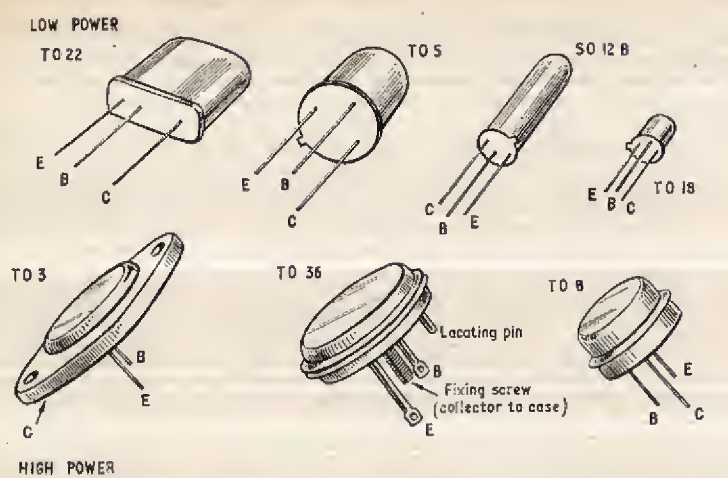


Fig. 16. Some typical transistor encapsulations from the Newmarket range

TRANSISTOR *DO*s AND *DON'T*s

DO:

1. Check polarity (*npn* or *pnp*).
2. Check battery supply polarity.
3. Identify leads correctly.
4. Ensure correct type.
5. Ensure whether transistor should be insulated from chassis.
6. Ensure contact of the faces of power transistors are smooth and that thermal contact with the heat sink is efficient.

DON'T:

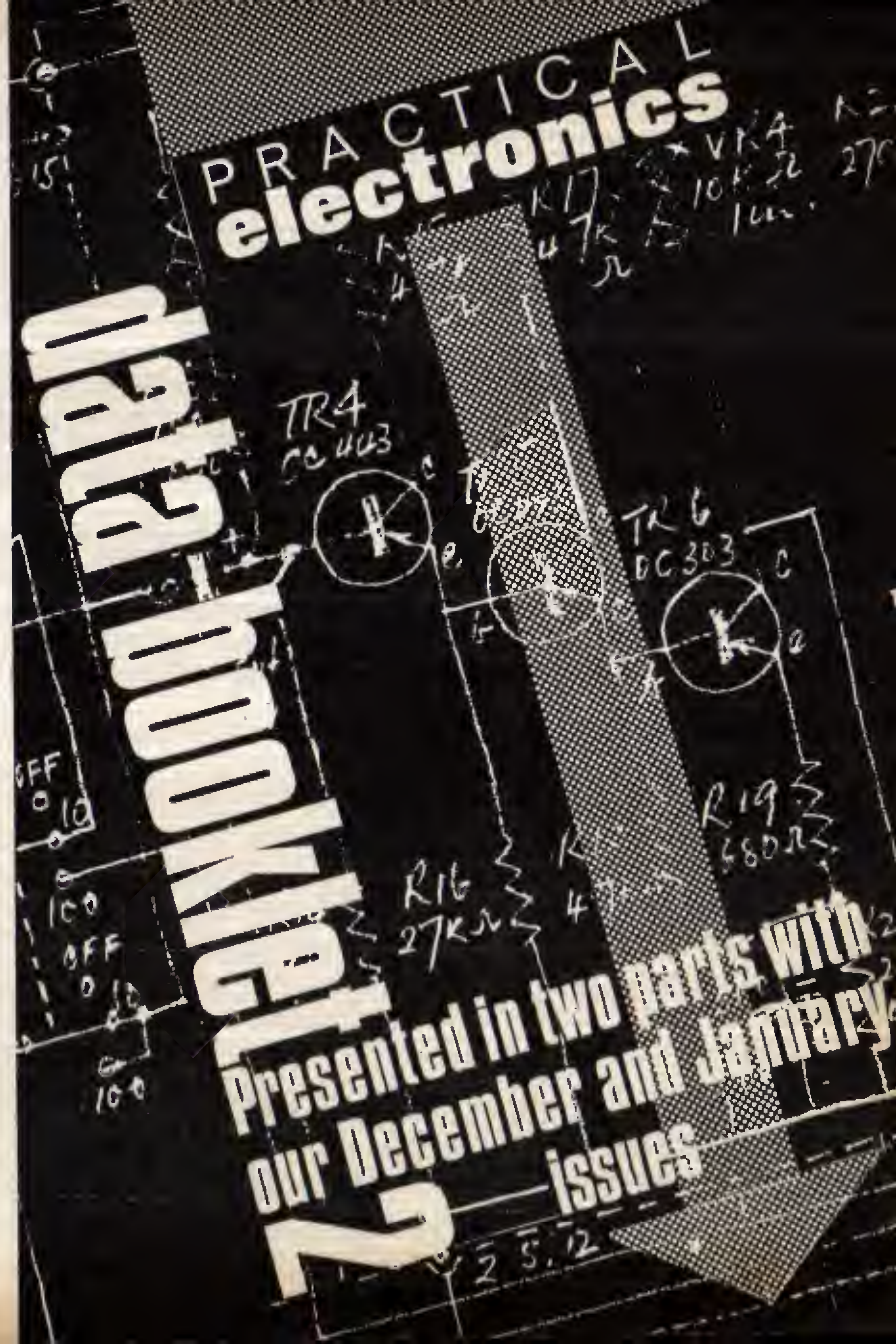
1. Bend leads too close to the seal.
2. Solder leads without heat shunt.
3. Apply heat too long.
4. Mount in or near strong magnetic or electrostatic fields.
5. Operate transistors above maximum ratings.
6. Use "quick heat" gun type soldering irons.

Useful Tips

1. Silicone grease smeared on the surfaces in contact with the heat sink will increase heat conduction.

2. Black matt heat-resistant paint used on heat sinks and transistors helps dissipation of unwanted heat.

3. Long nose pliers, or a crocodile clip with two copper slugs soldered into the jaws, serve as heat shunts, when soldering into position. The heat shunt should be attached to the wire being soldered.



THERMIONIC DEVICES

Diode

Construction

The circuit symbol and typical construction of a diode are shown in Figs. 1 and 2, with indirect heating to cause electron emission from the oxide coated cathode. Less common now is the method of direct heating where the cathode (often made of tungsten wire similar to an electric lamp filament) is directly heated by passing a current through it.

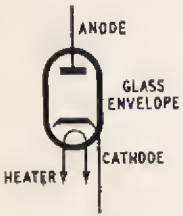


Fig. 1. **Circuit Symbol**

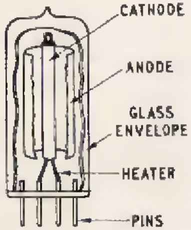


Fig. 2. **Construction**

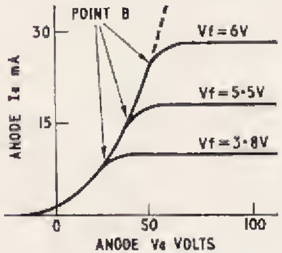


Fig. 3. **Characteristics**

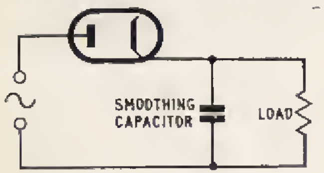
Theory

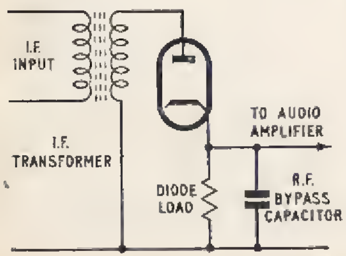
The curves of the characteristics in Fig. 3 conform to a definite law where the current through the valve $I_a = V_a^{3/2}$ and is known as the "threehalves law" up to point B on the curves. Above point B saturation occurs where all the electrons in the space charge around the cathode are being drawn to the anode and no further increase in anode current is possible for a given heater voltage V_f.

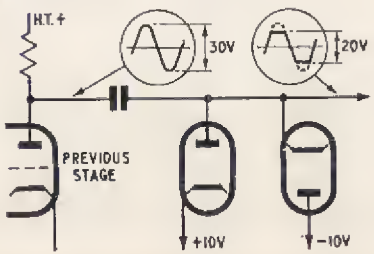
Applications

Diodes are used in numerous circuits some examples of which are shown in Figs. 4, 5, and 6.

Fig. 4. **A.C. rectification (left)**
Fig. 5. **Detection (below left)**
Fig. 6. **Signal Limiting (below)**







Basic Configurations

The circuits in Fig. 15 show the three basic configurations in which transistors are used and the table gives some typical characteristics and parameters of low power transistors.

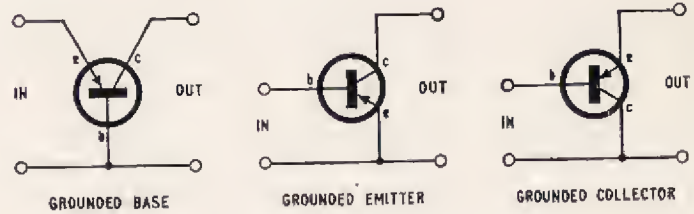


Fig. 15. **Basic transistor configurations**

	Grounded Base	**Grounded Emitter**	**Grounded Collector**
INPUT SIGNAL TO	Emitter	Base	Base
OUTPUT SIGNAL FROM	Collector	Collector	Emitter
CURRENT GAIN	approx. 1	approx. 50	approx. 50
VOLTAGE GAIN	High (approx. 160)	High (approx. 160)	Low (approx. 1)
INPUT IMPEDANCE	Low (200Ω)	Medium (1000Ω)	High (100kΩ)
OUTPUT IMPEDANCE	High (200kΩ)	Medium (40kΩ)	Low (1000Ω)
POWER GAIN	Medium (30dB)	High (40dB)	Low (16dB)
H.F. RESPONSE (POWER = 3dB DOWN)	High (400kc/s)	Low (12kc/s)	Dependant on Load resistance
PHASE SHIFT	0 deg (output in phase with input)	180 deg (output inverse to input)	0 deg (output in phase with input)

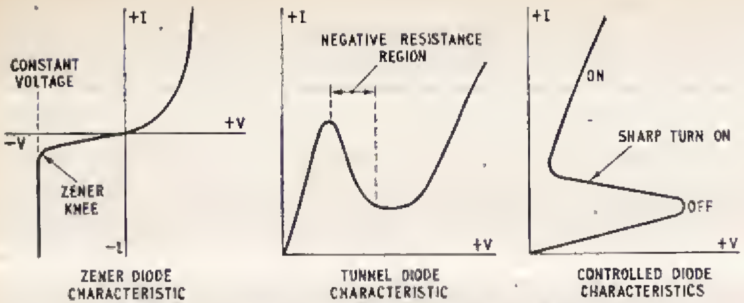


Fig. 13. Characteristics of special purpose diodes

Transistor

For the purpose of this booklet *pnp* transistors only will be considered but the information given will also apply to *npn* types except that biasing and h.t. supplies have reverse polarity d.c. voltages applied.

The addition of an extra element to the junction diode, *p*-type material in the *pnp* transistor and *n*-type in the *npn* transistor produced a device capable of amplification. In practice the *n*-type material in a *pnp* transistor is extremely thin. Typical constructions of some transistors are shown in Fig. 14.

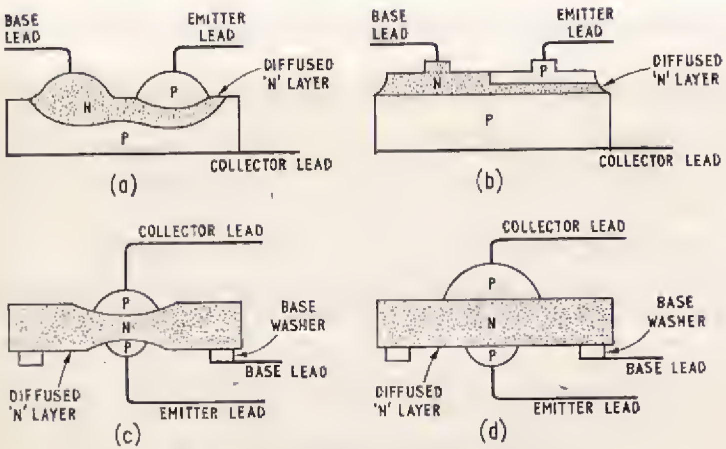


Fig. 14. Transistor construction methods
(a) post alloy diffused (p.a.d.t.) *(b) 'MESA' type*
(c) microalloy diffused (m.a.d.t.) *(d) 'Drift' type*

Triode

De Forest found that the addition of a third element or electrode (called a grid) to the diode placed close to the cathode relative to the anode enabled a small variation of voltage on the grid to produce a large variation of anode current. This discovery and its development precipitated a technological revolution, the implications of which the world still hasn't fully realised.

Construction

The varieties of triode types are too numerous to be treated fully by this booklet but a typical receiving triode, the construction of which is common to all types, is shown diagrammatically in Fig. 8. The grid can be seen to be a form of spiral wire. The electrons pass from cathode to anode through the spaces between each turn of the coil.

Theory

The characteristic curves given in Fig. 9 of anode current against anode voltage for various values of negative grid voltage are similar to those for the diode except that the grid voltage is the third parameter.

From the characteristics it can be seen that as the grid voltage is made more negative the anode current is eventually reduced to zero. It is this variation of anode current with grid voltage that produces amplification and is known as mutual conductance. The change in voltage across a load resistor, placed in series with the valve anode and h.t. positive rail, is greater than the change in grid voltage that produced it. More detailed information on this principle is given in the centre portion of this Data Booklet to be given with the January issue of PRACTICAL ELECTRONICS.

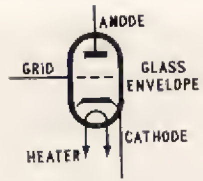
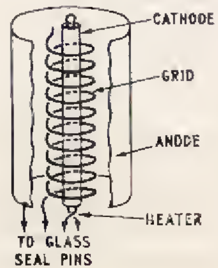
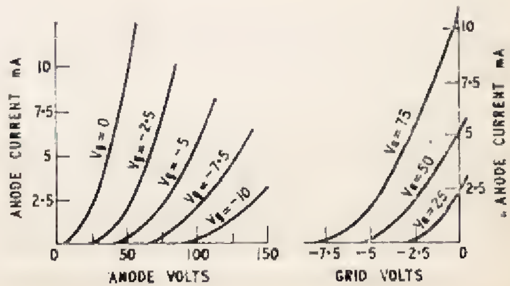


Fig. 7. Triode circuit symbol (left)

Fig. 8. Triode construction (below left)

Fig. 9. Triode characteristics (below)





Applications

The applications of triodes are as varied as the different types, but generally speaking triodes are usually found in stages where a low noise factor is more important than high amplification or high frequency response. At high frequencies triodes become less effective due to the shunting effects of interelectrode capacitance, especially the capacitance between anode and cathode, known as the Miller Effect.

At very high frequencies special triodes are used which have very low capacitance. Special triodes are used in some transmitter circuits but neutralisation of the interelectrode capacitance by "external" means is still necessary.

In the tuner sections of television circuits an arrangement is often used whereby the anode load of a triode r.f. amplifier is in the form of another triode circuit with its grid grounded to a.c. This arrangement is known as a "cascode" amplifier; the grounded grid prevents feedback of the amplified signal and so reduces the Miller Effect.

Tetrode

The tetrode as its name suggests is a triode with an extra electrode interposed between the grid and anode. The fourth electrode is known as the screen grid and is held at a steady voltage approaching that of the anode, providing extra amplification and greater mutual conductance.

In the characteristics shown in Fig. 10, a region of what is known as "negative resistance" occurs due to the secondary emission of electrons from the anode resulting in the repulsion of electrons arriving at the anode from the cathode.

This condition is normally a disadvantage in most applications and is avoided. However, it has been found that it can be usefully employed in some types of oscillator.

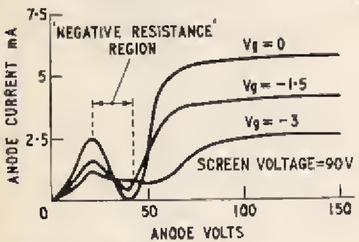


Fig. 10. Tetrode

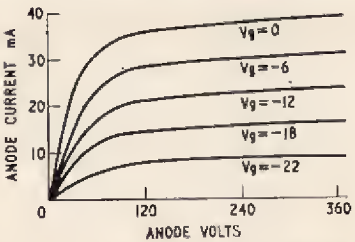


Fig. 11. Pentode

Pentode

The pentode has a fifth electrode interposed between the screen grid and anode and is normally held at cathode potential. Its function is to increase the effective working portion of the characteristic available by reducing secondary emission from the anode (Fig. 11). The "negative resistance" region described in the tetrode section is eliminated.

Continued on page 13

Continued from page 4

Other Types of Valves

Further additions of electrodes are often provided to facilitate the function of two or more valves inside one envelope. One example of this is the triode-hexode arrangement of the superheterodyne receiver. The triode section is the local oscillator while the hexode (six electrodes) is the r.f. amplifier. The two stages are combined to form the mixer, the resulting signal being passed on to the intermediate frequency amplifiers.

★ ★ ★

SEMICONDUCTOR DEVICES

The use of semiconductors dates back many years, in fact the "crystal and cat's whisker" device was probably the earliest type used. Later developments led to the "fixed" point contact diode which was found to be more reliable in radar applications during the Second World War. The outcome of post-war work led to the discovery of techniques for producing germanium junction diodes and triodes.

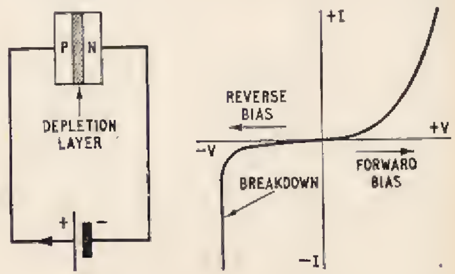
It is not intended to deal with point contact devices fully in this booklet due to their obsolescence. The physics of semiconductor devices has also been omitted because such information is adequately covered by many authoritative text books.

The main advantages of semiconductor diodes over thermionic diodes are:

(i) no heater power is required;
(ii) smaller physical size;
(iii) lower forward voltage drop.

The theoretical diagram of a *pn* junction is shown in Fig. 12 with typical forward and reverse biasing characteristics.

Fig. 12. Basic circuit and characteristics of a semiconductor diode



Further developments of the junction diode have produced unique devices such as the Zener diode, tunnel diode, silicon controlled rectifier, and gate controlled rectifier. Some of their characteristics are shown in Fig. 13.