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THE "AVO" TRANSISTOR ANALYSER

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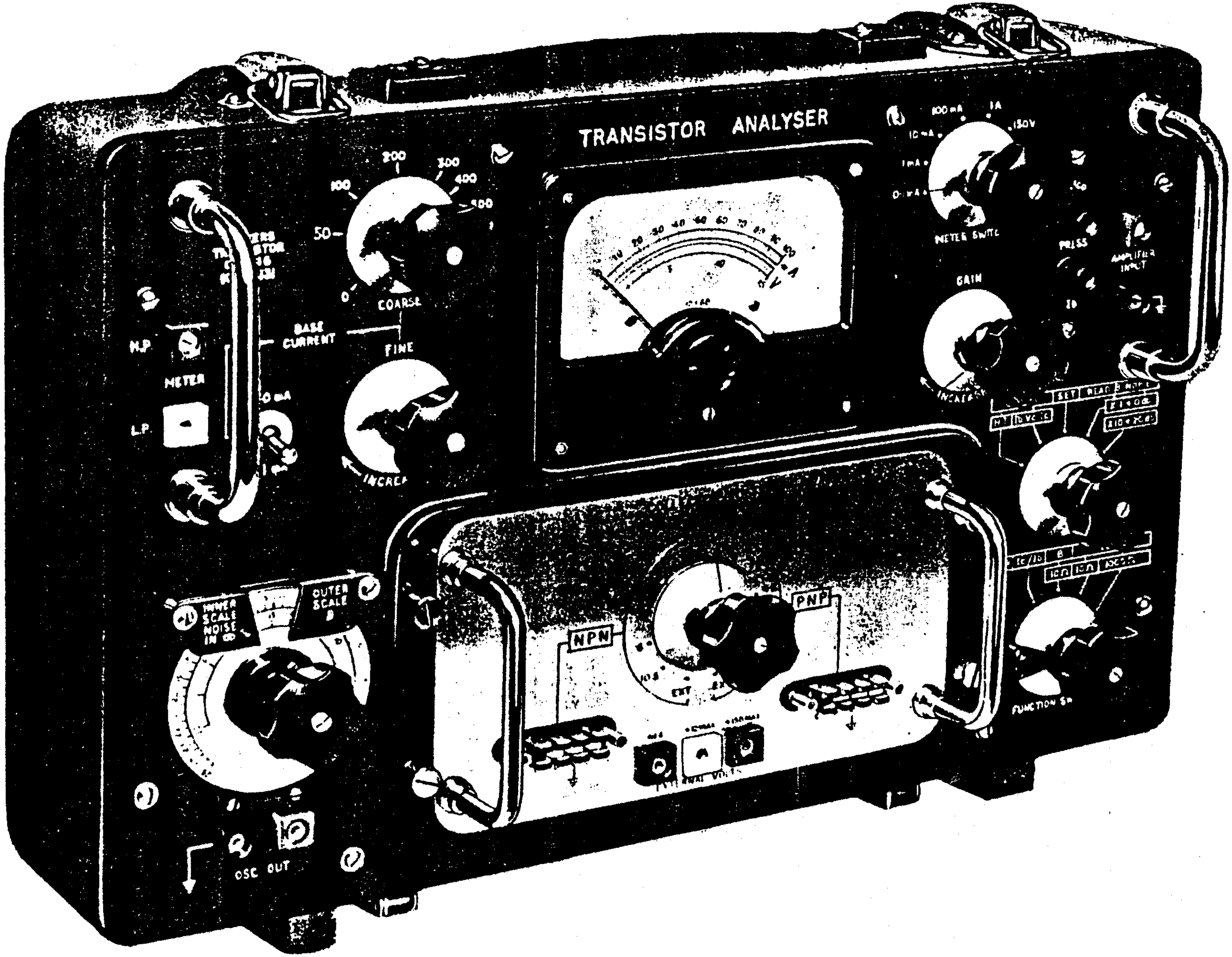

AVO TRANSISTOR ANALYSER

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 that 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.

CONTENTS

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. This instrument which is portable, and battery operated, is capable of measuring the more generally useful transistor parameters.

The instrument will normally be used in conjunction with the "AVO" International Transistor Data Manual which contains test data for approximately 3,000 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 is 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.

V_{CEO} **Vce**	Collector to Emitter voltage.
β h_{fe} h_{21e} α'	Small signal current gain in the grounded emitter configuration.
I'co I_{ceo}	Collector to emitter leakage current.
$\bar{\beta}$ α' h_{FE}	D.C. or large signal current gain $= \dfrac{\text{change of Ic}}{\text{change of Ib}}$
I_{co} I_{cbo}	Collector current with collector junction reverse biased and emitter open circuit.
V_T	Turnover voltage.
NF	Noise figure.
∝	Small Signal Current gain in the grounded-base configuration.

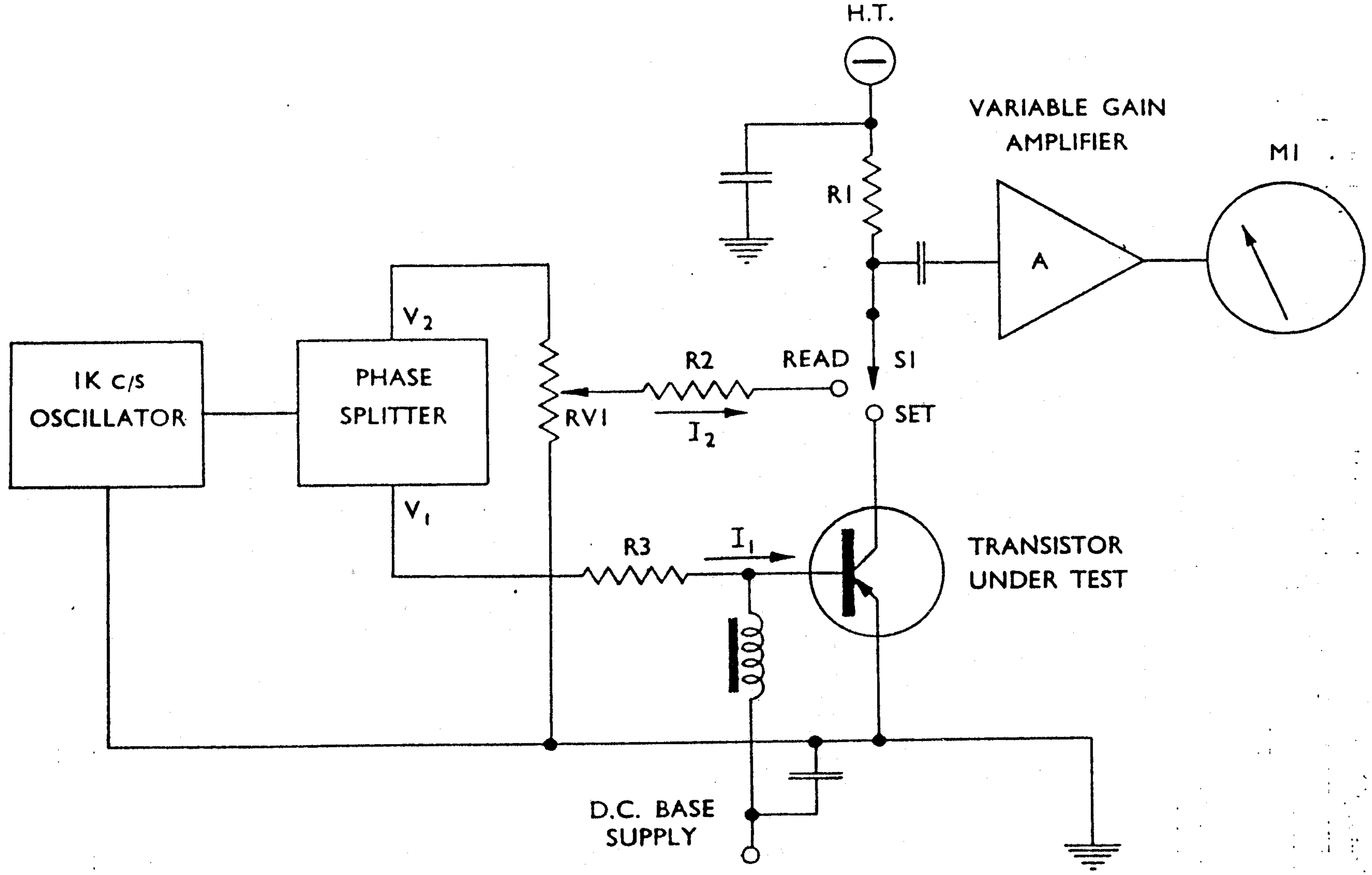

Fig. 1. Basic circuit for measurement of Beta

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 internal batteries: 1.5, 3, 4.5, 6, 10.5V.

Using an external supply: 0–12V (for all measurements).

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

Range of Collector Current

0–250mA Using the internal batteries.

0–1A Using 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.

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. D.C. current gain ($\bar{\beta}$) and the measurement of the A.C. current gain (β) at any given point on the D.C. 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 and Vc.

These are direct measurements of D.C. voltage and current, Conventional metering methods are used, the necessary switching is provided to enable the internal meter to measure the appropriate current or voltage.

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 micro amperes into the base of the transistor under test.

With S1 in the SET position, a current of 0.5 micro amperes 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.

Switch S1 is now set to the **read** position. The output voltage V_2 from the phase splitting network is fed into series resistors R1 and R2 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 are 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 dependant 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 H.T. supply, 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

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.

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, were substantially the same as results obtained by the standard methods of noise measurements.

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

Referring to Figure 2 with switch S_1 in the **set** position the voltage developed across R_1 consists entirely of a wide band L.F. 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.

S_1 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 milli-micro-A. 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 $\frac{1}{f}$ noise within the transistor under test, the amplifier response has been designed to fall off below 800c/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.

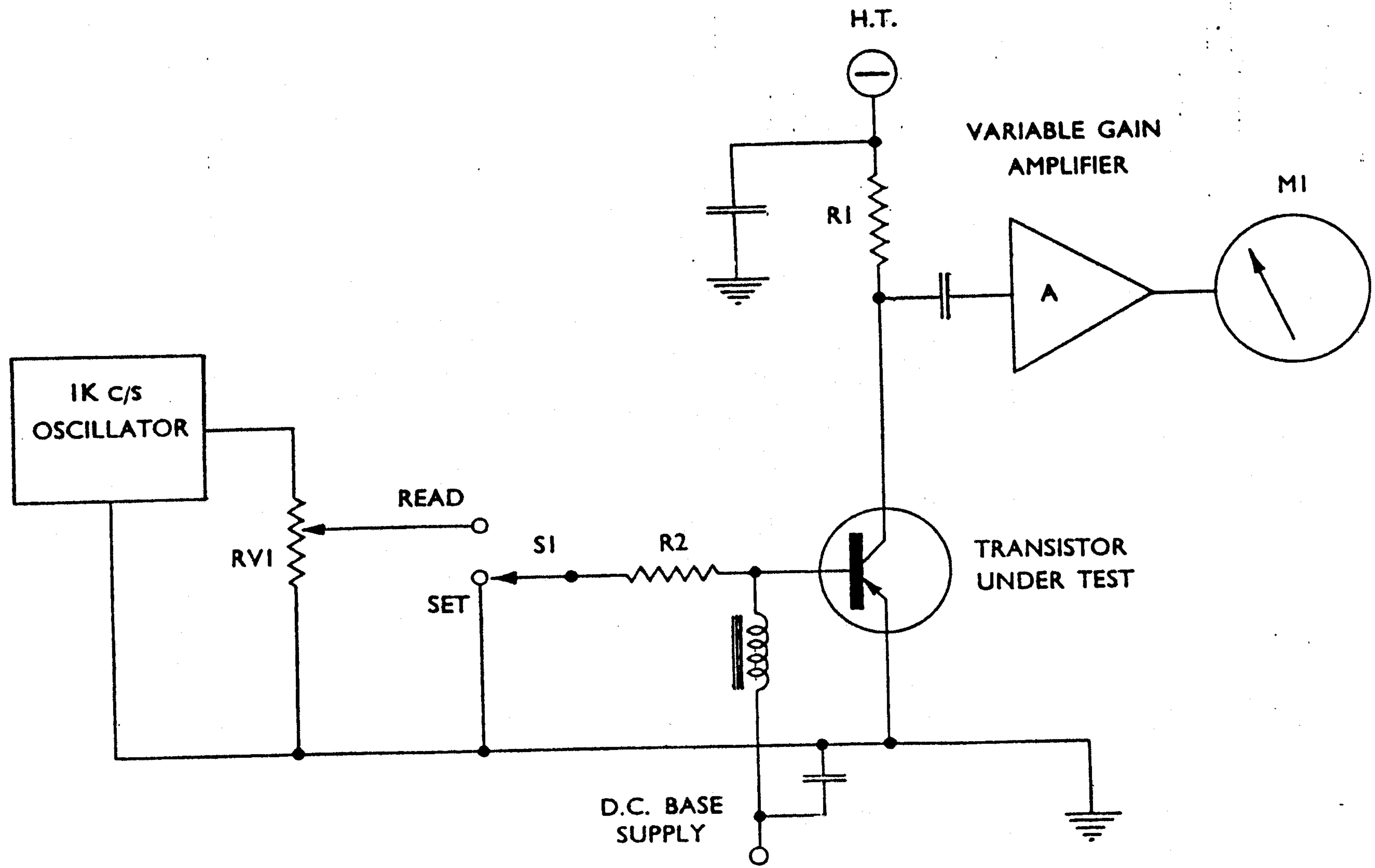

Fig. 2 **Basic circuit for measurement of Noise**

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 OPERATIONS

All the controls necessary for carrying out the essential transistor testing functions are situated on the front panel of the instrument, by the manipulation of 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 $\bar{\beta}$.
(iii) Measurement of Beta (β).
(iv) Measurement of Noise (NF).
(v) *In-situ* measurements.

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 arbitrarily calibrated 0–1000μA.
(iii) A fine control continuously variable for accurate settings of base current.

4.3 Meter Switch

This selects the voltage or current range of the meter required for testing transistors (using both 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

By depressing the appropriate button, base current or I′co can be monitored on the internal meter.

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 H.T. Voltage of the internal amplifier and oscillator may be monitored.
(ii) *Check/Ib. Vc. Ic.* Enables all of the D.C. characteristics 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.

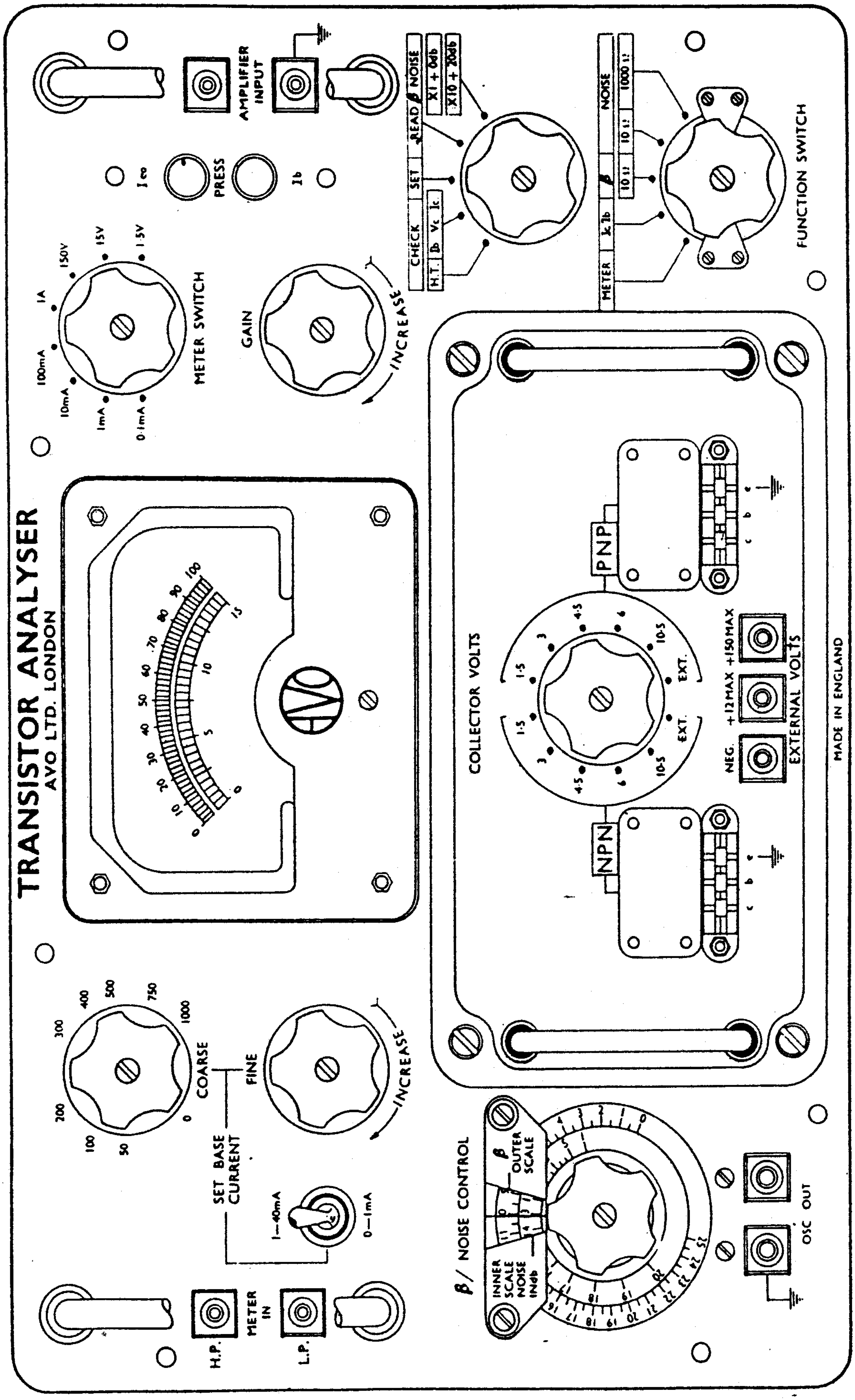

Fig. 3. Layout of the front panel controls

(iv) *Read Beta Noise.* Two positions for the measurement of Beta and Noise are provided as follows:

(*a*) XI + Odb for the measurement of Beta over the range 0–25 and Noise from 1–20db.

(*b*) X10 + 20 db for the measurement of Beta over the range 0–250 and Noise from 21–40db.

4.7 The 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 voltages and current.

(ii) *Ic/Ib.* This position enables the D.C. characteristics to be set up.

(iii) β/10Ω. This position is used for setting up the instrument when measuring small signal current gain (β), the collector load being 10Ω.

(iv) *Noise*/10Ω. This position is used for setting up the instrument when measuring noise with collector currents exceeding 9mA, the collector load being 10Ω.

(v) *Noise*/1000Ω. 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 (1000Ω) 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 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 **Ext.** and a suitable voltage injected into the equipment via sockets marked **External Volts,** either between **Neg.** and **+12** Max. or **Neg.** and **+150** Max. depending upon the tests to be undertaken.

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 as outlined in section 10.0.

N.B. *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*, 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 volts control to the figure quoted in the "AVO" International Transistor Data Manual, switch the **Check/Set/Read** control to the **Check/** I_b. V_c. I_c. position, and the **Function Switch** to the I_c/I_b 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.

* Using NPN or PNP sockets as required.

5.2 Measurement of I_c. V_c. I_b. $\bar{\beta}$

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

If it is impossible to obtain the required I_c 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 internal supply should be limited to 250mA. Collector currents above this should be obtained from an external supply, which will be limited to 1A to avoid overloading the meter. (*See* section 6).

Collector voltages shown in brackets in the "AVO" International Transistor Data Manual are in excess of the internal supply voltages. Where it is required to make measurements at these voltages it will be necessary to use an external supply. Normally the characteristics will not be affected using the maximum internal voltage.

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, to determine the value of I_b more accurately, or when using the 1–40mA range, with the controls as set, depress the **Push Button** marked I_b. The meter now indicates the value of I_b. It will be necessary to select a suitable current range on the **Meter Switch.** Having set up the collector volts and collector current, it is now possible to obtain an approximate figure for $\bar{\beta}$ as follows: Readjust I_b by a known amount and note the change in I_c. $\bar{\beta}$ is then given by dividing the change in I_c by the change in I_b.

5.3 To Measure Beta

The figures for β, quoted in the "AVO" International Transistor Data Manual are, for the same settings of V_c 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 V_c and I_c the controls will need to be reset, using the foregoing procedure. Having decided on the required V_c and I_c conditions β is measured as follows:

Set the **Function Switch** to the β/10Ω position and check that the collector voltage and current has not altered from the original settings, due to the inclusion of the 10Ω collector load. If the current has fallen readjust the base currents 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, to obtain an identical meter reading by operation of the **β/Noise Control.** β is then directly indicated on the calibrated dial of the **β/Noise Control,** and should be multiplied by the range setting of the **Check/Set/Read Control,** i.e. × 1 or × 10.

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

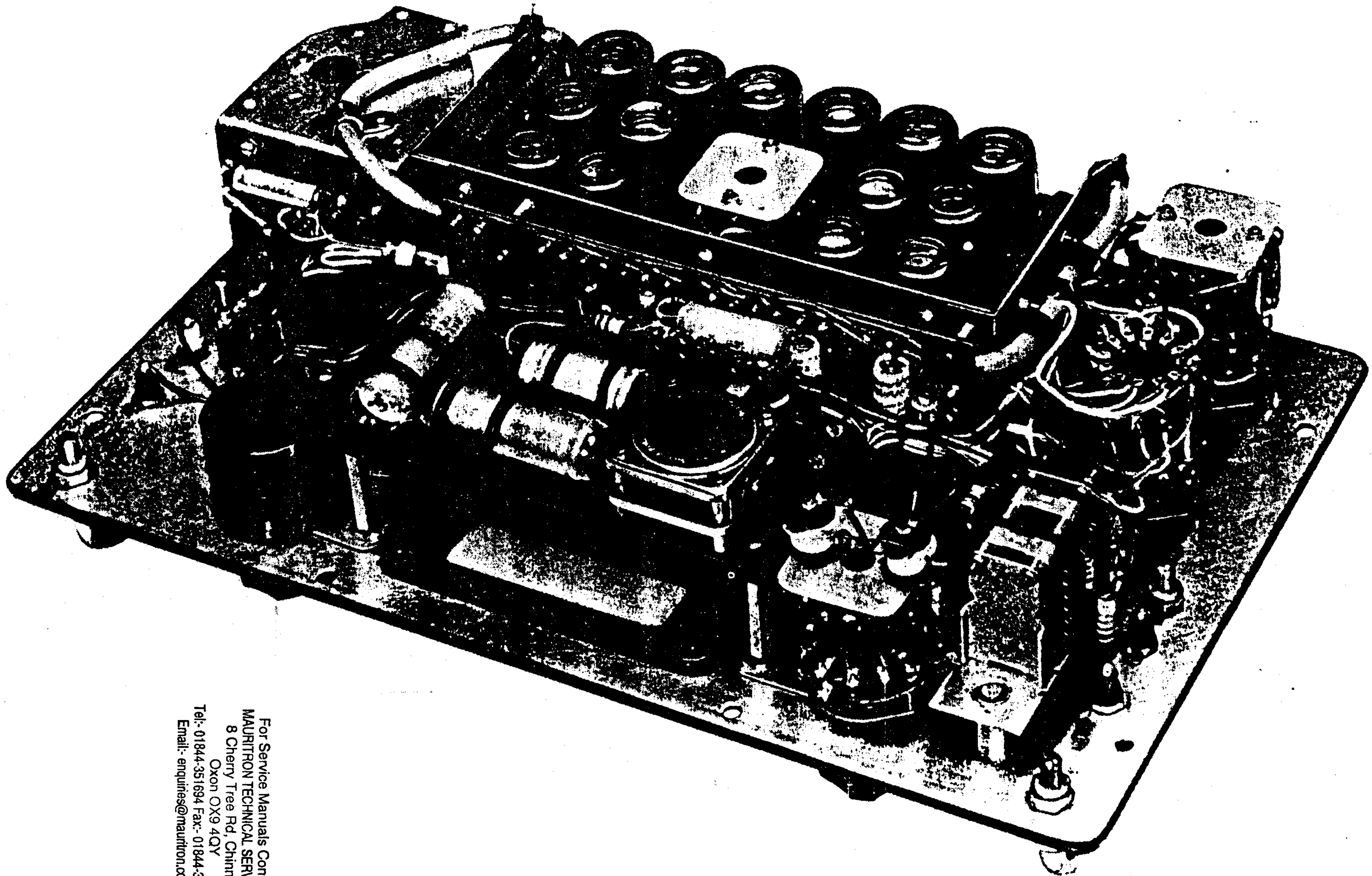

Fig. 4. Interior of the Instrument

5.4 To Measure Noise

Manufacturers quote a noise figure as being measured at a particular V_c and I_c. These are the figures given in the "AVO" International Transistor Data Manual, and in most cases are different from the values of V_c and I_c quoted for measurement of β. Before measuring noise therefore it will be necessary to set up the instrument for the correct V_c and I_c as outlined in sections 5.1 and 5.2. Having set the V_c and I_c 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 positions as required. Adjust the **β/Noise Control** to obtain a meter reading of twice the original indication. The noise figure may then be read directly from the calibrated dial of the **β/Noise Control** in decibels, adding the dial reading 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 D.C. supply should be connected to the sockets marked **150 Max.** and **Neg** 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 Neg and +150V Max. sockets on the instrument.

6.0 THE MEASUREMENT OF I'co, Ib, Ic, β, $\bar{\beta}$ 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. it will be necessary to use an appropriate external D.C. voltage supply. There are two positions on the instrument for connecting an external supply, as follows:

(i) **Negative—+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) **Negative—+150 Max.** This position can be used for D.C. measurements only, that is I'co. Ib. Ic and Vc as outlined in sections 5 to 5.2 inclusive, 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).

NOTE. When switched to the external position on the **Collector Volts Control** base current is still supplied from internal batteries. 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. socket and the negative line to the socket marked Neg. 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.

7. THE USE OF HEAT SINKS

It will be necessary to use heat sinks in certain cases where the power dissipation in free air is in excess of that recommended by the manufacturer for continuous use at an ambient temperature of 25°C. Wherever possible the collector dissipation in mW has been marked thus * to indicate that a heat sink should be employed.

8. IN SITU MEASUREMENTS

All the measurements outlined in the previous sections may be carried out on transistors wired into equipment by using the connecting lead supplied with the instrument.

This lead is terminated at one end by a connecting plug, which is designed to fit into the PNP or NPN sockets on the front panel of the instrument. This plug is reversible and should be inserted with letters c b e matching those on the panel.

The free end of this lead is terminated with three clips coded c b e (collector, base and emitter respectively).

These clips are removable from the end of the lead, leaving a flat section enclosed by a rubber sleeve. This may be used to connect to transistors having very close and short terminations.

It may be necessary to disconnect other components or wiring from the transistor to avoid misleading results, otherwise the procedure for test is identical to that already outlined.

9. OTHER FACILITIES AVAILABLE

Although the instrument is primarily intended for measurement of transistor parameters, facilities are available for using the internal meter amplifier and oscillator. An outline of their use follows.

9.1 Use of Meter for External Voltage and Current Measurements

The internal meter, which has a sensitivity of 20,000Ω/V and associated shunts and multipliers may be used for measurements of D.C. voltage and D.C. current on external equipment, and is primarily intended for tests on transistorised equipment, and not as a general purpose test-meter. The accuracy on all ranges is ± 2% of F.S.D. The procedure is as follows: Set the **Check/Set/Read Control** to **Ic. Vc. Ib.** and set the **Function Switch** to the **Meter** position (the instrument is now switched off). All the other controls are now inoperative with the exception of the **Meter Switch** and **Collector Volts Control.** The **Meter Switch** should be set to the appropriate range and the external voltage or current to be measured connected to the sockets marked **Meter HP** and **LP.** The polarity of the sockets is determined by the setting of the **Collector Volts Control,** such that when the switch is set to any **NPN** position the **HP** socket is positive and the **LP** socket is negative. With the **Collector Volts Control** set to any **PNP** position, the **HP** socket is negative and the **LP** socket is positive.

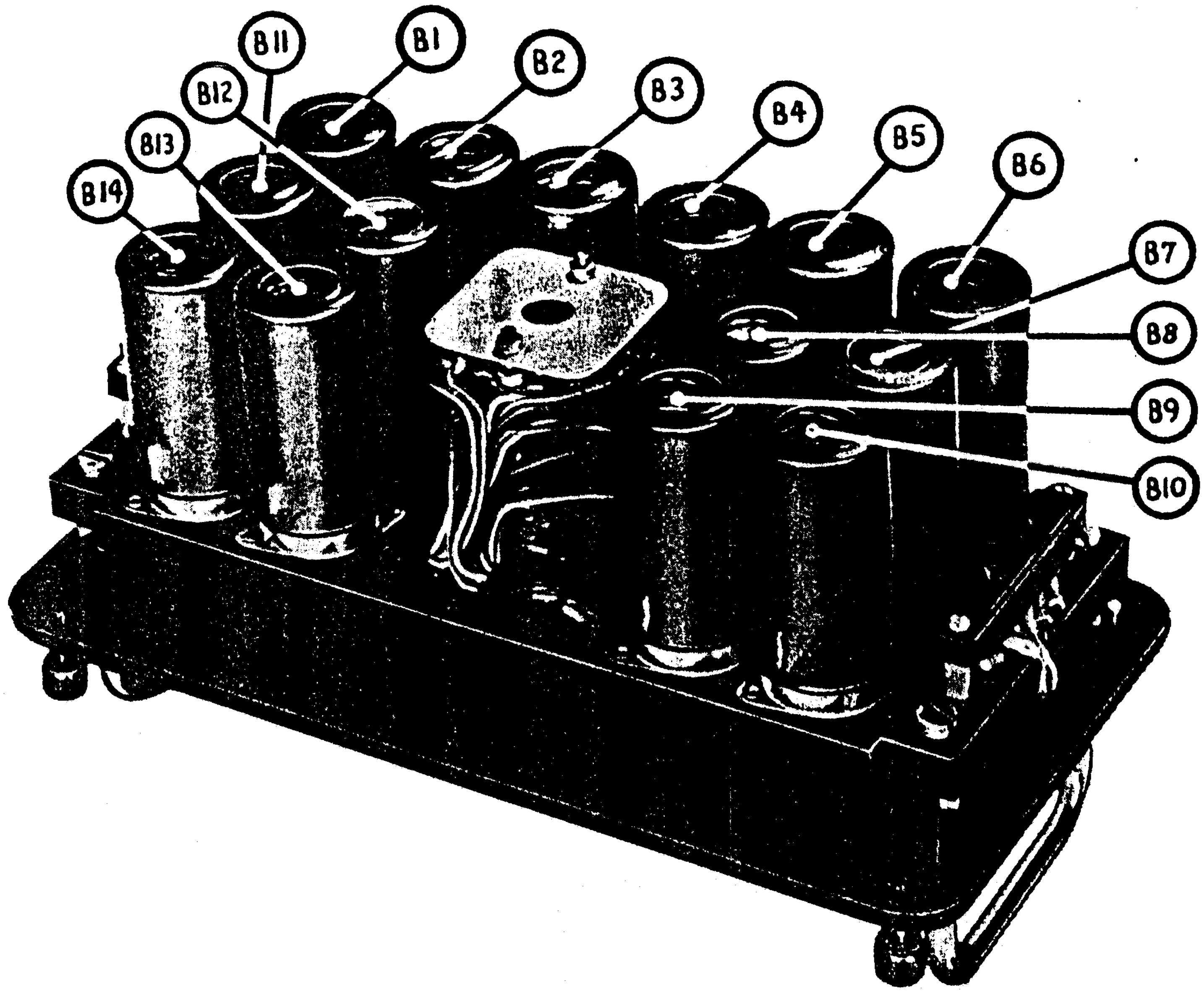

Fig. 5 Interior of the Battery Box

9.2 Use of the Internal Amplifier

The internal amplifier may be used for fault finding and signal tracing etc. on electronic equipment. To use the amplifier the **Check/Set/Read Control** should be switched to the **Set** position and the **Function Switch** should be set to Ib/Ic, Vc. All the other controls are inoperative with the exception of the **Gain Control** which may be adjusted to give a suitable meter deflection, depending on the input level. The signal being monitored should be connected to the sockets marked **Amp In.** The maximum input level is approximately 12.5μA with a superimposed D.C. voltage not exceeding 100V. With the **Gain Control** set to maximum the input required for a meter deflection of one tenth F.S.D. is 12mμA. The amplifier bandwidth extends approximately from 800 c/s to 10 kcs with input impedence of approximately 2kΩ.

9.3 Using the Internal Oscillator

The 1,000 cycles oscillator output is available from the sockets marked **OSC OUT.** This signal is suitable for circuit checking, gain measurements, etc., on external equipment. The output available is varied by the adjustment of the **β/Noise Control** to a maximum of 12.5mV r.m.s. The source impedance is 1kΩ. This output is available at the sockets marked OSC out at all times providing the **Function Switch** is not at the position marked **Meter.**

10.0 CHECKING THE CONDITION AND REPLACEMENT OF THE INTERNAL BATTERIES

So that the instrument gives 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:

10.1 To Check the Internal Amplifier/Oscillator Batteries

Switch the **Function Switch** to any position marked **On** 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 the 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.

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

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, and the **Meter Switch** to the range of 15V. The meter should now indicate 10.5V. If the voltage is 9V or less then the batteries should be replaced.

10.3 Replacement of Internal Batteries

The internal power supplies consist of a number of U10 batteries, 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 for the internal amplifiers and oscillator are located in the single row below the **Collector Volts Control** and those for the transistor test supplies are the 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 box from the main instrument the four captive screws at the corners should be unscrewed until free, and the battery box lifted away from the main panel. The necessary replacements can now be made.

11.0 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.
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 Vce 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 x 1** or **β x 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 Vce 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.**

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.

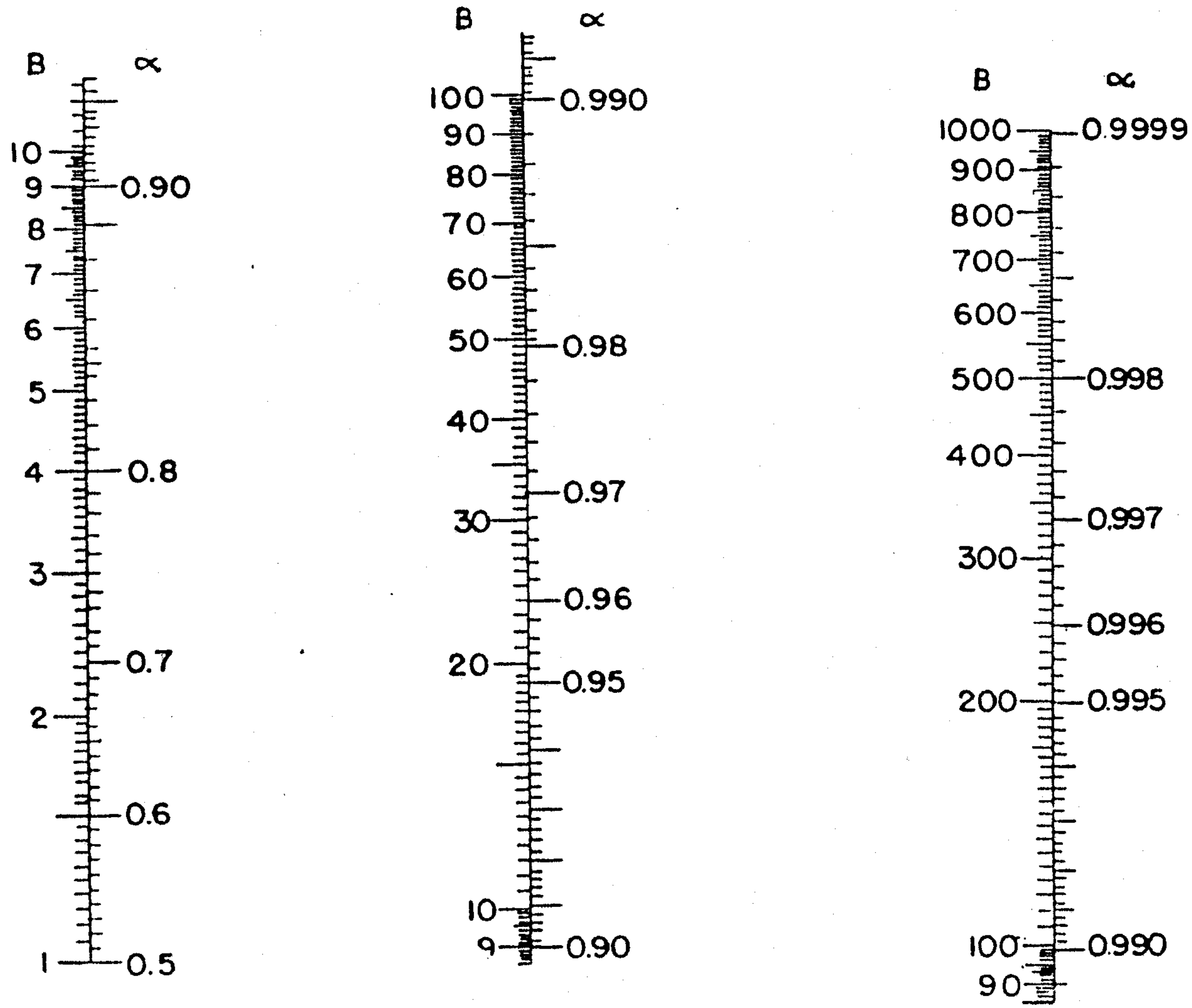

Fig. 6. β to α Conversion Chart

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–A

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	40703–E	Case Assembly. See page 35 for breakdown detail ...		1
2	40717–A	Chassis Assembly. See below for breakdown		1
3	21214–A	Flying Lead Assembly. See page 36 for breakdown detail		1
4	S11535	Round Head Screw, 4 BA x 11/16", chromium plated ...		8
5	W3	Washer, 4 BA, nickel plated, for item 4		8
6	10072–277	Operating Instruction Manual		1
7	10072–264	International Transistor Data Manual (1st Edition) ...		1

CHASSIS ASSEMBLY 40717–A

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. See page 33 for breakdown detail	M.1	1
3	40706–A	Battery Box Assembly. See page 29 for breakdown detail		1
4	40716–C	Battery Box Container. See page 33 for breakdown detail		1
5	15837–A	Function Switch Assembly. See page 30 for breakdown detail		1
6	40719–A	Oscillator Assembly. See page 31 for breakdown detail		1
7	15839–A	Meter Switch Assembly. See page 30 for breakdown detail		1
8	21216–A	Compt. Board Assembly. See page 31 for breakdown detail		1
9	21242–A	Ferrox-cube Choke	L.1	1
10	15220–A	Knob Assembly, with skirt (engraved marker line). See page 32 for breakdown detail		5
11	15220–F	Knob Assembly (function switch). See page 32 for breakdown detail		1
12	15220–E	Knob Assembly (β/noise control). See page 33 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 I'co/Ib		2
21	13845–9	Handle (large), nickel plated		2
22	13846–6	Bush, for item 20		4
23	20006–2	Gaskett, between movement and panel		1
24	14941–26	Bush, Stand-off, for item 18		2
25	15842–A	Support Plate, between item 35 and item 77		4
26	11310–A	Tag Board Assembly, 8 tags		1

* See note re Movement Servicing on page 26

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
27	13659–5	Insuloid Clip, ¼″ dia.		1
28	13659–6	Insuloid Clip, 5/16″ dia.		2
29	13659–4	Insuloid Clip 3/16″ dia.		2
30	21027–22	Switch Check, set, read β noise	SW.5	1
31	13657–1	Toggle Switch, 1–40 mA, 0–1 mA	SW.2	1
32	21027–18	Push Switch, less button	SW.1	1
33	13483–61	Pillar, between item 31 and front panel		2
34	15838–2	Pillar, holding item 25		2
35	15841–4	Pillar, ⅜″, on push switch		1
36	13483–79	Pillar, Stand-off, holding movement fixing panel		4
37	15718–3	Cable Clip		1
38	15191–1	Dust Washer, on push buttons, item 19		2
39	14013–1	Mod. Record Plate		1
40	15638–2	Cradle } holding C.14, C.15, C.16		3
41	15638–5	Clip } holding C.14, C.15, C.16		3
42	21219–2	Movement Board (main fixing panel)		1
43	15581–12	Silicon Diode, International Rectifier, type 2E1	REC.2 REC.3	2
44	10770–33	Potentiometer, 100KΩ log.	RV.3	1
45	14558–11	Potentiometer, 1.5KΩ–250Ω	RV.4 AB	1
46	14558–12	Potentiometer, 11KΩ–25MΩ	RV.5 AB	1
47	12049–311	Resistor 100Ω ± 1%, type C.22	R.51	1
48	12049–437	Resistor, 1KΩ ± 10%, type 16	R.43	1
49	12049–728	Resistor, 1.3KΩ ± 2%, type C.21	R.47	1
50	12049–386	Resistor, 10KΩ ± 1%, type C.21	R.41	1
51	12049–729	Resistor, 11KΩ ± 2%, type C.21	R.50	1
52	12049–342	Condenser, 1µF 250V	C.16	1
53	12049–731	Condenser, 8µF 12V	C.18	1
54	12049–730	Condenser, 500µF 12V	C.14, C.15	2
55	P.V.C.124	Screened Cable, 1 ft. State length reqd.		1
56	N2	Hex. Locknut, 2 BA, nickel plated		4
57	N62	Hex. Nut, 4 BA, tin plated		7
58	N61	Hex. Nut, 6 BA, tin plated		2
59	N11	Hex. Nut, 8 BA, nickel plated		4
60	NS2	Hex. Stiff Nut, ¼″, BSF, nickel plated		4
61	S427	Round Head Screw, 4 BA x ¼″, nickel plated		3
62	S420	Cheese Head Screw, 4 BA x 7/16″, nickel plated		4
63	S1524	Cheese Head Screw, 4 BA x 9/16″, tin plated		7
64	S637	Cheese Head Screw, 6 BA x ⅛″, nickel plated		1
65	S674	Round Head Screw, 6 BA x ¼″, nickel plated		9
66	S715	Round Head Screw, 6 BA x ⅜″, tin plated		4
67	S661	Round Head Screw, 6 BA x ⅝″, nickel plated		2
68	S830	C'sk. Head Screw, 8 BA x ⅜″, nickel plated		3
69	S802	Cheese Head Screw, 8BA x ½″, nickel plated		4
70	AS52	Socket Grub Screw, 4 BA x 5/16″		4
71	10266–1	Tag, 2 BA		2
72	15720–1	Tag on item 34		1
73	W3	Washer, 4 BA, nickel plated		2

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
74	W5	Washer, 6 BA, nickel plated		10
75	W57	Washer, 8 BA (shake proof)		4
76	W21	Washer, ¼", nickel plated		4
77	15980–1	Felt Washer, under item 17		2
78	40707–2	Front Panel less battery container...		1

BATTERY BOX 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)		1
10	14829–4	Socket (black)		1
11	14829–3	Socket (red)		1
12	15639–2	Connector Socket, 6-way, battery connections		1
13	15639–4	Connector Socket, 8-way, battery connections		1
14	21027–19	Collector Volts Switch		1
15	15717–3	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 Box Base, between battery box base and front cover		4
21	13483–59	Pillar 0.75" x ⅛ AF		4
22	15712–2	Battery Contact, long, on battery box base		14
23	16019–A	Retainer, for U.10 battery complete with sleeve		14
24	15711–1	Skirt, for item 23		14
25	12379–4	Battery (Ever Ready, type U.10) (see item 40)		14
26	15295–7	Captive Screw, securing front cover		4
27	15715–2	Contact, short, on battery box base		3
28	15626–2	Tab, on rear of item 7		4
29	12049–587	Condenser, 470 pfd....		2
30	N6	Hex. Nut, 6 BA, nickel plated		8

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
31	R10	Rivet, .064/.068" dia. x $\frac{3}{32}$", for item 8		8
32	R123	Rivet, .117/.121" dia. x $\frac{5}{16}$"...		31
33	S202	Cheese Head Screw, 2 BA x $\frac{5}{8}$", nickel plated		4
34	S746	Round Head Screw, 6 BA x $1\frac{1}{4}$", nickel plated		4
35	W1	Washer, 2 BA, nickel plated		4
36	W3	Washer, 4 BA, nickel plated		4
37	14048–25	Sleeve, on rear of transistor socket		6
38	10042–1	Sleeve, cut in two sections for battery connecting sockets		7
*39	16025–A	Battery Tube Assembly		14
*40	12379–16	Battery, Ever Ready, type U.7		14
41	14941–24	Spacer, retainer between battery socket and battery box base...		4

FUNCTION SWITCH ASSEMBLY 15837–A

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	21027–21	Function Switch	SW.3	1
2	15717–3	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	1
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

METER SWITCH ASSEMBLY 15839–A

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	21027–20	Meter Switch...	SW.4	1
2	15717–3	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

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

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 (General Electric Co., type GEX.34)	REC.1	1
4	15581–8	Transistor (Mullard, type OC.75)	TR.3, TR.4	2
5	15581–9	Transistor, CV.2400...	TR.5	1
6	12049–402	Condenser, .04μFd. 150V	C.13	1
7	12049–709	Condenser, 8μFd. 12V	C.17	1
8	12049–717	Condenser, 0.1 μFd. 150V	C.6, C.7, C.8	3
9	12049–708	Condenser, 25 μFd. 12V	C.10, C.11 C.12	3
10	12049–707	Condenser, 100 μFd. 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
5	AS52	Socket Grub Screw, 4 BA x $\frac{5}{16}$" (for item 4)		2
6	40719–47	Component Board, connecting front and rear plates ...		1
7	21213–A	Transformer Oscillator	L2	1
8	15581–10	Transistor (Mullard, type OC.71)	TR.1, TR.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	Condenser, .04 μFd.	C.5, C.19	2
15	12049–717	Condenser, 0.1 μFd. 150V	C.1, C.2	2
16	12049–709	Condenser, 8 μFd. 12V	C.3	1
17	12049–707	Condenser, 100 μFd. 12V	C.4	1

Item No	Part No.	Description	Circuit Ref.	Qty. Off
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	SUPP.	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
31	N61	Hex. Nut, 6 BA		1
32	S740	Cheese Head Screw, 6 BA x $\frac{3}{16}$", tin plated		13
33	S723	Cheese Head Screw, 6 BA x $\frac{1}{4}$"		1
34	S859	Cheese Head Screw, 8 BA x $\frac{3}{16}$"		4
35	W5	Washer, 6 BA, nickel plated		4
36	W69	Washer, 8 BA, tin plated		4

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, $\frac{5}{16}$" x $\frac{1}{8}$" dia.		1
7	S745	Special Screw		1
8	W39	Spring Washer, 6 BA, phosphor bronze D.C.		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, $\frac{5}{16}$" x $\frac{1}{8}$" dia.		1
7	S745	Special Screw		1
8	W39	Spring Washer, 6 BA, phosphor bronze D.C.		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, $\frac{9}{16}$" x $\frac{1}{8}$" dia.		1
4	S745	Special Screw		1
5	W39	Spring Washer, 6 BA, phosphor bronze, D.C.		1

BATTERY BOX CONTAINER ASSEMBLY 40716–C

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	40716–B	Battery Box Container Assembly		1
2	15639–3	Connector Plug, 8-way		1
3	15639–1	Connector Plug, 6-way		1
4	15834–2	Connector Cover		2
5	14829–4	Socket Test Point		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 (Tufnel)		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 osc. cableform		1
14	15718–1	Clip, securing item 13		2
15	11982–8	Grommet		2
16	N61	Hex. Nut, 6 BA, tin plated		17
17	R80	Rivet, .090"/.094" x $\frac{1}{4}$", for securing battery box to front panel		12
18	S757	Round Head Screw, 6 BA x $\frac{1}{4}$", tin plated		6
19	S715	Round Head Screw, 6 BA x $\frac{3}{8}$", tin plated		8
20	S731	Cheese Head Screw, 6 BA x $\frac{7}{16}$", tin plated		6
21	S744	Round Head Screw, 6 BA x $\frac{5}{8}$", tin plated		1
22	S627	Round Head Screw, 6 BA x $\frac{13}{16}$", nickel plated		1
23	10055–1	Tag, 6 BA		1
24	W63	Washer, 6 BA, tin plated		9

* 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

* See note regarding Movement Servicing on page 26

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
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
11	N4	Hex. Locknut, 4 BA		3
12	N55	Round Nut, 6 BA, for item 5		4
13	S751	Inst. Head Screw, 6 BA x $\frac{1}{4}$", 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
20	S401	Cheese Head Screw, 4 BA x $\frac{7}{8}$"		1
21	S804	Cheese Head Screw, 8 BA x $\frac{1}{8}$"		2
22	10358–1	Tag		2

*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 37 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		2
13	10190–1	Insulator Bush , for rear hairspring tag		1
14	10188–2	Locknut, for item 13		1
15	10191–4	Rear Hairspring Tag		1
16	10069–1	Spring Washer, for item 10		1
17	10197–2	Locknut, for item 16		1
18	10189–1	Washer, for item 15		2
19	10358–2	Tag, for movement connection		1
20	N4	Hex. Locknut, 4 BA, brass nickel plated		2
21	N11	Hex. Nut, 8 BA, brass nickel plated		2
22	S802	Cheese Head Screw, 8 BA x $\frac{1}{2}$", brass nickel plated ...		1
23	S804	Cheese Head Screw, 8 BA x $\frac{1}{8}$", brass nickel plated ...		2

* See note regarding Movement Servicing on page 26

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
24	S824	Cheese Head Screw, 8 BA x $\frac{3}{8}$", steel nickel plated		1
25	S877	Raised Csk. Head Screw, 8 BA x $\frac{3}{16}$", brass nickel plated		2
26	S882	Cheese Head Screw, 8 BA x $\frac{3}{16}$", steel nickel plated		2
27	S886	Cheese Head Screw, 8 BA x $\frac{23}{32}$", brass nickel plated		1
28	W8	Washer, 8 BA, brass nickel plated		3
29	S887	8 BA, x $\frac{5}{32}$", brass nickel plated		1

*MOVING COIL ASSEMBLY 21124–D

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	15304–3	Moving Coil Bare		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	10158–2	Pivots, 0.020"		2
7	10075–16	Hairsprings		2
8	15300–2	Pointer Plate		1
9	15433–1	Pointer		1

CASE ASSEMBLY 40703-E

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
1	40703–F	Complete Case, finished		1
2	40703–A	Case Assembly Top		1
3	40703–D	Case Assembly Bottom		1
4	11727–A	Handle Assembly		1
5	11727–5	End Cap, for handle assembly		2
6	P.V.C.174	P.V.C. Strip, 3' 0"		1
7	40704–1	Gasket		1
8	15700–2	Clasp Bottom (on bottom case)		4
9	15701–2	Clasp Plate (outside bottom case)		4
10	15702–2	Clasp Plate (inside bottom case)		4
11	15700–1	Clasp Top		4
12	15702–4	Clasp Plate (on case lid)		4
13	15706–2	Cover Washer		4
14	15703–1	Panel Clamp		8
15	14235–1	Anchor Nut, 4 BA		8
16	R66	Rivet, .090"/.094" x $\frac{1}{4}$"		28
17	15713–1	Strap		1
18	R65	Rivet, .090"/.094" x $\frac{7}{32}$"		16
19	12231–5	Name Plate		1
10	N3	Hex. Nut, 4 BA		12
21	N6	Hex. Nut, 6 BA, nickel plated		2
22	S1545	Round Head Screw, 4 BA x $\frac{5}{16}$", nickel plated		8
23	R76	Rivets .090/.094 x $\frac{5}{16}$"		2

* See note regarding Movement Servicing on Page 26

Item No.	Part No.	Description	Circuit Ref.	Qty. Off
24	S1542	Round Head Screw, 4 BA x $\frac{7}{16}$", nickel plated		8
25	S1535	Round Head Screw, 4 BA x $\frac{11}{16}$", chrome...		2
26	S636	Round Head Screw, 6 BA x $\frac{1}{4}$", nickel plated		2
27	S642	Round Head Screw, 6 BA x $\frac{3}{8}$", nickel plated		2
28	SX14	Self-tapping Screw, No. 6 x $\frac{3}{8}$"		6
29	W3	Washer, 4 BA, nickel plated		4
30	W55	Washer (Shakeproof), 4 BA		10

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
16	15844-2	Hex. Nut, 4 BA, for captive screw		2
17	N6	Hex. Nut, 6 BA, nickel plated		2
18	R3	Rivet, .064″/.068″ x $\frac{5}{32}$″		6
19	S636	Round Head Screw, 6 BA x $\frac{1}{4}$", nickel plated		2
20	S854	Round Head Screw, 8 BA x $\frac{1}{4}$", nickel plated		8
21	W5	Washer, 6 BA, nickel plated		2
22	W8	Washer, 8 BA, nickel plated		8

PART No. 10072/316

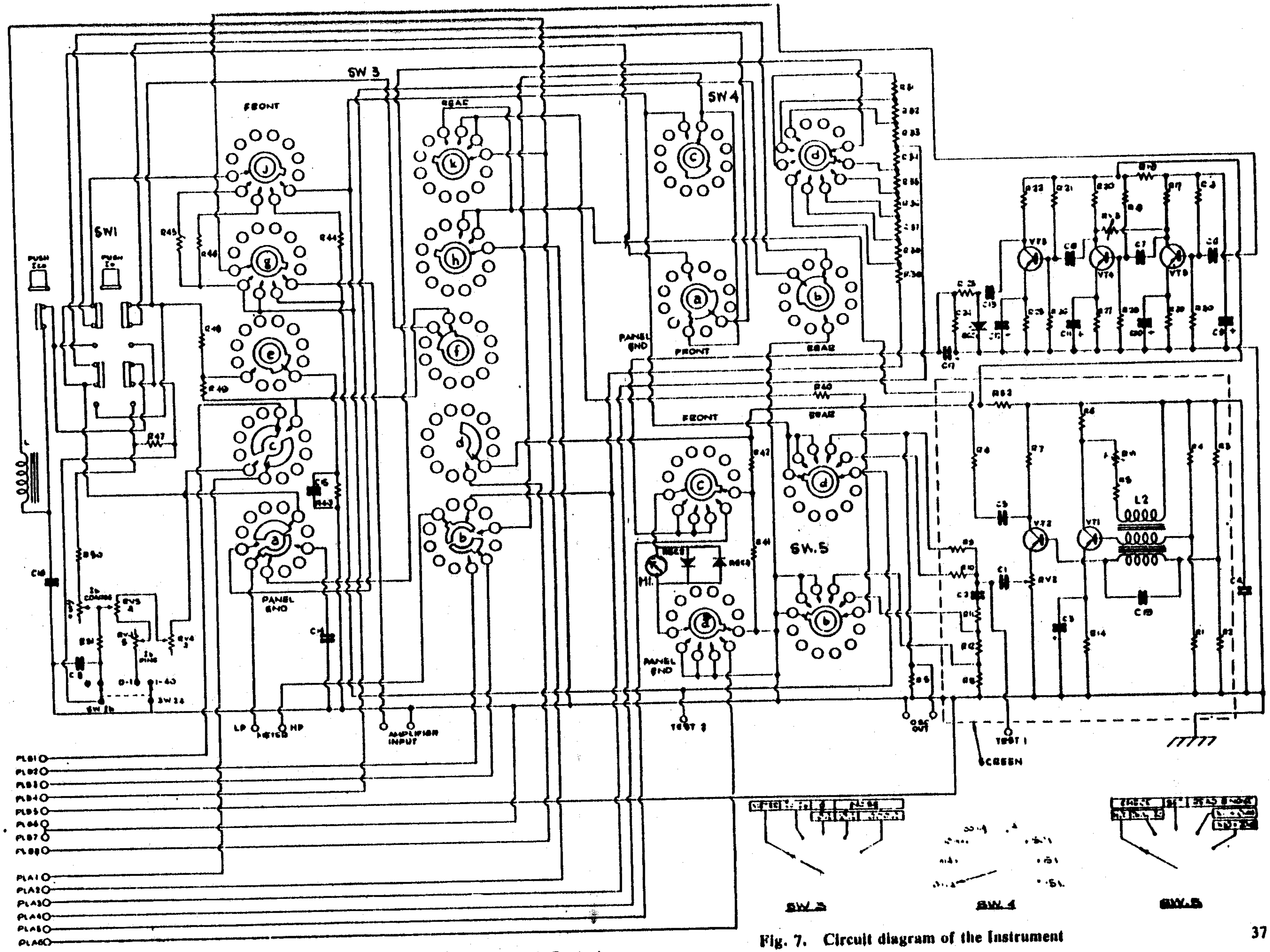

Fig. 7. Circuit diagram of the Instrument

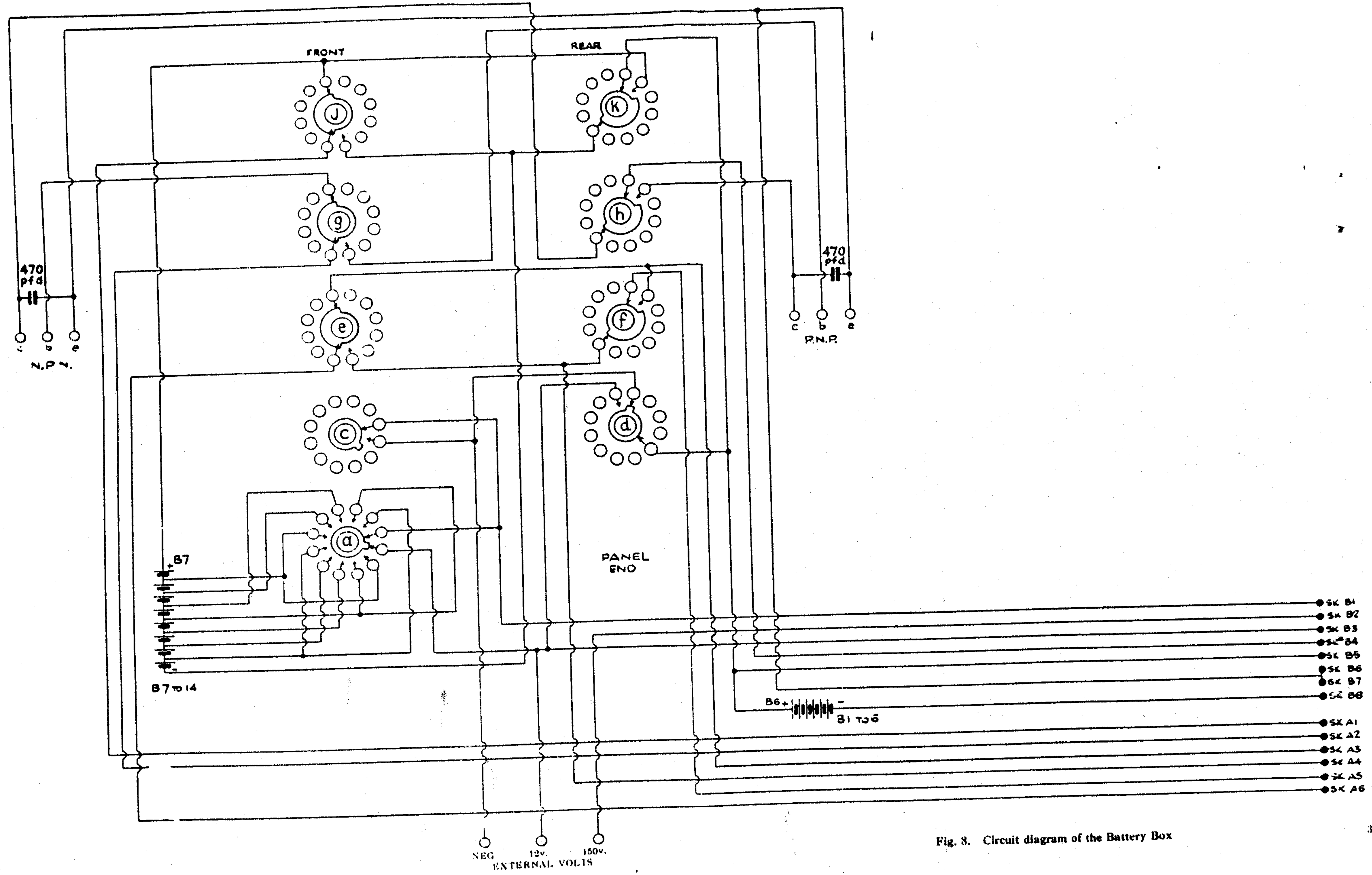

Fig. 8. Circuit diagram of the Battery Box