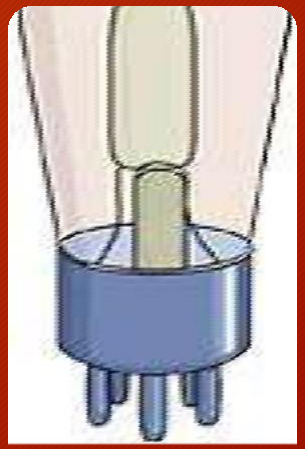
27-Transistors

Introduction

- Beside diodes, the most popular semiconductor devices is transistors. Eg: Bipolar Junction Transistor (BJT)
- Transistors are often said to be the most significant invention of the 20th Century.
- If cells are the building blocks of life, transistors are the building blocks of the digital revolution. Without transistors, the technological wonders you use every day -- cell phones, computers, cars -- would be vastly different, if they existed at all.
- Most important feature: can amplify signals and as switch

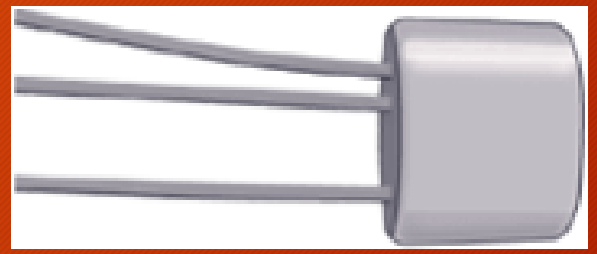
A Brief History

- Guglielmo Marconi invents radio in 1895
- Problem: For long distance travel, signal must be amplified
- Lee De Forest improves on Fleming's original vacuum tube to amplify signals
- Made use of third electrode
- Too bulky for most applications



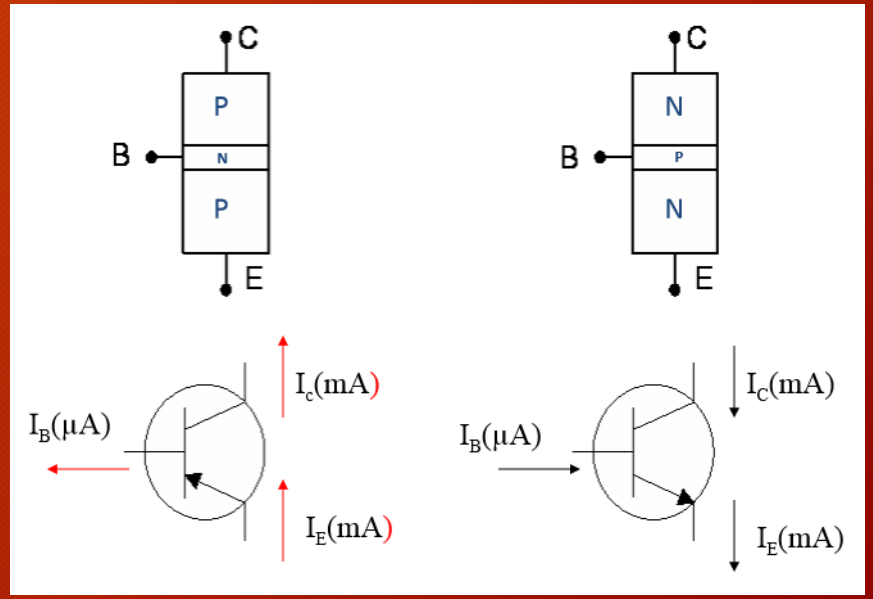
The Transistor is Born

- Bell Labs (1947): Bardeen, Brattain, and Shockley
- Originally made of germanium
- Current transistors made of doped silicon



Transistor Structure

- BJT is bipolar because both holes (+) and electrons (-) will take part in the current flow through the device
  - N-type regions contains free electrons (negative carriers)
  - P-type regions contains free holes (positive carriers)
- 2 types of BJT
  - NPN transistor
  - PNP transistor



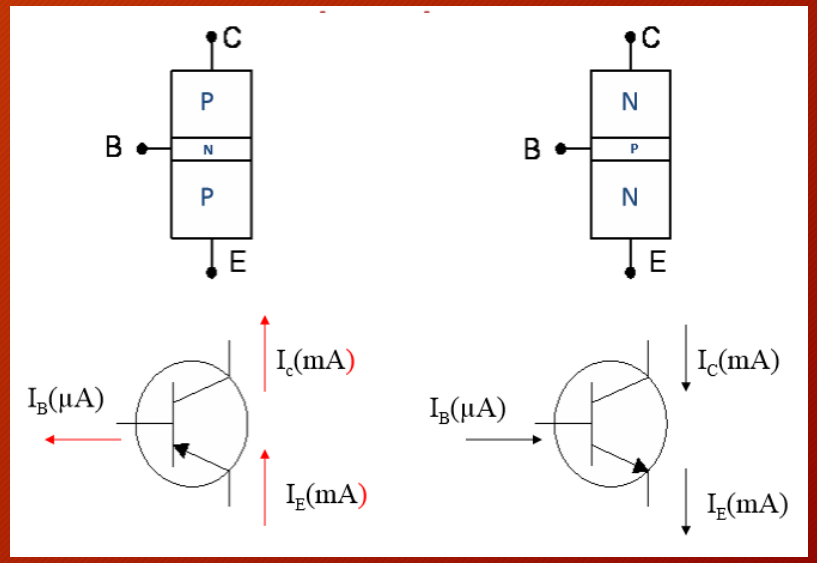
Transistor Structure

- The transistor regions are:

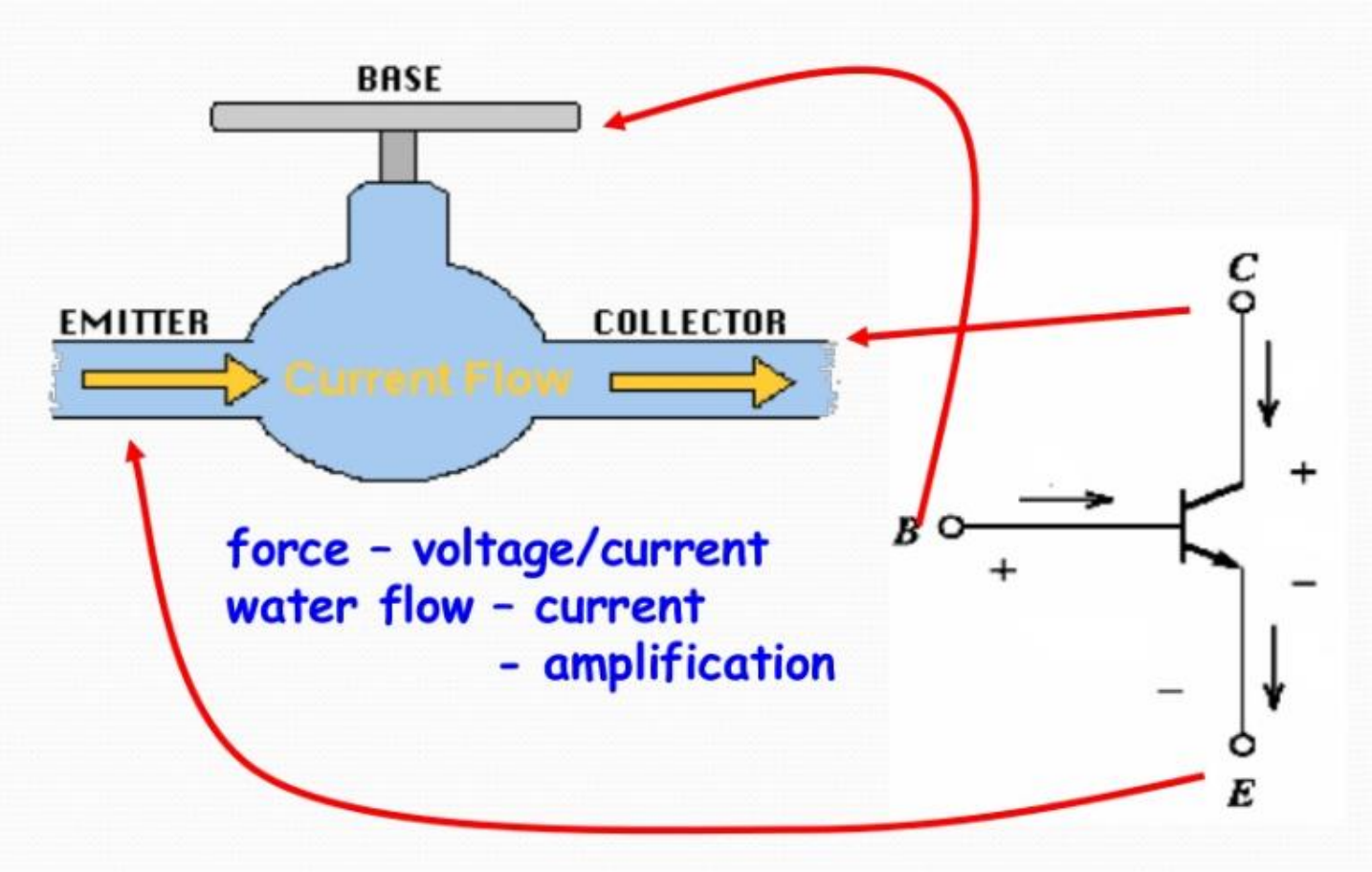
- Emitter (E) - send the carriers into the base region and then on to the collector

- Base (B) - acts as control region. It can allow none,some or many carriers to flow

- Collector (C) - collects the carriers



Transistor Operation

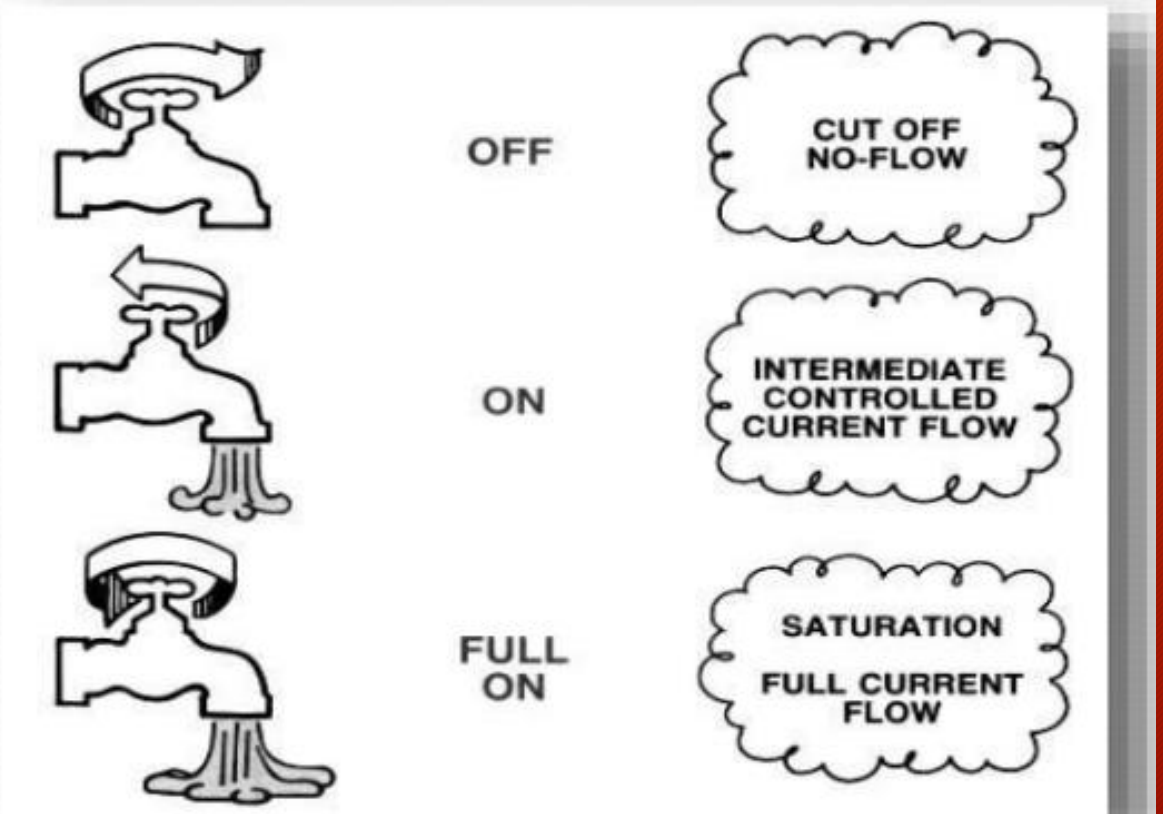


Operating Regions

Cut off region

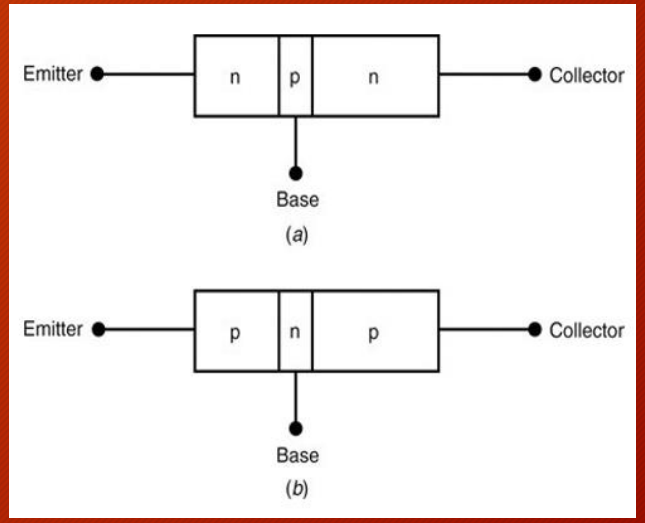
Linear region

Saturation region

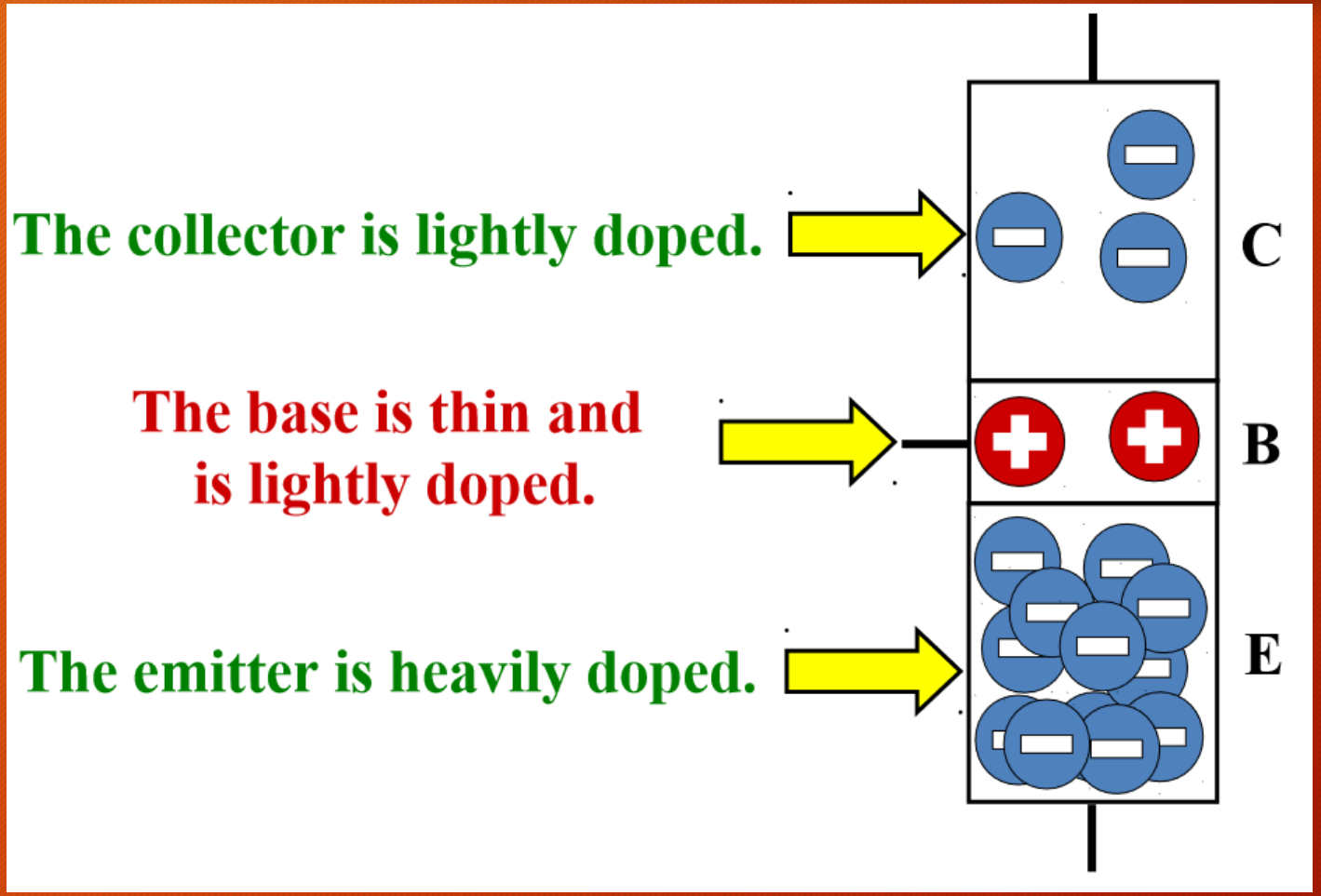


Transistor Construction

- A transistor has three doped regions.
- For both types, the base is a narrow region sandwiched between the larger collector and emitter regions.
- ▫ The emitter region is heavily doped and its job is to emit carriers into the base.
- ▫ The base region is very thin and lightly doped.
- ▫ Most of the current carriers injected into the base pass on to the collector.
- ▫ The collector region is moderately doped and is the largest of all three regions



NPN Transistor Structure



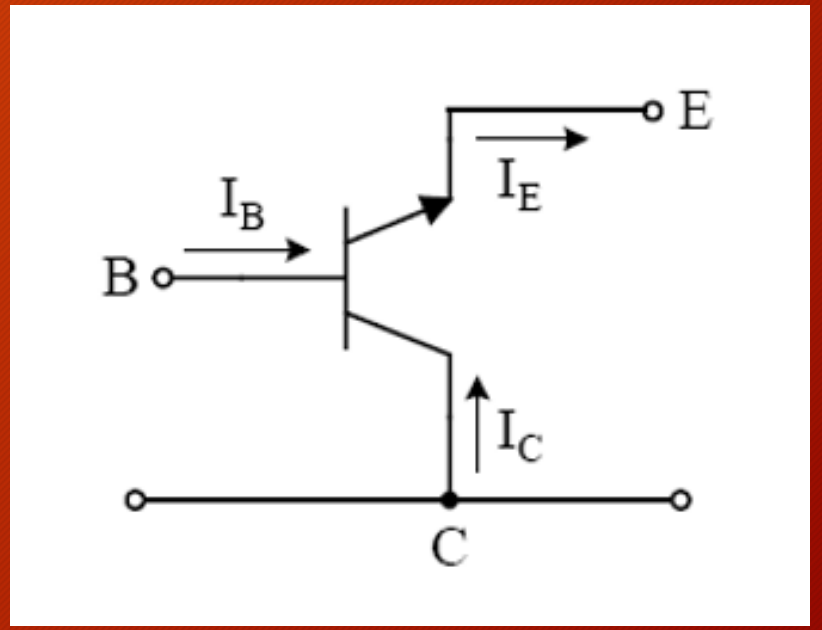
Transistor configuration

- Transistor configuration –is a connection of transistor to get variety operation.
- 3 types of configuration:
- – Common Collector.
- – Common Base.
- – Common Emitter

Common-Collector Configuration

- The input signal is applied to the base terminal and the output is taken from the emitter terminal.
- Collector terminal is common to the input and output of the circuit
- Input – BC
- Output – EC

Common collector configuration, also known as emitter follower provides high input impedance and low output impedance. So they are used for the purpose of impedance matching

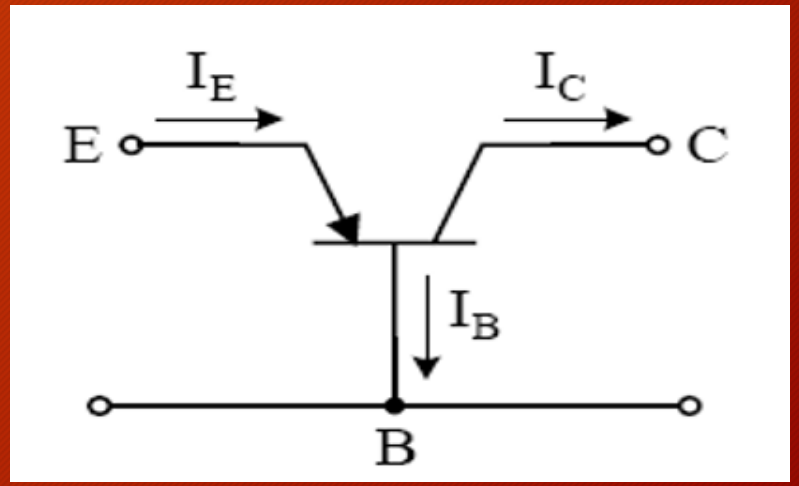


Also used in power amplifiers.

Common-Base Configuration

- Base terminal is a common point for input and output.
- Input – EB
- Output – CB
- Not applicable as an amplifier because the relation between input current gain (IE) and output current gain (IC) is approximately 1

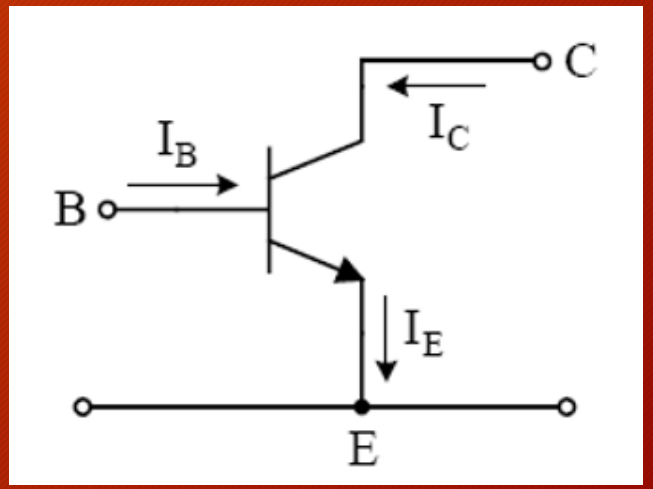
In electronics, a common-base (also known as grounded-base) amplifier is one of three basic single-stage bipolar junction transistor (BJT) amplifier topologies, typically used as a current buffer or voltage amplifier



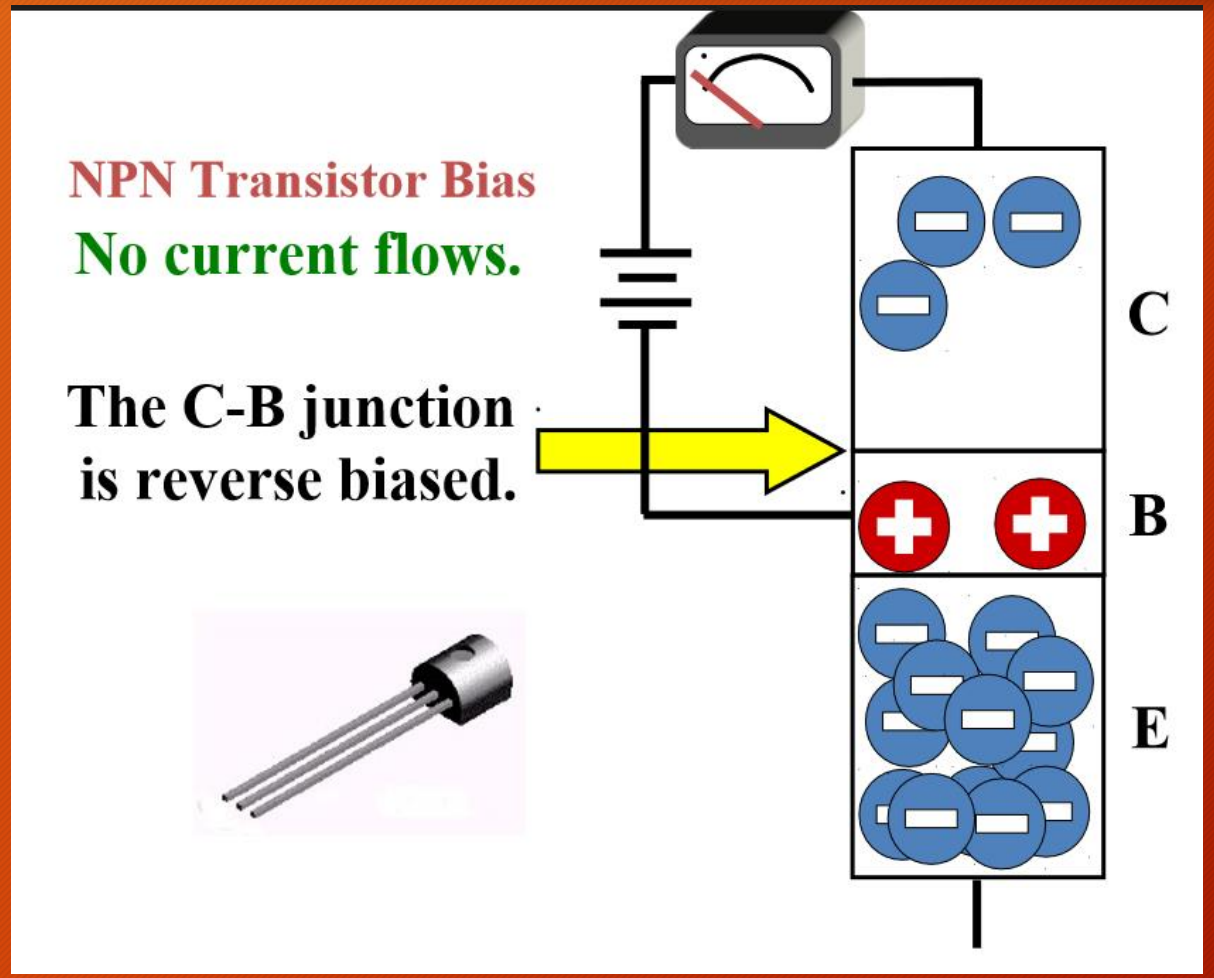
Common-Emitter Configuration

- • Emitter terminal is common for input and output circuit
- Input – BE
- Output – CE
- Mostly applied in practical amplifier circuits, since it provides good voltage, current and power gain

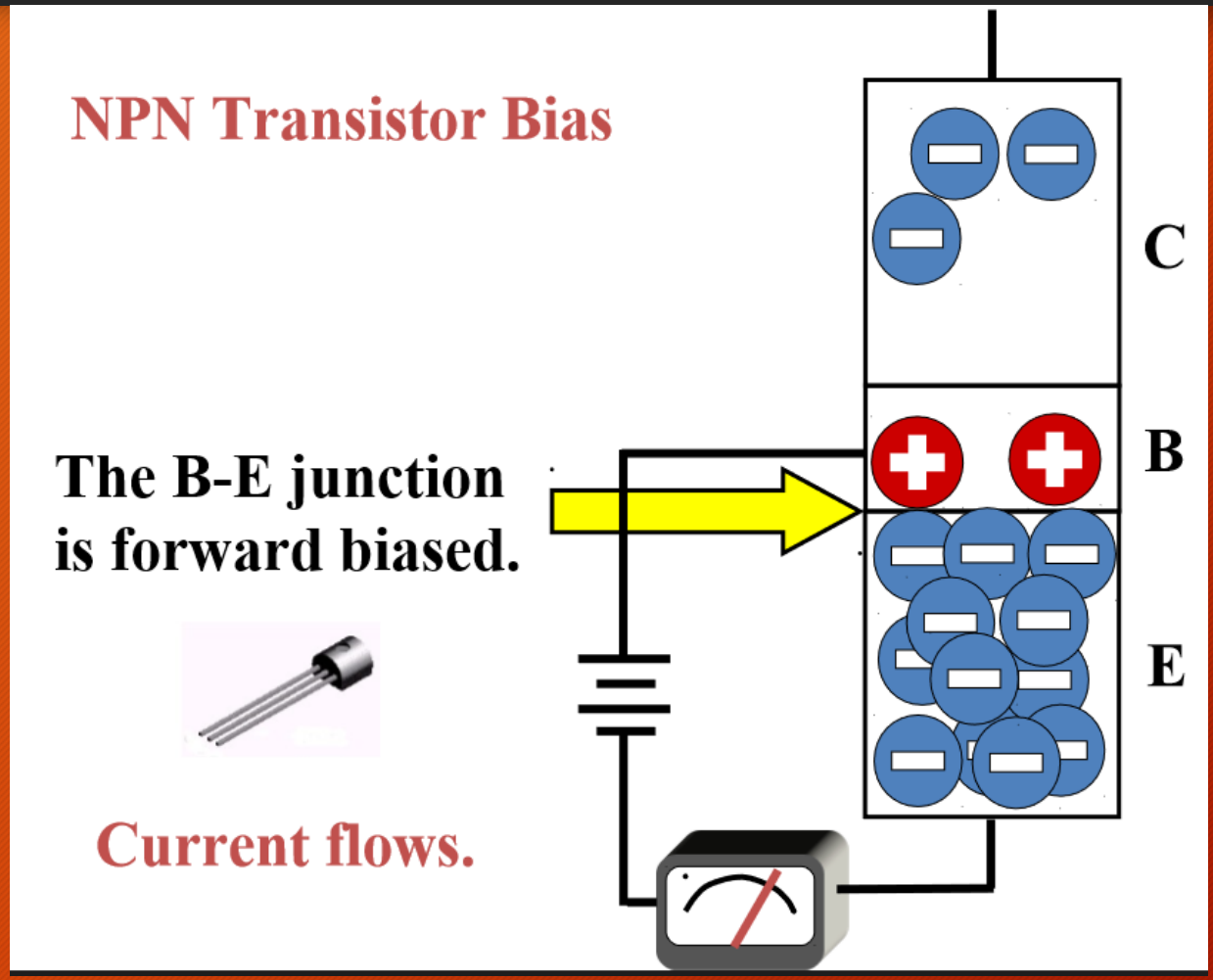
One of the most popular applications for common emitters is audio amplification. Audio amplifiers are typically used to amplify low-level signals, such as those from a microphone or music player. Common emitters are also used in power amplifiers.



NPN Transistor Bias



NPN Transistor Bias



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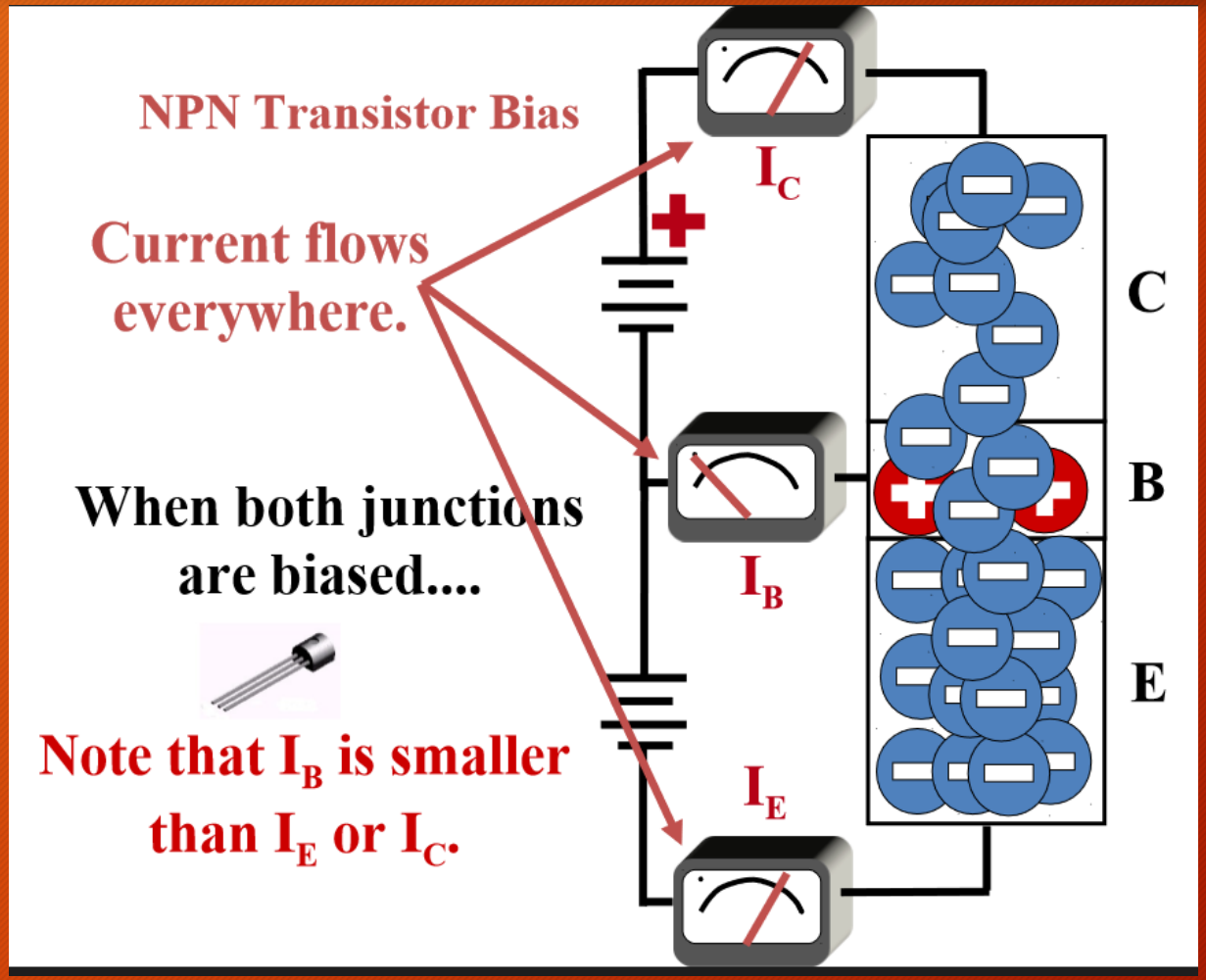
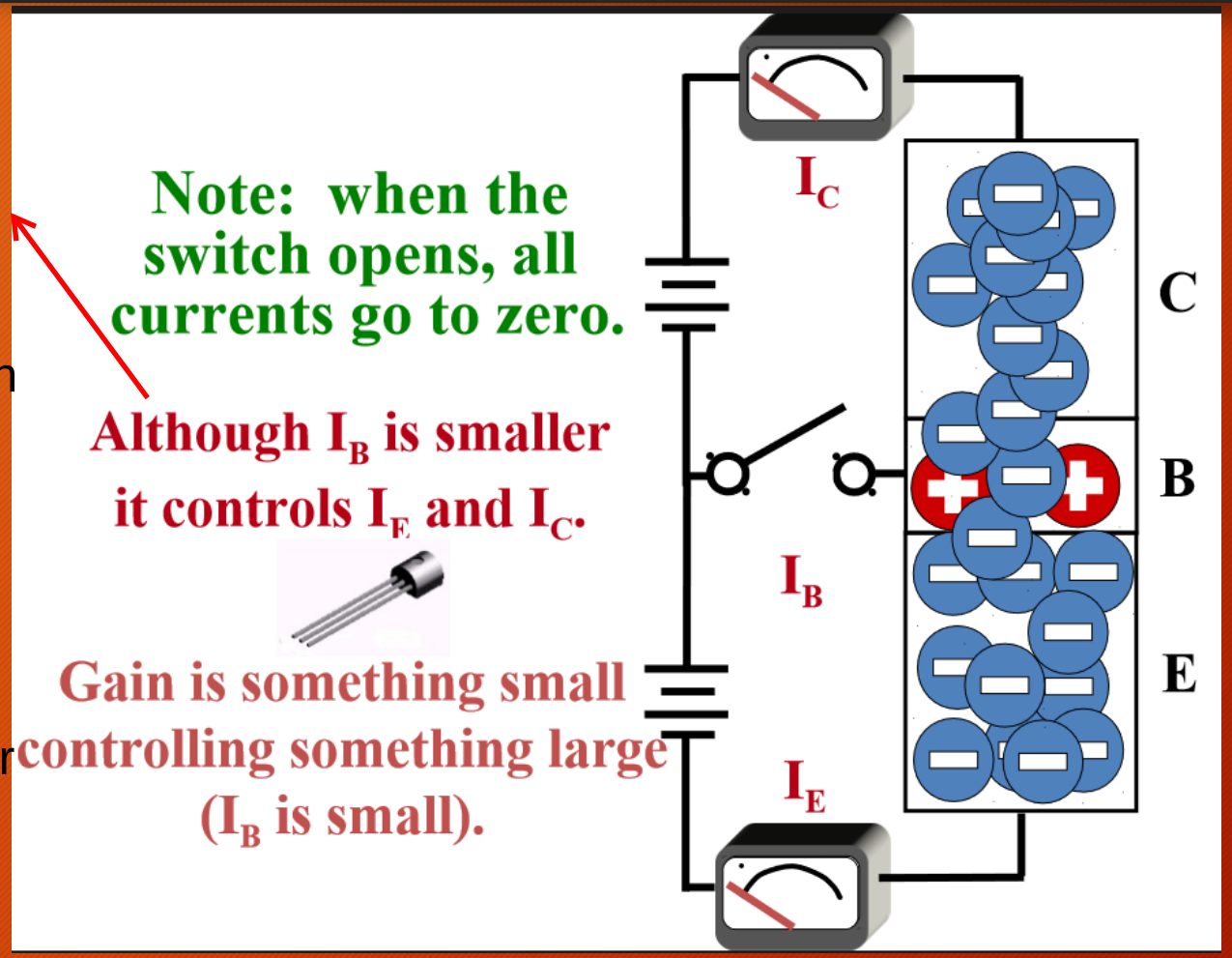


NPN Transistor Bias

The base region is made very thin so that there is a better conduction of charge carriers from emitter to collector through the base. Moreover the thin base reduces the combination of holes and electrons so that base current is negligibly small and collector current is nearby same as emitter current.



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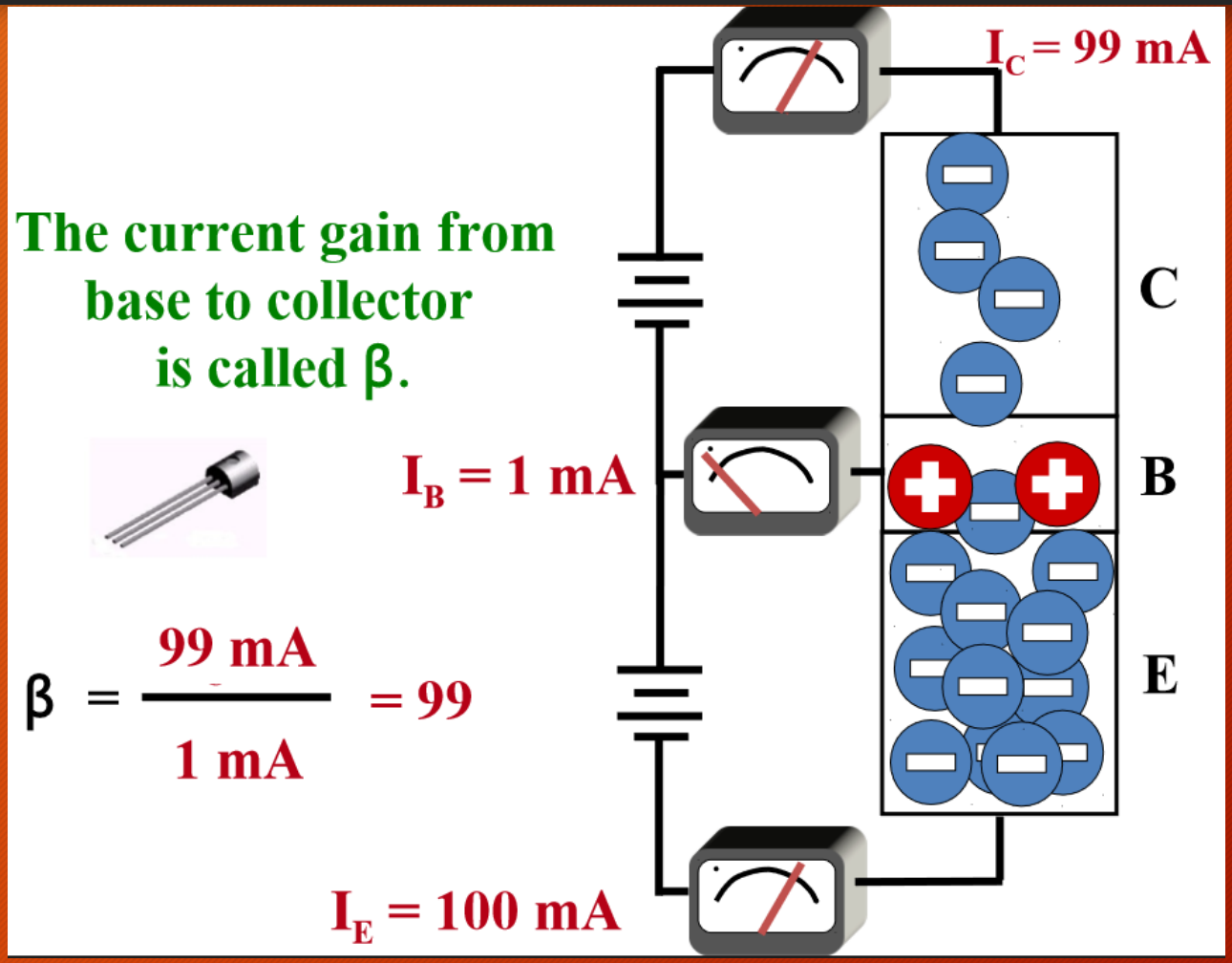
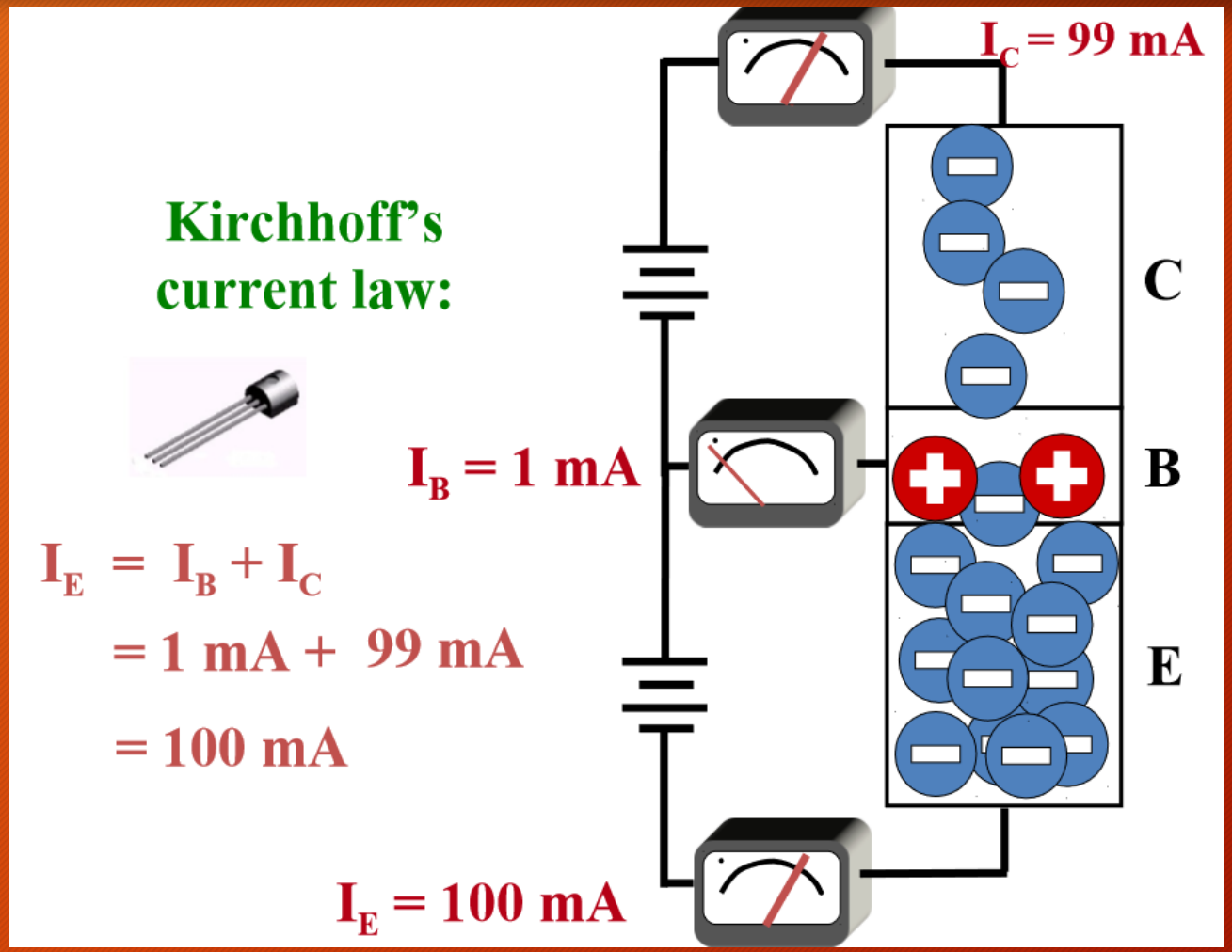
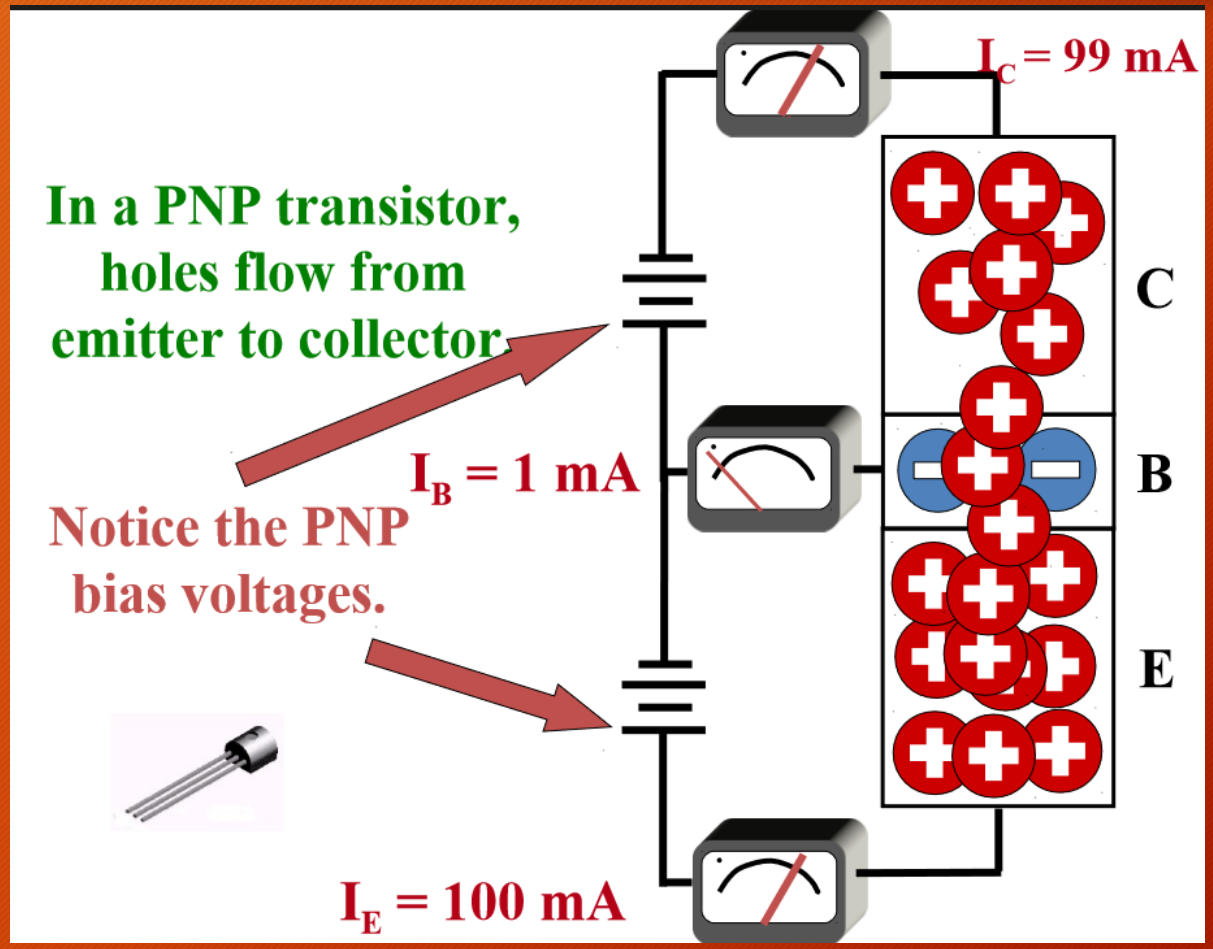


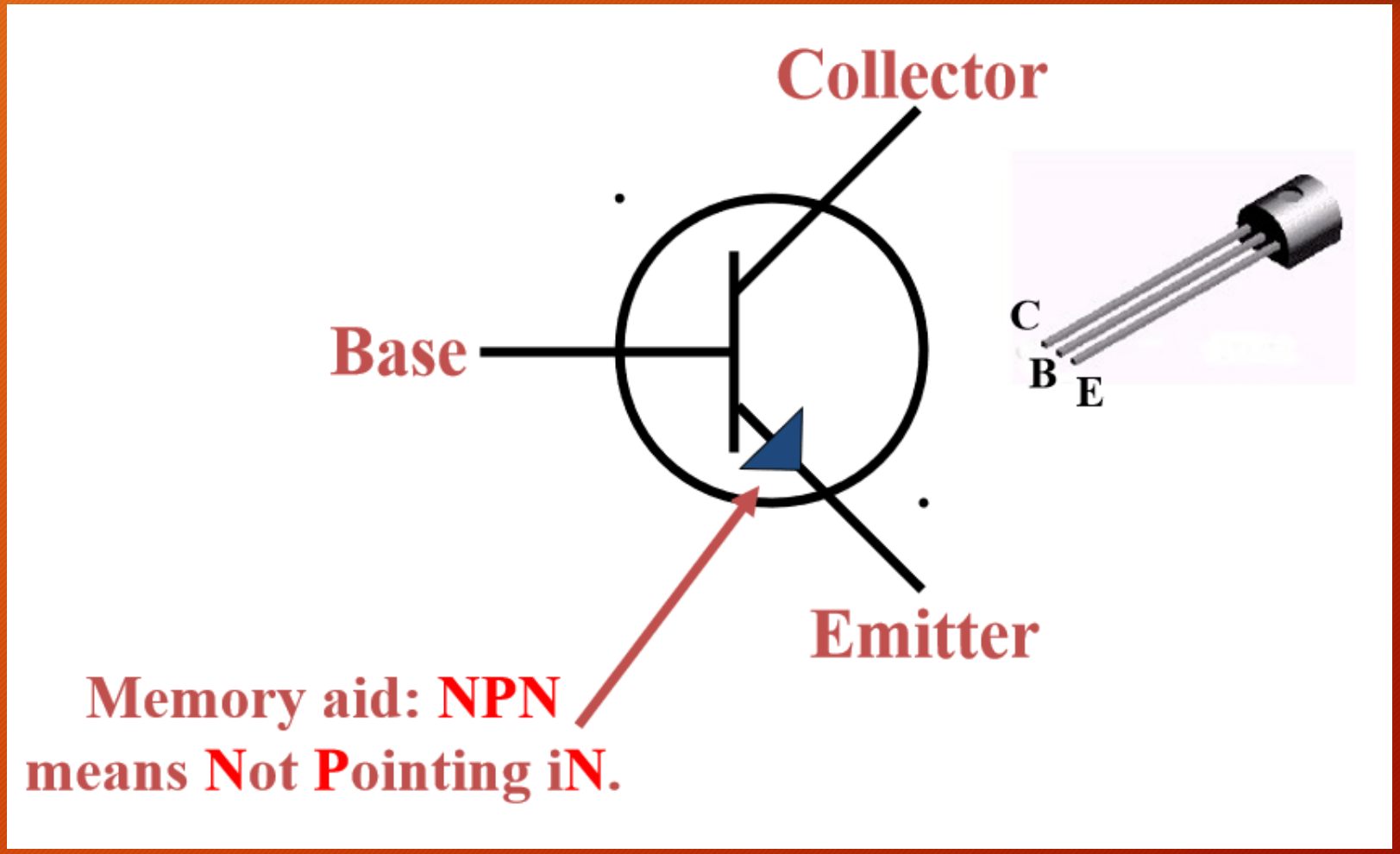
NPN Transistor Bias



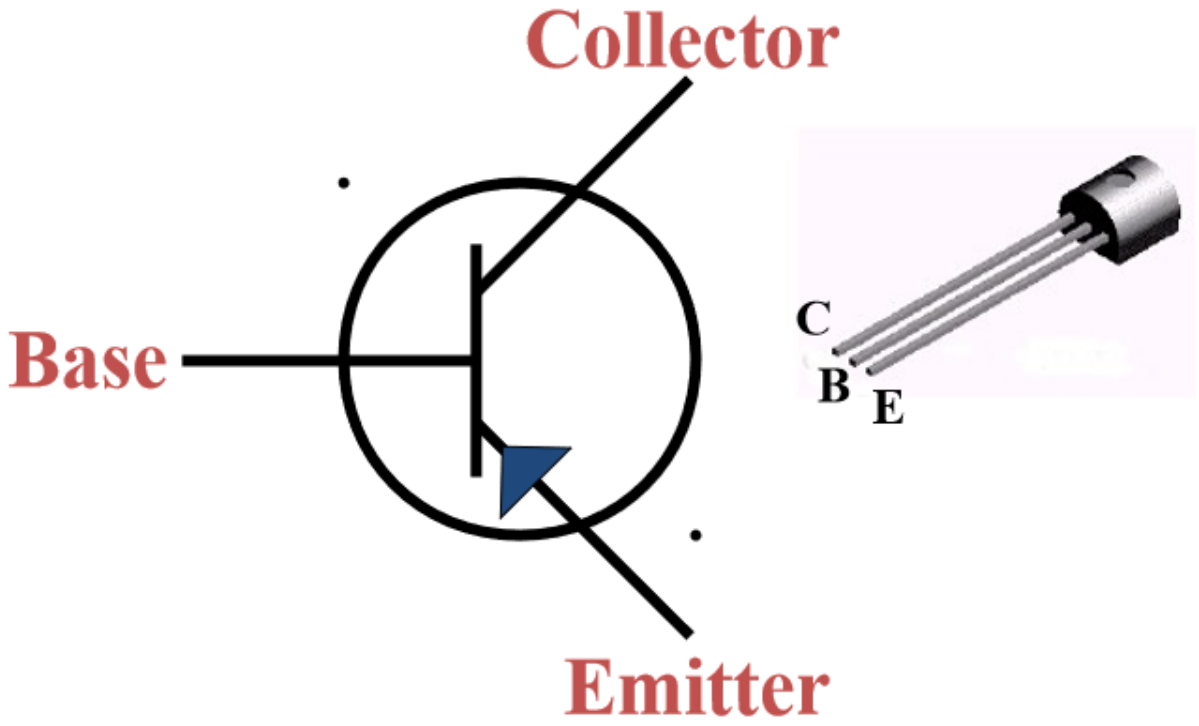
PNP Transistor Bias



NPN Schematic Symbol



PNP Schematic Symbol



Memory aid: NPN
means Pointing iN Properly.