ELECTRONICS DEVICES AND CIRCUITS

SECTION - C

TRANSISTORS

OBJECTIVE

BJT

Bipolar Junction Transistors

First - BJTs

The transistor was probably the most important invention of the 20th Century.

The story behind the invention is one of clashing egos and top secret research.

Interesting story…

Picture shows the workbench of John Bardeen (Stocker Professor at OU) and Walter Brattain at Bell Laboratories. They were supposed to be doing fundamental research about crystal surfaces.

The experimental results hadn't been very good, though, and there's a rumor that their boss, William Shockley, came near to canceling the project. But in 1947, working alone, they switched to using tremendously pure materials.

It dawned on them that they could build the circuit in the picture. It was a working amplifier! John and Walter submitted a patent for the first working point contact transistor.

Interesting story…

Shockley was furious and took their work and invented the junction transistor and submitted a patent for it 9 days later. The three shared a Nobel Prize in 1955. Bardeen and Brattain continued in research (and Bardeen later won another Nobel).

Shockley quit to start a semiconductor company in Palo Alto. It folded, but its staff went on to invent the integrated circuit (the "chip") and to found Intel Corporation.

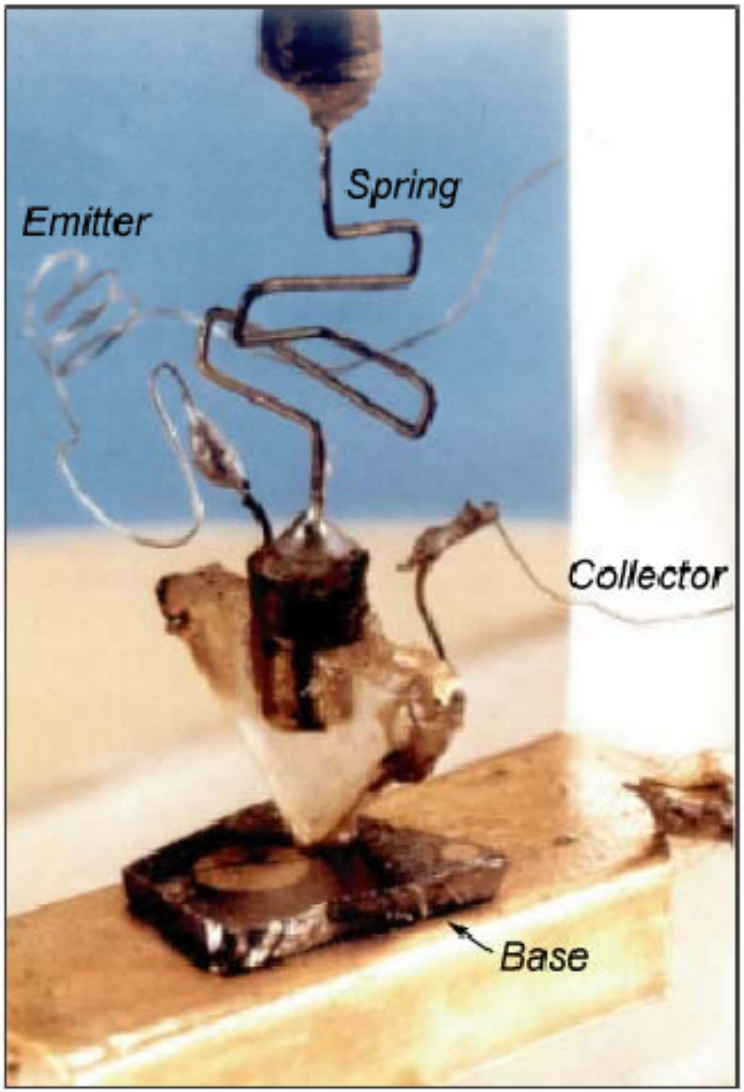
By 1960, all important computers used transistors for logic, and ferrite cores for memory.

Point-Contact Transistor – first transistor ever made

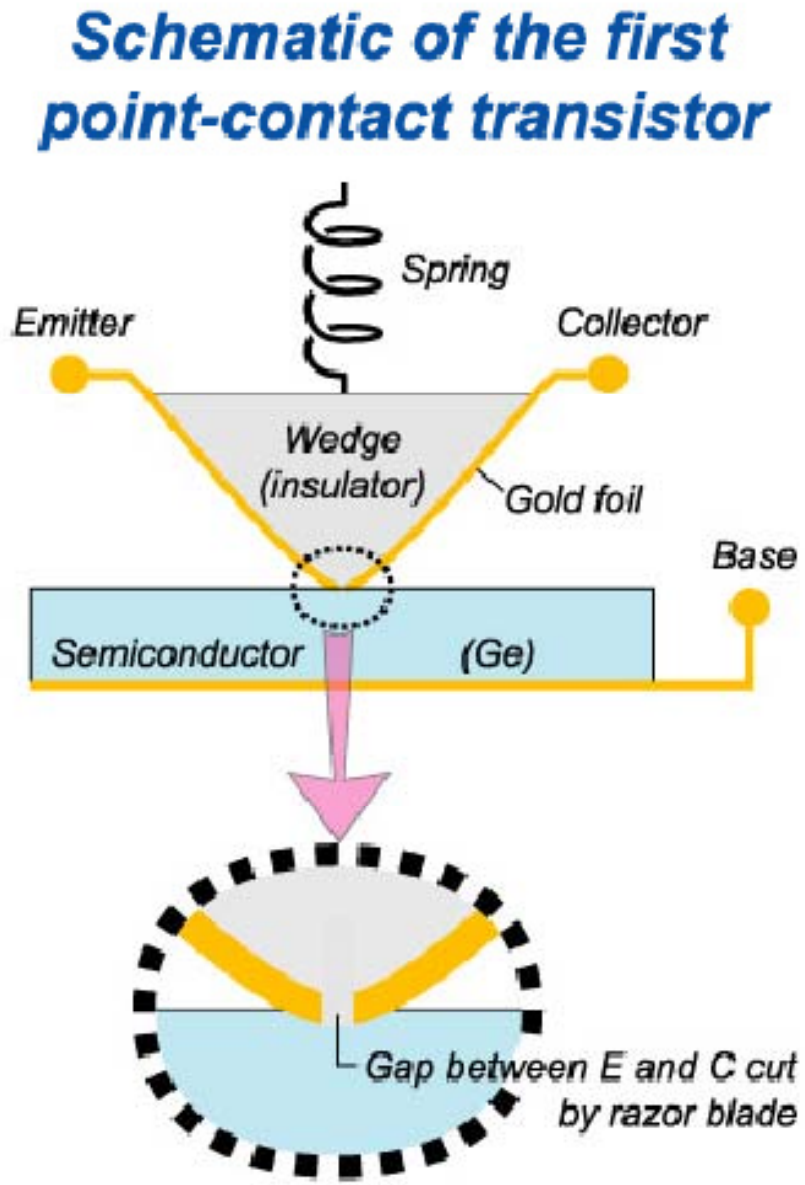
The first transistor was a point-contact transistor

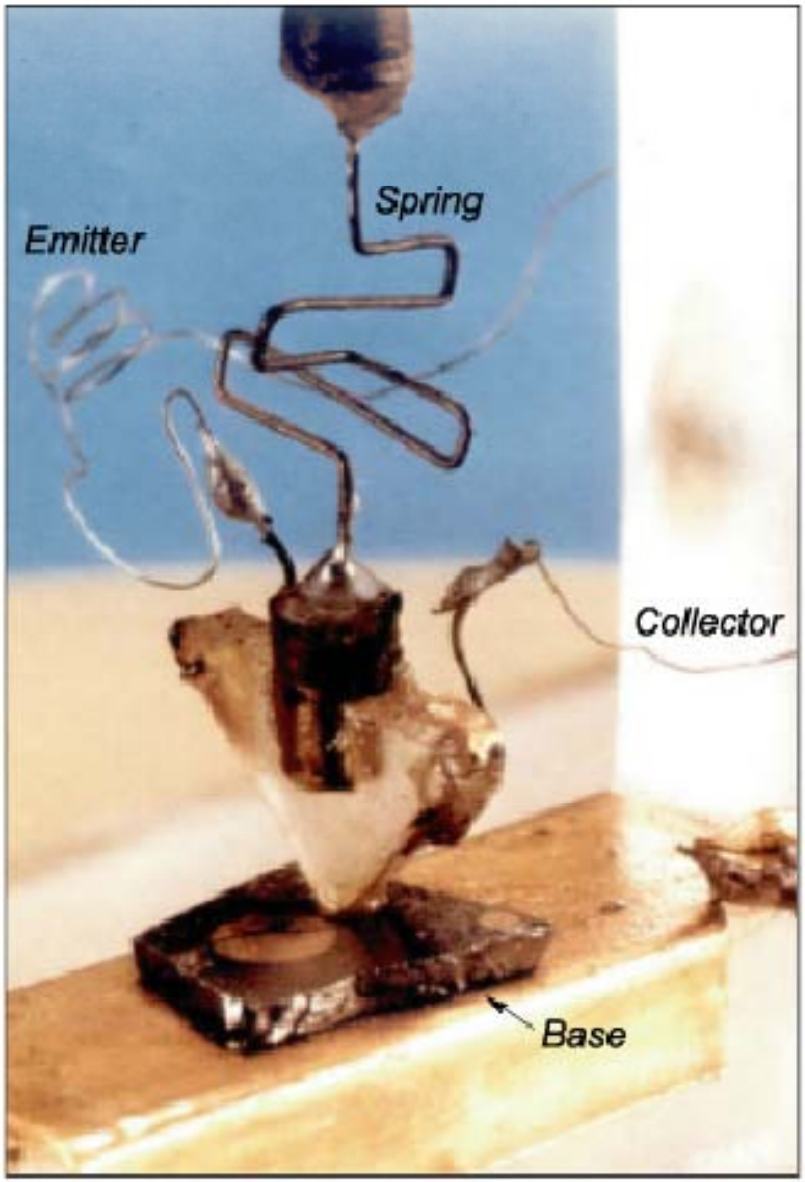
The first point-contact transistor

John Bardeen, Walter Brattain, and William Shockley
Bell Laboratories, Murray Hill, New Jersey (1947)



How did first point-contact transistor work?





Qualitative basic operation of point-contact transistor

A gold foil was glued to a triangular insulating wedge.

A narrow gap was cut with a razor blade to form the E and C.

The gap was approximately 50 μm wide.

Under forward bias of the EB junction, minority carriers are injected into base (In case of point-contact transistor, strong forward bias is required).

Most minority carriers are collected by the reverse-biased BC junction.

Thus the base controls the current flow between E and C.

Problems with first transistor…

The point-contact transistor is a surface-effect device, *i. e.* important effects occur at the semiconductor surface.

Surfaces are easily contaminated.

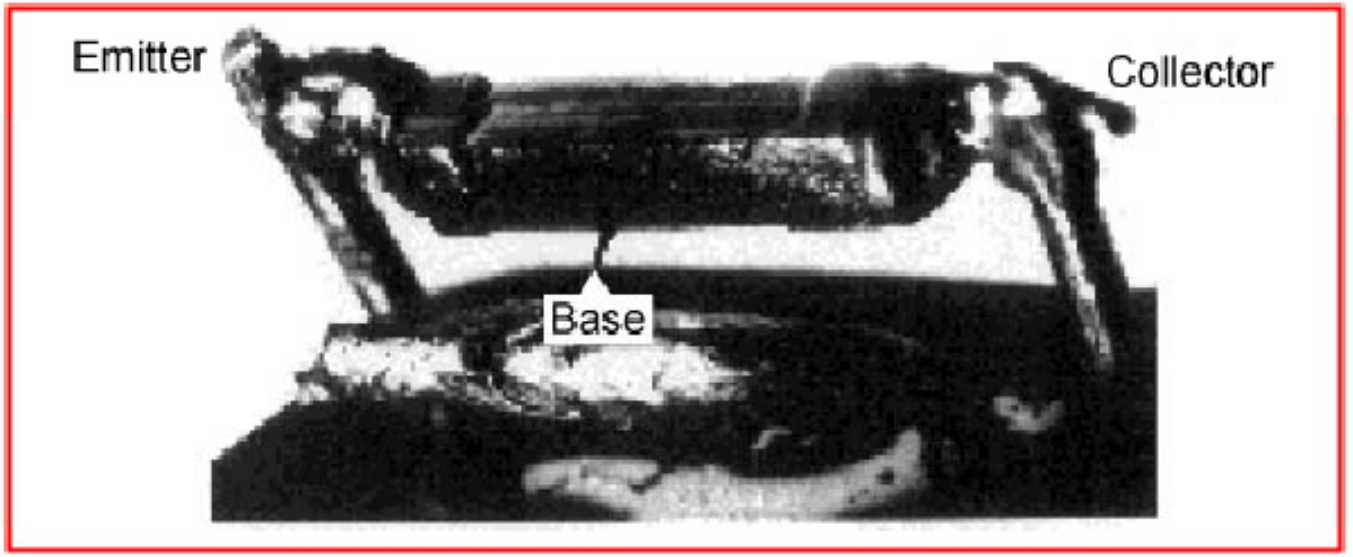
Surface-effect devices are unstable (*e. g.* mechanical vibrations).

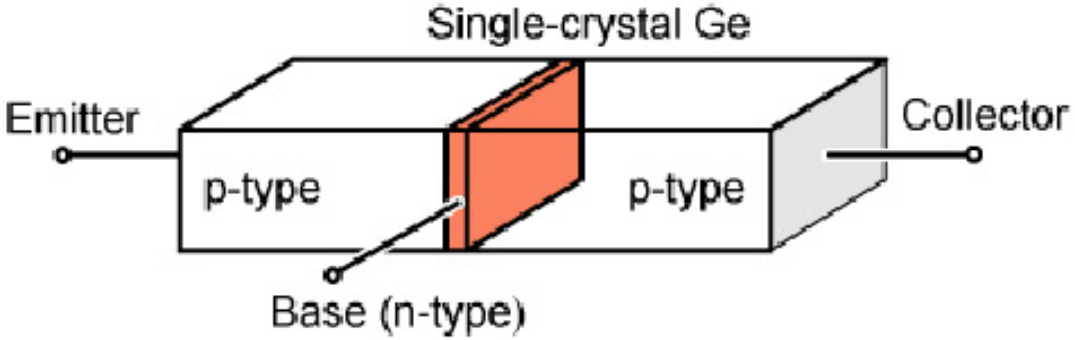
First Bipolar Junction Transistors

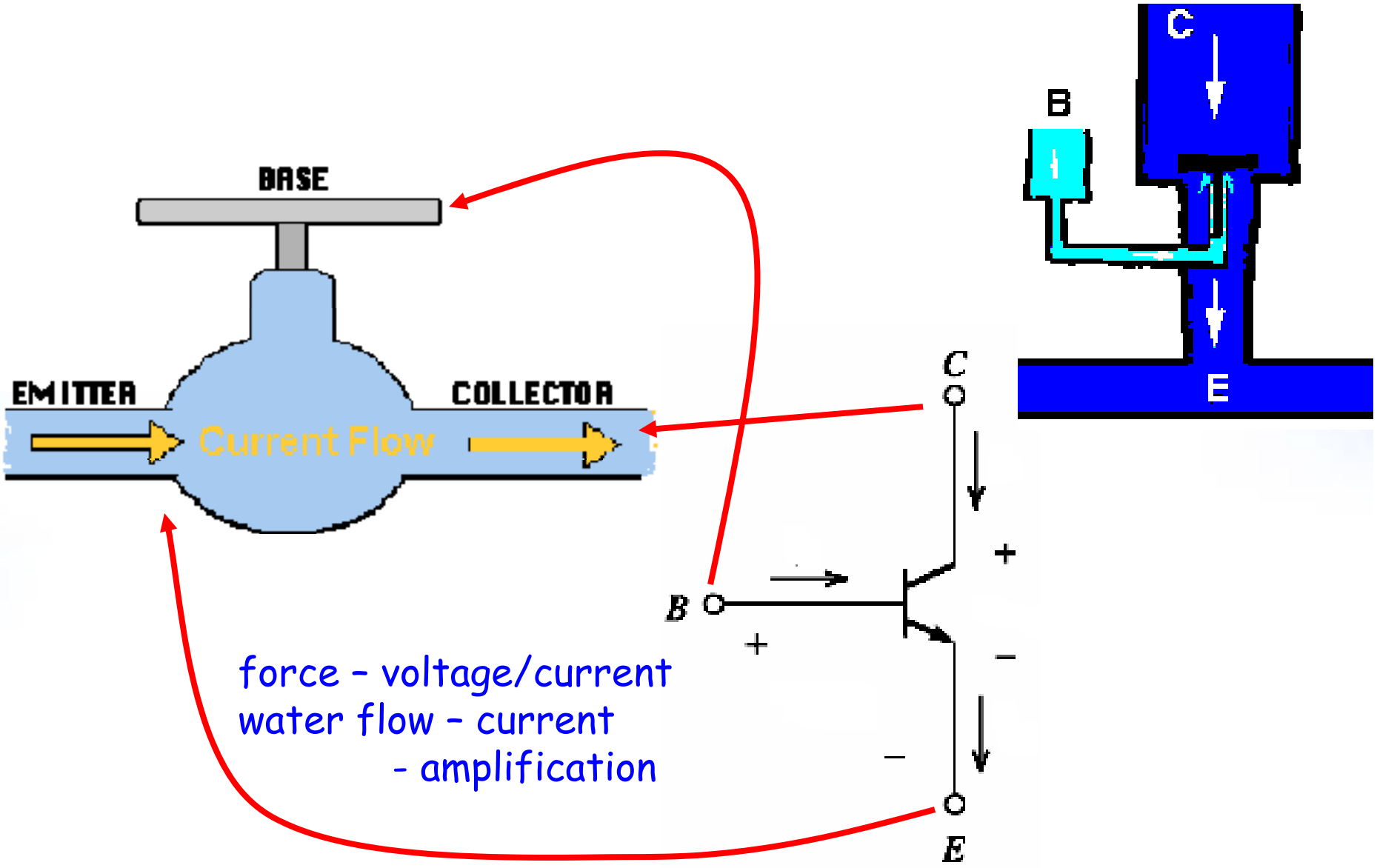
W. Shockley invented the p-n junction transistor
The physically relevant region is moved to the bulk of the material

The First Junction Transistor

First transistor with diffused pn junctions by William Shockley
Bell Laboratories, Murray Hill, New Jersey (1949)

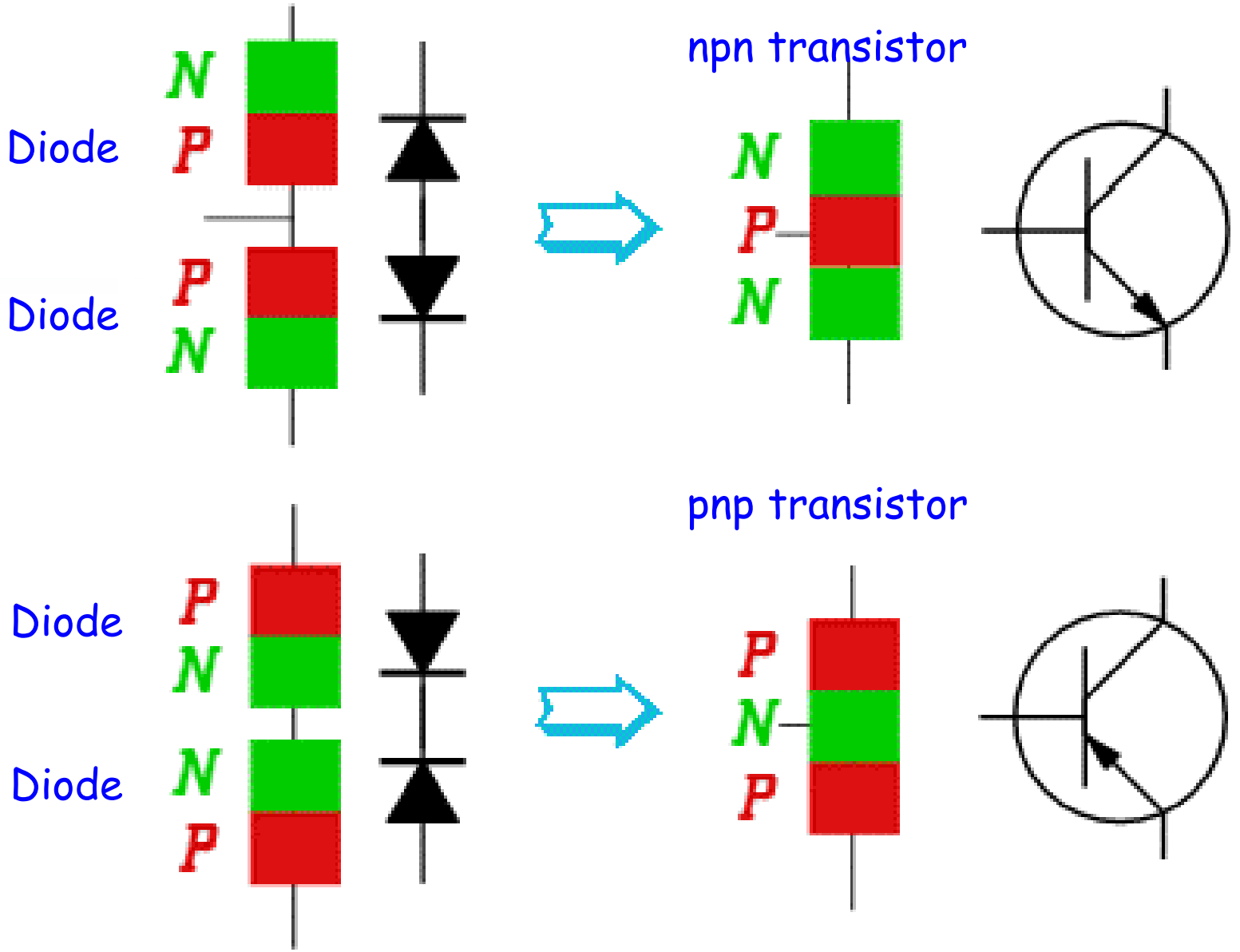






Understanding of BJT

Basic models of BJT



Qualitative basic operation of BJTs

A BJT consists of two back-to-back p-n junctions.

The middle region, the base, is very thin.

The three regions are the emitter, base, and collector.

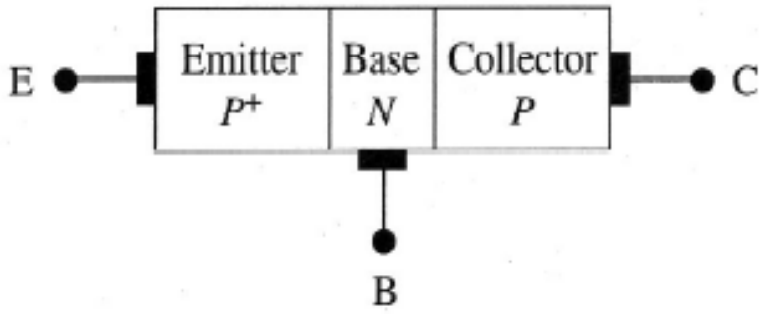
Carriers are injected ("emitted") into the base from the emitter.

Since the base is thin, most carriers injected into base diffuse into collector.

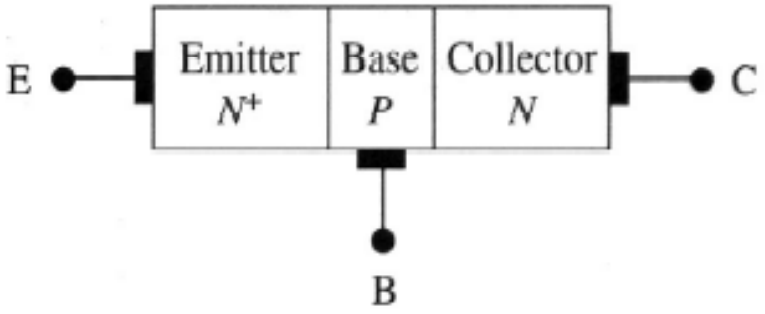
What does a "thin base thickness" mean? ➔ Base thickness is much thinner than the diffusion length of carriers injected from the emitter.

Basic models of BJT

Bipolar Junction Transistor Fundamentals

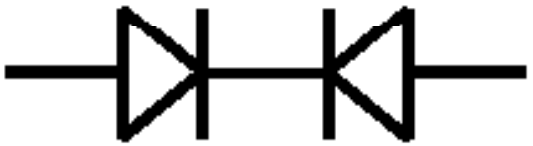


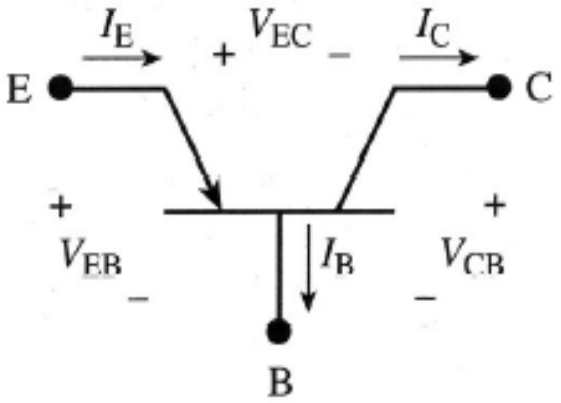
pnp

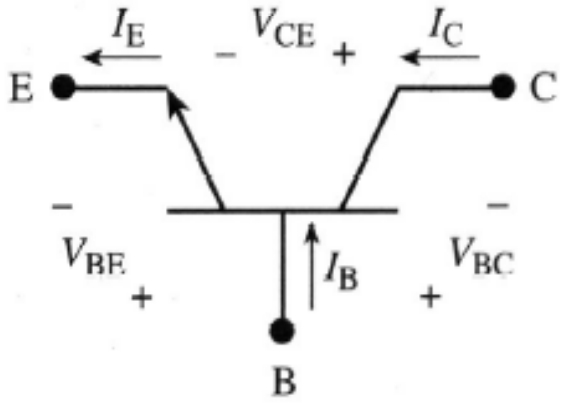


npn

Looks sort of like two diodes back to back







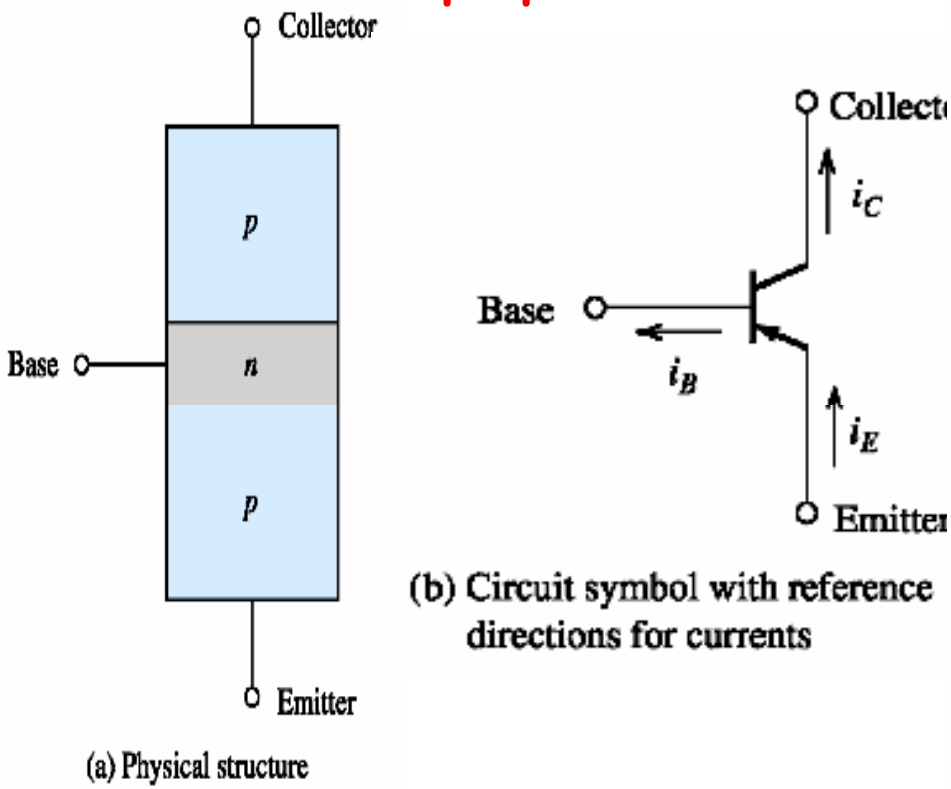
BJTs – Basic Configurations

Fluid Flow Analogy

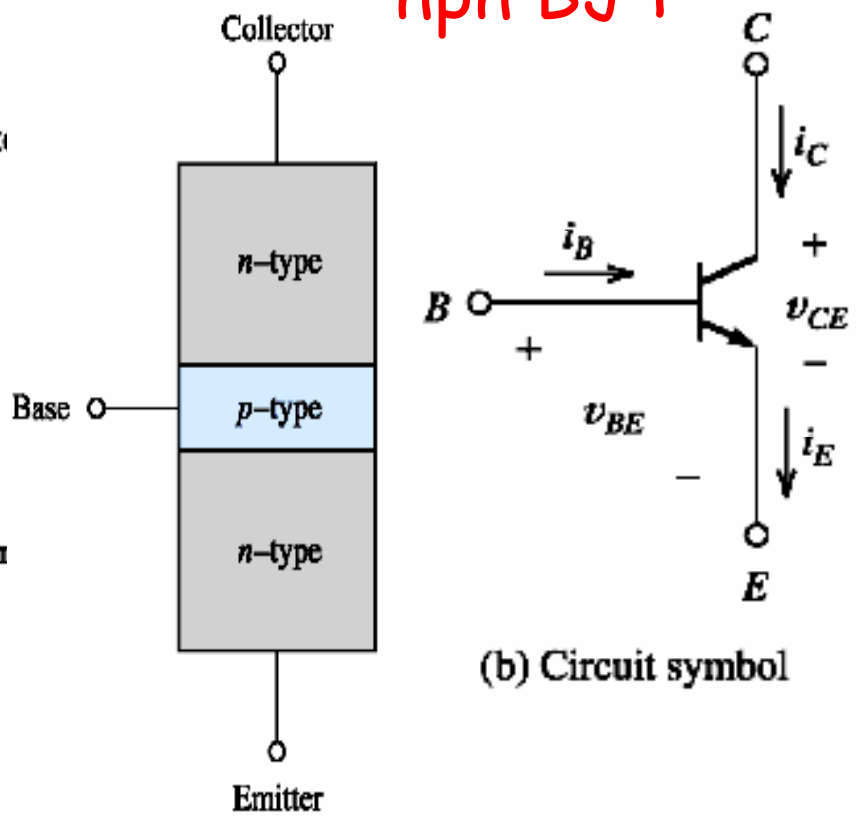
Difference between FET (field effect transistor) and BJT

Technology of BJTs

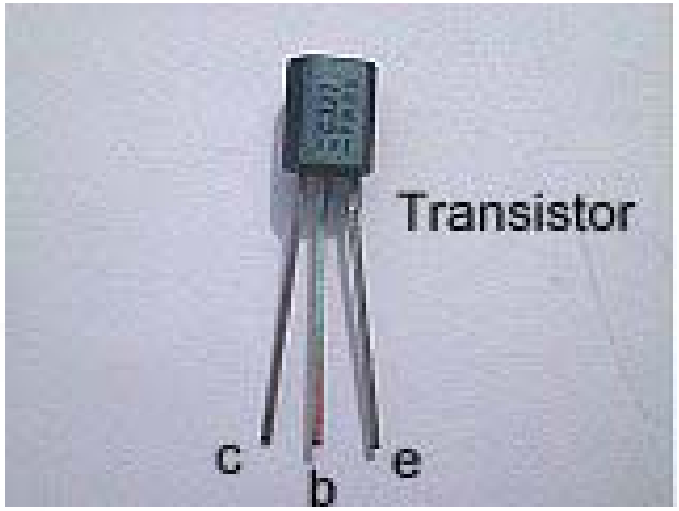
pnp BJT



npn BJT



BJTs – Practical Aspects



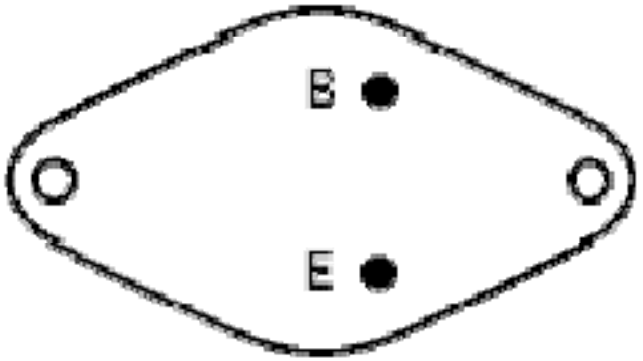
Heat sink

TO18
TO39

TO92A TO92B TO92C

Views are from below with the leads towards you.

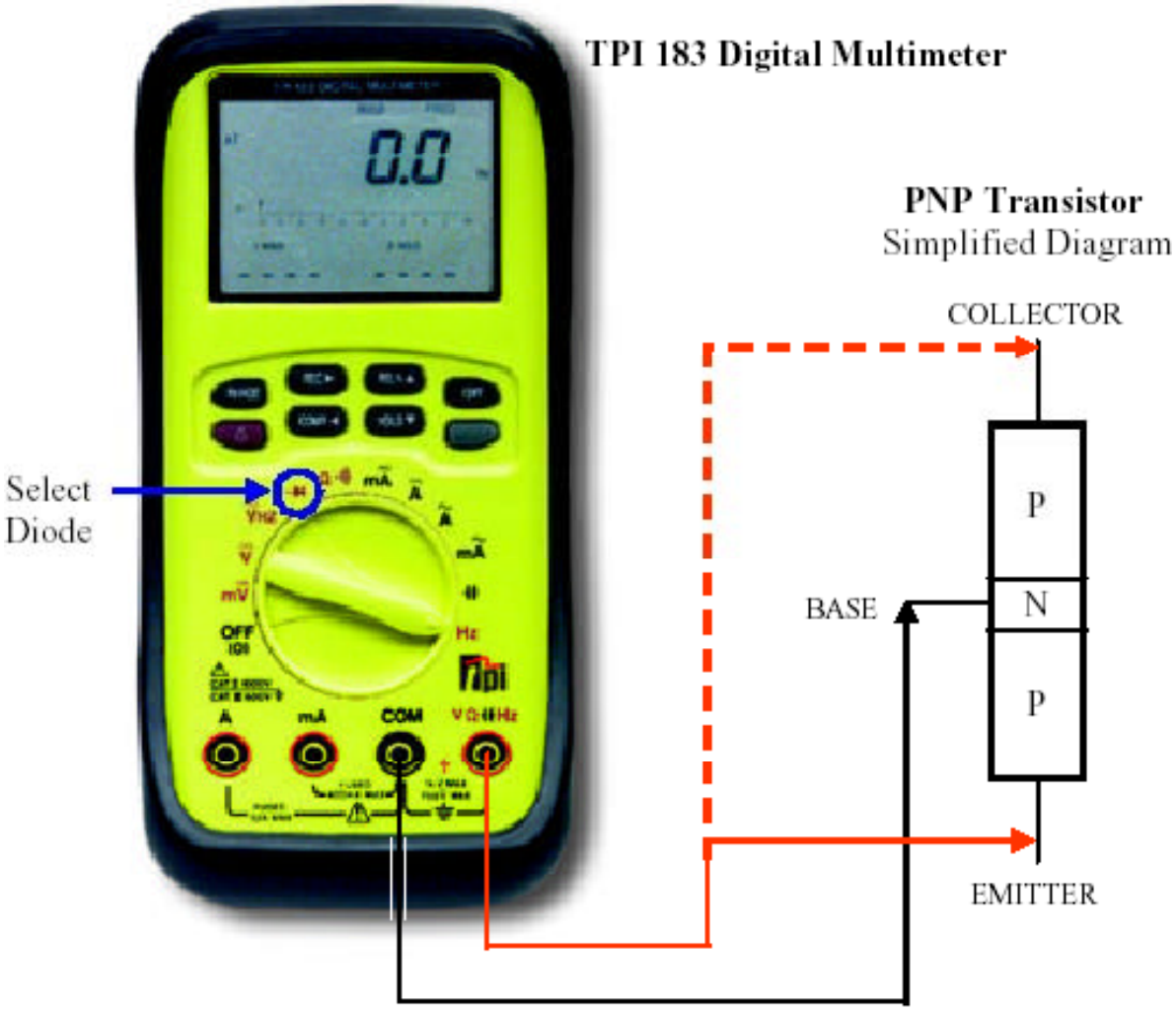
TO218
TO220



C is the metal case itself

TO3

BJTs – Testing



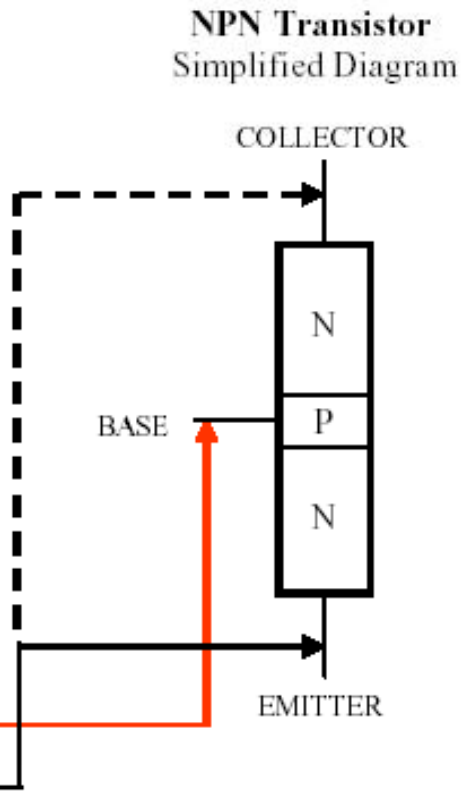
PNP Test Procedure

Connect the meter leads with the polarity as shown and verify that the base-to-emitter and base-to-collector junctions read as a forward biased diode: 0.5 to 0.8 VDC.

Reverse the meter connections to the transistor and verify that both PN junctions do not conduct. Meter should indicate an open circuit. (Display = OUCH or OL.)

Finally read the resistance from emitter to collector and verify an open circuit reading in both directions. (Note: A short can exist from emitter to collector even if the individual PN junctions test properly.)

BJTs – Testing



PNP Test Procedure

Connect the meter leads with the polarity as shown and verify that the base-to-emitter and base-to-collector junctions read as a forward biased diode: 0.5 to 0.8 VDC.

Reverse the meter connections to the transistor and verify that both PN junctions do not conduct. Meter should indicate an open circuit. (Display = OUCH or OL.)

Finally read the resistance from emitter to collector and verify an open circuit reading in both directions. (Note: A short can exist from emitter to collector even if the individual PN junctions test properly.)