5.4 CALIBRATION PROCEDURE

The calibration procedure is detailed below. Note that any calibration adjustments found necessary must not be made until a 15 minute warm-up period has elapsed. The locations of the various preset components are shown in Figs.14 and 15.

5.4.1 TEST EQUIPMENT REQUIRED

1. Multimeter to measure up to 1500 volts with better than 20kΩ per volt impedence. Accuracy to be within ± 2%.
2. Variable Autotransformer (Variac, etc.) Output voltage range 200 – 270 volts at 1A with a.c. r.m.s. voltmeter.
3. Function Generator with frequency range of 0.1Hz to 10kHz, preferably with sawtooth output.
4. Digital Voltmeter with 3½ digit display and 1mV basic resolution. Accuracy to be within ± 0.2%.
5. Source of Time and Voltage Calibration signals, to cover the range 0.1μs – 0.5s. and 25mV – 100V.
6. Square-wave generator to provide 500kHz flat top square wave with amplitude adjustable between 25mV and 1 volt. Risetime to be less than 5ns.
7. Constant amplitude r.f. sine-wave generator to cover the range 500kHz to 15MHz with a 50kHz reference frequency. Output amplitude 25mV to 5 volts pk-pk when terminated with 50Ω load. Amplitude accuracy over the frequency range to be within ± 3%.
8. Capacitance standardiser. 1MΩ/28pF with B.N.C. connections.
9. 50Ω B.N.C. through-termination.
10. E.H.T. meter to measure 3kV.
11. Frequency Counter to measure 1kHz at 1 volt.

5.4.2 POWER SUPPLY VOLTAGES

1. Set the INTENSITY control to minimum.
2. Set the SUPPLY VOLTAGE switch on the rear panel to suit the available supply. Using the autotransformer, set the supply to the instrument to within ± 1% of the selected nominal voltage.
3. Check that the POWER neon, N51, is lit and that the SCALE control varies the graticule illumination.
4. Check the voltages with respect to the chassis at the pins on the lower edge of the power supply board as follows:-

pin	limits min.	voltage max.
+5	5.0	5.5
–20	–19	–21
–6	–5.5	–6.5
+12	11.4	12.6
+20	19	21
+170	155	185

5. Measure the voltage across C403 (see Fig.15) on the E.H.T. board and adjust R409 (SET E.H.T.) to bring this to 145V with the supply voltage adjusted as in 2. above.
6. Measure the voltage at the – 1kV pin on the E.H.T. board (near C403). This voltage should be between – 950V and – 1050V with respect to the chassis, check that it does not vary by more than 10V when the supply voltage to the instrument is varied by ± 10% of the nominal voltage selected with the SUPPLY VOLTAGE switch.
7. Check that the voltage on the '+ 3kV' pin at the rear of the E.H.T. board (to which the cable from the c.r.t. cavity cap connector is fitted), is greater than 2.5kV relative to chassis.

5.4.3 GEOMETRY

1. Set the MODE switch to NORMAL, the TIME/CM. switch to 1ms/cm. and ensure the TRIGGER LEVEL control is pushed in ('Bright Line' position). With the INTENSITY control advanced approximately half way and the Y MODE switch in the CH1 and CH2 position, obtain two traces on the screen.
2. Adjust the FOCUS control in conjunction with R417 ('ASTIG') on the E.H.T. board to obtain clear traces.
3. Adjust the TRACE ROTATION control, R529, on the rear panel to align the traces with the horizontal graticule lines.
4. Apply a 1kHz sinewave to one channel and adjust the sensitivity and triggering controls to obtain a stable display with an amplitude of 8 cms. pk-pk. Adjust R408 (GEOM) on the E.H.T. board for minimum distortion of the display in both X and Y axes. Reset the FOCUS and ASTIG controls to optimise the trace quality.

5.4.4 Y CALIBRATION AND SHIFT RANGE

1. With the input coupling switch in the GND position select CH1 on the Y MODE switch and adjust the front panel BALance control, R373, so that there is no trace shift when changing from the 0.2V/cm range to the 0.5V/cm. range. Adjust R369 (VAR BAL) on the A.D.C. board so that there is no shift when the CH1 variable sensitivity control is operated.
2. Repeat the preceding step for CH2 using R374 (BAL) and R370 (VAR BAL).
3. With CH1 and CH2 selected set the two Y shift pots, R1 and R2, so that the wipers (measured at the pins marked 'SH' on the front of the A.D.C. board) are at +4V with respect to chassis. Adjust R377 (SHIFT CENTRE) so that the two traces are equally spaced each side of the central horizontal graticule lines.
4. Apply a sinewave signal to each channel in turn and set the amplitude for 8cm. pk-pk display. Check that the traces can be shifted completely off the screen in each direction.
5. With CH1 only selected, set the attenuator switch to 20mV/cm. and apply a 100mV., 1kHz square wave signal from the calibrator. Monitor the signal voltage at the junction of R389 and D316 cathode on the A.D.C. board with an oscilloscope. Adjust R320 on the CH1 pre-amplifier board to set the signal level to 185mV. Repeat the procedure on CH2.
6. With a 100mV signal still applied on the 20mV/cm. range, set R438 (in the centre of the E.H.T. board) for 5cms display. Check calibration of other channel.

5.4.5 ATTENUATOR COMPENSATION

1. Check that attenuator cover is fitted.
2. Set CH1 attenuator switch to 0.2V/cm. and apply a 2V, 1kHz square wave via a 1MΩ/28pF standardiser.. Adjust C301 for a square corner to the display. Repeat procedure with CH2 adjusting C302.
3. Set CH1 attenuator to 0.5V/cm. and apply a 2.5V, 1kHz square wave direct. Adjust C305 for a square corner to the display. Repeat step with CH2 adjusting C306.
4. With CH1 attenuator still set at 0.5V/cm. apply a 5V, 1kHz square wave via the standardiser and adjust C303 for a square corner. Repeat step with CH2 adjusting C304.
5. Remove standardiser and check all attenuator ranges applying the appropriate amplitude, to ensure all ranges give a square corner to the applied waveform and are accurate in amplitude to within ± 3%.

5.4.6 TIMEBASE CALIBRATION

1. Set TIME/CM. control to 1ms/cm. and X EXPAND control to X10 (fully clockwise position). Apply 1ms. markers to CH1, adjusting Y sensitivity to give approximately 3cm amplitude, triggering with bright line off (TRIGGER LEVEL control pulled out). Adjust R990 (SET x 10) on the timebase board for exactly 10cms. between markers.
2. Set X EXPAND to X1 (fully counter clockwise) and adjust R988 (SET X1) on timebase board for 1cm. between markers.
3. With 1ms. markers still applied, vary the supply voltage to the instrument by ± 10% from the nominal value and check that there is less than ± 1% change in timebase calibration.
4. Set TIME/CM to 10μs/cm. and apply 10μs markers. Adjust the trimmer, C95, on the timebase range switch for 1cm. between markers.
5. Set TIME/CM to 1μs/cm and apply 0.1μs markers with the X EXPAND control in the X10 position. Using the X shift control, ensure that the calibration of the first 10cms. of trace and the middle 10cms. of the trace are within ± 4%.
6. With the X EXPAND control at X1, check all the timebase ranges from 1μs/cm to 0.5s/cm, with the appropriate markers, to within ± 3%. Check that the REFRESHED mode is automatically selected on ranges below 0.5s/cm.
7. Check that the trace length is greater than 11 cms. on all timebase ranges.
8. Move DISPLAY MODE switch to REFRESHED. Select 1ms/cm. range and apply 1ms. markers. Check accuracy is within ± 3%. Check that the trace length increases when switching from REFRESHED to NORMAL. This increase should be approximately 0.5cm and can be varied by R973.

5.4.7 TRIGGER BALANCE

1. With the DISPLAY MODE switch in the NORMAL position and no trigger signals applied, check that the timebase free runs with the BRIGHT LINE on and does not free run with the BRIGHT LINE off.
2. Apply a 1kHz sine wave and adjust amplitude to give approximately 6cms. display. Adjust R1012 on the timebase board (below the timebase range switch, S6) so that there is no vertical shift in the trigger point when moving the TRIGGER SOURCE control between + and −. Check that the TRIGGER LEVEL is midway through its range when the timebase is triggering at the zero crossing point on the displayed waveform.
3. With the signal applied to CH1 input, adjust R1011 on the timebase board so that there is no change in trigger point when the TRIG. COUPLING switch is moved from AC to DC. Repeat this adjustment with R1009 for CH2.
4. Check that the LF and HF REJECT positions of the TRIG. COUPLING switch are functional.
5. Apply a 1kHz square wave input signal and reduce the amplitude to 2mm. Check that stable triggering can be obtained on both + and − slope positions for both input channels.
6. Set the TRIG SOURCE selector to EXT. and apply a 1 volt, 1kHz square wave to the EXT TRIG input. Check that stable triggering can be obtained on both + and − slope settings with the BRIGHT LINE either on or off.
7. Check the LINE trigger facility is functional and that the l.e.d. lamp associated with the TRIGGER LEVEL control is working.

5.4.8 INTERNAL CALIBRATOR

Set the pk-pk amplitude of the 1V calibrator output using R1017 on the timebase board (SET CAL). Check the 0.1V output is accurate within ± 2%.

5.4.9 Y PULSE RESPONSE

1. With the CH1 attenuator set at 20mV/cm. apply a fast risetime 500kHz flat topped square wave to CH1, using a 50Ω termination to prevent cable reflections. Adjust amplitude for a 5cm. display and set C419 and C424 on the E.H.T. board for a square corner with less than 1% undershoot or overshoot. Check CH2 at the same sensitivity.
2. Set the Y attenuators to 5mV/cm. and apply a signal from the constant amplitude r.f. generator. Set the signal amplitude at 50kHz to give 5cm. display and then increase the input frequency until the display height falls to 3.5cm. This frequency should be greater than 11MHz. Repeat this procedure with CH2.
3. Apply the 500kHz square wave and check the pulse response on all attenuator ranges with 5cms. display. Both channels must exhibit less than 2% undershoot or overshoot on any range.

5.4.10 H.F. TRIGGER

Apply a 10MHz sine wave to CH1 and adjust amplitude for 1cm. of display on the 20mV/cm. attenuator range. Check that steady triggering can be obtained with the BRIGHT LINE switched off. Switch the attenuator to 0.1V/cm. to give 2mm. display and reduce the input frequency to 2MHz. Check for stable triggering and repeat both tests on CH2.

5.4.11 CLOCK OSCILLATOR FREQUENCY

Set the TIME/CM control to 1ms/cm., and connect the output of the internal CALibrator to a frequency counter and adjust C601 at the rear of the store logic board to obtain a reading of 890Hz within ± 1%. If a counter is not available, monitor the calibrator on CH1 with the NORMAL mode selected and adjust C601 for 8 complete cycles in 9cms.

5.4.12 ANALOGUE TO DIGITAL CONVERTOR

1. Measure the voltage across the pins of the A.O.T. resistor, R163, on the A.D.C. board with a d.v.m. Adjust R106 on the current source board to bring this voltage to 2.80V.
2. Measure the voltage across the pins of A.O.T. resistor R289. Adjust R124 on the current source board to bring this voltage to 0.817V.
3. With the DISPLAY MODE switch in the REFRESHED position apply a triangle or sine wave input signal and set the amplitude for a display of 8cms. Adjust the timebase and trigger controls so that one half cycle is displayed from the positive peak to the negative peak. Ensure that the l.e.d. associated with the TRIGGER LEVEL control is lit.
4. Adjust R122 to minimise conversion errors (notches) at the ¾ scale point (i.e. at approx. 2cms. above the graticule centre line) on the display.
5. Adjust R114 to minimise conversion errors occuring at the ¼ and ½ scale points. Errors at these points will also be affected by R122. If the conversion errors cannot be entirely removed by these two adjustments, it may be necessary to fit a resistor of between 10kΩ and 27kΩ in value, in the position marked R163. Similarly, if there are regular groups of errors occurring in each quarter of the screen, a resistor of value 3k9 to 12kΩ may be fitted in the position marked R289. It is emphasised that these adjustments should only be used for correcting SMALL conversion errors: large errors in the displayed signal should be investigated as described in the Faultfinding Procedure (section 5.3).

5.4.13 DIGITAL TO ANALOGUE CONVERTOR

The range of the D.A.C. must be set up such that the trace can just be deflected off the screen (approx. 9cms). Proceed as follows:-

1. Set the DISPLAY MODE switch to ROLL and remove the input signal. Rotate the Y shift control fully counter clockwise to deflect the trace to its lower limit and adjust R774 on the Timing Logic board to position the trace on the lower graticule line.
2. Apply a 100mV square wave to CH1 input and set the CH1 attenuator switch to 20mV/cm. Adjust the Y shift control to obtain a 0.5cm. display and then re-adjust R774 to position the top of the displayed waveform on the lower graticule line.
3. Rotate the shift control fully clockwise and use R730 to position the trace on the top graticule line. Reset the shift control to display a 0.5cm. amplitude trace as before and re-adjust R730 to set the lower edge of the display on the top graticule line.

5.4.14 SCALING AMPLIFIER

With a 5cm. square wave displayed in the NORMAL mode, set R208 on the A.D.C. board to give no change in amplitude when switching from NORMAL to REFRESHED modes. Set R217 for no change in vertical position between the two display modes. Ensure that full coverage of the screen can be obtained in the REFRESHED mode.

5.4.15 DOT JOINER

1. Set the DISPLAY MODE switch to REFRESHED and apply a 10kHz square wave. Adjust the amplitude to give a 4cm. display and set the TIME/CM. switch to 5μs/cm. Adjust C712 on the Timing Logic board (accessible through a hole in the screen) to give 'cleanest' trace free from ripples.
2. Set the timebase rate to 20μs/cm. and the Y MODE switch to CH1. Adjust R785 on the Timing Logic board for minimum undershoot or overshoot on the displayed waveform.
3. Set the timebase range to 0.1ms/cm. and the X EXPAND control for approximately X5 expansion. Set C713 for a square corner.
4. Switch the Y MODE control to CH1 and CH2 and adjust R786 for a square corner.

5.4.16 FUNCTIONAL CHECKS

Check all timebase ranges in the REFRESHED mode and ensure that the single shot STORE facility is functioning correctly. Check the operation of the two LOCK STORE pushbuttons in both single and dual trace modes.