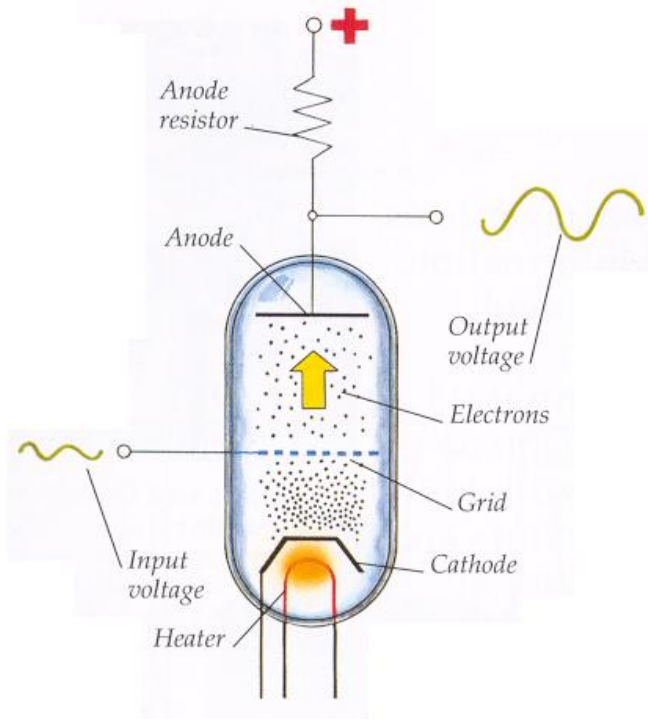


Milestones in electronics

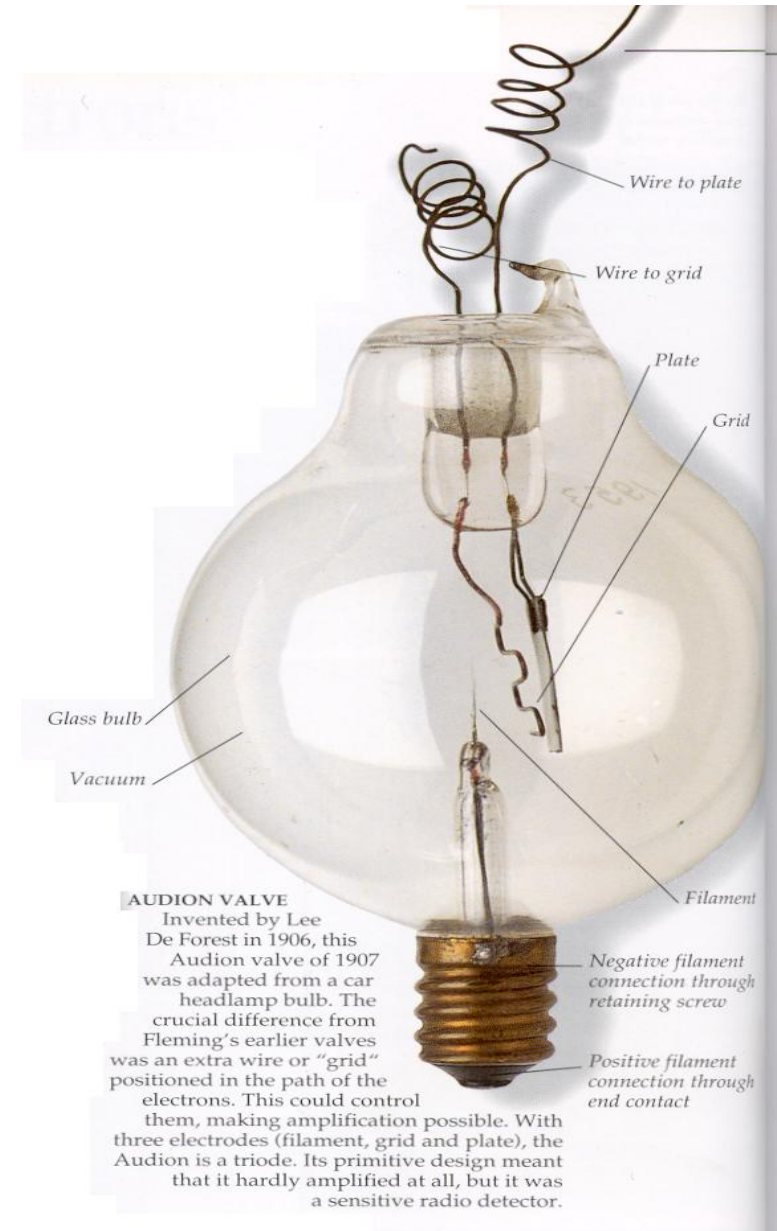
Year	Event
1895	Marconi (<i>1909 Nobel of Physics - in recognition of contributions to the development of wireless telegraphy</i>) first radio transmission (~ 2.4 km)
1904	Fleming Valve (Diode Vacuum Tube)
1906	De Forest – Triode vacuum tube (Audion) – Age of electronics begins
1925	TV demonstrated
1940	Radar developed during World War II
1946	ENIAC (Electronic Numerical Integrator And Computer) is announced
1947	Bipolar transistors invented by Bardeen, Brattain & Shockley at Bell Laboratories (<i>Nobel Prize of Physics in 1956 for invention of bipolar transistors</i>)
1952	Commercial production of silicon bipolar transistors at Texas Instruments

- 1958 Simultaneous development of the integrated circuit by Kilby (2000 Nobel Prize) at Texas Instruments & Noyce and Moore at Fairchild Semiconductor
- 1961 First commercial digital IC available from Fairchild Semiconductor
- 1963 **AIEE and IRE merge to become the Institute of Electrical and Electronics Engineers (IEEE)**
- 1968 Introduction of the first commercial IC operational amplifier – the $\mu\text{A} - 709$ – by Fairchild Semiconductor
- 1971 Introduction of the 4004 microprocessor by Intel
- 1978 First 16-bit microprocessor

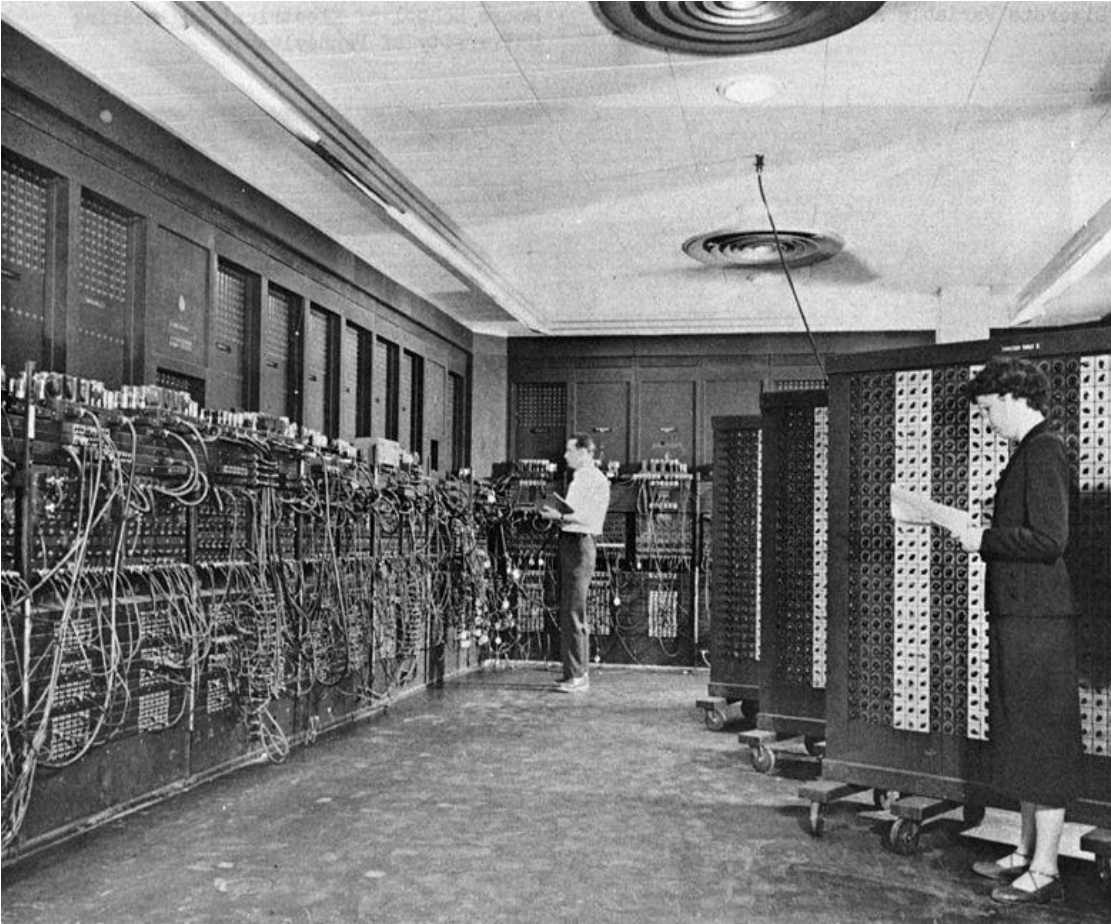
1906 Lee de Forest developed the triode vacuum tube (Audion)
Age of electronics begins.



Audion photograph (right) and
schematics (up)



ENIAC (1946)



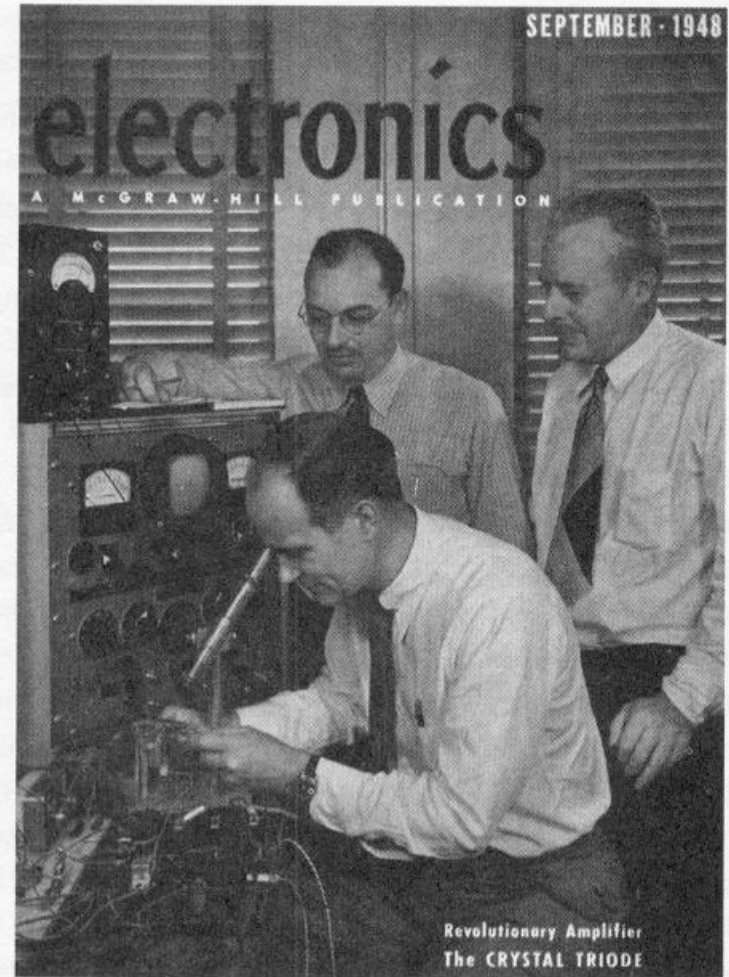
17,468 vacuum tubes
7,200 crystal diodes,
1,500 relays,
70,000 resistors,
10,000 capacitors
~5 million hand-soldered
Weight ~ 27 t
Dimensions 2.4 m × 0.9 m ×
30 m
150 kW

Bipolar transistor invented
by Bardeen, Brattain & Shockley
at Bell Laboratories in 1947.

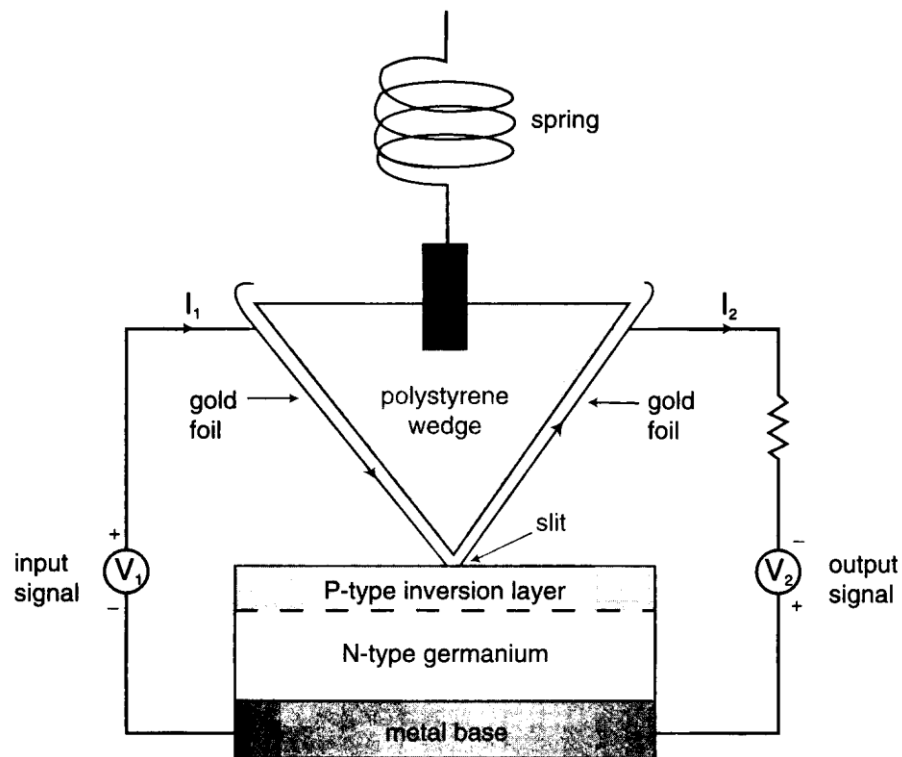
The Nobel Prize in Physics 1956 was awarded jointly to William Bradford Shockley, John Bardeen and Walter Houser Brattain "for their researches on semiconductors and their discovery of the transistor effect".

Electronics

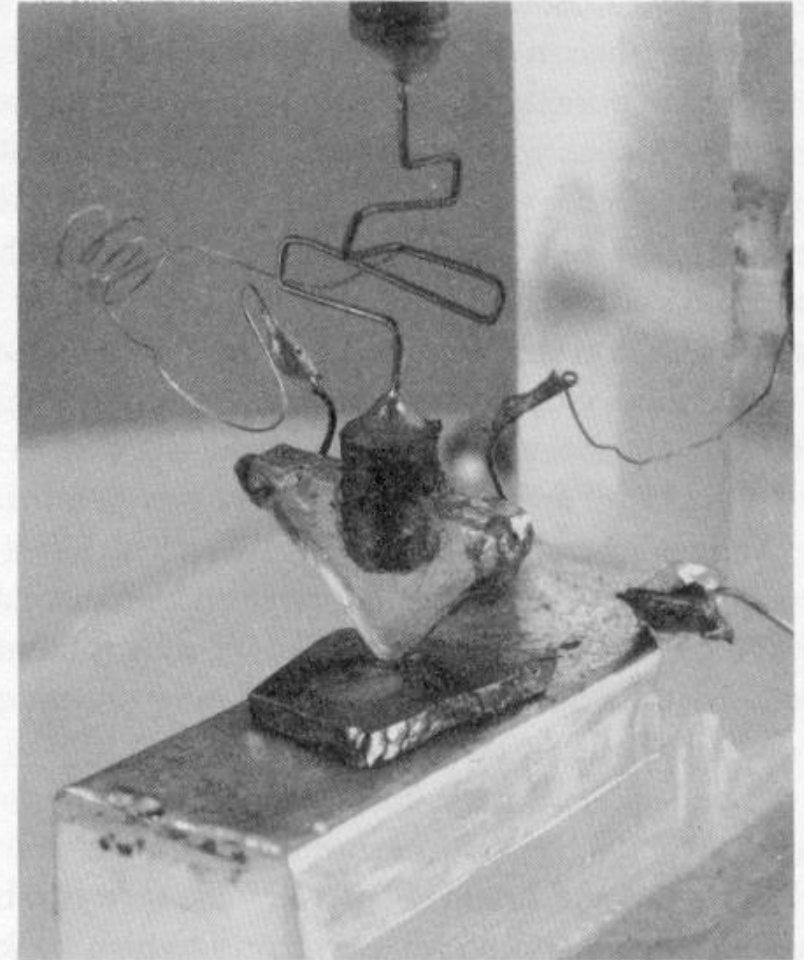
Bardeen, Brattain, and Shockley as featured on the cover of the September 1948 issue of Electronics. Shockley manipulates point contacts using Brattain's laboratory setup.



Point contact transistor 1947

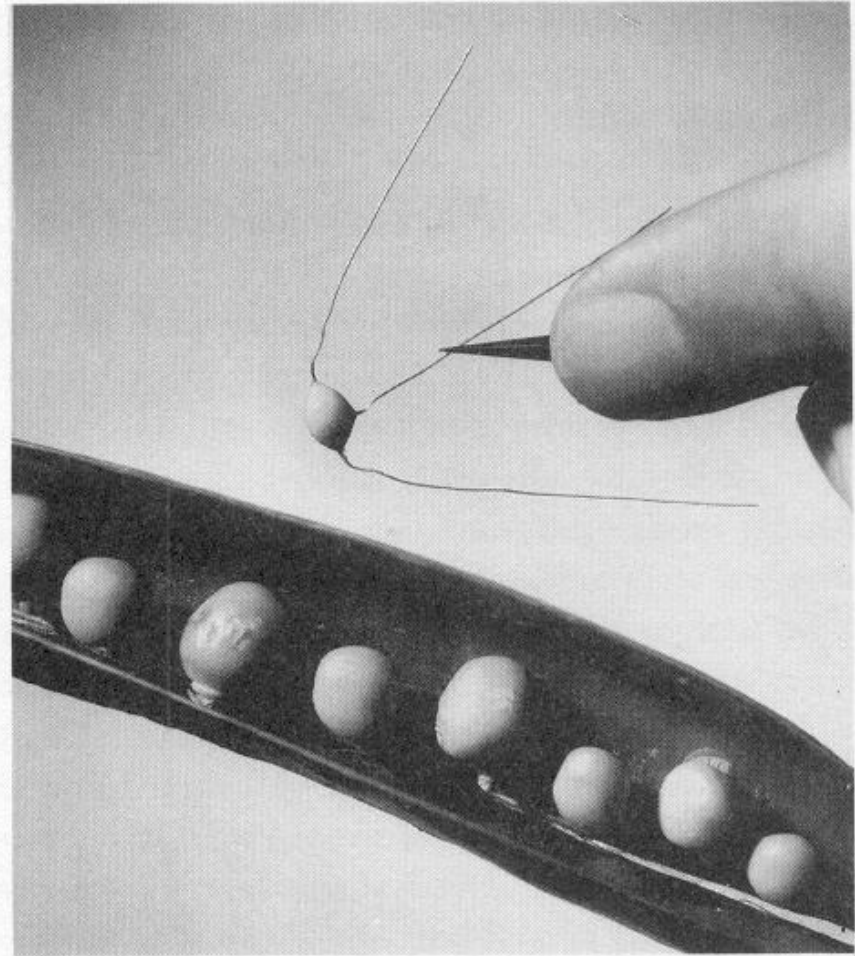


Bardeen and Brattain's point-contact semiconductor amplifier.



Microwatt bipolar junction transistor 1951

The three-legged spidery object is one of the microwatt junction transistors revealed to the press in July 1951.



First integrated circuit (TI, 1958)

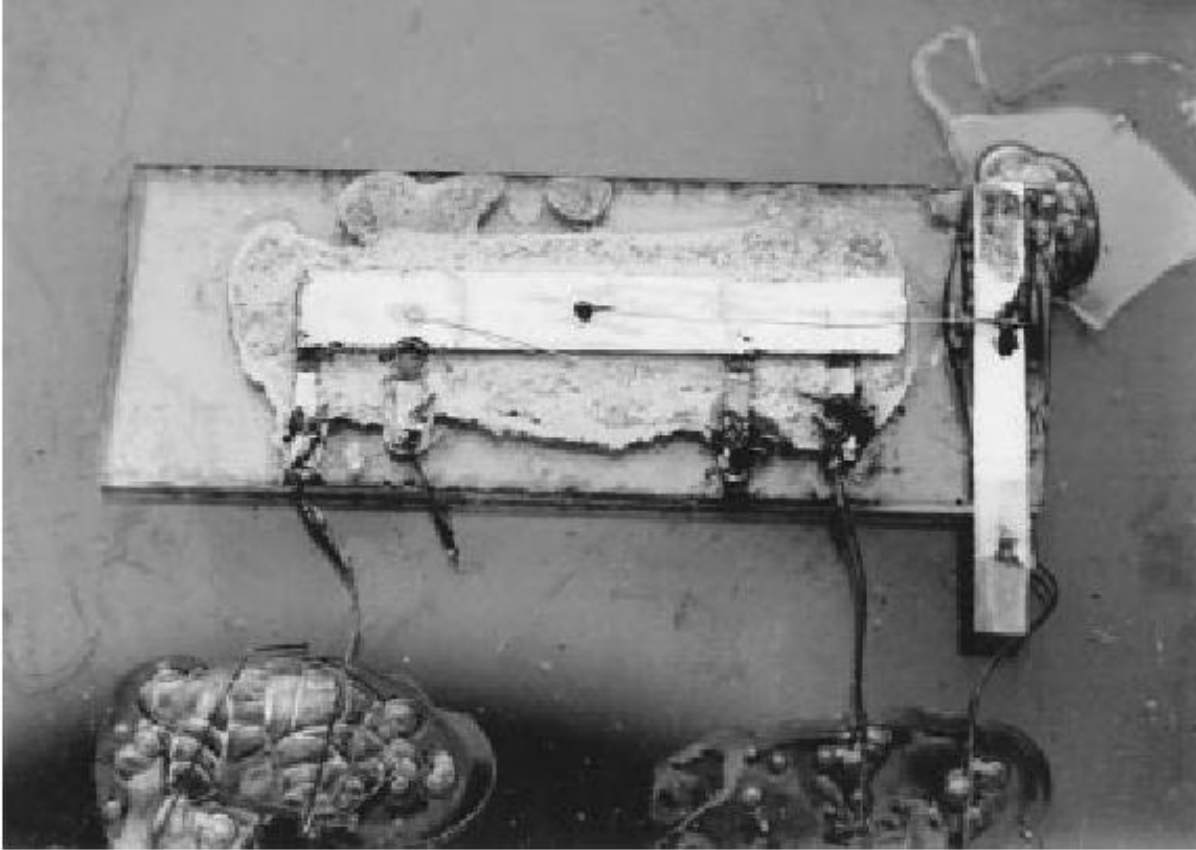
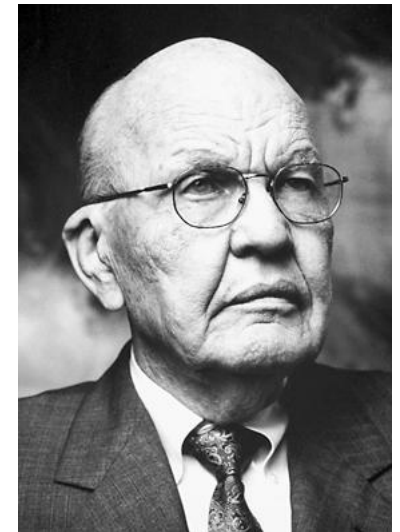
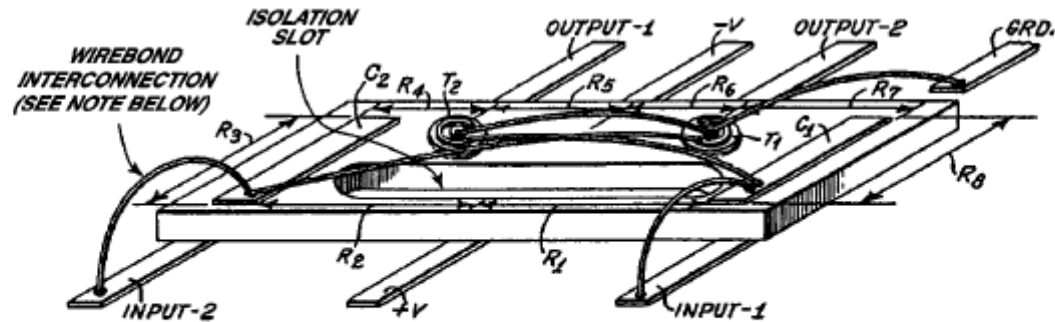


Fig. 2. Kilby's first IC.

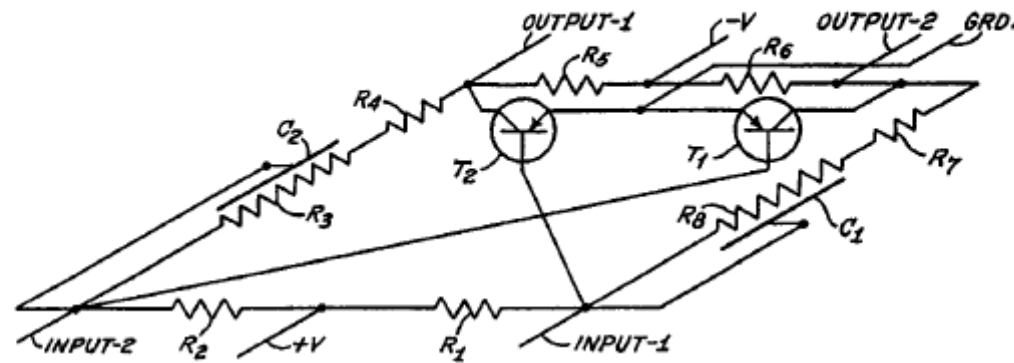


The Nobel Prize in Physics 2000 was awarded "for basic work on information and communication technology" with one half jointly to Zhores I. Alferov and Herbert Kroemer "for developing semiconductor heterostructures used in high-speed- and opto-electronics" and the other half to Jack S. Kilby "for his part in the invention of the integrated circuit".

Schematics of the first IC

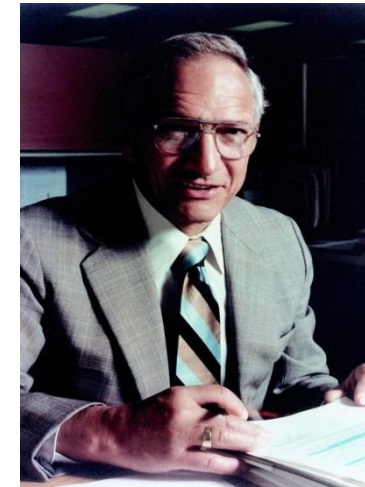


Note: Wirebonds were used several places for interconnection

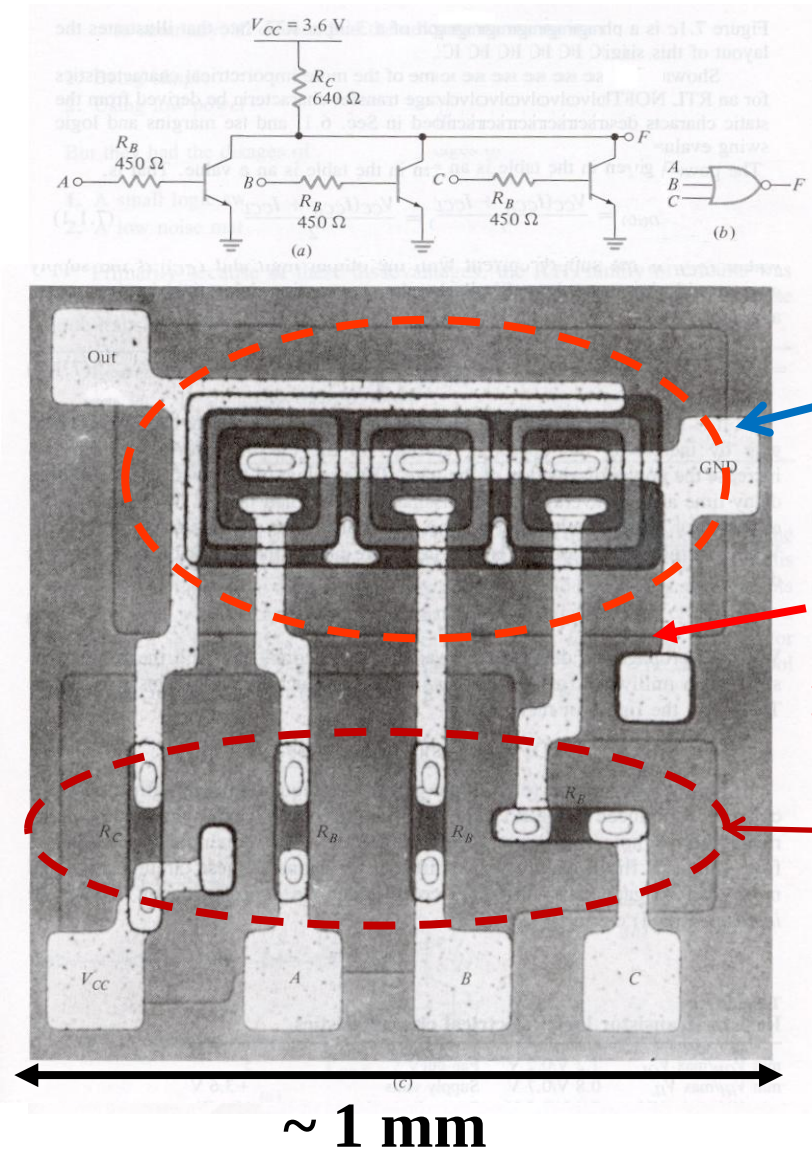


Fairchild

1962: Resistor-transistor logic (TTL) First IC with wide acceptance in the commercial market



Robert Norton Noyce (Dec 12, 1927 – June 3, 1990), nicknamed "the Mayor of Silicon Valley", co-founded Fairchild Semiconductor in 1957 and Intel Corporation in 1968. He is also credited (along with Jack Kilby) with the invention of the integrated circuit or microchip.



Transistors

Connection metal

Resistors

Moore's law

The number of transistors that can be placed on an integrated circuit doubles approximately every two years

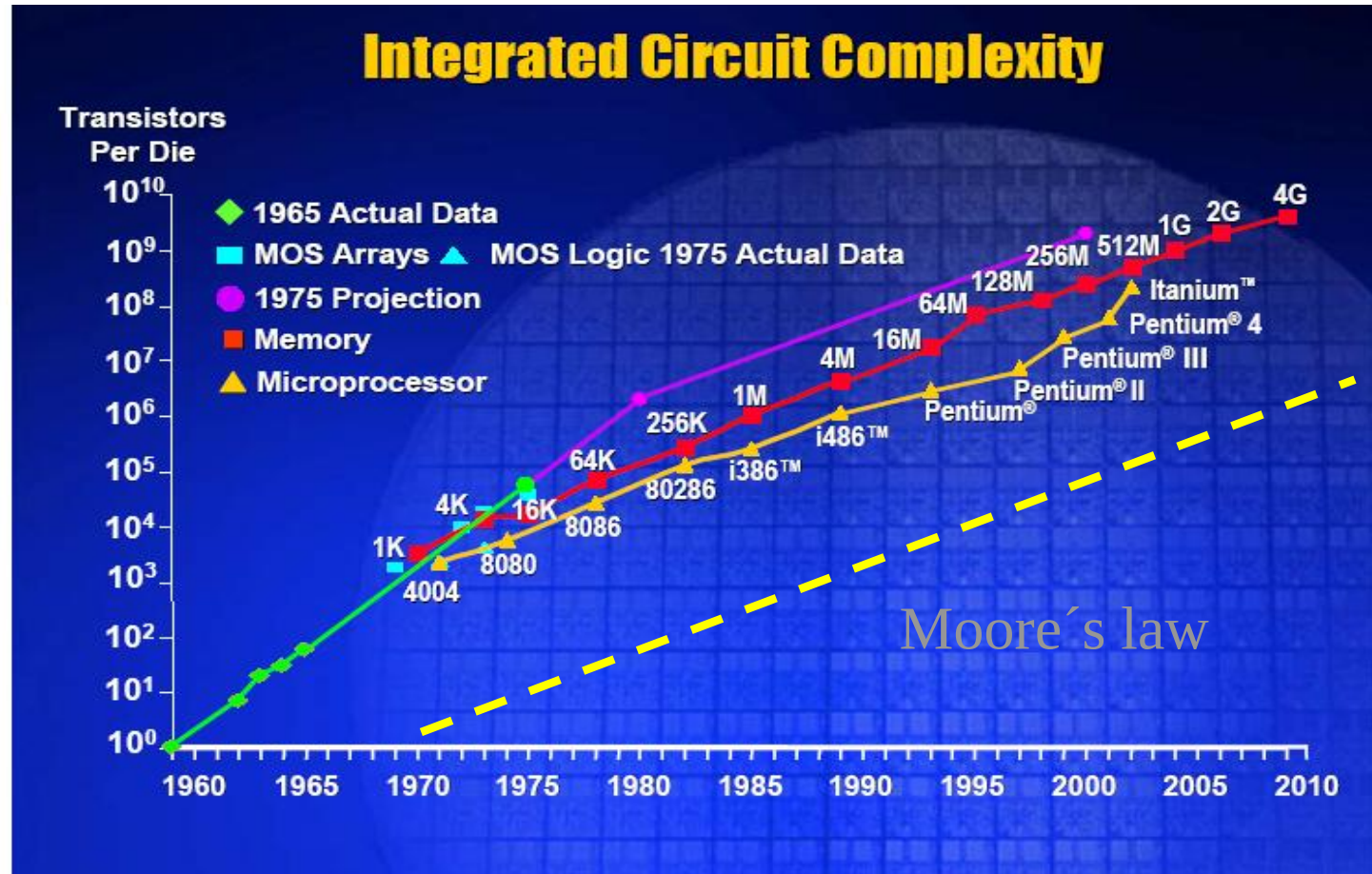


Gordon Moore

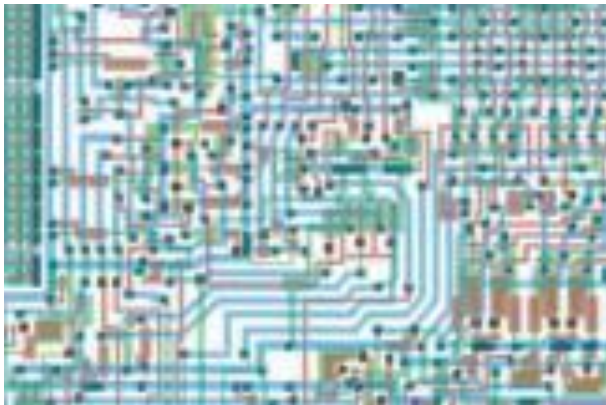
Born	January 3, 1929 (age 91) San Francisco, California, USA
Nationality	American
<i>Alma mater</i>	<u>University of California, Berkeley</u> ; <u>California Institute of Technology</u>
Occupation	Retired / Chairman Emeritus, co-founder and former Chairman and CEO of <u>Intel Corporation</u>
Net worth	\$11.9 billion USD (2019) [[]

Moore's law

Transistors/chip x time



Moore's law



General Info

Launched	late 1971
Discontinued	1981
Common manufacturer(s)	•Intel

Performance

Max. <u>CPU clock rate</u>	740 kHz
Data width	4 bits
Address width	12 (multiplexed)

Architecture and classification

Application	Busicom calculator, arithmetic manipulation
<u>Min. feature size</u>	<u>10 μm</u>
<u>Instruction set</u>	4-bit <u>BCD</u> oriented
<u>Transistors</u>	•2,250

Moore's law

A 32 nm, 3.1 billion transistor,
12 wide issue Itanium® Processor
for Mission-Critical Servers



32 nm CMOS technology
9 layers of Cu
Die measures 18.2 mm by 29.9 mm
Maximum thermal design power 170 W

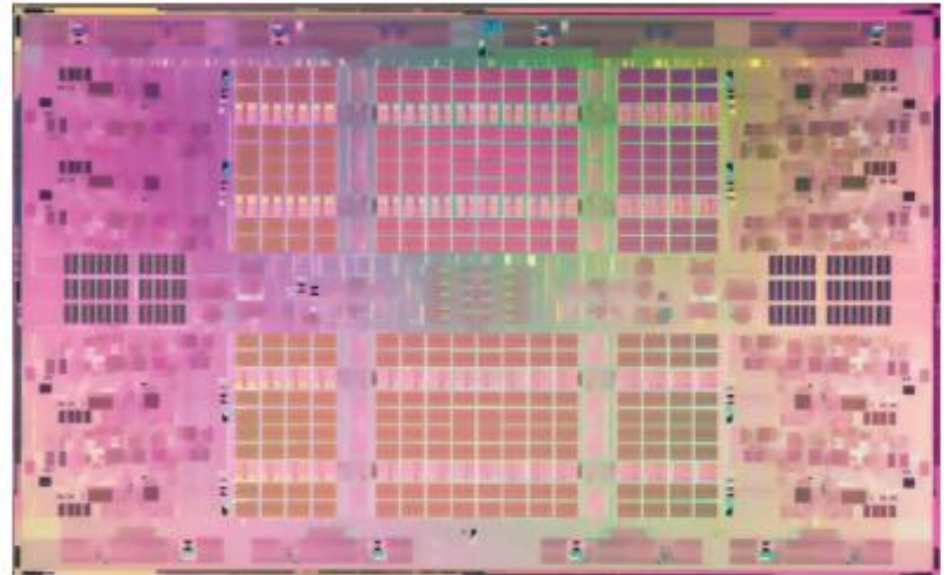
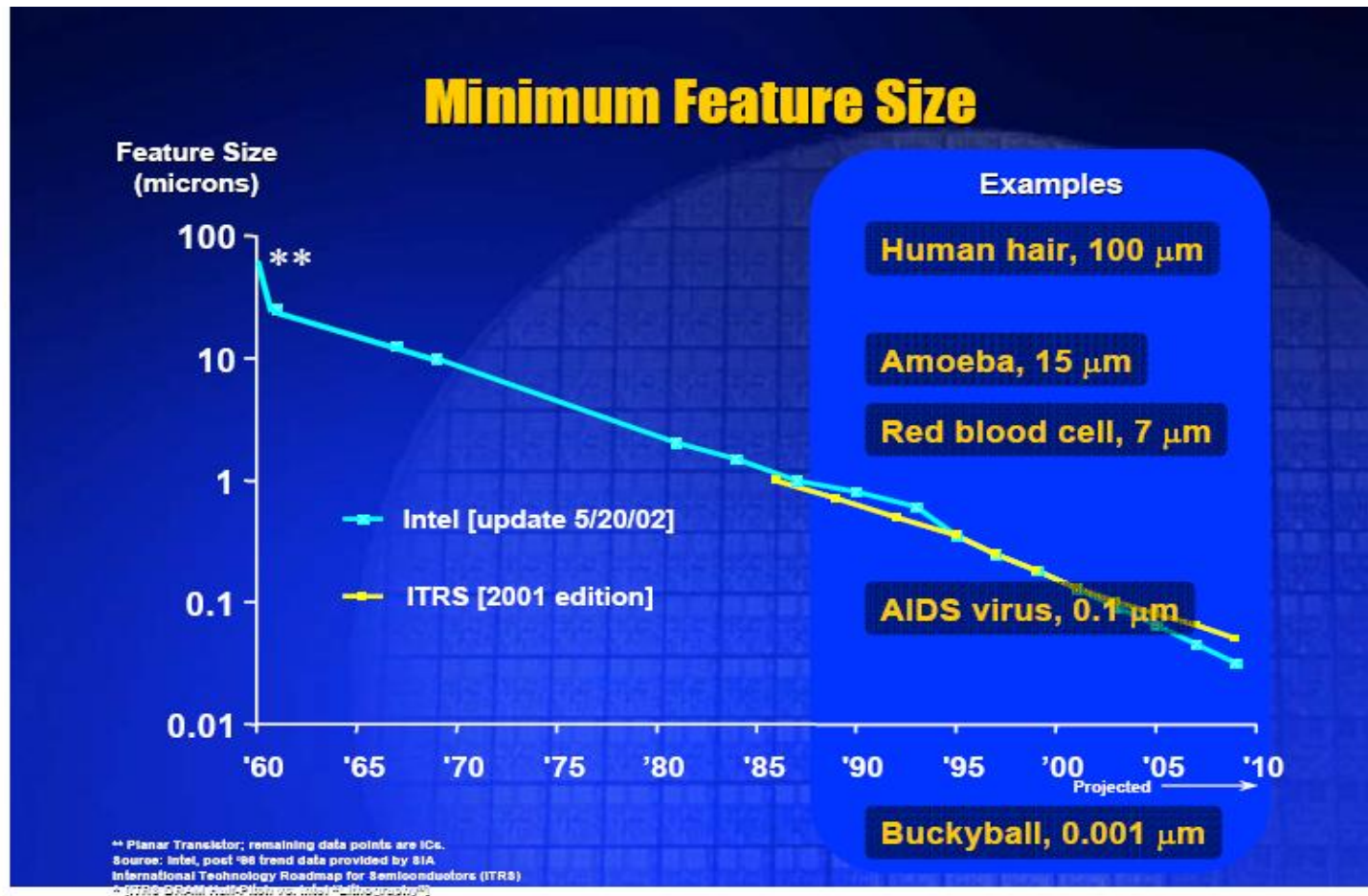


Figure 1: Poulson Die Photo

Moore's law

Minimum feature size x time



Moore's law

Average price (US\$)/transistor x time



Source: Intel

Electronics

~10 X reduction/5-year period

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