

TYPE 531

Serial Numbers 101 through 6019

SUGGESTED FACTORY CALIBRATION PROCEDURE

Preset front panel controls as follows:*

POWER SWITCH--OFF.
TRIGGERING LEVEL--O.
STABILITY--CCW.
TRIGGER SLOPE--+INT.
TRIGGERING MODE--AC SLOW.
TIME/CM--100 usec.
5X MAGNIFIER--OFF.

MULTIPLIER--X1.
HORIZONTAL DISPLAY--INTERNAL SWEEP
EXTERNAL SWEEP ATTENUATOR--CW.
HORIZONTAL POSITION--MS.
VERNIER--MS
CALIBRATOR--OFF
INTENSITY--CCW.

Preset the internal screwdriver-slotted potentiometer controls (with the exception of CAL ADJ control) to mid-scale. This operation involves thirteen controls. The CAL ADJ control may be left at the setting where it is found.

Preset the following capacitors to mid-scale: C240, C254, C278, C286. These are located at the rear of the top deck.

With no plug-in unit in position, check the resistances to ground of the low-voltage power supplies. (While no tolerances are specified, it may be stated as a guide that the resistance of the -150-volt supply generally runs in the neighborhood of 4,000 to 5,000 ohms. The resistances of the remaining supplies are progressively higher as you go to the more positive voltages. The 500-volt supply might be expected to have a resistance of about 50,000 ohms.) After the check of resistances to ground, make a check for short circuits between supplies.

Carry out the following calibration procedure:

1. To check relay time delay.--With power-test plug-in unit in position, turn POWER SWITCH on. Check that the time required for the relay to operate lies between 15 sec and 45 sec.
2. To check low-voltage power-supply operation.--
 - a. Give a quick check to each low-voltage supply so as to determine that it is delivering approximately its correct voltage. This quick check helps to reveal overloads or other gross irregularities in operation.
 - b. Set the -150 VOLTS ADJ control for correct output from the -150-volt supply.
 - c. Determine that the low-voltage supplies regulate between the following limits:

*Front-panel controls are indicated by UNDERLINED CAPITALS. Internal adjustments are indicated by PLAIN CAPITALS. These abbreviations are used: CW, Clockwise; CCW, counter-clockwise; MS, mid-scale

Lower limit--line volts, 105; plug-in set at HI load.

Upper limit--line volts, 125; plug-in set at LO load.

Regulation should not exceed 2% within these limits. (Usually the regulation is much smaller than this value.)

- d. Low-voltage supplies, other than the -150-volt supply, should check within these tolerances:

+100-volt supply	100 volts	+ 2%
+225-volt supply	225 volts	+ 3%
+350-volt supply	350 volts	+ 3%
+500-volt supply	500 volts	+ 3%

- e. Set the test oscilloscope for 1 millisec/div X5 sweep speed and for 0.01 volts/div. Determine that the power-supply ripple does not exceed

10 mv for -150-, +100- and +225-volt supplies, and

15 mv for +350- and +500-volt supplies.

The predominant ripple frequency should be 120 cps, as evidenced by a display of approximately six cycles over the graticule of the test oscilloscope.

3. To set CAL ADJ.--Use 117 line volts. With calibrator turned off, set CAL ADJ for +100 volts at Pin 3 of V246 (bottom of oscilloscope). To assure suitable symmetry of the calibrator waveform, this voltage should drop to not more than 55 volts and not less than 45 volts when the calibrator is turned on.

4. To adjust and check high-voltage supply.--

- a. Set -1350-volt output of high-voltage supply to its rated value with HV ADJ control. (Measure at first left-hand terminal of ceramic strip adjacent to CRT GEOM ADJ control.)

- b. Check regulation of -1350-volt output between these limits:

Lower limit--line volts, 105; plug-in set at HI load; INTENSITY advanced to produce a (defocused) spot or glow.

Upper limit--line volts, 125; plug-in set at LO load; INTENSITY at CCW.

5. To check sweep and vertical systems for operation.--Use 117 line volts.

- a. Bring up INTENSITY control slowly from CCW position until a spot or glow appears on screen. Position spot on screen, keeping INTENSITY setting at minimum useful point. Bring up STABILITY control from CCW position until sweep is produced. Adjust FOCUS, INTENSITY and ASTIGMATISM controls to produce a trace of suitable sharpness and intensity.

- b. Rotate CRT so that trace coincides with horizontal graticule line when properly positioned with VERTICAL POSITION control. Clamp CRT in position. Recheck trace orientation.

- c. Apply 0.2 volts from calibrator to input connector of plug-in unit. With TRIGGERING LEVEL and STABILITY controls, obtain a stable trace. Then remove calibrator signal.

d. Check oscilloscope **for** microphonics.

6. To check for vertical shift with varying line voltage.--The vertical position of the trace may shift as the power-line voltage is changed. This shift may be due to either or both of two independent causes: (1) a variation in emission unbalance with heater temperature of the 6CL6 vertical driver tubes, V508 and V509; or (2) a possible redirection of the electron streams, because of the magnetic effects of heater current, causing a change in the screen- to plate-current ratios in V508 and V509. (Below SN 593, 6BQ7's were used). To check for this vertical shift from either cause:

With the power-line voltage set at 105 volts, center the trace vertically with the VERTICAL POSITION control. Raise the line voltage to 125 volts. If any resulting shift in vertical position of the trace exceeds 0.5 cm. V508 or V509 should be changed.

7. To adjust vertical AMPL GAIN.--Use 117 line volts. Again apply 0.2 volts from calibrator to input of power-test plug-in unit. Set AMPL GAIN control for 2 cm vertical deflection (peak-to-peak). (This is a preliminary adjustment only.)
8. To adjust CRT GEOM control.--
- a. Apply more vertical signal from the calibrator than is needed to cover the graticule vertically. Position the display vertically so that the flat tops of the square waves are off the screen both above and below the graticule. Turn up the INTENSITY control so that the spot, moving rapidly in the vertical direction, makes a visible trace. Now set the CRT GEOM adjustment so that the vertical traces near the ends of the graticule are as nearly straight and vertical as possible.
- b. As a further check on the CRT GEOM adjustment, remove the calibrator signal, and position the simple trace first to the uppermost graticule line and then to the lowest line of the graticule. The trace should lie along the upper and lower graticule lines without noticeable upward or downward bowing.
- c. Within the limits of a and b above, the adjustment should be that which produces the least noticeable flare on the screen.
9. To check for compression in the vertical system.--Apply a calibrator signal which provides 2 cm vertical deflection when the display is centered vertically. This deflection should not be reduced by more than 1 mm when the display is raised to the top of the graticule or lowered to the bottom of the graticule by the VERTICAL POSITION control.
10. To check dc balance of vertical system.--

- a. Remove calibrator signal. Short-circuit vertical plates of CRT, and observe the trace position. With the short-circuit removed, adjust the VERTICAL POSITION control for the same position of the trace.
- b. Short-circuit Pins 2 and 7 of V606. Change V 606 if the resulting vertical shift in trace position exceeds 0.25 cm. (If at any point in the present Step 9 it becomes necessary to interchange or replace tubes, redo Part a after the change.)
- c. Short-circuit Pin 2 of V570 to Pin 2 of V580. Interchange or replace these tubes if the resulting vertical shift in trace position exceeds 1 cm.
- d. Short-circuit Pins 2 and 7 of V558, and change V558 if the resulting vertical shift in trace position exceeds 1 cm.
- e. Short-circuit grid of V508 to grid of V509 by operating push-button switch on panel of power-test plug-in unit. Interchange or replace these tubes if resulting vertical shift in trace position exceeds 2 cm.

11. To adjust DC SHIFT COMP control.--

- a. Insert 53C plug-in unit into oscilloscope. Set INPUT SELECTOR to DC. Set OPERATING MODE switch to "A ONLY" or "B ONLY." Position the trace at -3 cm (that is, $\bar{3}$ cm below the graticule center line).
- b. Connect a 1.5-volt cell (or an ohmmeter) between GND on the oscilloscope and the plug-in input connector. Adjust the VOLTS/CM control on the plug-in unit so that the trace moves to +3 cm. (That is, make the settings such that the trace is at -3 cm when the cell is disconnected, but rises to +3 cm when the cell is connected.)
- c. Note the position of the trace immediately upon connecting the cell. Leaving the cell connected for several seconds, observe whether or not the trace slowly drifts 1 or 2 mm up or down. If it does, adjust DC SHIFT COMP control so that the drift occurring when the cell is connected is a minimum.

12. To recheck vertical AMPL GAIN adjustment, and to check the calibrator attenuator.--

- a. Reinsert power-test plug-in unit. Set AMPL GAIN control so that 0.2 volts from the calibrator produces a vertical deflection of 2 cm.
- b. Replace the power-test plug-in unit with the 53C plug-in. Set INPUT SELECTOR at DC. Set VOLTS/CM control at 0.05 and feed in 100 millivolts from the calibrator. Be sure that the red VARIABLE knob on the VOLTS/CM control is CW. A deflection of 2 cm should be obtained. Other positions of the calibrator should be checked similarly. The results should be those tabulated:

<u>VOLTS/CM setting</u> <u>on plug-in</u>	<u>Calibrator</u> <u>attenuator</u> <u>setting</u>	<u>Deflection</u>
0.05	100 mv	2 cm
0.05	0.2 volts	4
0.1	0.5	5
0.2	1	5
0.5	2	4
1	5	5
2	10	5
5	20	4
10	50	5
20	100	5

13. To set TRIGGERING LEVEL control to physical center.--(For this adjustment, the TRIGGERING MODE control should NOT be set to AC AUTO.)

- a. Connect a voltmeter from the junction of R16 and R17 to chassis. Set TRIGGERING LEVEL so that zero deflection is obtained even on the 3-volt range of the voltmeter.
- b. Loosen the TRIGGERING LEVEL knob on its shaft. Turn the knob so that its index points to "0" on the panel, and tighten the knob on its shaft. Recheck that a voltmeter reading of zero is obtained when the knob index is at "0."

14. To adjust TRIGGERING LEVEL CENTERING.--Settings:

<u>TRIGGERING LEVEL</u> --0.	<u>TIME/CM</u> --1 millisec.
<u>TRIGGER SLOPE</u> --+INT.	<u>5X MAGNIFIER</u> --OFF
<u>TRIGGERING MODE</u> --AC SLOW.	<u>HORIZONTAL DISPLAY</u> --INTERNAL SWEEP.

- a. Display calibrator signal. Set calibrator output and the VOLTS/CM switch for 3 or 4 mm of vertical deflection. Set STABILITY control and the TRIGGERING LEVEL CENTERING control so that a stable display is obtained. Then make further adjustments of TRIGGERING LEVEL CENTERING so that the sweep triggers equally well on +INT and -INT settings of the TRIGGER SLOPE switch.
- b. Check the polarity of the TRIGGER SLOPE switch on +INT and -INT positions. The leading edge at the left end of the graticule should be a rising edge when the switch is in the + INT position, and it should be a falling edge when the switch is in the -INT position.
- c. Connect VERT. SIG. OUT to TRIGGER IN. In a manner similar to that of Part b of this step, check the polarity of the TRIGGER SLOPE switch on +EXT and -EXT positions. Leading edge at left end of graticule should be a rising edge when the switch is in the +EXT position, and vice versa.

15. To adjust TRIGGER SENSITIVITY control.-- Settings of the oscilloscope being calibrated:

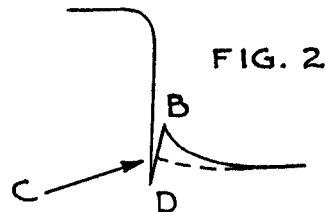
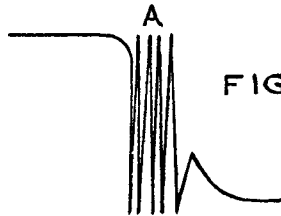
<u>TRIGGERING LEVEL</u> --0.	<u>TIME/CM</u> --100 usec.
<u>STABILITY</u> --CCW	<u>5X MAGNIFIER</u> --OFF.
<u>TRIGGER SLOPE</u> --+LINE.	<u>MULTIPLIER</u> --X1.
<u>TRIGGERING MODE</u> --AC SLOW.	<u>INTENSITY</u> --CCW.
<u>HORIZ. DISPLAY</u> --INTERNAL SWEEP	

Settings of test oscilloscope:

TRIGGER SELECTOR--+ LINE.
TIME/DIVISION--1 millisec.
MULTIPLIER--X1

5X MAGNIFIER--ON
VOLTS/DIVISION--1 (AC)
MULTIPLIER--X1.

Connect 2X probe of test oscilloscope to Pin 1 of V20 (or to lead from that pin to the TRIGGERING MODE switch). With TRIGGER SENSITIVITY turned CW, the waveform of Fig. 1 should be seen on the test oscilloscope. (Figure may be inverted. If so, switch to -LINE triggering on test oscilloscope.)



The TRIGGER SENSITIVITY control should now be gradually turned CCW until the self-oscillation indicated at A just dies out. The result is a display shown in the solid line of Fig. 2. The TRIGGER SENSITIVITY control should be turned further in the CCW direction until the peak B drops to a point C (dotted line, Fig. 2) which has a height above D equal to one-half its original height.

After this adjustment, it is often possible to return to Step 14, and by slightly readjusting the TRIGGERING LEVEL CENTERING control, to obtain triggering on both the +INT and -INT positions with deflections appreciably smaller than the 3 to 4 mm used initially.

16. To set INT TRIG DC LEVEL.--Display calibrator waveform at about 2 cm deflection, keeping the display centered vertically on the graticule horizontal centerline. Use these settings:

TRIGGERING LEVEL--0.
TRIGGER SLOPE--+INT.
5X MAGNIFIER--OFF.
HORIZ. DISPLAY--INTERNAL SWEEP.

TRIGGERING MODE--DC.
TIME/CM--10 usec.
MULTIPLIER--X1

Adjust the STABILITY control and the INT TRIG DC LEVEL control for a stable trace. With correct adjustment of INT TRIG DC LEVEL control, the sweep will trigger equally well on +INT and -INT slope settings, with a given setting of the STABILITY control. Also, the leading edges of the displays obtained with +INT and with -INT slope settings should be symmetrical with each other about the horizontal center line of the graticule.

17. To check AC AUTO operation.--Settings:

TRIGGERING LEVEL--0.
STABILITY--CCW.
TRIGGER SLOPE--+EXT.
TRIGGERING MODE--AC AUTO.

TIME/CM--100 usec.
MULTIPLIER--X1
5X MAGNIFIER--OFF.
HORIZ. DISPLAY--INTERNAL SWEEP.

Use no signal input. Operation of the AC AUTO mode is indicated if, upon ad-

vancing the STABILITY control slowly CW, you obtain a trace--and if further advance of this control results abruptly in a brightening of the trace. (The first trace results from triggering of the sweep by the trigger-shaper multivibrator operating in a free-running manner at about 50 cps. The brightening occurs when the sweep-generating circuits themselves become free-running at advanced STABILITY settings.)

18. To adjust EXT SWP AMPL DC BAL.--Ground EXTERNAL SWEEP IN. Set:

HORIZONTAL DISPLAY--EXT SWP X1.
5X MAGNIFIER--ON
EXTERNAL SWEEP ATTENUATOR 10-1--CW.

Position the spot on the screen by means of the HORIZONTAL POSITION control. Adjust EXT SWP AMPL DC BAL control so that the spot remains stationary on the screen as EXTERNAL SWEEP ATTENUATOR 10-1 knob is turned back and forth throughout its range.

19. To set C240 and C254.--Settings:

TRIGGERING LEVEL--0.
TRIGGER SLOPE--EXT.
TRIGGERING MODE--AC SLOW.
TIME/CM--1 millisec.
HORIZ. DISPLAY--EXT SWP X1.

EXT SWP ATTEN. 10-1--CW.
5X MAGNIFIER--ON
MULTIPLIER--X1.
VOLTS/CM--10

- a. Connect 1-kc output of Type 105* to EXTERNAL SWEEP IN. Connect Sync Output of Type 105 to TRIGGER INPUT of oscilloscope. Connect SAWTOOTH OUT to input of plug-in. Adjust STABILITY for stable square-wave display which appears vertically rather than horizontally across the screen. Set Output Amplitude of Type 105 for about 4 cm of horizontal deflection. Adjust C240 (at right rear of top deck) for best square-wave reproduction.
- b. Next, turn the 5X MAGNIFIER off, and increase the Output Amplitude from the Type 105 for a horizontal deflection of about 2 cm. Adjust C254 (near C240) for best square-wave response.
20. To adjust C101.--After completing Step 19, turn the 5X MAGNIFIER back on. Change the HORIZONTAL DISPLAY setting to EXTERNAL SWEEP ATTENUATOR X10. Re-adjust the Output Amplitude of the Type 105 for about 1 cm deflection. Set C101 (on HORIZONTAL DISPLAY switch) for best square-wave response.
21. To adjust delay line and set vertical amplifier coils.--
- a. Insert special "high-frequency " plug-in unit, identified by its plastic chassis.**
- b. Check that the video leads from the preamplifier plug are clear of each other and of other wires. Similarly for the video leads to the delay-line input. Use spudger, if necessary, to dress the cabled leads back under the preamplifier plug and away from the video circuits.

*Unless otherwise indicated, in these procedures the Type 105 is terminated in a 52-ohm terminating resistor and is connected to its load through a 52-ohm cable having a 5:1 (14-db) 52-ohm L-pad at the load end.

**There is a possibility, at the time these procedures are prepared, that the 53/54K plug-in unit may later be specified for this step, rather than the special high-frequency unit mentioned above.

- c. Make sure that R570 and R580 (in vertical output amplifier) are dressed well away from the CRT shield and other objects.
- d. Preset L570 and L580 (in vertical output amplifier) so that slugs project about 3/16" below the lowest turns of the coils, as seen when the light source is placed on the opposite side of the translucent coil from the viewer.
- e. Preset the delay-line input coils so that the slugs are five turns in from their outermost position.
- f. Settings:

TRIGGERING LEVEL--0.
TRIGGER SLOPE--+EXT

HORIZONTAL DISPLAY--INT SWEEP
5X MAGNIFIER--OFF

- g. Feed 300-kc to 500-kc output of Type 105 to input of plug-in. Use about 4 cm of deflection. Also connect Sync Output of Type 105 to TRIGGER INPUT.
- h. The delay line affects only the first half microsecond of the square wave. Delay-line "trimmer" capacitors at the bottom of the oscilloscope affect the early part of the wave; upper capacitors affect later parts of the wave. The portion of the wave affected by a particular capacitor can be identified by the downward bump occurring when that capacitor is touched with the metal bit of a screwdriver.

CAUTION

The capacitors have +200 volts on them. Do not touch them with the fingers.

Adjust the capacitors of the delay line so that "wrinkles" of magnitude greater than the trace width are absent, and so that the "level" of the trace is constant across the top of the square wave. Avoid use of the first positive wave triggered on + slope. (This may have a slight curvature in these instruments.) Neglect negative portions of the wave--the Type 105 provides a wave which is square only on the positive portion of its cycle. Vary the TIME/CM settings and MULTIPLIER settings to obtain faster sweeps for checking the general level.

(NOTE: A small residual wrinkle called a "termination bump" may sometimes remain at about the mid-point of the square wave. If this is excessive, the values of the line termination resistors and their associated capacitors should be checked.)

- i. When the wrinkles have been eliminated and the general level of the square wave has been made satisfactory, try small increases in L570 and L580. These changes have the effect of raising the level of the early portion of the wave. The level may be restored to normal by readjusting the first trimmer capacitors. The overall result is a "squaring up" of the leading edge of the wave. This process should be continued, a half-turn or a turn of each coil at a time, as far as practicable from the viewpoint of obtaining a good square-wave response.
- j. The delay-line input coils should now be adjusted for increased inductance. These affect the leading edge only. Make equal small adjustments on both coils. Then make any needed compensating adjustments of the first trimmer capacitors. Continue this process as far as necessary.

22. To check bandwidth of vertical system.--Feed into the plug-in unit connector a frequency in the lowest-frequency band of the Type 190. A 52-ohm terminating resistor should be inserted between the output cable attenuator of the Type 190 and the input connector of the oscilloscope. With TIME/CM set at 100 usec, set the vertical deflection exactly upon some whole number of centimeters--say 3 cm or 4 cm. Without disturbing the other settings, increase the output frequency of the Type 190 until the deflection decreases to a value which is 70% of the original deflection. The frequency which gives this deflection is the 3-db-down frequency of the oscilloscope vertical system. Typical values obtained range from 12.1 mc to 12.3 mc. If the bandwidth is insufficient, recheck items 21b, 21c, 21i, and 21j.
23. To check HF SYNC operation.--Supply a 30-mc signal from the Type 190, with amplitude sufficient to produce 4 mm of deflection. Use these settings:

<u>TRIGGERING LEVEL</u> --0.	<u>TIME/CM</u> --0.1 usec.
<u>TRIGGERING SLOPE</u> --+INT.	<u>MULTIPLIER</u> --X1.
<u>TRIGGERING MODE</u> --HF SYNC.	<u>5X MAGNIFIER</u> --ON.

A setting of the STABILITY control should be found at which the 30-mc sine-wave display is stable.

24. To adjust SWP CAL.--Reinsert 53C plug-in unit. Settings:

<u>TRIGGER SLOPE</u> --+ INT.	<u>TIME/CM</u> --1 millisc.
<u>TRIGGERING MODE</u> --AC SLOW	<u>MULTIPLIER</u> --X1.
<u>5X MAGNIFIER</u> --OFF.	

Display a 1-millisecond markers from Type 180, and adjust STABILITY and TRIGGERING LEVEL for a stable display. Keeping the second marker under the 1-cm graticule line with the HORIZONTAL POSITION control, adjust the SWP CAL control so that the tenth marker falls precisely under the 9-cm graticule line.

25. To adjust SWP LENGTH--With the same settings as those used in Step 24, adjust SWP LENGTH control for a sweep of 10.5 cm. Use free-running sweep.
26. To adjust MAG GAIN.--
- With the same settings as those used in the step just completed, feed in 1-millisecond and 100-usec markers from Type 180. Adjust STABILITY and TRIGGERING LEVEL for a stable display.
 - Now turn 5X MAGNIFIER on. With the HORIZONTAL POSITION control, set the sixth 1-millisecond marker approximately under the vertical center line of the graticule.
 - Adjust MAG GAIN and HORIZONTAL POSITION so that 100-usec markers fall precisely under the 1-cm and the 9-cm graticule lines, with two markers for each cm in the region between these lines. At graticule lines within the middle 8 cm, the markers should align with the graticule lines with +1% of full scale.
27. To adjust SWP/MAG REGIS.--After completing the above step, position the first marker beneath the graticule center line by means of the HORIZONTAL POSITION

control. Then turn the 5X MAGNIFIER off, and reposition the first marker beneath the center line by means of the SWP/MAG REGIS. control.

28. To check the sweep timing, 5 sec/cm to 100 usec/cm.--After completing the step above, and using the same setup, position the second 1-millisecond marker (with 5 X MAGNIFIER off) under the 1-cm graticule line by means of the HORIZONTAL POSITION control. Then
- a. Switch TIME/CM to 100 usec, and check that the markers coincide with the middle 8 cm of the graticule.
 - b. Return the TIME/CM switch to 1 millisecond. Turn off the 100 usec markers on the Type 180, and make any necessary readjustment of TRIGGERING LEVEL for a stable display. Now check the timing over the middle 8 cm of the graticule on the MULTIPLIER X2 (2 markers/cm) and on the MULTIPLIER X5 (5 markers/cm). Here, also, the tolerance is +2%. (This checks the multiplier resistors for the ranges from 10 usec/cm to 100 millisecond/cm, inclusive.)
 - c. With the MULTIPLIER in the 2.5-1 position, check that the red variable multiplier knob provides control of the number of markers per cm over at least the range from 2.5 to 1.
 - d. With the MULTIPLIER in the 5-2 position, check that the red variable multiplier knob provides control of the number of markers per cm over at least the range from 5 to 2.
 - e. Turn the MULTIPLIER knob to the 12-5 position, and set the red variable multiplier knob CW. Switch to a TIME/CM position of 100 usec. Six markers should appear, approximately filling the graticule space horizontally. At least 13 markers should appear in the same horizontal distance when the red variable multiplier knob is turned CCW.
 - f. Set TIME/CM at 10 millisecond and MULTIPLIER at X1. Feed in 10-millisecond markers. Check that timing (1 marker/cm) is within tolerance of +2% over the middle 8 cm of the graticule.
 - g. Repeat Part f of this step, but use 100-millisecond markers and a TIME/CM setting of 100 millisecond. Tolerance, +2%
 - h. Inserting 1-sec markers, and using a TIME/CM setting of 1 sec, check timing on MULTIPLIER settings of X1, X2, and X5. Tolerance, +2% (On X1 multiplier position, one marker/cm should be observed. On X2, two markers/cm should be observed. On X5, five markers/cm should be observed.)
29. To set timing of sweep, 10 usec/cm to 0.1 usec/cm.--
- a. Preset C278 and C286 to mid-range positions.
 - b. Set TIME/CM at 10 usec with MULTIPLIER X1. Display 10-usec markers for this purpose. The adjustment is made on C99F (on TIME/CM switch) for proper timing (1 marker/cm) over the middle 8 cm of the graticule. Tolerance, +2%.
 - c. Repeat Part b of this step, but this time display 1-usec markers with a

TIME/CM setting of 1 usec. This time, adjust C99H. Check timing on MULTIPLIER X2 and X5 positions. (On X1 position, you should observe 1 marker/cm; on X2 position, two markers/cm; on X5 position, five markers/cm.) Tolerance, +2%.

- d. Set TIME/CM at 0.1 usec and MULTIPLIER at X5. Insert 1-usec markers. Position the first marker off the screen to the left with the HORIZONTAL POSITION control, and position the second marker under the 1-cm graticule line. Maintaining this position of the second marker with the HORIZONTAL POSITION control, adjust C99J so that the sixth marker lies under the 9-cm graticule line (that is, the separation between markers is 2 cm).
- e. Set TIME/CM at 0.1 usec and MULTIPLIER at X1. Feed in 10 mc sine waves from Type 180. Touch up C254 and adjust C267 for best linearity and timing of display, obtaining 1 cycle of the 10-mc sine wave for each centimeter of graticule length, over the middle 8 cm of the graticule. Settings of C254 and of C267 interact; C254 serves principally to set the sweep speed while C267 serves principally as a linearity adjustment.
- f. Adjustments d and e interact. They should be repeated as many times as necessary.

30. To adjust C278 and C286.--Settings:

TRIGGERING LEVEL--0.
TRIGGER SLOPE--+EXT.
TRIGGERING MODE--AC SLOW.

TIME/CM--0.1 usec.
MULTIPLIER--X1
5X MAGNIFIER--ON.

Connect Trigger Output of Type 180 to TRIGGER INPUT on oscilloscope, setting Trigger Rate Selector of Type 180 at 10 kc. Capacitively couple the 50-mc output of the Type 180 to one of the vertical plates of the CRT. (The value of the coupling capacitor is not at all critically--a suggested value is 20 uuf.) Set the STABILITY control for a stable display of the 50-mc sine wave. Make these adjustments:

- a. Set the VERNIER of the horizontal position control at mid-scale. Set the HORIZONTAL POSITION control at about the position of 1100 hours (slightly CCW from mid-scale). Adjust C278 and C286 (keeping them approximately balanced with respect to each other) for best timing and linearity of the display. There should be one cycle of the sine-wave display for each cm along the horizontal length of the graticule. Tolerance, +2%.
 - b. Turn the HORIZONTAL POSITION and VERNIER knobs CCW. Check the trace for timing and linearity. Tolerance, +2%.
 - c. Turn the HORIZONTAL POSITION knob CW until the left end of the display becomes visible. Now turn the control a short way CCW until the first few cycles, which are obviously non-linear, are positioned off the left end of the screen. Check the trace for linearity and timing. Tolerance, +2%.
31. To check the horizontal gain.--Set HORIZONTAL DISPLAY on EXTERNAL SWEEP X1, and turn 5X MAGNIFIER on. Have EXTERNAL SWEEP ATTENUATOR set CW. Feed 0.2 volt from calibrator to EXTERNAL SWEEP IN. Position the sweep on the screen with the HORIZONTAL POSITION control. Length of sweep should be not less than 1 cm.

Now increase the calibrator output to 2 volts. Adjust the EXTERNAL SWEEP ATTEN. knob for a horizontal deflection of 10 cm. Turn the HORIZONTAL DISPLAY switch to the EXT. SWEEP X10 position, and turn the calibrator output to 20 volts. The new horizontal deflection should be 10 cm + 1 minor division. This establishes the correctness of the attenuation ratio in the X10 attenuator.

32. To check sweep waveform for sufficient holdoff.--Settings:

<u>TRIGGERING LEVEL</u> --0	<u>5X MAGNIFIER</u> --OFF
<u>TRIGGERING SLOPE</u> --+INT.	<u>MULTIPLIER</u> --X1
<u>TRIGGERING MODE</u> --AC SLOW.	<u>STABILITY</u> --Set for free-run.
<u>HORIZ. DISPLAY</u> --INT. SWEEP.	

Connect 10X probe of test oscilloscope to right-hand end of C240. Observe waveforms on all sweep speeds obtained by turning the TIME/CM switch. Have the test oscilloscope set for DC input. Holdoff in each case should be sufficient to prevent any retrace transients from extending into trace. As a general guide, the horizontal interval from the end of retrace to beginning of trace usually has a duration of 5 usec or more, even on fastest sweeps.

33. To check waveforms available on panel terminals.--With test oscilloscope, check these waveforms:

- a. +GATE OUT.--With oscilloscope under calibration free-running, this waveform should be a rectangular form with an amplitude of 18 to 35 volts.
- b. SAWTOOTH OUT.--This sawtooth wave should have an amplitude of 135 to 165 volts.
- c. VERT. SIG. OUT.--Insert calibrator signal into plug-in input. Reproduction of the square wave should be obtained at VERT. SIG. OUT. This reproduction is only approximate because the bandwidth of the channel which feeds this terminal is restricted to about 6 mc. The amplitude of the reproduction is about 2 volts for each centimeter of deflection.

34. To check neons and scale illumination.--With the HORIZONTAL and VERTICAL POSITION controls, move the trace off the screen--both up and down, and right and left. Check that the appropriate neon directional indicators light up in each case. Then bring up the SCALE ILLUM. control, and check that it provides control of the graticule scale illumination. See that the lamps associated with this circuit are positioned into the subpanel and panel by the proper amount and are firmly mounted.

35. To check dual-trace operation.--Feed calibrator signal into Channel A of 53C plug-in unit. Check that the square-wave display is obtained on "A ONLY" position of the OPERATING MODE switch, while a simple trace is obtained on the "B ONLY" position. These displays should be independently positionable by means of the appropriate VERTICAL POSITION controls. On the "CHOPPED" position of the OPERATING MODE switch, both the square wave and the simple trace should be seen--and the vertical position controls should again be checked. Similarly for the "ALTERNATE SWEEPS" position of the OPERATING MODE switch.

36. Check CRT cathode input circuit