THE "AVO" TRANSISTOR ANALYSER Mk 2

OPERATING INSTRUCTIONS

SECOND EDITION

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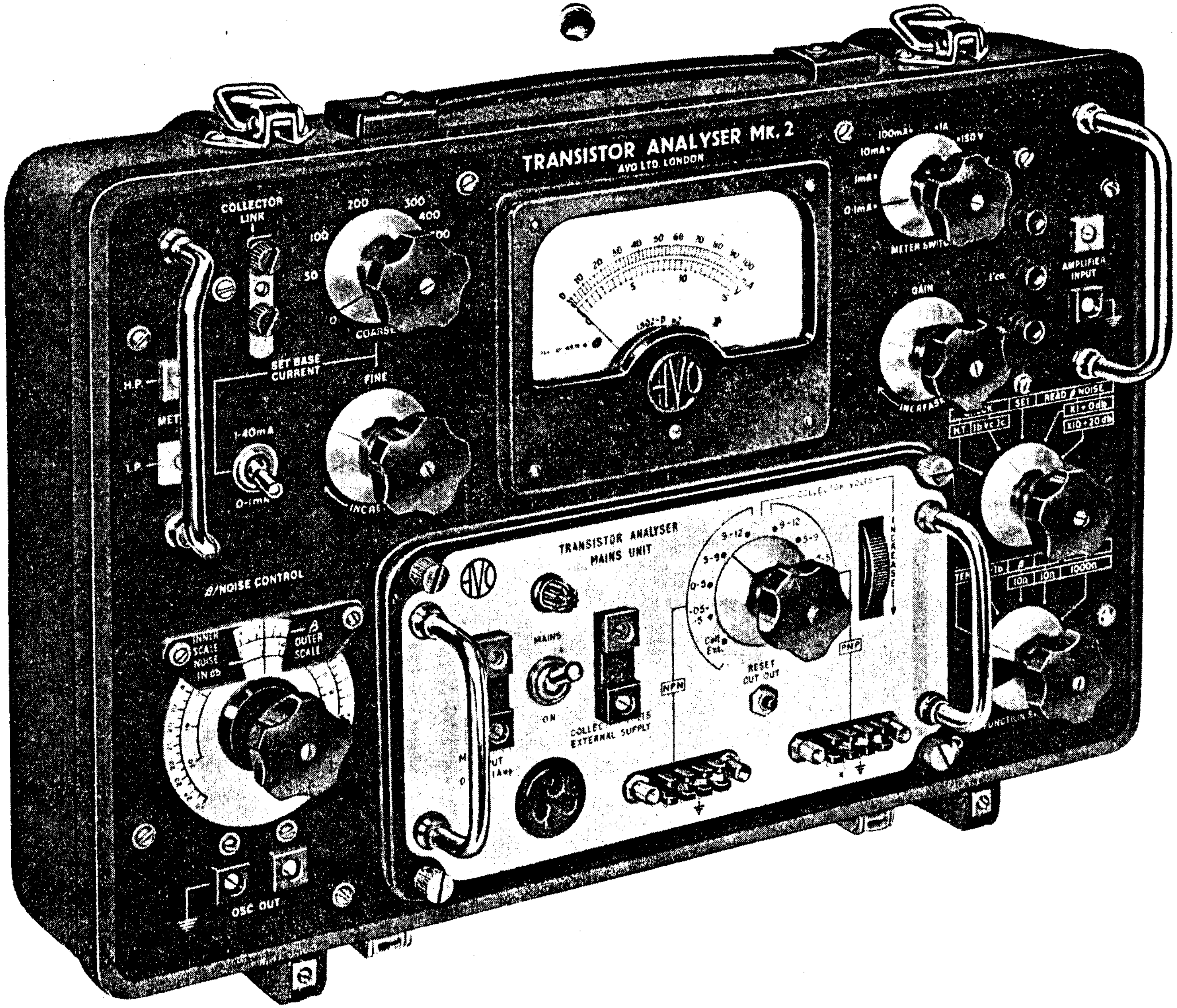

AVO TRANSISTOR ANALYSER MK. 2
(WITH MAINS POWER UNIT)

FOREWORD

FOR more than a quarter of a century we have been engaged in the design and manufacture of "AVO" Electrical Measuring Instruments. Throughout that time we have consistently pioneered the design of modern multi-range instruments and have kept abreast of, and catered for, the requirements of the epoch-making developments in the fields of radio and electronics.

The success of our steadfast policy of maintaining high standards of performance in instruments of unexcelled accuracy, and making such instruments available at reasonable cost, is reflected in the great respect and genuine goodwill which "AVO" products enjoy in every part of the World.

It has been gratifying to note the very large number of instances where the satisfaction obtained from the performance of one of our instruments has led to the automatic choice of other instruments from the "AVO" range. This process, having continued over a long period of years, has resulted in virtual standardisation on our products by numerous Public Bodies, The Services, Railway Systems, Post Office and Telegraph Undertakings throughout the World.

Our designers have thereby been encouraged to ensure that new instruments or accessories for inclusion in the "AVO" range fit in with existing "AVO" apparatus and serve to extend the usefulness of instruments already in use. Thus, the user who standardises on "AVO" products will seldom find himself short of essential measuring equipment, for, by means of suitable accessories, his existing equipment can often be adapted to meet unusual demands.

It is with pleasure that we acknowledge that the unique position attained by "AVO" is due in no small measure to the co-operation of so many users who stimulate our Research and Development staffs from time to time with suggestions, criticisms, and even requests for the production of entirely new instruments or accessories. It is our desire to encourage and preserve this relationship between those who use "AVO" instruments and those who are responsible for their design and manufacture and correspondence is therefore welcomed, whilst suggestions will receive prompt and careful consideration.

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ILLUSTRATIONS

The "AVO" International Transistor Data Manual

This instrument will produce maximum information when used in conjunction with the transistor manufacturer's graphs and technical data, but to enable rapid checks to be made relative to a transistor's general efficiency, the "AVO" International Transistor Data Manual has been produced.

This instruction book refers throughout to the "AVO" International Transistor Data Manual, a copy of which should always be kept with the instrument. New editions of this manual will be published from time to time. Watch our advertisements in the technical press for further announcements.

INTRODUCTION TO THE AVO TRANSISTOR ANALYSER

The rapid increase in the use of transistors in electronic equipment, has resulted in the need for a versatile and comprehensive instrument capable of measuring the basic characteristics of a transistor. The instrument should also be capable of assisting the designer in determining whether any given transistor is suitable for a particular application. With these ideas in mind the "AVO" Transistor Analyser has been introduced. The instrument is capable of measuring the more generally useful transistor parameters. It is portable, and may be operated either from the Mains Power Unit or from a Battery Power Unit which can be inserted in place of the Mains Power Unit.

The instrument will normally be used in conjunction with the "AVO" International Transistor Data Manual which contains test data for approximately 5,000 transistors (both obsolete and current types), and enables I′co, β or $\bar{\beta}$ and noise measurements to be made without the necessity to consult manufacturers' data. This publication includes maximum ratings and a diagram of transistor terminations, thus reducing the possibility of damage due to overloads, or incorrect connections.

The products of more than sixty manufacturers are listed, providing a useful guide to the selection of a suitable transistor for any given application; also included are test data for service type transistors, together with service equivalents of commercial products.

1. SYMBOLS AND EQUIVALENTS USED IN THIS MANUAL

The large number of symbols adopted by transistor manufacturers has given rise to considerable confusion. Therefore, to assist the user, a list of symbols and equivalents is listed below. The symbols printed in heavy type are used in the "AVO" International Transistor Data Manual and this publication.

Vce	Collector to emitter voltage.
$Vce_{(sat)}$	Collector to emitter voltage under saturation conditions.
β, h_{fe}, h_{21e}, α'	Small signal current gain in the grounded-emitter configuration.
I′co, I_{CEO}	Collector to emitter leakage current.
$\bar{\beta}$, $\bar{\alpha}'$, h_{FE}	Large signal or d.c. current gain $= \dfrac{Ic - I_{CBO}}{Ib + I_{CBO}} \simeq \dfrac{Ic}{Ib}$
I_{co}, I_{cbo}	Collector to base leakage current with emitter open circuit.
V_T, BV_{CEO}	Turnover or breakdown voltage.
NF	Noise figure.
α, h_{fb}, h_{21b}	Small Signal Current gain in the grounded-base figuration.

2 SPECIFICATION

The instrument has in general been constructed to meet the requirements of the United Kingdom Inter-Service Specification K.114, and will enable measurements to be made on PNP, NPN and Point Contact transistors.

Range of Collector Volts

Using the Battery Power Unit: 1.5, 3, 4.5, 6, 10.5V of either polarity.

Using an external supply in conjunction with the Battery Power Unit or the Mains Power Unit on its own:

0–12V of either polarity (for all measurements).

Using an external supply in conjunction with either the Battery Power Unit or the Mains Power Unit:

0–150V (for dc characteristics, $\bar{\beta}$ and turnover voltage (V_T) only.

Range of Collector Current

0–250mA using the Battery Power Unit.

0–1A using the Mains Power Unit or an external supply.

Range of Base Current

0–1mA and 1–40mA in two ranges.

Small signal current gain (β)

0–25 and 0–250, in two ranges.

Noise Measurements (*NF*)

1–40db in two ranges.

Collector Emitter leakage current ($I'co$)

First indication 2 micro-amperes.

2.1 Mains Power Unit

The unit provides stabilised outputs for the transistor under test and for the internal circuits of the Transistor Analyser. It is mechanically and electrically (except for collector supplies) interchangeable with the battery power unit.

The mains unit operates from mains supplies of 110V–128V or 190–250V ac, 50/60 c/s. Instructions for changing the voltage tapping are printed on the side of the mains transformer.

Collector voltage is continuously variable over the range 0.05V to 12V at a collector current of 1 amp. max. The stability of collector voltage is better than ± 0.25% for a 10% change in mains input and the ripple voltage does not exceed 5mV peak to peak.

Overload protection is provided by an electronic cut-out which is pre-set to operate where a collector current of 1.1A is exceeded. This protects both the Transistor Analyser and the Mains Unit, should a transistor under test develop a short circuit. The cut-out may try (*a*) when changing from voltage to current measurement (*b*) when the mains unit is switched off and on again (*c*) when the collector voltage switch is changed from 9–12 PNP to 9–12 NPN or vice versa. This is due to the smoothing capacitors taking current during charging and has no harmful effect. In the event of this happening the cut-out should be reset by depressing the reset button.

An indication that the cut-out has tripped is given by very low values of Vc and Ic. The instrument may be re-set by depressing the re-set button provided.

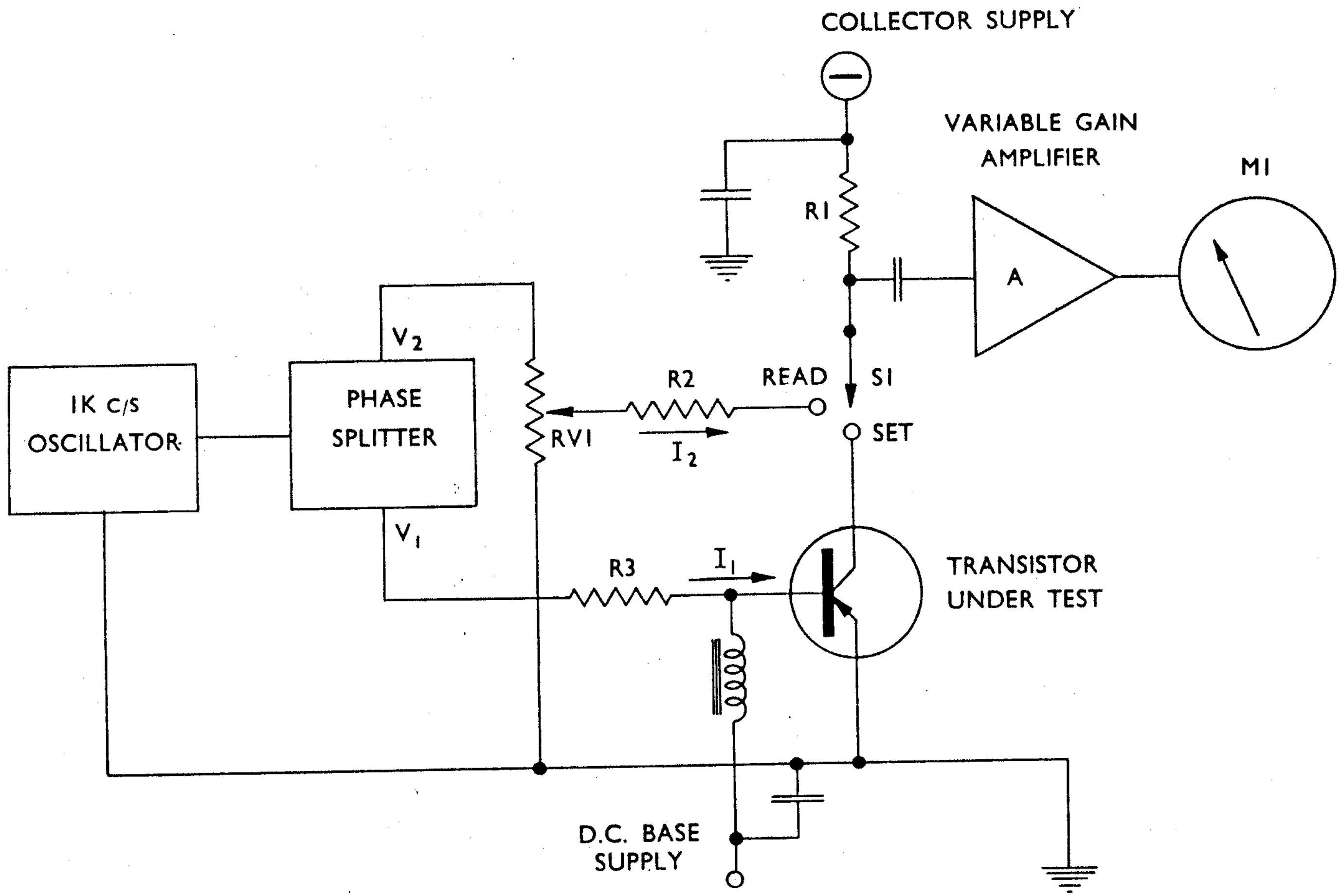

Fig. 1. **Basic circuit for the measurement of Beta (β)**

3. BASIC METHODS OF CHARACTERISTIC CHECKING

The parameters of most general use relating to transistors whether for design purposes or routine testing are, an indication of the leakage current, means of checking change of collector current with changes in base current, i.e. dc current gain (h_{FE}) and the measurement of the ac current gain (β) at any given point on the dc characteristic.

Another useful indication of a transistor's condition is that of noise. Normally the first indication of a ruptured junction is that there is a marked increase in the noise developed within the transistor.

With these requirements in mind, methods were devised for obtaining this information, bearing in mind that the instrument should be simple and straightforward to operate, even when used by a relatively unskilled operator.

A brief outline of the methods employed for the measurement of parameters follows.

3.1 Measurement of I'co, Ib, Ic, Vc and Vcs

These are direct measurements of dc current and voltage, Conventional metering methods are used, the necessary switching is provided to enable the internal meter to measure the appropriate current or voltage. Provision is made for an external load to be inserted in the collector circuit, under which conditions the meter may be switched to read the actual collector voltage, so that saturation voltage (Vcs) can be measured.

3.2 Measurements of Beta (β)

In accordance with techniques used by leading transistor manufacturers, small signal current gain is measured at 1 kc/s. The procedure employed is as follows:

Referring to Fig. 1, an output from the 1 kc/s oscillator is fed into a phase splitting network, the outputs of which have a ratio of 10 : 1. The smaller output V_1 is fed via a series resistor R3, to provide a fixed input of 0.5 microampere into the base of the transistor under test.

With S1 in the **Set** position, a current of 0.5 microampere times Beta (where Beta is the test transistor gain) develops a voltage across R1. This voltage is fed into the amplifier. The gain control of the amplifier is then adjusted to give an arbitrary reading on the meter M1.

NOTE. β measurements are taken with a collector load of 10Ω (R1). The voltage drop across this resistor may have to be taken into account when setting V_{CE}.

Switch S1 is now set to the **Read** position. The output voltage V_2 from the phase splitting network is fed into series resistors R2 and R1 via the potentiometer RV1, the voltage developed across resistor R1 being fed into the amplifier. The gain control of the amplifier is left unaltered. RV1 is then adjusted to give the same meter deflection as previously obtained. If the ratio of the two currents I_1 and I_2 is known, then Beta will also be known. Therefore, RV1 which varies current I_2 and thus the ratio, may be directly calibrated in terms of Beta.

Using this method, the accuracy of measurement is dependent on the phase splitting network and associated resistors, which provide the two signal currents. Should the phase splitter or oscillator output voltage change due to variation in supply voltage, accuracy of measurement will not be impaired, since the ratio of the currents I_1 and I_2 will remain constant.

3.3 Measurement of Noise (N.F.)

Noise figures quoted by leading manufacturers are in general measured at 1kc/s over a very narrow bandwidth. This presents difficulties in design, for example it would be necessary to use a narrow band selective amplifier, and the oscillator providing the reference signal would require to be very stable as far as frequency was concerned. These design requirements are obviously outside the scope of a portable measuring instrument.

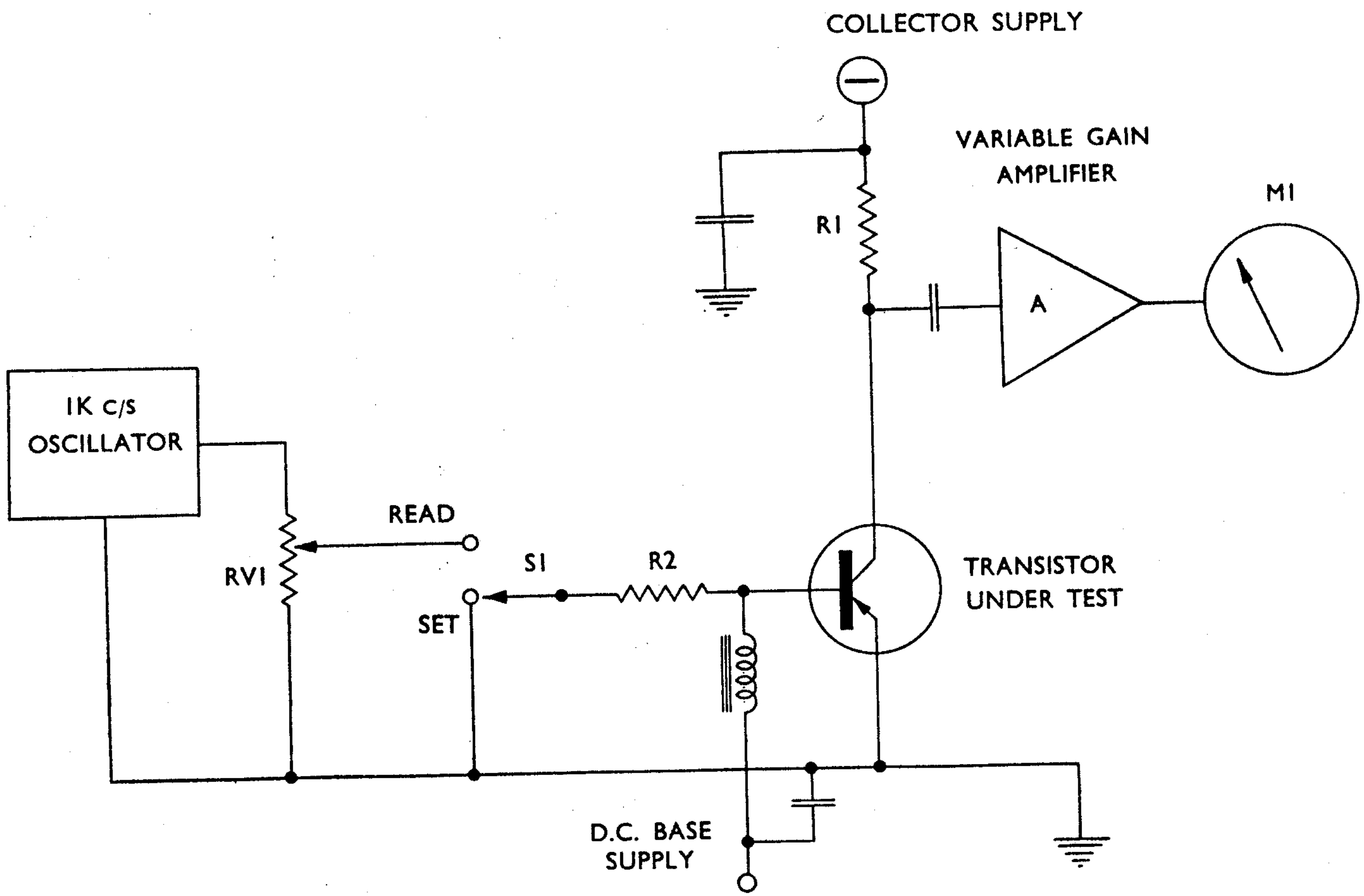

Fig. 2. Basic circuit for the measurement of Noise

It has been found that noise measurements using a 1kc/s reference signal, together with an amplifier having a bandwidth covering the normal audio range, are substantially the same as results obtained by the standard methods of noise measurement.

The method of noise measurement in the "AVO" Transistor Analyser is as follows:

Referring to Figure 2, with switch S1 in the **Set** position the voltage developed across R1 consists entirely of wide band noise generated within the transistor under test. This voltage is fed into the amplifier, the gain being adjusted to give a meter reading of half full scale deflection or less.

S1 is then set to the **Read** position. This results in a 1kc/s signal being fed into the base of the transistor under test, via R2. RV1 is now adjusted until the original meter reading is doubled.

If the level of signal current being fed into the base of the transistor is known, then the equivalent peak noise figure current is known. However, since most manufacturers quote noise in decibels it is necessary to give the readings accordingly.

It has been found that a noise figure of 6 db is equivalent to a signal current fed into the base of the transistor of 0.45 millimicroampere. This figure has been used as a reference point. Thus RV1 which controls the level of current fed into the transistor may be directly calibrated in db.

The amplifier bandwidth extends from 800c/s to 10kc/s. To compensate for the increase in 1/f noise within the transistor under test, the amplifier response has been designed to fall off below 800 c/s. This in effect gives a flat output characteristic of noise, without this fall off below 800c/s the increase in noise would give misleading results.

Adequate filtering of the voltage and current supply circuits ensures that spurious noise is not injected into the measuring circuits.

4. THE CONTROLS, THEIR FUNCTIONS AND OPERATION

All the controls necessary for carrying out the essential transistor testing functions are situated on the front panel of the instrument. By manipulating these controls, and the use of the "AVO" International Transistor Data Manual, or manufacturers data, the following tests can be undertaken:

(i) Measurement of I'co.
(ii) Measurement of Ic, Ib, Vc and β.
(iii) Measurement of Beta (β).
(iv) Measurement of Noise (NF).
(v) Measurement of Saturation Voltage (Vcs).
(vi) Measurement of Turnover Voltage (VT).

The separate functions of the controls available are as follows:

4.1 Beta and Noise Control

This calibrated control enables direct readings of beta and noise to be taken.

4.2 Base Current Controls

Base current may be varied by means of three associated controls as follows:

(i) A two position switch to select the appropriate range required, i.e. either 0–1mA or 1–40mA.
(ii) A continuously variable control which is calibrated 0–1000μA. This calibration applies only to the 0-1mA range and is very approximate.
(iii) A fine control continuously variable.

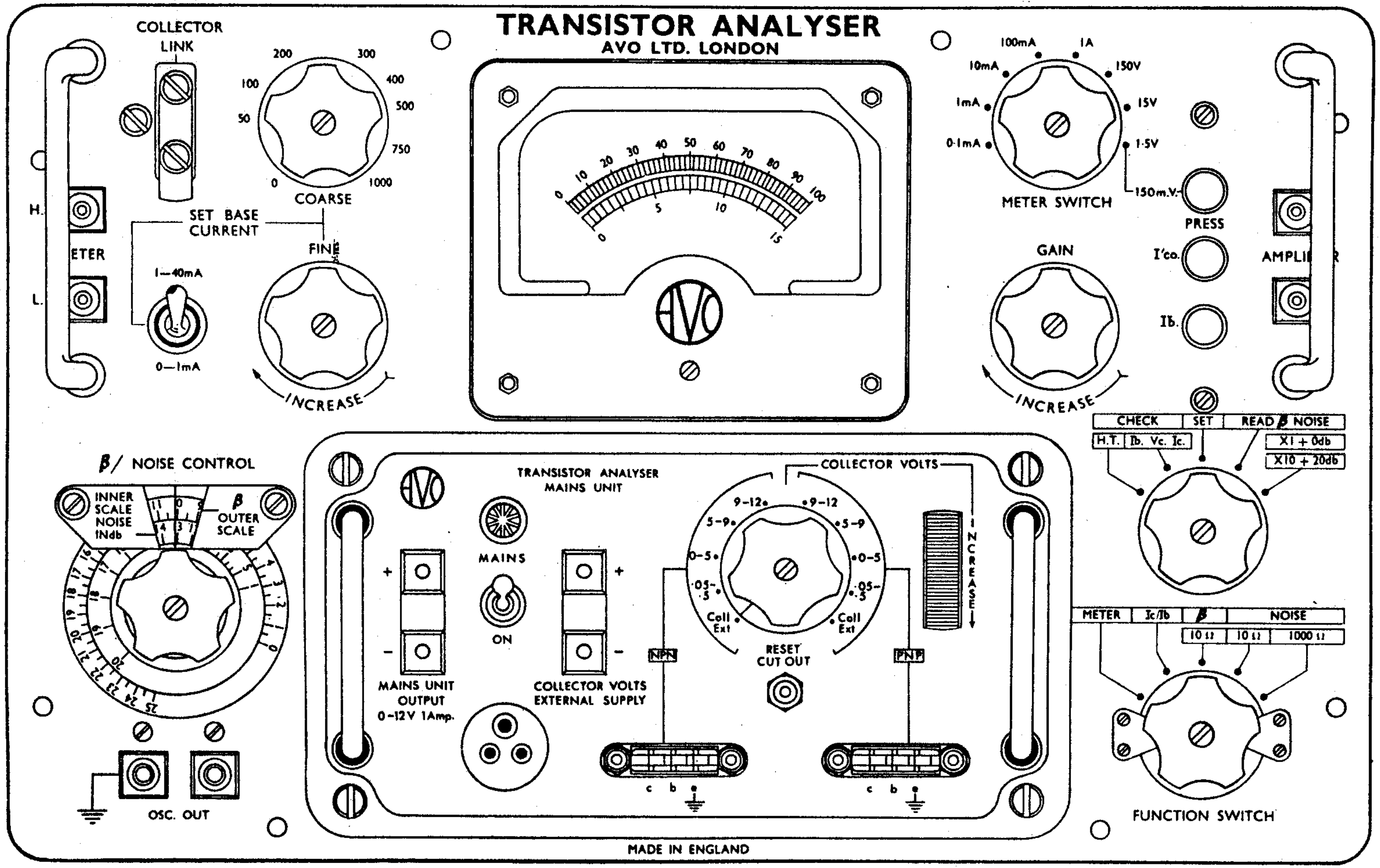

Fig. 3. Layout of the front panel controls (mains operated version)

4.3 Meter Switch

This selects the voltage or current range of the meter required for testing transistors (using either internal or external supplies) as well as for using the instrument for external measurement of voltage and current on transistorised equipment.

4.4 Press Buttons

With the controls set so that the meter is reading collector current Ic, by pressing the appropriate button leakage current I'co or base current Ib may be measured instead. When the 1.5V meter range is in use, pressing the 150mV button will change the range to 150mV full scale.

4.5 Gain Control

This is used when setting the instrument up for the measurement of Beta or Noise, or when using the amplifier for external measurements.

The gain of the amplifier may be varied by means of this control, thus ensuring that a suitable reading can be obtained on the meter.

4.6 Check/Set/Read Control

This is a five-position switch and when used in conjunction with the **Function Switch,** enables the instrument to be set up for all tests.

(i) *Check/H.T.* The ht voltage of the internal amplifier and oscillator may be monitored.
(ii) *Check/Ib. Vc. Ic.* Enables all of the dc conditions to be set up and monitored on the meter.
(iii) *Set.* Used for the initial setting up of the internal amplifier for the measurement of Beta and Noise.
(iv) *Read* β *Noise.* Two positions for the measurement of Beta and Noise are provided as follows:
  (*a*) x1 + 0db for the measurement of Beta over the range 0–25 and Noise from 1–2db.
  (*b*) x10 + 2db for the measurement of Beta over the range 0–250 and Noise from 21–40db.

4.7 Function Switch

This is used in conjunction with the **Check/Set/Read** control.

(i) *Meter.* At this setting the instrument is switched **Off** and the sockets marked **Meter** are connected to the internal meter, enabling it to be used for the measurement of external voltage and current (Section 8.1).
(ii) *Ic/Ib.* This position enables the dc conditions to be set up.
(iii) β/10 Ω. This position is used for setting up the instrument when measuring small signal current gain(β), the collector load being 10 Ω.
(iv) *Noise*/10 Ω. This position is used for setting up the instrument when measuring noise with collector currents exceeding 9mA, the collector load being 10 Ω.
(v) *Noise*/1000 Ω. When noise measurements are being made on transistors having collector currents of 9mA or less, this position is used for the initial setting up of the instrument. The higher collector load (1000 Ω) will enable larger meter deflections to be obtained.

4.8 Collector Volts Control

This switch enables the collector volts to be set up using the internal power supplies over the voltage range quoted in the Specification (Section 2). With this control set to any PNP position (except EXT) Collector and Base supplies are only available at the PNP socket, likewise for NPN the reverse occurs. When it is required to use an external voltage supply, this switch must be set to one of the two positions marked **Coll. Ext.** or **Ext.** and a suitable voltage injected into the equipment via the sockets marked **Collector Volts External Supply**or **External Volts,** either between **Neg.** and + **12 Max.** or **Neg.** and + **150** Max. or — and + (see Section 6).

5. GENERAL PROCEDURE FOR TESTING A TRANSISTOR

The following procedure is intended as a general guide when using the "AVO" International Transistor Data Manual. The user will obviously be able to carry out measurements of his own, such as plotting complete characteristics or measuring β at any required point on the characteristic.

Before carrying out tests on a transistor it is advisable to check the condition of the internal power supplies (if using a Battery Power Unit) as outlined in Section 9.0.

If using a Mains Power Unit check that the fuse (250mA delay type) is inserted in the correct clips on the voltage selector panel for the mains supply available.

NOTE. The voltage selector panel will be found at the rear of the Mains Unit. Should it be necessary to alter the position of the fuse, remove the two screws to release the transparent plate which covers the selector panel.

A neon indicator lamp provides visual indication that the mains supply is applied when the mains ON/OFF switch is in the "ON" position.

If replacing a Battery Power Unit by a Mains Power Unit care should be taken, when connecting the unit to the Transistor Analyser, to ensure that the plugs are inserted the correct way round and they should be secured by means of the retaining clips provided.

NOTE. To avoid damaging the transistor ensure that the variable base current controls are set to zero, and that the base current switch is set to the 0–1*mA position.*

A transistor may now be connected to the instrument (using NPN or PNP sockets as required), without fear of damage. Reference to columns 3 and 4 of the "AVO" International Transistor Data Manual and to the diagram of transistor connections will enable the transistor to be correctly connected to the instrument.

5.1 Measurement of I′co

Set the collector voltage to the figure quoted in the "AVO" Internationa Transistor Data Manual, switch the **Check/Set/Read** control to the **Check/ Ib. Vc. Ic.** position, and the **Function Switch** to the Ic/Ib position. Select a suitable current range on the meter by means of the **Meter Switch**, and depress the push button marked I′co. The value of I′co is given by the meter reading. It must be borne in mind that I′co is very temperature dependent.

5.2 Measurement of Ic, Vc, Ib, $\bar{\beta}$

Switch the **Check/Set/Read** control to the **Check/Ib. Vc. Ic.** position and the **Function Switch** to the Ic/Ib position. The Meter will now monitor either Ic or Vc depending on whether a current or voltage range is selected on the **Meter Switch.** To set up for the required Ic as indicated in the "AVO" International

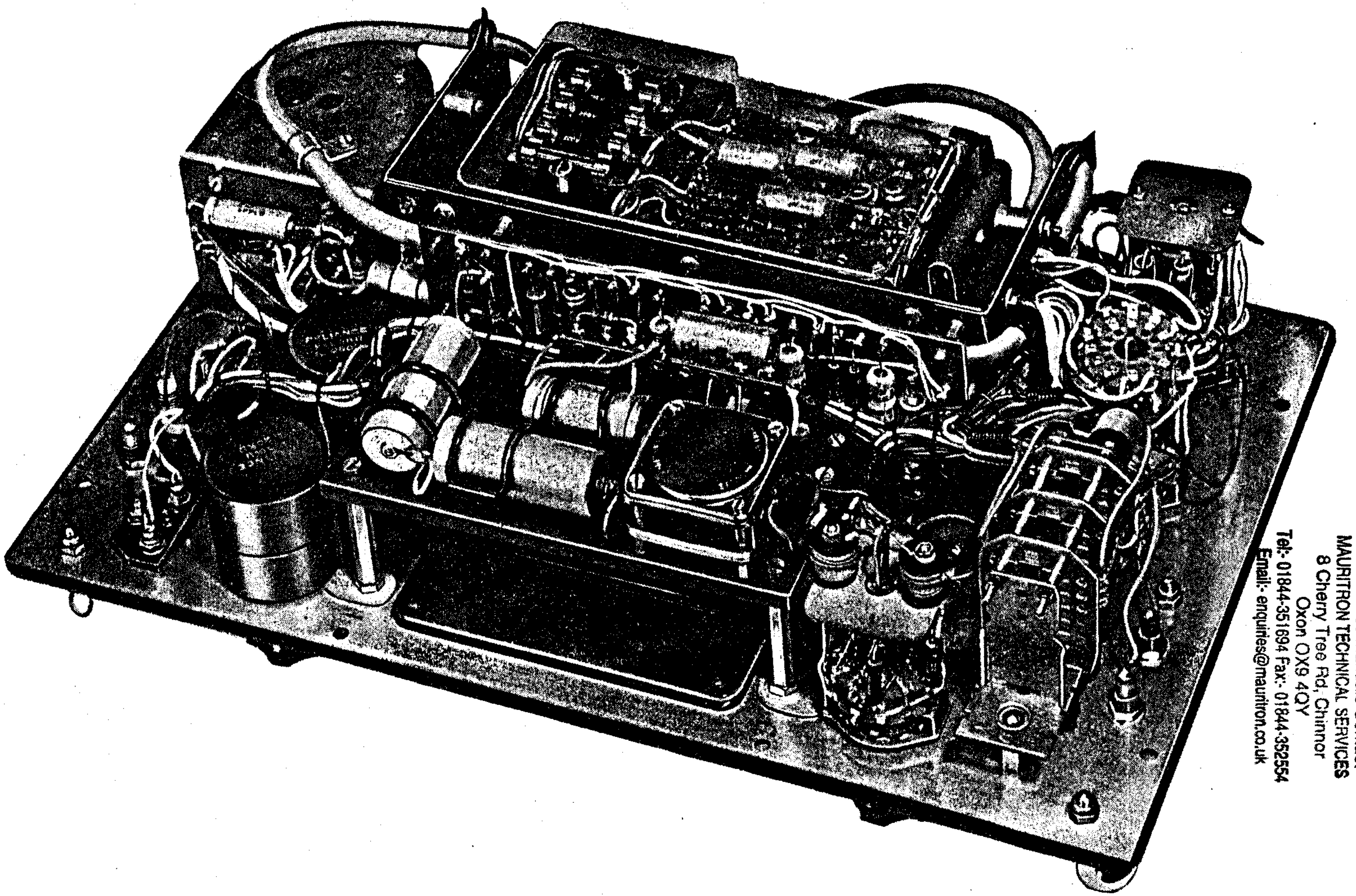

Fig. 4. Interior of the Instrument (mains operated)

Transistor Data Manual or from Manufacturers' data sheets, select an appropriate current range on the **Meter Switch** and with the base current range switch left in the 0–1mA position adjust the **Coarse** and **Fine Base Current Controls** for the required Ic.

If it is impossible to obtain the required Ic return the **Coarse** and **Fine** controls to zero and switch to the 1–40mA position on the base current range switch. Readjust the **Coarse** and **Fine Controls.**

NOTE. The maximum collector current taken from the Battery Power Unit should be limited to 250mA. Collector currents above this should be obtained from the Mains Power Unit or an external supply, and limited to 1A to avoid overloading the meter. (*See* section 6).

The calibrations on the **Coarse Base Current Control** apply only when the **Base Current Range Switch** is in the 0–1mA position. These calibrations will also be affected by the setting of the **Fine Base Current Control.** Therefore, when using the 1–40mA range, or to determine the value of Ib more accurately on the 0–1mA range, with the controls set as above, depress the push button marked Ib. The meter now indicates the value of Ib. It will be necessary to select a suitable current range on the **Meter Switch.**

An approximate value for the dc current gain (h_{FE}) is obtained by dividing Ic by Ib (provided Ico is small). If Ico is known an exact figure can be obtained using

the formula $h_{FE} = \dfrac{Ic - Ico}{Ib + Ico}$

Having set up the collector volts and collector current, it is possible to obtain an approximate figure for $\bar{\beta}$ as follows: Readjust Ib by a known amount and note the change in Ic. $\bar{\beta}$ is then given by dividing the change in Ic by the change in Ib.

5.3 To Measure Beta (β)

The figures for β, quoted in the "AVO" International Transistor Data Manual, are for the same settings of Vc as those given for measurement of I'co and $\bar{\beta}$. Therefore, with the instrument set up as outlined in sections 5.1 and 5.2 measurement of β may be carried out. However, if it is required to measure β at some other setting of Vc and Ic the controls will need to be reset, using the foregoing procedure. Having decided on the required Vc and Ic conditions β is measured as follows:

Set the **Function Switch** to the β/10Ω position and check that the collector voltage and current have not altered from the original settings, due to the inclusion of the 10Ω collector load. If the current has fallen readjust the base current controls and/or the collector volts to give the required values*. Having checked these settings, switch the **Check/Set/Read Control** to position **Set** and adjust the **Gain Control** for an arbitrary meter reading, for example 80. (This meter reading is not critical and in fact in some cases it may be possible to obtain only 1/10 full scale deflection). Set the **Check/Set/Read Control** to position **Read β × 1** or **× 10** as required, and obtain an identical meter reading by operation of the **β/Noise Control.** β is then given by the reading on the outer scale of the **β/Noise Control,** multiplied by the range factor, x1 or x10, for the chosen setting of the **Check/Set/Read Control.**

* A slight increase of collector current reading may occur, this should be ignored. The increase is due to the leakage current of the capacitor introduced into the circuit when measuring β.

5.4 To Measure Noise (N.F.)

Manufacturers quote a noise figure as being measured at a particular Vc and Ic. These are the figures given in the "AVO" International Transistor Data Manual, and in most cases are different from the values of Vc and Ic quoted for measurement of β. Before measuring noise therefore it will be necessary to set up the instrument for the correct Vc and Ic as outlined in sections 5.1 and 5.2. Having set the Vc and Ic proceed as follows:

Set the **Function Switch** to one of the two noise positions either 10Ω or 1000Ω depending on the collector current. (*See* sections 4.7 (iv) and 4.7 (v)). Recheck the collector current and voltage, readjusting the **Base Current** and **Collector Volts Controls** if necessary (as in section 5.3). Set the **Check/Set/Read Control** to position **Set** and adjust the **Gain Control** for a meter deflection of half full scale or less.

The meter reading is not critical and in some cases a meter deflection of only one-tenth of full scale may be obtained. It will also be noted that the meter reading will fluctuate a small amount, this is normal owing to the random nature of the noise from the transistor. Therefore, in setting the meter reading, the average indication of the pointer should be observed. Having obtained this meter reading, set the **Check/Set/Read Control** to one of the **Read Noise** positions, selecting the + 0 db or + 20 db position as required. Adjust the **β/Noise Control** to obtain a meter reading of twice the original indication. The noise figure may then be read from the calibrated dial of the **β/Noise Control** in decibels, adding the dial reading in decibels to the **Check/Set/Read Control** indication.

5.5 To Measure Turnover Voltage

Connect the transistor collector to the collector socket and the base connection to the emitter socket leaving the emitter open circuit. An external dc supply should be connected to the sockets marked **Collector Volts External Supply** (+ 150 **Max.** and **Neg.** on the Battery Power Unit) via a suitable limiting resistor. Set the **Meter Switch** to select a suitable current range and the **Collector Volts Control** to an external position (PNP or NPN as required). Set the **Check/Set/Read Control** to position **Ib. Vc. Ic.** and set the **Function Switch** to the Ic/Ib position. The external voltage should now be increased until a sharp rise in the meter reading is noted. Set the **Meter Switch** to the 150V position. The value of V_T is given by the meter reading. If it is desired to monitor the current and voltage simultaneously it will be necessary to connect a voltmeter across the external volts sockets on the instrument.

5.6 To Measure Saturation Voltage (Vcs)

For saturation measurements it is usually best to use the highest available collector supply voltage, provided that this does not exceed the Vc rating for the transistor with collector current flowing. In the AVO Transistor Analyser up to 10.5 volts are available using the Battery Power Unit, or up to 12 volts using the Mains Power Unit.

If the collector-emitter saturation voltage is quoted at a given base current and collector current, one can proceed as follows:

Disconnect the link between the two collector link terminals. Connect a variable resistor between the terminals (a resistance box may be suitable if it will carry the current), and set to zero resistance. Turn the coarse and fine base current controls fully counter clockwise. Insert the transistor into the appropriate socket (PNP or NPN), and select the collector volts. Set the **Check/Set/Read Control** to **Check/Ib. Vc. Ic.** and the **Function Switch** to **Ic/Ib.** Press the Ib button, and while

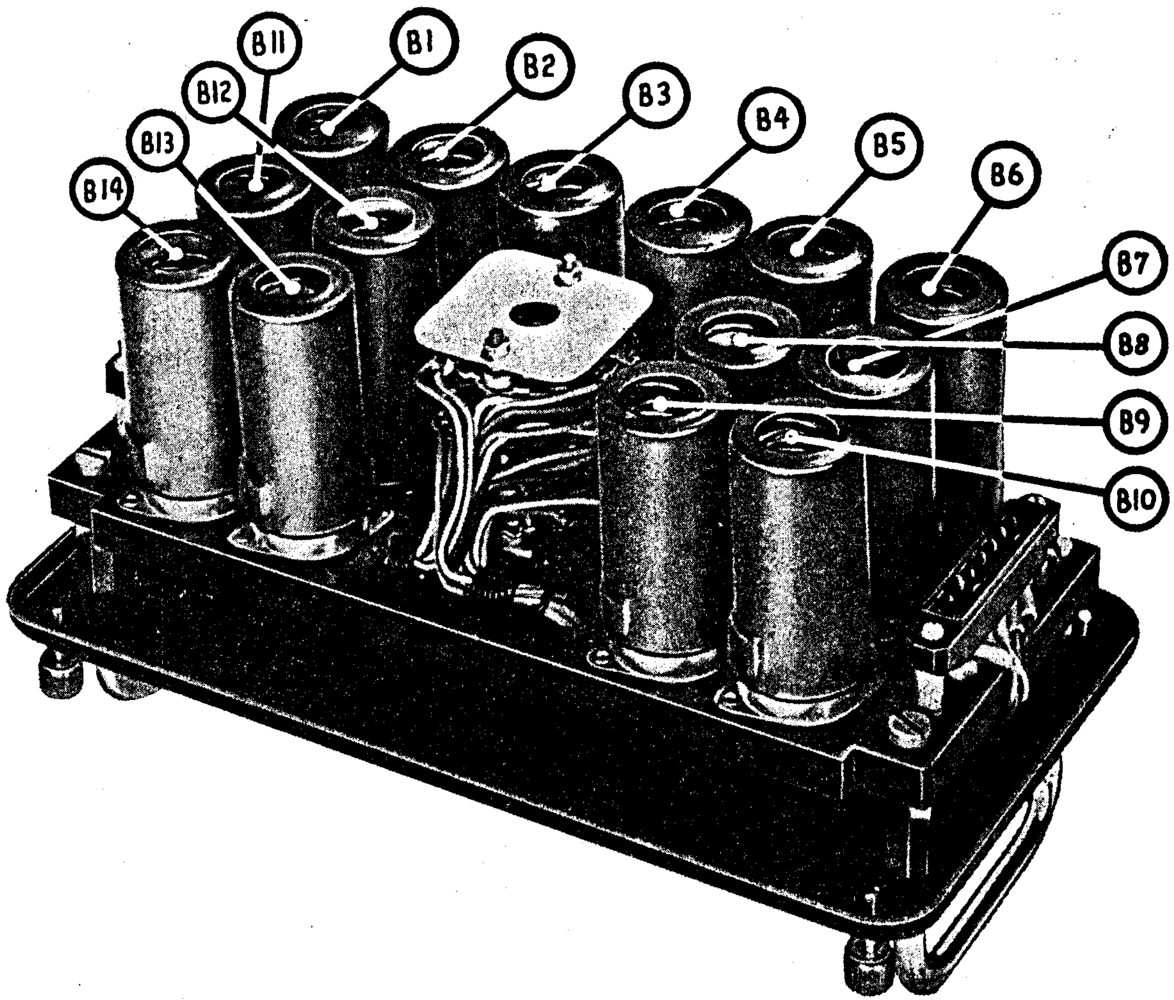

Fig. 5 Interior of the Battery Power Unit

keeping it pressed, set the **Meter Switch** to a range suitable for measuring the desired base current. Still keeping the Ib button pressed select the appropriate base current range and adjust the coarse and fine base current controls until the desired base current is attained. It will usually be found that subsequent adjustments affecting collector current and voltage hardly alter this base current. Still keeping the Ib button pressed, turn the **Meter Switch** to a range suitable for reading the quoted collector current at not more than half f.s.d., and then release the Ib button. The meter now reads the collector current, which must not be less than the value quoted for the saturation condition. Now increase the variable resistor until the collector current has fallen to the value given by the manufacturers. The meter current range may be changed to enable the current to be read more accurately. Then turn **Meter Switch** until a voltage range is reached which enables the collector voltage to be read. If the collector voltage is so low that less than 10% of f.s.d. is obtained on the 1.5V range, press the 150mV button to obtain a more accurate reading.

The reading thus obtained is the collector saturation voltage Vcs for the given conditions. When taking this reading, the meter is drawing extra current through the variable resistor. The meter current when it is acting as a voltmeter is proportional to the deflection, amounting to 40μA at full scale, and is usually an unimportant fraction of the collector current.

Remember to reduce the variable resistor to zero or replace the Collector Link before making any other of the measurements described in these instructions.

6. MEASUREMENT OF I′co, Ib, Ic, β, $\bar{\beta}$, Vcs AND NOISE USING EXTERNAL SUPPLIES

When carrying out continuous or inspection testing of transistors requiring measurements with a collector current in excess of 250mA but not above 1 amp, in conjunction with the Battery Power Unit, or voltages in excess of 12V in the case of the Mains Power Unit, it will be necessary to use an appropriate external dc voltage supply. There are two positions on the Battery Power Unit for connecting an external supply, as follows:

(i) **Neg. ... + 12 Max.** This will enable all characteristics to be measured as outlined in Section 5. A similar procedure should be adopted with the exception that the **Collector Voltage Control** should be set to the appropriate external position, i.e., PNP or NPN as required, adjusting the external supply to the collector voltage required.

(ii) **Neg. ... + 150 Max.** This position can be used for dc measurements only, that is I′co, Ib, Ic, Vc and Vcs as outlined in Sections 5 to 5.2 inclusive and 5.6, again switching to the **EXT** positions on the **Collector Volts Control** as required. This position is also used for measurement of turnover voltage. (*See* Section 5.5).

On the Mains Power Unit there are only two sockets marked **Collector Volts External Supply.** These can be used in the same way as the **Neg.** and **150 Max.** sockets on the Battery Power Unit.

NOTE. When switched to the external position on the **Collector Volts Control,** base current is still supplied by the internal supply. The external supply is always connected to the instrument with the same polarity, i.e., The + ve line to either the **+ 12 Max.** or **+ 150 Max.** or + socket and the negative line to the socket marked **Neg.** or —. The polarity to the test transistor is reversed by the **Collector Volts Control** by switching to the appropriate **Ext.** position. Also when switched to the **Ext.** positions, the internal amplifier and oscillator are still operated by the internal supplies.

9. CHECKING THE CONDITION AND REPLACEMENT OF THE INTERNAL BATTERIES

When using the battery operated version of the instrument, in order to give satisfactory performance under all conditions of use, it is necessary to maintain the internal batteries in a reasonable condition. Therefore, a brief procedure for checking their condition follows:

9.1 To Check the Internal Amplifier/Oscillator Batteries

Switch the **Function Switch** to any position except **Off** and the **Check/Set/Read Control** to the **Check/H.T.** position. Under these conditions the **Meter** has a full scale deflection of 10V regardless of the **Meter Switch** position. With a new set of batteries a reading of 9V should be obtained. If the voltage falls to 7.2V., or less, the batteries should be replaced.

9.2 To Check the Condition of the Internal Supplies for the Transistor under Test

Set the **Meter Switch** to the 15V range, switch the **Check/Set/Read Control** to position **Check/Ib. Vc. Ic.** and the **Function Switch** to **Ic/Ib.** A 220Ω 1 Watt resistor should be connected between the collector and the emitter connections on the PNP sockets.

Set the **Collector Volts Control** to the 10.5V position on the PNP section. The meter should now indicate 10.5V. If the voltage is 9V or less then the batteries should be replaced.

9.3 Replacement of Internal Batteries

The internal power supplies of a battery operated instrument consist of a number of U10 batteries (U7 in the United States of America and Canada), which are arranged to provide the internal oscillator and amplifier h.t. as well as the supply for the transistor under test.

Reference to Figure 5 will show that the batteries are held in position by means of spring loaded retainers. The batteries (B1 to B6) for the internal amplifier and oscillator are located in the single row below the **Collector Volts Control** and the batteries for the transistor test supplies (B7 to B14) are in sets of four on either side of the **Collector Volts Control.**

NOTE. WHEN THE INSTRUMENT IS LIABLE TO BE OUT OF USE FOR LENGTHY PERIODS, IT IS DESIRABLE TO REMOVE THE BATTERIES TO AVOID CORROSION OF THE COMPONENTS.

To remove the battery Power Unit from the main instrument the four captive screws at the corners should be unscrewed until free, and the battery Power Unit lifted away from the main panel. The necessary replacements can now be made.

10. ABBREVIATED OPERATING INSTRUCTIONS FOR THE "AVO" TRANSISTOR ANALYSER

1. Check condition of the internal supplies.
2. Set the variable **Base Current Controls** to zero, and the range switch to 0–1mA position.
3. Referring to the "AVO" International Transistor Data Manual for the diagram of connections and columns 3 and 4, connect the transistor to the instrument.
4. Set the collector volts to value indicated in the "AVO" International Data Manual.
5. Switch the **Check/Set/Read Control** to the **Check/Ib. Vc. Ic.** position, and the **Function Switch** to the Ic/Ib position.

6. Select a suitable current range on the **Meter.**
7. Depress the **Press Button** marked **I'co** and read value of **I'co** from the **Meter.**
8. Release the **Press Button** and select a current range on the **Meter Switch** to read the collector current.
9. Adjust the **Base Current Controls** for the value of collector current in the "AVO" International Transistor Data Manual.
10. Read the value of base current by depressing the **Press Button** marked Ib, selecting a suitable current range on the **Meter Switch.**

Measurement of $\bar{\beta}$

1. Readjust Ib by a known amount, and note the change in Ic. $\bar{\beta}$ is then given by dividing the change of Ic by the change in Ib.

Measurement of β

1. Set the **Function Switch** to β/10Ω and check that Vc and Ic have not altered from the values already set up.
2. Switch the **Check/Set/Read Control** to **Set.**
3. Adjust the **Gain Control** for an arbitrary meter reading.
4. Set the **Check/Set/Read Control** to **Read: β × 1** or **β × 10.**
5. Adjust the β/**Noise Control** for the same meter reading.
6. Read off β from calibrated β/**Noise Control** dial and multiply by x1 or x10 as required.

Measurement of Noise

1. Reset Vc and Ic to values quoted in "AVO" International Transistor Data Manual for the measurement of noise.
2. Set the **Function Switch** to either the 10Ω or the 1000Ω position, and recheck dc conditions.
3. Set the **Check/Set/Read Control** to **Set.**
4. Adjust the **Gain Control** for a meter reading of one half full scale deflection or less.
5. Set the **Check/Set/Read Control** to either + 0 db or + 20 db.
6. Adjust the β/**Noise Control** for twice the original meter reading.
7. Read off the noise figure in db's from the calibrated dial of the β **Noise Control** adding + 0 db or + 20 db as indicated on the **Check/Set/Read Control.**

If using the Battery Power Unit, after carrying out measurements, the instrument should be switched off to avoid exhausting the batteries.

NOTE. WHEN THE INSTRUMENT IS LIABLE TO BE OUT OF USE FOR LENGTHY PERIODS, IT IS DESIRABLE TO REMOVE THE BATTERIES TO AVOID CORROSION OF THE COMPONENTS.

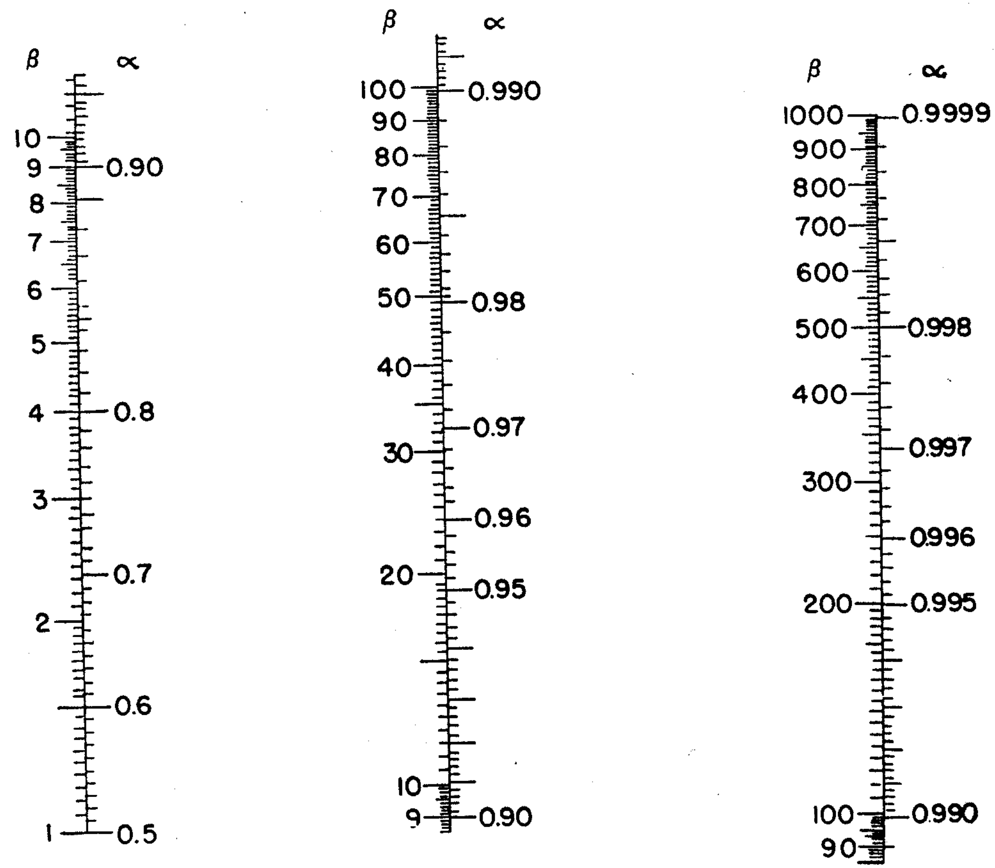

Fig. 6. β to α Conversion Chart

APPENDIX I

THE "AVO" TRANSISTOR ANALYSER

Schedule of Spare Parts

INTRODUCTION

Throughout the past decade the Avo instruments have proved themselves to be unrivalled for versatility and reliability. It is, however, inevitable that this instrument will fail from time to time and, when it does, we are anxious to ensure that it is repaired to the highest possible standard. We have, therefore, produced this schedule of spares which will form a useful guide to the trained engineer who has the task of servicing this instrument.

Procedure for ordering spare parts.

If you will kindly follow the procedure set out below, delays will not occur due to the exchange of unnecessary correspondence.

1. State the part number of the items required, also the quantity.
2. State the serial number of the instrument. This will be found on an identification label attached to the base of the instrument.

Overseas users of our instruments should send their requirements to our Agents on their territory.

If the spares are required for use in Great Britain, application should be made direct to our Spares Department in London.

MOVEMENT SERVICING

Due to modifications in movement design it will now be necessary in some circumstances to return the complete assembly to Avo, Ltd., for overhaul.

Movements in this category can be identified by the letter "T" incorporated in the serial number on the scale-plate.

UNDER NO CIRCUMSTANCES SHOULD ANY ATTEMPT BE MADE TO SERVICE BASIC MOVEMENT ASSEMBLIES OF THIS TYPE AS IT IS NOT POSSIBLE WITHOUT SPECIALISED EQUIPMENT.

The part number for this type of movement complete is 40650–L.

The spare parts shown in this schedule under assembly 40650–G, items 6, 9, 15, 18, 19, 21, 22, together with assemblies 40651–F and 21124–D are not therefore applicable to "T" type movements.

MAIN ASSEMBLY 40695–D

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	40703–E	Case Assembly. See page 37 for breakdown detail ..		1
2	40717–C	Chassis Assembly. See below for breakdown		1
3	21214–A	Flying Lead Assembly. See page 38 for breakdown detail		1
4	S1535	Round Head Screw, 4 BA × $\frac{11}{16}$", chromium plated ..		8
5	10072–355	Operating Instruction Manual		1
6	10072–349	International Transistor Data Manual (2nd Edition) ..		1

CHASSIS ASSEMBLY 40717–C

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	40707–2	Front Panel less battery container		1
*2	40650–G	Movement and Case Assembly (32μA 3250Ω). See page 35 for breakdown detail	M.1	1
3	40706–A	Battery Power Unit. See page 32 for breakdown detail ..		1
4	40716–C	Battery Power Unit Container. See page 35 for breakdown detail		1
5	15837–A	Function Switch Assembly. See page 32 for breakdown detail		1
6	40719–A	Oscillator Assembly. See page 33 for breakdown detail ..		1
7	15839–A	Meter Switch Assembly. See page 33 for breakdown detail		1
8	21216–A	Component Board Assembly. See page 33 for breakdown detail		1
9	21242–A	Ferroxcube Choke	L.1	1
10	15220–A	Knob Assembly, with skirt (engraved marker line). See page 34 for breakdown detail		5
11	15220–F	Knob Assembly (Function switch). See page 34 for breakdown detail		1
12	15220–E	Knob Assembly (β/noise control). See page 35 for breakdown detail		1
13	15714–1	Masking Block (Function switch)		2
14	14829–3	Socket (red)		3
15	14829–4	Socket (black)		2
16	14829–2	Socket (white)		1
17	14630–2	Cover, circular, black (β/noise control)		1
18	14559–3	Dial (β/noise control)		1
19	15716–2	Cursor Block (marked inner/outer scale)		1
20	15160–1	Push Button for item 32, 150mV/I'co/Ib		3
21	20006–2	Gasket, between movement and panel		1
22	14941–26	Bush, Stand-off, for item 18		2
23	15842–A	Support Plate, between item 35 and item 57		4
24	11310–A	Tag Board Assembly, 8 tags		1

* See note regarding Movement Servicing on page 29

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
25	13659–5	Insuloid Clip, ¼″ dia.		1
26	13659–6	Insuloid Clip, 5/16″ dia.		2
27	13659–4	Insuloid Clip, 3/16″ dia.		2
28	21027–22	Switch, Check/Set/Read β Noise		1
29	13657–1	Toggle Switch, 1–40 mA, 0–1 mA		1
30	21027–27	Push Button Switch	SH SJ SK	1
31	13483–61	Pillar, between item 32 and front panel		2
32	15838–2	Pillar, holding item 25		2
33	15841–4	Pillar, ⅜″, on push switch		1
34	13483–79	Pillar, Stand-off, holding movement fixing panel		4
35	15718–3	Cable Clip		1
36	15191–1	Dust Washer, on push buttons, item 20		2
37	15638–2	Cradle } holding C.14, C.15, C.16		3
38	15638–5	Clip } holding C.14, C.15, C.16		3
39	21219–2	Movement Board (main fixing panel)		1
40	15581–12	Silicon Diode, International Rectifier, type 2E1	MR.2 MR.3	2
41	10770–33	Potentiometer, 100kΩ log.	RV.3	1
42	14558–11	Potentiometer, 1.5kΩ–250Ω	RV.4 ab	1
43	14558–12	Potentiometer, 11kΩ–25MΩ	RV.5 ab	1
44	12049–311	Resistor, 100Ω ± 1%, type C.22	R.51	1
45	12049–437	Resistor, 1kΩ ± 10%, type 16	R.43	1
46	12049–728	Resistor, 1.3kΩ ± 2%, type C.21	R.47	1
47	12049–386	Resistor, 10kΩ ± 1%, type C.21	R.41	1
48	12049–729	Resistor, 11kΩ ± 2%, type C.21	R.50	1
49	12049–342	Capacitor, 1μF 250V	C.16	1
50	12049–731	Capacitor, 8μF 12V	C.18	1
51	12049–730	Capacitor, 500μF 12V	C.14, C.15	2
52	P.V.C.124	Screened Cable, 1 ft...		1
53	40707–2	Front Panel, less battery container..		1
54	30006–KJ	Resistance Bobbin for Push Button Switch, 1.38kΩ ± 1%		1
55	16389–A	Link Assy. See page 37 for Breakdown details		1
56	40716–D	Battery Power Unit Container		1
57	13845–16	Handle		2
58	15708–2	Handle Bush		4
59	N57	2 BA Hex. Stiff Nut for Handles		4
60	14013–2	Mod. Record Plate		1
61	50154–A	Mains Power Unit. See page 38 for Breakdown details ..		1
62	30006–KJ	Wound Bobbin, 1.38kΩ ± 1%	R.53	1

BATTERY POWER UNIT ASSEMBLY 40706–A

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	21207–1	Panel (engraved)		1
2	21206–3	Box Cover, less item 1		1
3	21208–1	Gasket, sealing		1
4	13845–7	Handle, nickel plated		2
5	15708–2	Handle Bush		4
6	21199–A	Holder Assembly, NPN, PNP		2
7	15710–2	Socket, on item 6		4
8	15709–1	Overlay (perspex)		2
9	14829–2	Socket (white)	SKT.4	1
10	14829–4	Socket (black)	SKT.3	1
11	14829–3	Socket (red)	SKT.5	1
12	15639–2	Connector Socket, 6-way, battery connections	SKT.1	1
13	15639–4	Connector Socket, 8-way, battery connections	SKT.2	1
14	21027–19	Collector Volts Switch	SA	1
15	15717–4	Switch Plate (support plate at rear of item 14)		1
16	15220–A	Knob Assembly (collector volts switch)		1
17	15707–2	Switch Bush (collector volts switch)		1
18	13908–2	Hex. Nut (collector volts switch)		1
19	13909–1	Washer (collector volts switch)		1
20	40705–1	Battery Power Unit Base, between battery Power Unit base and front cover		4
21	13483–59	Pillar 0.75″ × $\frac{1}{8}$ AF		4
22	15712–2	Battery Contact, long, on battery Power Unit base		14
23	16019–A	Retainer, for battery complete with sleeve		14
24	15711–1	Skirt, for item 23		14
25	12379–4	Battery (Ever Ready, type U.10) (see item 33)		14
26	15295–7	Captive Screw, securing front cover		4
27	15715–2	Contact, short, on battery Power Unit base		3
28	15626–2	Tab, on rear of item 7		4
29	12049–587	Capacitor, 470 pF		2
30	14048–25	Sleeve, on rear of transistor socket		6
31	10042–1	Sleeve, cut in two sections for battery connecting socket		7
*32	16025–A	Battery Tube Assembly		14
*33	12379–16	Battery, Ever Ready, type U.7		14
34	14941–24	Spacer, retainer between battery socket and battery Power Unit base		4

FUNCTION SWITCH ASSEMBLY 15837–A

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	21027–21	Function Switch	SE.	1
2	15717–4	Switch Plate, support plates rear of item 1		1
3	12049–718	Resistor, 0.53Ω ± 2.5%	R.42	1
4	12049–718	Resistor, 0.53Ω ± 2.5%	R.49	1
5	12049–720	Resistor, 10Ω ± 5%	R.44, R.46	2
6	12049–720	Resistor, 10Ω ± 5%	R.46	1
7	12049–464	Resistor, 1kΩ ± 1%	R.45	1
8	12049–635	Resistor, 240kΩ ± 2%, type C.21	R.42	1
9	12049–719	Resistor, 1MΩ ± 2%, type C.21	R.40	1

* Used only on instruments for the United States of America and Canada

METER SWITCH ASSEMBLY 15839–A

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	21027–20	Meter Switch	SF.	1
2	15717–4	Switch Plate, support plate rear of item 1		1
3	30006–BH	Wound Bobbin, 0.4Ω ± 1%	R.39	1
4	30006–AH	Wound Bobbin, 3.58Ω ± 1%		1
5	12049–725	Resistor, 35.8Ω ± 1%, type C.22	R.37	1
6	12049–724	Resistor, 358Ω ± 1%, type C.21	R.36	1
7	12049–723	Resistor, 3.58kΩ ± 1%, type C.21	R.35	1
8	12049–722	Resistor, 6kΩ ± 1%, type C.21	R.34	1
9	12049–721	Resistor, 35.3kΩ ± 1%, type C.21	R.33	1
10	12049–726	Resistor, 340kΩ ± 1%, type C.21	R.32	1
11	12049–727	Resistor, 3.4MΩ ± 1%, type C.22	R.31	1

COMPONENT BOARD ASSEMBLY 21216–A

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	21216–13	Component Board Tagged		1
2	15719–1	Transistor Holder		3
3	12241–21	Germanium Diode, type GEX34	MR.1	1
4	15581–8	Transistor (Mullard, type OC75)	VT.3, VT.4	2
5	15581–9	Transistor, CV.2400	VT.5	1
6	12049–402	Capacitor, 0.04μF 150V	C.13	1
7	12049–709	Capacitor, 8μF 12V	C.17	1
8	12049–717	Capacitor, 0.1μF 150V	C.6, C.7, C.8	3
9	12049–708	Capacitor, 25μF 12V	C.10, C.11, C.12	3
10	12049–707	Capacitor, 100μF 12V	C.9	1
11	12049–650	Resistor, 150Ω ± 2%, type C.21	R.19	1
12	12049–437	Resistor, 1kΩ ± 5%, type 16	R.25, R.27, R.29	3
13	12049–693	Resistor, 5.6kΩ ± 5%, type 16	R.17	1
14	12049–610	Resistor, 10kΩ ± 5%, type 16	R.20, R.22, R.24, R.26, R.28, R.30	6
15	12049–188	Resistor, 24kΩ ± 5%, type 16	R.23	1
16	12049–184	Resistor, 120kΩ ± 5%, type 16	R.16, R.18, R.21	3

OSCILLATOR ASSEMBLY 40719–A

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	21218–2	Oscillator Container Front and Rear Plates		2
2	40719–46	Oscillator Board Tagged		2
3	15144–4	Oscillator Container Body		1
4	14928–8	Bush, on drive spindle		1

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
5	AS52	Socket Grub Screw, 4 BA × $\frac{5}{16}$" (for item 4)		2
6	40719–47	Component Board, connecting front and rear plates		1
7	21213–A	Oscillator Transformer	L2	1
8	15581–10	Transistor, type OC.71	VT.1, VT.2	2
9	15719–1	Transistor Holder, for item 8		2
10	11982–3	Grommet		1
11	15840–1	Insulation Strip, for item 3		1
12	14558–10	Potentiometer, 1kΩ ± 1%	RV.2	1
13	15832–1	Potentiometer, 4700Ω	RV.1	1
14	12049–402	Capacitor, 0.04μF	C.5, C.19	2
15	12049–717	Capacitor, 0.1μF 150V	C.1, C.2	2
16	12049–709	Capacitor, 8μF 12V	C.3	1
17	12049–707	Capacitor, 100μF 12V	C.4	1
18	12049–504	Resistor, 15Ω ± 20%, type 9	R.52	1
19	12049–716	Resistor, 100Ω ± 1%, type C.21	R.7, R.13	2
20	12049–712	Resistor, 900Ω ± 1%, type C.21	R.12	1
21	12049–464	Resistor, 1kΩ ± 1%, type C.21	R.15	1
22	12049–437	Resistor, 1kΩ ± 10%, type 16	R.1	1
23	12049–631	Resistor, 1.5kΩ ± 2%, type C.21	R.14	1
24		Resistor, 3kΩ–10kΩ, type C.21	R.5	1
25	12049–194	Resistor, 3.9kΩ ± 5%, type 16	R.4	1
26	12049–710	Resistor, 4.7kΩ ± 5%, type 16	R.2, R.3, R.6	3
27	12049–714	Resistor, 16kΩ ± 1%, type C.21	R.10	1
28	12049–713	Resistor, 79kΩ ± 1%, type C.21	R.11	1
29	12049–715	Resistor, 160kΩ ± 1%, type C.21	R.9	1
30	12049–711	Resistor, 400kΩ ± 1%, type C.21	R.8	1

KNOB ASSEMBLY 15220–A

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	14267–1	Knob		1
2	14266–6	Knob Carrier		1
3	14268–4	Knob Skirt, silver, with marker line		1
4	15066–2	Knob Washer		1
5	14269–4	Retaining Nut		1
6	20245–52	Spring dowel, $\frac{5}{16}$" × $\frac{1}{8}$" dia.		1
7	S745	Special Screw		1
8	W39	Spring Washer, 6 BA, phosphor bronze double coiled		1

KNOB ASSEMBLY 15220–F

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	14267–1	Knob		1
2	14266–6	Knob Carrier		1
3	14268–7	Knob Skirt, silver, marker line, 2 coloured zones		1
4	15066–2	Knob Washer		1
5	14269–4	Retaining Nut		1
6	20245–52	Spring dowel, $\frac{5}{16}$" × $\frac{1}{8}$" dia.		1
7	S745	Special Screw		1
8	W39	Spring Washer, 6 BA, phosphor bronze double coiled		1

KNOB ASSEMBLY 15220–E

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	14267–1	Knob		1
2	14670–2	Knob Carrier		1
3	20245–52	Spring dowel, $\frac{5}{16}$" × $\frac{1}{8}$" dia.		1
4	S745	Special Screw		1
5	W39	Spring Washer, 6 BA, phosphor bronze double coiled ..		1

BATTERY POWER UNIT CONTAINER ASSEMBLY 40716–C

Item No.	Part No.	Description	Circuit Ref.	Qty Off
1	40716–B	Battery Power Unit Container Assembly		1
2	15639–3	Connector Socket, 8-way	PL.2	1
3	15639–1	Connector Socket, 6-way	PL.1	1
4	15834–2	Connector Cover		2
5	14829–4	Socket Test Point	SKT.17	1
6	13483–75	Stand-off Pillars, for component board assembly (medium)		1
7	13483–77	Pillar, Stand-off, for component board assembly (short)..		1
8	13483–73	Pillar, Stand-off, for component board assembly (long) ..		3
9	15979–2	Pillar (Tufnol)		2
10	13659–7	Insuloid Clip, $\frac{3}{8}$" dia.		1
11	13659–5	Insuloid Clip, $\frac{1}{4}$" dia.		1
12	13659–6	Insuloid Clip, $\frac{5}{16}$" dia.		4
13	13924–3	Screening Tube, for oscillator cableform		1
14	15718–1	Clip, securing item 13		2
15	11982–8	Grommet		2
16	N61	Hex. Nut, 6 BA, tin plated		11
17	R80	Rivet, .090"/.094" × $\frac{1}{4}$", for securing battery Power Unit to front panel		12

* MOVEMENT AND CASE ASSEMBLY 40650–G

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	40537–2	Front Case		1
2	40538–B	Rear Case		1
3	Misc.139	Rubber, approx. 16", for sealing items 1 and 2		1
4	12730–2	Movement Glass		1
5	14823–2	Hex. Stud, for securing items 1 and 2		4
6	10054–1	Movement Zero Adjuster		1
7	10077–4	Main Fixing Stud, 2 BA		2
8	10064–1	Tag, for item 7		2
9	40651–F	Basic Movement Assembly. See below for breakdown assembly		1
10	N2	Hex. Locknut, 2 BA		2

* See note regarding Movement Servicing on page 29

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
11	N4	Hex. Locknut, 4 BA		3
12	N55	Round Nut, 6 BA, for item 5		4
13	S751	Inst. Head Screw, 6 BA × $\frac{1}{4}$", brass nickel plated		1
14	30006–W	Wound Bobbin, 900Ω approx.		1
15	15438–2	Magnetic Shunt		1
16	12927–1	Movement End Stop		2
17	30008–10	Washer, for bobbin (item 14)		1
18	15440–1	Hex. Pillar Support, for item 9		2
19	P.V.C.147	Friction Bush, $\frac{5}{32}$" long		1

* BASIC MOVEMENT ASSEMBLY 40651–F

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	14824–8	Scaleplate		1
2	15439–1	Mounting Plate, for item 1		1
3	15301–1	Magnet		1
4	21122–2	Support Plate, for item 3		1
5	15303–2	Concentrator		1
6	15296–2	Pole Piece		2
7	21121–1	Concentrator Support		1
8	21124–D	Moving Coil Assembly. See page 38 for breakdown		1
9	21123–2	Yoke		1
10	15436–1	Zero Adjuster		1
11	15437–1	Movement Support Pillar		2
12	10184–B	Sprung Jewel Assembly		1
13	10194–B	Fixed Jewel Screw Assembly		1
14	10190–1	Insulator Bush, for rear hairspring tag		1
15	10188–2	Locknut, for item 14		1
16	10191–4	Rear Hairspring Tag		1
17	10069–1	Spring Washer, for item 10		1
18	10197–2	Locknut, for item 12		1
19	10189–1	Washer, for item 16		2
20	10358–2	Tag, for movement connection		1

* MOVING COIL ASSEMBLY 21124–D

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	15304–3	Moving Coil (less items 2—9)		1
2	10161–4	Pivot Plate		1
3	10159–1	Pivot Holder		2
4	10084–1	Tag, for hairsprings		2
5	10162–1	Pad, for items 2 and 8		4
6	10158–4	Pivots, 0.020"		2
7	10075–16	Hairsprings		2
8	15300–2	Pointer Plate		1
9	15433–1	Pointer		1

* See note regarding Movement Servicing on page 29

CASE ASSEMBLY 40703–E

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	40703–A	Case Assembly, Top		1
2	40703–D	Case Assembly, Bottom		1
3	11727–A	Handle Assembly		1
4	11727–5	End Cap, for handle assembly		2
5	P.V.C.174	P.V.C. Strip, 3′ 0″		1
6	40704–1	Gasket		1
7	15700–2	Clasp Bottom (on bottom case)		4
8	15701–2	Clasp Plate (outside bottom case)		4
9	15702–2	Clasp Plate (inside bottom case)		4
10	15700–1	Clasp Top		4
11	15702–4	Clasp Plate (on case lid)		4
12	15706–2	Cover Washer		4
13	15703–1	Panel Clamp		8
14	14235–1	Anchor Nut, 4 BA		8
15	R66	Rivet, .090″/.094″ × $\frac{1}{4}$″		28
16	15713–1	Strap		1
17	R65	Rivet, .090″/.094″ × $\frac{7}{32}$″		16
18	12231–5	Name Plate		1

LINK ASSEMBLY 16389–A

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	40467–2	Top Cap Escutcheon		1
2	14657–4	Link		1
3	14242–4	Screwed Socket		2
4	13834–A	Knob		2
5	14656–1	Spring		1
6	14243–2	Hex. Nut		2
7	14247–3	Spring Washer		2

FLYING LEAD UNIT ASSEMBLY 21214–A

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	P.V.C.175	Lead, length 2′ 6″		1
2	14048–32	Marker Sleeve (marked b)		1
3	14048–31	Marker Sleeve (marked c)		1
4	14048–33	Marker Sleeve (marked e)		1
5	15724–1	Crocodile Clip		3
6	15721–1	Bakelite Base		2
7	13483–63	Pillar		4
8	15723–2	Contact		3
9	11982–7	Grommet		1
10	15722–3	Case		1
11	15831–6	Contact (lead end clip connector)		3
12	15725–3	Contact (for crocodile clip)		3
13	15718–2	Cable Clip		1
14	15295–6	Captive Screw		2
15	15843–2	Bush, for captive screw		2

MAINS POWER UNIT ASSEMBLY 50154

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	21206–5	Front Panel Mounting Plate		1
2	21207–2	Front Panel, Engraved		1
3	15295–11	Mounting Block		2
4	16879–1	Captive Screw		4
5	16882–1	Bracket, for item 4		2
6	16887–1	Coil Spring, for item 7		1
7	16888–2	Plug Retainer Clip		1
8	16891–3	Cable Clip		1
9	16883–A	Pin Connection Board		1
10	21527–1	Insulation Sheet Top, located beneath fuse board ..		1
11	21199–A	Transistor Holder Assembly		2
12	15710–2	Retaining Stud for Flying Lead Assembly		4
13	15220–A	Indicator Knob Assembly (see page 34 for breakdown details)		1
14	15708–2	Handle Bush		4
15	13845–7	Handle		2
16	15029–B	Fuse Board Assembly	SKT.6	1
17	14829–3	Socket (red)	SKT.10, SKT.12	2
18	14829–4	Socket (black)	SKT.9, SKT.11	2
19	15639–2	Six-way Connector Socket	SKT.7	1
20	15639–4	Eight-way Connector Socket	SKT.8	1
21	16387–2	Strap located round C101/C102		1
22	21531–1	Printed Circuit (large), less components		1
23	21530–1	Printed Circuit (small), less components		1
24	12049–1017	Resistor, 1Ω ± 5%	R.101	1
25	12049–994	Resistor, 470Ω ± 7% T.E.	R.130, R102	1
26	12049–995	Resistor, 2.2kΩ ± 7% T.E.	R123, R.103, R.104	2
27	12049–996	Resistor, 100kΩ ± 7% T.E.	R.105	1
28	12049–997	Resistor, 68Ω ± 7% T.E.	R.106	1
29	12049–998	Resistor, 10kΩ ± 7% T.E.	R.107	1
30	12049–1012	Resistor, 4.3kΩ ± 1%	R.108	1
31	12049–1013	Resistor, 3.5kΩ ± 1%	R.109	1
32	12049–999	Resistor, 2.7kΩ ± 7% T.E.	R.110	1
33	12049–1000	Resistor, 1kΩ ± 7% T.E.	R.111	1
34	12049–1011	Resistor, 330Ω ± 7% T.E.	R.112	1
35	12049–1001	Resistor, 8.2kΩ ± 7% T.E.	R.113	1
36	12049–1002	Resistor, 3.3kΩ ± 7% T.E.	R.114	1
37	12049–1003	Resistor, 15kΩ ± 7% T.E.	R.115	1
38	12049–1004	Resistor, 47kΩ ± 7% T.E.	R.116	1
39	12049–1005	Resistor, 220kΩ ± 7% T.E.	R.117	1
40	12049–1015	Resistor, 0.5Ω ± 10%	R.118	1
41	12049–1006	Resistor, 560kΩ ± 10%	R.119	1
42	12049–1017	Resistor, 1Ω ± 5%	R.120	1

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
43	12049–1014	Resistor, 9.5kΩ ± 2%	R.121	1
44	12049–1007	Resistor, 330kΩ ± 10%	R.122	1
45	12049–1008	Resistor, 39Ω ± 7% T.E.	R.124	1
46	12049–1009	Resistor, 1.8kΩ ± 7% T.E.	R.125	1
47	12049–1010	Resistor, 1.2kΩ ± 7% T.E.	R.126	1
48	12049–1016	Resistor, 10Ω ± 5%	R.127	1
49	12049–998	Resistor, 10kΩ ± 7% T.E.	R.128	1
50	12049–1004	Resistor, 47kΩ ± 7% T.E.	R.129	1
51	12049–981	Capacitor, 2000μF 25V (electrolytic)	C.101, C.102	2
52	12049–982	Capacitor, 50μF 25V (electrolytic)	C.103, C.109, C.110, C.113, C.114, C.115	6
53	12049–402	Capacitor, 0.04μF 250V	C.105, C.107	2
54	12049–984	Capacitor, 25μF 25V (electrolytic)	C.106	1
55	12049–985	Capacitor, 250μF 25V (electrolytic)	C.108	1
56	12049–587	Capacitor, 470–500pF	C.111, C.112	2
57	12049–1021	Capacitor, 0.25μF 150V	C.116	1
58	15581–51	Diode, type OA81	MR.101, MR.102, MR.103, MR.104, MR.105, MR.106, MR.107, MR.108	8
59	15581–52	Zener Diode, type NEZ 18T5	MR.109	1
60	15581–54	Zener Diode, type SX 561	MR.110	1
61	15581–55	Zener Diode, type SX 8.2 (Sel.)	MR.111	1
62	15581–53	Zener Diode, type SX 4.7	MR.112	1
63	15581–56	Diode, type ZS 72	MR.113, MR.114, MR.115, MR.116	4
64	21027–31	Switch for Collector Volt supply	SB	1
65	16897–1	"On/Off" Switch	SC	1
66	16896–1	Cut-out Re-set Switch	SD	1
67	12239–2	Fuse, 250mA delay type	FS.1	1
68	16895–1	Neon Indicator Lamp	ILP.101	1
69	16903–1	Collector Voltage Potentiometer	RV.101	1

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
70	12049–1019	Potentiometer, 1k$\Omega \pm 20\%$, wire wound	RV.102	1
71	12049–1016	Potentiometer, 100$\Omega \pm 20\%$, wire wound	RV.103	1
72	15581–57	Transistor, type GET 535	VT.101, VT.102, VT.103, VT.106, VT.107, VT.108, VT.110	7
73	15581–58	Transistor, type GET 116	VT.104, VT.109	2
74	15581–59	Transistor, type OC 35	VT.105	1
75	40925–8	Mains Transformer	T.101	1
76	16899–1	Mains Input Socket		1
77	16899–2	Mains Input Plug		1
78	12049–983	Capacitor, 50µF 50V	C104	1
79	12049–982	Capacitor, 50µF 25V	C117	1

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FIGURE 7

Circuit Ref.	Description	Remarks
C.201	470pF	
C.202	470pF	
B1–B6	Battery Type U10	Type U7 in USA and Canada
B7–B14	Battery Type U10	Type U7 in USA and Canada
SA	Collector Volt Switch	
SKT.1	6-way Socket	
SKT.2	8-way Socket	
SKT.3	Neg. socket (black)	
SKT.4	12V socket (white)	
SKT.5	150V socket (red)	

FIGURE 9

Circuit Ref.	Description
R.1	1kΩ ± 10%
R.2	4.7kΩ ± 5%
R.3	4.7kΩ ± 5%
R.4	3.9kΩ ± 5%
R.5	3kΩ–10kΩ
R.6	4.7kΩ ± 5%
R.7	100Ω ± 1%
R.8	400kΩ ± 1%
R.9	160kΩ ± 1%
R.10	16kΩ ± 1%
R.11	79kΩ ± 1%
R.12	900Ω ± 1%
R.13	100Ω ± 1%
R.14	1.5kΩ ± 2%
R.15	1kΩ ± 1%
R.16	120kΩ ± 5%
R.17	5.6kΩ ± 5%
R.18	120kΩ ± 5%
R.19	150Ω ± 2%
R.20	10kΩ ± 1%
R.21	120kΩ ± 5%
R.22	10kΩ ± 1%
R.23	24kΩ ± 5%
R.24	10kΩ ± 1%
R.25	1kΩ ± 5%
R.26	1kΩ ± 1%
R.27	1kΩ ± 5%
R.28	10kΩ ± 1%
R.29	1kΩ ± 5%
R.30	10kΩ ± 1%
R.31	3.4MΩ ± 1%
R.32	340kΩ ± 1%
R.33	35.3kΩ % 1%
R.34	6kΩ ± 1%
R.35	3.58kΩ ± 1%
R.36	358Ω ± 1%
R.37	35.8Ω ± 1%
R.38	3.58Ω ± 1%
R.39	0.4Ω ± 1%
R.40	1MΩ ± 2%
R.41	10kΩ ± 1%
R.42	240kΩ ± 2%
R.43	1kΩ ± 10%
R.44	10Ω ± 5%
R.45	1kΩ ± 1%
R.46	10Ω ± 5%
R.47	1.3kΩ ± 2%
R.48	0.53Ω ± 2.5%
R.49	0.53Ω ± 2.5%
R.50	11kΩ ± 2%
R.51	100Ω ± 1%
R.52	15Ω ± 20%
R.53	1.38kΩ ± 1%
C.1	0.1μF 150V
C.2	0.1μF 150V
C.3	8μF 12V
C.4	100μF 12V
C.5	0.04μF
C.6	0.1μF 150V

Circuit Ref.	Description
C.7	0.1μF 150V
C.8	0.1μF 150V
C.9	100μF 12V
C.10	25μF 12V
C.11	25μF 12V
C.12	25μF 12V
C.13	0.04μF 150V
C.14	500μF 12V
C.15	500μF 12V
C.16	1μF 250V
C.17	8μF 12V
C.18	8μF 12V
C.19	0.04μF
L.1	Ferroxcube Choke
L.2	Oscillator Transformer
RV.1	4700Ω
RV.2	1kΩ ± 1%
RV.3	100kΩ log.
RV.4 a, b	1.5kΩ and 250Ω
RV.5 a, b	11kΩ and 25MΩ
SE	Function Switch
SF	Meter Switch
SG	Check/Set/Read switch
SH	Push Ico
SJ	Push Ib
SK	Push 150mV
SL	Base Current Switch
MR.1	Germanium Diode, type GEX 34
MR.2	Silicon Diode, type 2E1
MR.3	Silicon Diode, type 2E1
SKT.13	Meter Input Socket (Red
SKT.14	Meter Input Socket (Whi
SKT.15	Amplifier Input Socket (red)
SKT.16	Amplifier Input Socket (black)
SKT.17	Test Socket
SKT.18	Oscillator Output Socket (black)
SKT.19	Oscillator Output Socket (red)
SKT.20	Test Socket 2 (White)
VT.1	Transistor, type OC 71
VT.2	Transistor, type OC 71
VT.3	Transistor, type OC 75
VT.4	Transistor, type OC 75
VT.5	Transistor, type CV 2400
M.1	Meter Movement 30μA, 3250Ω
PL.1	8-way Plug
PL.2	6-way Plug

FIGURE 8

Circuit Ref.	Description
R.101	1Ω ± 5%
R.102	470Ω ± 7% T.E.
R.103	2.2kΩ ± 7% T.E.
R.104	2.2kΩ ± 7%
R.105	100kΩ ± 7% T.E.
R.106	68Ω ± 7% T.E.
R.107	10kΩ ± 7% T.E.
R.108	4.3kΩ ± 1%
R.109	3.5kΩ ± 1%
R.110	2.7kΩ ± 7% T.E.
R.111	1kΩ ± 7% T.E.
R.112	330Ω ± 7% T.E.
R.113	8.2kΩ ± 7% T.E.
R.114	3.3kΩ ± 7% T.E.
R.115	15kΩ ± 7% T.E.
R.116	47kΩ ± 7% T.E.
R.117	220kΩ ± 7% T.E.
R.118	0.5Ω ± 10%
R.119	560kΩ ± 10%
R.120	1Ω ± 5%
R.121	9.5kΩ ± 2%
R.122	330kΩ ± 10%
R.123	2.2kΩ ± 7% T.E.
R.124	39Ω ± 7% T.E.
R.125	1.8kΩ ± 7% T.E.
R.126	1.2kΩ ± 7% T.E.
R.127	10Ω ± 5%
R.128	10kΩ ± 7% T.E.
R.129	47kΩ ± 7% T.E.
R.130	470Ω ± 7% T.E.
C.101	2000μF 25V
C.102	2000μF 25V
C.103	50μF 25V
C.104	50μF 50V
C.105	0.04μF 250V
C.106	25μF 25V
C.107	0.04μF 250V
C.108	250μF 25V
C.109	50μF 25V
C.110	50μF 25V
C.111	470–500pF
C.112	470–500pF
C.113	50μF
C.114	50μF
C.115	50μF
C.116	0·25μF
C.117	50μF 25V
T.101	Mains Transformer
MR.101	Diode, type OA 81
MR.102	Diode, type OA 81
MR.103	Diode, type OA 81
MR.104	Diode, type OA 81
MR.105	Diode, type OA 81
MR.106	Diode, type OA 81
MR.107	Diode, type OA 81
MR.108	Diode, type OA 81

Circuit Ref.	Description
MR.109	Zener Diode, type NEZ 18T5
MR.110	Zener Diode, type SX 561
MR.111	Zener Diode, type SX 8.2 (Sel.)
MR.112	Zener Diode, type SX 4.7
MR.113	Diode, type ZS 72
MR.114	Diode, type ZS 72
MR.115	Diode, type ZS 72
MR.116	Diode, type ZS 72
SKT.6	Fuse Holder/Socket
SKT.7	6-way Socket
SKT.8	8-way Socket
SKT.9	Mains Output Socket (black)
SKT.10	Mains Output Socket (red)
SKT.11	Coll. Volt. Ext. Supply Socket (black)
SKT.12	Coll. Volt. Ext. Supply Socket (red)
SB	Collector Volt Switch
SC	On/Off Switch
SD	Cut-out Re-set
FS.1	250mA Delay
ILP.101	Neon Indicator Lamp
RV.101	Collector Volts Pot.
RV.102	1kΩ ± 20% wire wound
RV.103	100Ω ± 20% wire wound
VT.101	Transistor, type GET 535
VT.102	Transistor, type GET 535
VT.103	Transistor, type GET 535
VT.104	Transistor, type GET 116
VT.105	Transistor, type OC 35
VT.106	Transistor, type GET 535
VT.107	Transistor, type GET 535
VT.108	Transistor, type GET 535
VT.109	Transistor, type GET 116
VT.110	Transistor, type GET 535

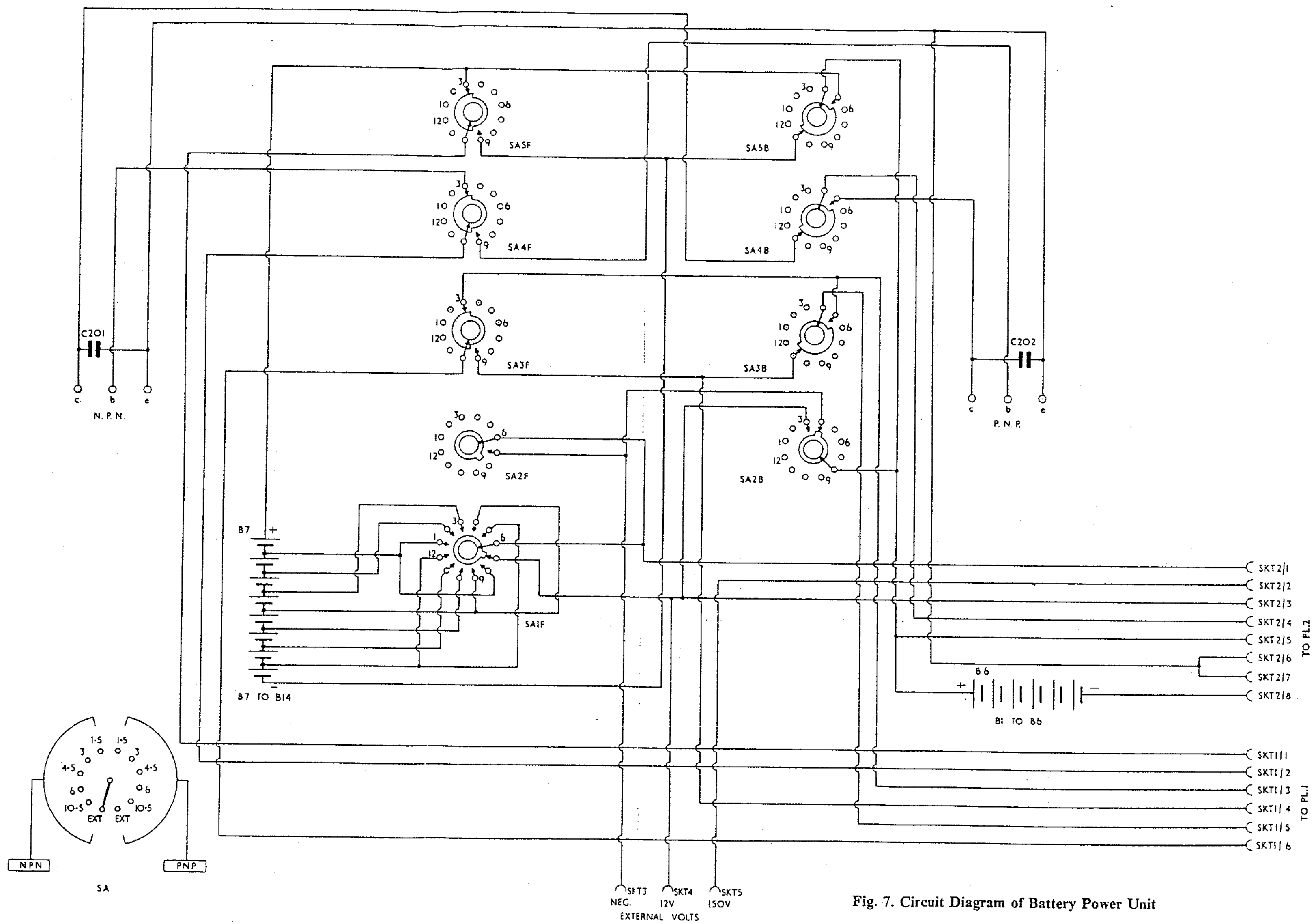

Fig. 7. Circuit Diagram of Battery Power Unit

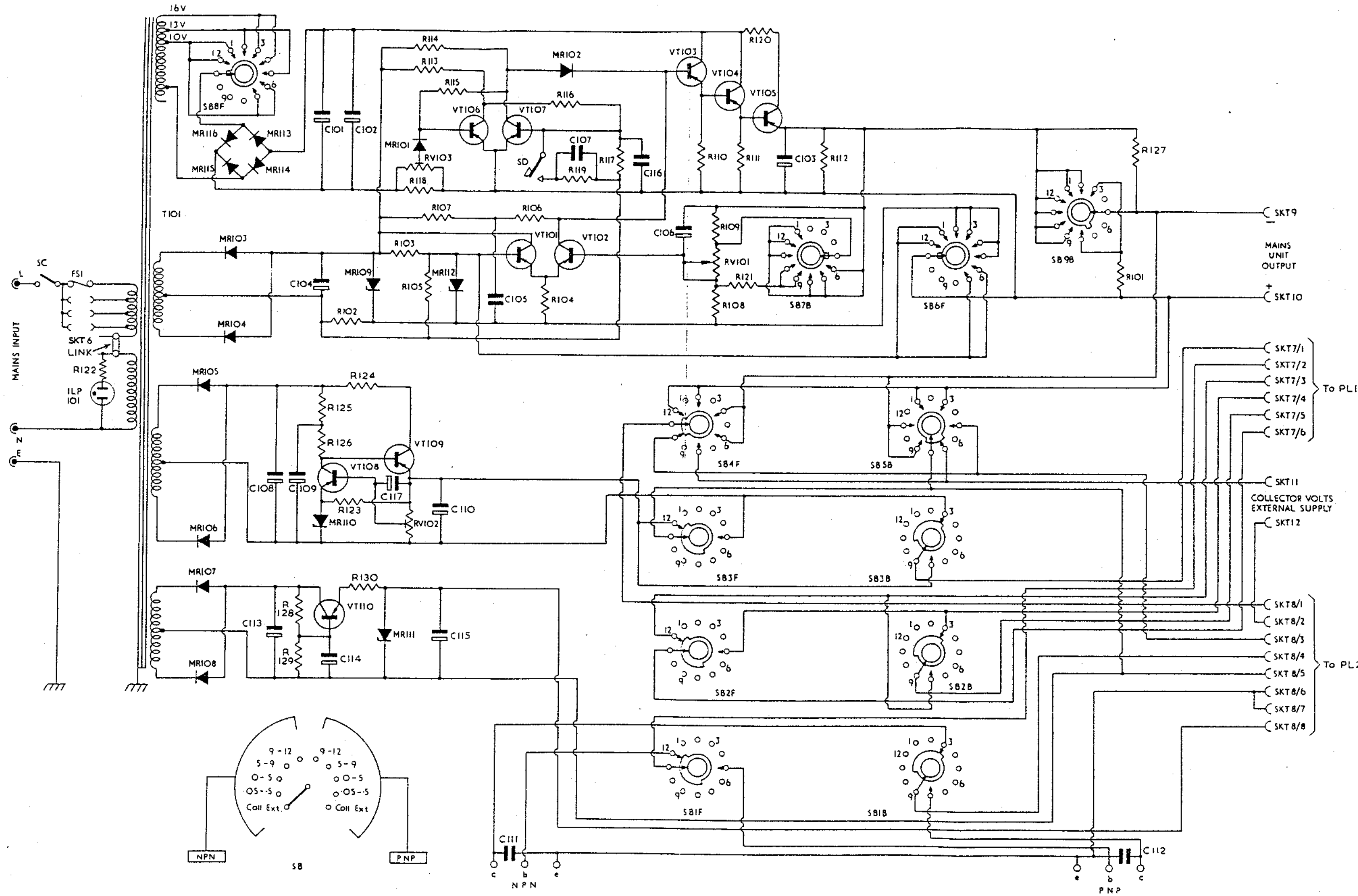

Fig. 8. Transistor Analyser Mains Power Unit

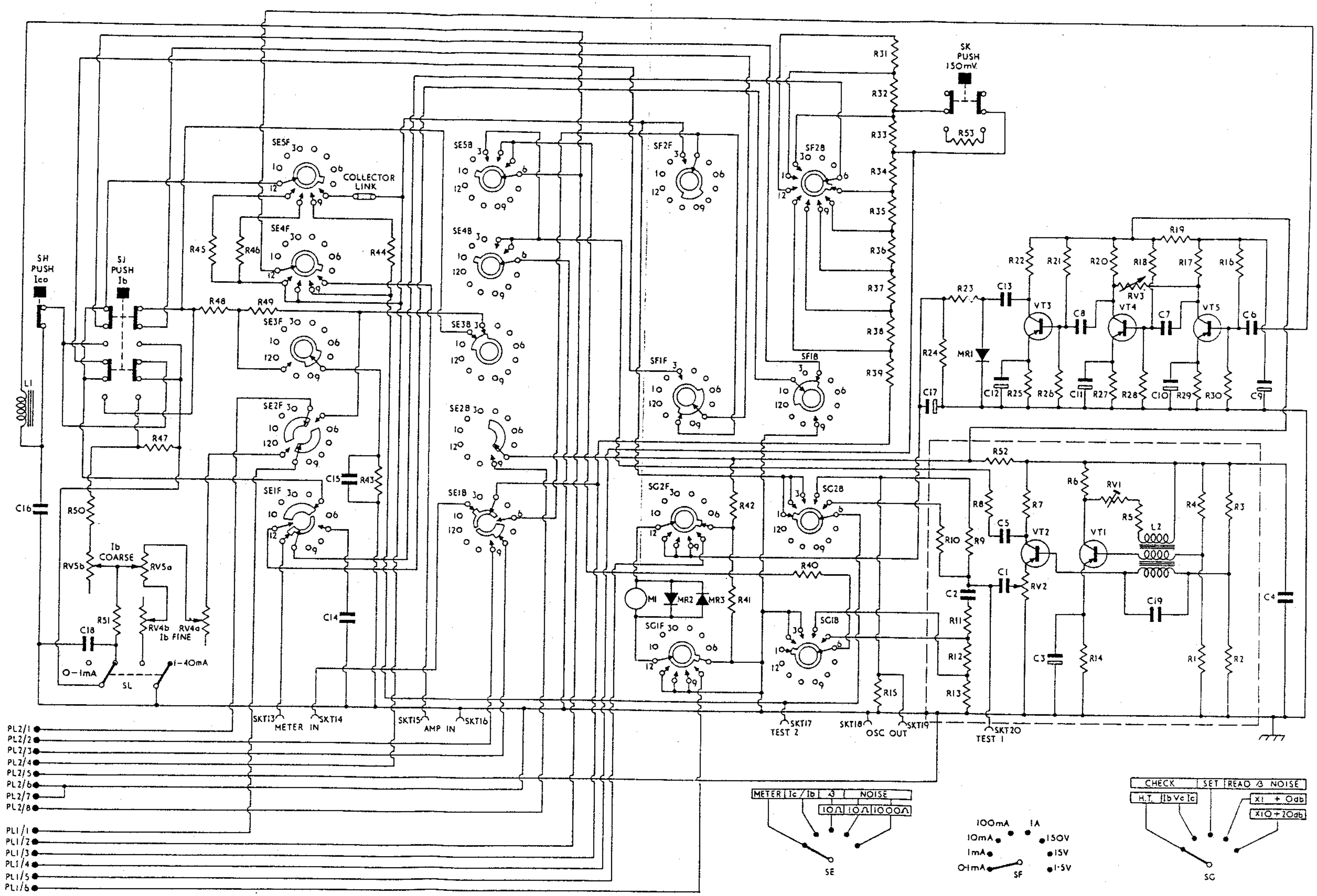

Fig. 9. Transistor Analyser Mk. 2. Circuit Diagram