babbage, invented a
loom that wove patterns
using patterns of hole
punched in cards.



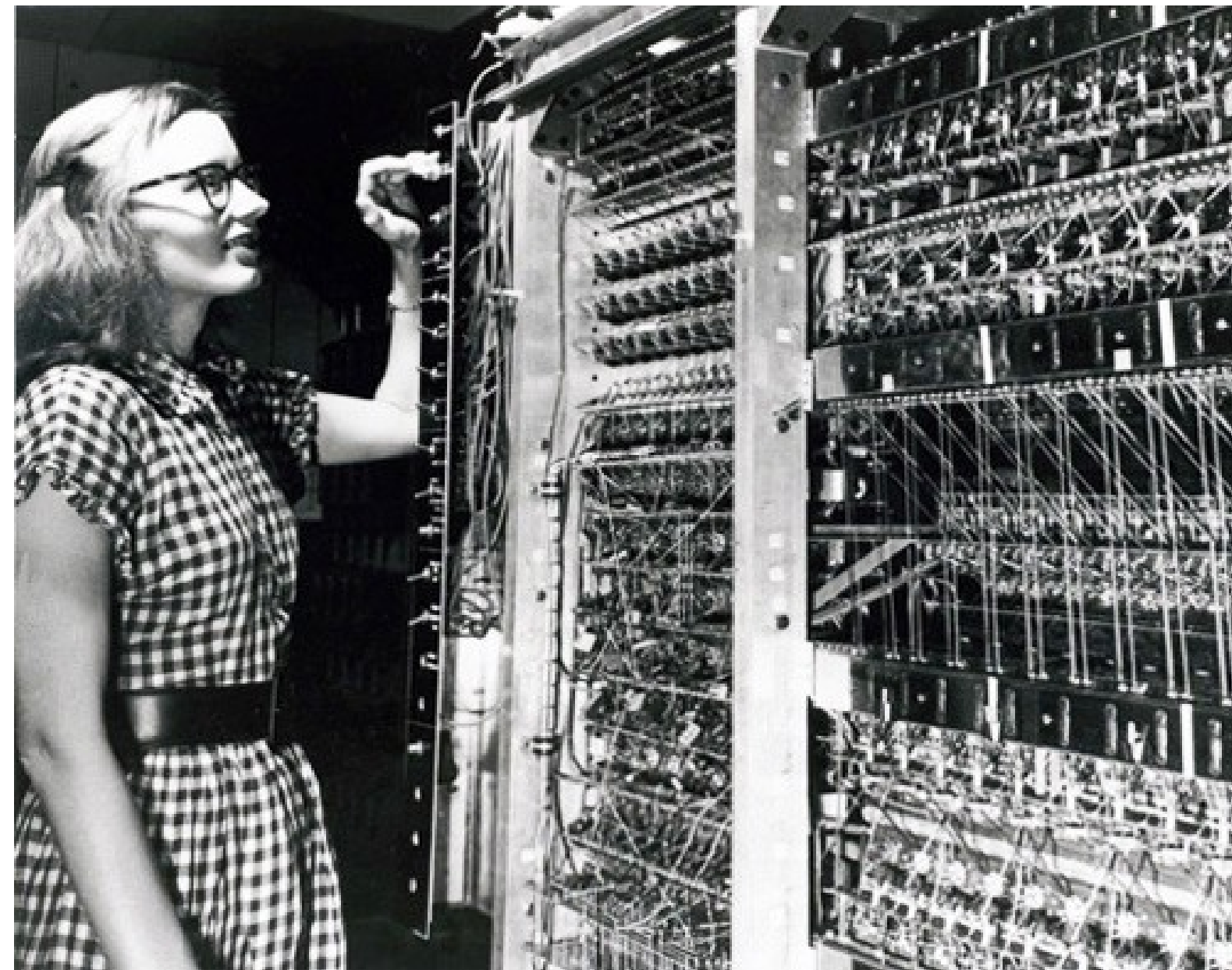
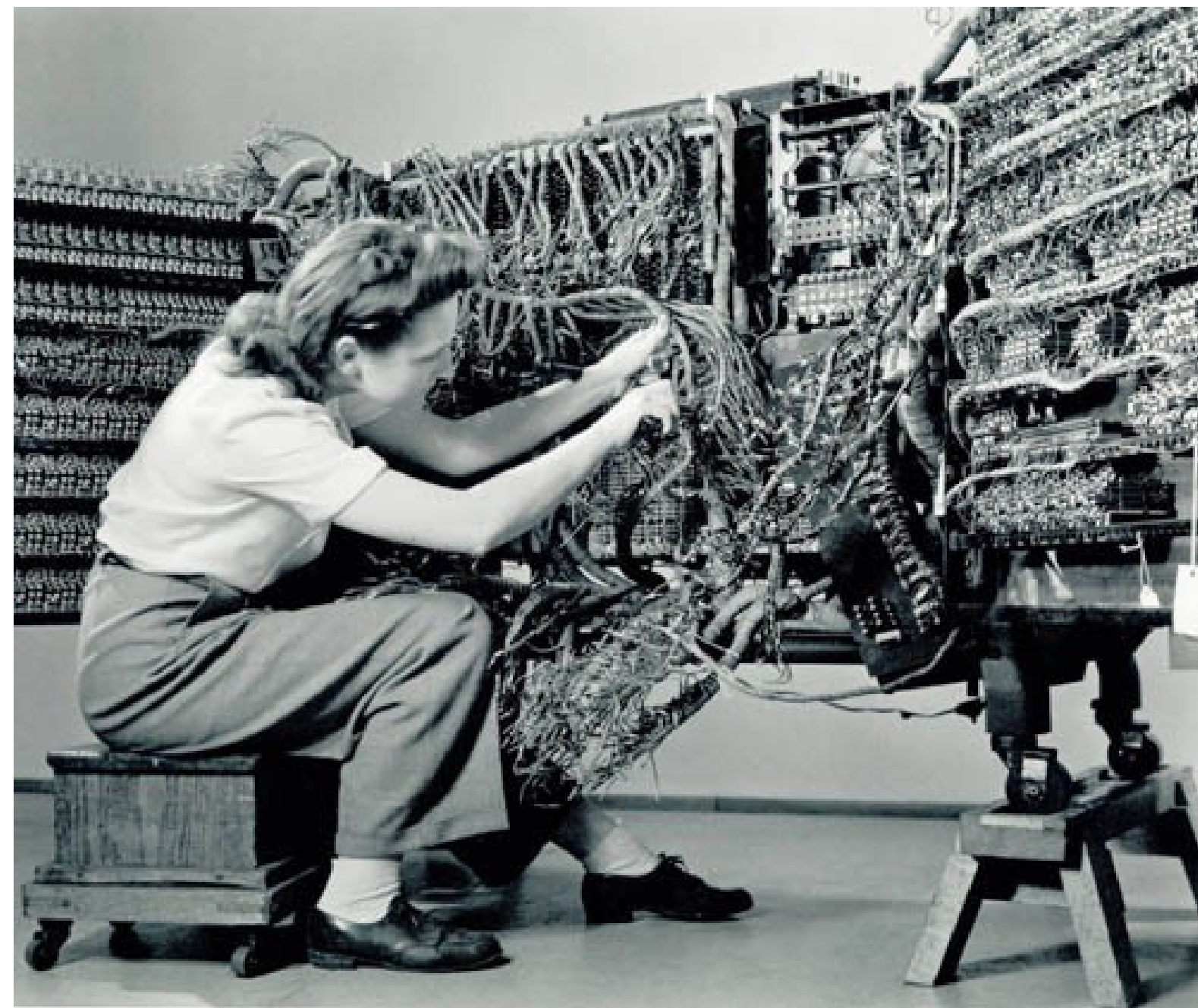
In a vivid demonstration of the power of his invention, using 10,000 punch cards, he programmed a loom to weave a portrait of himself in black and white silk.



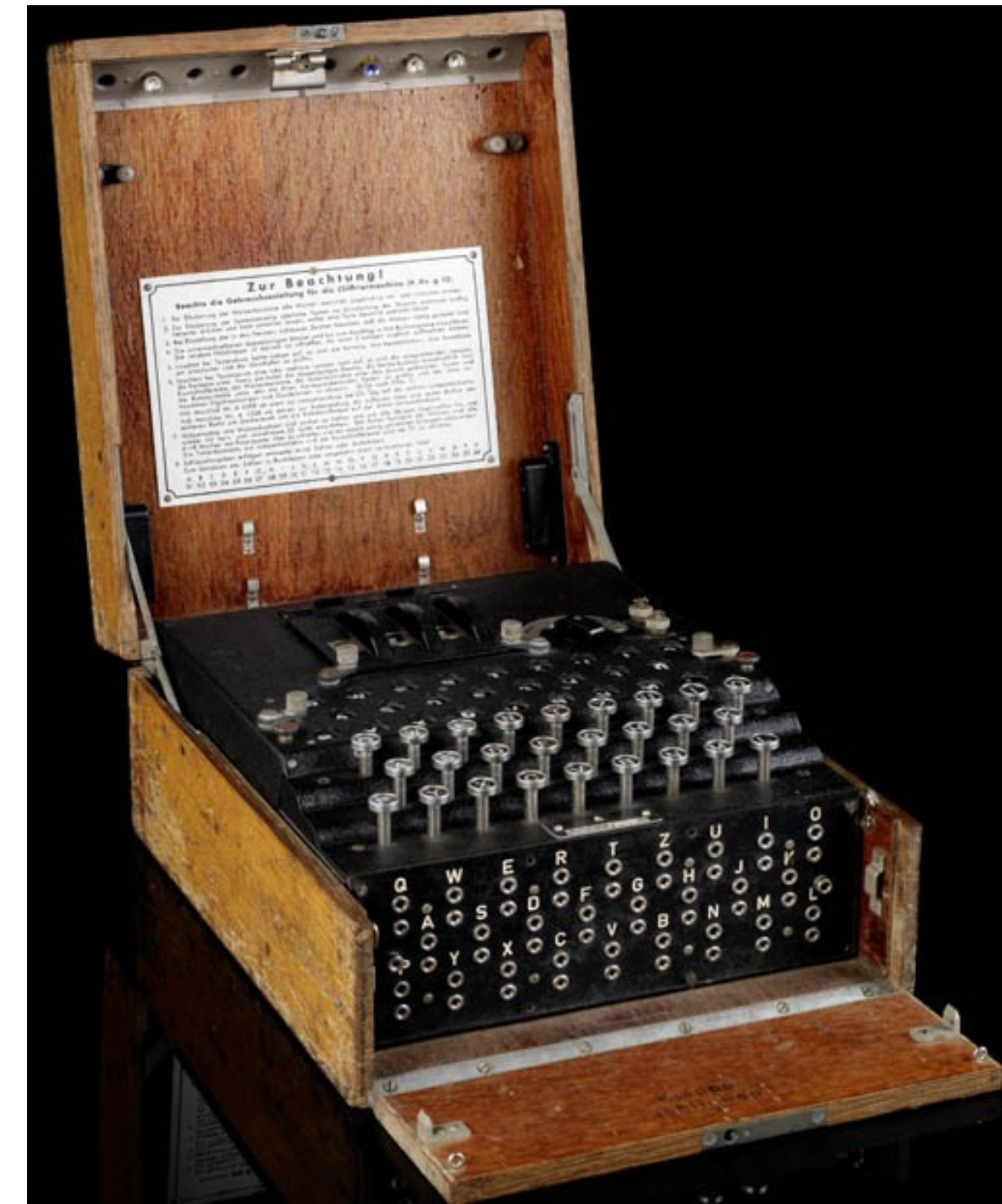
*One of Babbage's first
computing machines,
Difference Engine #1*



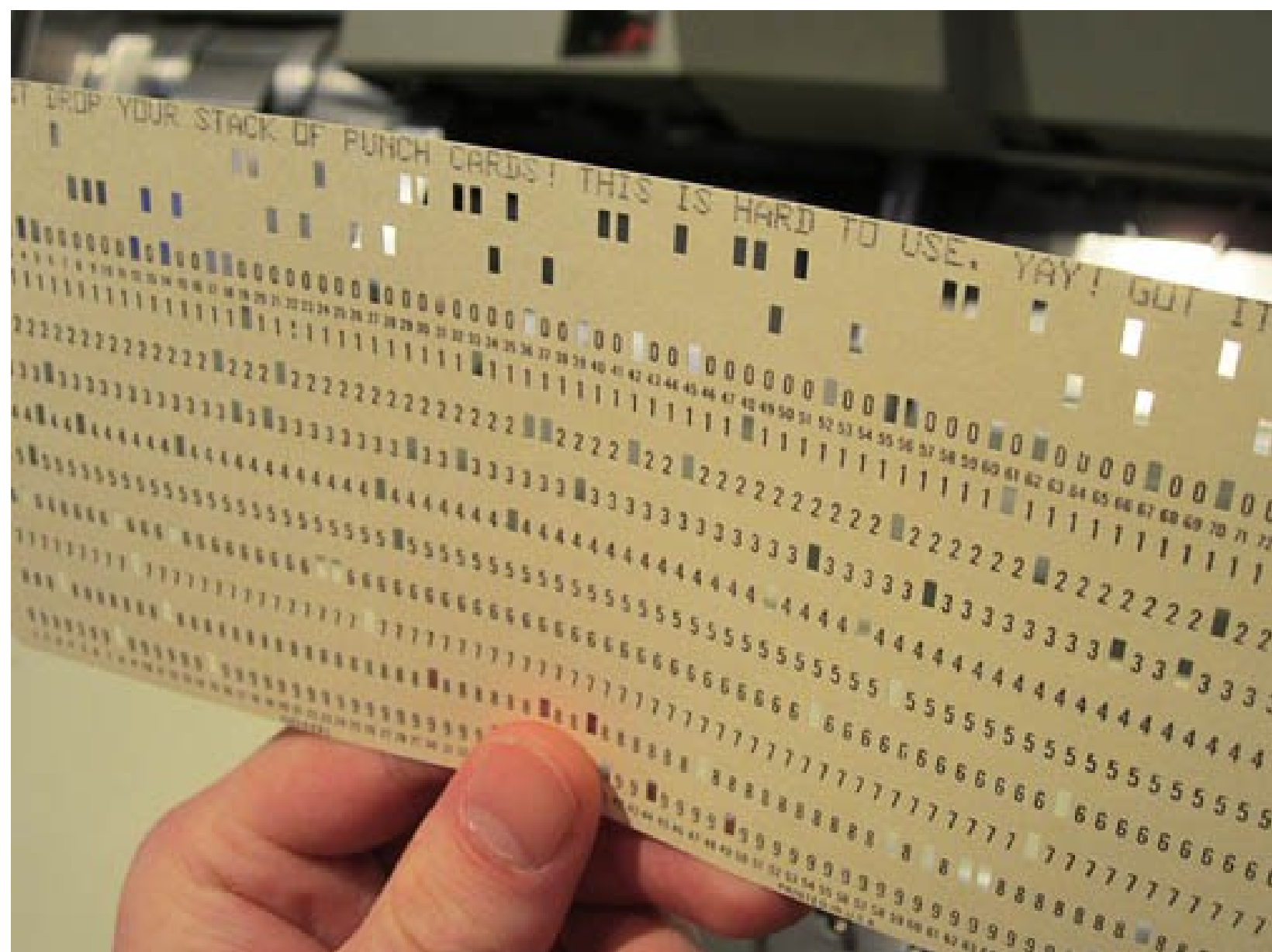
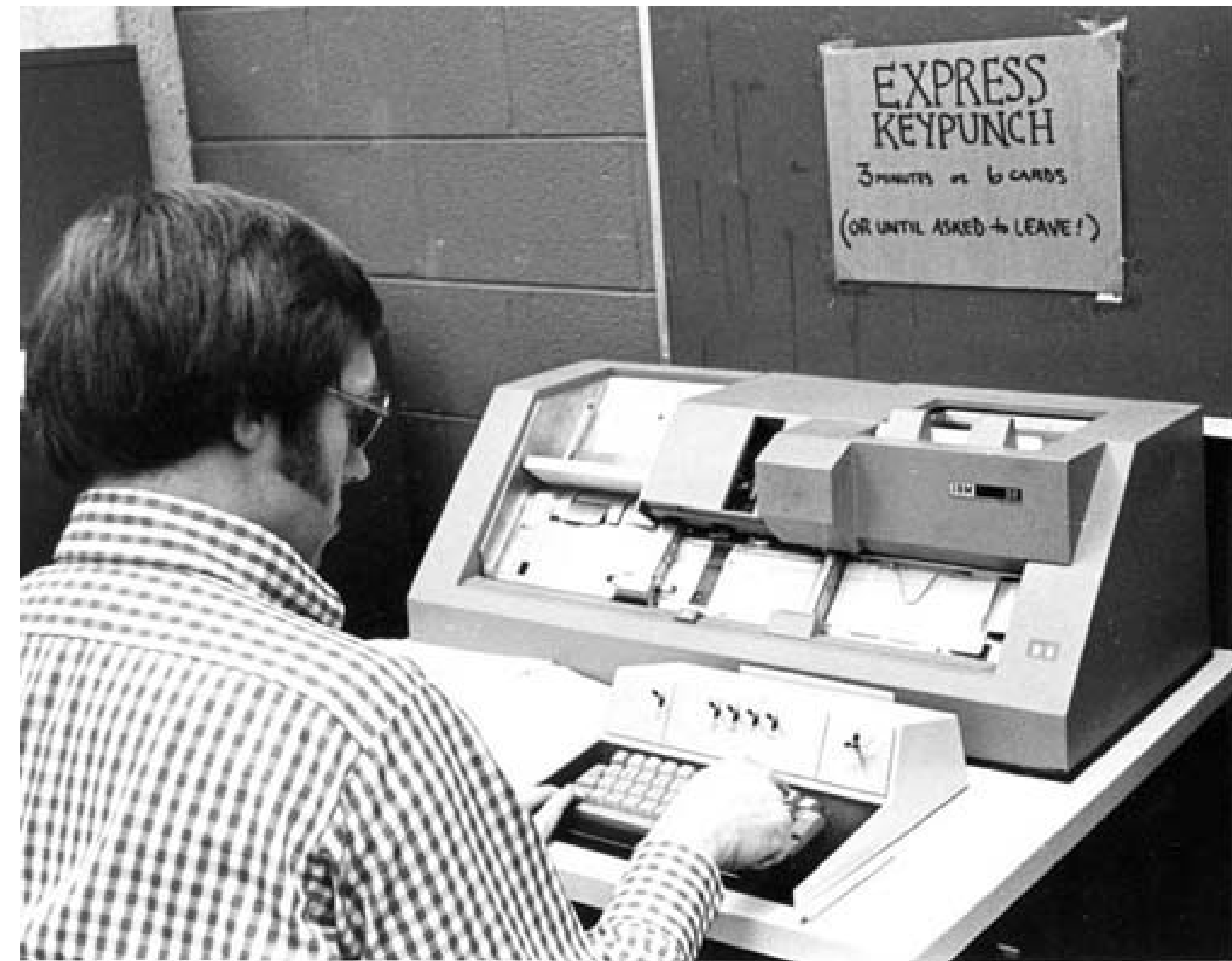
The Science Museum in London project: constructing a working Difference Engine No. 2 from 1989 to 1991



*Code-breaker Alan Turing
ca. 1945 (with the German
"Eniga Machine")*



Building of digital electronic computers was crucial to the US and Great Britain during and after World War II, with the defense department funding most of the research.



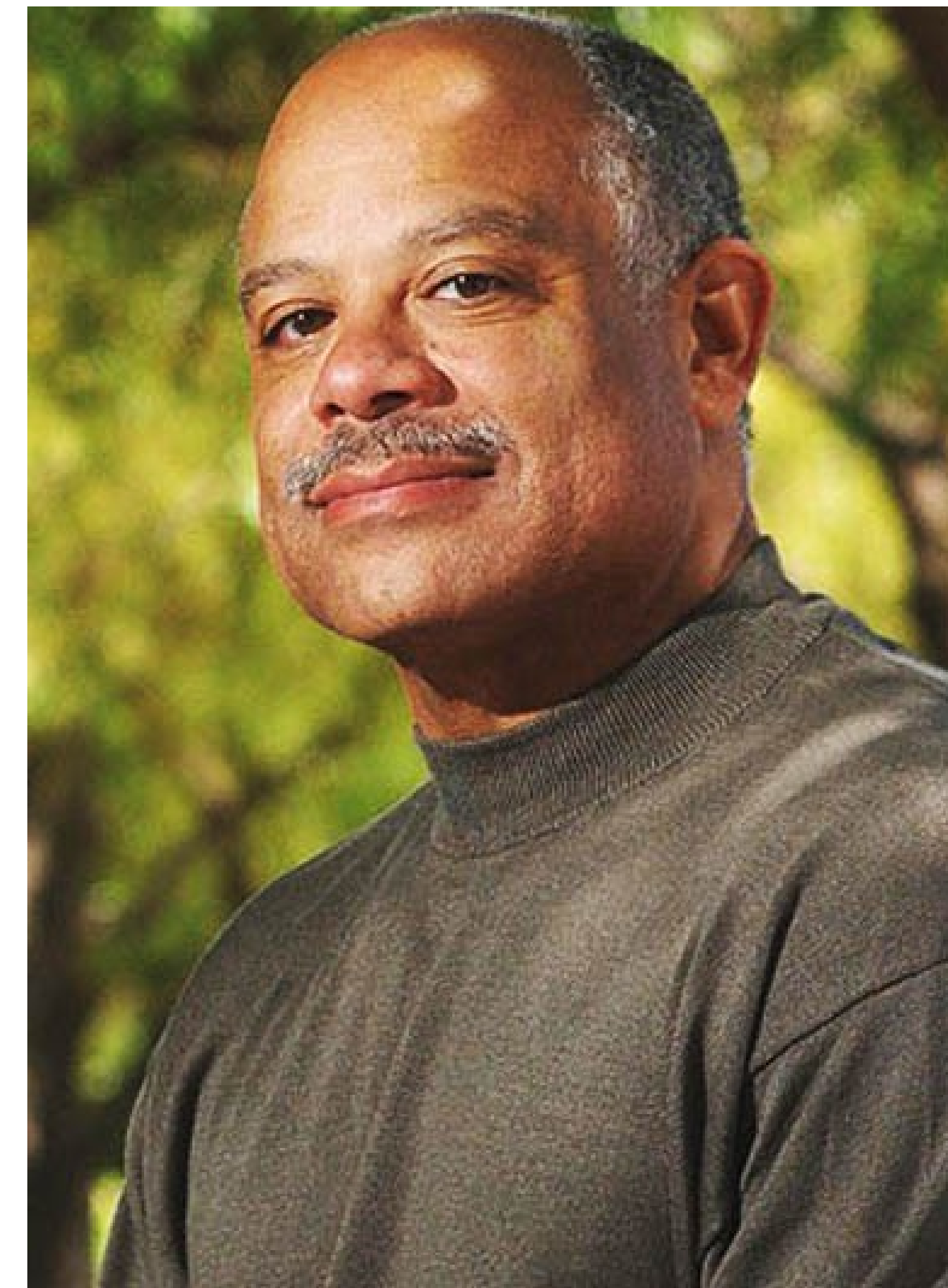
Early digital computers were programmed using punch cards, as Jacquard had used almost a century earlier.



The personal computer revolution in the 80's.



Apple Computers was founded in 1976 in a garage in California.



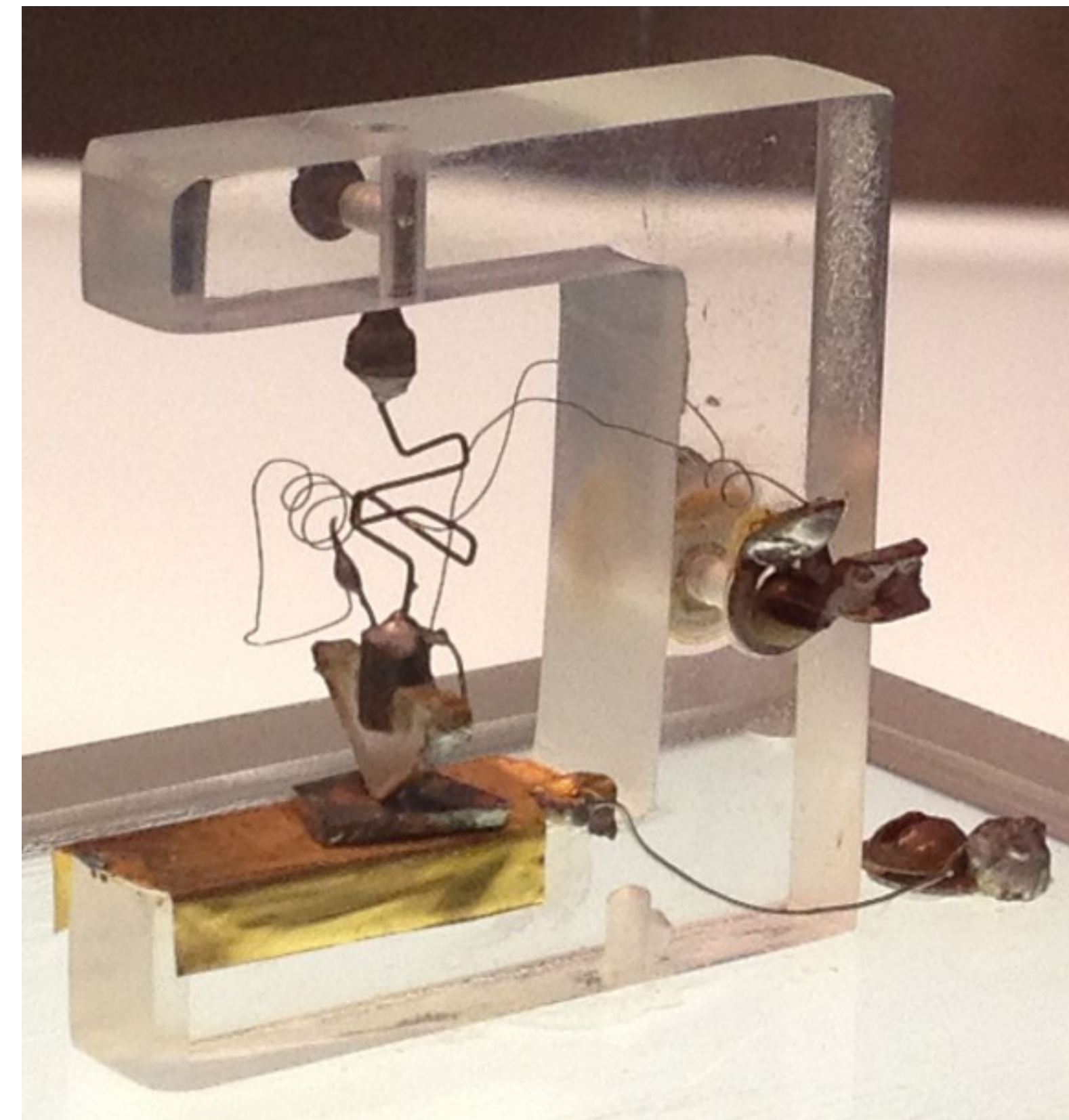
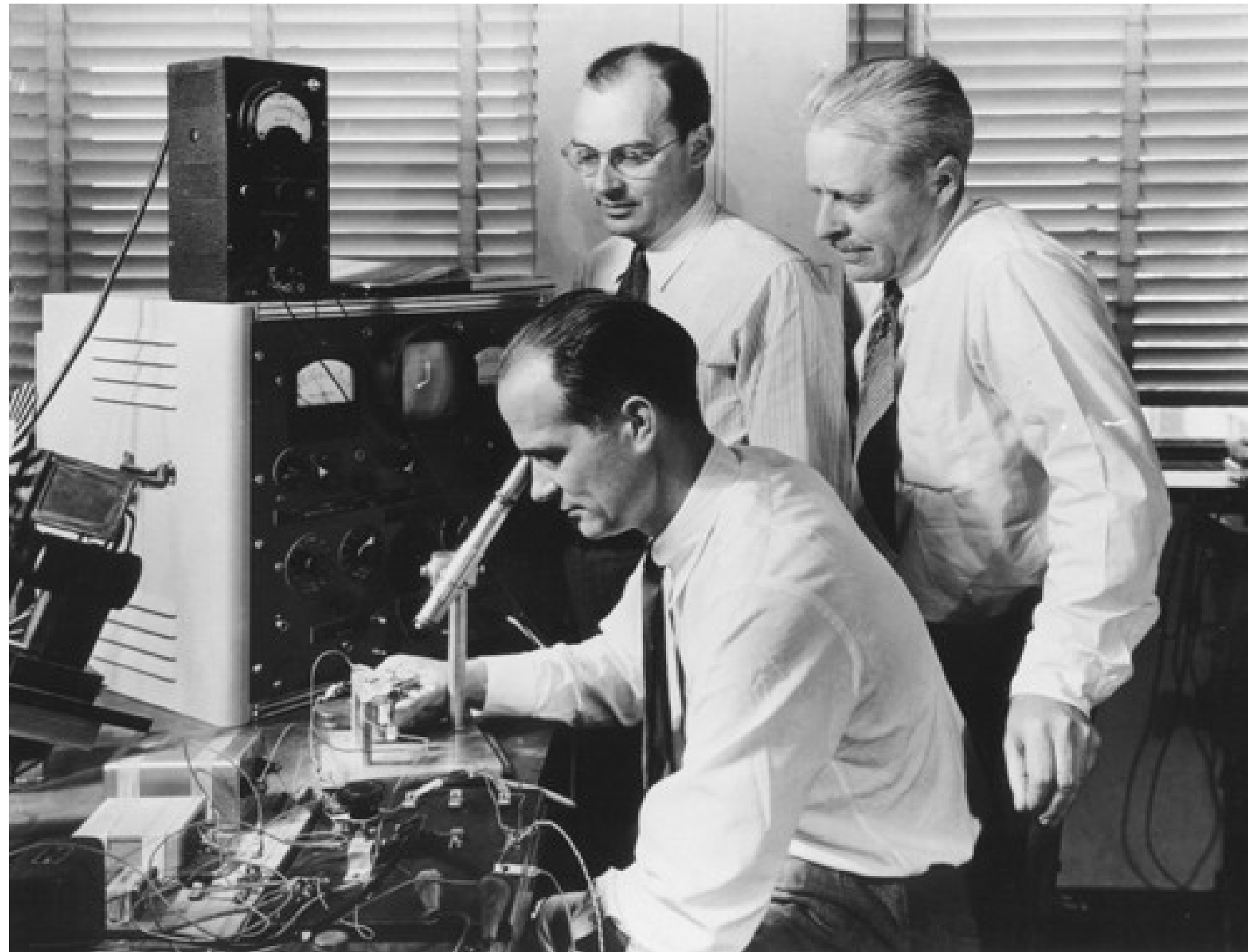
Dr. Mark Dean, an African-American computer scientist and engineer, spent over 30 years at IBM. He was chief engineer of the team that designed the original IBM PC in the early '80s, earning him three of the nine original patents for that device.

3. Microcontrollers

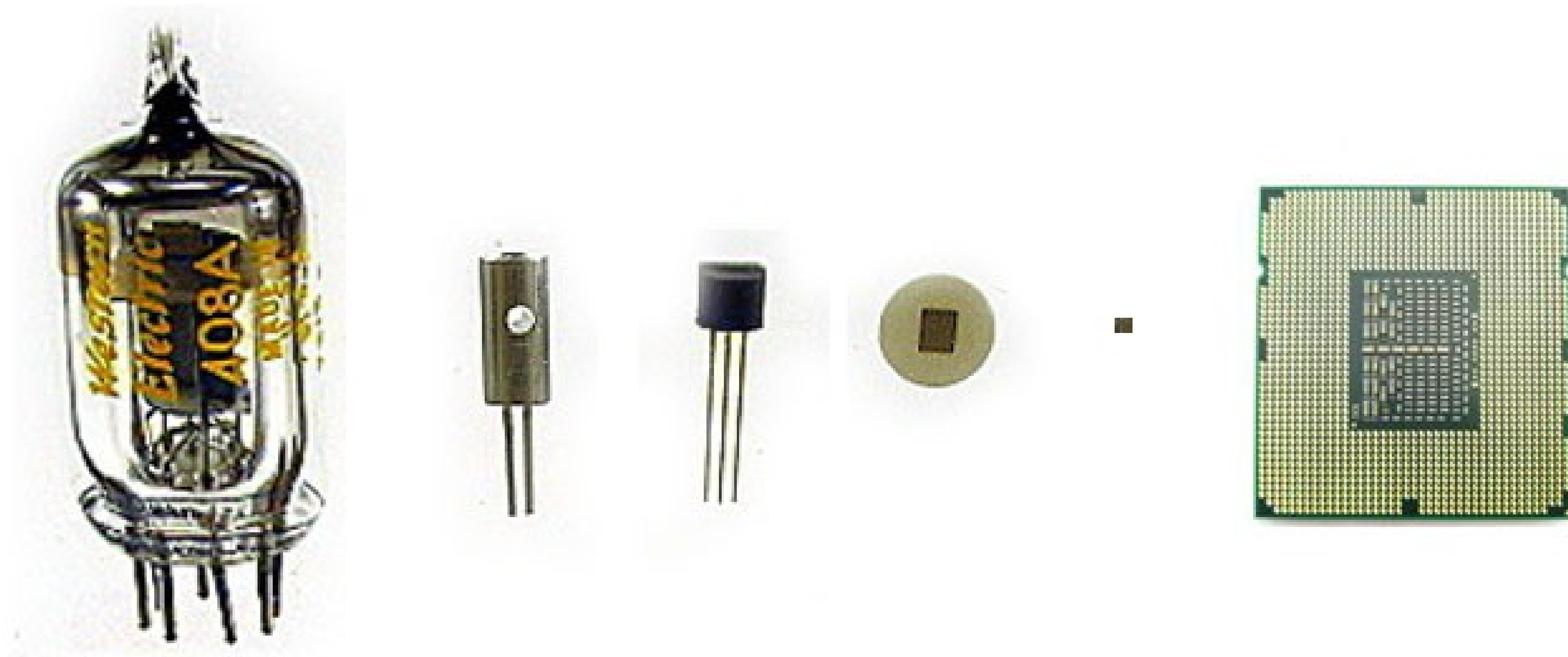
A microcontroller is a small computer (a “system on a Chip”, SoC) on a single integrated circuit containing a processor core, memory, and programmable input/output.

They were first developed in the 1970's.

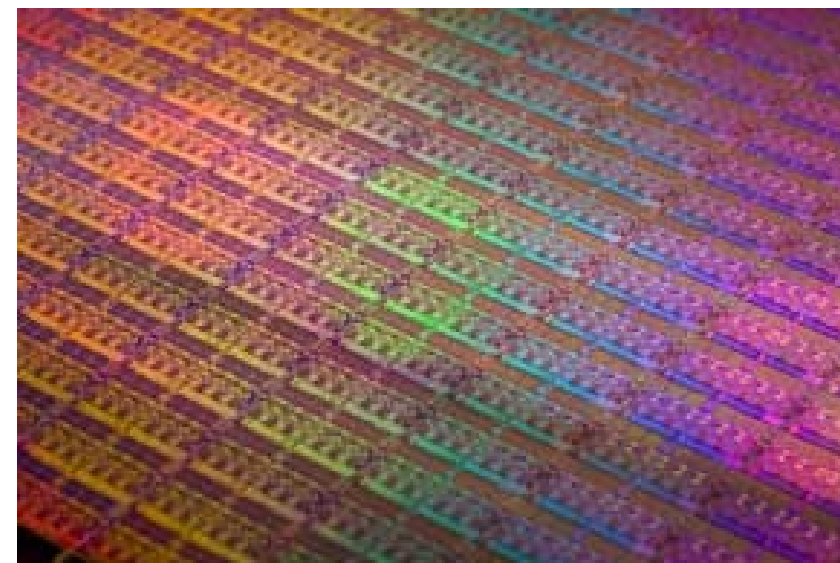
The microcontrollers and microprocessors were made possible as a result of the invention of **the transistor**.



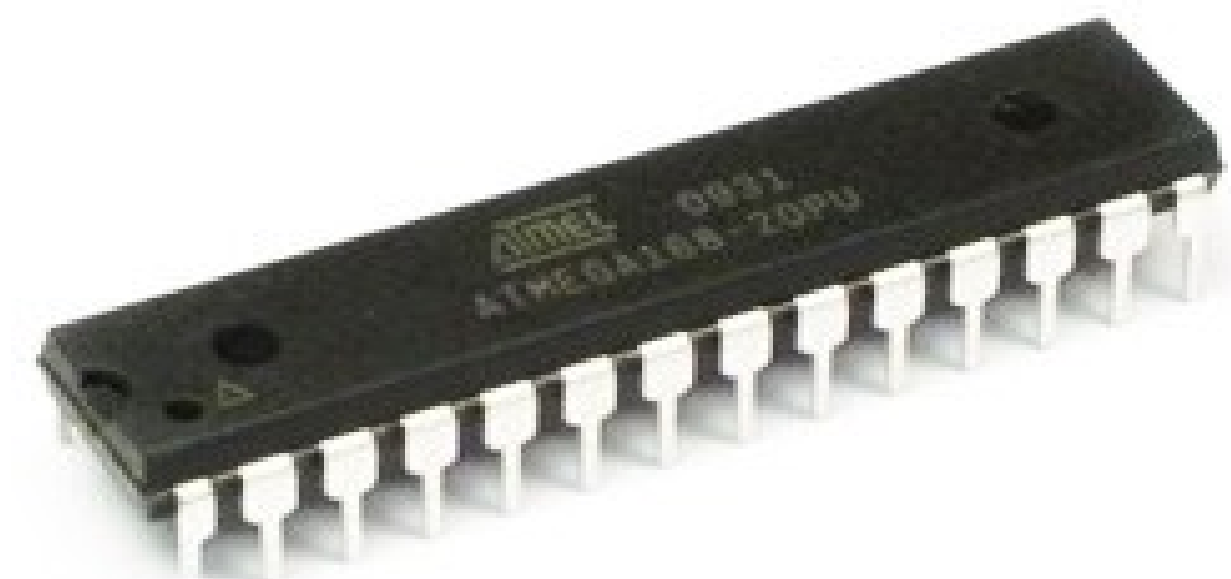
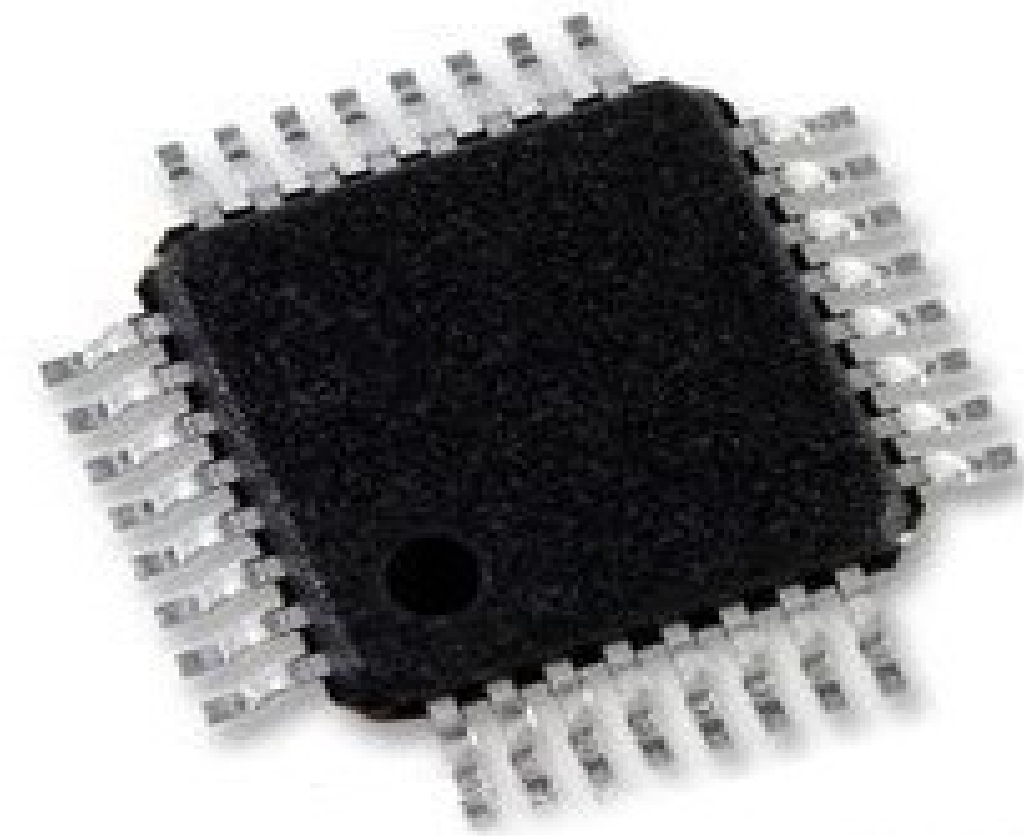
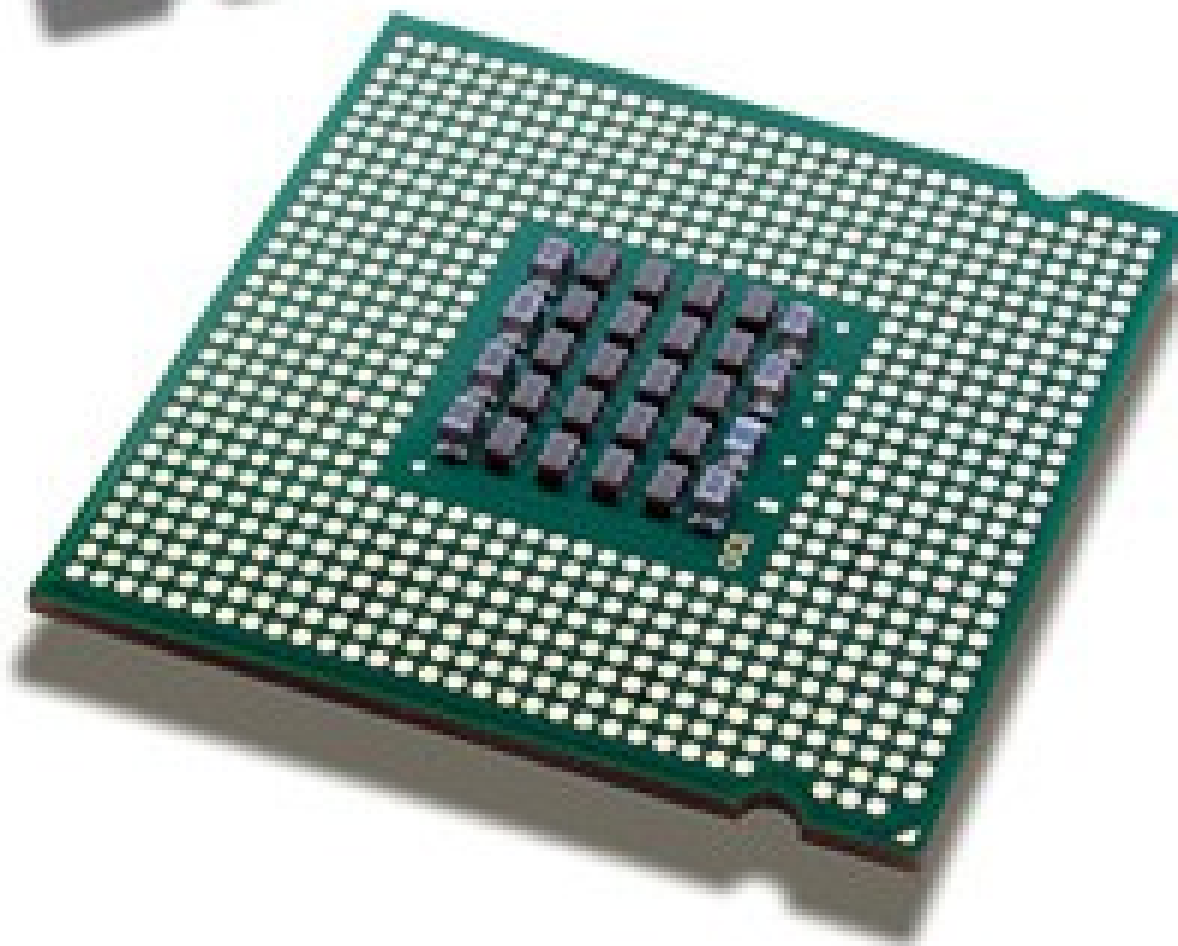
The inventors at Bell Labs, 1948:
John Bardeen, William Shockley and Walter Brattain and their original device



- The evolution from vacuum tubes to chips.
- The current generation of Intel i7 chips have *1.16 billion* transistors on a single integrated chip.



What's the difference between a microprocessor
and a microcontroller?



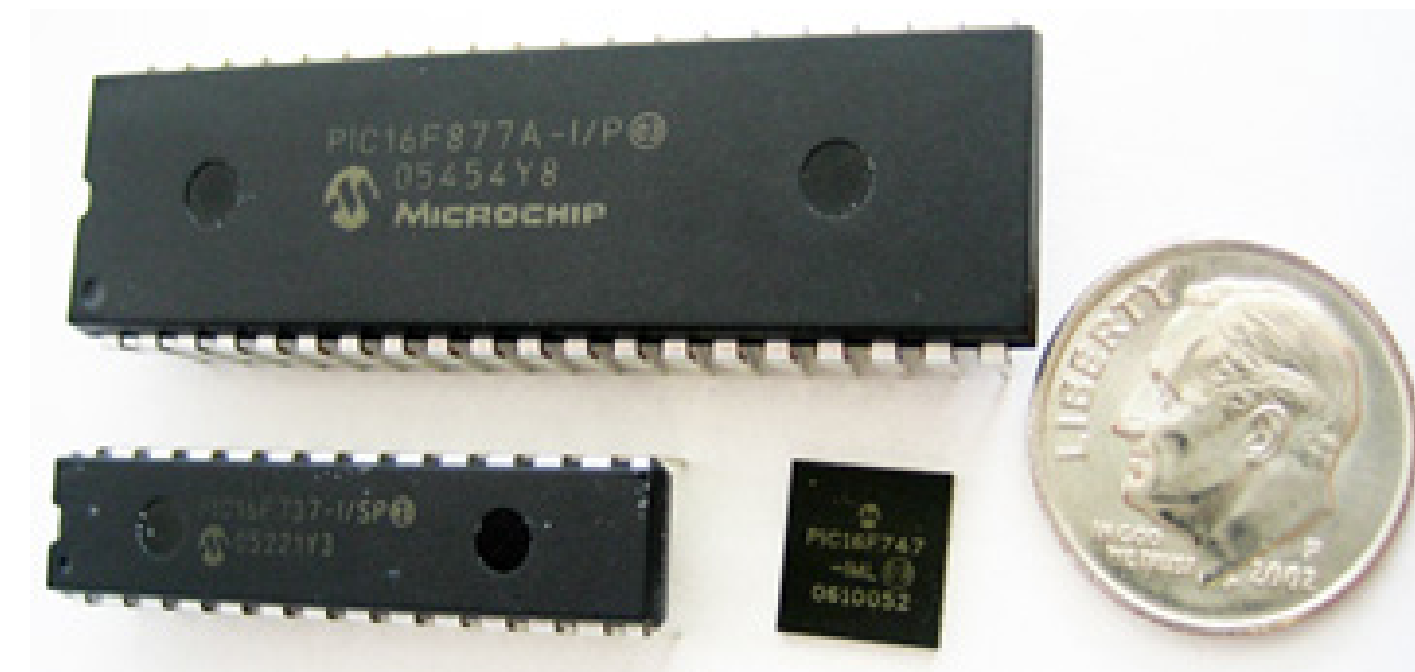
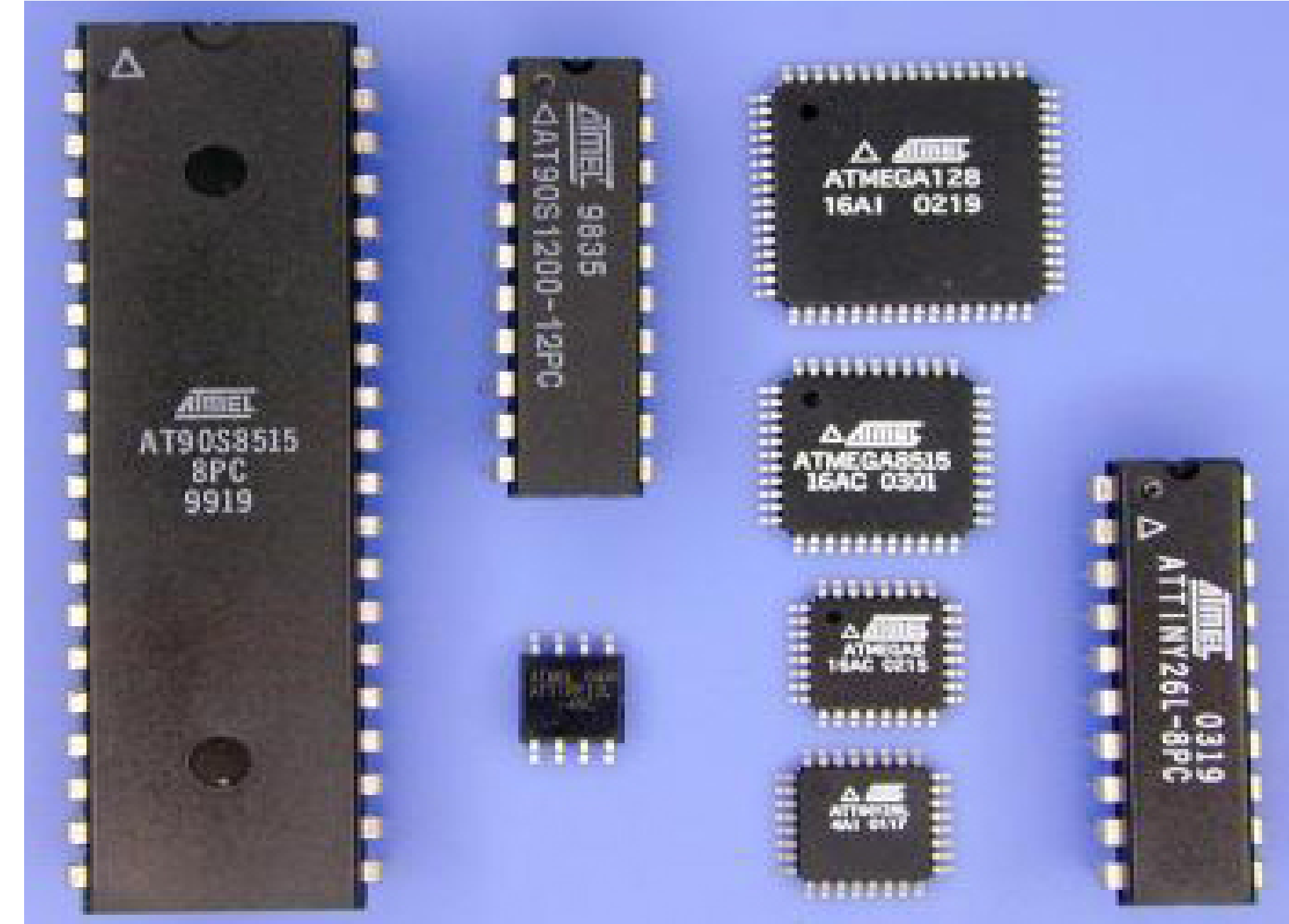
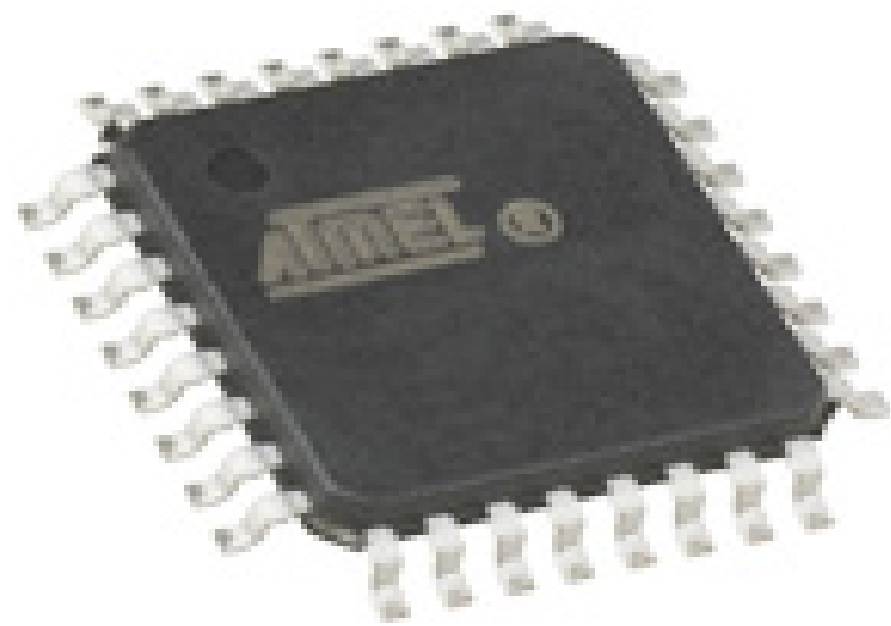
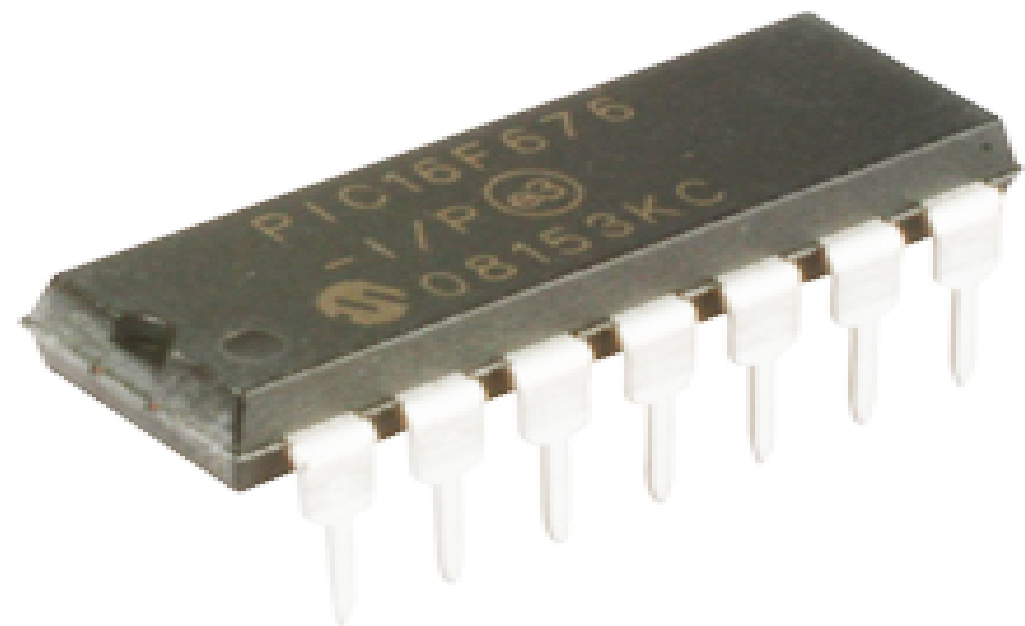
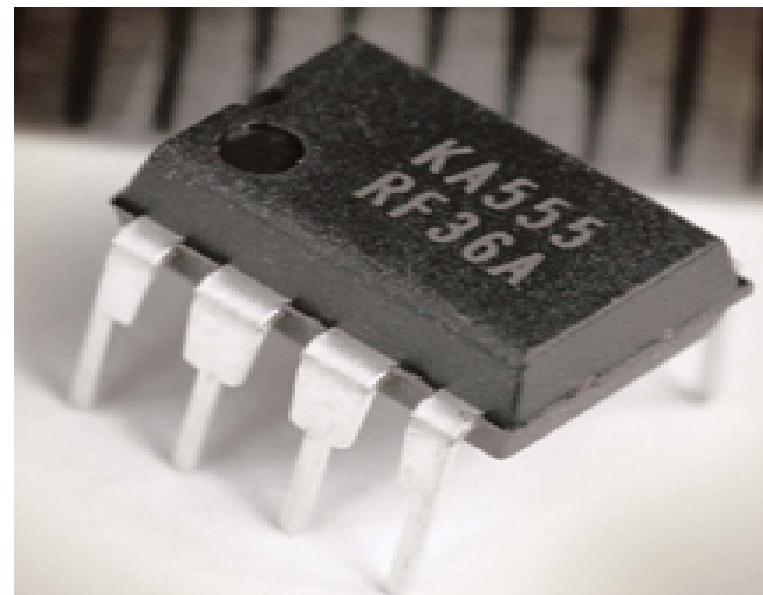
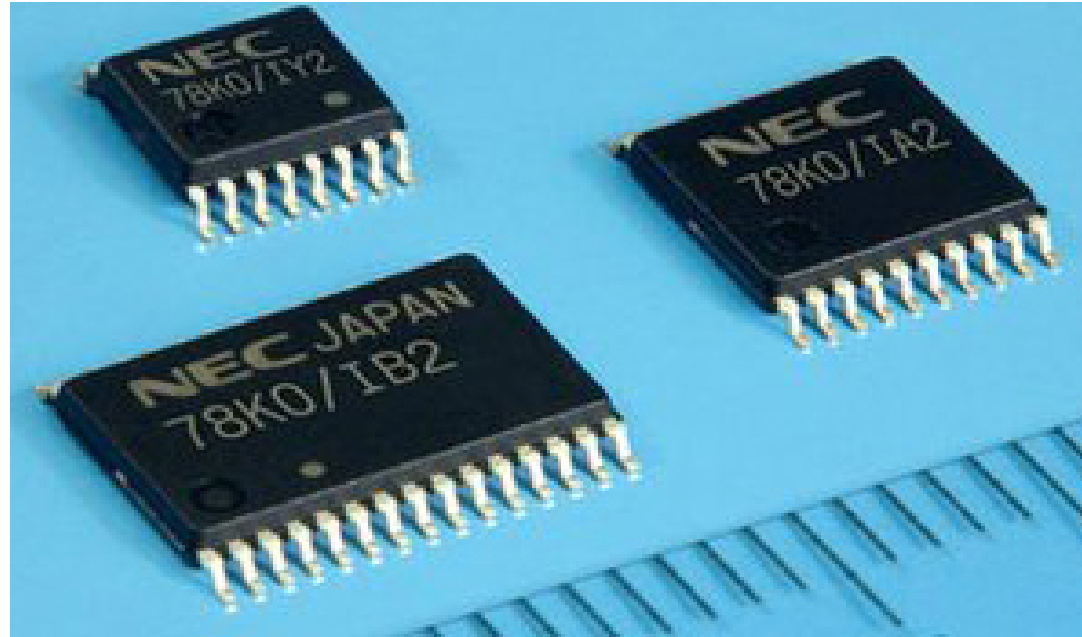
A microprocessor:

- an IC with only the Central Processing Unit (CPU)
- No RAM, ROM, or peripheral I/O on the chip.
(System designers must add these externally to make these function in Desktop PC's, Laptops, notepads, tablets, etc.)
- (Manufacturers include:
Intel's Pentium, core 2 duo, i3, i5, ARM, PowerPC, AMD, etc.)

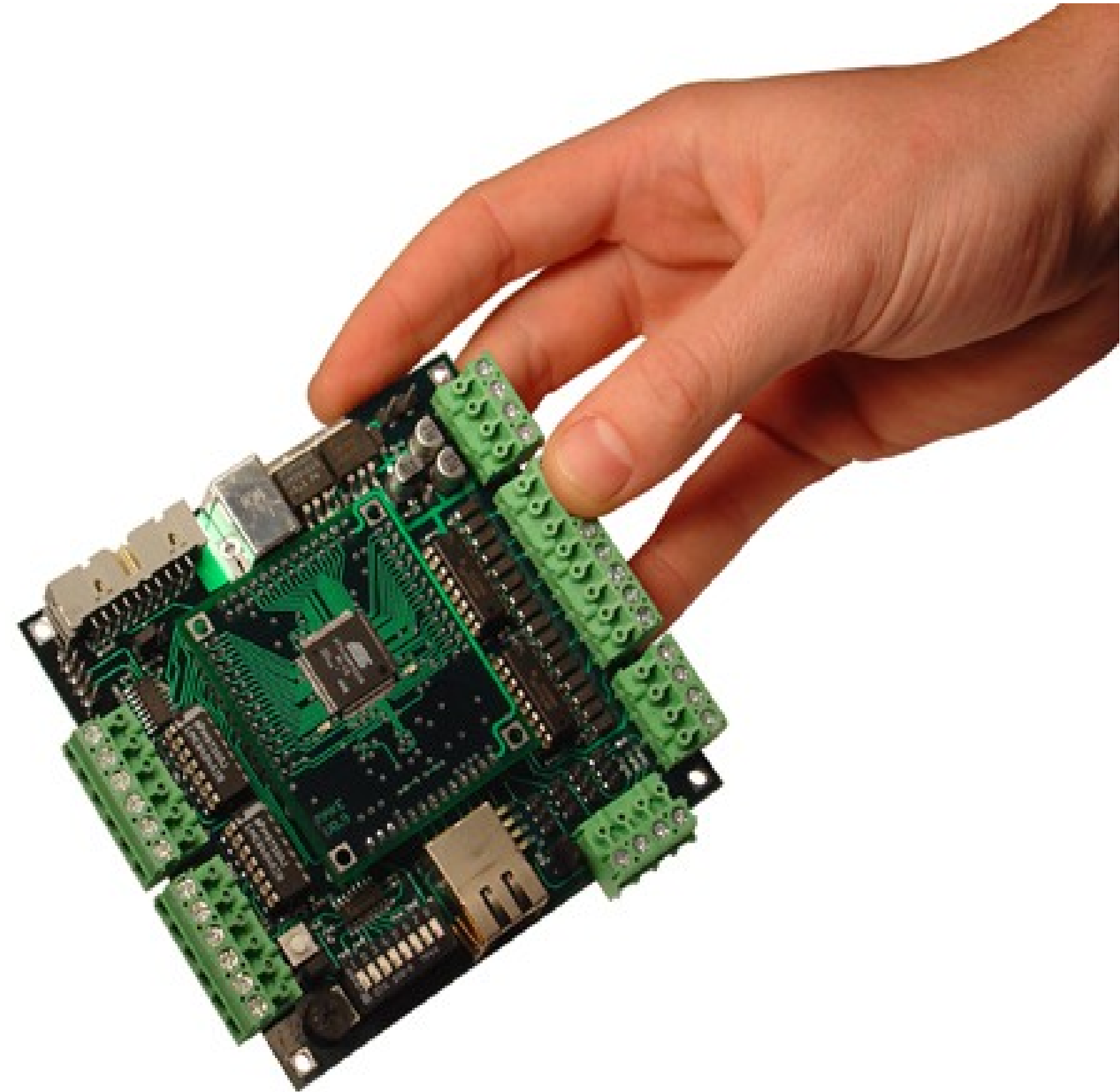
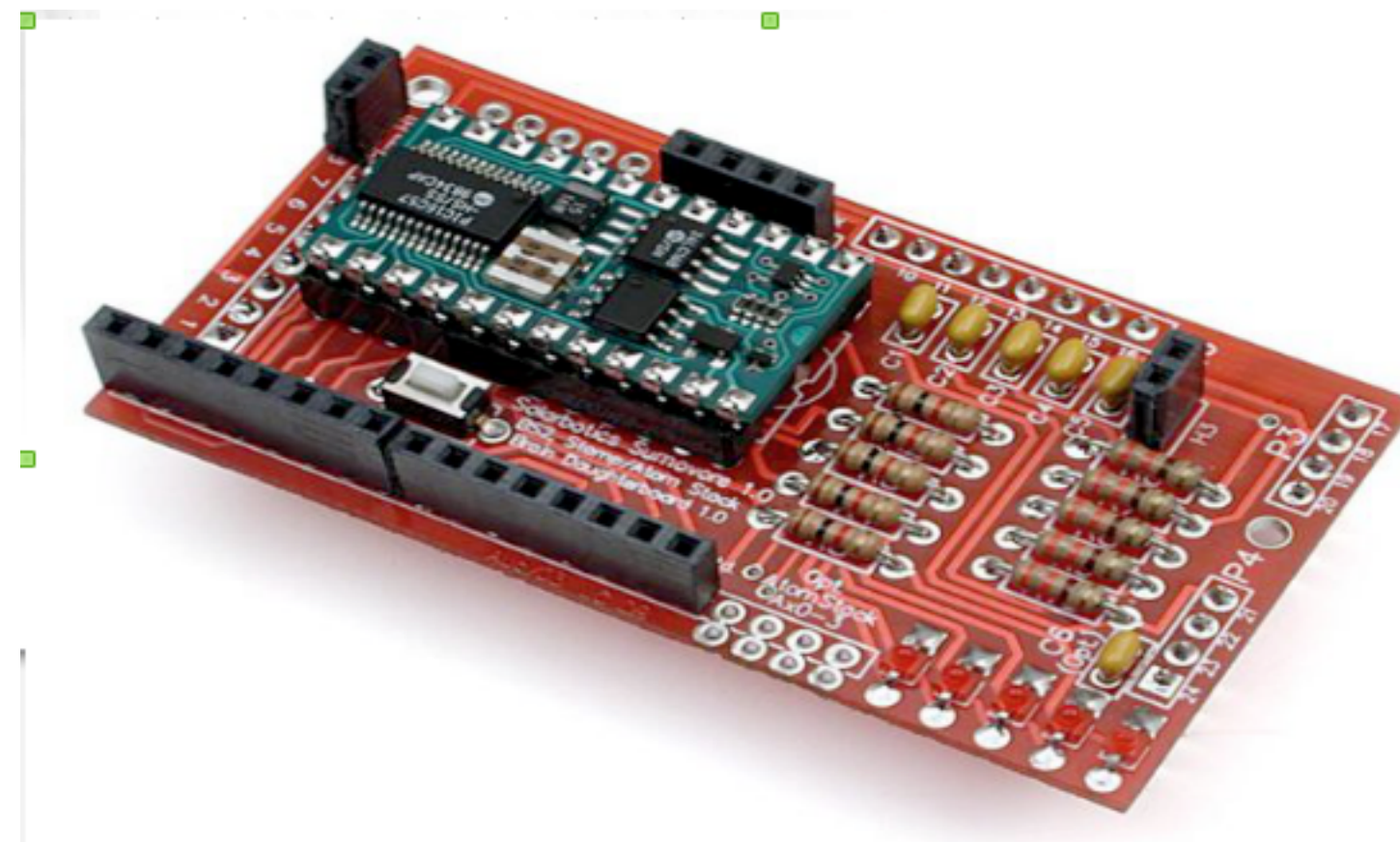
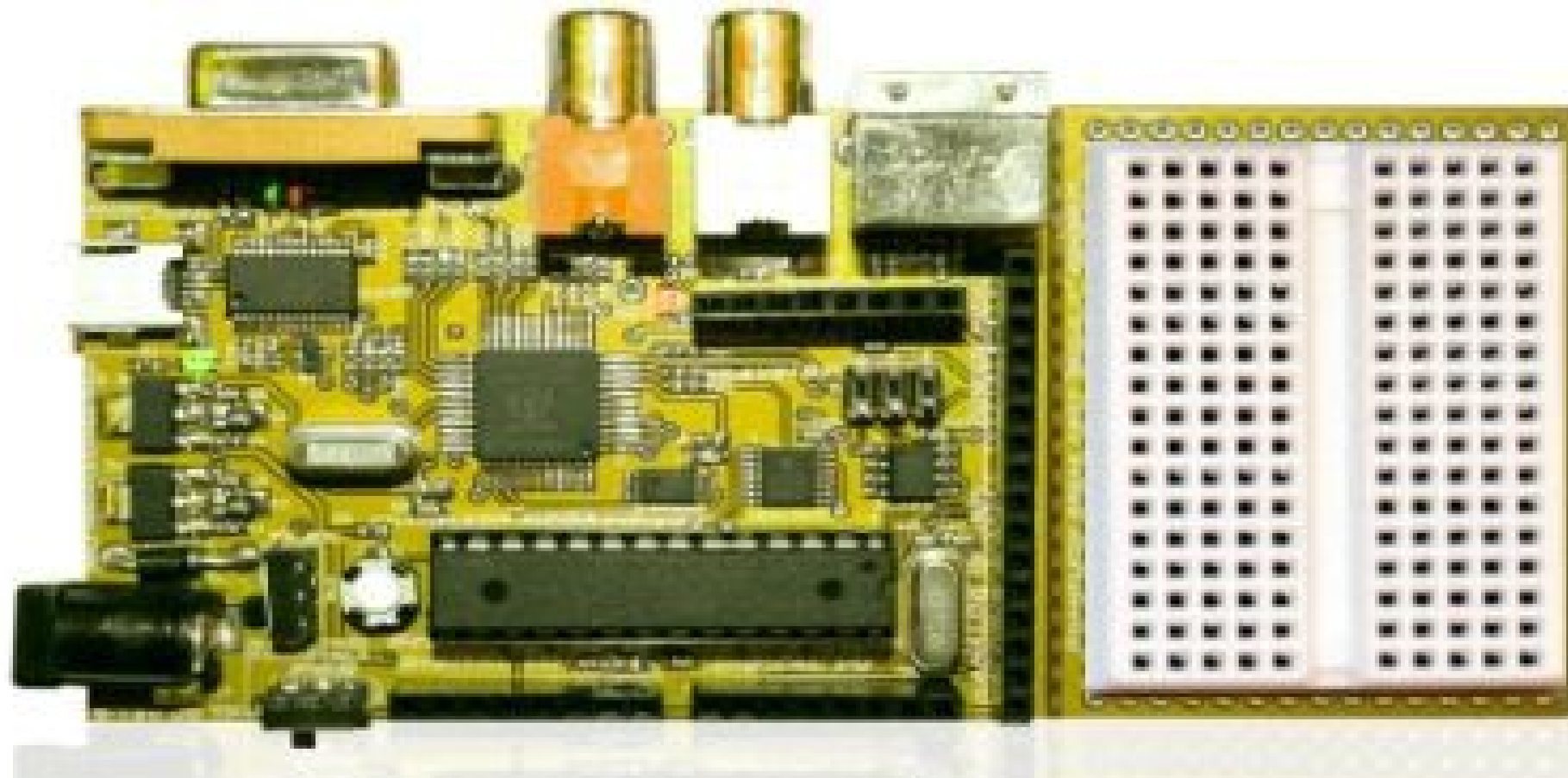
A microcontroller:

- an IC with CPU, I/O pins, a fixed amount of RAM, ROM, all embedded on a single, 'all in one' chip.
- (Manufacturers include:
Microchip, ATMEL, TI, Freescale, Philips, Motorola)

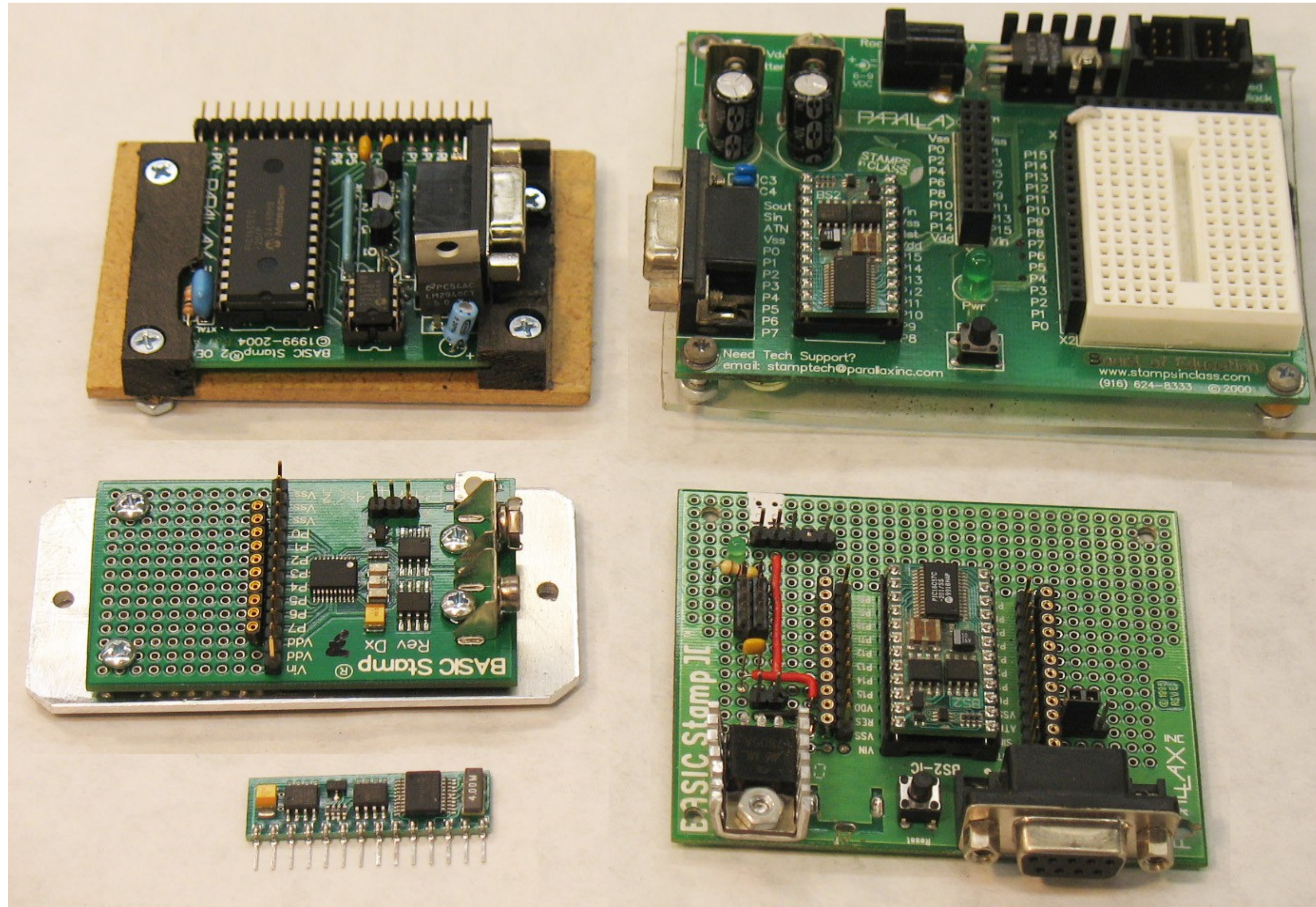
There are many different microcontroller ICs...



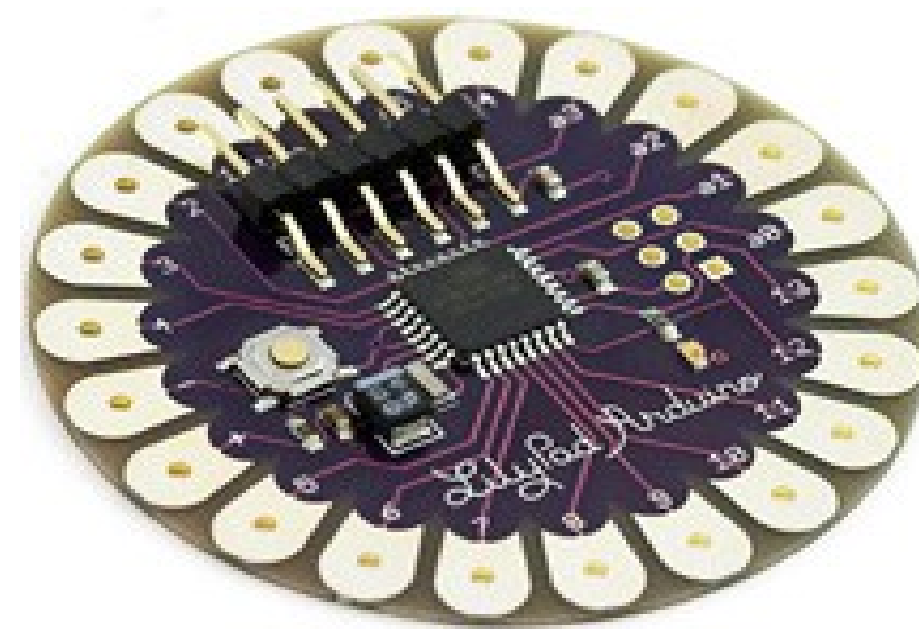
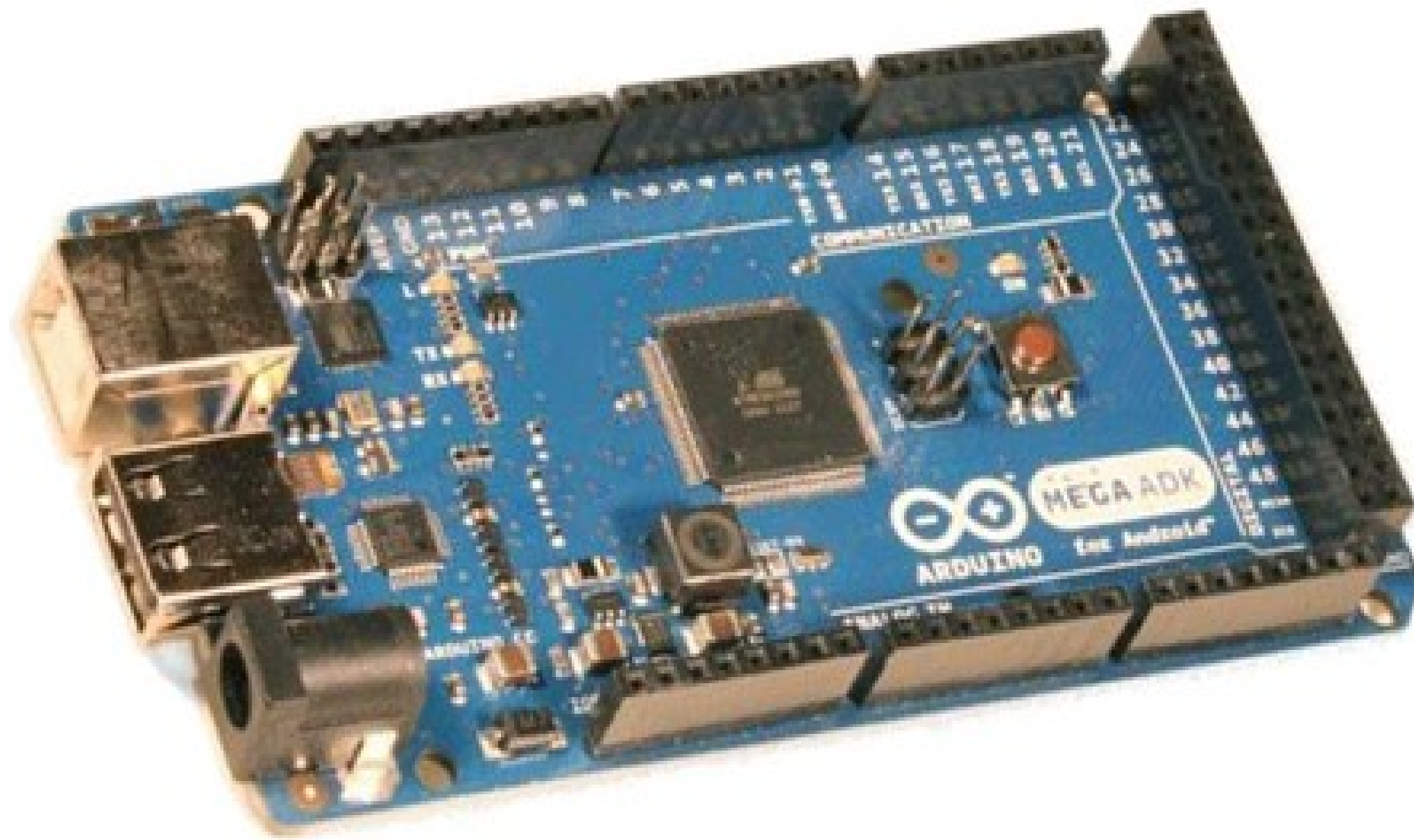
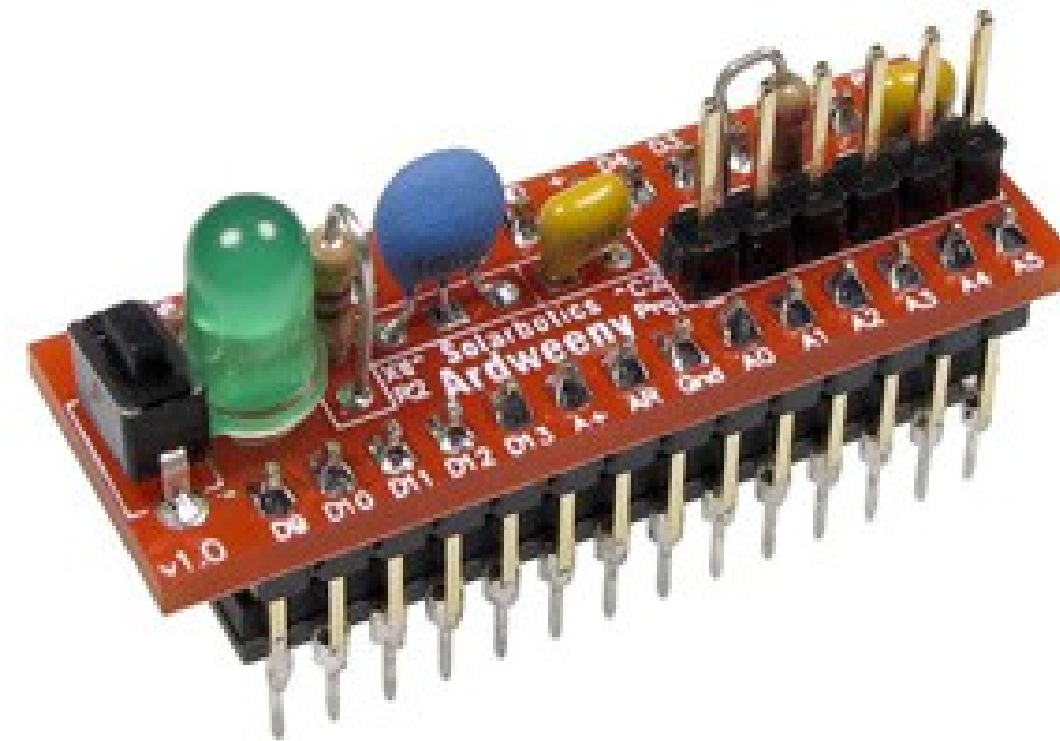
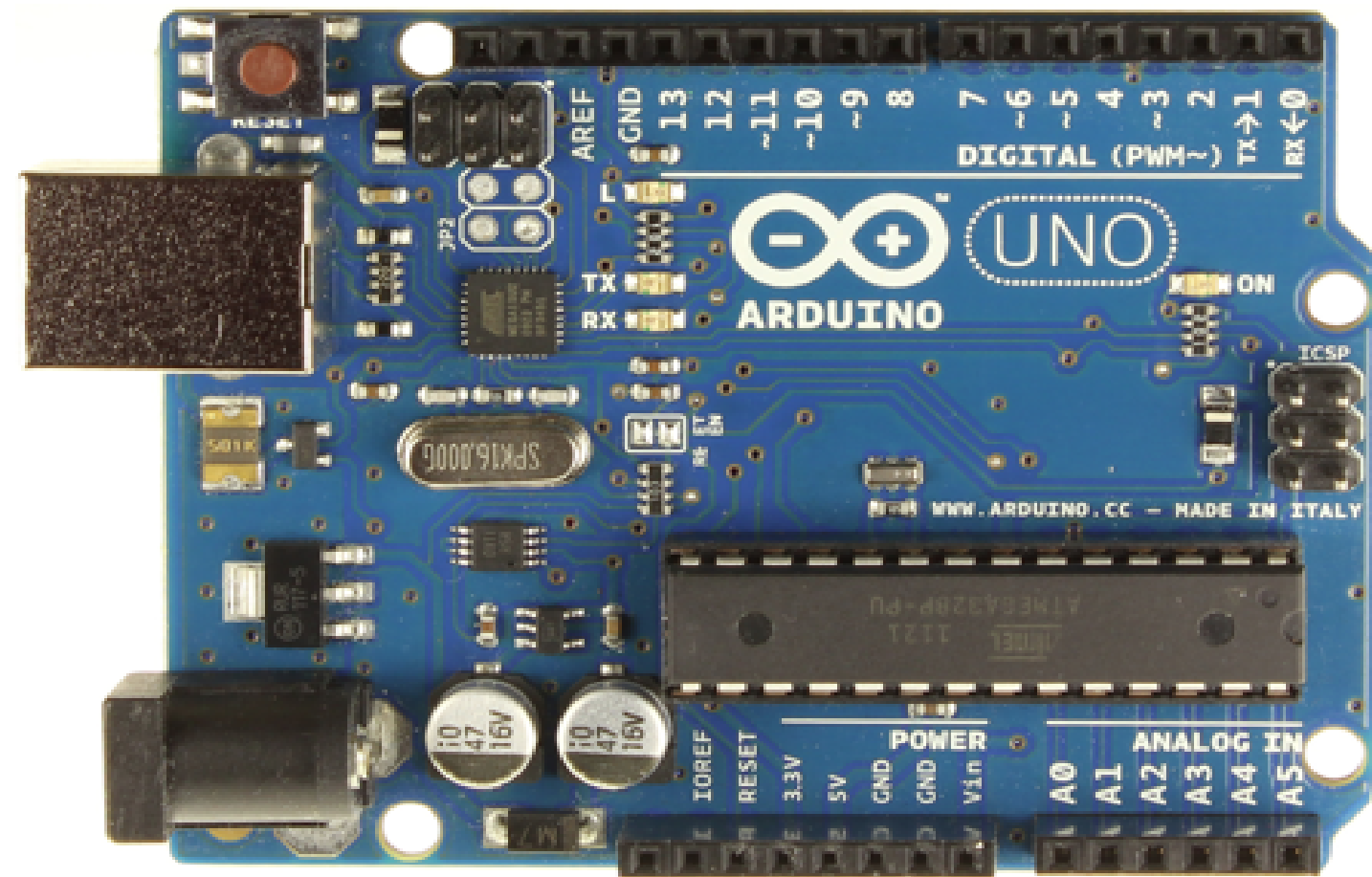
Many are available on handy “development boards”.



Parallax "Basic Stamp" :



Arduino boards...



Leah Beuchley