FACTORY CALIBRATION PROCEDURE

CONTENTS:

INTRODUCTION:

551

This is the guide for calibrating brand-new instruments, it therefore, calls out many procedures and adjustments that are rarely required for subsequent recalibration. *This procedure is company confidential.* In this procedure, all front panel control labels or Tektronix equipment names are in capital letters (VOLTS/DIV, etc.) internal adjustment labels are capitalized only (Gain Adj, etc.).

Tek form number:
0-303
September 1967

For all serial numbers.
Supercedes
December 1966

FACTORY TEST LIMITS:

We initially calibrate the instrument to Factory Test Limits. These limits are often more stringent than advertised performance requirements. This helps insure that the instrument will meet advertised requirements after shipment, allows for inaccuracies of test equipment used, and may allow for changes in environmental conditions.

QUALIFICATION:

Factory test limits are qualified by the conditions specified in the main body of the calibration procedure. The numbers and letters to the left of the limits correspond to the factory calibration procedure steps where the check or adjustment is made. Instruments may not meet factory test limits if calibration or check-out methods and test equipment differ substantially from those in this procedure.

ABBREVIATIONS:

Abbreviations in this procedure will be found listed in TEKTRONIX STANDARD A-100.

CHANGE INFORMATION:

This procedure has been prepared by Product Manufacturing Staff Engineering. For information on changes that have been made to this procedure, to make suggestions for changing this procedure, or to order additional copies: please contact PMSE, 47-261. (KM)

EQUIPMENT REQUIRED:

The following equipment is necessary to complete this procedure:

a. TEKTRONIX Instruments

*1	TYPE 547 SERIES OSCILLOSCOPE with:
*1	TYPE 1A1 DUAL-TRACE PLUG-IN
1	TYPE P6028 1X PROBE
1	TYPE P6006 10X PROBE
*2	TYPE 1A1 (or TYPE 1A2) DUAL-TRACE PLUG-INS
1	TYPE TU-76 LINE VOLTAGE CONTROL UNIT
1	TYPE 106 SQUARE WAVE GENERATOR
*1	TYPE 184 TIME-MARK GENERATOR
*1	TYPE 191 CONSTANT AMPLITUDE SINE WAVE GENERATOR

b. Test Fixtures and Accessories

*2	(1M1) CALIBRATION FIXTURES (067-0521-00)
*1	(SAC) STANDARD AMPLITUDE CALIBRATOR (067-0502-00)
1	T connector, BNC (103-0030-00)
3	50Ω 42" cables, BNC (012-0051-00)
1	50Ω termination, BNC (011-0049-00)
1	BNC to banana patch cord (012-0091-00)

c. Other equipment

1	20,000Ω/VDC multimeter
1	Shorting strap

*This equipment must be traceable to NBS for instrument.

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.

It is assumed that all equipment is provided with BNC connectors; if equipment used has other than BNC connectors, adapters, not listed, may be needed.

QUALIFICATION

Factory test limits are qualified by the conditions specified in the main body of the calibration procedure. The numbers and letters to the left of the limits correspond to the factory calibration procedure steps where the check or adjustment is made. Instruments may not meet factory test limits if calibration or checkout methods and test equipment differ substantially from those in this procedure.

1. PRELIMINARY INSPECTION

b. CRT face plate tilt, concavity, and convexity: 1/32", max

2. 551 PRESETS

3. RESISTANCE CHECKS

4. LOW VOLTAGE POWER SUPPLIES

c. Regulation: 105 to 125 VAC:

Supply	Tolerance	Ripple
-150V	±2%	5mV
+100V	±2%	10mV
+225V	±2%	5mV
+350V	±2%	20mV
+500V	±2%	20mV

5. SQUARE-WAVE CALIBRATOR DUTY CYCLE

b. Duty cycle: 45 to 55%
c. Frequency: 1kHz ±20%

6. CRT AND HIGH VOLTAGE

d. High Voltage: -1350 ±1.5%
e.f. HV regulation: 105 to 125 VAC
h. Shield voltage: 300V ±10V
i. CRT geometry: 1° max tilt
j. CRT focus: No overlap of 1mm-spaced vertical time marks in middle horizontal 8.8cm and no overlap of 1mm-spaced horizontal lines over 4cm vertical graticule area. Both beams must focus with same setting of FOCUS control
k. Compression and expansion: 0.75mm max, with 2cm display.
l. Intensity balance: both beams must extinguish with same setting of INTENSITY control
n.o. Beam registration: time markers must coincide within 0.5mm.

7. BEAM INDICATORS AND SCALE ILLUMINATION

b. Beam indicators: Indicator for direction of spot movement must light and opposite indicator must go out before beam leaves appropriate display area

8. DISTRIBUTED AMPLIFIERS

b. Microphonics: normal; 2.5mm, max ringing; none
c. Bias: -1V to -2.5V
d. Suppressor: +165V to +180V
e. Pair balance: ±2mm, max deviation
f. Overall balance: ±2mm, max deviation

9. INPUT AMPLIFIERS AND GRID-LINE DRIVERS

a. Microphonics: normal: 2.5mm, max ringing: none
b. Grid-line driver balance: ±1cm, max deviation
c. Input amplifier balance: ±1.5cm, max deviation

10. VERTICAL AMPLIFIERS

c. DC shift: 0.25mm, max, after 2cm deflection.

d. Trace shift: 0.5cm, max, between 105VAC

11. ALTERNATE TRACE

a. Alternate sync pulse: amplitude, 60 volts min; rise time, 1μs max

b. Alternate sweep operable at all sweep rates.

12. SQUARE-WAVE CALIBRATOR

* a. 100V accuracy: within 1%
100mV to 50V accuracy: within 2%

13. TIME BASE TRIGGERING

f. Time base triggering on 1kHz signal

±UPPER and ±LOWER TRIGGER SLOPE:

AUTO	2mm
AC LF REJECT	1mm, LEVEL fixed
AC	1mm, LEVEL fixed
DC	1mm; LEVEL fixed at '0', trace within 4mm of graticule center
	2mm, LEVEL variable, trace within 2mm of graticule center

±EXT TRIGGER SLOPE:

DC	.1V, LEVEL variable
AC	.1V, LEVEL variable
AC LF REJECT	.1V, LEVEL fixed
AUTO	.2V

±LINE TRIGGER SLOPE:

AUTO	triggered
AC LF REJECT	not operable at any LEVEL setting
AC	operable, LEVEL fixed
DC	operable, LEVEL fixed

14. AC LF REJECT

15. DELAY LINE AND HF ADJUSTMENTS

16. BANDWIDTH

b. No more than 3dB down at 25MHz

17. HIGH SPEED BEAM REGISTRATION

b. HF beam registration: within 1mm

18. 551 PRESETS

19. TIME BASE HF SYNC ON 30MHz SIGNAL

c. ±UPPER and LOWER HF SYNC: 2cm of 30MHz signal, horizontal trace width: 1mm, max

d. ±EXT HF SYNC: 0.5V of 30MHz signal, horizontal trace width: 1mm, max

20. HORIZONTAL AMPLIFIER GAIN

* d.	5X mag	±3%
* e.	Normal	±2%

21. TIME BASE SWEEP LENGTH

a. Length: 10.2cm to 10.6cm

22. NORMAL-MAGNIFIED REGISTRATION

23. TIME BASE TIMING

* a. VARIABLE TIME/CM ratio: 2.5 to 1, min
5 to 1 SEC/CM accuracy: within 2.5% (unmagnified)
* .5 SEC to .1 MILLISEC/CM accuracy: within 2% (unmagnified)
* b. 50 to .1μSEC/CM accuracy: within 2% (unmagnified)

24. TIME BASE HOLDOFF

TIME/CM	HOLD OFF TIME
.1 to .5μSEC:	4 to 9μs
1 to 50μSEC:	15 to 40μs
.1 to .5 MILLISEC:	150 to 400μs
1 to 5 MILLISEC:	1.5 to 4ms
10 to 50 MILLISEC:	15 to 40ms
.1 to 5 SEC:	150 to 400ms

25. LOCKOUT LEVEL

26. EXTERNAL HORIZONTAL DEFLECTION FACTOR

* a. With 1 volt applied: ≥5.6cm deflection
b. HORIZONTAL INPUT ATTEN Range: ≥10 - 1

27. EXTERNAL HORIZONTAL BANDWIDTH

* c. ≤3dB down at 400kHz (maximum gain)

28. CRT CATHODE INPUT

29. FRONT PANEL WAVEFORMS

a. +GATE OUT: 20V, min
SAWTOOTH OUT: 130V, min

THE END

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

1. PRELIMINARY INSPECTION

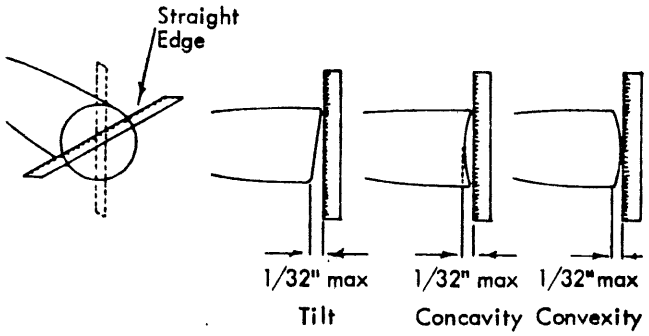
a. General

Check for unsoldered joints, rosin joints, poor lead dress and long ends. Check controls for smooth mechanical operation and proper indexing except TRIGGERING LEVEL knob which hasn't been adjusted or tightened yet.

b. CRT

Inspect CRT for visible defects, such as phosphor burns, flaking, etc.

Check that CRT neck pin connections are tight and that HV shields are installed. Loosen CRT clamp, remove graticule, push CRT forward and check as follows:



c. Check fuses

DC SUPPLIES FUSE:

Power Line	Description	Part Number
117V 50Hz	6.25A 3ag slo-blo	159-0011-00
117V 60Hz	6A 3ag fast-blo	159-0013-00
234V 50Hz	3A 3ag slo-blo	159-0005-00
234V 60Hz	3A 3ag fast-blo	159-0015-00

AC SUPPLY FUSE:

117V 50Hz	8A slo-blo	159-0035-00
117V 60Hz	8A fast-blo	159-0046-00
234V 50Hz	4A slo-blo	159-0027-00
234V 60Hz	4A fast-blo	159-0017-00

2. 551 PRESETS

FOCUS	ccw
INTENSITY	ccw
ASTIGMATISM	ccw
SCALE ILLUM	cw
HORIZONTAL DISPLAY	NORMAL
TIME BASE:	
TRIGGERING LEVEL	---
STABILITY	ccw (not PRESET)
TRIGGER SLOPE	+UPPER
TRIGGERING MODE	AC
TIME/CM	1 MILLISEC
VARIABLE TIME/CM	cw (CALIBRATED)
SINGLE SWEEP	OUT
HORIZONTAL POSITION	midrange
VERNIER horizontal position	ccw
SQUARE-WAVE CALIBRATOR	100
VOLTS-MILLIVOLTS-OFF	OFF
POWER	OFF
C372	¼ turn from max

Set all other internal adjustments, except vertical amplifier and delay line adjustments, to midrange.

At the start of each step, leave controls and adjustments as they were in the step preceding, unless noted otherwise.

3. RESISTANCE CHECKS

Install both 1M1's and set for LOW LOAD. Connect ohmmeter to proper slots on ceramic strip next to power transformer and check following resistances to ground:

3. (cont'd)

Supply	approx resistance
transformer term 1	inf
transformer term 4	inf
-150V	2.5kΩ
+100V	300Ω
+225V	5kΩ
+350V*	10kΩ*
+500V	15 to 30kΩ

Remove meter.

* Note: You may have to reverse ohmmeter polarity to obtain 10k reading because of protective diode across the filter capacitor.

4. LOW VOLTAGE POWER SUPPLIES

a. Time delay: 15 to 60 seconds

Connect TYPE 551 to TYPE TU-76, set source to 117 VAC and turn POWER ON. Power relay must delay at least 15 seconds but no longer than 60 seconds.

b. -150 Adj R627: 150V, ±3V

Adjust -150V Adj R627 to bring -150V within 3V of -150V and to bring other regulated supplies within tolerance.

c. Supply, tolerance, and ripple

Check regulated low voltage power supplies (measure on power supply chassis) for tolerance, ripple and regulation between 105 and 125 VAC line as follows:

Supply	Tolerance	max P-P ripple, 105 VAC HIGH LOAD to 125VAC LOW LOAD
-150V	±3V	5mV
+100V	±2V	10mV (including HV hash)
+225V	±4.5V	5mV
+350V	±7V	20mV
+500V	±10V	20mV

Return line voltage to 117 VAC.

NOTE: For first-time turn-on, on raw instruments, reduce line voltage to 1/6 normal line, set TRIGGERING MODE to LINE and measure the power transformer secondary voltages. Low readings indicate a shorted secondary circuit. It's important that any shorted filament secondaries are located before full line voltage is applied because the cables will usually burn up before the fuse blows.

4. (cont'd)

d. Elevated heaters

Check elevated heater supplies as follows:

T750 terminals	approx voltage to gnd
13-14, 15-16	+95V
5-6, 7-8, 11-12	+220V
9-10	-1000V to -1500V

T602 terminals	approx voltage to gnd
12-13	+350V

5. SQUARE-WAVE CALIBRATOR DUTY CYCLE

a. Cal Adj R879: +100V

Keep VOLTS-MILLIVOLTS-OFF at OFF, connect voltmeter to Cal Test Pt (V334A cathode, pin 3) and adjust Cal Adj R879 for 100V.

b. Duty cycle: 45% to 55%
(primary method--using test scope)

Remove meter, connect test scope probe to TYPE 551 CAL OUT and turn VOLTS-MILLIVOLTS-OFF to MILLIVOLTS. Set test scope for about 3cm of vertical display and so one cycle of TYPE 551 calibrator waveform extends over exactly 10cm of horizontal deflection. Change test scope triggering from + to - and note test scope display: center of calibrator waveform (point where calibrator switches from plus to minus) lies at center of test scope graticule, ±0.5cm, indicating duty cycle between 45% and 55%. Remove probe.

(alternate method--using meter)

Turn VOLTS-MILLIVOLTS-OFF to MILLIVOLTS and check for a meter reading of 45V to 55V, indicating duty cycle between 45% and 55%. Remove meter.

c. Frequency: 1kHz ±20%

Change test scope TIME/CM to .2mSEC and observe one cycle of calibrator waveform per 5cm ±1cm.

6. CRT AND HIGH VOLTAGE

a. Well-defined trace

Turn TIME BASE STABILITY cw (free run sweep). Use FOCUS, INTENSITY and ASTIGMATISM controls and 1M1 VERTICAL POSITION controls to obtain a usable, well-defined trace on both Upper and Lower Beams.

b. Align CRT

Tighten CRT clamp and use vernier rotator knob to align traces parallel to horizontal graticule lines.

c. Connect TYPE 184

184 MARKER OUTPUT--BNC T connector--
50Ω cable--1M1 INPUT
50Ω cable--1M1 INPUT

Set 184 for 1mS and 100μS markers. Use STABILITY and TRIGGERING LEVEL to trigger display (may also have to preadjust Trig Level Centering R39).

d. Preadjust HV Adj R811: -1350V ±20V

Connect meter to HV Adj Test Point (V862-R822 junction) and adjust HV Adj R811 for exactly -1350V.

e. HV regulation, low line

Use FOCUS to slightly defocus trace to prevent phosphor burns. Set line voltage to 105V, set TEST FUNCTION to HIGH LOAD, and turn INTENSITY full cw. Check display for blooming (expanding vertically or horizontally) and check meter for $\leq$20V change in the -1350V supply.

f. HV regulation, high line

Change both 1M1 TEST FUNCTION to LOW LOAD, turn INTENSITY full ccw, change line voltage to 125V and check meter for $\leq$20V change in the -1350V supply.

Remove meter. Return line voltage to 117V and install High Voltage and F and I shields.

6. (cont'd)

g. Adjust graticule

Set FOCUS, INTENSITY and ASTIGMATISM for usable, well-defined display. Position the Lower Beam display to the lower edge of its display area and position the Upper Beam to the upper edge of its display area. Note that total height (vertical scan) of the display is slightly greater than the 6cm-ruled vertical graticule height. Adjust graticule cam to place graticule in center of CRT vertical scan.

Change both 1M1's to GAIN SET and check scan: each beam must cross the other's center line before extinguishing. Change both 1M1's to COMMON MODE.

h. Preadjust Vert Defl Plates Shield Volts R841: 300V, ±10V

Connect meter to CRT vertical deflection plates shield (center arm of Vert Defl Plates Shield Volts pot R841) and preadjust R841 for 300V.

i. Preadjust Geometry R842: ≤0.67mm bowing

Adjust Geometry R842 for minimum bowing of vertical lines in time marker display: 1° (0.67mm with 4cm amplitude) max deviation allowed from true vertical. Change 1M1 to GAINSET: use VERTICAL POSITION control to move traces to top and bottom graticule lines and check for any horizontal or vertical bowing. You may have to readjust Geometry for best compromise of vertical and horizontal geometry.

j. Focus: no overlap of 1mm-spaced lines

Change 1M1's to COMMON MODE and set TIME/CM and VARIABLE TIME/CM for one 1ms mark per cm (and ten 100µs marks per cm). Set FOCUS and Focus Adj R832 so both beams are focused with one setting of FOCUS control.

h. Adjustments for Shield Volts, High Voltage, and Geometry Adj all interact to affect compression-expansion, geometry, focus, and gain.

If you have difficulty finding an acceptable compromise between these three adjustments, replace the 1M1's with TYPE M or TYPE 1A4 PLUG-IN UNITs. Connect a 2V⎓ signal to EXT TRIGGER and Lower Beam A, B (INV), & C INPUTS; adjust the VOLTS/CM controls for a 2cm display in each channel; and align the Channel A & C displays with the top and bottom lines of the Lower Beam display area. The Channel B trace will supply a reference for adjusting vertical gain Channels A & C indicate the amount of compression-expansion; and .1mS time marks applied to Channel D can be used to check vertical geometry and edge focus.

When the adjustments are satisfactory for the Lower Beam display, move the signals to the Upper Beam Plug-In Unit and repeat the procedure until both displays satisfy the requirements.

6j. (cont'd)

Check that all 100μs marks within the middle 8.8cm are well defined with no overlap. Remove time marker signal.

Connect CAL OUT to both 1M1 EXT INPUTS, set CALIBRATOR to .2 VOLTS and preadjust Gain Adj's R1027 and R2027 for 2cm deflection.

Change CALIBRATOR to 10 MILLIVOLTS. Set STABILITY cw (free run), position each display vertically over its 4cm and check that both pairs of traces are well defined with no overlap.

k. Compression-expansion: ≤0.75mm

Use 1M1 VERTICAL POSITION control to center display and note deflection (2cm). Move top of waveform to top graticule line (top of lower beam's area for lower beam) and note deflection: 2cm, ±0.75mm.

Move bottom of waveform to bottom of Upper Beam's area (bottom graticule line for Lower Beam) and note deflection: 2cm, ±0.75mm.

Remove SAC signal

l. Intensity Bal R859

Set INTENSITY for low intensity. Adjust Intensity Bal R859 for equal intensity on both beams. Check that both beams extinguish at the same setting of the INTENSITY control.

m. Focus Adj R832

Set FOCUS control and adjust Focus Adj R8322 so both beams are focused with one setting of FOCUS control. Recheck focus (Step 6-j) if the setting of R832 is changed.

k. If the display shows excessive compression or expansion, reverse the Vertical Amp. leads to the CRT to determine if the trouble is in the CRT or in the Vertical Amp.

If the Vertical Amp. is at fault, it will be corrected by the line tuner in Steps 8 & 9; if the error is caused by the CRT, it will be necessary to make a compromise in the setting of H.V. Adj (Step 6-d), Shield Volts (Step 6-h) and Geometry (Step 6-i).

6. (cont'd)

n. Horiz Beam Regis R844

Use 1M1 VERTICAL POSITION controls to overlap traces. Adjust Horiz Beam Regis R844 so start of both traces coincide.

o. Horiz Sens R823

With both beams overlapped, adjust Horiz Sens R823 for equal horizontal gain. Markers must coincide within ±0.5mm.

Steps 1 thru o interact, repeat.

7. BEAM INDICATORS AND SCALE ILLUMINATION

a. Setup, check 5X MAG ON light

Set STABILITY ccw (not PRESET), FOCUS ccw and ASTIGMATISM ccw. Set INTENSITY to obtain spot on screen, set 5X MAGNIFIER to ON and check that 5X MAG neon lights up.

b. Beam position indicators

In the following checks, the spot must move off-screen in the direction indicated, the proper beam position indicator neon must come on and the opposite neon must go off before the spot moves out of the display area:

Check both displays.

POSITION Control	Turn	Spot Moves	Beam Position Indicator
1M1 VERTICAL	cw	up	↑
1M1 VERTICAL	ccw	down	↓
TYPE 551 HORIZ	ccw	left	←
TYPE 551 HORIZ	cw	right	→

Change 5X MAGNIFIER to OFF.

7. (cont'd)

c. SCALE ILLUM

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

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

8. DISTRIBUTED AMPLIFIERS

Steps 8 through 10 are for both the Upper and Lower Beam amplifiers. Circuit numbers for the Lower Beam amplifiers are in parentheses. Perform all three steps for the Upper Beam, then repeat for the Lower.

Steps 8, 9, 15, 16 and 17 are normally done by line-tuners and not by calibrators.

a. CRT electrical center

Set STABILITY cw (free run), short CRT vertical deflection plates together and note trace vertical position (CRT electrical center). Remove short.

b. Microphonics: normal; 2.5mm ringing; none

Use an anti-oscillation jumper to connect DA grid lines together, V1054 pin 1 to V1064 pin 1 (V2054 to V2064). Rap lightly on top of 551 and check display for microphonics. Normal type: 2.5mm, max; ringing type: none.

c. Bias: -1V to -2.5V

Keep jumper connected. Connect voltmeter common lead to either DA grid line and connect other meter lead to cathodes (pin 2) of all tubes, one by one, on one side of DA.

Either V1054, 1104, 24, 44, 64, 84 and 1204 or V1064, 1114, 34, 54, 74, 94 and 1214 (either V2054, 2104, 24, 44, 64, 84 and 2204 or V2064, 2114, 34, 54, 74, 94 and 2214).

Meter reading (bias) of each pair of tubes must be between -1V and -2.5V. Remove meter.

8. (cont'd)

d. Suppressor voltage: +165V to +180V

Keep jumper connected. Connect voltmeter common lead to ground and measure suppressor voltages of all DA tubes, V1054 through V1214 (V2054 through V2214): must be between +165V and +180V. Remove meter.

e. Individual DA tube pair balance: ≤2mm shift

Keep jumper connected. Connect a test lead (one from multimeter will do) to 1M1 +225V jack and connect other end to each DA tube pair's cathodes (pin 2), starting with V1024-V1214 (V2204-V2214). Push the 1M1 +225V button. This applies +225V to that tube pair's cathodes, cuts them off and thus eliminates their effect from overall DA balance.

If any DA tube pair contributes more than 2mm of vertical trace shift, replace one or both tubes in the pair. If you replace any tubes, repeat paragraphs b through d. Remove meter.

f. Overall DA balance: ≤2mm shift

Keep jumper connected. Trace position must be within ±2mm of CRT's upper gun (lower gun) electrical center, indicating an overall DA balance within ±2mm. Remove jumper.

Proper DA bias and balance is essential for minimum vertical compression or expansion, minimum vertical trace shift with varying line voltages, and proper delay line tuning.

9. INPUT AMPLIFIERS AND GRID-LINE DRIVERS

Steps 8, 9, 15, 16 and 17 are normally done by line-tuners and not by calibrators.

a. Microphonics: normal; ≤2.5mm
ringing; none

Rap lightly on top of TYPE 551 and check display for microphonics--normal type: 2.5mm, max; ringing type: none.

9. (cont'd)

b. Grid-line driver balance: ≤1cm shift

Use anti-oscillation jumper to connect grid-line driver grids together, V1033 pin 2 to V1043 pin 2 (V2033 to V2043). Note trace shift from CRT electrical center: ±1cm, max. Remove jumper.

c. Input amplifier balance: ≤1.5cm shift

Set 1M1 to COMMON MODE and note trace shift from CRT electrical center: ±1.5cm, max.

Proper vertical amplifier balance (including DA, grid-line drivers and input amplifiers) is essential for minimum vertical compression or expansion, minimum vertical trace shift with varying line voltages and proper delay line-tuning.

10. VERTICAL AMPLIFIERS

a. Gain Adj R1027 (R2027) range, 1.8 to 2.2cm; adjust, 2cm

Connect SAC to 1M1 EXT INPUT. Set SAC to 50V and 1M1 to GAIN SET. Turn Gain Adj R1027 (R2027) full cw (max gain) and check display: 2.2cm, min vertical deflection. Turn Gain Adj full ccw (min gain) and check display: 1.8cm, max vertical deflection. Adjust Gain Adj for exactly 2cm deflection.

Remove the cable from 1M1 EXT INPUT.

b. DC Shift Adj R1091 (R2091): ≤0.25mm shift

Position trace to within a mm or so of the top graticule line. Change the 1M1 to COMMON MODE. Trace will move rapidly to a new position and then slowly drift a small amount either up or down. Adjust DC Shift Adj R1091 (R2091) so that drift after initial deflection is less than 0.25mm.

10. (cont'd)

c. Trace shift with line voltage change: ≤0.5cm

Change line voltage to 105VAC, wait for heaters to react and then move trace to graticule vertical center. Change line voltage to 125VAC, wait for heaters to react and then note any trace shift: ±0.5cm, max. Return line voltage to 117 VAC.

d. Repeat for Lower Beam

Repeat steps 8 through 10 for the Lower Beam amplifier. Circuit numbers for the Lower Beam amplifier are in parentheses following the numbers for the Upper Beam amplifier.

11. ALTERNATE TRACE

a. Check alternate trace sync pulse: amplitude, ≥60V risetime, ≤1μs

Set TIME/CM to .1μSEC. Set 1M1 TEST FUNCTION to ALTERNATE. Connect the test scope 10X probe to pin 16 of the plug-in compartment connector. Check the amplitude and risetime of the pulse at all sweep rates; repeat for the other plug-in compartment.

b. Check ALTERNATE operation: all sweep rates

Connect 100V calibrator signal to 1M1 EXT INPUT and check ALTERNATE sweep at all sweep rates; repeat for the other vertical amplifier.

12. SQUARE WAVE CALIBRATOR

a. Adjust Cal Adj R879: within 1%

Set both TRIGGERING MODE switches to TRIG. Connect a coax cable from the

12a. (cont'd)

SAC output to the test scope vertical input. Connect a coax cable from the TYPE 551 CAL OUT to the SAC UNK-IN. Set the SQUARE-WAVE CALIBRATOR to OFF and the SAC to 100V, MIXED, +DC. Set the test scope TYPE 1A1 VOLTS/CM to 1. Trigger the test scope in AUTO, -LINE and set the TIME/CM to .5mSEC. Adjust Cal Adj. R879 for ≤1cm deflection as read on the test scope.

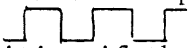
b. Check voltage accuracy: within 2% (except 100 VOLTS: within 1%)

Change the instrument controls as listed in the following table while checking the AMPLITUDE CALIBRATOR error, trace separation.

AMPLITUDE CALIBRATOR	SAC VOLTS	TYPE 1A1 VOLTS/CM	max trace separation
100 VOLTS	100	1	1cm
50	50	.5	2cm
20	20	.2	2cm
10	10	.1	2cm
5	5	.05	2cm
2	2	.02	2cm
1	1	.01	2cm
.5	.5	.005	2cm
.2	.2	.005	8mm
100 MILLIVOLTS	.1	.005	4mm

c.

Note the error in the 100 MILLIVOLTS position and add it to the worst error in the same direction of any of the higher voltage positions. Total error must not exceed 2%.

b. The start of the sweep shows the level of the SAC voltage. The unknown voltage is the next level. The unknown voltage is more positive than the SAC if the display looks like this: 
and less positive if the display looks like this: 

13. TIME BASE TRIGGERING

a. PRESET STABILITY R111

Set TRIGGER SLOPE to +LINE, TRIGGER MODE to AUTO, STABILITY to PRESET, and TIME/CM to .1 MILLISEC. Connect voltmeter (-300V range) to center arm of Preset Stability R111.

(Leave STABILITY set to PRESET throughout step 13).

Turn Preset Stability R111 full ccw (no trace); then slowly turn it cw until trace appears and note meter reading. Continue turning cw until trace brightens (free running) and note meter reading again: must be at least 15 volts difference between the two readings.

Adjust Preset Stability for meter reading halfway between the first and second readings. Position both traces to the center of their respective graticule areas.

b. Adjust TRIGGERING LEVEL Knob

Connect meter to R19-R20 junction (on TRIGGERING MODE switch) and turn TRIGGERING LEVEL for zero volts on the meter.

Loosen TRIGGERING LEVEL knob set-screw; position knob on shaft so white dot lies directly under '0' on front panel; then retighten screw, making sure TRIGGERING LEVEL is still zero'd (zero volts on meter).

(Use most sensitive voltmeter range for final adjustment)

c. Trig Level Centering R39

Set both 1M1's to HIGH LOAD, set the TYPE 551 TRIGGER SLOPE to + or -EXT, TRIGGERING MODE to AC, and ground R19-20 junction by setting the meter to a high-current range

Turn Trigger Sensitivity R37 full cw and adjust Triggering Level Centering R39 to the center of the range which gives a trace in both + & -EXT SLOPE.

Turning R37 full cw sets the Trigger Schmitt to free run when its input grid voltage matches the Multi's inherent hysteresis voltage. R39 is then set so this level is the same as the trigger Amplifier output plate voltage when both grids are at zero volts.

13. (cont'd)

d. Int Trig DC Level (Upper, R3)
(Lower, R8)

Set TRIGGER SLOPE to + or - UPPER and adjust Int. Trig. DC Level Upper R8 to the center of the range over which the Upper Beam trace appears on the CRT.

Change TRIGGER SLOPE to + or - LOWER and adjust Int. Trig. DC Level Lower R8 to the center of the range over which the Lower Beam trace appears on the CRT.

The Int Trig DC Level adjustments set the Trigger Amplifier grid at zero volts when the appropriate trace is centered on its section of the CRT.

e. Trigger Sensitivity R37

Set TRIGGER SLOPE to + or - EXT, TRIGGERING MODE to AC, and SQUARE WAVE CALIBRATOR to 1 VOLT. Connect CAL OUT to TRIGGER INPUT and Lower Beam EXT INPUT.

Adjust 1M1 VARIABLE for exactly 1cm of deflection. Change SQUARE WAVE CALIBRATOR to .1V (1mm of deflection).

Turn Trigger Sensitivity R37 ccw until the trace disappears; then cw just far enough for proper triggering in both + and -EXT. (Slight readjustment of Triggering Level Centering R39 may be necessary.)

Remove the ground connection from R19-R20.

This step adjusts the trigger cir t so that it will trigger on 0.1 volts EXT or 1mm Internal signals, but not on smaller signals.

(The hysteresis gap closes as the Schmitt Tube ages--if trigger sensitivity is set too sensitive, it will have to be reset after the tube ages a short time.)

f. Check triggering

+ & - LOWER; + & - UPPER:

Check for proper triggering (correct slope and no jitter) on + & - LOWER and + & - UPPER under the following conditions:

13f. (cont'd)

TRIGGERING MODE	TRIGGERING LEVEL	Applied Signal	Other Conditions
AUTO	No effect	2mm	----
AC LF REJECT	Fixed	1mm	----
AC	Fixed	1mm	----
DC	Fixed at 0	4mm	Within 4mm of graticule center
DC	Variable	2mm	Within 2mm of graticule center

TRIGGERING LEVEL:
Fixed--must remain at one setting for both + and - TRIGGER SLOPE settings.
Variable--can be reset if necesary, for + and - TRIGGER SLOPE settings.

+ & - EXT.

Check for proper triggering (correct slope and no jitter) on + & - EXT under the following conditions:

TRIGGERING MODE	TRIGGERING LEVEL	EXT TRIG Signal
AUTO	No effect	0.2V
AC	Variable	0.1V
DC	Variable	0.1V

+ & - LINE

Connect the 10X probe to a 1M1 EXT INPUT and connect probe tip to 117VAC at term 4 of T750. Change TRIGGER SLOPE back and forth between + & - LINE to check trigger for correct slope and no jitter under the following conditions:

TRIGGERING MODE	TRIGGERING LEVEL	Display
AUTO	No effect	Triggered
AC LF REJECT	Variable	Not Triggered
AC	Fixed	Triggered
DC	Fixed	Triggered

Disconnect the probe from the IM1 and the transformer.

14. AC LF REJECT

Connect output of Audio Generator to EXT INPUT. Set TRIGGER MODE to AC LF REJECT. Apply 2mm of 3kHz signal and adjust triggering for a stable display.

Set Generator for 2mm of 500Hz signal. Check that the sweep cannot be triggered for a stable display.

15. DELAY LINE AND HF ADJUSTMENTS

Steps 8, 9, 15, 16 and 17 are normally done by line-tuners and not by calibrators.

Set TIME/CM to.5μSEC, TRIGGERING MODE to AC, and TRIGGERING SLOPE to + UPPER. Set Upper Beam 1M1 TEST FUNCTION to + PULSE and adjust AMPLITUDE for a 3cm square-wave display.

Set STABILITY and TRIGGERING LEVEL for a stable display and use VERICAL POSITION to center display. Adjust delay line trimmers, plate line reverse termination network and vertical amplifier inductors for minimum termination bump, even level, minimum wrinkles and a fast rise with no overshoot or under shoot. Remove 106 signal.

16. BANDWIDTH

a. Connect TYPE 191

See note for Step 15

Type 191--GR 50Ω cable--GR to BNC 50Ω termination--Upper Beam TYPE 1A1 INPUT

Set TYPE 191 for exactly 3cm of 50kHz

b. Passband: 25Mhz (2.1cm)

Increase TYPE 191 frequency to exactly 25MHz and note deflection: 2.1cm, min, indicating a passband of at least 25MHz at the -3dB point.

c. Lower Beam

Repeat steps 15 and 16 for the Lower Beam amplifier

17. HIGH SPEED BEAM REGISTRATION

a. Connect TYPE 106

See note for Step 15

TYPE 106--50Ω GR CABLE--50Ω GR to BNC termination

BNC T connector --50Ω cable--TYPE 1A1
--50Ω cable--TYPE 1A1

Set TYPE 106 for about 2cm on each beam, approximately 500kHz.

b. Coincidence: ≤1mm, separation

Set TIME/CM to .1μSEC and HORIZONTAL DISPLAY to 5X MAG. Check for coincidence of the leading edge of both beams: maximum allowable difference is 1mm. If difference exceeds 1mm, match delay line delays as follows:

c. Adding delay to Upper Beam

Determine which delay line has the least delay. If it is the Upper Beam, add delay as needed by wiring one or both of the additional delay line sections into the circuit. Thses sections are mounted on a board under the Upper Beam vertical amplifier chassis, near the delay line. After installing the additional delay, recheck the delay line and HF adjustments (step 15) and passband (step 16).

d. Adding delay to Lower Beam (test mod 90902)

Occasionally, the Lower Beam needs more delay. There are no additional delay line sections for the Lower Beam already mounted in the 551, as there are for the Upper Beam. If you need more Lower Beam delay, make an additional section by modifying a 631-412 assembly and then mounting it on the delay line. After installing the additional delay, recheck the delay line and HF adjustments (step 15) and passband (step 16).

Modify a 631-412 assembly by cutting it in half and using a smaller insulating post.

18. 551 PRESETS

FOCUS	best display
INTENSITY	best display
ASTIGMATISM	best display
SCALE ILLUM	usable display
HORIZONTAL DISPLAY	5X MAG
TIME BASE	
TRIGGERING LEVEL	--
STABILITY	--
TRIGGER SLOPE	+UPPER
TRIGGERING MODE	HF SYNC
TIME/CM	.1μSEC
VARIABLE TIME/CM	cw (CALIBRATED)
HORIZONTAL POSITION	usable display
SQUARE-WAVE CALIBRATOR	OFF

19. TIME BASE HF SYNC

a. Connect TYPE 191

TYPE 191--50Ω GR to BNC Termination--

--T--50Ω cable--TYPE 1A1 INPUT
  --50Ω cable--551 TRIG INPUT

Set TYPE 191 frequency to exactly 30MHz and amplitude to exactly 2cm.

Set TRIGGERING MODE to HF SYNC, TIME/CM to .1μSEC and HORIZONTAL DISPLAY to 5X MAG.

b. INT HF SYNC: 2cm of 30MHz, ≤1mm trace width.

Change TRIGGER SLOPE to +EXT. Change TYPE 191 for 0.5V of 30MHz. Check that STABILITY control is capable of providing a stable synchronized display and that the horizontal trace width is no greater than 1mm. Remove TYPE 191 signal and set HORIZONTAL DISPLAY to NORMAL.

20. HORIZONTAL AMPLIFIER GAIN

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

b. Connect TYPE 184

TYPE 184 MARKER OUT--50Ω cable--TYPE 1A1 INPUT

Set TYPE 184 for 1mS and 100μS markers.

c. Front Panel Settings

Set TIME/CM to 1 MILLISEC and HORIZONTAL DISPLAY to 5X MAG. Set TYPE 1A1 to 5V/cm. Set TRIGGERING MODE to AC, TRIGGER SLOPE to +UPPER and set STABILITY and TRIGGERING LEVEL for a stable display.

d. Mag Gain R375 *± 3%*

Adjust Mag Gain R375 for two 100μsec markers per cm.

e. Swp Cal R349

Change HORIZONTAL DISPLAY to NORMAL and adjust Swp Cal R349 for one 1msec mark per cm.

21. TIME BASE SWEEP LENGTH

a. Swp Length R176: 10.2cm to 10.6cm

Adjust Swp Length R176 for a trace length of 10.5cm, +1mm or -3mm (10.6cm to 10.2cm).

22. NORMAL-MAGNIFIED REGISTRATION

a. Norm/Mag Regis R358

Set HORIZONTAL DISPLAY to 5X MAG and use HORIZONTAL POSITION controls to place first time marker (trace start) to graticule center. Change HORIZONTAL DISPLAY to NORMAL and adjust Norm/Mag Regis R358 to reposition first mark to graticule center. Adjustments interact, repeat.

23. SWEEP TIMING

1SEC - 5SEC: within 2.5%
.5SEC - .1μSEC: within 2%
VARIABLE range: ≥2.5:1

a. Check .1mSEC - 5SEC timing as follows:

TIME/CM	TYPE 184 marker	Check for
.1 MILLISEC	.1mS	1 mark/cm, ±1.6mm

Change TYPE 184 to 1mS and turn VARIABLE TIME/CM ccw: UNCALIBRATED neon must light up and 10cm marker must move to within 2.5cm of the left edge of the graticule.

Return VARIABLE to CALIBRATED: UNCALIBRATED neon must go out.

.2 MILLISEC	.2mS	2 marks/cm, ±1.6mm
.5 MILLISEC	.5mS	1 mark/cm, ±1.6mm
1 MILLISEC	1mS	1 mark/cm, ±1.6mm
2 MILLISEC	1mS	2 marks/cm, ±1.6mm
5 MILLISEC	5mS	1 mark/cm, ±1.6mm

Increase TYPE 184 amplitude (change TYPE 1A1 VOLTS/CM to more sensitive setting) and position base line off-screen to prevent phosphor burns.

10 MILLISEC	10mS	1 mark/cm, ±1.6mm
20 MILLISEC	10mS	2 marks/cm, ±1.6mm
50 MILLISEC	50mS	1 mark/cm, ±1.6mm
.1 SEC	100mS	1 mark/cm, ±1.6mm
.2 SEC	100mS	2 marks/cm, ±1.6mm
.5 SEC	500mS	1 mark/cm, ±1.6mm
1 SEC	1S	1 mark/cm, ±2mm
2 SEC	1S	2 marks/cm, ±2mm
5 SEC	5S	1 mark/cm, ±2mm

b. Check and adjust HF timing

Connect Type 184 triggers to TYPE 551 TRIGGER INPUT; set TYPE 184 for 10μS triggers and markers.

23b. (cont'd)

Set the TYPE 551 as follows:

TRIGGER SLOPE	+ EXT
TRIGGER STABILITY	stable display
TRIGGER LEVEL	stable display
HORIZONTAL DISPLAY	5X MAG

Switch TIME/CM back and forth between 50μSEC and 100μSEC; adjust C340 for coincidence of the first time marks.

Check or adjust the settings of the HF timing capacitors as directed below:

TIME/CM	TYPE 184 Markers	Check or adjust	for
.5μSEC	.5μS	C160A*	1 mark/cm
	Change HORIZ DISPLAY to NORMAL		
10μSEC	10μS	C160E	1 mark/cm
1μSEC	1μS	C160C	1 mark/cm
.1μSEC	.1μS	C350*	1 mark/cm
	Change HORIZ DISPLAY to 5X		
.1μSEC	50nS	C364*, C384*	1 mark/cm at left end of display
	Position first 7 marks off left end of graticule.		
.1μSEC	.1μS	C372*	1 mark/cm at left end of display
.2μSEC	50nS	check	2 marks/cm at center of display

*C160A, C350, C364, C384, and C372 interact, so repeat until all are adjusted satisfactorily

Change HORIZ DISPLAY to NORMAL

.2μSEC	.1μS	check	2 marks/cm
2μSEC	1μS	check	2 marks/cm
5μSEC	5μS	check	1 mark/cm
20μSEC	10μS	check	2 marks/cm
50μSEC	50μS	check	1 mark/cm

24. TIME-BASE HOLDOFF

Set TRIGGERING MODE to AC and STABILITY cw (free run). Set test scope to DC and connect 10X probe to R340-C340-SW340 junction and check holdoff as follows:

TIME/CM	holdoff
.1 SEC	4 to 9 s
.2 SEC	4 to 9 s
.5 SEC	4 to 9 s
1 SEC	15 to 40 s
2 SEC	15 to 40 s
5 SEC	15 to 40 s
10 SEC	15 to 40 s
20 SEC	15 to 40 s
50 SEC	15 to 40 s
.1 MILLISEC	150 to 400 s
.2 MILLISEC	150 to 400 s
.5 MILLISEC	150 to 400 s
1 MILLISEC	1.5 to 4ms
2 MILLISEC	1.5 to 4ms
5 MILLISEC	1.5 to 4ms
10 MILLISEC	15 to 40ms
20 MILLISEC	15 to 40ms
50 MILLISEC	15 to 40ms
.1 SEC	150 to 400ms
.2 SEC	150 to 400ms
.5 SEC	150 to 400ms
1 SEC	150 to 400ms
2 SEC	150 to 400ms
5 SEC	150 to 400ms

Remove probe.

25. LOCKOUT LEVEL

a. SINGLE SWEEP OUT; 1cm signal: check for triggered display

Set HORIZONTAL DISPLAY to NORMAL, SINGLE SWEEP to OUT, TRIGGER SLOPE TO +UPPER and TRIGGERING MODE to AC. Connect CAL OUT to TYPE 1A1 INPUT and set SQUARE-WAVE CALIBRATOR and TYPE 1A1 VOLTS/CM controls for 1cm of deflection. Set STABILITY and TRIGGERING LEVEL for a triggered display.

b. SINGLE SWEEP OUT, no signal: check for no trace; note voltage at V125 pin 7

Connect voltmeter to V125 pin 7 (cathode), disconnect CAL OUT signal from TYPE 1A1 INPUT (trace should disappear) and note meter reading.

c. SINGLE SWEEP IN, 1cm signal: check that READY neon is extinguished

hange SINGLE SWEEP to IN and connect CAL OUT signal to TYPE 1A1 INPUT. READY neon should extinguish, indicating that the sweep generator is locked out. If READY neon doesn't extinguish, increase CAL OUT signal amplitude until it does, then return amplitude to 1cm.

d. Adjust Lockout Level Adj R125

Adjust Lockout Level Adj R125 for a voltmeter reading 11V less negative than the first reading (paragraph b).

e. SINGLE SWEEP IN, 1cm signal: check that pushing RESET gives trace

Push the RESET button: single trace must occur.

f. SINGLE SWEEP IN, no signal: check that pushing RESET lights READY neon

Disconnect CAL OUT signal and push the RESET button: READY neon must light, indicating trace is ready to be triggered; no trace must appear.

25. (cont'd)

g. SINGLE SWEEP IN, 1cm signal: check for single trace, READY neon extinguished.

Connect CAL OUT signal to TYPE 1A1 INPUT: single trace must occur and READY neon must extinguish.

26. EXTERNAL HORIZONTAL DEFLECTION FACTOR

a. 1V gives ≥ 5.6cm horizontal deflection

Connect CAL OUT to HORIZ INPUT. Set CALIBRATOR to 1 VOLT, HORIZONTAL DISPLAY to EXT and EXT HORIZ INPUT ATTEN (ganged with stability control) full cw. Note horizontal deflection: 5.6cm, min.

b. EXT HORIZ INPUT ATTEN range: 10-1 min

Turn EXT HORIZ INPUT ATTEN full ccw and increase amplitude of CAL OUT to 10 VOLTS. Check horizontal deflection: equal to or less than the deflection noted in step 28a.

27. EXTERNAL HORIZONTAL PASSBAND

a. Setup

Keep HORIZONTAL DISPLAY at EXT.
Change EXT HORIZ INPUT ATTEN full cw.

b. Connect TYPE 191

TYPE 191 -- 50Ω term -- 50ΩGR cable -- GR to BNC -- 551 HORIZ INPUT

Set TYPE 191 for exactly 4cm of 50kHz

27. (cont'd)

c. Passband: 400kHz (2.8cm)

Increase TYPE 191 frequency to exactly 400kHz and note deflection: 2.8cm, min, indicating a passband of at least 400kHz at the -3dB point. Remove TYPE 191.

28. CRT CATHODE INPUT

a. Setup

CAL OUT -- BNC patch cord
-- TYPE 1A1 INPUT
-- BNC-to-Banana patch cord -- EXT CRT CATH (scope rear)

Loosen EXTERNAL CRT CATHODE and GND binding posts and swing strap away from EXTERNAL CATHODE.

(Strap must pivot around GND post)

b. Set the controls as follows:

HORIZONTAL DISPLAY	NORMAL
TIME/CM	1 MILLISEC
AMPLITUDE CALIBRATOR	20 VOLTS
VOLTS/CM	10 VOLTS

c. Intensity modulation

Alternately disconnect and connect 20V calibrator signal to EXTERNAL CRT CATHODE and check that upper half of calibrator waveform dims (calibrator signal intensity-modulating CRT) and returns to normal intensity with calibrator signal disconnected. Remove CAL OUT connections and reconnect CRT GND strap.

29. FRONT PANEL WAVEFORMS

Use test scope 10X probe to check amplitude of:

+ GATE OUT	20V, min
SAWTOOTH OUT	130V, min

Remove probe.

THE END