F A C T O R Y C A L I B R A T I O N P R O C E D U R E

This procedure is company confidential.

CONTENTS:

April, 1972

This is the guide for calibrating new instruments. The procedure consists of 3 sections:

432 and 434

Equipment Required

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.

For all serial numbers

Main Procedure - The Main Procedure gives more detailed instructions for the calibration of the instrument.

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:

For information on changes made to this procedure, to make suggestions for changing this procedure, or to order additional copies: Please contact Staff Engineering, 47-896.

EQUIPMENT REQUIRED:

The following equipment is necessary to complete this procedure:

a. TEKTRONIX INSTRUMENTS

1	Type 453 Oscilloscope or equivalent
1	Type 106 Square-Wave Generator
1	Type 184 Time-Mark Generator
1	Type 191 Constant Amplitude Signal Generator
1	Type 109 Pulse Generator

b. TEST FIXTURES AND ACCESSORIES

1	Standard Amplitude Calibrator (SAC)	(067-0502-01)
1	Sine-Wave Generator (LFSWG)	(067-0542-99)
1	DC Voltage Bridge (DCVB)	(067-0543-99)
1	24 PF Input Normalizer	(067-0539-00)
1	P6010 10X Probe	
1	P6028 1X Probe	
1	P6021 AC Current Probe	
1	Passive Termination	(011-0105-00)
2	50Ω BNC Terminations	(011-0049-01)
2	50Ω BNC 10X Attenuator	(011-0059-01)
1	BNC T Connector	(103-0030-00)
1	BNC Female to GR Adapter	(017-0063-00)
1	Dual Input Coupler	(067-0525-00)
2	50Ω 42" BNC Cables	(012-0057-01)
1	76 TU Line Voltage Control	
1	2:1 Line Voltage Isolation Transformer	
1	20,000 Ω/VDC Multimeter	

SHORT FORM PROCEDURE

1. PRELIMINARY INSPECTION

2. PRESETS

3. RESISTANCE

   a. Check power supply resistance

   b. Check power cord resistance

4. POWER SUPPLY

   b. Adjust R1074: 40μs period
   c. Adjust -15V (R1122)
   d. Adjust HV(R963): -3940V
   e. Check converter period: 40μs
   f. Check ripple and regulation:
      90-264VAC

Supply	Error	Ripple Line	Ripple Conv.
-15V	0.25%	10mv	40mv
+15V	0.75%	10mv	40mv
+115V	3%	0.5V	0.5V
+250V	-3% +4%	1V	1V
-3.9KV	2%		
-75V	+2%-4%	2V	2V

5. CRT GRID BIAS

   a. Adjust Grid Bias (R980)
   b. Check intensity limiting: 55-65V
   c. Check max. drive: 80V, min.

6. Z-Axis Transient Response

   Adjust compensation (C953)

7. Focus and Astigmatism

   Adjust Focus (R968) and ASTIG
   Check Focus tracking

8. TRACE ROTATION

   Adjust TRACE ROTATION
   Range: 0.1 div from correct setting

9. STORAGE (434 Only)

   a. Adjust Nonstore Level: Upper(R1224)
      Lower(R1274)

   b. Adjust Store Level: Upper (R1226)
      Lower (R1276)

   c. Adjust Collimation: CE-1(R1293)
      CE-2(R1295)

   d. Check Nonstore Level

   e. Check enhance pulse:
      Width: 1-3 ms
      Ampl: ≤ 30V to ≥ 70V

   f. Check erase pulse

   g. Check stored writing speed:
      100 div/ms, min
      500 div/ms with option 1 CRT

   h. Check vertical writing speed:
      6.4 div of 5KHz sinewave
      6.4 div of 25 KHz sinewave with option 1 CRT

   i. Check enhanced writing speed:
      500 div/ms
      5 div/μs with option 1 CRT

   j. Check INTEGRATE

   k. Check LOCATE

10. GEOMETRY

   a. Adjust Geometry (R967):
      0.1 div, max.
      (434: Preset R1292 for 230V)

   b. Check horizontal geometry:
      0.1 div, max.
      (434: 0.2 div top and bottom div of grat.)

11. CH1 BALANCE

a. Adjust STEP ATTEN BAL: 0.1 div shift, max.

b. Adjust Var Bal (R212): 0.3 div shift, max.

c. Check position centering: ± 2 div of grat center

12. CH2 BALANCE

a. Adjust STEP ATTEN BAL: 0.1 div shift, max.

b. Adjust Var Bal (R312): 0.3 div shift, max.

c. Adjust Invert Bal (R348): 1.0 div shift, max.

d. Check position centering: ±2 div of grat center

13. CH2 VOLTS/DIV

a. Check Gain Range 4.6 div to 5.4 div min.

b. Adjust GAIN 10mv/div

c. Check VAR range: 2.5: 1, min

d. Check VOLTS/DIV accuracy: ± 2%

e. Check linearity: 0.1 div, max

14. CH1 VOLTS/DIV

a. Check Gain Range 4.6 div to 5.4 div. min.

b. Adjust GAIN 10mv/div

c. Check VAR range: 2.5: 1, min

d. Check linearity: 0.1 div, max.

e. Check VOLTS/DIV accuracy: ± 2%

15. ADD GAIN

Check ADD accuracy: ± 1%

16. INPUT SWITCHES

17. SCALE FACTOR SWITCHING

18. VERTICAL POSITION RANGE

a. Check CH2 position range: + and - 12 div, min.

b. Check CH1 position range: + and - 12 div, min.

19. INPUT GATE CURRENT

a. Check CH1 gate current: 300 pA, max

b. Check CH2 gate current: 300 pA, max

20. ALTERNATE

21. POSITION CROSSTALK

Check crosstalk: 0.3 div, max

22. VOLTS/DIV COMPENSATION

b. Adjust CH1 Compensation: ± 1%, max.

Volts/Div	Corner	Flat Top
10mv		C9(C19 CH2)
20mv	C106	C107
50mv	C110	C111
.1V	C114	C115
1V	C118	C119

22. VOLTS/DIV COMPENSATION Cont'd

c. Adjust CH2 Compensation:
± 1%, max.

23. HIGH FREQUENCY COMPENSATION

b. Adjust CH1 10mV Comp:
2% P-P, max.
(C461, R461, C572, L533, L584, C217 and C226)

c. Adjust CH2 10mV comp:
2% P-P, max.
C317 and C326)

d. Check position effect:
7% P-P, max.

e. Check - pulse aberrations:
4% P-P, max

f. Check - pulse position effect:
9% P-P, max

g. Adjust CH2 5, 2 and 1mv Comp

Volts/Div	Adjust	Max. Aberrations
5mv	C325	2% P-P
2mv	C323	3% P-P
1mv	C320	3% P-P

h. Adjust CH1 5, 2, and 1mv comp.

Volts/Div	Adjust	Max. Aberrations
5mv	C225	2% P-P
2mv	C223	3% P-P
1mv	C220	3% P-P

i. Check 20mv to 10V/Div aberration.

20mv to 2V/Div	+ pulse 4% - pulse 6%
5V and 10V/Div	+ pulse 8% - pulse 10%

24. BANDWIDTH (with cans off)

b. Check 10mv/div: 30 MHz, min

c. Check 5mv/div: 27 MHz, min

d. Check 2mv/div: 23 MHz, min

e. Check 1mv/div: 20 MHz, min

g. Check bandwidth limiting:
5 MHz, ± 20%

25. COMMON MODE REJECTION RATIO

b. Check CMRR: 10:1 at 10 MHz

26. TRIGGER LEVEL CENTERING

b. Adjust Trig Level Centering (R629)

c. Adjust Comp Trig DC Level (R274)

d. Adjust CH1 Trig DC Level (R284)

27. TRIGGERING

a. Check triggering:

	5MHz	25MHz
CH1	.3 div	1 div
Comp	.3 div	1 div
Ext	50mv	175 mv

b. Check HF REJ: not triggered with .7 div of 1 MHz

c. Check LF REJ: not triggered with .7 div of 100 Hz

d. Check single sweep

e. Check EXT LEVEL range:
1:1; + and - 2V, min
1:10; + and -20V, min

f. Check LINE triggering

28. SWEEP CAL

a. Adjust Offset (R703):
0V, ± 10mv

c. Adjust sweep Cal (R727):
11 ms sweep length

d. Adjust Horiz Gain (R817):
1 ms/div

29. MAG REGISTER

Adjust Mag Regis (R868):
0.1 div shift, max

30. HORIZONTAL POSITION RANGE

Check range: ends of sweep
past grat center at 1ms/div.

31. VARIABLE TIME/DIV

Check VAR range: 2.5:1, min

32. HIGH SPEED TIMING

a. Adjust .2μs/div (C716)

b. Adjust horiz amp hf response
(C871 and C881)

(.02μs/div X10 and X50 mag)

33. TIME/DIV ACCURACY

a. Check unmagnified timing: ± 2%

b. Check magnifier accuracy:
within 1% of unmag sweep

c. Check high speed mag timing: ± 3%

34. EXT HORIZ

Check sensitivity: .5V/div, ± 10%

35. Z AXIS

a. Check sensitivity: 5V P-P, min

b. Check max usable freq. 20MHz,min

36. CHOPPED OPERATION

Check Frequency: 100 KHz, ± 20%

37. BEAM FINDER

Check operation: trace must remain
within grat area

38. CALIBRATOR

a. Adjust amplitude: 0.6V ± 1.0%

b. Adjust frequency: 1 KHz ±1.0%

1. PRELIMINARY INSPECTION

Check front panel controls for correct indexing and spacing from panel. Check CRT for phosphor defects and scratches. Check fuse for 1.5A fast-blow. Install current modifications. Visually inspect instrument for parts workmanship, mods and possible problem spots.

2. PRESETS

POWER	Off
INTENSITY	CCW
HORIZ. POSITION	Midr
TIME/DIV	1 ms
VAR	CAL
MODE	AUTO
TRIGGER SLOPE	+
LEVEL	Midr
SOURCE	COMP
COUPLING	AC
CH1 and CH2	
VOLTS/DIV	10mv
VAR.	CAL
POSITION	Midr
STEP ATTEN. BAL.	Midr
GAIN	Midr
COUPLING	DC
5 MHz BW	In
INVERT.	In
Vert. Mode	CH1
ASTIG	Midr
TRACE ROTATION	Midr
434 Only	
ENHANCE LEVEL	CCW
ENHANCE	Out
STORE	Out
Internal Adjustments	Midr

3. RESISTANCE

a. Check power supply resistance to ground (-polarity meter lead to gnd)

SUPPLY	METER SCALE	APPROX. RESISTANCE 432	434
-15V	X10	22Ω	13Ω
+15V	X10	110Ω	110Ω
+115V	X1K	23K	10K
+250V	X1K	30K	20K
-75V	X1K		2K

3. RESISTANCE Cont'd

b. Check both sides of power cord for infinite resistance to ground.

4. POWER SUPPLY

a. Setup

Connect instrument to the 76TU thru the 2:1 step up transformer. Set for 120 VAC output. Connect current probe from test scope to both collector leads (8-4 and 8-7) of Q1080

b. Adjust R1074

Turn instrument on and check for correct current waveform at collector of Q1080. Adjust R1074 for 40μs period between waveform peaks.

c. Adjust R1122

Connect DCVB to -15 supply on the secondary board and adjust R1122 for -15.00V.

d. Adjust High Voltage

Set DCVB to 11KV range and connect lead to HV input. Connect to -3940V test point and adjust HV adj. (R963) for -3940V.

e. Check converter period

Recheck current waveform period and re-adjust R1074 for 40μs if necessary.

f. Check ripple and regulation

Check ripple and voltage regulation as in the following table while varying line voltage between 90VAC with maximum intensity and 264 VAC at minimum intensity.

4. POWER SUPPLY Cont'd

SUPPLY	MAX. ERROR	MAX. RIPPLE LINE FREQ.	MAX. RIPPLE CONV. FREQ.
-15V	±37.5 mV	10mV	40mV
+15V	±112.5mV	10mV	40mV
+115V	± 3.45V	500mV	500mV
+250V	-7.5V + 10V	1V	1V
-3.9KV	±78V		
-75V (434 only)	+1.5V - 3.0V	2V	2V

NOTE: Swapping C1104 and C1106 or CR1104 and CR1106 may be necessary to bring +15V within spec's.

Return line voltage to 120 VAC

Turn instrument off and install guard box cover and power supply shield. Turn back on.

5. CRT GRID BIAS

a. Adjust Grid Bias

Connect test scope 10X probe to TP 924 and check voltage level with intensity full CCW. With intensity at minimum check for a base line voltage of 9V ± 1.5V. Adjust intensity to a 24 Volt level. Switch TIME/DIV to EXT. HORIZ. AND adjust CRT Bias (R980) so spot is just cut off. (Adjust focus and ASTIG to obtain well defined spot.)

b. Check Intensity Limiting 55 to 65V

Position spot off screen and turn INTENSITY FULL CW. Check level at TP924 for 55 to 65V with TIME/DIV in EXT. HORIZ. and for sweep speeds of .1S/Div and slower.

c. Check Maximum Drive ≥80V

Set TIME/DIV to 1MS and set INTENSITY so baseline rises to the CRT cut off level (15V rise). Check amplitude of the waveform for 80V or greater.

6. Z AXIS TRANSIENT RESPONSE

Adjust Compensation

Set TIME/DIV to .2μs and INTENSITY dim trace. Disconnect probe from TP924. Adjust C953 out until bright spot appears at front of trace. Adjust C953 back in no more than necessary to make trace brightness uniform. Insure front rise-time portion of fast rise signal shows up at normal intensity.

7. FOCUS AND ASTIGMATISM

Set TIME/DIV to EXT. HORIZ. ADJUST R968 to min. resistance end and adjust Astigmatism control for round spot. Set TIME/DIV to .1 ms/div and connect approximately 2 divisions of 10 μs markers from 184 time mark generator. Adjust R968 for optimum focus of markers and baseline over the full screen area. Adjust Astigmatism control only slightly from original setting if necessary to obtain optimum definition or better edge focus definition. Connect 2 div. signal of 50KHz from 191 and check focus tracking while changing intensity.

NOTE: The manual has an alternate procedure to obtain optimum focus adjustments. The manual also has a procedure for selecting values of R964 for focus range and R83 for focus tracking.

8. TRACE ROTATION

Adjust TRACE ROTATION Range: 0.1 div from correct setting

Turn TRACE ROTATION cw and ccw checking for a range of at least 0.1 div in each direction from correct setting.

Adjust to align trace with center horizontal graticule line.

9. STORAGE (434 Only)

Note: All voltages given on CRT Tag are with respect to flood gun cathode (TP1236).

(a) Adjust Nonstore Level

Connect DC Multimeter to P145-8 and adjust Upper Nonstore Level (R1224) for 73V.

Connect DC Multimeter to P145-9 and adjust Lower Nonstore Level (R1274) for 73V.

(b) Adjust Store Level

Push in both STORE switches. Connect DC Multimeter to P145-8 and adjust Upper Store Level (R1226) for operating point shown on CRT tag.

Connect DC Multimeter to P145-9 and adjust Lower Store Level (R1276) for the same voltage.

Note: If operating point is not available from the CRT tag, adjust as follows:

In STORE mode adjust R1226 up in voltage until background begins to fade positive. Lower the voltage in small increments, erasing screen with each change, until background stops fading positive. Note the voltage at P145-8 and adjust to 10V below that level. Set R1276 for the same voltage at P145-9. This is the operating pcint. Note this voltage on the vertical IBM card for future use.

Note: Operating levels can be changed for graticule line write up, writing speed, background pull in when enhanced, screen too bright or too dim or trace fade out. Note any change on IBM card for future reference. Appearance of upper and lower screen may not match on some CRT's with operating levels set the same. This mismatch should require no more than 10V difference in setting.

(c) Adjust collimation

Do not use CRT Tag Voltages for collimation. Requirements appear to vary with each scope. Fully flood the screen. In STORE mode, not ENHANCED, adjust CE2 (R1295) from lower voltage limit up until pull in at the bottom of the screen is just outside of viewing area. If no pull up is visible, set CE2 about one quarter up from lower limit. Adjust CE1 (R1293) from lower voltage limit up until bright line on the left side of the screen just disappears (usually around the first vertical graticule line).

Note: Collimation voltages may need to be changed for bright areas along edges, holes in trace along right side, trace fade out or uneven writing. Each change should be made with CE2 (R1295) first and CE1 (R1293) readjusted for the bright line on the left side as before.

(d) Check Nonstore Level

Fully write the screen by slowly positioning a free running trace vertically. Switch the upper screen to nonstore and check that the stored display disappears nearly instantly.

If the display does not disappear quickly, reduce the Nonstore Level in 3V increments, repeating the above check until it does. Adjust the Lower Nonstore Level to the same voltage as the upper.

Readjust Upper and Lower Store Levels to the operating point set in step (b) if Nonstore Levels are changed.

(e) Check Enhance Pulse Width: 1.5 to 2.5ms
Ampl: 30V to 70V

Connect 10X probe from test scope to P145-8. Push in both ENHANCE and both STORE buttons. Set triggering for a free running trace

Check pulse width for 1.5 to 2.5 mS and that amplitude is adjustable from 30V or less to 70V or greater with the ENHANCE LEVEL control.

Connect test scope probe to P145-9 and check lower enhance pulse.

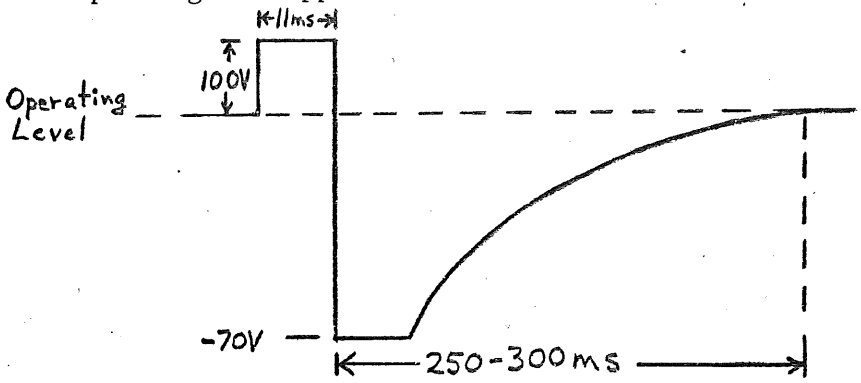
Switch ENHANCE to off (out).

9. STORAGE Cont'd

(f) Check erase pulse.

Check for waveform similar to that shown below at P145-9 when pushing the lower screen ERASE button.

Connect probe to P145-8 and check waveform when pushing the upper screen ERASE button.



(g) Check stored writing speed .100 div/mS, Min

Connect 10μs markers from the TYPE 184 to CH1 input. Set sweep speed for 1 mark/div using the TIME/DIV switch and VAR. Remove time marks and set TRIGGER SOURCE to LINE and MODE to SINGLE sweep. Set INTENSITY so the spot at the start of the sweep is just extinguished. With both STORE switches in, erase the upper and lower screens.

Repeatedly push the RESET button while positioning the trace vertically. Must write over the inner 6 by 8 divisions of screen with no breaks greater than 0.025".

Note: Option 1 CRT must write 500 div/ms, min. After screen has been faded positive for 5 minutes, the spec. is 550 div/ms, min.

(h) Check vertical writing speed 6.4 div of 5 kHz Sinewave

Connect 6.4 div of 5 kHz signal from the LFSWG to CH1 input. Set TIME/DIV to .2mS, TRIGGER MODE to SINGLE and SOURCE to COMP. set INTENSITY so spot at start of trace is just off.

(h) Check vertical writing speed Cont'd

With waveform centered around the center of the screen, push RESET button and check that complete waveform is stored with no breaks greater than 0.025" within the inner 6 by 8 divisions of screen. Position bottom of waveform to center graticule and push RESET button. Check for waveform stored as before. Position top of waveform to graticule center and check storage again.

Note: Option 1 CRT must write 6.4 div of 25kHz sinewave before any fading positive. After 5 min. fade pos., it must write 6.4 div of 27.5 kHz.

(i) Check enhanced writing speed 400 div/ms

Switch TRIGGER SOURCE to COMP and MODE to NORM. Apply 10μs markers and set TIME/DIV and VAR for 4 div per time mark.

Remove time marks and switch to single sweep and LINE trigger. Set INTENSITY so the spot is just off. Push in both ENHANCE switches. Adjust the ENHANCE LEVEL so that the screen is just starting to fade up when the RESET button is pushed. Erase the display after each sweep.

Check that the trace will store over the inner 6 by 8 divisions of the screen with no breaks greater than 0.025".

Switch ENHANCE off.

Note: Option 1 CRT's must write 4 div/μs before any fading positive. After 5 min. fade positive, it must write 5 div/μs, min.

Varying intensity may improve writing speed. Lower intensity may focus enough to improve writing speed. Intensity may be raised above cutoff only to the point where the spot in single sweep will not store.

Reject Option 1 tubes are used as standard CRT's. Writing speed may have to be checked at faster sweep speeds or lower intensity to prevent background fade up when sweep is fired.

(j) Check INTEGRATE

Set TIME/DIV to 1μs and TRIGGER MODE to NORM. With sweep triggered on line and moderate intensity check that trace does not store.

Hold INTEGRATE button in momentarily (up to 5 seconds is allowed) and check that trace does store.

(k) Check LOCATE

Position free running trace so it starts at left edge of graticule. Switch to single sweep and push LOCATE button. Check for dot in the locate zone left of the graticule area.

10. GEOMETRY

a. Adjust Geometry: 0.1 div, max.

Connect 1MS and .1MS markers from the Type 184 to CH1 input and set VOLTS/DIV and position so markers extend from bottom to top of graticule area. Adjust Geometry (R967) for minimum curvature of the markers.

(For the 434 preset R1292 for 230V at the emitter of Q1292 before adjusting R967.)

b. Check Horizontal Geometry: 0.1 div, max.

Remove time marks and position free-running trace to top and bottom graticule lines checking for not more than 0.1 div deviation from graticule lines.

(For the 434 check for not more than 0.2 div in the top and bottom div and not more than 0.1 div in the center 6 div.)

Note: Emphasis should be placed on obtaining the best Horizontal Geometry while keeping the Vertical Geometry within specs. This is a matter of customer preference.

11. CH1 BALANCE

a. Adjust STEP ATTEN BAL: 0.1 div shift, max

Adjust STEP ATTEN BAL for no trace shift when switching VOLTS/DIV from 10MV to 1MV.

b. Adjust VAR BAL: 0.3 div shift, max

Adjust VAR BAL (R212) for no trace shift when rotating variable thru its range.

c. Check position centering ± 2 div of grat. center

Set POSITION so dot on the knob is straight up and check that trace is within 2 div of graticule center.

12. CH2 BALANCE

a. Adjust STEP ATTEN BAL: 0.1 div shift, max.

Switch mode to CH2 and adjust CH2 STEP ATTEN BAL for no trace shift when switching VOLTS/DIV from 10MV to 1MV.

b. Adjust Var Bal: 0.3 div shift, max.

Adjust Var Bal (R312) for no trace shift when rotating variable thru its range.

c. Adjust Invert Bal: 1.0 div shift, max.

Adjust Invert Bal (R348) for no trace shift when pushing INVERT switch.

d. Check position centering ± 2 div of grat center

Set POSITION so dot on the knob is straight up and check that trace is within 2 div of graticule center.

13. CH2 VOLTS/DIV

a. Check GAIN Range 4.6 to 5.4 div, min.
Set VOLTS/DIV to 10MV and connect 50MV SAC signal to Chan. 2 input. Check extremes of GAIN adjustment for ± .4 div, min.

b. Adjust GAIN

Adjust GAIN to 5 divisions

c. Check VAR range: 2.5:1, min

Turn VAR to min deflection and check for not more than 2 div display. Return VAR to CAL.

13. CH2 VOLTS/DIV.

The value of R220 (CH1) and R320 (CH2) can be selected to meet 1MV/Div gain requirement. The value of R223 (CH1) and R323 (CH2) can be selected to meet 2MV/div gain requirements. (A larger resistor decreases gain).

d. Check VOLTS/DIV accuracy ± 2%

Check CH2 VOLTS/DIV accuracy as in the following table:

VOLTS/DIV	SAC	DIV DEFLECTION	± DIV
1MV	5MV	5	.1
2MV	10MV	5	.1
5MV	20MV	4	.08
10MV	50MV	5	.1
20MV	.1V	5	.1
50MV	.2V	4	.08
.1V	.5V	5	.1
.2V	1V	5	.1
.5V	2V	4	.08
1V	5V	5	.1
2V	10V	5	.1
5V	20V	4	.08
10V	50V	5	.1

e. Check Linearity: .1 div, max

Set VOLTS/DIV to 10MV and SAC to 20 MV position top of waveform to top graticule line and note compression or expansion: .1 div, max.

Position bottom of display to bottom graticule line and note compression or expansion: .1 div, max.

14. CH 1 VOLTS/DIV

a. Check GAIN Range 4.6 to 5.4 div., min.

Switch mode to CH1 and connect SAC signal to CH1 input. Set CH1 VOLTS/DIV to 10MV and SAC to 50MV. Check extremes of GAIN adjustment for ± .4 div., min.

b. Adjust GAIN

Adjust GAIN to 5 div.

c. Check VAR range: 2.5:1, min.

Turn VAR to min deflection and check for not more than 2 div display. Return VAR to CAL.

d. Check linearity: .1 div, max.

Set SAC to 20 MV and check compression or expansion at top and bottom of graticule for .1 div, max.

e. Check VOLTS/DIV accuracy: ± 2%

Check CH1 VOLTS/DIV accuracy using table in Step 13 (d).

15. ADD GAIN

Check ADD accuracy: ± 1%

Connect SAC signal to CH1 and CH2 inputs using the dual input coupler. Set both VOLTS/DIV to 10MV, mode to ADD and SAC to 20MV. Check deflection for 4 div ± .04 div.

16. INPUT SWITCHES

Switch mode to CH1 and with coupling in DC position baseline of display to graticule center. Switch coupling to GND and check for baseline trace at graticule center with no vertical deflection. Switch coupling to AC and check for display approximately centered around the center graticule line. Switch mode to CH2 and repeat the vertical coupling checks.

17. SCALE FACTOR SWITCHING

Short between the BNC connector and the coding ring on the CH1 and CH2 inputs and check that only the X10 scale factor lights are lit. Check that the X1 lights are on when not shorted.

18. VERTICAL POSITION RANGE

a. Check CH2 position range: + and -12 div, min.

Switch CH2 input coupling to DC and SAC to .1 VOLT + DC. Check that trace can be positioned at least 2 div below graticule center.

Switch SAC to -DC and check that trace can be positioned at least 2 div above graticule center.

b. Check CH1 position range: + and -12 div, min.

Switch mode to CH1 and CH1 input coupling to DC. Repeat position range checks for CH1.

Remove SAC signal.

19. INPUT GATE CURRENT

a. Check CH1 gate current: 300 pA, max.

Set CH1 VOLTS/DIV to 1MV. Switch input between GND and DC checking for .3 div or less vertical trace shift.

b. Check CH2 gate current: 300 pA, max.

Switch mode to CH2 and CH2 VOLTS/DIV to 1MV. Switch input between GND and DC checking for .3 div or less vertical trace shift.

Note: With Cans on at 25°C ambient the following specs apply:

30 min. warmup	.3 div
1 hr. warmup	.4 div
2 hr. warmup	.6 div
4 hr. warmup	.7 div

20. ALTERNATE

Switch mode to ALT and position traces 2 divisions apart. Check for alternate sweep at all TIME/DIV settings.

21. POSITION CROSSTALK

Check crosstalk: .3 div., max.

Set TIME/DIV to 1MS and position start of sweep to graticule center. With mode in ALT turn CH1 position full CW and CCW while checking movement of CH2 trace for .3 div., max.

Repeat using CH2 POSITION and checking movement of CH1 trace.

22. VOLTS/DIV COMPENSATION

a. Setup

Type 106 HI AMPLITUDE OUTPUT -- GR to BNC adapter -- 50Ω cable -- 10X attenuator -- 50Ω termination -- 24 PF input normalizer -- CH1 input.

Set TIME/DIV to .2 MS, mode to CH1, VOLTS/DIV to 10MV and input to DC. Adjust Type 106 for 5 div of 1KHz signal.

22. VOLTS/DIV COMPENSATION Cont'd

b. Adjust CH1 compensation: ± 1%, max.

Check or adjust for best square wave as in the following table. Remove attenuator as needed to maintain 5 div display.

VOLTS/DIV	CORNER	FLAT TOP
10MV		C9 (C19 for CH2)
20MV	C106	C107
50MV	C110	C111
.1V	C114	C115
.2V	Check	Check
.5V	Check	Check
1V	C118	C119
2V	Check	Check
5V	Check	Check
10V	Check	Check

c. Adjust CH2 compensation: ± 1%, max.

Change mode to CH2 and type 106 signal to CH2 input. Check or adjust for best square wave as in the table in Step B.

23. HIGH FREQUENCY COMPENSATION

a. Setup

TYPE 106 + OUTPUT -- GR to BNC adapter -- 50Ω cable -- 50Ω termination -- CH1 input

Set mode to CH1, both VOLTS/DIV to 10mV and TIME/DIV to .05 μs. Adjust TYPE 106 for 6 div of 100 kHz FAST RISE signal and center on screen.

b. Adjust CH1 10mV compensation: 2% P-P, max. aberrations

Adjust C461, R461, C572, L533, L584, C217 and C226 for optimum square wave response and rise time. Peak to peak aberrations must not exceed .12 div.

c. Adjust CH2 10mV compensation: 2% P-P, max.

Change mode to CH2 and TYPE 106 signal to CH2 input. Adjust C317 and C326 for optimum square wave response with not more than .12 div P-P aberrations.

Note: C460 may be selected for flat level of both channels.
C573 may be selected for range of C572 (18 pf nominal, removed or 33pf)

23. HIGH FREQUENCY COMPENSATION Cont'd

d. Check position effect: 7% P-P, max.

Switch mode to CH2 and position top of display from the top to the bottom graticule line. Check aberrations for not more than .42 div P-P.

e. Check negative pulse aberrations: 4% P-P, max.

Connect TYPE 106 - OUTPUT to CH2 input and adjust for 6 div deflection. Switch TRIGGER SLOPE to - and position display to graticule center. Check aberrations for not more than .24 div. P-P.

f. Check - pulse position effect: 9% P-P, max.

Position bottom of display from bottom to top graticule line checking aberrations for not more than .54 div P-P.

Repeat steps d, e and f for CH1.

g. Adjust CH2 5, 2 and 1mV compensation.

Adjust for optimum square wave response as in the following table maintaining 6 div display amplitude (use 10X attenuator).

VOLTS/DIV	ADJUST	MAX. ABERRATIONS
5mV	C325	2% P-P
2mV	C323	3% P-P
1mV	C320	3% P-P

Note: C322 may be selected for range of C320 (68pf or 82pf)

h. Adjust CH1 5, 2 and 1mV compensation.

Switch mode to CH1, and connect TYPE 106 to CH1 input. Adjust for optimum square wave response as in the following table maintaining 6 div display amplitude.

VOLTS/DIV	ADJUST	MAX. ABERRATIONS
5mv	C225	2% P-P
2mv	C223	3% P-P
1mv	C220	3% P-P

Note: C222 may be selected for range of C220 (68pf or 82pf)

23. i. Check 20mv to 10V/Div aberrations

Using type 109 pulse generator check + pulse and -pulse aberrations in CH1 and CH2.

20mv to 2V/Div	+pulse 4% -pulse 6%
5V and 10V/Div	+pulse 8% -pulse 10%

24. BANDWIDTH

a. Setup

TYPE 191 -- GR to BNC adapter -- 50Ω cable -- 10X Attenuator -- 50Ω termination -- CH1 input

b. Check 10mV/DIV bandwidth: 30 MHz, min.

Set VOLTS/DIV to 10mV and adjust TYPE 191 for 6 div of 50 kHz signal. Increase frequency until deflection is reduced to 4.2 div. check that frequency is at least 30 MHz.

c. Check 5mV/DIV bandwidth: 27 MHz, min.

Set VOLTS/DIV to 5mV and adjust TYPE 191 for 6 div of 50 kHz. Increase frequency until deflection is reduced to 4.2 div. Check that frequency is at least 27 MHz.

d. Check 2mV/DIV bandwidth: 23 MHz, min

Set VOLTS/DIV to 2mV and adjust TYPE 191 for 6 div of 50 kHz. Increase frequency until deflection is reduced to 4.2 div. Check that frequency is at least 23 MHz.

e. Check 1mV/DIV bandwidth: 20 MHz, min.

Set VOLTS/DIV to 1mV and adjust TYPE 191 for 6 div of 50 kHz. Increase frequency until deflection is reduced to 4.2 div. Check that frequency is at last 20 MHz.

Note: After 4 hour warmup with cans on an ambient temp. (25°C), the specs are as follows:

10mV	28MHz
5mV	25MHz
2mV	22MHz
1mV	18.5MHz

24. BANDWIDTH

f. Check CH2 bandwidth

Change mode to CH2 and connect TYPE 191 to CH2 input. Repeat 10, 5, 2 and 1mV bandwidth checks for CH2.

g. Check bandwidth limiting: 5MHz, ± 20%

Set VOLTS/DIV to 10mV and adjust TYPE 191 for 6 div of 50 kHz. With 5MHz BW switch out, increase frequency until deflection is reduced to 4.2 div. Check frequency for 4 to 6 MHz.

Push in 5MHz BW switch.

25. COMMON MODE REJECTION RATIO

a. Setup

Connect TYPE 191 to CH1 and CH2 inputs using the dual input coupler. Set both VOLTS/DIV to 10mV and mode to CH1.

b. Check CMRR: 10:1 at 10MHz

Adjust TYPE 191 for 8 div of 50 kHz. Change mode to ADD and invert CH2. Adjust CH2 GAIN for minimum deflection. Switch mode to CH1 and adjust TYPE 191 for 8 div of 10 MHz. Switch to ADD and check deflection for .8 div, max.

Reset CH2 GAIN with SAC signal, if it was adjusted for CMRR check.

26. TRIGGER LEVEL CENTERING

a. Setup

Vertical Mode	CH1
TRIGGER MODE	NORM
SOURCE	COMP
COUPLING	AC

Connect TYPE 191 to CH1 input and set for .3 div of 50 kHz signal. Vertically center the display around the center graticule line.

26. TRIGGER LEVEL CENTERING Cont'd

b. Adjust Trigger Level Centering

Center TRIGGERING LEVEL and adjust R629 for a stable display while switching slope to + and -.

c. Adjust Comp Trig DC Level

Switch TRIGGER COUPLING to DC and adjust R274 for a stable display when positioned to center graticule line.

d. Adjust CH1 Trig DC Level

Switch TRIGGER SOURCE to CH1 and adjust R284 for a stable display.

27. TRIGGERING

a. Check triggering

Connect TYPE 191 signal to CH1 input and EXT. TRIG input using a T connector at the 191 and two long cables. (Terminate cables from T connector with X10 Attenuator and 50Ω Term. at both inputs).

Check that stable triggering can be obtained in + and - slope at the frequencies and amplitudes listed below.

	5 MHz	25 MHz
CH1 AC, DC, LF REJ	.3 div	1 div
COMP AC, DC, LF REJ	.3 div	1 div
EXT AC, DC, LF REJ	50mV	175mV

Note: For external set correct amplitude at 50 KHz read on scope under test, then switch to higher frequency to check triggers.

27. TRIGGERING Cont'd

b. Check HF REJ

Switch TRIGGER SOURCE to COMP and COUPLING to HF REJ. Check that stable triggering can be obtained with .7 div of 50 kHz and cannot be obtained with .7 div of 1 MHz signal.

c. Check LF REJ

Connect LFSWG signal to CH1 input and switch TRIGGER COUPLING to LF REJ. Check that stable triggering can be obtained with .7 div of 50 kHz and cannot be obtained with .7 div of 100 Hz signal.

d. Check single sweep

Switch TRIGGER COUPLING to AC and set LFSWG for .3 div of 1 kHz. With sweep mode in NORM adjust LEVEL for a triggered display (just on edge of triggering). Set CH1 input to GND, set MODE to SINGLE and push RESET button. Check that READY light turns on. Switch CH1 input to DC. Check that one sweep is displayed and that READY light is extinguished.

e. Check EXT LEVEL range: 1:1; + and -2V, min
1:10; +and -20V, min

Switch sweep MODE to NORM, TRIGGER COUPLING to DC, SOURCE to EXT and CH1 VOLTS/DIV to 1V. Connect LFSWG to CH1 input and EXT TRIG input and adjust for 4 div of 1kHz signal. Check that triggering can be obtained over the full amplitude of the waveform in + and - slope.

Switch EXT ATTEN to 1:10 and CH1 VOLTS/DIV to 10V. Adjust LFSWG for 4 div signal. Check that triggering can be obtained over the full amplitude in + and - slope.

27. TRIGGERING Cont'd

F. Check LINE triggering

Switch TRIGGER SOURCE to LINE and connect a 10X probe from CH1 input to a line voltage source, in phase with the power source to the instrument. Switch TRIGGERING SLOPE to + and - and check that the sweep is triggered on the corresponding polarity of the waveform.

28. SWEEP CAL

a. Setup

TRIGGER SOURCE	COMP
SWEEP MODE	AUTO
TIME/DIV	1mS

b. Adjust Offset: 0V, ±10mV

Connect test scope 1X probe to TP 701 and adjust R703 for 0V in SINGLE sweep mode. (Start of ramp set at 0V when sweep running)

c. Adjust Sweep Cal

Switch sweep MODE to NORM. Connect TYPE 184 to CH1 input and set for 5mS, 1mS and .1mS markers. Adjust R727 for 11 mS sweep length (1st 1mS marker after the 3rd 5mS marker).

d. Adjust Horiz Gain

Adjust R817 for one 1mS marker each div.

29. MAG REGISTER

Adjust Mag Regis. 0.1 div shift, max.

Adjust R868 for no horizontal shift at graticule center when switching from X50 mag to X1.

30. HORIZONTAL POSITION RANGE

Check position range: ends of sweep past graticule cent.

With mag off rotate horiz POSITION full cw and ccw and check that ends of sweep position past center graticule line at 1ms/div.

31. VARIABLE TIME/DIV

Check VAR range: 2.5:1, min.

Set TYPE 184 for 10mS markers. Turn VAR for min spacing between markers. Check for 4 div or less between markers. Return VAR to CAL.

32. HIGH SPEED TIMING

a. Adjust .5μs/div timing

Set TIME/DIV to .5μs and TYPE 184 for .5μs markers. Adjust C716 for 1 marker per division.

b. Adjust horiz amp hf response

Set TIME/DIV to .02μs (X10 mag from .2μs) and TYPE 184 to 20 nS. Adjust C871 and C881 for best timing and linearity excluding the first and last 2 div of sweep.

Set TIME/DIV to 1μs and turn MAG to .02μS (X50 mag). Check that timing is within 3% excluding the first and last 10 div of sweep. Re-adjust C871 and C881 if necessary to compromise between X10 and X50 mag .02μS/Div timing.

33. TIME/DIV ACCURACY

a. Check unmagnified timing: ± 2%, max.

Check all unmagnified TIME/DIV positions for 0.2 div, max timing error over the first 10 div of sweep.

b. Check magnifier accuracy: Within 1% of Unmag sweep

Set unmagnified TIME/DIV to 1mS. Push in and turn TIME/DIV to .5mS, .2mS, .1mS, 50μS and 20μS. Checking that timing is within 1%.

Set unmagnified TIME/DIV to .5mS and note timing error. Push in and turn TIME/DIV to .2mS and to 20μS checking that timing is within 1% of that noted at .5mS/DIV.

Set unmagnified TIME/DIV to .2mS and note timing error. Push in and turn TIME/DIV to 50μS and to 5μS checking that timing is within 1% of that noted at .2mS/DIV.

Note: This 1% Mag match spec. is a guideline spec. to insure all mag. timing will be within 3%. If 1% is exceeded, the 3% mag. timing spec. applies to all ranges. The algebraic sum of mag. match error checked above and any unmagnified timing error of each range must not exceed 3% (worst case). The absolute spec. is 3% magnified timing of the worst case - timing range and mag. position.

c. Check high speed mag timing: ± 3%

Check magnified timing as in the following table at the start, middle and end of the sweep excluding the portions indicated. Must be within 3% over the full 10 graticule divisions.

UNMAGNIFIED TIME/DIV	MAGNIFIED TIME/DIV.	EXCLUDE FIRST & LAST
1μS	.5μS	.5 div
	.2μS	1 div
	.1μS	2 div
	.05μS	5 div
	.02μS	10 div
.5μS	.2μS	.5 div
	.1μS	1 div
	.05μS	2 div
	.02μS	5 div
.2μS	.1μS	.5 div
	.05μS	1 div
	.02μS	2 div

34. EXT. HORIZ

Check sensitivity .5V/div, ± 10%

Switch TIME/DIV to EXT HORIZ. Connect SAC to EXT Horiz. input and set for 2 VOLTS. Check horizontal deflection for 3.6 to 4.4 div.

35. Z AXIS

a. Check sensitivity 5V P-P, Min.

Connect 5V SAC signal to Z AXIS and EXT TRIG inputs. Set TIME/DIV to .5mS and TRIGGER SOURCE to EXT. Adjust TRIGGER LEVEL for triggered display. and check for trace Modulation at normal intensity.

b. Check max usable frequency 20 MHz, min.

Set TYPE 191 for 5V of 20 MHz and connect to Z AXIS and EXT TRIG inputs using the 50Ω termination. Set TIME/DIV to .2μS and check for noticeable intensity modulation.

36. CHOPPED OPERATION

Check Frequency: 100 kHz ± 20%

Set mode to CHOP, TIME/DIV to 2μS and TRIGGER SOURCE to COMP. Check the duration of one complete cycle of chopped waveform for 8.35 to 12.5μS. Check for complete blanking of switching transients between chopped segments.

37. BEAM FINDER

Check operation: Trace must remain within graticule area

Set mode to CH1. Hold BEAM FINDER button in and turn vertical and horizontal POSITION controls full cw and ccw. Check that trace remains within the graticule area. Insure there is some vertical and horizontal deflection with the BEAM FINDER button pushed.

38. CALIBRATOR

a. Adjust amplitude 0.6V ± 1.0%

Connect DCVB between gnd and the PROBE CAL jack. Remove Q905 and adjust R915 for 0.6V. Replace Q905.

b. Adjust Frequency 1 kHz ± 1.0%

Connect calibrator to CH1 input of scope being tested and 1mS marks from the TYPE 184 to CH2 input. Set TIME/DIV to .1mS, mode to ALT and TRIGGER SOURCE to COMP. Position both waveforms to vertical center of graticule and adjust TRIGGERING LEVEL for stable display.

Adjust R904 to align second cycle of calibrator waveform with second time mark. Push in and turn TIME/DIV to 2μS (50X mag) to make final adjustment. Must be within 2.5 μS.