

FACTORY CALIBRATION PROCEDURE

CONTENTS:

This is the guide for calibrating new instruments in Product Manufacturing. The procedure consists of 4 sections:

Equipment Required

Factory Test Limits - Factory Test Limits are limits an instrument must meet before leaving Manufacturing. These limits are often more stringent than advertised performance requirements. This is to insure that the instrument will meet advertised requirements after shipment, allows for individual differences in test equipment used, and (or) allows for changes in environmental conditions.

*This procedure is
company confidential*

544

Short Form Procedure - The Short Form Procedure has the same sequence of steps and the same limits on checks or adjustments as the Main Procedure.

December 1968

For all serial
numbers.



Main Procedure - The Main Procedure gives more detailed instructions for the calibration of the instrument. This procedure may require that some checks and adjustments be made so that performance is better than that required by the Factory Test Limits. This insures the Factory Test Limits will be met when side panels are added, permits some normal variation in test equipment and plug-in scopes, etc.

Abbreviations in this procedure will be found listed in TEKTRONIX STANDARD A-100. Definitions of terms used in this procedure may be found in TEKTRONIX STANDARD A-101.

In this procedure, all front panel control labels and Tektronix instrument names are in capital letters (VOLT/DIV, etc). Internal adjustment labels are capitalized only (Gain Adj, etc).

CHANGE INFORMATION:

This procedure has been prepared by Product Manufacturing Staff Engineering. For information on changes made to this procedure, to make suggestions for changing this procedure, or to order additional copies: please contact PMSE, 39-307.

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EQUIPMENT REQUIRED:

The following equipment is necessary to complete this procedure:

a. TEKTRONIX Instruments

- 1 TYPE 544, 546 or 547 OSCILLOSCOPE
- 1 TYPE 1A1 PLUG-IN UNIT
- 1 TYPE P6006 10X Probe
- 1 TYPE P6028 1X Probe
- *1 TYPE 184 TIME-MARK GENERATOR
- *1 TYPE 191 CONSTANT AMPLITUDE SIGNAL GENERATOR
- 1 TYPE P6019 CURRENT PROBE

b. Test Fixtures and Accessories

- 1 76TU Line Voltage Control (067-0048-00)
- 1 Sine-wave Generator (067-0542-00)
- 1 Test Load Plug-in Unit (067-0521-01)
- *1 Standard Amplitude Calibrator (067-0502-00)
- 1 50 Ω BNC Termination (011-0049-00)
- 1 50 Ω Termination (067-0120-00)
- 1 T BNC Connector (103-0030-00)
- 3 50 Ω BNC cables (012-0057-00)
- 3 BNC to Binding Post Adapters (103-0033-00)
- 3 Patch Cords (012-0031-00)
- 1 External Function Checker (067-0564-00)

c. Other Equipment

- 1 20,000 Ω /Volt Multimeter

* Equipment must be traceable to NBS for certification of measurement characteristics.

Substitute test equipment may be used. The Plant Staff Engineer must approve any substitutions. All equipment listed must perform within its manufacturer's specifications, unless otherwise stated.

FACTORY TEST LIMITS

Factory Test Limits are qualified by the conditions specified in the main body of the Factory Calibration Procedure. The numbers and letters to the left of the limits correspond to the procedure steps where the check or adjustment is made. Steps without Factory Test Limits (setups, presets, etc.) are not listed. Instruments may not meet Factory Test Limits if calibration or checkout methods and test equipment differ substantially from those in this procedure.

4. POWER SUPPLIES

- b. Delay Relay: 15 to 60 sec
 - d. Regulated low voltage power supplies tolerance, ripple and regulation
- | Supply | Max
Error | 102.5 VAC high load to
127.5 VAC low load
max 120 Hz ripple |
|--------|--------------|---|
| -150V | ±3V, ±2% | 3mV |
| +100V | ±2V, ±2% | 7mV |
| +225V | ±4.5V, ±2% | 3mV |
| +350V | ±7V, ±2% | 20mV |
| + 75V | ±75V, ±10% | 7mV |
- f. High Voltage -1850V ±2%
 - g. HV regulation: 102.5 to 127.5 VAC

5. AMPLITUDE CALIBRATOR

- *c. .1 VOLTS position accuracy: ±2%
- *d. 50 to .2 volts accuracy observed error: ±2%; observed error plus 100:1 divider error: ±2%
- e. 50Ω Voltage error: ±2%
- g. Duty Cycle: 45% to 55%
- h. Frequency: 1 kHz, ±25%
- i. Risettime: .2mVOLTS to 5 VOLTS, .4μs, max; 10 to 100 VOLTS: .6μs, max
- j. 5mA error: ±2%
DC present in 100 VDC position

6. CRT

- a. Horizontal deflection - graticule alignment within 3°
- b. TRACE ROTATION range: 3°, min
- c. Geometry max vertical deviation: 1mm
- f. Horizontal geometry max deviation: 1mm
- g. Focus: both traces well defined with no overlap in graticule area

7. VERTICAL AMPLIFIER

- a. Transistor stage unbalance: 0.5cm, max
- b. Vert DC Bal error: 1cm range: ±1cm
- *c. Vert Gain error: 1%
- d. Compression - expansion: 0.5mm, max
- e. Common mode rejection: 3mm, max
- f. DC Shift: 0.5mm, max

8. DUAL-TRACE PULSE AND CHOPPED BLANKING

- a. Waveform and risetime
Pulse amplitude: >60V
Pulse risetime: <1μs
- b. ALTERNATE: all sweep rates

9. TRIGGER ADJUSTMENTS

- b. Trigger Sens and Trigger Level centering: stable display on 100mV EXT, 2mm INT: untriggered display on 20mV EXT
 - d. Oscillations: none
 - f. TRIGGERING LEVEL range: normal: at least + and - 2V X10: at least + and - 20V
 - g. AUTO triggering: <20 Hz repetition rate
 - h. Line Triggering: Correct Slope
 - j. Sine-wave triggering
- | With TRIGGERING controls set to: | Sweep will trigger on: | will not trigger on: |
|----------------------------------|------------------------|----------------------|
| NORM INT: | | |
| + & - AC | 2mm 1 kHz | |
| + & - DC | 4mm change in DC level | |
| + & - LF REJ | 2mm 2 kHz | 4mm 200 Hz |
| EXT: | | |
| + & - AC | 0.1V 1 kHz | 0.02V 1 kHz |
| + & - DC | | |

11. FRONT PANEL NEONS, SCALE ILLUMINATION

b. Beam position indicators

In the following checks the proper beam position indicator neon must come on before the spot moves out of the scan area. The opposite position indicator must not be on after crossing graticule center.

<u>POSITION</u> <u>Control</u>	<u>Turn</u>	<u>Spot</u> <u>must</u> <u>move</u>	<u>Beam</u> <u>position</u> <u>indicator</u>
TU-7 vertical	cw	up	↑
TU-7 vertical	ccw	down	↓
544 horizontal	cw	right	→
544 horizontal	ccw	left	←

c. SCALE ILLUM: cw max brilliance ccw extinguished

12. HORIZ AMP GAIN X10, X1, X100

- *b. X10 Cal error: within 3%
- *c. X1 Cal error: within 1%
- *d. X100 Cal error: within 3%
- *e. X50, X20, X5, X2 accuracy error: within 3%

13. NORMAL-MAGNIFIED REGISTRATION

- b. Swp/Mag Regis: within 1mm

14. SWEEP LENGTH ≤ 10.2 to ≥ 10.8 cm

15. VARIABLE TIME/CM

- a. Range 2.5:1
- b. Horizontal position controls
VERNIER control range: ≥ 1 cm trace shift
Total control range: + and - 5cm

16. .1 μ SEC - 10 μ SEC/CM TIMING

- *a. 10 μ SEC: $\pm 1\%$
- *b. 1 μ SEC: $\pm 1\%$
- *c. .1 μ SEC and .5 μ SEC: $\pm 1\%$

17. MAG ON TIMING

- *c. X10 MAG comp: $\pm 3\%$ between 4th and 80th
- *d. X20 MAG comp: $\pm 3\%$
- *e. X5 MAG comp: $\pm 3\%$
- *f. X2 MAG comp: $\pm 3\%$
- *g. X100, X50, X20 MAG comps: $\pm 3\%$

18. TIME BASE TIMING

*Sweep timing MAG OFF: within 1%

19. EXTERNAL HORIZONTAL AMPLIFIER

- b. Ext Horiz DC Bal: 2mm
- d. Ext HORIZ VARIABLE range: $\leq 10:1$
- e. OUTPUT compensation: $\pm 3\%$ max aberration
- f. X10 attenuator accuracy: 2% compensation: $\pm 3\%$ max aberration
- g. X100 attenuator accuracy: within 2%; compensation: $\pm 3\%$ max aberration
- *h. Bandpass: ≥ 450 kHz at -3dB

20. CRT CATHODE INPUT

- b. Intensity modulation: noticeable modulation $\leq 10V$

21. EXTERNAL WAVEFORMS

- a. VERT SIG OUT: $\geq .3V/cm$
risetime: $\leq 20nS$
- b. SWEEP OUT: $\geq 9.0V/cm$, at 1mSEC/CM
- c. +GATE A: $\geq 20V$

22. TIME BASE HOLDOFF

<u>TIME/CM</u>	<u>Holdoff</u>
.1 μ SEC	9-27 μ s
.2-5 μ SEC	5-15 μ s
10-50 μ SEC	16-28 μ s
.1-.5mSEC	70-130 μ s
1-5mSEC	0.9-1.7ms
10-50mSEC	9-17ms
.1-.5 SEC	90-170ms
1-5 SEC	0.5-0.9s

23. SINGLE SWEEP RESET INPUT

- b. External reset function 15V
max risetime: 0.5 μ s

24. VERTICAL AMPLIFIER HF ADJUSTMENTS

- *b. Vertical HF aberrations: $\pm 1\%$
Max risetime: ≤ 6.75 ns with TU-7
- c. Transient response: 1.5mm, max change
- d. Corner Symmetry: ± 0.5 mm
- e. Spoiler Switch: total risetime ≤ 10 ns

25. HF TRIGGERING

- b. Int HF triggering: 6mm at 50 MHz
 ≤ 2 mm jitter
- c. Ext HF triggering: 200mV at 50 MHz

THE END

* Indicates measurement characteristic; test equipment used must be traceable to NBS for instrument certification.

SHORT FORM PROCEDURE

This instrument must meet Factory Test Limits before it leaves Manufacturing; therefore, it must be possible to inspect to these limits. Because of normal variations in test equipment and plug-in scopes, addition of side panels, etc, this procedure may require that some checks and adjustments be made so that performance is better than that required by Factory Test Limits.

1. PRELIMINARY INSPECTION

- a. Install current modifications
- b. Check fuses
- c. Check CRT
- d. Check graticule lights

2. 544 PRESETS

- a. Preset external controls
- b. Preset internal controls

3. RESISTANCE CHECKS

- b. Check Power Supply resistance
- c. Check plug-in load switch resistance

4. POWER SUPPLIES

- a. Check Line Voltage Selector
- b. Check Delay Relay: 15 to 60 sec
- c. Adjust -150V, R616
- d. Check regulated low voltage power supplies for tolerance, ripple and regulation
- e. Check elevated filaments
- f. Adjust High Voltage, R840 -1850V
- g. Check HV regulation: no blooming

5. AMPLITUDE CALIBRATOR

- b. Adjust Cal Adj
- c. Check .1 VOLT position: $\pm 2\%$
- d. Check 50 VOLTS to .2 VOLTS position
observed error: $\pm 2\%$
observed error plus 1000:1
divider error: $\pm 2\%$
- e. Check voltage accuracy at ($R_o = 50\Omega$)
position: within 2%

- 5f. Check 50mV to .2mV operation
- g. Check Duty Cycle: 45% to 55%
- h. Check frequency: 1 kHz, $\pm 25\%$
- i. Check risetime: 5 VOLTS $\leq .4\mu S$
100 VOLTS $\leq .6\mu S$
- j. Check 5mA error: $\pm 2\%$
DC present in 100 VDC position

6. CRT

- a. Check Horizontal deflection -
graticule alignment: within 3°
- b. Check TRACE ROTATION range:
 3° , min
- c. Adjust Geometry (R861), max
deviation: 1mm
- d. Check Horiz focus
- e. Check Orthogonality
- f. Check Horizontal geometry -
max deviation: 1mm
- g. Check Vertical Focus

7. VERTICAL AMPLIFIER

- a. Check transistor stage unbalance:
0.5cm, max
- b. Adjust DC Bal, R1004: error: $\leq 1cm$
range: $\pm 1cm$
- c. Adjust Vert Gain, R1017 error: 1%
- d. Check compression-expansion: $\pm .5mm$
- e. Check common mode rejection:
3mm, max
- f. Check DC shift: 0.5mm, max

8. DUAL-TRACE PULSE AND CHOPPED BLANKING

- a. Check waveform and risetime:
Pulse amplitude: $\geq 60V$
Pulse Risettime: $\leq 1\mu S$
- b. Check ALTERNATE operation
all sweep rates
- c. Check dual-trace chopped blanking

9. TRIGGER ADJUSTMENTS

- b. Adjust Trigger Sens, R245 and Trigger Level Centering R225: stable display on 100mV EXT, 2mm INT; untriggered display on 20mV EXT
- c. Adjust Int Trig DC Level, R209: 4mm at graticule center
- d. Check for oscillations: none
- e. Align TRIGGER LEVEL knob
- f. Check TRIGGERING LEVEL range: normal, at least + and -2V; X10, at least + and - 20V
- g. Check AUTO triggering: ≤ 20 Hz repetition rate
- h. Check LINE triggering: correct slope
- i. Check PLUG-IN INT triggering
- j. Check sine-wave triggering

10. SINGLE SWEEP

- b. Check Single Sweep

11. FRONT PANEL NEONS, SCALE ILLUMINATION

- b. Check Beam position indicators
- c. Check SCALE ILLUM
- d. Check TIME BASE indicator lights

12. HORIZ AMP GAIN X10, X1, X100

- b. Adjust X10 Cal, R544
- c. Adjust X1 Cal, R566
- d. Adjust X100 Cal, R565
- e. Check X50, X20, X5, X2 accuracy: $\pm 3\%$

13. NORMAL-MAGNIFIED REGISTRATION

- b. Adjust Swp/Mag Regis: R569, for min shift

14. SWEEP LENGTH

Adjust sweep length, R325: 10.5cm

15. VARIABLE TIME/CM

Check variable range: $\geq 2.5:1$

16. .1 μ SEC-10 μ SEC/CM TIMING

- a. Adjust 10 μ SEC Timing, C290C
- b. Adjust 1 μ SEC Timing, C290B
- c. Adjust .1 μ SEC and .5 μ SEC timing

17. MAG ON TIMING

- b. Adjust X10 mag accuracy (C572, C582, C591, C576, C586)
- c. Adjust X10 MAG comp, C557H $\pm 3\%$ between 4th and 80th
- d. Adjust X20 MAG comp, C557K
- e. Adjust X5 MAG comp, C557F
- f. Adjust X2 MAG comp, C557D
- g. Check X100, X50, X20 MAG comps: $\pm 3\%$

18. TIME BASE TIMING

Check Sweep timing, MAG OFF: within 1%

19. EXTERNAL HORIZONTAL AMPLIFIER

- b. Adjust Ext Horiz DC Bal, R519
- c. Adjust Ext Horiz Gain, R510
- d. Check EXT HORIZ VARIABLE range: $\leq 10:1$
- e. Adjust Output Compensation, C524
- f. Check X10 attenuator accuracy: $\pm 2\%$, compensation: $\pm 3\%$ max aberration
- g. Check X100 attenuator accuracy: $\pm 2\%$, compensation: $\pm 3\%$ max aberration
- h. Check Bandpass: ≥ 450 kHz at -3dB

20. CRT CATHODE INPUT

- b. Check Intensity modulation: noticeable modulation $\leq 10V$

21. EXTERNAL WAVEFORMS

- a. Check VERT SIG OUT: $\geq 0.3\text{V/cm}$
 risetime: $\leq 20\text{ns}$
- b. Check SWEEP OUT: 9.0V/cm , min at
 1mSEC/CM
- c. Check +GATE A: $\geq 20\text{V}$

22. TIME BASE HOLDOFF

- b. Check Holdoff

23. SINGLE SWEEP RESET INPUT

- b. Check External reset function: 15V
 max risetime: $0.5\mu\text{s}$

24. VERTICAL AMPLIFIER HF ADJUSTMENTS

- b. Adjust Vertical HF aberrations
- c. Check transient response
 1.5mm , max change
- d. Check corner symmetry
- e. Check spoiler switch

25. HF TRIGGERING

- b. Check INT HF triggering: 6mm at 50 MHz
 $\leq 2\text{mm}$ jitter
- c. Check EXT HF triggering: 200mV at 50 MHz

THE END

1. PRELIMINARY INSPECTION

a. *Install current modifications*

b. *Check fuses*

115V	6.25A	mdx	slo-blo
230V	3 A	mdx	slo-blo

c. *Check CRT*

Adjust the CRT so the front of the plastic light injector plate is even with the front of the plastic "eyebrow." both edges must go flush with each other. Adjust the CRT by adjusting the rear support bracket, if necessary.

Temporarily place a scribed graticule over the front of the CRT. Orient the CRT, then tighten the CRT clamp. Remove temporary graticule.

Check neck pin connection tightness.

Inspect for mechanical defects: phosphor defects, scratches, cracks around neck pins, etc.

d. *Check Graticule lights*

Check that graticule lights are properly positioned. Place plastic protector over the light injector and "eyebrow." Replace graticule cover.

c. This is a simplified description of CRT defects. For a more detailed description see the CRT Checkout Procedure or consult a trained CRT checker.

2. 544 PRESETS

a. *Preset External controls*

Time Base:

TRIGGERING LEVEL	cw (push in)
MODE	AUTO
SLOPE	+
COUPLING	AC
SOURCE	NORM INT
TIME/CM	1mSEC
VARIABLE TIME/CM	CALIBRATED

2a. (cont'd)

HORIZONTAL DISPLAY	NORMAL
SINGLE SWEEP	NORMAL
EXT HORIZ VARIABLE	cw
AMPLITUDE CALIBRATOR	OFF
HORIZONTAL POSITION	midr
VERNIER, horiz position	midr
INTENSITY	0
FOCUS	0
ASTIGMATISM	0
SCALE ILLUM	0
POWER	off

b. Preset Internal adjustments

TRACE ROTATION (adjustment
within ASTISMATISM) midr

All other internal adjustments midr

3. RESISTANCE CHECKS*a. Setup*

Install TU-7 and preset:

TEST FUNCTION	LOW LOAD
VARIABLE	midr
AMPLITUDE	midr
VERTICAL POSITION	midr
REPETITION RATE	LOW

b. Check Power Supply resistance

Connect ohmmeter to proper slots on
ceramic strip next to power transformer
and check following resistances to ground:

<u>Supply</u>	<u>Approx Resistance</u>
-150V	1 to 3k Ω
+100V	1 to 3k Ω
+225V	2 to 5k Ω
+350V	15k to 25k

3. (cont'd)

c. Check Plug-in load switch resistance

Pull out TU-7.

Connect ohmmeter from ground to the back terminal (violet-white) of plug-in load switch. Note resistance, approx 750Ω , then press load switch and note that the resistance increases to above $5k\Omega$. Then pull load switch all the way out and again note a resistance of over $5k\Omega$.

Remove meter and replace TU-7.

4. POWER SUPPLIES*a. Check Line Voltage Selector*

Connect the multimeter between terminals 19 and 20 of T601. Check the RMS voltage with the Line Voltage Selector connected as indicated below:

<u>Line Voltage Selector</u>	<u>Approximate Voltage (RMS)</u>
230 H	80 VAC
115 H	160 VAC
M	170 VAC
L	200 VAC

a. Check these voltages with the Time Delay Relay de-energized.

Position the Selector switch plugs for 115V M and replace the cover.

b. Check Delay Relay: 15 to 60 SEC

Connect 544 to variable line voltage source, set line voltage source to 115 VAC and turn POWER ON. Time delay must delay at least 15 sec but no longer than 60 sec. Connect meter to regulated supply points and check for no voltages before relay closes.

c. Adjust -150V supply

Adjust R616 for -150V with multimeter connected to -150V test point.

4. (cont'd)

d. Check regulated low voltage power supplies for tolerance, ripple, and regulation as follows:

Supply	Max Error	102.5 VAC high load to
		127.5 VAC low load max 120 Hz ripple
-150V	<u>+3V, +2%</u>	3mV
+100V	<u>+2V, +2%</u>	7mV
+225V	<u>+4.5V, +2%</u>	3mV
+350V	<u>+7V, +2%</u>	20mV
+ 75V	<u>+75V, +10%</u>	7mV

e. Check elevated filaments

Check point	Approx DC Elevation
T601 term 34	+100V
T601 term 32	+350V
T601 term 9	-1850V

f. Adjust High Voltage: -1850V +2%

Connect multimeter to HV Test point and adjust R840 for -1850V.

Remove multimeter.

g. Check HV regulation

Insert 10ms and 100 μ s markers to TU-7 INPUT from TYPE 184. Trigger on 6cm amplitude. Change line voltage between 102.5 VAC and 127.5 VAC and check for blooming. Rotate INTENSITY thru its range and check for blooming.

Return to 115 VAC.

5. AMPLITUDE CALIBRATOR

a. Setup

Preset the test scope as follows:

VOLTS/CM	.5
VARIABLE VOLTS/CM	CALIBRATED
Input Selector	A, AC

d. High load: TU-7 set to HIGH LOAD; TYPE 544 MODE set to AUTO, SWEEP MAGNIFIER to X10, and AMPLITUDE CALIBRATOR to any ON position.
Low load: TU-7 set to LOW LOAD; TYPE 544 MODE set to TRIG, SWEEP MAGNIFIER to NORMAL X1 and AMPLITUDE CALIBRATOR to OFF.

Measure ripple using X1 probe connected from test scope to supply distribution strip next to the power transformer. For +75V measure at pin 15 of plug-in connector.

P-P spikes in 100V supply with sweeps and calibrator running will normally exceed 7mV.

5. Trigger the test scope in AUTO, + LINE and set TIME/CM to 5mSEC. The start of the test scope will be the SAC voltage or reference point. The direction of error can be determined by the direction of

5a. (cont'd)

Connect the AMPLITUDE CALIBRATOR under test to the SAC/UNK IN connector. Connect the SAC OUTPUT through a Coaxial cable to the TYPE 1A1 INPUT, AC coupled. Set the SAC to +100V, DC MIXED. Set the AMPLITUDE CALIBRATOR under test to 100 VOLTS. Remove V945 from the instrument under test.

b. *Adjust Cal Adj*

Adjust the Cal Adj, (R879) for a null voltage (the point where the display appears as a straight line).

c. *Check .1 VOLTS position $\pm 2\%$* d. *Check 50V to .2V position*
observed error: $\pm 2\%$
observed error plus 1000:1 divider error: $\pm 2\%$ e. *Check 50 Ω Voltage error: $\pm 2\%$*

Set TYPE 544 AMPLITUDE CALIBRATOR to .2 VOLTS and SAC to 100mV. Insert special 50 Ω termination between TYPE 544 CAL OUT and adapter.

TYPE 544 CAL OUT--special 50 Ω term--
50 Ω cable--SAC Unk-in

With test scope sensitivity at .005 V/CM, note a max deflection of 0.2cm. Replace V945. Remove special 50 Ω termination.

f. *Check 50mV to .2mV operation*

Switch SAC OUTPUT SELECTOR for UNKNOWN INPUT. Check for squarewave in all positions from 50mV to .2mV.

Remove SAC signal.

g. *Check Duty Cycle 45% to 55%*

Connect CAL OUT to TU-7 input.

Set AMPLITUDE CALIBRATOR to .2 VOLTS, A TIME/CM to 50 μ SEC, and adjust A TRIGGERING LEVEL for stable display.

the first difference voltage. A positive going waveform would indicate a positive going error and a negative going waveform would indicate a negative error.

c. If 100V is exactly 100V the error read in c is the divider error. If 100V is not adjusted to exactly 100V, subtract algebraically the 100 VOLTS error (including sign) from .1 VOLT error (including sign) to find 1000:1 divider error (include sign).

5g. (cont'd)

Adjust A VARIABLE TIME/CM for exactly one cycle in 10cm. Change A SLOPE from + to - and note display: center of calibrator waveform (point where calibrator switches from plus to minus) must fall within 0.5cm of graticule center, indicating duty cycle between 45% and 55%.

Remove connection to CAL OUT. Reset A VARIABLE TIME/CM to CALIBRATED and SLOPE to +.

h. Check Frequency 1 kHz, $\pm 25\%$

Connect test scope 10X probe to CAL OUT. Note time for one cycle of waveform: 1ms; $\pm 25\%$, max.

i. Check Risetime

Note risetime of calibrator waveform: 5 VOLTS, $\leq 0.4\mu\text{s}$; 100 VOLTS, $\leq 0.6\mu\text{s}$.

Remove probe.

j. Check 5mA error $\pm 2\%$

Connect the P6019 through its termination (011-0078-00) to the test scope TYPE 1A1 input. Set the test scope TIME/CM to 1mSEC and the TYPE 1A1 VOLTS/CM to .005. Clip the P6019 head to the TYPE 544 calibrator current loop (observe the arrows) and set the termination to 2mA/mV.

Check for no deflection on the test scope in the .2mV through 100V positions of the TYPE 544 CALIBRATOR switch. Check for a pulse amplitude of about $\pm 5\text{mm}$ in the 5mA position.

Switch back and forth between the 100V and 100VDC positions. Check for a positive-going spike on the trace each time the CALIBRATOR is switched to the 100VDC position, and for a negative-going spike when it is switched from the 100VDC position.

Remove current probe connections.

6. CRT

- a. *Check Horizontal deflection -
graticule alignment: within 3°*

Set MODE to AUTO. Connect voltmeter across terminals of trace rotator coil L778. Adjust TRACE ROTATION for zero voltage.

Adjust TU-7 to position the trace so it starts at the intersection of the graticule left edge and center horizontal line.

Check that the beam crosses the right edge of the graticule within 0.5cm from the center horizontal line. Remove the meter.

- b. *Check TRACE ROTATION range: 3° , min*

Turn TRACE ROTATION cw and note the trace moves cw.

Turn TRACE ROTATION full cw and ccw. Note the point the beam crosses the graticule's right edge in each instance: 0.5cm, min up or down from the previously noted trace position with 0V across L778.

Adjust TRACE ROTATION so the trace is parallel with the center graticule line.

- c. *Adjust Geometry max vertical
deviation: <1mm*

TYPE 184 MARKER AMPLIFIER OUTPUT--50 Ω cable--
50 Ω term--TU-7 input

Set TYPE 184 for lms markers. Set TIME/CM to .5mSEC. Adjust VARIABLE TIME/CM for 1 marker per cm and Sweep Length R325 for approx 10.5cm trace length.

Set TYPE 184 to 100 μ s markers. Adjust Geometry R861 for min bowing. Max deviation of vertical trace from vertical graticule line, top to bottom, is 1mm. Recheck TRACE ROTATION setting.

6. (cont'd)

d. Check Horizontal Focus

Set TYPE 184 to 50 μ s markers. Check that all marks within the graticule are well defined with no overlap. Change TYPE 184 to 100 μ s markers.

e. Check Orthogonality

Position the display so one time mark falls at the intersection of the graticule bottom edge and center vertical line.

Note the point the time mark crosses the graticule's top edge: 1mm, max either side of the center vertical line.

Remove TYPE 184 signal. with MODE at AUTO, set TRIGGERING LEVEL full cw. Reset VARIABLE TIME/CM to CALIBRATED.

f. Check Horizontal geometry max horiz deviation: 1mm

Move the trace to the top and bottom graticule lines and check for any deviation of the trace: 1mm, max.

g. Check Vertical Focus

Connect CAL OUT to TU-7 input. Set TIME/CM to 5 μ SEC.

Set AMPLITUDE CALIBRATOR to 10 VOLTS, and adjust TU-7 VARIABLE for 5cm deflection.

Set AMPLITUDE CALIBRATOR to .1 VOLTS and adjust FOCUS, ASTIGMATISM, and INTENSITY for well-defined trace at graticule center.

Position the trace vertically over full 6cm and check that both traces are well-defined, with no overlap.

Remove calibrator signal.

7. VERTICAL AMPLIFIER

- a. Check Transistor stage unbalance
0.5cm, max*

Momentarily short collectors of Q1114 and Q1134 together and note trace vertical position (electrical center) from graticule center: 0.5cm, max.

Short the cases of Q1074 and Q1084 together. Note trace deviation from electrical center, 0.5cm, max, then remove short.

Short Q1044 collector to Q1034 collector. Note trace deviation from electrical center, 0.5cm, max, then remove short.

Short the cases of Q1014 and Q1024 together. Note trace deviation from electrical center, 0.5cm, max, then remove short.

- b. Adjust Vert DC Bal error: 1cm
range: ± 1 cm*

Set TU-7 to COMMON MODE. Set Vert DC Bal R1004 full cw, then full ccw. At each extreme note deviation of trace from graticule center: 1cm, min.

Adjust R1004 to move trace to graticule center.

- c. Adjust Vert Gain error: 1%*

Set TU-7 to GAIN SET and connect 100V SAC signal to TU-7 input. Set TIME/CM to .5mSEC. Adjust A TRIGGERING LEVEL for a stable display.

Center the display on the graticule. Adjust Vert Gain R1017 for max gain and note deflection: 4.4cm, min. Adjust R1017 for min gain and note deflection: 3.8cm, max. Adjust R1017 for exactly 4cm deflection.

- b. Vertical DC Bal must be adjusted for a trace at graticule center to compensate for circuit drift.

7. (cont'd)

d. Check Compression-expansion

Set SAC to 50V.

Position top of 2cm display to top of graticule. Compression or expansion must not exceed 0.5mm.

Position bottom of display to bottom of graticule. Compression or expansion must not exceed 0.5mm.

e. Check Common mode rejection

Set TU-7 to COMMON MODE and SAC to 1V.
Note deflection: 3mm, max.

Remove calibrator signal.

f. Check DC shift 0.5mm, max

Set TU-7 to GAIN SET. Position trace to bottom graticule line. Change TU-7 to COMMON MODE; trace will shift rapidly to a new position and then slowly drift a small amount either up or down. Slow drift must not exceed 0.5mm.

8. DUAL-TRACE PULSE AND CHOPPED BLANKING*a. Check Waveform and risetime:*

Amplitude: >60V

Risetime: $\leq 1\mu S$

Connect 10X probe from test scope to pin 16 of the plug-in compartment connector and check waveform amplitude and negative risetime at all sweep rates.

8. (cont'd)

- b. Check ALTERNATE operation: all sweep rates*

Set HORIZONTAL DISPLAY to NORMAL. Connect 10V calibrator signal to TU-7 input.

Set TU-7 to ALTERNATE. Check display for two traces on all TIME/CM positions. Cal signal will be seen on one trace only.

Remove calibrator signal.

- c. Check Dual-trace chopped blanking*

Set TU-7 to CHOPPED. Adjust TYPE 544 TIME/CM and TRIGGERING LEVEL for a stable display of several cycles of chopped waveform.

Change CRT CATHODE SELECTOR (scope rear) to CHOPPED BLANKING and check that fast chopping transients (vertical lines) disappear.

Return CRT CATHODE SELECTOR to EXTERNAL CRT CATHODE and set TU-7 to LOW LOAD.

9. TRIGGER ADJUSTMENTS

- a. Setup*

Apply a 100mV square wave signal from the SAC to a "T" connector on the TU-7 EXT INPUT. Ground the outboard terminal of the TRIGGER LEVEL X10 switch and connect the test scope 10X probe to the junction of the 56 Ω resistor, R252, and 5 μ H coil, L250.

Set the TRIGGERING controls as follows:

SLOPE	+
MODE	TRIG
SOURCE	EXT
COUPLING	AC

9. (cont'd)

- b. *Adjust Trigger Sens R245 and
Trigger Level Centering R225:
stable display on 100mV EXT, 2mm INT;
untriggered display on 20mV EXT*

Turn Trigger Sens R245 to midrange. Adjust Trigger Level Centering R225 for a stable square wave display (approx 200-300mV P-P) on the test scope. Note the adjustment range of R225 through which the square wave display remains stable. Set R225 to the approximate center of this range.

Turn R245 to the most ccw position giving a stable display at both settings of the SLOPE switch. Turn R225 ccw until the test scope display breaks up or reduces to about 50mV; then set it slightly cw so that the stable display reappears on the test scope. Check at both settings of the SLOPE switch.

Repeat the above procedure until the adjustment 'window' of R225 is as narrow as possible and R245 is set to the most ccw position providing a stable test scope display of about 200-300mV amplitude (+ and - SLOPE).

Set the SAC to 50mV and check that the test scope display amplitude decreases to about 50mV.

Set the SAC to 5 VOLTS and adjust TU-7 VARIABLE for 1cm of amplitude. Change TRIGGER SOURCE to NORM INT.

Change the SAC to 1 VOLT (2mm display) and check that triggered displays can be obtained in + SLOPE and - SLOPE without readjustment of TRIGGER LEVEL.

- c. *Adjust Int Trig DC Level R209
4mm at graticule center*

Set the SAC to 10 VOLTS and the TU-7 to GAIN SET (4mm display). Position the TYPE 544 display to the graticule center. Change COUPLING to DC. Ground the out-board terminal of the TRIGGER LEVEL X10 switch again and adjust Int Trig DC Level R209 for stable display.

Remove the ground from the TRIGGER LEVEL switch.

- b. If a stable display can not be obtained by adjusting R225, turn R245 slightly cw and repeat the preliminary adjustment of R225.

CAUTION: Do not preset R245 to the cw end of its rotation; in some TYPE 544's, this will cause the final settings of the trigger circuit to bias the trigger tunnel diode D245 so that it will rest at its high-state voltage level. The resulting excessive power dissipation in the diode will lead to trigger sensitivity drift and premature diode failure.

9. (cont'd)

d. Check for oscillations: none

Set COUPLING to AC and SAC to .5 VOLTS (1mm display). Check for no oscillations on the test scope display when TRIGGER LEVEL is rotated through its range.

Remove the SAC signal from the "T" connector.

e. Align TRIGGER LEVEL knob

Set the test scope VOLTS/CM to 0.1 DC-coupled and establish its zero volts DC reference line.

Connect the test scope's 10X probe to the output terminal of TRIGGER LEVEL X10 switch and adjust TRIGGER LEVEL for zero volts on the test scope. Without moving the pot shaft, set the knob index to front panel "0", tighten the set screw, and recheck the test scope display.

f. Check TRIGGERING LEVEL range:

Normal, at least + & - 2V;

X10, at least + & - 20V

Check the voltage swing on the test scope display when the TRIGGERING LEVEL control is rotated through its range. Check for a range of at least + and - 2 volts.

Pull TRIGGERING LEVEL knob out for 10X RANGE INCREASE and check for a range of at least + and - 20 volts.

Push in on TRIGGERING LEVEL knob and remove the test scope probe.

g. Check AUTO triggering: ≤ 20 Hz repetition rate

Apply 50mS markers from the TYPE 184 to EXT INPUT. Set the front panel controls as follows:

(TU-7) VARIABLE	1cm display
TIME/CM	10mS
TRIGGERING MODE	AUTO STABILITY
TRIGGERING LEVEL	stable display

9g. (cont'd)

Change the TYPE 184 to 100ms and check for an untriggered display at all settings of the TRIGGERING LEVEL control.

Remove the TYPE 184 markers and check that the baseline remains when TRIGGERING LEVEL is rotated from one extreme to the other.

Set the TRIGGERING MODE switch to TRIG and check that no baseline exists while the sweep is not triggered.

h. Check LINE triggering: correct slope

Change TRIGGERING SOURCE to LINE. Connect the 10X probe from the TU-7 EXT INPUT "T" connector to the fuse holder terminal.

Check that the display triggers on the correct slope with COUPLING in AC and DC.

Remove the 10X probe from the TYPE 544 and TU-7.

i. Check PLUG-IN INT triggering

Apply a 100 volt square wave signal from the SAC to the TU-7 EXT INPUT. Set the front-panel controls as follows:

TRIGGERING SOURCE	PLUG-IN INT
TRIGGERING LEVEL	0
TIME/CM	1mSEC
(TU-7) TEST FUNCTION	CHOPPED

Rotate the VARIABLE TIME/CM and check that the square wave signal is triggering the display.

Remove the SAC from the "T" connector.

j. Check sine-wave triggering

Connect the output of the LF Sine Wave Generator to the "T" connector. Adjust amplitude and frequency of the applied signal as directed in the following chart:

j. Be sure to check triggering in both positions (+ and -) of the SLOPE switches.

9j. (cont'd)

COUPLING	SOURCE	LFSWG Frequency	Signal Amplitude, P-P	
			Stable display with TRIGGER LEVEL Fixed	No display at any setting of TRIGGER LEVEL
AC	NORM INT	1 kHz	2mm	
DC	NORM INT	1 kHz	4mm*	---
AC LF REJ	NORM INT	60 Hz	---	4mm
AC LF REJ	NORM INT	2 kHz	2mm	
AC	EXT	1 kHz	0.1 V	0.02 V
DC	EXT	1 kHz	0.1 V	0.02 V

* When positioned within 1/2cm of graticule center; anywhere on the graticule with adjust of TRIGGER LEVEL.

10. SINGLE SWEEP

a. Setup

Apply 0.5cm calibrator signal to TU-7 input. Set MODE to TRIG and HORIZONTAL DISPLAY to NORMAL.

Adjust A TRIGGERING LEVEL for a stable display. Remove calibrator signal.

b. Check Single sweep

Press SINGLE SWEEP lever to RESET. Spring loaded switch will return lever to SINGLE SWEEP. Note A READY neon is lit.

Reapply calibrator signal to TU-7 input, note that A sweep runs once and the neon extinguishes.

Return SINGLE SWEEP lever to NORMAL.

11. FRONT PANEL NEONS, SCALE ILLUMINATION

a. Setup

Set INTENSITY full ccw.

Set HORIZONTAL DISPLAY to EXT. Adjust INTENSITY for a low intensity spot on the CRT.

11. (cont'd)

b. Check Beam position indicators

In the following checks the proper beam position indicator neon must come on before the spot moves out of the scan area. The opposite position indicator must not be on after crossing graticule center.

<u>POSITION</u> <u>control</u>	<u>turn</u>	<u>Spot</u> <u>must</u> <u>move</u>	<u>Beam</u> <u>position</u> <u>indicator</u>
TU-7 vertical	cw	up	↑
TU-7 vertical	ccw	down	↓
544 horizontal	cw	right	→
544 horizontal	ccw	left	←

Change HORIZONTAL DISPLAY to NORMAL.

c. Check SCALE ILLUM

Turn SCALE ILLUM full cw: graticule bulbs must increase brilliance.

Turn SCALE ILLUM full ccw: graticule bulbs must completely extinguish.

d. Check TIME BASE indicator lights

TIME/CM UNCALIBRATED neon: lit any time VARIABLE TIME/CM out of CALIBRATED. Reset to CALIBRATED.

READY neon: lit when single sweep function is ready. Reset to NORMAL.

MAGNIFIER ON neon: lit when SWEEP MAGNIFIER is at X2, X5, X10, X20, X50, X100 (not lit when HORIZONTAL DISPLAY is at EXT). Reset to X1 OFF.

MAGNIFIER UNCALIBRATED neon: lit when sweep speeds exceed 10ns/cm.

b. CRT scan area is the total area in which a trace can be displayed.

12. HORIZ AMP GAIN X10, X1, X100*a. Setup*

TYPE 184--50 Ω cable--TU-7 input

Set TYPE 184 to 10 μ s, 50 μ s, 100 μ s and lms markers.

b. Adjust X10 Cal error: $\pm 3\%$

Set SWEEP MAGNIFIER to X10. Adjust X10 Cal R544 for one 100 μ s marker per cm.

c. Adjust X1 Cal error: $\pm 1\%$

Set SWEEP MAGNIFIER to NORMAL. Adjust X1 Cal R566 for one lms marker per cm.

d. Adjust X100 Cal error: 3%

Set HORIZ DISPLAY to X100. Adjust R565 for one 10 μ s marker per cm.

Adjustments of R544, R566 and R565 interact, repeat as necessary.

e. Check X50, X20, X5, X2 accuracy error: $\pm 3\%$

Set SWEEP MAGNIFIER to X50. Note two 10 μ s marks per cm: $\pm 3\%$, max.

Set SWEEP MAGNIFIER to X20. Note one 50 μ s mark per cm: $\pm 3\%$, max.

Set SWEEP MAGNIFIER to X5. Note two 100 μ s markers per cm: $\pm 3\%$, max.

Set SWEEP MAGNIFIER to X2. Note one lms marker per 2cm: $\pm 3\%$, max.

Reset SWEEP MAGNIFIER to NORMAL.

12. Unless noted otherwise, use the middle 8 horizontal centimeters when making horizontal amplifier gain and timing checks or adjustments.

13. NORMAL-MAGNIFIED REGISTRATION

a. Setup

Set TYPE 184 to 5ms markers.

TYPE 544 presets:

TIME/CM	1mSEC
HORIZONTAL DISPLAY	NORMAL
MODE	TRIG
SLOPE	+
COUPLING	AC
SOURCE	NORM INT

b. Adjust Swp/Mag Regis: $\pm 1mm$

Note position of the middle 5ms marker.
Set SWEEP MAGNIFIER to X100. Position
the middle 5ms marker to graticule
center.

Set SWEEP MAGNIFIER to X1 OFF. Adjust
Swp/Mag Regis R569 to position the 5ms
marker to graticule center.

Repeat adjustment as needed.

14. SWEEP LENGTH

Adjust Sweep Length

Adjust Sweep Length R325 for 10.5cm sweep
length at 1mSEC.

15. VARIABLE TIME/CM

a. Check VARIABLE range: $\geq 2.5:1$

Set TYPE 184 to 10ms markers. Set
VARIABLE TIME/CM full ccw. Note dis-
tance between markers: 4cm, max.

Reset VARIABLE to CALIBRATED.

15. (cont'd)

- b. Check HORIZONTAL POSITION controls
Range of VERNIER control alone: $>1\text{cm}$
trace shift.
Total control range: at least + and -
5cm trace shift.

Check that cw rotation of either HORIZONTAL POSITION control moves the trace to the right and ccw rotation moves the trace to the left.

Check that HORIZONTAL POSITION VERNIER can shift the display at least 1cm.

Check that the start of the trace can be positioned to graticule center, and the end of the trace can be positioned to within 0.5cm of graticule center (using both controls if necessary).

16. $.1\mu\text{SEC}$ - $10\mu\text{SEC}$ /CM TIMING

- a. Adjust $10\mu\text{SEC}$ $\pm 1\%$

Switch TIME/CM to $10\mu\text{SEC}$. Set TYPE 184 to $10\mu\text{s}$ markers.

Adjust C290C for one marker per cm, $\pm 1\%$.

- b. Adjust $1\mu\text{SEC}$ $\pm 1\%$

Switch TIME/CM to $1\mu\text{SEC}$. Set TYPE 184 to $1\mu\text{s}$ markers.

Adjust C290B for one marker per cm, $\pm 1\%$.

- c. Adjust $.5\mu\text{SEC}$ and $.1\mu\text{SEC}$ $\pm 1\%$

Switch TIME/CM to $.5\mu\text{SEC}$. Adjust C290A for one marker per 2cm, $\pm 1\%$, max.

Switch TIME/CM to $.1\mu\text{SEC}$. Set TYPE 184 to $.1\mu\text{s}$ markers. Adjust C299 for 1 marker per cm, neglecting the first marker.

Recheck C290A setting as C299 and C290A interact.

16. The addition of side panels may cause slight variations in characteristics.

17. MAG ON TIMING*a. Setup*

TYPE 544 presets:

HORIZONTAL DISPLAY	NORMAL
TIME/CM	.1 μ SEC
Triggering	TRIG, +, AC, EXT

Apply .1 μ s markers to TU-7 input.
Apply 10 μ sec TYPE 184 triggers to EXT
TRIGGER INPUT.

Recheck and reset if necessary, C299
adjustment for 1 marker cm.

Preset C576 and C586 to 4-6 turns from
max.

b. Adjust C572, C582, C591, C576, C586

Set TYPE 184 to 20ns.

Set start of sweep to left graticule
line. Set SWEEP MAGNIFIER to X10.
Adjust TRIGGERING LEVEL for a stable
display.

Use an insulated tool to adjust C572
and C582 for max expansion of the sweep.

Adjust C591 for max sweep expansion and
best linearity (to be reset later).

Adjust C576 and C586 for best timing
at sweep center (see notes). These
two capacitors should not be allowed
to differ greatly in adjustment. If
the sweep seems too long with C576 and
C586 at this setting, adjust C572 to
reduce displayed gain.

*c. Adjust X10 MAG comp: $\pm 3\%$ between
4th and 80th*

Position start of sweep to graticule
left edge. Adjust TRIGGERING LEVEL so
a cycle peak falls at 4th cm mark.

Position trace so the cycle peak falls
at the left graticule edge.

b. C576, C586

Best overall tuning of the TYPE
544 will be achieved if C567 and
C586 are kept fairly close in
adjustment.

If C576 and C586 don't seem to
have enough range, repeat adjust-
ment procedures for C572, C582,
and C591. If, after the repeat
adjustment, the compensation seems
to be getting worse rather than
better, C576 and C586 were preset
to wrong value. Back C576 and
C586 off a turn or two and re-do
the amplifier compensation once
again.

17c. (cont'd)

Adjust C557H for 1 cycle per 2cm. Readjust C591 for best linearity. Recheck center of sweep.

Readjust C572 for correct gain.

Set SWEEP MAGNIFIER to NORMAL. Adjust HORIZONTAL POSITION so the end of the sweep falls 2cm to the right of graticule center.

Set SWEEP MAGNIFIER to X10 and note timing error in this 80th cm range; $\pm 3\%$, max.

If some nonlinearity is noted in the 20th cm range, recheck C591.

d. *Adjust X20 MAG comp: $\pm 3\%$*

Set SWEEP MAGNIFIER to NORMAL and TIME/CM to .2 μ SEC. Set start of sweep to the 4.5cm graticule line. Turn SWEEP MAGNIFIER to X20 and adjust C557K for 1 cycle/2cm.

e. *Adjust X5 MAG comp: $\pm 3\%$*

Set SWEEP MAGNIFIER to X5 and TIME/CM back to .1 μ SEC. Adjust C557F for 1 cycle per cm. Ignore the first 2 cycles.

f. *Adjust X2 MAG comp: $\pm 3\%$*

Set SWEEP MAGNIFIER to X2. Adjust C557D for 2.5 cycles per cm. Ignore the first cycle.

g. *Check X100, X50, X20 MAG comps: $\pm 3\%$*

Set TYPE 184 to 20ns \sim and check MAGNIFIER X100, X50, X20 compensations between 5% of sweep start and 80% of displayed sweep length, $\pm 3\%$:

<u>TIME/CM</u>	<u>Sweep Magnifier</u>	<u>Display</u>
1 μ SEC	X100	1 cycle/2cm
.5 μ SEC	X50	1 cycle/2cm
.2 μ SEC	X20	1 cycle/2cm

c. X10 MAG comp

When adjusting C557H, disregard first 40nsec of sweep.

If center of sweep is out of timing specs, slight adjustment of C576 and C586 should correct.

g. 5% of sweep start is obtained by turning MAG OFF and positioning sweep start to the 4.5cm mark then turn MAG to RANGE being checked.

80% of displayed sweep length is obtained by turning MAG OFF; positioning end of trace to the 7cm mark; and then returning MAG to range being checked.

18. TIME BASE TIMING

Check sweep timing, mag off: within 1%

Set SWEEP MAGNIFIER to NORMAL and check all sweep rates as follows:

<u>TIME/CM</u>	<u>TYPE 184 Marks</u>	<u>Check for</u>
.1 μ SEC	20ns	1 cycle/cm
.2 μ SEC	50ns	1 cycle/cm
.5 μ SEC	1 μ s	1 mark/2cm
1 μ SEC	1 μ s	1 mark/cm
2 μ SEC	1 μ s	2 marks/cm
5 μ SEC	5 μ s	1 mark/cm
10 μ SEC	10 μ s	1 mark/cm
20 μ SEC	10 μ s	2 marks/cm
50 μ SEC	50 μ s	1 mark/cm
.1mSEC	100 μ s	1 mark/cm
.2mSEC	100 μ s	2 marks/cm
.5mSEC	500 μ s	1 mark/cm
1mSEC	1ms	1 mark/cm
2mSEC	1ms	2 marks/cm
5mSEC	5ms	1 mark/cm
10mSEC	10ms	1 mark/cm
20mSEC	10ms	2 marks/cm
50mSEC	50ms	1 mark/cm
.1 SEC	100ms	1 mark/cm
.2 SEC	100ms	2 marks/cm
.5 SEC	500ms	1 mark/cm
1 SEC	1 s	1 mark/cm
2 SEC	1 s	2 marks/cm
5 SEC	5 s	1 mark/cm

19. EXTERNAL HORIZONTAL AMPLIFIER

a. Setup

SWEEP OUT--jumper--BNC to banana plug adapter
--TU-7 input

CAL OUT--BNC to banana plug adapter--
jumper--HORIZ INPUT--jumper--BNC to
banana plug adapter--ext TRIGGER INPUT

19a. (cont'd)

544 presets:

HORIZONTAL DISPLAY	EXT .1 volts
EXT HORIZ VARIABLE	cw
AMPLITUDE CALIBRATOR	.5 VOLTS
TIME/CM	.2mSEC
Triggering	AUTO, +, AC
	EXT
A TRIGGERING LEVEL	midr

Set TU-7 to LOW LOAD.

b. Adjust Ext Horiz DC Bal: 2mm, max

Adjust HORIZONTAL POSITION to place left edge of the calibrator signal to mid-screen. Adjust TU-7 amplitude for several cycles of calibrator signal.

Rotate EXT HORIZ VARIABLE back and forth and adjust Ext Horiz DC Bal R519 for no shift of the left edge of the calibrator signal.

c. Adjust Ext Horiz Gain

Set EXT HORIZONTAL VOLTS/CM to .1.

Rotate EXT HORIZ VARIABLE to cw position and adjust R510 for a 5cm display. Re-check Horiz DC Balance, R519.

d. Check EXT HORIZ VARIABLE range $\geq 10:1$

Set AMPLITUDE CALIBRATOR to .5 VOLTS. Note deflection with EXT HORIZ VARIABLE full cw. Rotate EXT HORIZ VARIABLE full ccw. Note deflection: no greater than 1/10 of previous deflection. Return EXT HORIZ VARIABLE full cw.

*e. Adjust Output compensation: $\pm 3\%$
max aberrations*

Adjust C524 for best corner on square wave: $\pm 3\%$ max aberrations.

*f. Check X10 attenuator accuracy: $\pm 2\%$
compensation: $\pm 3\%$ max aberrations*

Set AMPLITUDE CALIBRATOR to 5 VOLTS. Switch EXT HORIZ VOLTS/CM to 1 and check for 5cm display within 2%.

19f. (cont'd)

Adjust C503C for best corner of square wave; max aberrations: 3%.

g. *Check X100 attenuator accuracy: $\pm 2\%$
compensation: $\pm 3\%$ max aberration*

Set AMPLITUDE CALIBRATOR to 50 VOLTS. Switch EXT HORIZ VOLTS/CM to 10 and check for 5cm display within 2%.

Adjust C503C for best corner of square wave; max aberrations: 3%.

Remove calibrator signal.

h. *Check Bandpass > 450 kHz at -3dB*

Set EXT HORIZONTAL VOLTS/CM to .1 VOLTS/CM position.

Set EXT HORIZ VARIABLE full ccw.

Connect TYPE 191 to TYPE 544 HORIZ INPUT. Adjust TYPE 191 for 4cm of 50 kHz.

Increase TYPE 191 frequency to 450 kHz and note deflection: 2.8cm, min.

Set HORIZONTAL DISPLAY to NORMAL.

Remove TYPE 191 from HORIZ INPUT. Remove connection from SWEEP OUT to TU-7 input.

20. CRT CATHODE INPUT

a. *Setup*

Set TIME/CM to 1mSEC.

Loosen EXTERNAL CRT CATHODE and GND binding posts (scope rear) and swing strap away from EXTERNAL CRT CATHODE (strap must pivot around GND binding post).

b. *Check intensity modulation:
noticeable modulation $\leq 10V$*

Connect 10V calibrator signal to EXTERNAL CRT CATHODE. Note that the display is intensity modulated at normal intensity with CRT CATHODE SELECTOR set to EXTERNAL CRT CATHODE.

Remove calibrator signal and reconnect CRT gnd strap.

21. EXTERNAL WAVEFORMS

- a. Check VERT SIG OUT: $\geq 0.3V/cm$
 risetime: 20ns, max

Set TU-7 to + PULSE and REPETITION RATE to MED. Adjust TU-7 PULSE AMPLITUDE for 4cm display.

Set TIME/CM to .5 μ SEC and A SOURCE to NORM INT. Adjust A TRIGGERING LEVEL for a stable display.

Connect test scope 10X probe to VERT SIG OUT binding post.

Note test scope waveform amplitude: 1.2V, min.

Obtain exactly 4cm display on test scope and change test scope TIME/CM to .1 μ SEC. Set 5X MAG to on (20nSEC/CM). Observe displayed risetime of 21.5ns or less.

- b. Check SWEEP OUT: $\geq 9.0V/cm$
 at 1mSEC/CM

Set TIME/CM to 1mSEC.

Connect test scope 10X probe to SWEEP A binding post. Check sawtooth amplitude: 9.0V/cm of 544 sweep . . . i.e., if sweep is 10.5cm, sawtooth must be 94.5V, min.

- c. Check + GATE A: $\geq 20V$

Connect test scope 10X probe to + GATE A binding post. Note square wave amplitude: 20V, min.

- a. Test scope must be properly calibrated in order to see this risetime.

Checking risetime to 21.5ns or less with TYPE 544 - 546 - 547 and P6006 insures an actual risetime of 20ns or faster.

$$T_r = \sqrt{(T_r^1)^2 + (T_r^2)^2 + \dots}$$

22. TIME BASE HOLDOFF

- a. Setup

Set HORIZONTAL DISPLAY to NORMAL and MODE to AUTO. Set TU-7 to LOW LOAD.

22. (cont'd)

b. Check Holdoff

Connect test scope 10X probe to D298-R299 junction. Check holdoff as follows:

<u>TIME/CM</u>	<u>Holdoff</u>
.1 μ SEC	9-27 μ s
.2-5 μ SEC	5-15 μ s
10-50 μ SEC	16-28 μ s
.1-.5mSEC	70-130 μ s
1-5mSEC	0.9-1.7ms
10-50mSEC	9-17ms
.1-.5 SEC	90-170ms
1-5 SEC	0.5-0.9 s

23. SINGLE SWEEP RESET INPUT*a. Setup*

CAL OUT--50 Ω cable--CAL INPUT, External Function Checker

SINGLE SWEEP RESET INPUT--50 Ω cable--single sweep input, External Function Checker.

TYPE 544 presets:

TIME/CM	.1mSEC
HORIZONTAL DISPLAY	NORMAL
AMPLITUDE CALIBRATOR	100V

b. Check External reset function
15V max risetime: 0.5 μ s

Note normal display of sweep. Set SINGLE SWEEP lever to SINGLE SWEEP and note sweep disappears.

Set Function Checker to position 2. Press RESET button on Function Checker and note a single sweep.

Remove Function Checker.

- a. The 4 conductor cable from the External Function Checker is not used on the 544.

24. VERTICAL AMPLIFIER HF ADJUSTMENTS*a. Setup*

TYPE 544 presets:

HORIZONTAL DISPLAY	NORMAL
SWEEP MAGNIFIER	X1 OFF
TIME/CM	.1mSEC
Triggering	AUTO, +, AC, NORM INT

Set TU-7 to + PULSE and PULSE REPETITION RATE to 4kHz. Adjust PULSE AMPLITUDE for 4cm amplitude display. Position the pulse vertically to the CRT center.

Position the pulse rise to the CRT center.

*b. Adjust Vertical HF aberrations: $\pm 1\%$
max risetime: $\leq 6.75\text{ns}$ with TU-7*

Most of the vertical HF adjustments interact, repeat as necessary to obtain a waveform with flat top and minimum aberrations: 0.4mm max with waveform centered on the CRT.

Adjust R1091 for the best square corner on the top of the display. Set the 067-0521-01 repetition switch to 20 μ sec. Adjust R1077 for the best square corner on the top of the display.

Set the 067-0521-01 repetition rate to 80kHz and the TIME/CM switch to .1 μ SEC.

Make final adjustments with SWEEP MAGNIFIER at X10. Move back and forth between X10 and NORMAL (X1) to check overall level.

Note risetime at X10: $\leq 6.75\text{ns}$ with TU-7.

b. When adjusting C1029, if no effect is seen at the 340ns point, this means the delay line terminations are very good, so adjust C1029 for best risetime as seen on display.

<u>Adjustment</u>	<u>Location</u>
L1157, adjust for min wrinkles at leading edge.	main Vert Amp chassis
C1029, delay line termination, approx 340ns from start of sweep.	main Vert Amp chassis

24b. (CONT)

<u>Adjustment</u>	<u>Location</u>
C1076, med time constant compensation.	pc board
C1105, fast time constant compensation.	pc board
C1106, med time constant compensation.	pc board
C1126, long time constant compensation.	pc board
R1076, adjust with C1076.	pc board
R1106, adjust with C1106.	pc board
C1027, adjust for ≤ 6.7 ns risetime.	pc board

c. *Check Transient response 1.5mm, max change*

Set pulse upper edge to bottom of the graticule: 1.5mm, max change from center graticule setting.

d. *Check corner symmetry: + or -0.5mm*

Switch TRIGGERING SLOPE to - and TU-7 TEST FUNCTION to - PULSE. Position display to center 4cm of graticule and note overshoot or undershoot: ± 0.5 mm.

Switch TRIGGERING SLOPE and TU-7 PULSE back to +.

e. *Check spoiler switch*

Set TIME/CM to .1 μ SEC and SWEEP MAGNIFIER to X10.

Note risetime, then depress spoiler switch. The risetime will typically reduce by 1ns, total risetime must not exceed 10ns.

25. HF TRIGGERING*a. Setup*

544 presets:

SWEEP MAGNIFIER	X10
TIME/CM	.1 μ SEC
Triggering	TRIG, +, AC
	NORM INT

Set TU-7 to LOW LOAD. Connect 50 MHz
TYPE 191 signal to TU-7 input.

b. Check Int HF triggering 6mm at 50 MHz

Adjust TU-7 or TYPE 191 for 6mm deflection.

Adjust TRIGGERING LEVEL for a stable display and check for no more than 2mm of jitter. Set HORIZONTAL DISPLAY to NORMAL.

c. Check Ext HF triggering: 200mV at 50 MHz

Switch TYPE 191 to 50 kHz, and connect it to the test scope. Adjust TYPE 191 for 200mV output. Remove the TYPE 191 signal from the test scope and connect it to the TYPE 544 TRIGGER INPUT and TU-7 INPUT using a BNC T connector and 50 Ω cables. Set the TYPE 544 SOURCE to EXT and COUPLING to AC.

Change the TYPE 191 frequency to 50 MHz and check for a stable display with adjustment of TRIGGER LEVEL.

Switch COUPLING to AC-LF REJECT and again check for a stable display with adjustment of TRIGGER LEVEL.

THE END