WS No. 19 Mark III

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ELECTRICAL AND MECHANICAL
ENGINEERING REGULATIONS
(By Command of the Defence Council)

TELECOMMUNICATIONS
A 412

SERVICING SEMI-CONDUCTOR EQUIPMENTS

Errata

Note: These Pages 0 - 01, are to be filed immediately in front of Page 1, Issue 1, dated 5 Oct 62.

1. The following amendments are to be made to the regulation.

2. Page 1, para 1, line 1

   Insert after This 'is'

3. Page 4, para 10, line 4

   Delete: 'A 552'
   Insert: 'A 522'

4. Page 9, para 35, line 5

   Delete second 'may'

5. Page 10,

(a) para 37, line 4

Delete whole line
Insert: 'but generally an Avometer 9SX, on its two higher resistance ranges, is suitable to perform this test.'

(b) para 39

Delete whole para
Insert: '39. Radio receivers using transistors in their front ends, even if not switched on, must not be placed close to radiating transmitters, particularly if they are being operated on similar frequencies. Some receivers eg A13 have built in protection, but many older types do not.'

EME 8a/984

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SERVICING SEMI-CONDUCTOR EQUIPMENTS

INTRODUCTION

1. This is the third of a series of three ERERs dealing with semi-conductor devices, division of the series is as follows:-

(a) Tels A 018 A series of brief descriptions, each one dealing with a distinct kind of semi-conductor device. No reference will be made to any individual type. This section will be kept up to date by the issue of additional sheets, as new kinds become available.

(b) Tels A 339 Description and examples of basic circuits involving the use of semi-conductor devices.

(c) Tels A 412 The elements of servicing, and techniques peculiar to circuits using semi-conductor devices.

2. The two semi-conductor devices most likely to be found in current equipments are either the semi-conductor diode or the transistor.

THE SEMI-CONDUCTOR DIODE

3. The semi-conductor diode is used in different forms and widely varied applications:-

(a) Crystal mixers - germanium or silicon point contact diodes

(b) Signal detectors - germanium or silicon point contact diodes

(c) Pulse shapers, Amplitude limiters, Switching - germanium or silicon junction diodes

(d) Power rectifying diodes - silicon junction diodes

(e) Voltage regulating diodes - 'zener' diodes either silicon or germanium

4. The semi-conductor diode is found in a number of different shapes and sizes some typical examples being shown in Fig 1.

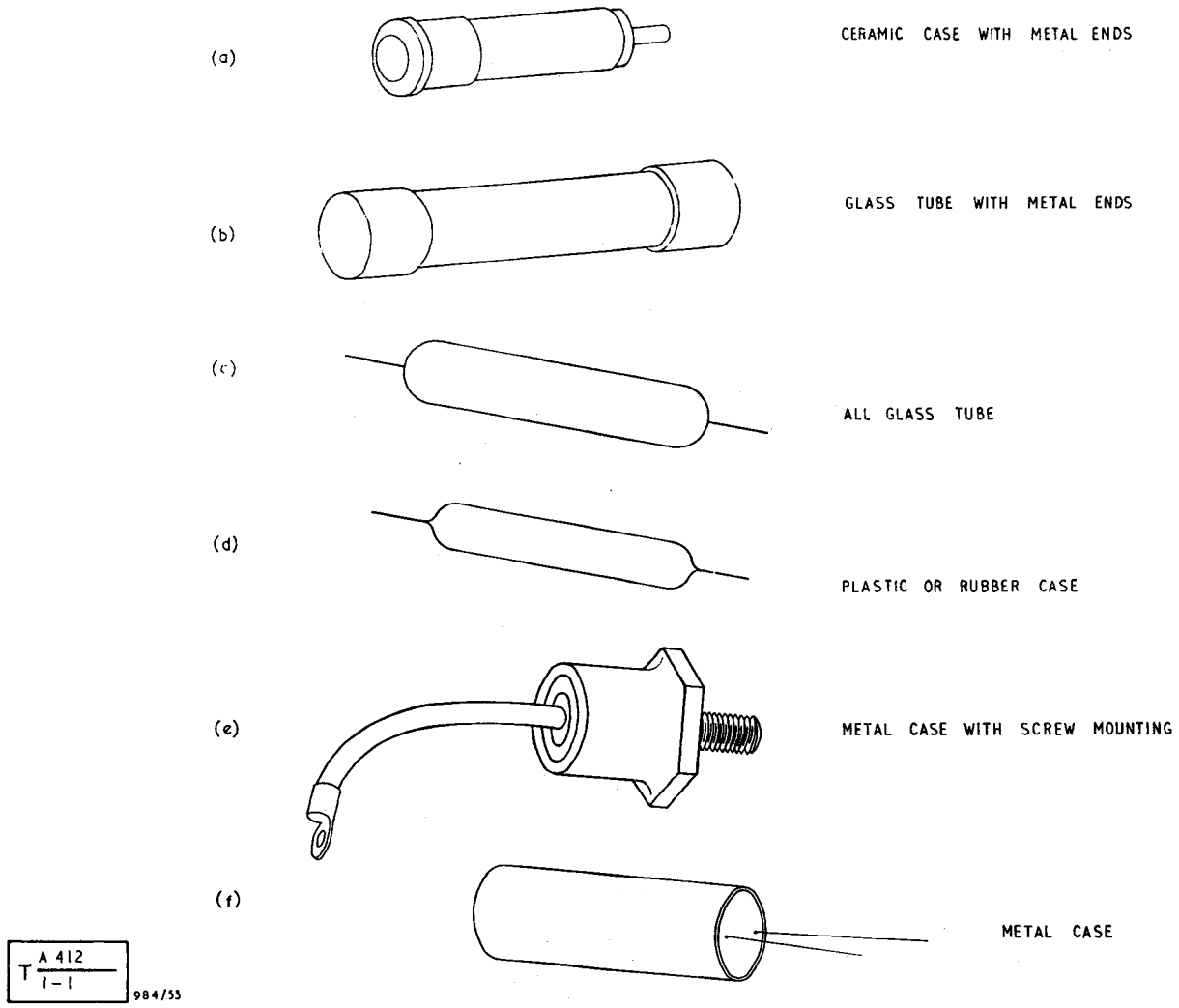

Fig 1 - Typical semi-conductor diodes

5. All Services semi-conductor diodes can be identified by a CV number marked on the body of the device. The CV number is indicated either by figures or by the standard resistor colour code. The colour code is read from the 'positive marked' end of the diode. For a single ended diode such as in Fig 1(e) the colour code is read from the 'lead in' or the free terminal.

6. Fig 2 shows the way in which the polarity of diode is indicated.

7. The diodes in Fig 3 are drawn such that when connected in circuit with the right hand end made positive with respect to the left hand end, a small reverse current flows; with the right hand end made negative, a large forward current flows. In other words, the end of the diode marked + etc is equivalent to the cathode of a thermonic valve type diode.

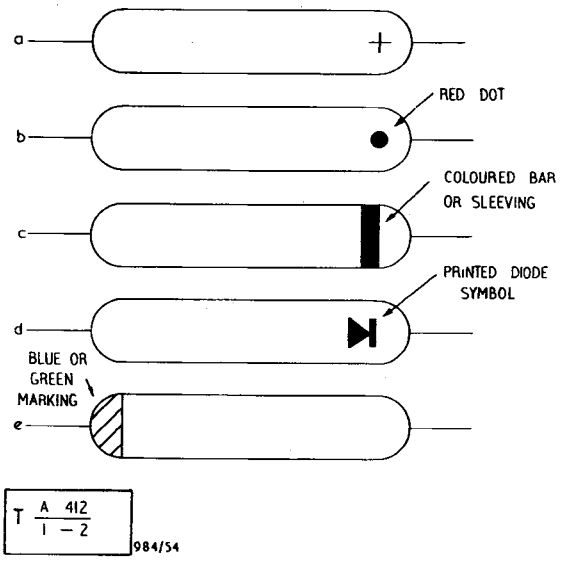

Fig 2 - Diode polarity markings

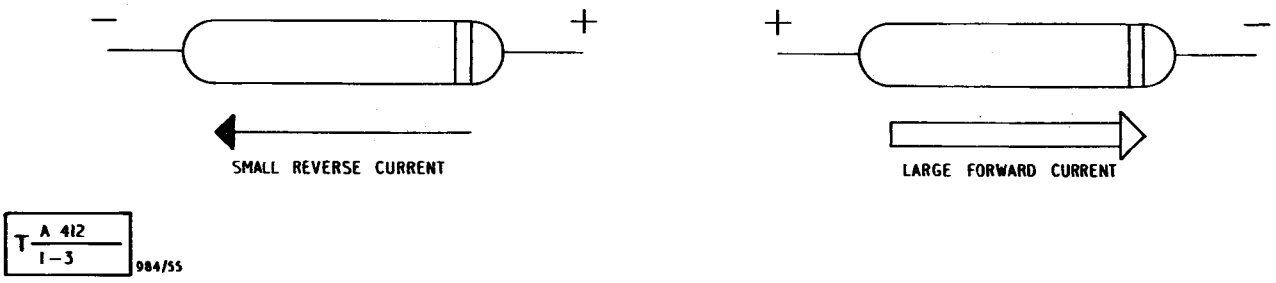

Fig 3 - Current in diodes

8. All semi-conductor diodes can be adversely affected by:-

(a) excess of heat

(b) forward current in excess of rated value

(c) reverse voltage in excess of rated value

(d) ingress of moisture

(e) incorrect storage temperature.

9. Some types may be affected by:-

(a) exposure to light

(b) electrostatic or electromagnetic fields

10. Thus care must be taken to avoid damaging the semi-conductor device during servicing by subjecting it to any of the factors listed in para 8 and 9. To ensure that the diode is not damaged by heat, soldering techniques as described in Tels A 582 must be carefully followed.

11. Semi-conductor diodes used to handle high powers normally have one terminal connected to the outer metal housing or case. This may be fixed to the chassis to improve the heat dissipation of the diode. If the case of the diode is at some potential other than that of the chassis, mica washers and bushes are provided to electrically isolate the two. Should the washer be damaged, it must be replaced by another mica washer or a washer which has similar high heat conducting and electrical insulating properties.

12. (a) Any low impedance voltage source (eg, test oscillators, power supplies) is a potential danger to the semi-conductor diode, since if a potential is applied in the forward direction across the diode and there is only a small valued limiting resistance, then a heavy current will flow. This current can destroy the diode.

(b) In the same way if a limiting resistance is shorted by non-insulated test prods, excessive current will flow in the diode.

(c) When testing a circuit, special care must be taken to ensure that polarities of supplies connected to the circuit are in the correct sense.

13. When resistance measurements are made within a circuit, care must be taken to ensure that the internal emf of the ohmmeter is not such that excess forward current is caused to flow in the diode. Also this internal emf must not exceed the reverse voltage of the diode.

14. Devices which are sensitive to light are covered with opaque paint or sleeving. Care should be taken to ensure that such covering is not scratched or removed.

15. The leads emerging from the encapsulated diode are hermetically sealed. They should not be bent directly at the seal. Possible future damage by ingress of moisture may occur if the seal is stressed.

16. A simple method of testing a semi-conductor diode is to measure the forward and reverse resistance of the diode. An AVO 8 will cause about 1/2mA to flow through the forward resistance of the diode. Typical resistance values are as follows:-

(a) Forward Resistance 100-1000Ω

(b) Reverse Resistance 1MΩ

17. In the case of certain types of crystal mixers 1/2mA may exceed the permissible forward current. In this case a series limiting resistor of appropriate value should be used in conjunction with the AVO. It must also be noted that Avometers on resistance ranges, due to the internal battery, give a terminal polarity opposite to that shown at the meter terminals, ie, + terminal is negative and - terminal is positive.

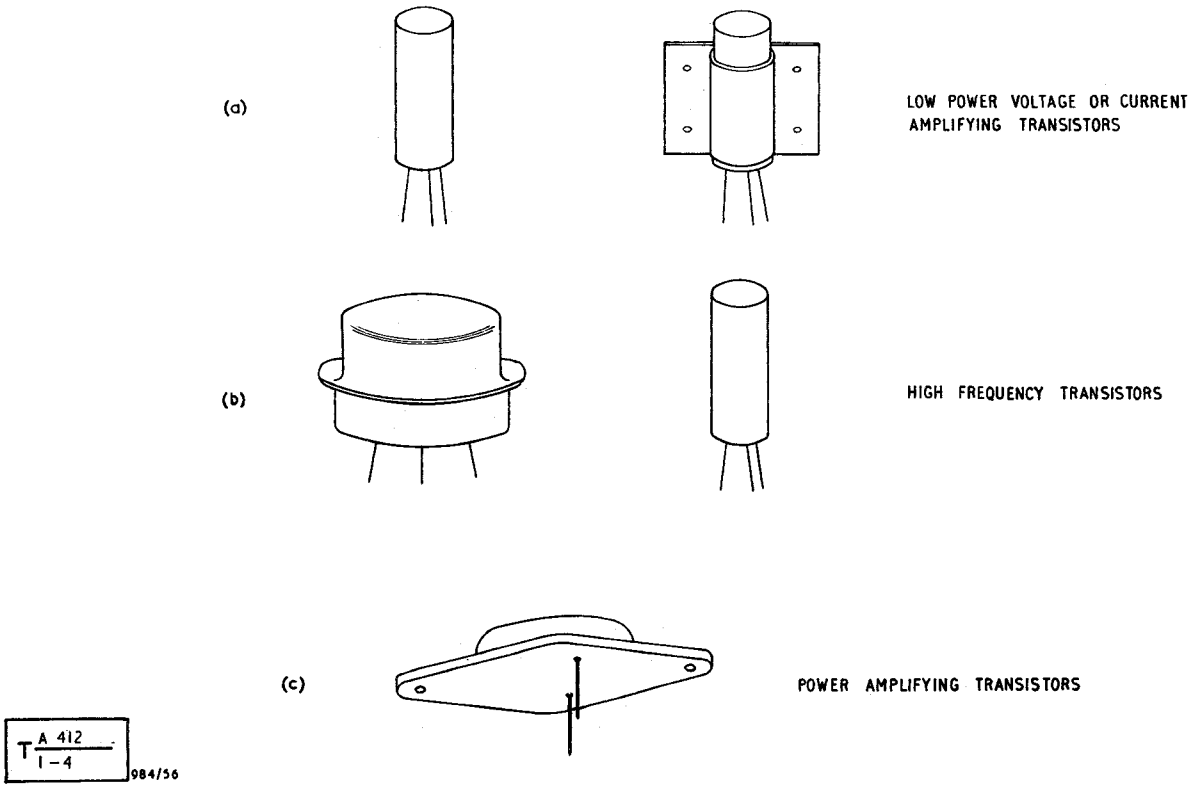

Fig 4 - Typical transistors

THE TRANSISTOR

18. The transistor is found in many different shapes and sizes dependent upon the particular role of the transistor. These can be divided into broad groups as shown in Fig 4.

19. Transistors can be divided into two fundamental types. Fig 5 shows these two types with their circuit symbols.

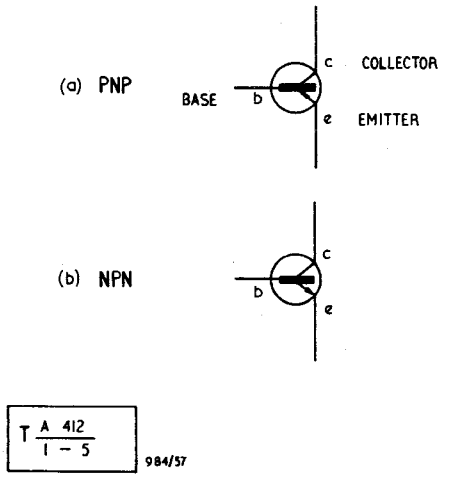

Fig 5 - Transistor circuit symbols

20. The only difference in circuit operation between the two types is the direction of the polarity of the connected power supplies as shown in Fig 6.

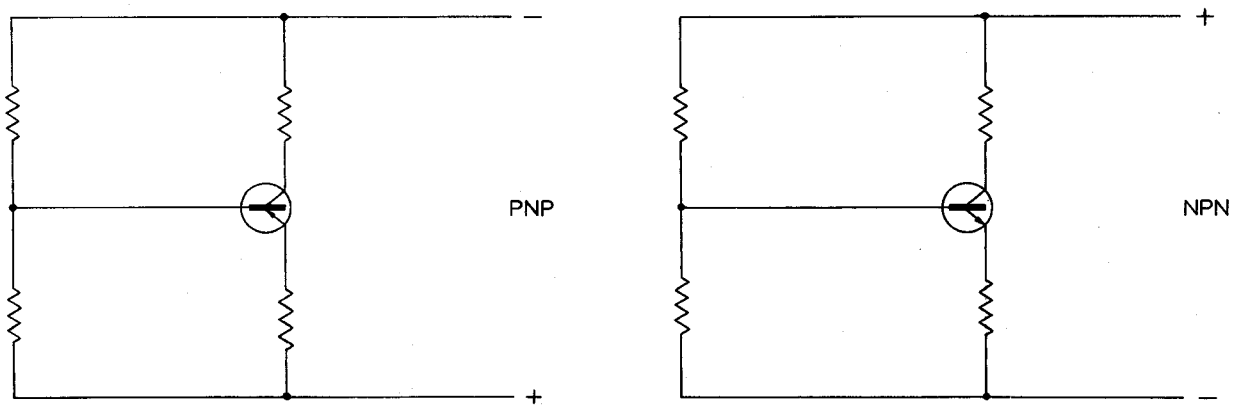

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Fig 6 - Polarity of transistor power supplies

21. The important operating factors in a transistor are:- (See Fig 7)

(a) The base current Ib

(b) The emitter current Ie

(c) The collector current Ic

(d) The max permissible collector-base voltage Vcb

(e) The max permissible base-emitter voltage Vbe

(f) The max permissible collector power dissipation Pc

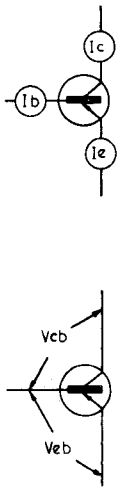

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Fig 7 - Transistor operating factors

22. It is possible to exceed the maximum collector power whilst within the permissible values of collector current or collector-base voltage (Pc = Ic x Vcb). Care must be taken to avoid this.

23. All transistors in Service equipment are identified by a CV number marked on the body of the transistor either in figures or by the colour code.

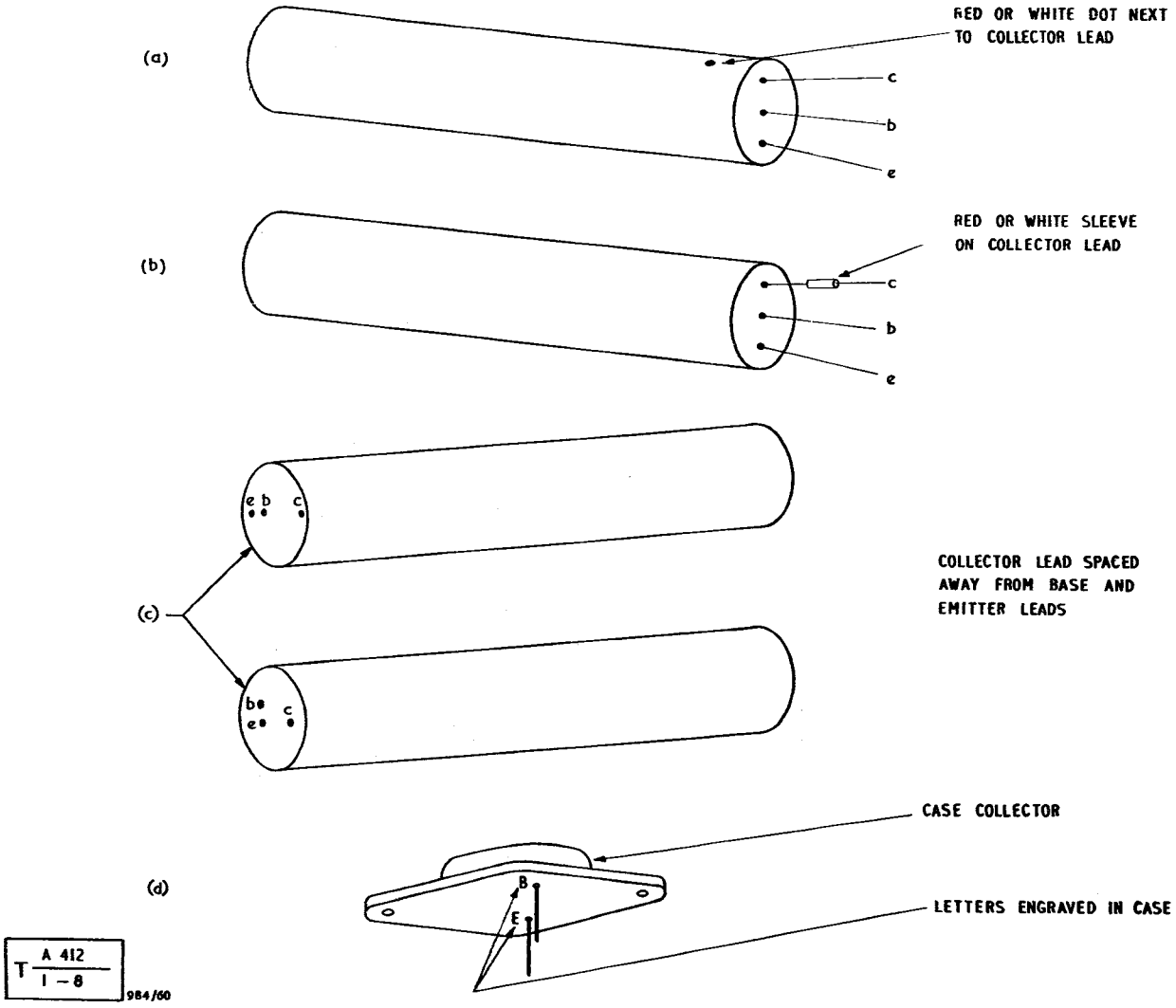

Fig 8 - Marking of transistor leads

24. The collector, base, or emitter leads are marked in different ways which depend upon the manufacturer and the type of transistor. Some typical examples are shown in Fig 8.

25. Transistors can be adversely affected by

(a) excess of heat

(b) current in excess of rated value

(c) voltage in excess of rated value

(d) ingress of moisture

(e) exposure to light

(f) electrostatic or electromagnetic fields

(g) incorrect storage temperature

26. As with the semi-conductor diode, soldering techniques as described in Tels A 522 must be carefully followed.

27. Power transistors normally have the collector connected to the outer metal case. This increases the effective heat dissipating area of the collector. The case can then be clamped to the chassis or to a metal plate called a 'heat sink' to increase even further the heat dissipating properties. It may be necessary to isolate electrically the transistor from the chassis or the heat sink. In this case mica washers (which are electrical insulators but heat conductors) are used. If the transistor is removed from its mounting and new washers are required these must be made from mica or a material with similar properties.

28. The transistor may be regarded as consisting of two diodes; one between the emitter and base and the other between the collector and the base (Fig 9). If a low impedance voltage source is connected across either of these two diodes so that polarity is as shown in Fig 3b then a heavy current, which could destroy the transistor, will flow.

29. The current flowing in the collector circuit of a transistor is some 30-150 times the current flowing in the base circuit. Any changes of current which occur in the base circuit result in much larger changes of current in the collector circuit. Therefore any change of circuit conditions which increases the base current of a transistor is a potential source of danger.

30. The following are some of the ways in which a transistor may be damaged by increasing the base current to a point where either it or the collector current is excessive.

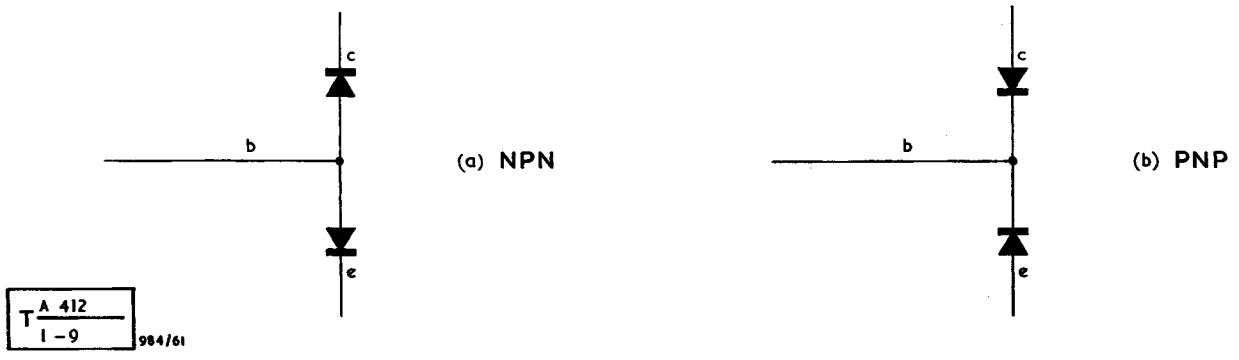

Fig 9 - Transistor considered as two diodes

In Fig 10 R1 and R2 are so chosen that the potential at their junction causes the correct base current to flow.

(a) If the supply is connected in the opposite sense the potential division may be such that excessive base current flows.

(b) If R1 is shunted by a low impedance excessive base current will flow.

(c) If R3 is shunted by a low impedance the transistor will have no load and excessive current will flow.

(d) When making voltage measurements the impedance of the voltmeter may present a dangerously low impedance path. This would be particularly true of a voltmeter placed across R1. For this reason the AVO 8 is the preferred instrument for making voltage measurements.

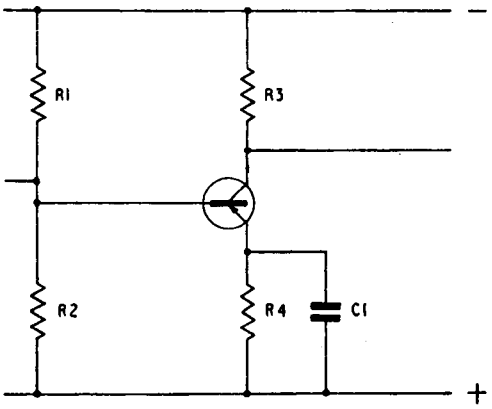

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Fig 10 - Typical circuit arrangement

31. The points mentioned above can be summarised.

(a) Check polarity of supply.

(b) Be careful not to short circuit components either by faulty test prods or by using a low resistance meter.

32. Care must be taken when making resistance measurements that the voltage source of the ohmmeter is not placed across any of the electrodes of the transistor.

33. Transistor circuits often include large values of capacitance. These are usually electrolytic type, and may have quite a low d.c. working voltage. Care must be taken:

(a) To ensure that any voltage source connected across them has the correct polarity.

(b) That resistance measurements are not confused by the presence of an electrolytic capacitor.

34. The transistor will not tolerate voltage or current overloads for even a short time. The supply therefore must be switched off before components are removed or replaced.

35. Care must be taken when using d.c. power supplied obtained by rectifying a.c. eg, Battery superseder. Switching from one voltage range to another or from one load to another, ie Send to Receive, causes large spikes of voltage due to back e.m.f.s from transformers, tranducers, chokes etc. These peaks can destroy transistors and add-on protection units may ~~may~~ have to be used.

36. Earth leakage currents in electrical equipment such as a soldering iron can be sufficient to cause excessive current to flow in the transistor. To prevent this a common earth connection should be used between the circuit under test and any test equipment connected to an earthed supply.

37. Transistors can be checked as two diodes connected back to back. The collector-base and emitter-base 'diodes' should show a front to back ratio of at least ten to one. Care must be taken not to exceed the ratings of the transistor but generally an Avometer 9SX ~~is suitable to perform this test.~~ ON ITS TWO HIGHER RESISTANCE RANGES, IS SUITABLE TO PERFORM THIS TEST.

38. Before a transistor is replaced the fault which caused the failure should be located.

39. Radio ~~receivers~~ using transistors in their ~~front~~ ends ~~must~~ not be placed geographically close to transmitters being operated, particularly ~~if~~ they use similar frequencies, even if not switched on. Some ~~receivers~~ eg, A13, have built in protection, but older types eg A43, do not.

Radio receivers using transistors in their front ends, even if not switched on, must not be placed close to radiating transmitters, particularly if they are being operated on similar frequencies. Some receivers eg A13 have built in protection, but many older types do not.

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END