SECTION 1 ONE

1. INTRODUCTION

This high grade instrument, the second wide range voltmeter to be produced by Advance, has 12 overlapping ranges from 1 mV F.S.D. to 300V F.S.D. The accuracy is ± 3% F.S.D. over the frequency range of 1 c/s to 1 Mc/s, and the input impedance is 2 megohms shunted by 30 pF.

The scale is calibrated in r.m.s. volts of a sine wave ; 0 to 1 and 0 to 3, and also +2 to −12 dB ; 0 dB being 1 mW in 600 ohms.

The VM78 consists of three main sections ; a high input impedance stage ; a two section attenuator and a directly coupled amplifier which feeds the meter via the rectifier circuit.

Mercury cells are used to power the instrument, giving stable operation and long life, without hum, which together with the low noise design make possible the measurement of very small voltages.

Great care has been taken in protecting the instrument against damage from the application of an incorrectly high input voltage, and the instrument has been designed for the wide temperature range of 0 to 45°C.

2. SPECIFICATION

Voltage Ranges F.S.D.	*Attenuator Settings*
.001V	−60 dBm
.003V	−50 „
.01V	−40 „
.03V	−30 „
.1V	−20 „
.3V	−10 „
1V	0 „
3V	+10 „
10V	+20 „
30V	+30 „
100V	+40 „
300V	+50 „

Frequency Range	1 c/s to 1 Mc/s
Accuracy	± 3% F.S.D.
Input Impedance	2 megohms shunted by 30 pF.
Overload Protection	Protected for inputs up to 400V peak on 0.3V and higher ranges, and for 100V r.m.s. on 0.1V and lower ranges.
Power Supply	Battery operation only. Two mercury cells Mallory Type TR-233-R. Three mercury cells Mallory type RM−3. Battery life approximately 350 hours.
Temperature Range	0 to + 45°C.

SECTION 2 TWO

Noise	Less than 50 microvolts referred to the input when terminated in 47 Kohm or less on the .001V range.
Residual Reading	Less than 3% F.S.D. on ranges other than .001V F.S.D.
Turn-on time	High frequency position requires 20 secs. Low frequency position requires 50 secs.
Accessories	Supplied with VM78 is shielded lead type PL50, which has a capacity of 60pF. Also available is lead type PL45A which has a 10:1 capacity Divider giving an effective input capacity of 9pF.
Dimensions	$8\frac{7}{8}''$ wide x $6\frac{1}{2}''$ high x $5\frac{1}{2}''$ deep.
Weight	6 lbs. 10 ozs.
Colour	Front panel: Off white to B.S. 2660, tint No. 9-093. Case: Egg shell finish, blue to B.S. 2660, tint No. 7-086.

3. OPERATION

3:1 Function Switch

Check the battery by rotating switch to the BAT. TEST position. The meter should read above 7V on the 0 to 1 meter scale. If there is no reading or the reading is low, refer to MAINTENANCE, Section 4.

Select the required frequency response.

In general the switch will be used in the 15 c/s to 1 Mc/s position to avoid the longer time constants of the 1 c/s to 1 Mc/s position.

3:2 Range Switch

Where possible select a range which will give a reading in the upper two thirds of the meter scale. This will ensure that the accuracy of the instrument is fully utilized.

It is good practice to always switch the instrument to a high voltage range before applying external voltages and then work down to a range which will allow the external voltage to fall on the upper two thirds of the meter scale. This is particularly the case where measurements of small amounts of ripple are being made superimposed on a high D.C. potential.

MAXIMUM PEAK VOLTAGE for which the instrument is protected is 400 VOLTS on ranges 0.3 VOLT and above, and 100 VOLTS R.M.S. on 0.1 VOLT and below. There is D.C. protection of 400 volts on all ranges, but note that peak volts, that is D.C. + peak r.m.s. should not exceed 400V.

3:3 Input Terminals

The black terminal is connected to the instrument case and chassis and should normally be connected to the earth side of apparatus being tested if this is not possible care should be taken to insulate the VM78 case from ground.

3:4 Overload Protection

The instrument is fully protected against overload up to 400 volts peak on 0.3V and higher ranges, and 100V r.m.s. on 0.1V and lower ranges. On the upper ranges the method of protection is a D.C. blocking condenser and attenuators. On the lower ranges the method of protection is by diode clamps. If the overload is applied for any length of time, a 60 mA fuse will blow. This can be easily replaced by removing the instrument from its case. A spare fuse will be found adjacent to the instrument fuse in use.

SECTION 3 THREE

3:5 Non-sinusoidal Operation

The instrument is an average responding device calibrated in terms of the r.m.s. value of a sine wave. When harmonics are present additional error is introduced in accordance with the following table :—

Harmonic Content		*Error*
10%	2nd harmonic	+ 0.5%
20%	„ „	− 2%
50%	„ „	− 10%
10%	3rd „	± 4%
20%	„ „	± 8%
50%	„ „	− 20% to + 4%

3:6 Decibel Measurement

Set to the range required, bearing in mind the warning of Para. 3:2. The range indicates the number of dB to be added to the meter reading using the − 12 dB to + 2 dB scale. For example, if the meter reads − 10 dB and the range is − 40 dB, the level is − 50 dB.

To read power directly in dBm the measurement must be made across 600 ohms. (0dBm = 1mW into 600 ohms).

SECTION 4 FOUR

4. MAINTENANCE

The mercury cells should be replaced when the voltage indicated on the meter falls to 7V.

This may be easily carried out by removing the instrument from its case and unscrewing the battery cover. The position and polarity of the individual cells are shown on the top of the battery cover.

Note: The insulating tubing around the RM—3 cells should not be discarded but should be placed on the replacement cells before their insertion in the battery clip.

SECTION 5 FIVE

5. TECHNICAL DESCRIPTION

5:1 Circuit Description

The Advance VM78 transistorised A.C. Millivoltmeter consists of three main sections, a high input impedance stage, a two section attenuator and a directly coupled amplifier.

The two section attenuator is arranged with a high impedance input section before the input stage and a low impedance section between the input stage and the main amplifier.

The two sections of the attenuator are arranged to work alternately in the following sequence.

Between 1 mV and .1V inclusive the signal is applied directly to the high input impedance stage and the low impedance attenuator section is operative in five steps.

Between .3V and 10V inclusive the signal is attenuated to one hundredth of its value before being directed to the input stage. The low impedance attenuator section is then operative, over four steps.

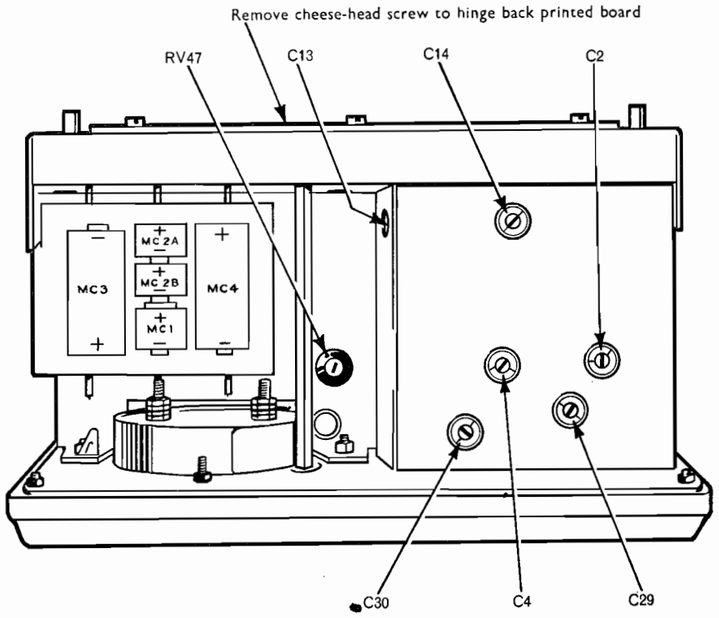
Between 30V and 300V inclusive the signal is attenuated to one ten thousandth of its value before being directed to the input stage. The low impedance attenuator section is then operative over three steps.

The high input impedance stage is basically two emitter followers in cascade. There is feedback to the collector of the first emitter follower, however, to minimise the effect of the base-collector impedance.

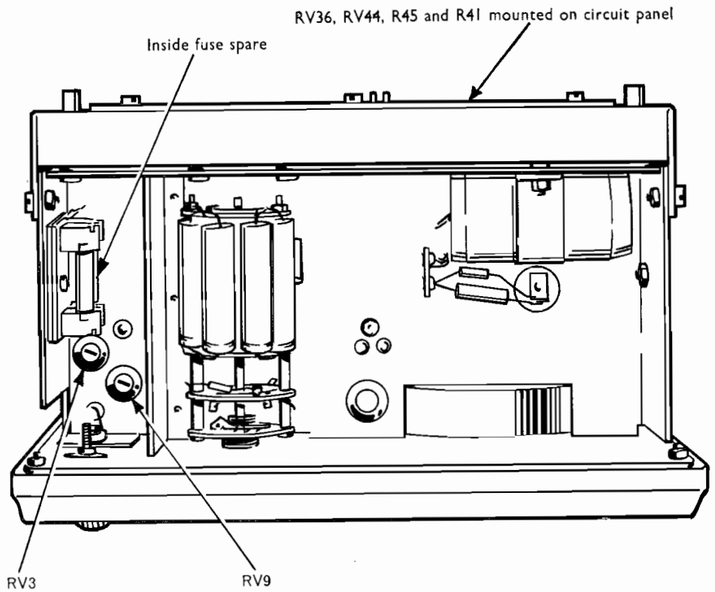
Two diodes are also employed in the input circuit to give protection against overload by clamping the voltage swing at the input base to approximately ± 3V, the excess voltage swing is absorbed by R13.

A 60 mA fuse in series with the input circuit will blow if large overload currents flow for more than a few seconds. The main high gain amplifier which follows the low impedance section of the attenuator is directly coupled in order to extend its frequency response down to 1 c/s. A.C. and D.C. feedback paths are arranged to keep the amplifier gain constant between 1 c/s and 1 Mc/s. The feedback and meter circuit time constants must necessarily be large for accurate measurements down to 1 c/s.

This means that several seconds must elapse after a voltage change before taking a reading off the meter. To obviate this the function switch is arranged to switch out some of the circuit capacitance if readings below 15 c/s are not required. The speed of response of the instrument is then correspondingly increased.



Upper Chassis view — Figure 1.



Under Chassis view — Figure 2.

5 : 2 Calibration Procedure

1 Set battery volts. Before batteries are inserted apply 12 volts D.C. to R45, switch to Bat. Test position of the function switch and set meter to read 8.2V by means of RV47.

2 Insert batteries. Place shorting link across input terminals. Set range switch to 300V. Set function switch to the 15 c/s — 1 Mc/s position.

3 Measure voltage between ground and collector of TR7, set to 2.2V by means of RV36.

4 Check that voltage across R41 is approximately 0.6V.

5 Set range switch to 1 mV position. Note that meter reading does not exceed 50 μV.

6 Set Function switch to 1 c/s — 1 Mc/s position. Allow approximately $1\frac{1}{2}$ mins. for instrument to stabilise. Check that meter reading again does not exceed 50 μV.

7 Set range switch to 3 mV. The input signal to be 3 mV at 1 Kc/s. Adjust RV44 for full scale in this range.

8 Adjustments to input Capacity. Connect the input terminals to a Q Meter (for example Advance type T2) whose internal capacity is set to a minimum. Switch to the 10 mV range. Plug in any suitable coil and resonate in the frequency range 200 Kc/s to 3 Mc/s. Switch to the 10V range and using an insulated trimmer adjust C29 to resonance. Switch to the 100V range and similarly adjust C30.

9 *Attenuator Alignment*

Input frequency 1 Kc/s from low impedance source.

Function switch at 15 c/s — 1Mc/s.

a 0.3V input, switch to 0.3V, set RV3 for full scale
b 30V „ „ „ 30V „ RV9 „ „ „

Input frequency 1 Mc/s from low impedance source.

c 3 mV input, switch to 3 mV, set C28 for full scale
d 30 mV „ „ „ 30 mV, „ C13 „ „ „
e 100 mV „ „ „ 100 mV, „ C14 „ „ „
f 0–3V „ „ „ 0–3V, „ C2 „ „ „
g 30V „ „ „ 30V, „ C4 „ „ „

Check through and repeat all 9 if necessary.

PARTS LIST

RESISTORS

Ref.	*Description*	*Part No.*
R1	2 M Ω ±1% R.R.C. 2HS2	1724
R2	19·6 K Ω ±1% R.R.C. 2HS2	1725
RV3	2·2 K Ω Potentiometer Plessey M.P. Dealer	1756
R4	2M Ω ±1% R.R.C. 2HS2	1724
R5	221 Ω ±1% R.R.C. 2HS2	11502
R6	2·7 Ω ±5% R.R.C. 2HS2	1726
R8	1500 Ω ±1% R.R.C. 2HS2	11498
RV9	2·2 K Ω Potentiometer Plessey M.P. Dealer	1756
R10	470 K Ω ±10% Dubilier B.T.T.	10730
R11	120 K Ω ±10% Dubilier B.T.T.	1732
R12	120 K Ω ±10% Dubilier B.T.T.	1732
R13	1000 Ω ±2% R.R.C. N.25	1993
R14	5600 Ω ±10% Dubilier B.T.T.	10991
R15	1200 Ω ±10% Dubilier B.T.T.	10621
R16	15 K Ω ±10% Dubilier B.T.T.	1130
R17	68 K Ω ±10% Dubilier B.T.T.	11316
R18	6·8 K Ω ±10% Dubilier B.T.T.	1733
R19A	3419 Ω ±0·3% Electronic A.P.¼	1853
R19B	1081 Ω ±0·3% Electronic A.P.¼	1854
R19C	341·9 Ω ±0·3% Electronic A.P.¼	1855
R19D	108·1 Ω ±0·3% Electronic A.P.¼	1856
R19E	50 Ω ±0·3% Electronic A.P.¼	1857
R20	1080 Ω ±1% R.R.C. 2HS2	1727
R21	634 Ω ±1% R.R.C. 2HS2	1728
R22	920 Ω ±1% R.R.C. 2HS2	1729
R23	1030 Ω ±1% R.R.C. 2HS2	1730
R24	15 K Ω ±10% Dubilier B.T.T.	1130
R25	56 K Ω ±10% Dubilier B.T.T.	10732
R26	27 K Ω ±10% Dubilier B.T.T.	10733
R27	4700 Ω ±10% Dubilier B.T.T.	11240
R28	3300 Ω ±10% Dubilier B.T.T.	7116
R29	5600 Ω ±10% Dubilier B.T.T.	10991
R30	47 K Ω ±10% Dubilier B.T.T.	1128
R31	47 K Ω ±10% Dubilier B.T.T.	1128
R32	180 Ω ±10% Dubilier B.T.T.	1735
R33	1500 Ω ±10% Dubilier B.T.T.	10622
R34	4700 Ω ±10% Dubilier B.T.T.	11240
R35	15 K Ω ±10% Dubilier B.T.T.	1130
RV36	22 K Ω Potentiometer Plessey M.P. Dealer	1757
R37	4700 Ω ±10% Dubilier B.T.T.	11240
R38	180 Ω ±10% Dubilier B.T.T.	1735
R39	15 K Ω ±10% Dubilier B.T.T.	1130
R40	3300 Ω ±10% Dubilier B.T.T.	7116
R41	680 Ω ±10% Dubilier B.T.T.	10988
R42	100 Ω ±10% Dubilier B.T.T.	10985
RV44	50 Ω Potentiometer Egen 195	1858
R45	2700 Ω ±10% Dubilier B.T.T.	10990
R46	120 K Ω ±10% Dubilier B.T.T.	1732
RV47	56 K Ω Potentiometer Plessey M.P. Dealer	1758
R48	180 Ω ±10% Dubilier B.T.T.	1735
R49	150 K Ω ±10% Dubilier B.T.T.	1126
R50	4700 Ω ±10% Dubilier B.T.T.	11240
R51	5600 Ω ±10% Dubilier B.T.T.	10991
R53	37·35 Ω ±1% R.R.C. 2HS2	1860
R54	180 Ω ±1% R.R.C. 2HS2	1861
R55	30 Ω ±1% R.R.C. 2HS2	1862
R56	3·3 K Ω ±10% Dubilier B.T.T.	7116

CAPACITORS

C1	0·47 µF 400V. Mullard C296 AC/A 470 K	1740
C2	2 to 8 pF Trimmer Triko 10 B.M. D20	11495
C3	560 µF 20% Erie Ceramicon H1-K AD K120051	329

CAPACITORS (*cont.*)

Ref.	*Description*	*Part. No.*
C4	2 to 8 pF Trimmer Triko 10 B.M. D20	11495
C5	·033 µF 10% Mullard C296 AA/A	790
C7	4 µF 70V. Electrolytic Plessey CE 1204	1741
C8	10 pF Lemco S/M 10% 500V. 1510 Insul.	1737
C9	500 µF 3V. Wima Printilyt 1038	1742
C10	250 µF 6V. Wima Printilyt 1056	1743
C11	100 µF 12V. Wima Printilyt 1074	1744
C12	10 µF 30V. Wima Printilyt 1088	1745
C13	1·5 to 60 pF Trimmer Mullard C010 AA/60E	1866
C14	15 to 60 pF Trimmer Mullard C010 AA/60E	1866
C15	100 µF 12V. Wima Printilyt 1074	1744
C16	500 µF 3V. Wima Printilyt 1038	1742
C17	2000 µF 12V. Plessey CE 1237/1	1864
C18	250 µF 6V. Wima Printilyt 1056	1743
C19	50 µF 6V. Wima Printilyt 1052	1746
C20	100 µF 12V. Wima Printilyt 1074	1744
C21	250 µF 6V. Wima Printilyt 1056	1743
C22	250 µF 6V. Wima Printilyt 1056	1743
C23	50 µF 6V. Wima Printilyt 1052	1746
C24	50 µF 6V. Wima Printilyt 1052	1746
C25	250 µF 6V. Wima Printilyt 1056	1743
C26	250 µF 6V. Wima Printilyt 1056	1743
C27	200 pF 5% Lemco S/M 350V. 1106 Insul.	11931
C28	140 pF Trimmer Cyldon MT 31A/5	1738
C29	6·30 pF Trimmer 004A/10B/D50	2097
C30	4/20 pF Trimmer Triko 004a/10B	11580

TRANSISTORS

TR1	N.K.T. 144 Newmarket	1875
TR2	O.C. 170 Mullard	1557
TR3	O.C. 170 Mullard	1557
TR4	O.C. 170 Mullard	1557
TR5	O.C. 139 Mullard	1067
TR6	O.C. 170 Mullard	1557
TR7	O.C. 170 Mullard	1557

DIODES

CR1	O.A. 200 Mullard	1874
CR2	O.A. 200 Mullard	1874
CR3	I.S. 916 Texas	1949
CR4	I.S. 916 Texas	1949

SWITCHES

SW1	Range Switch	1754
SW2	Function Switch	1873

BATTERIES

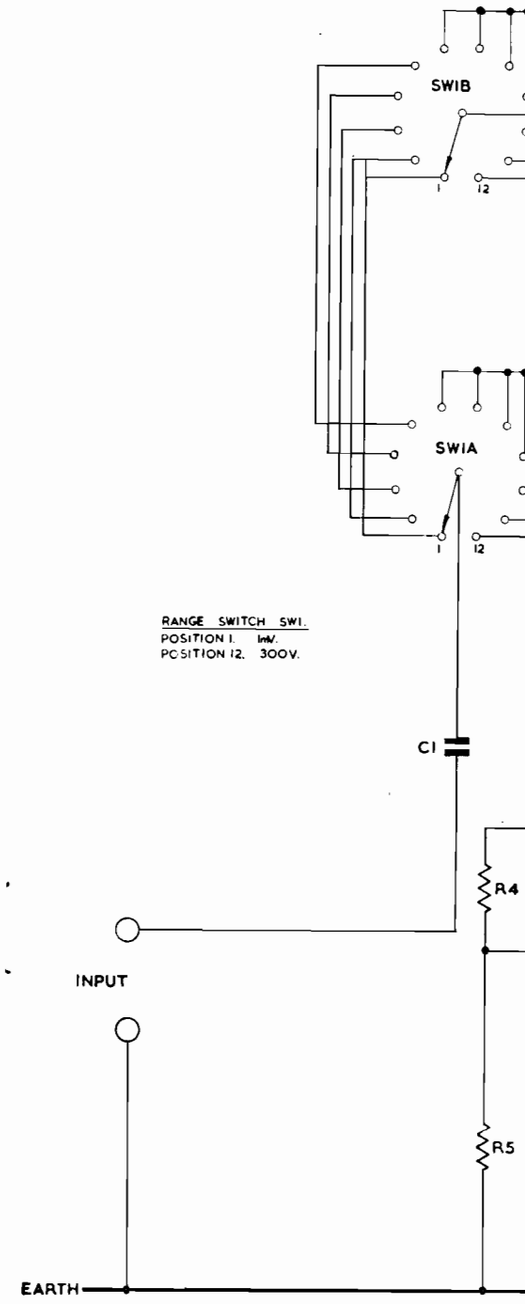
B1	4V. Mercury Mallory TR-233R	1761
B2	4V. Mercury Mallory TR-233R	1761
B3	1·34V. Mercury Mallory RM-3	1760
B4	1·34V. Mercury Mallory RM-3	1760
B5	1·34V. Mercury Mallory RM-3	1760

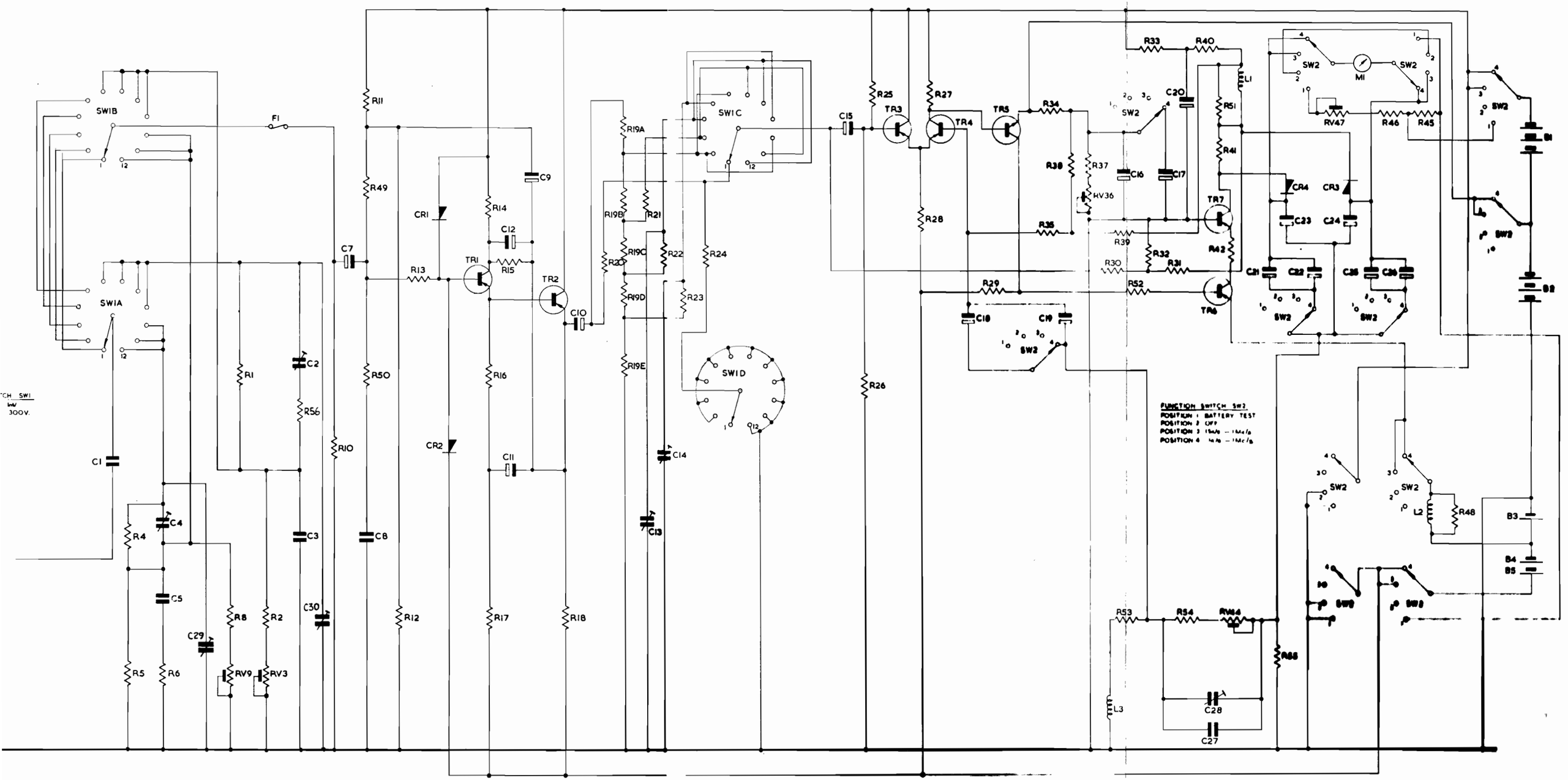
CHOKES

L1	1mH	C153
L2	6·8 µH	C155
L3	1 µH	C154

MISCELLANEOUS

M1	100 µA F.S.D. 3000 Ω	A15026
F1	60 mA Belling Lee L1055	1759





Circuit Diagram — *Figure 3*