Assembly Manual

Transistor Tester Kit

K-3052

DICK SMITH ELECTRONICS PTY LTD KIT

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Intended mainly for checking bipolar transistors and FETs, this simple transistor checker can also be used to test most other discrete semiconductor devices. It is easy to build, low in cost, and provides an excellent way of becoming familiar with basic device operation.

The design of this simple transistor FET/checker can hardly be considered new. It was originally described by Jim Rowe in August 1971 and, over the years, has proven an immensely popular project. Literally thousands have been built!

Recently, we decided to take another look at the unit with a view to updating it. The circuit is still perfectly valid, but the original method of construction is now dated and not quite in tune with the '80s.

In particular, the diecast metal box used to house the prototype is now quite expensive, its cost being out of all proportion to the total cost of the project!

Our approach has been to re-design the unit into one of the low cost plastic 'zippy' boxes. At the same time, we have designed a small printed circuit board (the original used tagboard) and provided the unit with a front panel to match our recent RLC Bridge and Audio Oscillator projects. Total cost of the updated unit should be well below that of comparable commercial testers.

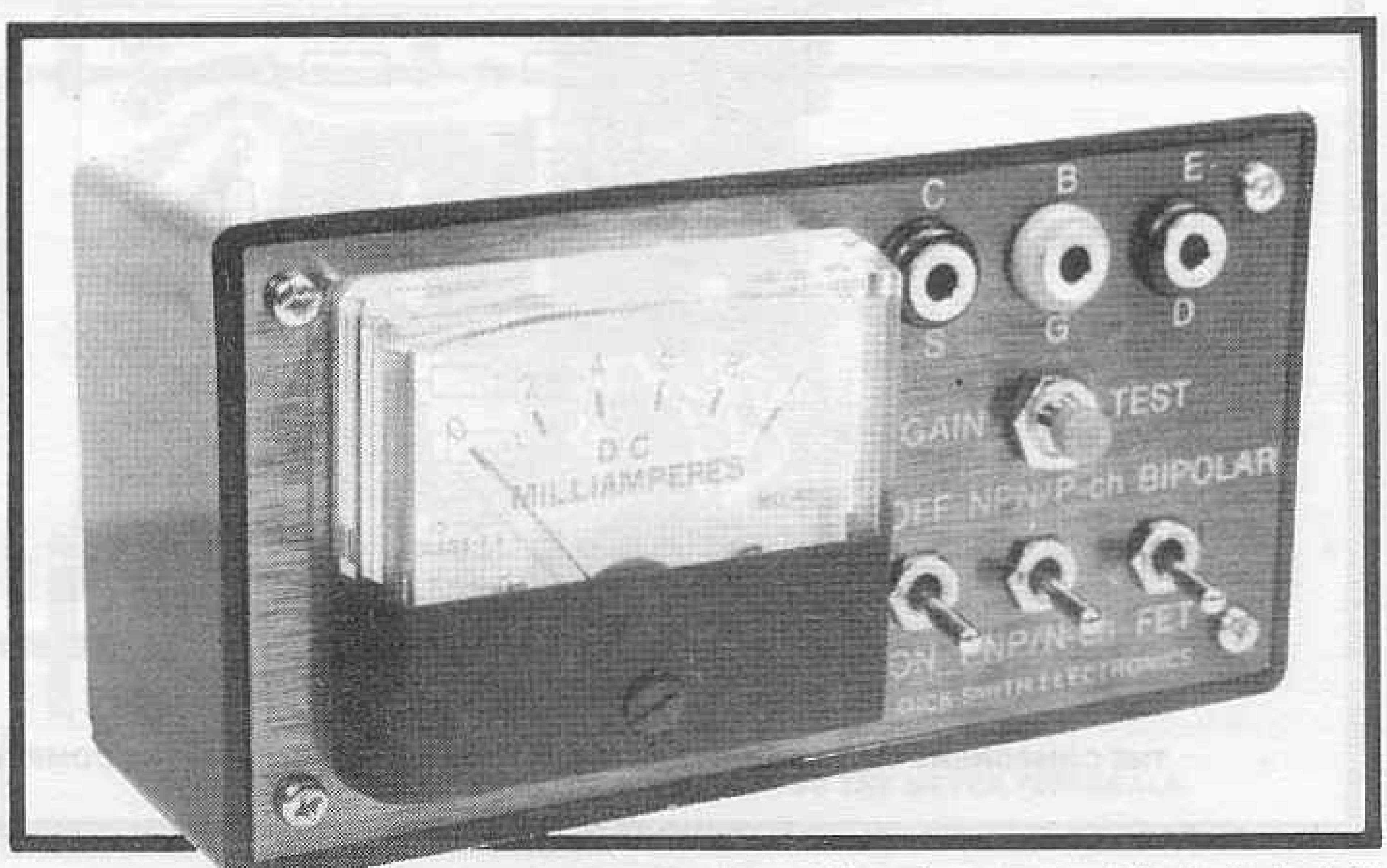
Despite its basic simplicity, the unit is capable of making most of the practical tests normally required when experimenting with transistors or servicing transistorised equipment. It can test both bipolar transistors and FETs, in addition to diodes, SCRs and PUTs. And it is capable of providing a detailed insight into device performance when required.

Thus it can be used for such purposes as the selection and/or matching of bipolar transistors on the basis of current gain, or of FETs on the basis of zero-bias current and transconductance.

Apart from its practical uses as a testing instrument, it also offers a simple and straightforward means whereby a beginner can gain a valuable first-hand insight into practical device operation. There is nothing quite as effective in dispelling some of the mystery of transistors or FETs, as hooking a device up to the checker, and demonstrating to one's own satisfaction that it really does perform as the theory book describes!

The checker can also be used to demonstrate what happens when a bipolar transistor is connected to the supply 'the wrong way around', or when the drain and source of a FET are reversed, or the effect on leakage and saturation currents when the temperature rises. All this from only 17 basic parts: a meter, a battery, three toggle switches, one pushbutton, five diodes, and six resistors.

The tests performed by the



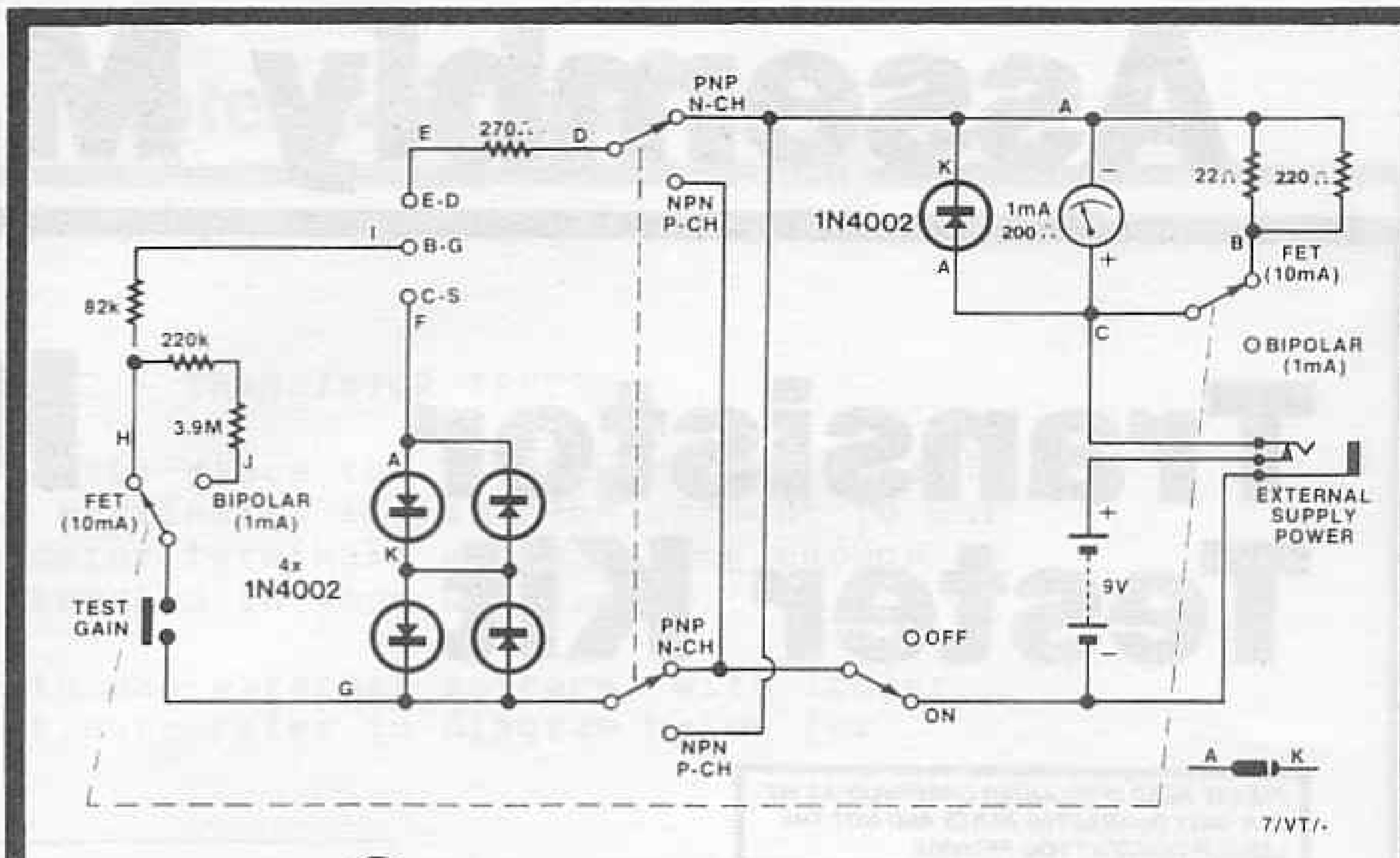
Text and Illustrations courtesy of Electronics Australia

checker are straightforward. For bipolar transistors, it first measures the leakage-saturation current Iceo, the collector-emitter current which flows when the base is left unconnected. It then applies a known base current to the device, and measures the resulting change in collector current. This gives an indication of the DC current gain, or DC-beta.

The test for Iceo is a good preliminary check for bipolar transistors, because there are few faults in this type of device which do not cause a significant increase in Iceo. And those few faults which do not show up in this test will generally make themselves quite apparent in the gain test. Thus although an open circuit in the base, collector or emitter-lead will not show up in the Iceo test, it will certainly become evident in the gain test, as a zero reading!

Actually the checker is designed to test for both Iceo and gain at two alternative current levels. It can test for Iceo on a 0-1 mA scale, and then apply a 2-microamp base current to observe the current gain on what becomes virtually a 0-500 scale. Alternatively it can test for Iceo on a 0-10 mA scale, and then apply a 100uA base current to observe current gain on what then becomes a 0-100 scale.

The advantage of the two current levels is greater flexibility. The lower current tests are appropriate for modern low power silicon transistors, which tend to have very low Iceo combined with quite high DC beta figures at low current levels. On the other hand the higher current tests are more appropriate for higher power silicon transistors, and many of the older germanium devices. These tend to have a higher Iceo, and a lower DC beta. The higher power silicon devices also tend to display a more realistic DC beta figure when tested at the higher current level.



SIMPLE TRANSISTOR-FET TESTER

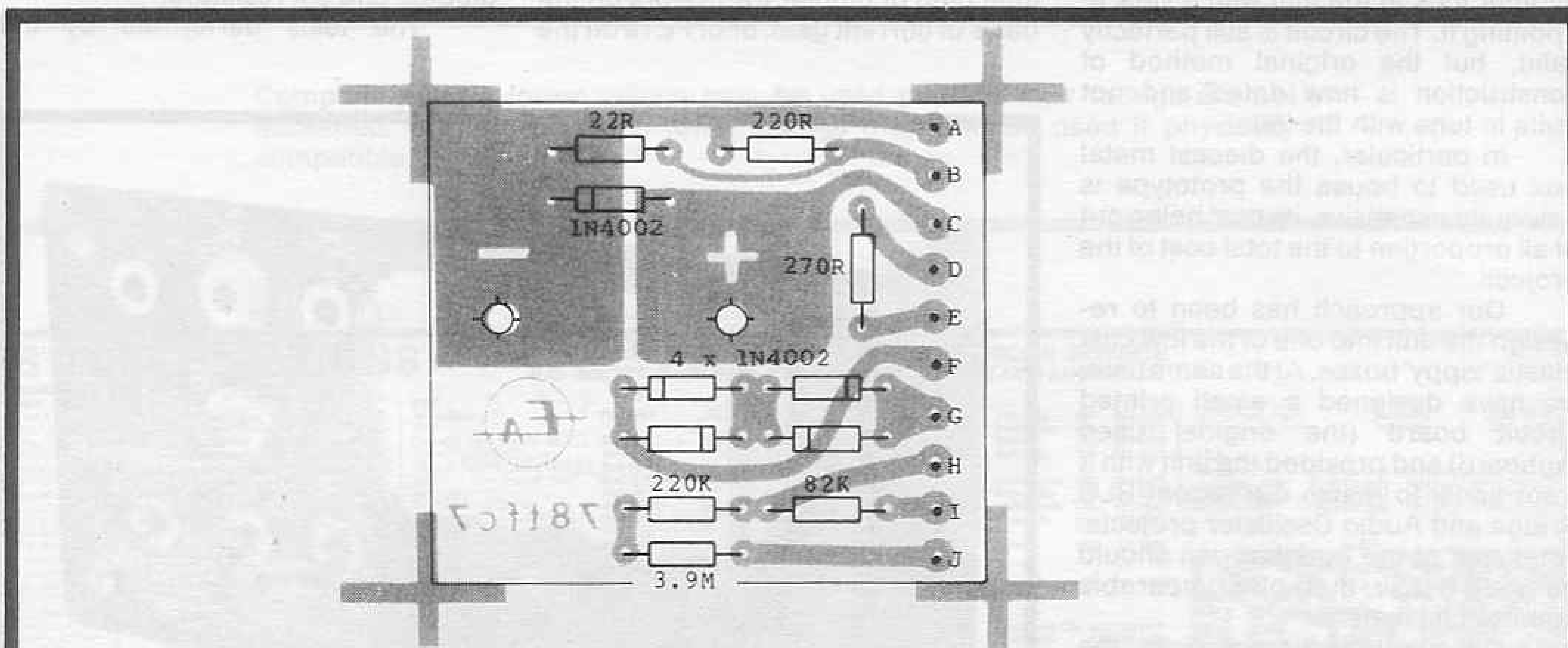
DESPITE ITS SIMPLICITY, THE CIRCUIT WILL PERFORM MOST OF THE USEFUL TESTS ON THE MAJORITY OF MODERN DISCRETE SEMICONDUCTOR DEVICES.

For FETs, the checker first measures the zero-bias channel current Idss, the current which flows between drain and source when the gate is either left open-circuited or connected to the source. A reverse gate bias of approximately 1.2 volts is then applied, and its effect in reducing the drain source current may be seen. This gives a measure of the device transconductance(gm). The transconductance is not indicated directly, but may be readily calculated by dividing the observed drop in channel current by 1.2.

The test for Idss is a very useful one for checking FETs, and Idss is one of the main parameters which determine the DC behaviour of a FET in most circuits. It is also a parameter which varies quite significantly among currently available devices, and is therefore an important one to be taken into account when selecting or matching FETs. The transconductance check is also a very useful test, both for straightforward 'good-bad' testing, and for selection and matching.

As with the bipolar transistor tests, the FET tests may be performed at either of two current levels. These are in fact the same two current levels used for the bipolar tests, with a meter sensitivity of either 1mA or 10mA respectively. With most FETs the 10mA range will be the more appropriate, as most of the useful devices currently available have an Idss falling within the range 1mA-10mA. However the 1mA range may be useful for checking devices with a very low Idss, and/or a high transconductance.

With the FET tests, the reverse gate bias voltage remains constant at 1.2V for both ranges. This means that the ranges may be selected purely on the basis of convenience in reading the channel current. It is thus possible to switch from the 10mA range down to the lower range if the transconductance of a device is sufficient to reduce its current from



THE COMPONENT OVERLAY PATTERN SHOWS THE PC BOARD FROM THE COMPONENT SIDE.

greater than 1mA to well below this figure.

Diodes may also be tested on the checker, both for reverse leakage/ saturation current Ir, and also for forward conduction. These test are usually sufficient for 'good/bad' testing. As before both a 1mA and a 10mA meter range are available for both tests. This makes it possible to test virtually any type of rectifier diode likely to be met, whether of silicon or germanium.

Other types of diode may also be tested, such as varicap diodes and varactors. It will be possible to test 'zener' diodes, but only those having a breakdown voltage above the 9 volts applied by the internal battery of the checker.

Although the checker has basically been designed to test bipolars, FETs and diodes, it can also be used to test various other devices if a little ingenuity is used. Thus it is possible to test sensitive low power SCRs, for example, by connecting them to the checker as for an NPN transistor (anode corresponding to collector, cathode to emitter, etc.), and noting if the device triggers into conduction when current is applied to the gate via the gain test button.

Higher power SCRs may be tested in a similar fashion, but in this case an external resistor may have to be connected between the anode and gate to provide sufficient triggering current to initiate conduction.

Programmable unijunctions or 'PUTs' may be checked in much the same way as low power SCRs, but with the anode and cathode reversed so that they correspond respectively to the emitter and collector of a bipolar. The polarity switch in this case should be set to the 'PNP' position.

Refer now to the circuit diagram of the Transistor Checker.

Basically, the unit consists of a 9V battery and a 1mA meter movement in series, connected via a polarity reversing switch to the pair of terminals marked 'E-D' and 'C-S'. The first of these terminals connects to the emitter of bipolar transistors, or alternatively to the drain of FETs; similarly the other terminal connects to the collector of bipolars, or the source of FETs. Note the converse way in which the terminals are used for the two different types of device. The reason for this will be explained shortly, along with the reason for the four diodes in series with the 'C-S' terminal.

The third terminal is that marked 'B-G', intended to connect to the base of bipolars, or the gate of FETs. This terminal connects via the 'gain test' button and a selected resistance to the side of the reversing switch which leads to the 'C-S' terminal.

The 'FET-Bipolar' switch has two poles, one of which merely serves to connect the 22 ohm and the 220 ohm resistors as a 10mA shunt across the meter in the 'FET' position. The other pole of the switch selects the value of the resistance in series with the 'B-G' terminal.

The purpose of both the 270 ohm resistor in series with the 'E-D' terminal, and the single diode in parallel with the meter, is to protect the latter in the event of a complete short-circuit between the 'E-D' and 'C-S' terminals. With these components in circuit the meter is effectively protected from any possibility of electrical damage due to shorts either in the device tested, or due to accidental touching of the test leads.

When a bipolar transistor is connected to the checker, its collector is connected to the 'C-S' terminal. Because the current drawn by a bipolar device is largely independent of the actual value of collector voltage, rather like a pentode valve, the four diodes in series with this terminal have virtually no effect upon device operation. They merely reduce the effective battery voltage between collector and emitter to about 7.8 volts (9V less 1.2V, the voltage drop of the two forward-biased diodes).

The bipolar device therefore draws its normal Iceo when connected into the checker with the polarity switch set to the correct position and the battery switch moved to 'ON'. The current will be read on the meter either on the basic 1mA scale, or on an effective 10mA scale if the 'FET-Bipolar' switch has been set to the FET position.

Then when the 'gain test' button is pressed, the base of the device will be connected to the collector supply rail via a resistance producing either 2uA or 100uA of base current, depending upon the position of the 'FET Bipolar' switch. The meter therefore indicates the normal DC beta of the device on an effective scale of either 0-500 or 0-100.

The very same circuit is arranged to perform the tests on FETs simply by connecting these devices to the checker in the converse manner. The drain is connected to the 'E-D' terminals, while the source is connected to the 'C-S' terminal. This has the effect of placing the four diodes in series with the source lead, where their voltage drop may now be used to provide a reverse bias.

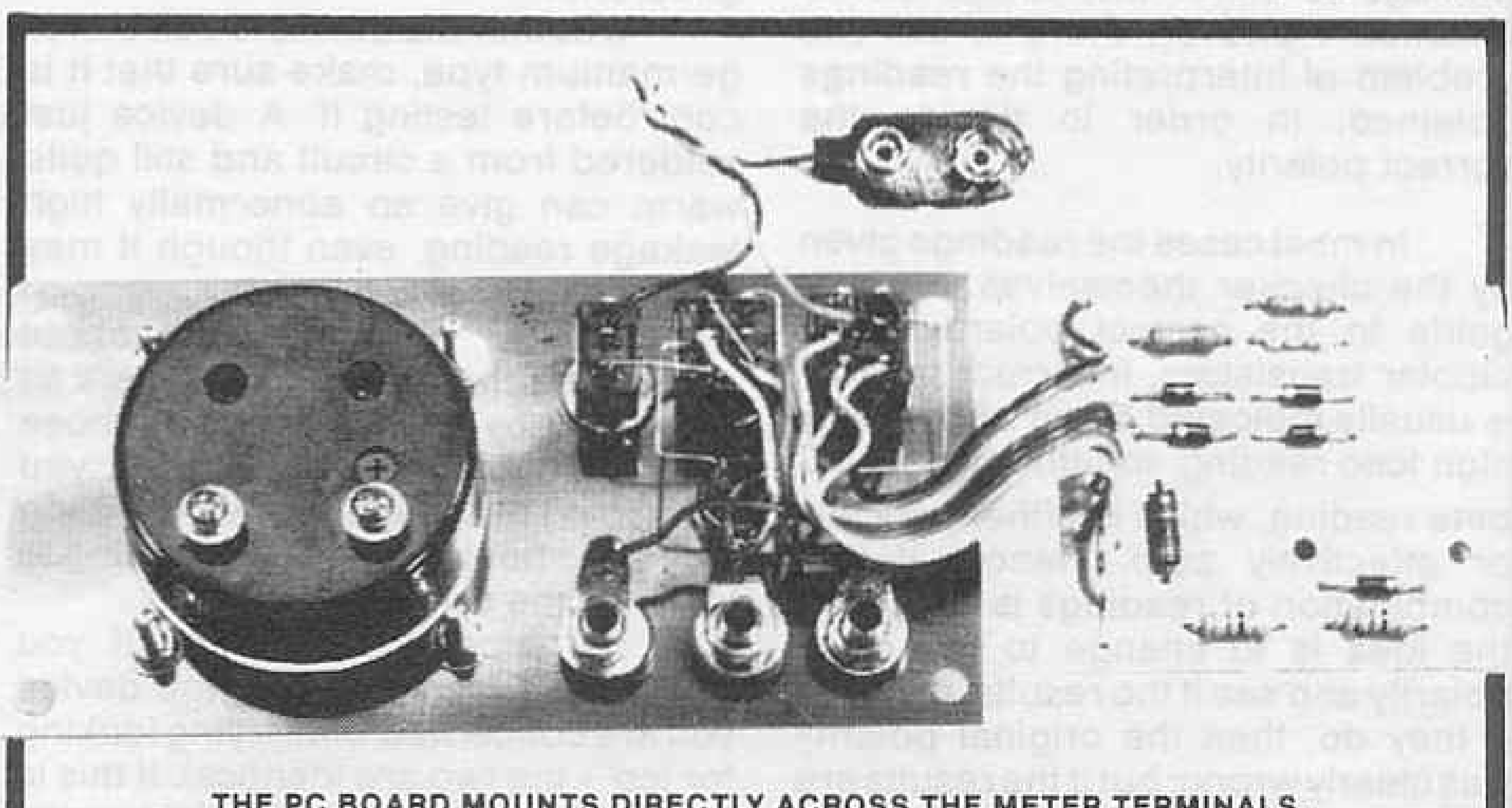
When a FET is connected into circuit it initially draws its zero-bias current Idss, which may be read on either the 10mA meter range or the 1mA range as appropriate. Pressing the 'gain-test' button then has the effect of connecting the gate to a point which is reverse-biased with respect to the source, by the substantially constant 1.2V drop across whichever two of the diodes in series with the source are conducting, according to the selected polarity.

The reason why four reverse-parallel connected diodes are used in series with the 'C-S' terminal is that this arrangement provides a substantially fixed 1.2V drop regardless of polarity, without requiring additional poles on the polarity switch.

Note that although the resistance in series with the gate of the FET will vary according to the position of the 'FET-Bipolar' switch, this does not affect the tests as the gate of a FET does not normally draw significant current. The function of the 'FET-Bipolar' switch is only to adjust meter sensitivity and the series resistance in the base/gate lead, for base current adjustment in the case of bipolar transistors.

The 'Bipolar' and 'FET' positions marked for this switch are those that will normally be the most appropriate for the majority of devices of each type. However, as explained above, both positions can be used for either device type, depending upon requirements.

Diodes are tested on the checker by connecting them between the 'C-S' and the 'E-D' terminals. The way in which they are connected is not important. In one position of the polarity switch the diode will be forward-biased, and the meter should accordingly give a full-scale reading - unless the diode is defunct. In the



THE PC BOARD MOUNTS DIRECTLY ACROSS THE METER TERMINALS.

other position of the switch the diode will be reverse-biased, and the meter will read the reverse current Ir. With most diodes this should be a very low reading, even on the 1mA range.

As can be seen from the photographs, construction is quite straightforward. All components, with the exception of the switches and input sockets, are mounted on a small printed circuit board measuring 58 x 51mm and coded 78tfc7. The board, in turn, mounts directly across the meter terminals.

Commence construction by fitting all the hardware to the front panel. The battery sits directly under the front panel switches and is packed in pieces of scrap foam to prevent short circuits and to hold it in place. Alternatively a clamp may be made from a scrap of aluminium.

Refer to the combined overlay and wiring diagram when wiring up the unit. PC board pins have been provided to facilitate connections from the board to the front panel switches and sockets. The connections are run in rainbow cable, while tinned copper wire is supplied for inter-switch wiring.

The meter is mounted directly on the front panel, with the 'gain-test' push button beside it. Since the circuit runs from a 9V supply rail, it can be also powered from one of the now commonly available "plugpack" power supplies. A special input jack socket is used for the external power supply, and this should be mounted in the end of the case furthest from the meter. Constructors may, however, consider this feature as optional.

Operating the checker when it is completed should present few problems, as the control switch markings clearly show the various functions. However, one type of testing situation where the user may need guidance is where the polarity of the device to be tested is not known.

The circuitry of the checker is such that checking a device with the polarity switch in the incorrect position will generally not cause damage to either the device or the checker. However, there is still the problem of interpreting the readings obtained, in order to decide the correct polarity.

In most cases the readings given by the checker themselves the best guide to the correct polarity. With bipolar transistors, incorrect polarity is usually indicated by an abnormally high Iceo reading, together with a DC beta reading, which is either very low or effectively zero. Hence, if this combination of readings is obtained, the idea is to change to the other polarity and see if the results improve. If they do, then the original polarity was clearly wrong: but if the results are the same as before, then either the device is a dud or you have its connections jumbled.

With FETs an incorrect polarity setting generally does not show up in the Idss test, because the channel of most FET devices is symmetrical and conducts equally in either direction. However, incorrect polarity will immediately show up when the 'gain-test' button is pressed: the meter reading will increase rather than decrease, revealing that the gate is being forward-biased instead of reverse-biased. This effect should always be taken as a sign that the polarity switch has been set to the incorrect position.

There may be some occasions, when testing bipolar transistors, where it is difficult to decide whether the leakage/saturation current Iceo is acceptably low, or 'too high'. This matter is one for which there is no simple answer, becuase a 'good' germanium device may have an Iceo many times higher than a 'faulty' silicon device - particularly if it is a high-gain power type.

Temperature also plays a part. With germanium devices Iceo roughly doubles for every 8-10 degrees C rise in temperature, while with silicon devices it doubles for every five degrees C rise. Also the Iceo of a device is roughly proportional to its gain, so that the gain should also be taken into account.

In general any silicon bipolar transistor which produces a sigificant Iceo reading on this checker, at any normal temperature, should be regarded as suspect. All except the very high-gain, high-power types should give virtually zero reading, even on the 1mA range.

Unfortunately no similar rule-of-thumb can be given for germanium devices, some of which may exhibit quite a high Iceo. The best plan with these is to compare them with a known good device, if one is available. Failing this , all you can do is make the decision on the basis of the gain check. If the current increases quite substantially when you press the gain button, then the device is probably a good one.

Whether the device is a silicon or germanium type, make sure that it is cool before testing it. A device just soldered from a circuit and still quite warm can give an abnormally high leakage reading, even though it may be quite normal.

Finally, a brief note about comparing the device parameters as measured by this checker with those given in manufacturers' data. If you want to do this, and there is no reason why you should not, the main thing to watch is the symbols used.

For bipolar transistors, if you cannot find Iceo listed for the device you are concerned with, trying looking for Ico' - the two are identical. If this is not listed either, the data may alternatively give Icbo or Ico, the collector-base saturation current But as this is equivalent to Iceo divided by the gain of the device, it is not hard to convert between the two. Most manufacturers use the symbol hFE to represent DC beta, so that it is the figure or figures listed under this symbol which should be used for comparison.

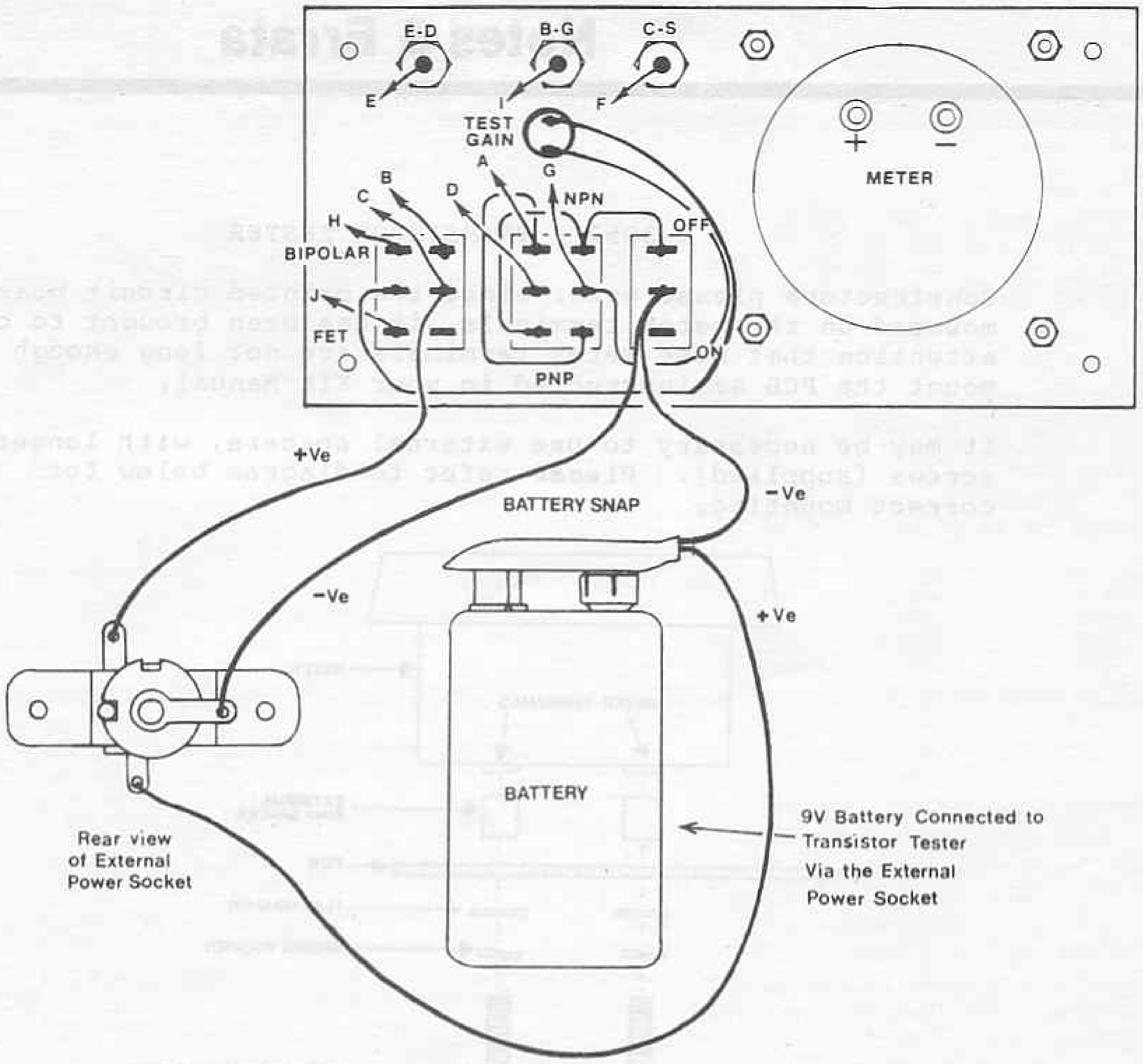
Where FETs are concerned, the symbol Idss is almost universally used for zero-bias drain current, so that there should be no problem with that parameter. But be careful where transconductance is concerned, as two different symbols are used: Yfs and gmo. Fortunately, the definitions of both are sufficiently close to the test performed by our checker to make the figures comparable in practice. ●

PARTS LIST

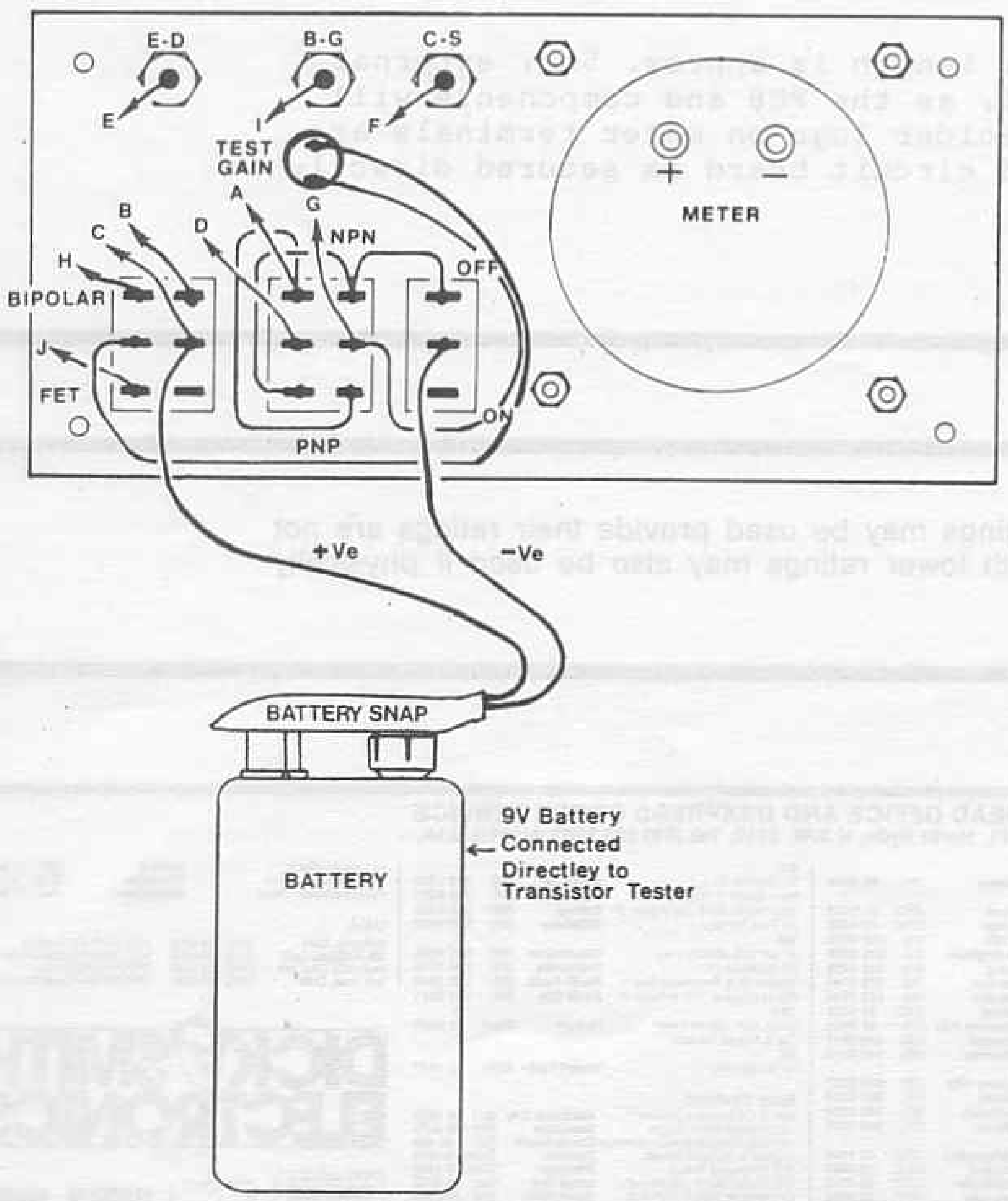
RESISTORS
All resistors are 1/4W unless specified
1 x 22R Resistor ☐
1 x 220R Resistor ☐
1 x 270R Resistor ☐
1 x 82K Resistor ☐
1 x 220K Resistor ☐
1 x 3.9K Resistor ☐

TRANSISTORS
5 x 1N4002 Diode ☐

HARDWARE
Case, front panel, meter, toggle switches, push-button switch, PCB, sockets and plugs, DC socket, hook-up wire, PCB pins, rubber feet, battery snap, solder, tinned copper wire, screws, nuts and bolts ☐



Battery supply can either be connected directly to the unit or via an external power socket (supplied). We show both connections in these diagrams.

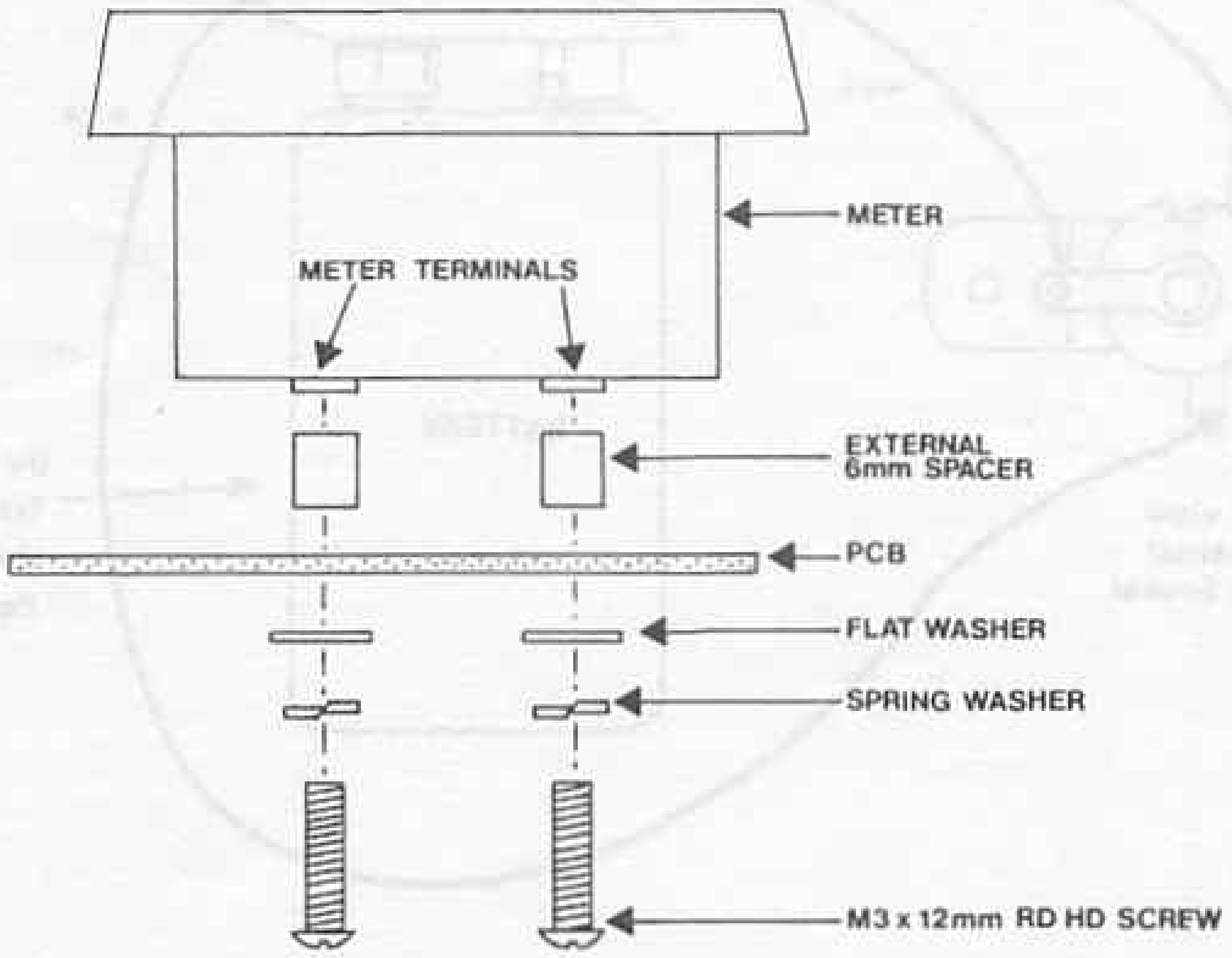


Notes & Errata

K-3052 - TRANSISTOR TESTER

Constructors please note: since the printed circuit board is mounted on the meter terminals, it has been brought to our attention that some meter terminals are not long enough to mount the PCB as instructed in your Kit Manual.

It may be necessary to use external spacers, with longer screws (supplied). Please refer to diagram below for correct mounting.



NOTE: If meter terminal length is approx. 5mm, external spacers are not required, as the PCB and components will clear the meter body. Solder lugs on meter terminals are not used, as the printed circuit board is secured directly to the meter terminals.

Components with lower ratings may be used provide their ratings are not exceeded. Components with lower ratings may also be used if physically compatible.

Text and Illustrations courtesy of Electronics Australia