

TYPE 310 OSCILLOSCOPE

SUGGESTED FACTORY CALIBRATION PROCEDURE (applicable to instruments after S/N 314)

Preset front-panel controls as follows:*

PWR--OFF.
INTENSITY--CCW.
TRIGGER (black)--INT.
TRIGGER (red)--AC.
TIME DIV (black)--100 μ sec.
TIME DIV (red)--CW.
TRIG. LEVEL--MS.
STABILITY--CCW.

MAG.--X1.
CALIBRATOR--OFF.
HORIZ. POSITION--MS.
VERT. POSITION--MS.
AC-DC--AC.
VOLTS DIV (black)--0.1.
VOLTS DIV (red)--CW.

Preset SWEEP LENGTH internal screwdriver-slot control to MS. (This control is situated at the lower left-hand side of the oscilloscope.) Preset ADJ HV control (on high-voltage supply printed-circuit board) to CCW.

Preset these capacitors to MS: C175B (on TIME/DIV switch); C205 (behind TIME/DIV switch); C213 (behind C205).

Check the resistances to ground of the low-voltage power supplies. (While no tolerances are specified, it may be stated as a guide that these resistances generally are about 10,000 ohms for the -150-volt supply; 12,000 ohms for the +100-volt supply; and 16,000 ohms for the +300-volt supply.) After the check of resistances to ground, make a check for short circuits between supplies.

Carry out the following calibration procedure:

1. To check low-voltage power-supply operation.--

- a. Apply primary ac power. Turn PWR switch on. Give a quick check to each low-voltage supply to determine that it is delivering approximately its rated voltage. This quick check helps to reveal overloads or other gross irregularities in operation.
- b. Set the -150 V ADJ control (at front right-hand side of oscilloscope) for correct output voltage from the -150-volt supply.
- c. Determine that the low-voltage supplies deliver voltages which are constant within 2% as the line voltage is varied from 105 to 125 volts. (Usually the voltages remain constant within much less than the 2% figure.)
- d. The positive 100- and 300-volt supplies should check within $\pm 3\%$ of their rated values, when a line voltage of 117 volts is used.
- e. Use a line voltage of 117 volts. Set the Type 531 test oscilloscope for 1 millisec/cm X5 sweep speed. Using the 53B plug-in unit, set the VOLTS/CM control for 0.01 volts/cm. Using a 2X probe, determine that the ripple does not exceed 10 mv on any low-voltage supply in the oscilloscope under test. The predominant ripple frequency should be 120 cps, as evidenced

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

by a display of approximately six cycles over the graticule of the test oscilloscope.

2. To set CAL ADJ.---Use 117 line volts. With calibrator turned off, set CAL ADJ for +100 volts at Pins 7 and 2 of V520. 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.
3. To adjust and check high-voltage supply.---Set -1675-volt output of high-voltage supply to its rated value with ADJ HV control. (Measure at anode terminal of V730.) Then check that the output voltage of the -1675-volt portion of the supply regulates between these limits:

Lower limit---line volts, 105; INTENSITY advanced to produce a (defocused) spot or glow.

Upper limit---line volts, 125; INTENSITY at CCW.

Now apply specially-perforated shield to right-hand side of oscilloscope for remainder of calibration procedure.

4. 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. Adjust VERT. GAIN control (at rear of oscilloscope) if necessary to permit positioning of spot on screen. Bring up STABILITY control from CCW position until sweep is produced. Adjust FOCUS and INTENSITY controls for a trace of suitable brightness 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. With TRIGGERING LEVEL and STABILITY controls, obtain a stable trace. Adjust ASTIGMATISM control (at rear of oscilloscope) in conjunction with FOCUS and INTENSITY controls, for a display of suitable brightness and sharpness.

Now remove calibrator signal.

- d. Check main amplifier for microphonics.
5. To adjust vertical DC BAL.---Ground INPUT. Set VOLTS/DIV (black) at 0.1. Advance STABILITY to obtain simple trace. Position trace on screen by means of HORIZ. POSITION control. Adjust DC BAL control (at top of oscilloscope) so that the trace remains stationary on the screen as the red VOLTS/DIV knob is turned back and forth throughout its range.

Now set the red VOLTS/DIV control fully CW.

6. To adjust VERT. GAIN.---Set VOLTS/DIV (black) knob at 0.1. Have VOLTS/DIV (red) knob CW. Set AC-DC switch at AC. Apply 1/2 volt from calibrator to INPUT. Set VERT. GAIN control (at rear of oscilloscope) so that a vertical deflection of 5 major divisions is obtained. Next, turn the AC-DC switch to the DC position.

The vertical deflection provided by the calibrator signal, after the display has been repositioned vertically, should be different from 5 major divisions by not more than $\pm 1\%$.

7. To check for compression in vertical system.--With the AC-DC switch in the AC position, apply a calibrator signal which provides 2 major divisions of vertical deflection when the display is centered vertically. This deflection should not be reduced by more than 1/2 minor division when the display is raised to the top of the graticule or lowered to the bottom of the graticule by means of the VERTICAL POSITION control.
8. To set PRE-AMP GAIN.--Set VOLTS/DIV (black) knob at 0.01. Have VOLTS/DIV (red) knob CW. Set AC-DC switch to AC. Apply 0.05 volt from calibrator to INPUT. Set PRE-AMP GAIN control (on pre-amplifier printed-circuit board) so that a vertical deflection of 5 major divisions is obtained.

Now check pre-amplifier for microphonics.

9. To check CALIBRATOR attenuator against VOLTS/DIV control.--Set AC-DC control to DC. Set VOLTS/DIV (black) knob at 0.01 and apply 0.05 volts from calibrator to INPUT. Be sure that VOLTS/DIV (red) knob is CW. A deflection of 5 major divisions should be obtained. Other positions of the calibrator attenuator should be checked similarly against the VOLTS/DIV (black) control. The deflections obtained should be those tabulated, within a tolerance of $\pm 2\%$.

<u>VOLTS/DIV setting</u>	<u>Calibrator attenuator setting</u>	<u>Deflection (maj. div.)</u>
0.01	0.05 volts	5
0.02	0.1	5
0.05	0.2	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
50	100	2

10. To adjust probe and VOLTS/DIV attenuators.--Settings:

<u>TRIGGER</u> (black)--INT.	<u>MAG.</u> --X1.
<u>TRIGGER</u> (red)--AC.	<u>AC-DC</u> --AC.
<u>TIME/DIV</u> (black)--1 millisec.	<u>VOLTS/DIV</u> (black)--0.1.
<u>TIME/DIV</u> (red)--CW.	<u>VOLTS/DIV</u> (red)--CW.

- a. Connect cable of 2X probe to INPUT. Connect probe to output of calibrator. Adjust output of calibrator for about 10 major divisions of vertical deflection. Adjust TRIG. LEVEL and STABILITY for a stable trace. Adjust probe for best square-wave response.

- b. Set VOLTS/DIV (black) knob successively to the positions listed below. In

each case, adjust the capacitor(s) listed, setting them for the best square-wave response. Keep the calibrator output set for about 10 major divisions of vertical deflection.

<u>VOLTS/DIV setting</u>	<u>Adjust capacitors</u>
0.2	C309, C310
Set red <u>VOLTS/DIV</u> knob CCW.	
0.2	C413
Set red <u>VOLTS/DIV</u> knob CW.	
0.2	Retouch C310
0.5	C306, C307
1	C303, C304
10	C300, C301
0.01	C320

11. To set L.F. ADJ.--Settings:

<u>VOLTS/DIV</u> (black)--0.1.	<u>TIME/DIV</u> (red)--CW.
<u>VOLTS/DIV</u> (red)--CW.	<u>TRIGGER</u> (black)--+INT.
<u>AC-DC--AC</u> (important).	<u>TRIGGER</u> (red)--AC.
<u>TIME/DIV</u> (black)--5 millisec.	<u>MAG.</u> --X1.

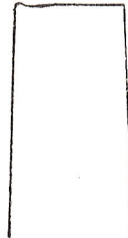
- a. Set Type 105 for 50-cps square-wave output, with 52-ohm terminating resistor at Output connection of Type 105. Connect cable to 2X probe to INPUT connector of oscilloscope under test. Insert probe test tip in terminating resistor of Type 105, and ground the alligator clip lead of the probe to the Type 105 chassis.
- b. Adjust Type 105 Output Amplitude control for a vertical deflection of from 6 to 8 major divisions. Adjust TRIG. LEVEL and STABILITY controls for stable sweep. Observe display closely, especially noting the amount of slope of the wave tops.
- c. Change VOLTS/DIV (black) knob setting to 0.01. Adjust Type 105 Output Amplitude control for the same amplitude of deflection as that used in Part b of this step. By means of the L. F. ADJ control (at top of oscilloscope) adjust the pre-amplifier response so that the slope of the wave tops is the same as that observed in Part b.

12. To adjust high-frequency compensation of main vertical amplifier.--Settings:

<u>VOLTS/DIV</u> (black)--0.1.	<u>TIME/DIV</u> (red)--CW.
<u>VOLTS/DIV</u> (red)--CW.	<u>TRIGGER</u> (black)--+INT.
<u>AC-DC--AC</u> .	<u>TRIGGER</u> (red)--AC.
<u>TIME/DIV</u> (black)--0.5 μ sec.	<u>MAG.</u> --X1.

- a. Apply a square-wave signal of about 400 kc from Type 105 to INPUT connector. Use 52-ohm connecting cable. Have a 52-ohm terminating resistor at the Type 105 Output connector, and a 5:1 (14-db) 52-ohm L pad at the oscilloscope INPUT connector.

- b. Adjust Type 105 Output Amplitude control for a vertical deflection of about 6 major divisions. Adjust TRIG. LEVEL and STABILITY controls for stable sweep.
- c. Adjust L409 and L418 (at top center of left side of oscilloscope) and L450 and L451 (farther to the rear of the oscilloscope) so that a waveform like that shown below appears on the screen. (In the case of L450 and L451, a workable adjustment may be obtained with the slug in either of two positions. Select the adjustment which places the slug farther inside the coil form--that is, with the threaded rod screwed farther into the coil form.) In making the adjustments, neglect negative portions of the wave--the Type 105 provides a wave which is square only on the positive portion of its cycle. L409 and L418 affect the leading edge. L450 and L451 affect the portion of the wave just following the leading edge. In the final adjustment, L409 and L418 should be approximately balanced; similarly for L450 and L451. There may be a small amount of rise along the top of the observed wave; the small spike atop the leading edge should be of about the same overall height as the back edge of the wave. In particular, you should try to get the leading edge as steep as possible.



13. To adjust high-frequency compensation of pre-amplifier.--After completing the above step, switch the VOLTS/DIV (black) knob to 0.01. Use a 200- to 400-kc square wave from the Type 105, with the same cable and terminations as those used in the previous step. Set the Type 105 Output Amplitude control for about 6 major divisions of vertical deflection. Adjust L325 (on left side of oscilloscope) and L341 (on rear of VOLTS/DIV switch) for a waveform as nearly like that of the previous step as possible, with particular attention to steepness of the leading edge. Bring up the "level" of the waveform with L325--then sharpen the leading edge with L341, readjusting L325 as necessary to maintain a satisfactory general "level" of the waveform.

14. To check bandwidth of main vertical amplifier.--Settings:

VOLTS/DIV (black)--0.1.
VOLTS/DIV (red)--CW.
AC-DC--AC.
TIME/DIV (black)--1 millise.
TIME/DIV (red)--CW.

TRIGGER (black)--+INT.
TRIGGER (red)--AC.
TRIG. LEVEL--MS.
STABILITY--CW.
MAG.--X1.

Connect cable output attenuator of Type 190 to INPUT. Apply 350-kc sine wave from Type 190, and adjust Output control and cable attenuator of Type 190 so that a bright band, just 4 major divisions in height, is obtained on the screen. Without disturbing the Output control or the cable attenuator of the Type 190, increase the output frequency of the Type 190 until the height of the band on the screen is reduced to 2.8 major divisions. The Type 190 is now set to the

3-db-down frequency of the oscilloscope main amplifier. This should be not less than 4.0 mc.

15. To check bandwidth of vertical pre-amplifier.--Repeat the above step, this time having the VOLTS/DIV (black) control in the 0.01 position. The bandwidth obtained should be not less than 3.5 mc.
16. To adjust SWEEP CAL.--Apply 1-millisecond markers from Type 180 to INPUT. Use the settings of Step 14, with these exceptions: VOLTS/DIV (black) knob should be set for a vertical deflection of 4 or 5 major divisions; STABILITY and TRIG. LEVEL should be set for a stable display. Set SWEEP CAL. adjustment (on back of oscilloscope) for 1 marker per major division over the entire horizontal graticule distance. Make this adjust in such a fashion that markers are precisely aligned with the initial and with the final graticule lines. Then markers within the graticule length should align with the vertical graticule lines marking the major divisions with a tolerance of $\pm 2\%$.
17. To set SWEEP LENGTH.--After completing the above step, set SWEEP LENGTH control (on lower left side of oscilloscope) for a sweep length of 10.5 major divisions.
18. To adjust MAG. CENTER.--
 - a. After completing Step 17, turn MAG. control to X5. With the HORIZONTAL POSITION control, center the second marker horizontally on the graticule. Turn MAG. control to X1. Reset second marker to the center position using the MAG. CENTER control at back of oscilloscope.
 - b. Turn MAG. control to X5 position. With HORIZONTAL POSITION control, center the second marker. The first and third markers should now fall at the ends of the graticule, within a tolerance of $\pm 2\%$. If these markers fail to coincide with the graticule ends within this tolerance, check resistors R213 and R214 (to rear of MAG. switch) for tolerance.
 - c. Check linearity of sweep with MAG. control in X5 position by positioning successive markers at the horizontal center of the graticule with the HORIZONTAL POSITION control. In each case, the preceding and the succeeding markers should lie at the beginning and at the end, respectively, of the graticule, within a tolerance of $\pm 2\%$.
19. To check timing-multiplier resistors.--These resistors, having values of 600K, 600K and 1.2 M, are mounted in the TIME/DIV switch. To check them, after completing Step 18, turn MAG. to X1 position and locate the first marker at the initial vertical graticule line by means of the HORIZONTAL POSITION control. Turn TIME/DIV (black) knob to the 500- μ sec position. The marker at the right end of the graticule should now be displaced from the final graticule line by not more than $\pm 1\%$. Now turn the TIME/DIV (black) knob to the 2-millisecond position. The marker at the right end of the graticule should be displaced from the final graticule line by not more than $\pm 2\%$.
20. To check sweep speeds on the 10-millisecond, 100-millisecond and 100- μ sec ranges.--After completing Step 19, apply successively 10-millisecond, 100-millisecond and 100- μ sec markers from Type 180, in each case setting the TIME/DIV (black) knob to corresponding sweep speeds and setting the TRIG. LEVEL and STABILITY

controls for stable displays. In each case, there should appear one marker per major division of horizontal graticule distance, with a tolerance of $\pm 1\%$.

21. To adjust sweep speed on 10- μ sec range.--

- a. After completing step 20, apply 10- μ sec markers from Type 180 to INPUT. Turn MAG. switch to X5. Turn HORIZONTAL POSITION control CCW. Adjust C175-B (on TIME/DIV switch) for 1 marker for each 5 major divisions.
- b. Now turn the HORIZONTAL POSITION control so that the left end of the trace is displayed. Adjust C205 (to rear of TIME/DIV switch) for 1 marker for each 5 major divisions. (Operations a and b of this step interact--recheck them as necessary.)
- c. Turn MAG. control to X1. Adjust linearity of first tenth of sweep (that is, of the first major division of length) by means of C213.

22. To adjust sweep speed on 1- μ sec range.--Now switch the TIME/DIV (black) knob to the 1- μ sec division. Apply 1- μ sec markers from Type 180 to INPUT. Set C175-A (on TIME/DIV switch) for 1 mark/div.

23. To adjust sweep speed on 0.5- μ sec range.--Now switch the TIME/DIV (black) knob to the 0.5- μ sec position. Turn MAG. to X5. Display 10-megacycle sine waves from Type 180. Turn TRIGGER (black) knob to +INT. Connect 100-kc triggers from Type 180 Trigger Output connector to TRIG. INPUT. Set TRIG. LEVEL and STABILITY controls for stable display. The display should show 1 cycle of the sine wave for each division along the length of the graticule, with a tolerance of $\pm 5\%$ (actual results are usually within half this tolerance). Adjust of C250 (inside the oscilloscope, at rear of the left bank) provides control of the spacing of the first several cycles of the display.

(A further control of the timing on this range consists of changing the dress, with respect to each other, of the white-with-red-tracer and the white-with-green-tracer wires which leave the TIME/DIV switch by way of grommets near the rear of the switch. However, this change also affects Step 22, which must then be rechecked.)

24. To check operation of sweep-triggering circuits.--Settings:

<u>VOLTS/DIV</u> (black)--0.1.	<u>TRIGGER</u> (black)--+INT.
<u>VOLTS/DIV</u> (red)--CW.	<u>TRIGGER</u> (red)--AC.
<u>AC-DC</u> --AC.	<u>TRIGGERING LEVEL</u> --MS.
<u>TIME/DIV</u> (black)--500 μ sec.	<u>CALIBRATOR</u> --0.1 volt.
<u>TIME/DIV</u> (red)--CW.	<u>MAG.</u> --X1.

- a. Connect CALIBRATOR to INPUT, obtaining 1 major division of vertical deflection. Adjust STABILITY for a stable display, making any necessary changes in TRIG. LEVEL to accomplish this. A stable, triggered display should be obtained as the TRIGGER (black) knob is switched from +INT to -INT and back. It may be necessary to readjust TRIG. LEVEL in order to get reliable triggering on both +INT and -INT. If resulting setting of TRIG. LEVEL is other than MS, loosen TRIG. LEVEL knob on its shaft and set it to MS when reliable triggering is obtained on both +INT and -INT.
- b. Triggering should be obtained on both +INT and -INT settings of TRIGGER

(black) knob, even when the vertical deflection is reduced to about 1 minor division. However, for such small signals, it may be necessary to readjust TRIG. LEVEL when switching from +INT to -INT or vice versa, in order to maintain reliable triggering.

- c. Use about 1 major division of vertical deflection from calibrator. Have TRIG. LEVEL at MS, and do not disturb this control during this part of the step. Center the display vertically on the screen. Set STABILITY for a stable display. Now switch the TRIGGER (red) control to DC. If the trace no longer appears, adjust VERTICAL POSITION to obtain trace. When the trace reappears, it should not be off center by more than 2 major divisions in the vertical direction.
- d. Turn TRIGGER (red) control to AUTO. Adjustment of the STABILITY control should produce a stable display.
- e. Turn TRIGGER (black) control to +LINE. Have TRIGGER (red) control on AUTO. Set TIME/DIV (black) control on 2 millisecc, and VOLTS/DIV (black) control to 10. Instead of connecting INPUT to calibrator, connect INPUT to source of a few volts of 60-cps signal. (This may be, for example, the heater voltage of one of the tubes in the oscilloscope—or, in many cases, sufficient induced 60-cps voltage is obtained simply by taking the end of the INPUT lead in the hand.) A stable display should be obtained by adjusting the STABILITY control. Switching the TRIGGER (black) knob to -LINE should reverse the polarity of this display.

f. Use these settings:

VOLTS/DIV (black)—0.1.
VOLTS/DIV (red)—CW.
AC-DC—AC.
TIME/DIV (black)—500- μ sec.
TIME/DIV (red)—CW.

TRIGGER (black)—+INT.
TRIGGER (red)—AC.
TRIG. LEVEL—MS.
CALIBRATOR—0.1 volt.
MAG.—XI.

Check the polarity of the TRIGGER (black) control on +INT and -INT positions. The leading edge at the left end of the display 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.

- g. Increase CALIBRATOR output to 0.2 volt. Connect the calibrator to both the INPUT connector and the TRIG. INPUT connector. In a manner similar to that of Part f of this step, check the polarity of the TRIGGER (black) control on +EXT and -EXT positions. Leading edge at left end of display should be a rising edge when the switch is in the +EXT position, and vice versa.
25. To check HORIZ. INPUT circuit.—After completing Step 24, return the TRIGGER (black) control to the +INT position. Have the calibrator connected to the HORIZ. INPUT terminal (at the rear of the oscilloscope) only. Turn the MAG. control to the HORIZ. INPUT position. Turn the HORIZ. INPUT control (at rear of oscilloscope) to the CW position. Set the calibrator to deliver 10 volts. A horizontal deflection of not less than 6-2/3 major divisions should be obtained, controllable by the HORIZ. INPUT control.

26. To check CRT CATHODE circuit.--After completing Step 25, turn the MAG. control to the X1 position. Remove the jumper between the CRT CATHODE terminal (at the rear of the oscilloscope) and ground. Remove the calibrator lead from the HORIZ. INPUT terminal, and connect the calibrator (set for 10 volts) to the INPUT connector only. Obtain a stable display. Now connect the calibrator also to the CRT CATHODE terminal. If the INTENSITY is not set too high, a very noticeable decrease in brightness of the top of the square wave, and a corresponding increase in brightness at the bottom, should occur.

Now replace the jumper between the CRT CATHODE terminal and ground.