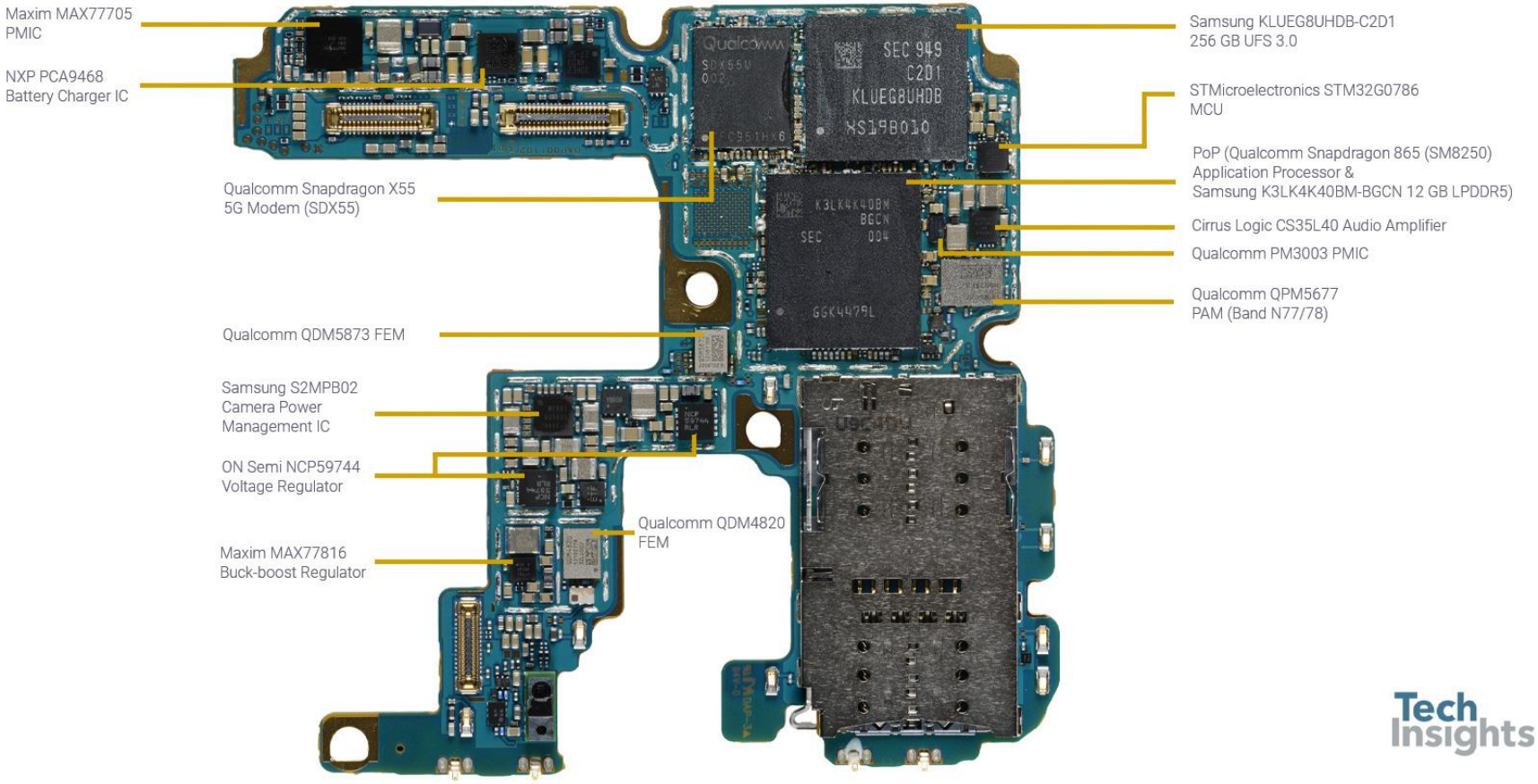
4K

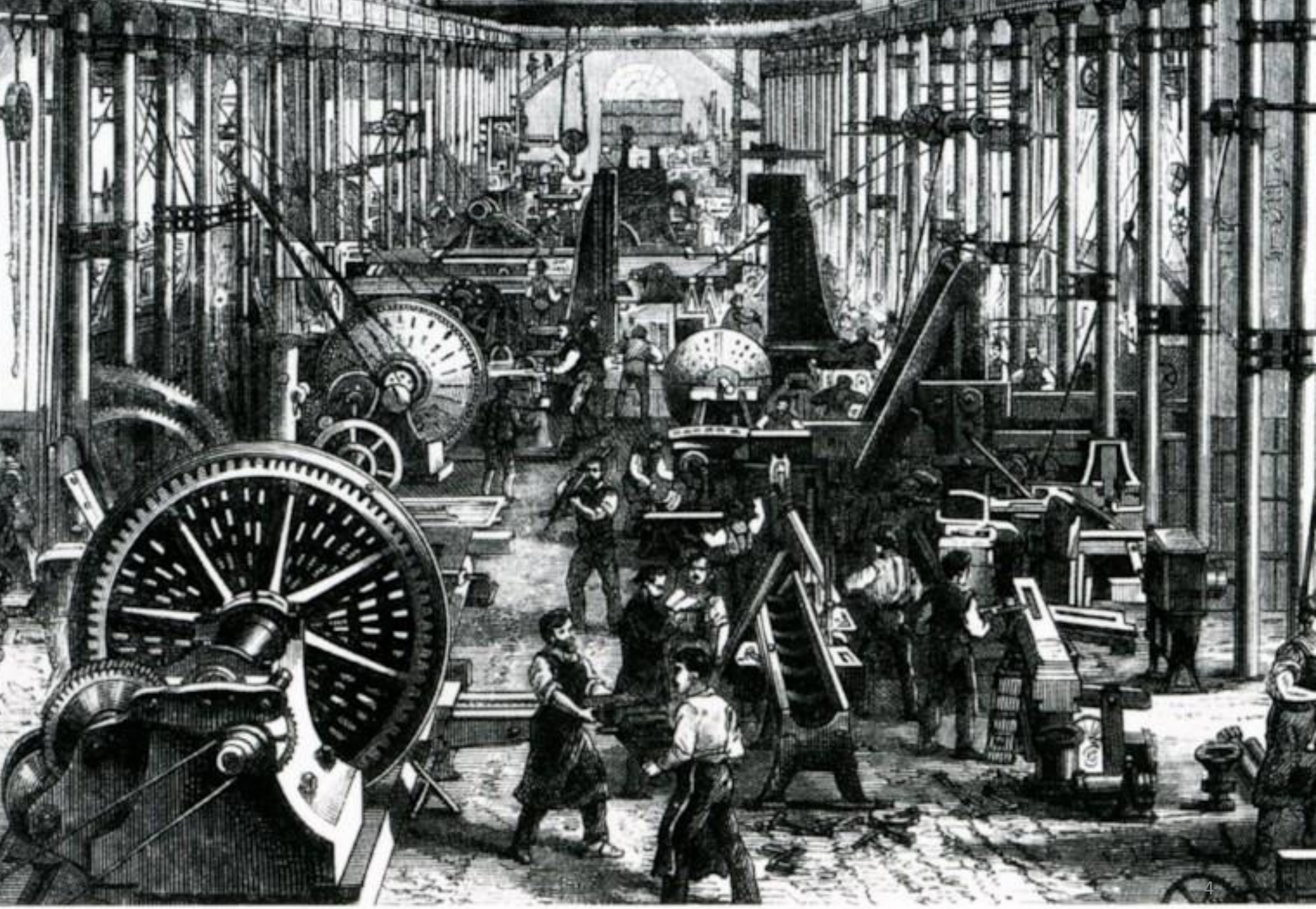
Tear-Down of Galaxy Note 20



Introduction on Digital Integrated Circuit

Hanwool Jeong

hwjeong@kw.ac.kr

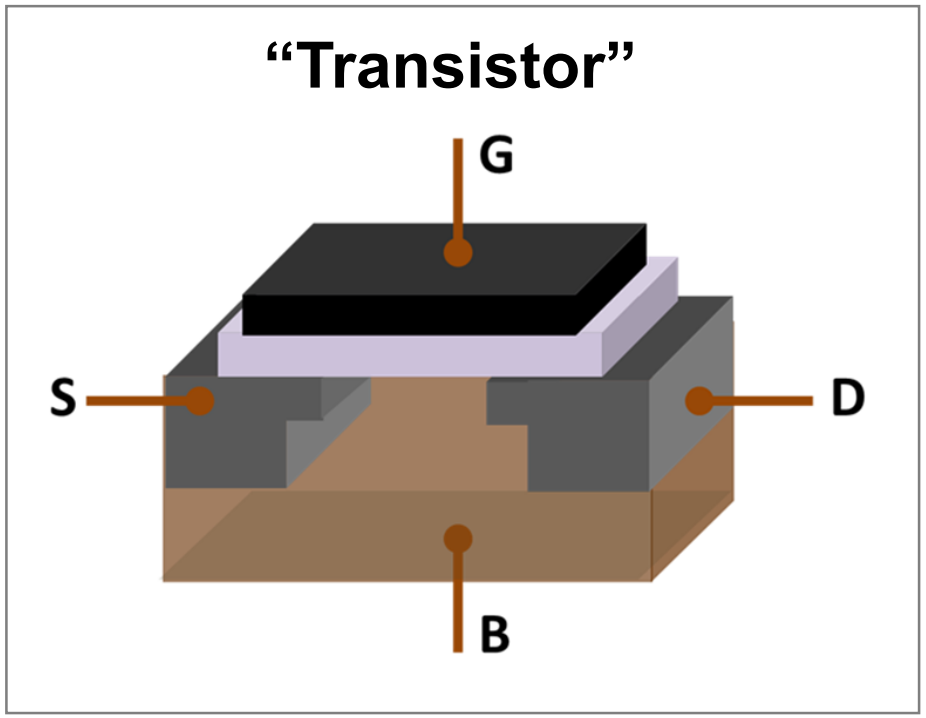


Development of Engineering Technology

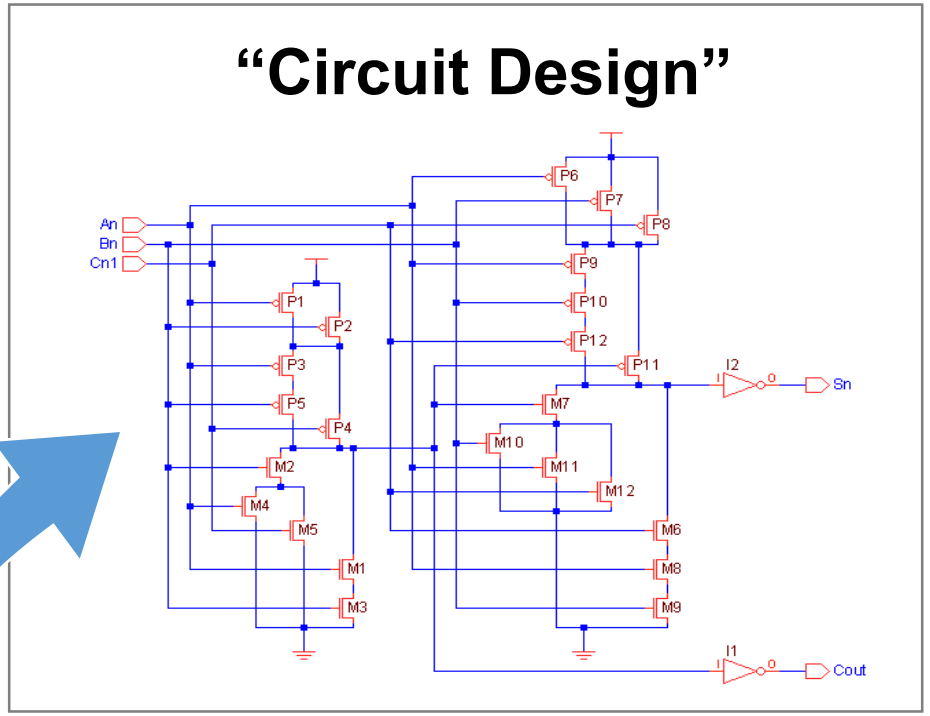
- 1st Industrial Revolution : Water/Steam energy → Mechanical
- 2nd Industrial Revolution : Electrical energy → Mechanical
- Key is that
  - How we can utilize energy
  - Then make a machine doing a useful work, with the energy.

I · A · T · R · P = 1.21×10^5
= 8.613×10^-5 sr
A_AM = 3×10 cm
P = .17534
cm^-1 sec^-1 sr^-1
M = π(.26π/180)

How Can We Make Machine “Calculate”?

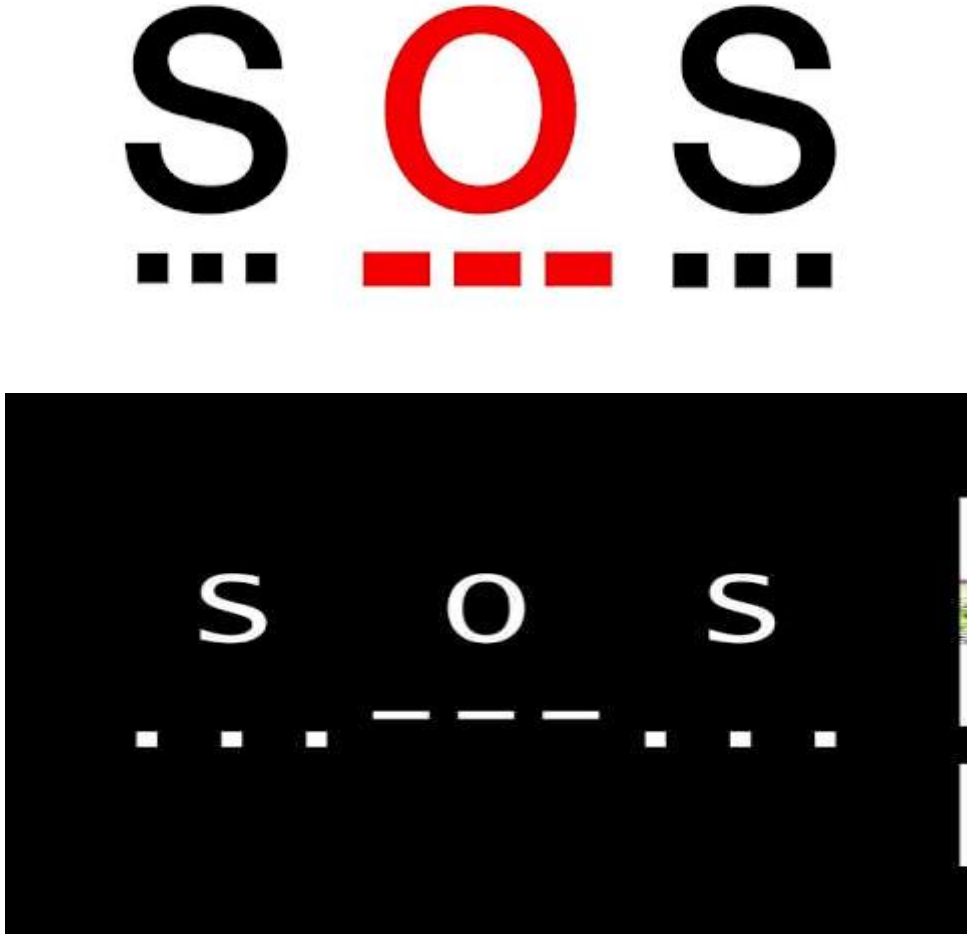


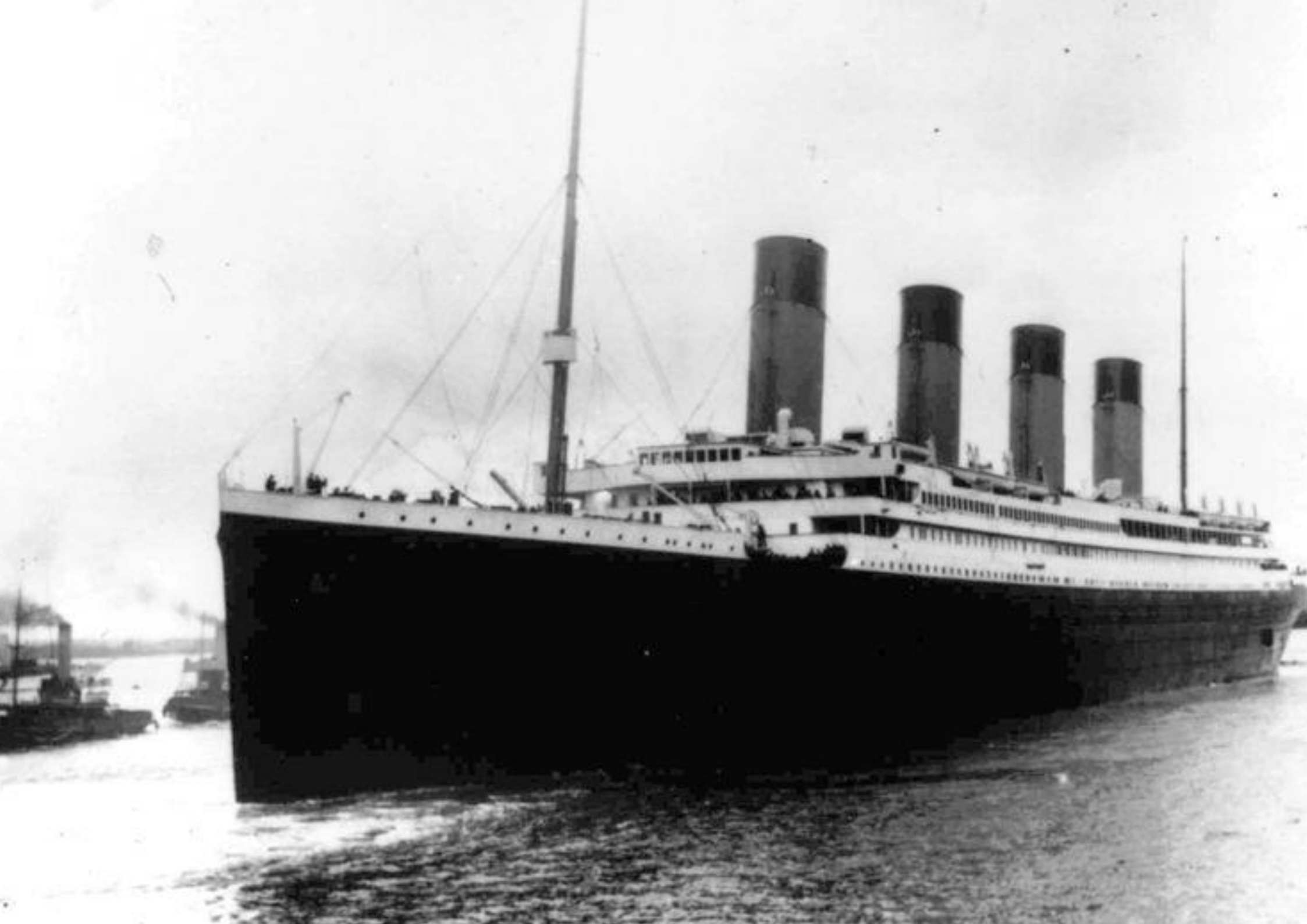
+



Operated with “Electrical Energy”

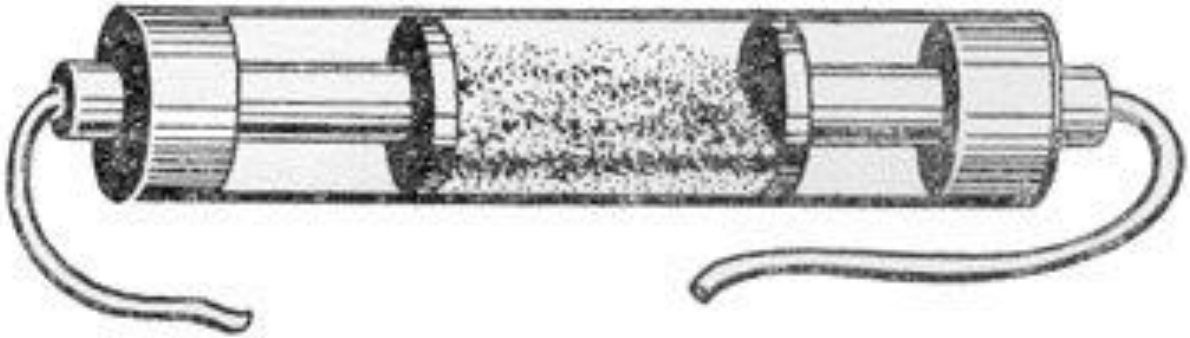
Morse Code of SOS

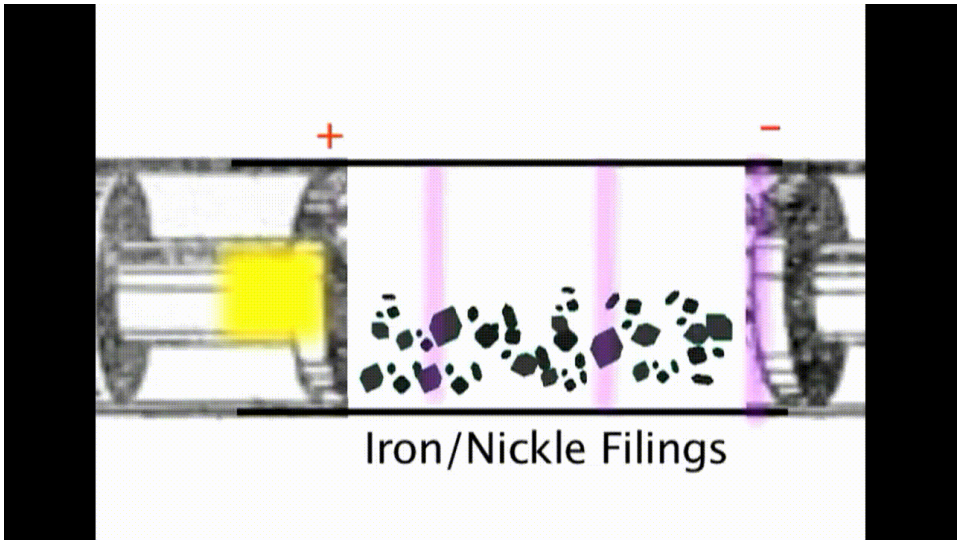




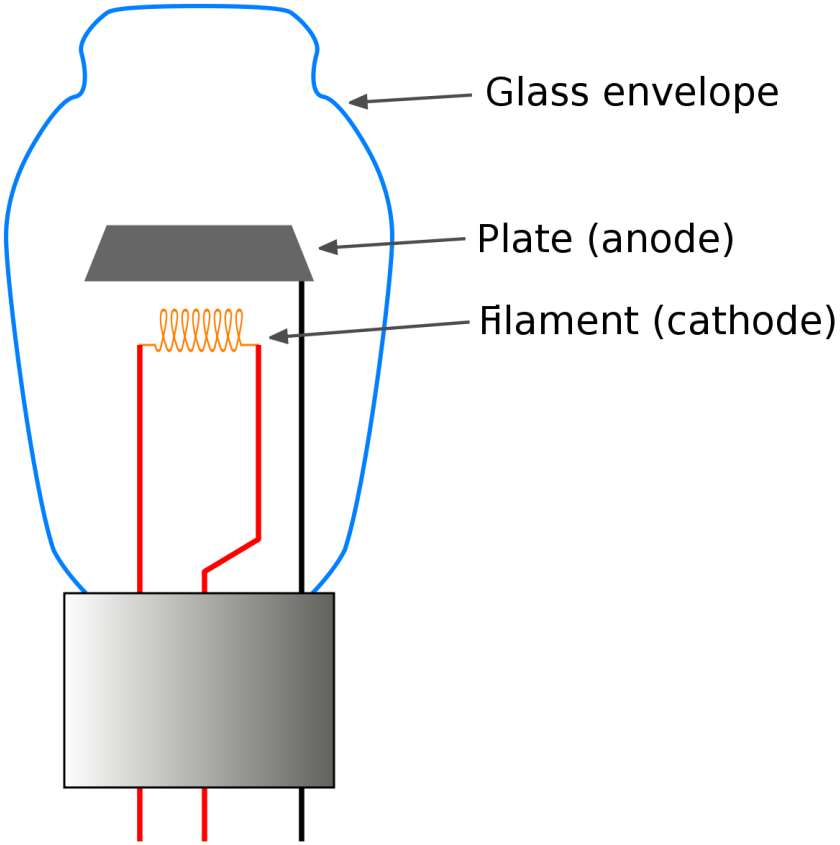
Coherer

- Key component enable signal reception ➔ It Rectifies!

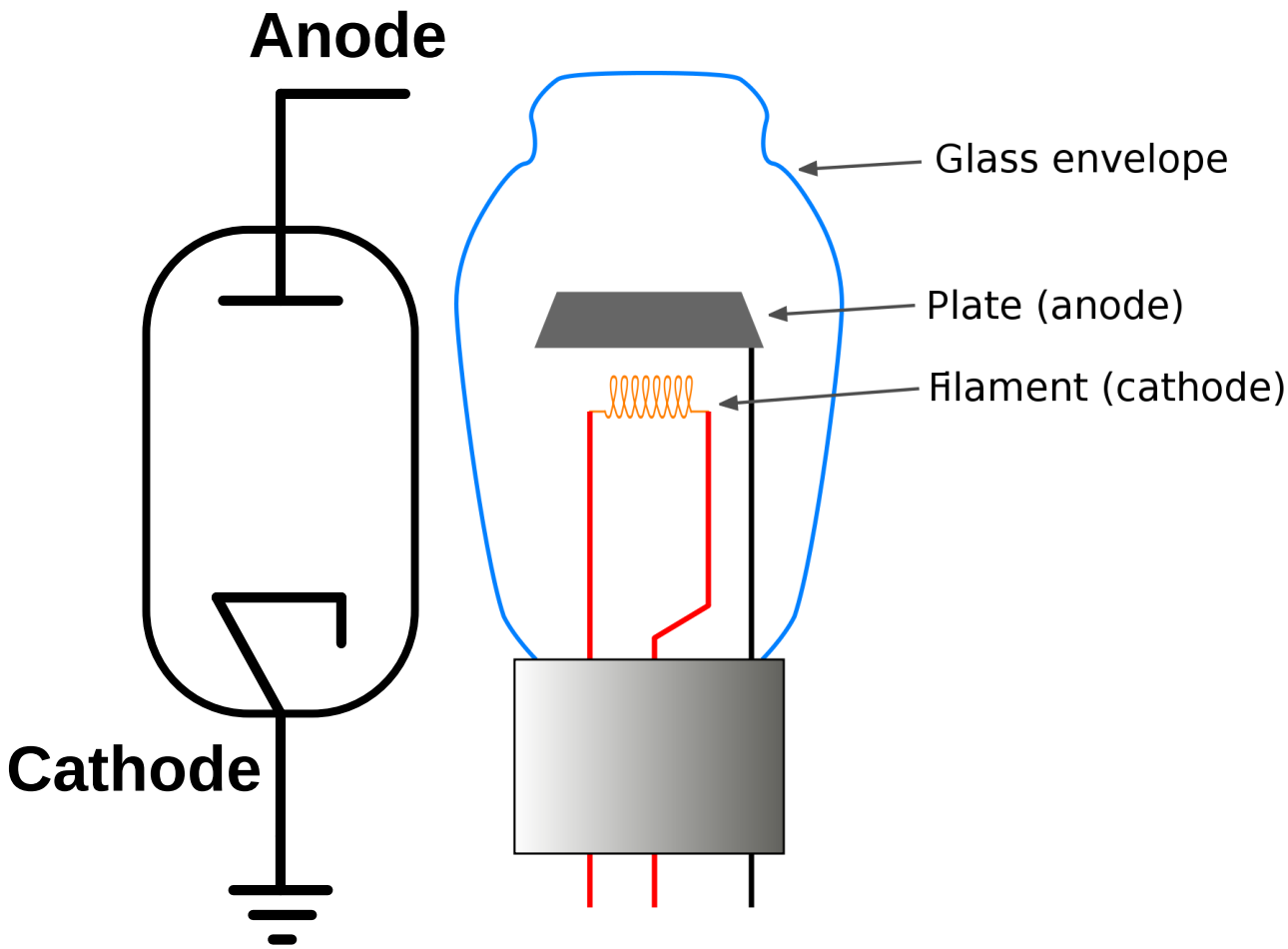




Vacuum Tube

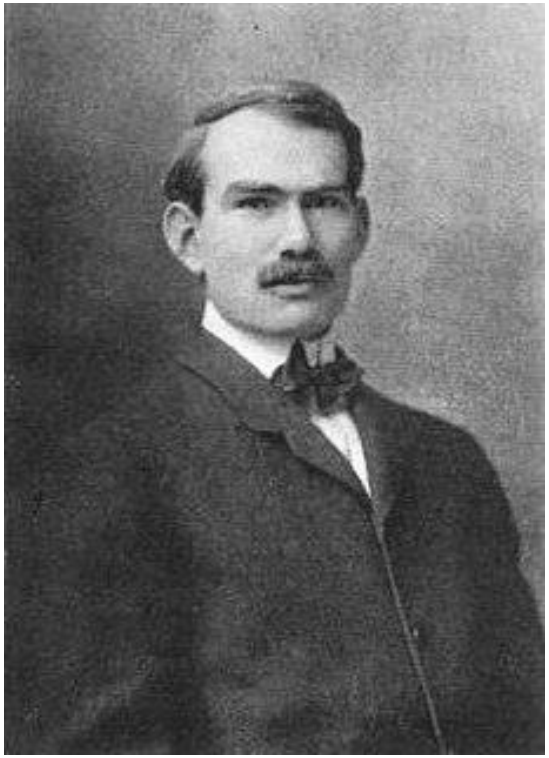


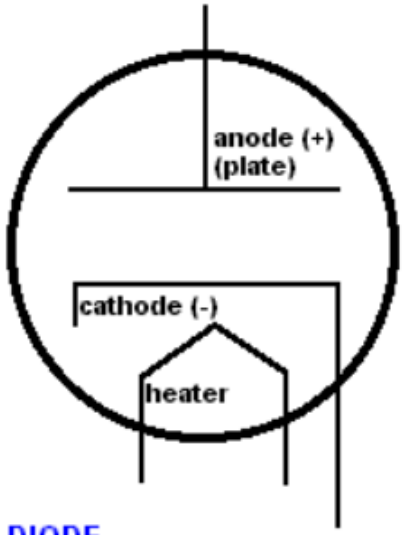
How Does It Works?



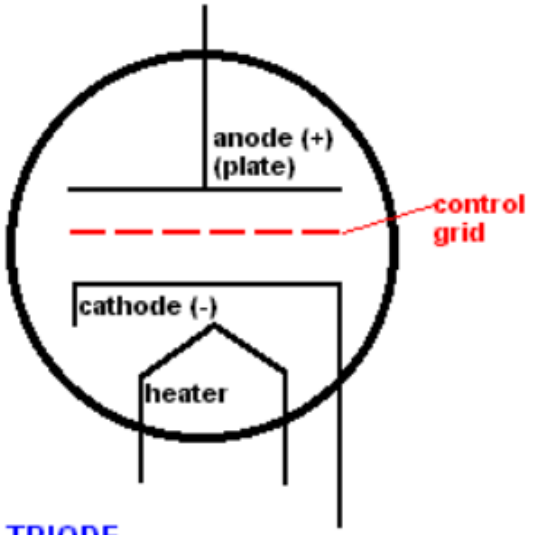
Vacuum Tube as Triode

- 1906 Lee de Forest (1873-1961)





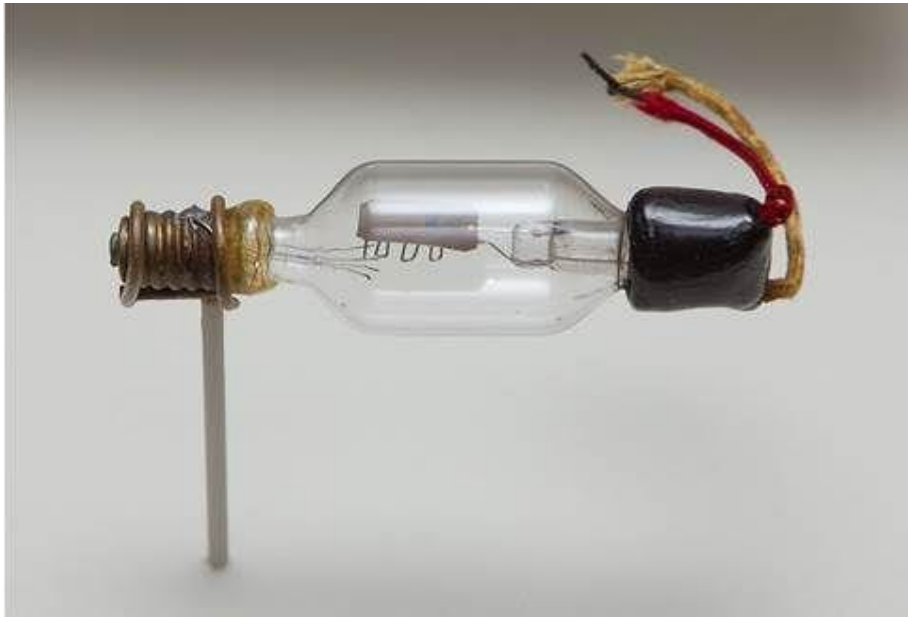
DIODE



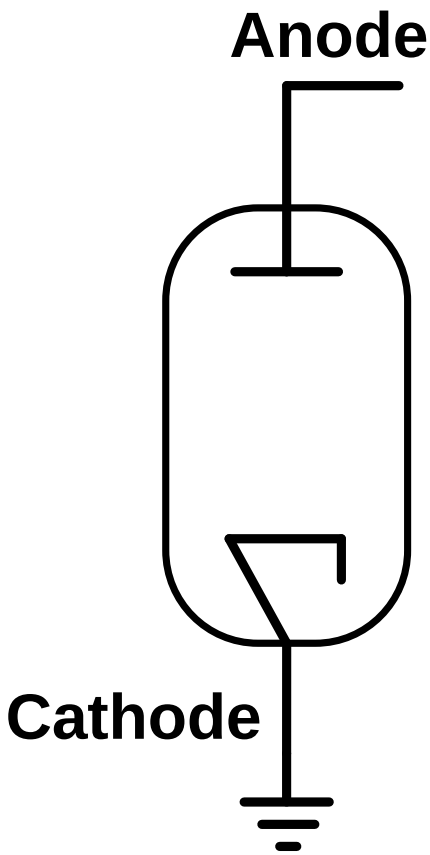
TRIODE

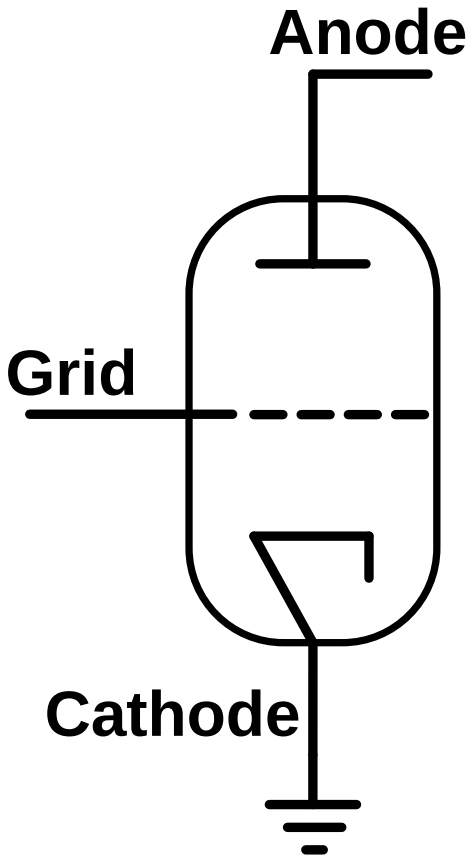
Audion by Lee de Forest

- In the patent filed,
- “The object of the invention is to provide an audion circuit which is simple and particularly adapted for amplification usage of the audion ….”



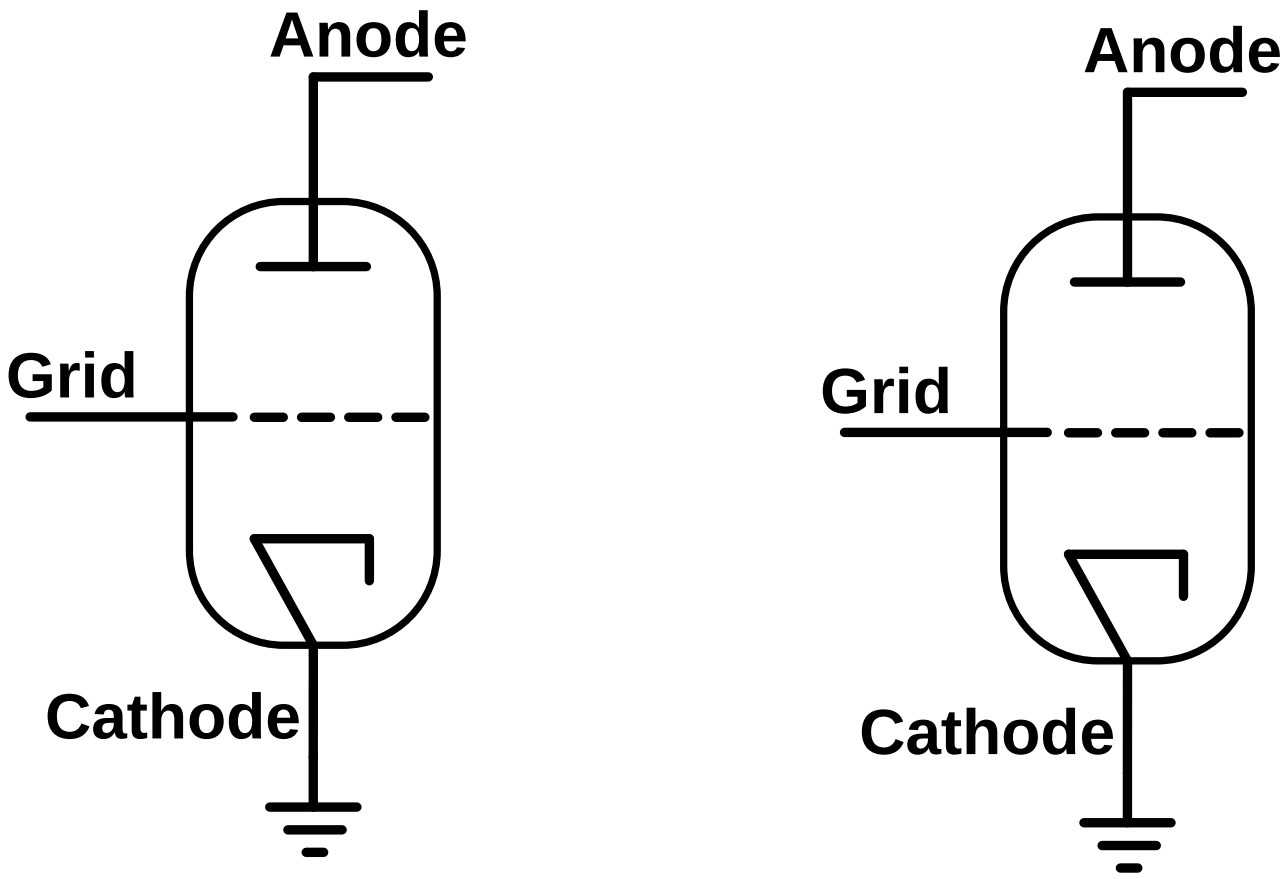
Diode vs. Triode Vacuum Tube



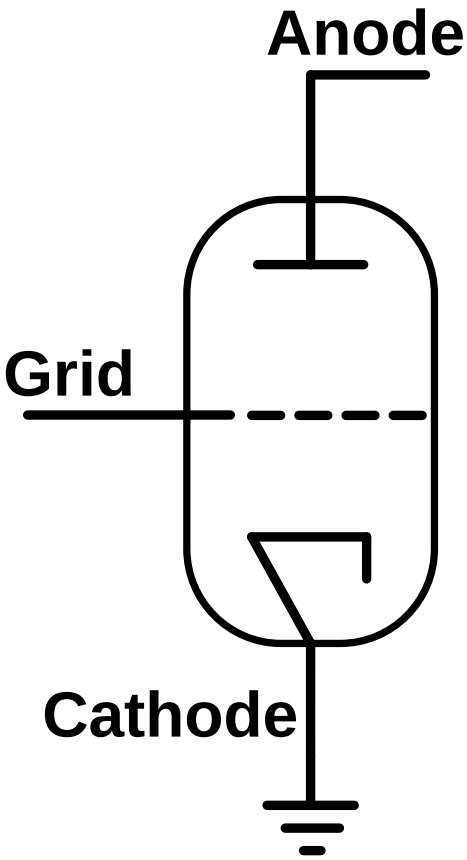


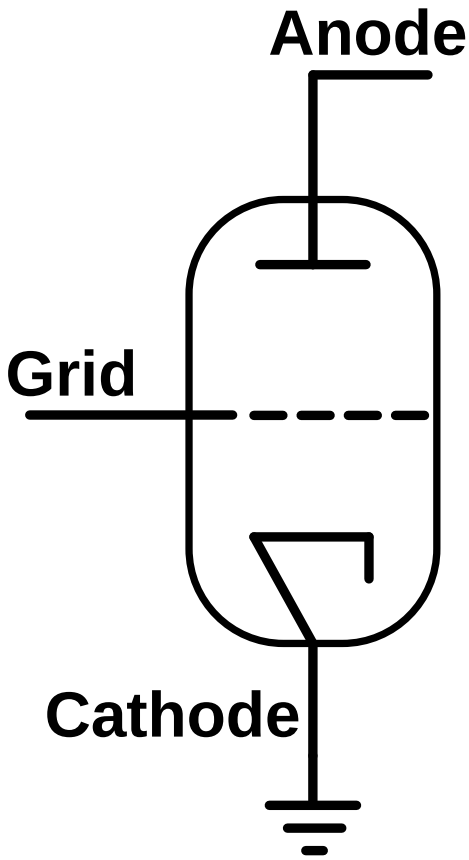
Nobsound
POWER
VU
VU
VOLUME
MAX

Two Extreme Voltages For Grid

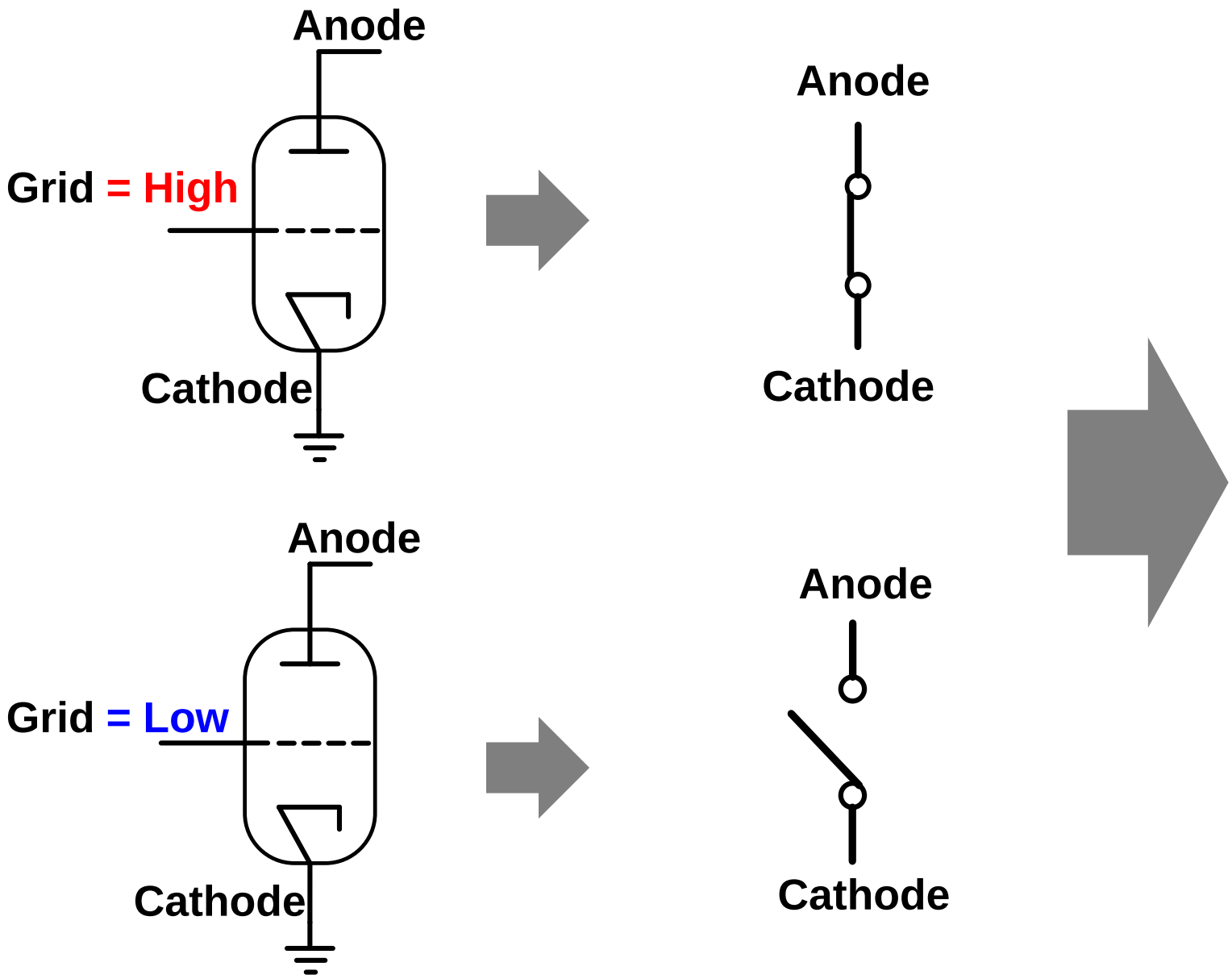


Vacuum Tube As Amplifier vs. Switch





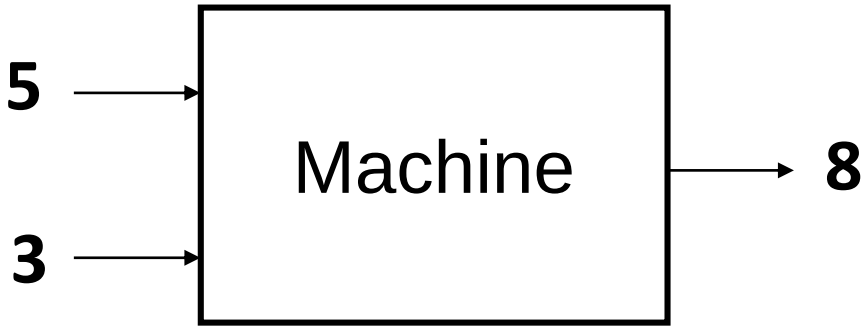
Switch Operation of Vacuum Tube



Remember Our Goal!

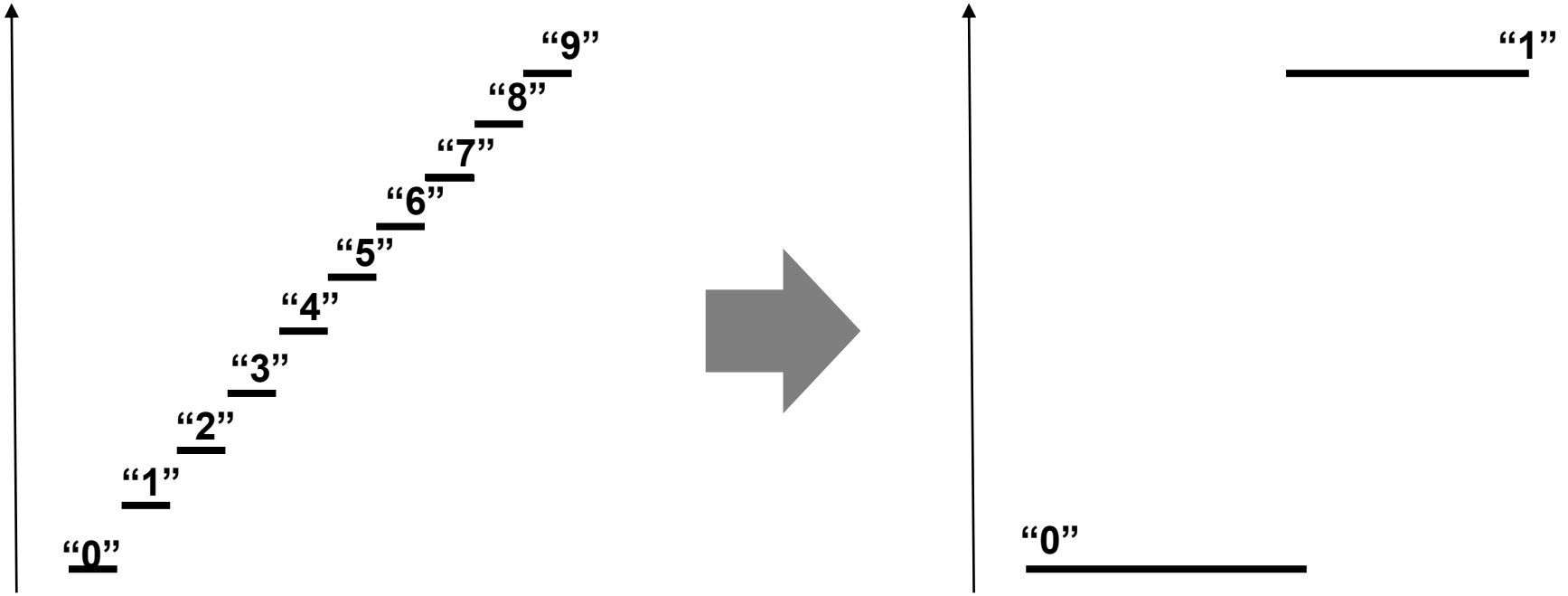
Example

- Add!



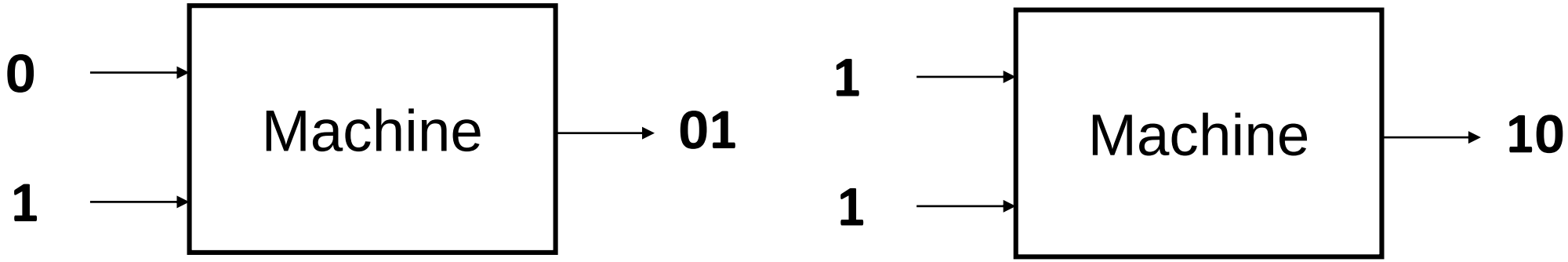
Mapping Number to Voltage

- To utilize the switch characteristic of vacuum tube



Example

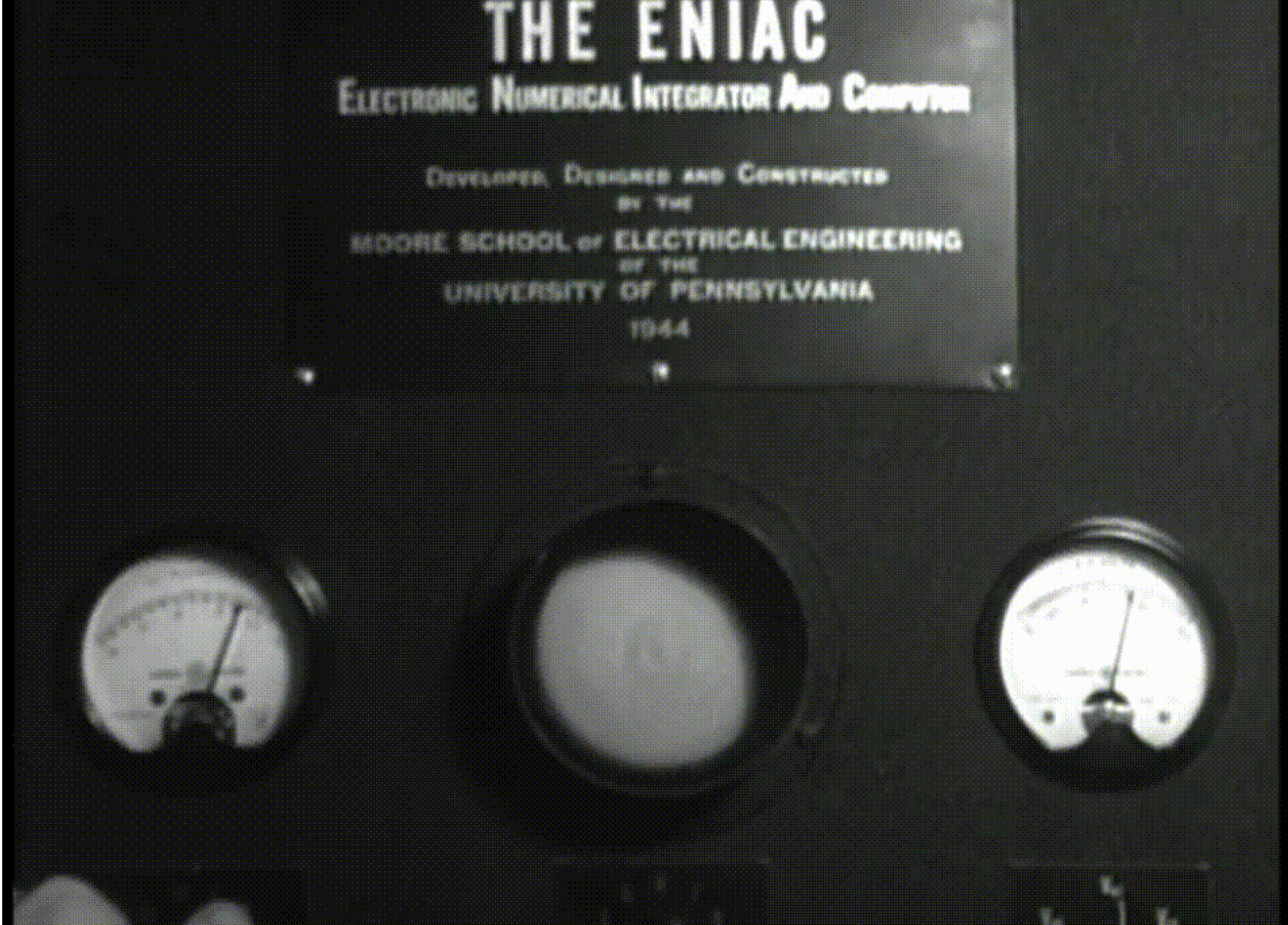
- Add!



How?

- Goal

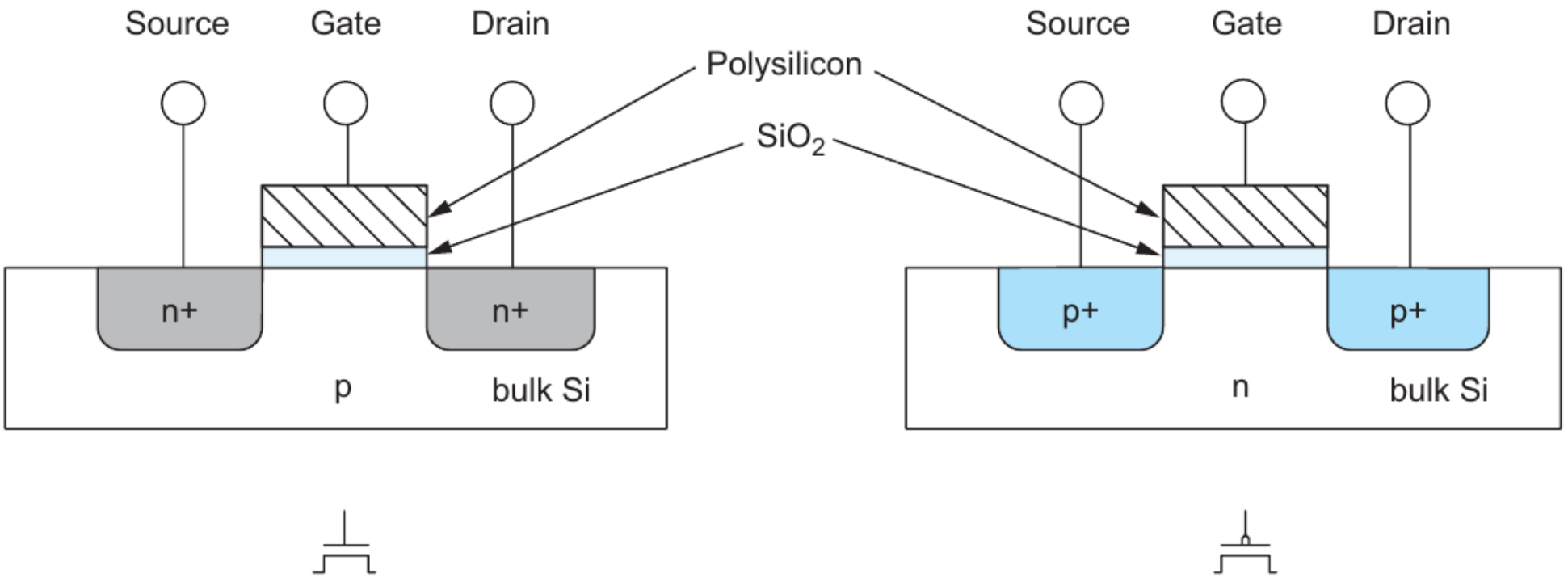
A	B	Y[1]	Y[0]
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0


THE ENIAC
ELECTRONIC NUMERICAL INTEGRATOR AND COMPUTER
DEVELOPED, DESIGNED AND CONSTRUCTED
BY THE
MOORE SCHOOL OF ELECTRICAL ENGINEERING
OF THE
UNIVERSITY OF PENNSYLVANIA
1944

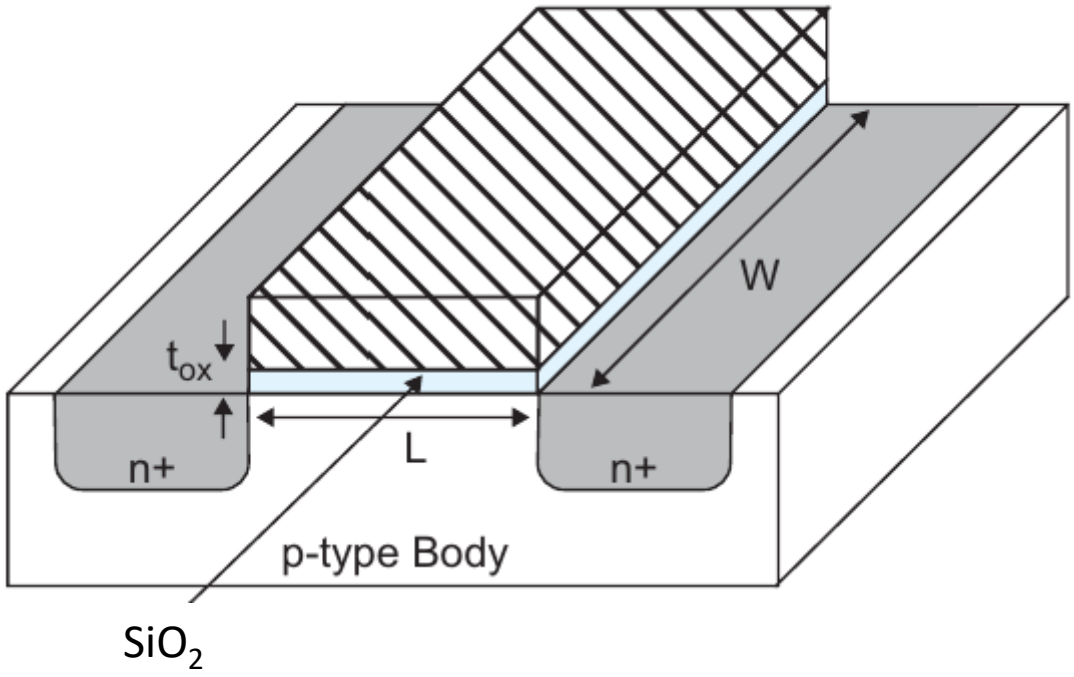
Mohamed Atalla

Dawon Kahng

MOSFET

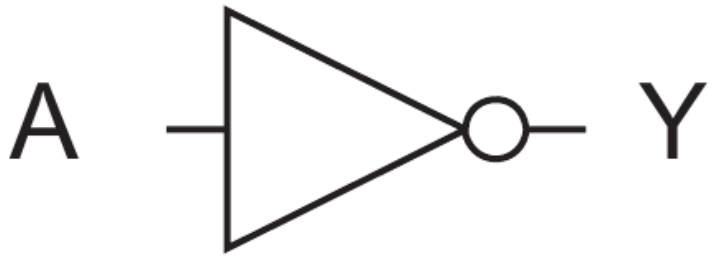

Source
Gate
Drain
Polysilicon
SiO_2
n+
n+
p
bulk Si
Source
Gate
Drain
p+
p+
n
bulk Si

NMOSFET

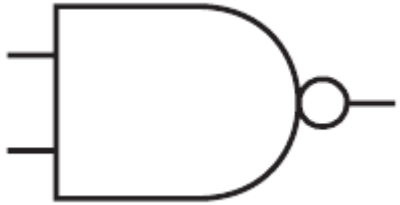


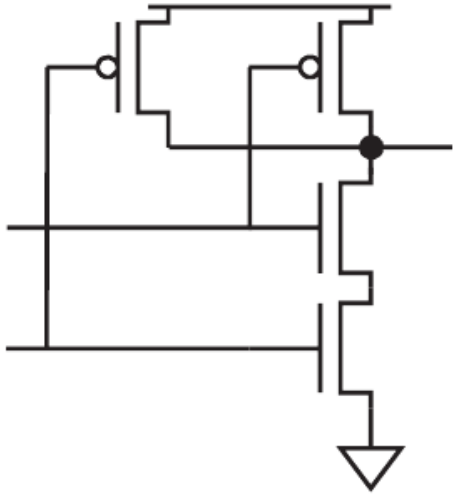
NMOSFET vs. PMOSFET

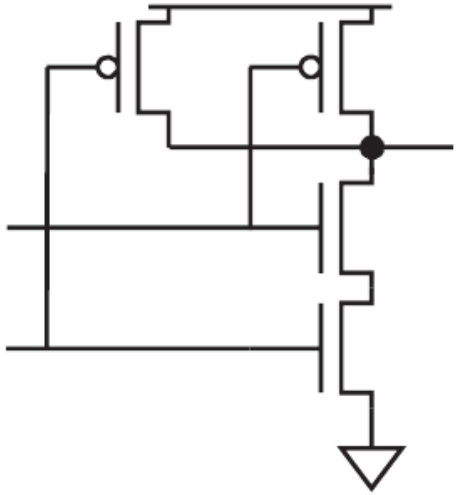
Inverter Gate

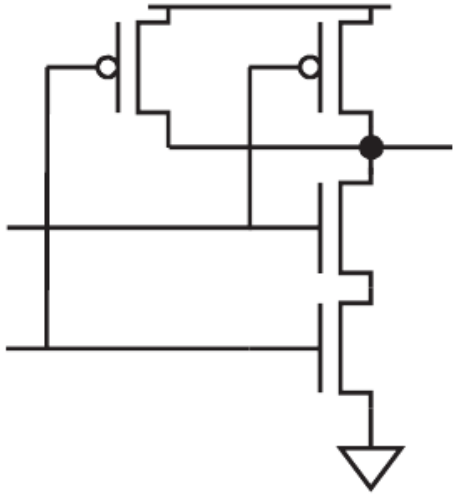


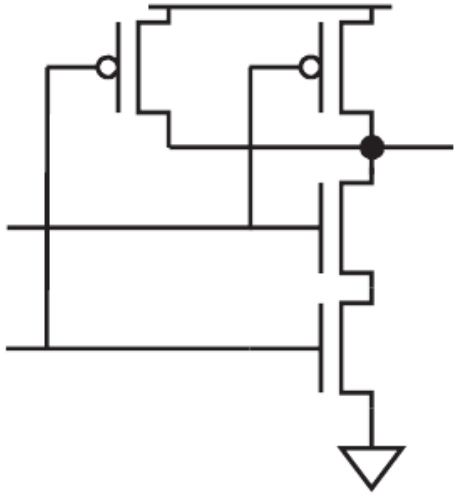
NAND2 Gate



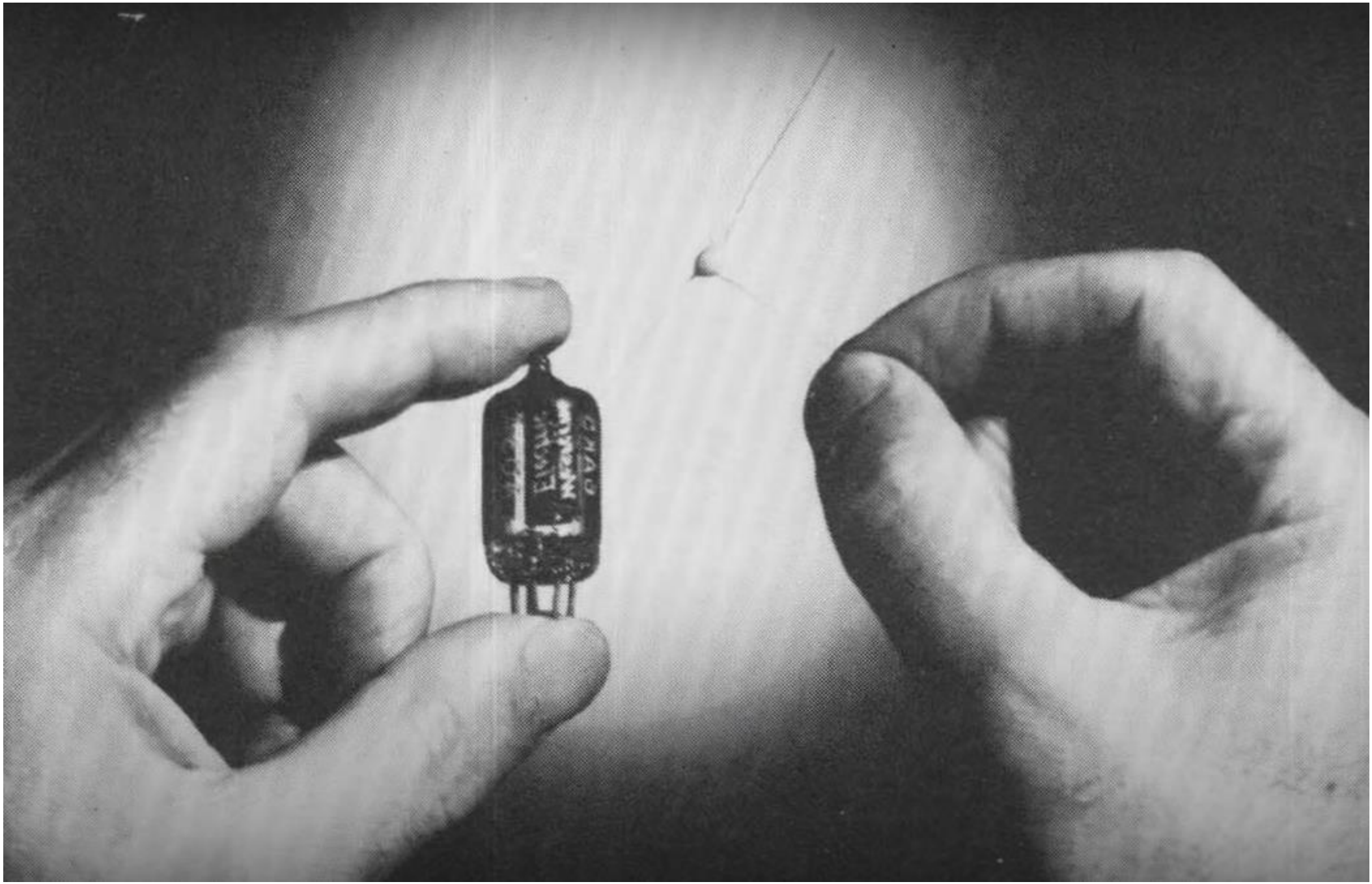






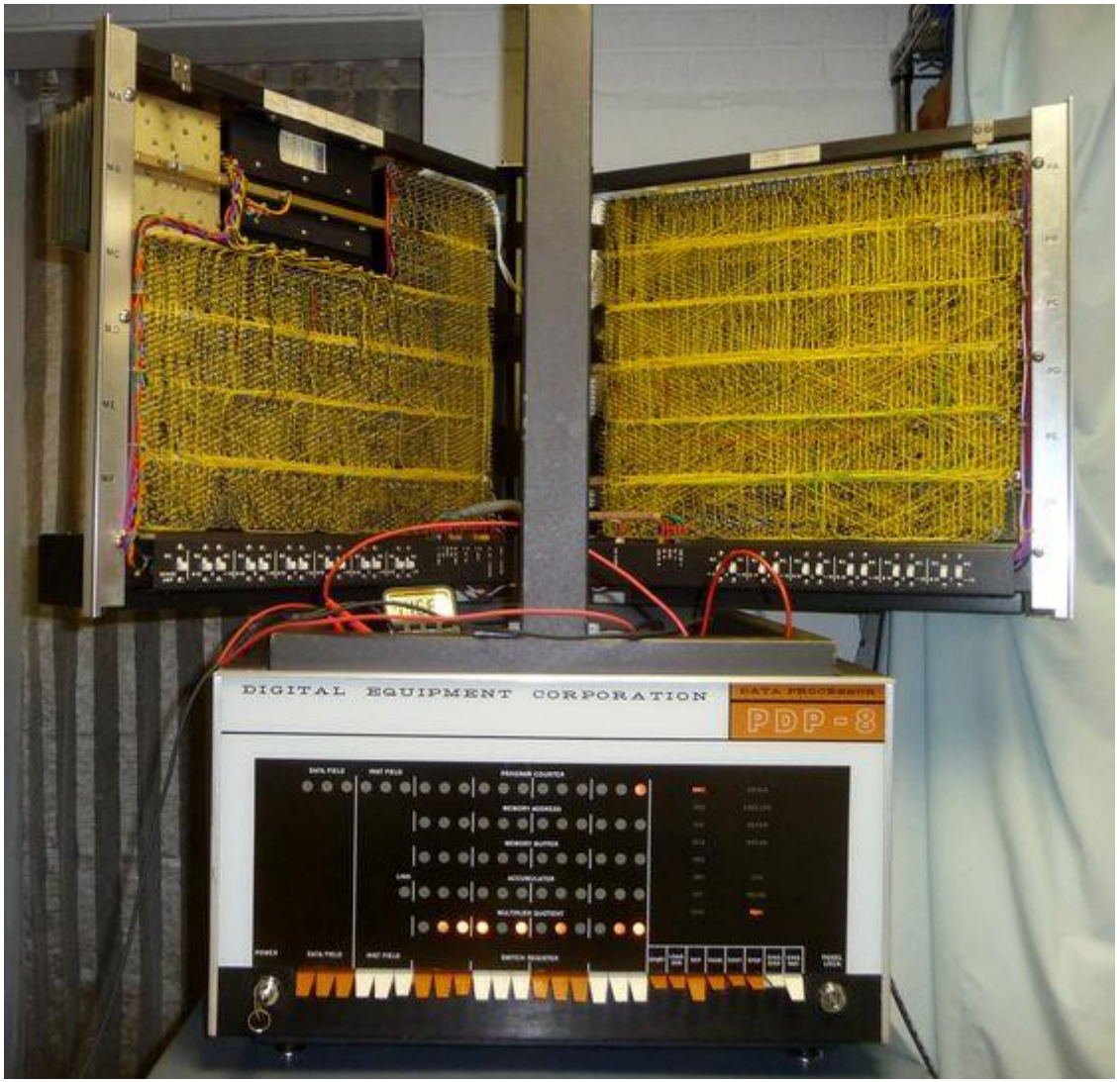


Adder Revisit



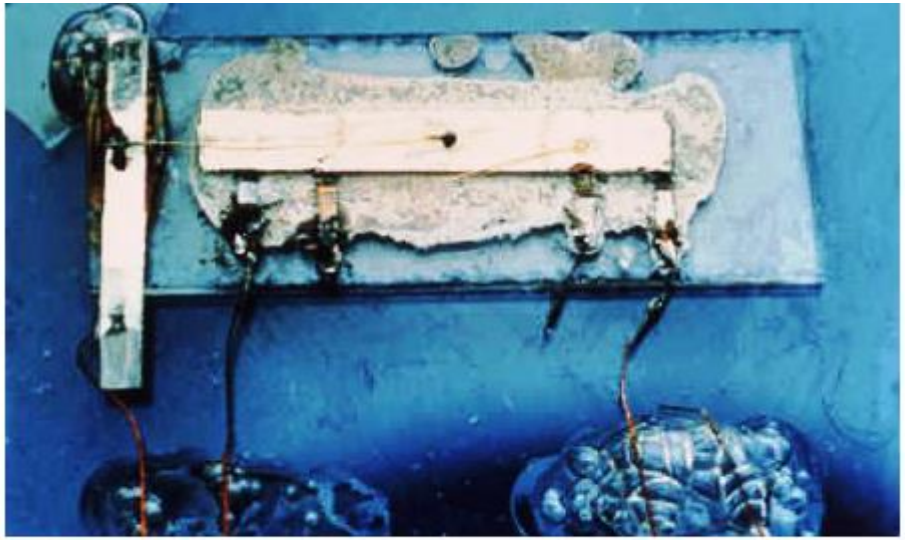
Can Transistor Solve Problem of the Vacuum Tube?

- Yes, but..

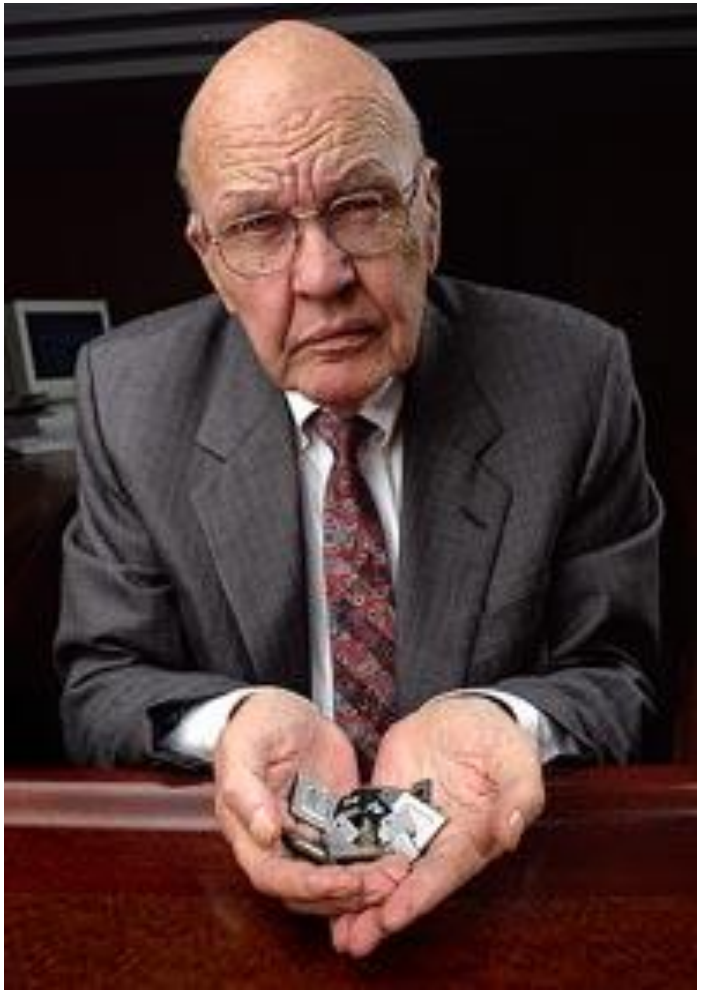


Integrated Circuit

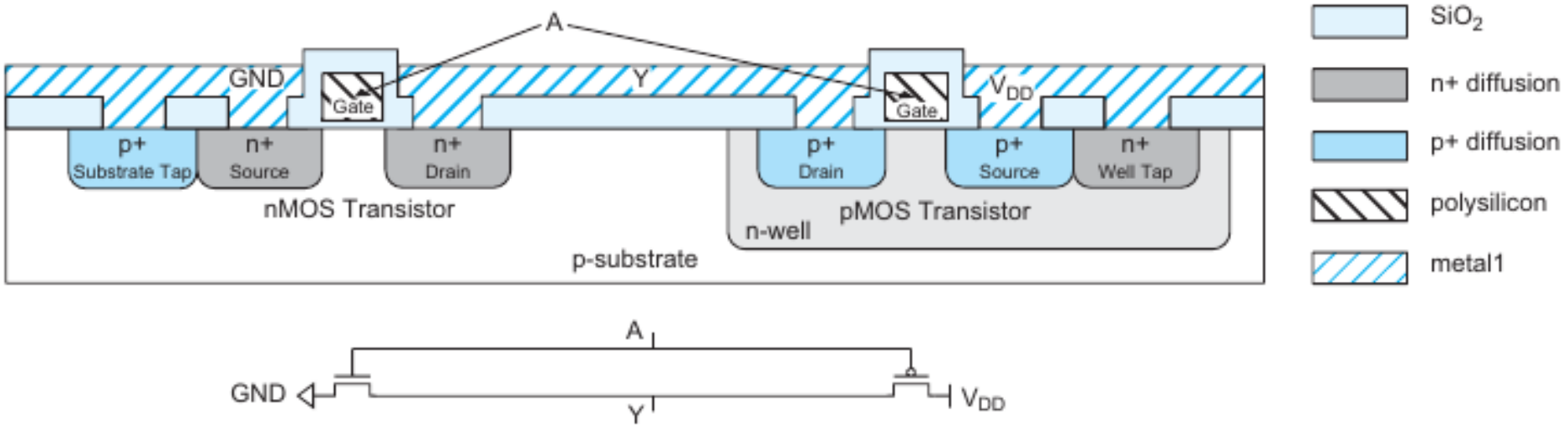
- Opposite of discrete circuit



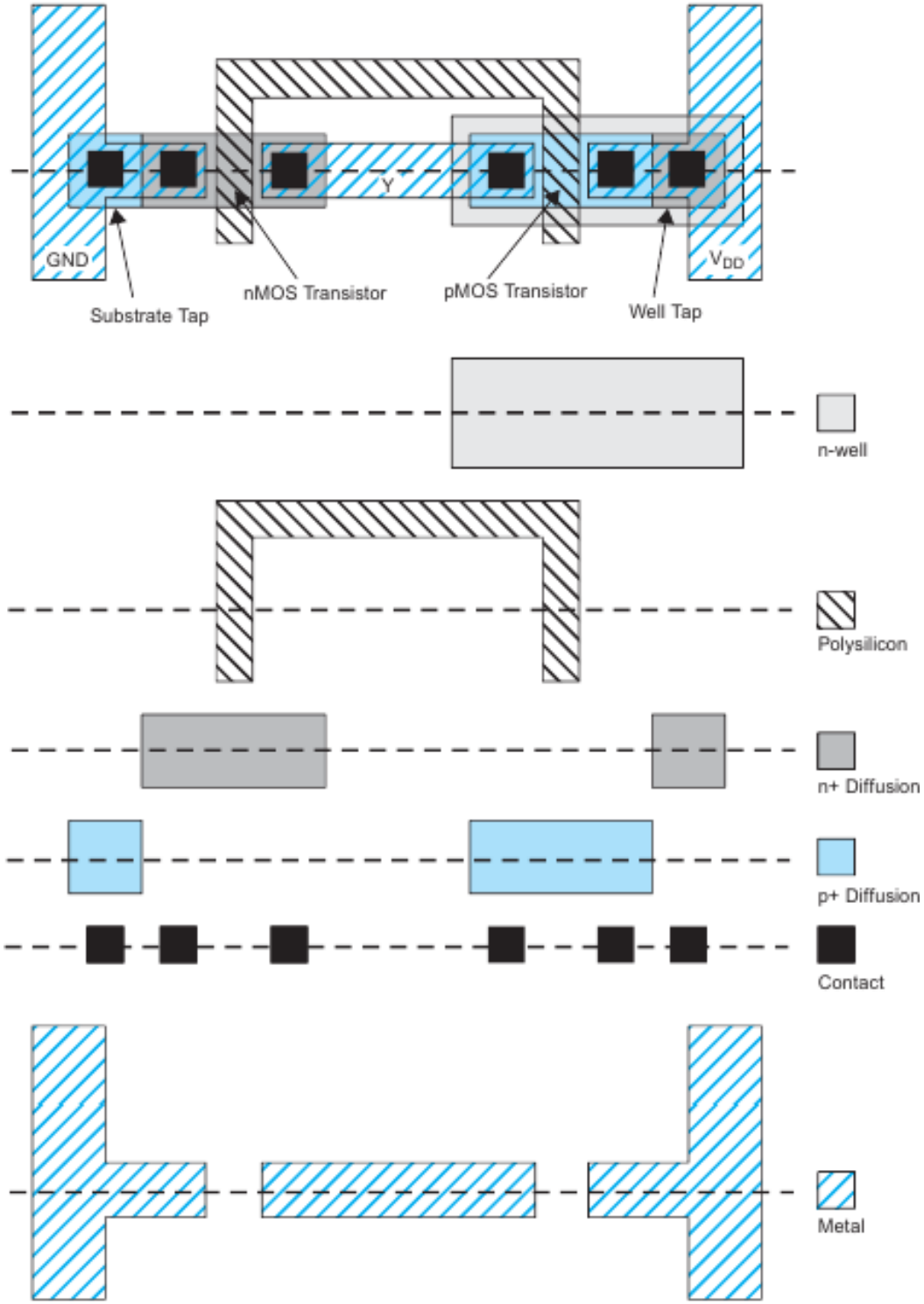
Jack Kilby's Original Integrated Circuit



Inverter

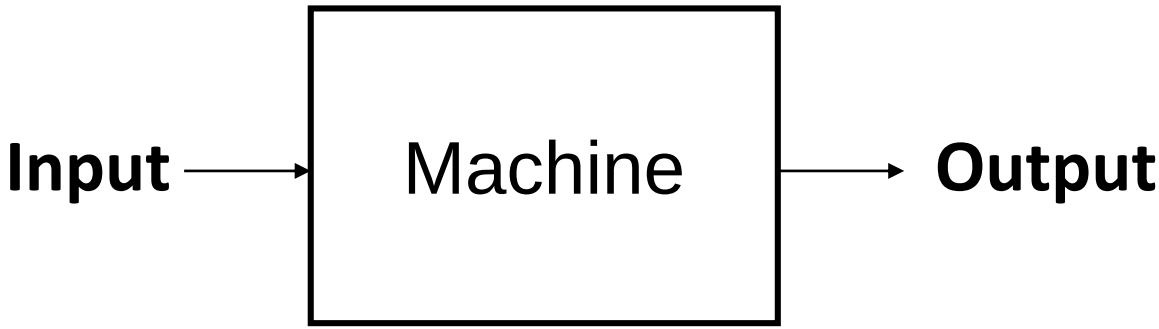

A
GND
Y
V_{DD}
Gate
Gate
p+
Substrate Tap
n+
Source
n+
Drain
p+
Drain
p+
Source
n+
Well Tap
nMOS Transistor
pMOS Transistor
n-well
p-substrate
SiO_2
n+ diffusion
p+ diffusion
polysilicon
metal1

A
GND
V_{DD}
Y

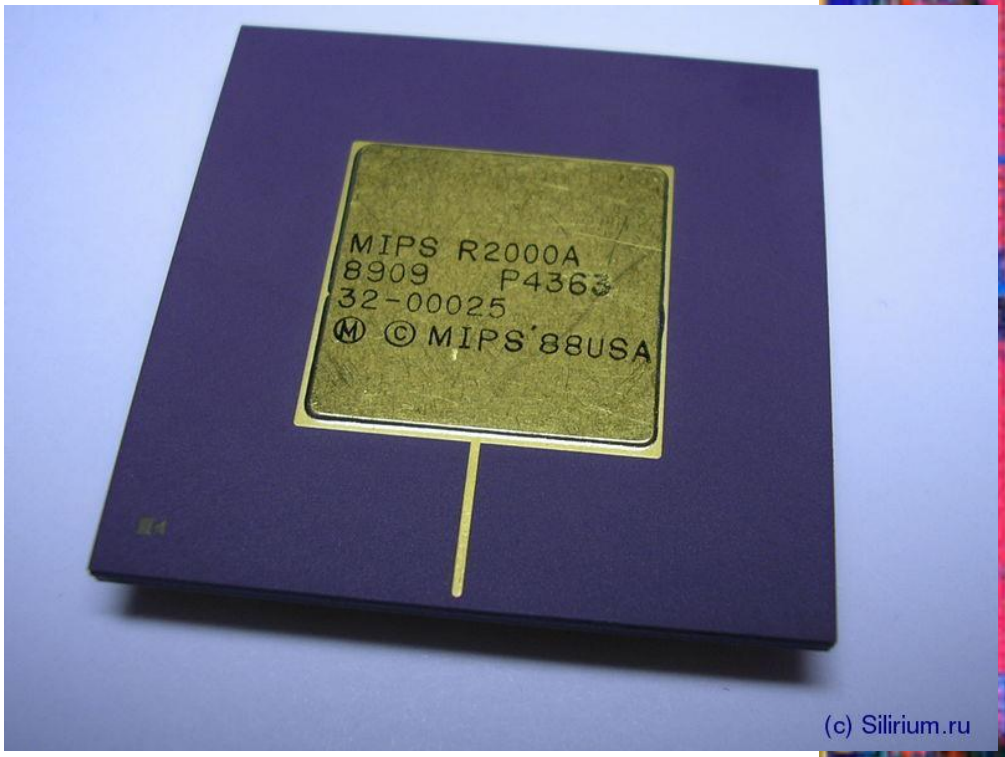

GND
Substrate Tap
nMOS Transistor
Y
pMOS Transistor
Well Tap
V_{DD}
n-well
Polysilicon
n+ Diffusion
p+ Diffusion
Contact
Metal

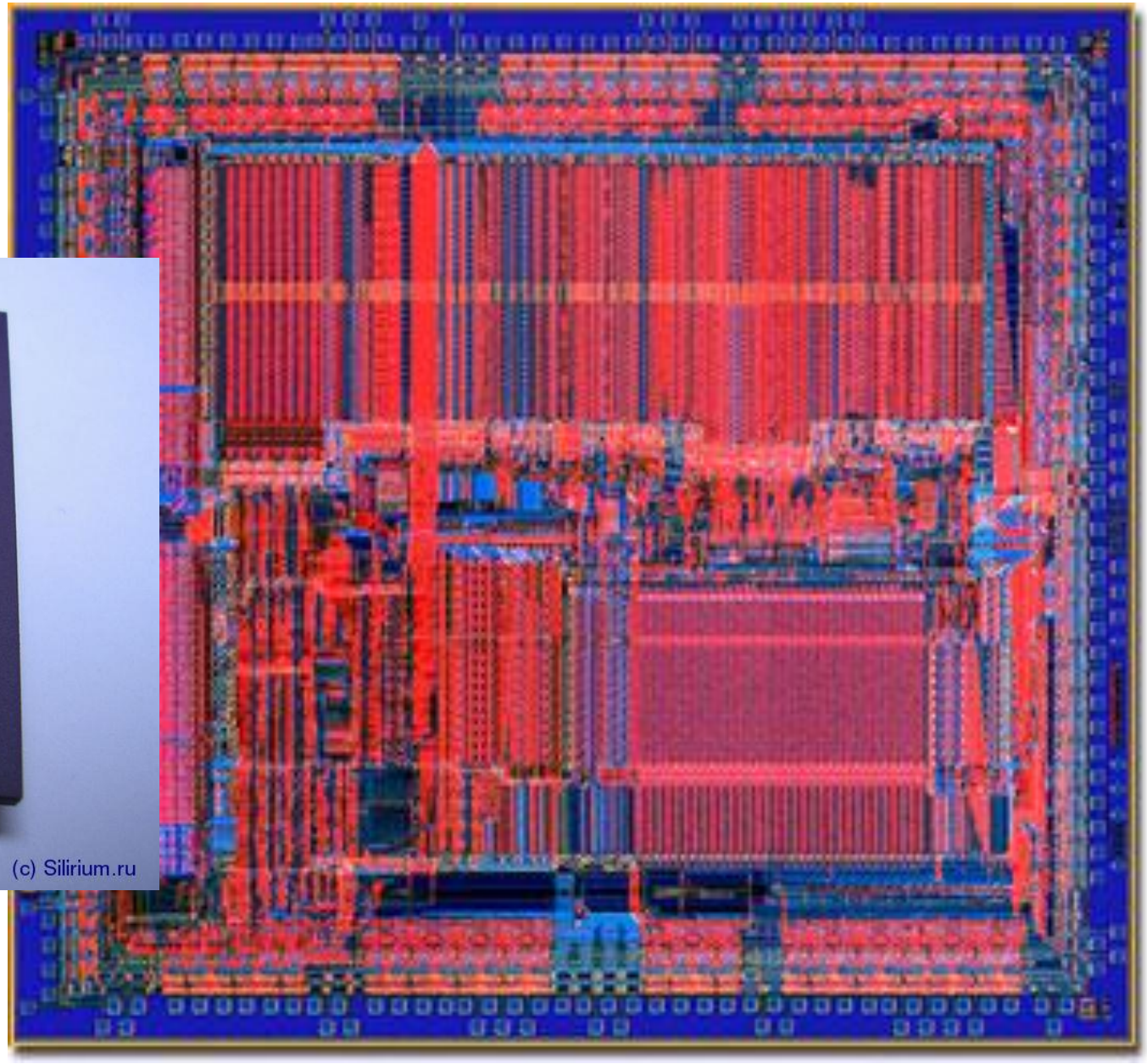
General Electronic System

- Various input/output cases
- Specific input-output mapping



MIPS R2000 in 1984





What We Will Learn

- Transistor level circuit design for various logic gates/flip-flop/Memory
- What should be considered for digital circuit design