1 Introduction

The OS25 is a dual trace oscilloscope. This instrument is the continuation of an already successful range of high quality oscilloscopes and although retaining simplicity of operation and ease of servicing it incorporates many features normally associated with more expensive oscilloscopes.

One of these features is automatic selection of the operating mode most suited to time base speed. This is achieved by changing from beam switching, for the two slowest time base ranges, to alternate sweep for the four upper ranges.

The bandwidth of the vertical amplifier extends from DC to 5 MHz and the time base from 1 sec/cm to 0.5μS/cm, using switched and fine controls. The triggering facilities of the OS25 are fully comprehensive; both input channels can be triggered internally using either channel input signal, or externally using a suitable source, including the pulses of a composite TV waveform.

In this attractively designed instrument reliability has been achieved by the partial use of solid state circuitry and this has also contributed to its lightweight, yet rugged, construction.

2 Specification

VERTICAL AMPLIFIERS
Bandwidth: DC to approx. 5 MHz (-3dB)
Sensitivity: 100mV/cm
Input Impedance: Nominally 1MΩ/35pF
Measuring accuracy: Typically ±5%

INPUT ATTENUATOR
Nine-position switched attenuator giving sensi tivities of 100mV/cm to 50V/cm in a 1, 2, 5 sequence.
For AC input a 400V DC blocking capacitor is provided.

TIME BASE
Calibrated speeds of 100, 10, 1mS/cm and 100, 10, 1μS/cm
Measuring accuracy: ±5% typically
Continuous adjustment from 1sec/cm to 0.5μS/cm using X GAIN and VARIABLE TIME controls.

X EXPANSION
Up to two screen diameters. Any part of expanded trace can be centred on screen.

TIME BASE OUTPUT
Available at a rear panel socket (X OUT) as a negative-going saw-tooth waveform of approx-imately 4.5V.

HORIZONTAL AMPLIFIER (X IN)
Bandwidth: 5Hz to 100kHz approx
Sensitivity: 0.25V/cm to 0.5V/cm approx

TRIGGERING
Internal or external
Auto: 50Hz to 1 MHz. positive or negative
Trigger level selection: Up to 3MHz, positive or negative.
Trigger sensitivity: Internal, typically 2mm vertical deflection. External, typically 1V.
TV sync: A built-in TV sync. integrator permits triggering from frame pulses of a composite TV waveform.

Z MODULATION
An input terminal at the rear of the instrument is AC coupled to the CRT. Negative going pulses brighten the trace. Sensitivity 50V pk.

CATHODE RAY TUBE
5in. helical PDA type operated at 3kV overall.
Display area: 10cm horizontal, 8cm vertical.

POWER REQUIREMENTS
100 to 125V, 200 to 250V, 50 to 60Hz, 80VA.
Voltage taps at 110, 200, 220 and 240V. The above specification applies at the nominal tap of 240V.

DIMENSIONS
11in. high, $8\frac{3}{16}$ in. wide, $15\frac{5}{8}$ in. deep. (28 x 21.3 x 40 cm).

WEIGHT
$18\frac{3}{4}$ lb (8.5 kg).

3 Operation

3.1 PREPARATION FOR USE

When despatched from the factory the instrument is normally set to operate from a nominal 240V AC supply. Before the instrument is switched on, the input to the supply transformer should be checked and set to the correct tapping as indicated in Table 3.1.

TABLE 3.1 TRANSFORMER TAPPINGS

Input supply	Transformer tapping
105 to 115V	110V
190 to 210V	200V
210 to 230V	220V
230 to 250V	240V

TABLE 3.1 TRANSFORMER TAPPINGS

From the table it can be seen that there is a choice of transformer tappings. In general it is preferable to use the higher supply tappings (e.g. if the supply is 230V set the tapping to 240V rather than 220V).

Access to the transformer is obtained by removing the right-hand side panel (see Fig. 2).

3.2 FRONT PANEL CONTROLS

The illustration in Section 1 shows the front panel controls of the OS25 oscilloscope and the functions of these controls are detailed in Table 3.2.

TABLE 3.2 FRONT PANEL CONTROLS

Control	Function	Remarks
ON/OFF	Controls the input supply	Incorporated in the BRILL(iance) control.
BRILL(iance)	Controls the brightness of the trace.	
FOCUS	Controls the definition of the trace.	
Y1 SHIFT ↕	Controls the vertical position of Y1 trace.	
Y2 SHIFT ↕	Controls the vertical position of Y2 trace.	
VOLTS/CM	Controls the sensitivity of the vertical amplifiers (Y1 and Y2).	
AC/DC	Determines whether the input to each Y axis is AC or DC coupled.	
X SHIFT ↔	Controls the horizontal position of the trace.	
X GAIN	Controls the sensitivity of the X amplifier.	Affects the accuracy of the TIME/CM control.
STABILITY	Affects the operation of the time base circuit.	
LEVEL	Controls the point at which the Schmitt trigger fires when operating in the manual mode.	In the extreme counter clockwise position a switch operates to provide triggering in the AUTO mode.
TIME/CM	Controls the speed of the time base sweep.	Only accurate when X GAIN and variable time controls are at CAL.
VARIABLE TIME	Provides fine adjustment for the time base speed.	Affects the accuracy of the TIME/CM switch.

3.3 USE OF CONTROLS

The following guidance on the correct operation of the instrument and its various controls is given to ensure that the best results are obtained, and is applicable to all modes of operation.

(1) Always keep the display in the centre of the screen.

(2) When making time or frequency measurements, use the centre six centimetres of horizontal deflection whenever possible. This ensures maximum accuracy.

(3) Avoid using vertical displays which exceed the eight centimetres height of the screen.

NOTE The VOLTS/CM control enables a maximum Y input voltage of 400V peak-to-peak to be displayed on the screen. This is the maximum safe Y input voltage. See also para 4.3 Input Protection.

(4) Avoid using the Y SHIFT control to examine positive and negative peaks, otherwise non-linearity may be introduced.

(5) Do not display stationary traces which are too bright. Doing so will impair the focus of the trace and may also burn the screen of the tube.

(6) When a waveform is being displayed adjust the FOCUS control to obtain optimum sharpness over the whole trace.

(7) When making measurements, set all controls which affect the accuracy of the TIME/CM controls to their CAL position (see Table 3.2). Rotate the graticule so that it is accurately aligned with a horizontal line on the centre of the screen.

3.4 FUNCTIONAL CHECK

(1) Turn the ON/OFF switch, which is incorporated in the BRILL(iance) control, clockwise until it operates. (This is indicated by the glowing of the adjacent neon indicator).

(2) Set the BRILL(iance) control to three quarters clockwise and set the TRIG MODE switch to Y1+.

(3) Allow five minutes for the instrument to warm up.

(4) Set the TIME/CM switch to 1mS/cm.

(5) Set the variable TIME control to the CAL position.

(6) Set the STABILITY control fully clockwise.

(7) Rotate the LEVEL control to the AUTO position and then turn it clockwise until the AUTO switch just operates.

(8) Adjust the X SHIFT and Y SHIFT controls to produce two lines across the centre of the screen.

(9) Adjust the BRILL control to obtain a trace of reasonable brightness.

(10) Adjust the FOCUS control to produce sharp edged lines across the centre of the screen.

NOTE At this stage the time base is free running.

(11) Adjust the STABILITY control anti-clockwise until the trace just disappears. When this control is set correctly, the trace will reappear when the LEVEL control is rotated anti-clockwise to the AUTO position.

NOTE At this point the time base is being triggered at approximately 50Hz which is the output produced by the time base trigger circuit.

(12) Rotate the TIME/CM switch through all positions. The trace should remain on the screen at all positions but will become dimmer at the higher switch positions (μS positions), and it may be necessary to reset the position of the STABILITY control to produce a trace on the highest switch position (1μS).

NOTE The reason for the dimming of the trace is that the trigger source repetition rate is much lower than the time base sweep time. This is not important when operating under normal conditions as the time base is triggered by an internal or external trigger source appropriate to the waveform being displayed, which will restore the brightness.

The sequence detailed above checks that the instrument is operating correctly.

3.5 AUTO OPERATION

(a) Normal Mode

AUTO operation provides automatic triggering or synchronisation of the time base from one of the input signals applied to the vertical amplifiers or to the EXT. TRIG socket. The deflection required for this mode of triggering is less than 5mm and the trigger may be positive-going or negative-going. This mode is normally used when it is required to display a repetitive waveform.

To set the instrument to this mode of operation, using internal triggering proceed as follows:

(1) Adjust the STABILITY and LEVEL controls as detailed in Section 3.4 (6), (7) and (11).

(2) Set the input selector switch to AC.

(3) Apply the input signal across the Y1 and earth terminals.

(4) Set the TRIG MODE switch to Y1 and + or - respectively.

(5) Adjust the VOLTS/CM control to produce three centimetres of vertical deflection.

NOTE If the trace appears as a fairly solid rectangle the time base is too slow and the TIME/CM switch should be set to a higher speed.

If horizontal sloping lines appear, the trace is too fast and the TIME/CM switch should be set to a lower position.

(b) Displaying TV Waveform

If a composite television signal is to be displayed, the foregoing procedure should be adopted but the TRIG MODE switch should be set to Y1, TV +.

When the TV position is in use, line pulses are attenuated and frame pulses are integrated, so that

the time base is triggered by the frame synchronisation pulses. The TV position is also useful when it is required to trigger the time base from a low frequency source superimposed with a large level of h.f. noise.

NOTE TV triggering is available only on channel 1 (Y1).

(c) External Triggering.
If it is required an external trigger source can be used to trigger the time base circuit. In this instance the trigger source (1V minimum) is applied to the EXT. input on the front panel and the TRIG MODE is set to EXT. + or -.

3.6 MANUAL OPERATION
When the instrument is used in the manual mode the time base is no longer triggered by a fixed level of trigger input but by a level determined by the LEVEL control. This trigger voltage may again be positive or negative going.
To set the instrument to the manual mode of operation, proceed as follows:

(1) Set-up the STABILITY and LEVEL controls as detailed in para 3.4 (6), (7) and (11).
(2) Apply a signal across the Y1 and earth terminals and obtain a suitable display by adjustment of the TIME/CM and variable TIME controls.
(3) Rotate the LEVEL control clockwise until the trace disappears then reappears.

NOTE Further clockwise rotation will cause the trace to commence at a higher or lower level on the leading edge depending on the choice of positive or negative. If positive, the trace will disappear. again if the trigger point voltage equals or exceeds the most positive point of the input signal. If negative, then the trace will disappear when the trigger point voltage equals or exceeds the most negative point of the input signal.

3.7 USE OF X INPUT FACILITIES
When the time base is switched off (TB OFF EXT. X), any AC signal applied to the X IN and earth sockets at the rear of the oscilloscope will produce a horizontal deflection of the trace on the screen. The length of this deflection can be varied by the X GAIN control. If the trace cannot be reduced to 10 cm or less by use of this control, the input signal is too large. If an AC signal is also applied to the vertical (Y) amplifiers a Lissajous figure will be displayed on the screen.
On the 100mS/cm and 10mS/cm time base ranges two Y channels are available for X-Y plotting. On the other time base ranges (1mS/cm to 1μS/cm inclusive) only one Y channel is available and the choice of the channel, Y1 or Y2, depends on the state of the bistable. A particular channel may be chosen by switching the time base speed switch between 1mS/cm and 10mS/cm several times until the correct channel appears.

3.8 Z MODULATION
Bright-up of a particular part (or parts) of the displayed signal can be obtained by applying a negative going signal to the cathode of the tube via the Z MOD socket at the rear of the instrument.

4 Circuit Description

4.1 GENERAL

A functional diagram of the oscilloscope is shown in Fig. 1. The following circuit description considers the functions of these blocks and builds up an overall picture of the circuit operation, with the aid of circuit diagrams Fig. 3 and 4.

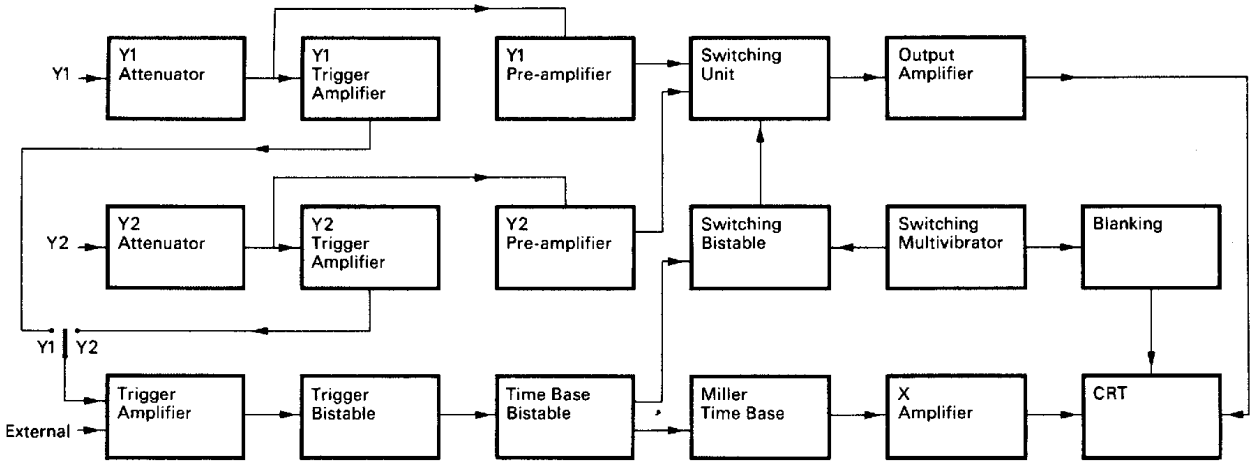

Fig. 1. Functional Diagram

4.2 INPUT ATTENUATORS

Each of the identical attenuators for channel 1 and channel 2 (Y1 and Y2) consists of a nine position switch selecting cascade pairs of frequency compensated networks which provide nine calibrated input sensitivities in 1. 2. 5 steps.

4.3 INPUT PROTECTION

For AC input conditions a 400V blocking capacitor is provided. For DC input conditions the input impedance appears as 1MΩ shunted by 35pF, and the input is limited by the dissipation in the associated components. The maximum input level of 400V pk.pk. applies up to approximately 20kHz. Above 20kHz consideration must be given to the level of current that may flow in the equivalent input capacitor.

4.4 VERTICAL PRE-AMPLIFIERS

Each input channel is identical, therefore, a description of channel 1 also applies to channel 2. Two component references are used (one for each channel) and are separated by an oblique stroke. Input signals pass from the input terminals through the attenuators to the grids of the input cathode follower (V101b/V102b). RV101/RV102 are preset to equalise the gains of the two channels. From V101b/V102b signals pass through zener diode-potentiometer shift networks (MR101, RV1/MR102, RV2) to the bases of two emitter followers. Associated with each pre-amplifier is a trigger amplifier (V101a/V102a) the outputs being taken to the trigger selection switch.

4.5 SWITCHING UNIT

This consists of a bistable (VT105, VT106) driven by input pulses from a multivibrator (VT107, VT108) and from the time base bistable. The switching bistable drives a four diode gate (MR103, MR105/MR104, MR106) which is in turn fed by inputs from the two pre-amplifiers. The output of the gate is taken to the main Y amplifier. This output consists of either a 75kHz square wave containing the two input signals on alternate half cycles (beam switching), or a variable frequency sqare wave locked to the time base frequency (alternate sweep).
The two lower time base ranges operate on beam switching while the four upper ranges use alternate sweeps. Change over from one mode to the other is automatic with the setting of the time base speed. In the beam switching mode of operation, pulses from the multivibrator are taken to the blanking valve V205b. This valve blanks-off the CRT grid during the transition period.

4.6 OUTPUT AMPLIFIER

The output from the switching unit is fed to the base of VT103 which together with VT104, V103a and V104a form a hybrid cascode amplifier. The overall gain of the amplifier (both channels together) is set by RV105 and the h.f. response is set by C139. The output from the anodes of V103a and V104a is applied to the Y plates of the CRT via cathode followers V103b and V104b. RV106 adjusts astigmatism and RV107 adjusts pincushion geometry (see paras. 5.8 and 5.9).

4.7 TIMEBASE TRIGGER

The time base trigger circuit comprises an amplifier V201a, a phase splitter V201b and a cathode coupled bistable circuit V202. The time base can be triggered either internally from a signal derived from either of the vertical trigger amplifiers (V101a, V102a) or externally from a trigger source applied to the EXT. socket. The trigger input is amplified by V201b, phase split by V201a and applied to the bistable circuit (V202) via the polarity switch S5.

The selected signal is applied to the grid of V202b, part of the cathode coupled bistable. This circuit is controlled by S7 (AUTO) and acts as a bistable device locking to positive or negative pulses at a point determined by the setting of RV3A (LEVEL), when the switch is in the manual position, or a free running multivibrator when S7 is in the AUTO position. In this position, in the absence of a trigger signal, the repetition frequency of the circuit is determined by C205, R212 and R213 and is approximately 50Hz.

When operating in this mode the circuit locks readily to positive or negative inputs up to 2 MHz applied to V202b grid. The output of V202a anode is differentiated by R218 and C207 and the positive excursions are removed by MR201.

The negative spikes are applied to the grid of V203b in the time base circuit via MR202. The first negative going spike drives V203b to cut-off and triggers the time base valve V203a. Subsequent negative going signals are ineffective until the time base circuit has completed its action.

When S5 is set to TV, the input signals to V202b are integrated and the time base trigger is generated by the frame pulse of the composite TV waveform.

NOTE This position is also useful when it is required to trigger the time base from a low frequency source superimposed with a large level of h.f. noise.

4.8 TIMEBASE

The timebase circuit consists of V203, V204b and associated components. The negative signal from MR202 is applied to V203b and drives the grid to cut-off. The anode voltage rises and is applied to V204b grid via S6 (TIME/CM) causing the voltage at V204b anode to fall. This fall is fed back to V203b grid and the action becomes cumulative so that V203b anode rises to h.t. and V204b anode (and hence V203b grid) falls to a relatively low voltage. When V203b cuts-off its cathode potential falls and so does V203a anode. This is also applied to V203a grid via the appropriate timing capacitor between S6a and S6b. This set of circumstances creates a situation where both anode and grid have fallen in potential simultaneously, the valve is almost cut-off therefore, and current is drawn via R220. The Miller run-down action now starts and V203a grid rises due to the current flowing through the timing resistor (R225, R226, R236) and capacitor. As the grid voltage rises the timing capacitor (C210 - C216) discharges through the valve and the anode voltage falls, thus causing the cathode voltage of V203b to fall also. At some point V203b cathode voltage approaches the voltage on its grid and the valve starts to conduct once more. Cumulative action between V203b and V224b causes V203b to quickly reach its fully conducting state again. The circuit will repeat the foregoing action when the next negative going spike is received.

The action described takes place when RV3b (STABILITY) is adjusted so that the time base just fails to free-run. If RV3b is too far advanced the time base will free-run at a rate determined by the hold-off capacitors on S6c and S6d. These capacitors act as speed-up elements for the trigger action of V203b and V204b and also provide recovery time for the time base.

The required potential for the timing capacitors is derived via RV4 (VARIABLE TIME) which is in series with RV202 (SET SPEED). RV202 is a preset potentiometer which is adjusted during manufacture.

When switch S5 is set to TB OFF. EXT. X the cathode circuit of V204b is made open circuit and prevents the valve operating, thus stopping the time base circuit. Also, S5 disconnects the blanking electrode of the CRT from the anode of V203b.

The output of the time base is applied to the horizontal (X) amplifier via the frequency compensating network R224, C209, C208 and RV203, C223.

4.9 HORIZONTAL (X) AMPLIFIER AND PRE-AMPLIFIER.

V204a and V205a form a long tail pair which makes up the horizontal (X) amplifier. The anode outputs of these valves are applied to the X deflection plates of the CRT. RV204 (set gain) is a preset control which is adjusted during manufacture so that full clockwise rotation of the X GAIN control (RV5a), on the front panel, causes the trace to be expanded by a factor of two. The signal at V204a cathode (a sawtooth waveform) is available at a rear panel socket (X OUT). The output is only linear however, when the trace is not expanded, i.e. X GAIN control is fully anticlockwise. In any other position the output will flatten out top and bottom and will contain a linear portion proportional to that part of the trace occupying the centre 10cm of horizontal deflection.

The grid of V204a is also connected to the X IN socket at the rear of instrument and the applied input is fed to V204a via C2.

When the time base circuit is switched off, any

input applied to the X IN socket is amplified by the X amplifier and applied to the X deflection plates as before.
V205a has the X shift voltage applied to its grid by RV5b.

4.10 CATHODE RAY TUBE (CRT)
A helical PDA type tube is used in this instrument and provides a vertical deflection of 8cm and a horizontal deflection of 10cm. Astigmatism is corrected by RV106 (ASTIG) and is preset during manufacture together with RV107 which affects the geometry of the display. Direct coupled bright-up is provided from the time base circuit (V203b) to g2 of the tube. When the time base is switched off, g2 assumes the same potential as a1. Signals applied to the Z MOD socket (at the rear) are fed to the grid of the tube providing brightness modulation.
The brilliance and focus circuits are conventional and control g1 and a2 of the tube respectively.

4.11 POWER SUPPLY
MR212, MR213, C238 and C239 form a voltage doubling circuit providing the h.t. for the X and Y deflection circuits. Two +150V regulated h.t. lines are provided by MR214 and MR215. MR211 provides the + 1750V DC for the PDA terminal (a4) and MR210 provides the -1200V DC supply for the cathode. MR205 - MR209 and C230 provide a +15V DC which is regulated to provide +10V (MR204) and +5V (MR203).
The centre tap of the 6.3V AC heater winding is connected to a suitable positive line to avoid voltage stresses between the heaters and cathodes of the valves.

5 Maintenance

5.1 GENERAL

Maintenance is normally restricted to replacing valves and this action may incur slight re-calibration. The following data and guidance is provided in order to help servicing personnel maintain the instrument in first class condition.
The voltages and waveforms shown on the circuit diagrams (Fig. 4 and 5) are a useful aid to maintainance and fault finding. They,are, however, only typical results and some deviations can be expected. The voltages indicated are measured with an AVOmeter (20,000Ω/volt).
CAUTION All tubes are directly coupled and the instrument must not be operated unless all the tubes are fitted.

5.2 TEST EQUIPMENT

The following items of test equipment are recommended for use when servicing the OS25.
(1) Square wave generator. Frequency range 1kHz to 1 MHz, voltage range 0 - 500mV; rise time less than 100nS. Suitable instruments are the Advance Double Pulse Generator PG5002D and the Advance Wide Range Oscillator SG67.
(2) AVOmeter Mk. VIII (20,000 Ω/volt).

5.3 INPUT ATTENUATORS (VOLTS/CM)

To align the attenuators the following procedure should be adopted:
(1) Apply a 3 kHz square wave to the Y1 and Y2 sockets of the instrument.
(2) Set both VOLTS/CM switches to 0.1.
(3) Adjust the TIME/CM control (and variable TIME control if necessary) to display three or four cycles of the input waveform on the screen.
NOTE This action checks the quality of the pulse output from the generator since in the 0.1 position the attenuator path is a short circuit.
(4) Set the VOLTS/CM switches to 0.2 and adjust the output of the square wave generator to produce a vertical display two or three centimetres high.
(5) Adjust C107, C108 to produce sharp corners on the displayed square waves.
(6) Repeat steps (2) and (3) with the VOLTS/CM switch set as detailed in Table 5.1 and adjust the corresponding trimmer.

TABLE 5.1 ATTENUATOR ADJUSTMENTS

VOLTS/CM Setting	Adjust Trimmer	
	Y1	Y2
0.2	C107	C108
0.5	C113	C114
1.0	C119	C120
2.0	C117	C118
5	See Note 1	
10	C125	C126
20	C123	C124
50	See Note 2	

NOTES
(1) 5 VOLTS/CM settings are correct if adjustments to C117, C118 have been correctly made.
(2) 50 VOLTS/CM settings are correct if adjustments to C123, C124 have been correctly made.
C103, C104 and C109, C110 are adjusted during manufacture so that the input capacitance on all settings of the VOLTS/CM switches are equal to the input capacitance of the 0.1 positions. If it is found necessary to readjust these trimmers the following procedure should be followed.
(1) Connect a 1MΩ resistor in parallel with a 6 to 30pF trimming capacitor.
(2) Connect one end of this network to the Y1 socket.
(3) Apply the square wave signal between the other end of the network and ground.
(4) Set the VOLTS/CM control to 0.1.
(5) Adjust the output of the signal generator to produce a vertical display of two to three centimetres.
(6) Adjust the trimmer capacitor of the test network to produce the best possible square wave on the oscilloscope.
(7) Set the VOLTS/CM control to 0.2.
(8) Repeat step (5).
(9) Adjust C103 to produce the best possible square wave on the oscilloscope.
(10) Set the VOLTS/CM switch to 0.5.
(11) Repeat step (6).
(12) Adjust C109 to produce the best possible square wave on the oscilloscope.
(13) Repeat for Y2 adjusting C107 and C110.

5.4 VERTICAL (Y) AMPLIFIERS

(a) Sensitivity
RV101 and RV102 are adjusted during manufacture so that the gain of each amplifier is the same. RV105 is adjusted so that the overall gain is correct. To reset this sensitivity proceed as follows:
(1) Apply a signal of 3.55V r.m.s. (10V pk.pk.) to the 5 volts/cm input of each attenuator.
(2) Adjust RV105 to produce a vertical deflection of 2cm on the smaller trace. Adjust RV101 or RV102 to bring the larger trace down to the size of the smaller.
(b) Frequency compensation
C139 is the only variable component in the frequency compensation network of the vertical amplifier. Its accuracy may be checked as follows:
(1) Apply a square wave of 300 kHz at a level of 200 to 300mV to the Y1 socket.
(2) Set the VOLTS/CM switch to 0.1.
(3) Adjust C139 to produce the best flat top possible on the displayed waveform.

(c) Channel breakthrough
Breakthrough should be less than 2mm between channels with one channel filling the display area of the CRT, and with the other channel terminated in a shrouded 10kΩ resistor. This breakthrough should be viewed on the most sensitive Y amplifier range.
(d) Focus
Thickening of the trace in the Y axis may occur on the two lowest timebase ranges. RV103 (Y1) and RV104 (Y2) may be adjusted to minimise this.

5.5 TRIGGER CIRCUIT
The only component likely to need adjustment is RV201 (TRIG SENS).
The following adjustment should be carried out at 50Hz. Note that the typical trigger performance at 1 MHz will be approximately 5mm on AUTO and approximately 2cm at 3 MHz on trigger LEVEL selection.
The adjustment should be done as follows:
(1) Apply a square wave of 1 to 3 kHz.
(2) Adjust the VOLTS/CM switch to give a vertical display height of 2mm.
(3) Rotate the LEVEL control until the display is stationary. If this cannot be done, adjust RV201 until it is possible to lock the display using the LEVEL control.
(4) Reduce the input signal so that the vertical display height is less than 2mm and check that the LEVEL control can no longer lock the display.
NOTE The setting of RV201 must be set finally so that a minimum of 2mm vertical deflection allows the LEVEL control to lock the display. If less than 2mm of vertical display can be locked, the Schmitt trigger will be too sensitive and will produce instability and erratic triggering.
If the above limit cannot be obtained V202 should be checked.

5.6 HORIZONTAL AMPLIFIER
RV204 is the only preset control and this is set during manufacture so that full clockwise rotation of RV5A (X GAIN) expands the trace two and a half diameters.

5.7 TIME BASE CALIBRATION
To check the calibration of the time base proceed as follows:
(1) Apply a square wave of 1000 Hz ±2% to the Y1 socket of the oscilloscope.
(2) Set the TIME/CM control to the 1mS position.
(3) Set the X GAIN and variable controls to their CAL positions.
(4) Set RV203 (TB LENGTH) so that trace is approximately 12cm long.
(5) Adjust RV202 (SET SPEED) until the trace has a spread over the centre 8cm of X deflection of 1 pulse/cm.
(6) Set TIME/CM control to the 10μS position, apply approximately 100 kHz square wave and adjust C208 for best linearity of centre 8cm.
(7) Set the TIME/CM control to the 1μS position.
(8) Apply a square wave of 1 MHz ±2% to the Y1 socket.
(9) Adjust C210 until the trace has a spread over the centre 8cm of X deflection of 1 pulse/cm.
At the completion of this procedure the time base is correctly aligned at all speeds. This can be checked by setting the TIME/CM to each position in turn, and applying a square wave signal of equivalent period to the Y1 socket. In each position the trace should lock. If this does not occur, check the following components: R225, R226, C210-C216.

5.8 ASTIGMATISM
Astigmatism adjustment is provided by RV106 and is preset during manufacture. This control should be adjusted in conjunction with RV7 (FOCUS) to produce optimum definition over the whole display.

5.9 DISPLAY
RV107 is the interplate shield and geometry control and will require resetting only if the CRT is changed. This control should be adjusted using a raster of 10cm by 6cm and should be set to give a display with minimum trapezium shape, 'pin cushioning' and 'barrel distortion'.

NOTE Whenever RV106 and RV107 are adjusted, a complete recalibration of the instrument is necessary, since the X and Y plate sensitivities will be affected.

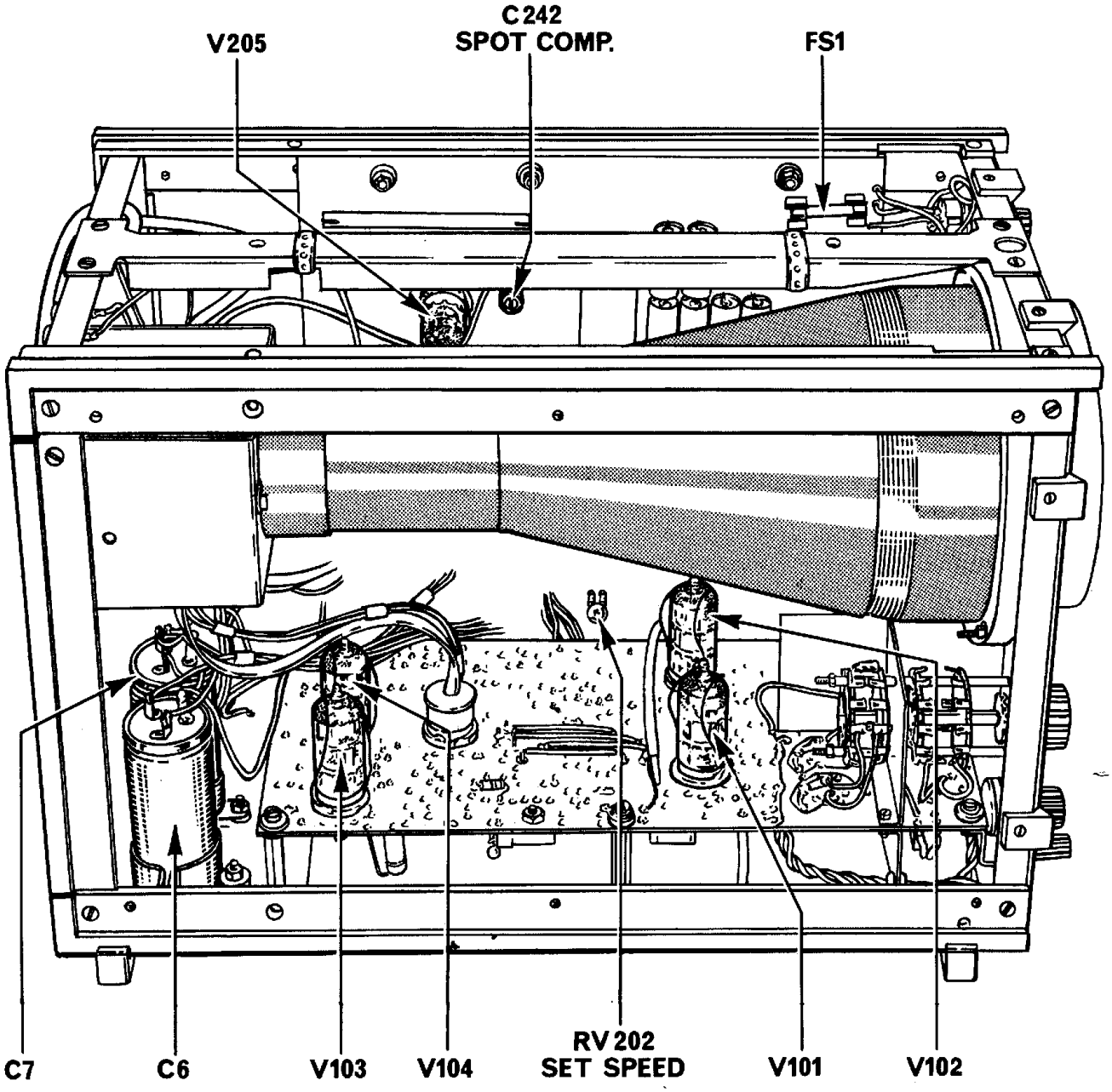

Fig. 2. Component Location Diagram - side view

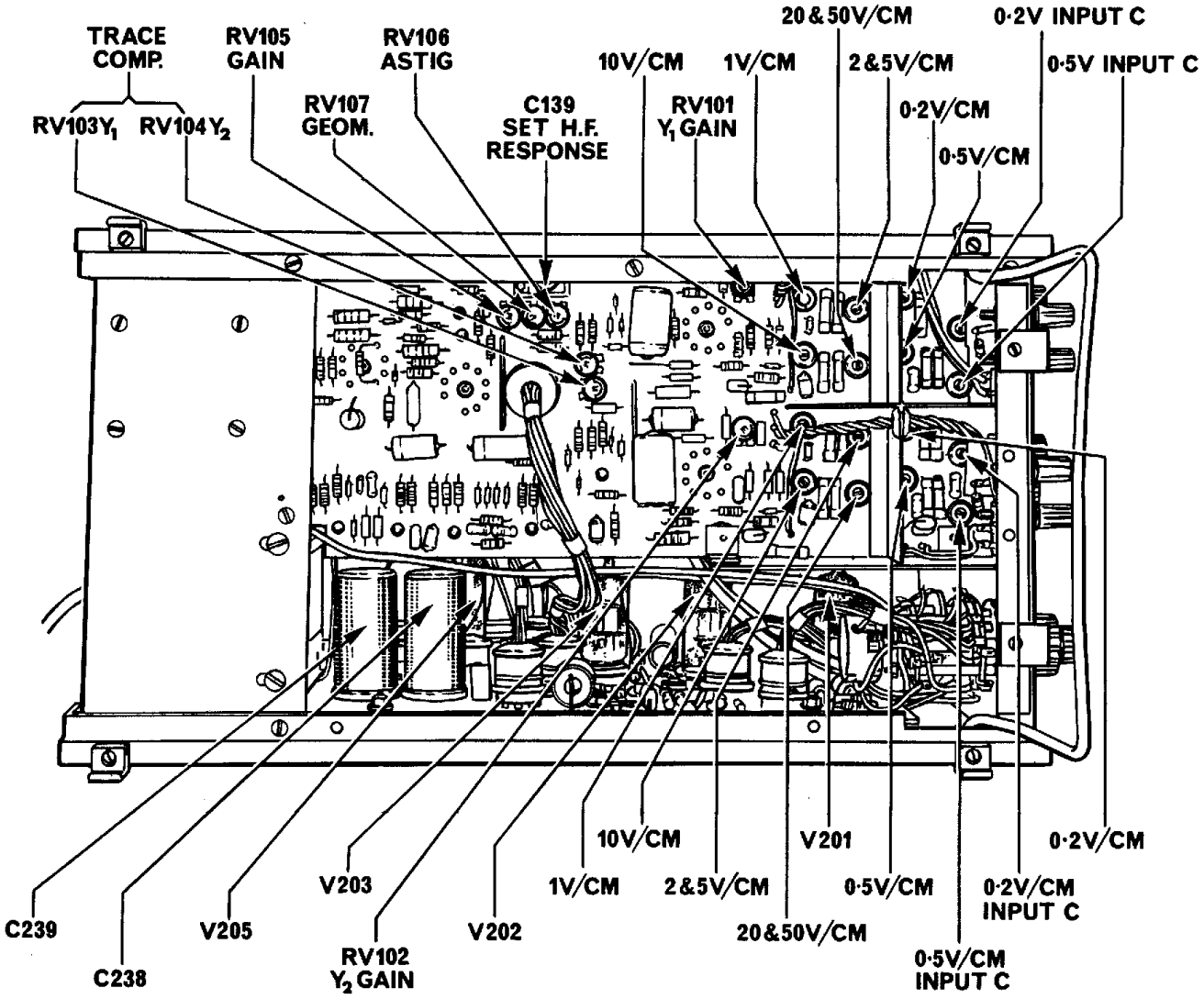

Fig. 3. Component Location Diagram - underside view

Ref	Value	Description			Part No
RESISTORS (10% ½W cracked carbon unless specified)					
R1	Not used				
R2	27K				868
R3	27K				868
R4	Not used				
R101	10				1903
R102	10				1903
R103	500K	1%	¼W	Dubilier	23609
R104	500K	1%	¼W	Dubilier	23609
R105	1M	1%	¼W	Dubilier	23610
R106	1M	1%	¼W	Dubilier	23610
R107	800K	1%	¼W	Dubilier	23611
R108	800K	1%	¼W	Dubilier	23611
R109	250K	1%	¼W	Dubilier	23612
R110	250K	1%	¼W	Dubilier	23612
R111	900K	1%	¼W	Dubilier	23613
R112	900K	1%	¼W	Dubilier	23613
R113	111K	1%	¼W	Dubilier	23614
R114	111K	1%	¼W	Dubilier	23614
R115	990K	1%	¼W	Dubilier	23615
R116	990K	1%	¼W	Dubilier	23615
R117	10.1K	1%	¼W	Dubilier	23616
R118	10.1K	1%	¼W	Dubilier	23616
R119	1M	1%	¼W	Dubilier	23610
R120	1M	1%	¼W	Dubilier	23610
R121	100K				1270
R122	100K				1270
R123	47				1818
R124	47				1818
R125	1.2K				1172
R126	1.2K				1172
R127	2.7K				3247
R128	2.7K				3247
R129	10K				671
R130	10K				1818
R131	47				1818
R132	47				1818
R133	680				7497
R134	680				7497
R135	10				1903
R136	10				1903
R137	100K	10%	1W		19061
R138	100K	10%	1W		19061
R139	2.7K				3247
R140	2.7K				3247
R141	1K				3424
R142	1K				3424
R143	100				3416
R144	100				3416
R145	100				3416
R146	100				3416
R147	10				1903
R148	10				1903
R149	1K				3424
R150	1K				3424
R151	2.7K				3247

Ref	Value	Description	Part No
RESISTORS Continued			
R152	2.7K		3247
R153	150K		3436
R154	150K		3436
R155	10K		671
R156	47		1818
R157	47		1818
R158	47		1818
R159	390		612
R160	390		612
R161	10		1903
R162	3.3K	10% 2W	23617
R163	47		1818
R164	47		1818
R165	10		1903
R166	10		1903
R167	10		1903
R168	10		1903
R169	6.8K	10% 1W	23618
R170	6.8K	10% 1W	23618
R171	10		1903
R172	10		1903
R173	100		3416
R174	100		3416
R175	6.8K	10% 1W	23618
R176	6.8K	10% 1W	23618
R177	10		1903
R178	10		1903
R179	4.7K	10% 2W	23619
R180	2.2K		867
R181	39K		869
R182	39K		869
R183	39K		869
R184	39K		869
R185	4.7K		3427
R186	4.7K		3427
R187	4.7K		3427
R188	4.7K		3427
R189	2.7K		3247
R190	2.7K		3247
R191	1K		3424
R192	1K		3424
R193	39K		869
R194	39K		869
R195	100K		1270
R196	330K		4408
R197	330K		4408
R198	1K		3424
R199	1K		3424
R200	100K		1270
R201	1M		1171
R202	10		1903
R203	1.2K		1172
R204	6.8K		6319
R205	6.8K		6319
R206	10		1903
R207	1M		1171
R208	470		3419

Ref	Value	Description	Part No
RESISTORS Continued			
R209	4.7K		3427
R210	4.7K		3427
R211	10		1903
R212	560K		4409
R213	560K		4409
R214	10K	10% 1W	1825
R215	56K		3435
R216	3.3K		3425
R217	2.7K		3427
R218	4.7K		3427
R219	10K	10% 3W	23575
R220	560K		4409
R221	3.3K		3425
R222	6.8K		6319
R223	470		3419
R224	1.8M	1% Dubilier	23576
R225	400K	1% Dubilier	23577
R226	8M	2% RRC 2HS2	23578
R227	10K		671
R228	820K	5% ½W	18585
R229	4.7K		597
R230	5.1M	5% ¼W	23579
R231	100K	10% 2W	23580
R232	10		1903
R233	1M	5% 1W	19073
R234	820K	5% ½W	18585
R235	1M		1171
R236	400K	1% Dubilier	23577
R237	68K		7296
R238	4.7K		3427
R239	4.7K		3427
R240	10		1903
R241	10		1903
R242	33K	10% 2W	23581
R243	33K	10% 2W	23581
R244	2.7K		3247
R245	220K		6703
R246	330K		4408
R247	330K		4408
R248	10K		671
R249	4.7K		3427
R250	10		1903
R251	1M		1171
R252	1.8K		3420
R253	1K		3424
R254	100		3416
R255	Not used		
R256	47		1818
R257	27K		868
R258	1M		1171
R259	10K		671
R260	Not used		
R261	1M		1171
R262	10K	10% 2W	23575
R263	10K	10% 2W	23575
R264	560	10% 5W Wirewound	23587

Ref	Value	Description	Part No
RESISTORS Continued			
R265	560	10% 5W Wirewound	23587
R266	Not used		
R267	Not used		
R268	Not used		
R269	10K		671
POTENTIOMETERS			
RV1	5K	Morganite type 30N	23627
RV2	5K	Morganite type 30N	23627
RV3A/B	1M + 100K	Trigger level/auto switch Morganite type AM (Part of S7)	23629
RV4	100K	Pot/timebase switch A. B. Metals (Part of S6)	23739
RV5A/B	100K + 10K	Dual concentric Morganite type AMN	23630
RV6	250K	Brilliance control/on-off switch A. B. Metals (part of S8)	23631
RV7	1M	Morganite type 30N	23628
RV101	470	Morganite type 62H	23620
RV102	470	Morganite type 62H	23620
RV103	10K	Morganite type 62H	23621
RV104	10K	Morganite type 62H	23621
RV105	100	Morganite type 62H	23622
RV106	1M	Morganite type 62H	23589
RV107	1M	Morganite type 62H	23589
RV201	100K	Morganite type 62H	23588
RV202	100K	Morganite type 62H	23588
RV203	1M	Morganite type 62H	23589
RV204	4.7K	Morganite type 62H	23590
CAPACITORS			
C1	0.01	1.5kV	23603
C2	1	160V	2364
C3	0.01	10% 400V Ceramic	22395
C4	0.01	10% 400V Ceramic	22395
C101	0.1	10% 400V	2385
C102	0.1	10% 400V	2385
C103	6 - 25p	Ceramic trimmer	23593
C104	6 - 25p	Ceramic trimmer	23593
C105	56p	10% 400V Ceramic	22373
C106	56p	10% 400V Ceramic	22373
C107	6 - 25p	Ceramic trimmer	23593
C108	6 - 25p	Ceramic trimmer	23593
C109	6 - 25p	Ceramic trimmer	23593
C110	6 - 25p	Ceramic trimmer	23593
C111	18p	10% 400V Ceramic disc	22367
C112	18p	10% 400V Ceramic disc	22367
C113	6 - 25p	Ceramic trimmer	23593
C114	6 - 25p	Ceramic trimmer	23593
C115	18p	10% 400V Ceramic disc	22367
C116	18p	10% 400V Ceramic disc	22367
C117	6 - 25p	Ceramic trimmer	23593
C118	6 - 25p	Ceramic trimmer	23593
C119	6 - 25p	Ceramic trimmer	23593
C120	6 - 25p	Ceramic trimmer	23593
C121	100p	10% 400V Polystyrene	23624
C122	100p	10% 400V Polystyrene	23624

Ref.	Value	Description	Part No
CAPACITORS Continued			
C123	6 - 25p	Ceramic trimmer	23624
C124	6 - 25p	Ceramic trimmer	23824
C125	6 - 25p	Ceramic trimmer	23624
C126	6 - 25p	Ceramic trimmer	23624
C127	1000p	10% 350V Polystyrene	23625
C128	1000p	10% 350V Polystyrene	23625
C129	0.01	10% 400V	3399
C130	0.01	10% 400V	3399
C131	320	6.4V Electrolytic Mullard	23591
C132	320	6.4V Electrolytic Mullard	23591
C133	8	250V Electrolytic Dubilier	19895
C134	8	250V Electrolytic Dubilier	19895
C135	AOT typically 680pF	150V Ceramic	22388
C136	AOT typically 680pF	150V Ceramic	22388
C137	0.01	10% 400V	3399
C138	1000p	10% 350V Polystyrene	23625
C139	100-500p	Mica trimmer	23626
C140	680p	10% Ceramic	22385
C141	320	6.4V Electrolytic Mullard	13591
C142	250	16V Electrolytic Mullard	20783
C143	68p	150V Polystyrene	4513
C144	330p	5% 150V Silvered mica	4516
C145	1000p	10% 350V Polystyrene	23625
C146	1000p	10% 350V Polystyrene	23625
C147	220p	10% 400V	2588
C148	220p	10% 400V	2588
C149	18p	10% 400V Ceramic	22367
C150	18p	10% 400V Ceramic	22367
C151	8	250V Electrolytic Dubilier	19895
C152	0.1	10% 400V	2385
C153-200	Not used		
C201	0.1	10% 400V	2385
C202	320	6.4V Electrolytic Mullard	
C203	8	250V Electrolytic Dubilier	19895
C204	0.1	10% 400V	2385
C205	0.1	10% 400V	2385
C206	39p	10% 400V Ceramic	22371
C207	100p	10% 400V Ceramic	22376
C208	3 - 30p	Ceramic trimmer	23592
C209	39p	10% 400V Ceramic	22371
C210	6 - 25p	Ceramic trimmer	23593
C211	18p	10% 400V	22367
C212	360p	2%	23594
C213	190p	2%	23595
C214	2000p	2%	23596
C215	0.02	2%	23597
C216	0.22	2%	23598
C217	0.1	10% 400V	2385
C218	0.1	10% 400V	2385
C219	0.01	10% 400V Ceramic	4737
C220	1000p	10% 400V Ceramic	1527
C221	100p	10% 400V Ceramic	22376
C222	39p	10% 400V Ceramic	22371
C223	200p	2% Silvered mica	18331
C224	8	250V Electrolytic Dubilier	19895
C225	4	450V Electrolytic Dubilier	23599

Ref	Value	Description	Part No
CAPACITORS Continued			
C226	0.01	1.5kV	23603
C227	0.1	10% 400V	2385
C228	0.01	10% 400V	4737
C229	1000	16V Electrolytic Mullard	21152
C230	1000	16V Electrolytic Mullard	21152
C231	4	450V Electrolytic Dubilier	23599
C232	4	450V Electrolytic Dubilier	23599
C233	4	450V Electrolytic Dubilier	23599
C234	4	450V Electrolytic Dubilier	23599
C235	4	450V Electrolytic Dubilier	23599
C236	4	450V Electrolytic Dubilier	23599
C237	0.05	2kV Polystyrene	23600
C238	64	275V Electrolytic Dubilier	23601
C239	64	275V Electrolytic Dubilier	23601
C240, C241	50+50	450V Electrolytic Dubilier	23602
C242	2 - 4p	Ceramic trimmer	23781
C243	0.01	10% 400V Ceramic	4737
C244	0.1	10% 400V	2385
TRANSISTORS			
VT101-8		U2978/1	4869
TUBES			
V101-4		ECF82 (6U8) Mullard	5070
V201-5		ECF82 (6U8) Mullard	5070
DIODES			
MR101-2		ZF4.7 5% Zener S.T.C.	4073
MR103-6		1S44 Texas	18970
MR107-15		CG62H	17956
MR116-17		1S44 Texas	18970
MR118-19		CG62H	17956
MR201		CG62H	17956
MR202		MS4H	20422
MR203		Zener 5V 5%	20218
MR204		Zener 10V 5%	19688
MR205-8		MS4H	20422
MR209		OA95 Mullard	23318
MR210-11		Z39EJ68 Westinghouse	
MR212-13		BX237	23605
MR214-15		Zener 150V 1W 10%	23606
MR216		Zener 15V 10%	4669
SWITCHES			
S1		AC/DC slider switch	4069
S2		AC/DC slider switch	4069
S3		Attenuator switch	23732
S4		Attenuator switch	23732
S5		Function switch	23740
S6		Timebase switch/pot. A.B. Metals	23739
S7		Auto switch/trigger level Morganite type AM (part of RV3A/B)	23629
S8		On-off switch/brilliance control A.B. Metals (part of RV6)	23631