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Large diagrams

The large diagrams are given in two formats – in A4 size sheets to allow easy printing, and complete as originally published to allow easy on-screen viewing. These versions are in different sections of the document, which can be found within the bookmarks.

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1. Work out the page numbers you want to print. If you want to print the whole document, then within "Bookmarks" (see above), click on "**End of A4 printable copy**" and note the page number given at the bottom of the Acrobat window (to determine the last page to be printed).

2. Select "File – Print" or click on the printer icon. This will bring up the print dialog box.

3. Select the correct printer if necessary.

4. In the area marked "Print Range" click on the radio button marked "Pages from..", then put the page number worked out in step 1 into the "to" box.

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Please get in touch with me at archivist@vmarsmanuals.co.uk.

Richard Hankins, VMARS Archivist, Spring 2004

Instruction Manual
for
Multimeter Type CT471

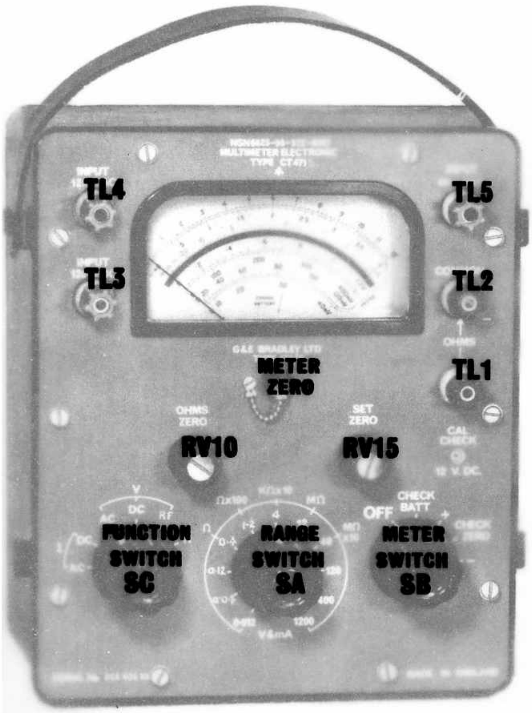
With Appendix covering Type CT471C

CT471 N.S.N. 6625-99-972-0247

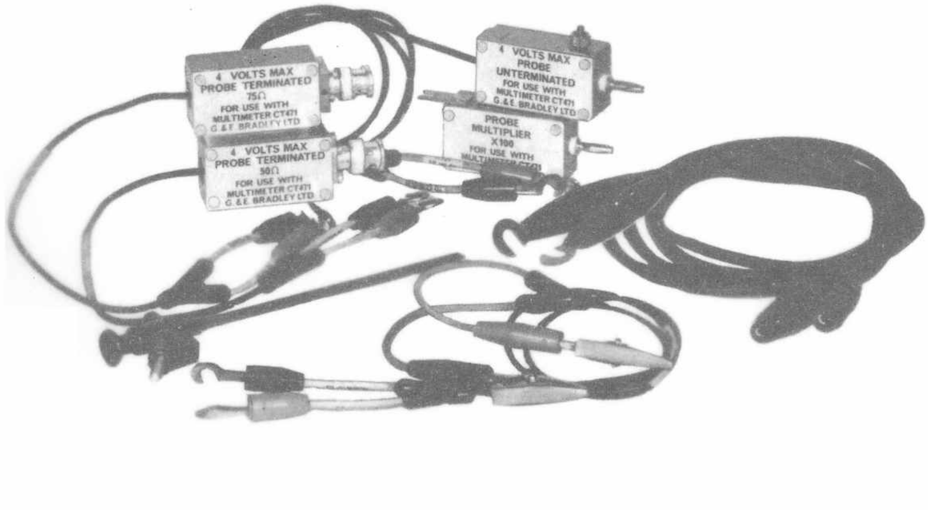
CT471C N.S.N. 6625-99-955-6255

G. & E. BRADLEY LIMITED
ELECTRONIC RESEARCH ENGINEERS & MANUFACTURERS
ELECTRAL HOUSE, NEASDEN LANE,
LONDON, N.W.10

Telephone - Dollis Hill 7811/7
Telegrams and Cables - Bradelec London N.W.10
Telex - Bradelec 25583


TL4
TL5
TL3
TL2
G.&E. BRADLEY LTD
METER ZERO
TL1
OHMS ZERO
SET ZERO
RV10
RV15
CAL CHECK
12 V. DC.
CHECK BATT
OFF
FUNCTION SWITCH SC
RANGE SWITCH SA
METER SWITCH SB
V&mA


PROBES AND ACCESSORIES ARE STOWED UNDER THIS PANEL
OPERATING INSTRUCTIONS
RELEASE PANEL BY A QUARTER TURN OF THIS FASTENER


4 VOLTS MAX PROBE TERMINATED 75Ω FOR USE WITH MULTIMETER CT471
4 VOLTS MAX PROBE UNTERMINATED FOR USE WITH MULTIMETER CT471 G.&E. BRADLEY LTD
PROBE MULTIPLIER X100 FOR USE WITH
4 VOLTS MAX PROBE TERMINATED 50Ω FOR USE WITH MULTIMETER CT471 G.&E. BRADLEY LTD

CAUTION

Switch off when not in use otherwise serious damage to the battery carrier will result unless leakproof batteries are used.

When the Multimeter is used with the mains operated Power Supply Type 10 it must be switched off by disconnecting the mains lead **and** setting the meter switch to OFF.

APPENDIX
MULTIMETER TYPE CT471C

Multimeter Type CT471C has a CENTRE ZERO facility in place of the CHECK ZERO facility fitted to the Type CT471. The centre-zero facility is available on the direct current and voltage functions in the following ranges.

VOLTAGE: 6-0-6mV; 20-0-20mV; 60-0-60mV; 200-0-200mV; 600-0-600mV; 2-0-2V; 6-0-6V; 20-0-20V; 60-0-60V; 200-0-200V; 600-0-600V.

CURRENT: 6-0-6μA; 20-0-20μA; 60-0-60μA; 200-0-200μA; 600-0-600μA; 2-0-2mA; 6-0-6mA; 20-0-20mA; 60-0-60mA; 200-0-200mA; 600-0-600mA.

ACCURACY

Voltage ranges: ±4% of f.s.d. up to 200V
±6% of f.s.d. on the 600V range

Current ranges: ±4% of f.s.d. up to 200mA
±6% of f.s.d. on the 600mA range

In all other respects Multimeter Type CT471C is the same as the Type CT471 described in the main text of this handbook.

OPERATING INSTRUCTIONS

The Operating Instructions given in Section 3 of the main text apply also to Multimeter Type CT471C with the following exceptions.

(i) The instructions in Section 3.2. apply to the normal full-scale ranges.

(ii) For Operation 3.2. (a) read as follows:

Connect the test leads to the INPUT 400V MAX and COMMON terminals of the instrument. Set the meter switch to +, connect the test leads together and adjust the SET ZERO control for zero meter indication.

NOTE: The coaxial lead should be used if there is a risk of inaccuracy due to pick-up from strong r.f. fields in the vicinity of the equipment under test.

(iii) Delete operation 3.2. (e).

To use the centre-zero facility on the direct current and voltage ranges, proceed as follows:

Connect the test leads to the INPUT 400V MAX and COMMON terminals of the instrument. Set the meter switch to CENTRE ZERO, connect the test leads together and adjust the SET ZERO control for centre-zero indication on the multimeter. Perform operations (b), (d) and (f) as described in Section 3.2. Rotate the range switch slowly counter-clockwise until a meter indication is obtained.

For direct voltage measurements on the 600-0-600V range the test leads should be connected between the INPUT 1200V DC and COMMON terminals.

April 1966

TECHNICAL DESCRIPTION

The centre-zero function is obtained by injecting a current of 50μA into the chopper circuit so that the basic meter is given a fixed half-scale deflection. The meter and function switches short circuit the source of this current when they are set to functions for which the centre-zero facility is not applicable. The circuit differences between Types CT471 and CT471C, and the location of the additional components, are shown in Appendix fig. 1.

The potential divider comprising R111, RV20 and R134 is connected between the +20V line and earth. The slider of RV20 is connected via R90 to the input of the chopper circuit. R90 provides a high input impedance for the meter biasing current with respect to the amplifier input impedance. RV20 is used to set the centre-zero. Switch wafer SC8 connects the slider of RV20 to earth on the r.f. and ohms ranges, switch wafer SB3 doing the same for the + and — settings of the meter switch. It is not necessary to connect the a.c. positions of the switch wafer SC8 because the chopper itself is not in circuit on the a.c. functions of the meter.

SETTING-UP AND CALIBRATION

The setting-up and calibration procedure for Multimeter Type CT471C is the same as that given in Section 5 of the main text with the following exceptions.

(i) In paragraphs 5.6.2. and 5.6.3. the meter switch should be set to +.

(ii) After paragraph 5.6.5. add a new paragraph as follows:

5.6.6. Centre-Zero Facility

Set the switches as follows:

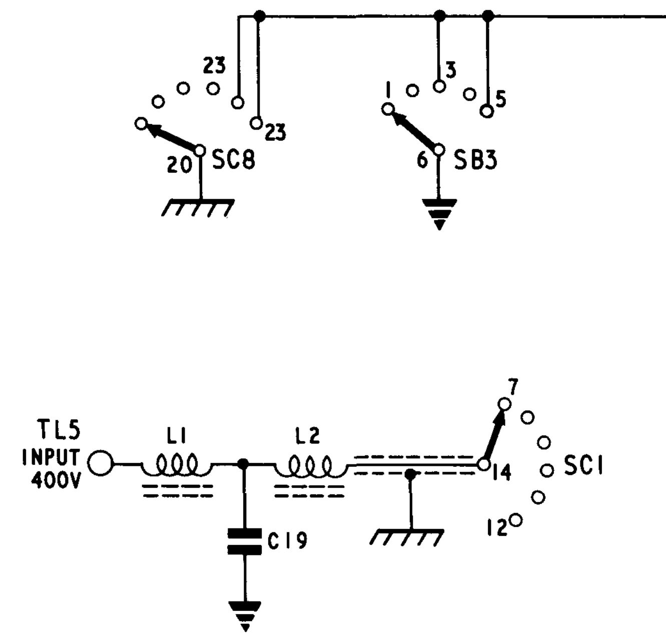
Function switch to V-DC
Range switch to 0.012V
Meter switch to +

Connect together the INPUT 400V MAX and COMMON terminals. Adjust the SET ZERO control for zero indication on the multimeter. Set the meter switch to CENTRE ZERO and adjust RV20 for centre-zero indication on the multimeter scale.

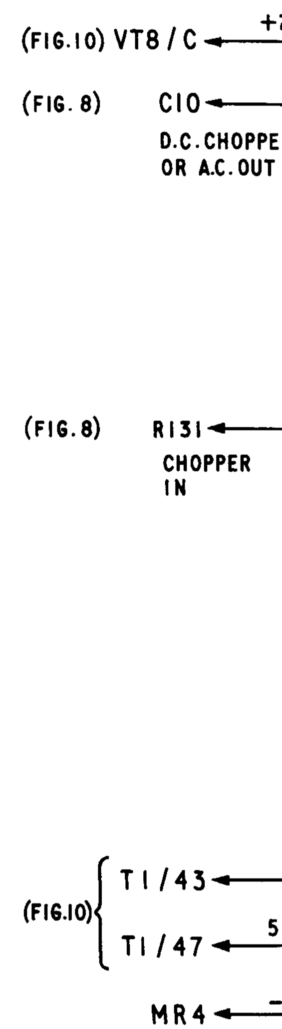
ADDITIONAL COMPONENTS FOR CT471C

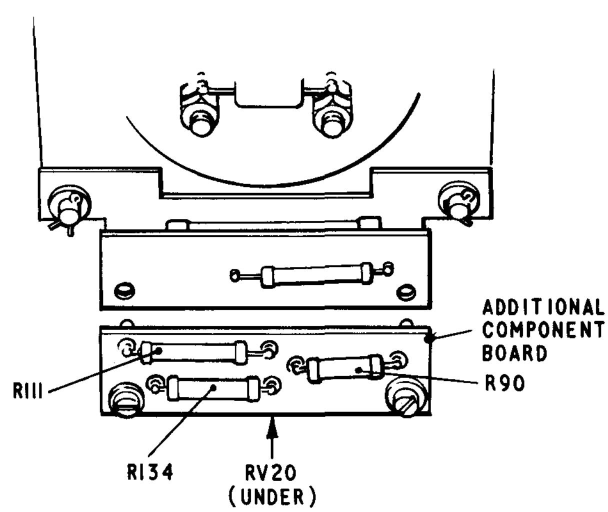
CCT. REF.	DESCRIPTION	MNFR. OR I.S. STYLE	REF. NO.
R90	22MΩ 10% ¼W	Dubilier Type B.T.T.	GR25050
R111	820kΩ 2% ¼W	RC2-E	5905-99-021-7801
R134	36kΩ 2% ¼W	RC2-E	5095-99-021-6341
RV20	22kΩ 20% ¼W	Plessey MP Dealer	GR35047

✱ REFER TO NOTE ON FIG. 8
ALL INSTRUMENTS TYPE CT471C
ARE FITTED WITH PLESSEY
TYPE SWITCHES.

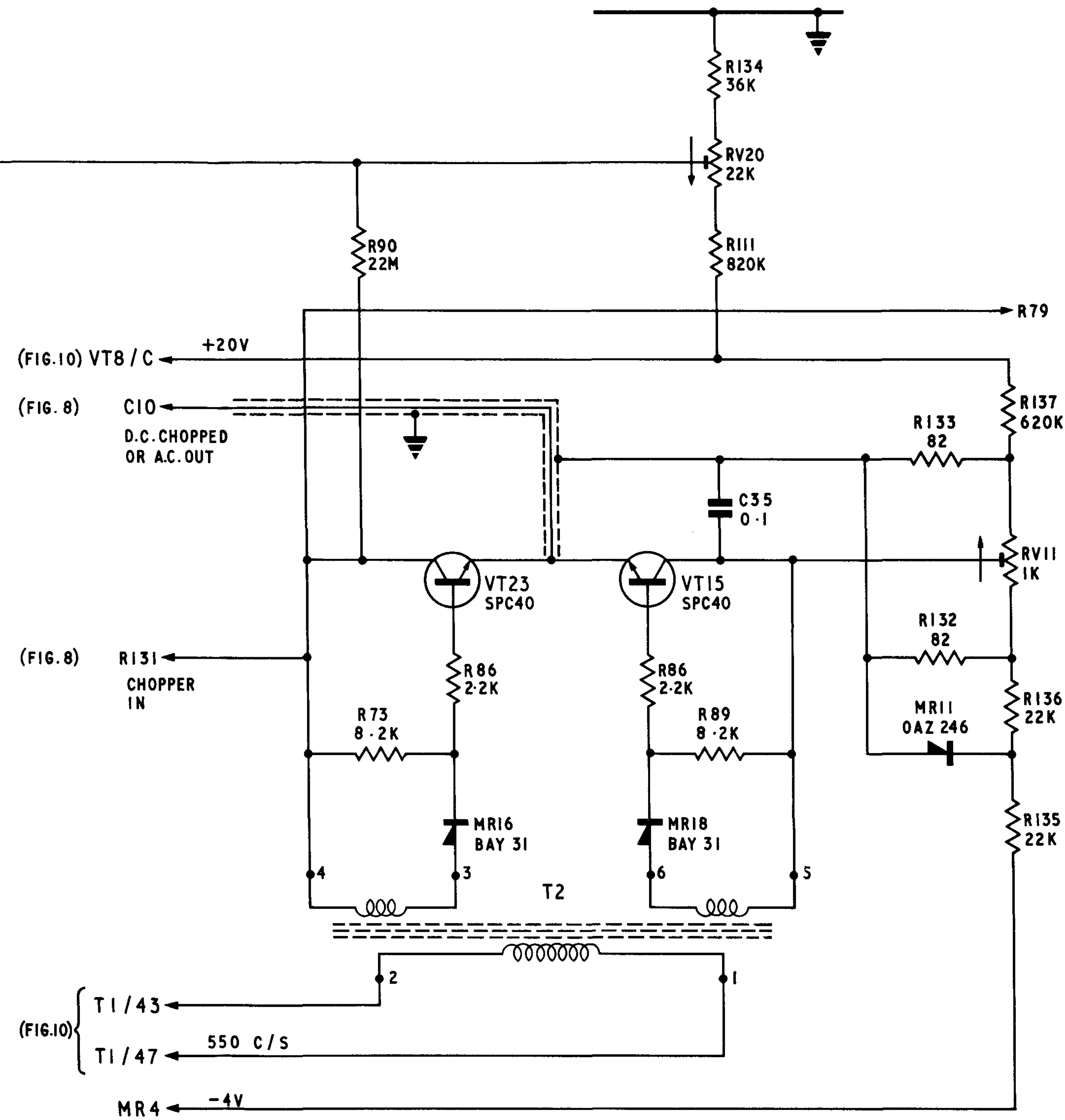


Part Of Fig.8





LOCATION OF ADDITIONAL COMPONENTS
ON CT471C COMPARE WITH FIG.6
IN MAIN TEXT



D. C. CHOPPER

Part Of Fig. 9

APPENDIX FIG. 1
CIRCUIT DIFFERENCES FOR MULTIMETER TYPE CT471C

INSTRUCTION MANUAL

FOR

MULTIMETER TYPE CT471

Amendment List - June 1965

1. Use of insturment in r.f. fields

The instrument case has been modified and filters have been fitted in series with the input terminals so that the instrument can be used in the vicinity of r.f. fields. The circuit diagram for the attenuator (fig.8) is modified as shown. On page 3, second paragraph, last sentence, delete "but, due to the ....high r.f. fields."

R162, R163	4.7K	10%	$\frac{1}{4}$W	RC7-K	Z222088
C11, C23, C24	1000pF	+50,	-25%	Lemco Type 07K	GC24155
L1, L3	G.E.B.	Ref. A10594			
L2, L4	G.E.B.	Ref. A10591			

2. Technical Description

Page 14. Section 4.3.2. (ii).

Add the following at the end of the first paragraph.

Transistor VT14 is a high slope resistance source of base current for the amplifier input stage VT11. The d.c. level stabilising feedback from the junction of R96/R97 is applied via R96 to the emitter of VT14 whose collector supplies the base current for VT11. The amplifier d.c. conditions are set, in the V-DC mode, by RV13 in the network comprising Zener diode MR21, RV13 and R104 (fig.9) and, in the V-AC mode, by R87 and RV12 (fig.8). Note that there is no passive base resistance for VT11.

INSTRUCTION MANUAL

FOR

MULTIMETER TYPE CT471

Amendment List - November 1965

Attenuator Circuit Diagram - Fig. 8.

(1) Add an asterisk against C27.

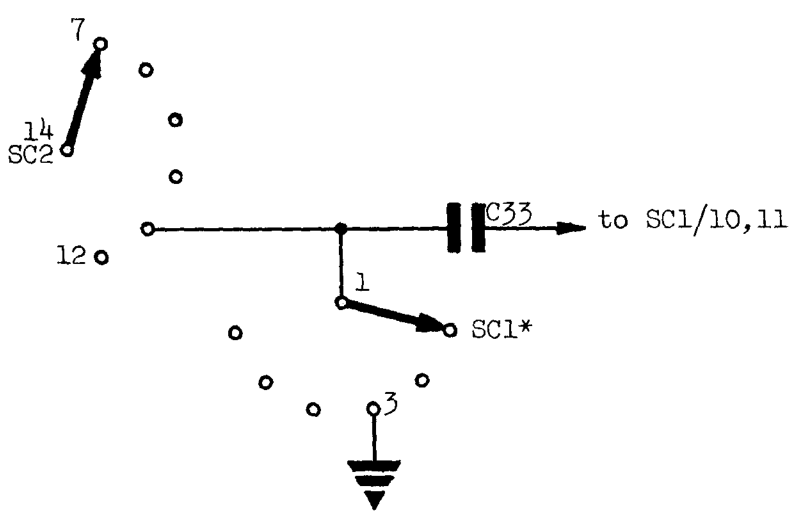
(2) Add switch SC1 (with an asterisk) as shown below:

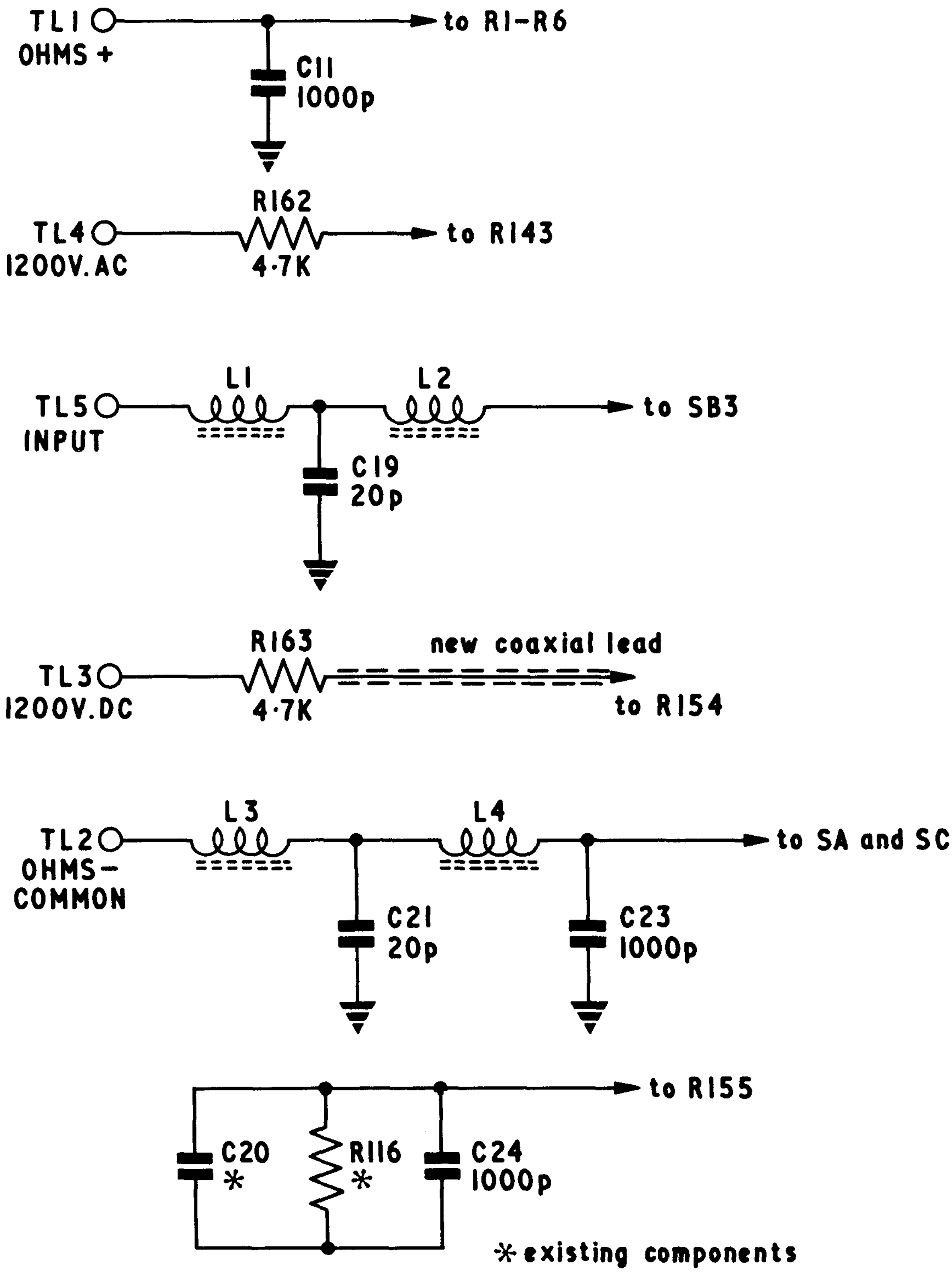
(3) To the asterisked Note (lower right of diagram) add

C27 is not fitted

SC1 is connected as shown.

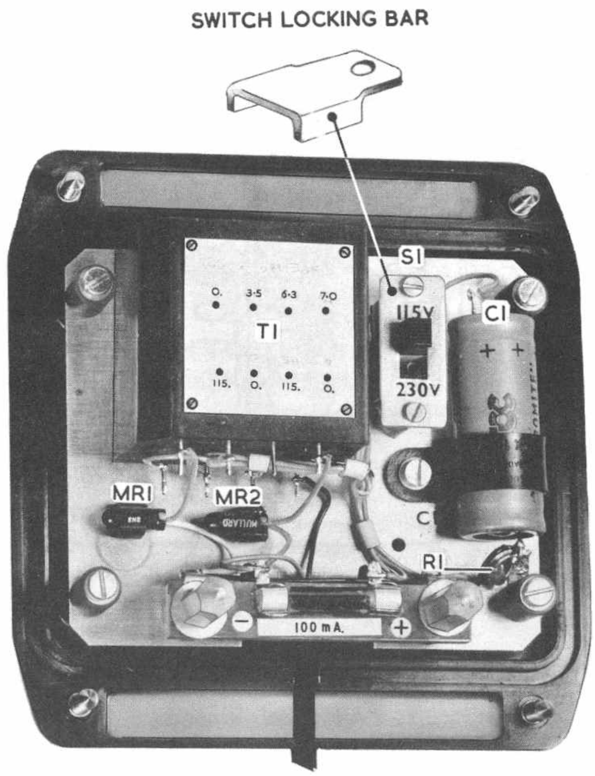
--------------------oOo--------------------





MULTIMETER CT471–AMENDMENT TO ATTENUATOR CIRCUIT FIG. 8

POWER SUPPLY UNIT TYPE 10

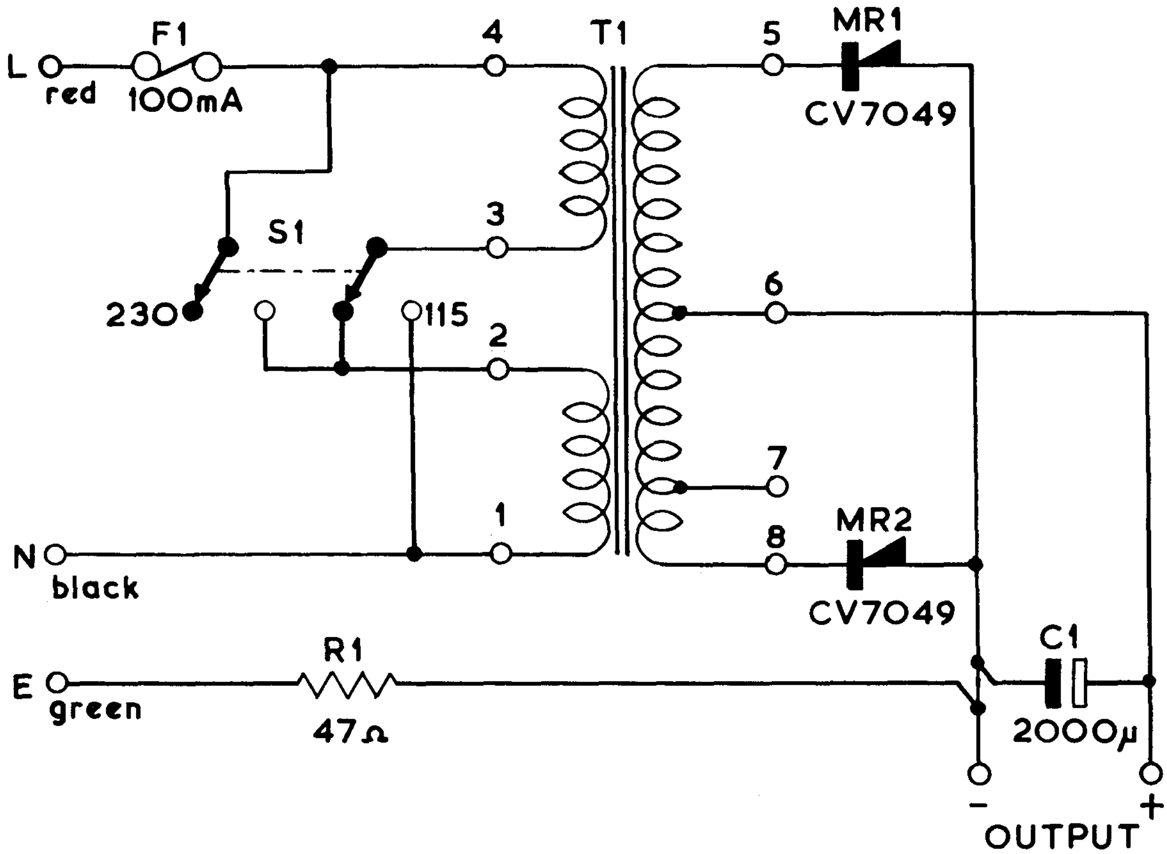


The Power Supply Unit Type 10 can be used as a direct replacement for the battery carrier in Multimeter Type CT471 and RF Millivoltmeter Type 112, thus allowing mains operation of these instruments.

The nominal output of the unit is 4V at 100mA unregulated and it has a nominal ripple of 150mV peak.

The switch S1 selects transformer T1 primary connections appropriate to a mains input of 230V or 115V 50/60/400 c/s, the permissible voltage range for each setting being 210-250V and 105-125V respectively.

To change the setting of S1, release the safety plate, operate the switch, then replace the plate at the opposite end of the switch, i.e. so that it covers the voltage not in use.



PARTS LIST

CCT. REF.	DESCRIPTION	MNFR. OR I.S. STYLE	REF. NO.
R1	47Ω 10% ¼W	RC7-K	Z221067
C1	2000μF +50%, −20% 6V	Plessey CE1254	GC10301
MR1, MR2		Mullard OA10	CV7049
F1	Fuse 100 mA		Z590131
S1	Switch D.P.D.T.	Arcoletric T225	GS01950
T1	Transformer	G.E.B.	B4465

When ordering spare parts please quote the Instrument Type and Serial Numbers, and the circuit reference and value of the required component.

CONTENTS

ILLUSTRATIONS

MULTIMETER TYPE CT471

SECTION 1—INTRODUCTION

Multimeter Type CT471 is a fully transistorized multi-range instrument for the measurement of voltage at frequencies up to 1000Mc/s (1500Mc/s with reduced accuracy), current at frequencies up to 2kc/s, and d.c. resistance.

Direct voltage and current measurements are each divided into 11 ranges, covering 12mV to 1200V f.s.d. and 12μA to 1.2A f.s.d. respectively. When measuring direct voltage, the input resistance of the instrument is 10M Ω/volt f.s.d. on the lower seven ranges and approximately 120M Ω on the remaining ranges. When measuring direct current, the voltage drop across the instrument (excluding external connections) is 40mV on ranges up to 40mA and rises to 200mV on the 1.2A range. The effects of superimposed a.c. on measurements of direct voltage and current are minimized by a low-pass filter circuit but, due to the multiple function characteristics of the instrument, superimposed r.f. voltages can cause errors up to a few per cent if the instrument is used in high r.f. fields.

Alternating voltage measurements are also divided into 11 ranges, covering 12mV to 1200V f.s.d. at frequencies up to 20kc/s. On these ranges the input resistance is 1M Ω/volt f.s.d. up to 1.2V, 1.2M Ω between 1.2V and 400V, and 3M Ω on the 1200V range. Alternating current measurements are divided into 11 ranges, from 12μA to 1.2A f.s.d. The voltage drop across the instrument (excluding external connections) is 40mV on ranges up to 40mA f.s.d. rising to 200mV on the 1.2A range.

RF voltage measurements are divided into five ranges from 40mV to 4V f.s.d. Three probes are provided (50 Ω, 75 Ω and unterminated). A multiplier is also provided, which extends the upper limit of measurements with the unterminated probe to 400V. The input resistance of the unterminated probe is approximately 200k Ω with 0.5 volt input at 10Mc/s.

Resistance measurements are divided into five ranges giving an overall coverage from 0.1 Ω to 1000M Ω with an accuracy of $\pm 5\%$ at mid-scale.

A mains operated power unit (Power Unit Type 10) is available and this can be used in place of the normal battery container supplied with the Multimeter. It is suggested that the Power Unit Type 10 be used for bench operation of the Multimeter, the battery unit being retained for the operation of the Multimeter in the field.

SECTION 2—SPECIFICATION

2.1. Ranges

Voltage Ranges—AC and DC:	0–12mV, 40mV, 120mV, 400mV, 1.2V, 4V, 12V, 40V, 120V, 400V and 1200V.
Current Ranges—AC and DC:	0–12μA, 40μA, 120μA, 400μA, 1.2mA, 4mA, 12mA, 40mA, 120mA, 400mA and 1.2A.
RF Voltage Ranges	0–40mV, 120mV, 400mV, 1.2V and 4V. A 40dB (×100) multiplier is supplied for use at higher voltages.
Resistance Ranges:	0.1 Ω–100 Ω (2.5 Ω mid-scale): source e.m.f.: 80mV. 10 Ω–10k Ω (250 Ω mid-scale): source e.m.f.: 2.5V 1k Ω–1M Ω (25k Ω mid-scale): source e.m.f.: 2.5V. 100k Ω–100M Ω (2.5M Ω mid-scale): source e.m.f. 2.5V. 1M Ω–1000M Ω (25M Ω mid-scale): source e.m.f. 2.5V.

2.2. Accuracy

Direct Voltage:	±2% of f.s.d. up to 400V, thereafter ±3% of f.s.d.
Direct Current:	±2% of f.s.d.
Alternating Voltage:	±3% of f.s.d.
Alternating Current:	±3% of f.s.d.
Resistance:	±5% at mid-scale.

2.3. Typical Input Characteristics

Direct Voltage:	10M Ω/volt f.s.d. up to 12V, thereafter constant 120M Ω approximately.
Alternating Voltage:	1M Ω/volt f.s.d. up to 1.2V, thereafter constant 1.2M Ω up to 400V. Input resistance on 1200V range is 3M Ω.
RF Voltage (unterminated probe with 0.5V input at 10Mc/s):	Approximately 200kΩ in parallel with 4pF.

2.4. Frequency Range

Alternating Voltage:	40c/s–20kc/s (ranges up to 400V f.s.d.).
Alternating Voltage:	40c/s–2kc/s (1200V range).
Alternating Current:	40c/s–2kc/s.
RF Voltage:	20kc/s–1000Mc/s.

2.5. RF Probes

Three probes are provided: unterminated, 50Ω and 75Ω.
Probe Accuracy: 50Ω and 75Ω—±5% of f. s. d. at 10 Mc/s.
Unterminated and Multiplier—±5% of f. s. d. at 100 kc/s.
Frequency Response relative to 10 Mc/s * or 100 kc/s I : see table.

Probe	Freq.	Typically better than	Limit
50Ω *	20 kc/s—500 Mc/s	±7%	±1dB (11%)
	500—1000 Mc/s	±10%	±1.5dB (16%)
75Ω *	20 kc/s—100Mc/s	±7%	±1dB (11%)
	100—500 Mc/s	±10%	—
Unterm. I	20 kc/s—100 Mc/s	±7%	±1dB (11%)
Mult'r I	20 kc/s—100 Mc/s	±7%	±1dB (11%)

2.6. Hum (DC Voltage and Current)

The permissible peak level of 50c/s hum is at least three times the full-scale value of the range in use.

2.7. DC Isolation (AC Voltage Ranges)

The internal capacitor will block up to 200V d.c.

2.8. DC Isolation (AC Current Ranges)

The permissible d.c. component is at least twice the full-scale value of the range in use.

2.9. Physical Data

Height	Width	Depth	Weight (approx.)
9.75 in	8½ in	8½ in	11 lb
24.8 cm	21.6 cm	21.6 cm	5kg

2.10. Ancillary Items Supplied

Probe, unterminated	- Ref. B4355	
Probe, terminated, 50 ohm	- Ref. A4354/1	
Probe, terminated, 75 ohm	- Ref. A4354/2	
Probe Multiplier	- Ref. A4353	
Coaxial Lead	- Ref: B4425	
Lead, Red	- Ref. B4681/1	} Equivalent to AVO Mk.1 leads
Lead, Black	- Ref. B4681/2	
Prod, Red	- Ref. B4680/1	
Prod, Black	- Ref. B4680/2	

SECTION 3—OPERATING INSTRUCTIONS

3.1. General

Before making any measurements, the meter switch should be set to CHECK BATT. If the meter indication is below the CHANGE BATTERY line, change the batteries as described in Section 5 of this manual.

To obtain the highest possible accuracy from the instrument, it should be operated face upwards.

NOTE: To conserve the battery, the instrument should be switched off when not in use.

The frontispiece shows the test leads, probes and the arrangement of the front panel controls, the control designations being shown on the overlay.

3.2. Direct Current and Direct Voltage up to 400V

(a) Set the meter switch to CHECK ZERO and adjust the SET ZERO control for zero meter indication.
(b) Select V-DC or I-DC on the function switch.
(c) Select the desired polarity on the meter switch.
(d) Set the range switch fully clockwise.
(e) Connect the test leads to the INPUT 400V MAX and COMMON terminals of the instrument.

NOTE: The coaxial lead should be used if there is a risk of inaccuracy due to pick-up from strong r.f. fields in the vicinity of the equipment under test.

(f) Connect the test lead crocodile clips to the voltage or current source to be measured.
(g) Rotate the range switch slowly counter-clockwise until a meter indication of at least one quarter full-scale is obtained. If the pointer deflects below zero, set the meter switch to the opposite polarity.
(h) Read the voltage or current from the meter, using the top scale for 0.012, 0.12, 1.2 volts etc., or the second scale for 0.04, 0.4, 4 volts etc.

3.3. Direct Voltage between 400V and 1200V

(a) Perform operations (a) to (d) as described in paragraph 3.2.
(b) Connect the INPUT 1200V DC and COMMON terminals to the source of voltage to be measured.
(c) Read the voltage from the top scale of the meter.

3.4. Alternating Current and Alternating Voltage up to 400V

NOTE: It is not necessary to adjust the SET ZERO control on alternating current or voltage ranges.

(a) Select V-AC or I-AC on the function switch.
(b) Set the meter switch to +.

(c) Rotate the range switch fully clockwise.
(d) Connect the test leads to the INPUT 400V MAX and COMMON terminals of the instrument.

NOTE: The coaxial lead should be used if there is a risk of inaccuracy due to pick-up from strong r.f. fields in the vicinity of the equipment under test.

(e) Connect the test lead crocodile clips to the voltage or current source to be measured.
(f) Rotate the range switch slowly counter-clockwise until a meter indication of at least one quarter full-scale is obtained.
(g) Read the voltage or current from the meter, using the top scale for 0.012, 0.12, 1.2 volts etc. and the second scale for 0.04, 0.4, 4 volts etc.

3.5. Alternating Voltage between 400V and 1200V

(a) Perform operations (a), (b) and (c) as in paragraph 3.4.
(b) Connect the source of voltage to be measured between the INPUT 1200V-AC and COMMON terminals.
(c) Read the voltage from the top scale of the meter.

3.6. RF Voltage up to 4V

CAUTION

The Probes stowed in the instrument lid must be used for all RF Voltage measurements. It is important that no direct voltage is applied to the terminated probes and that no direct voltage in excess of 100V is applied to the unterminated probe. Failure to observe this precaution will affect calibration and may damage the probes. For voltages in excess of 4V see next paragraph.

(a) Select a probe of suitable impedance. Three probes are provided: 75 Ω, 50 Ω, and unterminated.
(b) Connect the probe lead to the INPUT 400V MAX and COMMON terminals.
(c) Set the function switch to V-RF.
(d) Set the range switch to 40mV and adjust the SET ZERO control for zero meter indication.
(e) Set the range switch to 4V.
(f) Connect the probe to the voltage source.
(g) Rotate the range switch counter-clockwise until a convenient meter reading is obtained.
(h) Read the voltage from the PROBE scales on the meter. These cover the following ranges: 0.04V, 0.12V, 0.4V, 1.2V and 4V.

3.7. RF Voltage above 4V

(a) Attach the probe multiplier to the input of the unterminated probe.
(b) Perform operations (c) to (g) in paragraph 3.6.
(c) Read the voltage from the PROBE scales on the meter. The indicated voltage should be multiplied by 100.

3.8. DC Resistance

(a) Set the function switch to Ω.
(b) Set the range switch to the required resistance range.
(c) Set the meter switch to CHECK ZERO and adjust the SET ZERO control for a meter reading of INFINITY (left-hand extreme).
(d) Short-circuit the OHMS terminals and adjust the OHMS ZERO control for zero resistance reading (f.s.d.) on the meter.
(e) Remove the short-circuit from the OHMS terminals and connect the unknown resistor.

3.9. Calibration Check

A calibration voltage of 12V $\pm$ 0.5% is available at the front panel terminal CAL CHECK 12V DC. This may be used to check the overall accuracy of the instrument on the 12V and 40V d.c. ranges.

NOTE: The source resistance of this voltage is approximately 100,000 Ω. This is suitable for checking the 12V or 40V d.c. ranges (f.s.d. and one-third f.s.d. respectively) which have an input resistance of approximately 120M Ω. The check voltage cannot be measured accurately by other instruments unless the input resistance is greater than 100M Ω.

SECTION 4—TECHNICAL DESCRIPTION

4.1. Summary

Multimeter Type CT471 comprises an attenuator network, an amplifier and a power supply, together with ancillary probes and connectors. The quantity to be measured is processed in the attenuator network and then applied to the amplifier (via a chopper circuit if the unknown quantity is of a d.c. character). The output from the amplifier operates the meter movement. When reading the circuit description (Section 4.3.) refer to the circuit diagrams given in fig. 8, 9 and 10 at the end of the book.

4.2. Functional Description

4.2.1. *Attenuator Network and Probes*

The attenuator network comprises all the resistors and switches required to attenuate the input signal to a level suitable for driving the amplifier. The amplifier input components and feedback resistors are switched to establish appropriate circuit connections for the measurement of d.c., a.c. and r.f. inputs.
Resistance is measured by connecting a stabilized voltage to the test component in series with standard resistors. The voltage developed across one of the standard resistors is fed to the amplifier and measured as a direct voltage. The OHMS terminals are marked positive and negative to facilitate tests on diodes and other polarity-sensitive devices. The common negative terminal TL2 is disconnected from the common negative line of the instrument when the function switch SC is set to the OHMS position.

The three r.f. probes are similar in construction, each using semi-conductor diodes. Circuit diagrams for these items and the multiplier probe are given in fig. 11.

4.2.2. *The Amplifier*

When the instrument is used on the d.c., r.f. or resistance ranges, a sensitive a.c. amplifier preceded by a solid-state chopper circuit is used (see fig. 1a). The amplifier has two negative feedback loops. One controls the characteristics of the amplifier, the other provides overall feedback and includes the meter and rectifier circuits. The loop gain of the amplifier is approximately 38 on the 12mV d.c. range and approximately 60 on all other d.c. ranges.

When the instrument is used on the a.c. ranges, the chopper circuit is not used (see fig. 1b). The frequency response is sensibly flat between 40c/s and 20kc/s. The loop gain of the amplifier is approximately 20 on the 12mV a.c. range and 25 on all other a.c. ranges.

The output from the amplifier is fed via a phase sensitive detector to a pair of complementary class-B emitter followers which drive the meter either directly (d.c. ranges) or via a full-wave bridge rectifier (a.c. ranges). The meter excursion is limited by the current available from the emitter followers.

4.2.3. *The Power Supply (Fig. 1c)*

The instrument is powered by three series-connected leakproof U2 cells (Battery, Dry, $1\frac{1}{2}$V No. 1; US BA-30). Two stabilizer circuits are used to obtain stability against battery variations, ambient temperature effects, etc. The batteries drive the first stabilizer circuit whose 2.5V output feeds a square wave voltage converter and the OHMS circuits. The output from the converter is fed to a voltage doubler, which drives a 20V stabilizer circuit incorporating a thermistor which gives first-order correction for temperature coefficients. The converter output is also used in the chopper and phase sensitive detector circuits.

4.3. Circuit Description

4.3.1. *Attenuator Circuit*

The Attenuator circuit is shown in fig. 6. The circuit will be described for all settings of the function switch (SC).

4.3.1.(*i*) *Direct Voltage*

When measuring direct voltage up to 400 volts the unknown voltage is applied to TL5. It is then fed via contact 3 or 5 and the rotor of SB3 (according to polarity), the rotor and contact 10 of SC1 and the rotor of SA8 to the appropriate point along the series resistor chain R19–R23, R37–R40, R117–R121, R114, R115 and R131. The output from the resistor chain is applied directly to the input of the chopper circuit (fig. 7). When making measurements with the 40V, 120V and 400V ranges, voltage divider resistors R16–18 are brought into circuit by SA14. These resistors, in conjunction with capacitor C20, also form the low-pass filter which minimizes any superimposed alternating voltage. On the 1200V range, the unknown voltage is applied to terminal TL3 which is connected to the chopper circuit via R154, R155, R156 and R15.

4.3.1.(*ii*) *Direct Current*

When measuring direct current, the source is connected to TL5. The current passes via contact 3 or 5 and the rotor of SB3 (according to polarity), the rotor and contact 8 of SC1, through SA10 to shunt resistors R24–R35. The voltage developed across these resistors is applied to the 40mV point of the main resistor chain via SA15 and SC7 (contact 8).

4.3.1.(*iii*) *Alternating Voltage*

On the alternating voltage ranges, the voltage to be measured is applied to TL5 and fed via contact 3 or 5 and the rotor of SB3, and the rotor and contact 9 of SC1 to the contacts of SA2. SA2 and SA3 select 10:1 divider circuits as required by the setting of the range switch. The attenuated voltage passes via series resistors as selected by SA5, coupling capacitor C9 and switch SC7 to the input of the amplifier (base of VT11). The preset potentiometers RV16, RV18 and RV19 compensate for tolerance build-up in the divider networks (R148, R149, R150 and R127 to R130) associated with the a.c. voltage ranges 4V and above. When using the 1200V a.c. range, the voltage to be measured is applied to terminal TL4 and fed via attenuator R140–R143, coupling capacitor C9 and switch SC7 to the amplifier input.

4.3.1.(*iv*) *Alternating Current*

When measuring alternating current, the current source is applied to TL5. The current passes via contact 3 or 5 and the rotor of SB3 and the rotor and contact 7 of SC1 to the rotor of SA10 which selects the appropriate shunt resistor from the network R24–35; the voltage developed across this resistor passes via SA15 and the rotor and contact 7 of SC7 to the junction of R124 and R125 on the a.c. attenuation chain. The alternating signal reaches the amplifier input via R125, R126, C9 and contact 1 or 3 of switch SC7.

4.3.1.(*v*) *High Frequency Voltage*

When measuring high frequency voltages (20kc/s to 1000Mc/s), the voltage is applied to TL5 via one of the three probes. The circuit is similar to that described for the measurement of direct voltage except that the amplifier gain is adjusted by means of feedback potentiometers RV2–RV6; these are brought into circuit via the contacts and rotor of SA12 according to the range in use.

4.3.1.(*vi*) *Resistance*

The resistance to be measured is connected between terminals TL1 and TL2. With the range switch set to the lowest ohms position and the function switch in the Ω position, the positive side of the 2.5V stabilized supply is fed to the voltage divider R8/R9. The voltage at the junction of this divider network passes via the rotor and contact 4 of SA11 to one side of the unknown resistance. The other side of the unknown resistance is connected to R11 via SA9. The voltage developed across R11 is fed via the rotor and contact 6 of SC2 to the 40mV point (junction of R114 and R115) along the main chain of series resistors and thence to the amplifier as in the d.c. mode (see para. 4.3.1.(*i*)).

On the higher resistance ranges the potential divider R8/R9 is made inoperative since switch SA1 is open, but R9 forms part of a series network with R1 to R6. R1–R6, corrected slightly by R11–R14 and the input resistance of the amplifier, are chosen so that, with the terminals short circuited, the meter reads full scale, i.e. zero ohms. It follows that these resistors are equal to the half-scale mark on their respective ohms ranges. The voltage across R11–R14 is fed to the 40mV point as for the low ohms range; on the M Ω × 10 range no additional shunt is necessary, the amplifier input resistance itself being used for the purpose.

4.3.2. *Amplifier Circuit*

The Amplifier circuit is shown in fig. 9. The amplifier is here deemed to include the chopper and meter circuits.

4.3.2.(*i*) *Chopper Circuit*

When the instrument is used for the measurement of direct voltage and current, resistance, or r.f. voltage, the direct voltage appearing at the amplifier input is converted into an alternating voltage by a chopper circuit (VT15, VT23) connected across the amplifier input.

The square wave drive signal for the chopper circuit is derived from the 550c/s converter via T2. The square wave at the secondaries of T2 is then shaped by MR16, MR18, R73 and R89 to give intermittent forward bias to the base/collector junctions of VT23 and VT15. R86 and R88 determine the amount of bias current. The phasing is such that the two transistors act as a changeover switch.

The network comprising R132, R133, R135, R136, R137, RV11 and MR11 generates an adjustable low voltage of either polarity which is used to balance out the differential offset voltage of the two chopper transistors. MR11 acts as a simple regulator for the negative input to this network. The chopped signal is fed to the input of the amplifier via SC7 and C10.

4.3.2.(*ii*) *Amplifier Input Circuit*

The input to the amplifier (a.c. or chopped d.c.) is applied to the base of transistor VT11 which, in conjunction with emitter follower VT12, provides a high amplifier input impedance. The signal from the emitter of VT12 is applied to the base of amplifying stage VT13. Zener diode MR17 provides d.c. bias so that R85 can be connected to VT13 emitter as far as the signal is concerned. This helps to maintain a high input impedance at the base of VT11. The smoothing circuit comprising R138 and C34 reduces needle flicker which may result from excessive noise generated by some samples of the diode used for MR17.

The output from the collector of VT13 is connected to the base of the amplifying stage VT16, whose emitter is by-passed by R93 and C13 when SC6 is in the d.c., r.f. or resistance positions. Thus the gain of this stage varies according to the setting of the function switch. On d.c. functions the gain is given approximately by the ratio of R103 to R93 and is relatively high. On a.c. functions the gain is reduced and is given approximately by the ratio of R103 to R101. VT17 and VT18 form a compound stage. VT18 is an amplifier and VT17 is an emitter follower which reduces loading of the collector circuit of VT16. Thus the spread in current gain of VT18, which varies from about 20 to 300, has a negligible effect on the overall loop gain of the amplifier. The emitter by-pass capacitors for VT18 (C15 and C29) in conjunction with R74–R78 (as selected by the range switch) controls the gain of the amplifier so that the full range of input voltages can be accommodated. The output from the collector of VT18 is a.c. coupled by C26 or C16, either via a demodulator circuit (VT19 and VT22) on d.c. ranges, or directly on a.c. ranges, to a complementary emitter follower (VT20 and VT21).

4.3.2.(*iii*) *Phase Sensitive Detector Circuit*

VT19 and VT22 form a phase sensitive detector circuit which produces positive or negative voltage at the junction of the emitter of VT19 and R109 when the signal input is negative or positive respectively.

The d.c. output from the emitter of VT19 is fed via R109 and appropriate contacts of SC5 to the bases of the complementary emitter followers VT20 and VT21. When measuring alternating voltages, the phase-sensitive detector is not used, the output from the collector of VT18 being fed via contacts 7 and 9 and the rotor of SC5 to the bases of VT20 and VT21. VT20 and VT21 operate under class B conditions and thus pass both positive and negative signals, each transistor conducting in turn. By this means it is possible to obtain full scale deflection of the 1mA meter movement with an amplifying stage which draws only 0.5mA.

4.3.2.(*iv*) *Meter Circuit*

The output from VT20 and VT21 is fed directly to the meter on d.c. functions or via full-wave bridge rectifier MR12–MR15 on a.c. functions.

When the rotor of the meter switch (SB) is on contact 8, the meter is connected in series with R50 directly across the battery to check its voltage.

4.3.3. *Power Supply Circuit*

The power supply circuit is shown in fig. 10.

4.3.3.(*i*) 2.5*V Stabilizer*

VT1, VT2 and VT3 form a 2.5V series stabilizer driven by the three 1.5V cells via SB4. VT1 is the series element. Resistor R55 between its emitter and collector reduces the power dissipation of the transistor and improves the starting characteristics of the circuit.

VT2 is an emitter follower which provides impedance matching between the series element (VT1) and the amplifier (VT3). Amplifier VT3 is provided with a reference voltage via the two forward-connected Zener diodes MR1 and MR10. Voltage divider RV8 gives an output voltage adjustment of approximately 15% and compensates for the build-up of tolerances in the circuit. The OHMS ZERO control (RV10) is on the front panel and varies the output voltage from the regulator by 2% to 3% to zero the meter when the instrument is used for the measurement of resistance.

4.3.3.(*ii*) *Converter*

VT9 and VT10 form a low power multivibrator operating at approximately 550c/s. Diodes MR2 and MR3 are incorporated in the emitter circuits to overcome the tendency for this type of solid-state circuit to have two modes of operation. RV9 adjusts the mark/space ratio of the output waveform.

The square-wave outputs from the emitters of VT9 and VT10 drive the two switching transistors VT4 and VT5. These transistors, acting as a change-over switch, feed the primary winding of converter transformer T1 with a square wave derived from the 2.5V d.c. line.

The output from T1 is fed to a symmetrical voltage doubler, comprising C7, C8, MR6 and MR7, giving an output of 23V d.c. at the junction of C8 and MR6. Another secondary winding on T1 provides the drive for the phase sensitive detector circuit.

4.3.3.(*iii*) 20*V Stabilizer*

The 20V stabilizer comprising VT6, VT7 and VT8 is similar to the 2.5V stabilizer described in para. 4.3.3.(*i*) Thermistor TH1 provides temperature correction; Zener diode MR8 acts as a reference and MR9 improves the overall performance of the stabilizer.

Divider network R70 and R71 gives a voltage of 12V $\pm$ 0.5% which is fed to a front panel terminal (CAL. CHECK 12V DC) to facilitate a rapid check of the overall accuracy of the instrument on the 12V and 40V d.c. ranges. The source resistance at the 12V check terminal is approximately 100,000 Ω. This is satisfactory for checking the Multimeter on the 12V and 40V ranges (f.s.d. and one-third f.s.d. respectively) where the input resistance is 120M Ω. The check voltage cannot be accurately measured by instruments whose input resistance is lower than 100M Ω unless corrections are made for loading.

SECTION 5—MAINTENANCE

5.1. General

5.1.1. *Printed Circuit Boards*

As this instrument uses printed circuits, the following suggestions may be of assistance.

(i) When soldering, the iron should be sufficiently hot to ensure that the solder runs freely, but avoid using an excessively hot iron because the printed conductors may tend to separate from the board at temperatures appreciably above that required to melt the solder.

(ii) When a component other than a transistor is to be replaced, the lead wires of the unserviceable component should be cleanly cut close to the body of the component. The replacement component should be connected to the wire spills left by the removal of the old component.

5.1.2. *Replacement of Transistors*

Transistor failure can almost always be attributed to component breakdown in some other part of the circuit. A careful check should therefore be made to eliminate any other faults which may exist before a transistor is replaced.

When replacing a transistor, the soldered joints should be made as rapidly as possible, taking care to avoid over-heating the replacement. The use of a heat shunt is recommended. Special selection of replacements is not necessary.

Before attempting to adjust this instrument or replace any of its components, read Section 4 "Technical Description" as a guide to the signal paths and circuit elements.

5.2. Battery Replacement

CAUTION

Use leakproof batteries only for replacement purposes

The three U2 1.5V cells (Battery, dry, $1\frac{1}{2}$V, No. 1: U.S. Type BA-30) are located in a compartment at the rear of the instrument case. To replace the battery, unfasten the four coin-slotted screws at the corners of the battery holder at the rear of the instrument and remove the battery holder. The three cells are held in position by spring clips and can be removed by finger pressure. If the cells have become badly corroded, clean the holder and apply "Vaseline" to the contact springs. Replace the cells and replace the battery holder. Before tightening the coin-slotted screws, ensure that the rubber gasket is clean. After replacing the cells, set the meter switch to CHECK BATT. and check that the meter needle indicates above the CHANGE BATTERY line.

5.3. Component Access

To gain access to the interior of the instrument, proceed as follows.

(a) Place the instrument face-upwards on a flat surface.
(b) Remove the ten 2BA screws from the outer edges of the front panel.
(c) Carefully lift the front panel and component frame clear of the instrument case.

5.4. Component Board Removal

The majority of the components are located on three printed-circuit boards mounted at right-angles to the front panel. To remove either of the boards situated to the left and right of the meter movement, proceed as follows.

(a) Remove the 4BA screws which hold the U-bars to the cross bars on the appropriate side. Remove the 6BA screws and spacers which hold the attenuator board to the U-bars. Slacken the 4BA screws which hold the feet of the U-bar assembly to the bracket on the front panel, and swing the assembly outwards.

NOTE: In the case of the amplifier board, it may be necessary to disconnect the single white/orange and the three red leads from switch SC at the amplifier board.

(b) If the complete board is to be replaced, unsolder all leads.
(c) Remove the 6BA screws, nuts, washers and spacers holding the board to the main framework.
(d) Remove the board.

The procedure for the removal of the third board, containing the attenuator components and current shunts, is similar to that detailed above, except that the range switch must first be freed from the front panel and removed with the attenuator board, to which it is permanently attached. It may also be necessary to disconnect the following two leads:

Range switch SA to function switch SC.
Range switch SA to C9 on the amplifier board.

5.5. Test Equipment

To set up and calibrate the Multimeter the following test equipment is required.

(a) DC Signal Generator covering the range 12mV to 500V. G. & E. Bradley Type 123 or equivalent precision voltage source. Alternatively dry batteries and decade resistance boxes monitored by a precision voltmeter (e.g. digital voltmeter).
(b) Oscillator covering the frequency range 40c/s to 20kc/s with output variable from 12mV to 20V r.m.s.
Marconi Instruments Type TF1101 or similar instrument.
(c) Power Amplifier with maximum output 10W over the frequency range 40c/s to 20kc/s.
(d) Step-up Transformer, ratio 20:1 or greater, to give 600V output over the frequency range 40c/s to 20kc/s.
(e) AC Converter/Voltmeter, sensitive to average value of waveform, calibrated in r.m.s. values, to cover the voltage range 12mV to 500V with an accuracy of $\pm 1\%$ over the frequency range 40c/s to 20kc/s.
Solartron Type LM903 or similar.

(f) Digital Voltmeter, suitable for operation from item (e).
Solartron Type LM902/2 or similar.
NOTE: If items (b) to (f) inclusive are not available, the a.c. voltage ranges of the instrument may be checked at a single frequency between 50c/s and 1kc/s using readily available mains power supplies. For this purpose a precision meter (item (g)) with AC Range Box (item (h)) may be used.

(g) Precision DC Meter.
Cambridge Unipivot Type 41334.

(h) AC Range Box for item (g).
Cambridge Type 41392.

(j) DC Range Box for item (g).
Cambridge Type 41391.

(k) Oscilloscope—Tektronix 545 with plug-in unit type L and high impedance probe type P600.
NOTE: Alternative oscilloscopes with high impedance probe may be used if necessary.

(m) Testmeter—Avo Model 8 or Multimeter CT471 or similar testmeter, having at least 20,000 ohms per volt sensitivity.

(n) Adjustable Direct Current Supply, 0–1 ampere.

(p) Adjustable Alternating Current Supply 50c/s or 400c/s 0–1 ampere.
NOTE: Items (n) and (p) to be monitored with precision ammeters, e.g. items (g), (h) and (j).

(q) Variable Low Voltage Power Supply, regulated, at least 3 to 4.5V, 250mA. Startronic Model 119. Accuracy required is approximately $\pm 2\%$.

(r) Resistance 10,000 ohms, e.g. type RC7K, $\pm 5\%$. $\frac{1}{4}$ watt.
Resistance 2.5 ohms $\pm$ 1%.
Resistance 250 ohms $\pm$ 1%.
Resistance 25,000 ohms $\pm$ 1%.
Resistance 2.5 megohms $\pm$ 1%.
Resistance 25 megohms $\pm$ 1%.
Resistance 3 megohms $\pm$ 1%.
NOTE: If the equipment listed above is not available, the instrument may be returned for repair and recalibration to G. & E. Bradley Ltd., Technical Services Dept., Electral House, Neasden Lane, London, N.W.10.

5.6. Setting-up

In the following paragraphs the COMMON Multimeter input terminal is referred to as "earth"; this is electrically connected to the body of the instrument on all ranges except OHMS.

5.6.1. *Power Supplies*

Set the switches as follows:
Function switch to V-DC.
Range switch to 12V.
Meter switch to CHECK BATT.

Set the external power supply (para. 5.5(q)) to 3V and connect it to the Multimeter battery contacts. Check that the indication on the top scale of the Multimeter is between 6.2 and 7.2 volts.

Set the meter switch to +. Connect the testmeter (para. 5.5(m)) between the junction C2/R59 (positive) and the Multimeter COMMON terminal. Adjust RV8 until the testmeter reads 2.5 ± 0.07V. Adjust RV9 for minimum current from the power supply.

Spot calibrate the testmeter (para. 5.5(m)) at 12V against the DC Signal Generator (para. 5.5(a)). Connect the testmeter to the CAL CHECK 12V DC terminal and adjust RV14 until the testmeter reads 12 ± 0.05V.

5.6.2. *Amplifier DC Conditions*

Set the switches as follows:

Function switch to V-DC.
Range switch to 0.12V.
Meter switch to CHECK ZERO.

Connect the testmeter (para. 5.5(m)) to the collector of VT13. Adjust RV13 until the testmeter reads 13.6 ± 0.1V. Connect the testmeter to the collector of VT18. The meter should read 5V ± 0.1V; note the reading. Set the function switch to V-AC. Adjust RV12 until the testmeter indicates 5.25V ± 0.1V.

5.6.3. *Chopper Circuit*

Set the switches as follows:

Function switch to V-DC.
Range switch to 0.012V.
Meter switch to CHECK ZERO.

Short circuit the junction of R79 and R80 to earth. Adjust RV11 for zero reading on the Multimeter scale. Remove the shorting link. Adjust the SET ZERO knob for zero reading on the Multimeter. To check the operation of the chopper circuit, connect the probe of the oscilloscope probe (item 5.5(k)) to the collector of VT18. Set the Multimeter range switch to 12V. Connect the terminal CAL CHECK 12V DC to the Multimeter INPUT 400V MAX. The waveform on the oscilloscope should be approximately square and its amplitude 2V p-p. Noise on the waveform should be negligible.

NOTE: This test need be done only after major repairs. It may be omitted if the oscilloscope is not available.

5.6.4. *DC Overall Gain*

Set the switches as follows:

Function switch to V-DC.
Range switch to 0.04V.
Meter switch to +.

Connect the output of the DC Signal Generator (para. 5.5(a)), set to 40mV, to the Multimeter INPUT 400V MAX. Adjust RV1 until the Multimeter reads full scale.

5.6.5. *AC Overall Gain*

Set the switches as follows:

Function switch to V-AC.
Range switch to 0.04V.
Meter switch to +.

Set the oscillator (para. 5.5(b)) output to 40mV at 2kc/s and connect it to the Multimeter input. Monitor the oscillator output with the AC Converter and Digital Voltmeter (items 5.5(e) and (f)). Adjust RV17 to obtain f.s.d. on the Multimeter. If items 5.5(e) and (f) are not available, use mains power supplies monitored by items 5.5(g) and (h). Reduced accuracy may result in this case.

5.7. Calibration

5.7.1. *Direct Voltage*

Set the switches as follows:

Function switch to V-DC.
Range switch as required.
Meter switch to +.

With the DC Signal Generator connected as in para. 5.6.4. check the calibration at f.s.d. on all V-DC ranges up to 400V. The accuracy of the reading in each case should be ±2% of f.s.d. Set the range switch to 1200V. Connect the DC Signal Generator, set to 500V, between the 1200V-DC and COMMON terminals. The Multimeter should read 500 ± 20V.

5.7.2. *Direct Current*

Set the switches as follows:

Function switch to I-DC.
Range switch as required.
Meter switch to +.

Connect the d.c. supply (para. 5.5(n)) in series with a precision ammeter (items 5.5(g) and (j) to the Multimeter INPUT 400V MAX and check that f.s.d. accuracy on all ranges is ±2%.

5.7.3 RF Ranges

Set the switches as follows:

Function switch to V-RF.
Range switch as required.
Meter switch to +.

Connect the output of the oscillator (para. 5.5(b)) to the unterminated probe (B4355). Set the oscillator frequency to 100kc/s. Connect the probe output to the Multimeter INPUT 400V MAX terminal. Check that on each probe range (0.04V, 0.12V, 0.4V, 1.2V and 4V) the Multimeter f.s.d. reading is correct to ±0.5dB (approximately ±5%). Potentiometers RV2–RV6 may require resetting. If a probe is not available, the Multimeter r.f. ranges may be set up using the DC Signal Generator (para. 5.5(a)). The appropriate d.c. input given in column 3 of the following table should be connected to the Multimeter input via a resistor 3 Megohms $\pm 1\%$ and the relevant potentiometer (column 2) adjusted for f.s.d. The switches should remain set as above.

RF Range	*Potentiometer*	*DC Output*
0.04V	RV2	15.5mV*
0.12V	RV3	88.0mV*
0.4V	RV4	425mV
1.2V	RV5	1.5V
4V	RV6	5.4V

* These voltages should be applied via an accurate divider to obtain resolution.

A divider having a ratio of 10: 1 is suitable.

The preset potentiometer RV1 in the probe circuit is used to normalize the probe output and should be set on the 0.12V range.

5.7.4. *Alternating Voltage* (0.012*V to* 12*V Ranges*)

With the conditions and switch settings (except range) as given in para. 5.6.5., set the Multimeter range switch and oscillator output to 4V. Adjust RV19 to give full-scale deflection on the Multimeter. Repeat the procedure for the 12V range but adjusting RV18 for full-scale deflection. It is important that the adjustments are made in the order given. Check the full-scale deflection on the 12mV, 120mV and 400mV ranges; this should be within $\pm 1\%$ in each case.

5.7.5. *Alternating Voltage* (40*V*, 120*V and* 400*V Ranges*)

Proceed as in para. 5.7.4. but with a power amplifier and step-up transformer (items 5.5(c) and (d)) connected to the oscillator output to give signal levels up to 600V. Connect the AC Converter and Digital Voltmeter (items 5.5(e) and (f)) across the transformer output. Set the Multimeter range switch and the Multimeter input to 120V. Adjust RV16 for full-scale deflection on the Multimeter. Check the full-scale deflection on the 40V and 400V ranges; this should be within $\pm 1.5\%$ in each case. If items 5.5(c) and (d) are not available, the calibration of these ranges may be checked between 50c/s and 1kc/s from mains power supplies using items 5.5(e), (g) and (h).

NOTE: On instruments fitted with Trolex switches, a wire screen extension is fitted to RV19. This should be moved aside to adjust RV16, and then moved back to its original position.

5.7.6. *Alternating Voltage* (1200*V Range*)

Set the range switch to 1200V, other switches as in para. 5.6.5; connect the transformer output (para. 5.7.5.) between the INPUT 1200V AC and COMMON terminals. Check that the calibration accuracy is within $\pm 3\%$ of f.s.d. If necessary change the value of R140.

5.7.7. *Alternating Current*

Set the switches as follows:
Function switch to I-AC.
Range switch as required.
Meter switch to +.

Connect the alternating current supply (para. 5.5(p)), monitored by ammeter (items 5.5(g) and (j)), to the Multimeter INPUT 400V MAX. Check that the calibration accuracy at f.s.d. on all current ranges is within ±3%.

5.7.8. *Resistance Ranges*

Set the switches as follows:
Function switch to Ω.
Range switch as required.
Meter switch to +.

Using precision resistors from 2.5 ohms to 25 megohms (para. 5.5(r)), check the mid-scale calibration on all resistance ranges. The indication in each case should be within ±5%.

5.8. RF Probes

To set up the RF Probes and Multiplier, the following test equipment is required (in addition to that listed in para. 5.5):

(a) RF Signal Generator: Hewlett Packard Type TS 510/U.
(b) RF Signal Generator: Rohde & Schwarz Type SDR.BN 41022.
(c) Valve Voltmeter: Marconi Type 1041B (including 50Ω load).
(d) Symmetrical Power Divider: G. & E. Bradley Type 471.
(e) Power Meter: Hewlett Packard Type 431B.
(f) 6dB Pad (50Ω): G. & E. Bradley Type 202.
(g) 50Ω to 75Ω 6dB Matching Pad.
(h) BNC Connector Type LF12 fitted with brass earthing plate and terminated with a 50Ω ±5% carbon resistor.

5.8.1. *Unterminated Probe*

(i) Set the output of the oscillator (para. 5.5(b)) to 100mV at 100kc/s by means of the AC Converter and Digital Voltmeter (para. 5.5(e) and (f)). Connect the unterminated probe between the oscillator output and the multimeter CT471 (set to the 120mV RF range). Using an insulated trimming tool, adjust RV1 in the probe until the multimeter indicates 100mV.

(ii) Calibrate the valve voltmeter (para. 5.8(c)) at 200mV, 100kc/s using the AC Converter and the Digital Voltmeter (para. 5.5(e) and (f)). Connect the power divider input (para. 5.8(d)) to the RF Signal Generator (para. 5.8(a)). Connect the valve voltmeter to one output from the divider and the 6dB pad (para. 5.8(f)) to the other output. Connect the probe and multimeter to the pad via the BNC connector (para. 5.8(h)). Set the signal generator frequency to 10Mc/s and its output level to give an indication of 200mV on the valve voltmeter; note the indication of the multimeter. Vary the frequency of the signal generator from10Mc/s to 200 Mc/s and check that the multimeter indication does not vary by more than ±10%.

5.8.2. 50Ω *Terminated Probe*

(i) Using the set-up described in para. 5.8.1(ii) but with the 50Ω terminated probe in place of the unterminated probe andBNC connector, set the signal generator output to 200mV at 10Mc/s. Using an insulated trimming tool, adjust RV1 in the probe to give an indication of 100mV on the multimeter.

(ii) Connect the power meter (para. 5.8(e)) to the signal generator (para. 5.8(b)). Set the frequency of the signal generator to 500Mc/s and the output level to give an indication of 0.2mW on the power meter. Set the multimeter to the 120mV RF range and connect the probe input to the signal generator output. Check that the multimeter indication is within ±10% of 100mV.

(iii) Repeat the procedure given in para. 5.8.2(ii) but at a frequency of 1000Mc/s. Check that the multimeter indication is within ±15% of 100mV.

5.8.3. 75Ω *Terminated Probe*

(i) Using the set-up described in para. 5.8.1(ii) but with the valve voltmeter calibrated at 155mV, and with the 50Ω to 75Ω matching pad (para. 5.8(g)) substituted for the 6dB pad (para. 5.8(f)), connect the 75Ω probe between the 6dB pad and the multimeter. Adjust RV1 in the probe to give an indication of 100mV on the multimeter (use an insulated trimming tool).

(ii) Connect the power meter (para. 5.8(e)) to the signal generator (para. 5.8(a)) output; set the frequency of the signal generator to 420Mc/s and the output level to give an indication of 0.48mW on the power meter. Connect the 75Ω probe via the matching pad to the signal generator output and check that the multimeter indicates within ±10% of 100mV.

5.8.4. *Multiplier*

Set the frequency of the oscillator (para. 5.5(b)) to 100kc/s and calibrate its output at 40mV and 4V. Set the multimeter to the 40mV RF range and connect the unterminated probe between the oscillator and the multimeter. Set the oscillator output level to 40mV and note the indication on the multimeter. Connect the multiplier between the oscillator and the unterminated probe. Set the oscillator output to 4V and, using the insulated trimming tool, adjust trimmer capacitor C2 in the multiplier until the multimeter indication is the same as that previously noted.

SECTION 6—PARTS LIST

When ordering spare parts please quote the Instrument Type and Serial Numbers, and the circuit reference and value of the required component.

CCT. REF.	DESCRIPTION	MNFR. OR I.S. STYLE	REF. NO.
Resistors, Fixed			
R1	4·7MΩ 2% ½W	RC2-D	Z216939
R2, R3, R117, R118	10MΩ 1% 1W	Welwyn C13	GR70309
R4	2·46MΩ 1% ¾W	Welwyn C23	GR70310
R5	24·6kΩ 0·5% ¼W	Plessey Metalux AT	GR00028
R6	207Ω 0·5% ¼W	Plessey Metalux AT	GR90171
R7, R10, R31, R36, R140, R152 R153, R156	Adjusted on test	G.E.B.	A9450
R8, R11	1·26Ω ±0·012Ω	G.E.B.	A8856
R9	37·8Ω ½% ¼W	Plessey Metalux AT	GR90177
R12	4·1Ω ±0·05Ω ¼W	Plessey Metalux AT	GR00092
R13	410Ω 1% ¼W	Plessey Metalux AT	GR90166
R14, R96	47kΩ 2% ¼W	Electrosil NJ60	GR10039
		or Welwyn 54C21	GR25218
R15	109kΩ 0·5% ¼W	Plessey Metalux AT	GR90163
R16	334kΩ 0·5% ¼W	Plessey Metalux AT	GR90164
R17	1·2MΩ 0·5% ¼W	Plessey Metalux AT	GR90165
R18	4·63MΩ 1% ¾W	Welwyn C23	GR90146
R19, R48	1·8MΩ 2% ¼W	RC2-E	Z216981
R20	8·2MΩ 2% ¾W	RC2-C	Z216888
R21, R22, R23	10MΩ 2% ¾W	RC2-C	Z216894
R24	2606Ω 0·5% $\frac{1}{16}$W	Plessey Metalux AT	GR90178
R25	688Ω 0·5% $\frac{1}{16}$W	Plessey Metalux AT	GR90167
R26	236Ω 0·5% $\frac{1}{16}$W	Plessey Metalux AT	GR90168
R27	66·7Ω 0·5% $\frac{1}{16}$W	Plessey Metalux AT	GR00104
R28	23·3Ω 0·5% $\frac{1}{16}$W	Plessey Metalux AT	GR90169
R29	6·67Ω 0·5% $\frac{1}{16}$W	Plessey Metalux AT	GR00090
R30	3·4Ω 0·5% $\frac{1}{16}$W	Plessey Metalux AT	GR00091
R32	1Ω 0·5% ½W	Rivlin 43	GR25120
R33	0·333Ω 0·5% ½W	Rivlin 43	GR25126
R34	0·1Ω 0·5% ½W	Rivlin 43	GR25123
R35	0·0333Ω 0·5% ½W	Rivlin 43	GR25128
R37, R38, R39, R40, R155	10MΩ 2% ¾W	RC2-C	Z216894
R41	180kΩ 5% ¼W	RC2-E	Z216141
R42, R44, R46, R47	100kΩ 2% ¼W	RC2-E	Z216450
R43	150kΩ 2% ¼W	RC2-E	Z216490
R45, R87	330kΩ 5% ¼W	RC2-E	Z216925
R49, R109	12kΩ 10% ¼W	RC7-K	Z222142

CCT. REF.	DESCRIPTION	MNFR. OR I.S. STYLE	REF. NO.
R50	5·1kΩ 2% ¼W	RC2-E	Z215810
R51, R52, R101	13kΩ 2% ¼W	RC2-E	Z216241
R53, R62	1·8kΩ 10% ¼W	RC7-K	Z222037
R54, R57, R68, R86, R88, R94, R108	2·2kΩ 10% ¼W	RC7-K	Z222046
R55, R138	150Ω 10% ¼W	RC7-K	Z221130
R56	1kΩ 10% ¼W	RC7-K	Z222004
R58	330Ω 2% ¼W	RC2-E	Z215520
R59	620Ω 2% ¼W	RC2-E	Z215590
R60	560Ω 2% ¼W	RC2-E	Z215580
R61	3kΩ 2% ¼W	RC2-E	Z215750
R63	6·8kΩ 10% ¼W	RC7-K	Z222109
R64	10kΩ 10% ¼W	RC7-K	Z222130
R65	39kΩ 5% ¼W	RC2-E	Z216071
R66, R69, R72, R73, R89	8·2kΩ 5% ¼W	RC2-E	Z215351
R67	18kΩ 10% ¼W	RC7-K	Z222163
R70	160kΩ 1% ¼W	RC2-E	Z216494
R71	240kΩ 1% ¼W	RC2-E	Z216880
R74	1kΩ 5% ¼W	RC2-E	Z215241
R75	820Ω 5% ¼W	RC2-E	Z215231
R76	470Ω 5% ¼W	RC2-E	Z215201
R77, R84	180Ω 2% ¼W	RC2-E	Z215460
R78	33Ω 10% ¼W	RC7-K	Z221046
R79	22MΩ 10% ¼W	Dubilier BTT	GR25050
R80, R81	27kΩ 10% ¼W	RC7-K	Z222184
R82, R98, R105	100kΩ 10% ¼W	RC7-K	Z223037
R83	220kΩ 10% ¼W	RC7-K	Z223079
R85, R92	68kΩ 5% ¼W	RC2-E	Z216101
R91	1·1kΩ 2% ¼W	RC2-E	Z215650
R93	3·3kΩ 10% ¼W	RC7-K	Z222067
R95	3·3kΩ 2% ¼W	RC2-E	Z215760
R99, R129	1·08MΩ 0·5% ¼W	Plessey Metalux AT	GR90196
R100, R148	360kΩ 0·5% ¼W	Plessey Metalux AT	GR90191
R102	6·8kΩ 5% ¼W	RC2-E	Z215341
R103, R136	22kΩ 2% ¼W	RC2-E	Z216291
R104	150kΩ 2% ¼W	RC2-E	Z216490
R106, R107	20kΩ 2% ¼W	RC2-E	Z215281
R110	360Ω 1% ¼W	Plessey Metalux AT	GR90175
R112	43kΩ 2% ⅛W	Electrocil NJ60	GR10050
R113, R135	22kΩ 10% ¼W	RC7-K	Z222172
R114, R122	800kΩ 0·5% ¼W	Plessey Metalux AT	GR00095
R115, R123	280kΩ 0·5% ¼W	Plessey Metalux AT	GR00096
R116	3·3MΩ 10% ¼W	RC7-K	Z223226
R119, R120	8MΩ 1% 1W	Welwyn C13	GR70314

CCT. REF.	DESCRIPTION	MNFR. OR I.S. STYLE	REF. NO.
R121	2·8MΩ 1% ¾W	Welwyn C23	GR70311
R124	80kΩ 0·5% ¼W	Plessey Metalux AT	GR00097
R125	28kΩ 0·5% ¼W	Plessey Metalux AT	GR00098
R126	12kΩ 0·5% ¼W	Plessey Metalux AT	GR00099
R127	1·08MΩ 0·5% ¾W	Welwyn 54C23	GR70318
R128, R130	130kΩ 0·5% ¼W	Plessey Metalux AT	GR09431
R131	120kΩ 0·5% ¼W	Plessey Metalux AT	GR00035
R132, R133	82Ω 5% ¼W	RC2-E	Z215111
R137	620kΩ 5% ¼W	RC2-E	Z216964
R141	2·8MΩ 1% ¾W	Welwyn C23	GR70311
R142	7·5kΩ 1% ¼W	RC2-E	Z215845
R143	3MΩ 2% 2W	Welwyn C25	GR05501
R144	390Ω 10% ¼W	RC7-K	Z221184
R145	680Ω 10% ¼W	RC7-K	Z221214
R146	15kΩ 2% ¼W	RC2-E	Z216251
R147	2·2MΩ 2% ¾W	Welwyn 54C23	GR25217
R149, R150	910kΩ 0·5% ¼W	Plessey Metalux AT	GR00093
R154	120MΩ 2% 2W	Welwyn C14	GR20159
R157	4·7MΩ 5% ¼W	RC2-E	Z217811
R158	3·0MΩ 5% ¼W	RC2-E	Z216995
R159	2·0MΩ 5% ¼W	RC2-E	Z216983
R160, R161	1·2MΩ 5% ¼W	RC2-E	Z216971
R151	22kΩ 10% ¼W	RC7-K	Z222172
Resistors, Variable			
RV1	2·5kΩ 20% ¼W	Plessey G-Mk5	Z118260
RV2, RV3, RV4, RV5, RV6, RV12	100kΩ 20% ¼W	Plessey MP 'Dealer'	GR35048
RV7	2·2MΩ 20% ¼W	Plessey MP 'Dealer'	GR35028
RV8, RV9	4·7kΩ 20% ¼W	Plessey MP 'Dealer'	GR35027
RV10	10kΩ 10% 1W	Colvern CLR1206	A8804
RV11, RV17	1kΩ 20% ¼W	Plessey G-Mk5	Z118259
RV13, RV14	22kΩ 20% ¼W	Plessey MP 'Dealer'	GR35047
RV16, RV18	10kΩ 20% $\frac{1}{10}$W	Egen 123	GR09819
RV19	50kΩ 20% $\frac{1}{10}$W	Egen 123	GR09820
Capacitors, Fixed			
C1, C2, C7, C8	25μF +100%−20% 12V	Hunts L28/1 MEW 17T	GC10119
C3, C12, C16, C29	8μF +100%−20% 25V	Hunts L28/1 MEW 75T	GC10120
C4, C17, C25	0·47μF 10% 125V	Mullard B2N C296AA/A170K	GC04117
C5, C6, C18, C35	0·1μF 10% 125V	Mullard B2N C296AA/A100K	GC04112

CCT. REF.	DESCRIPTION	MNFR. OR I.S. STYLE	REF. NO.
C9, C20	2·0μF 20% 250V	Hunts M301 AM106	GC12050
C10	0·047μF 10% 125V	Suflex HS28/D	GC12094
C13, C14, C26	1μF 30V	Plessey CEP38/1	GC90003
C15	50μF +100% −20% 25V	Hunts L28/1 MEW 31T	GC10075
C27	4700pF 20% 500V	Erie Ceramicon Hi-K Style B	GC08026
C30	1·5pF ±¼pF 750V	Lemco 310S	GC24158
C31	2·7pF ±¼pF 750V	Lemco 310P100	GC26060
C33	0·022 ±10% 400V	Mullard C296AC/A22K	GC04158
C34	20μF +100%−20% 125V	Plessey CE19	GC24037
	OR:	Hunts L571-SM34	GC08173
C22	100μF 20% 6V	Wima 'Printilyt'	GC10106
C36	0·68pF ±0·1pF 750V	Lemco 310S	GC26062
C111	10pF ±10% 750V	Lemco 310P100	GC24160

Diodes

CCT. REF.	TYPE	REF. NO.
MR1, MR8, MR9, MR10, MR11, MR17	Mullard OAZ 246	GC24010
MR2, MR3, MR4, MR5, MR6, MR7, MR12, MR13, MR14, MR15	Mullard OA47	GV24012
MR16, MR18	STC Bay 31	GC25146
MR19, MR20, MR21	Mullard OA200	GV24022

Transistors

CCT. REF.	TYPE	REF. NO.
VT1	G.E.C. GET115	GV28100
VT2, VT7, VT9, VT10, VT19, VT22	Mullard OC44	CV7003
VT3, VT6	Mullard 2N1304	GV28076
VT4, VT5	Mullard OC84	GV28039
VT8	Mullard BCZ11	GV28040
VT11, VT13	S.T.C. BSY27	GV28131
VT12, VT14	Mullard OC202	GV28044
VT15, VT23	Semiconductors Ltd. SPC40*	GV01186
VT16, VT17, VT18	Mullard OC170	GV28069
VT20	G.E.C. GET888	GV28102
VT21	Mullard 2N1308	GV28075

* Some units are fitted with S.T.C. Type BSY27 selected in accordance with GEB Dwg. B9444.

Miscellaneous Components

CCT. REF.	TYPE	REF. NO.
M1	Meter	C8886
TH1	Thermistor, Mullard VA1047	GR70201
T1	Transformer	B8788
T2	Transformer	B9462
SA	Switch (Range)	B8653
SB	Switch (Meter)	B8654
SC	Switch (Function)	B8655
TL1	Terminal, Belling Lee, L1499/315/GREEN	GB10157
TL2	Terminal, Belling Lee, L1499/315/BLACK	GB10158
TL3, TL4, TL5	Terminal, Belling Lee, L1499/315/RED	GB10156

PROBES & MULTIPLIER

CCT. REF.	DESCRIPTION	MNFR. OR I.S. STYLE	REF. NO.
Unterminated Probe B4355			
R1	150Ω 10% $\frac{1}{10}$W	Radio Res LX	GR09206
R2, R3	3·9MΩ 1% $\frac{1}{4}$W	S.T.C. Type 4305	GR90046
RV1	3·3MΩ 20%	Egen 123	GR09494
C1	6800pF 20% 400V	Wima Tropyfol 'F'	GC24101
C2, C3	0·022μF 20% 30V	Mullard C280AA/P22K	GC00012
MR1, MR2	Diode	A.E.I. CG91H	GV25226
50Ω Terminated Probe A4354/1			
R1, R2	100Ω 5% $\frac{1}{4}$W	Morganite Type S	GR09535
R3	2MΩ 5% $\frac{1}{4}$W	RC2-E	Z216983
RV1	3·3MΩ 20%	Egen 123	GR09494
C1, C2	1000pF +50%−25% 750V	Lemco Disc Type 07K	GC24155
C3	0·022μF 20% 30V	Mullard C280AA/P22K	GC00012
MR1	Diode	A.E.I. CG91H	GV25226
75Ω Terminated Probe A4354/2			
R1	75Ω 5% $\frac{1}{4}$W	Morganite Type S	GR09534
R3	2MΩ 5% $\frac{1}{4}$W	RC2-E	Z216983
RV1	3·3MΩ 20%	Egen 123	GR09494
C1, C2	1000pF +50%−25% 750V	Lemco Disc Type 07K	GC24155
C3	0·022μF 20% 30V	Mullard C280AA/P22K	GC00012
MR1	Diode	A.E.I. CG91H	GV25226
Multiplier (×100) Probe A4353			
R1	10MΩ 5% $\frac{1}{4}$W	RC7-K	Z223286
R2	2·2MΩ 10% $\frac{1}{4}$W	RC7-K	Z223205
R3	12Ω 10% $\frac{1}{4}$W	RC7-K	Z221007
R4	470Ω 10% $\frac{1}{4}$W	RC7-K	Z221193
C1	1pF ±0·1pF 750V	Lemco 310 S	GC04144
C2	2-40pF Variable 500V	Wingrove & Rogers S14-01	GC20113
C3	75pF 2% 750V	Lemco 310N750	GC04146

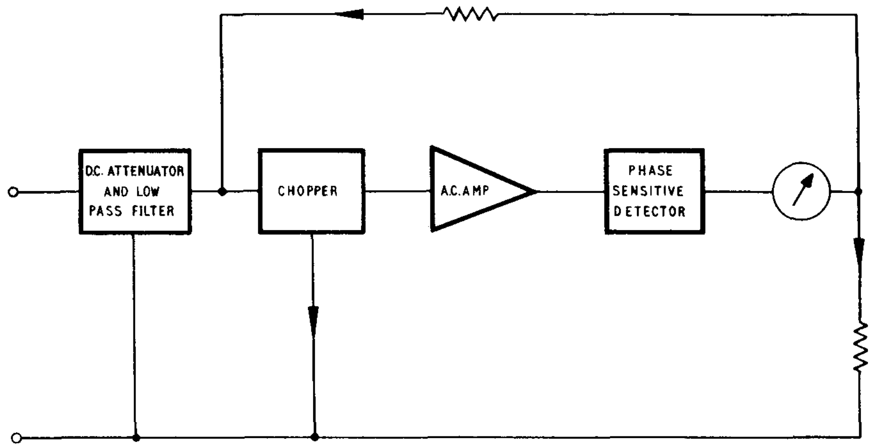


FIG.1a. MULTIMETER IN DC, OHMS OR RF MODE - BLOCK DIAGRAM

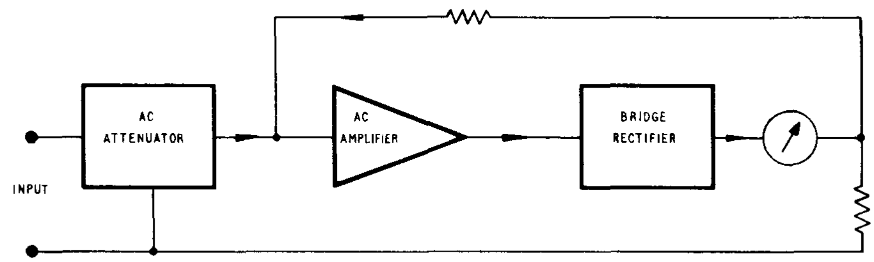


FIG. 1b. MULTIMETER IN AC MODE: BLOCK DIAGRAM

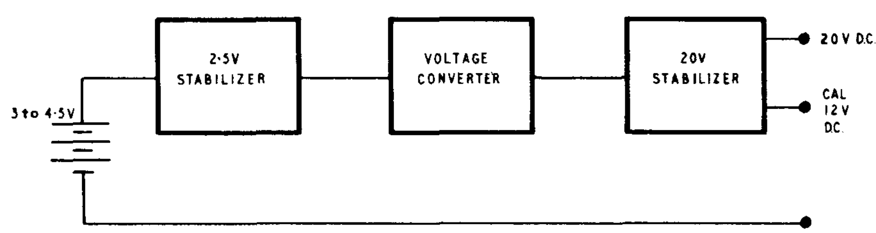


FIG. 1c. POWER SUPPLY: BLOCK DIAGRAM

Fig. 1: Multimeter Type CT471: Block Diagram

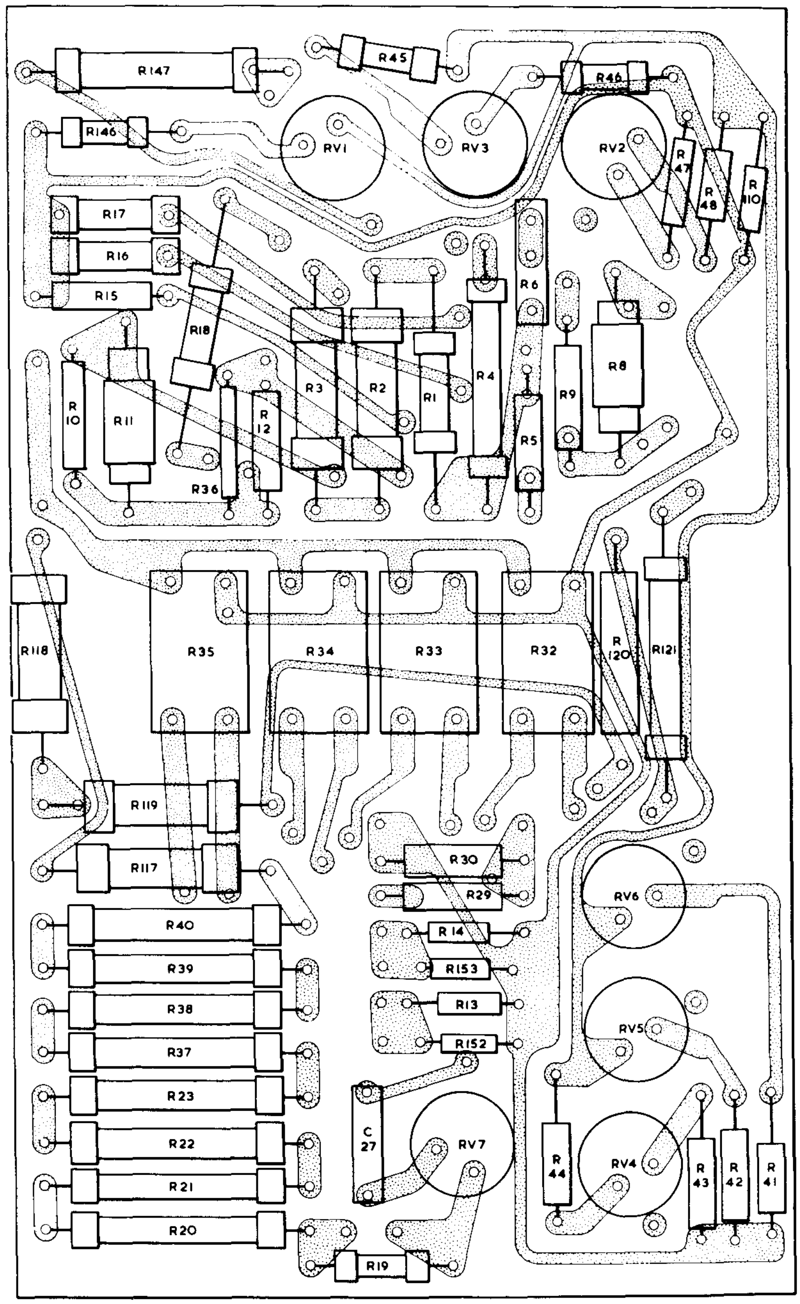


Fig. 2: Attenuator Board: Component Location

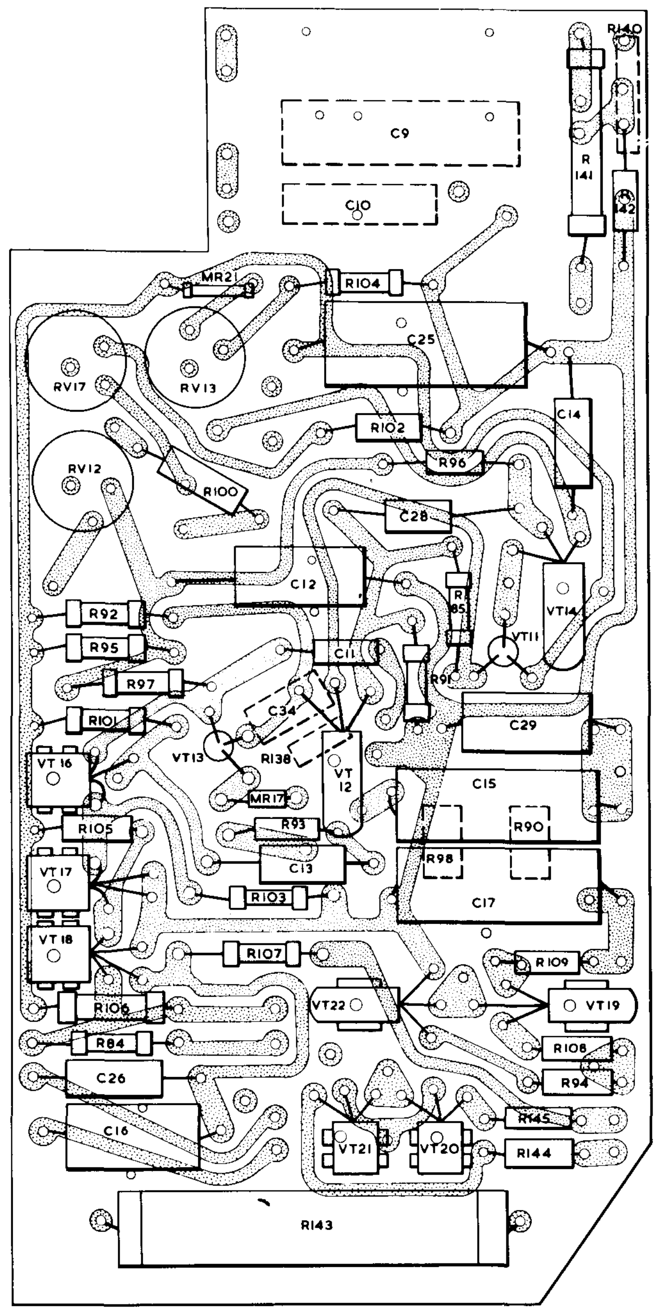


Fig. 3: Amplifier Board: Component Location

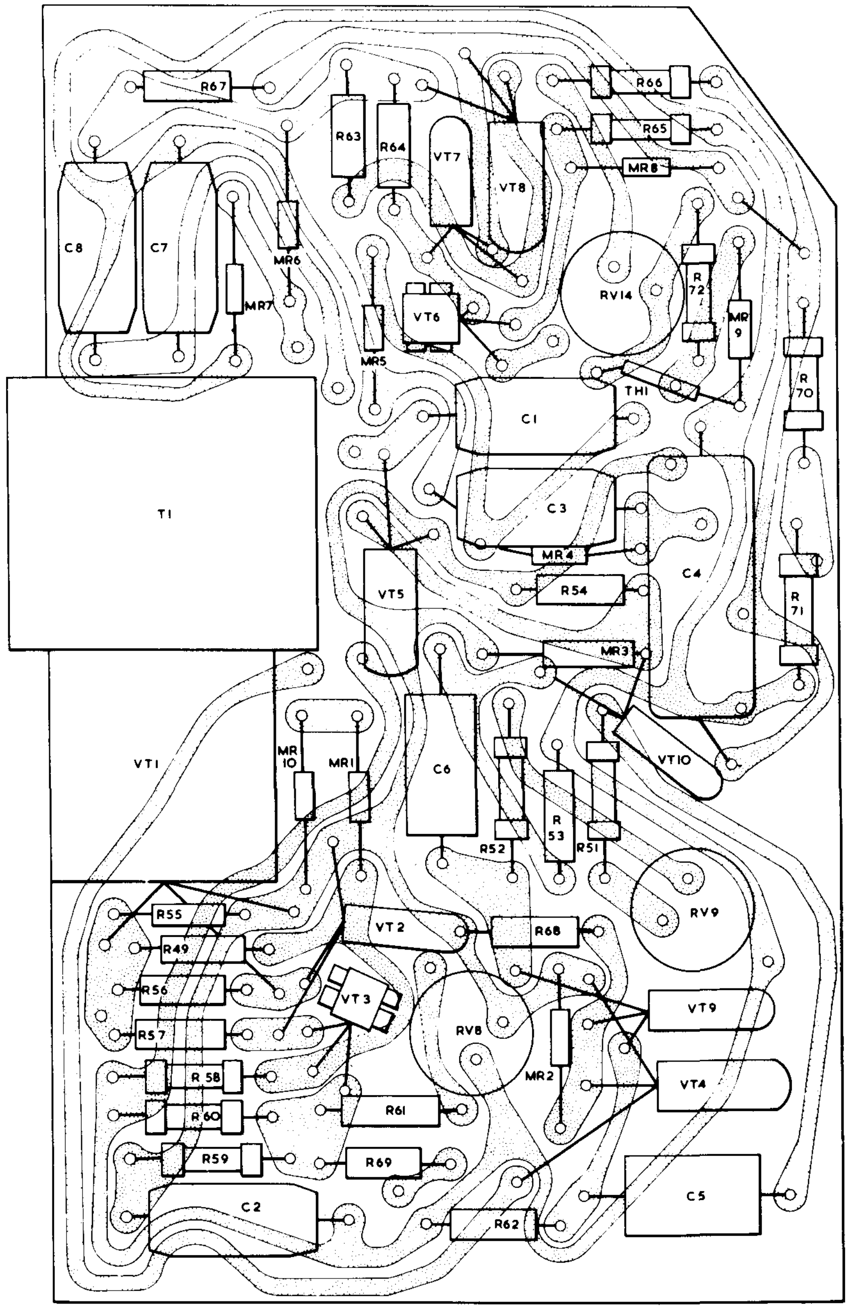


Fig. 4: Power Supply Board: Component Location

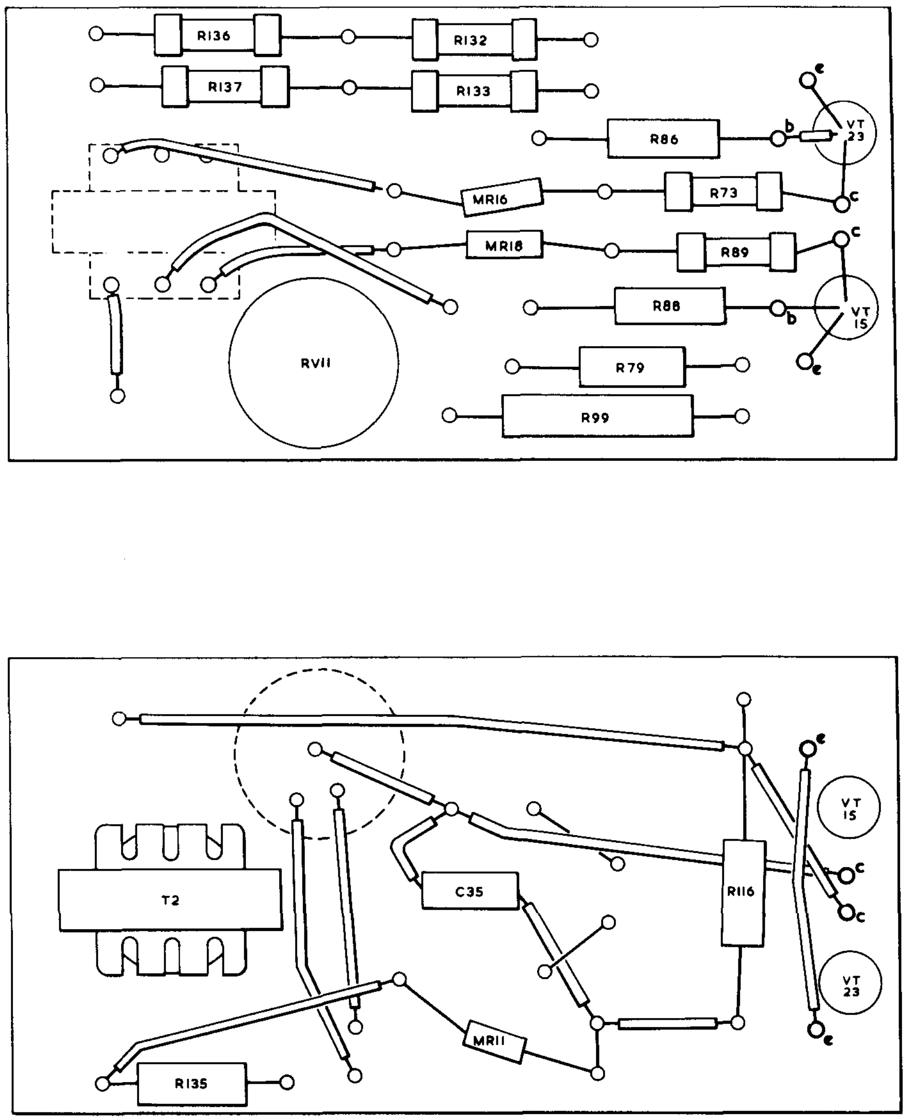


Fig. 5: Chopper Board: Component Location

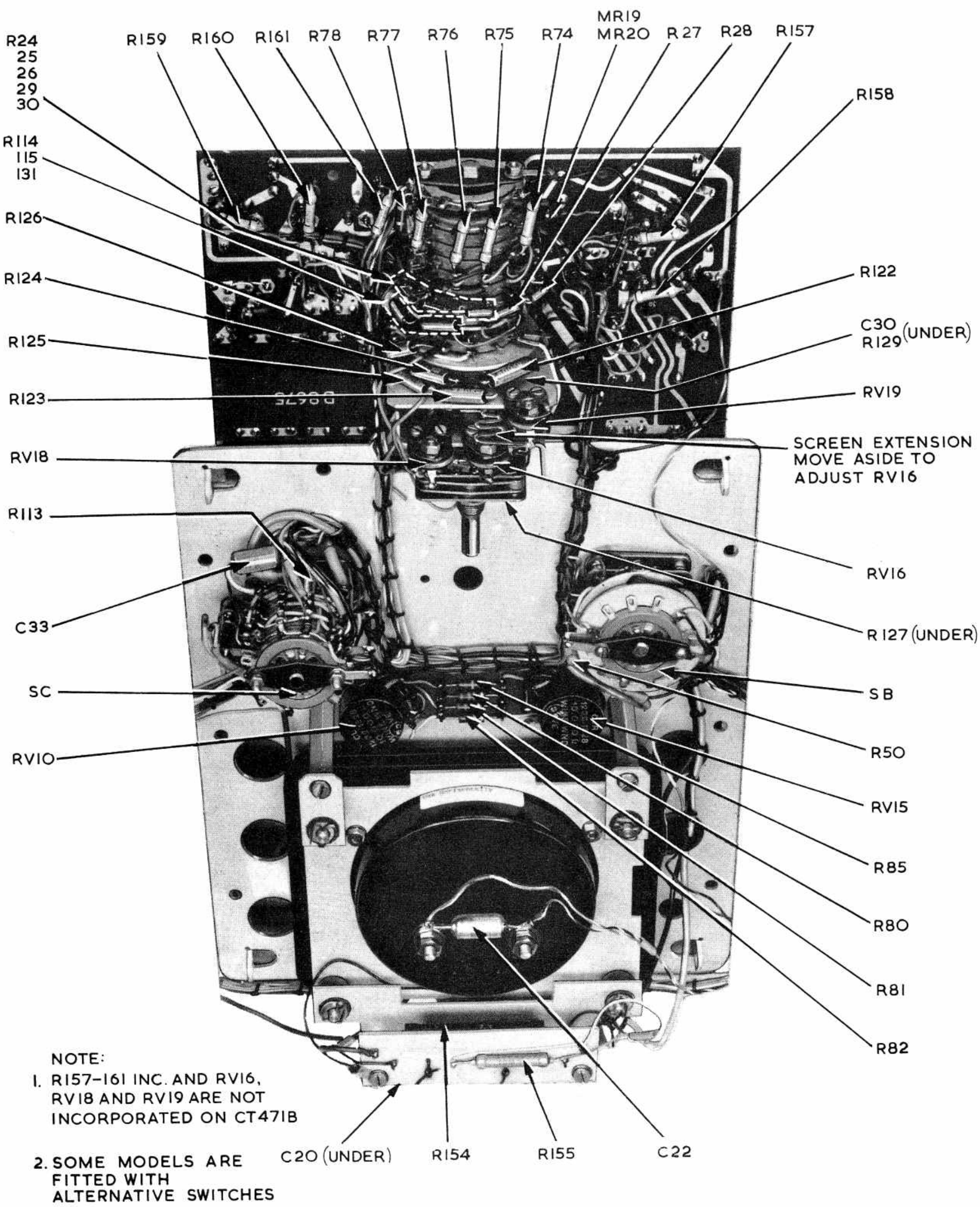


Fig. 6: Attenuator Board and Range Switch Assembly

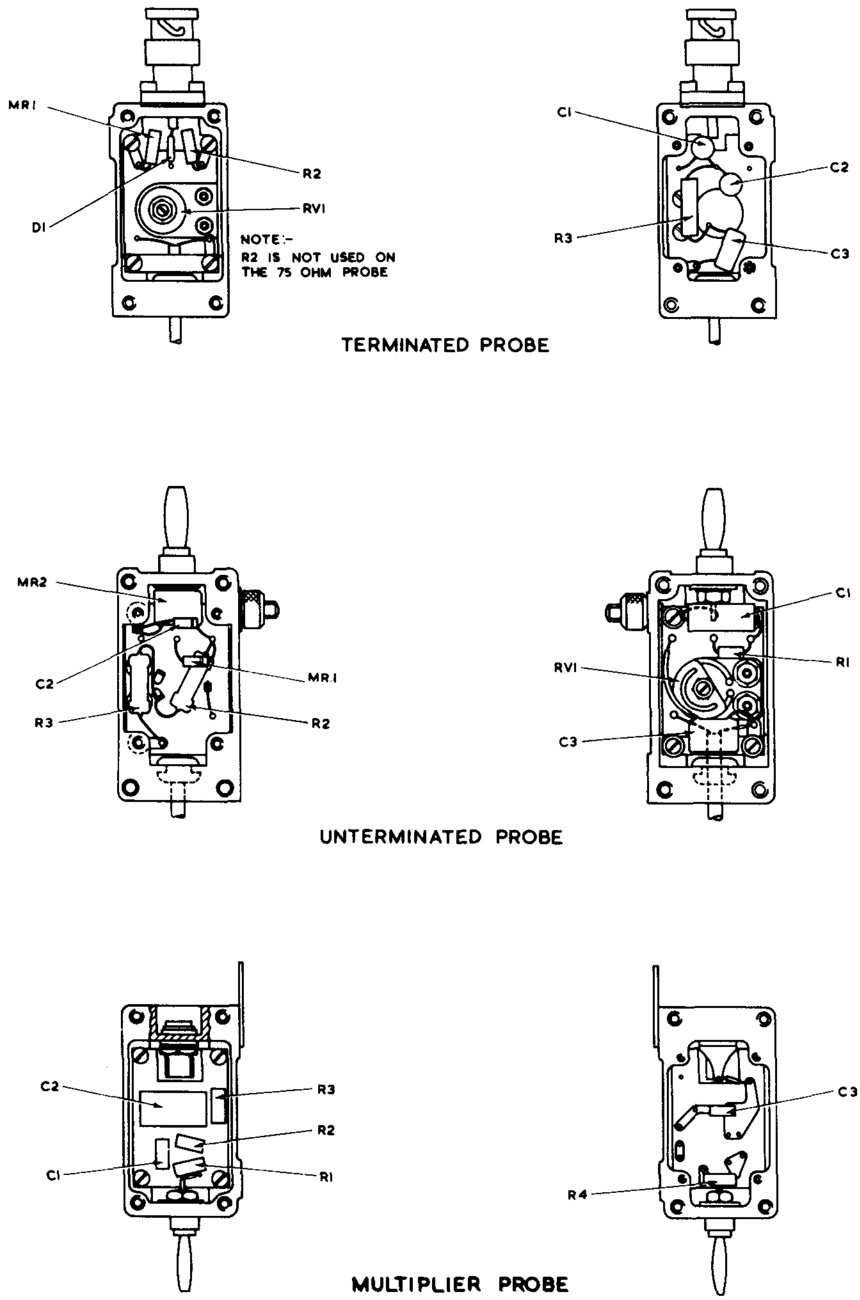
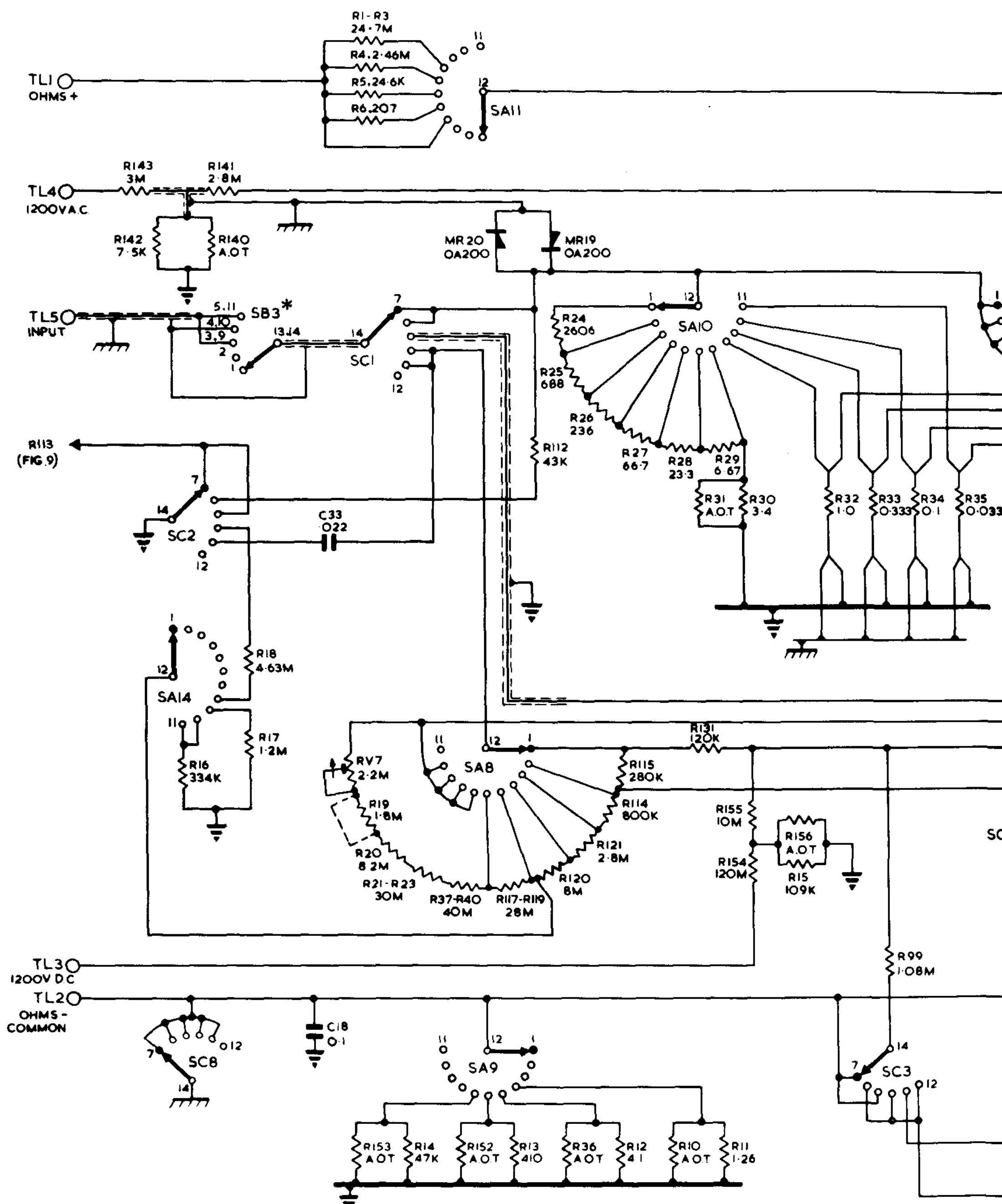
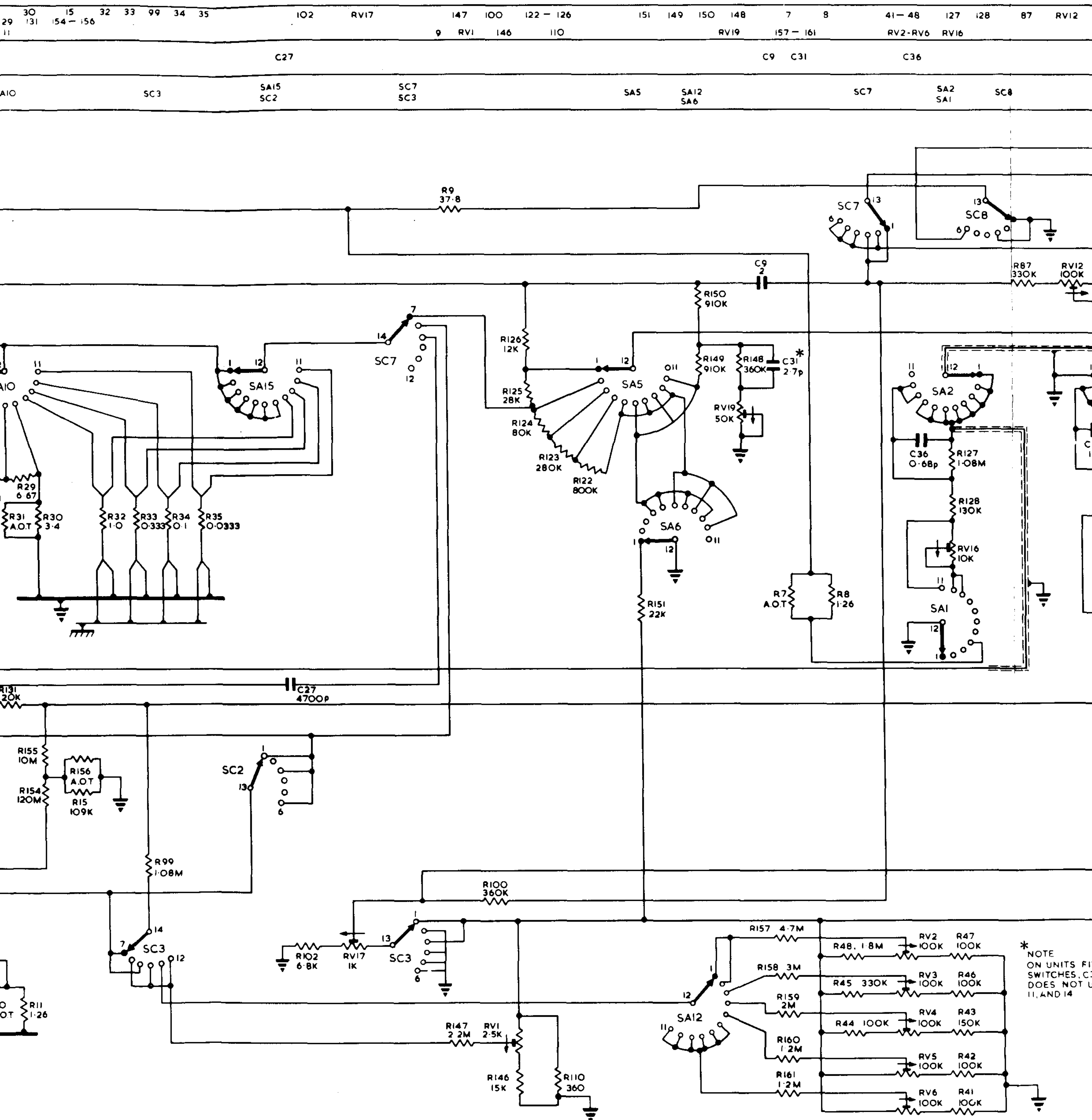
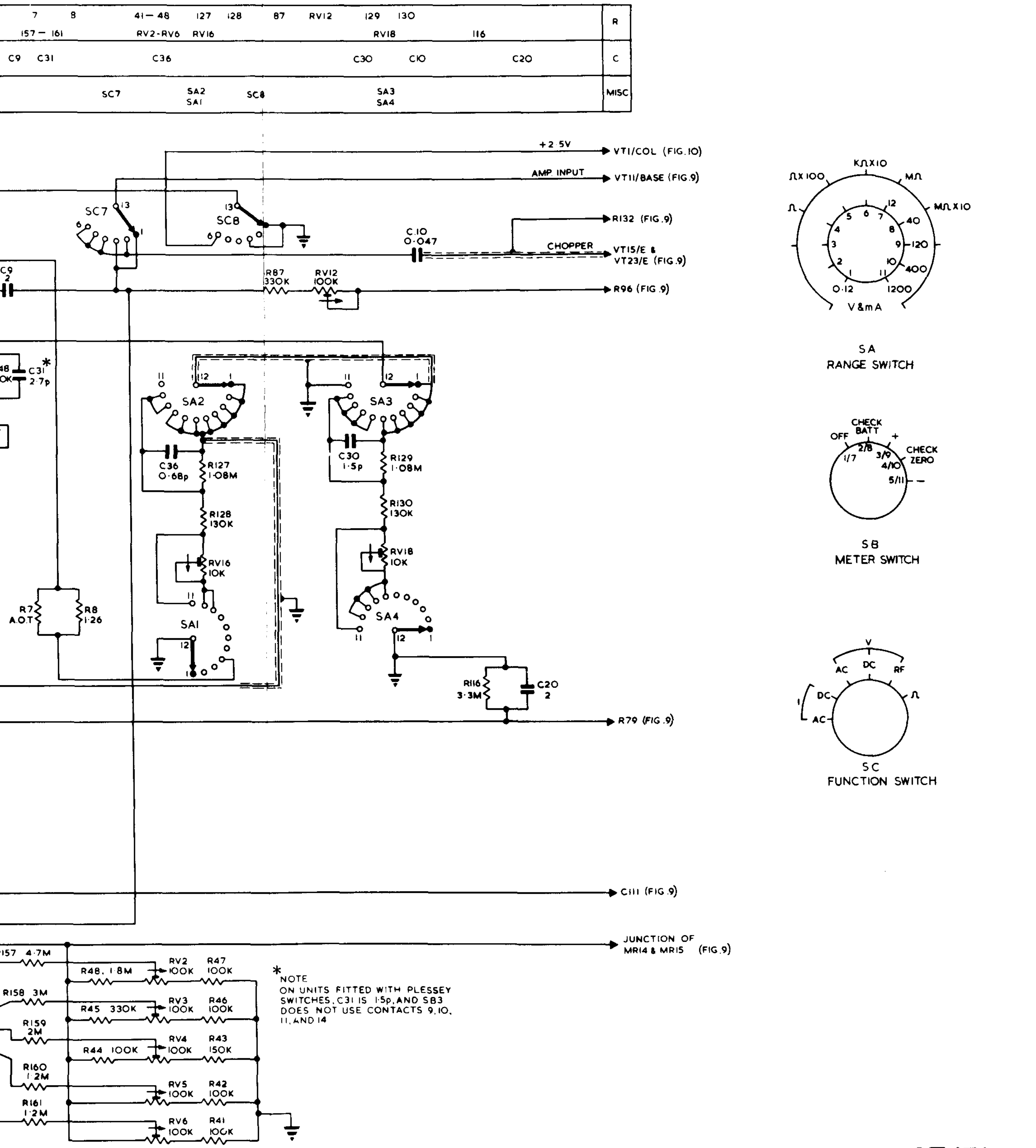


Fig. 7: Probes: Component Location

R	143 142 16 140 141 18 17 1–6 153 RV7 14 19–23 37–40 152 117–119 13 112 120 121 114 24–26 115 36 12 31 27–29 10 11 30 131 15 154–156 32 33 99 34 35
C	C18 C35
MISC	TL1-TL5 SC2 SA14 SC8 SB3 SC1 SA11 SA8 SA9 MR20 MR19 SA10 SC3




30 15 32 33 99 34 35 102 RV17 147 100 122 — 126 151 149 150 148 7 8 41—48 127 128 87 RV12
29 131 154—156 9 RV1 146 110 RV19 157—161 RV2-RV6 RV16
C27 C9 C31 C36
SA10 SC3 SA15 SC2 SC7 SC3 SA5 SA12 SA6 SC7 SA2 SA1 SC8
R9 37·8
SC7 SC8
C9 2
R87 330K
RV12 100K
R150 910K
R126 12K
R125 28K
R124 80K
R123 280K
R122 800K
R149 910K
R148 360K
C31 2·7p
RV19 50K
SA15
SA5
SA6
SA2
C36 0·68p
R127 1·08M
R128 130K
RV16 10K
SA1
R7 A.O.T
R8 1·26
R151 22K
R29 6·67
R31 A.O.T
R30 3·4
R32 1·0
R33 0·333
R34 0·1
R35 0·0333
R131 120K
C27 4700p
R155 10M
R156 A.O.T
R154 120M
R15 109K
SC2
R99 1·08M
SC3
R11 1·26
R100 360K
R102 6·8K
RV17 1K
R157 4·7M
R48 1·8M
RV2 100K
R47 100K
R158 3M
R45 330K
RV3 100K
R46 100K
SA12
R159 2M
R44 100K
RV4 100K
R43 150K
R160 1·2M
RV5 100K
R42 100K
R161 1·2M
RV6 100K
R41 100K
R147 2·2M
RV1 2·5K
R146 15K
R110 360
* NOTE
ON UNITS FI
SWITCHES, C
DOES NOT U
11, AND 14



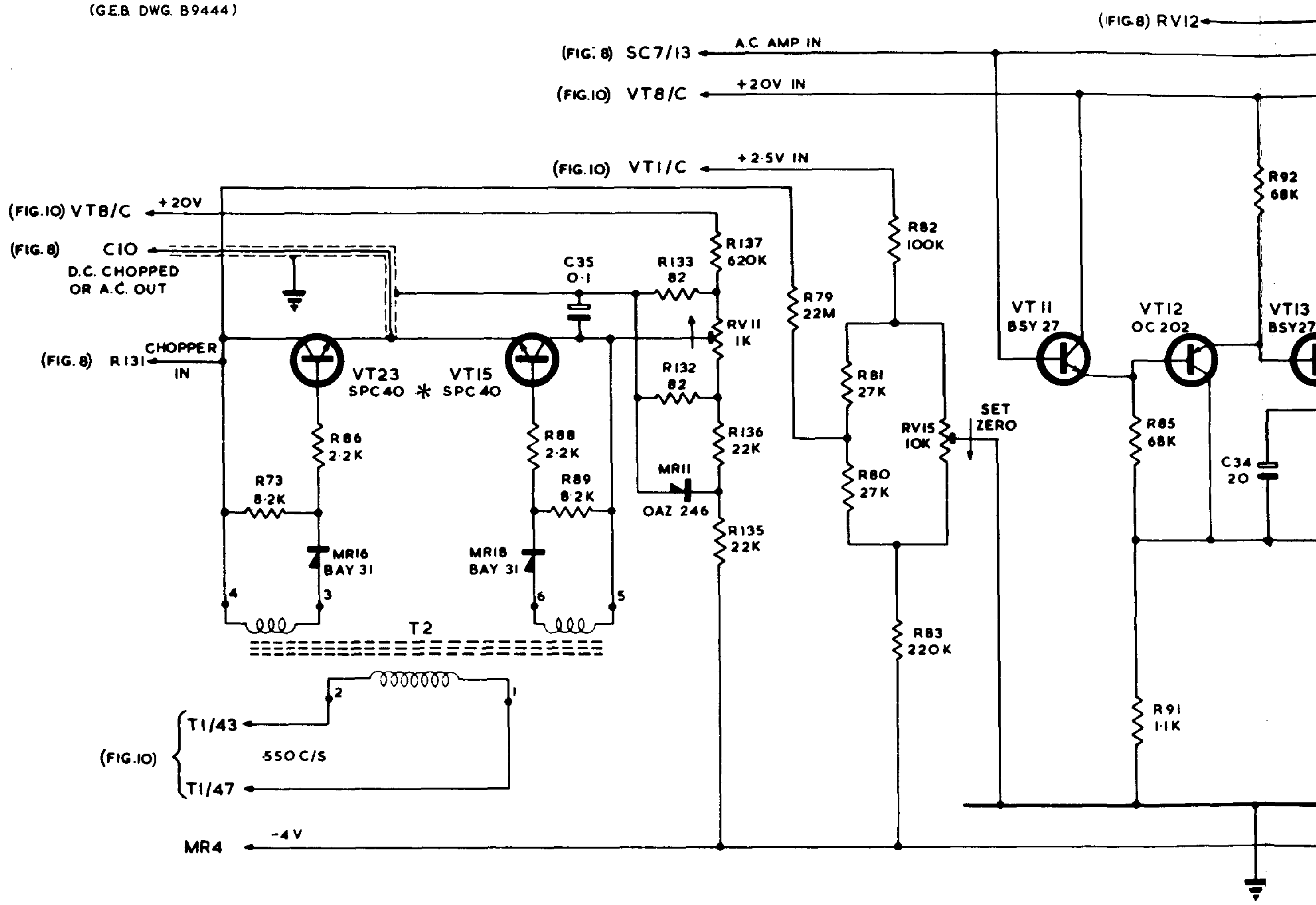
ATTENUATOR CIRCUIT DIAGRAM CT471

FIG. 8

GEB DWG. No. E4317

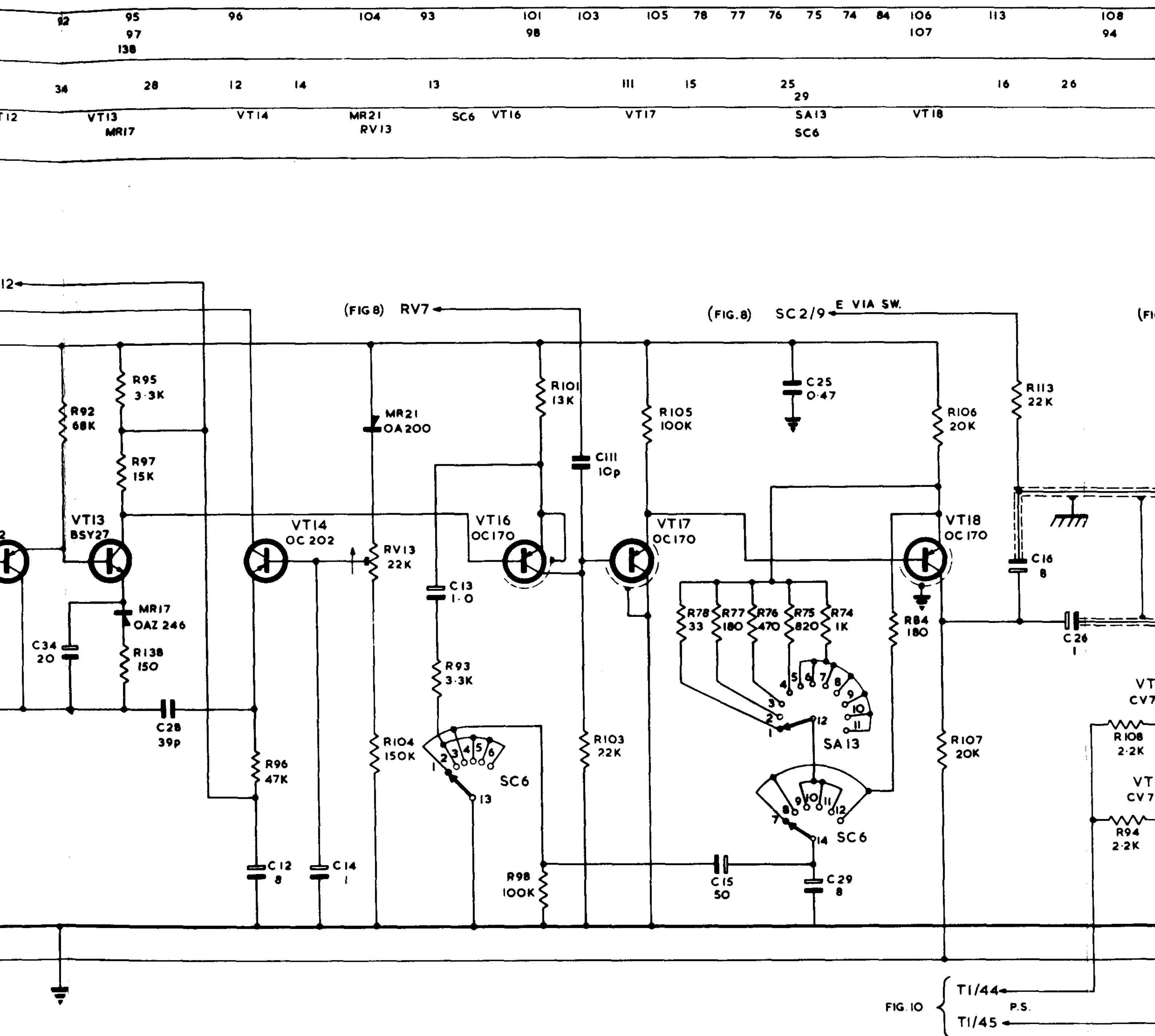
R	73	86		88	89		133 132	137 136 135	79	81 80	82 83		85 91		92	
C						35									34	
MISC.		VT 23 MR16	T 2	VT15	MR18		MR11	RV11			RV 15	VT 11		VT 12		VT1

* VT 15 AND VT 23
SOME UNITS ARE FITTED
WITH SELECTED BSY27
(G.E.B. DWG. B9444)



D.C. CHOPPER

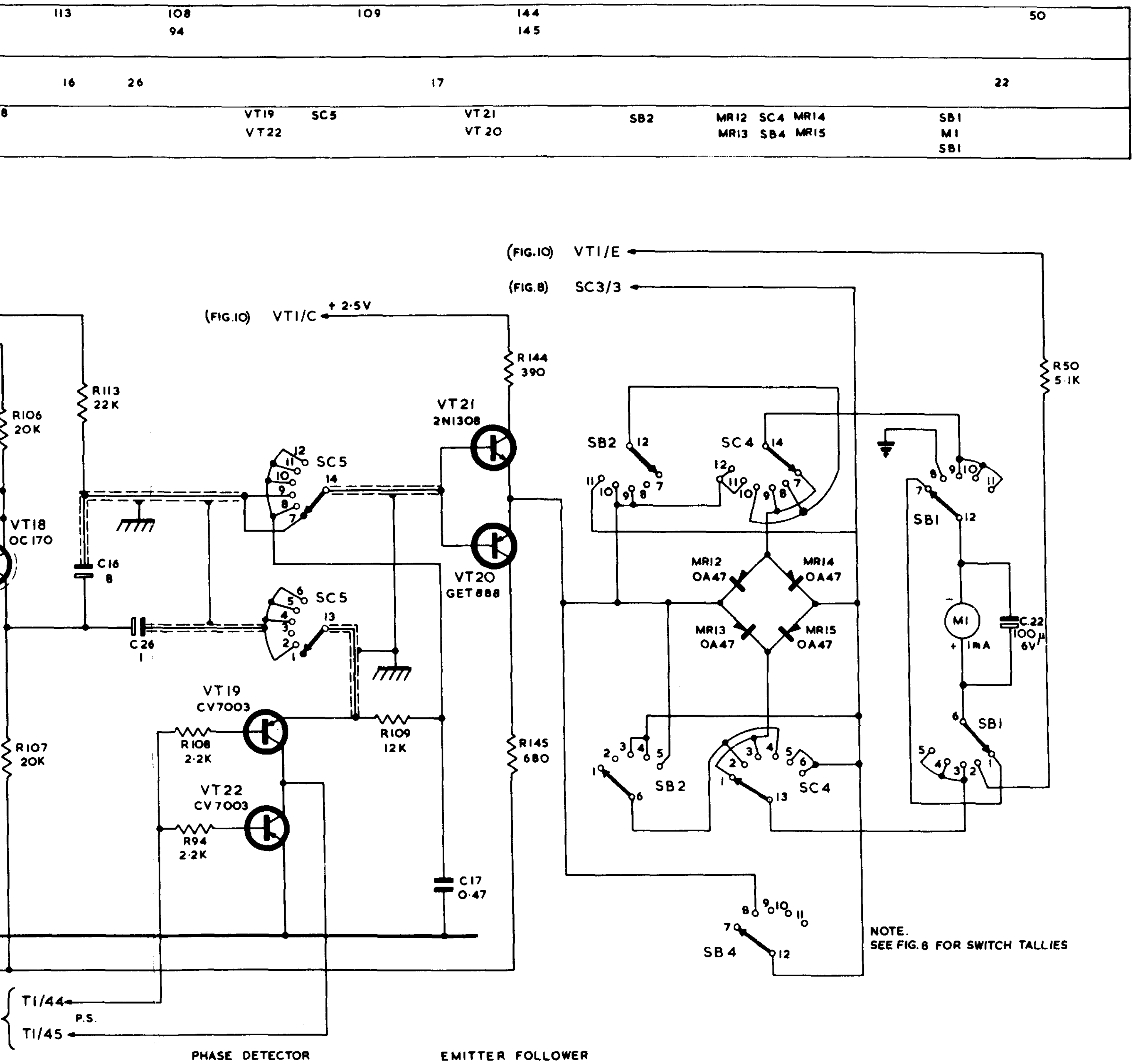
A.C. AMPLIFIER



C. AMPLIFIER

AMPLIFIER

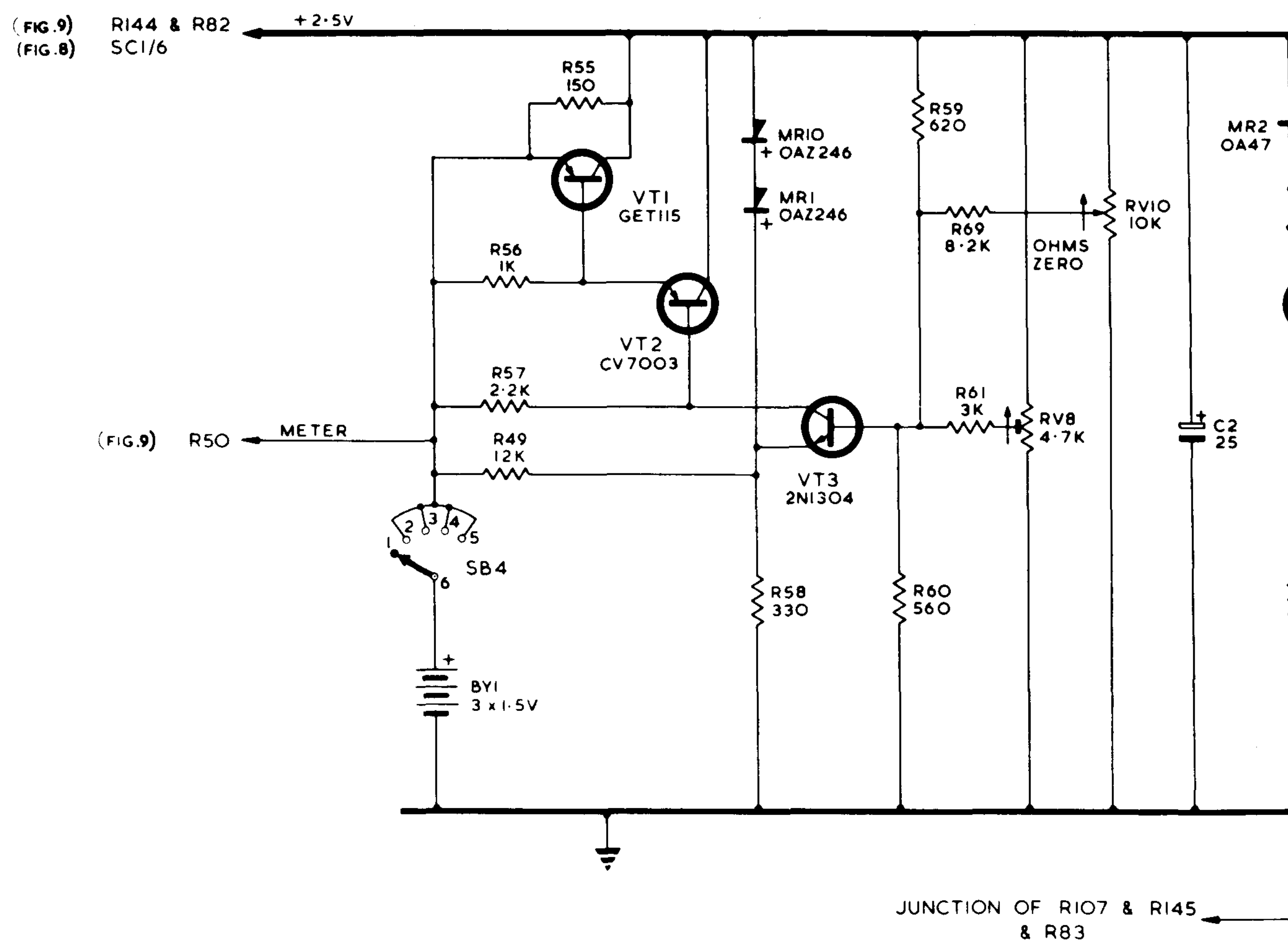
PHAS



AMPLIFIER & METER CIRCUIT DIAGRAM CT471
FIG.9

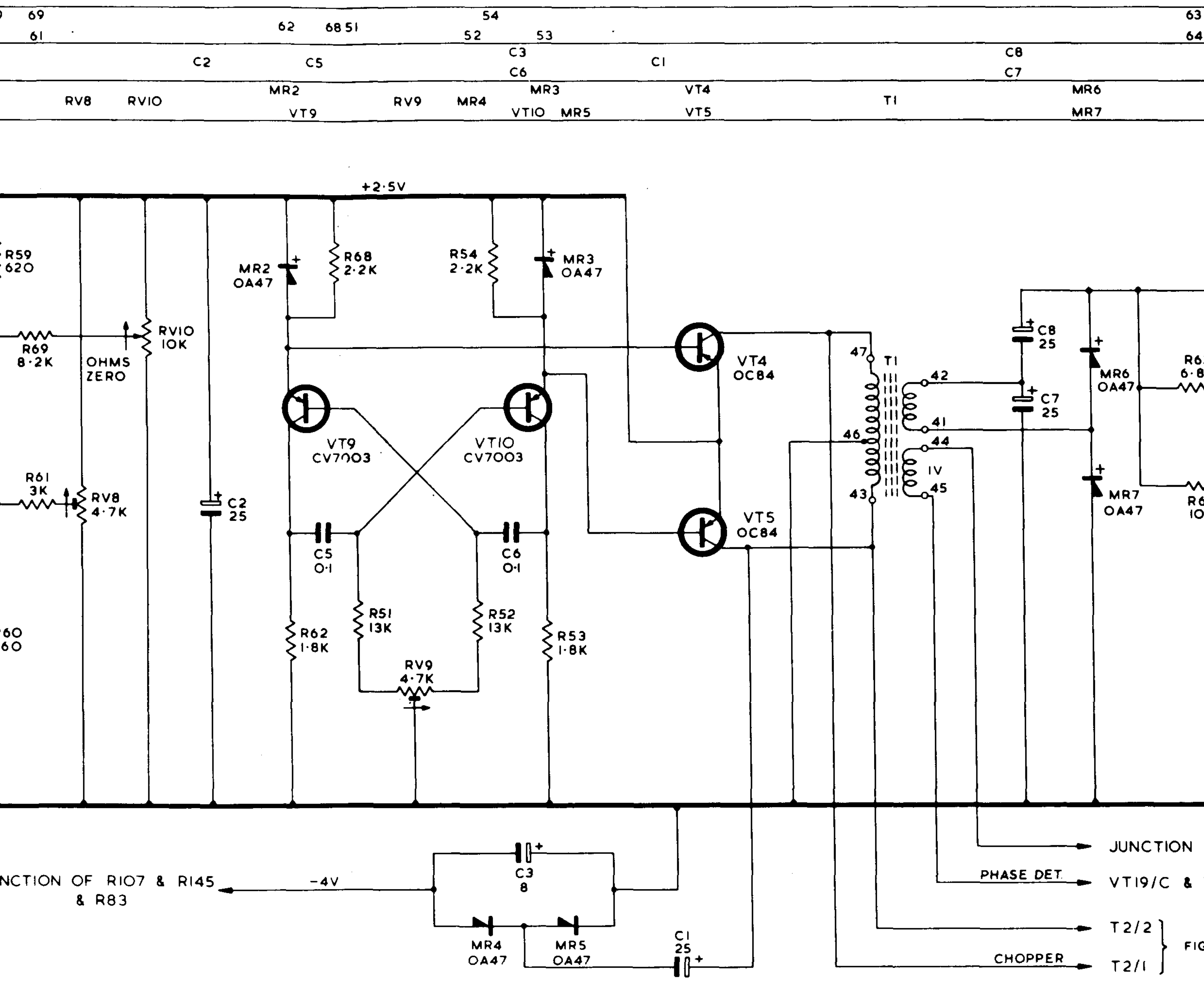
G.E.B DWG No E 4317

R	49 57 56 55 58 59 60 69 61 6
C	C2
MISC.	SB4 BY1 VT1 VT2 MR10 MR1 VT3 RV8 RV10 MR

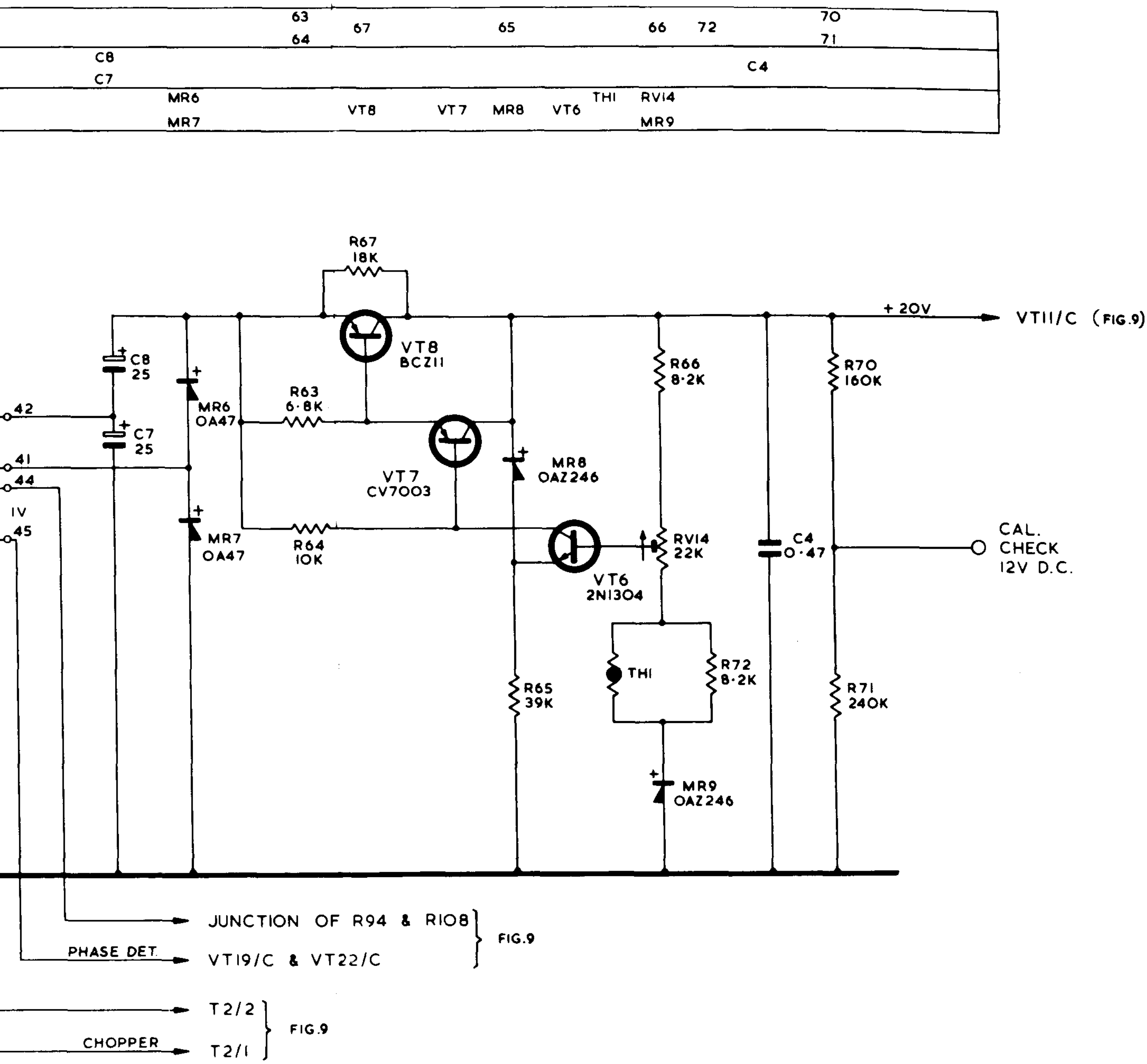


NOTE -
SEE FIG.8 FOR SWITCH TALLIES

2·5V STABILIZER



550c/s MULTIVIBRATOR SWITCH



20V STABILIZER

POWER SUPPLY CIRCUIT DIAGRAM CT471
FIG. 10

GEB DWG No E 4317

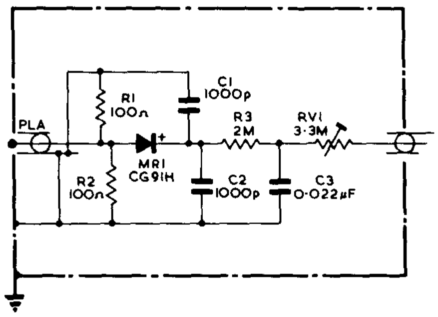


FIG. 11a 50-OHM TERMINATED PROBE

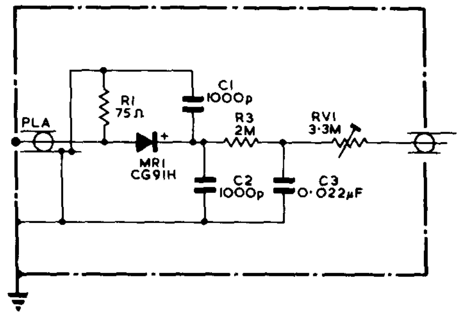
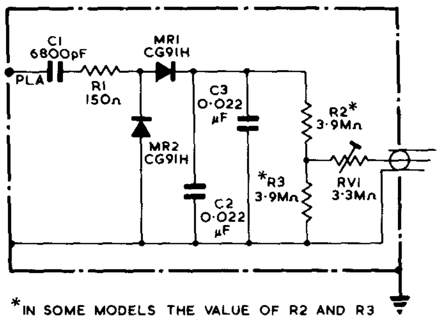


FIG. 11b 75-OHM TERMINATED PROBE



*IN SOME MODELS THE VALUE OF R2 AND R3 IS 4·7MΩ

FIG. 11c UNTERMINATED PROBE

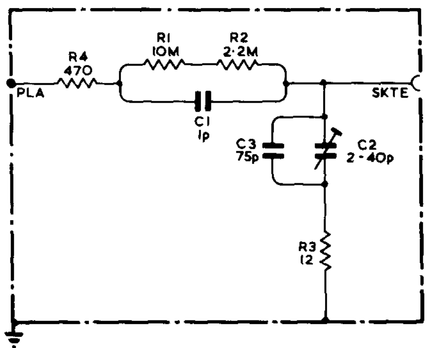


FIG. 11d MULTIPLIER PROBE

PROBES: CIRCUIT DIAGRAMS

FIG. 11

GEB G. No. A4484 A4485
A4495 A9432

GUARANTEE

We will make good by repair or replacement any defects in products of our manufacture not caused by wear and tear, accident, mis-use or neglect, provided

(1) that such defects are brought to our notice not later than 12 months from the date the goods were first despatched and

(2) that no unauthorized repair or replacement has been previously carried out or attempted. We do not guarantee the products of other manufacturers which form part of the goods of our manufacture, but will pass on to our customer the full benefits we have received in respect of guarantees offered by such other manufacturers in respect of their goods.

This guarantee is given in lieu of any warranty implied by statute or otherwise, and our liability thereunder is expressly limited to the cost of the repair or replacement made by us or to our order.

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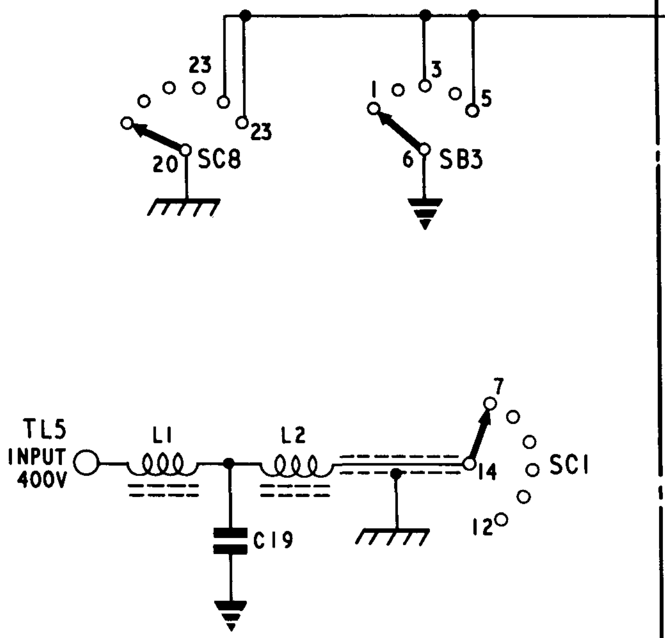
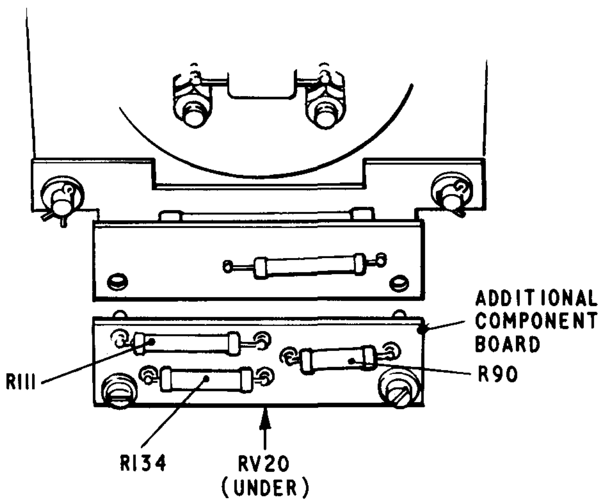
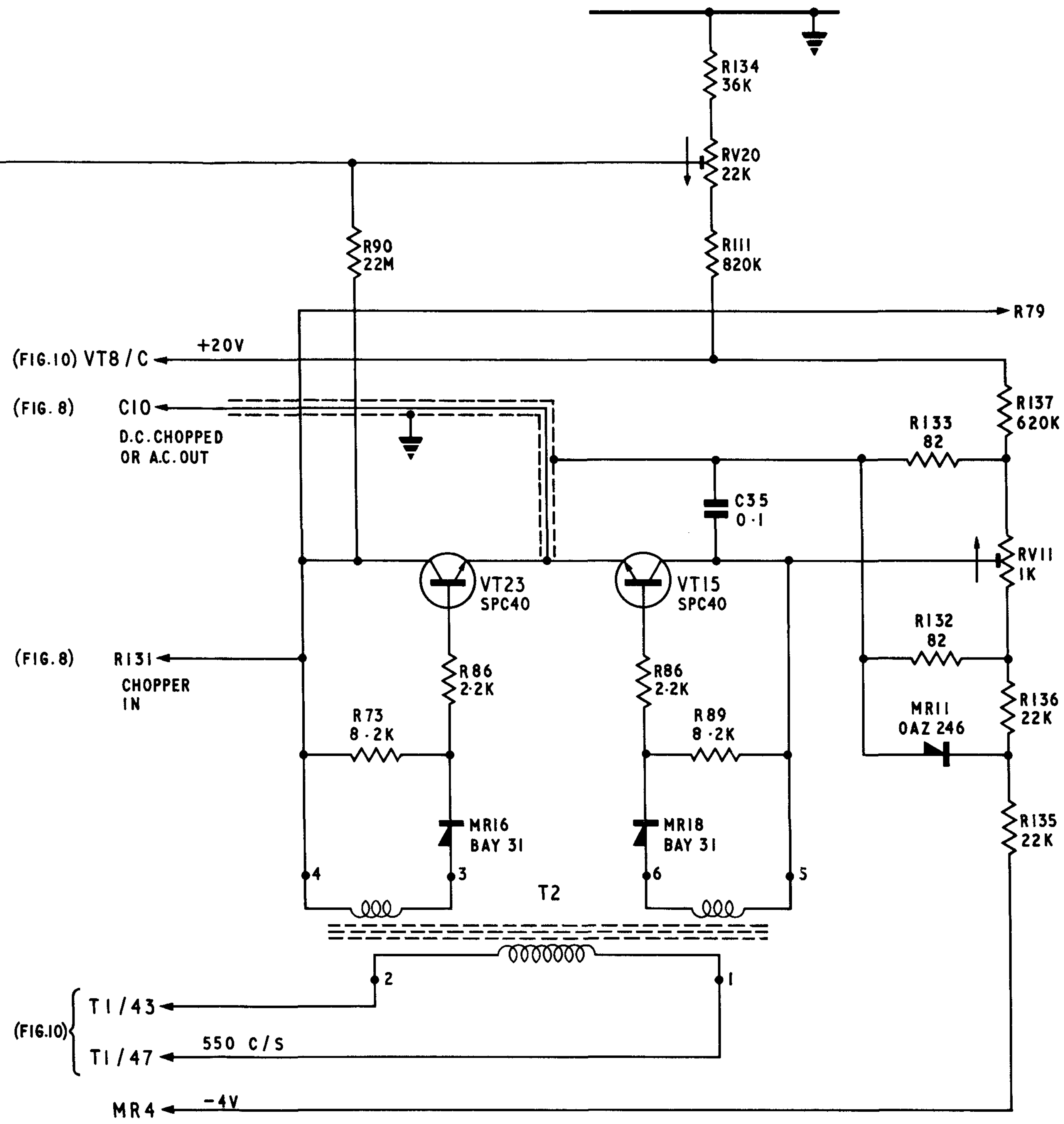
✱ REFER TO NOTE ON FIG. 8
ALL INSTRUMENTS TYPE CT471C
ARE FITTED WITH PLESSEY
TYPE SWITCHES.



Part Of Fig.8



LOCATION OF ADDITIONAL COMPONENTS ON CT471C COMPARE WITH FIG.6 IN MAIN TEXT

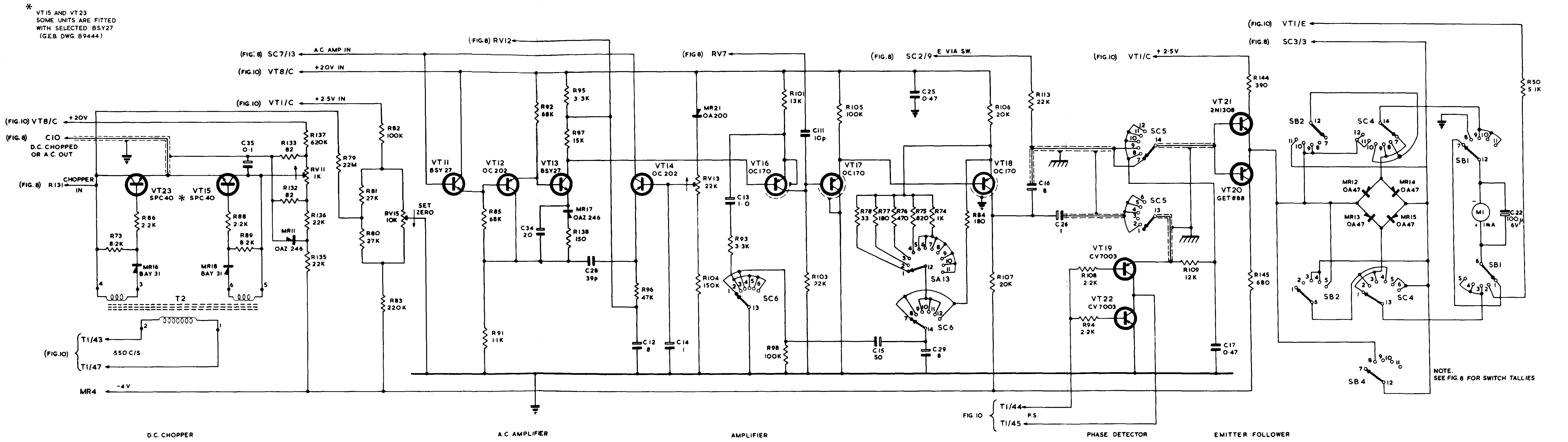


D. C. CHOPPER

Part Of Fig. 9

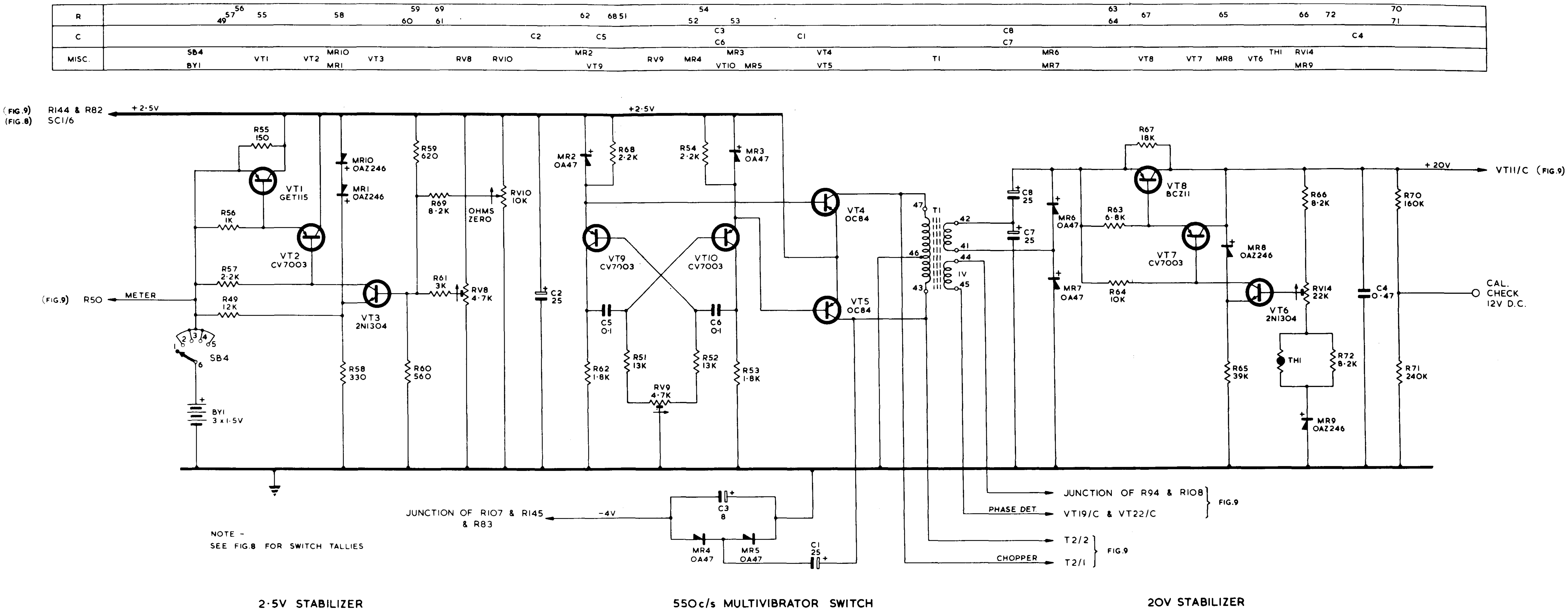
APPENDIX FIG. 1
CIRCUIT DIFFERENCES FOR MULTIMETER TYPE CT471C

R	73 86 88 89 133 132 137 136 135 79 81 80 82 83 85 91 92 95 97 138 96 104 93 101 98 103 105 78 77 76 75 74 84 106 107 113 108 94 109 144 145 50
C	35 34 28 12 14 13 111 15 25 29 16 26 17 22
MISC.	VT23 MR16 T2 VT15 MR18 MR11 RV11 RV15 VT11 VT12 VT13 MR17 VT14 MR21 RV13 SC6 VT16 VT17 SA13 SC6 VT18 VT19 VT22 SC5 VT21 VT20 SB2 MR12 MR13 SC4 SB4 MR14 MR15 SB1 M1 SB1



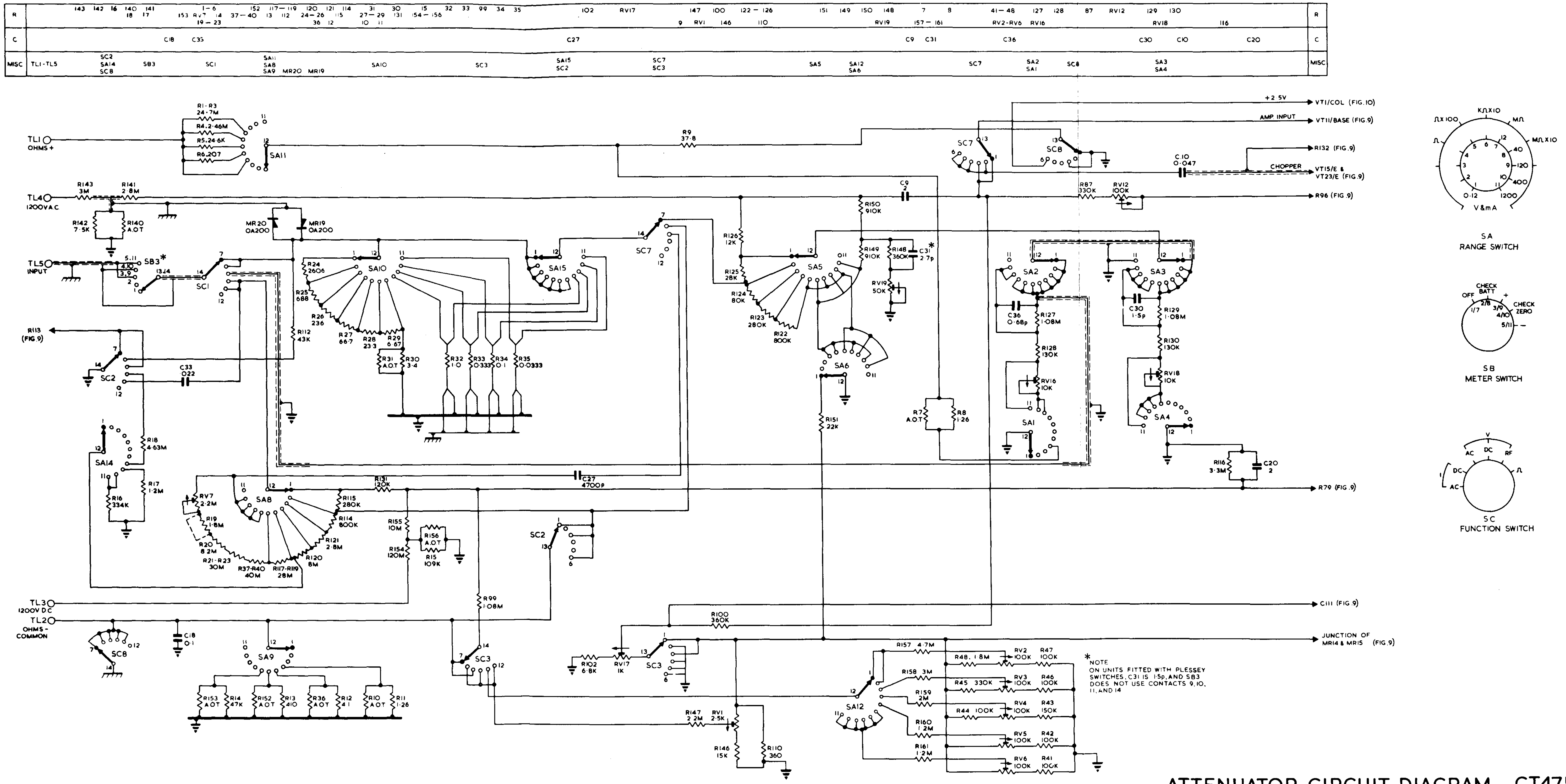
AMPLIFIER & METER CIRCUIT DIAGRAM CT471
FIG.9

G.E.B DWG No E 4317



POWER SUPPLY CIRCUIT DIAGRAM CT471
FIG. 10

GEB DWG No E4317



ATTENUATOR CIRCUIT DIAGRAM CT471

FIG. 8

GEB DWG No E4317