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DISTORTION AND NOISE METER F240

Type 1A94766

250270

Handbook 94766R
(Issue 2)

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PART 1

GENERAL INFORMATION

1. APPLICATION

The AWA Distortion and Noise Meter F240 Type 1A94766 is suitable for the measurement of total harmonic distortion, noise, or hum-plus-noise in audio frequency circuits. In conjunction with a suitable station monitor it may be used for overall performance tests of the audio frequency characteristics of broadcast type transmissions.

2. BRIEF DESCRIPTION

The F240 is a sensitive wide-band a.c. level meter incorporating facilities for rejecting any selected frequency in the range 10 Hz to 30 kHz. The meter circuit includes an r.m.s. sensing network so that very nearly true r.m.s. values are indicated for sine waves, square waves, random noise, and other waveforms having crest factors less than 3:1.

For level measurements (including noise measurements) the meter is calibrated in volts r.m.s. and dBm. Level and noise measurements may also be made in dB relative to a preset reference level. High-cut and low-cut filters permit the exclusion of noise above 15 kHz and hum and noise below 400 Hz.

Distortion measurements are referred to the incoming signal level and the meter is calibrated to indicate distortion factor either in dB or as a percentage. The fundamental rejection frequency can be tuned with very great precision by means of the parallel-T rejection network, and distortion factor measurements down to 0.003% are possible (0.01% f.s.d.).

An a.c. output is provided so that the distortion products may be displayed on an oscilloscope.

The instrument is normally powered by six Size "C" cells.

3. STANDARD ACCESSORIES

(i) A 2-terminal connector (Belling Lee Type 1568/61S) and a suitable fixing plate for fitting in place of the 3-contact connector (Siemens Halske Type 9 Rel kli 6a).

(ii) A fixing plate for fitting tip, ring, and sleeve jacks or carrier jacks. The recommended jack is Transmission Products Type TP1120; wiring details are shown on Drg 94766H1.

(iii) A 3-way connector (AC&E Type PCC-3S) for signal input.

(iv) An Allen key for the knobs.

(v) Handbook 94766R (Issue 2).

4. OPTIONAL ACCESSORIES

4.1 Power Supply Type 1H94770 (Option 3A)

This unit fits inside the F240. It has input connectors for alternative external d.c. or a.c. supplies. The nominal a.c. voltage range is 100 V to 250 V (50 Hz to 60 Hz); the d.c. range is -12 V (minimum) to -56 V (maximum). The output of the unit is approximately -9 V d.c. at up to 10 mA.

The unit is supplied complete with a mating d.c. input connector and a three-core cable and plug for connecting to an a.c. power source. A change-over switch, which is accessible from outside the F240, permits selection of the internal battery supply in place of the external supply when required.

The weight of the power supply is 1.7 pounds (0.77 kg).

4.2 Programme Weighting Network Type 1A94769 (Option 4A)

This active network, designed for weighting noise, meets the 1964 C.C.I.T.T. (Geneva) requirement for programme transmission as specified in Recommendation P53, Section B, of C.C.I.T.T. Red Book Volume V, New Delhi, 1960.

Components included in the network are mounted on a printed wiring card which may be fitted in the space provided in the F240. Connections are made by four flying leads which plug into adjacent colour-coded sockets.

4.3 Rack Mounting Adaptor (Option 5A)

A kit containing two adaptors for fitting in place of the front handles is available. With the adaptors fitted, the F240 may be mounted in a standard 19-inch rack occupying three vertical rack units (5.1/4 inches).

4.4 Input Jacks and Rear Connector (Option 130A)

A kit containing two jacks (Transmission Products Type TP1120) and two mating connectors (Preh Types 8-7505 and 8-7506) is available. These components can be fitted to the instrument to provide alternative front panel input arrangements and a rear panel input.

When fitted to the instrument, the rear connector is normalled through the front panel jacks.

NOTE: Options 3A, 5A, and 130A are usually required in broadcast and television studio applications.

5. DATA SUMMARY (STANDARD UNIT)

5.1 Level (or Noise) Measurement

Frequency Response:

Balanced Input:	10 Hz to 30 kHz ±0.2 dB.
Unbalanced Input:	10 Hz to 60 kHz ±0.2 dB.

Input Impedance:

Terminating:	600 ohms in parallel with 10.7 kilohms.
Bridging:	10.7 kilohms.
Return Loss of Terminated Input:	Not less than 25 dB from 10 Hz to 60 kHz.
Longitudinal Suppression at Balanced Input:	At least 40 dB with respect to transverse voltage up to 30 kHz.
Bridging Loss of Input:	Not greater than 0.25 dB up to 30 kHz.
Sensitivity (maximum):	100 μV or -78 dBm for full-scale deflection.

Input Level (maximum):

Terminating:	+30 dBm
Bridging:	30 V r.m.s.
Meter Range:	Covers -80 dB to +30 dB in 10 dB steps. Within ±0.3 dB of stated scale on all steps.

Low-cut Filter: Roll-off below 400 Hz is asymptotic to 18 dB/octave.

High-cut Filter: Roll-off above 15 kHz typically
-0.9 dB at 15 kHz
-3.0 dB at 18 kHz
-16.0 dB at 30 kHz

Oscilloscope Output: Approximately 100 mV r.m.s. for f.s.d. on meter.

5.2 Distortion Factor Measurement

Fundamental Frequency Range: 10 Hz to 30 kHz in seven semi-decade ranges.

Distortion Factor Ranges: In 10 dB steps down to -80 dB (meter calibrated from +2 dB full scale to -20 dB).

In nine semi-decade percentage steps down to 0.01% full scale.

Harmonic Frequency Range:

Balanced Input: 20 Hz to 60 kHz.
Unbalanced Input: 20 Hz to 90 kHz.

Second Harmonic Response:

20 Hz to 20 kHz Fundamentals: Within ±1.0 dB.

Residual Distortion:

Unbalanced Input: No significant distortion (0.003%).
Balanced Input: No significant distortion above 300 Hz (0.003%). Typically 0.05% at 30 Hz.

Sensitivity:

Input Levels 0.25 V to 1 V: Minimum distortion range 0.03% f.s.d.

Input Levels 1 V to 3 V: Minimum distortion range 0.01% f.s.d.

5.3 General

Input Connector:	Three-contact Siemens Halske Type 9 Rel kli 6a.
Dimensions:	
Height (including feet):	5.7/8 inch high (15 cm)
Width(including handles):	18.1/2 inch wide (47 cm)
Depth (including handles):	14 inch deep (35.5 cm)
Net Weight (with cells):	16 pound (7.2 kg)
Power Supply:	Internal 9 V battery comprising: Six Size "C" alkaline-manganese cells (Eveready E93 or equivalent) giving approximate life of 800 working hours, continuous duty. Alternatively six zinc-carbon cells (Eveready No. 1035) may be used but battery life is considerably shorter.

End of Part

PART 2

INSTALLATION

1. LOCATION

Place and operate the F240 outside the influence of any strong magnetic fields radiated by other equipment.

2. RACK MOUNTING

If the F240 is to be mounted in a 19-inch rack, remove the two side handles (2 screws each) and fit the two rack-mounting adaptors in their places. Identify the two side handles and put in safe storage for re-use if required.

3. INPUT CONNECTIONS

The standard Siemens Halske Type 9 Rel kli 6a input connector is a 3-contact in-line socket. The top contact is connected to chassis earth. Balanced input from a 600-ohm line to the other two contacts is normally bridged but may be terminated by selecting 600 ohm TERM. The bridging resistance is 10.7 kilohms. With unbalanced inputs the centre contact is "active" and the bottom contact is earthed internally. This condition is achieved when the push-button switch marked "BAL" is in "out" position.

A separate terminal is provided below the input connector for earthing the chassis.

A different input connector may be substituted for the Siemens Halske connector if required. Two fixing plates and a 2-terminal connector (Belling Lee Type L1568/61S) are supplied as standard accessories. One fixing plate is suitable for the Belling Lee connector, the other fixing plate may be used for fitting jacks. Select the preferred input connector and the appropriate fixing plate and proceed as follows:

1. Remove the F240 top and bottom access panels (4 screws each).

   NOTE: After removal of the screws, slide the panels back to clear the front finishing strips which need not be removed.

2. Remove the two screws securing the Siemens Halske input connector taking care not to lose the two nuts. Swing the connector clear of the components.

3. Identify the wire connections and then unsolder at the connector.

4. Substitute the preferred connector and fixing plate and re-solder the wires to the appropriate contacts.

   NOTE: If the earth wire formerly connected to the top contact of the Siemens Halske connector is not now required, either remove it completely or carefully insulate it and tape it back for possible future re-use.

5. Use the original two screws and nuts to secure the new connector. Then re-fit the top and bottom access panels.

4. STANDARD INTERNAL BATTERY POWER SUPPLY

1. Turn the F240 face down and remove the battery compartment cover plate (two screws).

2. Insert six Size "C" cells (Eveready E93 or equivalent) taking care to ensure correct polarity. Replace the cover plate and return the instrument to normal operating position.

3. Use the CHECK BATTERY switch to verify that the battery is properly connected and in good condition.

4. If no meter reading is obtained, remove the top access panel (four screws). Ensure that the shorting plug provided (pins 1 and 2 internally connected) is inserted in the connector SKE provided for the optional Power Supply Type 1H94770.

5. OPTIONAL POWER SUPPLY TYPE 1H94770

1. Remove the F240 top access panel and the rear blank cover plate. Retain the four screws removed from the cover plate for use in Step 2.

2. Place the power supply in position inside the F240 and secure with the four screws entering from the back.

3. Remove the shorting plug from the F240 connector SKE and connect the output plug from the power supply in its place. Place the shorting plug in the clip provided for storage. Replace the top access panel.

4. Attach the appropriate connector to a suitable power cable.

   NOTE: A 6-pin female connector (Bulgin Type P428) is provided for d.c. supplies, pins are not marked but identified from wiring side 1, 2, 3, 4, 5, 6 clockwise from the keyway. Connect lead from battery positive to Pin 1 (earth); connect lead from battery negative (-12 to -56 V) to Pin 2 (negative).

5. Set the INT/EXT switch on the Power Supply to INT for operation from the internal 9 V battery or to EXT for operation from an external power source.

6. If set to EXT, verify that the appropriate fuse link is intact; 100 mA for a.c. supply: 250 mA for d.c. supply. Connect either an a.c. supply (100 V to 250 V) or a d.c. supply (-12 V to -56 V) to the appropriate input connector.

   NOTE: The tolerances on supply fluctuations are such that the absolute maximum safe voltages are -56 V d.c. and 280 V a.c. and the absolute minimum voltages are -12 V d.c. and 90 V a.c.

6. OPTIONAL PROGRAMME WEIGHTING NETWORK TYPE 1A94769

1. Remove the F240 top access panel.

2. Remove the screws and washers from the four pillars provided in the F240 for fixing the weighting network board. Place the board component side uppermost in position on the pillars and secure with the four screws and washers. The flying leads should face the front of the unit.

3. Connect the four flying leads from the weighting network board to the adjacent sockets on the F240 which are identified by corresponding colours.

4. Re-fit the top access panel.

End of Part

PART 3

OPERATION

1. PRELIMINARY

1. If it is required to monitor the output of the circuit under test with an oscilloscope or a true r.m.s. voltmeter, connect the required monitoring equipment to the output terminals of the F240. The output voltage is 0.1 V for full-scale deflection. The source resistance is 5.6 kilohms.

2. The condition of the battery may be determined by pressing the CHECK BATTERY switch. The switch will return to the normal position automatically. The test should preferably be made with the battery under load, i.e. during normal operation. On some instruments momentary full-scale deflection of the meter may occur during operation of the CHECK BATTERY switch; such deflections should be ignored.

NOTE: This operation also checks the output from the optional power supply if used.

2. LEVEL (OR NOISE) MEASUREMENTS

1. Select LEVEL and wait 30 seconds for the circuit to stabilize.

2. Select the appropriate input configuration.

3. Connect the output of the circuit to be tested to the input of the F240.

4. If noise above 15 kHz or hum and low frequency noise are to be excluded from the measurement, select HI-CUT and/or LO-CUT as required.

5. If a weighted measurement is required and the optional weighting network is fitted, select PGM.WTG.

NOTE: Selection of the PGM.WTG. filter automatically inhibits the LO-CUT filter, should that have been selected as well. The HI-CUT filter has no significant effect on the frequency response of the PGM.WTG. filter.

6. Adjust the meter range switch for optimum meter reading and read the meter.

7. Switch the F240 off.

3. DISTORTION FACTOR MEASUREMENT

NOTE: The F240 measures distortion factor either as a percentage or in dB as follows:

$$\text{Percentage distortion factor} = 100\sqrt{\frac{V_2^2 + V_3^2 + \ldots V_n^2 + N^2}{V_1^2 + V_2^2 + \ldots V_n^2 + N^2}}$$

$$\text{Distortion factor in dB} = 10 \log \frac{V_1^2 + V_2^2 + \ldots V_n^2 + N^2}{V_1^2 + V_2^2 + \ldots V_n^2 + N^2}$$

where V_1, V_2, etc. represent the amplitudes of fundamental and harmonics, V_n represents the amplitude of the last harmonic in the admitted bandwidth, and N represents noise.

1. Select the appropriate input configuration.

2. Connect the output of the circuit to be tested to the input of the F240.

   NOTE: A suitable a.f. source if required is the AWA Audio Oscillator G231.

3. Select SET REF and wait 30 seconds for the circuit to stabilize.

4. If noise above 15 kHz or hum and low frequency noise are to be excluded from the measurement, select HI-CUT and/or LO-CUT as required.

   NOTE: Use of the filters restricts the range of signal frequencies that may be used for accurate measurement.

5. Set all six balance controls to the neutral position (engraved line vertical).

6. Set the meter range selector to 0 dB/100%.

7. Adjust the three-position SET REF switch and the concentric potentiometer to set the meter pointer either to 0 on the dB scale or to 10 on the % scale according to whether the distortion factor is to be measured in dB or as a percentage.

8. Select DISTN.

9. Select the appropriate rejection frequency range and adjust the frequency cursor until the meter needle dips.

10. Operate alternately the first pair of balance controls (greater than 1%) so as to balance the rejection network. Change the meter range when the meter reading falls below approximately one third of full-scale. Repeat as necessary to obtain a reading below -40 dB or 1%.

11. If greater resolution is required, proceed to the second pair of balance controls (greater than 0.1%) and, taking care not to disturb the setting of the first pair, obtain the best possible balance with the second pair of controls.

12. If maximum resolution is required, continue in the same way with the third pair of balance controls (less than 0.1%).

13. Switch the F240 off after use.

4. INTERPRETATION OF MEASUREMENTS

Interpret the measurements and make appropriate corrections where possible in accordance with the following information:

Accuracy of calibration:	±2% of full scale ±1% of reading.
Accuracy of meter range attenuator:	±0.3 dB (±3.5%).
Accuracy on non-sinusoidal signals:	
Random noise:	Typically -1%
Square waves:	Typically +2.5%
Effect of low battery p.d.:	Gain falls with falling battery p.d. at 0.2 dB/volt.
Correction for bridging loss:	Add 0.25 dB to the reading to obtain the level that would be present on a line terminated in exactly 600 ohms.
Transformer insertion loss on BAL. input:	±0.1 dB (±1%)

End of Part

PART 4

TECHNICAL DESCRIPTION

Refer to Drg 94766H1

1. INPUT CIRCUIT

Capacitors C1, C2 block d.c. at the input. The maximum safe d.c. level is limited to ±250 V relative to chassis earth ONLY WHEN UNTERMINATED (d.c. is not blocked from the terminating resistor).

Input mode is selected by switch SWA. Section SWA/1 routes the input signal through a 1:1 transformer (TR1) for balanced inputs. Section SWA/2 controls selection of the internal terminating resistor R1.

2. REJECTION CIRCUIT

The rejection circuit consists of a parallel-T rejection network and an amplifier. The parallel-T rejection network is by-passed and the rejection circuit is consequently inoperative except when DISTN is selected by means of SWE/3. The capacitors in the three reactive arms of the T are switched by SWD/1 to SWD/7 to provide seven frequency ranges. A 3-gang potentiometer RV1 varies the resistance of the three resistive arms to tune through each range. The effects of component tolerances and stray capacitance make it necessary to further vary two resistive arms of the T to obtain a true null at the rejection frequency. Three series potiometers are provided in each of two arms for this purpose. The variable elements (RV2, RV3, RV4 and RV5, RV6, RV7) form the six balance controls.

Diodes 1MR1 and 1MR2 limit the input to the rejection amplifier. Internal feedback stabilizes the gain over very wide frequency and dynamic ranges. Negative feedback to the input of the rejection network ensures a level harmonic response and narrows the notch characteristic at the selected rejection frequency. The output from the rejection amplifier passes through 1C5 to the main meter range attenuator.

3. METER RANGE ATTENUATOR

The meter range switch controls the action of three separate attenuators. The main meter range attenuator acts on the output from the rejection amplifier.

It consists of close tolerance high stability resistors R20 to R26 and it provides up to 50 dB attenuation selected in 10 dB steps by wafer SWC/5. Another attenuator acts on the input to the rejection amplifier and consists of R9, R10 and R27; it provides 40 dB, 30 dB or zero attenuation as selected by SWC/4. The third attenuator acts when LEVEL is selected as it affects only the positive meter range settings. On unbalanced inputs the third attenuator consists of R7, R8 and it provides 20 dB or zero attenuation as selected by SWC/3. On balanced inputs the third attenuator consists of R2, R3, R4, R5 and it also provides 20 dB or zero attenuation as selected by SWC/1 and SWC/2. This attenuator is placed in the primary circuit of TR1 to restrict high-level signals so as to avoid the introduction of non-linearities by the transformer. Attenuations of switch sections are related to meter range settings as follows:

METER	ATTENUATION INTRODUCED BY		
RANGE	SWC/3 OR SWC1+2	SWC/4	SWC/5
+30 dB	+20 dB	+40 dB	+50 dB
+20 dB	+20 dB	+40 dB	+40 dB
+10 dB	0 dB	+40 dB	+50 dB
0 dB	0 dB	+40 dB	+40 dB
-10 dB	0 dB	+40 dB	+30 dB
-20 dB	0 dB	+30 dB	+30 dB
-30 dB	0 dB	0 dB	+50 dB
-40 dB	0 dB	0 dB	+40 dB
-50 dB	0 dB	0 dB	+30 dB
-60 dB	0 dB	0 dB	+20 dB
-70 dB	0 dB	0 dB	+10 dB
-80 dB	0 dB	0 dB	0 dB

4. METER AMPLIFIER

Buffer stage 2VT1 is connected as an emitter follower to drive the high input impedance feedback amplifier 2VT2, 2VT3. The first section (2L1) of the 400 Hz low-cut filter is connected between 2VT1 and 2VT2. It is selected by one contact of SWF/2. If fitted, the optional programme weighting network is also connected between 2VT1 and 2VT2 and is selected by two contacts of SWF/1. Two more contacts of SWF/1 connect power to the network and disconnect SWF/2 to prevent connection of the low-cut filter if it is simultaneously selected.

The gain of the feedback amplifier (2VT2, 2VT3) is varied by switched fixed resistors and one variable potentiometer in the feedback loop. The fixed resistors are switched by the coarse SET REF control. The variable potentiometer RV8 is operated by the SET REF fine control. Operation of the SET REF coarse control also varies the setting of the 0/20 dB attenuator described in Section 3, "METER RANGE ATTENUATOR".

The second part of the low-cut filter follows 2VT3. It consists of the 1-megohm resistor 2R21 in series with 2C13 which together shunt 2C11. Normally 2R21 is shorted by one contact of SWF/2 so 2C13 is in parallel with 2C11 and the l.f. impedance is low. When the low-cut filter is selected SWF/2 removes the short across 2R21 and the l.f. impedance increases. A contact of SWF/1 restores the short across 2R21 if the programme weighting network is selected while the low-cut filter is also selected.

Following the second part of the low-cut filter is a second feedback amplifier (2VT4, 2VT5). Pre-set resistor 2RV8 controls the gain and is used as the overall gain calibration control for the F240. A high-cut filter follows 2VT5. It consists of tapped inductor 2L2 and two sets of de-coupling capacitors 2C20, 2C21, and 2C18, 2C19. Normally only a small part of the inductance of 2L2 and low-value de-coupling capacitors are connected to give a steep cut above 100 kHz. When HI-CUT 15 kHz is selected, three contacts of SWF/3 substitute all of 2L2 and much larger de-coupling capacitors thus giving steep attenuation of frequencies about 15 kHz.

The output from the high-cut filter passes via buffer 2VT6 to the OUTPUT terminals. It also passes directly to the meter drive amplifier (2VT7, 2VT8, 2VT9) which provides a full-wave rectified current output linearised by current feedback. A non-linear network drives the meter with a current approximately proportional to the r.m.s. value of the rectifier output current.

5. OPTIONAL PROGRAMME WEIGHTING NETWORK TYPE 1A94769

Transistors VT1, VT2 are connected as a feedback amplifier. Frequency selective attenuators before and after the amplifier shape the frequency response to conform to the requirements of the C.C.I.T.T. Component tolerances are arranged so that the total possible effect on the frequency response is extremely small.

6. OPTIONAL POWER SUPPLY TYPE 1H94770

Alternating-current inputs are reduced in voltage by TR1 and full-wave rectified by MR1-4. Capacitors C1, C2 provide smoothing. Diode MR5 provides protection from inadvertent connection of a d.c. input of the wrong polarity, or simultaneous connection of a.c. and d.c. mains. In the latter case, the unit will automatically operate from whichever supply is dominant. Transistor VT1 is a series stabilizer using Zener diode MR5 as the voltage reference.

End of Part

PART 5

MAINTENANCE

1. GENERAL

1.1 Battery

Always check the condition of the internal 9 V battery before using the instrument (refer to PART 3, "OPERATION" for details).

If the meter reading is below the BATT. MIN. mark after the instrument has been switched on several minutes, the cells must be replaced.

1.2 Mains Cable

Check the mains cable periodically for wear, with particular attention to the condition of the insulation and continuity of the earth lead.

1.3 Lubrication and Cleaning

Use a suitable solvent to clean switches and variable resistors when necessary.

To prevent electrical troubles due to adherence of dust to lubricated surfaces, re-lubricate using the smallest practicable amount of lubricant. Ensure that all surplus lubricant is removed.

1.4 Re-Calibration

Depending on the severity of the environment and the frequency of use, periodically check the basic calibration of the instrument by performing steps 1, 2, 3, 4 of Sub-Sub-Section 2.2.2, "Gain".

Following disassembly and re-assembly or replacement of any component, perform the full test procedure under Section 2, "TEST OF DISTORTION AND NOISE METER F240".

2. TEST OF DISTORTION AND NOISE METER F240

2.1 Test Equipment Required

Item	Description	Suitable Type
1	Audio oscillator with flat response over frequency range 10 Hz to 100 kHz. Capable of supplying up to +12 dBm into 600 ohm from 600 ohm source. Total harmonic distortion content less than 0.1% at 2 kHz. Two output impedances required: 600 ohms and 40 ohms (or less).	AWA Audio Oscillator G231
2	A.C. level meter with high input impedance. Capable of measuring 0.775 V r.m.s. ±1% at 1 kHz and levels from 0 dBm to -30 dBm ±0.5 dB, referred to 600 ohms, at 10 Hz.	Hewlett-Packard Model 400E.
3	Oscilloscope covering 10 Hz to 100 kHz with sensitivity of at least 50 mV/cm.	
4	D.C. voltmeter to read 0-10 V, ±3% f.s.d. Input resistance 200 kilohm or more	AWA Voltohmyst 2A56074, AVO Model 8.
5	600-ohm T-pad attenuator with accuracy of the order of ±0.01 dB and switched 0.1 dB attenuation steps from 0 to 80 dB.	Muirhead Type A-303-E
6	Longitudinal suppression pad as drawn in Fig. 1, Drg 94766D3.	
7	Return loss bridge as drawn in Fig. 2, Drg 94766D3	
*8	Stabilized d.c. power supply, adjustable from 7 V to 15 V (positive earth). Output current capability of 100 mA.	

* Not essential for calibration and test of complete unit.

2.2 Calibration and Test of Complete Unit

2.2.1 Amplifier Power Supplies

1. Remove the top and bottom access panels from the F240.

2. Connect the F240 to a suitable power source.

   NOTE: If internal power source is used the battery must be in good condition with a stable voltage of greater than 7.3 V under "on load" conditions.

3. Select LEVEL and, if the optional programme weighting network 1A94769 is fitted, select PGM. WTG.

4. Wait one minute for circuit conditions to stabilize.

5. Using the d.c. voltmeter (item 4) check the d.c. levels at the following points:

Test Point	Required Voltage
Meter amplifier board pin 3	Same as source (-9 V nominal)
Rejection amplifier board pin 3	Same as source
Programme weighting network board pin 9 (if fitted)	Approximately 0.8 to 1.0 V below source voltage

6. Depress CHECK BATTERY switch. Check that the voltage indicated by the F240 meter is within ±4% of the voltage indicated by the d.c. voltmeter at pin 3 of the meter amplifier board.

7. Refit the bottom access panel.

2.2.2 Level Calibration

1. Set up the F240 as follows:

   Unbalanced, bridging input; meter range 0 dB; LEVEL; all filters switched out.

2. Connect the oscilloscope (item 3) to the F240 OUTPUT terminals. Connect the audio oscillator (item 1) and the a.c. level meter (item 2) to the INPUT terminals.

3. Set the audio oscillator output impedance to 600 ohms, the frequency to 1 kHz, and the output level as indicated by the a.c. level meter to precisely 0.775 V r.m.s.

4. Adjust 2RV1 (accessible through a hole in the chassis) until the F240 meter indicates 0 dB. Check that the output waveform is pure.

5. Select BAL. Check that the F240 meter does not deviate from 0 dB by more than ±0.1 dB. If it does, change the value of R6 (nominally 1 kilohm) and repeat steps 4 and 5.

   NOTE: R6 is located on SWA/1.

6. Select unbalanced, 600 ohm TERM. Check that the F240 meter reading is reduced by nearly 6 dB.

7. Disconnect and remove the a.c. level meter. Refit the top access panel to the F240.

2.2.3 <u>Meter Range Attenuator Accuracy</u>

1. Ensure that the F240 is set as follows:

   Unbalanced, terminating input; meter range 0 dB; LEVEL; all filters out.

2. Insert the T-pad attenuator (item 5) between the audio oscillator and the F240 input.

3. Set the T-pad attenuation to 0 dB. Ensure that the audio oscillator is set for 1 kHz, 600 ohm. Adjust the audio oscillator output level until the F240 meter reads 0 dB.

4. Set the T-pad attenuation to 10 dB. Check that the F240 meter reads -10 dB ±0.5 dB.

5. Set the meter range switch to -10 dB. Check that the F240 meter reads 0 dB ±0.15 dB.

6. Increase the T-pad attenuation and re-set the meter range switch to check all ranges down to -80 dB. Check that the F240 meter reads 0 dB ±0.3 dB on each range.

   NOTE: The check at -30 dB is sufficient to ensure that the +10 dB range is within specification.

7. Return the meter range switch to -20 dB and select SET REF.

8. Switch the SET REF coarse control to the anti-clockwise position. Set the T-pad attenuation to 0 dB. Adjust the SET REF fine control to obtain a meter reading of 0 dB.

9. Set the T-pad attenuation to 20 dB. Turn the SET REF coarse control one step clockwise to the centre position.

   NOTE: Do not disturb the setting of the fine control. If the coarse and fine controls tend to lock together, check RV8 for correct mounting on the switch assembly. If necessary, readjust mounting then repeat steps 8 and 9.

10. Check that the F240 meter reading is 0 dB ±0.15 dB.

   NOTE: This check following steps 7, 8 and 9 ensures that the meter ranges from +20 dB to +30 dB are within specification, but it is necessary to check these ranges for correct functioning (see steps 11 and 12).

11. Select LEVEL and set meter range switch to +10 dB and T-pad to 0 dB. Check that the meter indicates approximately -10 dB.

12. Set meter range switch to +20 dB and check that the meter indicates approximately -20 dB.

13. Select BAL input and repeat steps 7 to 12 inclusive. In this operation the tolerance is ±0.25 dB.

2.2.4 Operating Range of SET REF. Gain Control

1. Ensure that the audio oscillator remains as set in step 3 of the previous test.

2. Re-set controls where necessary to ensure that the F240 is set as follows:

   Unbalanced input, 600 ohm TERM; meter range 0 dB; SET REF; all filters out; SET REF coarse control switched to centre position; SET REF fine control fully clockwise.

3. Adjust the T-pad attenuation until the F240 meter reads 0 dB. Check that the required T-pad attenuation is between 2.5 dB and 4 dB (typically 3.5 dB).

4. Turn the SET REF fine control fully anti-clockwise. Set the meter range switch to -20 dB. Adjust the T-pad attenuator to 0 dB. Check that the F240 meter reads between -1 dB and -4 dB (typically -3 dB).

5. Set the meter range switch to -10 dB. Switch the SET REF coarse control to the clockwise position. Adjust the T-pad attenuator until the F240 meter reads 0 dB. Check that the required T-pad attenuation is between 6.5 dB and 9.5 dB (typically 7.5 dB).

6. Set the meter range switch to 0 dB. Turn the SET REF fine control fully clockwise. Adjust the T-pad attenuator until the F240 meter reads 0 dB. Check that the required T-pad attenuation is at least 12.3 dB. Select BAL input and check that the meter reading does not change by more than ±0.1 dB.

7. Disconnect and remove the T-pad attenuator and the audio oscillator.

2.2.5 Noise

1. Re-set controls where necessary to ensure that the F240 is set as follows:

   Unbalanced input; 600 ohm TERM; meter range 0.1 mV; LEVEL; all filters out.

2. With no connection at the input of the F240, observe the noise waveform on the oscilloscope at the output. Check that it appears purely random and is free from spurious signals or noise pulses of regular amplitude.

3. Check that the noise level does not exceed 10 μV r.m.s.

   NOTE: The noise at 25 °C should give a meter reading of about 6 to 7 μV r.m.s. Possible sources of excessive noise are:

   (i) Transistor 1VT1.
   (ii) Inoperative high-cut filter above 100 kHz.
   (iii) Pick-up of hum or radio-frequency interference.

2.2.6 Longitudinal Suppression

1. Reset controls where necessary to ensure that the F240 is set as follows:

   BAL, bridging input; meter range 0 dB; LEVEL; all filters out.

2. Connect the audio oscillator (item 1) to the F240 INPUT terminals. Set the output impedance to 40 ohms and the frequency to 30 kHz. Adjust the output level until the F240 meter reads 0 dB.

3. Select 600 ohm TERM. Insert the longitudinal suppression pad (item 6) between the oscillator and the F240 as shown in Fig. 1, Drg 94766D3.

4. Set the meter range switch to give a clear reading on the F240 meter. The longitudinal suppression is the negative of the sum of the meter range setting and the meter scale reading. Check that it exceeds 40 dB.

2.2.7 Return Loss

1. Connect the audio oscillator (item 1) and the a.c. level meter (item 2) to the return loss bridge (item 7) as shown in Fig. 2. DO NOT CONNECT THE F240.

2. Set the audio oscillator output impedance to 600 ohms and the frequency to 10 Hz. Adjust the output level until the a.c. level meter indicates 0 dBm.

3. Set the F240 as follows:

   BAL, 600 ohm TERM; meter range 0 dB; OFF; SET REF coarse control switched to clockwise position.

4. Connect the INPUT terminals of the F240 to the return loss bridge as shown in Fig. 2, Drg 94766D3. Note the new reading indicated by the a.c. level meter. The negative of the new reading is the return loss; check that it exceeds 26 dB.

5. Disconnect the audio oscillator, the a.c. level meter, and the return loss bridge.

2.2.8 Frequency Response

1. Set the F240 as follows:

   Unbalanced, terminating input; meter range 0 dB; LEVEL; all filters out.

2. Connect the audio oscillator (item 1) to the F240 input. Set the audio oscillator output impedance to 600 ohm unbalanced.

3. Set the audio oscillator frequency to 1 kHz. Adjust the output level until the F240 meter reads 0 dB. Note the level indicated by the audio oscillator output meter.

4. Set the audio oscillator frequency to 10 kHz. Readjust the output level if necessary to ensure that it remains as noted in step 3. Check that the F240 meter reads 0 dB ±0.2 dB.

5. Set the audio oscillator frequency to 60 kHz. Repeat the procedure of step 4.

6. Select BAL. Set the audio oscillator frequency to 1 kHz. Readjust the output level until the F240 meter reads 0 dB. Note the level indicated by the audio oscillator output meter and maintain this level throughout the following procedure.

7. Repeat step 4 but maintain the oscillator output at the new level noted in step 6.

8. Set the audio oscillator frequency to 30 kHz. Repeat the procedure of step 4 but maintain the audio oscillator output at the new level noted in step 6.

9. Set the audio oscillator frequency to 1 kHz. Select the PGM WTG filter. If the filter is not fitted, check that after making the selection there is no 1 kHz output to the oscilloscope, only a rise in noise level. If the filter is fitted, check that the F240 meter reads approximately 0 dB.

10. Set the audio oscillator frequency to 400 Hz. Switch the PGM WTG filter out. Select the LO-CUT 400 Hz filter. Check that the F240 meter reading does not fall below -0.6 dB (typically -0.5 dB).

11. Set the audio oscillator frequency to 50 Hz. Check that the F240 meter reads at least -34 dB (typically -36 dB).

12. Set the audio oscillator frequency to 15 kHz. Switch the LO-CUT 400 Hz filter out. Select the HI-CUT 15 kHz filter. Check that the F240 meter reading does not fall below -2 dB (typically -0.9 dB).

13. Set the audio oscillator frequency to 30 kHz. Check that the F240 meter reading is at least -14 dB (typically -16 dB).

2.2.9 <u>Fundamental Rejection Network</u>

1. Set the F240 as follows:

   Unbalanced, bridging input, meter range 0 dB; LEVEL; all filters out.

2. Connect the audio oscillator (item 1) to the F240 input. Set the oscillator frequency to 2 kHz and adjust the output level until the F240 meter reads 0 dB.

3. Select SET REF. Switch the SET REF coarse control to the centre position. Adjust the SET REF fine control until the F240 meter reads 0 dB.

4. Select DISTN. Set the six balance controls approximately mid-range.

   NOTE: If necessary alter the positions of the knobs on the shafts to align the pointers with the centre marks on the panels.

5. Select the F240 1 kHz to 3 kHz frequency. Adjust the F240 variable frequency control to obtain a minimum reading on the meter.

6. Taking care not to alter the position of the F240 frequency control shaft, slacken the two screws securing the knob and cursor and align the cursor with the 20 calibration mark. Carefully re-tighten the two screws to secure the cursor and knob in the new position. Ensure that the meter reading remains at a minimum.

7. Use the balance controls in pairs, working from left to right, to obtain a true null at 2 kHz. Operate the meter range switch as necessary until a minimum reading is obtained on the -60 dB range. Check that all the balance controls work correctly.

   NOTE: If hum and noise are present on the input signal, use either or both of the filters (HI-CUT and LO-CUT) to obtain a sufficiently low distortion reading.

8. Return the meter range switch to 0 dB. Select SET REF; do not change the setting of the SET REF controls. Set the audio oscillator frequency to 4 kHz. Adjust the oscillator output level until the F240 meter reads 0 dB.

9. Select DISTN. Check that the F240 meter reading does not fall below -1 dB and does not rise above +1 dB.

10. Check top and bottom of each frequency range for the correct tuning. If necessary add a capacitor (C34, 680 pF, N750) in parallel with C30.

11. Disconnect and remove test equipment. Switch off the F240.

3. TEST OF POWER SUPPLY 1H94770

3.1 Test Equipment Required

- TABLE NEXT PAGE -

Item	Description	Suitable Type
1	D.C. voltmeter to read 0-10 V, ±3%, f.s.d. Input resistance 200 kilohm or more	AWA Voltohmyst 2A56074 AVO Model 8
2	Stabilized d.c. power supply adjustable from 7 V to 15 V (positive earth).	
3	Connector, 6-contact, female, free, Bulgin P428 (AWA code 233982) wired to convenient terminal strip or panel (to provide easy electrical access to the pins of the d.c. input connector SKB).	
4	1 kilohm ±10%, 1/4W resistor	

3.2 Test Procedure

1. Ensure that fuses FS1 (100 mA) and FS2 (250 mA) are in position.

2. Set the d.c. stabilized power supply (item 2) to -9V. Connect the negative lead to output connector PLC pin 1; connect the positive lead to PLC pin 3.

3. Switch SWA to INT. Use the d.c. voltmeter (item 1) to check that PLC pin 2 is at -9 V with respect to pin 3.

4. Switch SWA to EXT. Check that PLC pin 2 is at zero volts with respect to pin 3.

5. Disconnect the stabilized d.c. supply from PLC1 and PLC3.

6. Connect the 1 kilohm resistor (item 4) across the terminals of the d.c. voltmeter and connect the voltmeter between PLC2 and PLC3.

7. Connect the stabilized d.c. power supply to the d.c. input connector SKB (pin 1 positive, pin 2 negative).

   NOTE: SKB pins are identified from the wiring side and numbered clockwise from the key.

8. Gradually increase the input voltage from the stabilized d.c. power supply until the power supply output voltage reaches a stable value. Check that this value is between -7.8 V and -9.2 V and the input voltage is less than 12 V.

9. Further increase the input voltage to -15 V. Check that there is no significant change in the output voltage, and that it remains within the limits specified in 8.

10. Disconnect and remove the stabilized d.c. power supply. Connect a 200 V to 250 V a.c. supply to the a.c. input connector SKA. Check that the stable output voltage is similar to that observed in steps 8 and 9.

11. Switch SWA to INT and check that the output voltage is zero.

12. Switch off and disconnect the a.c. supply. Disconnect and remove all test equipment.

4. TEST OF PROGRAMME WEIGHTING NETWORK 1A94769

4.1 Test Equipment Required

Item	Description	Suitable Type
1	Audio oscillator with flat response over range 20 Hz to 14 kHz.	AWA Audio oscillator G231
2	A.C. level meter with 600 ohm unbalanced bridging input. Capable of measuring -40 dBm to -60 dBm (in 600 ohm) from 20 Hz to 14 kHz.	AWA Distortion and Noise Meter F240.
3	D.C. voltmeter to read 0-10 V, ±3% f.s.d. Input resistance 200 kilohm or more.	AWA Voltohmyst 2A56074; AVO Model 8
4	600 ohm T-pad attenuator with accuracy of the order of ±0.01 dB and switched 0.1 dB attenuation steps from 0 to 80 dB.	Muirhead Type A-303-E.
5	Frequency counter to measure 20 Hz to 14 kHz ±0.1%.	
6	Stabilized -8 V d.c. power supply.	

4.2 Test Procedure

1. Connect the stabilized -8 V d.c. supply (item 6) negative lead to pin 9 of the network. Connect the positive lead to pin E. Connect pin E to earth.

2. Use the d.c. voltmeter (item 3) to check that the voltage at VT2 collector is approximately -5.5 V. Remove the voltmeter after making the measurement.

3. Bypass R1 (576 ohm) with a short clip lead. Connect the audio oscillator (item 1) and the frequency counter (item 5) to the input of the T-pad attenuator (item 4). Connect the output of the T-pad attenuator to pins 5 and E of the network (the input). Connect the a.c. level meter (item 2) to pins 6 and E of the network (the output).

4. Set the T-pad attenuation to 40 dB. Set the audio oscillator frequency to 1 kHz ±0.1%. Adjust the oscillator output to obtain a level of -40 dBm at the network output. Note the level indicated by the audio oscillator output meter and maintain this level throughout the following procedure.

5. Reset the audio oscillator frequency to 20 Hz ±0.1%. Reset the T-pad attenuation to 0 dB. Check that the network output level is below -40 dBm, indicating that the attenuation of the network is greater than 40 dB.

6. Reset the audio oscillator frequency to 50 Hz ±0.1%. Adjust the T-pad attenuator until the network output level is -40 dBm. Subtract the T-pad attenuation from 40 dB to obtain the network attenuation. Check that the network attenuation is 34.3 dB ±1.5 dB.

7. Repeat step 6 substituting different audio oscillator frequencies (all set within ±0.1%) and checking for different values of network attenuation as follows:

Frequency	Network Attenuation (dB)
50 Hz	34.3±1.5
100 Hz	26.1±1.5
400 Hz	8.8±1.5
2 kHz	-5.3±1.5
5 kHz	-8.4±1.5
8 kHz	-5.1±1.5
9 kHz	0.3±3.0
10 kHz	9.7±3.0

8. Reset the T-pad attenuator to 30 dB. Reset the audio oscillator frequency to 14 kHz ±0.1%. Check that the network output level is below -60 dBm, indicating that the attenuation of the network is greater than 30 dB.

NOTE: Allow for any inaccuracies in the a.c. level meter when changing range from -40 dBm to -60 dBm.

9. Disconnect and remove all test equipment and remove the temporary clip lead bypassing R1.

End of Part

PART 6

COMPONENT SCHEDULE

1. EXPLANATORY NOTES

The component schedule is laid out as follows:

Column 1	Circuit Reference Number
Column 2	Description
Column 3	Component Manufacturer and Reference
Column 4	AWA Stock Code Number

Because of unavailability at the date of manufacture, some components in the equipment may differ slightly from the components listed in the schedule. These substitute components do not degrade the performance of the equipment.

When ordering replacement components from AWA, the type number of the unit (or sub-unit) and the circuit reference number of the component should be quoted in addition to the details appearing in the component schedule. This information will ensure the supply of a suitable substitute component should the listed component be obsolete or unavailable.

2. DISTORTION AND NOISE METER F240 TYPE 1A94766

2.1 Components Mounted on Chassis

(a) Capacitors

C1	5 μF ±10%, 250 VDCW, polyester	A.E.E.-PMT	228527
C2	5 μF ±10%, 250 VDCW, polyester	A.E.E.-PMT	228527
C3	0.47 μF ±5%, 160 VDCW, polyester	Ducon DMA120	
C4	0.15 μF ±5%, 160 VDCW, polyester	Ducon DMA114	
C5	0.047 μF ±5%, 160 VDCW, polyester	Ducon DMA108	
C6	0.015 μF ±5%, 160 VDCW, polyester	Ducon DMA102	
C7	4700 pF ±5%, 630 VDCW, polyester	Ducon DMA608	
C8	1500 pF ±5%, 630 VDCW, polyester	Ducon DMA602	
C9	470 pF ±5%, 630 VDCW, polystyrene	Allied Capacitors TCS608	
C10	0.47 μF ±5%, 160 VDCW, polyester	Ducon DMA120	

Components Mounted on Chassis (continued)

C11	0.15 μF ±5%, 160 VDCW, polyester	Ducon DMA114	
C12	0.047 μF ±5%, 160 VDCW, polyester	Ducon DMA108	
C13	0.015 μF ±5%, 160 VDCW, polyester	Ducon DMA102	
C14	4700 pF ±5%, 630 VDCW, polyester	Ducon DMA608	
C15	1500 pF ±5%, 630 VDCW, polyester	Ducon DMA602	
C16	470 pF ±5%, 630 VDCW, polystyrene	Allied Capacitors TCS120	
C17	0.47 μF ±5%, 160 VDCW, polyester	Ducon DMA120	
C18	0.15 μF ±5%, 160 VDCW, polyester	Ducon DMA114	
C19	0.047 μF ±5%, 160 VDCW, polyester	Ducon DMA108	
C20	0.015 μF ±5%, 160 VDCW, polyester	Ducon DMA102	
C21	4700 pF ±5%, 630 VDCW, polyester	Ducon DMA608	
C22	1500 pF ±5%, 630 VDCW, polyester	Ducon DMA602	
C23	470 pF ±5%, 630 VDCW, polystyrene	Allied Capacitors TCS608	
C24	0.47 μF ±5%, 160 VDCW, polyester	Ducon DMA120	
C25	0.15 μF ±5%, 160 VDCW, polyester	Ducon DMA114	
C26	0.047 μF ±5%, 160 VDCW, polyester	Ducon DMA108	
C27	0.015 μF ±5%, 160 VDCW, polyester	Ducon DMA102	
C28	4700 pF ±5%, 630 VDCW, polyester	Ducon DMA608	
C29	1500 pF ±5%, 630 VDCW, polyester	Ducon DMA602	
C30	470 pF ±5%, 630 VDCW, polystyrene	Allied Capacitors TCS608	
C31	Not used		
C32	1.0 μF -20+50%, 35 VDCW, electrolytic, tantalum	STC TAG 1.0/35	227850
C33	1000 μF -10+50%, 10 VDCW, electrolytic	Philips C436AR/D1000	229916
C34	Optimum value selected on test		
C35	0.1 μF ±10%, 250 VDCW, polyester	Philips C280	227096
C36	0.1 μF ±10%, 250 VDCW, polyester	Philips C280	227096
C37	10 μF ±20%, 50 VDCW, electrolytic, tantalum, CS13		

(b) Connectors

PLE	3-way, female (Lumberg K31 modified)	AWA 94766V332A	
SKA	3-way, female, chassis mounting	Siemens Halske 9 Rel kli 6a	233970
SKB	Single point terminal, black	Belling Lee L1568/ISC	

Components Mounted on Chassis (continued)

SKC	Two point terminal, black and red	Belling Lee L1568/6IS	
SKE	3-way, male	Lumberg SF3	233954
SK5	One contact, green	Harwin W3000	
SK6	One contact, blue	Harwin W3000	
SK9	One contact, white	Harwin W3000	
SK0	One contact, black	Harwin W3000	

(c) Resistors

R1	604 ±1%, 100 ppm/°C, metal film	Painton PMF70	606898
R2	4.53 kΩ ±1%, 100 ppm/°C, metal film	Painton PMF60	610863
R3	4.53 kΩ ±1%, 100 ppm/°C, metal film	Paintaon PMF60	610863
R4	562 Ω ±1%, 100 ppm/°C, metal film	Painton PMF60	606870
R5	562 Ω ±1%, 100 ppm/°C, metal film	Painton PMF60	606870
R6	1 kΩ ±5%, 1/4W, carbon film	TTK RD1/4 SZJ	608058
R7	9.09 kΩ ±1%, 100 ppm/°C, metal film	Painton PMF60	611960
R8	1.13 kΩ ±1%, 100 ppm/°C, metal film	Painton PMF60	608150
R9	10 kΩ ±1%, 100 ppm/°C, metal film	Painton PMF60	612062
R10	102 Ω ±1%, 100 ppm/°C, metal film	Painton PMF60	604120
R11	9.09 kΩ ±1%, 100 ppm/°C, metal film	Painton PMF60	611960
R12	9.09 kΩ ±1%, 100 ppm/°C, metal film	Painton PMF60	911960
R13	3.3 kΩ ±5%, 1/4W, carbon film	TTK RD1/4 SZJ	610322
R14	18 kΩ ±5%, 1/4W, carbon film	TTK RD1/4 SZJ	613319
R15	6.8 kΩ ±5%, 1/4W, carbon film	TTK RD1/4 SZJ	511547
R16	1.5 kΩ ±5%, 1/4W, carbon film	TTK RD1/4 SZJ	608722
R17	470 Ω ±5%, 1/4W, carbon film	TTK RD1/4 SZJ	606611
R18	27 kΩ ±5%, 1/4W, carbon film	TTK RD1/4 SZJ	614157
R19	8.2 kΩ ±5%, 1/4W, carbon film	TTK RD1/4 SZJ	611865
R20	1.47 kΩ ±1%, 100 ppm/°C, metal film	Painton PMF60	608674
R21	464 Ω ±1%, 100 ppm/°C, metal film	Painton PMF60	606526
R22	147 Ω ±1%, 100 ppm/°C, metal film	Painton PMF60	604620
R23	75 Ω ±1%, 100 ppm/°C, metal film	Painton PMF60	603674
R24	464 Ω ±1%, 100 ppm/°C, metal film	Painton PMF60	606526
R25	147 Ω ±1%, 100 ppm/°C, metal film	Painton PMF60	604620
R26	68.1 Ω ±1%, 100 ppm/°C, metal film	Painton PMF60	603606
R27	237 Ω ±1%, 100 ppm/°C, metal film	Painton PMF60	605350
R28	1.5 MΩ ±10%, 1/4W, carbon film	IRC DMB	

Component Mounted on Chassis (continued)

R29	1.8 kΩ ±5%, 1/4W, carbon film	TTK RD1/4 SZJ	609092
R30	1.8 kΩ ±5%, 1/4W, carbon film	TTK RD1/4 SZJ	609092
R31	470 Ω ±5%, 1/4W, carbon film	TTK RD1/4 SZJ	606611
R32	390 Ω ±5%, 1/4W, carbon film	TTK RD1/4 SZJ	
R33	68 Ω ±5%, 1/4W, carbon film	TTK RD1/4 SZJ	
R34	196 kΩ ±1%, 100 ppm/°C, metal film	Painton PMF70	616583
R35	8.2 kΩ ±2%, 1/2W, metal oxide	Electrosil TR5	611867
R36	68 kΩ ±2%, 1/2W, metal oxide	Electrosil TR5	615515
RV1-1	30 kΩ ±2%, variable, wire-wound, curve A)	Colvern CLR50/152/11	
RV1-2	30 kΩ ±2%, variable, wire-wound, curve A)		
RV1-3	15 kΩ ±2%, variable, wire-wound, curve A)		
RV2	5 kΩ ±10%, variable, wire-wound, linear law	Colvern CLR1206/11	
RV3	5 kΩ ±10%, variable, wire-wound, linear law	Colvern CLR1206/11	
RV4	5 kΩ ±10%, variable, wire-wound, linear law	Colvern CLR1206/11	
RV5	2.5 kΩ ±10%, variable, wire-wound, linear law	Colvern CLR1206/11	
RV6	2.5 kΩ ±10%, variable, wire-wound, linear law	Colvern CLR1206/11	
RV7	2.5 kΩ ±10%, variable, wire-wound, linear law	Colvern CLR1206/11	
RV8	10 kΩ ±10%, variable; wire-wound, linear law	Colvern CLR1206/10	

(d) Switches

SWA	Push-button, AB type 700 3-section	AWA 94766V94A
SWB	Oak type F, (mounts RV8)	AWA 94766V226A
SWC	Oak type F, 5-section	AWA 94766V159A
SWD	Push-button, AB type 700 7-section	AWA 94766V95A
SWE	Push-button, AB type 700 3-section	AWA 94766V151A
SWF	Push-button, AB type 700 3-section	AWA 94766V96A