TYPE 535 OSCILLOSCOPE Serial No. 6045 thru 20,000

FACTORY
CALIBRATION PROCEDURE

Quick check for long ends, unsoldered joints, wire dress, etc. Preset all pots and trimmers to mid-range, except delay line. Check to see that the crt pin connections are tight. Tighten set screws in both TRIGGER LEVEL knobs just snug enough so that the knob can be turned on the shaft. Install TEST LOAD UNIT switched to LO LOAD with the scope in upright position and turn the INTENSITY and SCALE ILLUM. controls full left (ccw). If, during the calibration there is any question concerning tolerances or limits of any of the circuits refer to the Factory Specifications on Type 531 and 535 Oscilloscopes.

1. CHECK POWER SUPPLY RESISTANCE TO GROUND.

   The transformer primaries should read infinity to ground. The 100 v will be more than 400 ohm to ground, the -150 v more than 4K ohm, 225 v more than 5K ohm, 350 v more than 10K ohm and the 500 v supply above 25K ohm. Check transformer primary for infinite resistance to ground.

2. CHECK TIME DELAY RELAY.

   Turn the scope on and check time delay relay (15 to 45 seconds).

3. CHECK VOLTAGES AND MEASURE RIPPLE AND REGULATION.

   Adjust -150 v supply with -150 ADJ. Check 100 v, 225 v, 350 v and 500 v supplies. (±2%) Check elevated heater supplies at transformer terminals. (100 v at 22 & 23, 225 v at 27 & 28, 350 v at 9 & 16, -hv at 24 & 25.)

4. SET CAL. ADJ.

   With the SQUARE-WAVE CALIBRATOR OFF adjust CAL. ADJ. for 100 v at CAL. TEST PT. Turn CALIBRATOR ON. Voltage at CAL. TEST PT. must read between 45 v and 55 v. (Calibrator symmetry ±10%.)

   Check power supplies for proper regulation with line at 105 v, TEST LOAD UNIT switched to HI LOAD and also, line at 125 v, TEST LOAD UNIT switched to LO LOAD. The ripple on each supply in regulation will be approximately as follows: -150 v, 5 millivolts; 100 v, 5 millivolts; 225 v 3 millivolts; 350 v, 6 millivolts; 500 v, 7 millivolts. (Measured with a test scope.)

5. SET H.V. ADJ.

   Turn scope to an upright position and adjust H.V. ADJ. control for -1350 v. Read at front of the 27K resistor at the forward ceramic strip located above the crt shield. This adjustment can be made conveniently on the 1200 v scale on the meter by measuring with respect to -150 v instead of ground. Turn off the scope and install shield over high voltage supply. (If protective slide rails are being used, install a modified shield.) With MAIN SWEEP TIME/CM switch at 1 MILLISEC advance STABILITY and INTENSITY controls and position the trace on the crt with the VERTICAL and HORIZONTAL POSITION controls.

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6. CHECK SCALE ILLUM. AND POSITIONING CONTROLS.

Check the SCALE ILLUM. control. Check position control against the position-indicating neon lights. Check scope for microphonics. Align trace with horizontal graticule lines, push crt forward against graticule and tighten crt clamp. Check for hv regulation by varying line from 105 v to 125 v. There should be no trace blooming.

7. SET CRT GEOM ADJ.

Insert from the SQUARE-WAVE CALIBRATOR enough signal so that only the rising and falling portions of the signal are visable within the graticule. Adjust STABILITY and TRIGGERING LEVEL controls for a stable display. (The trigger circuit has not been adjusted so if it is not possible to obtain a stable display, adjust the TRIG. SENS. and/or TRIGGERING LEVEL CENTERING pot.) Adjust GEOM. ADJ. (on F&I chassis directly below rear handle), to obtain minimum curvature of the vertical traces.

8. CHECK VERTICAL AMPLIFIER BALANCE.

Short crt vertical deflection plates to determine crt electrical center, then the 6197 grids (or 12BY7 plates), ect. thru each vertical stage. Allowable unbalance per stage is 0.75 cm. Determine over-all balance by pressing TEST LOAD UNIT SHORT button. Allowable over-all unbalance ±2 cm.

9. CHECK VERTICAL COMPRESSION OR EXPANSION.

Position 2 cm of calibrator signal up and down within the graticule lines. Allowable compression or expansion is ±0.5 mm.

10. SET VERTICAL GAIN ADJ.

Switch TEST LOAD UNIT to 250:1 and apply a 100 v signal from SQUARE-WAVE CALIBRATOR and adjust AMP. GAIN for 4 cm of vertical deflection. Check 40 ohm resistor in SQUARE-WAVE CALIBRATOR by switching SQUARE-WAVE CALIBRATOR to 0.2 v, TEST LOAD UNIT to 1:1 and check for 2 cm of vertical deflection.

11. CHECK ALTERNATE SWEEP OPERATION.

Check scope for ALTERNATE SWEEP operation by switching TEST LOAD UNIT to DUAL TRACE. Remove the TEST LOAD UNIT and install a 53/54 K PLUG-IN UNIT.

12. SQUARE-WAVE CALIBRATOR AND VOLTS TO MILLIVOLTS DIVIDER.

Check accuracy of SQUARE-WAVE CALIBRATOR voltage steps with the K UNIT VOLTS/CM step switch. Compare the VOLTS range to the MILLIVOLTS range.

13. CHECK DC SHIFT COMPENSATION.

Vertically deflect the trace with enough dc voltage to move the trace about 6 cm. See that there is not more than 1 mm of shift after deflection. This is a very slow drift and must be watched for a few seconds to see the direction of drift.

14. SET TRIGGERING LEVEL CONTROL.

Set the trigger controls to +INT and DC. TIME/CM to 100 μSEC. STABILITY full left but not to PRESET. Set the test scope VERTICAL INPUT to .05 VOLTS/CM, DC, set the trigger on LINE, AUTOMATIC and set the sweep TIME/CM switch to 1 MILLISEC, X2. Use a 10X probe properly adjusted. Center the trace on the test scope for zero reference. Connect the probe to the grid end of the 470K resistor from the arm of TRIGGERING LEVEL pot on scope under calibration and set pot to zero volts. Physically center knob and tighten set screw. Leave TRIGGERING LEVEL control at zero volts during succeeding adjustments.

15. SET INT. TRIG. D.C. LEVEL CONTROL.

Position the trace of the scope under calibration to the center of the graticule, re-check the test scope zero reference, and connect the probe to R8, 47 ohm to pin 7 of V8. This point should be at zero volts. Now switch the scope under calibration from +INT to -INT and adjust INT. TRIG. D.C. LEVEL ADJ. for zero volts as indicated on the test scope.

16. ADJUST TRIGGER LEVEL CENTERING.

Set TRIGGERING MODE switch to AC SLOW and TRIGGER SLOPE switch to +LINE. Switch test scope VOLTS/CM switch to 0.2 VOLTS/CM, AC. Connect probe to pin 6 of V20, on scope under calibration, and adjust TRIGGERING LEVEL CENTERING so that the waveform on the test scope is symmetrical. For final adjustment switch test scope MAGNIFIER, ON and horizontally center switching portion of the multi waveform. Now switch the TRIGGER SLOPE switch of the scope under calibration, back and forth from +LINE to -LINE and at the same time re-adjust TRIGGERING LEVEL CENTERING until there is no horizontal shifting of the switching portion of the multi waveform.

17. ADJUST TRIGGER SENS.

Turn the TRIG. SENS. pot to the right (cw) until oscillation occurs at the leading and trailing edges of the multi waveform. (Test scope should still be as in Step 16.) Note the amplitude of the spike on the waveform just at the point of oscillation. Now turn the TRIG. SENS. left (ccw) until this spike is slightly less than one-half (0.5) of the original size.

18. ADJUST PRESET STABILITY.

Turn TRIGGERING MODE to AUTOMATIC, +LINE. Turn the PRESET STABILITY control clockwise until the sweep triggers. The center arm of the control should read about 80 v on a meter. Now continue turning PRESET STABILITY until the sweep free-runs (trace will brighten), the center arm on the control should be between 15 v and 25 v higher. Turn the control back until the meter reads half way between the two readings obtained.

19. CHECK TRIGGER CIRCUIT FOR PROPER OPERATION.

Obtain 2 mm of vertical deflection from the calibrator and see that the trigger circuit will work properly in all positions, except LINE and HF SYNC, of the TRIGGER SLOPE and TRIGGERING MODE switches.

20. ADJUST DELAY LINE AND HF COMPENSATIONS.

With the VOLTS/CM switch at 0.05, variable VOLTS/CM control full right (cw), insert into the K UNIT from a properly terminated fast rise-time square-wave generator, a 400 kc signal of about 3 cm of vertical deflection. A Type 53/54 P unit can also be used. Switch the MAIN SWEEP TIME/CM to 1 μSEC, X5. Adjust the trimmers in the delay line with an insulated tool for optimum square-wave response. The variable coils control the amount of spike on the leading edge of the waveform.

21. MEASURE VERTICAL RESPONSE.

Measure the bandwidth with a constant amplitude sine-wave generator for example, Tektronix Type 190. Turn the generator to 500 kc and insert enough signal for 4 cm of vertical deflection, increase the frequency to 11 mc. The signal should still be at least 2.8 cm in amplitude.

22. CHECK HF SYNC.

Turn the signal generator to 30 mc, switch TRIGGERING MODE to HF SYNC. A stable display should be obtained with about 2 cm or less of vertical deflection by adjusting the MAIN SWEEP STABILITY.

23. ADJUST SWEEP CAL.

Apply 1 millisec time marks to INPUT. Turn HORIZONTAL DISPLAY to DELAYING SWEEP. DELAY SWEEP TIME/CM switch set to 1 MILLISEC. Jumper the TRIGGER OR EXT. SWEEP IN to VERTICAL SIG. OUT and adjust STABILITY and TRIGGERING LEVEL for a stable display. Adjust SWEEP CAL for one time-mark per cm. When any timing adjustments are made always make them from the 1 cm line to the 9 cm line on the graticule.

24. ADJUST MAIN-SWEEP TO DELAYING-SWEEP TIMING.

Switch HORIZONTAL DISPLAY to MAIN SWEEP, MAIN SWEEP TIME/CM at 1 MILLISEC and adjust R99M for exactly the same timing as in DELAYING SWEEP. (R99M is on the MAIN SWEEP TIME/CM switch bracket.)

25. ADJUST R64.

Set HORIZONTAL DISPLAY on MAIN SWEEP DELAYED with DELAYING SWEEP STABILITY full right (cw), set MAIN SWEEP TIME/CM switch to 100 μSEC. Turn the MAIN SWEEP STABILITY control until a trace first appears. Connect a test scope through a 10X probe to pin 8 of V37 and observe a composite sawtooth and gate waveform. Adjust R64 to the point where the sawtooth portion of the waveform is about two-thirds of the amplitude of the gate portion. The gate portion of the waveform must be at least 9 v in amplitude. Each time the setting of R64 is changed, readjust the MAIN SWEEP STABILITY as above or an erroneous adjustment of R64 will result.

26. ADJUST MAIN SWEEP LENGTH.

Adjust MAIN SWEEP LENGTH control for approximately 10.5 cm of horizontal sweep.

27. ADJUST MAG GAIN.

Turn MAIN SWEEP TIME/CM switch to 1 MILLISEC and insert 1 millisec and 100 μsec markers from the time mark generator. Turn MAGNIFIER ON and adjust MAG GAIN for 5X magnification. (1 large mark every 5 cm and 2 small marks every cm. Check magnifier linearity over the entire sweep length.

28. ADJUST SWP/MAG REGISTER

With MAGNIFIER ON, position the trace so that the first time mark falls on the center line of the graticule. Turn MAGNIFIER OFF and adjust SWP. MAG/REGIS. so that the first time mark again falls on the center line of the graticule. Check to see that the MAG. ON and MAG. OFF positions register properly in the middle and at the end of the sweep.

29. ADJUST EXT SWP AMPL DC BAL.

Connect MAIN SWEEP SAWTOOTH into vertical INPUT and switch HORIZONTAL DISPLAY to EXT. SWEEP adjust EXT. SWP. AMPL. D.C. BAL. for no horizontal shift of vertical trace when turning EXT. SWEEP ATTEN. back and forth.

30. ADJUST EXT. SWEEP AMP COMP.

Turn Var. Ext. Sweep Atten. fully right (cw).
Apply a fast rise square wave (about 2 kc) to EXT. SWP. IN. With MAGNIFIER ON, externally trigger sweep. Adjust C240 (this will be a long time-constant compensation) for optimum square-wave response. Turn MAGNIFIER OFF, and adjust C254 (short time constant). Adjust C267, mica trimmer on the pot bracket. (Very fast time-constant). C254 and C267 will be adjusted again for a linear sweep using a 10 mc sine wave. With MAGNIFIER ON, connect the square wave thru a standard 47 μμf probe into EXT. SWP. IN and adjust C110 for optimum flat top. Adjust EXT SWEEP 10X ATTEN. Compensation C100 and C101. Check slope switch for correct polarity (plus is left).

31. CHECK EXT. SWEEP IN DEFLECTION FACTOR.

With 0.2 v of calibrator signal fed into the EXT. SWEEP IN, EXT SWEEP ATTENUATOR switched to X1, variable control full right(cw) at least one cm of horizontal deflection must be observed. Increase calibrator signal to 2 V, switch EXT SWEEP ATTEN. to X10 and check for the same deflection as in X1 (within ±2%).

32. CHECK MAIN SWEEP RATES.

Check the MAIN SWEEP rates as follows:

TIME/CM	MULTIPLIER	TIME MARK GEN.	ACTION
100 μSEC	X1	1 millisec	check sweep rate
100 μSEC	X2	1 millisec	check multiplier
100 μSEC	X5	1 millisec	check multiplier

33. CHECK MAIN SWEEP VARIABLE MULTIPLIER CONTROL

Check MULTIPLIER on the 2.5-1, 5-2, 12-5 positions for sufficient range.

10 MILLISEC	X1	10 millisec	check sweep rate
100 MILLISEC	X1	100 millisec	check sweep rate
1 SEC	X1	1 sec	check sweep rate
1 SEC	X2	1 sec	check multiplier
1 SEC	X5	1 sec	check multiplier

34. ADJUST MAIN SWEEP TIMING.

Adjust the fast MAIN SWEEP rates as follows:

10 µSEC	X1	10 µsec	Adjust C99F
1 µSEC	X1	1 µsec	Adjust C99H
1 µSEC	X2	1 µsec	Check multiplier
1 µSEC	X5	5 µsec	Check multiplier
.1 µSEC	X5	1 µsec	Adjust C99J Position first marker to left off graticule.
.1 µSEC	X1	10 mc	Adjust for linearity C254 and C267.
.1 µSEC	X1 MAG ON	50 mc*	Adjust for linearity C278 and C286

* (Insert the 50 mc signal thru a small capacitor, 100 µµf or so, to one of the vertical deflection plates on the crt.) There will be interaction between the linearity adjustment of C267 and C254 and the timing adjustments of C99H and C99J so it will be necessary to go back and re-adjust these steps over again until the timing is correct.

35. SET DELAYING-SWEEP LENGTH

Swithc HORIZONTAL DISPLAY to DELAYING SWEEP, TIME/CM to 500 µSEC and install the DELAYING SWEEP, LENGTH control limiting resistors. R181B (usually 12K to 18K) shunts the length control. R182B (usually 47K to 68 K) shunts the 12K resistor between the length control pot and -150 v.

36. SET DELAY START ADJ. AND DELAY STOP ADJ.

Use 500 µsec/cm delaying sweep speed; 10 µsec/cm main sweep speed. From the time-mark generator feed 500 µsec marks to the INPUT. Trigger the DELAYING SWEEP by feeding from VERT. SIG. OUT with a jumper into TRIGGERING IN. Adjust STABILITY and TRIGGERING LEVEL for a stable sweep. Turn MAIN SWEEP STABILITY full right (cw) to free-run sweep. Check DELAY-TIME MULTIPLIER dial for mechanical zero. By turning the DELAY-TIME MULTIPLIER a brightened portion of the sweep can be moved along the trace. The size of this bright portion depends on the MAIN SWEEP speed. Turn the DELAY-TIME MULTIPLIER to 1.00. Adjust DELAY START ADJ. till the bright portion just reaches the first time mark. Turn the MULTIPLIER to 9.00 and adjust DELAY STOP ADJ. so that the bright spot reaches the ninth time mark. There will be interaction between these adjustments so it will be necessary to go back and forth several times. Switch HORIZONTAL DISPLAY to MAIN SWEEP DELAYED and make final adjustments. Check linearity of the DELAY-TIME MULTIPLIER at all major divisions.

37. CHECK DELAYING-SWEEP RATES

When timing or checking any range other than 500 μsec, of the DELAYING SWEEP first turn the DELAY TIME MULTIPLIER to 1.00 and notice the error in delay start, this is due to the trigger circuit. Now turn the DELAY TIME MULTIPLIER back to 9.00 plus the error noted at 1.00. When adjusting or checking the faster sweep ranges this trigger error may be as much as 15 minor divisions.

DELAY SWEEP TIME/CM	TIME MARK GEN.	HORIZONTAL DISPLAY*	MAIN SWEEP TIME/CM
200 μSEC	100 μsec	MAIN SWEEP DELAYED	10 μSEC
500 μSEC	500 μsec	MAIN SWEEP DELAYED	10 μSEC
1 MILLISEC	1 millisec	MAIN SWEEP DELAYED	10 μSEC
5 MILLISEC	5 millisec	MAIN SWEEP DELAYED	100 μSEC

38. ADJUST DELAYING-SWEEP RATES

50 μSEC	C190D	50 μsec	MAIN SWEEP DELAYED	1 μSEC
5 μSEC	C190F	5 μsec	MAIN SWEEP DELAYED	1 μSEC

* Make rough adjustments in DELAYING SWEEP.

39. CHECK DELAY TIME MULTIPLIER LINEARITY.

Check DELAY TIME MULTIPLIER on 50 μSEC and 5 μSEC ranges for linear sweep. Two minor division error allowed from 1.00 to 9.00.

40. CHECK MAIN-SWEEP DELAYED JITTER.

Set the DELAYING SWEEP TIME/CM control to 1 MILLISEC, and MAIN SWEEP TIME/CM to 1 μSEC. Display 1 millisec markers with the HORIZONTAL DISPLAY control at DELAYING SWEEP. Set the DELAY-TIME MULTIPLIER so that the brightened portion of the sweep coincides with the marker at the 1 cm graticule line. Switch the HORIZONTAL DISPLAY control to MAIN SWEEP DELAYED. The horizontal jitter should not exceed 2 mm. Repeat the process at the 9 cm graticule line, jitter at this position should not exceed 4 mm.

41. CHECK RESET MAIN-SWEEP AND READY NEON

With HORIZONTAL DISPLAY in MAIN SWEEP NORMAL, display about 2 cm of vertical deflection from the calibrator and set STABILITY and TRIGGERING LEVEL controls for a stable trace. The READY light should not be on. Switch HORIZONTAL DISPLAY to MAIN SWEEP DELAYED, and turn DELAY SWEEP STABILITY left (ccw). Press the RESET MAIN SWEEP button. A single trace should occur. If the calibrator signal is removed, instead of a single trace the READY light will ignite when the RESET MAIN SWEEP button is pressed, then when a signal is fed to the INPUT a trace will be triggered and a single trace will occur and the light will go out. Recheck steps 18 and 25.

42. CHECK MAIN-SWEEP HOLD-OFF.

Connect a probe from test scope, set for DC input, to the right hand end of C240. Set MAIN SWEEP STABILITY full right (cw). Check all ranges of MAIN SWEEP TIME/CM switch for sufficient hold-off.

43. CHECK DELAYING-SWEEP HOLD=OFF

Now switch HORIZONTAL DISPLAY to DELAYING SWEEP and repeat the last step.

44. CHECK FRONT PANEL WAVEFORMS.

With a test scope set for DC input position trace to the bottom graticule line (zero volts reference line), probe, check +GATE MAIN SWEEP for a gate waveform of about +20 v amplitude zero volts reference line on the test scope. SAWTOOTH MAIN SWEEP should be about 150 v in amplitude with its base line at zero reference, except on the two fastest speeds where the base line should raise about 20 v. DEL'D TRIG. from MAIN or DEL'G SWEEP, should be a spike of at least +5 from zero reference line, on all sweep rates. +GATE DEL'G SWEEP, +20 v from zero reference line. Out of the VERT. SIG. OUT post there should be 2 v of signal for every cm of vertical deflection on the scope under calibration. There should be 6.3 v of ac voltage out of binding post, labeled 6.3 V 1A. AC. This can be checked with the test scope or a meter.

45. CHECK CRT CATHODE INPUT.

Remove CRT CATHODE GND. strap from rear of scope and insert signal from calibrator and check sweep for intensity modulation. With normal intensity, 20 v of calibrator signal will modulate the trace.

46. MAKE A NOTE OF CRT TYPE AND SERIAL NUMBER AND RECORD ON CALIBRATION RECORD.

TYPE 535 OSCILLOSCOPE Serial No. 6045 thru 20,000

FACTORY
CALIBRATION PROCEDURE

Quick check for long ends, unsoldered joints, wire dress, etc. Preset all pots and trimmers to mid-range, except delay line. Check to see that the crt pin connections are tight. Tighten set screws in both TRIGGER LEVEL knobs just snug enough so that the knob can be turned on the shaft. Install TEST LOAD UNIT switched to LO LOAD with the scope in upright position and turn the INTENSITY and SCALE ILLUM. controls full left (ccw). If, during the calibration there is any question concerning tolerances or limits of any of the circuits refer to the Factory Specifications on Type 531 and 535 Oscilloscopes.

1. CHECK POWER SUPPLY RESISTANCE TO GROUND.

   The transformer primaries should read infinity to ground. The 100 v will be more than 400 ohm to ground, the -150 v more than 4K ohm, 225 v more than 5K ohm, 350 v more than 10K ohm and the 500 v supply above 25K ohm. Check transformer primary for infinite resistance to ground.

2. CHECK TIME DELAY RELAY.

   Turn the scope on and check time delay relay (15 to 45 seconds).

3. CHECK VOLTAGES AND MEASURE RIPPLE AND REGULATION.

   Adjust -150 v supply with -150 ADJ. Check 100 v, 225 v, 350 v and 500 v supplies. (±2%) Check elevated heater supplies at transformer terminals. (100 v at 22 & 23, 225 v at 27 & 28, 350 v at 9 & 16, -hv at 24 & 25.)

4. SET CAL. ADJ.

   With the SQUARE-WAVE CALIBRATOR OFF adjust CAL. ADJ. for 100 v at CAL. TEST PT. Turn CALIBRATOR ON. Voltage at CAL. TEST PT. must read between 45 v and 55 v. (Calibrator symmetry ±10%.)

   Check power supplies for proper regulation with line at 105 v, TEST LOAD UNIT switched to HI LOAD and also, line at 125 v, TEST LOAD UNIT switched to LO LOAD. The ripple on each supply in regulation will be approximately as follows: -150 v, 5 millivolts; 100 v, 5 millivolts; 225 v 3 millivolts; 350 v, 6 millivolts; 500 v, 7 millivolts. (Measured with a test scope.)

5. SET H.V. ADJ.

   Turn scope to an upright position and adjust H.V. ADJ. control for -1350 v. Read at front of the 27K resistor at the forward ceramic strip located above the crt shield. This adjustment can be made conveniently on the 1200 v scale on the meter by measuring with respect to -150 v instead of ground. Turn off the scope and install shield over high voltage supply. (If protective slide rails are being used, install a modified shield.) With MAIN SWEEP TIME/CM switch at 1 MILLISEC advance STABILITY and INTENSITY controls and position the trace on the crt with the VERTICAL and HORIZONTAL POSITION controls.

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6. CHECK SCALE ILLUM. AND POSITIONING CONTROLS.

Check the SCALE ILLUM. control. Check position control against the position-indicating neon lights. Check scope for microphonics. Align trace with horizontal graticule lines, push crt forward against graticule and tighten crt clamp. Check for hv regulation by varying line from 105 v to 125 v. There should be no trace blooming.

7. SET CRT GEOM ADJ.

Insert from the SQUARE-WAVE CALIBRATOR enough signal so that only the rising and falling portions of the signal are visable within the graticule. Adjust STABILITY and TRIGGERING LEVEL controls for a stable display. (The trigger circuit has not been adjusted so if it is not possible to obtain a stable display, adjust the TRIG. SENS. and/or TRIGGERING LEVEL CENTERING pot.) Adjust GEOM. ADJ. (on F&I chassis directly below rear handle), to obtain minimum curvature of the vertical traces.

8. CHECK VERTICAL AMPLIFIER BALANCE.

Short crt vertical deflection plates to determine crt electrical center, then the 6197 grids (or 12BY7 plates), ect. thru each vertical stage. Allowable unbalance per stage is 0.75 cm. Determine over-all balance by pressing TEST LOAD UNIT SHORT button. Allowable over-all unbalance ±2 cm.

9. CHECK VERTICAL COMPRESSION OR EXPANSION.

Position 2 cm of calibrator signal up and down within the graticule lines. Allowable compression or expansion is ±0.5 mm.

10. SET VERTICAL GAIN ADJ.

Switch TEST LOAD UNIT to 250:1 and apply a 100 v signal from SQUARE-WAVE CALIBRATOR and adjust AMP. GAIN for 4 cm of vertical deflection. Check 40 ohm resistor in SQUARE-WAVE CALIBRATOR by switching SQUARE-WAVE CALIBRATOR to 0.2 v, TEST LOAD UNIT to 1:1 and check for 2 cm of vertical deflection.

11. CHECK ALTERNATE SWEEP OPERATION.

Check scope for ALTERNATE SWEEP operation by switching TEST LOAD UNIT to DUAL TRACE. Remove the TEST LOAD UNIT and install a 53/54 K PLUG-IN UNIT.

12. SQUARE-WAVE CALIBRATOR AND VOLTS TO MILLIVOLTS DIVIDER.

Check accuracy of SQUARE-WAVE CALIBRATOR voltage steps with the K UNIT VOLTS/CM step switch. Compare the VOLTS range to the MILLIVOLTS range.

13. CHECK DC SHIFT COMPENSATION.

Vertically deflect the trace with enough dc voltage to move the trace about 6 cm. See that there is not more than 1 mm of shift after deflection. This is a very slow drift and must be watched for a few seconds to see the direction of drift.

14. SET TRIGGERING LEVEL CONTROL.

Set the trigger controls to +INT and DC. TIME/CM to 100 μSEC. STABILITY full left but not to PRESET. Set the test scope VERTICAL INPUT to .05 VOLTS/CM, DC, set the trigger on LINE, AUTOMATIC and set the sweep TIME/CM switch to 1 MILLISEC, X2. Use a 10X probe properly adjusted. Center the trace on the test scope for zero reference. Connect the probe to the grid end of the 470K resistor from the arm of TRIGGERING LEVEL pot on scope under calibration and set pot to zero volts. Physically center knob and tighten set screw. Leave TRIGGERING LEVEL control at zero volts during succeeding adjustments.

15. SET INT. TRIG. D.C. LEVEL CONTROL.

Position the trace of the scope under calibration to the center of the graticule, re-check the test scope zero reference, and connect the probe to R8, 47 ohm to pin 7 of V8. This point should be at zero volts. Now switch the scope under calibration from +INT to -INT and adjust INT. TRIG. D.C. LEVEL ADJ. for zero volts as indicated on the test scope.

16. ADJUST TRIGGER LEVEL CENTERING.

Set TRIGGERING MODE switch to AC SLOW and TRIGGER SLOPE switch to +LINE. Switch test scope VOLTS/CM switch to 0.2 VOLTS/CM, AC. Connect probe to pin 6 of V20, on scope under calibration, and adjust TRIGGERING LEVEL CENTERING so that the waveform on the test scope is symmetrical. For final adjustment switch test scope MAGNIFIER, ON and horizontally center switching portion of the multi waveform. Now switch the TRIGGER SLOPE switch of the scope under calibration, back and forth from +LINE to -LINE and at the same time re-adjust TRIGGERING LEVEL CENTERING until there is no horizontal shifting of the switching portion of the multi waveform.

17. ADJUST TRIGGER SENS.

Turn the TRIG. SENS. pot to the right (cw) until oscillation occurs at the leading and trailing edges of the multi waveform. (Test scope should still be as in Step 16.) Note the amplitude of the spike on the waveform just at the point of oscillation. Now turn the TRIG. SENS. left (ccw) until this spike is slightly less than one-half (0.5) of the original size.

18. ADJUST PRESET STABILITY.

Turn TRIGGERING MODE to AUTOMATIC, +LINE. Turn the PRESET STABILITY control clockwise until the sweep triggers. The center arm of the control should read about 80 v on a meter. Now continue turning PRESET STABILITY until the sweep free-runs (trace will brighten), the center arm on the control should be between 15 v and 25 v higher. Turn the control back until the meter reads half way between the two readings obtained.

19. CHECK TRIGGER CIRCUIT FOR PROPER OPERATION.

Obtain 2 mm of vertical deflection from the calibrator and see that the trigger circuit will work properly in all positions, except LINE and HF SYNC, of the TRIGGER SLOPE and TRIGGERING MODE switches.

20. ADJUST DELAY LINE AND HF COMPENSATIONS.

With the VOLTS/CM switch at 0.05, variable VOLTS/CM control full right (cw), insert into the K UNIT from a properly terminated fast rise-time square-wave generator, a 400 kc signal of about 3 cm of vertical deflection. A Type 53/54 P unit can also be used. Switch the MAIN SWEEP TIME/CM to 1 μSEC, X5. Adjust the trimmers in the delay line with an insulated tool for optimum square-wave response. The variable coils control the amount of spike on the leading edge of the waveform.

21. MEASURE VERTICAL RESPONSE.

Measure the bandwidth with a constant amplitude sine-wave generator for example, Tektronix Type 190. Turn the generator to 500 kc and insert enough signal for 4 cm of vertical deflection, increase the frequency to 11 mc. The signal should still be at least 2.8 cm in amplitude.

22. CHECK HF SYNC.

Turn the signal generator to 30 mc, switch TRIGGERING MODE to HF SYNC. A stable display should be obtained with about 2 cm or less of vertical deflection by adjusting the MAIN SWEEP STABILITY.

23. ADJUST SWEEP CAL.

Apply 1 millisec time marks to INPUT. Turn HORIZONTAL DISPLAY to DELAYING SWEEP. DELAY SWEEP TIME/CM switch set to 1 MILLISEC. Jumper the TRIGGER OR EXT. SWEEP IN to VERTICAL SIG. OUT and adjust STABILITY and TRIGGERING LEVEL for a stable display. Adjust SWEEP CAL for one time-mark per cm. When any timing adjustments are made always make them from the 1 cm line to the 9 cm line on the graticule.

24. ADJUST MAIN-SWEEP TO DELAYING-SWEEP TIMING.

Switch HORIZONTAL DISPLAY to MAIN SWEEP, MAIN SWEEP TIME/CM at 1 MILLISEC and adjust R99M for exactly the same timing as in DELAYING SWEEP. (R99M is on the MAIN SWEEP TIME/CM switch bracket.)

25. ADJUST R64.

Set HORIZONTAL DISPLAY on MAIN SWEEP DELAYED with DELAYING SWEEP STABILITY full right (cw), set MAIN SWEEP TIME/CM switch to 100 μSEC. Turn the MAIN SWEEP STABILITY control until a trace first appears. Connect a test scope through a 10X probe to pin 8 of V37 and observe a composite sawtooth and gate waveform. Adjust R64 to the point where the sawtooth portion of the waveform is about two-thirds of the amplitude of the gate portion. The gate portion of the waveform must be at least 9 v in amplitude. Each time the setting of R64 is changed, readjust the MAIN SWEEP STABILITY as above or an erroneous adjustment of R64 will result.

26. ADJUST MAIN SWEEP LENGTH.

Adjust MAIN SWEEP LENGTH control for approximately 10.5 cm of horizontal sweep.

27. ADJUST MAG GAIN.

Turn MAIN SWEEP TIME/CM switch to 1 MILLISEC and insert 1 millisec and 100 μsec markers from the time mark generator. Turn MAGNIFIER ON and adjust MAG GAIN for 5X magnification. (1 large mark every 5 cm and 2 small marks every cm. Check magnifier linearity over the entire sweep length.

28. ADJUST SWP/MAG REGISTER

With MAGNIFIER ON, position the trace so that the first time mark falls on the center line of the graticule. Turn MAGNIFIER OFF and adjust SWP. MAG/REGIS. so that the first time mark again falls on the center line of the graticule. Check to see that the MAG. ON and MAG. OFF positions register properly in the middle and at the end of the sweep.

29. ADJUST EXT SWP AMPL DC BAL.

Connect MAIN SWEEP SAWTOOTH into vertical INPUT and switch HORIZONTAL DISPLAY to EXT. SWEEP adjust EXT. SWP. AMPL. D.C. BAL. for no horizontal shift of vertical trace when turning EXT. SWEEP ATTEN. back and forth.

30. ADJUST EXT. SWEEP AMP COMP.

Turn Var. Ext. Sweep Atten. fully right (cw).
Apply a fast rise square wave (about 2 kc) to EXT. SWP. IN. With MAGNIFIER ON, externally trigger sweep. Adjust C240 (this will be a long time-constant compensation) for optimum square-wave response. Turn MAGNIFIER OFF, and adjust C254 (short time constant). Adjust C267, mica trimmer on the pot bracket. (Very fast time-constant). C254 and C267 will be adjusted again for a linear sweep using a 10 mc sine wave. With MAGNIFIER ON, connect the square wave thru a standard 47 μμf probe into EXT. SWP. IN and adjust C110 for optimum flat top. Adjust EXT SWEEP 10X ATTEN. Compensation C100 and C101. Check slope switch for correct polarity (plus is left).

31. CHECK EXT. SWEEP IN DEFLECTION FACTOR.

With 0.2 v of calibrator signal fed into the EXT. SWEEP IN, EXT SWEEP ATTENUATOR switched to X1, variable control full right(cw) at least one cm of horizontal deflection must be observed. Increase calibrator signal to 2 V, switch EXT SWEEP ATTEN. to X10 and check for the same deflection as in X1 (within ±2%).

32. CHECK MAIN SWEEP RATES.

Check the MAIN SWEEP rates as follows:

TIME/CM	MULTIPLIER	TIME MARK GEN.	ACTION
100 μSEC	X1	1 millisec	check sweep rate
100 μSEC	X2	1 millisec	check multiplier
100 μSEC	X5	1 millisec	check multiplier

33. CHECK MAIN SWEEP VARIABLE MULTIPLIER CONTROL

Check MULTIPLIER on the 2.5-1, 5-2, 12-5 positions for sufficient range.

10 MILLISEC	X1	10 millisec	check sweep rate
100 MILLISEC	X1	100 millisec	check sweep rate
1 SEC	X1	1 sec	check sweep rate
1 SEC	X2	1 sec	check multiplier
1 SEC	X5	1 sec	check multiplier

34. ADJUST MAIN SWEEP TIMING.

Adjust the fast MAIN SWEEP rates as follows:

10 µSEC	X1	10 µsec	Adjust C99F
1 µSEC	X1	1 µsec	Adjust C99H
1 µSEC	X2	1 µsec	Check multiplier
1 µSEC	X5	5 µsec	Check multiplier
.1 µSEC	X5	1 µsec	Adjust C99J Position first marker to left off graticule.
.1 µSEC	X1	10 mc	Adjust for linearity C254 and C267.
.1 µSEC	X1 MAG ON	50 mc*	Adjust for linearity C278 and C286

* (Insert the 50 mc signal thru a small capacitor, 100 µµf or so, to one of the vertical deflection plates on the crt.) There will be interaction between the linearity adjustment of C267 and C254 and the timing adjustments of C99H and C99J so it will be necessary to go back and re-adjust these steps over again until the timing is correct.

35. SET DELAYING-SWEEP LENGTH

Swithc HORIZONTAL DISPLAY to DELAYING SWEEP, TIME/CM to 500 µSEC and install the DELAYING SWEEP, LENGTH control limiting resistors. R181B (usually 12K to 18K) shunts the length control. R182B (usually 47K to 68 K) shunts the 12K resistor between the length control pot and -150 v.

36. SET DELAY START ADJ. AND DELAY STOP ADJ.

Use 500 µsec/cm delaying sweep speed; 10 µsec/cm main sweep speed. From the time-mark generator feed 500 µsec marks to the INPUT. Trigger the DELAYING SWEEP by feeding from VERT. SIG. OUT with a jumper into TRIGGERING IN. Adjust STABILITY and TRIGGERING LEVEL for a stable sweep. Turn MAIN SWEEP STABILITY full right (cw) to free-run sweep. Check DELAY-TIME MULTIPLIER dial for mechanical zero. By turning the DELAY-TIME MULTIPLIER a brightened portion of the sweep can be moved along the trace. The size of this bright portion depends on the MAIN SWEEP speed. Turn the DELAY-TIME MULTIPLIER to 1.00. Adjust DELAY START ADJ. till the bright portion just reaches the first time mark. Turn the MULTIPLIER to 9.00 and adjust DELAY STOP ADJ. so that the bright spot reaches the ninth time mark. There will be interaction between these adjustments so it will be necessary to go back and forth several times. Switch HORIZONTAL DISPLAY to MAIN SWEEP DELAYED and make final adjustments. Check linearity of the DELAY-TIME MULTIPLIER at all major divisions.

37. CHECK DELAYING-SWEEP RATES

When timing or checking any range other than 500 µsec, of the DELAYING SWEEP first turn the DELAY TIME MULTIPLIER to 1.00 and notice the error in delay start, this is due to the trigger circuit. Now turn the DELAY TIME MULTIPLIER back to 9.00 plus the error noted at 1.00. When adjusting or checking the faster sweep ranges this trigger error may be as much as 15 minor divisions.

DELAY SWEEP TIME/CM	TIME MARK GEN.	HORIZONTAL DISPLAY*	MAIN SWEEP TIME/CM
200 µSEC	100 µsec	MAIN SWEEP DELAYED	10 µSEC
500 µSEC	500 µsec	MAIN SWEEP DELAYED	10 µSEC
1 MILLISEC	1 millisec	MAIN SWEEP DELAYED	10 µSEC
5 MILLISEC	5 millisec	MAIN SWEEP DELAYED	100 µSEC

38. ADJUST DELAYING-SWEEP RATES

50 µSEC	C190D	50 µsec	MAIN SWEEP DELAYED	1 µSEC
5 µSEC	C190F	5 µsec	MAIN SWEEP DELAYED	1 µSEC

* Make rough adjustments in DELAYING SWEEP.

39. CHECK DELAY TIME MULTIPLIER LINEARITY.

Check DELAY TIME MULTIPLIER on 50 µSEC and 5 µSEC ranges for linear sweep. Two minor division error allowed from 1.00 to 9.00.

40. CHECK MAIN-SWEEP DELAYED JITTER.

Set the DELAYING SWEEP TIME/CM control to 1 MILLISEC, and MAIN SWEEP TIME/CM to 1 µSEC. Display 1 millisec markers with the HORIZONTAL DISPLAY control at DELAYING SWEEP. Set the DELAY-TIME MULTIPLIER so that the brightened portion of the sweep coincides with the marker at the 1 cm graticule line. Switch the HORIZONTAL DISPLAY control to MAIN SWEEP DELAYED. The horizontal jitter should not exceed 2 mm. Repeat the process at the 9 cm graticule line, jitter at this position should not exceed 4 mm.

41. CHECK RESET MAIN-SWEEP AND READY NEON

With HORIZONTAL DISPLAY in MAIN SWEEP NORMAL, display about 2 cm of vertical deflection from the calibrator and set STABILITY and TRIGGERING LEVEL controls for a stable trace. The READY light should not be on. Switch HORIZONTAL DISPLAY to MAIN SWEEP DELAYED, and turn DELAY SWEEP STABILITY left (ccw). Press the RESET MAIN SWEEP button. A single trace should occur. If the calibrator signal is removed, instead of a single trace the READY light will ignite when the RESET MAIN SWEEP button is pressed, then when a signal is fed to the INPUT a trace will be triggered and a single trace will occur and the light will go out. Recheck steps 18 and 25.

42. CHECK MAIN-SWEEP HOLD-OFF.

Connect a probe from test scope, set for DC input, to the right hand end of C240. Set MAIN SWEEP STABILITY full right (cw). Check all ranges of MAIN SWEEP TIME/CM switch for sufficient hold-off.

43. CHECK DELAYING-SWEEP HOLD=OFF

Now switch HORIZONTAL DISPLAY to DELAYING SWEEP and repeat the last step.

44. CHECK FRONT PANEL WAVEFORMS.

With a test scope set for DC input position trace to the bottom graticule line (zero volts reference line), probe, check +GATE MAIN SWEEP for a gate waveform of about +20 v amplitude zero volts reference line on the test scope. SAWTOOTH MAIN SWEEP should be about 150 v in amplitude with its base line at zero reference, except on the two fastest speeds where the base line should raise about 20 v. DEL'D TRIG. from MAIN or DEL'G SWEEP, should be a spike of at least +5 from zero reference line, on all sweep rates. +GATE DEL'G SWEEP, +20 v from zero reference line. Out of the VERT. SIG. OUT post there should be 2 v of signal for every cm of vertical deflection on the scope under calibration. There should be 6.3 v of ac voltage out of binding post, labeled 6.3 V 1A. AC. This can be checked with the test scope or a meter.

45. CHECK CRT CATHODE INPUT.

Remove CRT CATHODE GND. strap from rear of scope and insert signal from calibrator and check sweep for intensity modulation. With normal intensity, 20 v of calibrator signal will modulate the trace.

46. MAKE A NOTE OF CRT TYPE AND SERIAL NUMBER AND RECORD ON CALIBRATION RECORD.