TRANSISTOR TEST SET TYPE 166

OPERATING INSTRUCTIONS

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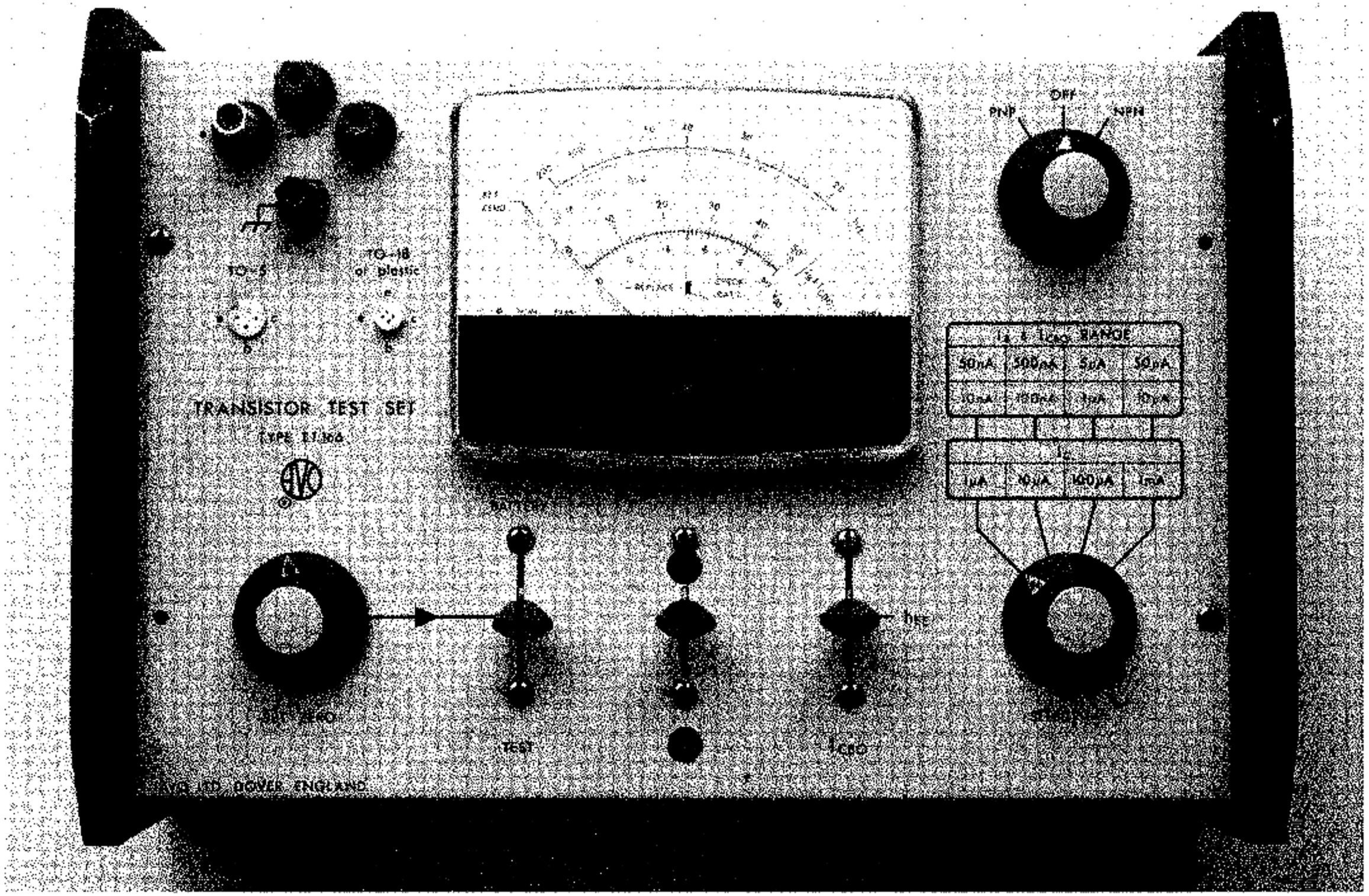


THE "AVO" TRANSISTOR TEST SET TYPE TT166

AVO TRANSISTOR TEST SET TYPE TT. 166

CONTENTS

GENERAL INFORMATION

The instrument is primarily intended for the rapid measurement of bi-polar transistor d.c. parameters. It is capable of measuring current gain at the very low collector currents appropriate to modern devices. Measurement of current gain can be made at four values of collector current over the range 1μA to 1mA on both NPN and PNP transistors. Facilities are also provided for the measurement of the emitter-base voltage and the collector-base leakage current at any one of the four values of collector current. Measurement can also be made of the reverse leakage current and forward conduction voltage of diodes.
The instrument is self-contained, operating from two internally located 9V batteries.

Construction
The instrument chassis and its base plate are carried on two cast aluminium end frames which have built-in handles. The chassis is painted and silk-screened directly to form the front panel.

SPECIFICATION

Transistors:

D.C. Current Gain (h_{FE}): Two ranges calibrated 19 to 200 and 100 to 2000 (h_{FE} inversely proportional to deflection). Accuracy ± 3 % at f.s.d. For deflections less than f.s.d.

$$\text{accuracy} = \left(\frac{100}{\%\text{ of f.s.d.}} + 2\right)\%$$

While the controls are set up for the measurement of h_{FE} it is also possible to read, on the appropriate I_B scale, the actual value of base current flowing in the transistor.

Emitter-base voltage (V_{BE}): 0 to 1V on a calibrated linear scale.

Collector-base leakage current (I_{CBO}): 10nA to 50μA f.s.d. monitored by the panel meter. Four basic ranges but a multiplication facility effectively provides eight ranges.

Nominal Collector Test Current (I_C): 1μA, 10μA, 100μA and 1mA (four pre-set values).

Collector Test Voltage (V_{CE}): 2V $\pm$ 0·5V (dependent upon test conditions).

Diodes:

Reverse Leakage Current (I_{DR}): 10nA to 50μA f.s.d. with a test voltage of 1V $\pm$ 0·25V (dependent on meter deflection). The leakage current is monitored on the panel meter. Four basic ranges but a multiplication facility effectively provides eight ranges.

Diode Forward Conduction Voltage (V_{DF}): 0 to 1V at a current of 1μA, 10μA, 100μA or 1mA.

Power Supply: Two 9V Ever-Ready type PP7 batteries or equivalents.

Dimensions: 12½ in. wide × 8½ in. high × 5 in. deep
(318 mm × 216 mm × 127 mm)

Weight: 7½ lb. (3 kg) approximately

CONTROLS

All controls are front panel mounted and their functions are clearly indicated. Details of the controls are as follows:

PNP/OFF/NPN: This control selects the appropriate polarity for the transistor under test and also switches the instrument off.

SELECT I_C: This switch enables any one of four fixed values of collector current to be selected for the measurement of h_{FE} and the corresponding value of I_B. For measurement of I_B and also I_{CBO}, full scale values of 50nA, 500nA, 5μA and 50μA are set automatically with the selection of a value of I_C and with the scale switch in the least sensitive (BLACK disc) position. If the scale switch is pressed down to the RED disc, the measurement sensitivity of each full scale value is increased by a factor of five.

V_{BE}/h_{FE}/I_{CBO}: This switch enables the measurement of emitter-base voltage, d.c. current gain or collector-base leakage current to be selected and with other controls set as appropriate, the measurement will be displayed on the panel meter.

SCALE: When the SCALE selection switch is in the upright position (the least sensitive position) the black ranges are in use on the panel and meter. Pressing this switch towards the RED disc increases the measurement sensitivity by a factor of five. The corresponding ranges on panel and meter are also identified in red.

CHECK BATTERY/ZERO/TEST: A spring-biased lever switch. In the CHECK BATTERY position the batteries may be checked at any time with the instrument switched on. The minimum battery level is marked on the meter. The marking indicates operation within the specified accuracy down to the beginning of the black area, operation at reduced accuracy within the black area and below this, battery replacement must be effected.
When this switch is pressed down to the TEST position the measurement selected will be displayed on the panel meter. In the centre biased position the control is correct for setting zero by means of the SET ZERO potentiometer.

CONTROLS

SET ZERO:

With the instrument switched on, and the CHECK BATTERY/ZERO/TEST switch in the centre biased position, this control may be adjusted to set the meter pointer to the zero position.

SOCKETS AND TERMINALS:

Sockets are provided for TO5, TO18 and plastic encapsulations. For other encapsulations and for diode measurements terminals are provided. The black terminal is connected to the circuit zero volts line and the instrument chassis. It may be used to ground the screen of any external jig used for high volume testing of devices.

PANEL METER:

The meter has five scales. For current and h_{FE} measurements the black scales are in use when the SCALE switch is in the upright position and the red scales when the SCALE switch is pressed down towards the RED disc. A single scale is provided for V_{BE} measurements.

BATTERY CHECK

The batteries may be checked at any time when the instrument is switched on. To check the batteries, press the left-hand lever switch upwards to the CHECK BATTERY position and observe the panel meter indication. Replace battery if the pointer is within the 'Replace' section. (See CHECK BATTERY/ ZERO/TEST control for further detail). Replacement is easily effected after removing the instrument base plate.

TRANSISTOR TESTING

(a) h_{FE} Measurement:

(i) Select the appropriate polarity, either PNP or NPN. This will also switch on the instrument.

(ii) If required adjust the SET ZERO potentiometer to bring the meter pointer to the zero position.

(iii) Insert the transistor to be tested into the appropriate test socket. Set the SELECT I_C switch to the required pre-set value of collector current, i.e. 1μA, 10μA, 100μA or 1mA. Set the adjacent function selector switch to h_{FE}.

(iv) The SCALE switch should preferably be upright to select the least sensitive (black) ranges. If it is required to increase the measurement sensitivity press the switch downwards towards the red disc to increase the sensitivity by a factor of five.

(v) Press down the spring-biased lever switch to the TEST position. Measurement of h_{FE} will then be displayed on the panel meter. With the SCALE switch in the BLACK position, the black scale calibrated 19 to 200 is used. With the SCALE switch in the RED position the red scale calibrated 100 to 2000 is used for measurement.

(vi) If required, another value of test current may now be selected. The position of the SELECT I_C control may be adjusted with the left-hand switch held in the TEST position. While the controls are set up for the measurement of h_{FE} it is also possible to read the actual value of base current flowing in the transistor, from the appropriate I_B scale on the meter.

(vii) Note: After measuring h_{FE} it is advisable, especially at low collector currents, to check that the collector-base leakage current is sufficiently small to have caused negligible error in the h_{FE} indication. To do this, observe the value of the base current reading on the I_B scale after having read the value of h_{FE}, then press the right-hand lever switch down to measure I_{CBO}. If the value of I_{CBO} is negligible compared with the I_B measurement, then the measured value of h_{FE} can be considered correct. For most silicon transistors this will be so, but if not, the true value of h_{FE} can be determined from the simple formula:

$$h_{FE} = \frac{I_C}{I_B + I_{CBO}}$$

(b) Calculation of a.c. current gain h_{fe}.

Under the operating conditions within the range of this instrument, modern bi-polar transistors show a d.c. current gain which is less than the a.c. gain by a factor M which is typically between 0·7 and 0·9. For many purposes the assumption M = 0·8 gives a sufficiently accurate measure of h_{fe}; however, if necessary it is normally possible to obtain the exact value of M from the formula:

$$M = 1 - \log_{10} P$$

In this formula, P is the factor by which the d.c. gain increases when the collector current is increased by a factor of 10.

(c) Emitter-base voltage (V_{BE})

(i) Set the function selector switch to V_{BE} and the SELECT I_C control to the required value of collector current. The SCALE switch may be in any position.

(ii) Press down the spring-biased lever switch to the TEST position. The required measurement will then be displayed on the panel meter, on the linear voltage scale calibrated 0 to 1V.

(d) Collector-base leakage current (I_{CBO})

(i) Set the function selector switch to I_{CBO} and the SELECT I_C control to the required range of I_{CBO}. The SCALE switch should be in the upright position.

(ii) Press down the spring-biased lever switch to the TEST position and the required measurement will then be displayed on the panel meter on the linear current scale calibrated 0 to 50. With the SCALE switch pressed towards the RED disc the measurement sensitivity will be increased by a factor of five and the measured value is read on the red scale calibrated 0 to 10.

DIODE TESTING

(a) Measurement of reverse leakage current.

(i) Connect the diode between the b and c terminals, with the anode to b.

(ii) Set the polarity switch to NPN and the right-hand lever switch to I_{CBO}. Set the SCALE switch in the upright position, and choose an appropriate current range by using the SELECT I_C switch.

(iii) Press the left-hand lever switch down to TEST and the leakage current will be displayed on the meter on the black scale calibrated 0 to 50. Pressing the SCALE switch down towards the RED disc will increase the measurement sensitivity by a factor of five and the value will then be read on the red scale calibrated 0 to 10. The current range may be varied by using the SELECT I_C control.

(b) Measurement of Forward Conduction Voltage.

(i) Connect the diode between the b and e terminals with the anode connected to b.

(ii) Set the polarity switch to NPN and the right-hand lever switch to V_{BE}.

(iii) Press the left-hand lever switch down to TEST and the value of forward conduction voltage, at a current determined by the setting of the SELECT I_C switch, will be displayed on the meter on the scale marked V_{BE}.

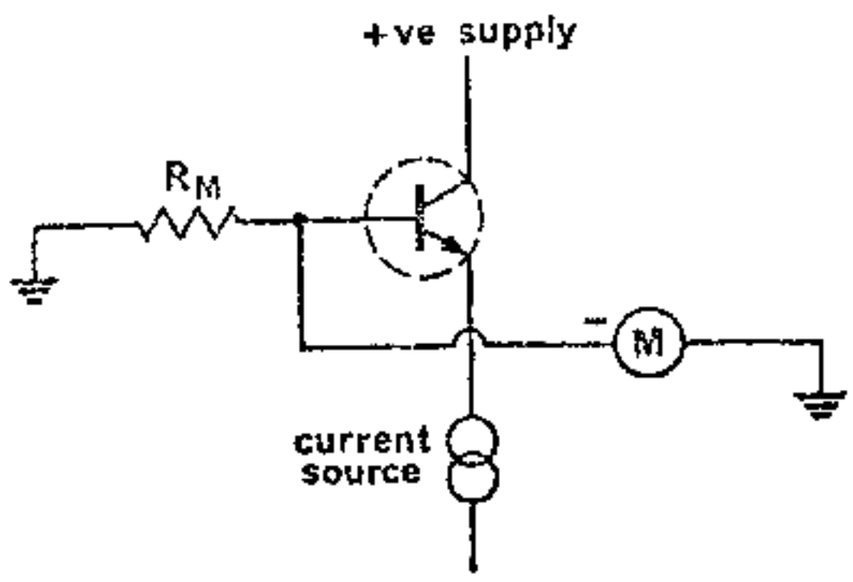


Fig. 1 h_{FE} measurement

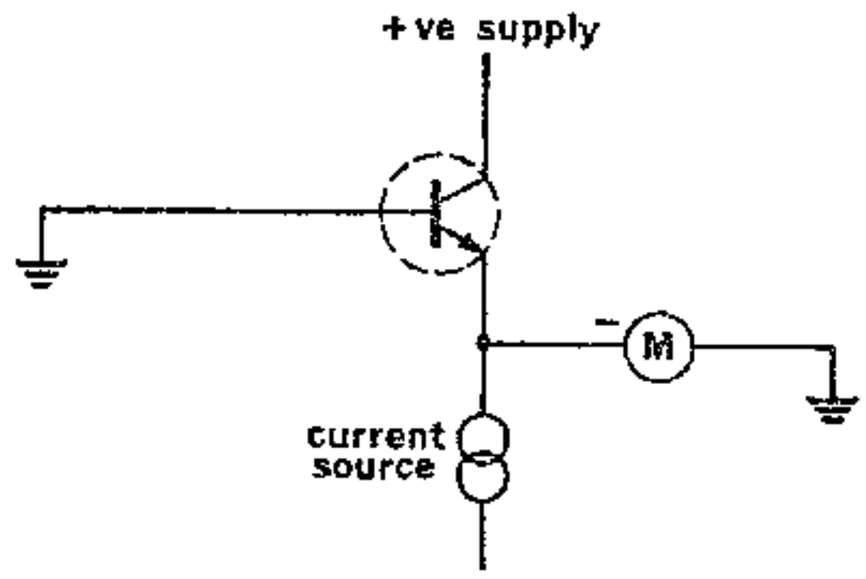


Fig. 2 V_{BE} measurement

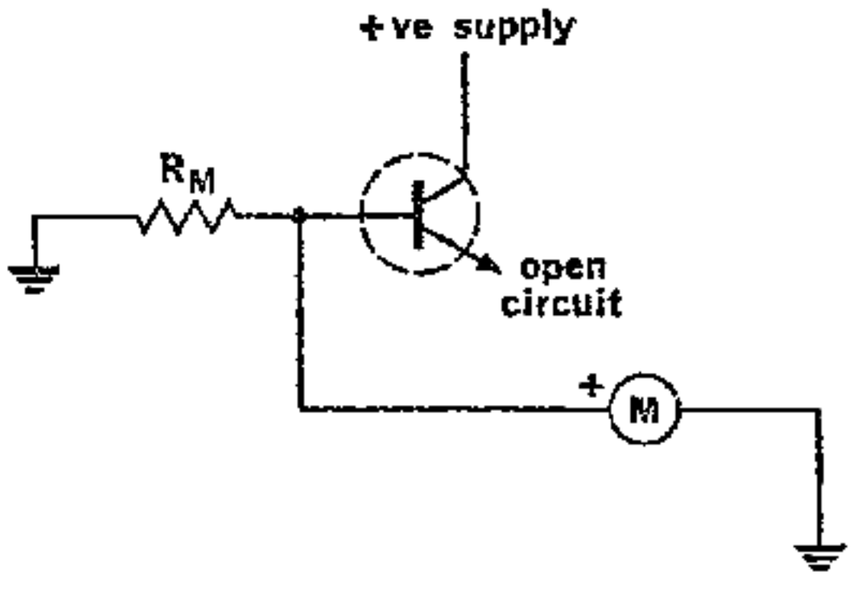


Fig. 3 I_{CBO} measurement

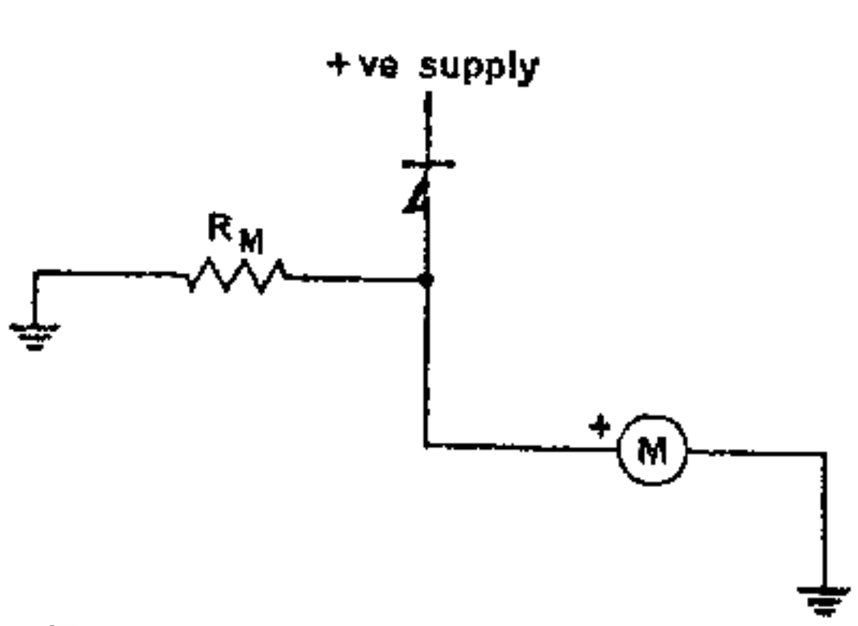


Fig. 4 Diode leakage measurement

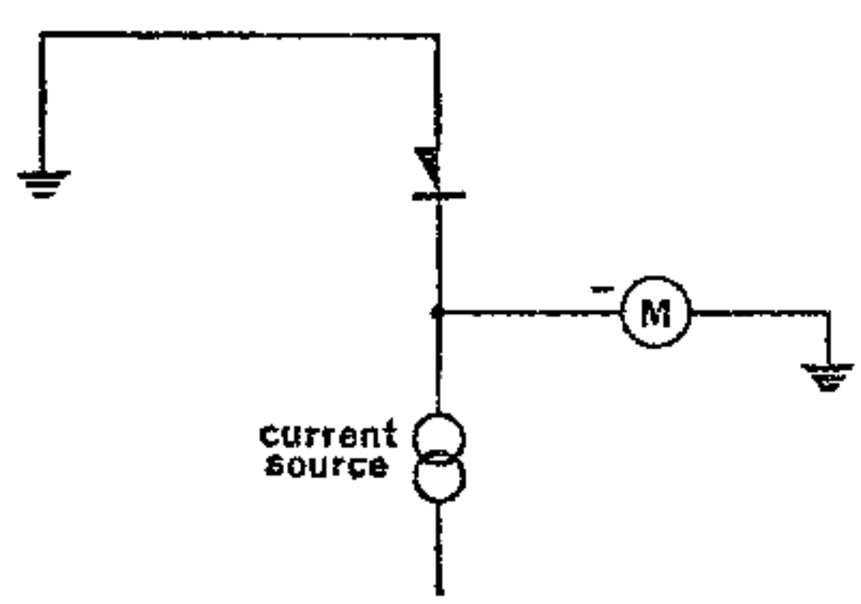


Fig. 5 Diode forward voltage measurement

The simplified diagrams Figs. 1 to 5 indicate the actual circuit arrangements for each of the five measurements which can be carried out. The meter M seen in all diagrams is a high impedance voltmeter with F.E.T. input. This voltmeter is used directly for the measurement of V_{BE} and diode conduction voltage as can be seen in Figs. 2 and 5. For current measurements the voltmeter is used in conjunction with a measuring resistor R_M as seen in Figs. 1, 3 and 4.

The transistor collector current is determined by a current source which has one of four pre-set values selected by the SELECT I_C switch. (Since CS is actually equal to $I_C + I_E$, I_C will be equal to its nominal value multiplied by a factor $h_{FE}/(1 + h_{FE})$ which in the worst case will be 95%. This has, of course, been allowed for in the calibration of the h_{FE} scale).

The value of the measuring resistor R_M in Figs. 1, 3 and 4 is also changed by the SELECT I_C switch in inverse proportion to the I_C value, thus the calibration of the h_{FE} scale is identical on all ranges.

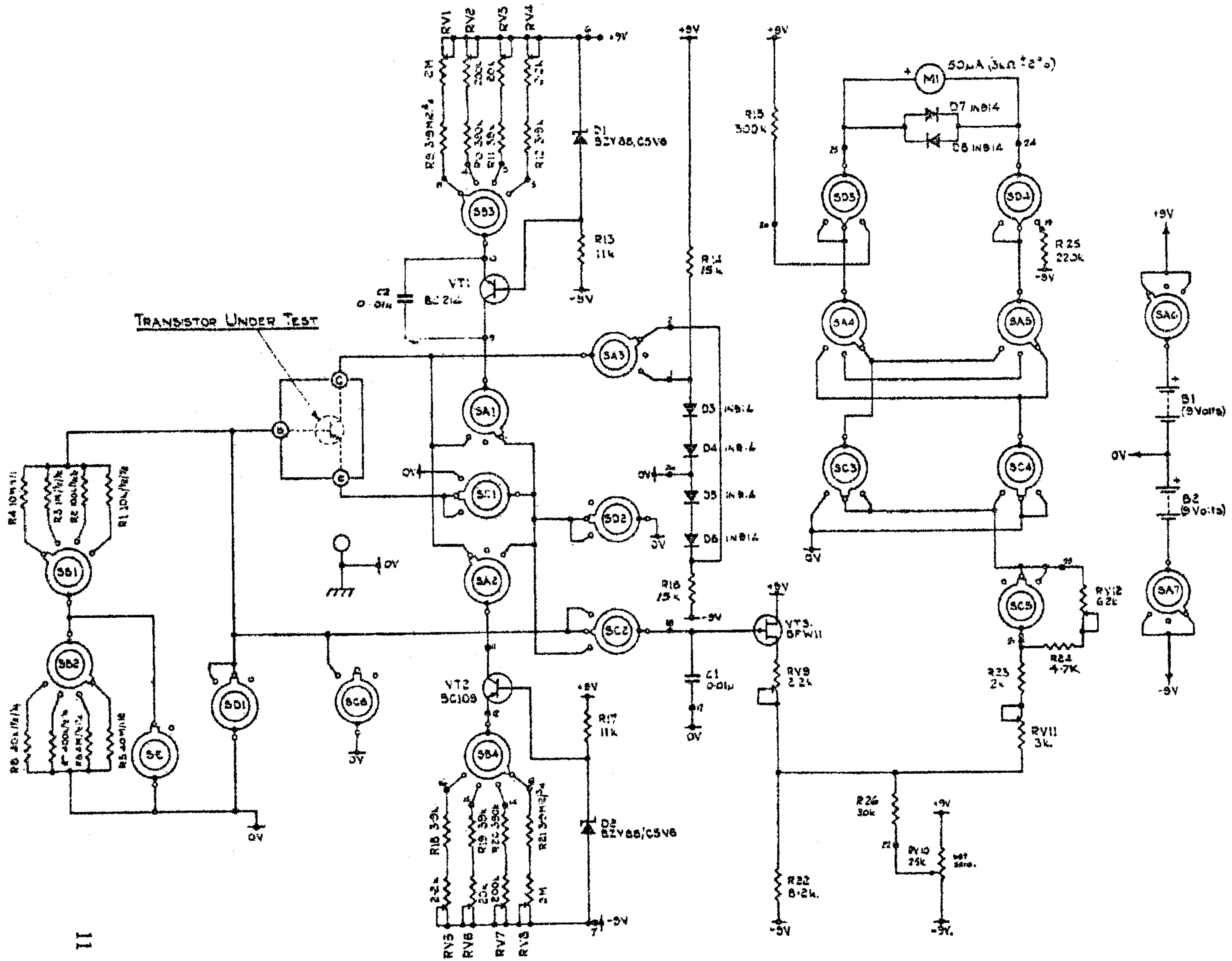
The polarity of the voltmeter M is reversed for I_{CBO} and diode reverse leakage measurements as seen in Figs. 3 and 4.

COMPONENTS LIST

Circuit Ref. No.	Description	
R1	10k Ω	± 0·5% ½W
R2	100k Ω	± 0·5% ½W
R3	1M Ω	± 0·5% ½W
R4	10M Ω	± 1% 1W
R5	40M Ω	± 1% 2W
R6	4M Ω	± 0·5% ¼W
R7	400k Ω	± 0·5% ¼W
R8	40k Ω	± 0·5% ¼W
R9	3·9M Ω	± 2% ¾W
R10	390k Ω	± 2% ½W
R11	39k Ω	± 2% ½W
R12	3·9k Ω	± 2% ½W
R13	11k Ω	± 2% ½W
R14	15k Ω	± 2% ½W
R15	300k Ω	± 2% ½W
R16	15k Ω	± 2% ½W
R17	11k Ω	± 2% ½W
R18	3·9k Ω	± 2% ½W
R19	39k Ω	± 2% ½W
R20	390k Ω	± 2% ½W
R21	3·9M Ω	± 2% ¾W
R22	8·2k Ω	± 2% ½W
R23	2k Ω	± 2% ½W
R24	4·7kΩ	± 2% ½W
R25	220k Ω	± 2% ½W

RV1	2M Ω
RV2	200k Ω
RV3	20k Ω
RV4	2·2k Ω
RV5	2·2k Ω
RV6	20k Ω
RV7	200k Ω
RV8	2M Ω
RV9	2·2k Ω
RV10	25k Ω
RV11	3k Ω
RV12	6·2k Ω

Circuit Ref. No.	Description
SA	PNP/OFF/NPN
SB	SELECT I_C
SC	$V_{BE}/h_{FE}/I_{CBO}$
SD	BATT. CHECK/ZERO/TEST
SE	SCALE
M1	50μA (3k Ω ± 2%)
C1	0·01μF
C2	0·01μF
D1	BZY88/C5V6
D2	BZY88/C5V6
D3	1N914
D4	1N914
D5	1N914
D6	1N914
D7	1N914
D8	1N914
B1	9V type PP 7
B2	9V type PP 7
VT1	BC214
VT2	BC109
VT3	BFW11



SA	
Posn	Function
1	PNP
2	Off
3	NPN

SB	Select Is
Posn	Function
1	1µA
2	10µA
3	100µA
4	1mA

SC	
Posn	Function
1	V_{BE}
2	h_{FE}
3	I_{CBO}

SD	
Posn	Function
1	Batt Check
2	Zero
3	Test

SE	Range
Posn	Function
1	Black
2	Red

Notes -

1. For all wafer switches, position 1 corresponds to the rotor being fully anticlockwise
2. For rotary switches (SA and SB), the wafers are shown in position 1.
3. For lever switches the wafer position shown corresponds to the central position of the lever. This is position 1 for SE (2 position) and position 2 for SC and SD (3 position) Movement of the lever towards the knob position corresponds to clockwise rotation of the rotor.
4. Lever switches SC and SE lock in all positions. Lever switch SD has a spring mechanism which returns the switch to its central position when the lever is released
5. All resistors are 1/4 watt ± 2% tolerance unless otherwise stated is follows :- value / tolerance % / wattage rating.
6. All potentiometers are shown with their sliders in the anti-clockwise position.
7. Printed circuit board termination pins shown thus. ⊕