INSTRUCTION MANUAL

Serial Number _____

TYPE 661 OSCILLOSCOPE

Tektronix, Inc.
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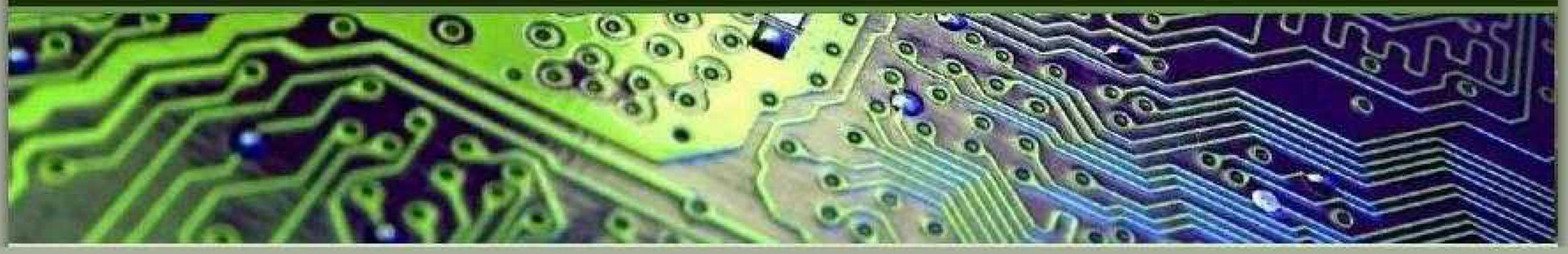


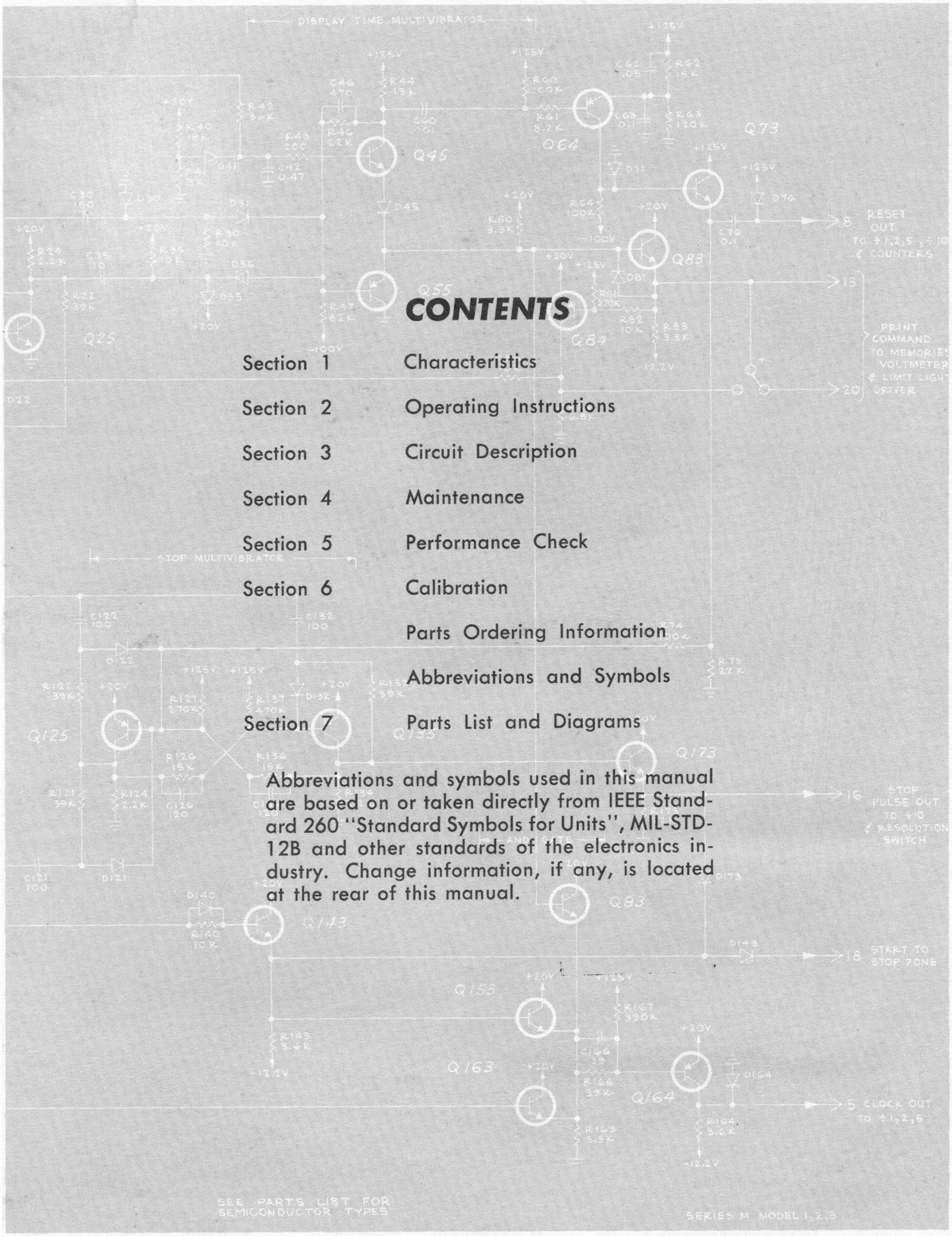
WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial or Model Number with all requests for parts or service.

Specifications and price change privileges reserved.



CONTENTS

Abbreviations and symbols used in this manual are based on or taken directly from IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

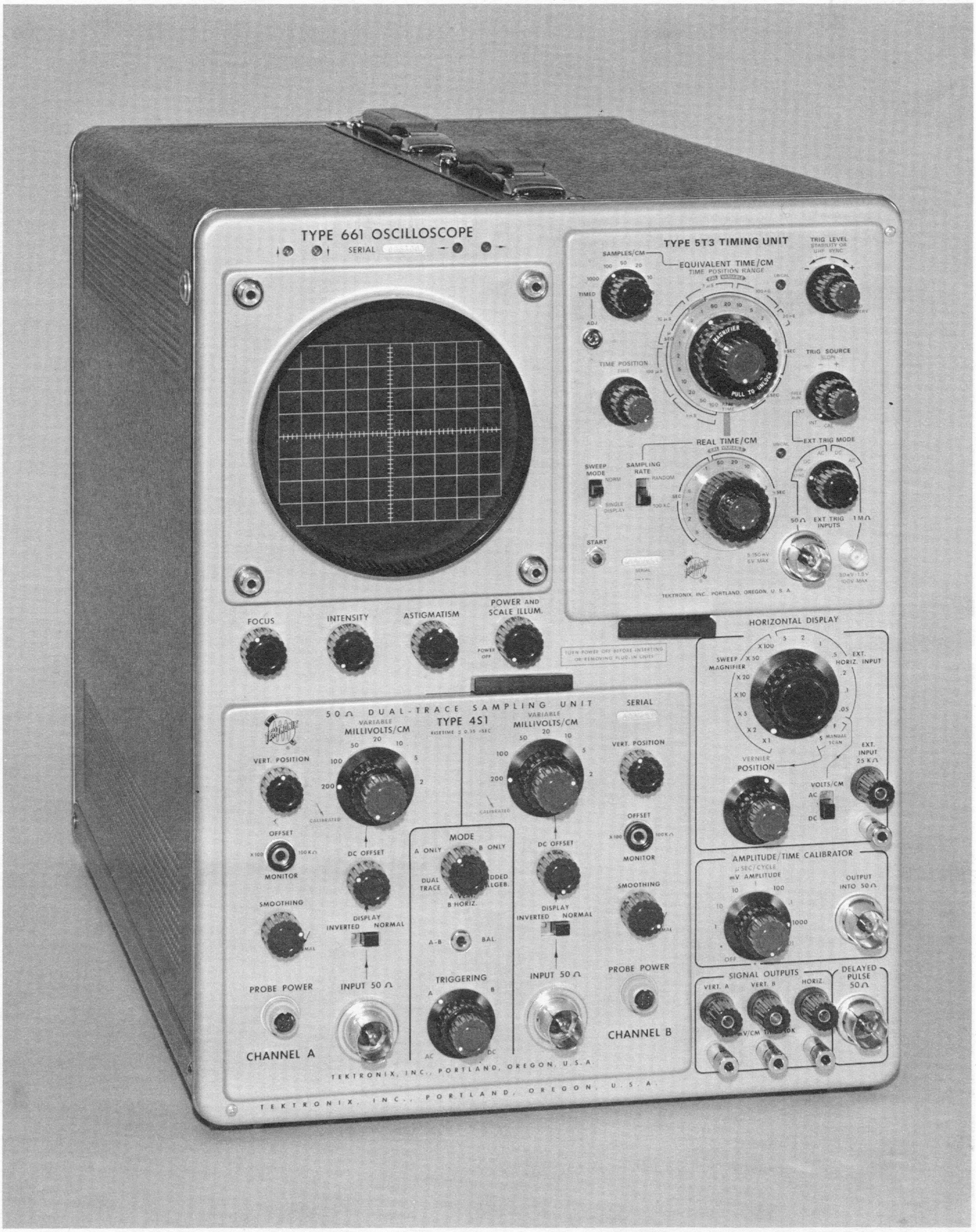


Fig. 1-1. Tektronix Type 661 Oscilloscope.

SECTION 1
CHARACTERISTICS

General Information

The Tektronix Type 661 Oscilloscope is intended for use with two associated plug-in units in a self-contained fractional nanosecond sampling system.[1]

The Type 661 is an indicator unit with power supplies for the vertical and horizontal plug-in units. It contains vertical and horizontal CRT deflection-plate drivers, a sweep magnifier, and an external horizontal input. Auxiliary circuits offer front-panel amplitude and time references, output signals from both the vertical and horizontal systems, and a delayed fast-rise pulse occuring soon after the beginning of each sweep. The delayed pulse can be used to check the vertical sampling unit risetime (in instruments SN 270 and up), with the exception of the Type 4S2A.

Input Characteristics

The vertical system of the Type 661 can be driven by any of the Tektronix '4' Series sampling units. The equivalent bandwidth, risetime, vertical deflection factor, and input impedance is a function of the individual plug-in unit in use.

The horizontal system of the Type 661 can be driven by any of the Tektronix '5' Series timing units or by an external input terminal at 25 kΩ input resistance. Individual timing unit sweep rates determine the Type 661 equivalent or real-time sweep rate per centimeter.

External Horizontal Input - External horizontal input sensitivity of 0.05 to 5 volts/cm in seven calibrated steps, either AC or DC coupled. Sampling and timing plug-in units must be in place for the external signals to provide horizontal scanning. External horizontal signals cannot be applied to to horizontal amplifier when the vertical unit MODE switch is at A VERT. B HORIZ.

Front-Panel Characteristics

Sweep Magnifier - ×1, ×2, ×5, ×10, ×20, ×50, and ×100 magnification, symmetrical about the CRT center. When using the magnifier, the time per sampling dot remains the same as at ×1.

Horizontal Position - Coarse and fine POSITION controls shift the display one CRT diameter about its center (unmagnified), and the total trace can be shifted into view on all ranges of sweep magnification.

Manual Scan - Two positions of the HORIZONTAL DISPLAY switch permit the sampling display to be horizontally scanned by rotation of the POSITION controls. Choice of slow or fast rates of change. The slow rate of change may be required when the output waveforms drive a pen recorder.

Amplitude/Time Calibrator - A clipped sine-wave signal with the following tolerances:

Amplitude	at 10, 1 and 0.1 μSEC/CYCLE	at 0.01 μSEC/CYCLE
1000 mV	±2%	±8%
100 mV	±4%	±9%
10 mV	±5%	±10%
1 mV	±6%	±11%
Time per cycle	±0.2%	±2%

For instruments having serial numbers from 101 through 1999, the Calibrator sine-wave ouput is not clipped.

Delayed Pulse—SN 3460-up. A tunnel diode pulse generator which delivers a fast rise pulse that begins at zero and steps to approximately —260 mV when the external load is 50 Ω. Output impedance is 50 Ω. 10% to 90% risetime at the output connector is ≤70 ps. The signal risetime will appear as 130 ps when the vertical unit is a Type 4S2A and the connecting cable is either RG 58/U with a 2 ns signal delay, or RG 213/U with a 5 ns signal delay. Each cable must have GR 874 connectors.

Pulse steps negative at a time that permits it to be viewed by each sampling unit: about 10 ns after free run sweep starts when using a Type 4S2A or Type 4S3, and about 55 ns after free run sweep starts when using a Type 4S1.

Pulse flatness eviation is ≤ ±2% from 6 ns after the pulse reaches 100% amplitude to at least 400 ns, when displayed by a Type 4S2A.

Delayed Pulse—SN 101-3459. A tunnel diode pulse generator that delivers a fast pulse of at least 350 mV, offset by about 200 mV DC into 50 ohms. Risetime at the connector, 150 ps or less (for instruments with serial numbers 270 and up). The pulse occurs about 50 ns after receipt of a trigger from the timing unit. Risetime appears at about 380 ps or less viewed by a Type 4S1 or Type 4S3, and about 180 ps or less viewed by a Type 4S2A. For instruments with serial numbers 101 through 269, risetime at the Delayed Pulse connector is 190 ps or less, appearing as about 390 ps with a Type 4S1 or Type 4S3 and about 210 ps with a Type 4S2A.

Signal Outputs - VERT. A, VERT. B, and HORIZ. system signals appear at front-panel terminals at 10 kΩ output impedance. Output amplitude of each signal is 200 mV/cm ±3% referred to the CRT display.

Cathode-Ray Tube

Type - T5030-2.

Phosphor - P2. Others available on special order.

Blanking - Deflection type, DC coupled.

[1]**In instruments SN 101-2829, an external connector provides circuit connections that allow use of a digital unit for readout of time and voltage information from the oscilloscope display.**

Accelerating Potential - Approximately 3000 volts.

Usable Viewing Area - 8 cm vertical by 10 cm horizontal.

Graticule

Illumination - Red or white variable edge lighting.

Marking - 8 vertical and 10 horizontal 1-cm divisions with 2-mm divisions on the centerlines.

Beam Position Indicators

Indicate direction of off-CRT spot or trace. All four lamps will be OFF when spot in near the CRT center.

Power Supplies

Temperature isolation, electronically regulated for stable operation with varying line voltage, load, or temperature. Supplies all operating voltages, plus some DC heater current for added stability with line voltage change.

Ventilation

Forced filtered air. Thermal relay interrupts instrument power in the event of overheating, and restores it after the inside temperature has dropped to a safe level.

Power Consumption

Approximately 445 watts with plug-ins installed.

Construction

Mechanical - Aluminum-alloy chassis and cabinet. Anodized front-panel, blue vinyl paint over textured aluminum cabinet.

Dimensions - Height 17½ inches, width 13 inches, depth 22 inches.

Weight - Approximately 49 pounds.

Accessories

Standard accessories supplied with this instrument are listed in the Mechanical Parts List. For optional accessories, see the current Tektronix, Inc. catalog.

SECTION 2

OPERATING INSTRUCTIONS

CAUTION

ALWAYS TURN OFF INSTRUMENT POWER BEFORE INSTALLING OR REMOVING PLUG-IN UNITS.

General Information

The Type 661 Oscilloscope is a specially designed indicator unit for Tektronix servo-type, slide-back sampling systems. Sophisticated circuitry permits some vertical sampling plug-in units with internal delay lines to contain all the required trigger-pickoff circuitry. Thus, the sampling system can be self-contained without need of external triggering accessories.

Although mechanical tolerances of the plug-in cells and plug-in units have been carefully controlled, you should use reasonable care when inserting or removing plug-in units. Always turn off instrument power when installing or removing plug-in units.

The Type 661 Oscilloscope and associated plug-in units are designed for operator convenience. For many applications, the system can be operated with the same ease as a conventional oscilloscope. The special controls, either required or permitted by the sampling circuitry, are discussed in this section of the manual. Operating procedures for the plug-in units are discussed in their respective manuals. General Applications are included later in this section.

FUNCTION OF CONTROLS

CRT

FOCUS — Used in conjunction with the ASTIGMATISM control to focus the CRT display.

INTENSITY — Adjusts the brightness of the display.

ASTIGMATISM — Used in conjunction with the FOCUS control to obtain a sharply focused display.

POWER AND SCALE ILLUM. — Main AC power on-off switch concentric with graticule scale illumination control to adjust brightness of the graticule markings.

HORIZONTAL DISPLAY

The HORIZONTAL DISPLAY switch serves three functions throughout its sixteen positions of rotation. Seven switch positions serve as the SWEEP MAGNIFIER. Seven switch positions serve as the EXT. HORIZ. INPUT gain control. Two switch positions allow a horizontal MANUAL SCAN of the display.

SWEEP MAGNIFIER — Expands the CRT display horizontally about the graticule centerline. When using the magnifier, the time between samples (dots) remains the same. Thus, the magnifier affects the CRT apparent sweep rate.

EXT. HORIZ. INPUT — Permits changing the horizontal amplifier gain for external horizontal signals. External signals are applied to the EXT. INPUT 25 KΩ connector. The sampling system permits the external horizontal signal to control the rate at which the CRT spot scans the display horizontally. With the HORIZONTAL DISPLAY switch in any EXT. HORIZ. INPUT position, the display can be the same as if internally controlled, but the scanning rate is a function of the rate of change of the external signal. When externally scanning a samped display, the samples per centimeter are not calibrated as when internally controlled.

MANUAL SCAN — Permits the POSITION controls to command the sampled waveform horizontal spot position. Rotation of the POSITION control will not move the display horizontally, but will move the spot, scanning the sampled display at a rate controlled by the operator. In the F position of MANUAL SCAN, the spot position moves at the same rate as the rotation of the POSITION control. In the S position of MANUAL SCAN, capacitance coupling in the circuit prevents the spot from starting or stopping quickly; thus, the spot usually moves more slowly than the rotation of the POSITION control. Scanning slowly with the POSITION control produces a high dot density on the display. The equivalent sweep TIME/CM is the same as when the SWEEP MAGNIFIER is at ×1, and is dependent upon the Timing Unit.

VOLTS/CM AC - DC — A two-position slide switch permitting either AC or DC coupling of the external horizontal input signal. Internal AC coupled time constant is about 25 milliseconds, assuming a zero source impedance external generator.

POSITION and VERNIER — The two POSITION controls permit adjustment of the horizontal position of the trace, or the horizontal position of the spot at the time of no trace. The operating voltage from the POSITION controls is combined with the external horizontal input voltage to control the spot position. Thus, an external scanning voltage can be correctly positioned to present the desired display.

AMPLITUDE/TIME CALIBRATOR

μSEC/CYCLE — Six-position switch with four active positions that select the frequency-determining components of the AMPLITUDE/TIME CALIBRATOR.

mV AMPLITUDE — Four-position switch that selects the proper attenuator for setting the output amplitude of the AMPLITUDE/TIME CALIBRATOR.

FUNCTION OF CONNECTORS AND TERMINALS

EXT. INPUT 25 KΩ — Input terminal for external horizontal scanning voltages, with the HORIZONTAL DISPLAY switch in one of the EXT. HORIZ. INPUT positions. The external input resistance is 25,000 ohms. (See Circuit Description, for additional details.)

OUTPUT INTO 50 Ω — 50-ohm General Radio Type 874 coaxial connector that is the output terminal of the AMPLITUDE/TIME CALIBRATOR.

SIGNAL OUTPUTS: 200 mV/CM THRU 10 K

VERT. A — A real-time replica of the vertical plug-in unit Channel A output signal, directly coupled from within the vertical unit before any position, dual-trace, or chopping signal. Includes any DC offset information. Can be used with the horizontal output to drive a pen recorder in a repetitive, single display, or manual scan mode.

VERT. B — A real-time replica of the vertical plug-in Channel B output signal. Function is identical with VERT. A terminal.

HORIZ. — A directly coupled real-time staircase signal from the output of the horizontal preamplifier. The ouput voltage goes negative as the spot moves to the right.

DELAYED PULSE 50 Ω — A 50-ohm General Radio Type 874 coaxial connector that delivers a fast-rise negative step from a tunnel diode pulse generator. Amplitude is approximately —260 mV, starting at zero volts, when external load is 50 Ω. Risetime at the connector is $\leq$ 70 ns. (190 ps or less, SN 101-269). The pulse repetition rate is controlled by the timing unit in use, and occurs about 50 ns after the timing unit is triggered or begins a free-run cycle of the trigger circuit. The DELAYED PULSE 50 Ω output may be used to trigger external equipment. Thus, the Type 661 and its timing unit can serve as a rate generator to initiate external signals that are to be viewed by the sampling system.

Readout Connector (Rear Panel) SN101-2829 Instruments only. — A rear panel jack permits external analog and/or digital readout of sampling displays. The analog information is similar to the signals that appear at the SIGNAL OUTPUTS terminals. A mating Bendix plug can be ordered from your local Tektronix Field Office (Part Number 131-0239-00).

PRELIMINARY INSTRUCTIONS

Cooling

Before operating the Type 661, a suitable location for the instrument must be chosen. The location should provide a stable support, adequate air circulation, and be far enough from walls or other equipment that might block air intake through the filter or the exhaust passage in the cabinet. If the flow of air through the unit is interrupted, overheating may cause a thermal relay to open, shutting down the power until the temperature drops to a safe operating level.

Power Line Voltage Requirements

The Type 661 Oscilloscope can be operated from 110, 117, or 124 volts, or 220, 234, or 248 volts. The only changes necessary to convert from one operating voltage to another are in the wiring of the power transformer primary, the fan motor, and the rating of the fuse. The power transformer used in the Type 661 uses two separate primary windings plus two 6% boost-buck windings. The primary windings are connected in parallel for 117-volt operation and in series for 234-volt operation. Proper connections for each line voltage are shown on the under side of the power transformer and on the Power Supply schematic.

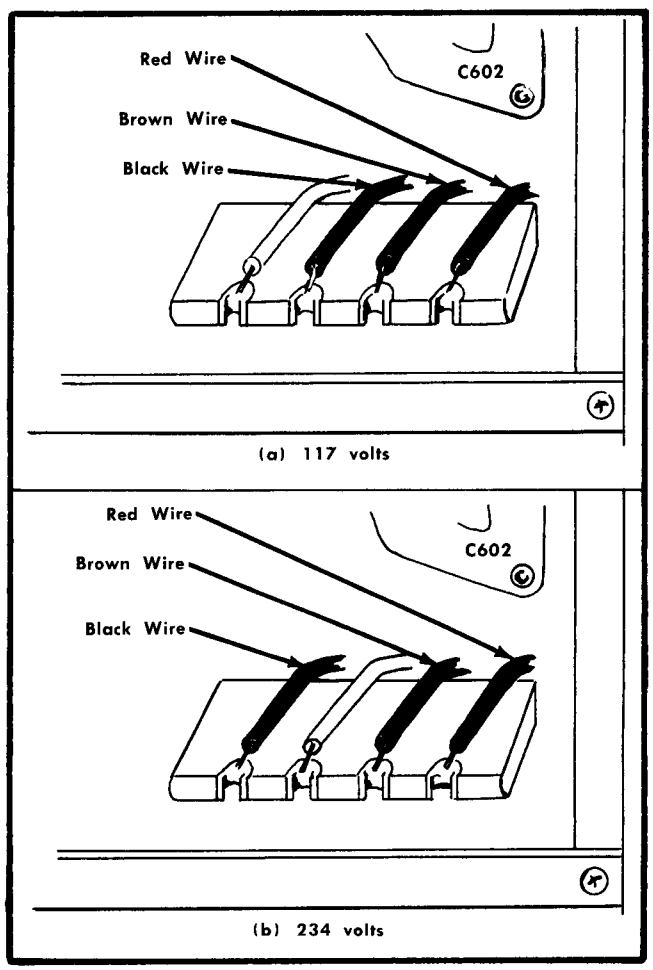


Fig. 2-1. Fan connections for 117- and 234-volt power line operation.

A small metal tag near the power receptacle at the rear of the instrument indicates the line voltage for which your unit was wired at the factory. If wired for 117-volts, the instrument will operate properly with line voltages between 105 and 125 volts, RMS. If wired for 234 volts, the instrument will operate properly from approximately 210 to 250 volts, RMS.

To change the power transformer connections for operation on another line voltage, change the location of the bare wire straps at the primary terminals. It is not necessary to move any of the plastic insulated wires. Place the new straps in accordance with the marking on the tag located on the power transformer side.

Correct fan motor wiring is illustrated for both 117-volt and 234-volt operation in Fig. 2-1. The ceramic strip shown in Fig. 2-1 is located on the right side near C602.

Fuse Data

Fuse data for proper power transformer protection is indicated on the rear panel adjacent to the fuse holder. Always use the correct fuse.

Time Delay

A time-delay relay in the Type 661 delays operation of the power supply DC voltages for about 30 seconds after the power switch is turned on. The delay allows a brief tube-warmup period before the DC operating voltages are applied. After the relay closes, some plug-in heater circuits require an additional warmup time before the total sampling system is ready for operation.

If the AC power is interrupted for longer than about one quarter of a second, the normal 30-second delay will recur before the power supplies will be turned on again.

Graticule

The graticule illuminated by two incandescent lamps located at the top edge of the graticule. The POWER AND SCALE ILLUM. control reduces the brightness of the graticule markings when rotated clockwise. The graticule can be inverted, permitting a choice of either red or white graticule coloring. White graticule lines are usually best for photographing CRT displays.

FIRST TIME OPERATION

General

When a suitable operating location has been chosen, set the POWER AND SCALE ILLUM. control to the POWER OFF position and connect the instrument to an appropriate source of power.

Be sure to observe the "power off" caution on the Type 661 front panel before inserting a plug-in unit. Otherwise, you will subject the plug-in units to possible semiconductor damage.

With the power OFF, place the desired '4' Series sampling unit in the larger cell under the CRT, and the desired '5' Series timing unit in the upper cell to the right of the CRT. Begin plug-in insertion by placing the gray locking latch perpendicular to the oscilloscope front panel, then push the plug-in unit into the cell as far as possible by hand. Move the locking latch flush with the panel to lock the plug-in unit in place.

To remove a plug-in unit, first turn the power off, then move the gray locking latch perpendicular to the front panel, and withdraw the unit by hand.

Checking Plug-In Unit Accuracy

The Type 661 Oscilloscope contains an AMPLITUDE/TIME CALIBRATOR to permit quick checks on the vertical sensitivity and horizontal timing accuracies. See the Characteristics section of this manual for the AMPLITUDE/TIME CALIBRATOR accuracies.

NOTE

On the assumption that the sampling system in use consists of the Type 661 Oscilloscope, a Type 4S1 Dual-Trace Sampling Unit, and a Type 5T3 Timing Unit, the following paragraphs on first time operation will be of value. (If other plug-in units are involved, see the individual unit instruction manual for first time operation informaton.)

The Type 661 Oscilloscope, and its plug-ins have been independently factory calibrated before shipment. The Type 661 vertical and horizontal amplifier deflection factors have been correctly calibrated and are not to be adjusted except by following the calibration procedures in this manual. The system, as received, should be assembled and checked for proper gain and timing before relying upon the overall sampling system for critical amplitude or time measurements.

Front-panel control settings should be:

Type 4S1

MODE	A ONLY
'A' POSITION	Midrange
'A' SMOOTHING	Clockwise
'A' MILLIVOLTS/CM	200
'A' VARIABLE	CALIBRATED (at detent)
'A' DISPLAY	NORMAL
TRIGGERING	A-AC
DC OFFSET	Set to zero with voltmeter connected to OFFSET MONITOR jack.

Other controls may be in any position.

Type 5T3

EQUIVALENT TIME/CM	10 nSEC
VARIABLE	CALIBRATED (at detent)
SWEEP MODE	NORM
TRIG SOURCE	FREE RUN
SLOPE	—
TIME POSITION	Fully clockwise
TRIG LEVEL	Midrange
SAMPLES/CM	100
STABILITY OR UHF SYNC	Midrange

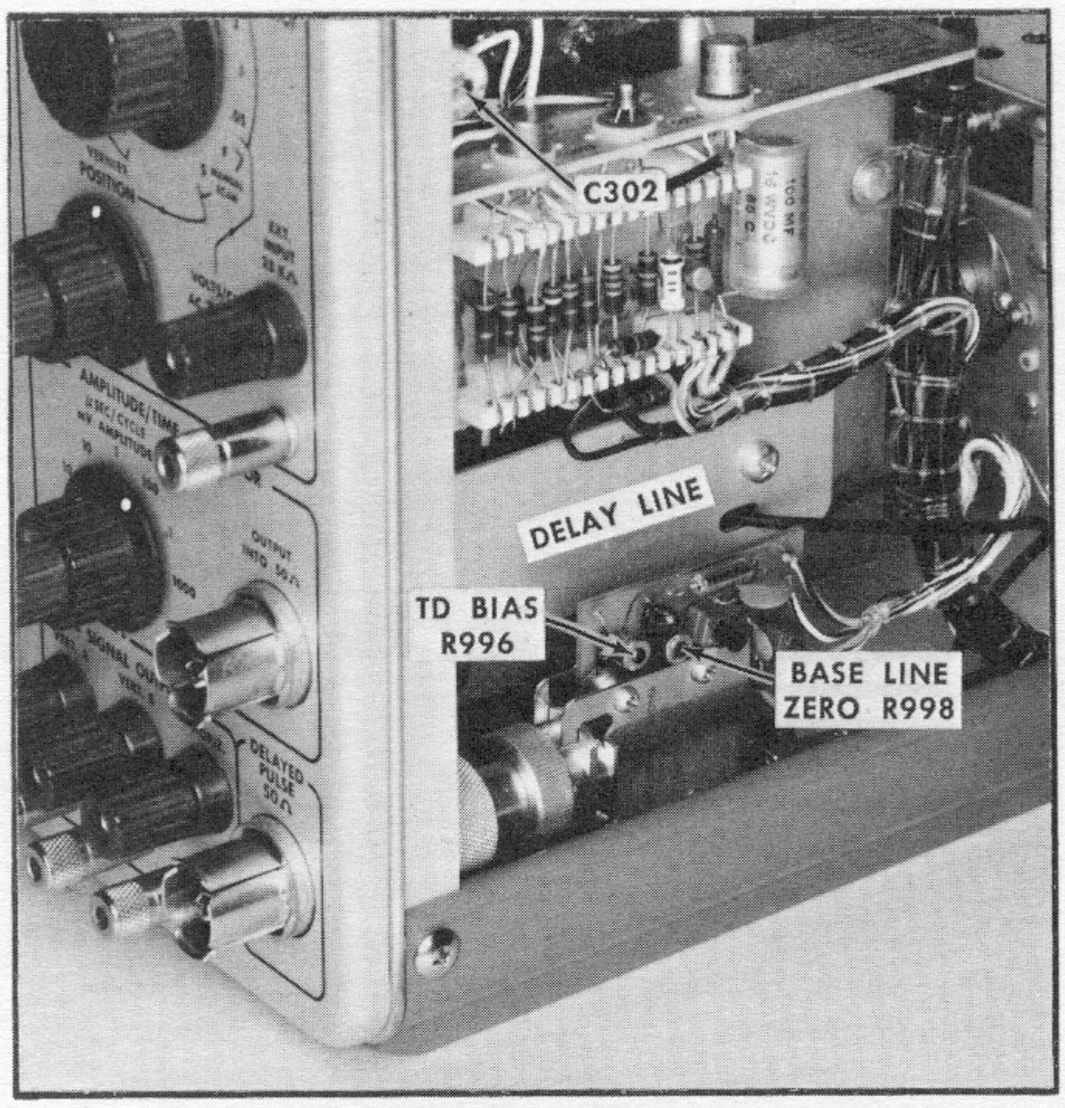


Fig. 2-2A. Delayed Pulse Generator, SN 3460-up.

The Type 5T3 control settings will produce a free-runnning trace.

Type 661

HORIZONTAL DISPLAY	×1
FOCUS	Midrange
INTENSITY	About 3 o'clock
ASTIGMATISM	Midrange
AMPLITUDE/TIME CALIBRATOR	OFF

It may be necessary to change the setting of the CRT controls for proper focus and intensity.

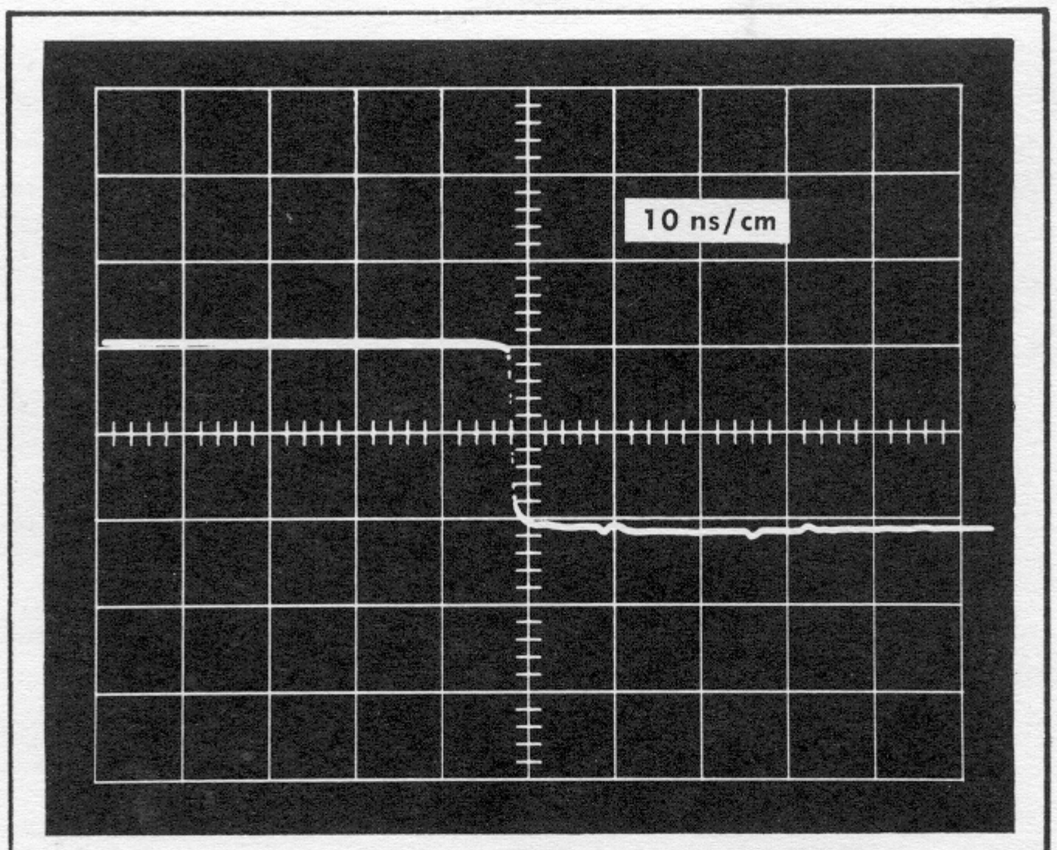
NOTE

The alignment of the CRT trace is partially a function of the earth's magnetic field. The alignment will change if the location of the instrument is changed, and will even vary slightly with a 90-degree change in position of the instrument. To align the trace, remove the left side panel and locate the red CRT rotation knob (part of the CRT mounting clamp). Rotate the CRT until the trace aligns with a horizontal graticule marking. This adjustment should be made when the instrument is in its most probable operating location and position.

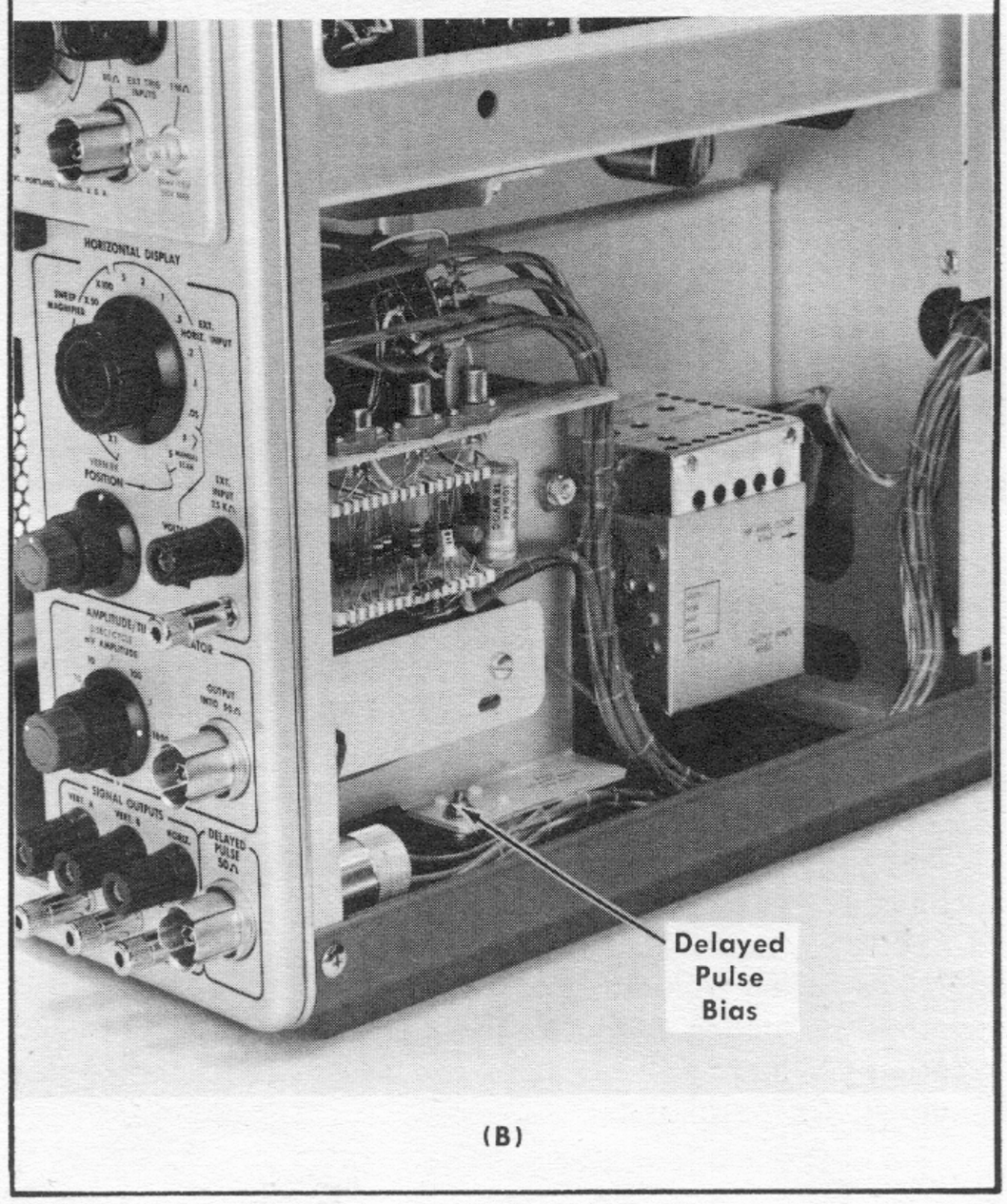
1. Check the DELAYED PULSE Generator Operation

Connect a short length of 50-ohm cable between the Type 661 DELAYED PULSE generator and the Type 4S1 Channel A input connector. Do not use an attenuator.

The display should now be a negative-going step of about two centimeters vertical amplitude, 40 to 60 nanoseconds after the start of the sweep. See Fig. 2-2A. It may be necessary to adjust the TIME POSITION (DELAY) or the vertical and horizontal POSITION controls to center the display. If there is no step signal, remove the Type 661 right side panel and locate the DELAYED PULSE GEN. BIAS potentiometer (R990) at the lower side near the front panel. See Fig. 2-2A and Fig 2-2B. Adjust it for a CRT display similar to Fig. 2-2A.



(A)



(B)

Fig. 2-2B. Delayed pulse waveform and R990 adjustment location, instruments up to SN 3459.

NOTE

Perform this check on instruments up to and including SN 3459.

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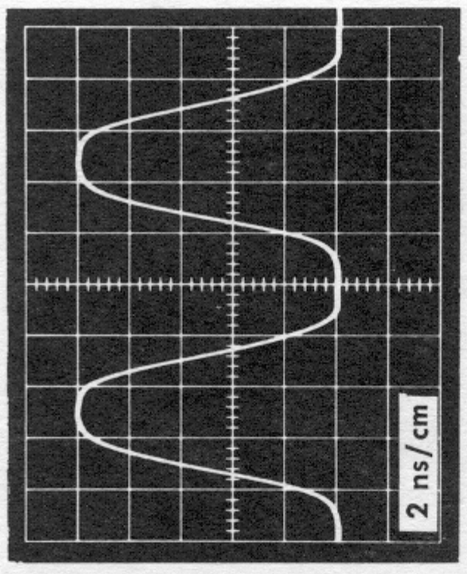
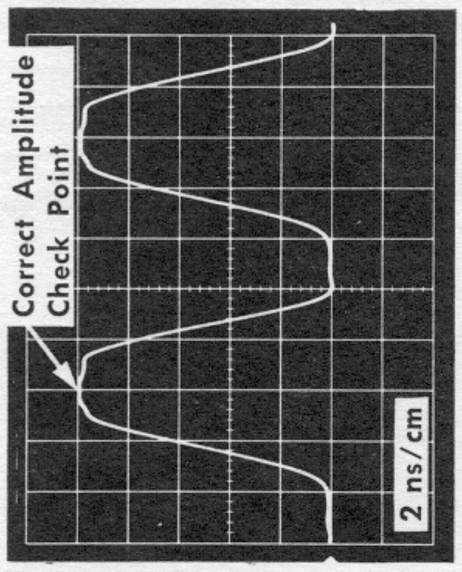
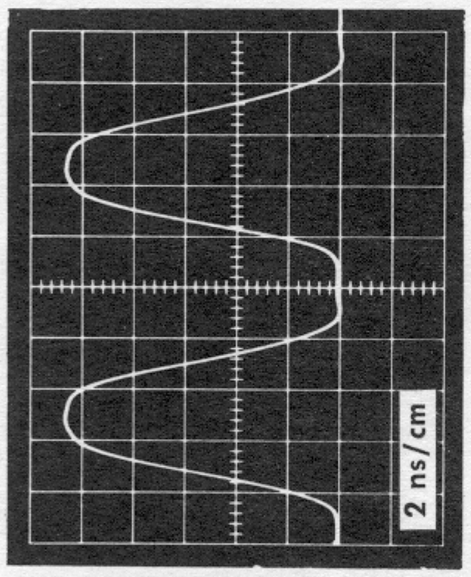
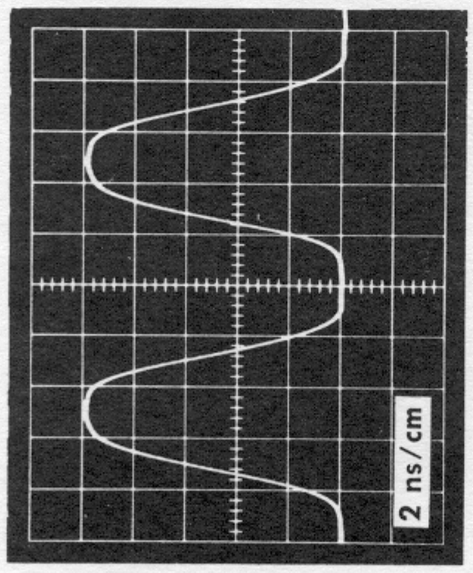
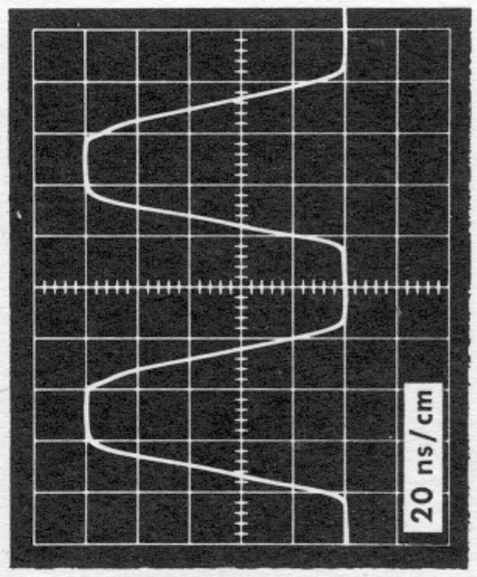
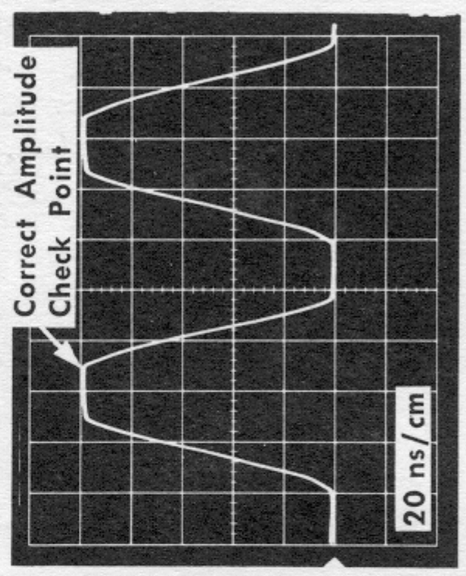
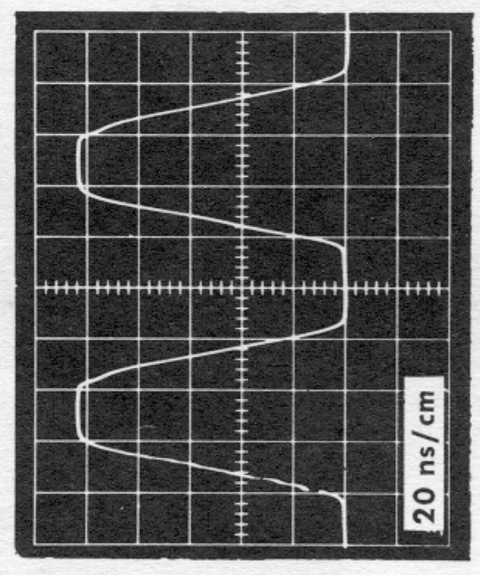
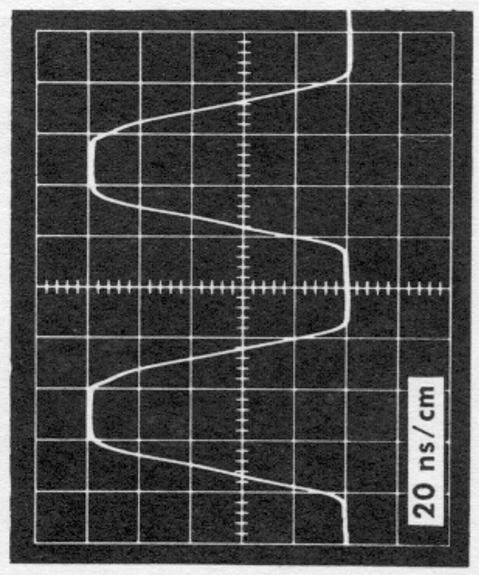
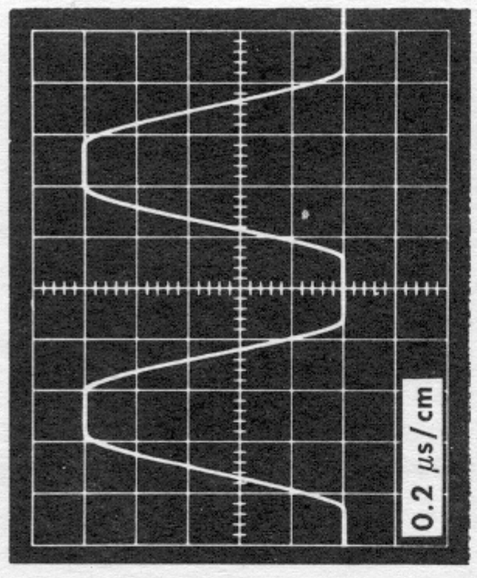
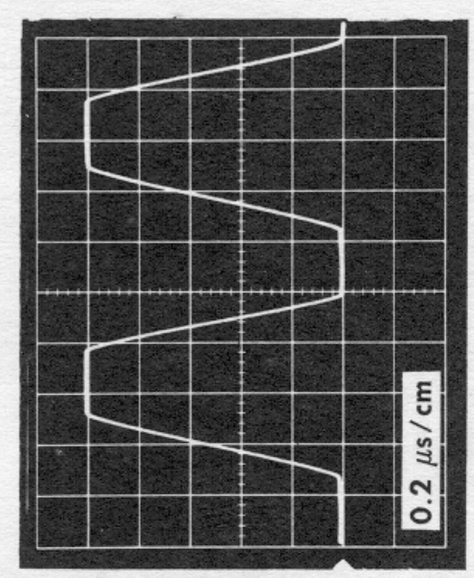
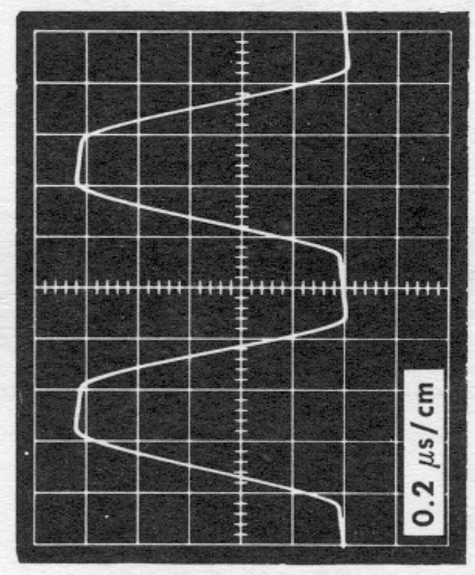
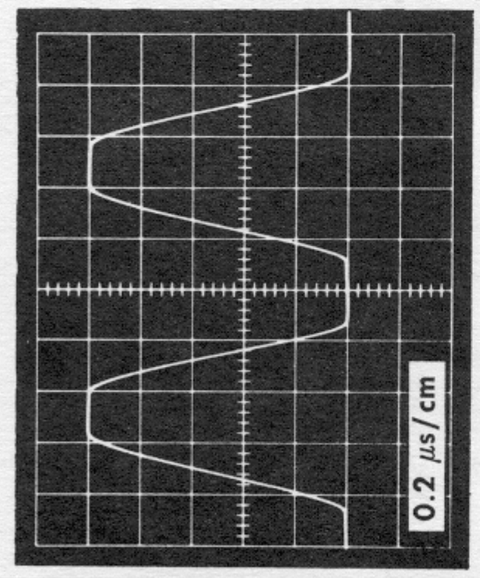
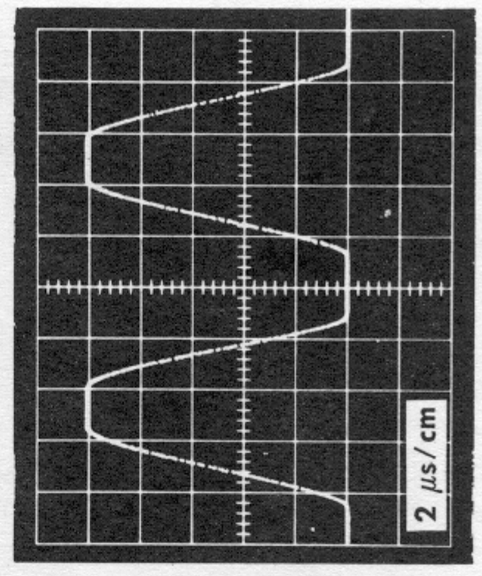
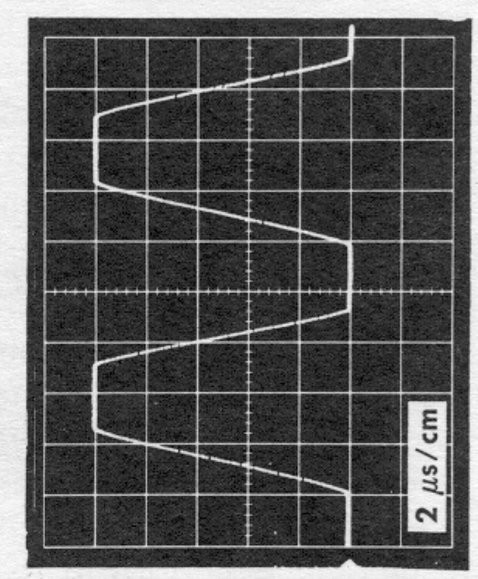
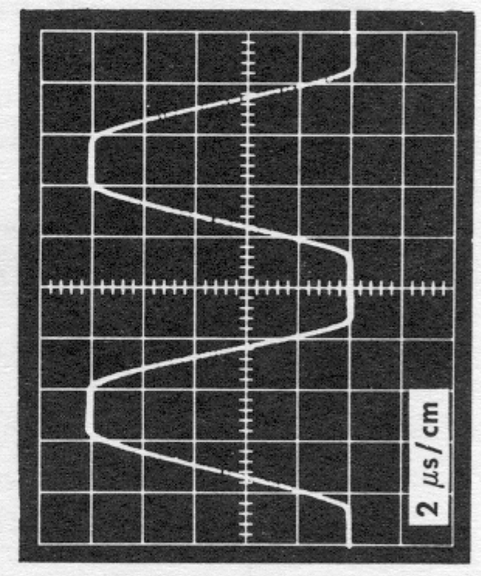
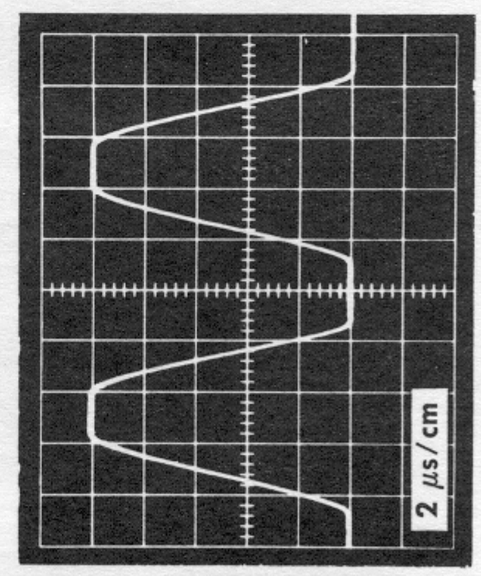
.01 (100 MHz)				
.1 (10 MHz)				
1 (1 MHz)				
10 (100 kHz)				

Fig. 2-3. Typical 1000 mV Amplitude/Time Calibrator displays as viewed with various vertical plug-in units. (This illustration applies only to Type 661 Oscilloscopes with serial numbers 2000 and above.)

2. Check the Type 4S1 Channel A Gain

Disconnect the cable from the DELAYED PULSE generator and connect it to the AMPLITUDE/TIME CALIBRATOR. Set the AMPLITUDE/TIME CALIBRATOR controls to .1 μSEC/CYCLE and 1000 mV AMPLITUDE. Set the Type 5T3 EQUIVALENT TIME/CM switch to .1 μSEC and TRIG SOURCE switch to CAL.

The front-panel screwdriver adjust control labeled A-B BAL. is the Channel A gain control. The panel is labeled A-B BAL. to indicate that the control permits a small adjustment of the Channel A gain when operating the Type 4S1 in the Added Algebraic mode. This control does not affect the Channel B gain.

Adjust the Type 5T3 TRIG LEVEL control to obtain a stable, triggered display. The display should now be a 10 MHz calibrated waveform, with a peak-to-peak vertical amplitude of 5 centimeters (±3%). Adjust the A-B BAL. control if the display is other than 5 centimeters.

NOTE

The appearance and amplitude of the calibrator signal may seem to change slightly with frequency and with the type of vertical plug-in unit used. In general, these changes are due to normal characteristics of the input cable and the vertical plug-in unit. It is important to keep these characteristics in mind when viewing any input signal in order to correctly interpret the display. Fig. 2-3 shows typical displays of the calibrator waveform with the calibrator circuit and the plug-in units all correctly calibrated.

3. Check the Type 4S1 Channel B Gain

Set the Channel B controls identical to the Channel A controls, the Type 4S1 MODE switch to B ONLY, and the TRIGGERING controls to B and Ac. Measure and adjust the OFFSET MONITOR to zero volts. Move the 50-ohm cable to the Channel B input connector.

If the vertical display is not within 3% of 5 centimeters, remove the left side panel and adjust the internal B CAL. control. The B CAL. control is located at the top rear of the Type 4S1 plug-in unit. Reach in from the top with a long insulated screwdriver, and adjust B CAL. for exactly a 5-centimeter vertical display.

4. Check the Type 5T3 Basic Timing

Leave the Type 5T3 EQUIVALENT TIME/CM at .1 μSEC and the Type 661 AMPLITUDE/TIME CALIBRATOR at .1 μSEC/CYCLE and 1000 mV AMPLITUDE.

The CRT display should now be a 10 MHz calibrator waveform with one cycle each horizontal centimeter. Tolerance with this test method is ±3%. If the timing is inaccurate, refer to the Type 5T3 Instruction Manual for procedure to adjust the timing.

Check the sweep timing through the range of the Type 5T3 EQUIVALENT TIME/CM switch as indicated in Table 2-1.

TABLE 2-1

EQUIVALENT TIME/CM	AMPLITUDE/TIME CALIBRATOR	Display
.1 μSEC	.1 μSEC/CYCLE	1 cycle/cm
2 nSEC	.01 μSEC/CYCLE	1 cycle/5 cm
10 nSEC	.01 μSEC/CYCLE	1 cycle/cm
1 μSEC	1 μSEC/CYCLE	1 cycle/cm
10 μSEC	10 μSEC/CYCLE	1 cycle/cm

With the checks just completed, the Type 661, Type 4S1, and Type 5T3 are calibrated as a unit within 3% vertically and horizontally. Replace the Type 661 side panels.

Both the vertical and horizontal systems can be made more accurate with external voltage and time references. For example, using the DC OFFSET with an accurate high impedance meter, vertical signals can be measured within 1%. Thus, the above system of gain calibration is not the ultimate. For the greatest accuracy, use the calibration procedure for the appropriate plug-in unit.

Operating the AMPLITUDE/TIME CALIBRATOR

The AMPLITUDE/TIME CALIBRATOR is a self-excited oscillator with both an external and internal signal output. The internal signal is coaxially coupled to the timing unit plug-in cell to provide internal triggering of the sampling display.

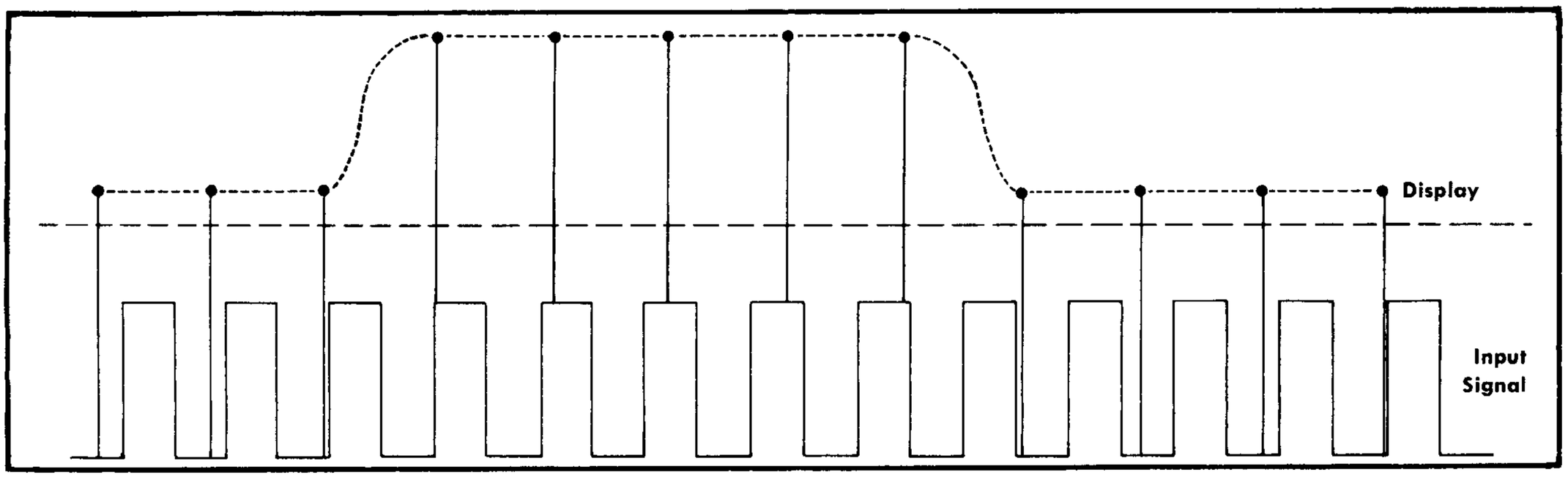


Fig. 2-4. Displaying an input signal by means of the sampling technique. The level of the display is altered only when the display level changes between samples. After the display level has been corrected, the CRT is turned on to show the new waveform level. A large number of sampling dots make up the CRT display.

The internal signal amplitude is independent of the front-panel mV AMPLITUDE control permitting stable triggering even in the 1-mV position. Turn the calibrator off when not being used to avoid display-time jitter.

The AMPLITUDE/TIME CALIBRATOR will operate independently of the sampling system and therefore can be employed as a signal generator for other applications. However, the calibrator accuracy listed in the Characteristics Section of this manual applies only when the calibrator load is 50 ohms.

Operating the DELAYED PULSE Generator

The DELAYED PULSE generator is a tunnel-diode step generator operated by the timing unit each time a signal is sampled. Free run the timing unit to use the DELAYED PULSE generator to check the vertical unit risetime, or to trigger an external system. Because the free run repetition rate of the timing unit trigger circuit controls the rate generator function, see the individual timing unit instruction manual for the DELAYED PULSE repetition rates at various sweep rates.

GENERAL APPLICATIONS

General applications for the Type 661 indicator can be accomplished with any present or future '4' Series vertical or '5' Series horizontal plug-in units. Applications for particular plug-in units are discussed in the individual plug-in unit instruction manuals.

External Control of the Sampling Display

As mentioned in the discussion of control functions, the EXT. INPUT 25 kΩ connector can receive external scanning signals. The normal sampling system operates on repetitive signals, viewing the signal repeatedly but at a slightly later time for each sample. Thus, the CRT display is a reconstructed waveform made up of bits of the original repetitive signal. Fig. 2-4 illustrates the normal equivalent time sampling concepts.

It is essential to a sampling system for the input signal to be repetitive. If the signal is a series of pulses, they may occur at random intervals (as in the use of an ordinary oscilloscope). A normal sampling display is a long-time reconstruction of a real-time signal, with a large real-time difference expressed as an equivalent time. The rate at which an equivalent-time display reconstructs the real-time waveform is controlled by (a) the signal repetition rate and (b) the number of samples per centimeter. The number of samples per centimeter can be controlled by the timing unit, the horizontal POSITION control for manual scan, or by an external horizontal voltage. Thus, the length of time required to reconstruct the equivalent time display does not necessarily bear a relationship to the real-time signal. (The Type 5T3 allows real time sampling for some sweep rates.)

After obtaining a sampling display, setting the HORIZONTAL DISPLAY switch to any of its EXT. HORIZ. INPUT positions permits the display to be scanned at a rate different from the timing unit.

As an example, the following steps will help you understand an externally scanned sampling display:

1. Coaxially couple the DELAYED PULSE to the vertical sampling unit.

2. Free-run the timing unit at 2 nSEC/CM.

3. Set the SWEEP MAGNIFIER at ×1 and position the start of the trace at the left edge of the graticule. With the timing unit TIME POSITION control, position the delayed pulse step to the center of the graticule.

4. Set the HORIZONTAL DISPLAY switch to the 2 EXT. HORIZ. INPUT position. The trace should disappear. The spot will be off the left edge of the graticule as indicated by the horizontal position indicator lamps.

5. Slowly turn the horizontal POSITION control fully clockwise. The spot will move to the right across the CRT, display the step at the center of the graticule where the original display step occurred, and stop before it reaches the right side of the graticule. The motion of the horizontal POSITION control is identical to introducing a positive-going external signal of about 15 volts.

6. Remove the left side panel and use a patch cord to couple approximately 6.3 volts AC from a graticule scale illumination lamp to the EXT. INPUT 25 kΩ connector.

7. Set the scale illumination at maximum brilliance. Increase the horizontal sensitivity to .5 volts/cm by setting the HORIZONTAL DISPLAY switch to .5 (EXT. HORIZ. INPUT). The display should now appear similar to the orginal internally controlled display, but it is now swept back and forth at a power line frequency rate.

The significant difference between an internally scanned display and the POSITION control scanned display is that the timing unit normally displays each sample as it is taken. For external scanning operation with a DC input, the timing unit continues to sample the incoming signal in a normal manner, but the CRT is permitted to show only one spot, representing one time point of the display. You can imagine that the display is held in the background, and slowly scanned to show where it should be. The vertical and horizontal signal output voltages (SIGNAL OUTPUTS) follow the visible display whether it is internally or externally scanned. In the external scan mode, the signal output voltages follow the display as it is scanned either by the POSITION control or by the external horizontal signal.

Analog X-Y Recording of Nanosecond Displays

External operation of the Type 661 sampling display can be valuable for paper recording of nanosecond waveforms by low-frequency X-Y plotters.

Connecting an X-Y plotter to the proper SIGNAL OUTPUTS terminals can produce a permanent paper record of nanosecond displays. Since most plotters function best on slow waveforms, the display scanning must be slowed down by using either the MANUAL SCAN control or an external scanning voltage. For very complex waveforms where the rate at which the display reconstruction must be externally controlled, the X-Y plotter horizontal system can be used to drive the Type 661 external input at its own most satisfactory rate.

If the Type 661 drives both the vertical and horizontal axis of the plotter, it may be necessary to invert the HORIZ. output signal. The HORIZ. output signal goes negative as the spot moves to the right. The VERT. output signals may not need inversion since the vertical voltage goes positive as the spot moves up.

SN 101-2829 ONLY

Digital Readout of Nanosecond CRT Displays

The 41-pin Bendix jack on the rear panel of the Type 661 permits digital readout of sampling displays. The schematics show which circuits are included. The rear-panel jack also contains information of an analog nature, similar to the information that appears at the front-panel SIGNAL OUTPUTS terminals. A mating Bendix plug can be ordered from your local Tektronix Field Office (Part Number 131-0239-00).

Viewing Pulses of Statistically Varying Amplitude

The Type 661 and its associated sampling units permits observation of nanosecond pulses of widely varying amplitude, such as those from radiation detectors. Special circuitry must be employed to permit a non-jumbled display. It is necessary to construct your own single-channel pulse height selector. It is necessary to modify your Type 661 if its serial number is 2830 or above. Suggestions for this application can be obtained from the article: "Sampling Oscilloscope for Statistically Varying Pulses" by Robert Sugarman, Review of Scientific Instruments, Nov., 1957, Vol. 28, No. 11.

SECTION 3
CIRCUIT DESCRIPTION

General Information

The Type 661 Oscilloscope consists of five major parts: the low-voltage Power Supply, the CRT Circuits ,the Horizontal Amplifier, the Vertical Amplifier, and the Amplitude/Time Calibrator. Auxiliary circuits are a 50--ohm Delayed Pulse Generator, and the Signal Output terminals.

The low-voltage Power Supply provides regulated outputs of —100, —25.2, —19, +19, +100, and +300 volts DC. —12.6 volts, obtained from the —25.2 volt supply, is used for heater current in cathode-follower probes. The +455 volt unregulated voltage is used by the CRT high-voltage supply, and is available to the sampling and timing cells for possible plug-in use.

The Horizontal Amplifier and the Vertical Amplifier receive information from the appropriate plug-in unit. They are current-sensitive operational amplifiers, used to drive the CRT deflection plates.

The CRT Circuits contain the high-voltage regulated power supply, the CRT, and a blanking mixer. The high-voltage supply provides a nominal 3000-volt accelerating potential for the CRT.

The Amplitude/Time calibrator is a self-excited, self-regulating, Colpitts oscillator controlled by the μSEC/CYCLE and mV AMPLITUDE switches.

The Delayed Pulse generator (Interconnecting Sockets schematic) is an internally triggered tunnel diode step generator, driven by the timing unit just before each sample is taken. Its output is a negative step of about 350 mV, offset by about 200 mV DC into 50 ohms. Risetime is 150 ps or less into 50 Ω at the connector.

LOW VOLTAGE POWER SUPPLIES

General

The Type 661 Oscilloscope regulated power supplies are designed for exceptional short- and long-term stability. Sampling circuitry demands current pulses from the —100, +100 and +300 volt supplies at irregular intervals. Thus, power supply leads and ground return current paths are carefully planned. All non-constant loads are supplied via individual leads from a common point at the output of the regulator circuits, and most grounds are returned to a common point at each regulator. The +300 volt supply reference tube V719 is temperature isolated for short-term stability. The CRT display jitter is maintained at a very low level by use of high-gain feedback amplifiers within each regulator circuit.

Line voltage is applied through fuse F601 and the thermal cutout relay TK601 to the primary windings of the power transformer T601. When the oscilloscope is operated on 117 volts, the fan will remain on in the event the thermal cutout opens. When the oscilloscope is operated on 234 volts, the fan will be turned off if the thermal cutout opens. The thermal cutout automatically restores power to the primary of T601 when the oscilloscope inside temperature drops to a safe level.

Secondary terminals 20 and 21 of T601 energize the thermal time-delay relay K600 that controls the turn-on delay of the low-voltage power supplies when power is applied. As the contacts of K600 close (pins 4 and 9) K601 connects the unregulated supply leads of the —100, +100, and +300 volt supplies to the respective regulator circuits. The —25.2, —19, and +19 volt regulated supplies are not switched by K601. The —25.2 volt supply operates at about —25 to —27 volts before K601 is energized. The —19 volt supply operates at about +15 volts before K601 is energized.

Voltage reference for the —100, —19, +19, +100, and +300 volt regulated supplies is V719, a gaseous voltage-regulator tube in the +300 volt supply. Voltage reference for the —25.2 volt regulator supply is a Zener diode, D643, in the —25.2 volt supply. The —12.6 volt supply is a shunt regulator utilizing Zener diode D649. This supply floats on the —25.2 volt supply.

+300 Volt Power Supply

The full-wave bridge rectifier circuit from terminals 9 and 16 of T601 is elevated upon the rectifier system of the +100 volt power supply. The total voltage of the two rectifier systems is about +455 volts at normal line voltage. It is used by both the CRT high-voltage supply and by the +300 volt regulator system. The total load current of the +455 volt unregulated lead and the +300 volt regulated supply passes through the +100 volt rectifier system.

Voltage-regulator tube V719 maintains a fixed reference voltage of about +85 volts at the junction of R718 and R719. R718 is the +300 VOLTS adjustment. The voltage at the grid of V716B is obtained from a divider between ground and the +300 volt supply. A small ripple signal from the +455 volt supply is injected at the grid of V716B via a voltage divider and selected resistor R706. R718 (+300 VOLTS) is adjusted to set the voltage at the grid of V716A essentially equal to the voltage at the grid of V716B. Thus, V716, A and B, act as a voltage comparator; the A grid voltage (properly set by R718) is the reference for the +300 volt supply.

The voltage at the plate of V716A (about +200 volts) is divided by R720-R721 to place the grid of V724 just below ground. V724 amplifies and inverts the signals from V716 and establishes the correct grid voltage for series tube V737, A and B.

If the output voltage changes from +300 volts, a sample of the change is applied to the grid of V716B. The error signal is amplified, without phase reversal, by V716A and

applied to the grid of V724. V724 amplifies and inverts the error signal, applying it to the grids of V737. V737 is a dual cathode follower; the cathodes follow the grid signal, restoring the +300 volt supply to its correct value.

Capacitors C707 and C720 increase the AC loop gain of the regulator circuit. Their function is to couple high-frequency error signals around the dividers to keep the feedback loop gain uniform with frequency. Thus, the supply will quickly compensate for rapid changes of output voltage. C696B, an electrolytic capacitor, aids in lowering the output impedance of the supply.

To assure minimum ripple and line voltage fluctuation in the output of the +300 volt supply, a small amount of ripple from the +455 volt supply is coupled to the grid of V716B. The value of R706 is selected to minimize the supply output ripple and null out any fluctuations when the AC line voltage is at its nominal value of 117 or 234 volts.

To assist in stabilizing the +300 volt supply against ripple and line fluctuation, Zener diode D726 provides a regulated supply voltage for V724. If the unregulated +455 volt bus were to be used as the plate supply voltage for V724, power line fluctuations would be coupled to the grids of V737 and the +300 volt supply leads.

Resistor R737, in parallel with V737, carries part of the current drawn from the +300 volt supply. R737 also provides for some voltage on the +300 volt supply leads (before the time delay relay closes) to turn on the —25.2 volt supply as soon as the AC power is turned on.

Resistors R731 and R733, located in the cathode circuit of V737, divide the load current between the two halves of the tube, avoiding the possibility of one side being overloaded while the other side does not carry its share of the load.

Due to careful reduction of ground currents, and by use of the special circuit design just discussed, the +300 volt supply output contains 120 Hz (60 Hz line) ripple of less than 14 millivolts, peak to peak. Normal load variations can be as great as 200 mA, ranging from a minimum of 50 mA to a maximum of over 250 mA.

+100 Volt Power Supply

A full-wave bridge rectifier circuit from terminals 7 and 14 of T601 supplies power to the +100 volt regulator circuit and to the +300 volt power supply rectifier system.

A voltage divider between the +100 volt regulator output and —100 volts, supplies a voltage near ground to the grid of error amplifier V694. If the supply voltage changes, a portion of this change is applied through the divider to the grid of V694. The error signal is then amplified and applied to the grid of series regulator tube V697. The change in voltage at the grid of V697 changes the voltage drop across V697, compensating for the change of the supply voltage.

A small amount of ripple from the unregulated lead of the +100 volt rectifiers is coupled to the grid of V694 via selected resistor R694. The ripple is amplified and used to cancel almost all of the ripple at the output of the regulator. Normal load variations are from a minimum of about 30 mA to a maximum of about 130 mA.

For instruments with serial numbers 900 and above, the output voltage of the +100 volt supply is adjusted by R686.

—100 Volt Power Supply

The —100 volt regulator supply has a comparator-amplifier in the feedback circuit. The greater amount of feedback gain obtained by using both a comparator and a pentode amplifier keeps the output ripple to a value less than about 14 mV with a load of 200 mA or more.

To assure that V624 has an adequate plate supply voltage, neon glow tube B627 serves as a DC step-down to the grids of V637. The signal of V624 can then be at a higher DC level than required by the grids of V637, without attenuation of error correcting signals. Capacitor C627 assures that high-frequency correcting signals are not attenuated by the slow following action of V627.

The operation of the regulator circuit is similar to the operation of the +300 volt regulator circuit previously discussed.

—25.2 Volt Power Supply

A full-wave bridge rectifier circuit from terminals 20 and 21 of T601 supplies power to the —25.2 volt regulator circuit. The —25.2 volts regulator then supplies power to the —19 volt power supply and the —12.6 volt probe power Zener diode regulator D649. The —25.2 volt power supply provides heater current for the vacuum tube feedback amplifiers of the other low voltage regulator circuits (this does not include the series tubes), and is available to the vertical and horizontal plug-in cells.

The output voltage of the 25.2 volt regulator is relatively independent of the other adjustable supplies. The reference voltage for the —25.2 volt supply is the drop across Zener diode D643 and the temperature compensating diode D644, compared to ground, at the emitter-base junction of Q644.

The operating current of D643 is set by R643. A small amount of additional current flows through R644, D644, and R645 to the +300 volt supply. R645 assures a forward bias for Q644, with D644 and D643 acting to limit Q644 base current to the correct value.

Normally, the voltage at the base of Q644 rests at about +0.5 volt. If the voltage at the base changes because of a change in the supply voltage, the error signal will be amplified and applied to the base of power transistor Q647. The change in base voltage at Q647 changes the drop across Q647 in a direction to restore the output to normal.

For example, if the supply output starts to go less negative, Q644 will conduct more heavily. This produces a negative drop in the voltage at the collector of Q644 and at the base of Q647. The negative going signal at the base of Q647 causes it to conduct more heavily, reducing its collector-to-emitter voltage and pulling the whole supply in a negative direction to correct for the error.

Diode D644 protects Q644 from large low-impedance positive-going error signals, such as might occur if the supply output lead is accidentally grounded. If the ouput lead should be grounded, and D644 opens due to its normal inverse bias characteristics, the base current of Q644 is

held to a safe limit by R645. As soon as the short is removed and the output voltage returns negative, D644 will again conduct, restoring normal regulator action. See the Maintenance section of this manual for probable damage and its correction for prolonged periods of short circuit of the —25.2 volt supply.

Electrolytic capacitor C644 assures that error signals are applied to the base of Q644 without delay, and that Zener diode D643 is not required to pass any high amplitude AC currents.

—19 Volt Power Supply

The —25.2 volt supply provides power to the —19 volt regulator circuit. A voltage divider between —19 volts and +19 volts provides a voltage near ground to the base of transistor Q654. This voltage is essentially compared to ground in the emitter-base junction of Q654. The emitter of Q654 is held about 0.4 volt above ground by the drop across diode D653. D653 is a first order temperature compensation, causing a small variation to Q654 emitter voltage with variations in temperature to correct for Q654 changes due to temperature.

R656, in the collector loads of Q653 and Q657, acts as a fuse in the vent of a heavy overload.

The output voltage of the —19 volt power supply is adjusted by R651. The output is also sensitive to change of both the +300 and +19 volt supplies.

Any changes of the output voltage are coupled to the base of Q654 via the divider R650-R651-R652, and by C652. Q654 amplifies the error and applies it as negative feedback to the base of emitter follower Q653. Q653 gives current gain to the correcting signal for the base of series regulator Q657. Q657 acts as an emitter follower for the —19 volt load, returning the output voltage to normal.

+19 Volt Power Supply

A full-wave bridge rectifier system from terminals 22 and 23 of T601 supplies power to the +19 volt regulator circuit.

Diode D672 gives the +19 volt power supply first order temperature compensation for added stability. R675 in the collector leads of Q673 and Q677, acts as a fuse in the event of a heavy overload.

Reference voltage for the +19 volt supply is adjusted by R666 as part of a voltage divider between the +300 volt supply and ground.

Any changes of the output voltage are coupled to the emitter of Q674 by D672, and compared to the base reference voltage. Q674 amplifies the error signal (in phase) and applies it to emitter follower Q673. Q673 gives current gain to the correcting signal for the base of series regulator Q677. As example, if a negative error occurs, the correction signal will cause Q677 to decrease the voltage between its emitter and collector, raising the output voltage back to normal.

Probe Power Supply

The —12.6 volt probe power supply is a Zener diode shunt regulator floating on the —25.2 volt supply. Its primary purpose is to stabilize the 12.6 volts for tube heaters of cathode follower signal probes. Other units such as the Type 281 TDR Pulser or the Type 282 Probe Adapter can be connected to each of the sampling unit PROBE POWER jacks. Current drawn from the +25.2 volt supply remains the same whether probes or other units are connected or not. Each probe heater draws about 180 mA.

CRT CIRCUITS

High-Voltage Power Supply

Unregulated +455 volts from the +300 volt power supply is applied to the high-voltage oscillator, V800. V800 and its associated circuitry is a modified Hartley oscillator. V809 and the primary of T801 form a tuned plate circuit for V800. The oscillator operates at approximately 40 kHz. High-voltage transformer T801 provides the high voltage and heater voltage for the high-voltage rectifier V822.

The high-voltage secondary winding of T801, and rectifier V822, supplies the high voltage for the CRT circuits. A voltage divider between the high voltage and the +300 volts supplies proper voltages to the CRT cathode, grid, focusing element, and the HIGH VOLTAGE control R841. The voltage at the junction of R841 and R842 is the grid voltage of V814B, to control the output voltage and regulation of the supply. If the high-voltage supply changes from its set value, a portion of the change appears at the grid of V814B as an error signal. The error signal is amplified by V814B and V814A to change the voltage at the screen grid of V800 in the correct direction to compensate for the output error.

Capacitor C842 increases the AC loop gain of the high-voltage regulator circuit. This permits the regulator to compensate quickly for changes in the output voltage.

CRT Intensity Control

Neon glow tubes B847 and B848 provide a low-impedance path from the high-voltage lead to the CRT cathode. The glow tubes also establish about 110 volts constant voltage across the INTENSITY control. Changing the setting of the INTENSITY control (R848) will change the CRT bias and the display brightness.

Other CRT Voltages

Voltages for the focus element of the CRT is obtained from potentiometer R845. Varying R845 adjusts the focus element voltage to permit proper spot focus.

Voltages for the astigmatism element is obtained from potentiometer R864. Varying R864 adjusts the astigmatism element voltage to permit best spot size and trace definition in conjunction with the FOCUS control.

A fixed voltage of about +160 volts for the deflection plate isolation shield is obtained from voltage divider R862-R863. This voltage divider is also connected to the CRT internal dag coating and is the electron beam return path. The deflection plate isolation shield minimizes the electrostatic fields between the two sets of deflection plates and reduces interaction between the vertical and horizontal systems to insignificance.

Blanking

The oscilloscope uses deflection blanking during the interval that the spot is moved from one sampling dot position to the next, and during retrace. The deflection method of blanking uses a special set of deflection plates in the electron gun to divert the electron beam and turn off the display. The CRT cathode experiences little or no change in current by the blanking action, because the positive deflection blanking plates accept the cathode current electrons when the display is turned off.

Blanking amplifier V874A rests at cutoff except when the blanking signal turns off the CRT beam current. A voltage divider in the grid circuit of V874A sets its grid voltage at about —10 volts. The voltage divider at the plate of V874A holds the plate at about +170 volts when the tube is cut off. Positive-going blanking signals can come from the vertical, the horizontal, or an external digital unit. The blanking signal at the plate of V874A takes the blanking deflection plate (pin 6 of the CRT) from about +170 volts to about +50 volts. The other blanking deflection plate voltage is adjusted to its correct value by the BLANK BAL. potentiometer R866. During the time the spot is turned off, R866 and its associated divider accept the CRT cathode current.

VERTICAL AMPLIFIER

The Vertical Amplifier receives input signals from the vertical sampling plug-in unit. The amplifier is a current sensitive operational amplifier with a very low input impedance. The amplifier output voltage drives the CRT vertical deflection plates and the vertical position indicators. The amplifier sensitivity is calibrated to be about 25 μA/cm.

The amplifier consists of two stages; an emitter-coupled paraphase input stage, and a plate-loaded push-pull output stage. The input current to an operational amplifier is always equal to the current in the feedback resistance. The plate voltage of V454A drives the feedback resistance (R472 sufficiently so that the feedback current is 25 μA/cm. The vertical amplifier has essentially no series input resistance, therefore its input sensitivity is 25 μA/cm. The push-pull output voltage of the amplifier is about 20 volts/cm as required by the CRT.

The plate load resistor of V454A is divided for signal take-off to V874B, the vertical beam-position indicator cathode follower. Neon glow tubes B468 and B469 are ignited or extinguished according to the position of the CRT spot when off screen. As an example, if the spot is off in a positive direction, the plate voltage of V454A will be somewhat lower than +130 volts. The cathode of V874B will be somewhat lower than +180 volts, B468 will be glowing and B469 will be dark.

HORIZONTAL AMPLIFIER

The Horizontal Amplifier consists of a three-transistor operational preamplifier, and a two-transistor, two-triode operational output amplifier. The preamplifier drives both the output amplifier and the front-panel horizontal signal outpur terminal. The preamplifier output signal is 200 mV/cm. The output amplifier drives the CRT horizontal deflection plates, the horizontal takeoff, and horizontal neon position indicators.

All input signals to the Horizontal Amplifiers pass either through terminals 6 and 19, or through terminal 8, of the vertical Interconnecting Socket, J1. Regardless of the type of horizontal presentation (sweep, external signal, X-Y operation), the vertical plug-in unit must be in place in its cell to complete the horizontal input signal path.

The horizontal preamplifier gain is varied from a minimum of 0.04 to a maximum of 4.0 by the HORIZONTAL DISPLAY switch. The input impedance at the base of Q313 is as low as 1 ohm when the magnifier gain is ×1 or the external horizontal deflection factor is 5 volts/cm. The Q313 input impedance rises to a maximum of 100 ohms when the magnifier gain is ×100 or the external horizontal deflection factor is 0.05 volt/cm. Since the input signal passes through R302 (except for X-Y operation), the input impedance then remains at essentially 25,000 ohms for all amplifier sensitivities. For X-Y operation, the input impedance is that of R303, 3,000 ohms, giving an increase in gain of 10 to the horizontal system.

Two silicon diodes are connected between the base of Q313 and ground to limit the input signal amplitudes to about ±0.6 volt. Higher input amplitudes could damage transistors or diodes in the rest of the horizontal amplifier system.

Q313 is an emitter-follower current amplifier, required for its low-impedance drive capabilities by the base of Q324. The collector circuit of Q313 is maintained at +6.3 volts by Zener diode D314, aiding in reducing the output impedance of Q313 to the required value. Amplifier Q324 has a first-order temperature compensating germanium diode in its emitter circuit.

Q333 is an output emitter follower required for its low output impedance to drive the feedback resistors, the output amplifier, and the horizontal signal output terminal. Since the emitter of Q333 rests at about —6 volts, and the output circuit of the operational preamplifier must rest near ground, Zener diode D334 alters the output DC level by 6.3 volts without signal attenuation.

The horizontal output amplifier is identical to the vertical output amplifier except its sensitivity is 20 μA/cm. In some instruments, the CRT horizontal deflection factor is adjusted to 16 volts/cm by adjusting the high voltage supply. In others, the horizontal output amplifier gain is adjusted by R359, and the high voltage supply is adjusted to establish the CRT vertical deflection factor. Since both vertical and horizontal amplifiers are basically low-frequency systems, the horizontal system was given the deflection plates requiring less drive per centimeter but a longer required scan.

Horizontal Takeoff Amplifier

The horizontal system of the Type 661 permits manual or external scanning of the sampling display. (In the MANUAL SCAN positions of the HORIZONTAL DISPLAY switch, the horizontal POSITION control acts as a scan control.) When either manually or externally scanning the display, the horizontal amplifier output voltage is used by the timing unit to control the delay time between triggering and sampling. Voltage from the plate of V364A is fed to the horizontal takeoff amplifier V384, which inverts, attenuates, and adjusts the DC level. The voltage from the takeoff amplifier is used by the timing unit as a fixed fast ramp voltage. Thus, each

triggered sample no longer slews along the fast ramp (and the display), but is held at a fixed point by the level of the takeoff voltage. Rotating the POSITION control changes the takeoff voltage to the timing unit, much the same as if the timing unit fast ramp voltage were functioning in a normal manner. (See the instruction manual for the timing unit in use.) The positions of the manually or externally scanned displays is made to agree with the normal timing unit scanned display by means of R378, the HORIZ. TAKEOFF DC LEVEL control. The takeoff amplifier voltage gain is calibrated to be about 0.6.

The horizontal beam position indicators are controlled by the voltage at the plate of V384A.

AMPLITUDE/TIME CALIBRATOR, SN 2000-up

The Amplitude/Time Calibrator is a transistorized Colpitts oscillator with four output amplitudes from 1 mV to 1 volt and four output frequencies from 100 kHz to 100 MHz. The calibrated amplitudes and frequencies are in decade steps.

Selection of the output frequency is provided by resonant circuits that can be switched into the base-emitter circuit of Q930 by SW910, the front-panel μSEC/CYCLE switch. Each resonant circuit consists of fixed capacitors and an inductor that is variable for frequency adjustment. At the .01 μSEC position (100 MHz), the resonant circuit consists of the capacitance of C934 and C935 and the inductance of L916 and its associated leads.

Excursion of the oscillator sine-wave output is from about −5 volts to +5 volts, set primarily by clamp diodes D930. Feedback current to the ocillator is adjusted by R942 (OSC. FEEDBACK (close), and at the high frequencies C942 assists in providing oscillator feedback. For the 100 MHz output (.01 μSEC/CYCLE), L955, R955 and C956 form a critically damped LRC circuit to insure a sinusoidal drive for the current-switching diode stage.

Current-switching diodes D958 and D959 receive approximately 40 mA of current from the −100 volt supply through R967, R965 and R964. At the .01 position of the μSEC/CYCLE switch, current is increased by shorting out R967. With the oscillator turned off, current is divided equally between the two diodes, with R962 (SYMMETRY) correctly adjusted. When the oscillator is operating, its sine-wave output is applied to the anode of D958. On the positive swing, current increases through D958 until the diode is conducting all of the 40 mA and D959 is cut off. The output level is at zero volts at that time. On the negative oscillator swing, current decreases through D958 until it cuts off and the 40 mA is conducted through D959 and the 25 Ω load. The output level is then at −1 volt. Thus the clipped sine-wave output has a peak-to-peak amplitude of one volt. Corrective networks provide compensation for circuit and diode capacitance in the current-switching stage. R970, L970 and C971 provide compensation for the 10 MHz signal. R968 and C968 compensate the 100 MHz waveform. L958 and L970 are self resonant at 100 MHz to reduce losses caused by L960 and the 10 MHz compensation network. Adjustments in these circuits are set to produce the best possible wave shape of the clipped sine-wave output.

The output from the diode stage is applied to a network of three 50-ohm 10× attenuators that can be connected in series with the load to produce the desired output amplitude. Attenuation of the 1-volt calibrator signal is selected by SW980, the front-panel mV AMPLITUDE switch.

A second output from the oscillator circuit is taken through isolation resistor R954 to the timing unit for internally triggering the sampling display. This feature is particularly useful for observing the calibrator signal when the vertical plug-in unit does not have a trigger takeoff or when the calibrator signal is of low amplitude. The internal calibrator trigger has the same amplitude (about 100 mV) regardless of the position of the mV AMPLITUDE switch. Because of this signal, the calibrator should be turned off when not in use to avoid triggering interference through stray coupling in the timing unit.

AMPLITUDE/TIME CALIBRATOR, SN 101-1999

The Amplitude/Time Calibrator is a modified Colpitts oscillator with four amplitude and frequency settings. V930 forms a parallel triode oscillator. Adjustment of feedback voltage from the cathode of V930 aids in estabishing the correct output amplitude. For the 10, 1 and .1 positions of the μSEC/CYCLE switch, the grid voltage of V930 is limited in amplitude by the emitter voltage of Q953. The voltage at the emitter of Q953 does not materially affect the output amplitude when the μSEC/CYCLE switch is in the .01 position.

V930 grid voltage limiting centers about ground potential. The emitter voltage of Q953 is adjusted during calibration to a value near +14 volts. Thus, diodes D942 and D952 conduct alternately when the voltage at their junction reaches ground and +14 volts. C941 thus maintains a nominal charge of 7 volts, permitting the grid of V930 to swing freely from about −7 to +7 volts each cycle. The oscillator feedback is high enough to drive the grid of V930 more than ±7 volts, thus diodes D942 and D952 limit the grid swing and the output amplitude.

The output circuit of the oscillator is capacitively coupled to a load of about 230 ohms made up of R976 in series with the two terminating resistors (R977-R978) and a 50-ohm four-position attenuator. The mV AMPLITUDE control switches in appropriate 50-ohm attenuators so that the oscillator amplitude can remain constant while the output connector receives the correct amplitude at the correct impedance.

A second oscillator output is taken through isolation resistor R966 to the timing unit for internally triggering the sampling display. This feature is particularly important when the vertical plug-in unit does not have triggering circuitry, or when the calibrator signal is less than that required by the vertical plug-in unit for proper internal trigger pickoff. Because of this signal, the calibrator should be turned off when not in use. If the calibrator is left on, there may be triggering interference due to stray coupling in the timing unit.

DELAYED PULSE GENERATOR SN 3460-up

General

The Delayed Pulse Generator is a special 50 Ω environment tunnel diode pulse generator that has a 50 Ω output resistance. The generator is driven by the timing unit to switch the output voltage from zero to about −260 mV and back to zero in time agreement with each sample. A special

double triggering circuit (using a tunnel diode and a back diode) triggers the output tunnel diode to deliver the output pulse during the most rapid change portion of the drive signal from the timing unit. The double triggering circuit serves to start the delayed pulse negative step in close time agreement with the timing unit time of trigger recognition, or time of start of each free run sample trigger. The result is a low jitter Delayed Pulse display when checking the vertical unit risetime. These low jitter conditions are advantageous when the timing unit is free run and the Delayed Pulse is used as a rate generator to trigger an external device that then produces a signal which is viewed by the vertical unit.

Drive and Tripping Circuit

Fig. 3-1 and Fig. 3-2 show the drive and tripping circuits for use with either timing unit, the Type 5T1A or the Type 5T3.

Drive from the Type 5T1A is a negative pulse coupled through D72 (see Fig. 3-1) when D65 switches to its high voltage state. When D65 returns to its low voltage state, Q73 conducts and turns off the negative drive to the Delayed Pulse Generator. While neither D72 nor Q73 is conducting, current from the —19-volt supply (through R990 and R73) holds D991 biased at its low voltage state.

Drive from the Type 5T3 occurs when Q265-Q275 (see Fig. 3-2) stop conducting. As the two transistors stop conducting, R289 and R990 in parallel provide about 23 mA to D991 causing it to switch to its high voltage state. When Q265-Q275 conduct, the current of R289-R990 is taken away from D991, holding it at its low voltage state.

In both cases above, when the timing unit ends the negative drive pulse, the positive-going portion of the signal couples through C991 to turn off the output tunnel diode D995. Details of the Delayed Pulse Generator operation follow.

One Complete Cycle of Operation

Refer to the Delayed Pulse Generator diagram during the following discussion.

Between samples, when the timing unit does not call for a Delayed Pulse, the following Quiescent conditions exist.

1. D991 has very little current in it and its cathode rests at about —0.02 volt.

2. D995 is biased very close to its peak current value and its cathode rests at its voltage state of about —0.12 volt.

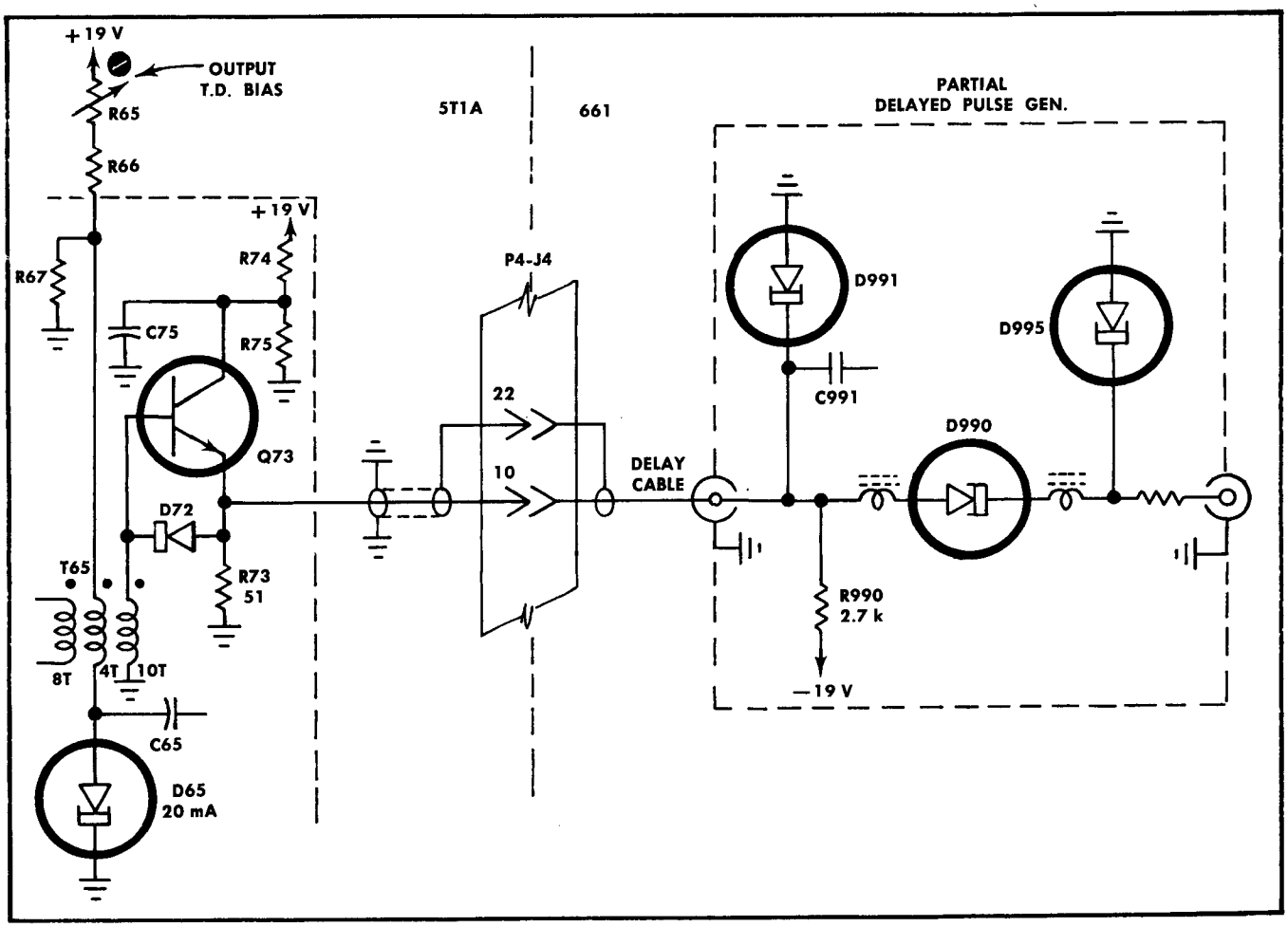


Fig. 3-1. Type 5T1A and Delayed Pulse drive connections.

3. D991-D995 cathode voltages hold D990 forward biased at about 0.1 volt, at a value near its 50 μA peak current, which is essentially an open circuit.

4. Q991 is conducting about 400 μA of current, limited by R992. The very low current assures that Q994 is not forward biased, but that Q991 is conducting just enough so that a turn-on pulse will produce an immediate collector change without the typical turn-on delay of a cut-off transistor, D995 bias is set by the TD BIAS control and Q995.

5. Even though D995 anode voltage is about —0.12 volt, the generator output voltage is at zero due to current in R997-R998-R999.

As the timing unit drive arrives, D991 is switched considerably beyond its 10 mA peak current. D991 cathode voltage switches to about —0.5 volt. This negative signal does two things: it charges C991 and momentarily cuts off Q991 (with no effect upon Q994), and D990 is reverse biased into its heavy reverse current region causing it to conduct current into D995. D995 switches to its high voltage state and its cathode drops to about —0.6 volt. Just as soon as D995 switches, D990 is forward biased near its 50 μA peak current and again becomes essentially an open circuit. The actual conduction time of D990 is less than 30 ps. As D990 current stops, L990 and L994 ferrite beads damp D990 leads from ringing to minimize any aberrations on the output pulse. (The back diode, D990, has the usual tunnel diode reverse conduction conditions of heavy current when reverse biased, but it has a very low current when forward biased.)

As the timing unit drive stops, D991 switches back to its low voltage state. The fast switching signal couples through C991 and turns Q991 on hard. Q991 collector current comes primarily from Q994 base, causing Q994 to saturate. Q991 holds Q994 in saturation briefly because C991 charges and drops the drive to Q991 base. Q994 saturation causes a 95 mA current pulse to be applied through R995 to D995, taking D995 cathode slightly positive as the output pulse ends. Q994 conduction drops rapidly to cut off in about 0.38 μs and the original quiescent conditions again apply.

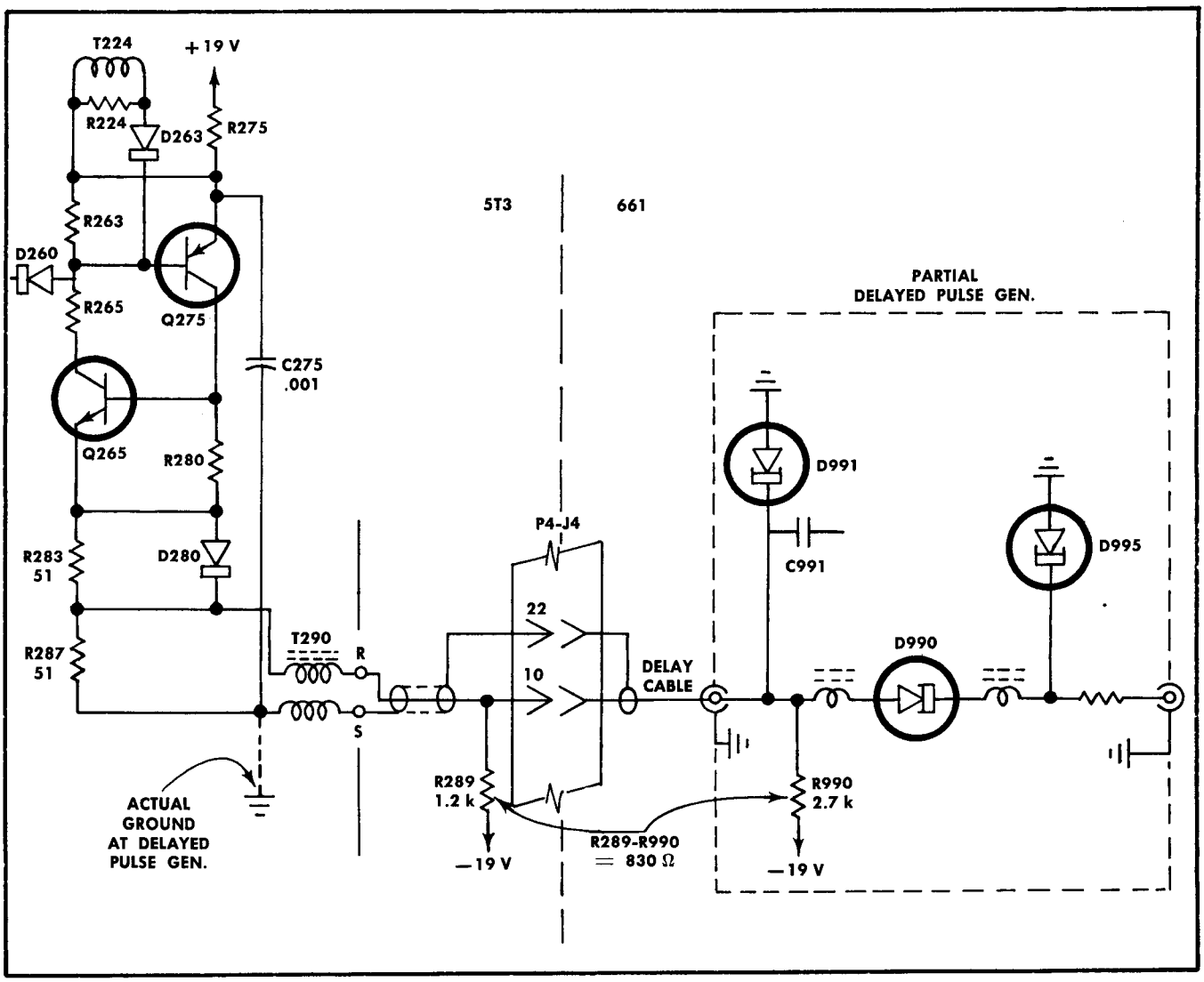


Fig. 3-2. Type 5T3 and Delayed Pulse drive connections.

The biasing circuit for D995 includes current through two main-frame tube filaments (V694 and V814), a temperature compensated adjustment control (R996), and the common base transistor Q995. Note that there is a diode junction to ground at each end of R996. Each diode junction dynamic resistance is small compared to the value of R996, and the two resistances change equally with temperature change. Changing the position of the slider of R996 changes the current through the two diodes. Since one of the diode junctions is the emitter of Q995, adjustment of R996 then causes changes in the collector current of Q995. Q995 collector current is adjusted to be about 2 mA greater than the peak current value of D995. The extra 2 mA is bypassed away from D995 by the BASE LINE ZERO control, placing the output connector end of R997 at ground voltage while D995 cathode is at about —0.12 volt. Q995 thus operates in normal saturation with current magnitude adjusted by R996. Q995 collector voltage is always equal to D995 cathode voltage, but it never goes far enough negative to alter the current.

It is the value of R997, plus D995 resistance in series that makes up the 50 Ω output resistance of the pulser. When loaded externally by 50 Ω, the two 50 Ω resistances divide D995 negative step voltage by 2.

C993, L993 and C994 form a power supply decoupling network so Q994 95 mA current pulse does not disturb the +19-volt supply for other circuits in the oscilloscope.

DELAYED PULSE GENERATOR SN 101-3459

The Delayed Pulse Generator employs a strip-line 50-mA tunnel diode to deliver a fast negative-going pulse to a 50-ohm load (at the DELAYED PULSE 50 Ω connector). Tunnel diode switching voltage comes from the timing unit plug-in. Static operating bias is obtained from the voltage drop across R990, the internal DELAYED PULSE GEN. BIAS control. Current for R990 comes from the —25.2 volt supply through the heaters of V694 and V814.

The tunnel diode is switched from its low-voltage state to its high-voltage state each time the timing unit is triggered. Thus, the negative step can be made to appear as a stable CRT display regardless of the sweep rate. If the timing unit is triggered, the delay pulse repetition rate is the same as that of the signal (up to a maximum determined by the count-down rate of the timing unit). If the timing unit is free running, the delayed pulse will appear at the free-run rate.

SECTION 4
MAINTENANCE

PREVENTIVE MAINTENANCE

Air Filter

The Type 661 Oscilloscope is cooled by air drawn through a washable filter at the rear of the instrument. The filter is constructed of aluminum wool treated with a dust adhesive. If the filter becomes excessively dirty, it will restrict the flow of air into the instrument and may cause overheating. High internal temperatures will not only reduce component life, but may also cause the thermal cutout to open at a crucial point in an experiment. If the thermal cutout opens, the filter should be checked immediately.

The filter should be visually checked every few weeks. It should be cleaned at least every three or four months, more often if required. To clean the filter, first remove the loose dirt by tapping the filter gently on a hard surface. Then wash the filter by running hot soapy water through it until it is clean, rinse, and allow to dry. Then coat the filter with an adhesive such as "Handi-Koter" or "Filter-coat" (products of the Research Products Corporation, Tektronix part no. 006-0580-00.) These products are generally available from air-conditioner suppliers.

Cleaning the Exterior

Loose dust accumulating on the outside of the Type 661 can be removed with a cloth or small paint brush. The paint brush is particularly useful for dislodging dust on and around the front-panel controls. Stubborn dirt can be removed with a soft cloth dampened in a solution of water and mild detergent. Abrasive cleaners should not be used.

Clean the graticule and the face of the CRT with a soft, lint-free cloth dampened with an alcohol, such as isopropanol, that has not been denatured.

CAUTION

Do not clean any plastic materials with organic chemical solvents such as benzene ,acetone or denatured alcohol. These solvents might damage the plastic.

Removal of Panels

The side and bottom panels of the Type 661 can be removed separately for maintenance work. The panels are held in place by coin-slotted screwhead fasteners. To remove them, use a screwdriver or coin to rotate the fasteners approximately two turns counterclockwise. Then pull the upper portion of the panels outward from the carrying handles.

Cleaning the Interior

Although air entering the Type 661 is filtered, some dust may penetrate into the interior of the instrument. This dust should be removed occasionally to prevent instrument failures due to its conductivity under high humidity conditions. The best way to keep the interior of the instrument clean is to blow away the dust with compressed air. Avoid using high-velocity air to prevent damage to some of the components. Remove stubborn dirt with a soft paint brush or a cloth dampened with a water and mild detergent solution.

Pay special attention to the high-voltage circuits, including parts inside the high-voltage shield. Accumulated dust should be removed, since dust combined with high humidity can produce high-voltage arcing. Arcing may cause false sweep triggering with a resulting unstable CRT display.

Visual Inspection

Troubles can sometimes be found by visual inspection of the instrument. For this reason, you should perform a complete visual check every time the instrument is calibrated or repaired. Look for such defects as loose or broken connections, loose set screws in the knobs or shaft couplers, damaged connectors, improperly seated tubes or transistors, scorched or burned parts, broken terminal strips, etc. Except for heat-damaged parts, the remedy for most of these troubles is apparent. Heat damage is often the result of other, less apparent, defects in the circuit. It is essential for you to determine the cause of overheating before replacing damaged parts.

Fan Motor

The fan motor bearings are factory lubricated. No additional lubrication is required for the life of the instrument.

Tube Checks

Tube-tester checks on the tubes used in the Type 661 Oscilloscope are not recommended. Tube testers may indicate a tube to be defective when tube is operating satisfactorily in a circuit, or they may fail to indicate tube defects which affect the performance of the circuits. We recommend that tubes be checked by substitution. If the tube is good, return it to its socket. Unnecessary replacement of tubes is not only expensive but may also result in needless recalibration of the instrument.

Recalibration

The Type 661 Oscilloscope is a stable instrument that will provide many hours of trouble-free operation. However, to insure that the unit is operating properly at all times, we suggest that you recalibrate the instrument after each 500 hours of operation (or every six months if used intermittently). A complete step-by-step procedure for calibrating the instrument and checking its operation is given in Section 6 of this manual.

Parts Removal and Replacement

Whenever a part is replaced, check and adjust the instrument calibration as necessary. Most parts in the Type 661 can be replaced without detailed instructions. Some, however, are best removed and replaced by using definite procedures contained in the following parapraphs. (Parts ordering information is included immediately preceding the Electrical Parts List section of this manual.)

CAUTION

Turn AC power off before removing tubes or transistors from their sockets.

Transistor Replacement. Transistors should not be replaced unless they are actually defective. Transistor defects usually take the form of the transistor opening, shorting or developing excessive leakage. To check a transistor for these and other defects, use a transistor curve display instrument such as a Tektronix Type 575. However, if a good transistor checker is not readily available, a defective transistor can be found by signal-tracing, by making in-circuit voltage checks, by measuring the transistor forward-to-back resistance using proper ohmmeter resistance, or by using the substitution method. The location of all transistors is silk-screened on the chassis next to each socket.

To check transistors using a voltmeter, measure the emitter-to-base and emitter-to-collector voltages and determine if the voltages are consistant with the normal resistances and currents in the circuit (see Fig. 4-1).

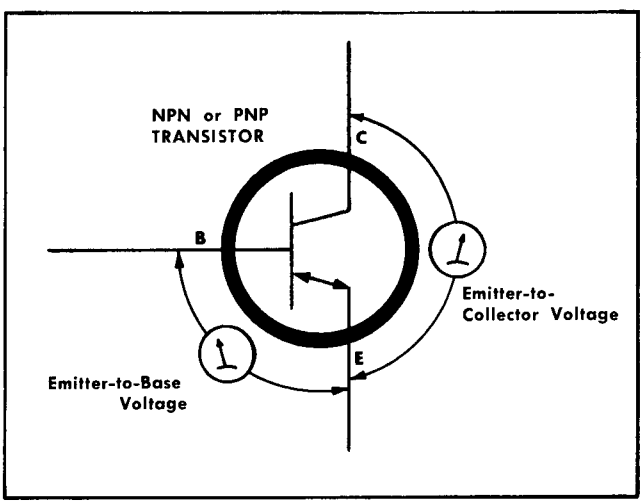


Fig. 4-1. In-circuit voltage checks NPN or PNP transistors.

To check a transistor using an ohmmeter, know your ohmmeter ranges, the currents they deliver, and the internal battery voltage(s). If ohmmeter does not have sufficient resistance in series with its internal voltage source, excessive current will flow through the transistor under test. Excessive current and/or high internal ohmmeter source voltage may permanently damage the transistor.

NOTE

As a general rule, use the R × 1 k range where the current is usually limited to less than 2 mA and the internal voltage is usually 1½ volts. You can quickly check the current and voltage by inserting a multimeter between the ohmmeter leads and measuring the current and voltage for the range you intend to use.

When you know which ohmmeter ranges will not harm the transistor, then use those ranges to measure the resistance with the ohmmeter connected both ways as given in Table 4-1.

TABLE 4-1

Transistor Resistance Checks

Ohmmeter Connections[1]	Resistance Readings That Can Be Expected Using the R × 1 k Range
Emitter-Collector	High reading both ways (about 60 kΩ to around 500 kΩ).
Emitter-Base	High reading one way (about 200 kΩ or more)). Low reading the other way (about 400 Ω to 2.5 kΩ).
Base-Collector	High reading one way (about 500 kΩ or more). Low reading the other way (about 400 Ω to 2.5 kΩ).

[1]**Test prods from the ohmmeter are first connected one way to the transistor leads and then the test prods are reversed (connected the other way). Thus, the effects of the polarity reversal of the voltage applied from the ohmmeter to the transistor can be observed.**

If there is doubt about whether the transistor is good or not, substitute a new transistor, but first be certain the circuit voltages applied to the transistor are correct before making the substitution.

When checking transistors by substitution, be sure that the voltages and loads on the transistor are normal before making the substitution. If a transistor is substituted without first checking out the circuit, the new transistor may immediately be damaged by some defect in the circuit.

DELAYED PULSE GENERATOR SN 101-3459

Removing the Delayed Pulse Generator

Fig. 4-2 shows two knurled nuts on the output end of the Delayed Pulse Generator. Both knurled nuts are tightened finger-tight and can be removed without the use of special tools. The panel mounting nut must be loosened to remove the pulser from its mounted position. Once the nut has been backed clear of the panel threads, the unit can be withdrawn by backing it out of the panel mounting.

To obtain access to the pulser components, loosen the knurled coaxial output section nut closest to the circuit board. It is not necessary to clear the threads fully. Then turn the male threaded portion 90° and slide the air-line outer section away from the circuit board. This will expose the center conductor of the output air line to view.

Now remove the four shield-mounting phillips round-head bolts and lift the two shields away from the circuit board. Component locations are identified in Fig. 4-2 of this insert.

To replace the circuit board shields and air-line outer section, proceed as follows Place both shields in place with the four bolts and nuts assembled as before it was taken

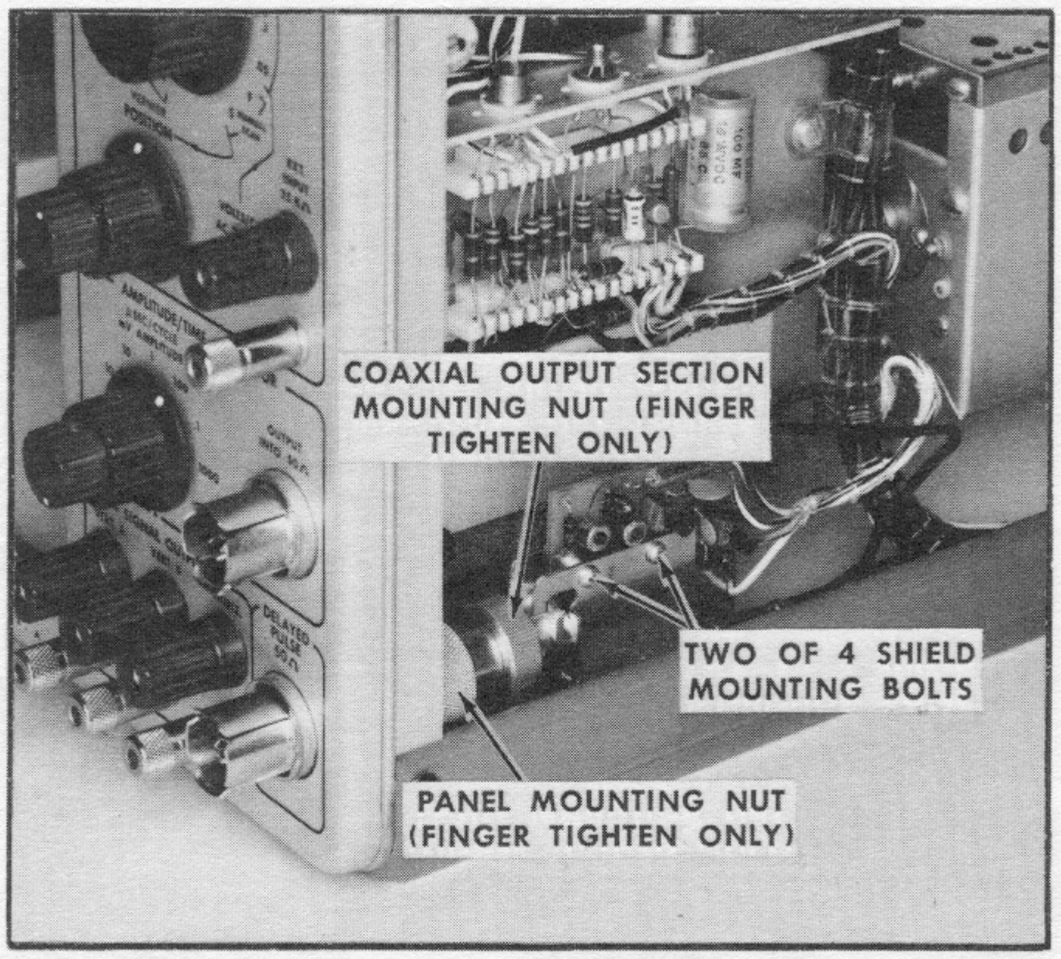


Fig. 4-2. Delayed Pulse Generator mounting nuts and shield bolt locations.

apart. Do not tighten the bolts firmly, but rather keep them just loose enough so the shields can be slipped a bit in their regular positions.

Now slip the air-line outer section over the center conductor, looking through the output end plastic piece to see the center conductor mating with the connector center piece. Fit the rear threaded section into place so both shields drop into the little notches at four points. (It may be necessary to orient the air-line outer conductor so the two rear notches fit over the circuit board edge.)

Finger tighten the rear knurled nut until the air-line outer conductor and the two shields are all held tightly together as one unit.

Finally place the air-line outer conductor two notches over the circuit board edge and push the whole metal section toward the rear of the circuit board. Tighten the four shield bolts. Check that the rear knurled nut is firmly finger tight to assure proper electrical and mechanical connections.

Insert the output connector through the panel mounting piece and finger tighten the panel mounting nut. This is only a mechanical and not an electrical connection. The unit is now back in place ready for either calibration or operation.

Replacement of Cathode-Ray Tube

WARNING

Use care when handling a CRT. Avoid striking it on any object that might cause it to crack and implode. Flying glass from an imploding CRT can cause serious injury. Use safety glasses or a plastic face mask for protection.

To remove the cathode-ray tube, carefully remove all leads connected to the neck of the tube and disconnect the tube socket at the rear of the tube. Loosen the base clamp and remove the graticule. Pull the CRT straight out through the front panel. Do not strike any of the neck pins on the inside of the CRT shield in the replacement process.

Carefully slip the new CRT into position. Place the graticule over the CRT face with the scribed lines on the inside, toward the phosphor. Then place the four rubber washers over the four graticule mounting studs. Replace the graticule cover and secure it in place with the four knurled nuts. Position the CRT with the neck-pins centered in the corresponding holes in the CRT shield, then tighten the base clamp. Following the color code information on the tube shield, connect the leads to the CRT pins and connect the tube socket at the rear of the tube. After replacement of the CRT, it will be necessary to recalibrate certain portions of the oscilloscope. Special attention should be given to the horizontal and vertical amplifier sensitivities (see the Calibration Procedure).

In replacing the graticule, if you use a Tektronix camera-mounting bezel, do not place the four rubber washers between it and the graticule.

NOTE

New type cathode-ray tubes for the Type 661 will not permit proper vertical and horizontal gain settings in the instruments having serial numbers lower than 310. (Instruments with serial number 310 and above have a variable horizontal gain control.) If the serial number of your instrument is below 310, we advise you to order Type 661 Mod 050-071 (no charge) at the time you order your first new cathode-ray tube. This modification will permit the horizontal and vertical amplifiers of the Type 661 to be properly adjusted to the deflection sensitivities of the new CRT. The Calibration Procedure in this manual will allow proper calibration after Mod 050-071 has been installed.

Replacement of Switches

Methods for removal of defective switches are, for the most part, obvious, and only a normal amount of care is required. Single wafers are normally not replaced in the switches used in the Type 661. If one wafer is defective, the entire switch should be replaced. Most switches can be ordered either wired or unwired, as desired. See the Parts List for parts ordering information.

Tube Replacement

Care should be taken that tubes are not replaced unless they are actually causing trouble. Occasionally it will be necessary for you to remove tubes from their sockets. It is important that these tubes be returned to the same sockets unless they are actually defective. Unnecessary replacement or switching of tubes will often force recalibration of the instrument. If tubes do require replacement, it is recommended that they be replaced by previously checked high-quality tubes. Check the Parts List before ordering replacements.

Soldering Precautions

In the production of Tektronix instruments a special silver-bearing solder is used to establish a bond to the ceramic terminal strips. This bond may be broken by repeated use or ordinary tin-lead solder, or by excessive heating of the terminal strip with a soldering iron. Occasional use of ordinary 60-40 solder will not break the bond unless excessive heat is applied.

If you are responsible for the maintenance of Tektronix instruments, it is advisable to have a stock of solder containing about 3% silver. It may be purchased directly from Tektronix in one-pound rolls; order by part number 251-0514-00.

Because of the shape of the terminals of the ceramic terminal strips, we recommend a wedge-shaped tip on your soldering iron. These tips allow you to apply heat directly to the solder in the terminals and reduce the amount of heat required. It is important to use as little heat as possible while producing a full-flow joint.

When removing or replacing components mounted on the ceramic strips, satisfactory results can be obtained if you proceed in the following manner:

1. Use a soldering iron of 50- to 70-watt rating.

2. Tin the tip with solder containing about 3% silver.

3. Apply one corner of the tip to the notch where you wish to solder.

4. Apply only enough heat to make the solder flow freely.

5. Do not attempt to fill the notch on the strip with solder; instead apply only enough solder to cover the wires adequately, and to form a small fillet on the wire. If the lead extend beyond the solder joint, clip the excess as close to the joint as possible. Remove all wire clippings from the chassis.

In soldering to metal terminals (for example, pins on a tube socket) a slightly different technique should be employed. Prepare the iron as described, and apply the iron to the part to be soldered. Use only enough heat to allow the solder to flow freely along the wire so that a small fillet will be formed.

Resistor Coding

The Type 661 uses a number of very stable metal film resistors identified by their gray background color and color coding.

If the resistor has three significant figures with a multiplier, the resistor will be EIA color coded. If it has four significant figures with a multiplier, the value will be printed on the resistor. For example, a 333-kΩ resistor will be color coded, but a 333.5-kΩ resistor will have its value printed on the resistor body.

The color-coding sequence is shown in Fig. 4-3, and Table 4-2.

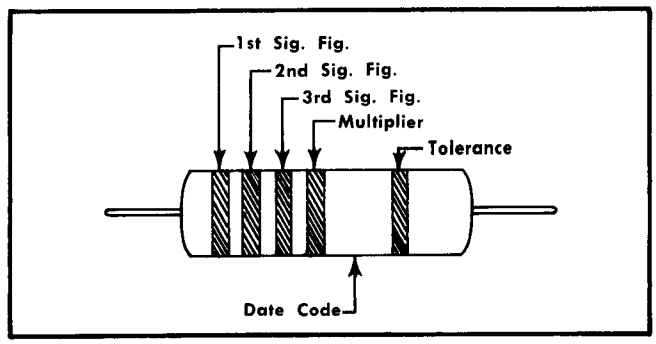


Fig. 4-3. Standard EIA color code for metal film resistors.

TABLE 4-2

Color Code Sequence

Color	1st Sig. Fig.	2nd Sig. Fig.	3rd Sig. Fig.	Multiplier	(±) % Tolerance
Black	0	0	0	1	—
Brown	1	1	1	10	1
Red	2	2	2	100	2
Orange	3	3	3	1,000	—
Yellow	4	4	4	10,000	—
Green	5	5	5	100,000	0.50
Blue	6	6	6	1,000,000	0.25
Violet	7	7	7	10,000,000	0.10
Gray	8	8	8	100,000,000	0.05
White	9	9	9	1,000,000,000	—
Gold	—	—	—	0.1	5
Silver	—	—	—	0.01	—
No Color	—	—	—	—	10

Ceramic Strips

Damaged ceramic strips are most easily removed by unsoldering all connections, then using a plastic or hard-rubber mallet to knock the plastic yokes out of the chassis. This can be done by using the mallet to hit the ends of the yokes protruding through the chassis. The strip with the two yokes can then be removed as a unit. The spacers will probably come out with the yokes; if not, they can be removed separately.

Another way of removing the terminal strip is to cut off the side of the yoke with diagonal cutters. This permits the strip to be removed from a difficult area where a mallet cannot be used. The remainder of the yokes and the spacers can be pulled out separately. Since a replacement strip is supplied with yokes already attached, the old yokes need not be salvaged. However, the old spacers can probably be used again.

When the damaged strip and yoke assembly has been removed, place the spacers into the holes in the chassis. Then set the ends of the yoke pins into the spacers. Then press or tap lightly directly above the yokes to drive the yoke pins down through the spacers. Be certain that the

yoke pins are driven completely through the spacers. Then cut off the portion of the yoke pin protruding through the spacers. Fig. 4-4 shows how the ceramic strip parts fit together.

Troubleshooting

In the event of trouble, help with the particular problem may be obtained by reading the circuit description. Voltage checks and normal troubleshooting procedures will lead to the trouble and its correction.

When a trouble occurs in the instrument, an attempt should be made to isolate the trouble by quick operational and visual checks. You should first recheck the settings of all controls on the oscilloscope and plug-in units. Then, operate the front-panel controls to see what effect, if any, they have on the trouble. The normal or abnormal operation of the various controls will allow you to identify the trouble symptoms.

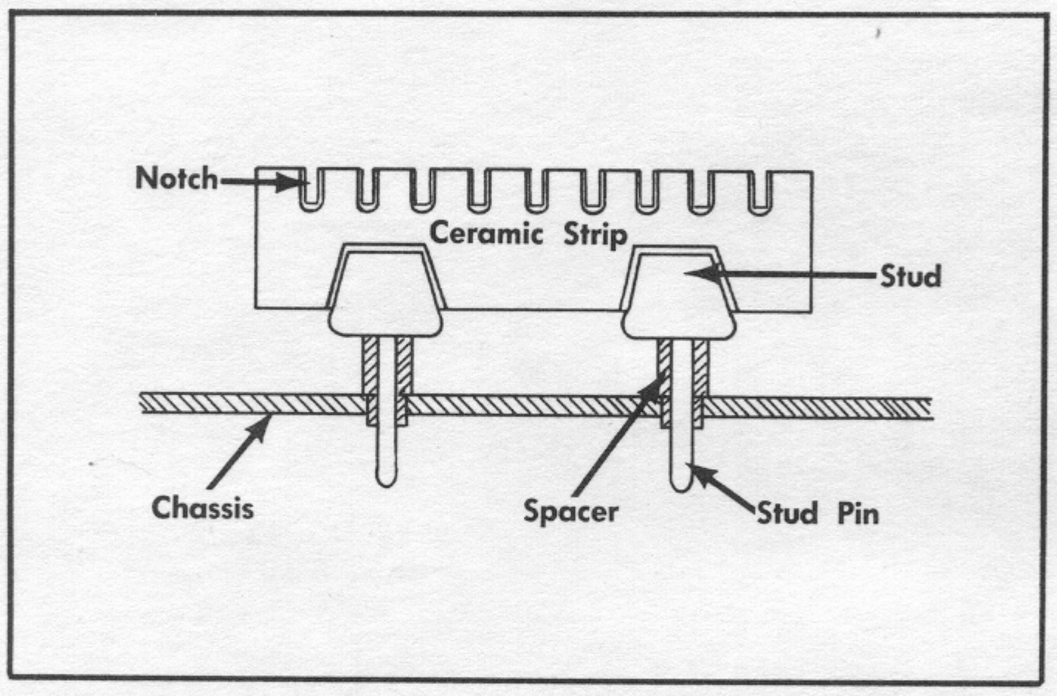


Fig. 4-4. Ceramic strip assembly.

The first step required in troubleshooting the system is to determine if the trouble is in the Type 661 or in one of the plug-in units. The fastest and best way to determine this is by substituting other plug-in units in the oscilloscope. If other plug-in units are not available, a quick check can be made by measuring the output and ripple voltages of each regulated power supply and by checking the operation of the CRT circuit. Table 4-3 lists normal resistances to ground for each power supply lead. If the regulated power supplies and the CRT circuit appear to be working properly, the trouble is most likely in one of the plug-in units. In this case, refer to the appropriate plug-in unit instruction manual for troubleshooting information. If the regulated power supplies or the CRT circuit are not operating correctly, the trouble is probably in the Type 661.

To assist in locating troubles in the power supplies, Table 4-3 lists the minimum DC resistance to ground for each of the power supply leads. Values are given for two conditions; no plug-in units in the Type 661, and with both a Type 4S1 Dual-Trace Sampling Unit and a Type 5T3 Timing Unit in place. Be sure to observe the proper ohmmeter polarity when checking the plus and minus power supply leads. Fig. 4-5 shows the location of the power supply test points.

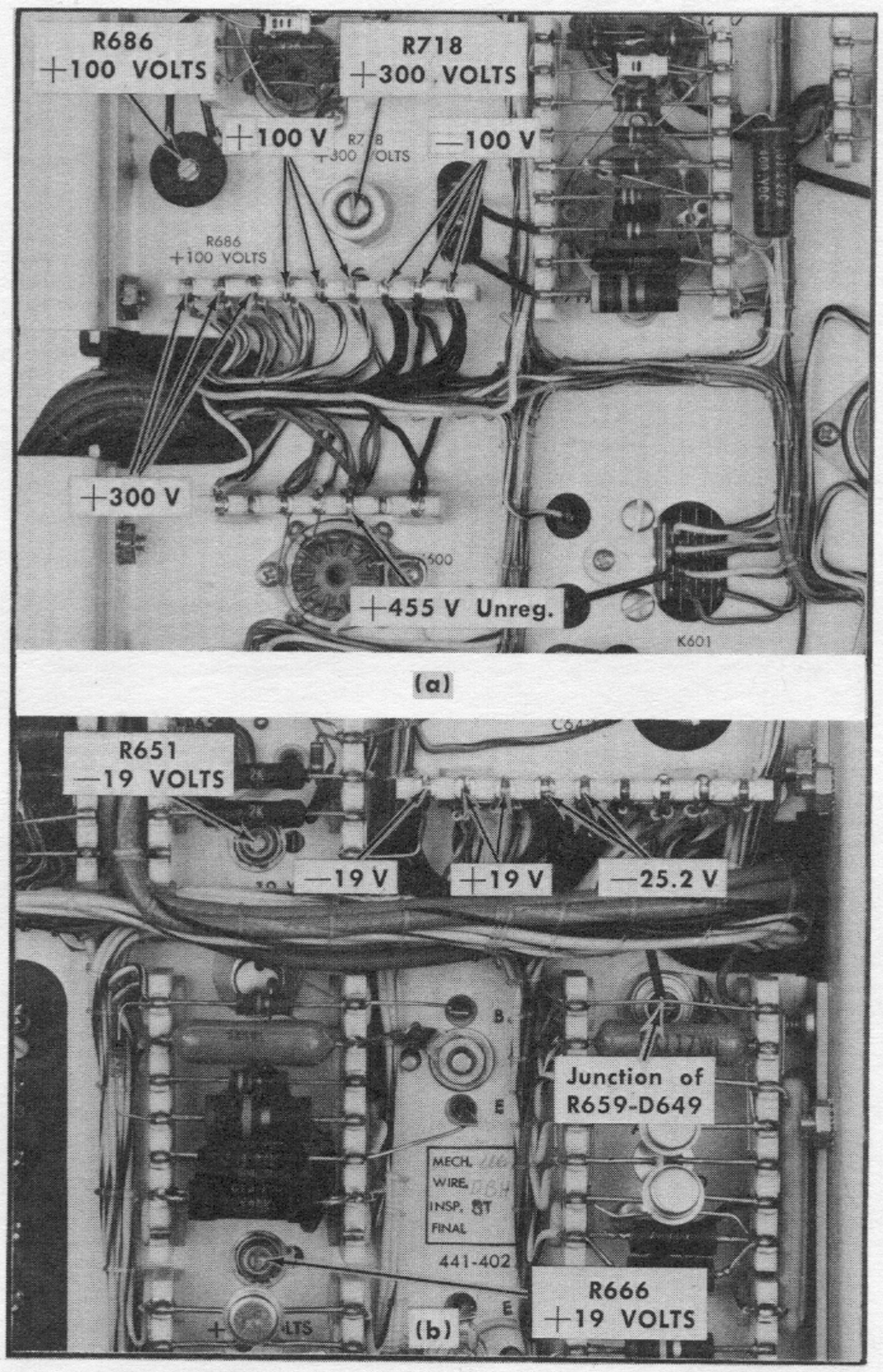


Fig. 4-5. Power supply test points. (A) Right side of oscilloscope; (B) left side of oscilloscope.

TABLE 4-3

Power Supply Lead	Minimum Resistance No Plug-In Units	Minimum Resistance With Plug-In Units
+455	18 kΩ	18 kΩ
+300	6.5 kΩ	4.5 kΩ
+100	60—75 kΩ	2 kΩ
—100	10 kΩ	1.2 kΩ
—25.2	9 Ω	6.5 Ω
—19	200—700 Ω	8 Ω
+19	600—800 Ω	10 Ω

Most troubles that occur in Tektronix instruments result from the failure of vacuum tubes or semiconductors. Therefore, if trouble occurs, tubes and semiconductors should be checked as one of the first steps. It is preferable to check them by substitution rather than with a tester, since testers frequently fail to indicate certain troubles which can affect oscilloscope performance. When a tube or semiconductor develops a short, associated components can be damaged.

To aid in troubleshooting the Type 661, typical voltages are indicated on the circuit diagrams. These voltages may vary slightly from instrument to instrument but should be quite close to the indicated values.

All wiring used in the Type 661 is color coded to facilitate circuit tracing. In addition, all requlated power supply leads are coded with specific color combinations for easy identification. In general, three stripes are placed on the wires of the regulated supplies. The first color (widest stripe) indicates the first number of the voltage on that lead using the standard EIA number-color code. The second color indicates the second number of the lead voltage and the third color is a multiplier. The method is similar to the color coding of resistors. Thus, the +100 volt leads are coded brown, black, brown. The voltage is positive if the main color of the wire is white and negative if the main color of the wire is black.

Reference voltage for most of the low-voltage power supplies is obtained from the +300 volt supply. Therefore, if the +300 volt supply is not operating properly, operation of the other low-voltage supplies will be affected. For this reason it is important, when trouble is detected in the low-voltage power supply, to check the +300 volt supply first. If the output of the +300 volt supply is correct, then troubleshoot the power supply where the trouble was first evident.

If the instrument is not operating, check the simple things first. Be sure the power cord is plugged in and that there is power at the socket. Check that the tube heaters are lit and the graticule illumination lamps are operating properly. If necessary check the line fuse. When the simple possibilities have been checked, proceed to a more detailed analysis of the trouble.

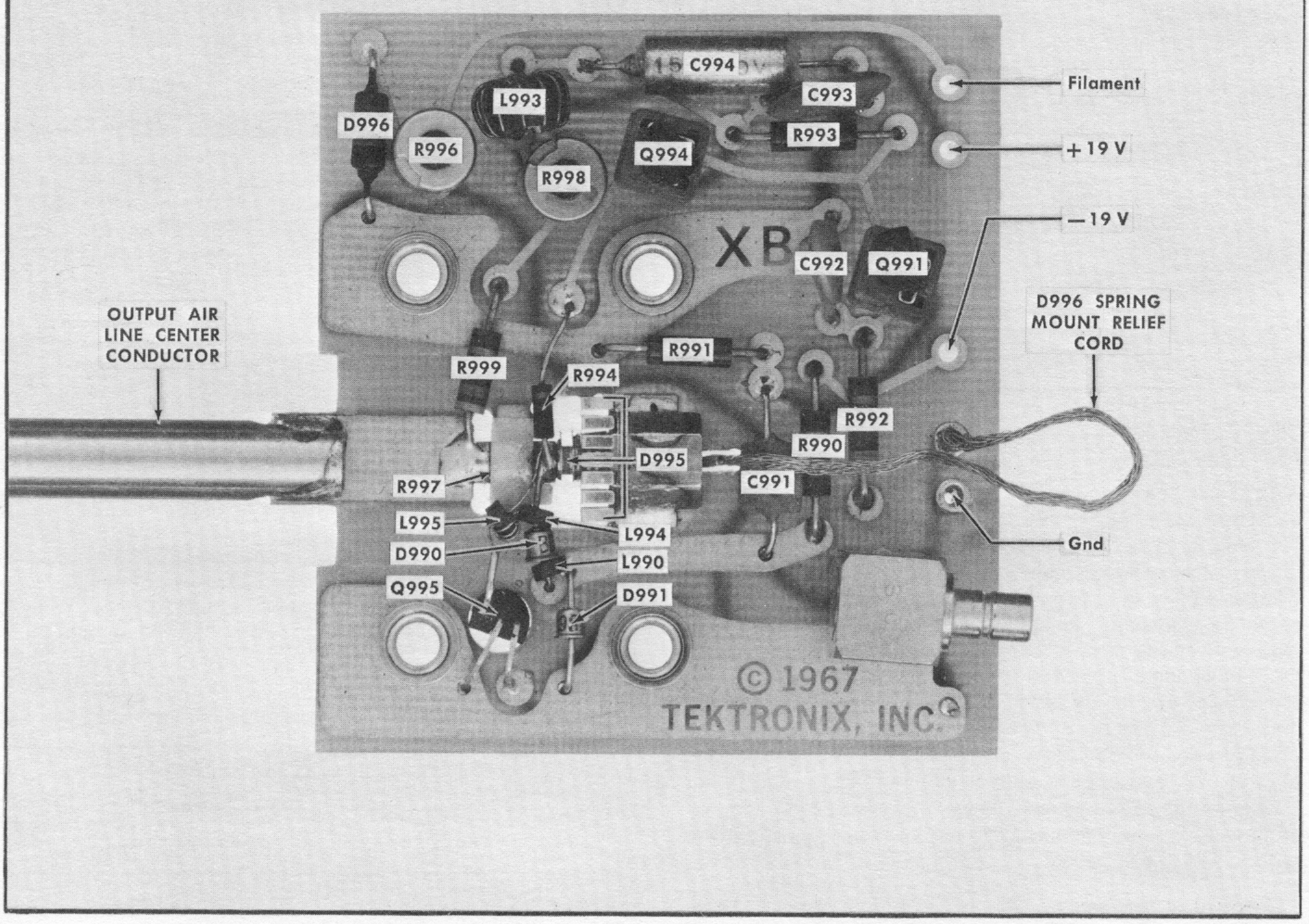


Fig. 4-6. Location of parts for the Delayed Pulse Generator.

SECTION 5
PERFORMANCE CHECK

Introduction

This section of the manual provides a means of rapidly checking the performance of the Type 661. It is intended to check the calibration of the instrument without the need for performing the complete Calibration Procedure. The Performance Check allows for one internal adjustment: the Delayed Pulse Generator bias. This adjustment is required only if the Type 661 was calibrated using a different timing unit. Failure to meet the requirments given in this procedure indicates the need for internal checks or adjustments, and the user should refer to the Calibration Procedure in this manual.

Recommended Equipment

The following equipment is recommended for a complete performance check. Specifications given are the minimum necessary to perform this procedure. All equipment is assumed to be calibrated and operating within the original specifications. If other equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

For the most accurate and convenient performance check, special calibration fixtures are used in this procedure. These calibration fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

1. Tektronix Type '4' Series Sampling Unit. Type 4S1 recommended and Type 4S2A recommended for optional check of the Delayed Pulse risetime.

2. Tektronix Type '5' Series Timing Unit. Type 5T3 recommended.

NOTE

The Type 661 Delayed Pulse Generator is driven by the Timing Unit and its bias should be adjusted whenever the Timing Unit is changed.

3. Variable autotransformer, capable of supplying at least 450 watts over a voltage range of 105 to 125 volts (210 to 250 volts for 234-volt nominal line) and AC voltmeter to indicate output voltage. General Radio W10MT3W Metered Variac Autotransformer recommended.

4. Test oscilloscope with differential inputs and an accurate voltage comparator, voltage tolerance of ±0.3% at 1 volt. Tektronix Type 545B Oscilloscope and Type W High-Gain Comparator Plug-In Unit recommended.

5. Time-mark generator, with marker or sine-wave outputs of 500 μs, 100 μs, 50 μs, 10 μs, 0.1 μs, 50 ns and 10 ns with an accuracy of ±0.02%, marker amplitude about 1-volt and sine wave amplitude about 0.3-volt into 50 Ω. Tektronix Type 184 Time-Mark Generator recommended.

6. 1× probe with BNC connector. Tektronix P6011, Part No. 010-0193-00.

7. Accurate amplitude signal generator for setting the input deflection factor to check the Amplitude Calibrator. Requires amplitudes of 1.2, 0.12, and 0.012 volts with an accuracy of ±0.25% into 50 Ω. Tektronix 50 Ω Amplitude Calibrator 067-0508-00 recommended.

8. Accurate amplitude signal generator for checking the Horizontal Signal Output and the External Horizontal Input Attenuator accuracy. Requires amplitudes of 0.2, 0.5, 1, 2, 5, 10, and 20 volts with an accuracy of ±0.3% into 25 kΩ. Tektronix Standard Amplitude Calibrator 067-0502-00 recommended.

9. 50 Ω coaxial cable, 2 ns signal delay, type RG 58, with GR 874 connectors. Tektronix Part No. 017-0505-00.

10. 50 Ω coaxial cable, 10 ns signal delay, type RG 58, with GR 874 connectors. Tektronix Part No. 017-0501-00.

11. Two 50 Ω coaxial cables, 42 inch length, type RG 58, with BNC connectors. Tektronix Part No. 012-0057-00.

12. 50 Ω 5:1 attenuator, with GR 874 connectors. GR 874-G14 (14 dB) Attenuator recommended. Tektronix Part No. 017-0079-00.

13. Coaxial connector adapter, UHF male to BNC female. Tektronix Part No. 103-0015-00.

14. Coaxial connector adapter, GR 874 to BNC male. Tektronix Part No. 017-0064-00.

15. BNC to Clip Lead Adapter. Tektronix Part No. 013-0076-00.

16. 50 Ω mid-line termination, GR 874 to BNC. Tektronix Part No. 017-0083-00.

17. CRT viewing hood, optional. Tektronix Part No. 016-0001-00.

Preliminary Procedure

1. Control check. Check all front-panel controls for proper indexing, the variable controls for smooth operation and correct any defects found.

2. Install both the Timing Unit and the Dual-Trace Sampling Unit in the Type 661.

3. Connect the power cord to the Autotransformer set to the line voltage for which the Type 661 is wired.

4. Set the controls as follows:

	Type 4S1
Mode	A Only
Triggering	A and AC
Both channels	
Vert Position	Midrange

Millivolts/cm	200
Variable (Millivolts/cm)	Calibrated (detent)
DC Offset	3 turns from either end
Smoothing	Normal (fully clockwise)
Display	Normal

Type 5T3

Samples/cm	20
Equivalent Time/cm	1 μSEC
Trig Level	Midrange
Stability or UHF Sync	Midrange
Trig Source	Free Run
Slope	+
Time Position	Fully clockwise
Sweep Mode	Norm

Type 661

HORIZONTAL DISPLAY	×1
POSITION	Midrange
VERNIER (POSITION)	Midrange
VOLTS/CM	DC
mV AMPLITUDE	100
μSEC/CYCLE	OFF
POWER AND SCALE ILLUM	Maximum graticule illumination
FOCUS, INTENSITY, and ASTIGMATISM	Set for a well focused, normal intensity trace.

(Rotate the Dual-Trace Sampling Unit DC Offset control to bring the trace on the CRT if necessary.)

5. Turn the POWER and SCALE ILLUM control clockwise and allow approximately 15 minutes warm-up time before proceeding with the performance check.

6. Note that the power supply relay turns on the instrument power within 2 minutes after the instrument is turned on.

PERFORMANCE CHECK PROCEDURE

General

In the following procedure, test equipment connections or control settings should not be changed except as noted. If only a partial check is desired, refer to the preceding step(s) for setup information.

The following procedure uses the equipment listed under Recommended Equipment. If substitute equipment is used, control settings or setup must be altered to meet the requirements of the equipment used.

1. Check Power Supply Regulation

a. Requirement—Stable display as line voltage is varied from 105 to 125 volts (210 to 250 volts).

b. Center the trace using the Sampling Unit Vert. Position control and the Type 661 POSITION control.

c. Observe the CRT trace as the autotransformer output voltage is changed slowly from 105 volts (210 volts) to 125 volts (250 volts). The trace should remain stable (no jitter, noise or gain changes more than one trace width) throughout the line voltage range.

d. Set the Autotransformer output to 117 volts (234 volts) for the remainder of the procedure.

2. Check CRT Alignment

a. Requirement—Trace must be parallel with the center graticule line within ±1 mm, between the check points shown in Fig. 5-1.

b. Vertically position the start of the trace to the center horizontal graticule line with the Sampling Unit Vert. Position control.

c. Check—Trace end at the right edge of the graticule is not more than 1 mm above or below the center horizontal graticule line, see Fig. 5-1.

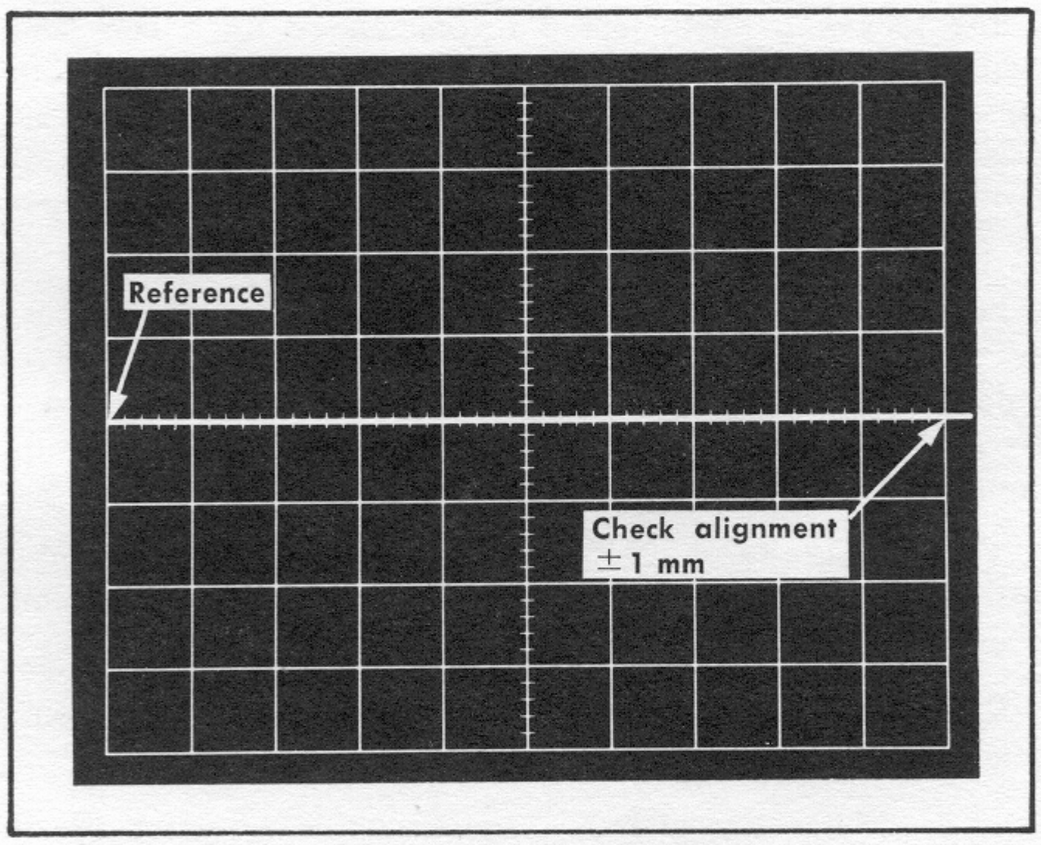


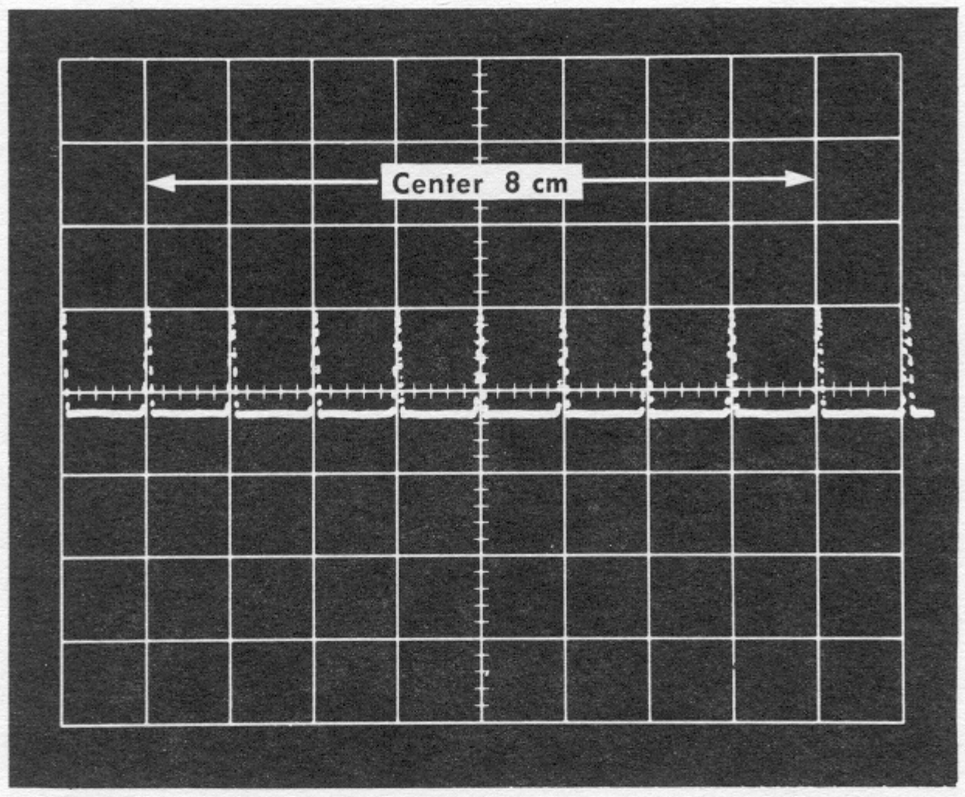
Fig. 5-1. Trace alignment check points.

NOTE

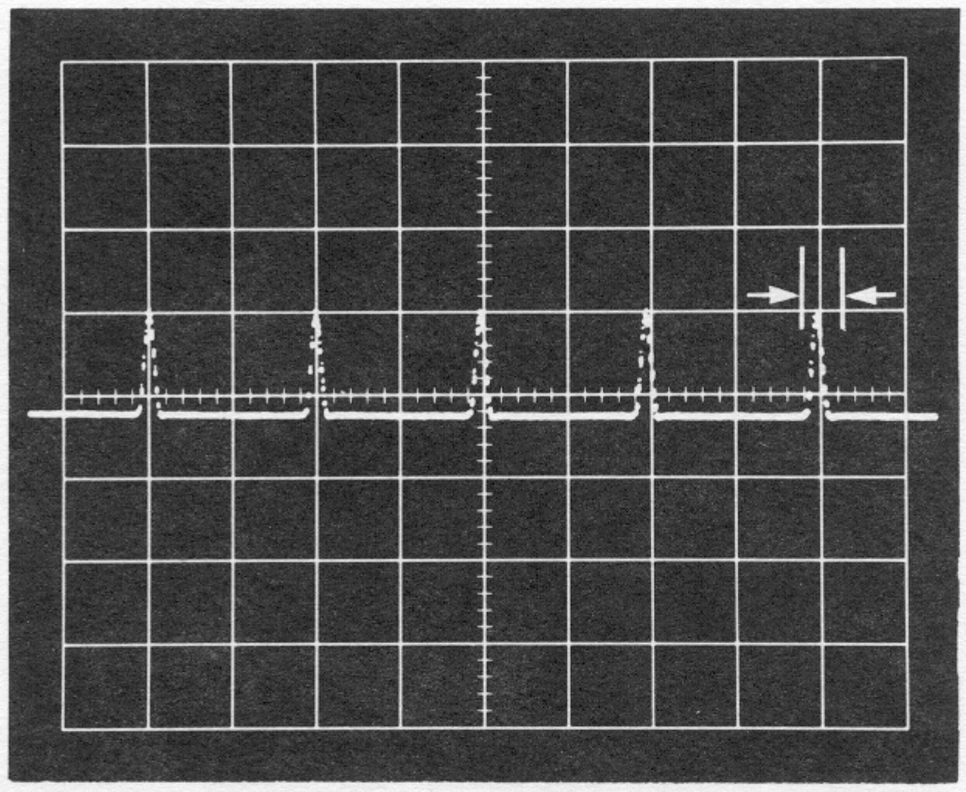
The alignment of the CRT trace is partially a function of the earth's magnetic field. The alignment will change if the location of the instrument is changed, and will even vary slightly with a 90-degree axis change in position of the instrument. To align the trace, remove the left side panel and locate the red CRT rotation knob (part of the CRT mounting clamp). Rotate the CRT until the trace aligns with a horizontal graticule marking. This adjustment should be made when the instrument is in its most probable operating location and position.

3. Check Vertical Position Indicating Neons

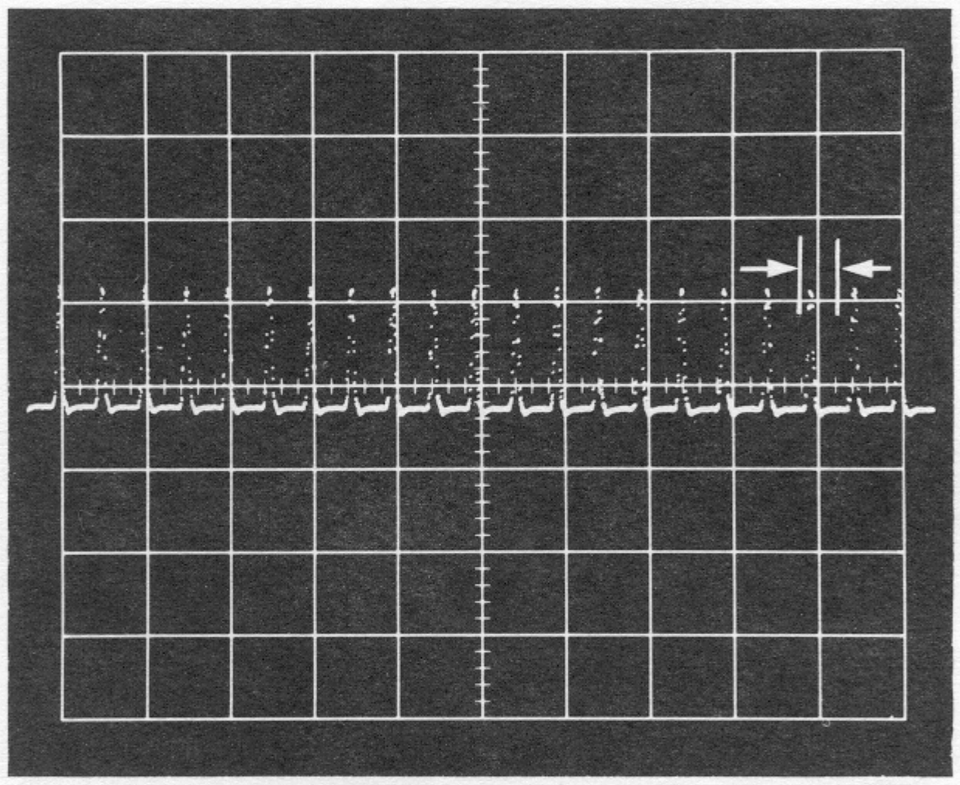
a. Requirement—One neon will be lit when the trace is outside the CRT graticule area, indicating the direction from the graticule center. The other neon should be off.



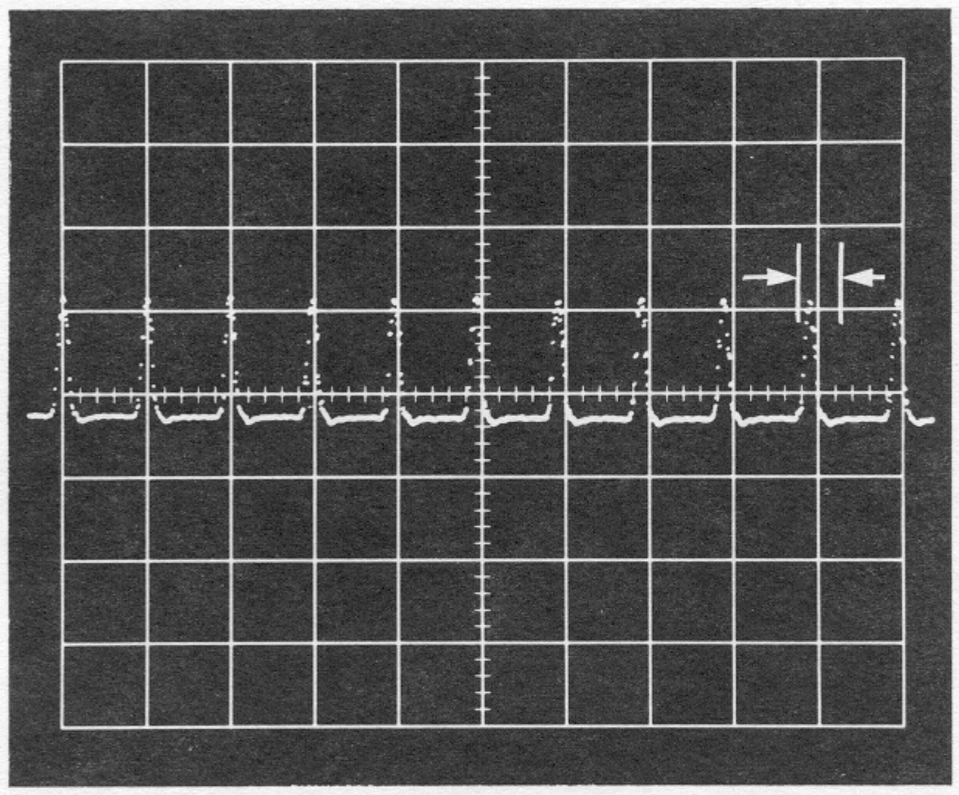
(A) ×1, adjusted



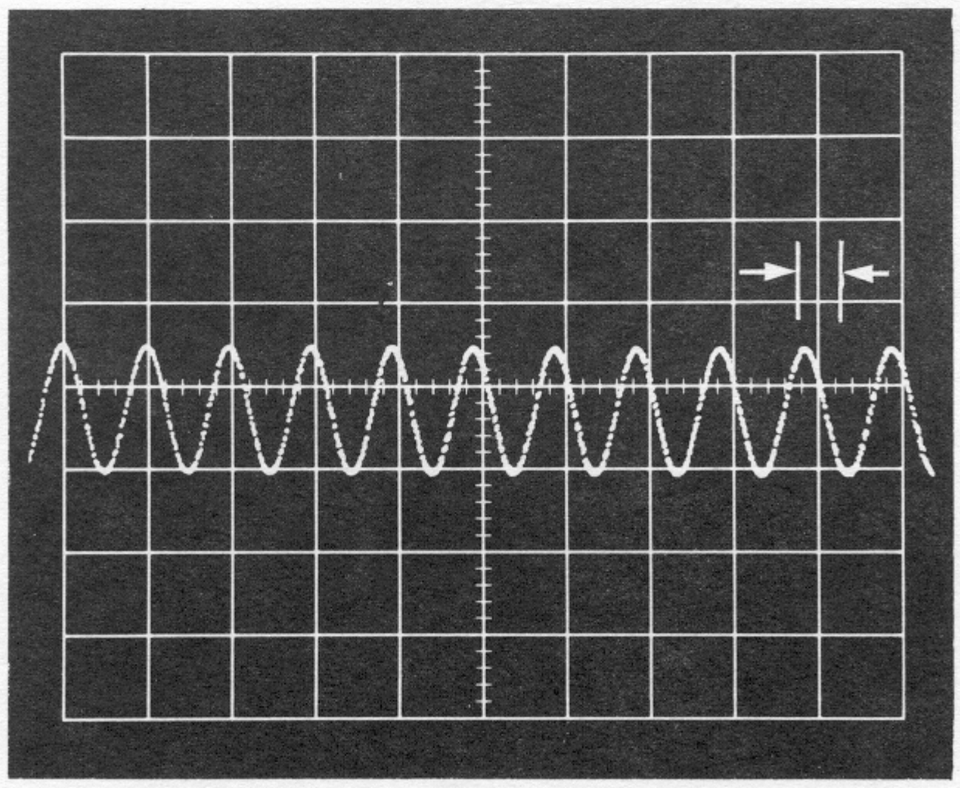
(B) ×2, ±3%, ±2.4 mm



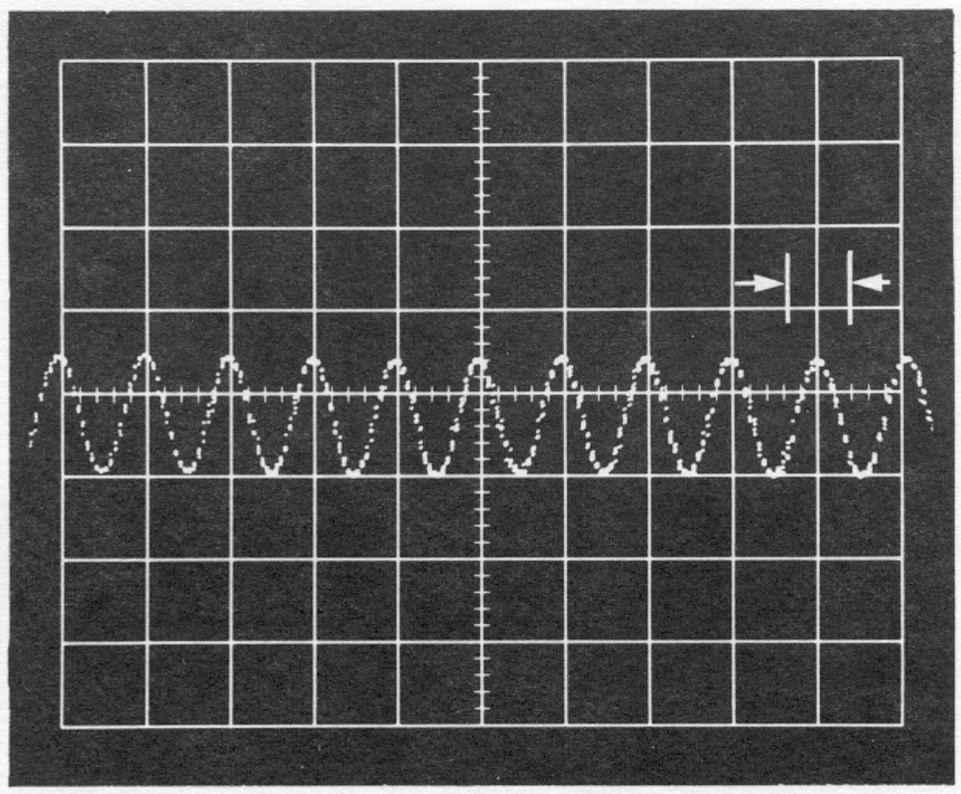
(C) ×5, ±3%, ±2.4 mm



(D) ×10, ±3%, ±2.4 mm



(E) ×20, ±3%, ±2.4 mm



(F) ×50, ±5%, ±4 mm

Fig. 5-2. Time marker displays and tolerances of SWEEP MAGNIFIER positions.

b. Position the trace above the top horizontal graticule line with the Sampling Unit Vert Position control.

c. Check—The up indicating neon is on and the down indicating neon is off.

d. Position the trace below the bottom horizontal graticule line.

e. Check—The down indicating neon is on and the up indicating neon is off.

4. Check the Horizontal Display Position and Vernier Controls

a. Requirement—Both controls fully counterclockwise will position the right end of the sweep to the left of the center vertical graticule line; both controls fully clockwise will position the start of the sweep to the right of the center vertical graticule line; the VERNIER control range must be at least 1 cm.

b. Center the trace with the Sampling Unit Vert Position control.

c. Rotate both the POSITION and VERNIER controls fully counterclockwise.

d. Check—End of the sweep is to the left of the center vertical graticule line.

e. Rotate both the POSITION and VERNIER controls fully clockwise.

f. Check—Start of the sweep is to the right of the center vertical graticule line.

g. Rotate the VERNIER control fully counterclockwise.

h. Check—Start of the sweep moves to the left at least 1 cm.

5. Check Horizontal Position Indicating Neons

a. Requirement—One neon should be lit when the spot is outside the CRT graticule area, indicating the direction from the graticule center and the other neon should be off.

b. Reduce the brightness by turning the INTENSITY control counterclockwise, set the HORIZONTAL DISPLAY switch to .5 EXT HORIZ INPUT, and check for a spot on the CRT. (Use the POSITION control if the spot is off the CRT graticule area.)

c. Position the spot outside the graticule area to the left.

d. Check—The left indicating neon is on and the right indicating neon is off.

e. Position the spot outside the graticule area to the right.

f. Check—The right indicating neon is on and the left indicating neon is off.

6. Check Sweep Magnifier Effect Upon Display Position

a. Requirement—Horizontal shift of the CRT display must not be more than 5 mm from the graticule center as the sweep magnifier is changed.

b. Set the HORIZONTAL DISPLAY switch to ×1 SWEEP MAGNIFIER, the Position VERNIER control to midrange and center the trace with the POSITION control.

c. Connect the Time Mark Generator to the sampling unit Channel A Input connector. Use a 42 inch coaxial cable with BNC connectors, a BNC to GR 874 adapter and a 5:1 attenuator (GR 874-G14).

Apply 1 μs time markers from the Time Mark Generator.

d. Set the Timing Unit Trig Source to Int, the Samples/cm to 100 and adjust the Trig Level control for a stable display.

e. Use the Type 661 POSITION controls to align a time marker with the center vertical graticule line. Maintain this alignment with the POSITION controls as the HORIZONTAL DISPLAY switch SWEEP MAGNIFIER is changed from ×1 to ×100, one setting at a time.

f. Leave POSITION controls as set. Set the HORIZONTAL DISPLAY switch SWEEP MAGNIFIER to the ×1 position and note any change in position of the chosen time marker in relation to the center vertical graticule line. A display horizontal change over 5 mm means the HORIZ DC BAL control needs adjustment. See step 17 of the Calibration Procedure.

7. Check Sweep Magnifier Accuracy

a. Requirement—SWEEP MAGNIFIER accuracy must be within ±3% at ×1 through ×20 settings, and ±5% at ×50 and ×100 settings.

b. Obtain a display of time marks similar to Fig. 5-2A. Use 1 μs time markers and set the timing unit controls as stated for ×1 Sweep Magnifier operation in Table 5-1. It may be necessary to adjust the Timing Unit Equivalent Time/Cm VARIABLE control in order to obtain exact agreement between the center 8 markers and the center 8 cm of the graticule.

c. Once the display is adjusted as in Fig. 5-2A, proceed to check the displays and timing tolerances as listed in Table 5-1. Timing limits are noted in Table 5-1 and Fig. 5-2. If any position of the SWEEP MAGNIFIER control produces a display out of tolerance, one or more precision resistors associated with the HORIZONTAL DISPLAY switch require replacement (R311 series resistors shown on the Horizontal Amplifier schematic diagram).

d. Remove the Time-Mark Generator signal cable from the Type 4S1.

TABLE 5-1

SWEEP MAGNIFIER	Time Mark Generator	Samples/cm	Display	Tolerance (Fig. 5-2)
×1	1 μs	100	1 per cm	Adjusted
×2	1 μs	100	1 per 2 cm	±3%
×5	.1 μs	1000	2 per cm	±3%
×10	.1 μs	1000	1 per cm	±3%
×20	50 ns/cycle	1000	1 per cm	±3%
×50[1]	20 ns/cycle	1000	1 per cm	±5%
×100[1]	10 ns/cycle	1000	1 per cm	±5%

[1]**It may be necessary to use a CRT viewing hood for the ×50 and ×100 measurements.**

8. Check Delayed Pulse Amplitude, SN 3460-up

a. Requirement—Delayed Pulse amplitude must be approximately —260 mV when the generator is loaded by 50 Ω. Delayed Pulse starting voltage must be near zero.

b. Connect a 2 or 5 ns signal delay coaxial cable from the DELAYED PULSE 50 Ω connector to the Sampling Unit Channel A Input connector.

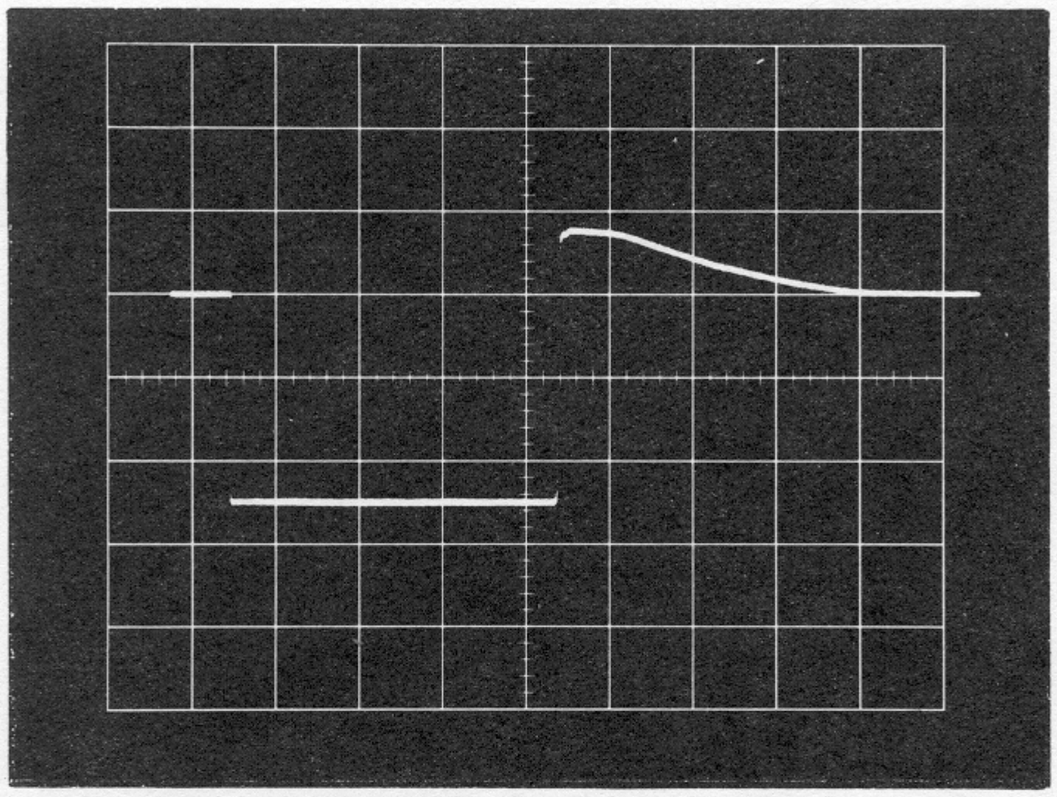


Fig. 5-3. Delayed Pulse amplitude check, SN 3460-up.

c. Set the Timing Unit Equivalent Time/Cm switch to .1 μSEC (if the unit is a Type 5T1A, set it to 1 μs and the Time Expander switch to ×2), the Trig Source switch to Free Run, the Samples/Cm control to about 10 o'clock, both Time Position controls fully clockwise, and the vertical unit Millivolts/Cm switch to 100.

d. Position the display vertically so it is similar to Fig. 5-3. The vertical amplitude should be approximately 260 mV.

e. Change the Timing Unit sweep rate to 5 ns/cm. There should be 2 or 3 centimeters of trace before the Delayed Pulse goes negative. Slowly withdraw the coaxial cable from the vertical unit input connector until the center conductors separate. Vertically position the straight line to a zero reference graticule line and reconnect the cable. There should not be any shift (vertically) of the trace beginning in the region just before the Delayed Pulse switches negative. There is no tolerance stated on the pulse zero-volt start, but if the trace start shift vertically over about ½ cm, the Delayed Pulser BASE LINE ZERO control needs adjustment.

8. Check Delayed Pulse Amplitude, SN 101-3459

a. Requirement—Delayed Pulse Amplitude must be 0.35 volts or more.

b. Connect a 2 ns signal delay coaxial cable from the DELAYED PULSE 50 Ω connector to the Sampling Unit Channel A Input connector.

c. Set the Timing Unit Equivalent Time/cm switch to .1 μSEC, Trig Source switch to Free Run, Samples/cm switch to 100, both Trig Level and Stability controls fully counterclockwise, and the Sampling Unit Millivolts/cm switch to 100.

d. Center the display with the Sampling Unit DC Offset control and measure the amplitude of the display. If the display is not similar to the display in Fig. 5-3, or is not stable, remove the right side panel of the Type 661 and adjust the Delayed Pulse Bias control, R990, for a correct, stable display (see step 21 of the Calibration Procedure).

e. Check—Delayed pulse amplitude is 3.5 cm or more (0.35 volts or more), as marked in Fig. 5-4.

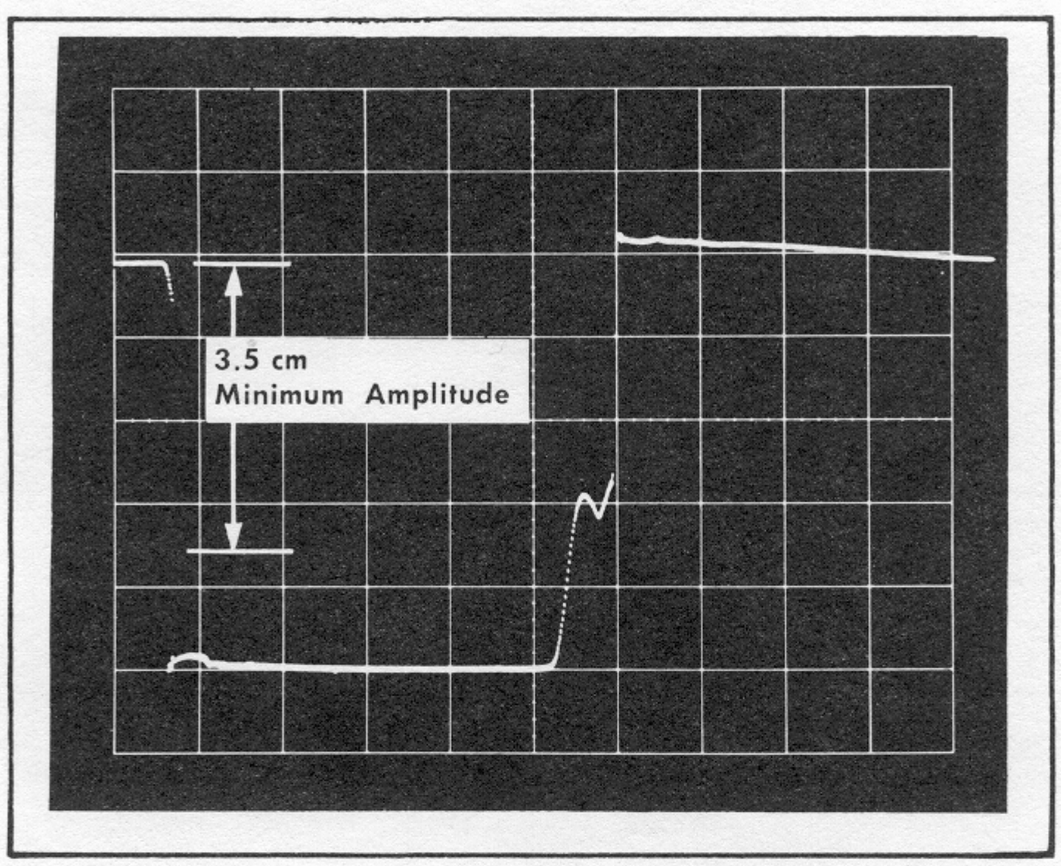


Fig. 5-4. Delayed Pulse amplitude check.

9. Check Delayed Pulse 10% to 90% Risetime SN 3460-up

a. Requirement—Risetime is 70 ps or less at the DELAYED PULSE 50 Ω connector. Risetime will appear on the Type 661 CRT in relation to the risetime of the vertical plug-in unit and the type and length of coaxial cable used between the DELAYED PULSE 50 Ω connector and the vertical unit input.

The Type 4S1 risetime (350 ps or less) is several times longer than that of the Delayed Pulse and therefore is the dominant risetime determining agent when used in the Type 661. The Delayed Pulse risetime will appear no greater than 360 ps using the Type 4S1 and either a 2 ns signal delay RG-58/U or a 5 ns signal delay RG-213/U coaxial cable.

The Type 4S2A risetime (90 ps or less) is slightly longer than that of the Delayed Pulse; therefore, the risetime as displayed on the Type 661 CRT will be longer than 90 ps. The Delayed Pulse risetime will appear no greater than 145 ps using the Type 4S2A and either a 2 ns signal delay RG-58/U or a 5 ns signal delay RG-213/U coaxial cable.

NOTE

The Delayed Pulse Generator signal risetime cannot be measured using a Type 4S1 or Type 4S3. It can be checked using only the Type 4S2A (or a Type 1S2). It is not a requirement to use the Type 4S2A (or the Type 1S2), but if one is not available, this step may be ignored. If using the Type 1S2, refer to its instruction manual for correct risetime measurement procedures.

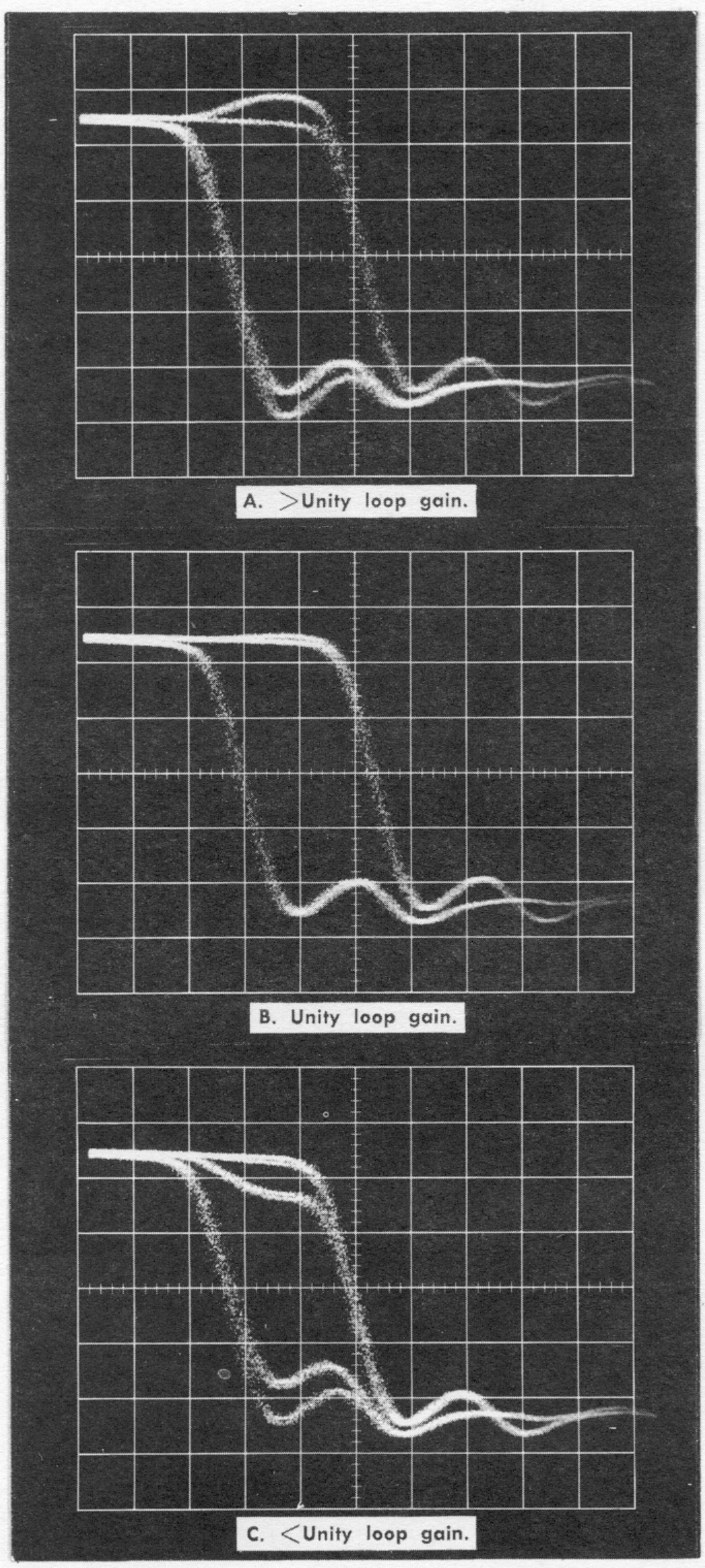


Fig. 5-5. 4S2A Unity loop gain displays, step 9, SN 3460-up.

b. Turn off the Type 661, remove the Type 4S1, install the Type 4S2A and turn on the Type 661 power. Allow about 5 minutes warm up.

c. Set the Type 4S2A Channel B loop gain to unity using the following control procedure. Place the coaxial cable between the DELAYED PULSE 50 Ω and the Type 4S2A B Input connectors.

Set the Timing Unit sweep rate to .1 ns with the blue Time Position Range control set to 2 ns. Set the Trig Source switch to Free Run. Set both the Trig Level and Stability controls tomidrange, and both Time Position controls near 3 o'clock, for a negative step display.

Slowly rotate the Trig Level control through its range until the negative step display shifts horizontally about 2 cm. There is a very sensitive adjustment at that control position which will produce a display with more than one negative step, such as is shown in Fig. 5-5. Adjustment of the Stability control permits vernier action of the dual step display.

Now adjust the Type 4S2A Channel B Smoothing control until the CRT display shows that the sampling system is operating at unity loop gain, as shown in Fig. 5-5B. Now move the Timing Unit Trig Level control to obtain just one stable negative step in the display.

d. Use the Type 4S2A DC Offset and millivolts/cm Variable controls to obtain an 8 cm display. See Fig. 5-6A. It is important that the pulse start point coincide with the graticule top line, and that the first full 100% peak coincide with the bottom graticule line. Fig. 5-6A shows that the bottom edge of the step display is used in making the risetime check. It is also permissible to use either the trace mid-point, or the top edge of the trace, but whichever you use, be consistent in using the same portion of the trace at both top and bottom.

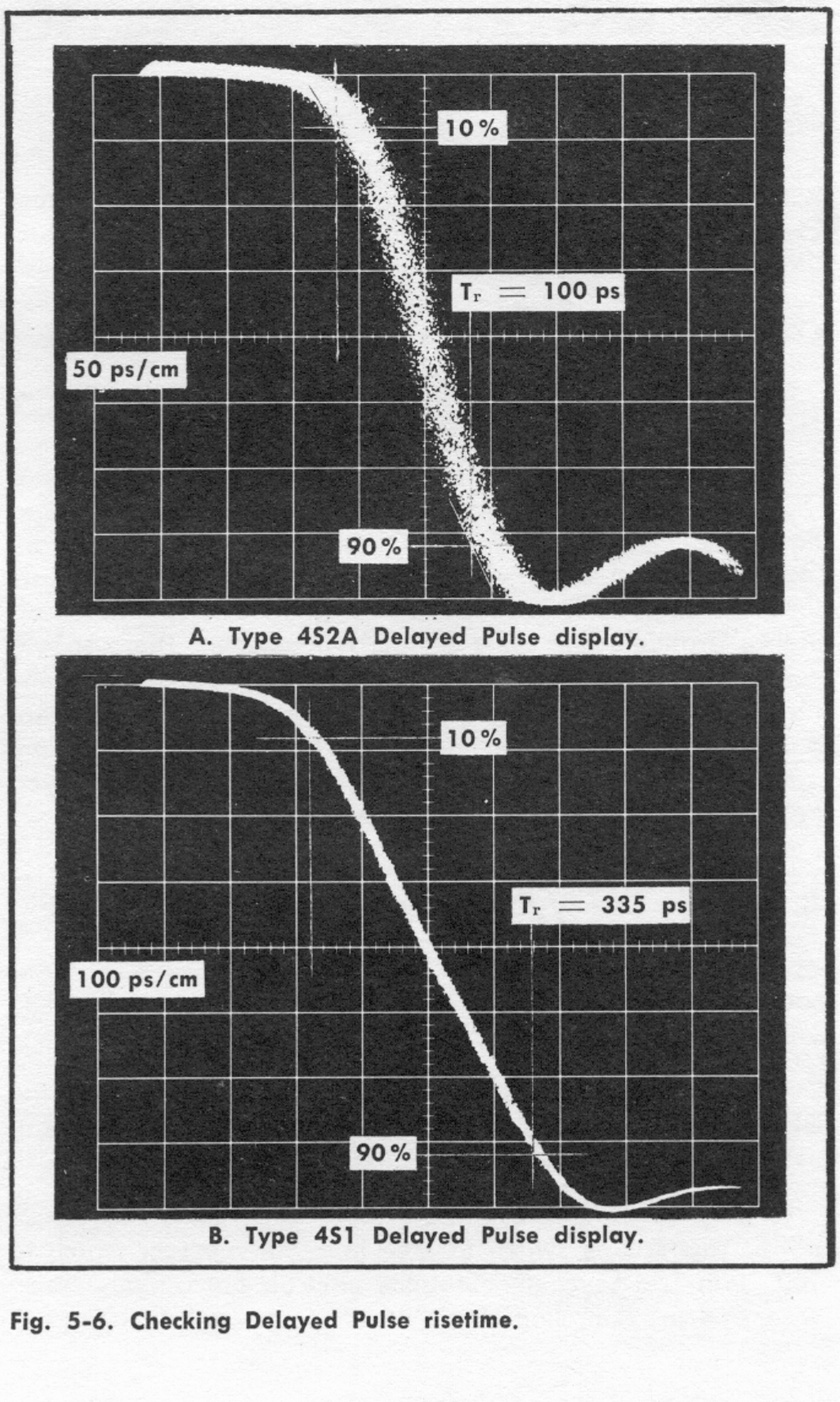


Fig. 5-6. Checking Delayed Pulse risetime.

Locate the 10% and 90% points. They are each located 8 mm (0.8 major division) from the graticule top and bottom. The time between these two points is the system risetime. (The most accurate way to make the risetime check is to photograph the display and scribe the print in the same manner as shown in Fig. 5-6A).

e. If you do not have a Type 4S2A and use a Type 4S1, refer to Fig. 5-6B for a typical display of the Delayed Pulse.

9. Check Delayed Pulse 10% to 90% Risetime SN101-3459

a. Requirement—Risetime is 150 ps or less at the DELAYED PULSE 50 Ω connector. Risetime will appear on the CRT of the Type 661 in relation to the risetime of the Vertical plug-in and the connecting cable used.

The Type 4S1 risetime (350 ps or less) is greater than that of the pulse risetime and, therefore, is the dominant risetime observed with the Type 661. The Delayed Pulse risetime will appear not greater than 380 ps using the Type 4S1 and a 2 ns signal delay RG 58 coaxial cable.

The Type 4S2A risetime (90 ps or less) is less than that of the pulse risetime and, therefore, the pulse risetime will be the dominant one observed on the CRT. The Delayed Pulse risetime will appear not greater than 180 ps using the Type 4S2A, and a 2 ns signal delay RG 58 coaxial cable.

NOTE

The sampling system loop gain is set to unity to check the Delayed Pulse 10% to 90% risetime. It is not a requirement to use the Type 4S2A, but the pulse risetime is not measurable with a Type 4S1. The rest of this step assumes a Type 4S2A is available. If you do not have a Type 4S2A, the remainder of this step may be disregarded.

b. Turn off the Type 661, remove the Type 4S1, install the Type 4S2A and turn on the Type 661. Allow about 5 minutes warm up.

c. Set the Type 4S2A controls the same as for the Type 4S1 in the preceding step, and set the Millivolts/Cm Variable control for a display amplituude of approximately 8 cm.

d. Set the Timing Unit Equivalent Time/Cm control to 2 nSec. Pull the Magnifier and set it for a sweep rate of .1 nSec (100 ps/cm). Use the Time Position controls to center the falling portion of the display on the graticule.

e. Set the Sampling System for unity gain; turn the Timing Unit Stability or UHF Sync control clockwise until the display is double triggered. Adjust the Sampling Unit Smoothing control so the lower line of the display is a straight line as marked in Fig. 5-7. Set the Timing Unit Stability or UHF Sync control fully counterclockwise and set the Sampling Unit Variable control for an amplitude of exactly 8 cm. (See Fig. 5-8A.) The Delayed Pulse Gen Bias control, R990, may require readjustment for a stable display with minimum noise. Minimum noise will occur with R990 adjusted in a direction that causes the step to move to the left toward instability.

f. Measure the time required for the waveform to fall from 10% of its total amplitude to 90% of its total amplitude, as marked in Fig. 5-8A. The risetime must be 180 ps or less (1.8 cm).

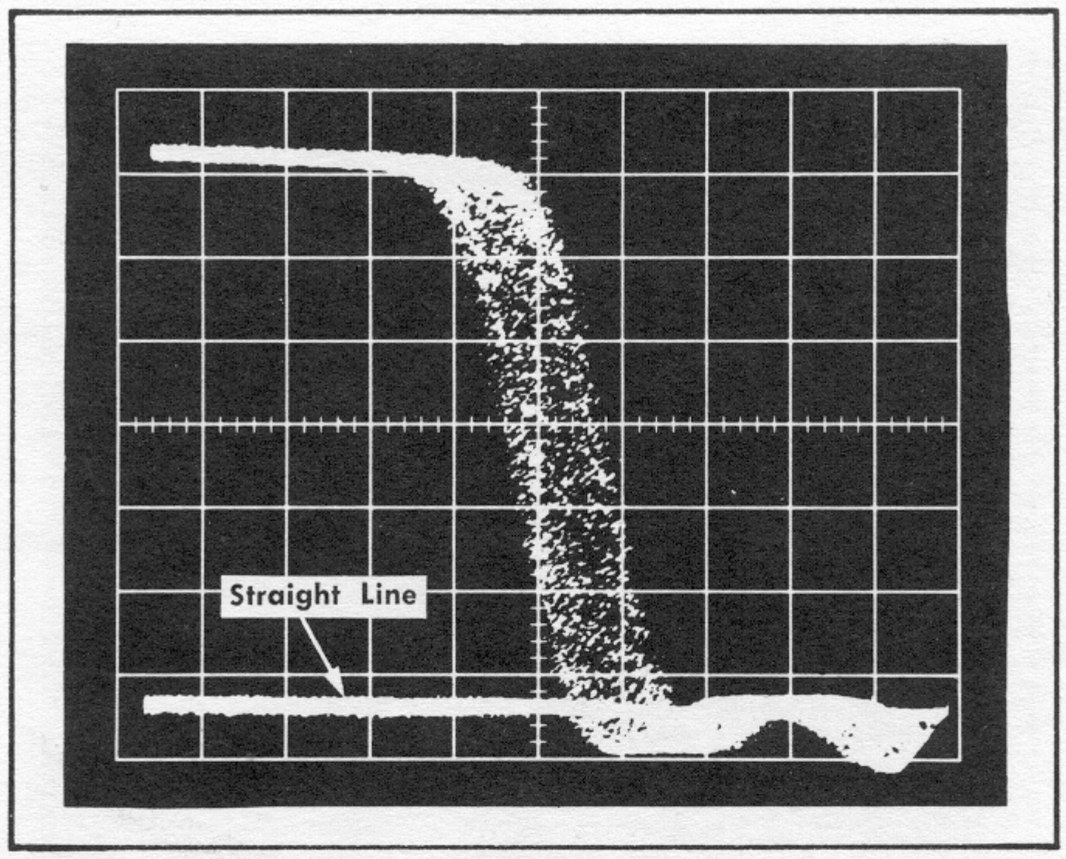


Fig. 5-7. Unity gain display.

h. Disconnect the coaxial cable, turn off the Type 661, remove the Type 4S2A, install the Type 4S1 and turn on the Type 661. Allow about 5 minutes warm-up time.

10. Check Amplitude/Time Calibrator Amplitude

a. Requirement—Signal amplitude must be within the following tolerances into a 50 Ω load:

b. Set the Sampling Unit Millivolts/Cm switch to 200, the Variable control to Calibrated and Smoothing control for unity gain. Set the Timing Unit Equivalent Time/cm switch to 5 μSec.

TABLE 5-2

Amplitude	Tolerance	
	10, 1, 0.1 μSEC/CYCLE	0.01 μSEC/CYCLE
1000 mV	±2%	±8%
100 mV	±4%	±9%
10 mV	±5%	±10%
1 mV	±6%	±11%

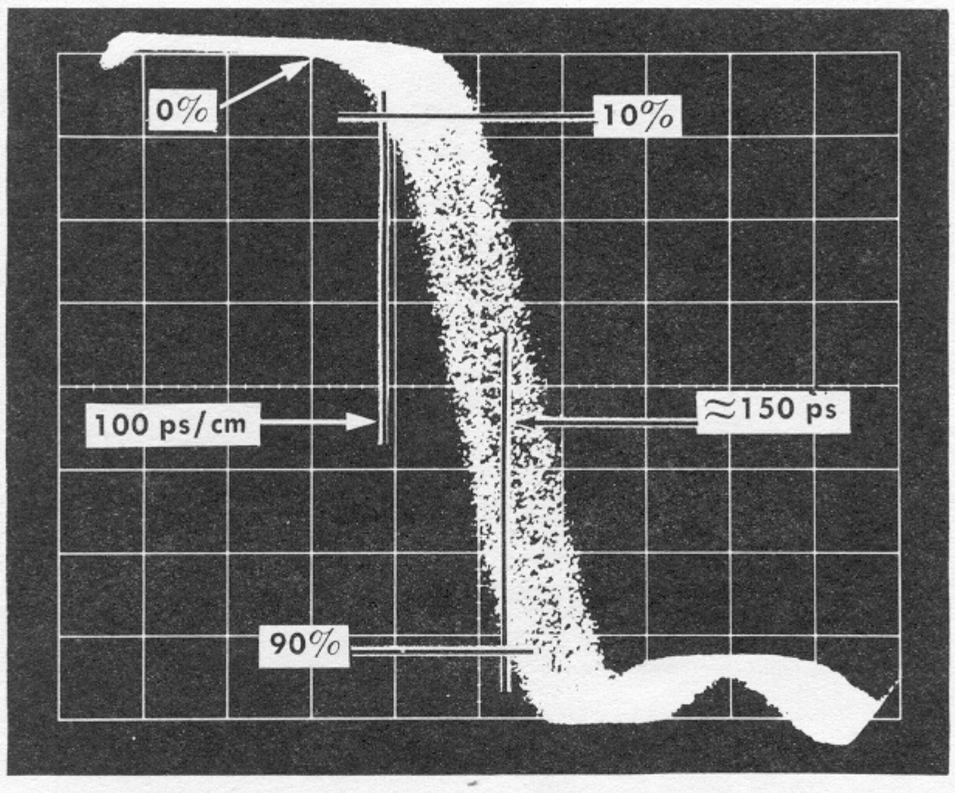
c. Connect the 50 Ω Amplitude Calibrator (item 6 Equipment list) Output connector to the Type 4S1 Channel A Input connector. Use a coaxial cable with GR 874 connectors.

Connect the 50 Ω Amplitude Calibrator Trigger Output connector to the Type 5T3 Ext Trig Input 1 MΩ connector. Use a coaxial cable with BNC connectors.

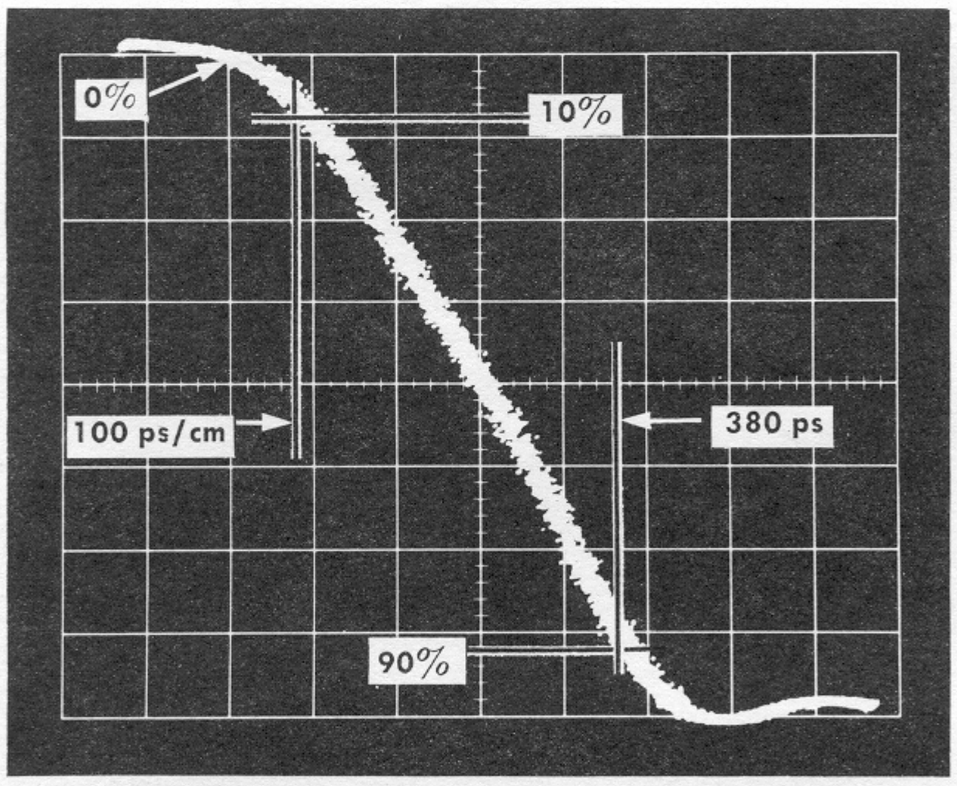
Set the 50 Ω Amplitude Calibrator controls:

Test—Operate switch	Operate (Square-wave)
Volts	1.2

d. Set the Timing Unit Samples/cm switch to 1000, Time Position controls clockwise, Trig Source to Ext, Slope to —, Ext Trig Mode to AC, and adjust the Trig Level control for a stable display.

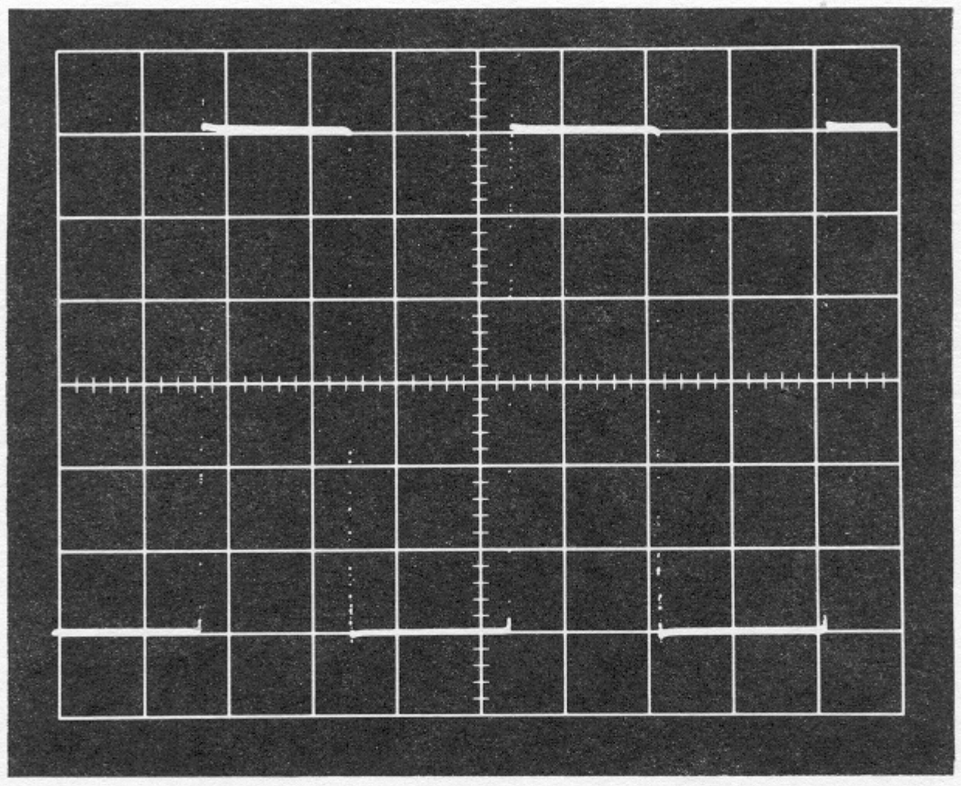


(A) Type 4S2A display at unity loop gain.

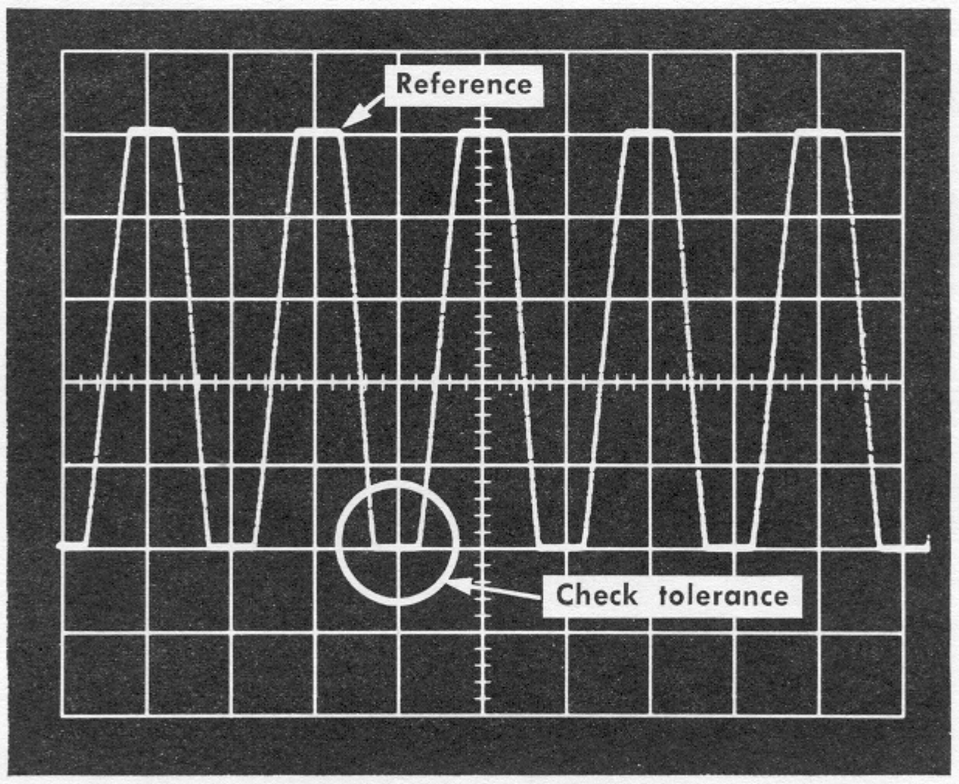


(B) Type 4S1 display at unity loop gain.

Fig. 5-8. Delayed Pulse risetime checks.



(A) Vertical calibration using 50 Ω Amplitude Calibrator



(B) 10 μSEC/CYCLE display

Fig. 5-9. AMPLITUDE/TIME CALIBRATOR testing displays.

e. Obtain a display amplitude of exactly 6 cm, adjust the Sampling Unit Variable control and/or Millivolts/cm switch if necessary (see Fig. 5-9A). The vertical is now accurately calibrated.

f. Set the Type 661 AMPLITUDE/TIME CALIBRATOR mV AMPLITUDE switch to 1000 and the μSEC/CYCLE switch to 10. Remove the signal cable from the 50 Ω Amplitude Calibrator Output connector and attach it to the AMPLITUDE/TIME CALIBRATOR OUTPUT INTO 50 Ω connector. Set the Timing Unit Trig Source switch to Cal.

g. The display amplitude should be 5 cm peak to peak ±1 mm. See Fig. 5-9B. Check the amplitude tolerances (at 1000 mV AMPLITUDE) at the other three settings of the μSEC/CYCLE switch. Tolerances and sweep rates are listed in Table 5-3.

h. Use the same amplitude adjustment method (as in e above) to set the vertical reference amplitude for each of the other positions of the mV AMPLITUDE switch according to figures in Table 5-3. Check each amplitude at all four μSEC/CYCLE switch positions.

TABLE 5-3

AMPLITUDE/TIME CALIBRATOR

Amplitude Checks				
mV AMPLITUDE	50 Ω Amplitude Calibrator	Timing Unit Time/cm	μSEC/CYCLE	Display ± tolerance
1000	1.2 volts	5 μSec		6 cm, adjusted
		5 μSec	10	5 cm ± 1 mm
		.5 μSec	1	5 cm ± 1 mm
		50 nSEC	.1	5 cm ± 1 mm
		5 nSec	.01	5 cm ± 4 mm
100	.12 volts	5 μSec		6 cm, adjusted
		5 μSec	10	5 cm ± 2 mm
		.5 μSec	1	5 cm ± 2 mm
		50 nSec	.1	5 cm ± 2 mm
		5 nSec	.01	5 cm ± 4.5 mm
10	.012 volts	5 μSec		6 cm, adjusted
		5 μSec	10	5 cm ± 2.5 mm
		.5 μSec	1	5 cm ± 2.5 mm
		50 nSec	.1	5 cm ± 2.5 mm
		5 nSec	.01	5 cm ± 5 mm

i. 1 mV AMPLITUDE position. All three attenuators of the mV AMPLITUDE switch are checked in the 100 mV and 10 mV positions. The 1 mV AMPLITUDE position is impractial to check, due to noise. The per cent error can be determined by first noting the error at the 100 mV position, then the error at the 10 mV position. Compute the error as follows:

$$100\text{ mV \% error} + \frac{10\text{ mV \% error}}{10} = 1\text{ mV \% error}$$

If there are any signal amplifiers out of tolerance, record them and look over the data for either an oscillator amplitude error or an attenuator section error. The tests as outlined above check both oscillator signal amplitude for all four ouput frequencies and the attenuation tolerances of all fixed attenuator sections. It may be that an atenuator error can be corrected (by calibration) by adjusting the oscillator amplitude so other amplitudes are different than recorded, but all are then within specifications.

j. Remove the cable from the Timing Unit Ext Trig Input connector and set the Sampling Unit Channel A Millivolts/cm switch to 200, Variable control to Calibrated, and the Smoothing control to Normal.

11. Check Amplitude/Time Calibrator Time/Cycle

a. Requirement—At 10, 1 and .1 μSEC/CYCLE, the time per cycle must be within ±0.2% and at .01 μSEC/CYCLE within ±2%.

b. Set the AMPLITUDE/TIME CALIBRATOR mV AMPLITUDE switch to 1000 and the μSEC/CYCLE switch to 10.

c. Set the Type W Unit for AC input coupling, A-B Display and 500 Millivolt/cm attenuation.

d. Connect the AMPLITUDE/TIME CALIBRATOR OUTPUT INTO 50 Ω connector to the Type W Input A connector. Use a GR to BNC adapter, a coaxial cable with BNC connectors and a 50 Ω mid-line termination, (item 15, Equipment list).

e. Connect the Time-Mark Generator to the Type W Input B connector. Use a coaxial cable with BNC connectors.

Set the Time-Mark Generator to deliver 10-μs markers.

f. Set the test oscilloscope time base controls for a triggered, stable display of the difference frequency displayed. Fig. 5-10 shows a typical beat frequency display.

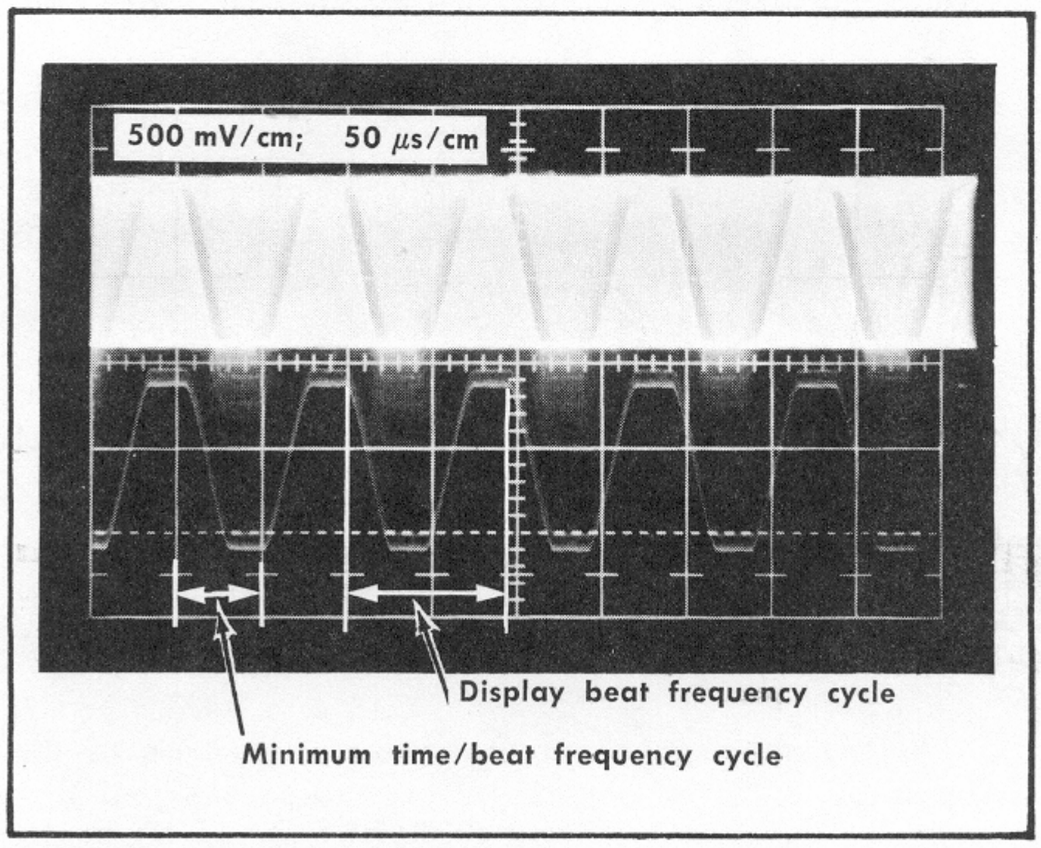


Fig. 5-10. Test oscilloscope display for step 10f.

NOTE

The beat or difference frequency is formed by the variation in amplitude which occurs when two signals of different frequency are mixed by addition or subtraction. Two signals of the same frequency produce no variation in amplitude and therefore no beat frequency.

g. Measure the beat frequency time per cycle of the test oscilloscope display. The tolerance is computed as follows:

$$f = \frac{1}{T} = \frac{1}{10\ \mu SEC} = 100\ kHz$$

$$100\ kHz \times 0.2\% = 200\ Hz$$

$$T = \frac{1}{f} = \frac{1}{200} = 5\ ms/cycle$$ (minimum time per difference frequency cycle)

h. Measure the frequency for the four conditions listed in Table 5-4.

i. Disconnect both signal cables.

12. Check Horizontal Signal Output

a. Requirement—The Horizontal signal output must be 200 millivolts per centimeter of the CRT display ± 3%.

b. Set the Timing Unit Trig Source switch to Free Run.

TABLE 5-4

AMPLITUDE/ TIME CALIBRATOR μSEC/CYCLE	Time-Mark Generator	Tolerance	Minimum Time per Cycle of beat frequency
10	10 μs	± 0.2%	5 ms
1	1 μs	± 0.2%	0.5 ms
.1	.1 μs	± 0.2%	50 μs
.01[2]	10 ns ∿	± 2%	0.5 μs

[2]**The Type W Unit input attenuation must be decreased.**

c. Set the HORIZONTAL DISPLAY switch to .1 EXT HORIZ INPUT and use the POSITION and VERNIER controls to position the spot to the left edge of the graticule.

d. Connect the Standard Amplitude Calibrator right side Output connector to the Type 661 EXT INPUT 25 kΩ connector. Use a coaxial cable with BNC connectors and a BNC to Clip Lead adapter. Connect the Clip Lead adapter red lead to the EXT INPUT 25 kΩ terminal, and the black lead to the adjacent plated ground terminal.

Set the standard Amplitude Calibrator Amplitude control to .5 Volts, the Mode switch for square-wave output and the Mixed switch to the up position.

e. Two dots will appear on the Type 661 CRT. Use the horizontal POSITION control for a centered two dot display. The distance between the two dots will be approximately 5 cm.

f. Multiply the number of centimeters separation of the two dots by 0.2 V to obtain the peak-to-peak signal that should be at the HORIZ SIGNAL OUTPUT terminal. (Example: 4.8 × 0.2 = 0.96 Volts.)

g. Connect the test oscilloscope 1× probe to the HORIZ SIGNAL OUTPUT terminal. Adjust the Type W DC Bal control for no test oscilloscope trace shift when turning the Millivolts/cm Variable control. Change the Type W Vc Range switch to 0, the Comparison Voltage (Vc) knob and dial to 0.000, and position the bottom of the test oscilloscope square-wave display to the graticule center line. This is the zero signal reference.

h. Set the Type W Vc Range switch to +1.1 and adjust the Comparison Voltage dial until the top of the display is at the graticule center line. Note the dial reading. This is the peak signal value.

i. Compare the dial reading to the CRT display as follows:

$$\frac{\text{(CRT display) (0.2) - dial reading}}{\text{(CRT display) (0.2)}} \times 100 = \%\ \text{error}$$

The horizontal output signal must be within 3% of the voltage calculated in f above.

j. Disconnect the 1× probe from the HORIZ SIGNAL OUTPUT jack. Leave the Standard Amplitude Calibrator as connected.

13. Check External Horizontal Input Attenuator Accuracy

a. Requirement—External horizontal attenuator accuracy must be within ± 5% at .05 and .1; ± 3% at all other positions.

b. Connect the 1× Probe between the Type 661 EXT. INPUT 25 kΩ connector and the Type W Unit Input A connector.

c. Set the Standard Amplitude Calibrator to .2 volts, the Type W Vc Range switch to 0, and the 661 HORIZONTAL DISPLAY switch to EXT HORIZ INPUT .05 VOLTS/CM.

d. Position the bottom line of the test oscilloscope display exactly at the center graticule line with the Type W Position control.

e. Set the Type W Vc Range switch to +1.1 and turn the Comparison Voltage (Vc) dial to position the top line of the display exactly on the center line. The dial reading is the voltage applied to the Type 661 EXT INPUT 25 kΩ connector.

g. Carefully determine the horizontal deflection on the Type 661 CRT and divide this deflection into the dial reading of the Type W Unit. The volts/cm computed is the external horizontal input deflection factor. Check its tolerance with Table 5-5.

h. Repeat this procedure to check all other positions of the EXT HORIZ INPUT switch according to Table 5-5.

NOTE

The .2 and 2 EXT HORIZ INPUT switch positions are the only positions not previously checked with the SWEEP MAGNIFIER positions of the HORIZONTAL DISPLAY switch.

i. Leave the Standard Amplitude Calibrator as connected.

14. Check External Horizontal Display AC Coupling

a. Requirement—Display should shift to the left by approximately half of its amplitude.

b. Center the display about the center graticule line with the POSITION control.

c. Set the VOLTS/CM AC-DC switch from DC to AC. The display must shift to the left by approximately half of its amplitude.

d. Disconnect the external horizontal signal.

15. Check Manual Scan Operation

a. Requirement—Fast rate of change movement of the spot is equal to the speed of control rotation; slow rate of change movement is slower than the speed of control rotation.

b. Set the Type 661 HORIZONTAL DISPLAY switch to MANUAL SCAN F.

c. Rotate the POSITION control counterclockwise and then clockwise and note the movement of the spot. The spot must move at the speed of rotation of the POSITION controls.

d. Set the HORIZONTAL DISPLAY switch to MANUAL SCAN S.

e. Rotate the POSITION control counterclockwise and then clockwise and note the movement of the spot. The spot movement must be slower than the speed of rotation of the POSITION controls.

This completes the performance check procedure for the Type 661 Oscilloscope. If the instrument has met all performance requirements given in this procedure, it is correctly calibrated and within the specified tolerances.

TABLE 5-5

EXT HORIZ INPUT Sw	Standard Amplitude Calibrator	Type W Vc Range	Comparison Voltage (Vc) knob	Computed Volts/cm	Maximum Allowable ± Error
.05	.2 V	+1.1	0	0.05	0.0025 V/cm
.1	.5 V	+1.1	0	0.1	0.005 V/cm
.2	1 V	+1.1	0	0.2	0.006 V/cm
.5	2 V	+1.1	1	0.5	0.15 V/cm
1	5 V	+1.1	4	1	0.03 V/cm
2	10 V	+1.1	9	2	0.06 V/cm
5	20 V	+11	1	5	0.15 V/cm

NOTES

SECTION 6

CALIBRATION

Introduction

The information in this section of the manual outlines the procedure used to calibrate and check the operation of the Type 661 Oscilloscope after each 500 hours of operation or every six months if used intermittently. This section may also be used as an aid in isolating troubles occuring within the instrument.

In the instructions that follow, the steps are arranged in the proper sequence for a complete calibration of the instrument. Each numbered step contains the information required to make one check or adjustment or a series of related checks or adjustments. The steps are arranged to avoid unnecessary repetition of checks or adjustments.

NOTE

The performance standards described in this section of the manual are provided strictly as guides to calibration of the Type 661 and should not be construed as advertised performance specifications. However, if the Type 661 performs within the guide tolerances given in the calibration precedure, it will also perform as listed in the Characteristics section of this manual. This procedure is correct for Type 661 instruments, SN 2000-up. Notes regarding calibration for earlier instruments follow the main procedure.

Equipment Required

Equipment required for the complete calibration of the Type 661 is shown in Fig. 6-1 and Fig. 6-2 and listed below. Alternate equipment may be substituted for that listed, if the performance specifications of the substituted equipment meet the particular requirements of the test. All test equipment must be calibrated and in good working order.

1. Autotransformer with output voltage variable between 105 and 125 (or 210 and 250) volts and a minimum rating of 600 watts. If autotransformer does not have an AC voltmeter to indicate output voltage, monitor output with an RMS reading voltmeter with a range of at least 125 (250) volts. For example, General Radio W10MT3W Metered Variac Autotransformer.

2. Bench multimeter, 20,000 ohm/volt, such as Simpson 262 or Triplett 630-NA.

3. A precision, non-loading DC voltmeter with the following minimum tolerances; ±0.07% at 19 and 300 volts, ±0.1% at 100 volts, and ±0.8% at 25.2 volts. A John Fluke Model 801B voltmeter meets these requirements.

4. Test oscilloscope with a deflection factor of 5 mV minimum, a differential input, and a voltage comparator voltage accuracy of 0.3% at 1 volt. Tektronix Type 545B Oscilloscope and Type W High-Gain Comparator Plug-In Unit recommended.

5. Time-mark generator , with marker or sine-wave outputs of 500 μs, 100 μs, 50 μs, 10 μs, .1 μs, 50 ns and 10 ns with an accuracy of ±0.02%. Tektronix Type 184 Time-Mark Generator recommended.

6. Tektronix Type '4' Series Sampling Unit. Type 4S1[1] recommended. Type 4S2A required for optional check of the Delayed Pulse risetime.

7. Tektronix Type '5' Series Timing Unit. Type 5T3 recommended.

8. Accurate amplitude signal generator for setting the input deflection factor to check the Amplitude Time Calibrator. Requires amplitudes of 0.12 and 0.012 volts with an accuracy of ±0.4%. Tektronix 50 Ω Amplitude Calibrator 067-0508-00 recommended.

9. 1× probe with BNC connector, such as Tektronix P6011, Part No. 010-0193-00.

10. 10× attenuator probe, such as Tektronix P6006 with BNC connector, Part No. 010-0127-00.

11. Two 50 Ω coaxial cables, 42 inch length, type RG58 with BNC connectors. Tektronix Part No. 012-0057-00.

12. 50 Ω coaxial cable, 2 ns signal delay, type RC58 with GR 874 connectors, such as Tektronix Part No. 017-0505-00.

13. 50 Ω coaxial cable, 10 ns signal delay, type RG58 with GR 874 connectors, Tektronix Part No. 017-0501-00.

14. 50 Ω 5:1 attenuator, with GR 874 connectors. GR874-G14 (14dB) Attenuator Recommended. Tektronix Part No. 017-0079-00.

15. 50 Ω mid-line termination GR 874 to BNC. Tektronix Part No. 017-0083-00.

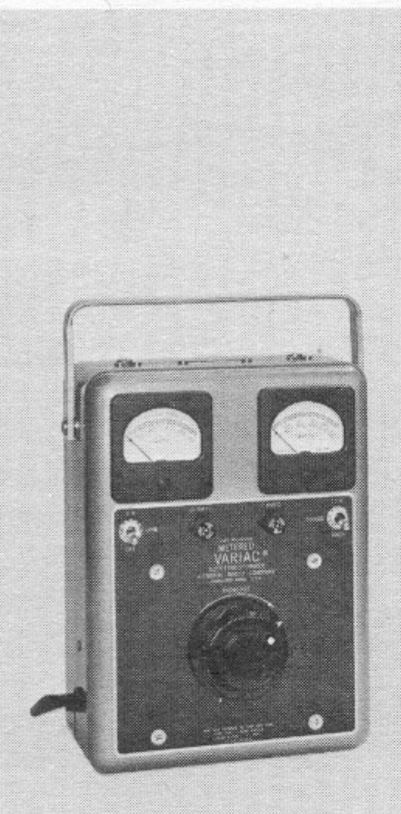
16. Coaxial connector adapter, GR 874 to BNC female. Tektronix Part No. 017-0063-00.

17. Coaxial connector adapter, UHF male to BNC female. Tektronix Part No. 103-0015-00.

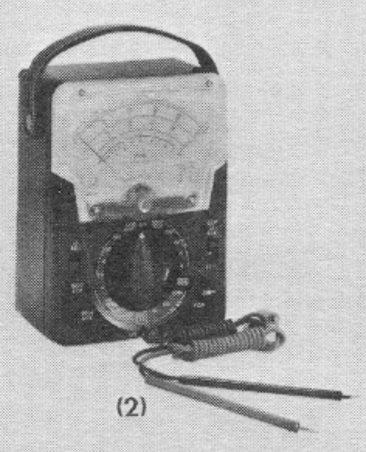
18. BNC to Clip Lead adapter. Tektronix Part No. 013-0076-00.

19. Four patch cords, length about 18 inch, with insulated alligator clips.

[1] **A Type 4S3 Sampling-Probe Dual-Trace Unit and P6038 Probes may be used instead of a Type 4S1. If a Type 4S3 is used, a VP-2 Voltage Pickoff (Tektronix part number 017-0077-00) and an accurate 50 Ω termination with GR connector (Tektronix part number 017-0081-00) will be required for connecting to input signals. External triggering will also be required in the procedure whenever internal triggering is specified with the Type 4S1.**



(1)



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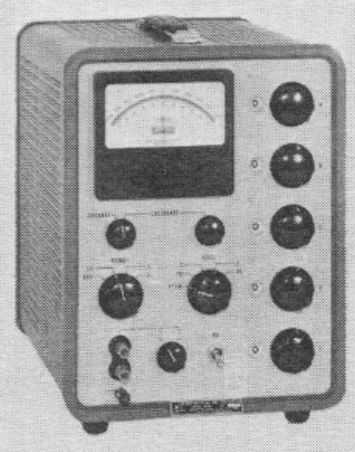
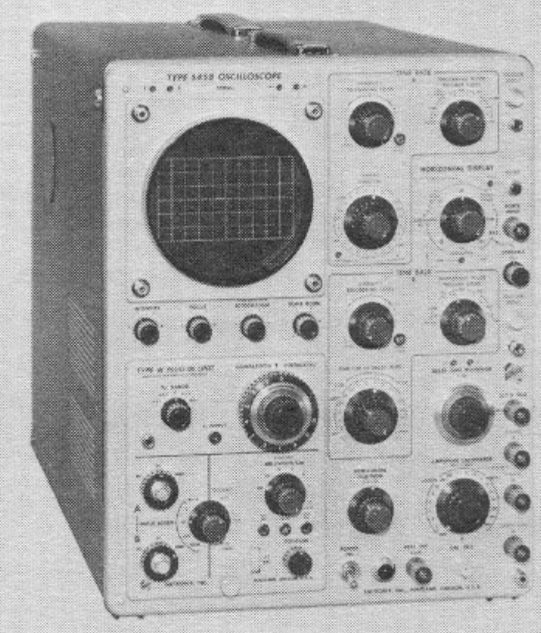


(3)



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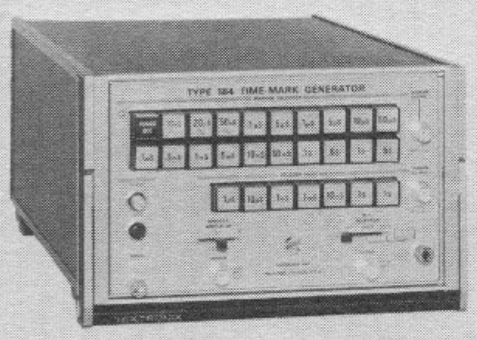

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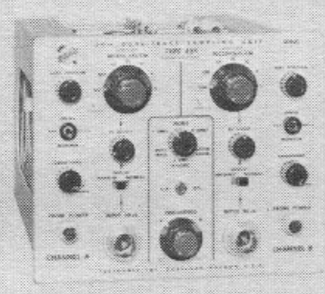

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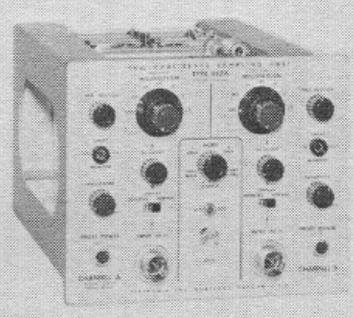

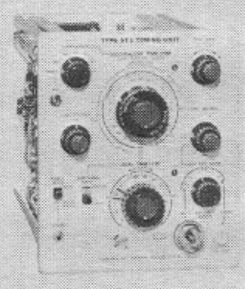

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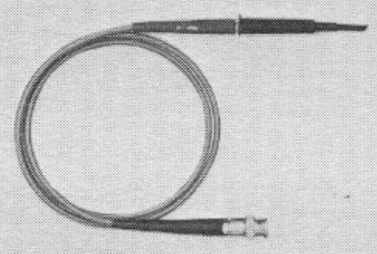

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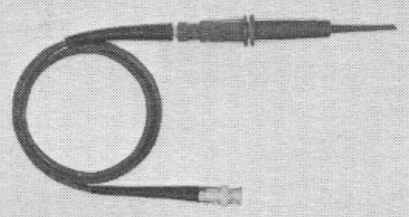

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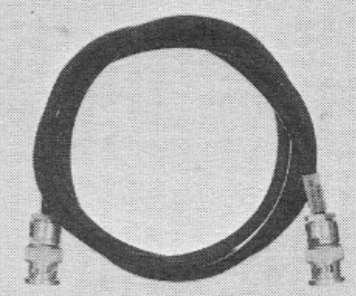

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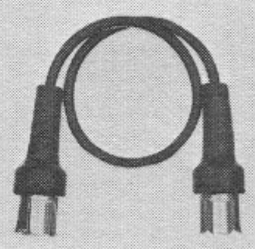

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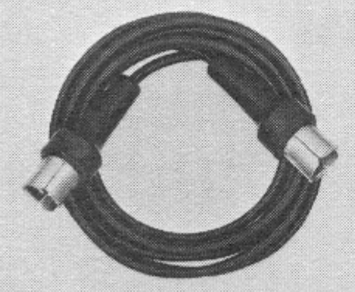

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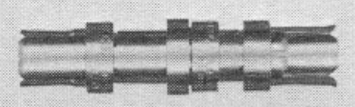

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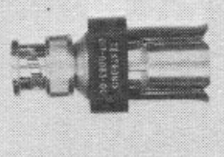

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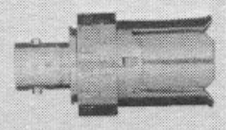

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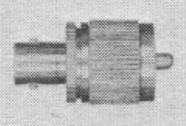


(17)

Fig. 6-1. Equipment required for calibration.

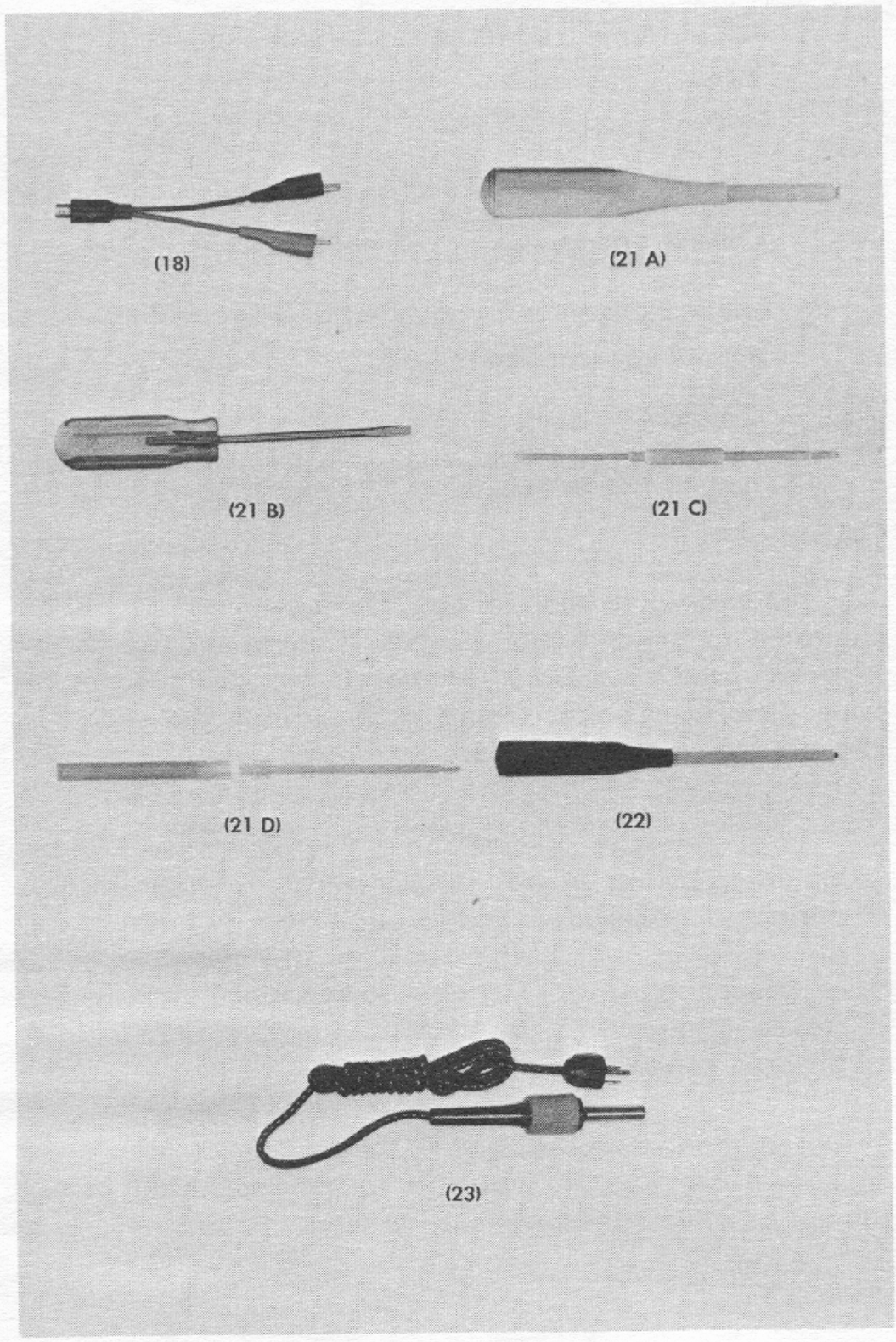


Fig. 6-2. Adjustment tools.

20. Resistors:

Description	Tektronix Part Number
1.5 kΩ, 1%, ½ W precision	323-0210-00
(Two) 1 MΩ, 1%, ½ W, precision	309-0148-00
24.9 kΩ, 1%, ½ W, precision	323-0327-00
(Two) 2 MΩ, 1%, ½ W, precision	309-0023-00

21. Adjustment tools:

a. An insulated screwdriver with a 1½-inch plastic shank for adjusting potentiometers and capacitors. Jaco No. 125 or Tektronix part number 003-0000-00.

b. A pocket screwdriver with an insulated shank at least 2 inches long and a blade width of approximately 3/32 inch.

c. A plastic tool for adjusting large-core variable inductors, such as Walsco No. 2543 or Tektronix part number 003-0301-00.

d. A plastic tool for adjusting small-core variable inductors, such as the combination of Tektronix part numbers 003-0307-00 and 003-0310-00.

22. SN 101-1999. An insulated screwdriver with a 7- inch plastic shank for adjusting the AMPLITUDE/TIME CALIBRATOR. Jaco No. 15 or Tektronix part number 003-0001-00.

23. SN 101-309. A 50- to 60-watt soldering iron.

CALIBRATION RECORD AND INDEX

This Abridged Calibration Procedure is provided to aid in checking the operation of the Type 661. It may be used as a calibrating guide by the experienced calibrator, or it may be used as a calibration record. Since the step numbers and titles used here correspond to those used in the complete Calibration Procedure, the following procedure serves as an index to locate a step in the complete Calibration Procedure.

Type 661 Serial No. _____

Calibration Date _____

☐ 1. Adjust +300-Volt Power Supply (page 6-6)
Meter reading of +300 volts, ±2 volts.

☐ 2. Adjust +100-Volt Power Supply (page 6-6)
Meter reading +100 volts, ±1 volt.

☐ 3. Check —100-Volt Power Supply (page 6-6)
Meter reading —100 volts, ±3 volts.

☐ 4. Adjust +19-Volt Power Supply (page 6-6)
Meter reading +19 volts, ±150 millivolts.

☐ 5. Check —25.2-Volt Power Supply (page 6-6)
Meter reading —25.2 volts, ±2 volts.

☐ 6. Adjust —19-Volt Power Supply (page 6-6)
Meter reading —12 volts, ±150 millivolts.

☐ 7. Check 12.6-Volt Power Supply (page 6-6)
Meter reading of —12.6 volts, ±1 volt.

☐ 8. Check Power Supplies Regulation and Ripple (page 6-6)
Refer to Table 6-1.

☐ 9. Adjust CRT Trace-to-Graticule Alignment (page 6-7)
Trace end at the right edge of the graticule is not more than 1 mm above or below the center horizontal graticule line when trace left end coincides with center horizontal graticule line.

☐ 10. Check Vertical Position Indicating Neons (page 6-7)
Neons indicate the direction the trace is outside the graticule area.

☐ 11. Adjust CRT High-Voltage Supply (page 6-8)
Spot movement of 6 cm as a 150 μA signal is alternately connected and removed at the vertical amplifier input.

☐ 12. Adjust Vertical DC Balance (page 6-9)
Spot positioned at the vertical centerline.

☐ 13. Adjust Horizontal Gain (page 6-9)
Spot moves 10 cm with 50-volt signal applied.

☐ 14. Check Horizontal Position Indicating Neons (page 6-10)
Neons indicate the direction the spot is outside the graticule area.

☐ 15. Check External Horizontal Input AC Coupling Capacitor (page 6-10)
Minimum spot movement with +100 V applied.

☐ 16. Adjust Blanking Balance (page 6-10)
Meter reading is 0 volts.

☐ 17. Adjust Horizontal DC Balance (page 6-10)
First dot of the trace is under the graticule vertical centerline at ×100 and ×1 positions of the SWEEP MAGNIFIER switch.

☐ 18. Adjust Horizontal Takeoff DC Level and Gain (page 6-13)
Sawtooth is 0 to 50 volt amplitude.

☐ 19. Check Horizontal Display Manual Scan (page 6-14)
Slow and Fast scan manually controlled by POSITION controls.

☐ 20. Check Horizontal Display External Input (page 6-16)
Correct display at all positions of the EXT HORIZ INPUT switch and correct operation of the VOLTS/CM AC-DC switch.

☐ 21. Check Horizontal Display Sweep Magnifier (page 6-18)
Correct display at all positions of the SWEEP MAGNIFIER switch.

☐ 22A. Adjust Delayed Pulse Generator, SN 3460-up

☐ 22B. Adjust Delayed Puuse Generator Bias SN 101-3459 (page 6-20)
Delay Pulse Generator signal is stable with minimum noise.

☐ 23. Check Delayed Pulse Risetime (page 6-20)
Delayed Pulse risetime is ≤180 ps with 4S2A; ≤380 ps with a 4S1.

☐ 24. Adjust Horizontal Amplitier Input Compensation (page 6-21)
Minimum horizontal tail at left of each dot.

☐ 25. Adjust Amplitude/Time Calibrator Waveshape and Timing (Preliminary) (page 6-23)
Preliminary adjustment; see Calibration Procedure.

☐ 26. Adjust Amplitude/Time Calibrator Amplitude (page 6-23)
Correct amplitude; see Calibration Procedure.

☐ 27. Adjust Amplitude/Time Calibrator Timing (page 6-28)
Correct timing.

☐ 28. Check Horizontal Signal Output (page 6-30)
200 mV per cm of CRT display.

CALIBRATION PROCEDURE

General

In the procedure that follows, test equipment setups are illustrated at major setup changes. Control settings for the Type 661 and associated instruments are given under the setup pictures. Control setting changes from the preceding step are indicated in bold-face type.

NOTE

When checking power supply voltages other than during a complete recalibration, do not change the voltages unless the supplies are actually out of tolerance. Changing any power supply voltages makes it necessary to perform the complete calibration procedure.

The calibration procedure uses the equipment listed under Equipment Required. If substitute equipment is used, control settings or setup must be altered to meet the requirements of the equipment used.

Preliminary Procedure

a. Check all front-panel controls for proper indexing, check the variable controls for smooth operation and correct any defects found.

b. Remove the side and bottom covers from the Type 661.

c. Install both the Type 5T3 Timing Unit and Type 4S1 Sampling Unit into the Type 661.

d. Connect the Type 661 power cord to the output of the variable autotransformer.

e. Set the INTENSITY control fully counterclockwise, turn on the instrument power and adjust the autotransformer for an output of 117 volts or other voltage for which the instrument is wired. Allow 15 minutes for warm up and stabilization.

f. Turn on all test equipment.

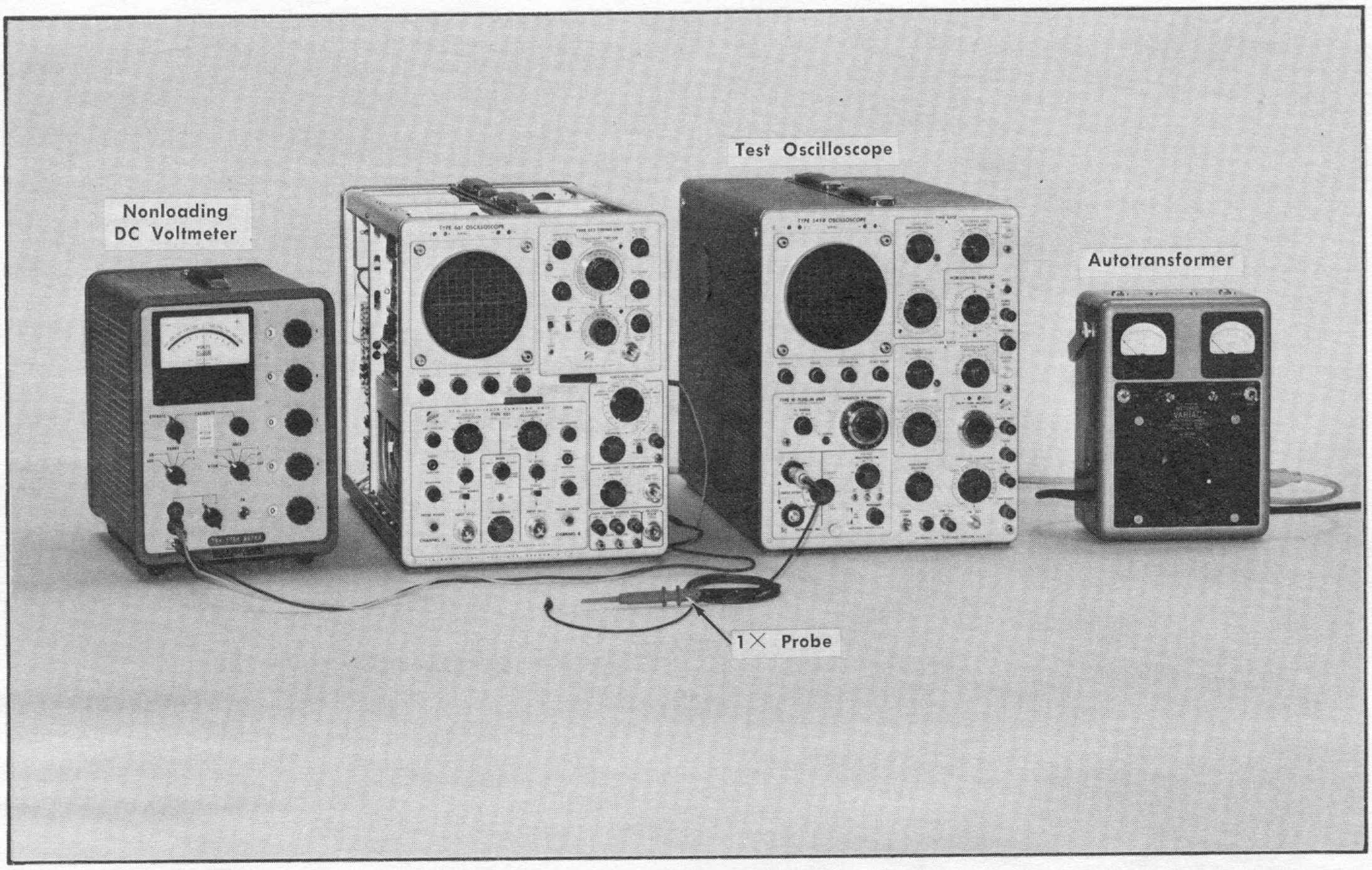


Fig. 6-3. Test equipment for checking the power supplies (steps 1 through 8).

Control Settings

Type 4S1

Mode	A Only
Triggering	A and AC
Both Channels	
Vert Position	Midrange
Millivolts/cm	200
Variable (Millivolts/cm)	Calibrated (detent)
DC Offset	3 turns from either end
Smoothing	Normal (fully clockwise)
Display	Normal

Type 5T3

Samples/cm	100
Equivalent Time/cm	.1 μsec, Calibrated
Trig Level	Fully counterclockwise (no sweep)
Stability or UHF Sync	Midrange
Trig Source	Ext
Slope	+
Time Position	Fully clockwise
Sweep Mode	Norm

Type 661

HORIZONTAL DISPLAY	×1
POSITION	Midrange
VERNIER (POSITION)	Midrange
VOLTS/CM	DC
mV AMPLITUDE	1000
μSEC/CYCLE	OFF
POWER AND SCALE ILLUM	Fully clockwise
FOCUS, INTENSITY and ASTIGMATISM	Fully counterclockwise

Test Oscilloscope and Type W

Time/cm	10 ms
Triggering	Auto
Input Coupling	AC
Input Atten	1
Millivolts/cm	5
Vc Range and Comparison Voltage	0
Display	A-Vc

Precision Non-loading DC Voltmeter

Set controls to measure the correct value and polarity of voltages as listed in the steps that follow before connecting the test leads to the oscilloscope test point.

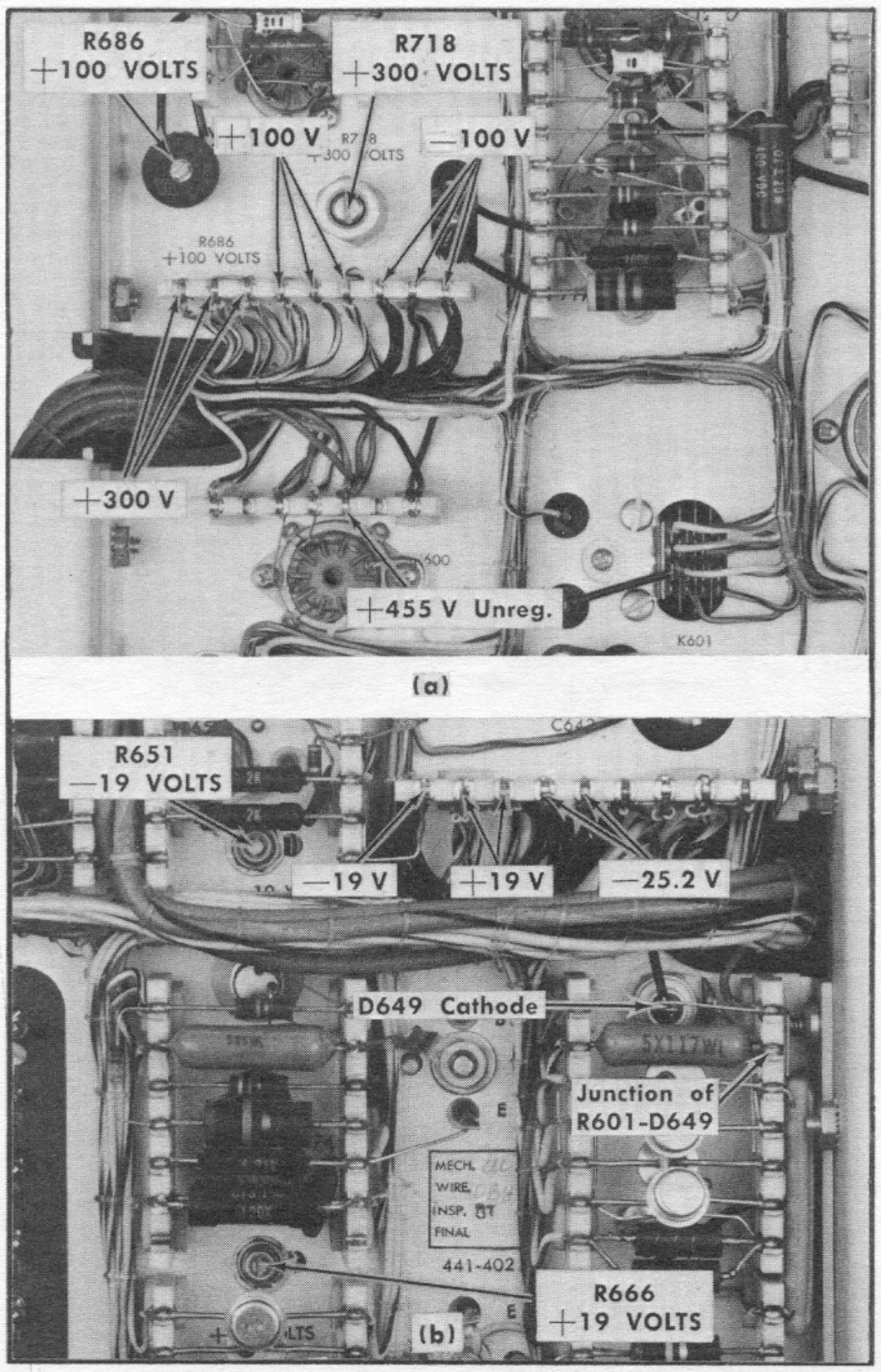


Fig. 6-4. Power supply test points. (A) Right side of oscilloscope; (B) left side of oscilloscope.

1. Check or Adjust +300-Volt Power Supply ◐

a. Use the equipment setup as shown in Fig. 6-3, and connect the nonloading DC voltmeter between a +300--volt test point and ground (right side of the oscilloscope). All power supply voltage test points are shown in Fig. 6-4.

b. Check—Meter reading; +300 volts, ±2 volts. If the voltage is higher than +302 or less than +298 volts, adjust R718, 300 VOLTS control, for +300 volts.

2. Check or Adjust +100-Volt Power Supply ◐

a. Connect the nonloading DC voltmeter between a +100-volt test point and ground (right side of the oscilloscope).

b. Check—Meter reading; +100 volts, ±1 volt. If the voltage is higher than +101 or less than +99 volts, adjust R686, 100 VOLTS control, for +100 volts.

3. Check —100-Volt Power Supply

a. Connect the nonloading DC voltmeter between a —100-volt test point and ground (right side of the oscilloscope).

b. Check—Meter reading; —100 volts, ±3 volts. If the voltage is greater than —103 or less than —97 volts, readjust the +300-volt power supply (within the ±2 volt tolerance) in an attempt to bring the —100-volt power supply within tolerance. Recheck the +100-volt power supply.

4. Check or Adjust the +19-Volt Power Supply ◐

a. Connect the nonloading DC voltmeter between a +19-volt test point and ground (left side of the oscilloscope, Fig. 6-4).

b. Check—Meter reading; +19 volts, ±150 millivolts. If the voltage is off from +19 V, more than 150 mV adjust R666, +19 VOLTS control, for +19 volts.

5. Check —25.2-Volt Power Supply

a. Connect the nonloading DC voltmeter between a —25.2-volt test point and ground (left side of oscilloscope).

b. Check—Meter reading; —25.2 volts, ±2 volts. If the voltage is more than —27.2 or less than —23.2 volts, check D643 or R643 and the transistors.

6. Check or Adjust —19-Volt Power Supply ◐

a. Connect the nonloading DC voltmeter between a —19-volt test point and ground (left side of oscilloscope).

b. Check—Meter reading; —19 volts, ±150 millivolts. If the voltage is more than —19.15 or less than —18.85 volts, adjust R651, —19 VOLTS control for —19 volts.

7. Check 12.6-Volt Probe Power Supply

a. Change the leads on the non-loading precision voltmeter to permit a difference measurement. If the voltmeter in use has no balanced input, isolate the meter from the power line ground return and from the Type 661 oscilloscope frame.

Connect the meter minus lead to the junction of R601-R649, and the plus lead to D649 cathode. See Fig. 6-4.

b. Check—Meter reading; 12.6 volts, ±1 volt. If the voltage is more than 13.6 or less than 11.6 volts, check D649 or R659.

8. Check Power Supply Regulation and Ripple

a. Equipment setup is shown in Fig. 6-3.

b. Connect the 1× probe from the test oscilloscope to each of the power supply test points in succession as listed in Table 6-1.

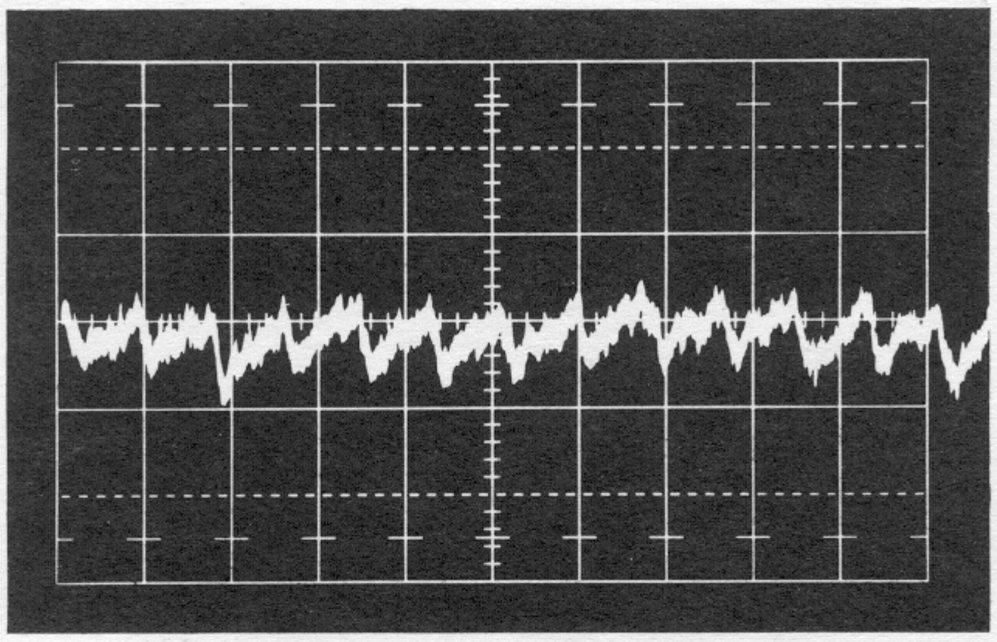


Fig. 6-5. Typical test oscilloscope display of the +300-volt power supply ripple.

c. Slowly vary the autotransformer output from 105 volts to 125 volts (or 210 to 250 volts for 234-volt instruments).

d. Check—Maximum ripple should not exceed that indicated in Table 6-1. Typical ripple on the +300-volt power supply is shown in Fig. 6-5.

TABLE 6-1

Typical Ripple

Power Supply	117/234-Volt Line (peak to peak)	Maximum Ripple (peak to peak)
+300	8 mV	14 mV
+100	6 mV	14 mV
—100	6 mV	14 mV
+19	4 mV	7 mV
—19	4 mV	7 mV
—25.2	15 mV	20 mV

e. Return the autotransformer output voltage to 117 (234) volts.

(If the line voltage is about 117 (234) volts, the Type 661 may be connected directly to the line; otherwise, leave the instrument connected to the autotransformer for the remainder of the procedure.)

9. Adjust CRT Trace-to-Graticule Alignment ❶

a. Use the control settings listed following Fig. 6-7 (the Type 4S1 installed).

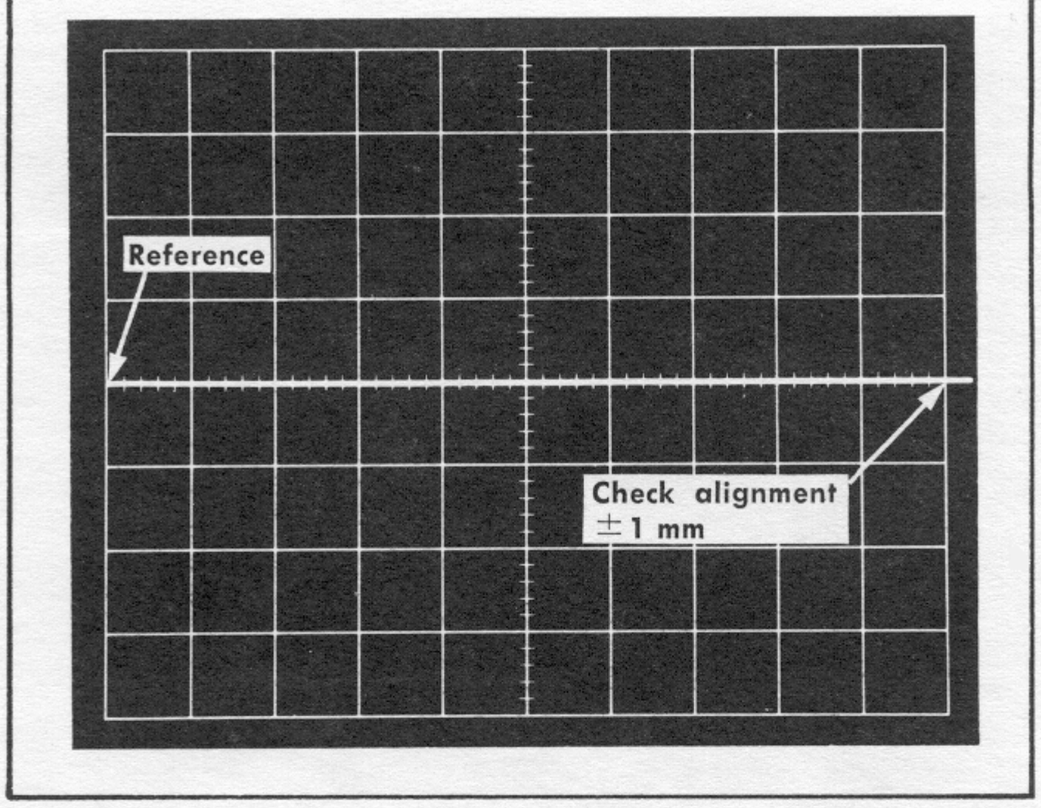


Fig. 6-6. Display of correct CRT trace-to-graticule alignment.

b. Horizontally position the start of the trace to the left edge of the graticule and position the trace vertically to the center horizontal graticule line.

c. Check—Trace end at the right edge of the graticule is not more than 1 mm above or below the center horizontal graticule line, see Fig. 6-6. If trace alignment is within tolerance, proceed to step 10.

d. Adjust the Red CRT rotation knob located on the CRT clamp until the trace is aligned with a horizontal graticule line. This adjustment should be performed again when the instrument is placed in its regular operating location.

10. Check Vertical Position Indicating Neons

a. Use the control settings listed following Fig. 6-7 (the Type 4S1 installed).

b. Position the trace above the top horizontal graticule line with the Sampling Unit Vert Position control.

c. Check—The neon next to the up arrow is on and the neon next to the down arrow is off.

d. Position the trace below the bottom horizontal graticule line.

e. Check—The neon next to the down arrow is on and the neon next to the up arrow is off.

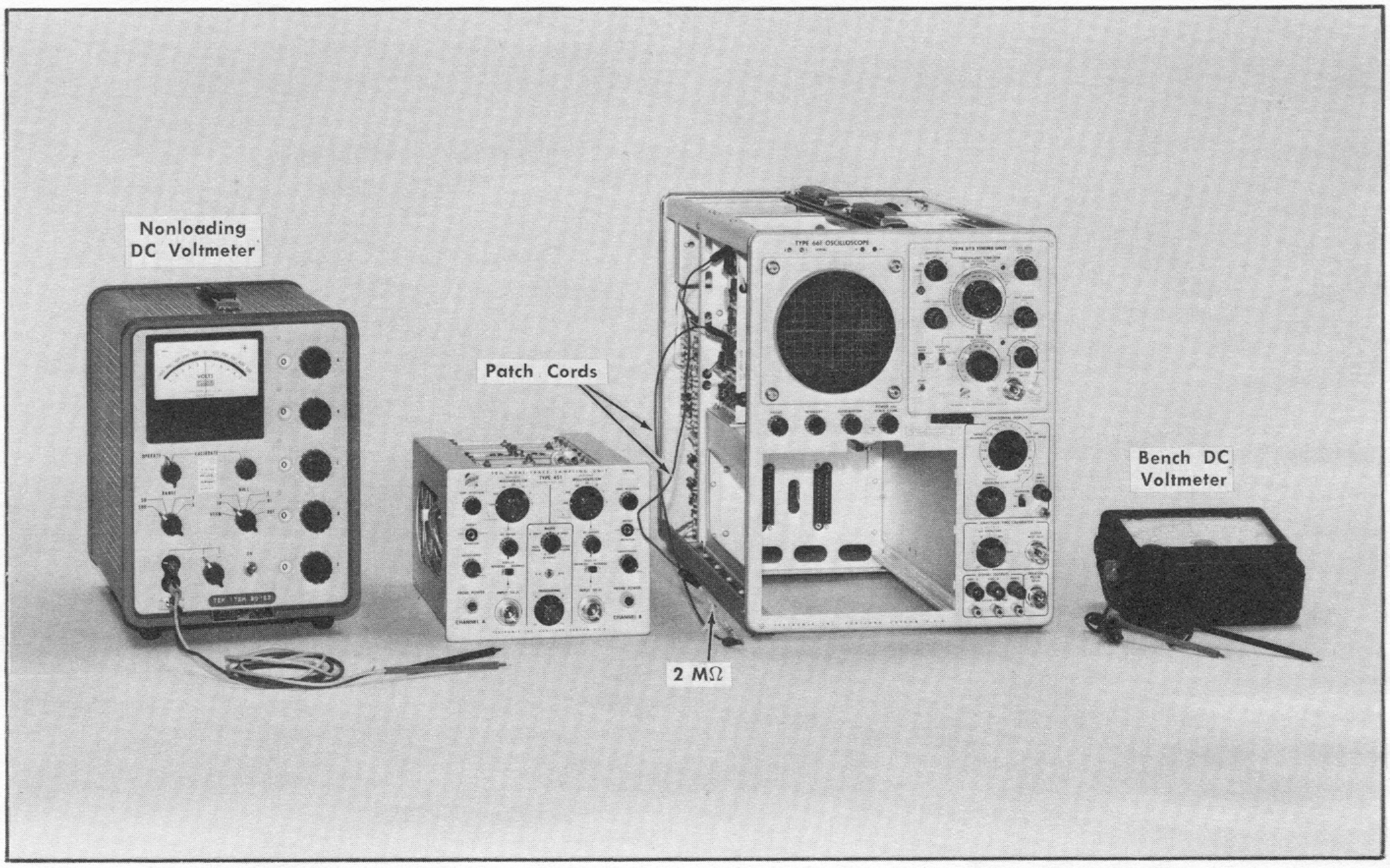


Fig. 6-7. Initial equipment setup for steps 11 through 17.

Type 4S1	
Mode	A Only
Triggering	A and AC
Channel A Controls	
Vert Position	Midrange
Millivolts/cm	**100**
Variable (Millivolts/cm)	Calibrated
DC Offset	**Trace centered**
Smoothing	Normal
Display	Normal
Type 5T3	
Samples/cm	100
Equivalent Time/cm	.1 μSEC, Calibrated
Trig Level	**Midrange**
Stability or UHF Sync	Midrange
Trig Source	**Free Run**
Slope	+
Time Position	Fully clockwise
Sweep Mode	Normal
Type 661	
HORIZONTAL DISPLAY	×1
POSITION	Midrange
VERNIER (POSITION)	Midrange
VOLTS/CM	DC
mV AMPLITUDE	1000
μSEC/CYCLE	OFF
POWER AND SCALE ILLUM	**Maximum illumination**
FOCUS. INTENSITY and ASTIGMATISM	**Normal intensity, well focused. trace**

NOTE

For steps 11 and 12, turn off the Type 661, remove the Type 4S1, and turn the Type 661 back on. Turn the intensity control counterclockwise so the spot will not burn the phosphor.

11. Adjust CRT High-Voltage Supply ❶

The CRT supply voltage should be between —2300 and —3200 volts to make the vertical amplifier deflection factor 25 μA/cm.

a. After the spot is stable, adjust R477, VERT DC BAL., until the spot rests 3 centimeters below the graticule centerline.

b. Alternately connect and disconnect two 1 MΩ 1% resistors in series between a +300-volt test point and the vertical

amplifier input (See Fig. 6-9). The spot should move alternately from 3 cm below to 3 cm above the center line, within ±2 mm.

c. If the spot moves more than 6.2 cm or less than 5.8 cm check the vertical amplifier transistors and tubes. If the vertical amplifier transistors and tubes are satisfactory, adjust R841, the HIGH VOLTAGE control, for 6 cm spot movement as the 2 MΩ resistor is alternately connected and removed.

12. Adjust Vertical DC Balance

a. Connect a 1.5 kΩ, 1% resistor between the vertical amplifier input and ground. See Fig. 6-9. (This establishes the correct input resistance, as if the vertical plug-in unit were in place.)

b. Horizontally position the CRT spot to the graticule centerline.

c. Adjust R477, the VERT DC BAL control, to position the spot to the vertical centerline.

d. Disconnect the 1.5 kΩ resistor. Turn off the Type 661, re-install the Type 4S1, and turn the Type 661 back on.

13. Adjust Horizontal Gain

a. Set the HORIZONTAL DISPLAY switch to EXT HORIZ INPUT, 5 VOLTS/CM. (An external 50-volt signal will now move the CRT spot 10 centimeters.)

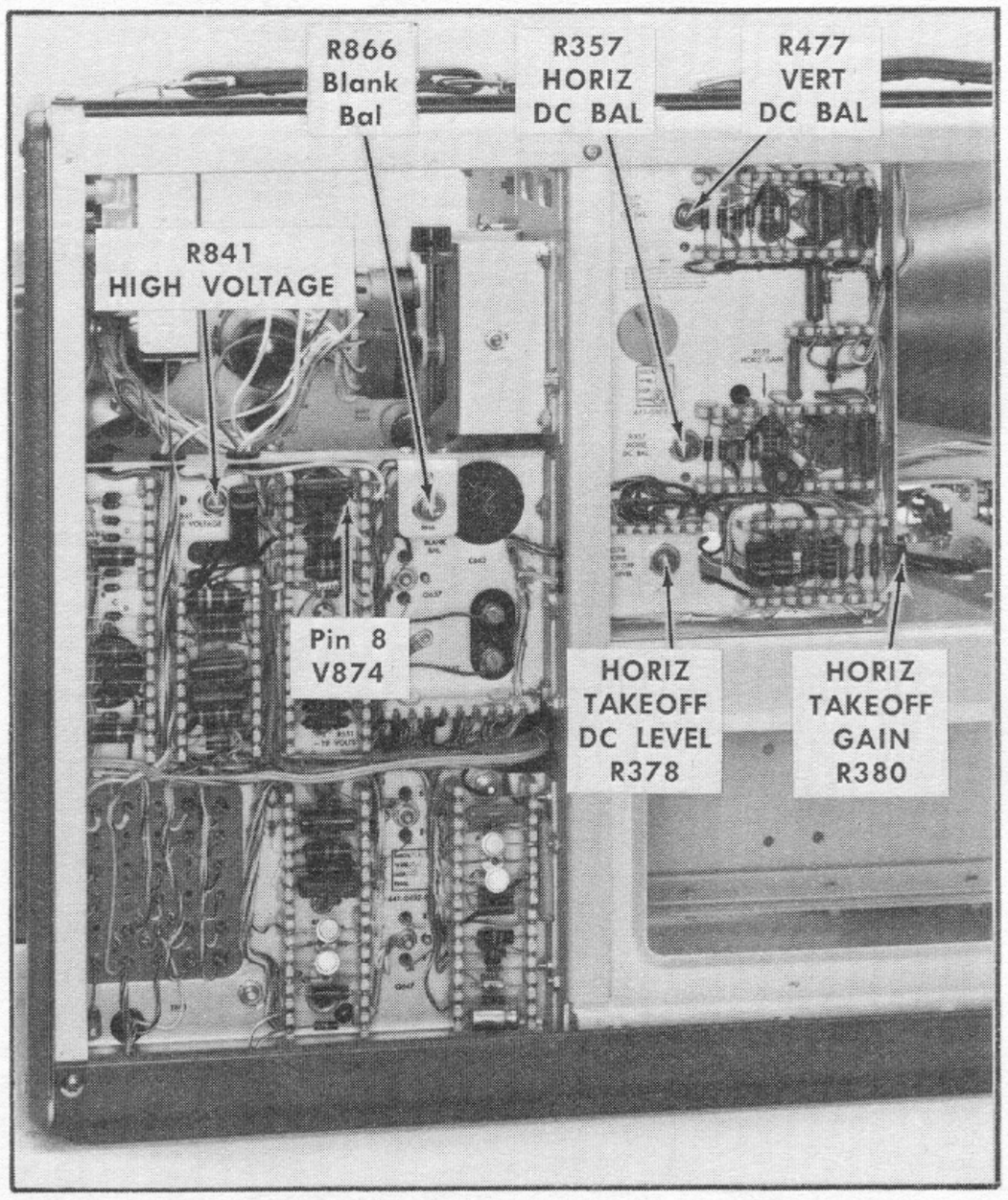


Fig. 6-8. Location of some adjustments on left side of oscilloscope.

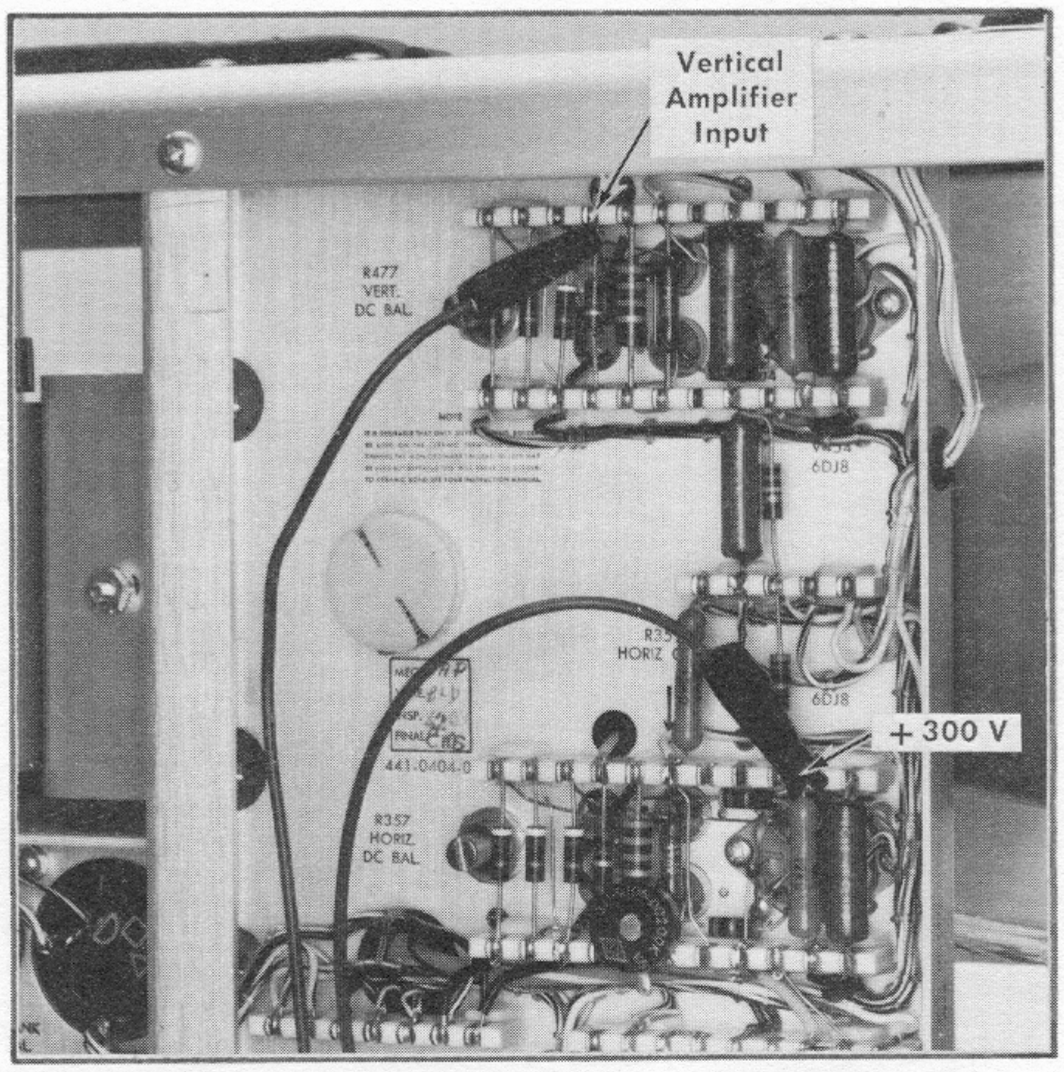


Fig. 6-9. 2 MΩ resistor between vertical amplifier input and +300 V supply, step 12.

CAUTION

In the following procedure, be careful not to ground the +100-volt power supply.

b. Connect a 24.9 kΩ, ½-watt, 1% resistor between a +100-volt test point and the EXT INPUT 25 kΩ terminal, See Fig. 6-10.

c. Measure the voltage at the EXT INPUT terminal with the non-loading DC voltmeter. If the voltage is other than +50 volts, determine the percentage difference and apply that error when adjusting the HORIZ GAIN ADJ control.

d. Disconnect the 24.9 kΩ resistor from the +100-volt test point and carefully position the CRT spot to the left edge of the graticule.

e. Reconnect the resistor to the +100-volt test point. The CRT spot should move 10 cm plus or minus the error determined in part c. If correct, proceed to part g.

f. If the spot did not move the correct distance, adjust R359, the HORIZ GAIN ADJ control (using an insulated screwdriver), until the CRT spot moves the correct amount. It may be necessary to repeat this procedure several times for proper adjustment.

g. Disconnect the resistor.

NOTE

The preceding step will assure a horizontal accuracy of about 0.5% which applies when the HORIZONTAL DISPLAY switch is at either the SWEEP MAGNIFIER ×1 or the EXT HORIZ INPUT 5 VOLTS/CM positions. Due to the tolerance of the horizontal amplifier feedback resistors, the horizontal system may be less accurate in all other positions of the HORIZONTAL DISPLAY switch (see steps 20 and 21).

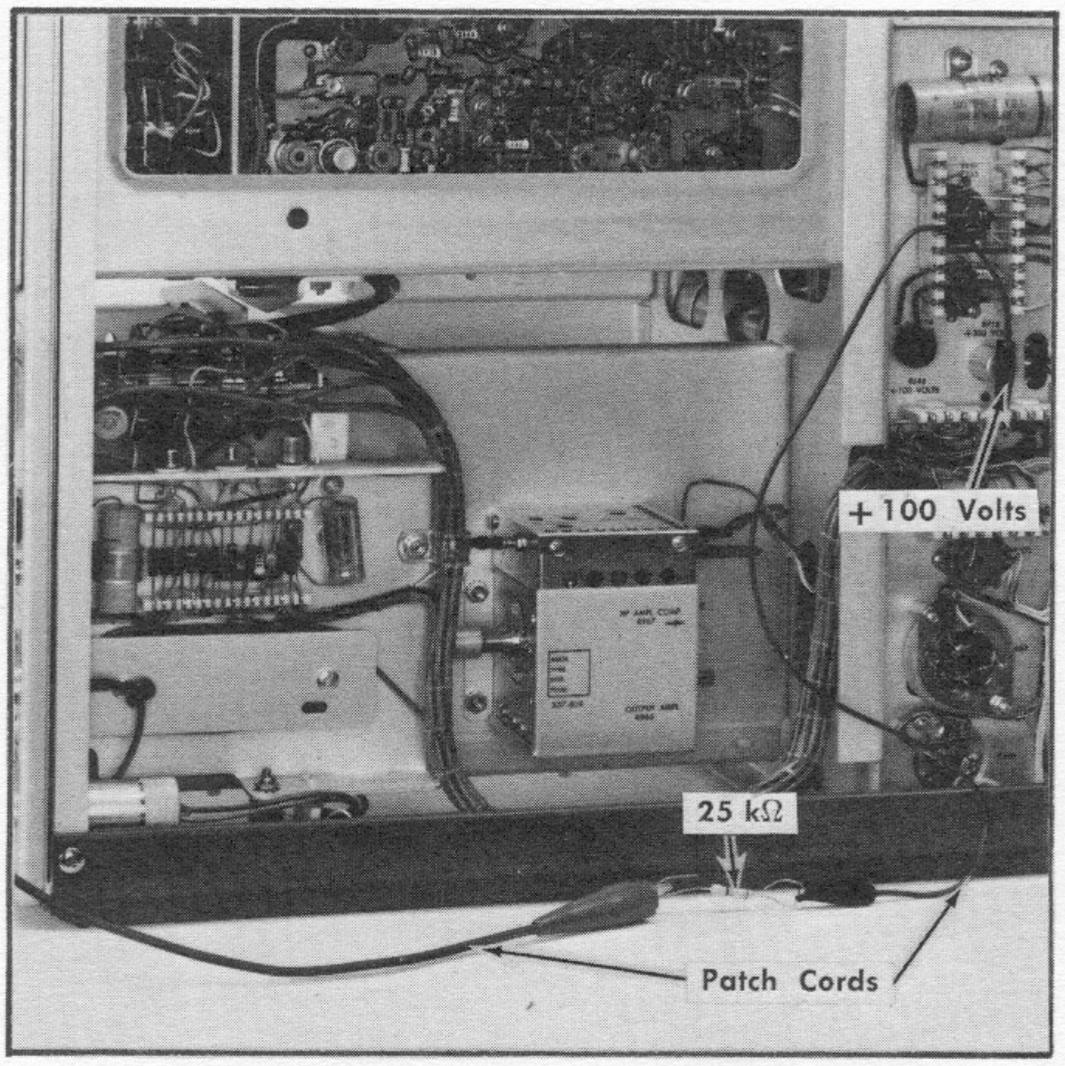


Fig. 6-10. Connection of the 25 kΩ resistor from +100 V to Ext. Input 25 k.

14. Check Horizontal Position Indicating Neons

a. Set the HORIZONTAL DISPLAY switch to .5 EXT HORIZ INPUT and position the spot outside the graticule area to the left.

b. Check—The neon next to the left arrow is on and the neon next to the right arrow is off

c. Position the spot outside the graticule area to the right.

d. Check—The neon next to the right arrow is on and the neon next to the left arrow is off.

15. Check External Horizontal Input AC Coupling Capacitor

a. Set the HORIZONTAL DISPLAY switch to .05 EXT HORIZ INPUT and the VOLTS/CM switch to AC.

b. Position the spot near the center of the graticule area.

c. Connect a patch cord to the EXT INPUT connector and then to a +100-V test point. (The spot will leave the CRT viewing area and should return quickly to the initial position as C301 charges.)

d. Remove the +100 V connection and note any small change in spot position. The spot should not move more than 1 cm from the initial position. If the spot moves more than 1 cm from the initial position while +100 V is applied, C301 should be replaced. (A new capacitor should cause no spot position change while the +100 volts is applied.)

e. Discharge the capacitor by touching the patch cord lead to ground. Disconnect the lead and set the VOLTS/CM switch to DC.

16. Adjust CRT Blanking Balance ❶

a. Turn off the Type 661, remove both plug-in units, and turn the Type 661 back on. Turn the INTENSITY control fully counterclockwise so that no spot is displayed on the CRT.

b. Set the HORIZONTAL DISPLAY switch to the SWEEP MAGNIFIER ×1 position and slowly turn the INTENSITY control clockwise so the spot can be seen, then counterclockwise to the point at which the spot is just extinguished.

c. Connect the bench voltmeter (set to a range that permits measuring at least 40 V) between the center terminal of R866, BLANK BAL control, and pin 6 of V874 to check the differential voltage between the CRT blanking deflection plates. (V874 is located between the two ceramic strips adjacent to the control, see Fig. 6-11.)

d. Adjust R866, BLANK BAL control (Fig. 6-11), for a meter reading of zero volts.

e. Disconnect the voltmeter, turn off the Type 661, install both plug-in units, and turn the Type 661 back on.

17. Adjust Horizontal DC Balance ❶

a. Allow a warm-up time of five minutes; turn up the INTENSITY for a visible trace and position the start of the trace to the center of the graicule.

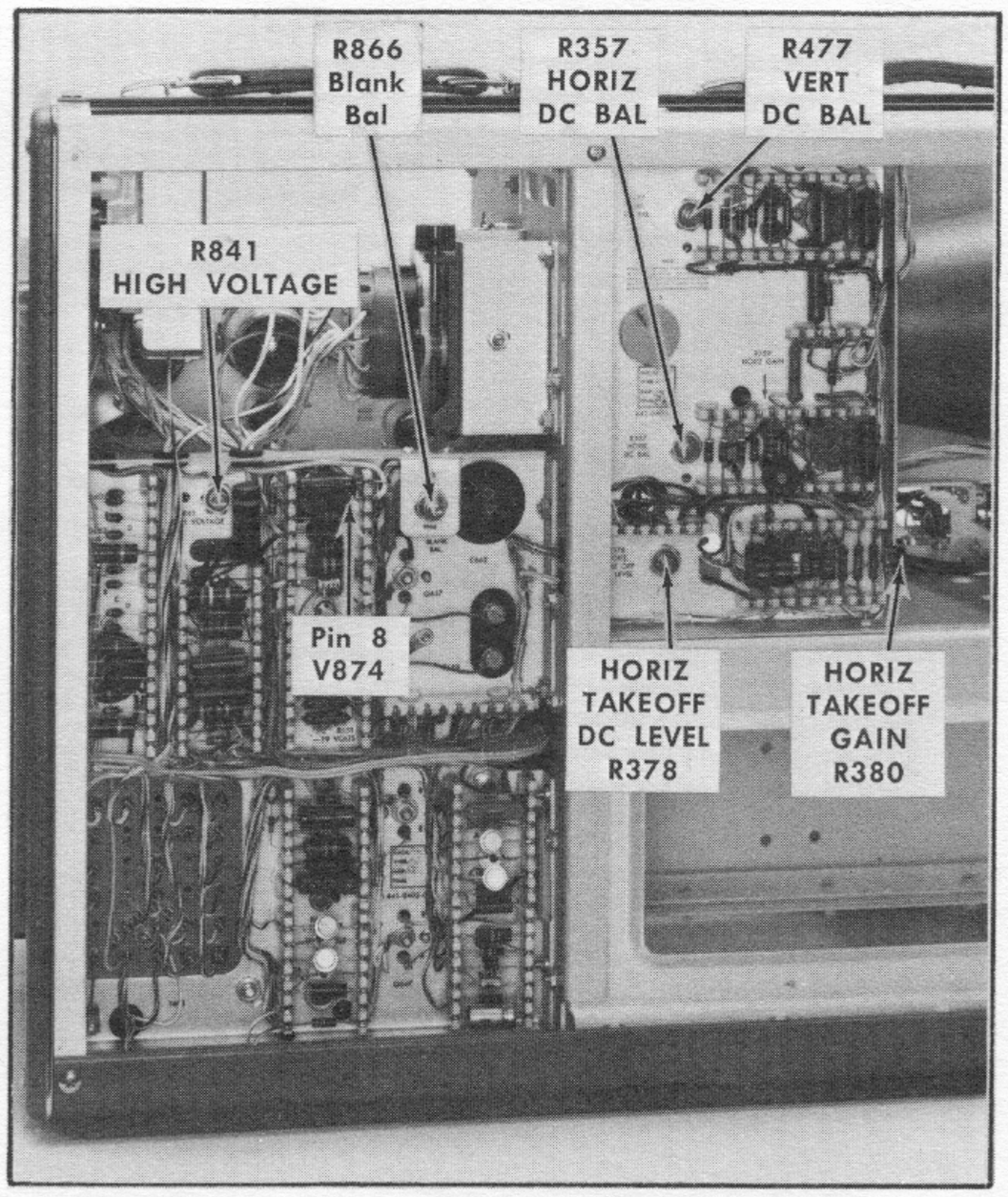


Fig. 6-11. Location of some adjustments on left side of oscilloscope.

b. Set the HORIZONTAL DISPLAY switch to SWEEP MAGNIFIER ×100 and reposition the trace so the first dot of the display lies under the graticule vertical centerline five divisions from left side.

c. Return the HORIZONTAL DISPLAY switch to SWEEP MAGNIFIER ×1. The first dot of the trace should be under the graticule vertical centerline. If correct, proceed to step 18.

d. Adjust R357, the HORIZ DC BAL control (Fig. 6-11), to return the first dot to the graticule centerline.

f. Repeat the procedure to be sure the adjustment is correct.

NOTES

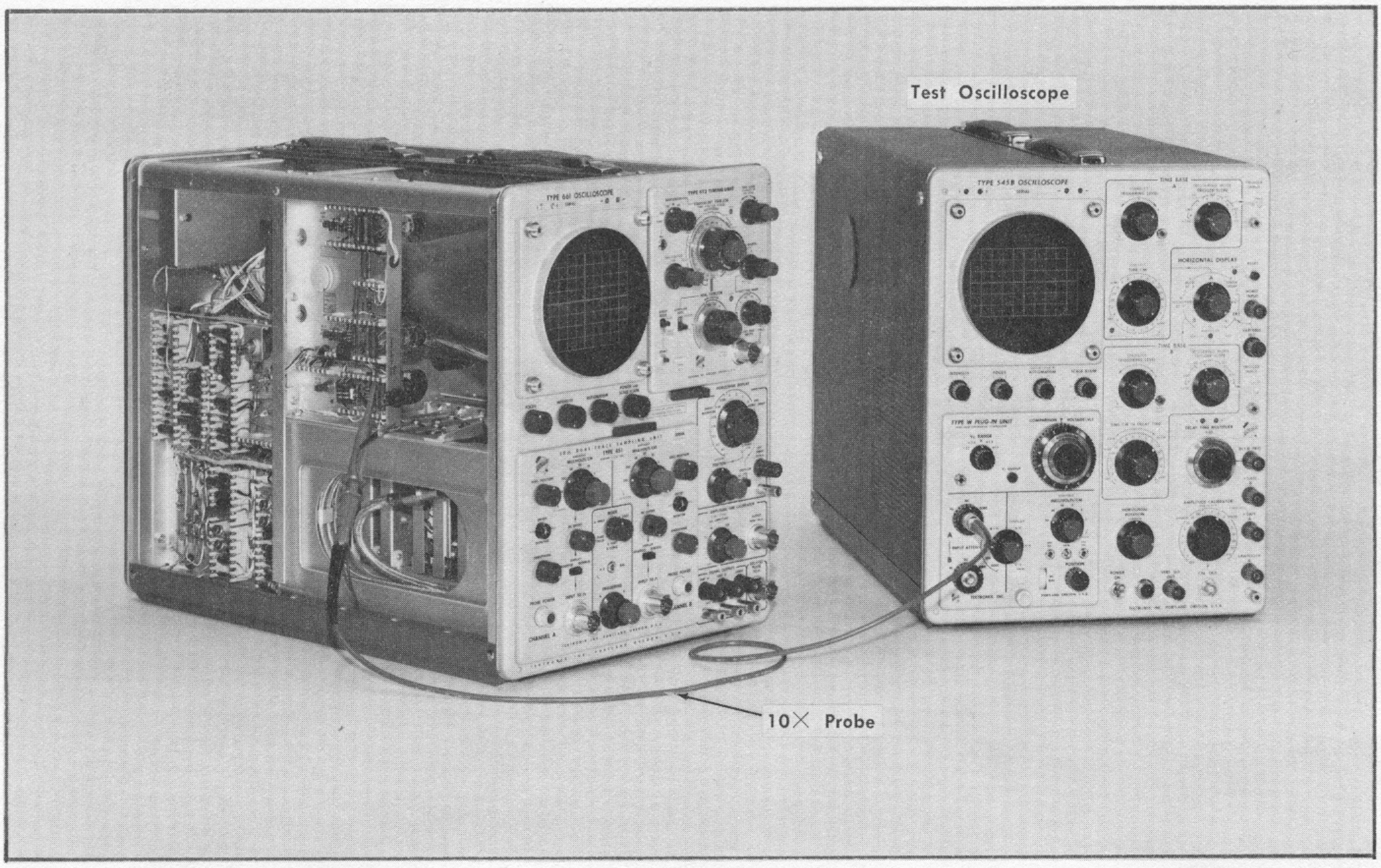


Fig. 6-12. Test equipment setup for step 18.

Control Settings

Type 4S1

Mode	A Only
Triggering	A and AC
Channel A Controls:	
Vert Position	Midrange
Millivolts/cm	100
Variable (Millivolts/cm)	Calibrated
DC Offset	Trace centered
Smoothing	Normal
Display	Normal

Type 5T3

Samples/cm	100
Equivalent Time/cm	.1 μsec, Calibrated
Trig Level	Midrange
Stability or UHF Sync	Midrange
Trig Source	Free Run
Slope	+
Time Position	Fully clockwise
Sweep Mode	Normal

Type 661

HORIZONTAL DISPLAY	×1
POSITION	Midrange
VERNIER (POSITION)	Midrange
VOLTS/CM	DC
mV AMPLITUDE	1000
μSEC/CYCLE	OFF
POWER AND SCALE ILLUM	Maximum illumination
FOCUS, INTENSITY and ASTIGMATISM	Normal intensity, well focused trace

Test Osciloscope and Type W

Time/cm	2 ms
Triggering	Auto, Int
Input Coupling	DC
Input Atten	10
Millivolts/cm	50
Vc Range and Comparison Voltage	0
Display	A-Vc

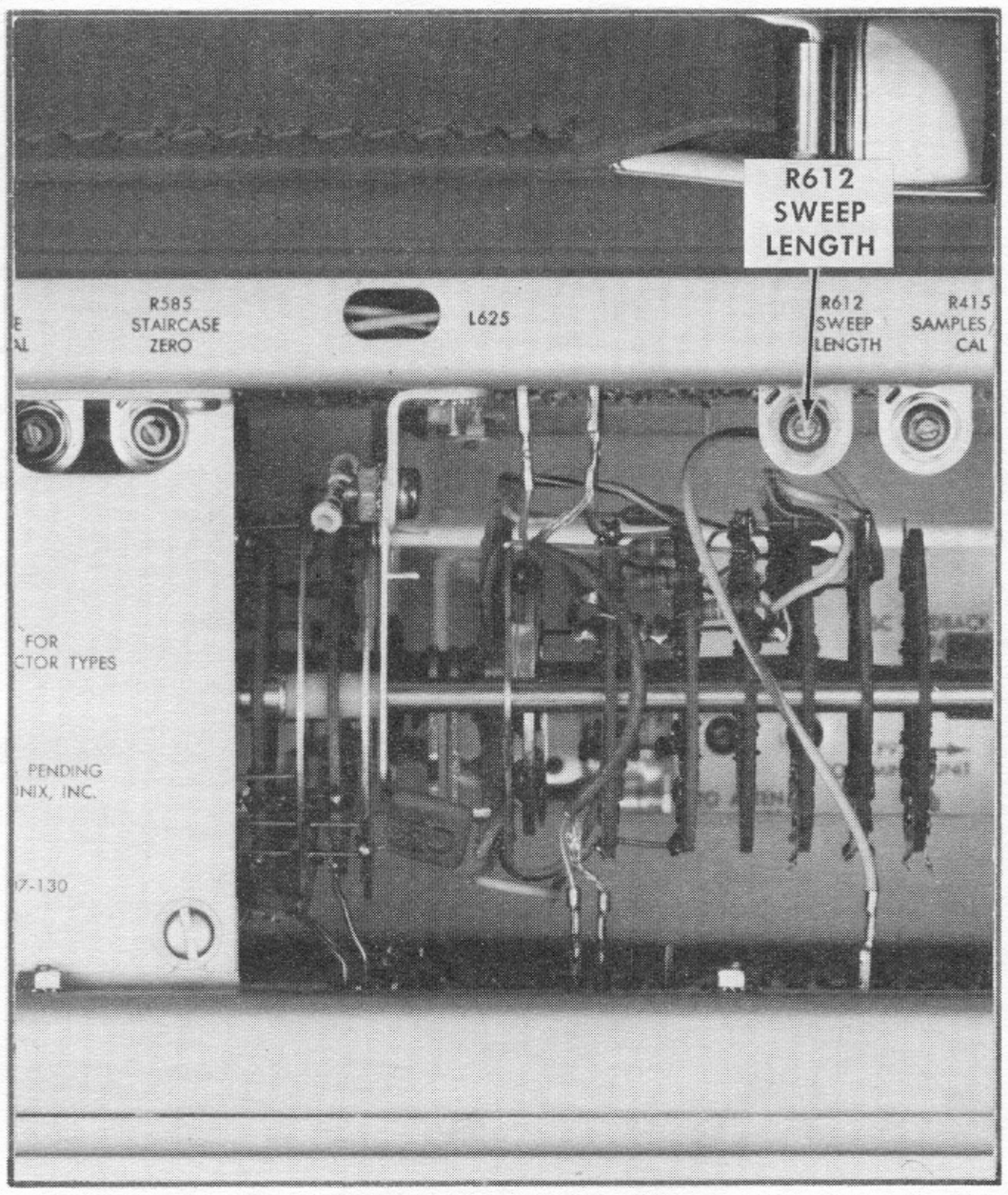


Fig. 6-13. Type 5T3 sweep length control location.

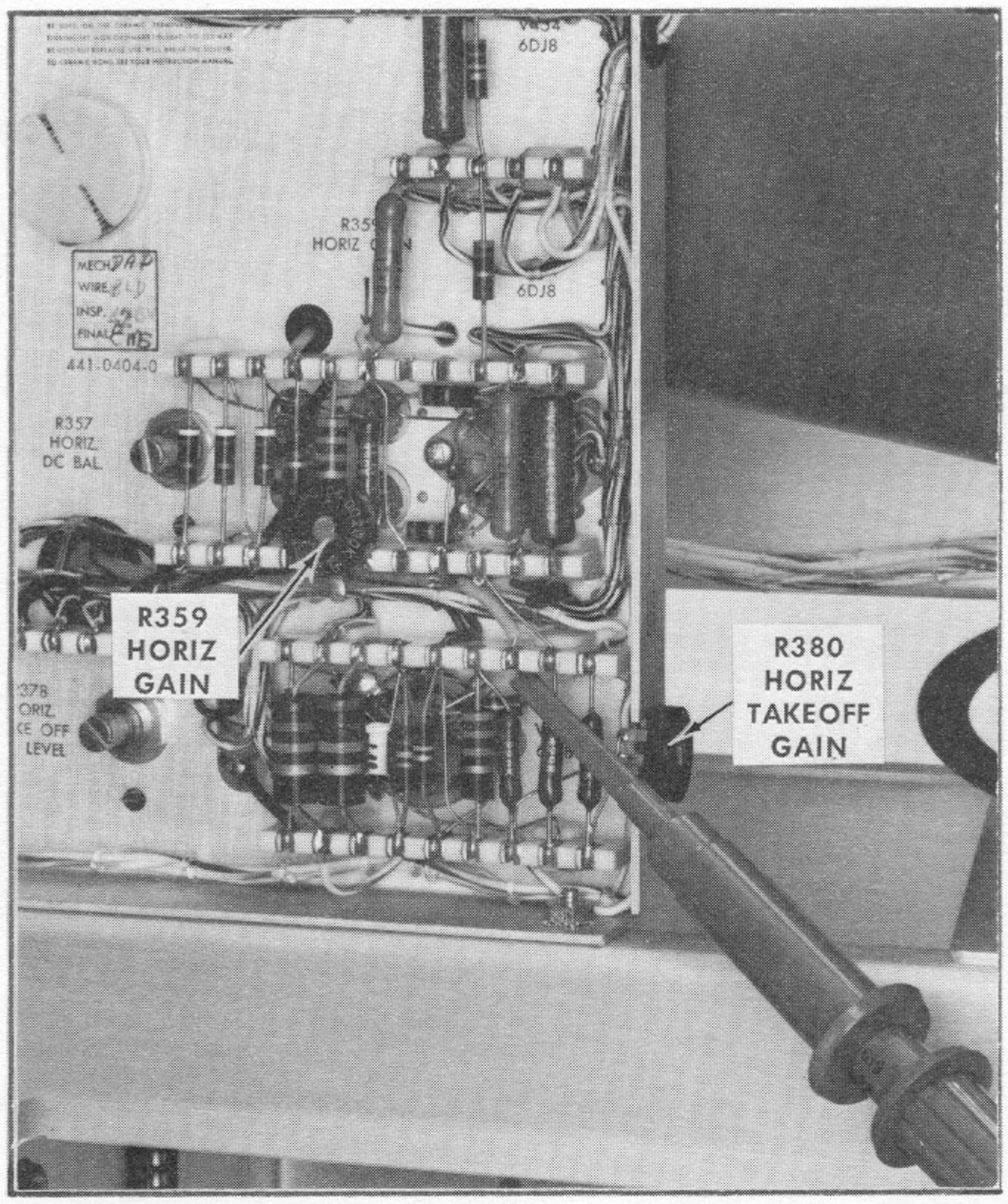


Fig. 6-14. Control and test oscilloscope connections for step 18.

18. Adjust Horizontal Takeoff DC Level and Gain ◐

a. Use the equipment setup as shown in Fig. 6-12.

b. Adjust the Timing Unit internal Sweep Length control (located at the top side of the Type 5T3, Fig. 6-13), so the Type 661 sweep length is exactly 10 centimeters long. Carefully center the trace.

c. Connect the test oscilloscope 10× probe to the junction of R391 (100 Ω) and the coaxial cable, see Fig. 6-14.

d. Check the test oscilloscope display. The beginning of the sawtooth should be at zero volts as shown in Fig. 6-15. If at zero volts, proceed to part f.

e. Use an isulated screwdriver and adjust the Type 661 HORIZ TAKEOFF DC LEVEL control, R378 until the beginning of the sawtooth rests at zero volts.

f. Set the test oscilloscope Millivolts/cm switch to 20 and the Input Attenuator to 100 (20 volts/cm with the 10× probe). The test oscilloscope display should be a zero to 50 volt sawtooth (2.5 cm, as in Fig. 6-16). If display is correct, proceed to part h.

g. Adjust R380, the HORIZ. TAKEOFF GAIN control, until the test oscilloscope display is a zero to 50 volt sawtooth.

h. Reset the Timing Unit internal Sweep Length control for a trace 10.7 cm long and remove the 10× probe.

NOTES

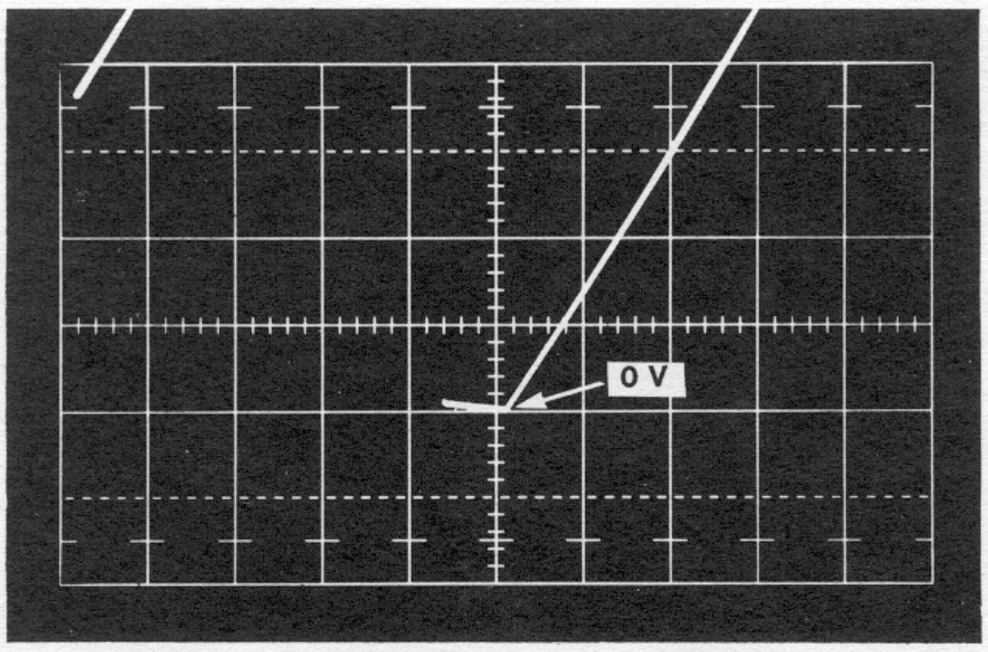


Fig. 6-15. Test oscilloscope display of zero volt start of Type 661 sweep start, step 18.

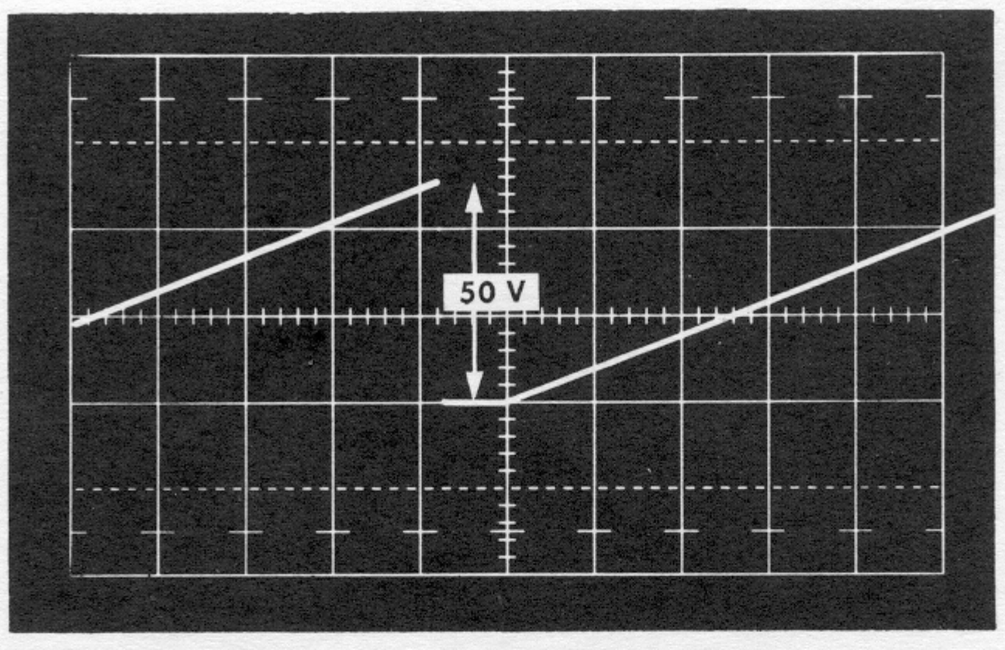


Fig. 6-16. 50-volt sawtooth of step 18g.

19. Check Horizontal Display Manual Scan

a. Set the HORIZONTAL DISPLAY switch to MANUAL SCAN F.

b. Rotate the POSITION and VERNIER controls counter-clockwise and clockwise and note the movement of the spot. The spot movement rate must equal the rate of rotation of the POSITION controls. The controls must be able to move the spot off the graticule area both to the left and right.

c. Set the HORIZONTAL DISPLAY switch to MANUAL SCAN S.

d. Rotate the POSITION and VERNIER controls counter-clockwise and clockwise and note the movement of the spot. The spot movement rate must be slower than the rate of rotation of the POSITION controls and must move off the graticule area to the left and right. If the spot movement is too fast for your use of slow scan, change C307 with a new capacitor of either the same or larger value.

NOTES

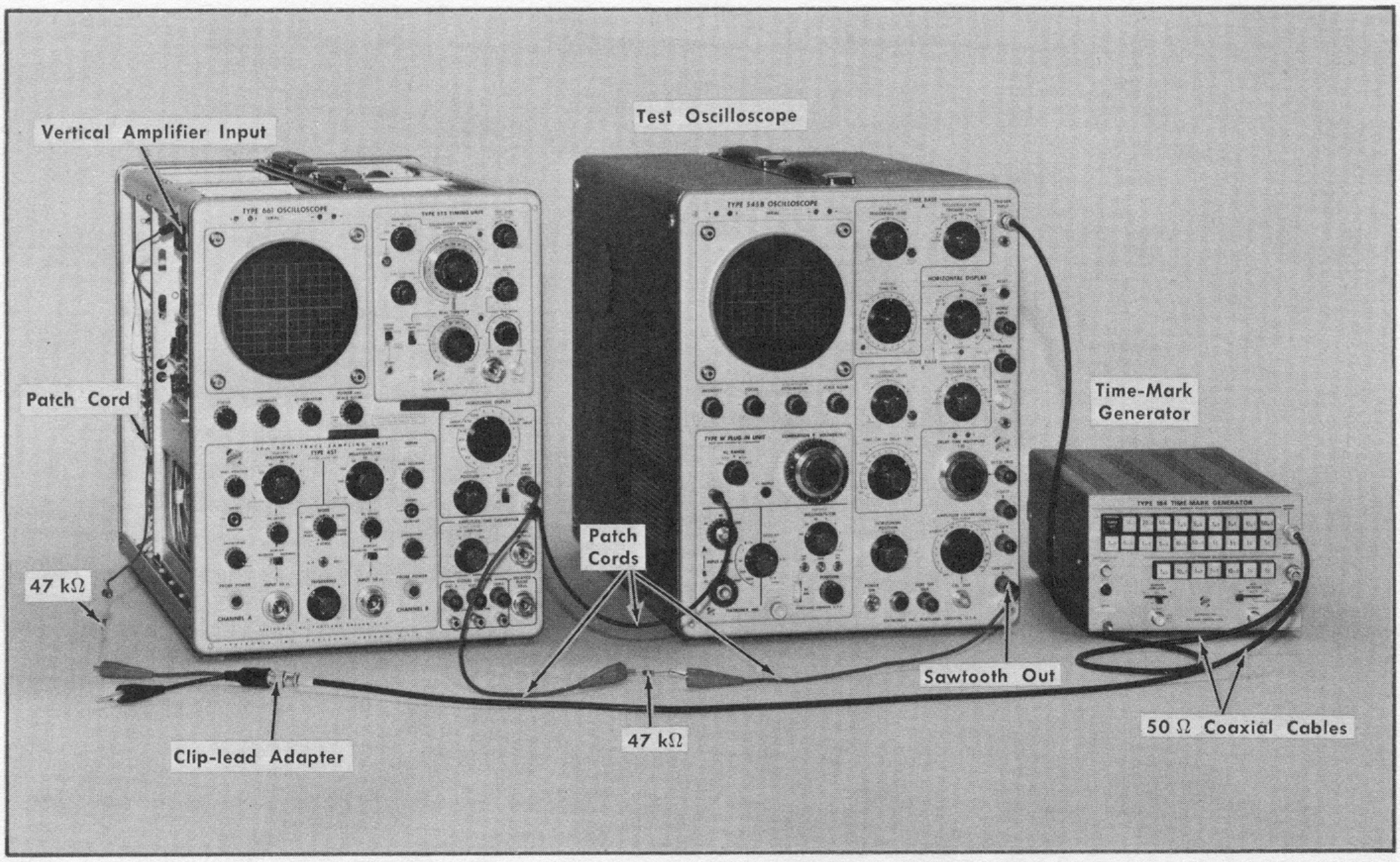


Fig. 6-17. Test equipment setup for steps 19 and 20.

Control Settings

Type 4S1

Mode	A Only
Triggering	A and AC
Set Channel A Controls:	
Vert Position	Midrange
Millivolts/cm	**200**
Variable (Millivolts/cm)	Calibrated
DC Offset	Trace centered
Smoothing	Normal
Display	Normal

Type 5T3

Samples/cm	100
Equivalent Time/cm	**2 μsec, Calibrated**
Trig Level	Midrange
Stability or UHF Sync	Midrange
Trig Source	Free Run
Slope	+
Time Position	Fully clockwise
Sweep Mode	Normal

Type 661

HORIZONTAL DISPLAY	**EXT HORIZ INPUT 5**
POSITION	Midrange
VERNIER (POSITION)	Midrange
VOLTS/CM	DC
mV AMPLITUDE	1000
μSEC/CYCLE	OFF
POWER AND SCALE ILLUM	Maximum illumination
FOCUS, INTENSITY and ASTIGMATISM	Normal intensity, well focused trace

Test Oscilloscope

Time/cm	**0.5 ms**
Triggering	**Auto, Ext**
Other controls	Optional

Time-Mark Generator

Marker Output	500 μs
Trigger Output	1 mS

TABLE 6-2

EXT HORIZ INPUT Switch	Time-Marks	Display	Tolerance Fig. 6-19	Feedback Resistor
5	500 μs	2 per cm	Adjusted	R311A
2	500 μs	2 per 2 ½ cm	±3%	R311H
1	100 μs	2 per cm	±3%	R311C
.5	100 μs	1 per cm	±3%	R311D
.2	50 μs	2 per 2 ½ cm	±3%	R311J
.1	10 μs	2 per cm	±5%	R311F
.05	10 μs	1 per cm	±5%	R311G

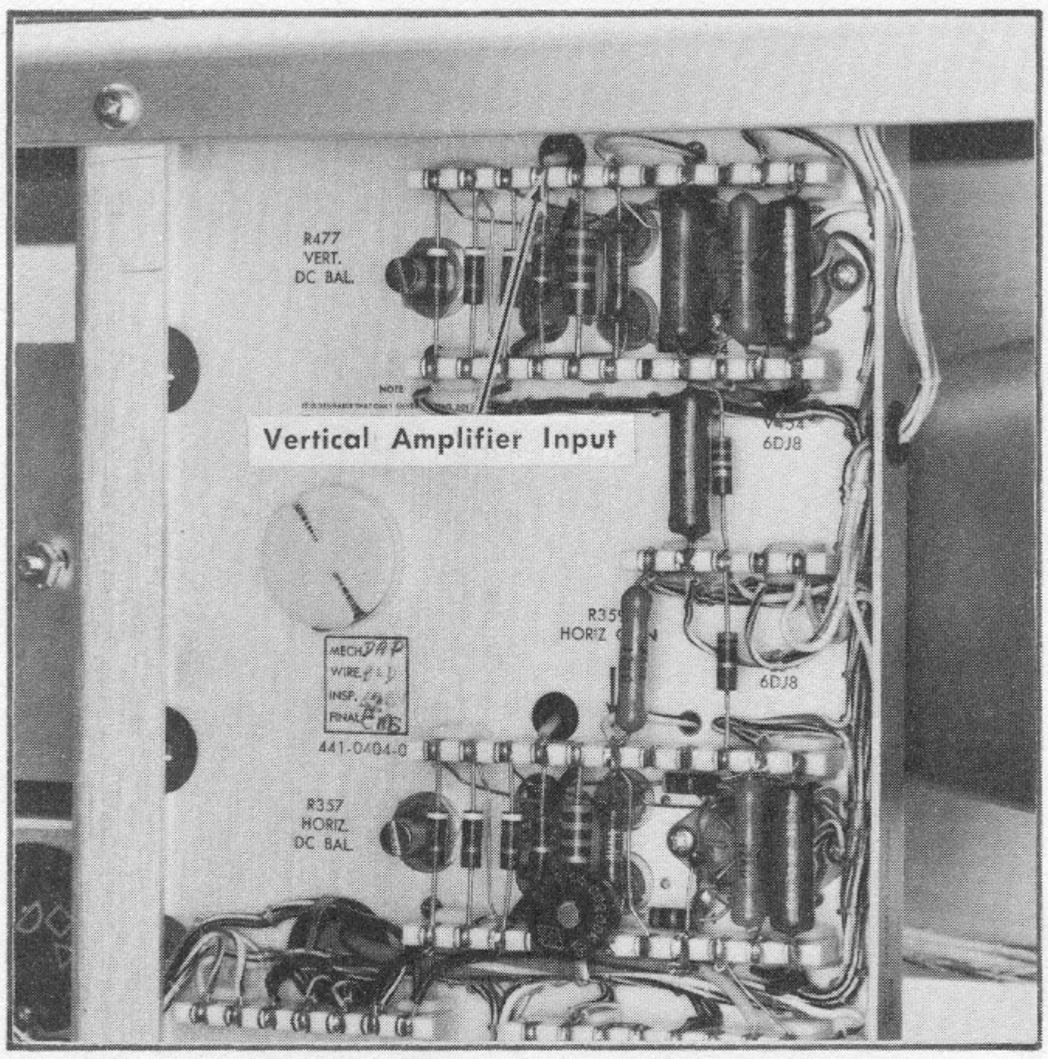


Fig. 6-18. Location of the Vertical Amplifier Input.

Connections

Time-Mark Generator. Connect the Marker output connector to the Type 661 vertical amplifier input. Use a 50 Ω coaxial cable, a BNC to clip-lead adapter and a series 47 kΩ ½ watt resistor. See Fig. 6-18.

Connect the Trigger output connector to the test oscilloscope External Trigger Input connector. Use a 50 Ω coaxial cable.

Test Oscilloscope. Connect the test oscilloscope sweep generator Sawtooth Out connector to the Type 661 EXT INPUT connector. Use a patch cord and series 47 kΩ ½ watt resistor. Connect the test oscilloscope chassis to the Type 661 chassis with a clip lead.

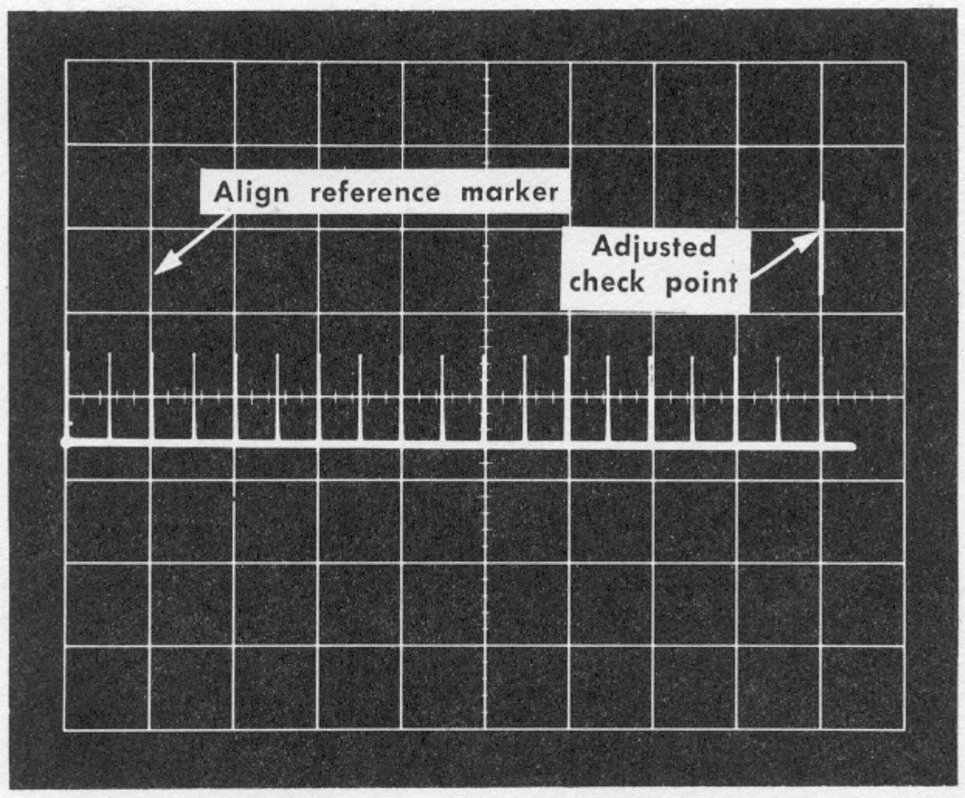
20. Check Horizontal Display External Horizontal Input

a. Set up the test equipment as shown and described with Fig. 6-17.

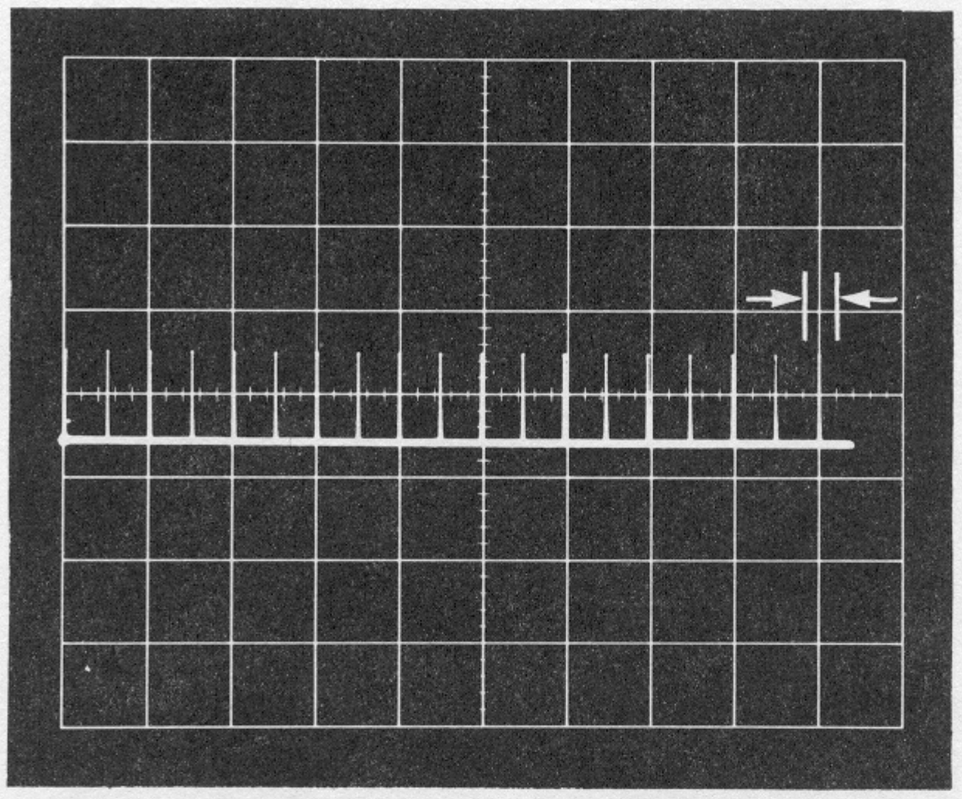
b. Obtain a stable, externally triggered sweep on the test oscilloscope. The Type 661 should now have a CRT display of time markers. Adjust the test oscilloscope Variable Time/cm control until the Type 661 display is exactly 2 time markers per centimeter, beginning at the left edge of the graticule (see Fig. 6-19).

c. Check the accuracy of the other positions of the EXT HORIZ INPUT switch according to Table 6-2. Do not change the setting of the test oscilloscope Variable control and disregard any hum or small amount of jitter during the checks.

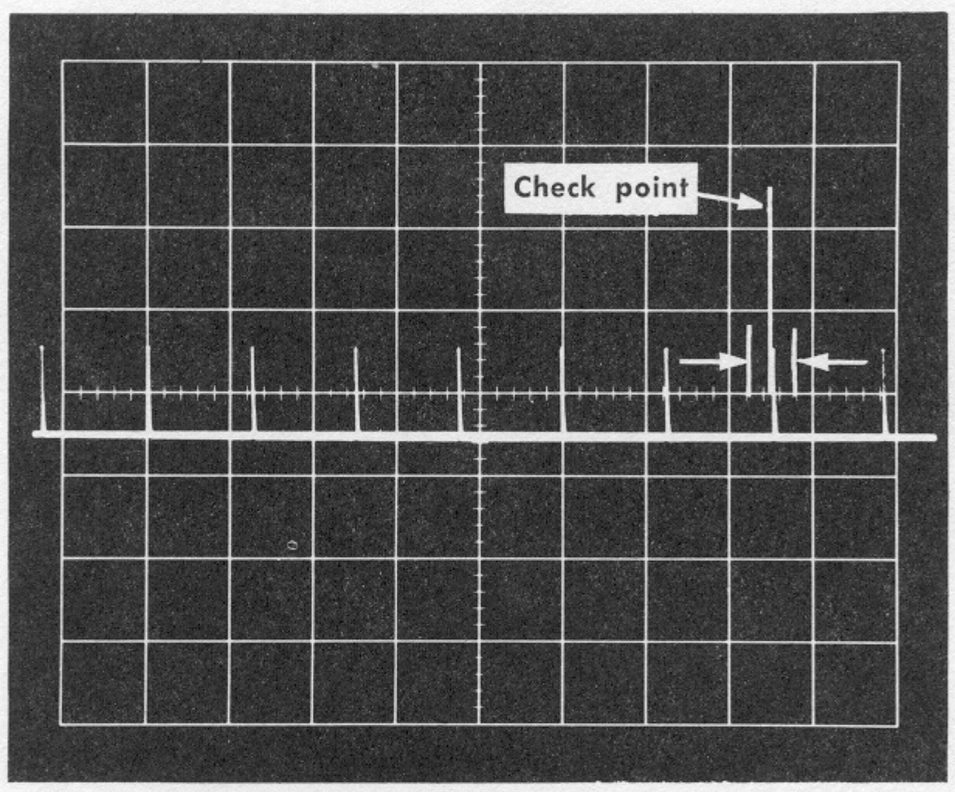
NOTES



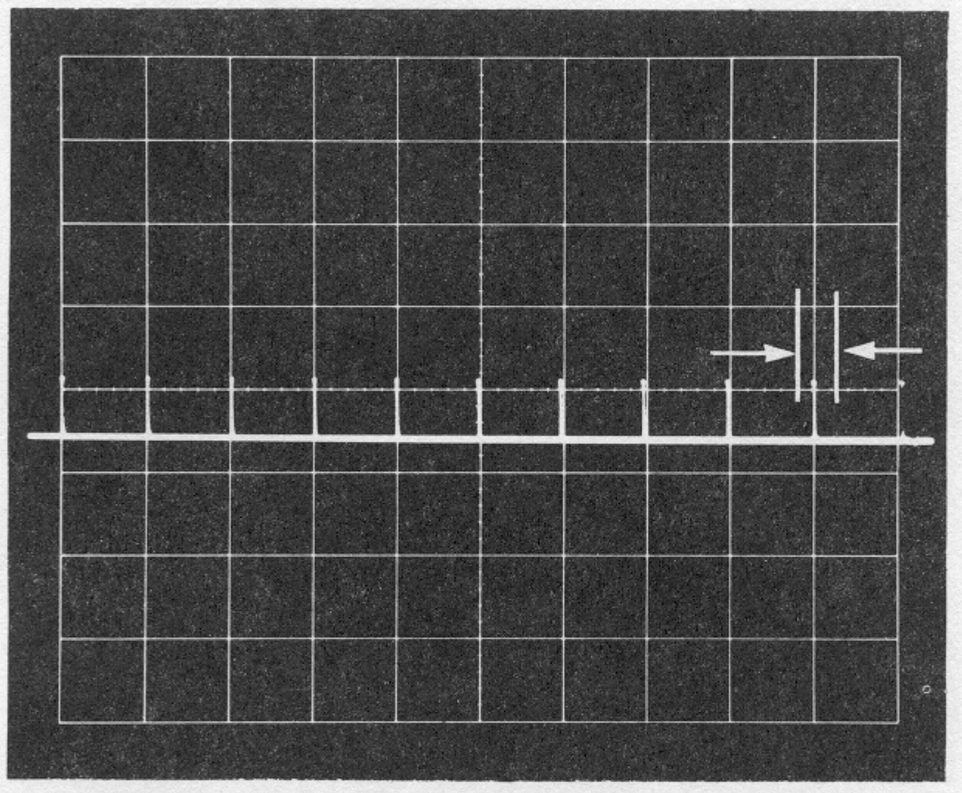
(A) Adjusted



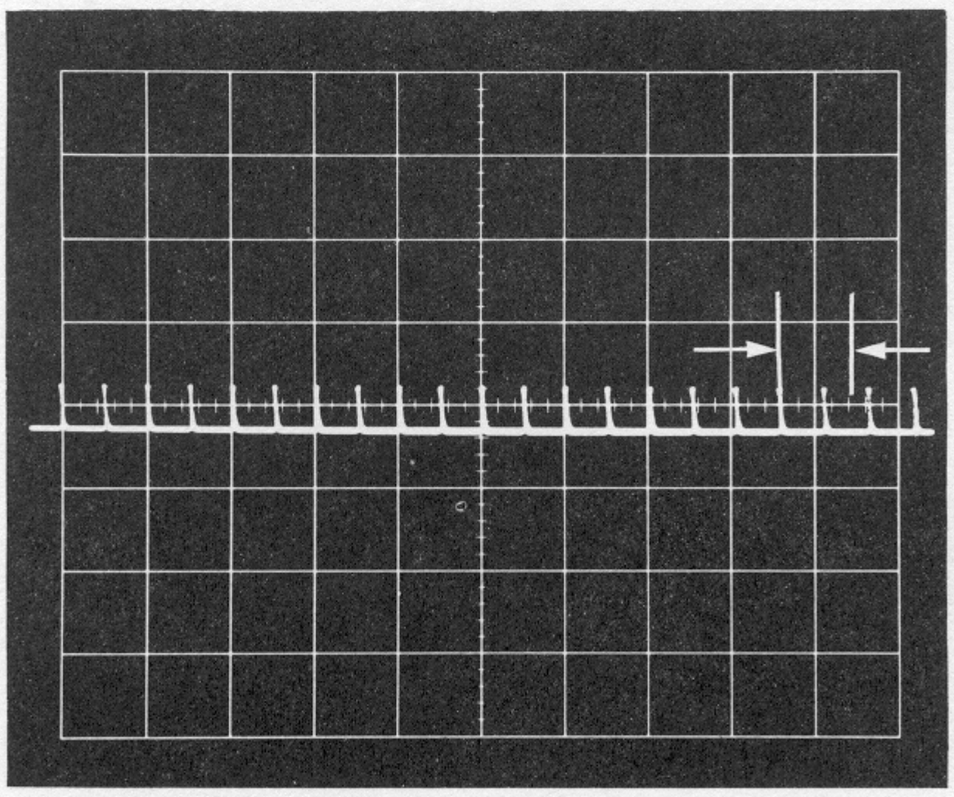
(B) ±3% (center 8 cm) ±2.4 mm



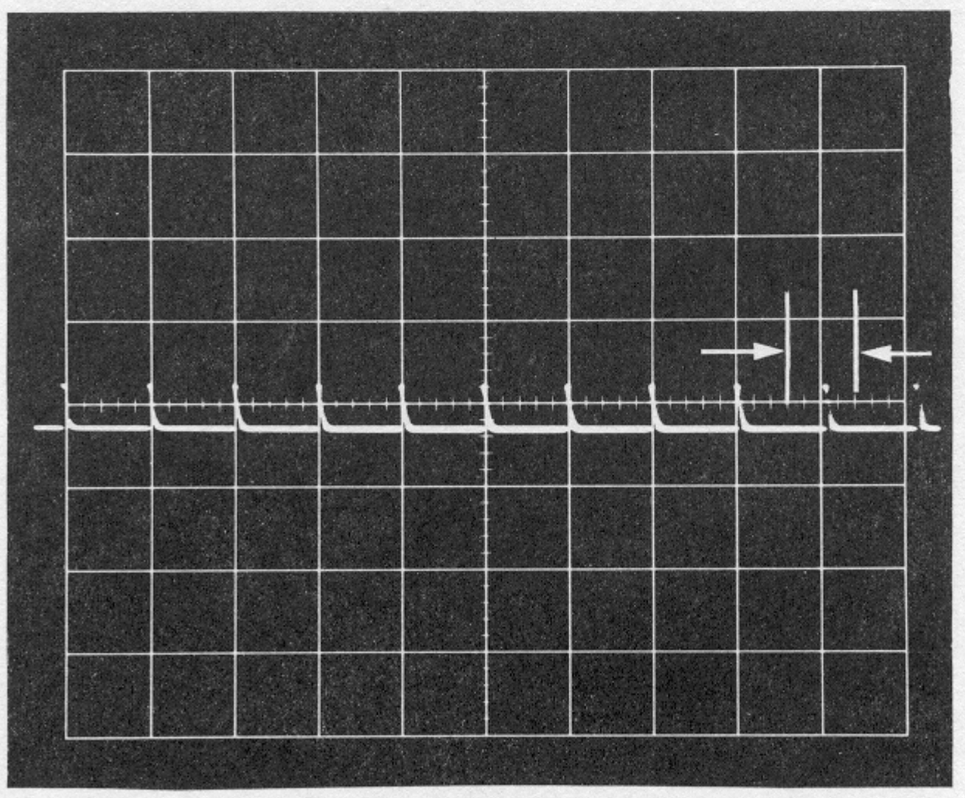
(C) ±3% (7.5 cm) ±2.25 mm



(D) ±3% (center 8 cm) ±2.4 mm

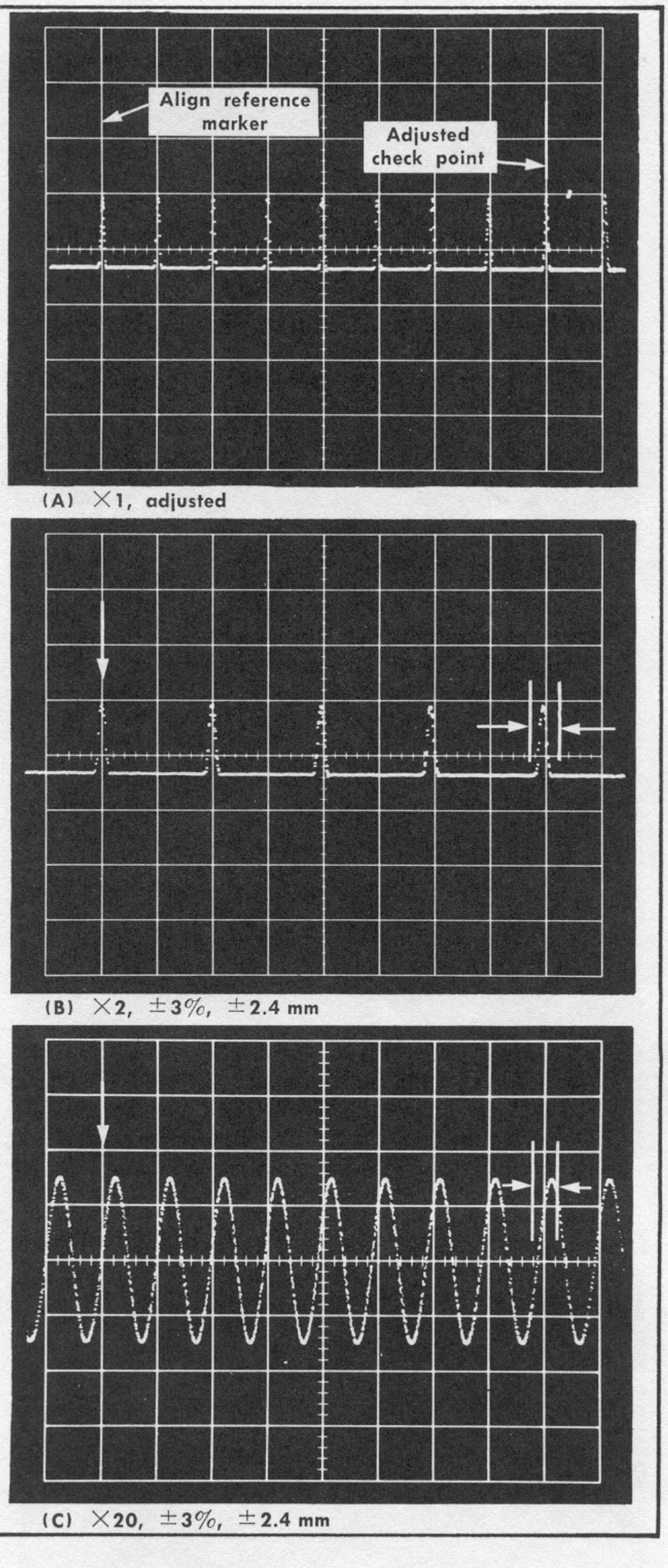


(E) ±5% (center 8 cm) ±4 mm



(F) ±5% (center 8 cm) ±4 mm

Fig. 6-19. Typical displays showing EXT. HORIZ. INPUT gain tolerances.



(A) ×1, adjusted

(B) ×2, ±3%, ±2.4 mm

(C) ×20, ±3%, ±2.4 mm

Fig. 6-20. Typical displays showing SWEEP MAGNIFIER gain tolerances.

If any one display is out of tolerance, it may be possible that the test oscilloscope Variable Time/cm control can be changed just enough so all are within tolerance. If one range is out of tolerance in a plus direction, and another is at the minus tolerance limit, change the corresponding R311 resistor for the plus error display.

d. Disconnect all the test equipment. The Time-Mark Generator will be used in the next step.

21. Check Horizontal Display Sweep Magnifier

a. Set the HORIZONTAL DISPLAY switch to SWEEP MAGNIFIER ×1.

b. Apply 1-μs time markers from the Time-Mark Generator to Sampling Unit Channel A Input connector. Use a 50 Ω coaxial cable, a BNC to GR 874 adapter, and a 5:1 attenuator.

c. Set the Timing Unit Trig Source switch to Int, Trig Level control for a stable display and the Equivalent Time/cm switch and Variable control for one 1-μs time mark per centimeter. Leave the Time/cm controls as set for the other SWEEP MAGNIFIER positions.

d. Check the accuracy of the SWEEP MAGNIFIER positions with the instrument controls set according to Table 6-3. See Fig. 6-20.

e. Disconnect the Time-Mark Generator.

NOTE

The horizontal preamplifier feedback resistors (R311A through R311J) are used in both the SWEEP MAGNIFIER and EXT HORIZ INPUT positions of the HORIZONTAL DISPLTY switch with the exceptions of SWEEP MAGNIFIER ×2 and ×20 and EXT HORIZ INPUT .2 and 2. Therefore, do not perform this check out of sequence.

TABLE 6-3

SWEEP MAGNIFIER	Time-Marks	Samples/cm Type 5T3	Display	Tolerance Fig. 6-20	Feedback Resistor
×1	1 μs	100	1 per cm	Adjusted	R311A
×2	1 μs	100	1 per 2 cm	±3%	R311B
×20	50 ns/cycle	1000	1 per cm	±3%	R311E

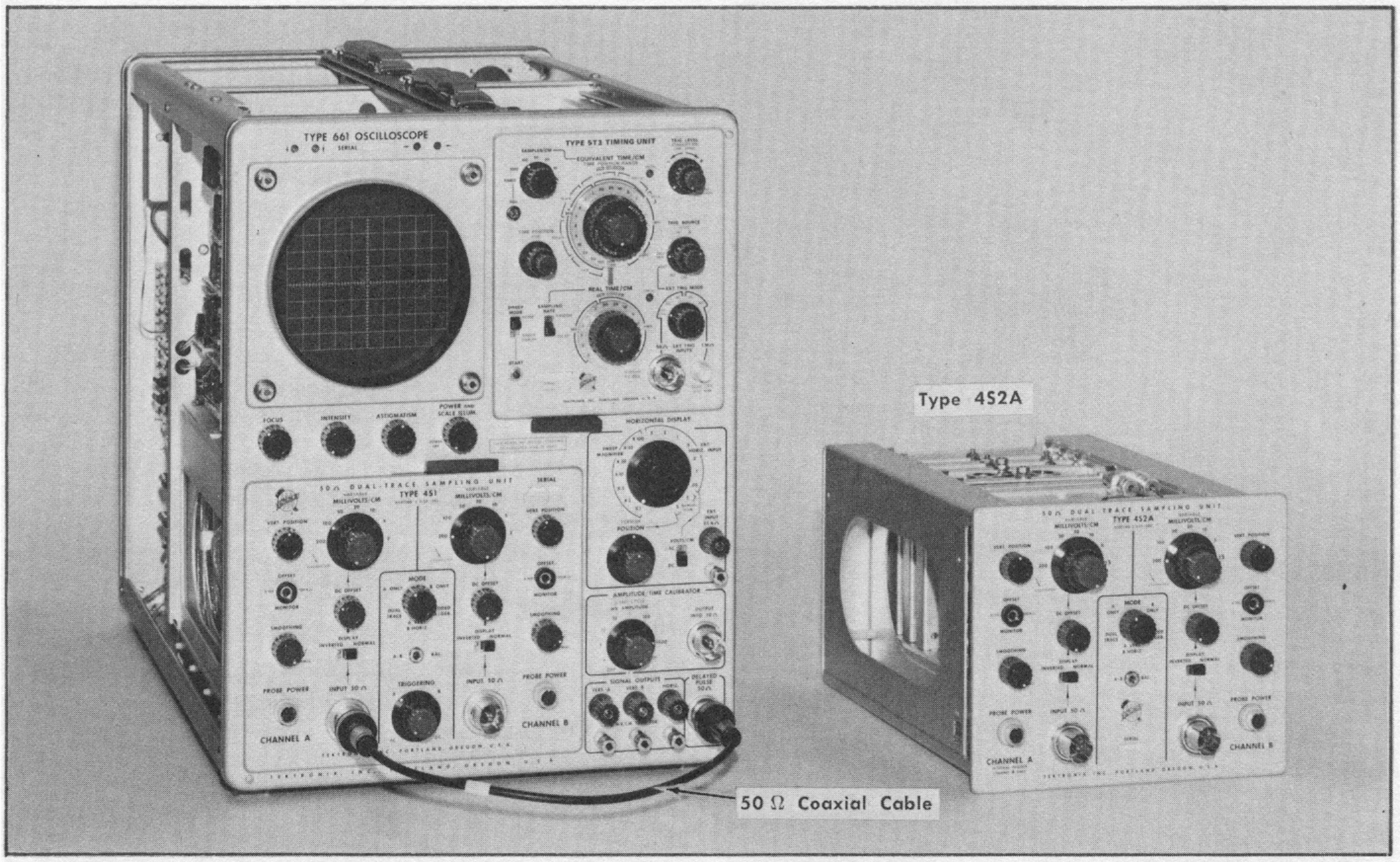


Fig. 6-21. Test equipment setup for step 22 and 23.

Control Settings

Type 4S1	
Mode	A Only
Triggering	A and AC
Channel A Controls:	
Vert Position	Midrange
Millivolts/cm	**100**
Variable (Millivolts/cm)	Calibrated
DC Offset	Trace Centered
Smoothing	Normal
Display	Normal
Type 5T3	
Samples/cm	**100**
Equivalent Time/cm	**0 μS**
Trig Level	**Fully counterclockwise**
Stability or UHF Sync	**Fully counterclockwise**
Trig Source	**Free Run**
Slope	+
Time Position	Fully clockwise
Sweep Mode	Normal
Type 661	
HORIZONTAL DISPLAY	**×1**
POSITION	Midrange
VERNIER (POSITION)	Midrange
VOLTS/CM	DC
mV AMPLITUDE	1000
μSEC/CYCLE	OFF
POWER AND SCALE ILLUM	Maximum illumination
FOCUS. INTENSITY and ASTIGMATISM	Normal intensity, well focused trace

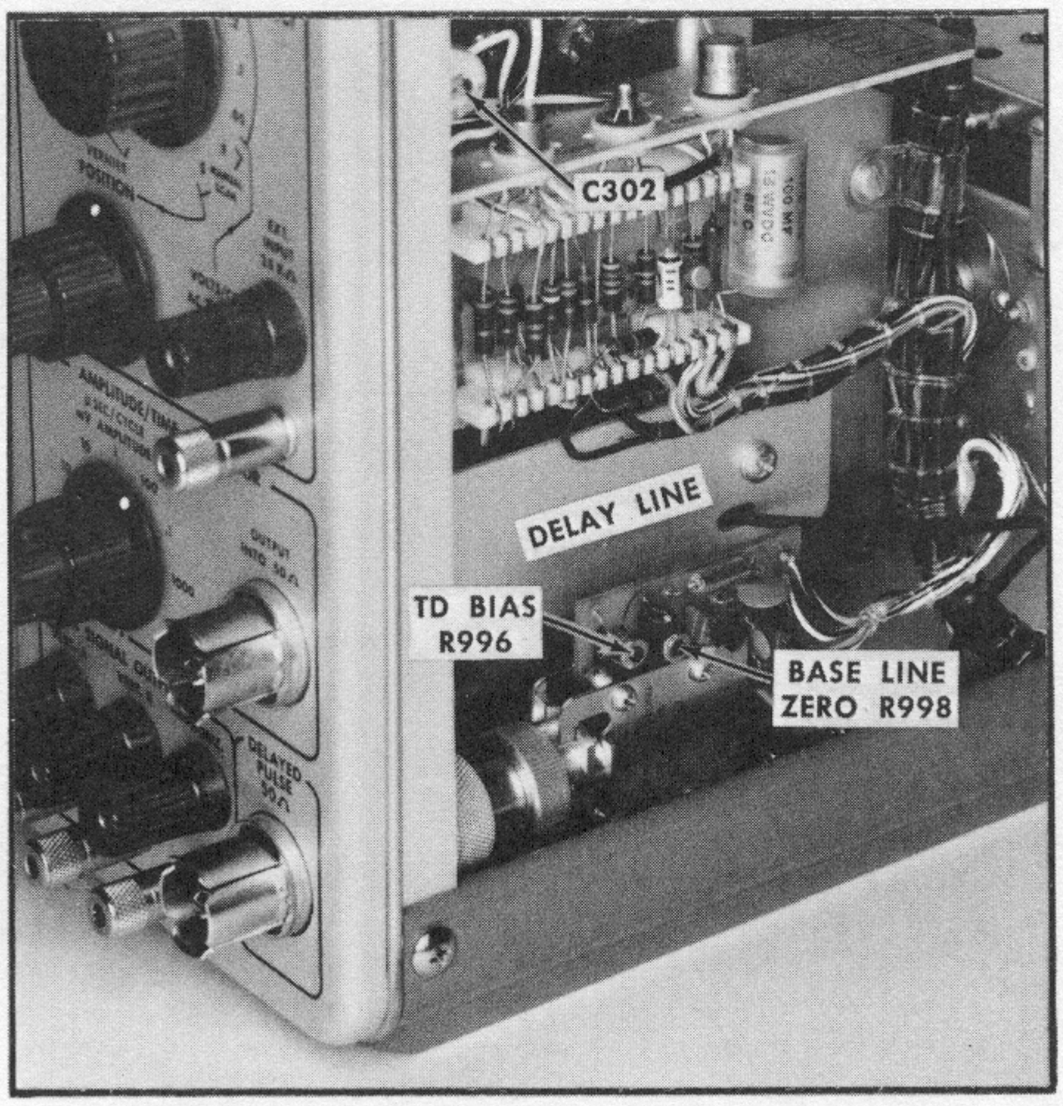


Fig. 6-22. Location of adjustments in instruments SN 3460-up for steps 22A and 24.

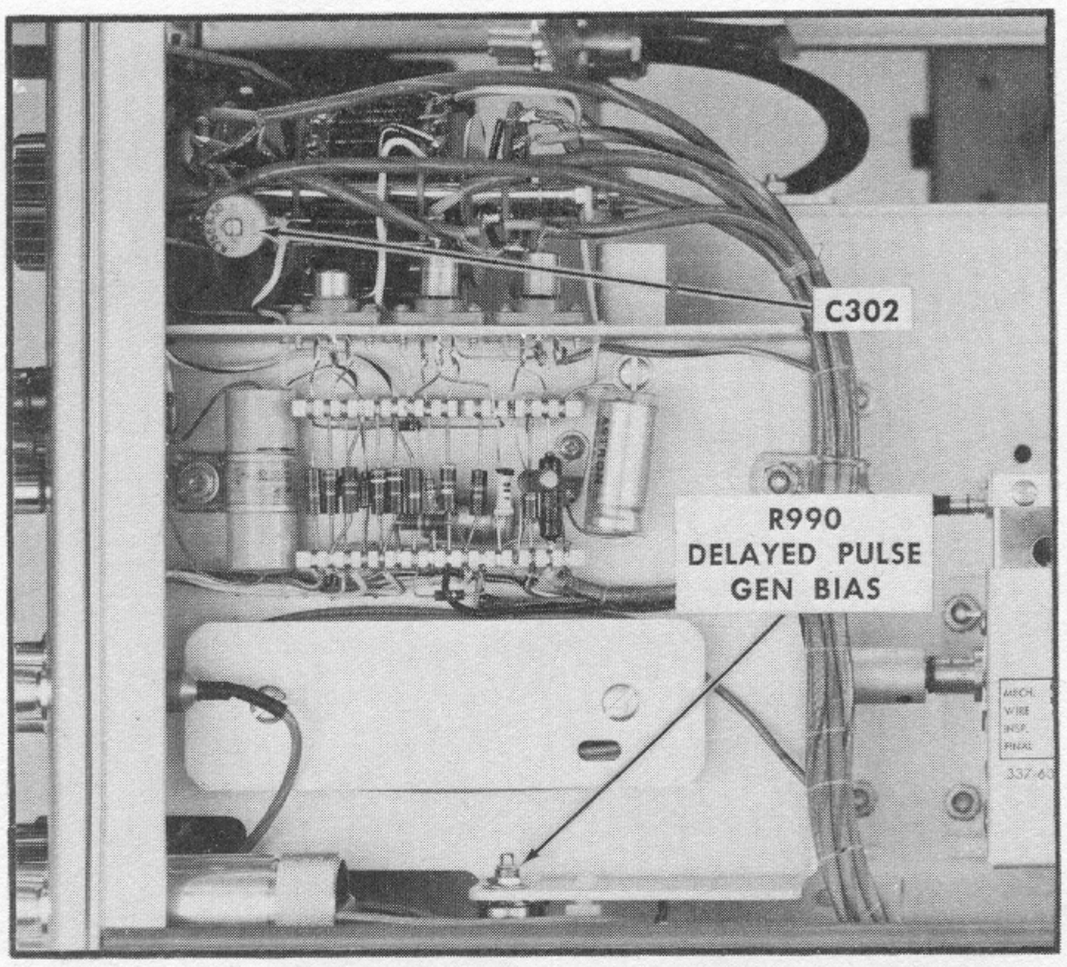


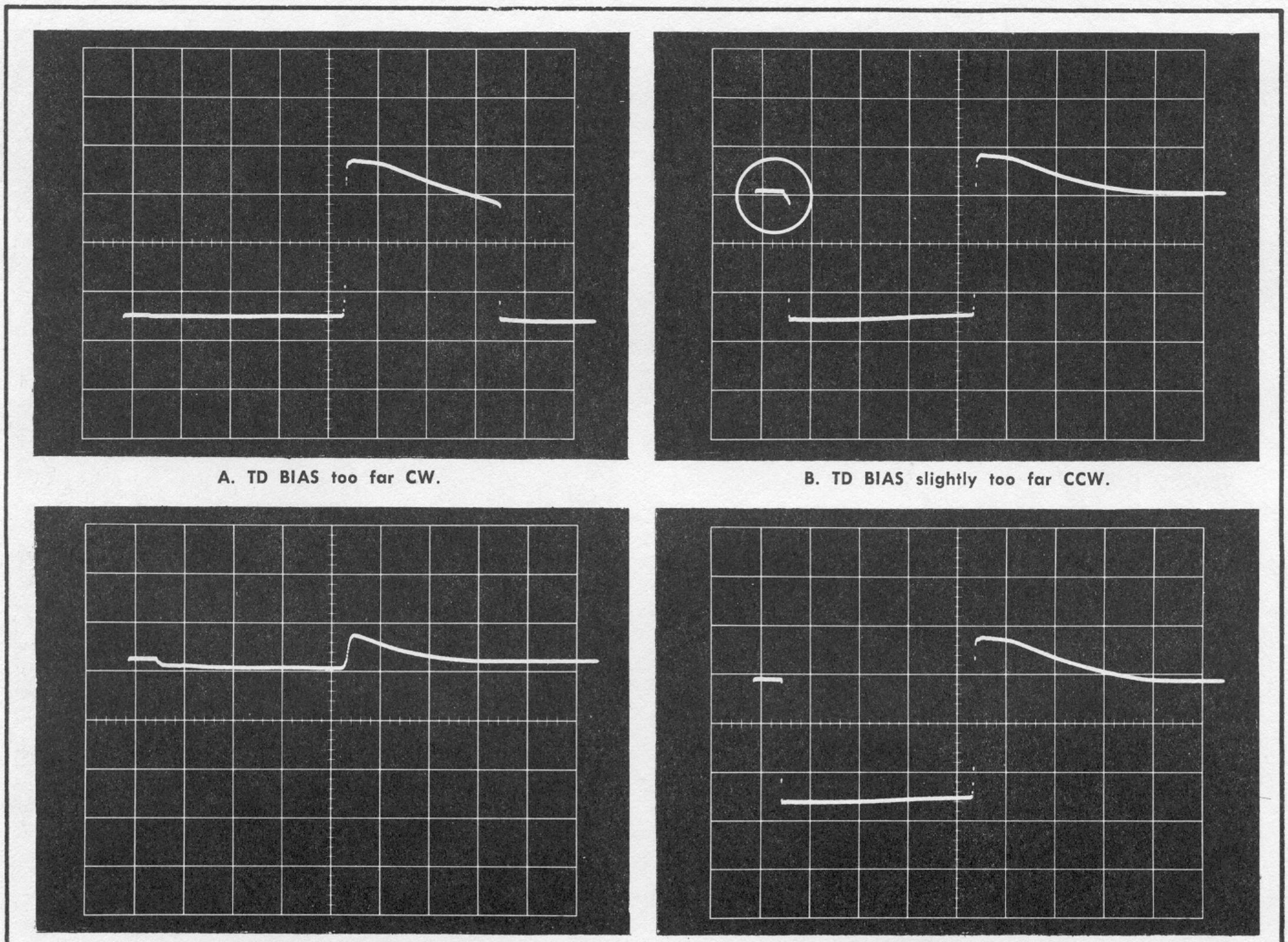
Fig. 6-23. Location of adjustments up to SN 3459 for steps 22B and 24.

22A. Adjust Delayed Pulse Generator, SN 3460-up

a. Use the equipment setup as shown in Fig. 6-21. Connect the 50 Ω coaxial cable from the Type 661 DELAYED PULSE 50 Ω connector to the sampling unit Channel A Input connector.

b. Adjust the two Time Position controls on the Timing Unit for a negative step display. The display should be similar to that shown in Fig. 6-24D. Fig. 6-24 shows waveforms for all possible improper and proper adjustment conditions of the TD BIAS control, R996. Adjust R996 until the display is like Fig. 6-24.

c. Change the Timing Unit Equivalent Time/Cm control to 2 ns/cm and adjust the Time Position control for a negative step display similar to the negative step portion of the double exposure of Fig. 6-25. Set the vertical unit mV/cm control to 50. Fig. 6-25 upper, and nearly flat trace, was obtained by pulling the coaxial cable away from the vertical unit just far enough so the center conductors capacitively coupled in the small ringing signal. With the coaxial cable center conductor not making contact, adjust the vertical Position (or DC Offset) control so the trace start coincides with a graticule line.



A. TD BIAS too far CW.

B. TD BIAS slightly too far CCW.

C. TD BIAS too far CCW.

D. TD BIAS set correctly

Oscilloscope controls: 100 mV/cm and .1 μs/cm.
Time position fully CW.
Vertical: Type 4S1.

Fig. 6-24. Displays that are possible during TD BIAS control adjustment, Step 22A.

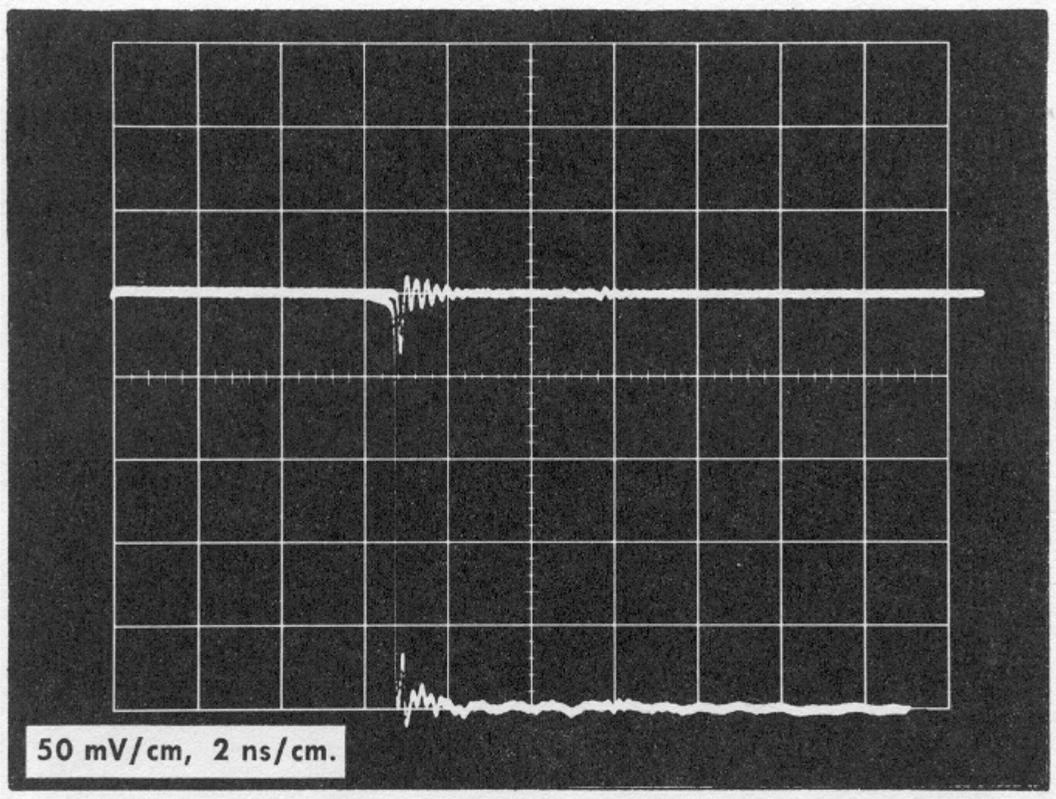


Fig. 6-25. Double exposure of displays while adjusting BASE LINE ZERO control, step 22A.

Now re-insert the coaxial connectors fully together and adjust the Delayed Pulser BASE LINE ZERO control, R998, until the display also starts at the same graticule line.

The two adjustment controls interact slightly. The final adjustment of both the TD BIAS and the BASE LINE ZERO controls is where the pulse starts negative (from zero volts) with only a very small drive signal slope apparent. Fig. 6-25 double exposure shows an example of proper adjustment of the two controls.

d. Check that the properly adjusted Delayed Pulse Generator output pulse is approximately —260 mV.

e. If using a Type 4S2A, set the Type 4S2A Channel B loop gain to unity using the following control procedure. Place the coaxial cable between the DELAYED PULSE 50 Ω and the Type 4S2A B Input connectors.

Set the Timing Unit sweep rate to .1 ns with the blue Time Position Range control set to 2 ns. Set both the Trig Level and Stability controls to midrange, and both Time Position controls near 3 o'clock, for a negative step display.

Slowly rotate the Trig Level control through its range until the negative step display shifts horizontally about 2 cm. There is a very sensitive adjustment at that control position that will produce a display with more than one negative step, such as is shown in Fig. 6-26. Adjustment of the Stability control permits vernier action of the dual step display.

Now adjust the Type 4S2A Channel B Smoothing control until the CRT display shows that the sampling system is operating at unity loop gain, shown in Fig. 6-26B. Now move the Timing Unit Trig Level control to obtain just one stable negative step in the display.

f. Pull the Type 5T3 Magnifier out and set it for a sweep rate of .1 ns if using a Type 4S1 vertical and 50 ps if using a Type 4S2 vertical (leave the blue Time Position control at 2 ns).

Adjust the Time Position controls so the Delayed Pulse is in view. Adjust the vertical unit millivolts/cm Variable control and the DC Offset control for an 8 cm display similar to that in Fig. 6-27. Check the display risetime as shown in Fig. 6-27. It is important that the pulse start point coincide with the graticule top line, and that the first full 100% peak coincide with the bottom graticule line. Fig. 5-7A shows that the bottom edge of the step display is used in making the risetime check. It is also permissable to use either the trace midpoint, or the top edge of the trace, but whichever you use, be consistent in using the same portion of the trace at both top and bottom.

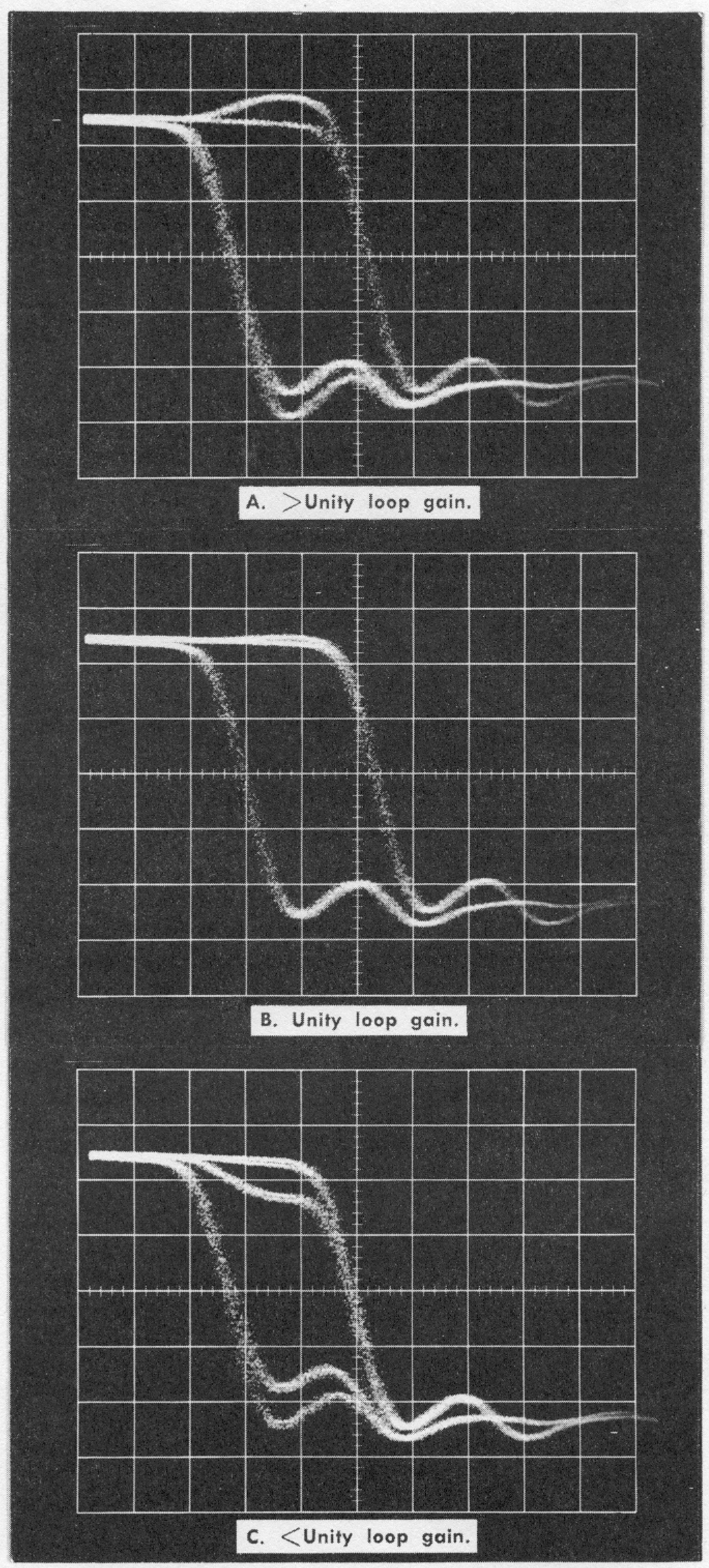
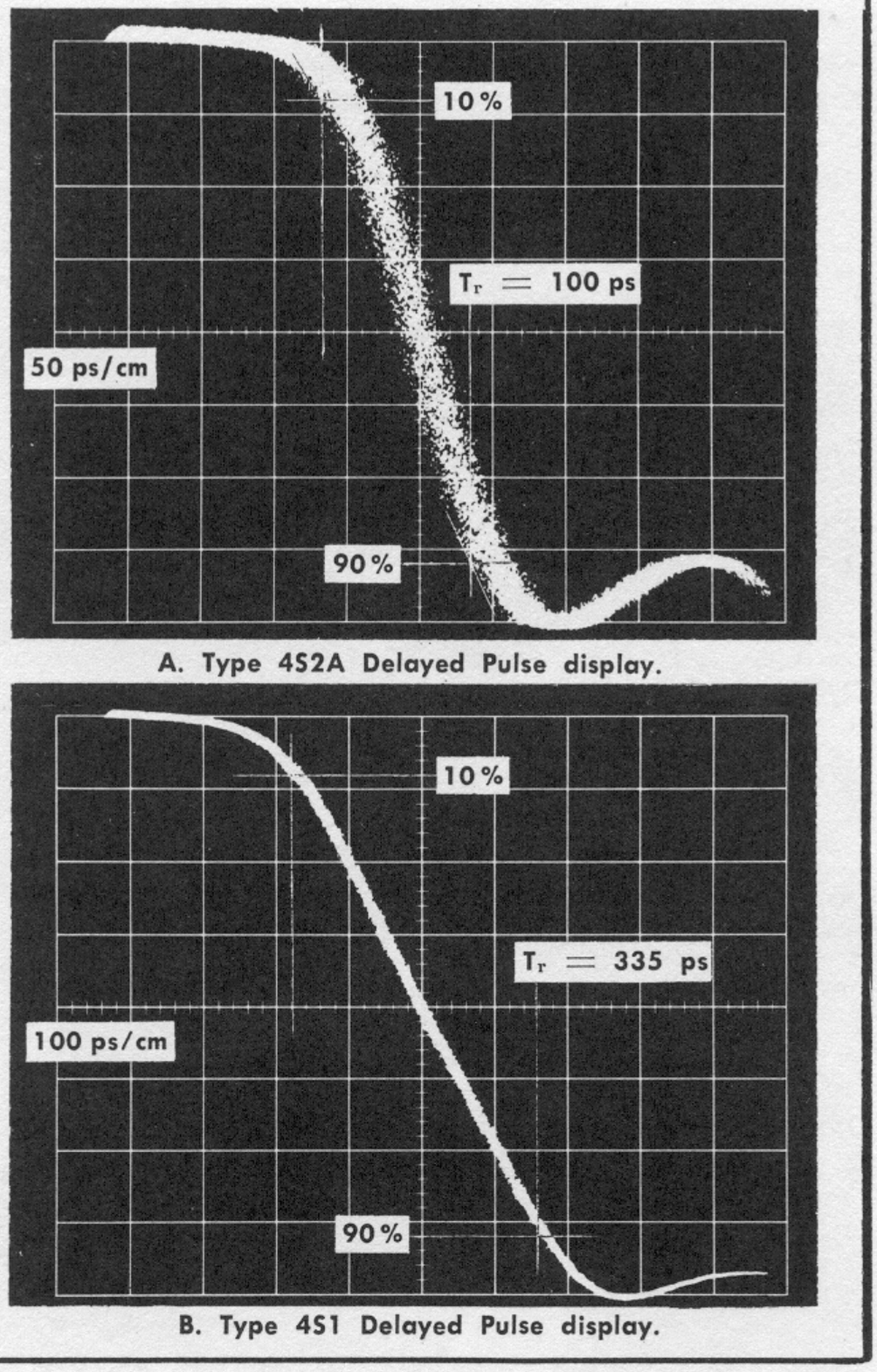


Fig. 6-26. 4S2A unity loop gain displays, step 22A, SN 3460-up.



A. Type 4S2A Delayed Pulse display.

B. Type 4S1 Delayed Pulse display.

Fig. 6-27. Checking Delayed Pulse risetime.

Locate the 10% and 90% points. They are each located 8 mm (0.8 major division) from the graticule top and bottom. The time between these two points is the system risetime. (The most accurate way to make the risetime check is to photograph the display and scribe the print in the same manner as shown in Fig. 6-27).

The Type 4S1 risetime (350 ps or less) is several times longer than that of the Delayed Pulse and therefore is the dominant risetime determining agent when used in the Type 661. The Delayed Pulse risetime will appear not greater than 360 ps using the Type 4S1 and either a 2 ns signal delay RG-58/U or a 5 ns signal delay RG-213/U coaxial cable.

The Type 4S2A risetime (90 ps or less) is slightly longer than that of the Delayed Pulse; therefore, the risetime as displayed on the Type 661 CRT will be longer than 90 ps. The Delayed Pulse risetime will appear not greater than 145 ps using the Type 4S2A and either a 2 ns signal delay RG-58/U or a 5 ns signal delay RG-213/U coaxial cable.

22B. Adjust Delayed Pulse Generator Bias ◑ SN101-3459

a. Use the equipment setup as shown in Fig. 6-21. Connect a 50 Ω coaxial from the Type 661 DELAYED PULSE 50 Ω connector to the Sampling Unit Channel A Input connector.

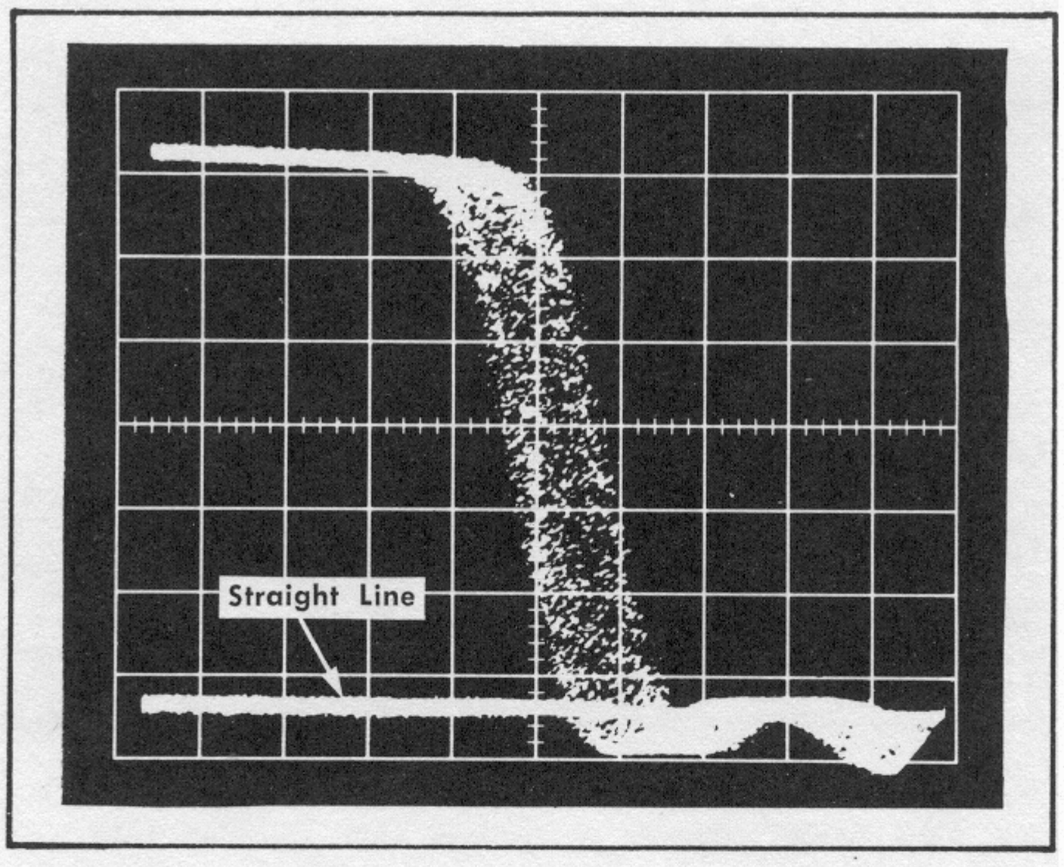


Fig. 6-28. Unity loop gain display.

b. Turn the Timing Unit Time Position control counterclockwise until the negative step of the display is at the center of the graticule area. Use the Sampling Unit DC Offset control to center the display vertically.

c. Turn the Sampling Unit Millivolts/cm VARIABLE control for a display amplitude of 8 cm.

d. Adjust R990, the DELAYED PULSE GEN BIAS control see Fig. 6-22 and Fig. 6-23), for a stable, negative step with the least amount of noise (see Fig. 6-29, risetime measurement, for the desired display). Minimum noise occurs as R990 is turned clockwise and at a control position just a few degrees before an unstable display occurs.

23. Check Delayed Pulse Risetime

NOTE

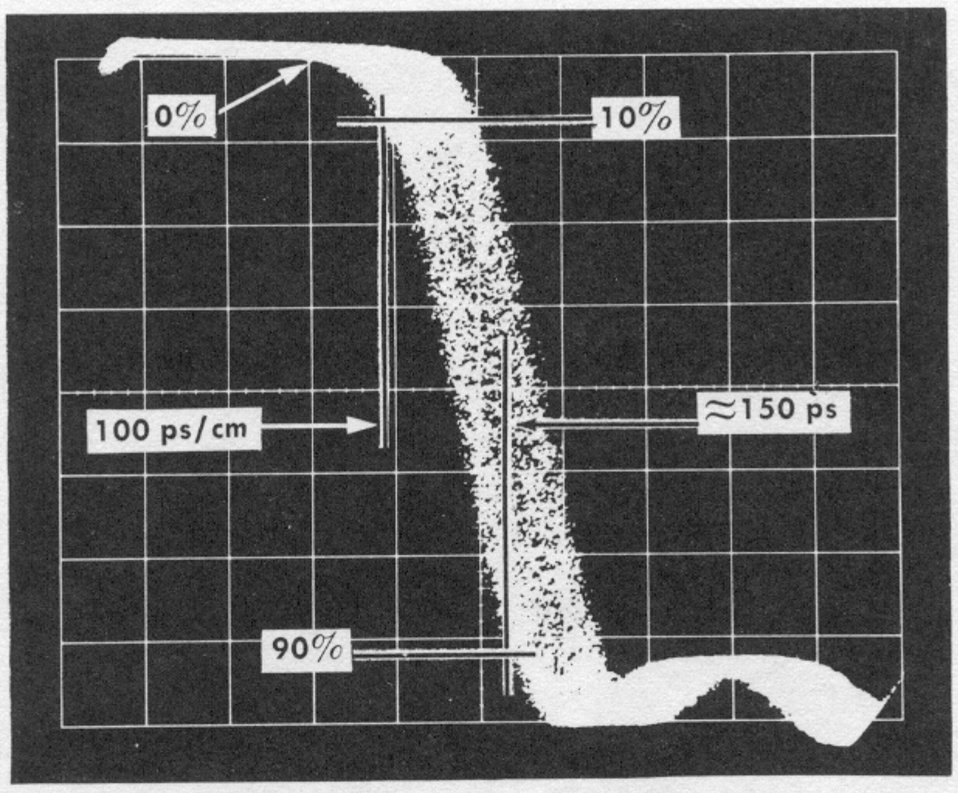
The Type 4S1 risetime (350 ps or less) is sufficiently longer than that of the Delayed Pulse risetime that only the risetime of the Type 4S1 is observed. When using a Type 4S1 and 2 ns signal delay RG58 cable, the Delayed Pulse risetime will appear no longer than 380 ps.

The Type 4S2A risetime (90 ps or less) is less than that of the Delayed Pulse risetime and, therefore, the pulse risetime can be determined from the CRT display. When using a Type 4S2A and 2 ns signal delay RG58 cable, the Delayed Pulse risetime will appear no longer than 180 ps.

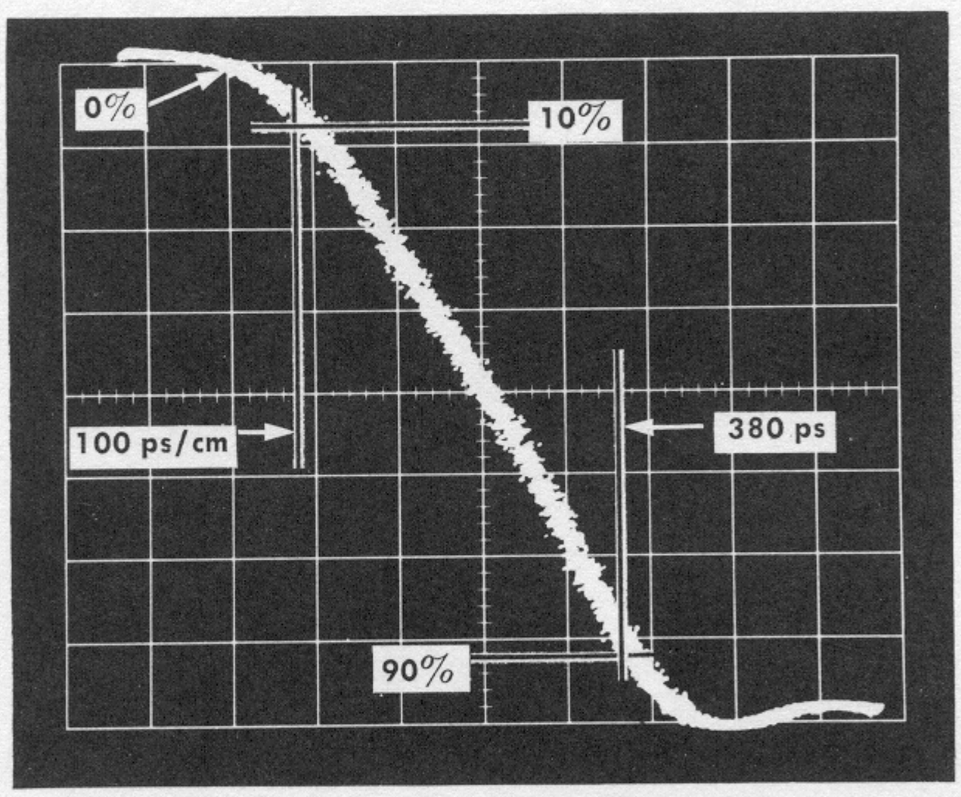
The Delayed Pulse 10% to 90% risetime is 150 ps or less at the DELAYED PULSE 50 Ω connector. Risetime will appear to be slower on the Type 661 CRT depending upon the risetime of the Vertical plug-in and connecting cable used.

Optional Procedure

a. Turn off the Type 661, remove the Type 4S1, install the Type 4S2A and turn on the Type 661. Allow about 10 minutes warm up.



(A) Type 4S2A display at unity loop gain.



(B) Type 4S1 display at unity loop gain.

Fig. 6-29. Delayed Pulse risetime measurement.

b. Set the Type 4S2A controls and connections as listed for the Type 4S1 below Fig. 6-21, where applicable, and set the Variable control for a display amplitude of 8 cm as in the preceding step.

c. Pull the Timing Unit Magnifier and set the Equivalent Time/cm switch for a sweep rate of .1 nsec. Reset the Time Position controls as necessary to center the falling portion of the display.

d. Set the Sampling System for unity gain; turn the Timing Unit Stability or UHF Sync control clockwise until the display is double triggered. Set the Sampling Unit Smoothing control so the bottom of the display is at the same level, see Fig. 6-28. Set the Timing Unit Stability or UHF Sync control counterclockwise and set the Sampling Unit Variable control for an amplitude of 8 cm. The Delayed Pulse Gen. Bias control, R990, may now be readjusted for the best display.

e. Measure the time required for the waveform to fall from 10% of its total amplitude to 90% of its total amplitude, see Fig. 6-29.

f. Check—Risetime must be 180 ps or less; 1.8 cm. (If viewed using the Type 4S1, the risetime should appear as 380 ps or less; 3.8 cm.)

g. Disconnect the coaxial cable, turn off the Type 661, remove the Type 4S2A, install the Type 4S1 and turn on the Type 661. Allow about 5 minutes warm-up time.

24. Adjust Horizontal Amplifier Input Compensation

a. Set the Timing Unit Samples/cm switch to 5 and center a free run display with the Sampling Unit DC Offset control.

b. Adjust C302 (see Fig. 6-23) for minimum tail at the left of each dot.

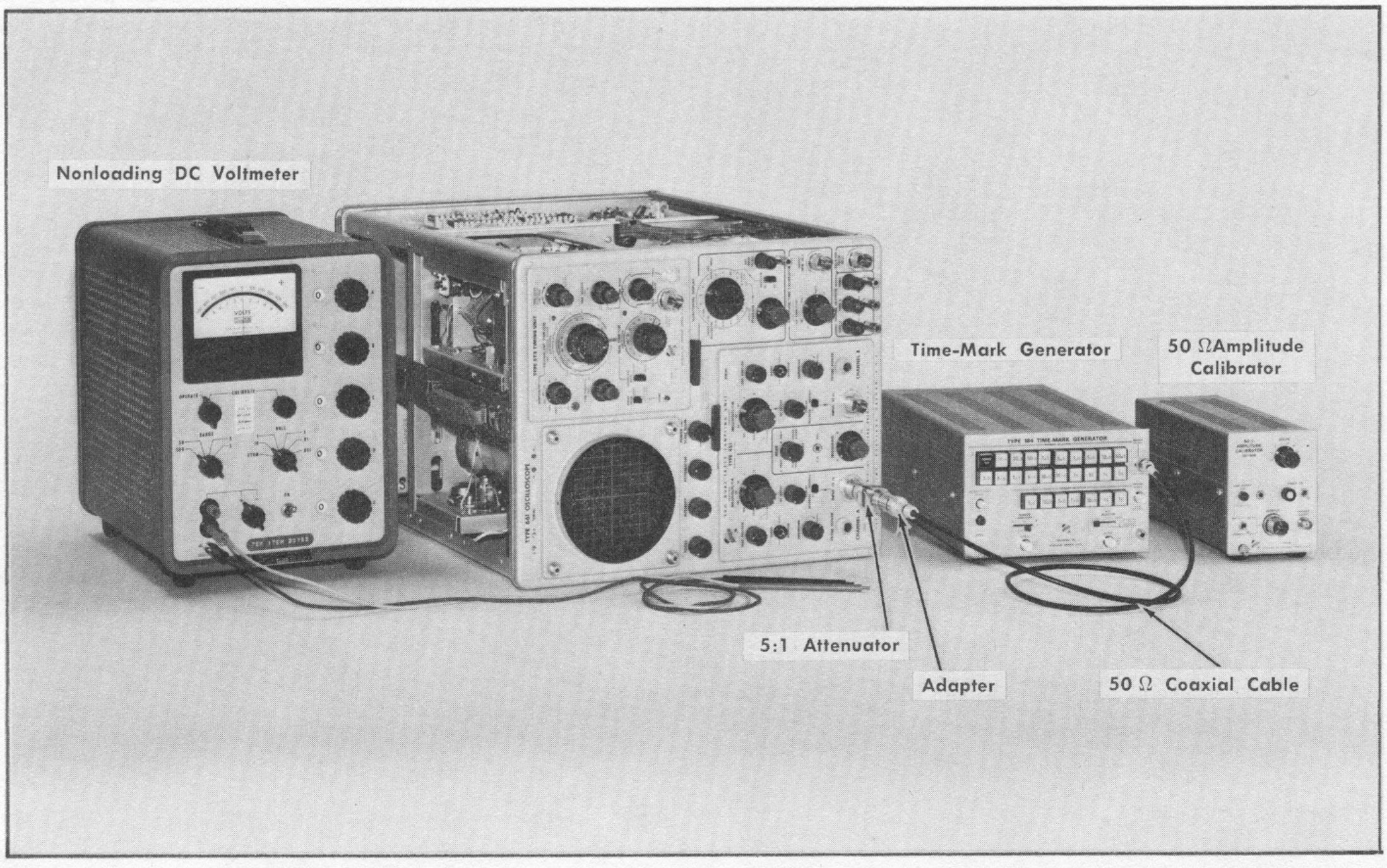


Fig. 6-30. Test equipment for steps 25 and 26.

Control Settings

Type 4S1

Mode	A Only
Triggering	A and AC
Channel A Controls:	
Vert Position	Midrange
Millivolts/cm	**200**
Variable (Millivolts/cm)	**Calibrated**
DC Offset	Trace Centered
Smoothing	**Unity gain**
Display	Normal

Type 5T3

Samples/cm	**100**
Equivalent Time/cm	**0.1 μSEC, Calibrated**
Trig Level	Midrange
Stability or UHF Sync	Midrange
Trig Source	**Int**
Slope	+
Time Position	**Fully clockwise**
Sweep Mode	Normal

Type 661

HORIZONTAL DISPLAY	×1
POSITION	Midrange
VERNIER (POSITION)	Midrange
VOLTS/CM	DC
mV AMPLITUDE	1000
μSEC/CYCLE	OFF
POWER AND SCALE ILLUM	Maximum illumination
FOCUS, INTENSITY and ASTIGMATISM	Normal intensity, well focused trace

Connections:

a. Connect the Time-Mark Generator Marker output connector to the Sampling Unit Channel A Input connector. Use a 50 Ω coaxial cable with GR 874 connectors, a GR to BNC adapter and a 5:1 attenuator.

NOTE

Due to interaction between the Amplitude/Time Calibrator internal timing and amplitude controls, a preliminary timing check is made before final adjustment of the output amplitude. The following AMPLITUDE/TIME CALIBRATOR adjustments must not be performed out of sequence.

25. Adjust Amplitude/Time Calibrator Waveshape and Timing (Preliminary)

NOTE

This step should not be necessary for an instrument receiving a normal recalibration. Perform this step whenever an Amplitude/Time Calibrator chassis is replaced or when major components within it are changed.

a. Lay the Type 661 on its left side and use the equipment setup as shown in Fig. 6-30.

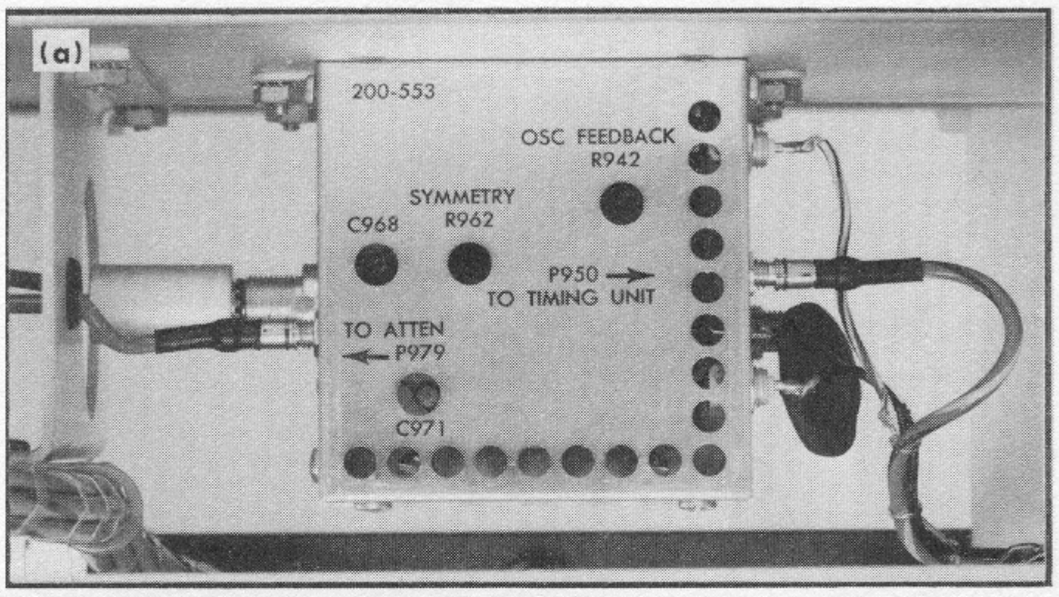


Fig. 6-31. Location of Amplitude/Time Calibrator adjustments (A) Top view; (B) side view; (C) bottom view. Leave covers on the Calibrator chassis and insert adjustment tools through the holes in the covers.

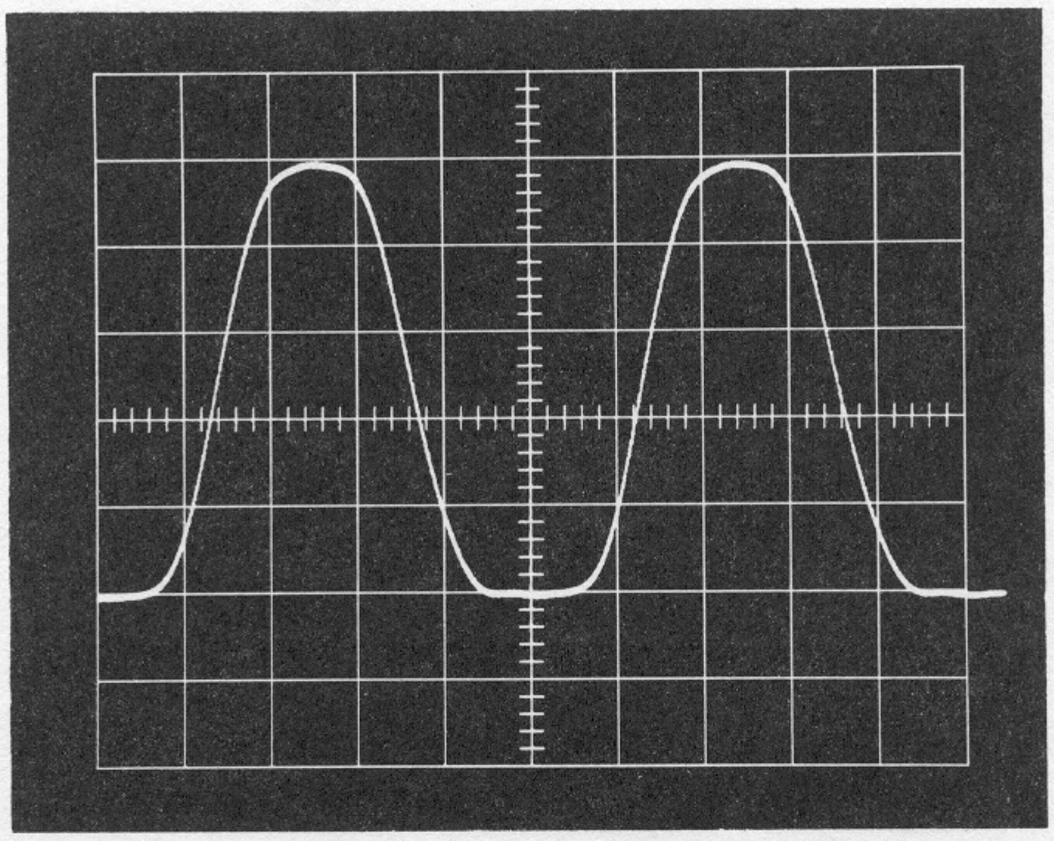


Fig. 6-32. Appearance of .01 SEC/CYCLE display with a Type 4S1 vertical plug-in unit when C968 is adjusted correctly. Waveform is flat on the bottom when C968 is adjusted with a Type 4S3 plug-in unit.

b. Set the Time-Mark Generator for 0.1-μs time marks. Trigger the display with the Timing Unit Trig Level control and check for 1 time mark per centimeter. If the display is other than 1 time mark per centimeter, refer to the Timing Unit Instruction Manual for procedure to correct the error.

c. Disconnect the Time-Mark Generator signal.

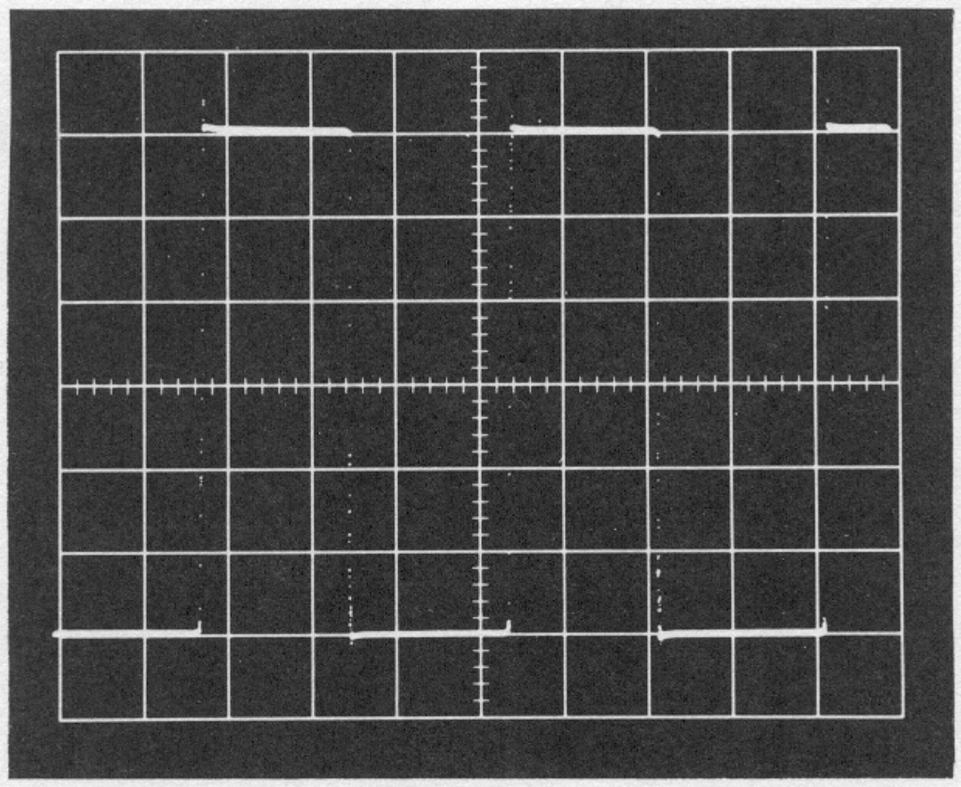
d. Set the Type 661 Amplitude/Time Calibrator μSEC/CYCLE switch to .1 and set the Timing Unit Equivalent Time/cm switch to 20 nSEC and the Trig Source switch to Cal.

e. Connect a 50 Ω coaxial cable from the AMPLITUDE/TIME CALIBRATOR OUTPUT to the Sampling Unit Channel A Input connector. Obtain a stable display with the Timing Unit Trig Level control. If there is no display, adjust R942 to start operation of the calibrator oscillator, see Fig. 6-31.

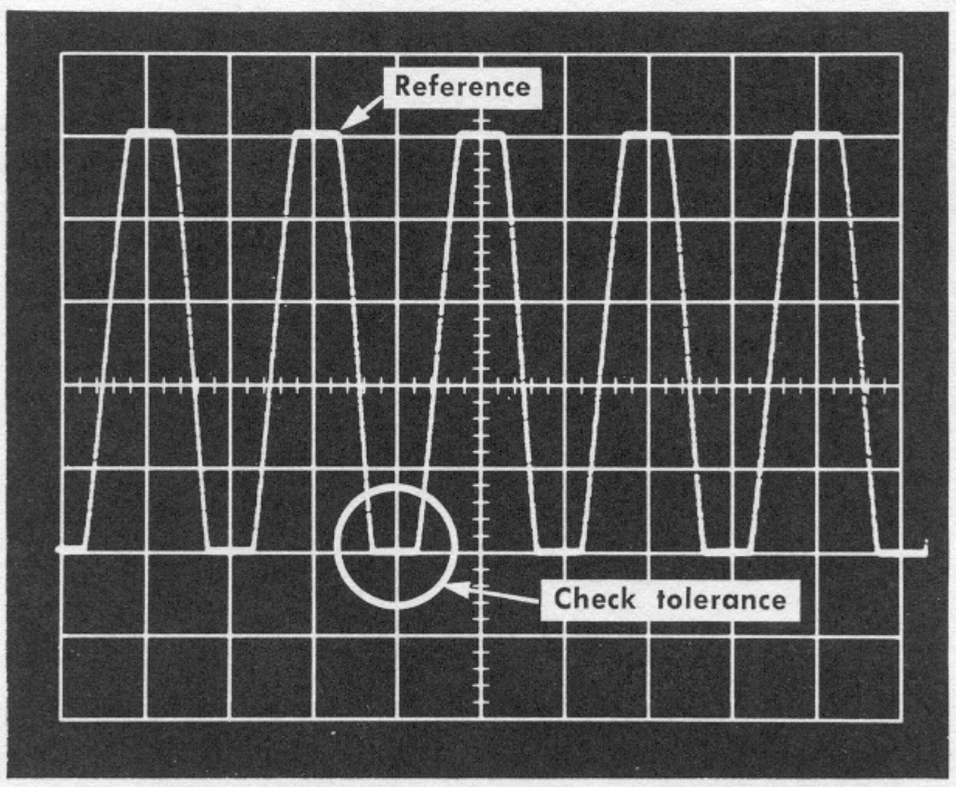
f. Check and adjust the AMPLITUDE/TIME CALIBRATOR controls listed in Table 6-4 to obtain the displays as indicated. Perform the adjustments in the sequence given, starting at the top of the table. Locations of the controls are shown in Fig. 6-31. Precise timing adjustments will be made later in the calibration procedure.

26. Adjust Amplitude/Time Calibrator Amplitude

a. Leave the AMPLITUDE/TIME CALIBRATOR OUTPUT connected to the Sampling Unit Input A connector.



(A) Vertical calibration using 50 Ω Amplitude Calibrator



(B) 10 μSEC/CYCLE display

Fig. 6-33. Step 26 waveforms.

b. Set the mV AMPLITUDE switch to 1000 and the Sampling Unit Millivolts/cm switch to 200, both channels.

c. Set the μSEC/CYCLE switch at .01. Trigger the display and position the positive peak of the waveform to the horizontal centerline.

d. Connect the non-loading DC voltmeter (initially set for at least 100 volts) to the Offset Monitor jack on the Sampling Unit and note the voltage at the jack. This voltage is 100 times the voltage Offset of the waveform peak.

e. Turn the DC Offset control to position the negative peak of the calibrator waveform to the horizontal centerline. (Make measurements from top to top of trace or bottom to bottom of trace.)

Measure the voltage at the Offset Monitor jack and determine the difference from the first reading. This difference is 100 times the peak-to-peak amplitude of the calibrator signal (see Table 6-5). Due to signal losses and compensation at 100 MHz at the Type 4S1 system input, the calibrator output offset amplitude will measure about 2% less than its actual amplitude.

f. Adjust R965 if the amplitude is not correct as measured at the Offset Monitor jack.

g. After adjusting R965 while the μSEC/CYCLE switch is at .01, set the μSEC/CYCLE switch to .1. Again measure the offset amplitude and adjust R967 (see Table 6-5) for correct signal amplitude without any —2% compensation as in f above. Check the 1000 mV amplitude at 1 and 10 μSEC positions for tolerance listed in Table 6-5.

TABLE 6-4

Preliminary Calibrator Adjustments

μSEC/ CYCLE	Timing Unit TIME/CM	Check for	Adjust	Tool (see Fig. 6-2)
.1	20 nSEC	Level top and bottom on waveform	C971	B
		Minimum waveform distortion	R942 (OSC FEEDBACK)	B
		Symmetry	R962 (SYMMETRY)	B
.01	10 nSEC	Approx 1 cycle/cm	L916	D
.1	.1 μSEC	Approx 1 cycle/cm	L911	C
1	1 μSEC	Approx 1 cycle/cm	L906	C
10	10 μSEC	Approx 1 cycle/cm	L901	B
.01	2 nSEC	Squarest possible corners	C942	B
		Waveshape similar to Fig. 6-27.[2]	C968 (Set mV AMPLITUDE to 100 and Mv/CM to 20 for this adjustment.)	B

[2]If a Type 4S3 Sampling Unit is used for Calibrator adjustments, set C968 for a level top and bottom on the waveform.

TABLE 6-5

Calibrator Amplitude Adjustments

μSEC/ CYCLE	Timing Unit TIME/CM	Amplitude (Measured with DC OFFSET) Type 4S1	Type 4S3[3]	Adjust
.01	5 nSEC	980 ±80 mV	1000 ±80 mV	R965
.1	50 nSEC	990 ±20 mV	1000 ±20 mV	R967
1	.5 μSEC	1000 ±20 mV	1000 ±20 mV	—
10	5 μSEC	1000 ±20 mV	1000 ±20 mV	—

[3]Used with P6038 Probe and VP-2 with 50-ohm termination at OUTPUT INTO 50 Ω connector.

NOTE

The remainder of this step is given for those cases where the vertical unit has been operating regularly in the Type 661. The vertical deflection factor of the Type 661 was previously adjusted (step 11), making it necessary to adjust the vertical unit gain now for correct input deflection factor. The remainder of this step is not necessary where the vertical unit will not operate regularly in the Type 661. Instead, adjust the vertical unit front panel Millivolts/cm VARIABLE controls to standardize the deflection factors to allow direct CRT comparison of AMPLITUDE/TIME CALIBRATOR amplitude checks.

h. Disconnect the DC Voltmeter from the Offset jack, set the Timing Unit Equivalent Time/cm switch to 50 nSEC and leave the Type 661 μSEC/CYCLE switch at .1.

i. Trigger the display and adjust the Sampling Unit A-B Bal (front-panel) control for a display amplitude of 5 cm.

j. Set the Sampling Unit Mode switch to B Only and apply the AMPLITUDE/TIME CALIBRATOR signal to the Channel B INPUT connector. Adjust the B Cal control on the Dual-Trace subchassis of the Sampling Unit, located internally under the CRT (use a long shank screwdriver) for the correct display amplitude (5 cm).

k. Set the Sampling Unit Mode switch to A Only and apply 0.12 volts from the 50 Ω Amplitude Calibrator to the Sampling Unit Channel A Input connector through a coaxial cable. Connect the Trigger Output of the 50 Ω Amplitude Calibrator to either Timing Unit Ext Trig Input connector using a 50 Ω coaxial cable.

l. Set the Timing Unit Samples/cm switch to 1000, Trig Source to Ext, AC, Equivalent Time/cm to 5 mSEC, and adjust the Trig Level control for a stable display.

m. Set the Sampling Unit Millivolts/cm and Variable control for exactly 6 cm of display amplitude. This is now the reference display. See Fig. 6-33A.

TABLE 6-6

AMPLITUDE/TIME CALIBRATOR

Amplitude Checks

mV AMPLITUDE Switch	50 Ω Amplitude Calibrator	Timing Unit Time/cm	μSEC/CYCLE Switch	Display ± tolerance
	.12 volts	5 μsec		6 cm reference
100		5 μsec	10	5 cm, ±2 mm
		.5 μsec	1	
		50 nsec	.1	
		5 nsec	.01	5 cm, ±4.5 mm
	.012 volts	5 μsec		6 cm, reference
10		5 μsec	10	5 cm, ±2.5 mm
		.5 μsec	1	
		50 nsec	.1	
		5 nsec	.01	5 cm, ±5 mm

n. Set the AMPLITUDE/TIME CALIBRATOR mV AMPLITUDE switch to 100 and the μSEC/CYCLE switch to 10. Disconnect 50 Ω Amplitude Calibrator signal and apply the AMPLITUDE/TIME CALIBRATOR signal to the Sampling Unit Channel A Input connector. Set the Timing Unit Trig Source switch to Cal.

Check for display amplitude of 5 cm, ±2 mm. See Fig. 6-28B. Check for the same amplitude ± tolerance listed in Table 6-6 at other settings of the μSEC/CYCLE switch. Use the same method to set the reference amplitude for checking the 10 mV AMPLITUDE position as listed in Table 6-6. Note the tolerance at the 100 mV and 10 mV positions to compute the tolerance at the 1 mV position.

o. Compute the tolerance for the 1 mV position as follows; determine the per cent tolerance at the 100 mV and 10 mV positions.

$$100\text{ mV \% tolerance} \frac{+\ 10\text{ mV \% tolerance}}{10} = \text{mV \%}$$

tolerance, which should be within ±6% at the 10, 1 and .1 μSEC/CYCLE positions and within ±11% at the 0.01 μSEC/CYCLES position.

p. Disconnect the coaxial cables.

NOTES

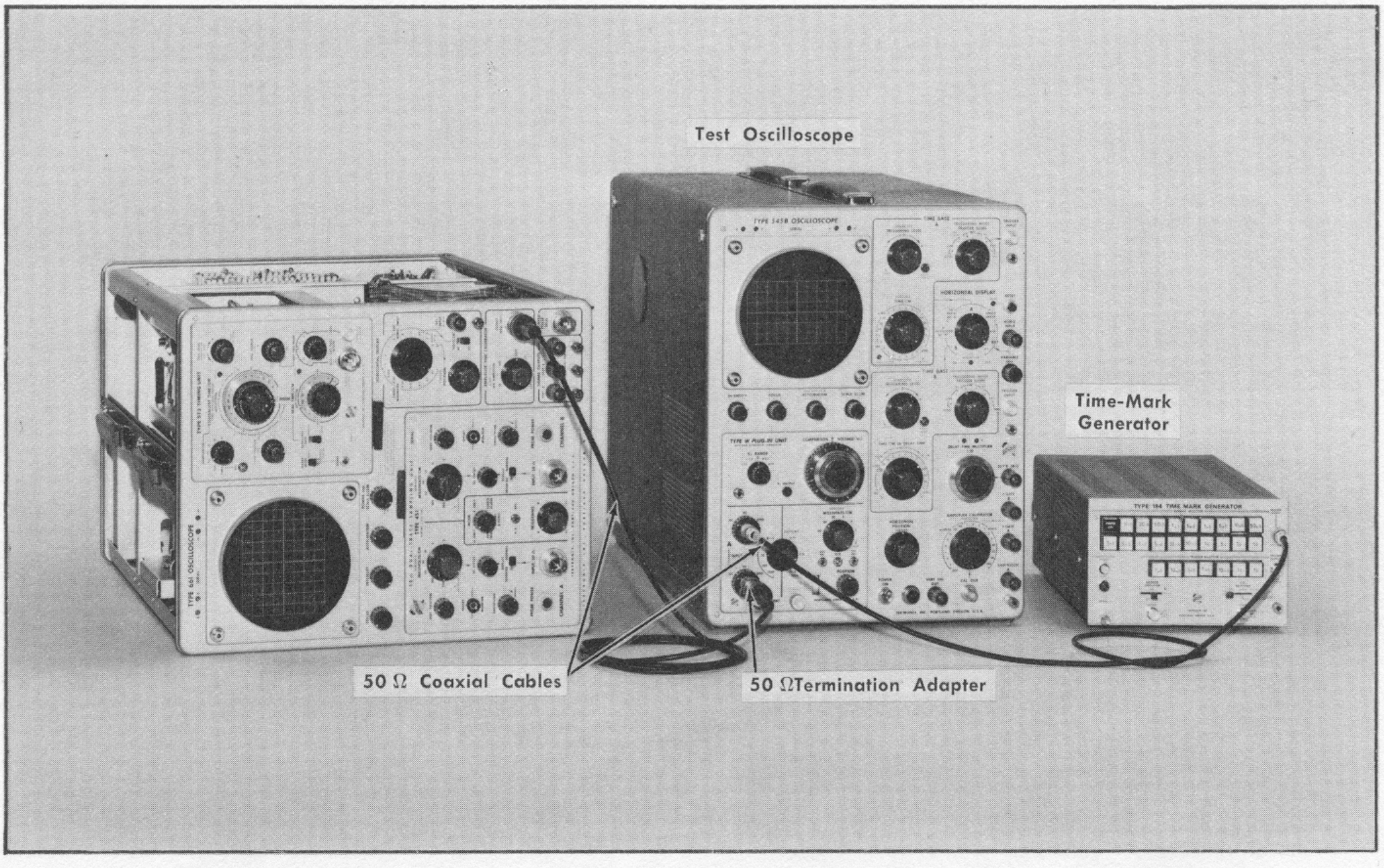


Fig. 6-34. Test equipment setup for step 27.

Control Settings

Type 4S1

Mode	A Only
Triggering	A and AC
Channel A Controls	
Vert Position	Midrange
Millivolts/cm	**200**
Variable (Millivolts/cm)	**Calibrated**
DC Offset	Trace Centered
Smoothing	Unity gain
Display	Normal

Type 5T3

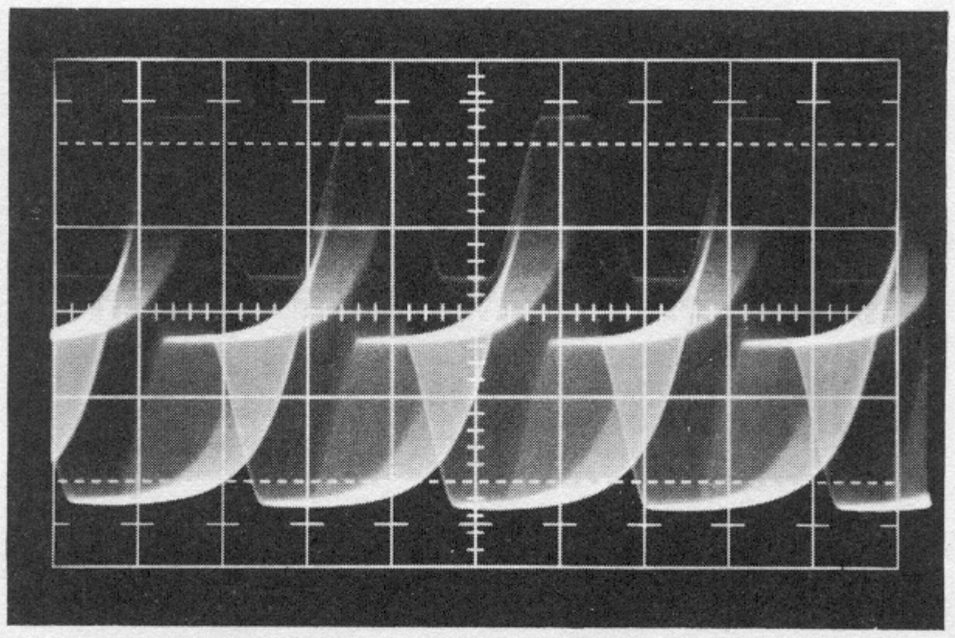
Samples/cm	100
Equivalent Time/cm	**50 nSEC, Calibrated**
Trig Level	Midrange
Stability or UHF Sync	Midrange
Trig Source	**Cal**
Slope	+
Time Position	Fully clockwise
Sweep Mode	Normal

Type 661

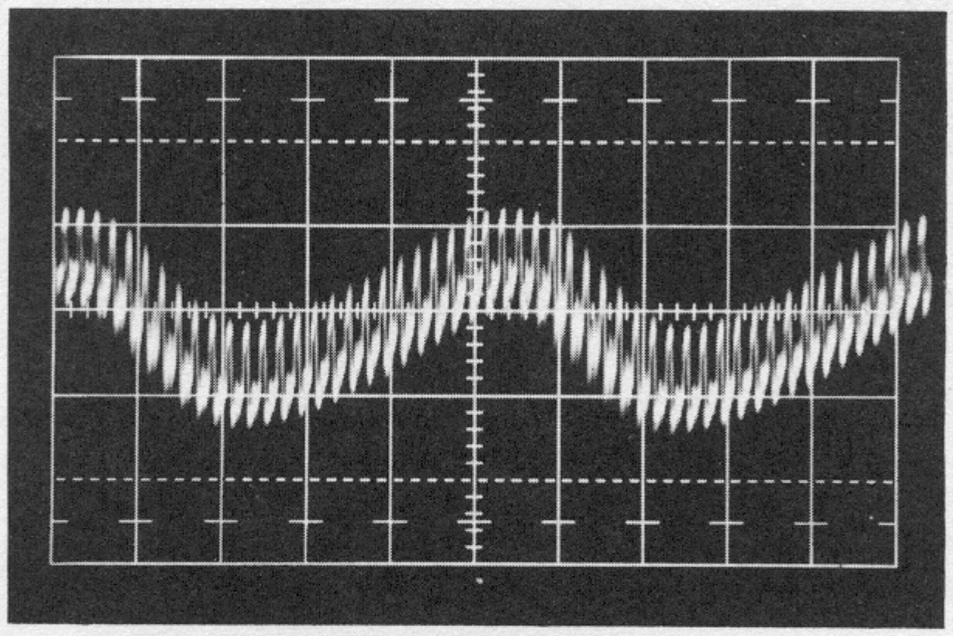
HORIZONTAL DISPLAY	×1
POSITION	Midrange
VERNIER (POSITION)	Midrange
VOLTS/CM	DC
mV AMPLITUDE	**1000**
μSEC/CYCLE	**10**
POWER AND SCALE ILLUM	As desired
FOCUS, INTENSITY and ASTIGMATISM	Normal intensity, well focused trace

Test Oscilloscope and Type W

Time/cm	5 mSEC/cm
Input Coupling	AC
Input Atten	10
Millivolts/cm	20
Vc Range	0
Comparison Voltage	0.000
Display	A - B



(A) 1 μSEC/CYCLE and 1 μs time marks



(B) .01 μSEC/CYCLE and 10 ns (100 MHz) sine wave

Fig. 6-35. Typical test oscilloscope displays of beat frequency discussed in step 27.

Connections:

a. Connect the Time-Mark Generator marker Output connector to the test oscilloscope Input A connector. Use a 50 Ω coaxial cable.

b. Connect the AMPLITUDE/TIME CALIBRATOR OUTPUT INTO 50 Ω connector to the test oscilloscope Input B connector. Use a 50 Ω coaxial cable and a 50 Ω mid-line BNC termination.

27. Adjust AMPLITUDE/TIME CALIBRATOR Timing

a. Set up equipment as shown in Fig. 6-34. Apply 10-μs time markers from the Time-Mark Generator to the test oscilloscope.

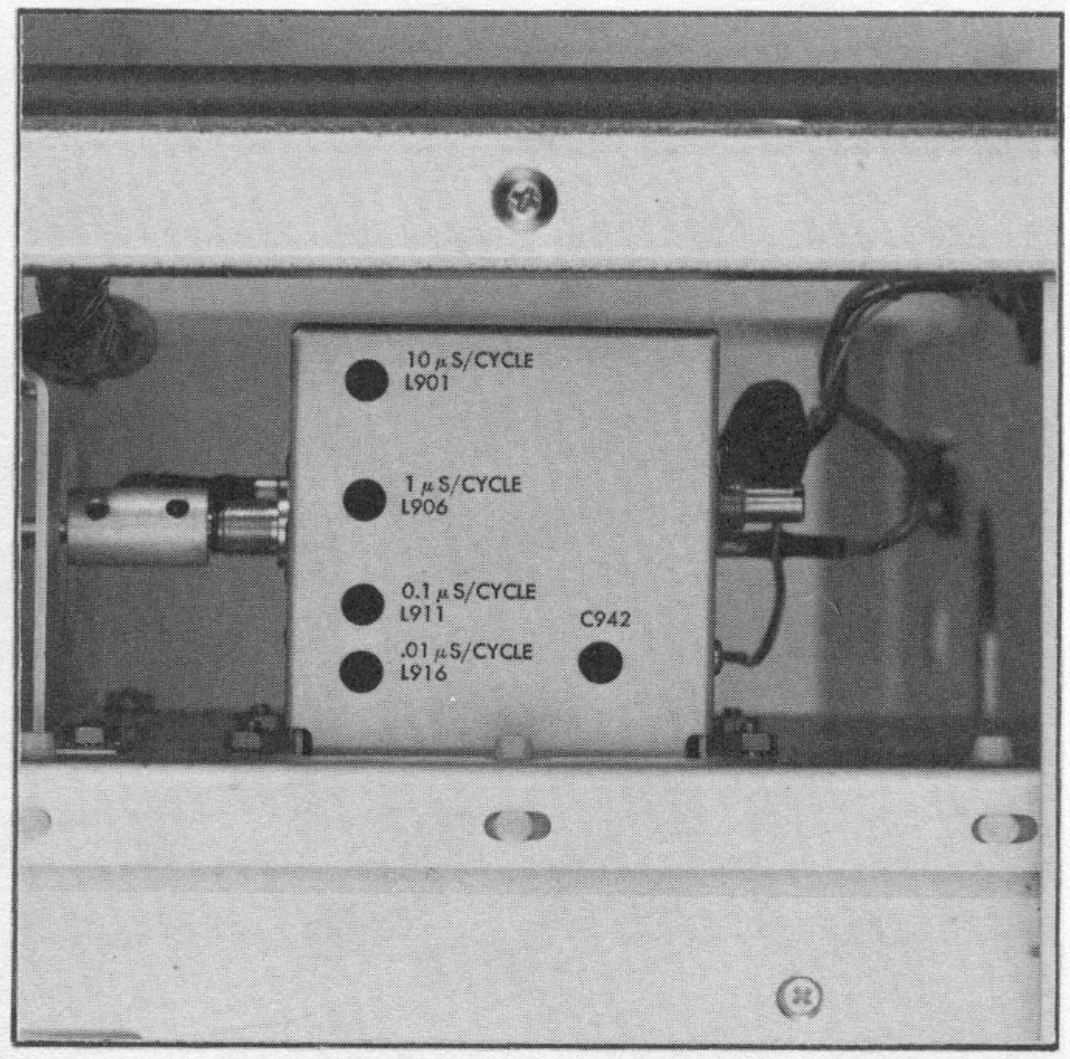


Fig. 6-36. Location of Amplitude/Time Calibrator timing adjustments (Bottom View).

b. Internally trigger the test oscilloscope on the beat frequency display, see Fig. 6-35.

Accurate timing adjustment of each output frequency from the AMPLITUDE/TIME CALIBRATOR is made by mixing the output signal with a time-mark signal and adjusting for the beat-frequency null point. The appearance of the display will depend somewhat on the bandwidth of the test oscilloscope and on the relative amplitudes of the time-mark and calibrator signals. Be sure the Type 661 oscilloscope and Time-Mark Generator are thorughly warmed up before making these adjustments.

c. Check and adjust the AMPLITUDE/TIME CALIBRATOR timing as indicated in Table 6-7. Change the test oscilloscope deflection factor for both channels as needed to display an amplitude of 2 cm or more. If no beat signal appears at the indicated sweep rate, set the test oscilloscope for a very fast sweep and observe the waveform. If the composite waveform is stable, the frequency coincidence is nearly perfect and requires no adjustment.

d. Disconnect all signal connections and place the Type 661 in the upright position.

TABLE 6-7

Calibrator Frequency Adjustments
Beat Frequency Sweep

μSEC/ CYCLE	Time-Mark Generator	Rate and Minimum time/cycle	Adjust Fig. 6-31	Tool Fig. 6-2
10	10 μs	5 mSEC/cm	L901	B
1	1 μs	.5 mSEC/cm	L906	C
.1	.1 μs	50 μSEC/cm	L911	C
.01	10 ns/cycle	.5 μSEC/cm	L916	D

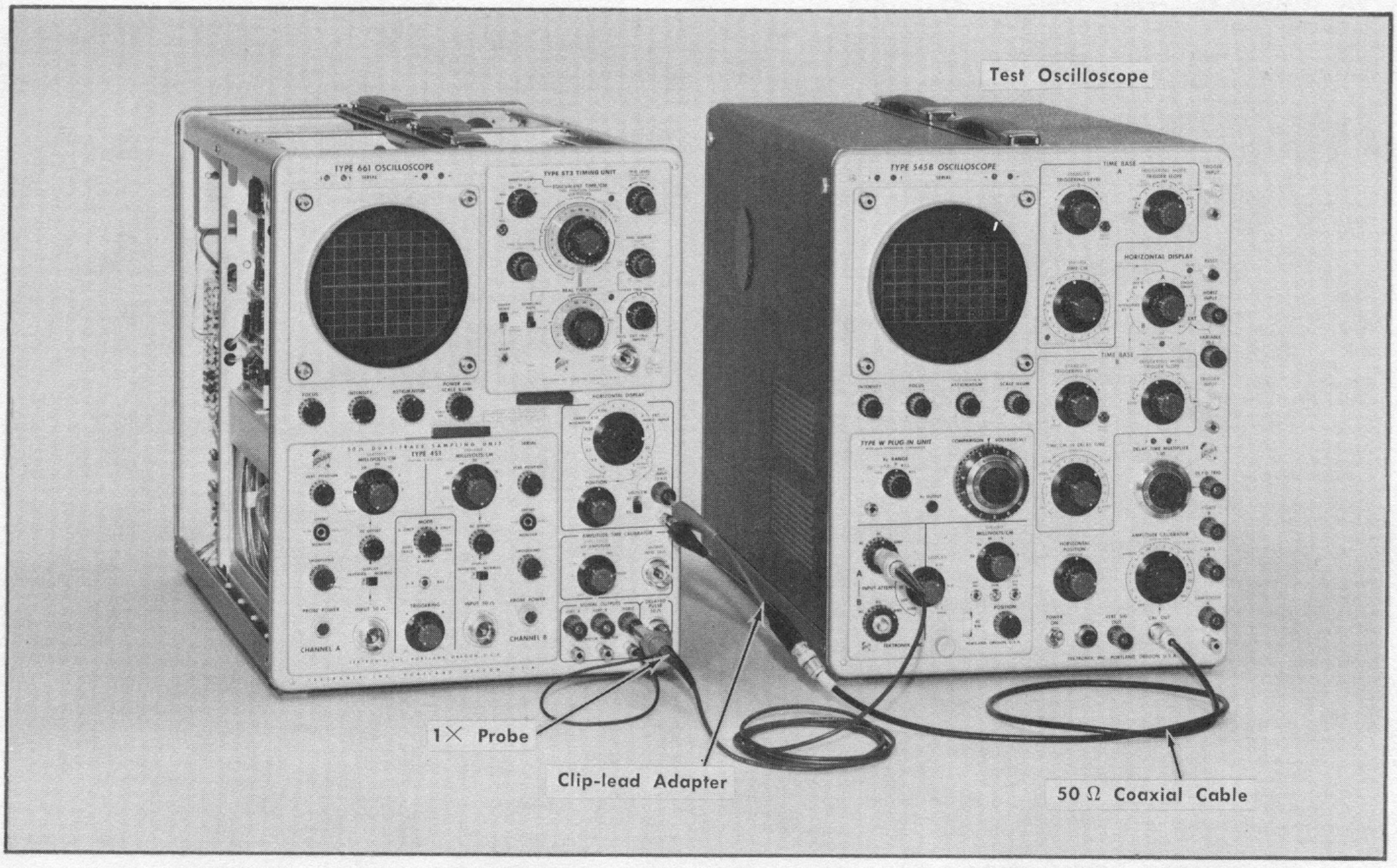


Fig. 6-37. Test equipment setup for step 28.

Control Settings

Type 4S1

Mode	A Only
Triggering	A and AC
Channel A Controls	
Vert Position	Midrange
Millivolts/cm	200
Variable (Millivolts/cm)	Calibrated
DC Offset	Trace centered
Smoothing	Unity gain
Display	Normal

Type 5T3

Samples/cm	100
Equivalent Time/cm	50 nSEC, Calibrated
Trig Level	Midrange
Stability or UHF Sync	Midrange
Trig Source	**Free Run**
Slope	+
Time Position	Fully clockwise
Sweep Mode	Normal

Type 661

HORIZONTAL DISPLAY	**.1 EXT HORIZ INPUT**
POSITION	Midrange
VERNIER (POSITION)	Midrange
VOLTS/CM	DC
mV AMPLITUDE	1000
μSEC/CYCLE	**.1**
POWER AND SCALE ILLUM	Maximum illumination
FOCUS, INTENSITY and ASTIGMATISM	Normal intensity, well focused trace

Test Oscilloscope and Type W

Time/cm	1 ms
Input Coupling	DC
Input Atten	10
Millivolts/cm	20
Vc Range	0
Comparison Voltage	0.000
Display	A-Vc

Connections:

Test oscilloscope Amplitude Calibrator Output connector to Type 661 EXT INPUT 25 KΩ connector. Use a coaxial cable with BNC connectors and a BNC to Clip Lead adapter. Connect the Clip Lead adapter red lead to the EXT INPUT 25 KΩ terminal and the black lead to the adjacent plated ground terminal.

Test oscilloscope Type W Input A connector to Type 661 HORIZ SIGNAL OUTPUT terminal. Use the 1× probe.

28. Check Horizontal Signal Output

a. Use the equipment setup as shown in Fig. 6-37 and set the test oscilloscope Amplitude Calibrator to 0.5 Volts.

b. Two dots will appear on the Type 661 CRT. Use the horizontal POSITION controls for a centered two dot display.

The distance between the two dots will be approximately 5 cm.

c. Multiply the number of centimeters separation of the two dots by 0.2 V to obtain the peak-to-peak signal that should be at the HORIZ SIGNAL OUTPUT terminal. (Example: 4.8 × 0.2 = 0.96 volts).

d. Adjust the Type W DC Bal control for no test oscilloscope trace shift when turning the Millivolts/cm Variable control. Position the bottom of the test oscilloscope square-wave display to the graticule centerline. This is the zero signal reference.

e. Set the Type W Vc Range switch to +1.1 and adjust the Comparison Voltage dial until the top of the display is at the graticule centerline. Note the dial reading. This is the peak signal value.

f. Compare the dial reading to the CRT display as follows:

$$\frac{\text{(CRT display) (0.2) - dial reading}}{\text{(CRT display) (0.2)}} \times 100 = \%\ \text{error}$$

The horizontal output signal must be within 3% of the voltage calculated in f. above.

g. Disconnect the 1× probe and the coaxial cable.

PROCEDURE BEFORE SN 2000

Calibration of the Type 661 instrument prior to Serial Number 2000 is performed according to the foregoing procedure with exceptions as follows (unless modified to the present circuitry):

SN 101-899

1. +100-Volt Power Supply

The +100-volt supply is not separately adjustable. In these instruments, check for a meter reading of +100 volts ±3 volts.

SN 101-309 Read NOTE concerning deflection sensitivities under Replacement of Cathode-Ray Tube, Maintenance section.

2. CRT High-Voltage Supply

The CRT supply voltage should be between −2300 and −3200 volts. This value is determined by the CRT horizontal deflection factor. The voltage is adjusted to make the horizontal system sensitivity agree with the front-panel EXT HORIZ INPUT volts per centimeter.

Set the Type 5T1A controls:

SWEEP TIME/CM	.1 μSEC
VARIABLE	CALIBRATED
SAMPLES/CM	100
SWEEP MODE	NORMAL (REPETITIVE)
TRIGGERING SOURCE	FREE RUN
TRIGGERING POLARITY	+
TIME POSITION (DELAY)	Clockwise (minimum)
TIME EXPANDER	×1
RECOVERY TIME	MIN

Other controls may be in any position.

Set the Type 4S1 MODE switch to A ONLY and the Channel A controls:

VERT POSITION	Midrange
DC OFFSET	Trace centered
MILLIVOLTS/CM	100
VARIABLE	CALIBRATED
SMOOTHING	NORMAL

Other controls may be in any position.

Set the Type 661 Oscilloscope controls:

SWEEP MAGNIFIER	×1
VOLTS/CM	DC
POSITION	Start trace at left edge of graticule.

Other controls may be in any position.

After obtaining a free-running trace, check the CRT trace-to-graticule alignment. The procedure included in this manual applies to all Serial Number instruments, step 8.

Set the HORIZONTAL DISPLAY switch to EXT HORIZ INPUT, 5 VOLTS/CM. An external 50-volt signal will now move the CRT spot 10 centimeters.

CAUTION

In the following procedure, be careful not to ground the +100-volt power supply.

Connect a 24.9 kΩ, ½-watt, 1% resistor between a +100 volt test point (Fig. 6-39) and the EXT INPUT 25 KΩ terminal. Measure the voltage at the EXT INPUT terminal with the nonloading DC voltmeter to assure that the horizontal system is receiving exactly +50 volts. If the voltage is other than +50 volts, determine the percentage difference, and apply that error when making the high voltage adjustment.

Disconnect the resistor from +100 volts. Carefully position the CRT spot to the left edge of the graticule. Reconnect the CRT spot to +100 volts. If the spot does not move exactly 10 centimeters (plus or minus the error percentage just determined), adjust R841 (HIGH VOLTAGE control, Fig. 6-38) until the spot moves the correct amount. It may be necessary to repeat this procedure several times for proper adjustment.

The preceeding step will assure a horizontal accuracy of about 0.5% which applies when the HORIZONTAL DISPLAY switch is at either the SWEEP MAGNIFIER ×1 or the EXT HORIZ INPUT 5 VOLTS/CM positions. Due to the tolerance of the horizontal amplifier feedback resistors, the horizontal system will be less accurate in all other positions of the HORIZONTAL DISPLAY switch.

3. Blanking Balance

Turn off the Type 661, remove both plug-in units, and turn the Type 661 back on. Set the HORIZONTAL DISPLAY switch to the ×1 position of the SWEEP MAGNIFIER and reduce the intensity to the point that the spot can no longer be seen.

Connect the DC voltmeter between the center terminal of R866 (BLANK BAL control) and pin 6 of V874 to check the differential voltage between the CRT blanking deflection plates. V874 is located between the two ceramic strips adjacent to the control (see Fig. 6-38). Adjust the BLANK BAL control for zero volts on the meter. Turn off the Type 661, install both plug-in units, and turn the Type 661 back on.

4. Horizontal DC Balance

Free run the timing unit at .1 μSEC/CM and 100 SAMPLES/CM. Turn up the intensity so the trace is visible. Position the start of the trace to the center of the graicule. Set the SWEEP MAGNIFIER to ×100 and reposition the trace so the first dot of the display lies under the graticule centerline.

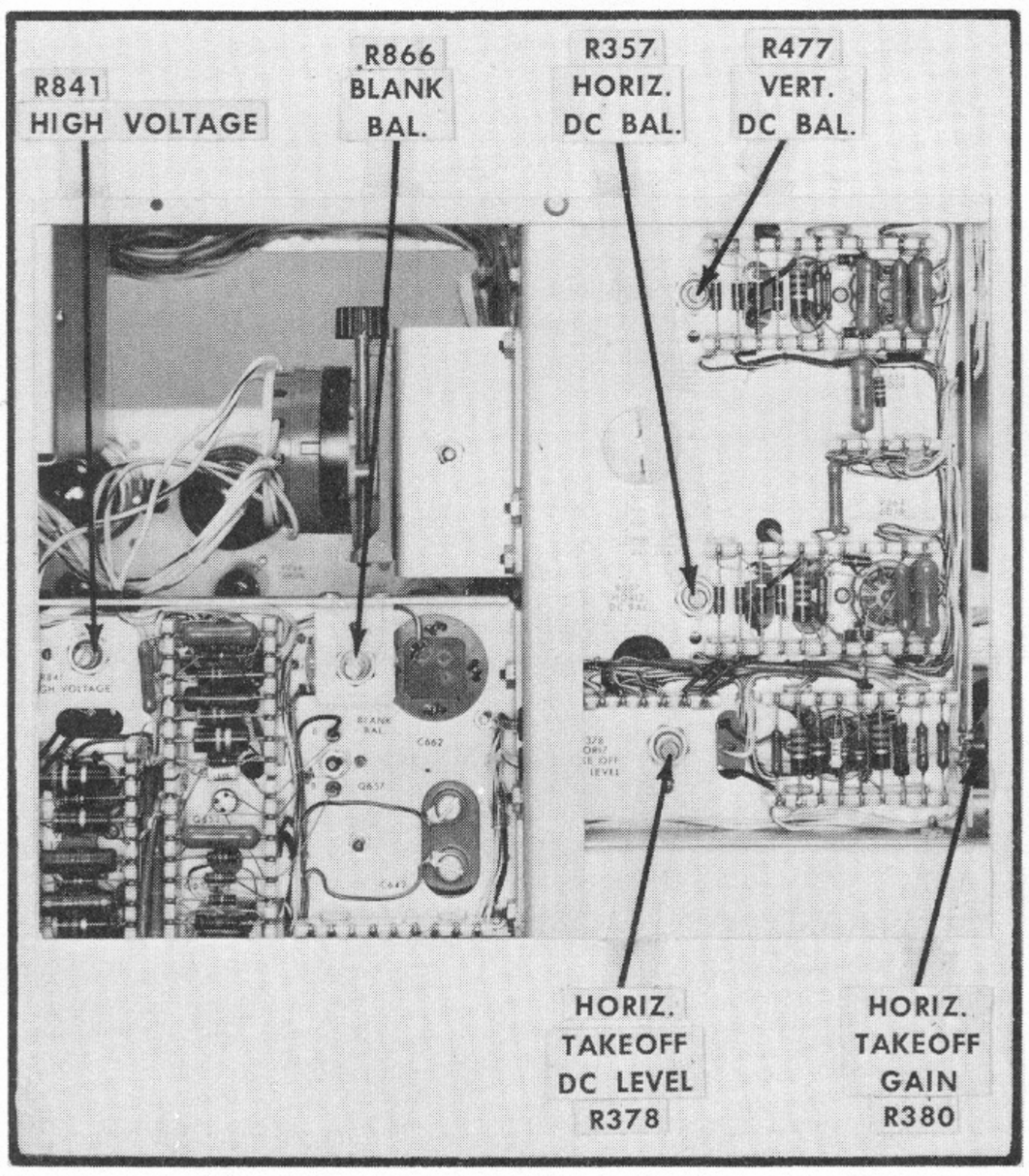


Fig. 6-38. Location of some adjustments on left side of oscilloscope (for instruments with serial numbers 101 through 309).

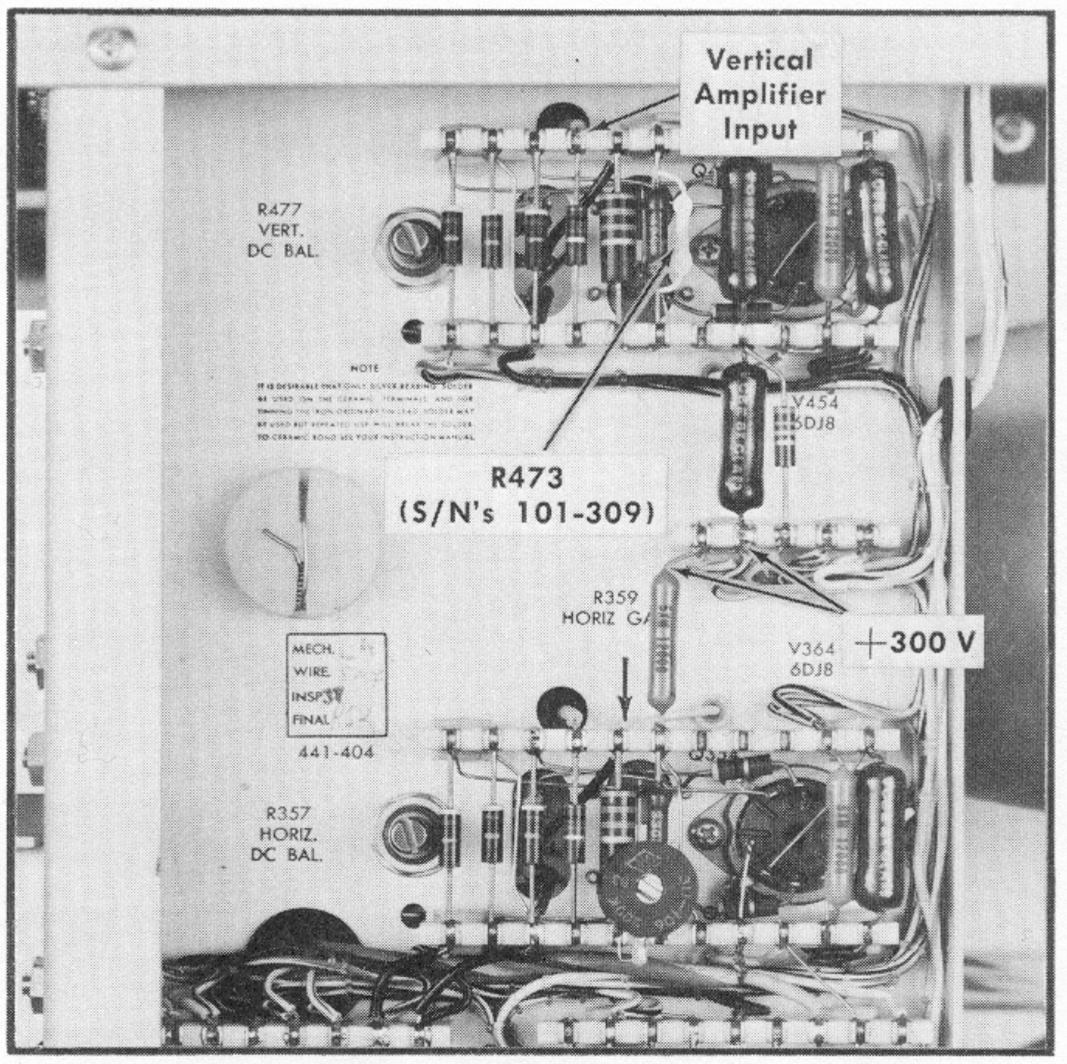


Fig. 6-39. Location of input to Type 661 Vertical Amplifier.

Return the SWEEP MAGNIFIER switch to ×1. Adjust R357 (HORIZ DC BAL) to return the first dot to the graticule centerline. Repeat the procedure to be sure the adjustment is correct.

5. Vertical Amplifier Sensitivity

Turn off the Type 661 and remove the Type 4S1. Turn the Type 661 back on. Reduce the CRT intensity so the spot will not burn the phosphor.

After the spot is stable, adjust R477, (VERT DC BAL) until the spot rests 3 centimeters below the graticule centerline.

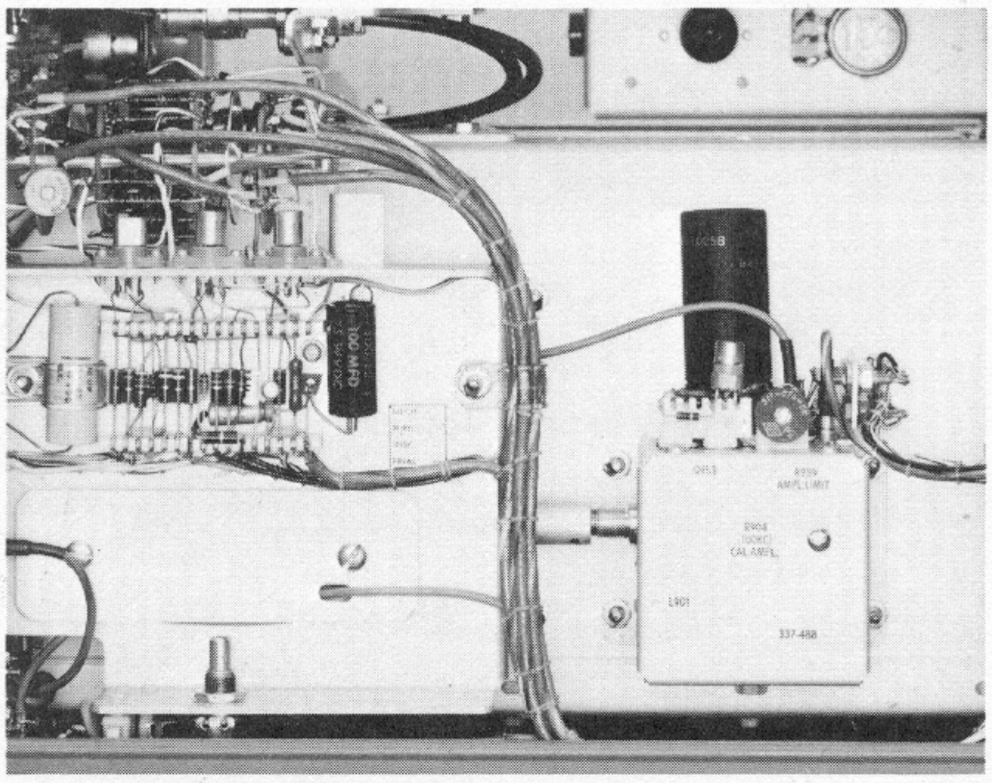
Alternately connect and disconnect a 2-meg, 1% resistor between a +300-volt test point and the vertical amplifier input (see Fig. 6-39). The display should be spot alternately at —3 and +3 centimeters, ±2 millimeters. If the scan is more than ±2 millimeters from being 6 centimeters, check the vertical amplifier transistors and tubes. If they are satisfactory, then change the value of R473 according to the following procedure.

NOTE

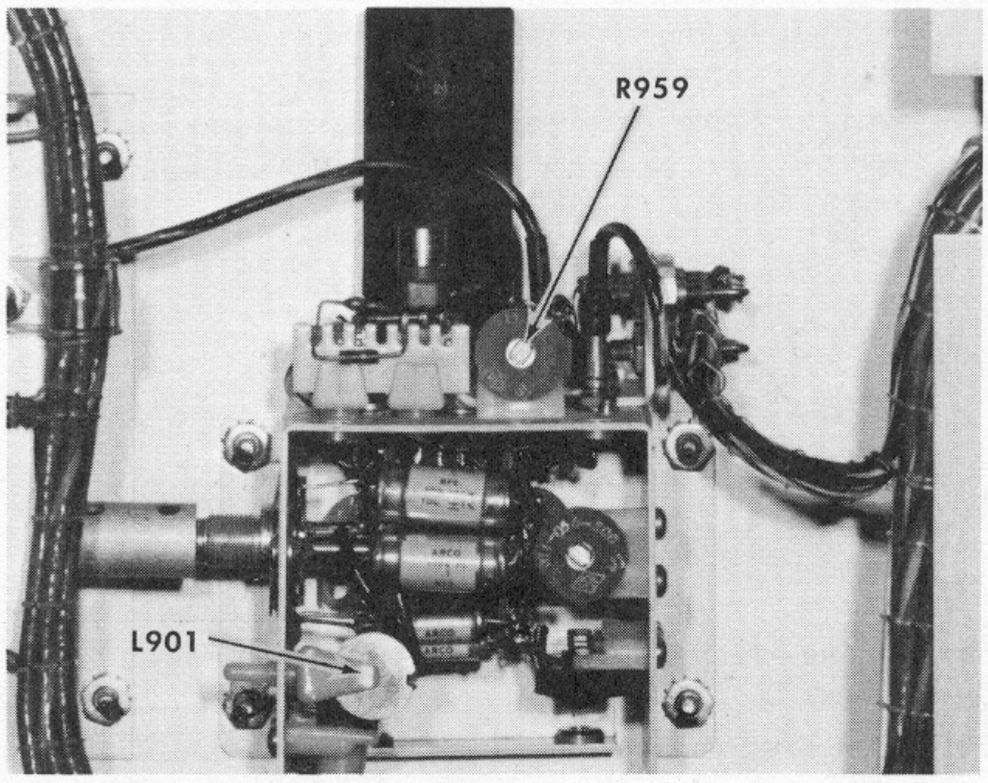
Be sure the CRT sensitivity has been properly adjusted (step 2) before changing the value of R473.

Procedure for Changing R473

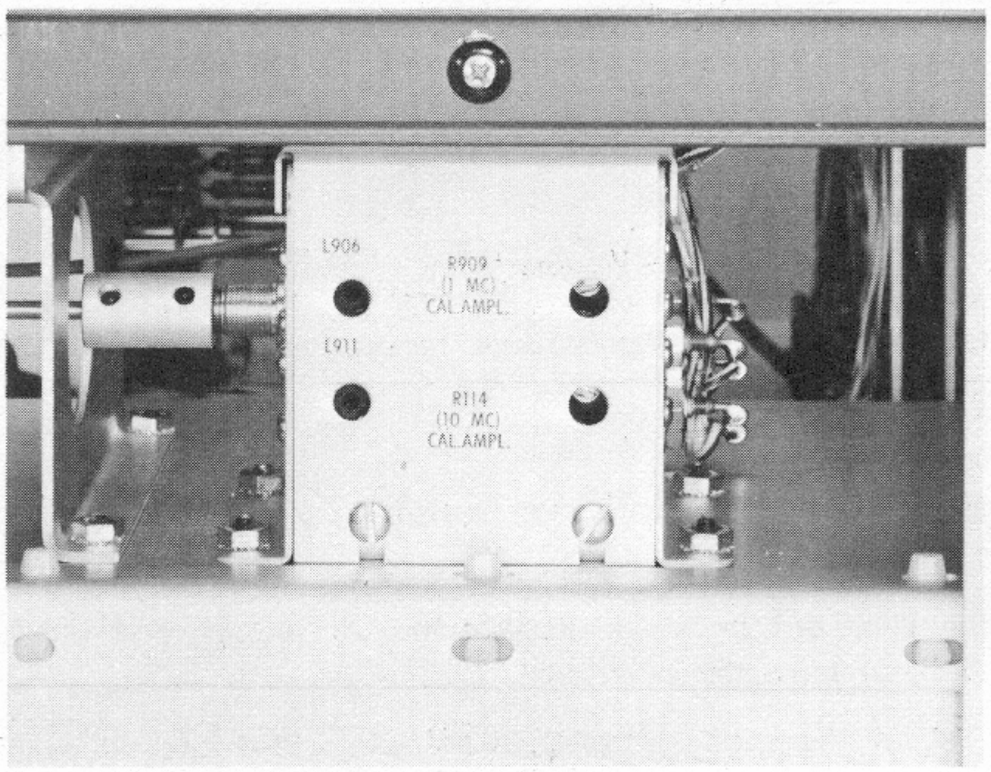
If it is necessary to change the value of R473, remove the existing resistor (Fig. 6-39.) Obtain a group of ¼-watt, 1% deposited-carbon resistors ranging from about 5 through 12 megohms (such as 5, 7.5, 9, 10, and 12). Grasp a new resistor with the pliers and touch its leads to the ceramic strip terminals at the location for R473. Observe the CRT display for



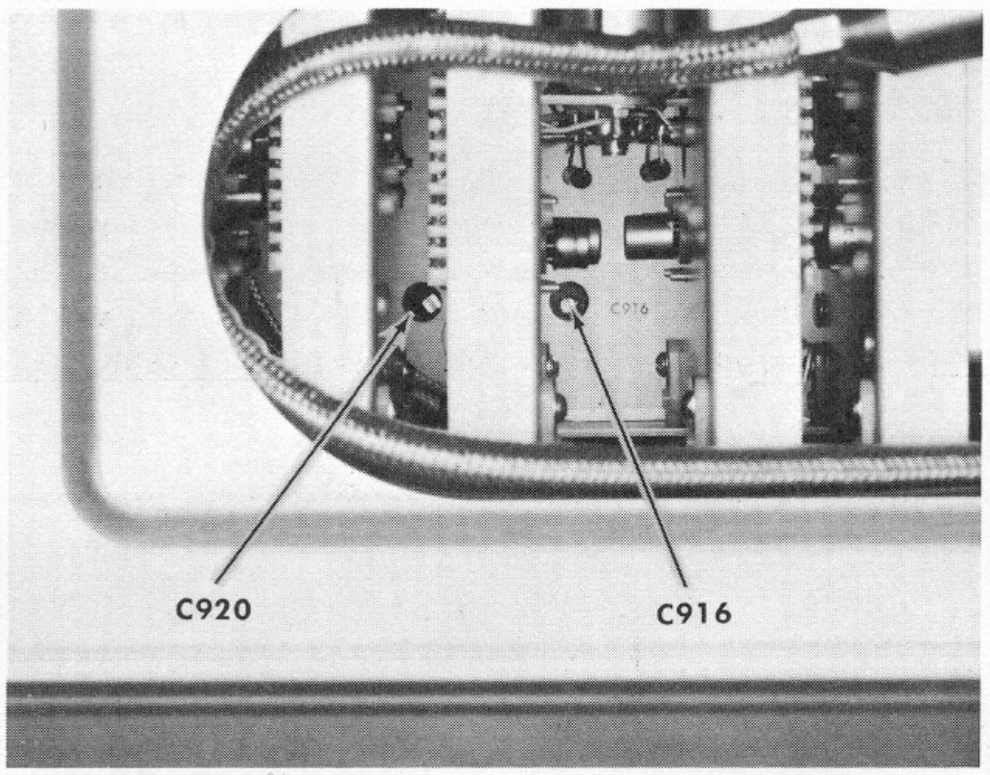
(a) Right-side view



(b) Inside view



(c) Bottom view



(d) Left-side view through Type 4S1

Fig. 6-40. Location of Amplitude/Time Calibrator adjustments (for instruments with serial numbers 101 through 1999), steps 7 and 8.

6 centimeters. When a resistor is found that gives the correct gain, trim its leads to the correct length and solder it in exactly the same position as the resistor removed.

Leave the Type 4S1 out of the oscilloscope for the next step.

6. Vertical DC Balance

Connect a 1.5 kΩ, 1% resistor between the vertical amplifier input and ground.

Horizontally position the CRT spot to the graticule centerline and adjust R477 (VERT DC BAL) to vertically position the spot to the centerline.

Remove the 1.5 kΩ resistor, turn off the Type 661, and reinstall the Type 4S1. Turn the Type 661 back on.

SN 101-1999 Amplitude/Time Calibrator

7. Amplitude (Preliminary)

Set the mV AMPLITUDE switch to 1000, and the μSEC/CYCLE switch to 1.

Set R959 (AMP LIMIT, located on top of the Calibrator chassis; see Fig. 6-40A) fully counterclockwise.

Calibrate the test oscilloscope to be accurate at 1 volt/2 cm.

Connect the 50-ohm midline termination to the input of the test oscilloscope.

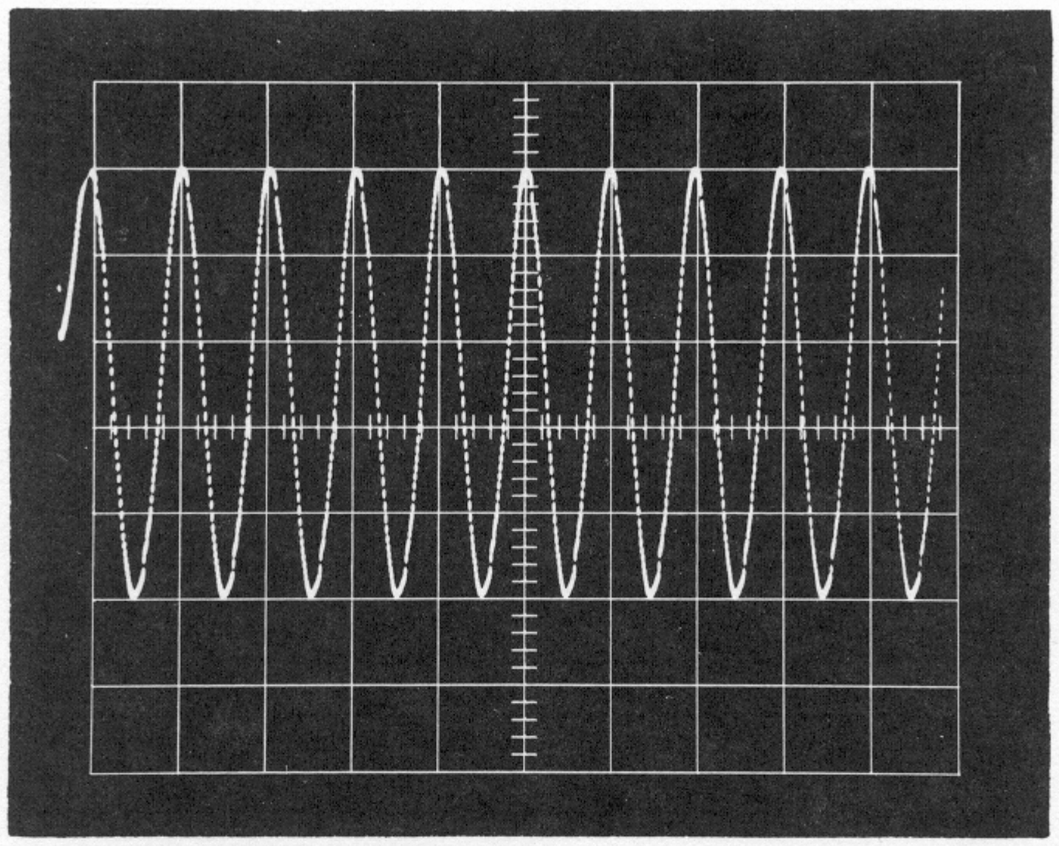


Fig. 6-41. Typical Calibrator signal for step 8 (for instruments with serial numbers 101 through 1999).

Connect the AMPLITUDE/TIME CALIBRATOR output to the 50-ohm termination on the test oscilloscope. Use the 10-ns cable and the appropriate connector adapter.

Set the Type 661 on its left side and adjust R909 (1 MC CAL AMPL) to produce exactly 1 volt of deflection on the test oscilloscope.

8. Frequency and Amplitude

Disconnect the signal cable from the 50-ohm termination and connect it to the Type 4S1 Channel B input. Set the Channel B MILLIVOLTS/CM control to 200, CALIBRATED. Set the Type 5T1A SWEEP TIME/CM control to 1 μSEC, the TRIGGERING POLARITY Switch to CAL., and the THRESHOLD control near—. If necessary, adjust the B CAL. control (top rear of Type 4S1) for a display of exactly 5 centimeters peak to peak. The Type 4S1 Channel B is now calibrated accurately for 200 mV/cm. (If you adjusted the B CAL control, repeat with Channel A and adjust the front-panel A-B BAL control.)

Connect the Time-Mark Generator to the Type 4S1 Channel A input through a 50 Ω cable and a 50 Ω 5×T Attenuator.

Apply a 10 MHz sine wave to Channel A. Connect the AMPLITUDE/TIME CALIBRATOR output to Channel B input and set the MODE switch to A ONLY. Set the TRIGGERING switch to A.

Set the Type 5T1A TRIGGERING POLARITY switch to +, the SOURCE switch to INT., the SWEEP TIME/CM switch to .1 μSEC, and the THRESHOLD control near + for a stable display. Note the timing accuracy of the 10 MHz waveform.

TABLE 6-8

AMPLITUDE/TIME CALIBRATOR Adjustments

Begin with R959 fully counterclockwise.				
Cal Range	Time-Mark Signal	Type 5T1A TIME/CM	Display	Adjust
	10 MHz	.1 μSEC	1 cycle/cm	Reference
.1			1 cycle/cm 5.2 cm 5.0 cm	L911 R914 R959
	10 μSEC	10 μSEC	1 cycle/cm	Reference
10			1 cycle/cm 5.0 cm	L901[4] R904
	1 μSEC	1 μSEC	1 cycle/cm	Reference
1			1 cycle/cm 5.0 cm	L906 R909
	50 MHz	10 nSEC	1 cycle/2	Reference
.01			cm 1 cycle/cm 5.0 cm	C916 C920

[4]L901 can be adjusted by removing the oscillator shield and changing the position of the rear ferrite core in relation to the front cup core by hand. Place the shield back in place when checking the CRT display for 1 cycle/cm.

There should be 1 cycle per centimeter. If the display is other than 1 cycle per centimeter, adjust R267 (Type 5T1A SWEEP CAL control) to correct the error.

Set the AMPLITUDE/TIME CALIBRATOR μSEC/CYCLE switch to .1.

Set the Type 4S1 MODE switch to B ONLY, the Type 5T1A TRIGGERING POLARITY switch to CAL, and the THRESHOLD control near — for a stable display.

Adjust L911 with a plastic adjusting tool until the display is exactly 1 cycle per centimeter (see Figs. 6-40C and 6-41).

Adjust R914, the 10 MC CAL AMPL control, for a display height of 5.2 centimeters. R914 has two possible positions for this amplitude. Use the position nearest the counterclockwise end of rotation.

Adjust R959 (AMPL LIMIT) for exactly 5 centimeters of display. R959 is now adjusted in its permanent position. The 10-MHz display will look like Fig. 6-41 when the adjustment is set correctly.

Follow the same procedure for adjusting the other AMPLITUDE/TIME CALIBRATOR ranges. The frequency of each range must be referenced to the Time-Mark Generator. Each CAL AMPL potentiometer must start at its farthest counterclockwise position. Table 5-4 lists the proper controls, control settings, and displays for all ranges of the AMPLITUDE/TIME CALIBRATOR. Use the screwdriver listed as item 22, Equipment Required.

NOTES

SECTION 7
PARTS LIST and DIAGRAMS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix Field Office.

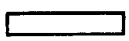
Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number including any suffix, instrument type, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix Field Office will contact you concerning any change in part number.

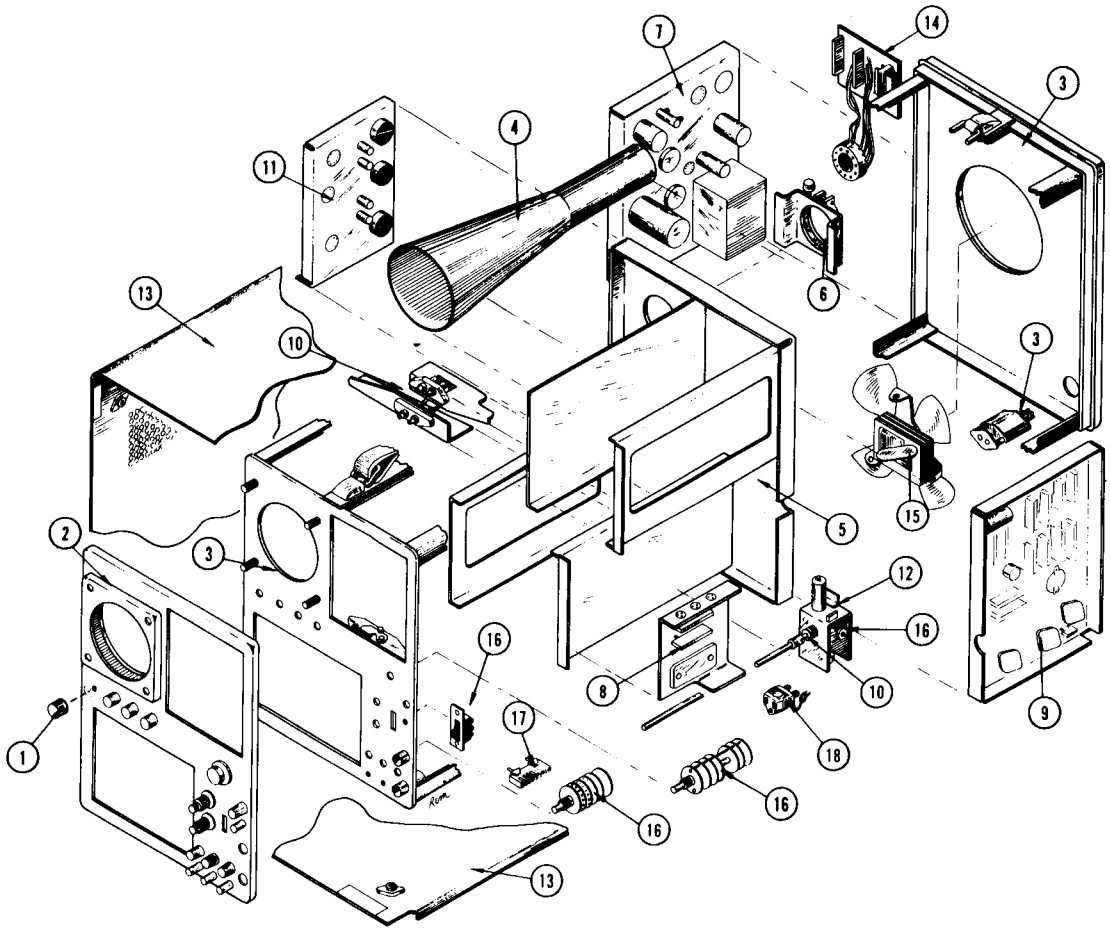
ABBREVIATIONS AND SYMBOLS

a or amp	amperes
BHS	binding head steel
C	carbon
cer	ceramic
cm	centimeter
comp	composition
cps	cycles per second
crt	cathode-ray tube
CSK	counter sunk
dia	diameter
div	division
EMC	electrolytic, metal cased
EMT	electroyltic, metal tubular
ext	external
f	farad
F & I	focus and intensity
FHS	flat head steel
Fil HS	fillister head steel
g or G	giga, or 10^9
Ge	germanium
GMV	guaranteed minimum value
h	henry
hex	hexagonal
HHS	hex head steel
HSS	hex socket steel
HV	high voltage
ID	inside diameter
incd	incandescent
int	internal
k or K	kilohms or kilo (10^3)
kc	kilocycle
m	milli, or 10^{-3}
mc	megacycle
mm	millimeter
meg or M	megohms or mega (10^6)
met.	metal
μ	micro, or 10^{-6}
n	nano, or 10^{-9}
Ω	ohm
OD	outside diameter
OHS	oval head steel
p	pico, or 10^{-12}
PHS	pan head steel
piv	peak inverse voltage
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
Prec	precision
PT	paper tubular
PTM	paper or plastic, tubular, molded
RHS	round head steel
rms	root mean square
sec	second
Si	silicon
S/N	serial number
t or T	tera, or 10^{12}
TD	toroid
THS	truss head steel
tub.	tubular
v or V	volt
Var	variable
w	watt
w/	with
w/o	without
WW	wire-wound

SPECIAL NOTES AND SYMBOLS

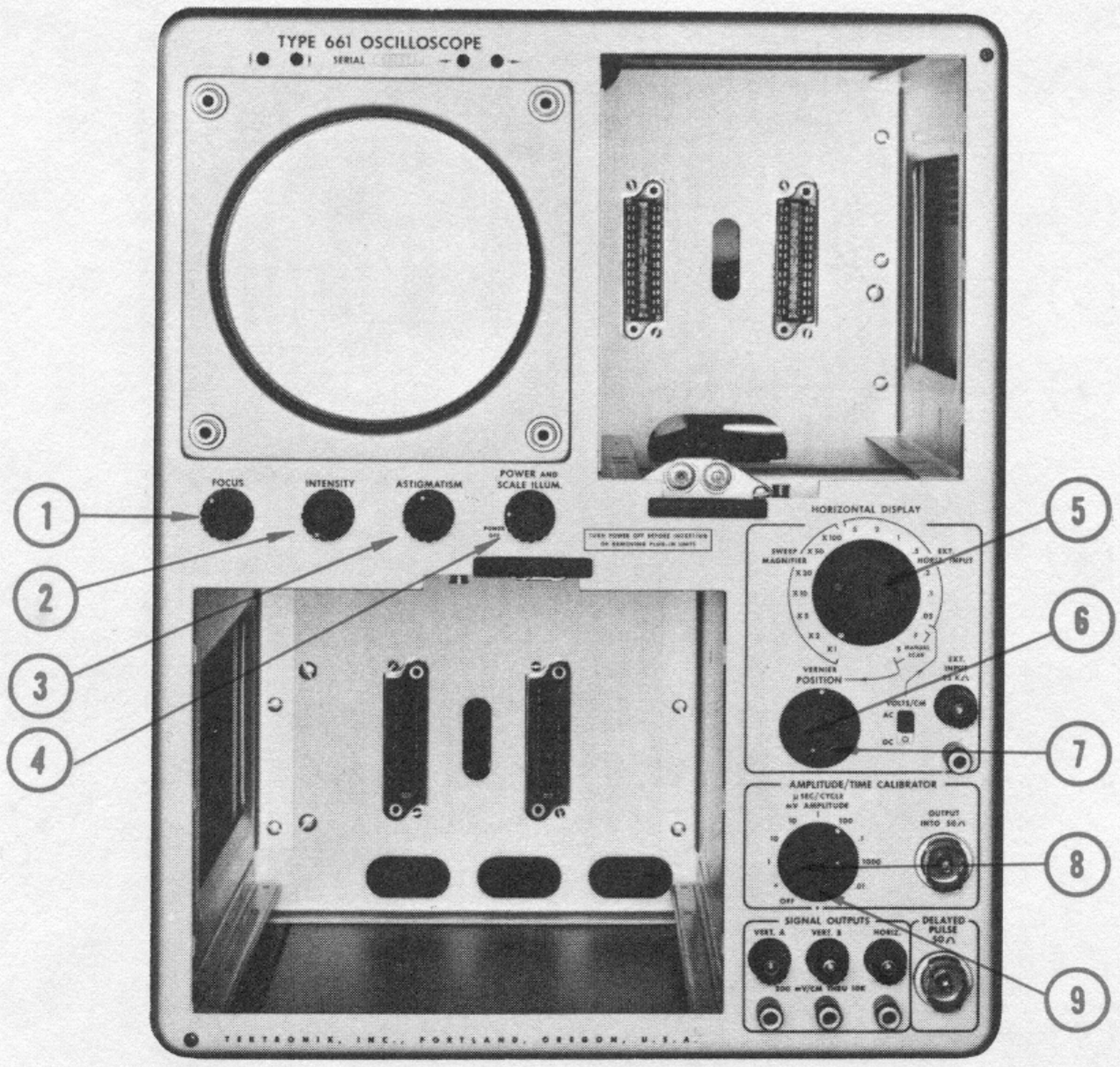
X000	Part first added at this serial number.
000X	Part removed after this serial number.
*000-000	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, or reworked or checked components.
Use 000-000	Part number indicated is direct replacement.
	Internal screwdriver adjustment.
	Front-panel adjustment or connector.

MECHANICAL PARTS
PARTS LOCATOR



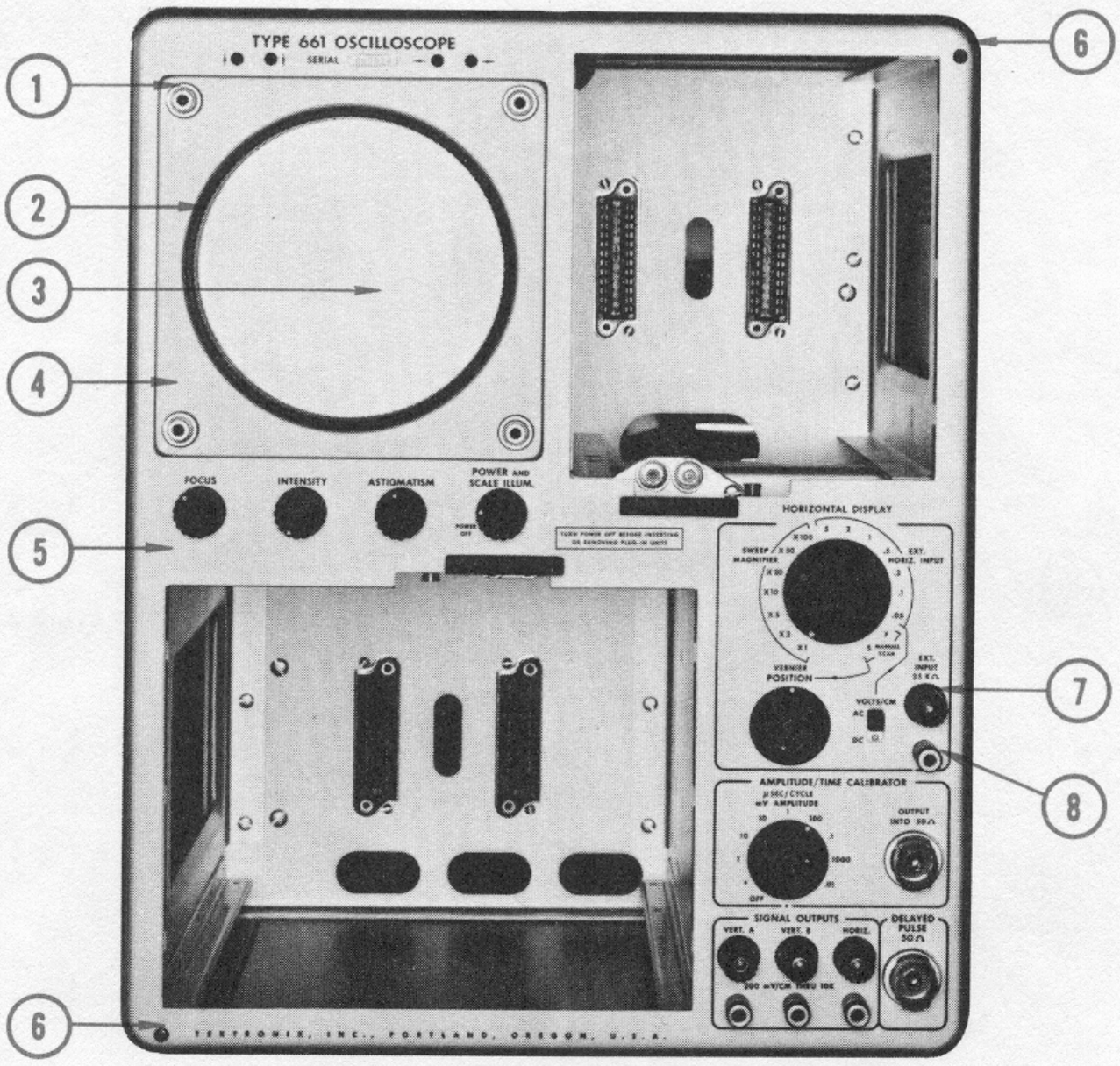
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	Pg. 7-3				KNOBS
-2	Pg. 7-4				FRONT
-3	Pg. 7-5				FRAME GROUP
-4	Pg. 7-9				CRT SHIELD
-5	Pg. 7-10				SUPPORT GROUP
-6	Pg. 7-13				CRT BRACKET AND ROTATOR
-7	Pg. 7-14				TRANSISTOR POWER CHASSIS
-8	Pg. 7-18				HORIZONTAL PREAMPLIFIER
-9	Pg. 7-20				TUBE POWER CHASSIS
-10	Pg. 7-23				5 OHM PLUG-IN CONNECTING BRACKETS
-11	Pg. 7-24				VERTICAL AMPLIFIER CHASSIS
-12	Pg. 7-26				CALIBRATOR CHASSIS
-13	Pg. 7-29				CABINET
-14	Pg. 7-30				FOCUS AND INTENSITY
-15	Pg. 7-32				FAN
-16	Pg. 7-33				SWITCHES
-17	Pg. 7-35				CERAMIC STRIPS
-18	Pg. 7-36				ACCESSORIES

KNOBS



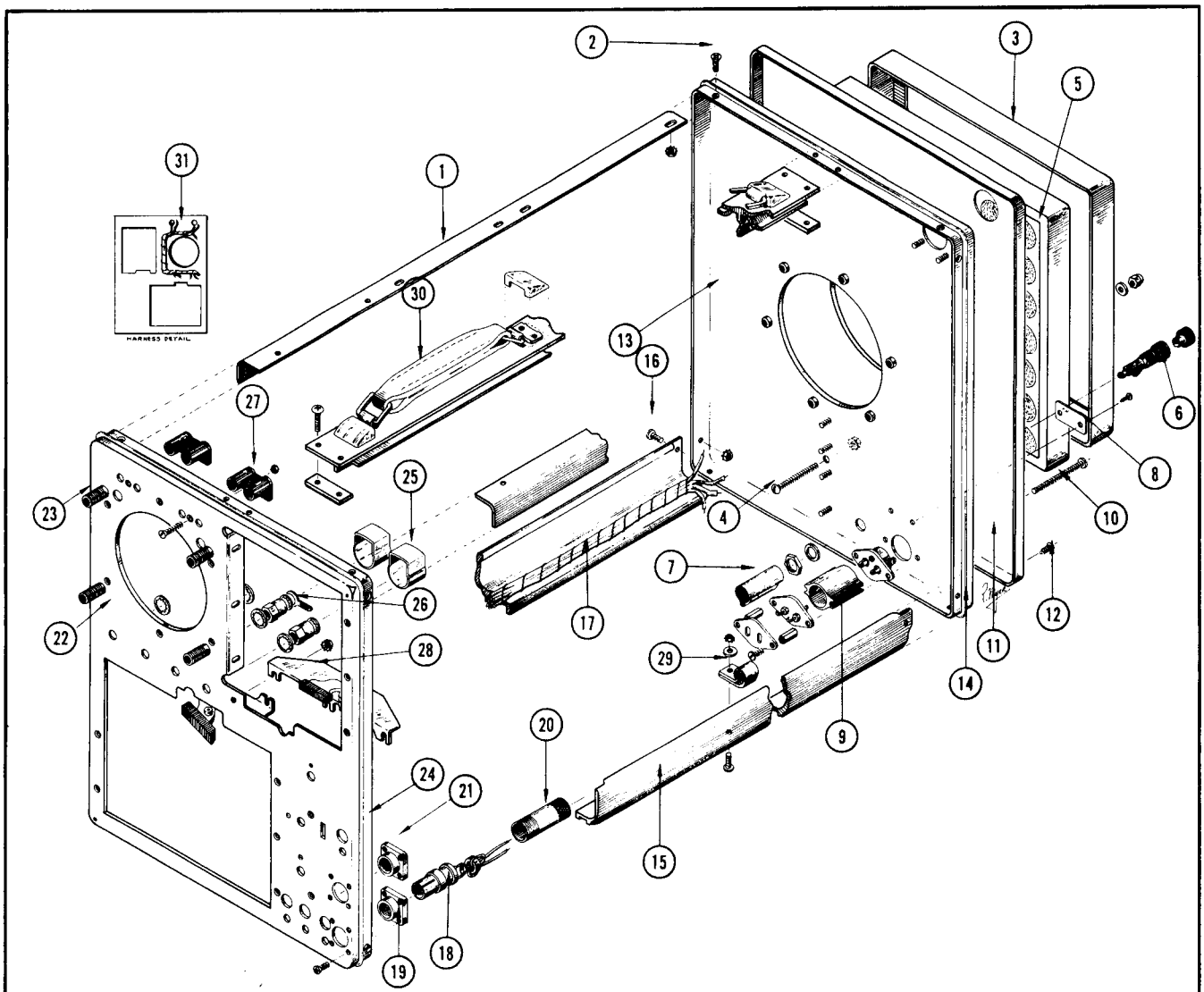
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	366-0113-00			1	KNOB, charcoal—FOCUS
	- - - - - -			-	knob includes:
	213-0004-00			1	SETSCREW, 6-32 x 0.188 inch, HHS
-2	366-0113-00			1	KNOB, charcoal—INTENSITY
	- - - - - -			-	knob includes:
	213-0004-00			1	SETSCREW, 6-32 x 0.188 inch, HHS
-3	366-0113-00			1	KNOB, charcoal—ASTIGMATISM
	- - - - - -			-	knob includes:
	213-0004-00			1	SETSCREW, 6-32 x 0.188 inch, HHS
-4	366-0113-00			1	KNOB, charcoal—POWER & SCALE ILLUM
	- - - - - -			-	knob includes
	213-0004-00			1	SETSCREW, 6-32 x 0.188 inch, HHS
-5	366-0115-00			1	KNOB, charcoal—HORIZONTAL DISPLAY
	- - - - - -			-	knob includes:
	213-0004-00			1	SETSCREW, 6-32 x 0.188 inch, HHS
-6	366-0032-00			1	KNOB, red—VERNIER
	- - - - - -			-	knob includes:
	213-0004-00			1	SETSCREW, 6-32 x 0.188 inch, HHS
-7	366-0146-00			1	KNOB, charcoal—POSITION
	- - - - - -			-	knob includes:
	213-0004-00			1	SETSCREW, 6-32 x 0.188 inch, HHS
-8	366-0031-00			1	KNOB, red—μSEC/CYCLE
	- - - - - -			-	knob includes:
	213-0004-00			1	SETSCREW, 6-32 x 0.188 inch, HHS
-9	366-0142-00			1	KNOB, charcoal—mV AMPLITUDE
	- - - - - -			-	knob includes:
	213-0004-00			1	SETSCREW, 6-32 x 0.188 inch, HHS

FRONT



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	210-0816-00			4	WASHER, rubber
	210-0424-00			4	NUT, knurled, 0.375-24 x 0.562 x 0.188 inch
-2	337-0187-00			1	SHIELD, 5 inch graticule light (under cover)
-3	331-0056-00			1	GRATICULE, 5 inch
-4	200-0382-00			1	COVER, graticule
-5	333-0684-00			1	PANEL, front
-6	213-0088-00			2	SCREW, thread forming, 4-40 x 0.25 inch PHS
-7	129-0063-00			4	POST, binding, 5 way, charcoal gray
	210-0206-00	101	1119X	4	LUG, solder, SE #10
	210-0010-00	101	1119X	4	WASHER, lock, internal, #10
	210-0445-00	101	1119	8	NUT, hex., 10-32 x 0.375 inch
	220-0410-00	1120		4	NUT, keps, 10-32 x 0.375 inch
	358-0169-00			4	BUSHING, binding post, charcoal
-8	129-0051-00			4	BINDING POST ASSEMBLY
	- - - - - -			-	binding post assembly includes:
	200-0182-00			1	CAP, binding post
	210-0011-00			1	WASHER, lock, internal 0.25 inch
	210-0455-00			1	NUT, hex., 0.25-28 x 0.375 x 0.094 inch
	355-0507-00			1	STEM, binding post adapter
	210-0223-00			3	LUG, solder, 0.25 inch hole

FRAME GROUP



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	122-0100-00			2	ANGLE, frame, top, ext. 20.438 inches long
	- - - - - -			-	mounting hardware: (not included w/angle)
-2	211-0559-00			8	SCREW, 6-32 x 0.375 inch, 100° csk, FHS
	210-0457-00			8	NUT, keps, 6-32 x 0.312 inch
-3	380-0018-00			1	HOUSING, air filter, 1 x 10.50 x 10.50 inches, plastic
	- - - - - -			-	mounting hardware: (not included w/housing)
-4	212-0031-00			2	SCREW, 8-32 x 1.25 inch, RHS
	210-0458-00			2	NUT, keps, 8-32 x 0.344 inch
	210-0402-00			2	NUT, cap, hex., 8-32 x 0.312 inch
-5	378-0011-00			1	FILTER, air, 1 x 10 x 10 inches
-6	352-0002-00			1	FUSE HOLDER ASSEMBLY
	- - - - - -			-	fuse holder assembly includes:
	200-0015-00			1	CAP, fuse, 3AG
	210-0873-00			1	WASHER, rubber, 0.50 ID x 0.688 OD x 0.047 inch
	352-0010-00			1	HOLDER, fuse 3AG

FRAME GROUP (cont)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-7	200-0237-00	101	1999X	1	COVER, insulation fuse holder, plastic
-8	334-0649-00			1	TAG, voltage rating
	- - - - - -			-	mounting hardware: (not included w/tag)
	213-0035-00			2	SCREW, thread forming, 4-40 x 0.25 inch, PHS
-9	650-0446-00			1	FILTER, AC line
	- - - - - -			-	filter includes:
	131-0102-00	101	3179	1	CONNECTOR, chassis mount, 3 wire, motor base
	131-0102-01	3180	3459	1	CONNECTOR, chassis mount, 3 wire, motor base
	131-0102-02	3460		1	CONNECTOR, chassis mount, 3 wire, motor base
	361-0015-00			1	SPACER, line filter
	387-0025-00			2	PLATE, 1.203 x 1.25 inches
	358-0146-00			2	ROD, hex., 0.25 x 0.688 inch
	211-0504-00			2	SCREW, 6-32 x 0.25 inch, PHS
-10	211-0552-00			2	SCREW, 6-32 x 2 inches, PHS
-11	386-0480-00	101	2829	1	PLATE, rear overlay
	387-0480-01	2830	2908	1	PLATE, rear overlay
	387-0480-02	2909		1	PLATE, rear overlay
	- - - - - -			-	mounting hardware: (not included w/plate)
-12	213-0104-00			4	SCREW, thread forming, #6 x 0.375 inch, THS
-13	387-0475-00			1	PLATE, subpanel, rear, 15.688 x 12.438 x 0.312 inches
	- - - - - -			-	plate includes:
-14	354-0056-00			1	RING, ornamental, 0.125 x 12.625 x 15.375 inches
-15	122-0099-00			2	ANGLE, frame bottom, ext. 20.438 inches long
	- - - - - -			-	mounting hardware: (not included w/angle)
-16	212-0039-00			4	SCREW, 8-32 x 0.375 inch, THS
	210-0458-00			4	NUT, keps, 8-32 x 0.344 inch
-17	179-0586-00			1	CABLE HARNESS, 110 V
-18	- - - - - -	101	3459	1	PULSE GENERATOR
	- - - - - -			-	pulse generator includes:
	344-0074-00			2	CLIP, grounding, berylco, 0.468 x 0.85 inch
	344-0073-00			1	CLIP, center, conductor berylco, 0.25 inch diameter
	352-0040-00			1	HOLDER, diode, 0.718 diameter x 0.203 inch thick
	358-0175-00			1	BUSHING, inner, hex., 0.25 x 0.734 inch long
	132-0023-00			1	SHELL, 0.625 OD x 0.562 ID x 0.75 inch
	132-0001-00			1	NUT, coupling
	132-0002-00			1	SLEEVE, conductor, outer
	132-0007-00			1	RING, snap
	132-0028-00			1	INSULATOR
	132-0029-00			1	CONDUCTOR, inner
	211-0012-00			1	SCREW, 4-40 x 0.375 inch, PHS
	- - - - - -			-	mounting hardware: (not included w/pulse generator)
-19	132-0040-00			1	ADAPTER, 1.05 inches square
	211-0038-00			4	SCREW, 4-40 x 0.312 inch, 100° csk, FHS

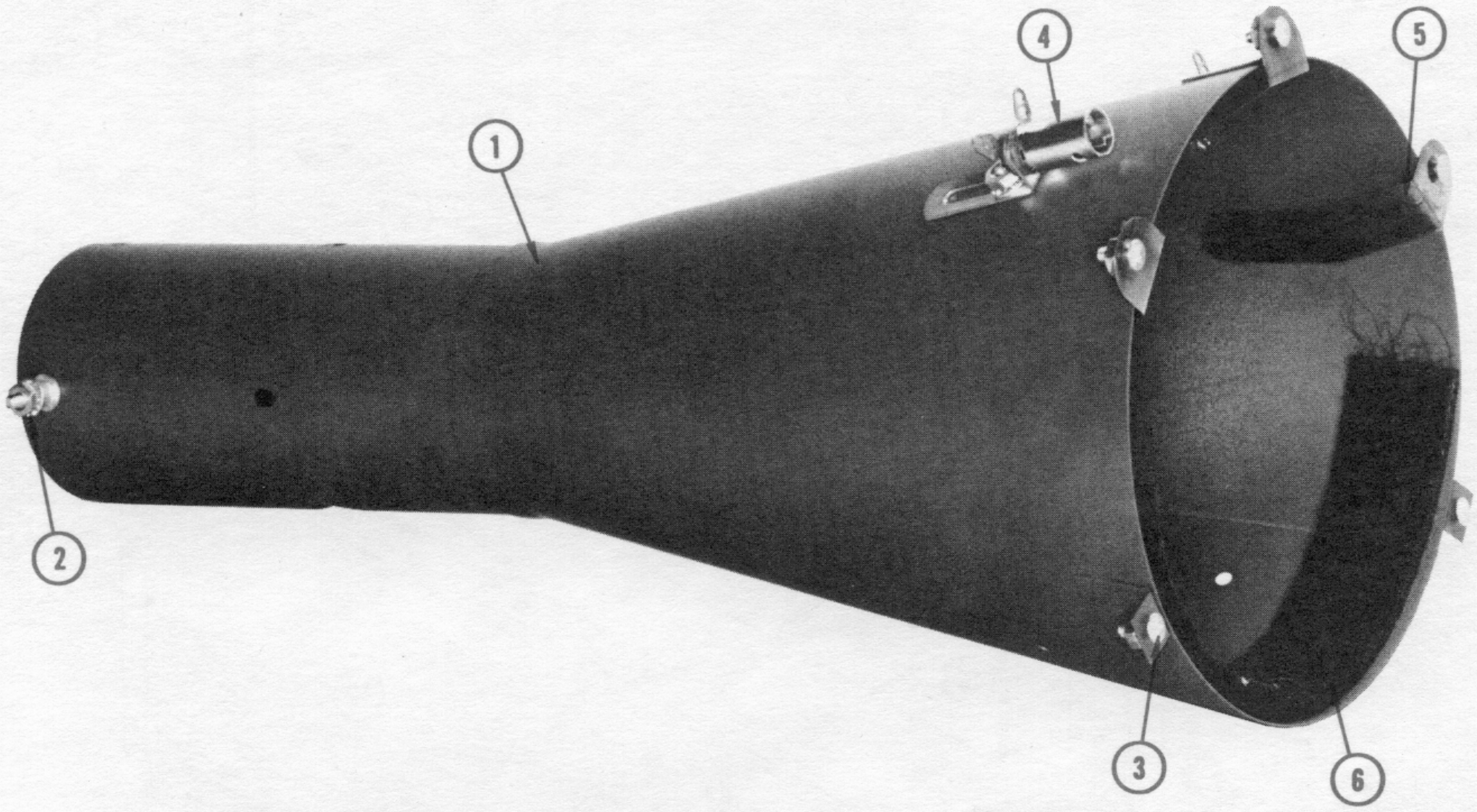
FRAME GROUP (cont)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-20	132-0016-00	101	361	1	NUT, retaining
	337-0553-00	362	3459	1	SHIELD, 0.50 x 0.406 inch
	670-0527-00	3460		1	CIRCUIT BOARD ASSEMBLY—PULSE GENERATOR
	- - - - - -			-	circuit board assembly includes:
	388-0871-00			1	CIRCUIT BOARD
	131-0265-00			1	CONNECTOR, coaxial
	136-0220-00			2	SOCKET, transistor, 3 pin, square
	214-0259-00			1	SPRING
	352-0097-00			1	HOLDER, resistor
	380-0103-00			1	HOUSING
	210-0676-00			1	EYELET
	119-0067-00			2	SECTION LINE, RF
	210-0586-00			4	NUT, keps, 4-40 x 0.25 inch
	211-0014-00			4	SCREW, 4-40 x 0.50 inch, PHS
	103-0054-00			1	ADAPTER
	103-0055-00			1	ADAPTER
	132-0001-00			1	NUT, coupling
	132-0002-00			1	SLEEVE, conductor, outer
	132-0007-00			2	RING, snap
	132-0028-00			1	INSULATOR
	132-0029-00			1	CONDUCTOR, inner
	220-0460-00			1	NUT, coupling
	220-0476-00			1	NUT, coupling
	119-0137-00			1	LINE SECTION, RF
	205-0086-00			1	SHELL
	361-0126-00			4	SPACER
	361-0130-00			8	SPACER, sleeve
-21	132-0040-00			1	ADAPTER, 1.05 inches square
	211-0038-00			4	SCREW, 4-40 x 0.312 inch, 100° csk, FHS
-22	387-0476-00			1	PLATE, subpanel, front, 15.688 x 12.438 x 0.812 inches
	- - - - - -			-	plate includes:
-23	355-0043-00			4	STUD, 0.375-32 x 0.897 inch long
-24	354-0056-00			1	RING, ornamental, 0.125 x 12.625 x 15.875 inches
-25	200-0269-00	101	3489	2	COVER, variable resistor, 1.115 x 1.938 inches
	200-0745-00	3490		2	COVER, variable resistor
-26	- - - - - -			-	VARIABLE RESISTOR MOUNTING HARDWARE
	210-0012-00			2	WASHER, lock, internal, 0.375 ID x 0.50 inch OD
	210-0013-00			2	WASHER, lock, internal, 0.375 ID x 0.688 inch OD
	210-0207-00			1	LUG, solder, 0.375-32 x 0.50 inch
	210-0413-00			5	NUT, hex., 0.375-32 x 0.50 inch
	210-0421-00			2	NUT, hex., 0.375-32 x 0.50 x 0.438 inch
-27	352-0006-00	101	2919	2	HOLDER, neon, double, plastic
	352-0064-00	2920		2	HOLDER, neon, double, plastic
	- - - - - -			-	mounting hardware for each: (not included w/holder)
	211-0031-00	101	2919	1	SCREW, 4-40 x 1 inch, 100° csk, FHS
	211-0109-00	2920		1	SCREW, 4-40 x 0.875 inch, 100° csk, FHS
	210-0406-00			2	NUT, hex., 4-40 x 0.188 inch

FRAME GROUP (cont)

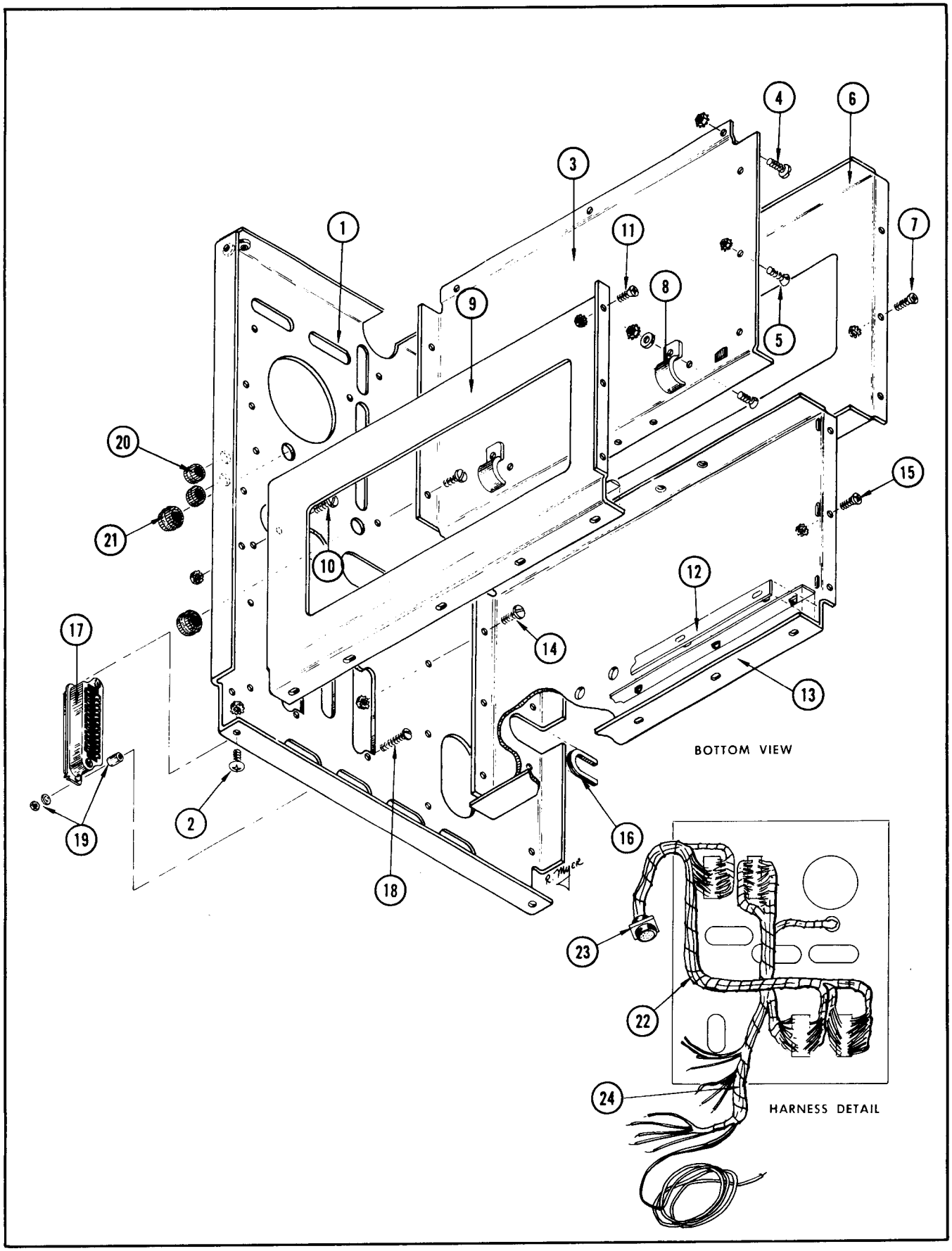
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
	378-0541-00	X2920		4	FILTER, lens, neon
-28	214-0307-00			2	LATCH ASSEMBLY, plug-in
	- - - - - -			-	latch assembly includes:
	210-0004-00			1	WASHER, lock, internal, #4
	210-0406-00			1	NUT, hex., 4-40 x 0.188 inch
	211-0008-00			1	SCREW, 4-40 x 0.25 inch, PHS
	214-0219-00			1	PIN, 0.312 x 0.344 inch
	214-0221-00			1	LATCH, retaining, 1.125 x 0.578 inches
	214-0235-00			1	SPRING, 0.375 x 0.469 inch
	367-0030-00			1	HANDLE, carrier assembly
	- - - - - -			-	mounting hardware for each: (not included w/latch assembly)
	210-0457-00			2	NUT, keps, 6-32 x 0.312 inch
-29	343-0006-00			1	CLAMP, cable, 0.50 inch diameter
	- - - - - -			-	mounting hardware: (not included w/clamp)
	212-0045-00			1	SCREW, 8-32 x 0.50 inch, THS
	210-0804-00			1	WASHER, #8 x 0.375 inch OD
	210-0458-00			1	NUT, keps, 8-32 x 0.344 inch
-30	381-0193-00			1	BAR, top support, 20.438 inches long, w/handles
	- - - - - -			-	bar includes:
	367-0011-00	101	3569	2	HANDLE
	367-0011-01	3570		2	HANDLE
	343-0145-00	X3570		4	HOLD DOWN, carrying handle
	343-0073-00			4	CLAMP, cover
	- - - - - -			-	mounting hardware: (not included w/bar)
	212-0039-00			4	SCREW, 8-32 x 0.375 inch, THS
	381-0073-00			2	BAR, 0.188 x 0.50 x 1.75 inches

CRT SHIELD



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	337-0364-00			1	SHIELD, CRT
	- - - - - -			-	mounting hardware: (not included w/shield)
-2	166-0107-00			2	TUBE, spacing, 0.18 ID x 0.25 x 0.219 inch
	210-0803-00			4	WASHER, flat, 0.15 ID x 0.375 inch OD
	210-0457-00			2	NUT, keps, 6-32 x 0.312 inch
	211-0559-00			2	SCREW, 6-32 x 0.625 inch, PHS
-3	211-0559-00			5	SCREW, 6-32 x 0.375 inch, 100° csk, FHS
	210-0457-00			5	NUT, keps, 6-32 x 0.312 inch
-4	136-0035-00			2	SOCKET, graticule light, with ground lug
	- - - - - -			-	mounting hardware: (not included w/socket)
	211-0534-00			1	SCREW, sems, 6-32 x 0.312 inch, PHS
	210-0803-00			1	WASHER, flat, 0.15 ID x 0.375 inch OD
	210-0457-00			1	NUT, keps, 6-32 x 0.312 inch
-5	406-0239-00			3	BRACKET, 0.625 x 0.75 x 2.25 inches
-6	124-0022-00			1	STRIP, felt, grey, 0.188 x 1 x 8 inches

SUPPORT GROUP



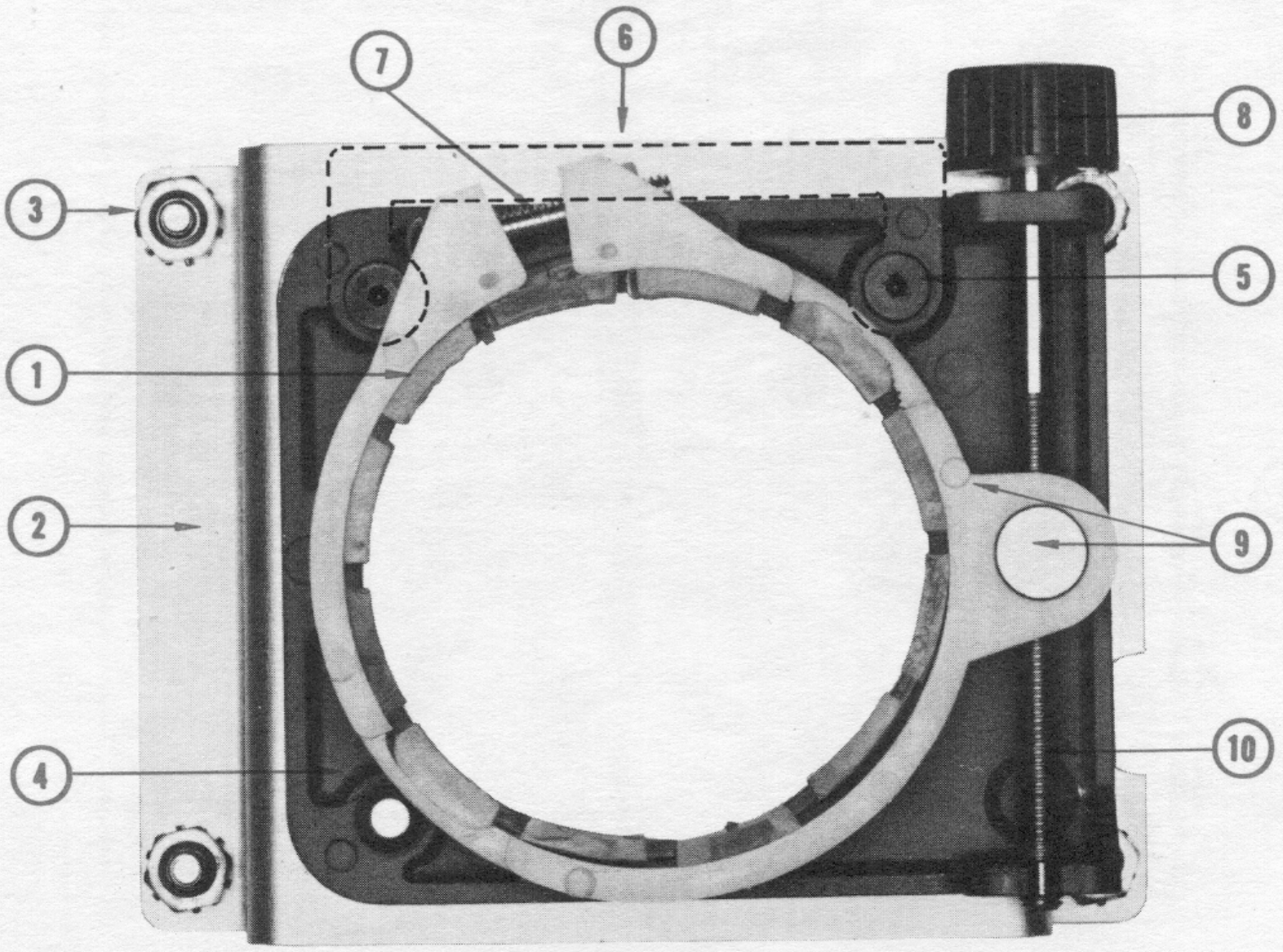
SUPPORT GROUP

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	387-0477-00			1	PLATE, bulkhead, 0.75 x 15.687 x 12.25 inches
	- - - - - -			-	mounting hardware: (not included w/plate)
-2	212-0039-00			8	SCREW, 8-32 x 0.375 inch, THS
-3	387-0481-00			1	PLATE, vertical support, 0.75 x 12.50 x 6.922 inches
	- - - - - -			-	mounting hardware: (not included w/plate)
-4	211-0510-00			6	SCREW, 6-32 x 0.375 inch, PHS
-5	211-0559-00			3	SCREW, 6-32 x 0.375 inch, 100° csk, FHS
	210-0457-00			9	NUT, keps, 6-32 x 0.312 inch
-6	387-0499-00			1	PLATE, housing plug-in, 0.688 x 12.50 x 6.922 inches
	- - - - - -			-	mounting hardware: (not included w/plate)
-7	211-0510-00			3	SCREW, 6-32 x 0.375 inch, PHS
	211-0559-00			3	SCREW, 6-32 x 0.375 inch, 100° csk, FHS
	210-0457-00			6	NUT, keps, 6-32 x 0.312 inch
-8	343-0042-00			2	CLAMP, cable, 0.312 inch plastic (cut in half)
	- - - - - -			-	mounting hardware for each: (not included w/clamp)
	210-0457-00			1	NUT, keps, 6-32 x 0.312 inch
	210-0803-00			1	WASHER, flat, 0.15 ID x 0.375 inch OD
	211-0559-00			1	SCREW, 6-32 x 0.375 inch, 100° csk, FHS
-9	387-0618-00			1	PLATE, housing, 0.688 x 12.50 x 6.671 inches
	- - - - - -			-	mounting hardware: (not included w/plate)
-10	211-0510-00			3	SCREW, 6-32 x 0.375 inch, PHS
-11	211-0559-00			3	SCREW, 6-32 x 0.375 inch, 100° csk, FHS
	210-0457-00			6	NUT, keps, 6-32 x 0.312 inch
-12	351-0052-00			4	GUIDE, shoe, 0.275 x 12.093 long x 0.375 inches wide
-13	387-0617-00	101	1999	1	PLATE, housing
	387-0902-00	2000		1	PLATE, housing
	- - - - - -			-	mounting hardware: (not included w/plate)
-14	211-0510-00			3	SCREW, 6-32 x 0.375 inch, PHS
-15	211-0559-00			3	SCREW, 6-32 x 0.375 inch, 100° csk, FHS
	210-0457-00			6	NUT, keps, 6-32 x 0.312 inch
-16	358-0166-00			1	BUSHING, 0.234 x 1.086 x 1.219 inches
-17	131-0148-00	101	2829	4	CONNECTOR, 24 contact, female
	131-0148-00	2830		3	CONNECTOR, 24 contact, female
	- - - - - -			-	mounting hardware for each: (not included w/connector)
-18	211-0016-00			2	SCREW, 4-40 x 0.625 inch, RHS
-19	166-0107-00	101	2779	2	TUBE, spacer, 0.219 inch long
	166-0030-00	2780		2	TUBE, spacer, 0.188 inch long
	210-0004-00			2	WASHER, lock, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 0.188 inch

SUPPORT GROUP (cont)

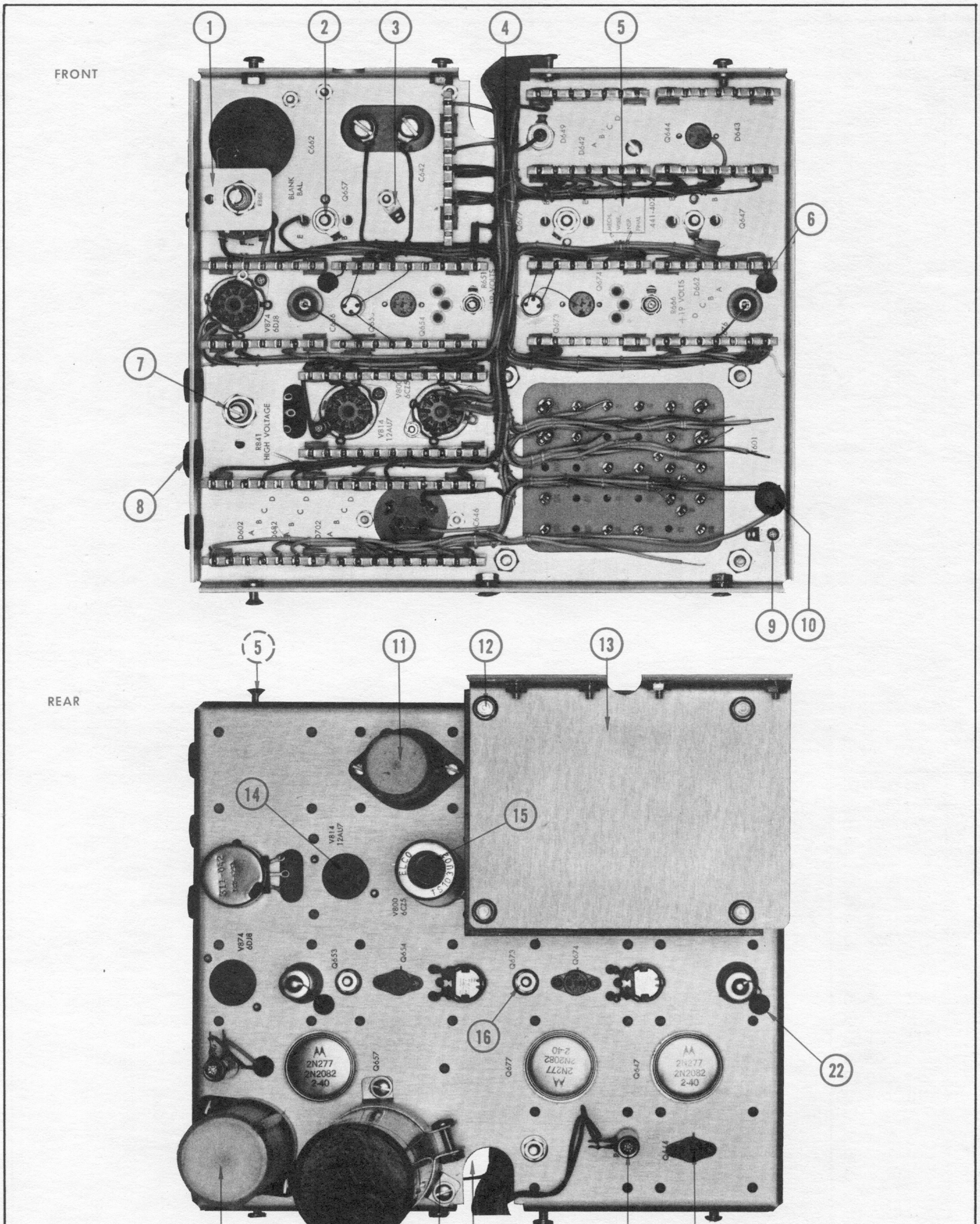
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-20	348-0003-00			2	GROMMET, 0.312 inch
-21	348-0012-00			2	GROMMET, 0.625 inch
-22	179-0589-00	101	2829X	1	CABLE HARNESS, readout
-23	131-0212-00	101	2829X	1	CONNECTOR, 41 pin socket
-24	179-0582-00	101	361	1	CABLE HARNESS, bulkhead
	179-0688-00	362	1999	1	CABLE HARNESS, bulkhead
	179-0871-00	2000	3459	1	CABLE HARNESS, bulkhead
	179-0871-01	3460		1	CABLE HARNESS, bulkhead
	- - - - - -			-	cable harness includes:
	131-0155-00	101	3459	1	CONNECTOR, coaxial
	131-0155-00	3460		2	CONNECTOR, coaxial

CRT BRACKET AND ROTATOR



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	354-0078-00	101	249	1	RING, plastic, 2.40 ID x 2.688 inches OD
	354-0178-00	250		1	RING, plastic, 0.266 ID x 2.688 inches OD
-2	432-0022-00	101	3579	1	BASE, 2.75 x 3.188 inches
	432-0022-02	3580		1	BASE, 2.75 x 3.188 inches
	- - - - - -			-	mounting hardware: (not included w/base)
-3	212-0023-00			4	SCREW, 8-32 x 0.375 inch, PHS
	210-0458-00			4	NUT, keps, 8-32 x 0.344 inch
	386-1465-00	X3580		1	PLATE, retaining
	211-0022-00	X3580		1	SCREW, 2-56 x 3/16 inch, PHS
-4	406-0735-00			1	BRACKET, CRT rotator
	- - - - - -			-	mounting hardware: (not included w/bracket)
-5	211-0561-00			2	SCREW, 6-32 x 0.375 inch, FHS
-6	210-0503-00			1	NUT, 0.656 x 2.50 inches
-7	211-0560-00			1	SCREW, 6-32 x 1 inch, RHS
	210-0407-00			1	NUT, hex., 6-32 x 0.25 inch
-8	366-0032-00			1	KNOB, small red
-9	354-0103-00			1	RING, clamping assembly
	- - - - - -			-	ring includes:
	210-0502-00			1	NUT, 10-32 x 0.375 inch
-10	355-0049-00			1	STUD, 10-32 x 3.25 inches

TRANSISTOR POWER CHASSIS



TRANSISTOR POWER CHASSIS

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	406-0734-00			1	BRACKET, 0.562 x 1.25 inches (Blanking Adj)
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0504-00			2	SCREW, 6-32 x 0.25 inch, PHS
	- - - - - -			-	VARIABLE RESISTOR MOUNTING HARDWARE:
	210-0413-00			1	NUT, hex., 0.375-32 x 0.50 inch
	210-0840-00			1	WASHER, 0.39 ID x 0.562 inch OD
-2	- - - - - -			-	DIODE MOUNTING HARDWARE:
	210-0410-00			1	NUT, hex., 10-32 x 0.312 inch
	210-0206-00			1	LUG, solder, SE #10
	210-0813-00			1	WASHER, fiber, #10 shouldered
	387-0428-00			1	PLATE, mica, 0.002 x 1.062 inch diameter
-3	210-0006-00	101	269	1	WASHER, lock, internal, #6
	210-0202-00	270		1	LUG, solder, SE #6, with 2 wire holes
-4	179-0585-00			1	CABLE HARNESS, transistor power
-5	441-0402-00			1	CHASSIS, power, left 9.656 x 8.469 x 0.75 inch
	- - - - - -			-	mounting hardware: (not included w/chassis)
	212-0023-00			4	SCREW, 8-32 x 0.375 inch, PHS
	212-0040-00			4	SCREW, 8-32 x 0.375 inch, 100° csk, FHS
	210-0458-00			8	NUT, keps, 8-32 x 0.344 inch
-6	354-0068-00			2	RING, securing, plastic, 0.50 ID x 0.562 OD x 0.50 inch high
-7	210-0413-00			1	NUT, hex., 0.375-32 x 0.50 inch
	210-0840-00			1	WASHER, flat, 0.39 ID x 0.562 inch OD
-8	348-0005-00			1	GROMMET, rubber, 0.50 inch
-9	210-0201-00			1	LUG, solder, SE #4
	213-0044-00			1	SCREW, thread cutting, 5-32 x 0.188 inch, PHS
-10	348-0004-00			3	GROMMET, rubber, 0.375 inch
-11	200-0532-00			1	COVER, capacitor, plastic, 2.031 x 1 inch diameter
	386-0252-00			1	PLATE, fiber, small
	- - - - - -			-	mounting hardware: (not included w/plate)
	211-0534-00			2	SCREW, sems, 6-32 x 0.312 inch, PHS
	210-0006-00			2	WASHER, lock, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-12	- - - - - -			-	TRANSFORMER MOUNTING HARDWARE:
	212-0542-00			4	SCREW, 10-32 x 5 inch, HHS
	210-0812-00			4	WASHER, fiber #10
	210-0010-00			4	WASHER, lock, internal, #10
	210-0445-00			4	NUT, hex., 10-32 x 0.375 x 0.125 inch thick
-13	406-0733-00			1	BRACKET, 4.688 x 2.719 x 0.844 inch
	- - - - - -			-	mounting hardware: (not included w/bracket)
	212-0040-00			4	SCREW, 8-32 x 0.375 inch, 100° csk, FHS
	210-0458-00			4	NUT, keps, 8-32 x 0.344 inch

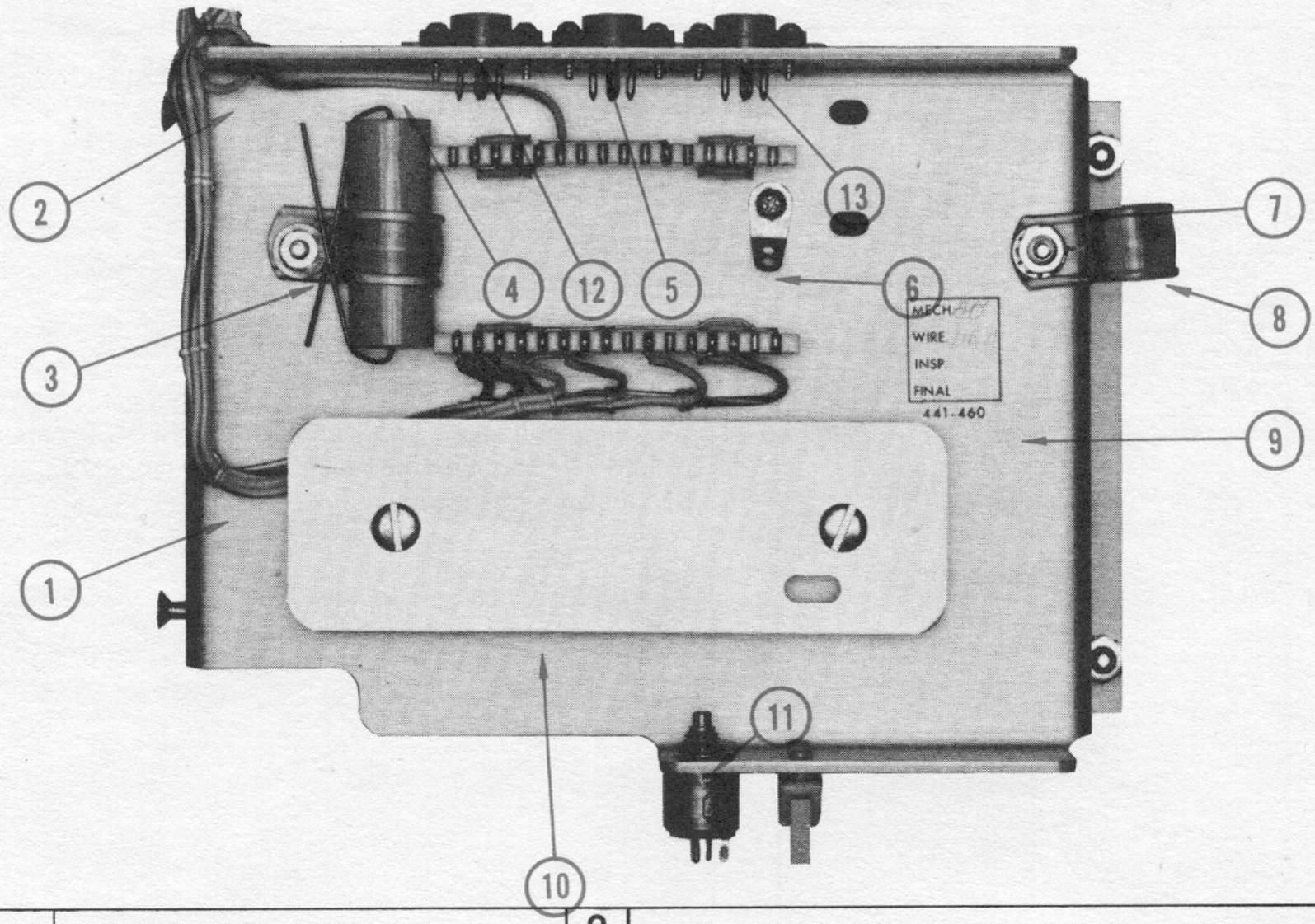
TRANSISTOR POWER CHASSIS (cont)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-14	136-0015-00			3	SOCKET, tube, 9 pin, w/ground lugs
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 0.188 inch, PHS
-15	337-0005-00			1	SHIELD, socket, 0.906 inch ID
	337-0009-00			1	SHIELD, tube, 0.344 inch high, with spring
	- - - - - -			-	mounting hardware: (not included w/shield)
	211-0033-00			2	SCREW, sems, 4-40 x 0.312 inch, PHS
	210-0004-00			2	WASHER, lock, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 0.188 inch
-16	- - - - - -			-	DIODE MOUNTING HARDWARE:
	210-0409-00			1	NUT, hex., 8-32 x 0.312 inch
	210-0008-00			1	WASHER, lock, internal, #8
	210-0813-00			1	WASHER, fiber, #10 shouldered
	210-0909-00			1	WASHER, mica, 0.625 OD x 0.196 ID x 0.002 inch thick
-17	200-0293-00			1	COVER, capacitor, plastic, 2.562 x 1.365 inch ID
	386-0254-00			1	PLATE, fiber, large
	- - - - - -			-	mounting hardware: (not included w/plate)
	211-0543-00			2	SCREW, 6-32 x 0.312 inch, RHS
	210-0006-00			2	WASHER, lock, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-18	343-0082-00			1	CLAMP, 1.812 inch diameter with 3 mounting feet
	- - - - - -			-	mounting hardware: (not included w/clamp)
	212-0509-00			1	SCREW, 10-32 x 0.375 inch, PHS
	211-0507-00			3	SCREW, 6-32 x 0.312 inch, PHS
	210-0006-00			3	WASHER, lock, internal, #6
	210-0010-00			1	WASHER, lock, internal, #10
	210-0803-00			3	WASHER, flat, 0.15 ID x 0.375 inch OD
	210-0407-00			3	NUT, hex., 6-32 x 0.25 inch
	210-0410-00			1	NUT, hex., 10-32 x 0.312 inch

TRANSISTOR POWER CHASSIS (cont)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-19	358-0166-00			1	BUSHING, plastic, 0.234 x 1.086 x 1.219 inches
-20	- - - - - -			-	RESISTOR MOUNTING HARDWARE:
	210-0478-00			1	NUT, hex., 0.312 x 0.656 inch long
	210-0601-00			1	EYELET, tapered barrel
	211-0507-00			1	SCREW, 6-32 x 0.312 inch, PHS
	211-0553-00			1	SCREW, 6-32 x 1.05 inch, RHS
-21	136-0095-00	101	2329	3	SOCKET, 4 pin transistor
	136-0180-00	2330		3	SOCKET, 3 pin transistor
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	213-0113-00	101	2329	2	SCREW, thread forming, 2-32 x 0.312 inch, RHS
	354-0234-00	2330		1	RING, transistor mounting
-22	348-0002-00			3	GROMMET, rubber, 0.25 inch

HORIZONTAL PREAMPLIFIER CHASSIS

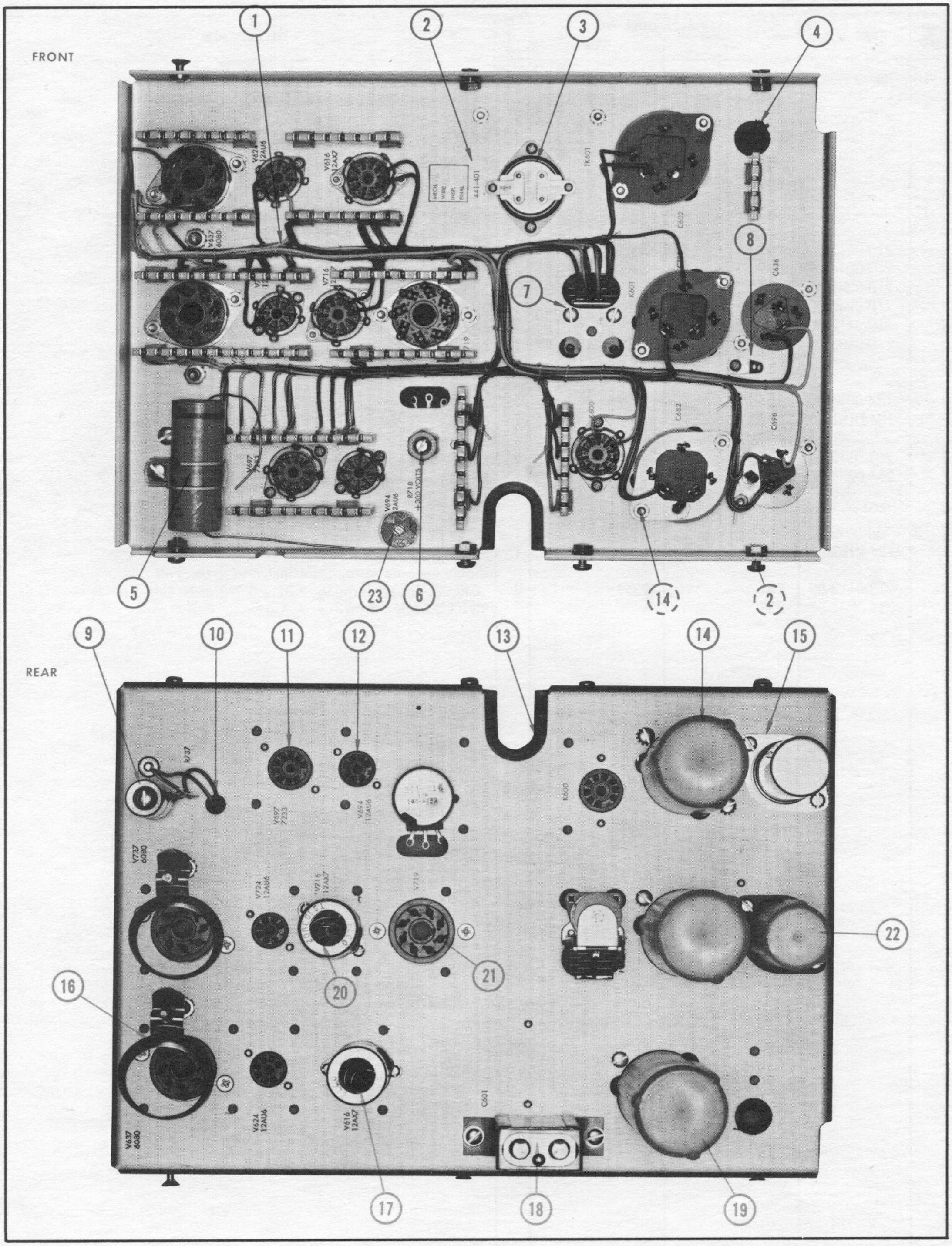


REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	179-0587-00			1	CABLE HARNESS, Horiz. Preamp
-2	348-0002-00			1	GROMMET, rubber, 0.25 inch
-3	343-0007-00			1	CLAMP, cable, 0.625 inch plastic
	- - - - - -			-	mounting hardware: (not included w/clamp)
	210-0006-00			1	WASHER, lock, internal, #6
	210-0407-00			1	NUT, hex., 6-32 x 0.25 inch
	210-0803-00			1	WASHER, flat, 0.15 x 0.375 inch OD
	211-0510-00			1	SCREW, 6-32 x 0.375 inch, PHS
-4	348-0031-00			4	GROMMET, plastic, snap-in, 0.25 inch diameter
-5	136-0095-00	101	2329	1	SOCKET, 4 pin transistor
	136-0182-00	2330	2479	1	SOCKET, 4 pin transistor, snap-in
	136-0181-00	2480		1	SOCKET, 3 pin transistor, snap-in
	- - - - - -			-	mounting hardware: (not included w/socket)
	213-0113-00	101	2329	2	SCREW, thread forming, 2-32 x 0.312 inch, RHS
	354-0234-00	2330		1	RING, transistor mounting
-6	210-0201-00			1	LUG, solder, SE #4
	213-0044-00			1	SCREW, thread cutting, 5-32 x 0.188 inch, PHS
	- - - - - -			-	(mounting screw)
-7	348-0003-00			1	GROMMET, rubber, 0.312 inch (on side of chassis)
-8	343-0005-00			1	CLAMP, cable, 0.438 inch plastic
	- - - - - -			-	mounting hardware: (not included w/clamp)
	210-0006-00			1	WASHER, lock, internal, #6
	210-0407-00			1	NUT, hex., 6-32 x 0.25 inch
	210-0803-00			1	WASHER, flat, 0.15 ID x 0.375 inch OD
	211-0510-00			1	SCREW, 6-32 x 0.375 inch, PHS
-9	441-0403-00	101	361	1	CHASSIS
	441-0460-00	362	3459	1	CHASSIS
	441-0460-01	3460		1	CHASSIS

HORIZONTAL PREAMPLIFIER CHASSIS (cont)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-10	387-0483-00			1	PLATE, drum, 4.438 x 1.438 inches
	- - - - - -			-	mounting hardware: (not included w/plate)
	212-0001-00			3	SCREW, 8-32 x 0.25 inch
	212-0002-00			1	SCREW, 8-32 x 0.25 inch, 100° csk, FHS
	385-0101-00			2	ROD, plastic, 0.625 x 0.375 inch
-11	- - - - - -	101	3459X	1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0012-00	101	361	1	WASHER, lock, internal, 0.375 ID x 0.50 inch OD
	210-0046-00	362	3459X	1	WASHER, lock, internal, 0.261 ID x 0.40 inch OD
	210-0840-00	101	361	1	WASHER, 0.39 ID x 0.562 inch OD
	210-0940-00	362	3459X	1	WASHER, 0.25 ID x 0.375 inch OD
	210-0413-00	101	361	1	NUT, hex., 0.375-32 x 0.50 inch
	210-0583-00	362	3459X	1	NUT, hex., 0.25-32 x 0.312 inch
-12	136-0095-00	101	2329	1	SOCKET, 4 pin transistor
	136-0181-00	2330		1	SOCKET, 3 pin transistor
	- - - - - -			-	mounting hardware: (not included w/socket)
	213-0113-00	101	2329	2	SCREW, thread forming, 2-32 x 0.312 inch, RHS
	354-0234-00	2330		1	RING, locking, transistor socket
-13	136-0092-00	101	2329	1	SOCKET, 4 pin transistor
	136-0182-00	2330		1	SOCKET, 4 pin transistor
	- - - - - -			-	mounting hardware: (not included w/socket)
	213-0113-00	101	2329	2	SCREW, thread forming, 2-32 x 0.312 inch, RHS
	354-0234-00	2330		1	RING, locking, transistor socket

TUBE POWER CHASSIS



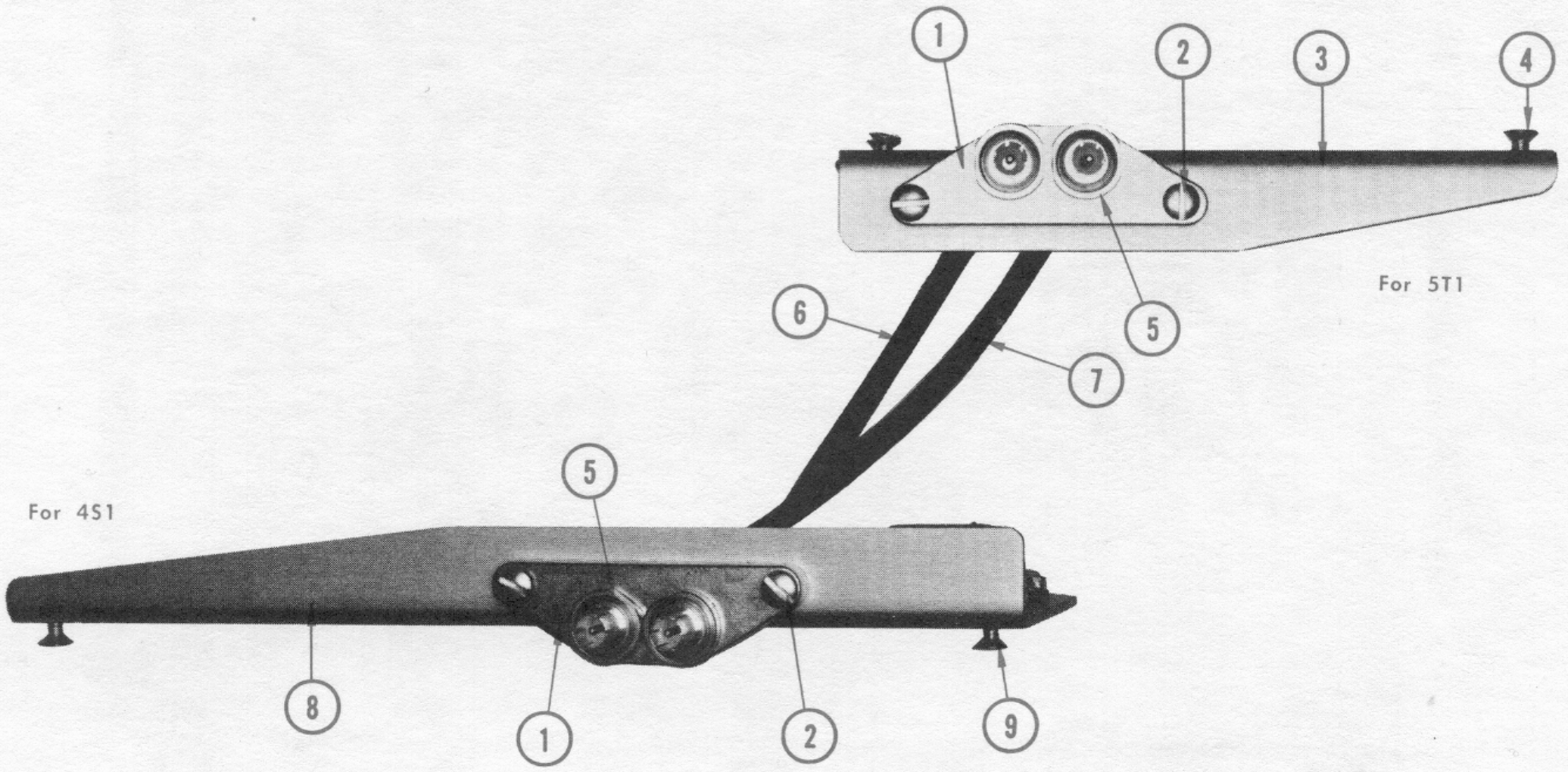
TUBE POWER CHASSIS

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	179-0584-00	101	3459	1	CABLE HARNESS, tube power
	179-0584-01	3460		1	CABLE HARNESS, tube power
-2	441-0401-00			1	CHASSIS, power, right, 12.25 x 8.469 x 0.75 inch
	- - - - - -			-	mounting hardware: (not included w/chassis)
	212-0040-00			3	SCREW, 8-32 x 0.375 inch, 100° csk, FHS
	211-0510-00			3	SCREW, 8-32 x 0.375 inch, PHS
	210-0458-00			6	NUT, keps, 8-32 x 0.344 inch
-3	260-0157-00	101	609	1	SWITCH, thermal cutout
	260-0120-00	610		1	SWITCH, thermal cutout
	- - - - - -			-	mounting hardware: (not included w/switch)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 0.188 inch, PHS
-4	348-0005-00			1	GROMMET, rubber, 0.50 inch
-5	343-0009-00	X251		1	CLAMP, cable, 0.875 inch, plastic
	212-0004-00			1	SCREW, 8-32 x 0.312 inch, PHS
-6	- - - - - -			-	RESISTOR MOUNTING HARDWARE:
	210-0444-00			1	NUT, hex., 0.50 x 0.625 inch long
	210-0840-00			1	WASHER, 0.39 ID x 0.562 inch OD
-7	211-0503-00			2	SCREW, 6-32 x 0.188 inch, PHS (relay mounting hardware)
-8	210-0201-00			1	LUG, solder, SE #4
	213-0044-00			1	SCREW, thread cutting, 5-32 x 0.188 inch, PHS
-9	- - - - - -			-	RESISTOR MOUNTING HARDWARE: (not included)
	210-0803-00			1	WASHER, centering
	212-0037-00			1	SCREW, 8-32 x 1.75 inches, Fil HS
	210-0462-00			1	NUT, hex., 8-32 x 0.50 x 0.562 inch
	212-0004-00			1	SCREW, 8-32 x 0.312 inch ,PHS
-10	348-0002-00			1	GROMMET, rubber, 0.25 inch
-11	136-0015-00			4	SOCKET, tube, 9 pin, w/ground lugs
	- - - - - -			-	mounting hardware: (not included w/socket)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 0.188 inch, PHS
-12	136-0008-00			3	SOCKET, tube, 7 pin, w/ground lugs
	- - - - - -			-	mounting hardware: (not included w/socket)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 0.188 inch, PHS
-13	358-0166-00			1	BUSHING, 1.086 x 1.219 x 0.234 inch
-14	200-0261-00			1	COVER, plastic, 4.062 x 1.375 inches diameter
	200-0364-00			1	COVER, plastic, 4.062 x 1.365 inches diameter
	386-0255-00			1	PLATE, metal, large
	- - - - - -			-	CAPACITOR MOUNTING HARDWARE:
	211-0516-00			2	SCREW, 6-32 x 0.875 inch, PHS
	166-0035-00			2	TUBE, spacer, 0.180 ID x 0.25 OD x 0.50 inch long
	210-0006-00			4	WASHER, lock, internal #6
	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-15	386-0253-00			1	PLATE, metal, small
	- - - - - -			-	CAPACITOR MOUNTING HARDWARE:
	211-0534-00			2	SCREW, sems, 6-32 x 0.312 inch, PHS
	210-0006-00			2	WASHER, lock, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch

TUBE POWER CHASSIS (cont)

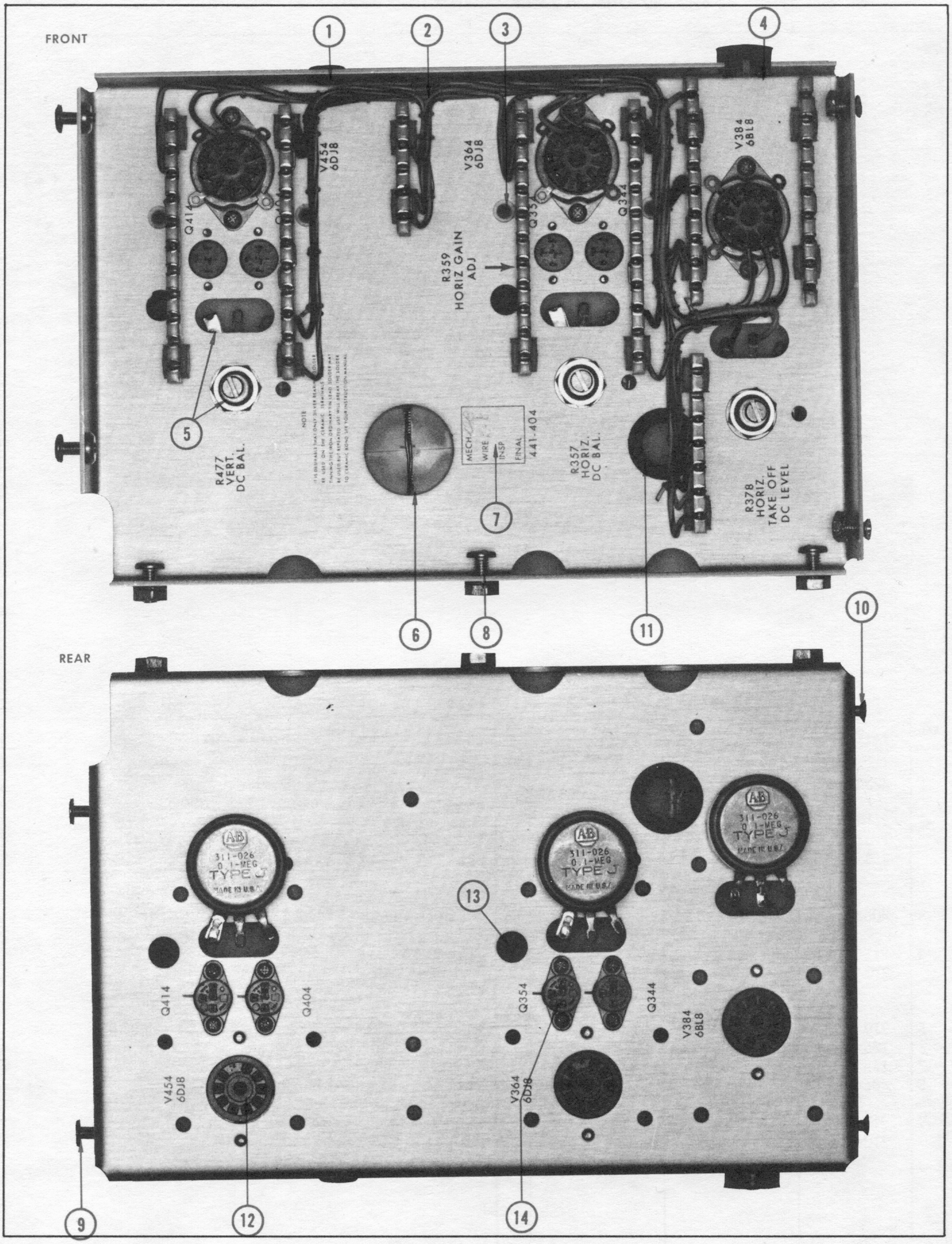
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-16	343-0074-00			2	CLAMP, tube, top hat
	- - - - - -			-	mounting hardware: (not included w/clamp)
	355-0070-00			1	STUD, 8-32 x 4.75 inches long
	210-0458-00			2	NUT, keps, 8-32 x 0.344 inch
-17	337-0005-00			1	SHIELD, socket, 0.906 inch ID
	337-0009-00			1	SHIELD, tube, 1.03 ID x 2.406 inches high, with spring
-18	- - - - - -			-	CAPACITOR MOUNTING HARDWARE:
	211-0507-00			2	SCREW, 6-32 x 0.312 inch, PHS
	210-0803-00			2	WASHER, flat, 0.15 ID x 0.375 inch OD
	210-0006-00			2	WASHER, lock, internal #6
	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-19	200-0261-00			2	COVER, plastic, 4.062 x 1.365 inch diameter
	386-0254-00			2	PLATE, fiber, large
	- - - - - -			-	CAPACITOR MOUNTING HARDWARE:
	211-0516-00			2	SCREW, 6-32 x 0.875 inch, PHS
	166-0035-00			2	TUBE, spacer, 0.180 ID x 0.25 OD x 0.50 inch long
	210-0006-00			4	WASHER, lock, internal #6
	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-20	337-0005-00			1	SHIELD, socket, 0.906 inch ID
	337-0008-00			1	SHIELD, tube, 1.031 ID x 1.938 inch high, with spring
-21	136-0013-00			3	SOCKET, STM8
	- - - - - -			-	mounting hardware: (not included w/socket)
	211-0538-00			2	SCREW, 6-32 x 0.312 inch, 100° csk, FHS
	210-0006-00			2	WASHER, lock, internal #6
	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-22	200-0256-00	101	2669	1	COVER, capacitor, 2.031 inches
	200-0532-00	2670	2889	1	COVER, capacitor, 1.594 inches
	200-0256-00	2890		1	COVER, capacitor, 2.031 inches
	386-0252-00			1	PLATE, fiber, small
	- - - - - -			-	CAPACITOR MOUNTING HARDWARE:
	211-0534-00			2	SCREW, sems 6-32 x 0.312 inch, PHS
	210-0006-00			2	WASHER, lock, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-23	- - - - - -	X900		1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	214-0321-00			2	FASTENER, variable resistor mounting

50 OHM PLUG-IN CONNECTING BRACKETS



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	426-0153-00			2	MOUNT, 50 Ω line connector
	- - - - - -			-	mounting hardware: (not included w/mount)
-2	211-0511-00			2	SCREW, 6-32 x 0.50 inch, PHS
	210-0006-00			2	WASHER, lock, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-3	406-0766-00			1	BRACKET, support, 5.344 x 2 x 0.75 inch
	- - - - - -			-	mounting hardware: (not included w/bracket)
-4	211-0559-00			3	SCREW, 6-32 x 10.375 inch, 100° csk, FHS
	210-0457-00			3	NUT, keps, 6-32 x 0.312 inch
-5	210-0455-00			4	NUT, hex., 0.25-28 x 0.375 x 0.094 inch (cable mounting)
-6	175-0230-00			1	CABLE, assembly, Inboard
-7	175-0231-00			1	CABLE, assembly, Outboard
-8	406-0767-00			1	BRACKET, support, 7.844 x 2.50 x 0.75 inch
	- - - - - -			-	mounting hardware: (not included w/bracket)
-9	211-0559-00			3	SCREW, 6-32 x 0.375 inch, 100° csk, FHS
	210-0457-00			3	NUT, keps, 6-32 x 0.312 inch

VERTICAL AMPLIFIER CHASSIS

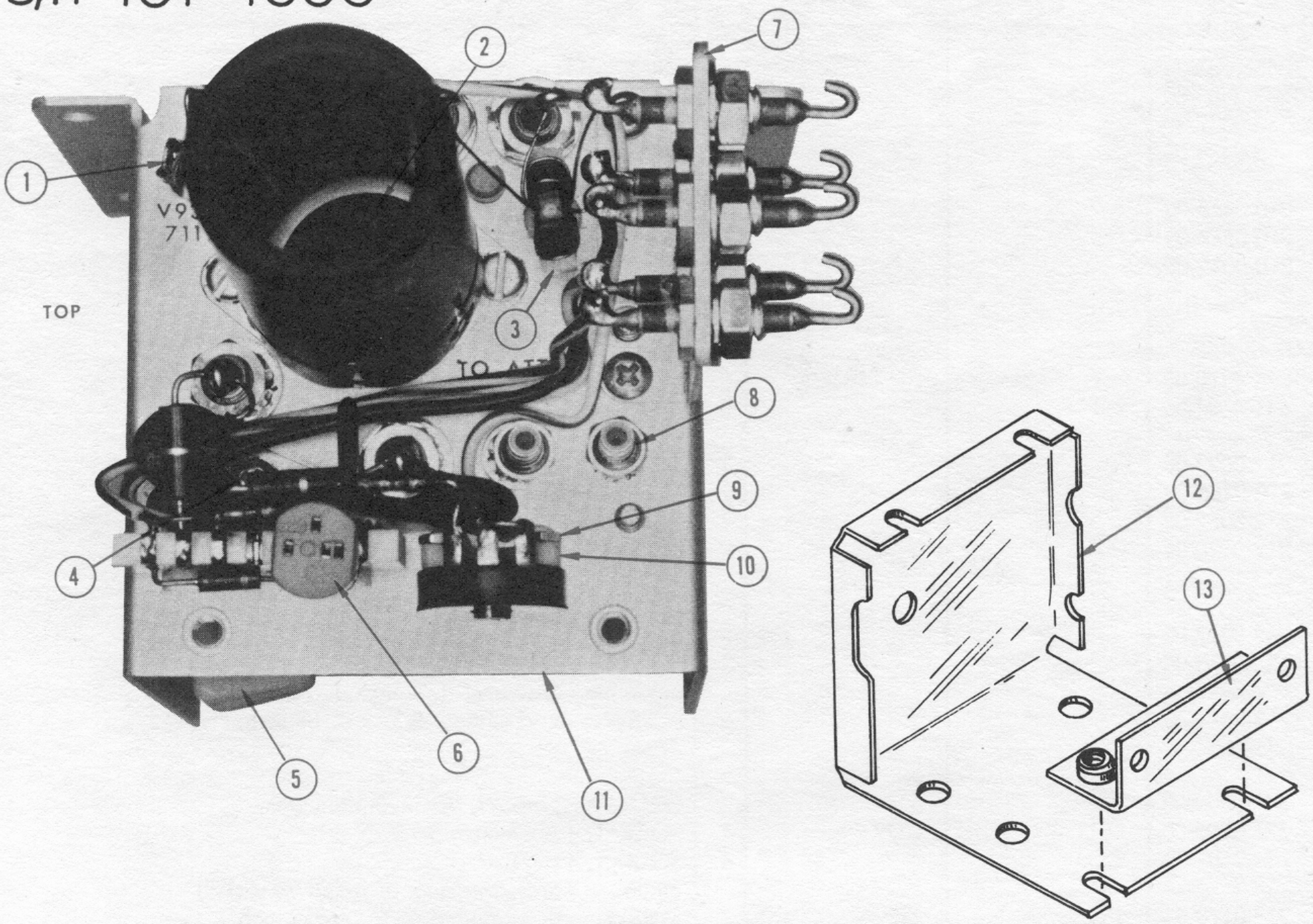


VERTICAL AMPLIFIER CHASSIS

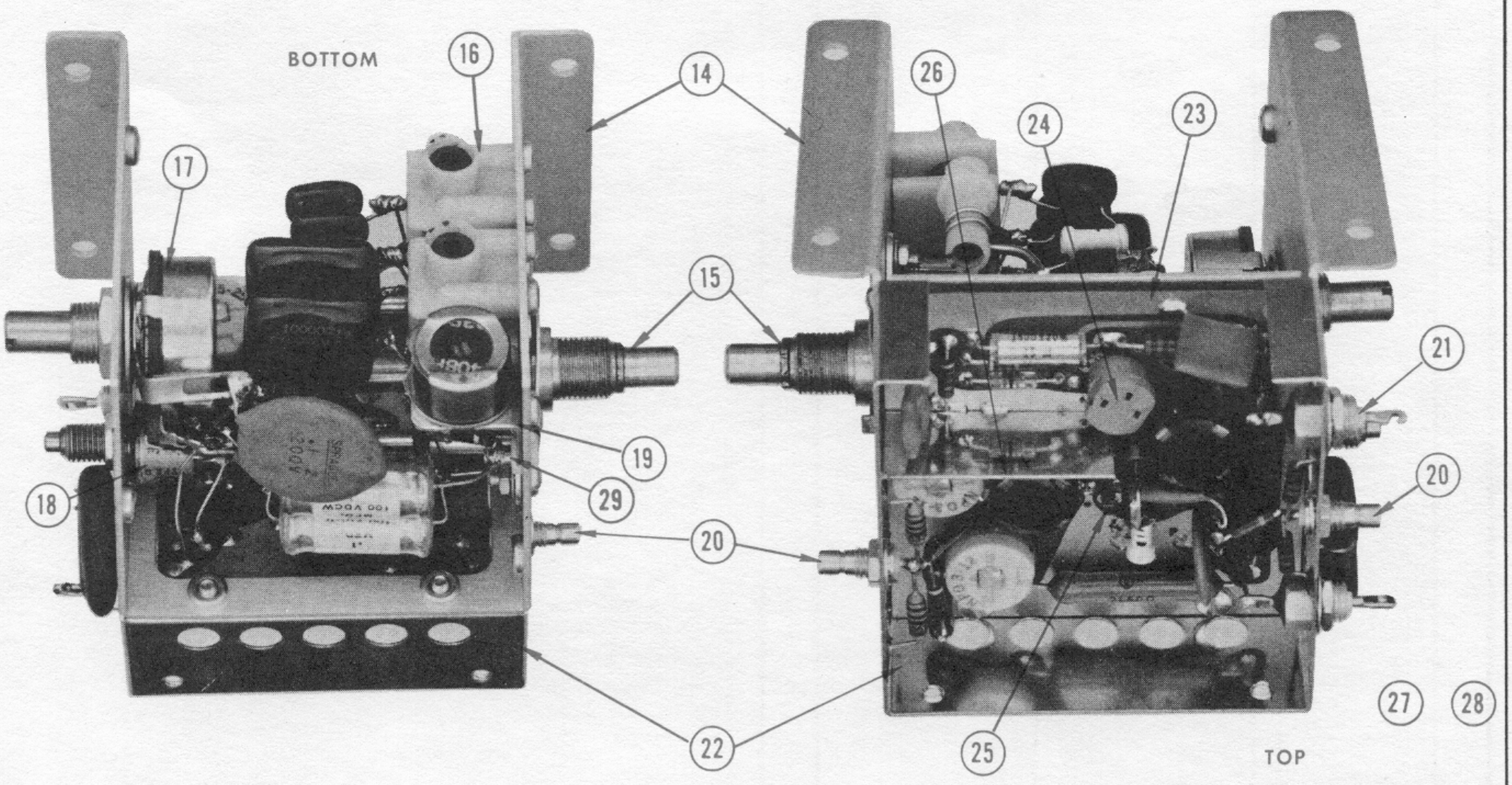
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	348-0003-00			1	GROMMET, rubber, 0.312 inch diameter
-2	179-0583-00			1	CABLE HARNESS
-3	348-0031-00			4	GROMMET, plastic, snap-in, 0.25 inch diameter
-4	210-0438-00			2	NUT, hex., 1-72 x 0.156 inch (variable resistor mounting)
-5	- - - - - -			-	VARIABLE RESISTOR MOUNTING HARDWARE:
	210-0413-00			3	NUT, hex., 0.375-32 x 0.50 inch
	210-0840-00			3	WASHER, flat, 0.39 ID x 0.562 inch OD
	210-0012-00			2	WASHER, lock, internal, 0.375 ID x 0.50 inch OD
	210-0207-00			2	LUG, solder, 0.375 inch
-6	214-0210-00			1	SPOOL, plastic, 1 inch OD x 0.562 inch long w/solder
-7	441-0404-00			1	CHASSIS, 8.438 x 5.562 x 1.062 inch
	- - - - - -			-	mounting hardware: (not included w/chassis)
-8	212-0023-00			3	SCREW, 8-32 x 0.372 inch, PHS
	210-0458-00			5	NUT, keps, 8-32 x 0.344 inch
-9	212-0039-00			2	SCREW, 8-32 x 0.375 inch, THS
-10	212-0040-00			2	SCREW, 8-32 x 0.375 inch, 100° csk, FHS
-11	348-0012-00			1	GROMMET, rubber, 0.625 inch diameter
-12	136-0015-00			3	SOCKET, tube, 9 pin, w/ground lugs
	- - - - - -			-	mounting hardware: (not included w/socket)
	213-0044-00			6	SCREW, thread cutting, 5-32 x 0.188 inch, PHS
-13	348-0002-00			2	GROMMET, rubber, 0.25 inch diameter
-14	136-0095-00	101	2329	4	SOCKET, 4 pin transistor
	136-0182-00	2330		4	SOCKET, 4 pin transistor
	- - - - - -			-	mounting hardware: (not included w/socket)
	213-0113-00	101	2329	2	SCREW, thread forming, 2-32 x 0.312 inch, RHS
	354-0234-00	2330		1	RING, transistor mounting

CALIBRATOR CHASSIS

s/n 101 - 1999



s/n 2000 up



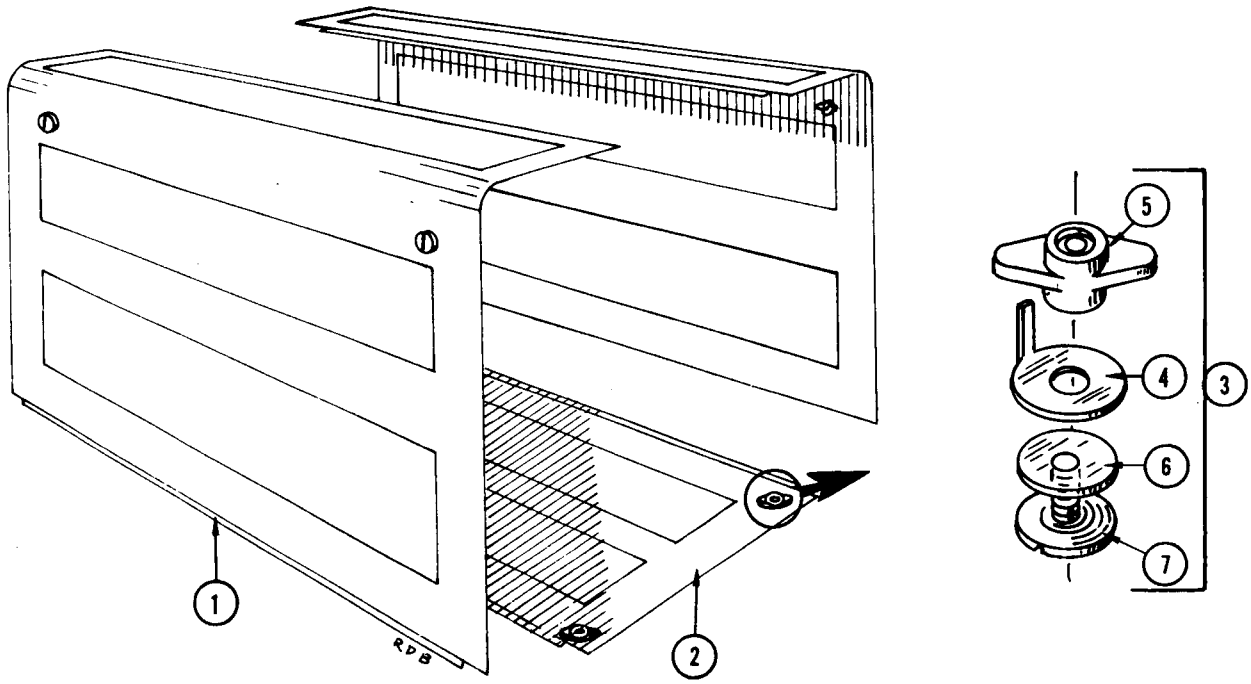
CALIBRATOR CHASSIS

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	129-0006-00	101	1999X	1	POST, connecting, insulated
	210-0202-00			2	LUG, solder, SE #6
	210-0407-00			1	NUT, hex., 6-32 x 0.25 inch
-2	136-0072-00	101	1999X	1	SOCKET, 9 pin, UHF miniature
	- - - - - -			-	mounting hardware: (not included w/socket)
	211-0033-00			2	SCREW, sems, 4-40 x 0.312 inch, PHS
	210-0004-00			2	WASHER, lock, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 0.188 inch
	337-0005-00	101	1999X	1	SHIELD, socket
	337-0491-00	101	1999X	1	SHIELD, tube shell
-3	426-0121-00	101	1999X	2	MOUNT, toroid, plastic
	- - - - - -			-	mounting hardware: (not included w/mount)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 0.188 inch, PHS
-4	210-0201-00	101	1999X	3	LUG, solder, SE #4
	- - - - - -			-	mounting hardware: (not included w/lug)
	213-0044-00			1	SCREW, thread cutting, 5-32 x 0.188 inch, PHS
-5	426-0154-00	101	1999X	1	MOUNT, toroid, holder, plastic, 0.38 inch wide
-6	136-0062-00	101	1999X	1	SOCKET, 4 pin tube
-7	406-0780-00	101	1999X	1	BRACKET
	- - - - - -			-	mounting hardware: (not included w/bracket)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 0.188 inch, PHS
-8	131-0156-00	101	1999X	2	CONNECTOR, coaxial, miniature, chassis mount
-9	210-0438-00	101	1999X	8	NUT, hex., 1-72 x 0.156 inch (variable resistor)
-10	406-0635-00	101	1999X	4	BRACKET, plastic, 0.50 x 0.576 inch
	- - - - - -			-	mounting hardware: (not included w/bracket)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 0.188 inch, PHS
-11	441-0425-00	101	1999	1	CHASSIS
	- - - - - -			-	mounting hardware: (not included w/chassis)
	210-0457-00			4	NUT, keps, 6-32 x 0.312 inch
-12	337-0488-00	101	1999X	1	SHIELD
	- - - - - -			-	mounting hardware: (not included w/shield)
	211-0504-00			4	SCREW, 6-32 x 0.25 inch
-13	406-0774-00	101	1999X	1	BRACKET
	- - - - - -			-	mounting hardware: (not included w/bracket)
	210-0457-00			2	NUT, keps, 6-32 x 0.312 inch

CALIBRATOR CHASSIS (cont)

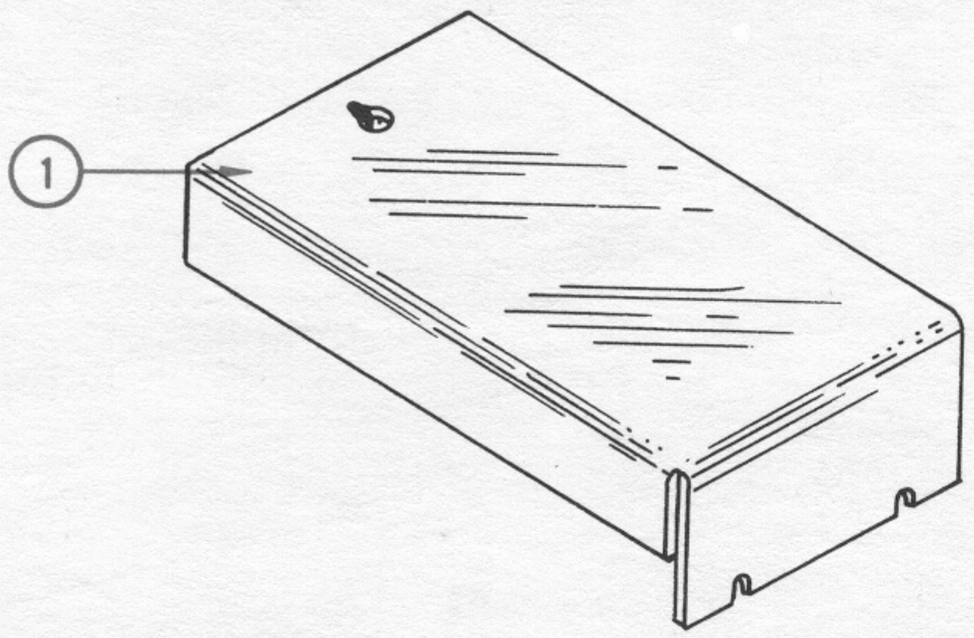
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-14	441-0533-00	2000		1	CHASSIS, calibrator
-15	- - - - - -			-	SWITCH, calibrator (see switch page)
-16	- - - - - -	X2000		2	COIL
	- - - - - -			-	mounting hardware for each: (not included w/coil)
	213-0035-00			2	SCREW, thread cutting, 4-40 x 0.25 inch, PHS
-17	- - - - - -	X2000		1	VARIABLE RESISTOR
	- - - - - -			-	mounting hardware: (not included w/variable resistor)
	210-0207-00			1	LUG, solder, 0.375 inch
	210-0013-00			1	WASHER, lock, internal, 0.375 x 0.688 inch
	210-0413-00			1	NUT, hex., 0.375 x 0.50 inch
-18	- - - - - -	X2000		1	VARIABLE RESISTOR
	- - - - - -			-	mounting hardware: (not included w/variable resistor)
	210-0046-00			1	WASHER, lock, internal, 0.261 ID x 0.40 inch OD
	210-0583-00			1	NUT, hex., 0.25-32 x 0.312 inch
-19	406-0964-00	X2000		1	BRACKET, toroid mounting
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0008-00	2000	2759	2	SCREW, 4-40 x 0.25 inch, PHS
	211-0116-00	2760		2	SCREW, sems, 4-40 x 0.312 inch, PHB
	210-0004-00			2	WASHER, lock, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 0.188 inch
-20	131-0156-00	X2000		2	CONNECTOR, coaxial
-21	- - - - - -	X2000		2	CAPACITOR
	- - - - - -			-	mounting hardware for each: (not included w/capacitor)
	210-0046-00			1	WASHER, lock, internal, 0.261 ID x 0.40 inch OD
	210-0583-00			1	NUT, hex., 0.25-32 x 0.312 inch
-22	337-0608-00	X2000		1	SHIELD, calibrator
-23	670-0402-00	X2000		1	CIRCUIT BOARD ASSEMBLY
	- - - - - -			-	circuit board assembly includes:
	388-0574-00	X2000		1	CIRCUIT BOARD
-24	136-0150-00	X2000	2379	1	SOCKET, transistor
	136-0183-00	2380		1	SOCKET, transistor
-25	344-0064-00	X2000		4	CLIP, diode
-26	337-0607-00	X2000		1	SHIELD, circuit board
-27	200-0553-00	X2000		1	COVER, calibrator shield (not shown)
	- - - - - -			-	mounting hardware: (not included w/cover)
	211-0007-00			4	SCREW, 4-40 x 0.188 inch, PHS
-28	337-0609-00	X2000		1	SHIELD, calibrator (not shown)
	- - - - - -			-	mounting hardware: (not included w/shield)
	211-0008-00	2000	2759	2	SCREW, 4-40 x 0.25 inch, PHS
	211-0116-00	2760		2	SCREW, sems 4-40 x 0.312 inch, PHB
-29	131-0180-00	X2000		1	CONNECTOR, terminal stand-off
	- - - - - -			-	mounting hardware: (not included w/connector)
	358-0135-00			1	BUSHING, plastic

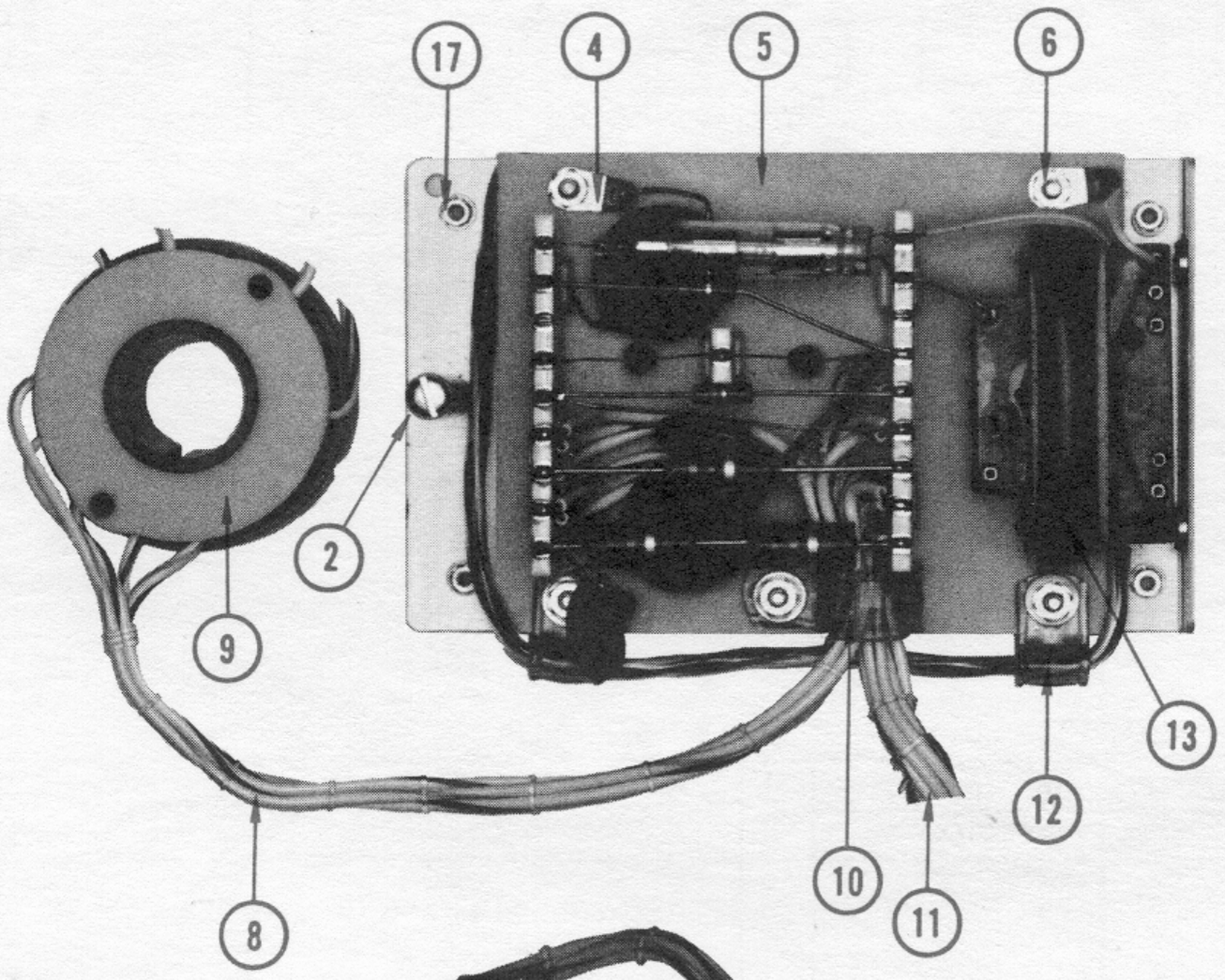
CABINET

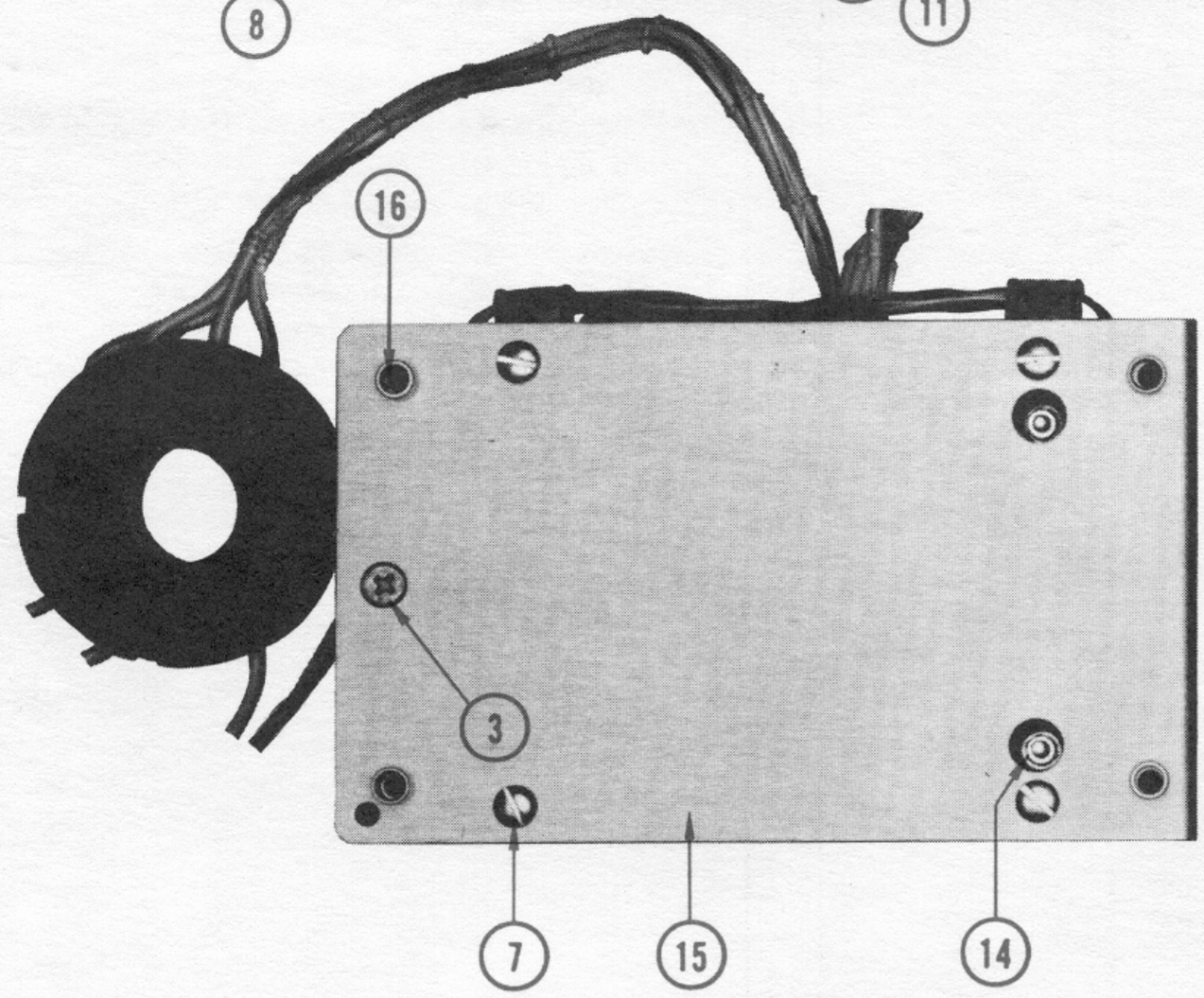


REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	387-0479-00			2	PLATE, cabinet side, 5.781 x 14.984 x 20.406 inches
	- - - - - -			-	each plate includes:
	214-0057-00			2	FASTENER, cabinet latch
-2	387-0478-00			1	PLATE, cabinet bottom, 0.312 x 10.188 x 20.406 inches
	- - - - - -			-	plate includes:
-3	214-0057-00			4	FASTENER, cabinet latch assembly
	- - - - - -			-	each fastener includes:
-4	105-0007-00			1	STOP, 0.219 ID x 0.656 inch OD
-5	210-0480-00			1	NUT, latch, plastic, cabinet fastener
-6	210-0847-00			1	WASHER, plastic, 0.164 ID x 0.50 inch OD
-7	213-0033-00			1	SCREW, fastening, 8.32 x 0.51 inch

FOCUS AND INTENSITY



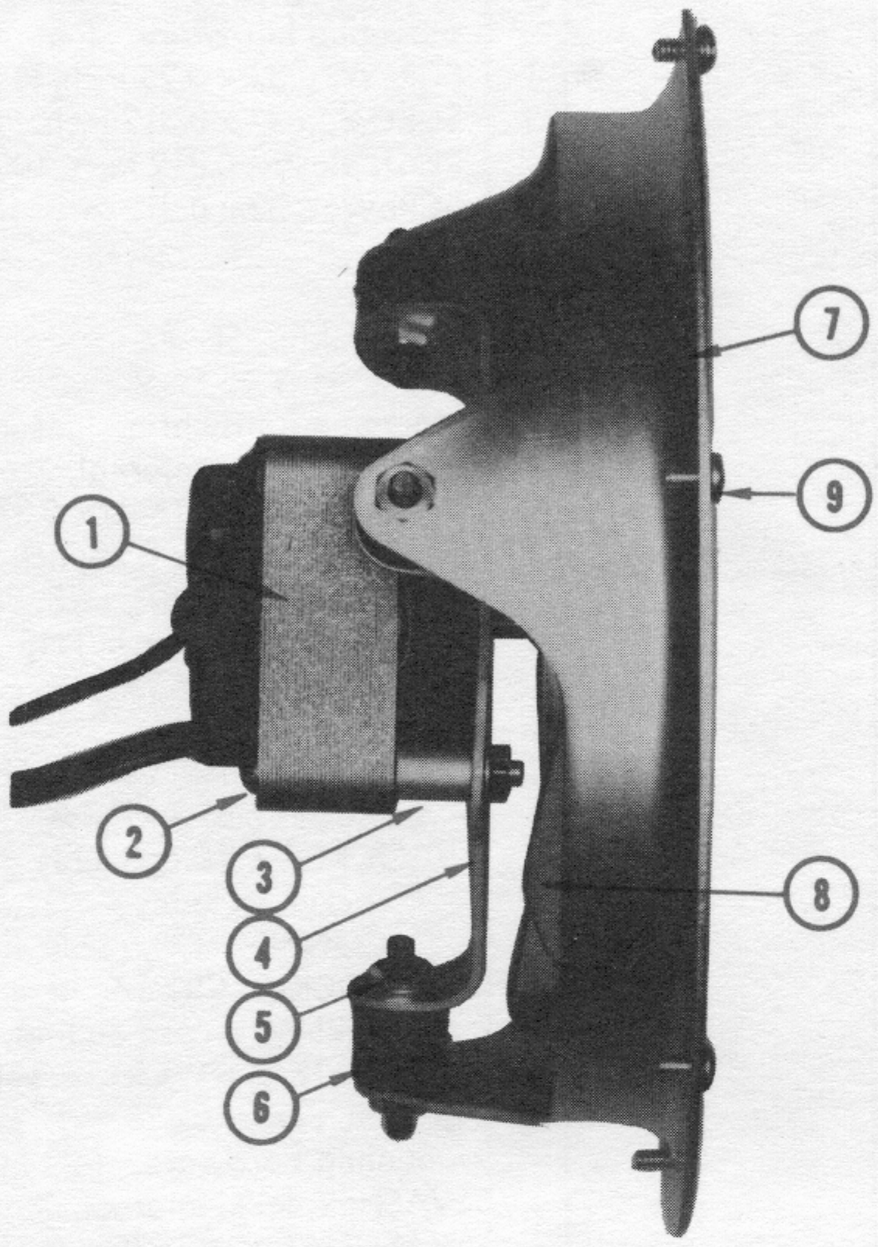




FOCUS AND INTENSITY

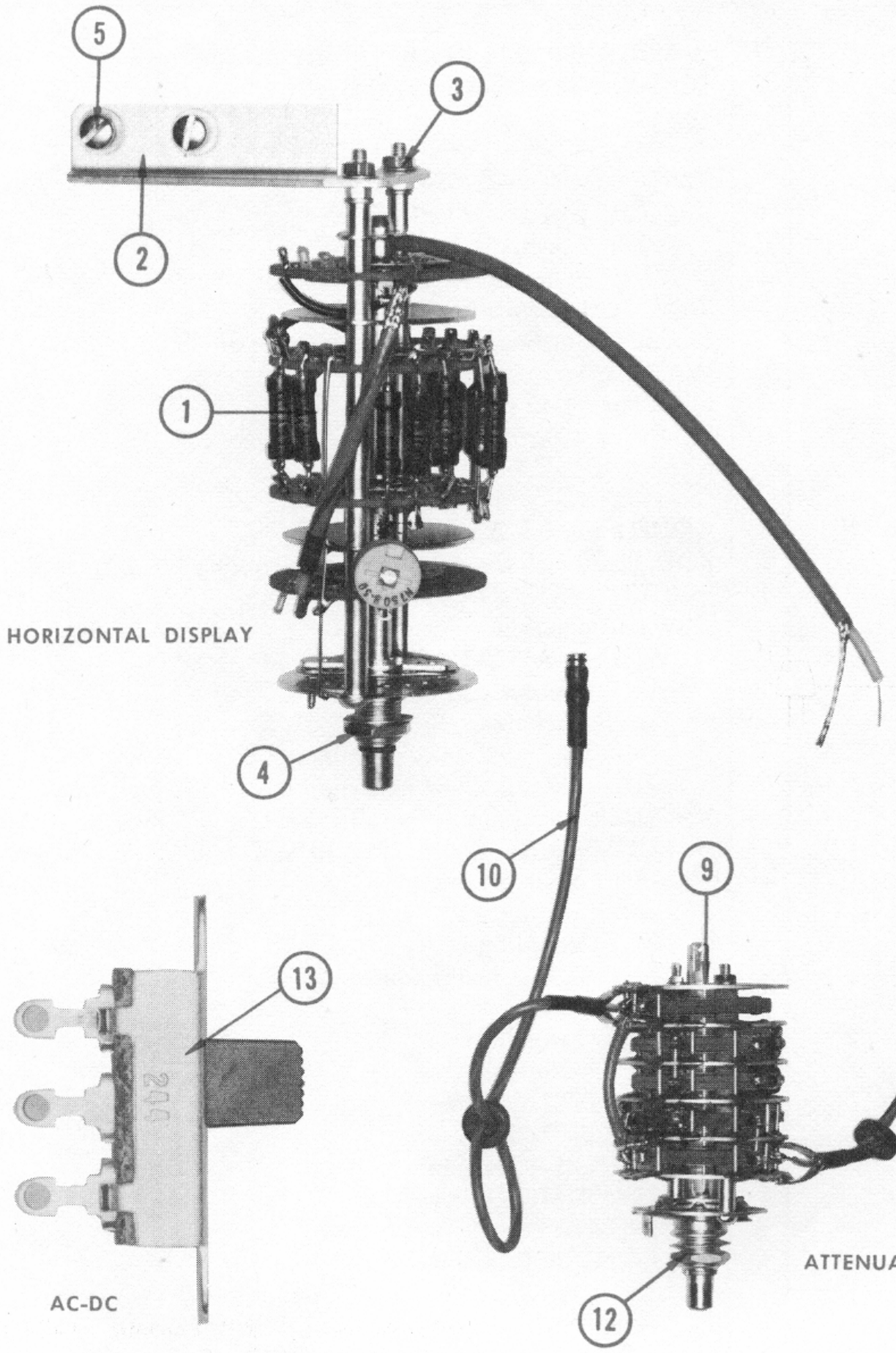
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	337-0473-00			1	SHIELD, H. V., 2.469 x 3.172 x 5.50 inches
	- - - - - -			-	mounting hardware: (not included w/shield)
-2	211-0504-00			1	SCREW, 6-32 x 0.25 inch, PHS
	211-0507-00			2	SCREW, 6-32 x 0.312 inch, PHS
	385-0020-00			1	ROD, plastic, 0.312 inch, 100° csk, FHS
-3	211-0538-00			1	SCREW, 6-32 x 0.312 inch, 100° csk, FHS
-4	210-0202-00			2	LUG, solder, SE #6
-5	387-0484-00			1	PLATE, H. V.
	- - - - - -			-	mounting hardware: (not included w/plate)
-6	210-0006-00			4	WASHER, lock, internal, #6
	210-0803-00			2	WASHER, flat, 0.15 ID x 0.375 inch OD
	210-0407-00			4	NUT, hex., 6-32 x 0.25 inch
-7	211-0516-00			2	SCREW, 6-32 x 0.875 inch, PHS
	211-0517-00			2	SCREW, 6-32 x 1 inch, PHS
-8	179-0591-00			1	CABLE HARNESS, CRT socket
	- - - - - -			-	cable harness includes:
-9	136-0128-00			1	SOCKET, CRT assembly
	- - - - - -			-	socket includes:
	131-0178-00			9	CONNECTOR, cable end, CRT for 14 pin
	136-0117-00			1	SOCKET, CRT 14 pin, 0.625 inch thick, without leads
	213-0086-00			2	SCREW, thread cutting, 2-32 x 0.438 inch, PHS
	387-0393-00			1	PLATE, back, CRT socket, 0.125 thick x 2.185 inches OD
-10	343-0007-00			1	CLAMP, cable, 0.625 inch, plastic
	- - - - - -			-	mounting hardware: (not included w/clamp)
	210-0006-00			1	WASHER, lock, internal, #6
	210-0803-00			1	WASHER, flat, 0.15 ID x 0.375 inch OD
	210-0407-00			1	NUT, hex., 6-32 x 0.25 inch
	210-0510-00			1	SCREW, 6-32 x 0.375 inch, PHS
-11	179-0588-00			1	CABLE HARNESS, F&I
-12	343-0002-00			2	CLAMP, cable, 0.188 inch plastic
-13	346-0001-00			1	STRAP, mounting, 0.312 x 4.25 inches
	- - - - - -			-	mounting hardware: (not included w/strap)
-14	210-0004-00			2	WASHER, lock, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 0.188 inch
-15	387-0482-00			1	PLATE, 0.50 x 3.375 x 5.50 inches (H. V. Support)
	- - - - - -			-	mounting hardware: (not included w/plate)
-16	166-0107-00			4	TUBE, spacing, 0.18 x 0.25 OD x 0.219 inch
-17	210-0004-00			4	WASHER, lock, internal, #4
	210-0406-00			4	NUT, hex., 4-40 x 0.188 inch

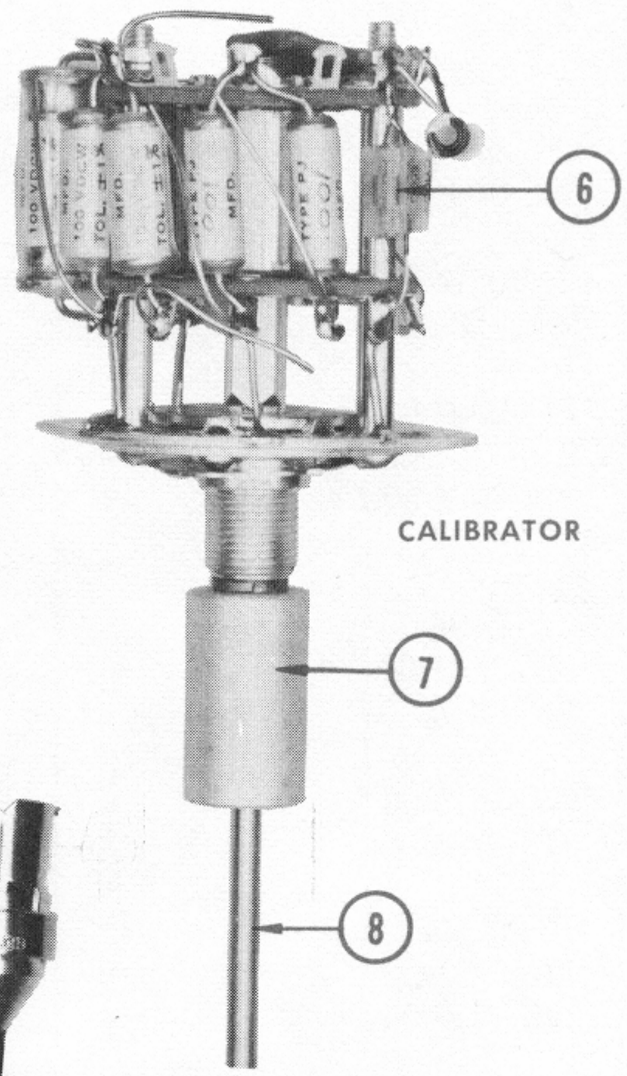
FAN



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-	635-0430-00	101	3189	1	FAN MOTOR ASSEMBLY
-	635-0427-00	3190		1	FAN MOTOR ASSEMBLY
	- - - - - -			-	fan motor assembly includes:
-1	147-0022-00			1	MOTOR, 115 volt, AC, 0.157 inch shaft
	- - - - - -			-	mounting hardware: (not included w/motor)
-2	212-0022-00			2	SCREW, 8-32 x 1.50 inches, RHS
	210-0008-00			2	WASHER, lock, internal, #8
	210-0409-00			2	NUT, hex., 8-32 x 0.312 inch
-3	166-0006-00			2	TUBE, spacer, 0.196 ID x 0.312 OD x 0.438 inch
-4	426-0046-00			1	MOUNT, fan motor
	- - - - - -			-	mounting hardware: (not included w/mount)
-5	210-0409-00			6	NUT, hex., 8-32 x 0.312 inch
	210-0008-00			6	WASHER, lock, internal, #8
-6	348-0008-00			3	SHOCKMOUNT, 0.50 OD x 0.50 inch long
-7	354-0051-00			1	RING, fan, 5.75 inches ID
-8	369-0015-00			1	FAN, clockwise, 5.50 inches
	- - - - - -			-	fan includes:
	213-0007-00			1	SETSCREW, 10-32 x 0.25 inch, HSS
	- - - - - -			-	mounting hardware: (not included w/fan motor assembly)
-9	211-0507-00			6	SCREW, 6-32 x 0.312 inch, PHS

SWITCHES



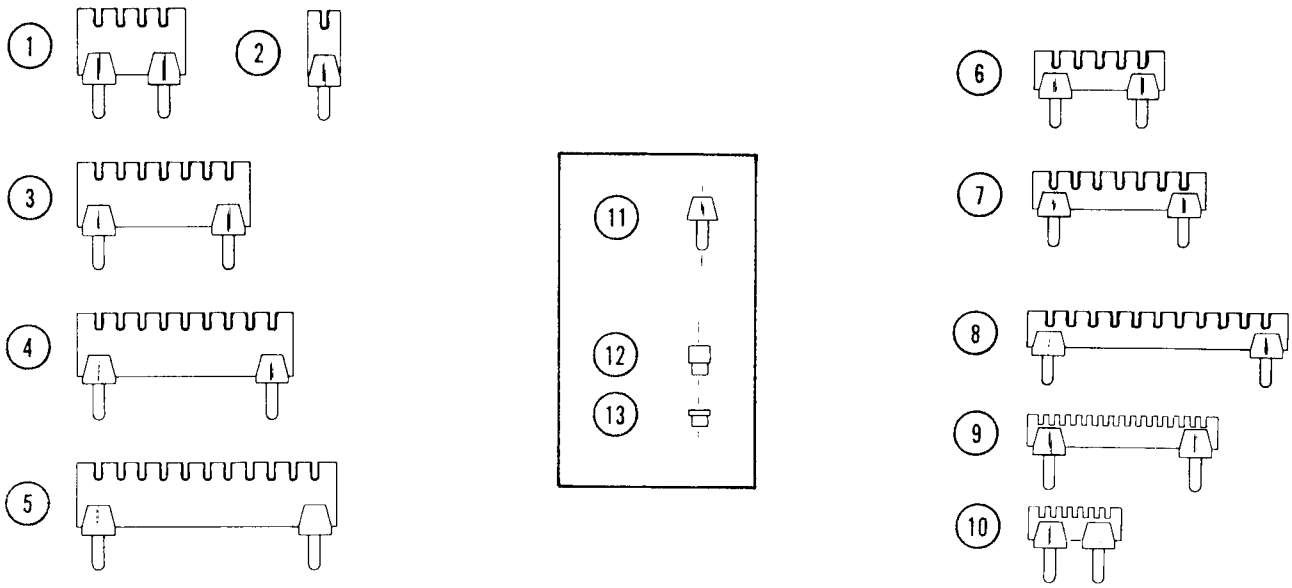


REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	262-0441-00			1	SWITCH—HORIZONTAL DISPLAY, wired
	- - - - - -			-	switch includes:
	260-0414-00			1	SWITCH—HORIZONTAL DISPLAY, unwired
-2	406-0777-00			1	BRACKET, 0.872 x 1.938 x 2.75 inches
-3	210-0006-00			2	WASHER, lock, internal, #6
	210-0449-00			2	NUT, hex., 5-40 x 0.25 inch
	- - - - - -			-	mounting hardware: (not included w/switch)
-4	210-0012-00			1	WASHER, lock, internal, 0.375 x 0.50 inch
	210-0413-00			1	NUT, hex., 0.375-32 x 0.50 inch
	210-0840-00			1	WASHER, 0.39 ID x 0.562 OD

SWITCHES (cont)

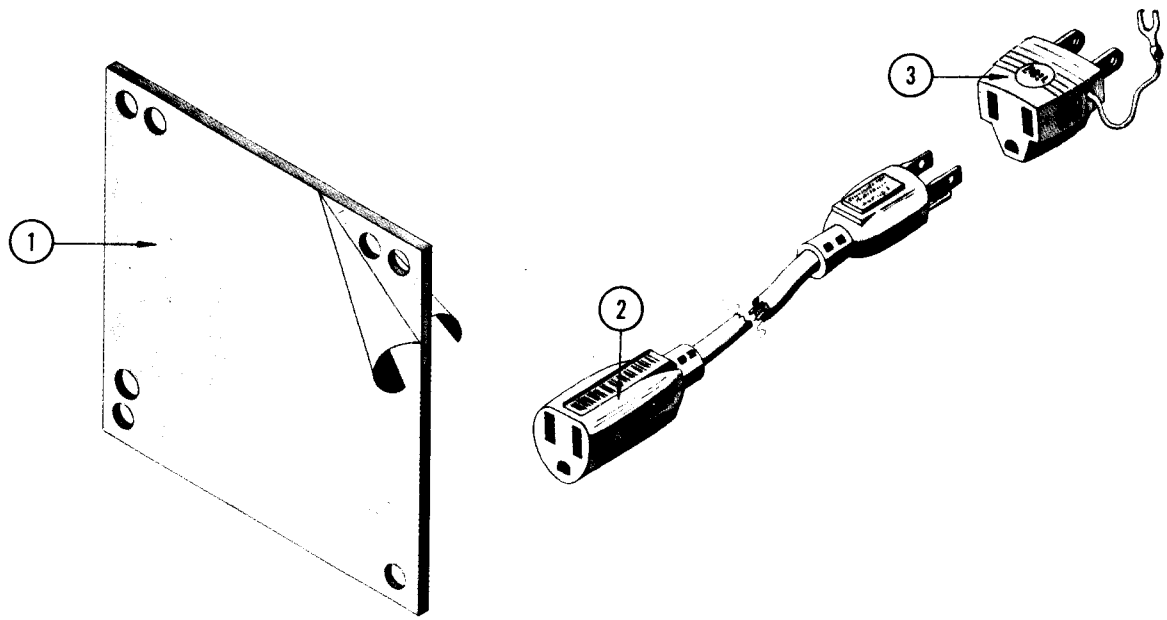
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-5	210-0803-00			2	WASHER, flat, 0.15 ID x 0.375 inch OD
	211-0507-00			2	SCREW, 6-32 x 0.312 inch, PHS
-6	262-0440-00	101	1999	1	SWITCH, wired—CALIBRATOR
	262-0636-00	2000		1	SWITCH, wired—CALIBRATOR
	- - - - - -			-	switch includes:
	260-0416-00	101	1999	1	SWITCH, unwired—CALIBRATOR
	260-0585-00	2000		1	SWITCH, unwired—CALIBRATOR
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0004-00			2	WASHER, lock, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 0.188 inch
	211-0008-00			2	SCREW, 4-40 x 0.25 inch, PHS
-7	376-0008-00			1	COUPLING, 0.875 inch long
-8	385-0161-00			1	ROD, 0.125 inch diameter x 7.875 inch long
-9	262-0464-00			1	SWITCH—ATTENUATOR, wired
	- - - - - -			-	switch includes:
	260-0415-00			1	SWITCH—ATTENUATOR, unwired
-10	175-0233-00			1	CABLE, Output assembly
	- - - - - -			-	cable includes:
	131-0155-00			1	CONNECTOR, coaxial, miniature
	166-0221-00			1	TUBE, ferrule, 0.087 inch diameter x 0.25 inch long
	166-0239-00			1	TUBE, coaxial, adapter, 0.156 OD x 0.75 inch
	276-0525-00			1	CORE, ferrite, 0.437 OD x 0.196 ID x 0.125 inch thick
-11	175-0232-00			1	CABLE, input assembly
	- - - - - -			-	cable includes:
	132-0001-00			1	NUT, coupling
	132-0002-00			1	SLEEVE, conductor, outer
	132-0007-00			1	RING, snap
	132-0016-00	101	1088	1	NUT, retaining
	132-0121-00	1089		1	NUT, retaining
	132-0026-00	101	749	1	TRANSISTION, outer
	132-0115-00	750		1	TRANSISTION, outer
	132-0027-00	101	749	1	TRANSISTION, inner
	132-0116-00	750		1	TRANSISTION, inner
	132-0028-00			1	INSULATOR
	132-0029-00			1	CONDUCTOR, inner
	166-0221-00			1	TUBE, ferrule, 0.089 inch diameter x 0.25 inch long
	166-0239-00			1	TUBE, coaxial, adapter, 0.156 OD x 0.75 inch
	276-0525-00			1	CORE, ferrite, 0.437 OD x 0.196 ID x 0.125 inch thick
	- - - - - -			-	mounting hardware: (not included w/cable)
-12	210-0012-00			11	WASHER, lock, 0.375-32 x 0.50 inch
	210-0413-00			1	NUT, hex., 0.375-32 x 0.50 inch
	210-0840-00			1	WASHER, flat, 0.39 ID x 0.562 inch OD
-13	260-0145-00			1	SWITCH, SLIDE, with black button, unwired
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0004-00			2	WASHER, lock, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 0.188 inch

CERAMIC STRIPS



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	124-0088-00			1	TERMINAL STRIP, ceramic, 0.75 inch h, 4 notch
-2	124-0100-00			1	TERMINAL STRIP, ceramic, 0.75 inch h, 1 notch
-3	124-0089-00			17	TERMINAL STRIP, ceramic, 0.75 inch h, 7 notch
-4	124-0090-00			12	TERMINAL STRIP, ceramic, 0.75 inch h, 9 notch
-5	124-0091-00			4	TERMINAL STRIP, ceramic, 0.75 inch h, 11 notch
-6	124-0093-00			1	TERMINAL STRIP, ceramic, 0.438 inch h, 5 notch
-7	124-0094-00			1	TERMINAL STRIP, ceramic, 0.438 inch h, 7 notch
-8	124-0106-00			2	TERMINAL STRIP, ceramic, 0.438 inch h, 11 notch
-9	124-0146-00			2	TERMINAL STRIP, ceramic, 0.438 inch h, 16 small notch
-10	124-0149-00			2	TERMINAL STRIP, ceramic, 0.438 inch h, 7 small notch
-11	355-0046-00			43	STUD, clip, plastic
-12	361-0008-00			35	SPACER, 0.25 inch high
-13	361-0007-00			8	SPACER, 0.156 inch high

STANDARD ACCESSORIES



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-1	378-0514-00	101	2774	1	FILTER, light, plastic, 5 inch green, with cam hole
	378-0567-00	2775		1	FILTER, light, smoke gray
-2	161-0010-00	101	3309	1	CORD, power, 16 gauge, 8 foot
	161-0010-03	3310		1	CORD, power, 16 gauge, 8 foot
-3	103-0013-00			1	ADAPTER, power cord, 3-wire to 2-wire
	070-0324-00			2	MANUAL, instruction (not shown)

ELECTRICAL PARTS

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description					S/N Range
		Bulbs					
B388	Use 150-027	Neon, NE-23					101-2919
B388	150-0030-00	Neon, NE-2V					2920-up
R389	Use 150-027	Neon, NE-23					101-2919
B389	150-0030-00	Neon, NE-2V					2920-up
R468	Use 150-027	Neon, NE-23					101-2919
B468	150-0030-00	Neon, NE-2V					2920-up
B469	Use 150-027	Neon, NE-23					101-2919
B469	150-0030-00	Neon, NE-2V					2920-up
B604	150-001	Incandescent #47	Graticule Light				
B605	150-001	Incandescent #47	Graticule Light				
B627	Use 150-027	Neon, NE-23					
B847	Use 150-027	Neon, NE-23					
B848	Use 150-027	Neon, NE-23					
		Capacitors					

Tolerance ±20% unless otherwise indicated.

Tolerance of all electrolytic capacitors are as follows (with exceptions):

3 V— 50 V = —10%, +250%
51 V—350 V = —10%, +100%
351 V—450 V = —10%, + 50%

C301	285-576	1 μf	PTM		100 v	10%	
C302	281-022	8-50 pf	Cer.	Var.			
C307	290-099	100 μf	EMT		15 v		
C318	290-121	2 μf	EMC		25 v		101-809
	290-107	25 μf	EMT		25 v		810-up
C336	281-504	10 pf	Cer.		500 v	10%	
C385	281-504	10 pf	Cer.		500 v	10%	
C600A	281-559	1500 pf	Cer.		500 v		
C600B	281-559	1500 pf	Cer.		500 v		
C601	285-588	2 μf	PMC		236 v		
C602	Use 290-077	2 x 100 μf	EMC		350 v		
C610	281-519	47 pf	Cer.		500 v	10%	
C620	281-504	10 pf	Cer.		500 v	10%	
C627	283-002	.01 μf	Disc Type		500 v		
C636	*290-054	2 x 15 μf	EMC		450 v		101-899
C636	Use 290-023	2 x 40 μf	EMC		150 v		900-up
C642	290-160	4000 μf	EMC		50 v		
C644	290-137	100 μf	EMT		30 v		
C646	Use 290-118	2 x 100 μf	EMC		50 v		
C652	283-003	.01 μf	Disc Type		150 v		
C656	290-015	100 μf	EMT		25 v		
C657	283-024	.1 μf	Disc Type		30 v		X810-up
C662	Use 290-086	2000 μf	EMC		30 v		
C668	283-024	.1 μf	Disc Type		30 v		
C676	290-015	100 μf	EMT		25 v		
C682	Use 290-077	2 x 100 μf	EMC		350 v		

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				S/N Range
C684	281-504	10 pf	Cer.	500 v	10%	
C694	290-0116-00	500 μf	EMT	25 v		X3460-up
C696A,B	Use 290-007	2 x 15 μf	EMC	450 v		
C702	Use 290-077	2 x 100 μf	EMC	350 v		
C707	281-519	47 pf	Cer.	500 v	10%	
C716	285-510	.01 μf	PTM	400 v		
C720	281-504	10 pf	Cer.	500 v	10%	
C801	283-006	.02 μf	Disc Type	600 v		
C803	285-501	.001 μf	PTM	600 v		
C807	285-501	.001 μf	PTM	600 v		
C809	Use 283-0619-00	.001 μf	Mica	1500 v		
C822	283-036	2500 pf	Disc Type	6000 v		
C841	283-006	.02 μf	Disc Type	500 v		
C842	283-036	2500 pf	Disc Type	6000 v		
C850	283-006	.02 μf	Disc Type	500 v		
C867	285-510	.01 μf	PTM	400 v		
C874	283-001	.005 μf	Disc Type	500 v		101-899
	285-527	.1 μf	MPT	600 v		900-up
C878	281-525	470 pf	Cer.	500 v		
C902	285-595	.1 μf	PTM	100 v	1%	
C903	285-595	.1 μf	PTM	100 v	1%	
C907	285-596	.01 μf	PTM	100 v	1%	101-1999
	283-593	.01 μf	Mica	100 v	1%	2000-up
C908	285-596	.01 μf	PTM	100 v	1%	101-1999
	283-593	.01 μf	Mica	100 v	1%	2000-up
C912	285-597	.001 μf	PTM	100 v	1%	101-1999
C912	283-594	.001 μf	Mica	100 v	1%	2000-up
C913	285-597	.001 μf	PTM	100 v	1%	101-1999
	283-594	.001 μf	Mica	100 v	1%	2000-up
C916	281-011	5-25 pf	Cer. Var.			101-399
	281-063	9-35 pf	Cer. Var.			400-1999
C916	281-501	4.7 pf	Cer Var.	500 v	±1 pf	2000-up
C917	281-590	56 pf	Cer.	500 v	2%	101-1999X
C918	281-590	56 pf	Cer.	500 v	2%	101-1999X
C919	Use 281-505	12 pf (Nominal value) selected				101-1999X
C920	281-013	8-50 pf	Cer. Var.			101-399
C920	281-063	9-35 pf	Cer. Var.			400-1999X
C922	Use 281-519	47 pf	Cer.	500 v	10%	101-1999X
C933	283-059	1 μf	Disc Type	25 v		X2000-up
C934	281-603	39 pf	Cer.	500 v	5%	X2000-up
C935	281-562	39 pf	Cer.	500 v		X2000-up
C936	281-559	1500 pf	Cer.	500 v		101-1999
	283-003	.01 μf	Disc Type	150 v		2000-up
C937	290-135	15 μf	EMT	20 v		X2000-up
C939	283-004	.02 μf	Disc Type	150 v		101-1999
	283-026	.2 μf	Disc Type	25 v		2000-up

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				S/N Range
C940	281-559	1500 pf	Cer.	500 v		101-1999
	281-598	1000 pf	Cer.			2000-up
C941	283-059	1 μf	Disc Type	25 v		101-1999X
C942	Use 281-061	5.5-18 pf	Cer.	Var.		X2000-up
C944	283-026	.2 μf	Disc Type	25 v		X2000-up
C947	283-079	.01 μf	Disc Type	250 v		X2000-up
C948	281-598	1000 pf	Cer			X2000-up
C949	283-008	.1 μf	Disc Type	500 v		X2000-up
C951	281-559	1500 pf	Cer.	500 v		101-1999X
C952	283-059	1 μf	Disc Type	25 v		101-1999X
C954	281-003	.01 μf	Disc Type	150 v		101-1999X
C955	281-559	1500 pf	Cer.	500 v		101-1999X
C956	283-003	.01 μf	Disc Type	150 v		101-1999
	281-509	15 pf	Cer.	500 v	10%	2000-up
C961	281-559	1500 pf	Cer.	500 v		101-1999X
C962	283-004	.02 μf	Disc Type	150 v		101-1999X
C963	281-559	1500 pf	Cer.	500 v		101-1999X
C964	283-026	.2 μf	Disc Type	25 v		101-1999X
C965	283-057	.1 μf	Disc Type	200 v		X2000-up
C968	Use 281-061	5.5-18 pf	Cer.	Var.		X2000-up
C971	Use 281-060	2-8 pf	Cer.	Var.		X2000-up
C991	283-0070-00	30 pf	Disc Type	50 v	10%	X3460-up
C992	283-0000-00	.001 μf	Disc Type	500 v		X3460-up
C993	283-010	.05 μf	Disc Type	50 v		101-361X
C993	283-0003-00	.01 μf	Disc Type	150 v		X3460-up
C994	290-116	500 μf	EMT	25 v		X251-3459
C994	290-0135-00	15 μf	EMT	20 v		3460-up
C996	281-559	1500 pf	Cer.	500 v		101-1999X
C997	281-559	1500 pf	Cer.	500 v		101-1999X
C998	281-559	1500 pf	Cer.	500 v		101-1999X
C999	281-559	1500 pf	Cer.	500 v		101-1999X

Diodes

D312	*152-045	Silicon Selected 1N622A	101-939
D312	Use *152-185	Silicon Replaceable by 1N4152	940-up
D313	*152-045	Silicon Selected 1N622A	101-939
D313	Use *152-185	Silicon Replaceable by 1N4152	940-up
D314	152-016	Zener RT6	
D323	152-008	Germanium T12G	101-2479X
D334	152-016	Zener RT6	
D602A,B,C,D	*152-047	Silicon Replaceable by 1N2862	101-3069
D602A,B,C,D	152-0066-00	Silicon 1N3194	3070-up
D642A,B,C,D	152-035	Silicon 1N1563A (or equal)	
D643	152-022	Zener 1M25Z5	
D644	152-008	Germanium T12G	101-2609
D644	*152-0185-00	Silicon Replaceable by 1N3605	2610-up
D649	152-089	Zener 10M12.6Z5	
D653	152-008	Germanium T12G	
D662A,B,C,D	152-035	Silicon 1N1563A (or equal)	
D672	152-008	Germanium T12G	

Diodes *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description			S/N Range
D682A,B,C,D	*152-047	Silicon Replaceable by 1N2862			101-3069
D682A,B,C,D	152-0066-00	Silicon 1N3194			3070-up
D702A,B,C,D	*152-047	Silicon Replaceable by 1N2862			101-3069
D702A,B,C,D	152-0066-00	Silicon 1N3194			3070-up
D726	152-068	Zener 1N3031A	1 W, 30 V, 10%		101-3559
D726	152-0292-00	Zener 1N3031B	1W, 30 V, 5%		3560-up
D879	152-025	Germanium 1N634			101-2829X
D930	152-141	Silicon 1N4152			X2000-3579
D930	152-0141-02	Silicon 1N4152			3580-up
D942	152-090	Silicon FD613			101-1999X
D952	152-090	Silicon FD613			101-1999X
D958, D959	*152-152	Tek GaAs (1 pair)			X2000-up
D990	152-0070-00	Tunnel BD4			X3460-up
D991	152-0098-00	Tunnel 1N3718			X3460-3569
D991	152-0182-00	Tunnel 1N3719 10 mA, 50 pf			3570-up
D992	Use *050-072	Replacement Kit			101-269
D992	152-099	Tunnel TD1081			270-3459X
D995	*152-0334-00	Tunnel 50 mA w/o leads			X3460-up
D996	*152-0107-00	Silicon Replaceable by 1N647			X3460-up

Fuses

F601	159-017	4 Amp 3AG Fast-Blo 117 v 50 & 60 Cycle			
	Use 159-0023-00	2 Amp 3AG Slo-Blo 234 v 50 & 60 Cycle			

Inductors

L901	*114-145	48-52 μh	Var.	Core 276-536	101-1999
L901	*114-162	49-53 μh	Var.	Core 276-548	2000-up
L906	Use *114-157	3.5-6 μh	Var.	Core 276-511	
L911	*114-146	.3-.55 μh	Var.	Core 276-511	
L912	276-507	Core, Ferramic Suppressor			X2000-up
L916	*108-242	35 nh			101-1999
L916	*114-161	35-52 μh	Var.	Core 276-506	2000-up
L936	*108-241	.05 μh			101-1999X
L940	108-249	12 μh			X2000-up
L948	108-226	100 μh			X2000-up
L955	*108-206	.15 μh			X2000-up
L958	*108-088	3.2 μh			X2000-up
L960	108-240	820 μh			X2000-up
L970	*108-088	3.2 μh			X2000-up
L979	276-525	Ferrite Core			
L984	276-525	Ferrite Core			
L990	*120-266	Toroid 10T TD63			101-361
L990	*120-202	Toroid 15T TD27			362-3459
L990	276-0543-00	Ferrite Core			3460-up
L992	*108-261	Air Core, 4 Turns #27 Wire on 1/8" Dia			X362-3579
L993	*120-0382-00	Toroid 14T			X3460-up
L994	276-0543-00	Ferrite Core			X3460-up
L995	*108-0467-00	5 μh			X3460-up

Connectors

P950	131-156	Coaxial, 50 Ω, mini	X2000-up
P979	131-156	Coaxial, 50 Ω, mini	X2000-up

Resistors

Ckt. No.	Tektronix Part No.	Description				S/N Range
Resistors are fixed, composition, ±10% unless otherwise indicated.						
R302	318-012	25 k	1/8 w	Prec.	1%	
R303	309-182	3 k	1/2 w	Prec.	1%	
R304	301-823	82 k	1/2 w		5%	
R305†	311-272	5 k	Var.		VERNIER	
R306	301-823	82 k	1/2 w		5%	
R307	301-392	3.9 k	1/2 w		5%	
R308	301-392	3.9 k	1/2 w		5%	101-3089
R308	301-0362-00	3.6 k	1/2 w		5%	3090-up
R309	301-822	8.2 k	1/2 w		5%	
R310†	311-272	5 k	Var.		POSITION	
R311A	309-115	1 k	1/2 w	Prec.	1%	
R311B	309-098	2 k	1/2 w	Prec.	1%	
R311C	309-159	5 k	1/2 w	Prec.	1%	
R311D	309-100	10 k	1/2 w	Prec.	1%	
R311E	309-153	20 k	1/2 w	Prec.	1%	
R311F	309-280	51.1 k	1/2 w	Prec.	1%	
R311G	Use 323-387	105 k	1/2 w	Prec.	1%	
R311H	309-181	2.5 k	1/2 w	Prec.	1%	
R311J	309-193	25 k	1/2 w	Prec.	1%	
R311K	309-115	1 k	1/2 w	Prec.	1%	
R311L	309-036	18 k	1/2 w	Prec.	1%	
R312	301-473	47 k	1/2 w		5%	101-939
R312	301-623	62 k	1/2 w		5%	940-up
R314	301-332	3.3 k	1/2 w		5%	
R317	301-622	6.2 k	1/2 w		5%	
R318	302-100	10 Ω	1/2 w			101-809
R318	316-101	100 Ω	1/4 w			810-up
R319	316-391	390 Ω	1/4 w			
R324	302-473	47 k	1/2 w			
R335	309-100	10 k	1/2 w	Prec.	1%	
R337	309-100	10 k	1/2 w	Prec.	1%	
R338	301-682	6.8 k	1/2 w		5%	
R341	302-101	100 Ω	1/2 w			
R344	301-912	9.1 k	1/2 w		5%	
R349	301-912	9.1 k	1/2 w		5%	
R354	301-912	9.1 k	1/2 w		5%	
R356	304-333	33 k	1 w			
R357	311-026	100 k	2 w	Var.	HORIZ. DC BAL.	
R358	309-390	429 k	1/2 w	Prec.	1%	101-309
	309-101	330 k	1/2 w	Prec.	1%	310-up
R359	311-106	200 k		Var.		X310-up

† R305 and R310 furnished as a unit.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R361	302-470	47 Ω	½ w				
R362	302-470	47 Ω	½ w				
R363	308-211	12 k	5 w		WW	5%	
R364	308-051	4 k	5 w		WW	5%	
R367	308-211	12 k	5 w		WW	5%	
R376	309-390	429 k	½ w		Prec.	1%	
R377	309-045	100 k	½ w		Prec.	1%	
R378	311-026	100 k	2 w	Var.		HORIZ. TAKEOFF DC LEVEL	
R379	309-049	150 k	½ w		Prec.	1%	
R380	311-078	50 k	.1 w	Var.		HORIZ. TAKEOFF GAIN	101-309
	311-115	100 k		Var.		HORIZ. TAKEOFF GAIN	310-up
R381	309-162	250 k	½ w		Prec.	1%	101-309
	309-052	220 k	½ w		Prec.	1%	310-up
R382	304-333	33 k	1 w				
R383	302-101	100 Ω	½ w				
R384	302-224	220 k	½ w				
R385	302-274	270 k	½ w				
R386	304-103	10 k	1 w				101-2399
R386	306-153	15 k	2 w				2400-up
R387	304-333	33 k	1 w				101-2399
R387	306-273	27 k	2 w				2400-up
R388	316-154	150 k	¼ w				
R389	316-154	150 k	¼ w				
R390	316-394	390 k	¼ w				X2400-up
R391	302-101	100 Ω	½ w				
R401	302-101	100 Ω	½ w				
R404	301-912	9.1 k	½ w			5%	
R409	301-912	9.1 k	½ w			5%	
R414	301-912	9.1 k	½ w			5%	
R441	302-470	47 Ω	½ w				
R444	308-211	12 k	5 w		WW	5%	
R449	308-051	4 k	5 w		WW	5%	
R451	302-470	47 Ω	½ w				
R456	308-051	4 k	5 w		WW	5%	
R458	308-053	8 k	5 w		WW	5%	
R461	302-334	330 k	½ w				
R462	302-101	100 Ω	½ w				
R463	302-685	6.8 meg	½ w				X2400-up
R466	306-104	100 k	2 w				
R467	316-394	390 k	¼ w				X2400-up
R468	316-154	150 k	¼ w				
R469	316-154	150 k	¼ w				
R472	309-390	429 k	½ w		Prec.	1%	
R473		Selected					101-309X
R476	304-333	33 k	1 w				
R477	311-026	100 k	2 w	Var.		VERT. DC BAL.	
R600	306-100	10 Ω	2 w				
R601	308-079	117 Ω	5 w		WW	5%	
R602	302-104	100 k	½ w				
R603	302-563	56 k	½ w				

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R604†	311-275	50 Ω		Var.	WW	SCALE ILLUM.	
R605	308-142	30 Ω	3 w		WW	5%	
R610	309-261	300 k	½ w		Prec.	1%	
R612	309-045	100 k	½ w		Prec.	1%	
R614	301-624	620 k	½ w			5%	
R616	302-224	220 k	½ w				
R617	301-624	620 k	½ w			5%	
R618	302-105	1 meg	½ w				
R620	302-105	1 meg	½ w				
R621	302-105	1 meg	½ w				
R623	302-471	470 Ω	½ w				
R626	Use 304-104	100 k	1 w				
R628	301-204	200 k	½ w			5%	
R629	301-513	51 k	½ w			5%	
R630	302-470	47 Ω	½ w				
R631	303-510	51 Ω	1 w			5%	101-1219
R631	301-330	33 Ω	½ w			5%	1220-up
R632	302-470	47 Ω	½ w				
R633	303-510	51 Ω	1 w			5%	101-1219
	301-330	33 Ω	½ w			5%	1220-up
R635	308-091	2 k	5 w		WW	5%	X2000-up
R640	*308-087	.5 Ω	1 w		WW	1%	
R641	*308-087	.5 Ω	1 w		WW	1%	X200-up
R643	301-512	5.1 k	½ w			5%	101-2609
R643	301-0202-00	2 k	½ w			5%	2610-up
R644	301-101	100 Ω	½ w			5%	101-2609
R644	315-0201-00	200 Ω	¼ w			5%	2610-up
R645	301-304	300 k	½ w			5%	
R646	Use 304-154	150 k	1 w			5%	
R647	Use 308-012	40 Ω	10 w		WW	5%	
R648	*310-537	2.47 Ω	8 w		Mica Plate	1%	
R649	308-012	40 Ω	10 w		WW	5%	101-2609
R649	308-0153-00	100 Ω	10 w		WW	5%	2610-up
R650	309-098	2 k	½ w		Prec.	1%	
R651	311-158	200 Ω		Var.		−19 VOLTS	
R652	309-098	2 k	½ w		Prec.	1%	
R653	302-472	4.7 k	½ w				101-809
R653	316-472	4.7 k	¼ w				810-up
R654	301-513	51 k	½ w			5%	
R655	301-273	27 k	½ w			5%	
R656	308-179	5 Ω	5 w		WW	5%	
R657	316-102	1 k	¼ w				X810-up
R659	308-0174-00	117 Ω	8 w		WW	5%	X2610-up
R660	*308-087	.5 Ω	1 w		WW	1%	
R664	310-087	120 k	1 w		Prec.	1%	
R665	310-087	120 k	1 w		Prec.	1%	
R666	311-155	1 k		Var.		+19 VOLTS	
R668	309-105	4.21 k	½ w		Prec.	1%	
R669	301-243	24 k	½ w			5%	

† R604 and SW604 are ganged. Furnished as a unit.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R671	305-823	82 k	2 w			5%	
R673	301-243	24 k	½ w			5%	
R674	301-123	12 k	½ w			5%	
R675	308-179	5 Ω	5 w		WW	5%	
R676	308-179	5 Ω	5 w		WW	5%	X717-up
R680	304-100	10 Ω	1 w				
R681	304-100	10 Ω	1 w				
R682	302-104	100 k	½ w				
R684	309-045	100 k	½ w		Prec.	1%	101-899
	309-044	95 k	½ w		Prec.	1%	900-up
R685	309-044	95 k	½ w		Prec.	1%	
R686	311-017	10 k	.1 w	Var.		100 v ADJ.	X900-up
R693	302-104	100 k	½ w				
R694		Selected					
R695	302-470	47 Ω	½ w				
R699	302-103	10 k	½ w				
R700	306-100	10 Ω	2 w				
R702	301-204	200 k	½ w			5%	
R704	302-335	3.3 meg	½ w				
R705	301-824	820 k	½ w			5%	
R706		Selected					
R707	309-125	300 k	½ w		Prec.	1%	
R708	309-161	106 k	½ w		Prec.	1%	
R710	301-244	240 k	½ w			5%	
R711	302-105	1 meg	½ w				
R712	309-243	193 k	½ w		Prec.	1%	
R713	301-244	240 k	½ w			5%	
R716	302-224	220 k	½ w				
R717	309-045	100 k	½ w		Prec.	1%	
R718	311-016	10 k	2 w	Var.		+300 VOLTS	
R719	305-473	47 k	2 w			5%	
R720	301-105	1 meg	½ w			5%	
R721	301-514	510 k	½ w			5%	
R723	302-471	470 Ω	½ w				
R726	308-112	6 k	5 w		WW	1%	
R727	302-104	100 k	½ w				
R730	302-470	47 Ω	½ w				
R731	303-510	51 Ω	1 w			5%	
R732	302-470	47 Ω	½ w				
R733	303-510	51 Ω	1 w			5%	
R737	308-176	4 k	20 w		WW	5%	
R801	306-681	680 Ω	2 w				
R803	306-473	47 k	2 w				
R804	302-101	100 Ω	½ w				
R806	302-104	100 k	½ w				

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R807	301-472	4.7 k	½ w			5%	
R814	302-102	1 k	½ w				
R815	302-474	470 k	½ w				
R817	302-101	100 Ω	½ w				
R840	Use 306-395	3.9 meg	2 w				
R841	311-042	2 meg	2 w	Var.		HIGH VOLTAGE	
R842	306-126	12 meg	2 w				
R843	306-126	12 meg	2 w				
R845	311-121	5 meg		Var.		FOCUS	101-3489
R845	311-0121-01	5 meg		Var.		FOCUS	3490up
R846	306-565	5.6 meg	2 w				
R847	302-684	680 k	½ w				
R848	311-043	2 meg		Var.		INTENSITY	101-3489
R848	311-0043-02	5 meg		Var.		INTENSITY	3490-up
R849	302-103	10 k	½ w				
R862	302-224	220 k	½ w				
R863	302-104	100 k	½ w				
R864	311-276	250 k		Var.	WW	ASTIGMATISM	
R865	303-223	22 k	1 w			5%	
R866	311-191	10 k		Var.		BLANK BAL.	
R867	303-303	30 k	1 w			5%	
R871	308-211	12 k	5 w		WW	5%	
R873	302-102	1 k	½ w				
R874	308-053	8 k	5 w		WW	5%	
R875	316-101	100 Ω	¼ w				X900-up
R876	316-221	220 Ω	¼ w				
R877	301-392	39 k	½ w			5%	
R878	301-152	1.5 k	½ w			5%	
R879	301-392	3.9 k	½ w			5%	
R904	311-056	500 Ω	.1 w	Var.		(100 KC) CAL. AMPL.	101-1999
	316-100	10 Ω	¼ w				2000-up
R909	311-056	500 Ω	.1 w	Var.		(1 MC) CAL. AMPL.	101-1999
R909	316-100	10 Ω	¼ w				2000-up
R912	316-390	39 Ω	¼ w				X2000-up
R914	311-056	500 Ω	.1 w	Var.		(10 MC) CAL. AMPL.	101-1999X
R919	316-103	10 k	¼ w				X2000-up
R927	315-100	10 Ω	¼ w			5%	101-1999X
R929	315-100	10 Ω	¼ w			5%	101-1999X
R933	315-100	10 Ω	¼ w			5%	101-1999
	315-471	470 Ω	¼ w			5%	2000-up
R934	315-100	10 Ω	¼ w			5%	101-1999
	315-471	470 Ω	¼ w			5%	2000-up
R935	315-100	10 Ω	¼ w			5%	101-1999
	301-181	180 Ω	½ w			5%	2000-up
R939	302-221	220 Ω	½ w				101-1999X
R942	311-433	100 Ω		Var.		OSC. FEEDBACK	X2000-up
R945	308-062	3 k	5 w		WW	5%	X2000-up

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R947	316-101	100 Ω	1/4 w				X2000-up
R951	315-101	100 Ω	1/4 w			5%	X2000-up
R952	315-512	5.1 k	1/4 w			5%	101-1999
	315-101	100 Ω	1/4 w			5%	2000-up
R954	315-100	10 Ω	1/4 w			5%	101-1999
R954	315-272	2.7 k	1/4 w			5%	2000-up
R955	315-101	100 Ω	1/4 w			5%	X2000-up
R957	Use 318-106	4.75 k	1/8 w		Prec.	1%	101-1999X
R958	318-073	5.88 k	1/8 w		Prec.	1%	101-1999X
R959	311-074	5 k	.1 w	Var.		AMPL. LIMIT	101-1999X
R960	308-172	3.5 k	5 w		WW	5%	101-1999
	315-101	100 Ω	1/4 w			5%	2000-up
R962	302-101	100 Ω	1/2 w				101-1999
	311-433	100 Ω		Var.		SYMMETRY	2000-up
R964	308-288	2.15 k	5 w		WW	5%	X2000-up
R965	311-434	500 Ω		Var.	WW	OUTPUT AMPL	X2000-up
R966	318-034	2 k	1/8 w		Prec.	1%	101-1999X
R967	318-090	104 Ω	1/8 w		Prec.	1%	101-1999
	311-097	200 Ω	.5 w	Var.		HF AMPL. COMP.	2000-up
R968	318-090	104 Ω	1/8 w		Prec.	1%	101-1999
R968	316-560	56 Ω	1/4 w				2000-up
R970	315-471	470 Ω	1/4 w			5%	X2000-up
R976	318-083	200 Ω	1/8 w		Prec.	1%	101-1999X
R977	318-091	120 Ω	1/8 w		Prec.	1%	101-1999X
R978	318-091	120 Ω	1/8 w		Prec.	1%	101-1999
R978	321-636	100 Ω	1/8 w		Prec.	1/2%	2000-up
R979	321-636	100 Ω	1/8 w		Prec.	1/2%	X2000-up
R981A	318-092	40.9 Ω	1/8 w		Prec.	1/2%	101-3459
R981A	321-0741-01	40.9 Ω	1/8 w		Prec.	1/2%	3460-up
R981B	318-092	40.9 Ω	1/8 w		Prec.	1/2%	101-3459
R981B	321-0741-01	40.9 Ω	1/8 w		Prec.	1/2%	3460-up
R981C	318-093	20.2 Ω	1/8 w		Prec.	1/2%	101-3459
R981C	321-0740-01	20.2 Ω	1/8 w		Prec.	1/2%	3460-up
R981D	318-093	20.2 Ω	1/8 w		Prec.	1/2%	101-3459
R981D	321-0740-01	20.2 Ω	1/8 w		Prec.	1/2%	3460-up
R982A	318-092	40.9 Ω	1/8 w		Prec.	1/2%	101-3459
R982A	321-0741-01	40.9 Ω	1/8 w		Prec.	1/2%	3460-up
R982B	318-092	40.9 Ω	1/8 w		Prec.	1/2%	101-3459
R982B	321-0741-01	40.9 Ω	1/8 w		Prec.	1/2%	3460-up
R982C	318-093	20.2 Ω	1/8 w		Prec.	1/2%	101-3459
R982C	321-0740-01	20.2 Ω	1/8 w		Prec.	1/2%	3460-up
R982D	318-093	20.2 Ω	1/8 w		Prec.	1/2%	101-3459
R982D	321-0740-01	20.2 Ω	1/8 w		Prec.	1/2%	3460-up
R983A	318-092	40.9 Ω	1/8 w		Prec.	1/2%	101-3459
R983A	321-0741-01	40.9 Ω	1/8 w		Prec.	1/2%	3460-up
R983B	318-092	40.9 Ω	1/8 w		Prec.	1/2%	101-3459
R983B	321-0741-01	40.9 Ω	1/8 w		Prec.	1/2%	3460-up
R983C	318-093	20.2 Ω	1/8 w		Prec.	1/2%	101-3459
R983C	321-0740-01	20.2 Ω	1/8 w		Prec.	1/2%	3460-up
R983D	318-093	20.2 Ω	1/8 w		Prec.	1/2%	101-3459
R983D	321-0740-01	20.2 Ω	1/8 w		Prec.	1/2%	3460-up
R990	311-001	10 Ω		Var.	WW	DELAYED PULSE GEN. BIAS	101-361
R990	311-258	100 Ω		Var.			362-3459

Resistors *(cont)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R990	315-0272-00	2.7 k	1/4 w		5%	3460-up
R991	315-100	10 Ω	1/4 w		5%	X362-3459
R991	315-0102-00	1 k	1/4 w		5%	3460-up
R992	301-150	15 Ω	1/2 w		5%	101-361
R992	317-150	15 Ω	1/10 w		5%	362-3459
R992	315-0474-00	470 k	1/4 w		5%	3460-up
R993	316-100	10 Ω	1/4 w			101-361
R993	317-150	15 Ω	1/10 w		5%	362-3459
R993	315-0103-00	10 k	1/4 w		5%	3460-up
R994	315-101	100 Ω	1/4 w		5%	X362-3459
R994	317-0201-00	200 Ω	1/8 w		5%	3460-up
R996	311-0643-00	50 Ω		Var.		X3460-up
R997	307-0099-00	48 Ω	1/4 w		1%	X3460-up
R998	311-0607-00	10 k		Var.		X3460-up
R999	315-0362-00	3.6 k	1/4 w		5%	X3460-up

Relays

K600	148-006	45 sec. Thermal Delay, 26 v.	
K601	148-012	150 Ω	18-v DC

Switches

	Unwired	Wired			
SW301	260-145		Slide	AC DC	
SW311	260-414	*262-441	Rotary	HORIZONTAL DISPLAY	
SW604†	311-275				
SW910	260-416	*262-440	Rotary	μSEC/CYCLE	101-1999
SW910	260-585	*262-636	Rotary	μSEC/CYCLE	2000-up
SW980	260-415	*262-464	Rotary	MV AMPLITUDE	
TK601	Use 260-120		Thermal Cutout 137° ±5° F.		

Transformers

T600	Use *120-164	Toroid 3T TD#12	
T601	*120-267	Low Voltage	
T801	*120-268	High Voltage	
T992	276-535	Ferrite Core	X362-3459X
T996	*120-193	Toroid 7T TD#26	101-1999X
T998	*120-193	Toroid 7T TD#26	101-1999X

Transistors

Q313	151-035	2N1592	101-939
Q313	*151-103	Replaceable by 2N2219	940-up
Q324	151-015	2N1516/OC170	101-2479
Q324	*151-133	Selected from 2N3251	2480-up
Q333	151-015	2N1516/OC170	
Q344	151-015	2N1516/OC170	
Q354	151-015	2N1516/OC170	
Q404	151-015	2N1516/OC170	
Q414	151-015	2N1516/OC170	
Q644	Use *151-103	Replaceable by 2N2219	
Q647	151-002	2N277	

†SW604 and R604 are ganged. Furnished as a unit.

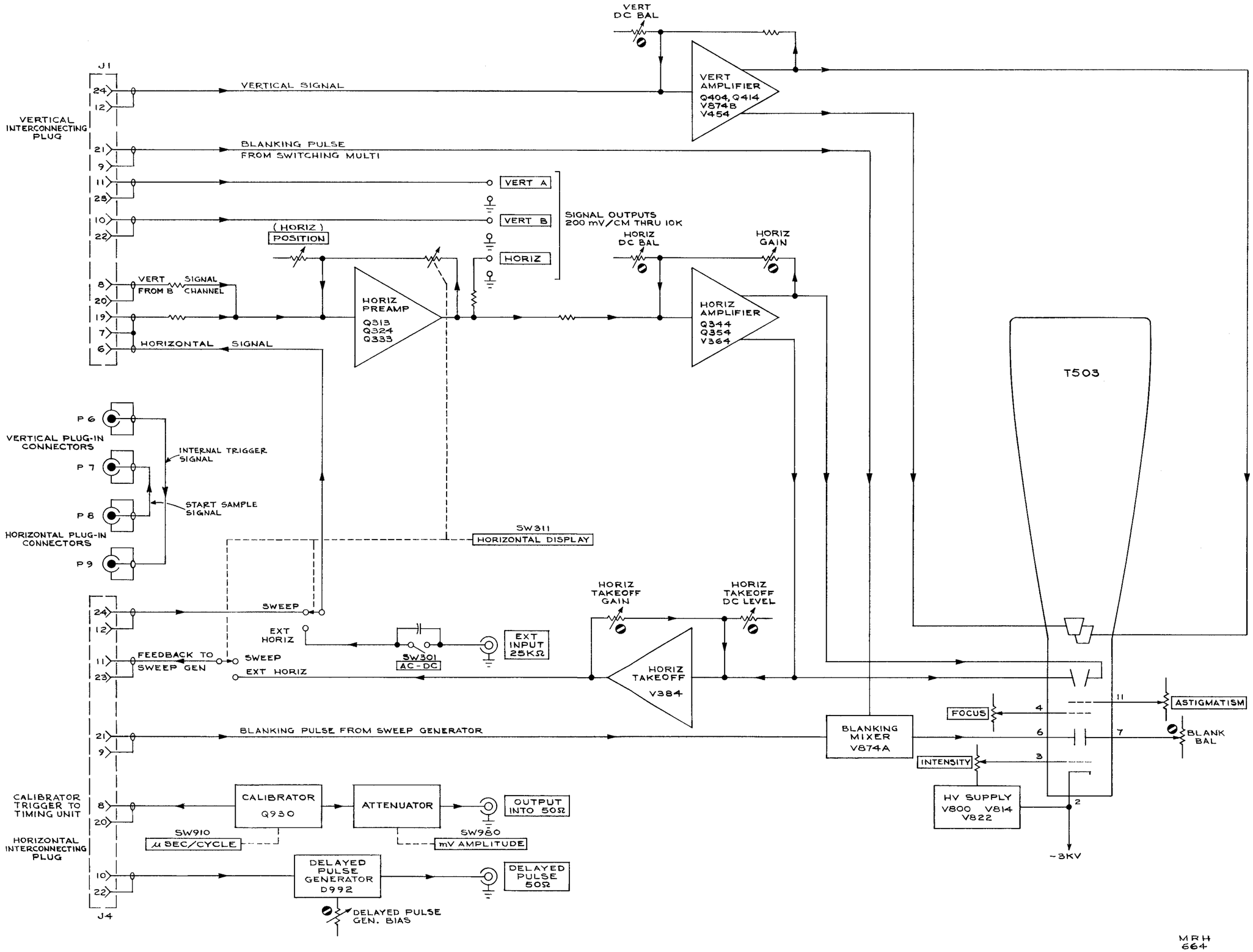
Transistors *(cont)*

Ckt. No.	Tektronix Part No.	Description	S/N Range
Q653	151-036	2N601	101-3559
Q654	151-064	2N650	3560-up
Q654	151-0164-00	2N3702	
Q657	151-002	2N277	
Q673	151-036	2N601	
Q674	151-064	2N650	101-3559
Q674	151-0164-00	2N3702	3560-up
Q677	151-002	2N277	
Q930	*151-103	2N1302	101-1999X
Q953	151-040	Replaceable by 2N2219	X2000-up
Q991	151-0190-00	2N3904	X3460-up
Q994	151-0188-00	2N3906	X3460-up
Q995	151-0190-00	2N3904	X3460-up

Electron Tubes

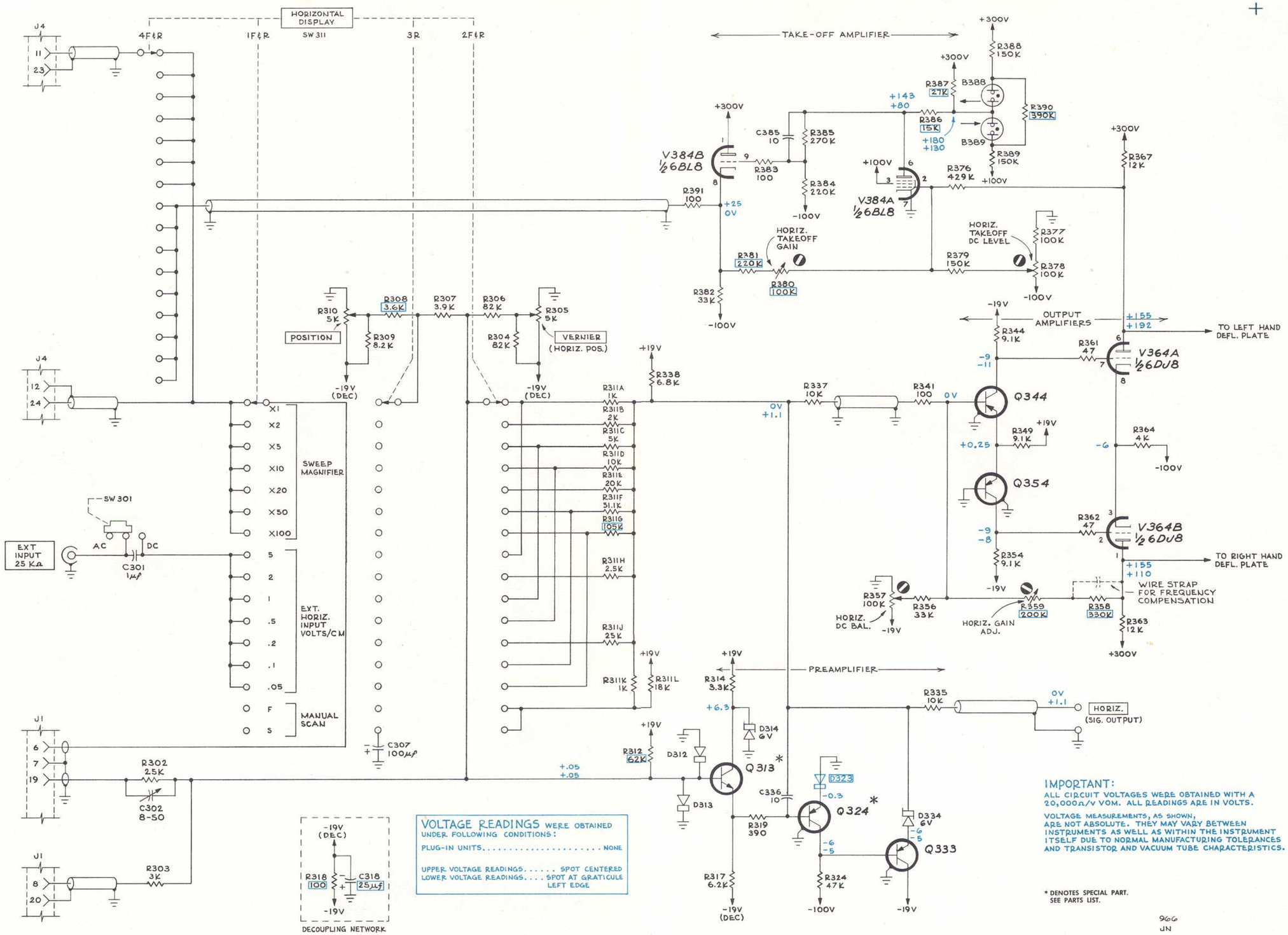
V364	154-187	6BL8	
V384	154-278	6DJ8	
V454	154-187	6DJ8	
V616	154-043	12AX7	
V624	154-040	12AU6	101-3539
V624	154-0040-05	8426/12AU6	3540-up
V637	154-056	6080	
V694	154-040	12AU6	101-3539
V694	154-0040-05	8426/12AU6	3540-up
V697	154-307	7233	
V716	154-043	12AX7	
V719	*157-067	OG3 checked	
V724	154-040	12AU6	101-3539
V724	154-0040-05	8426/12AU6	3540-up
V737	154-056	6080	
V800	154-167	6CZ5	
V814	154-041	12AU7	
V822	154-051	5642	
V859†	*154-265	T5030-2 CRT Standard Phosphor	101-309
V859	*154-265	T5030-2 CRT Standard Phosphor	310-up
V874	154-187	6DJ8	101-1999X
V930	154-340	7119	

†S/N 101-309 add *050-071 kit.



MRH
664

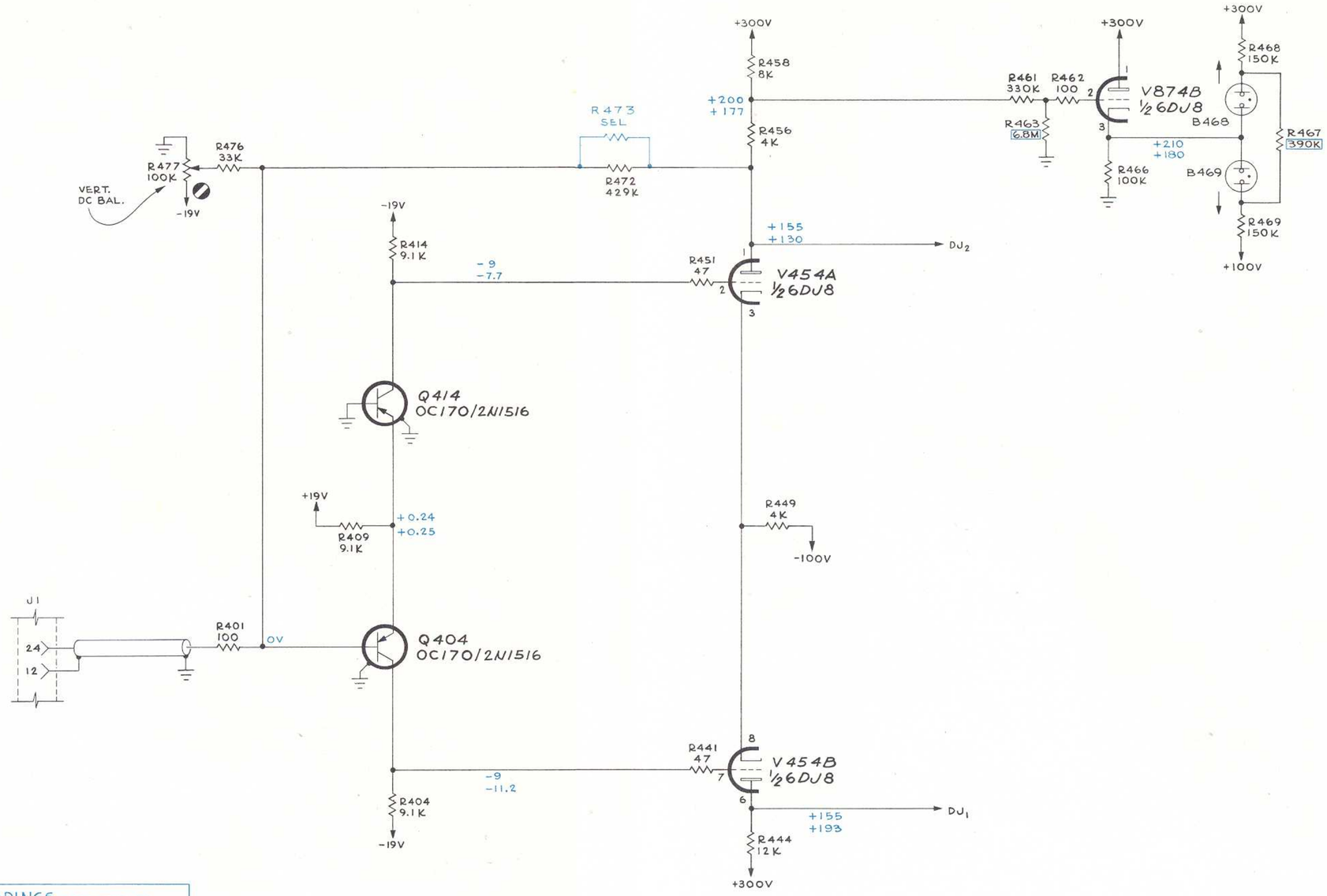
BLOCK DIAGRAM



TYPE 661 OSCILLOSCOPE

F

HORIZONTAL AMPLIFIER



VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

PLUG-IN UNIT . . . . . NONE

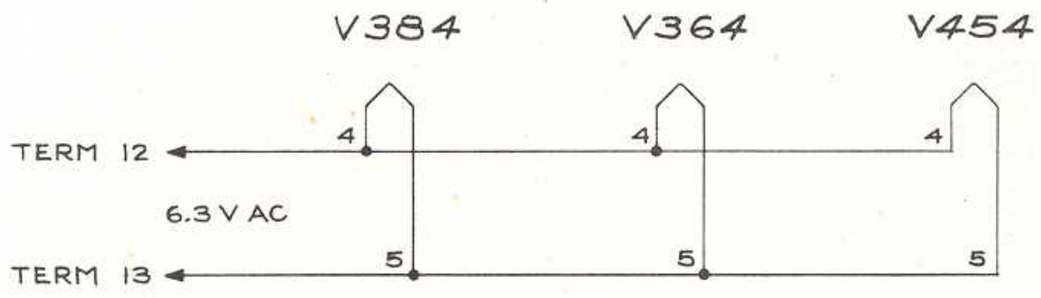
UPPER VOLTAGE READINGS . . . . . SPOT CENTERED
LOWER VOLTAGE READINGS . . . . . * SPOT AT +4 CM

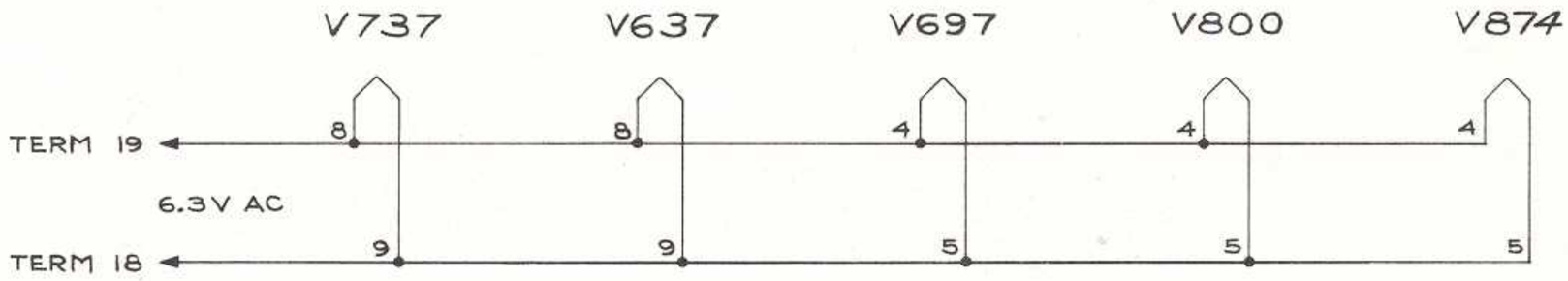
ALSO SEE IMPORTANT NOTE ON HORIZ. AMP. DIAG.

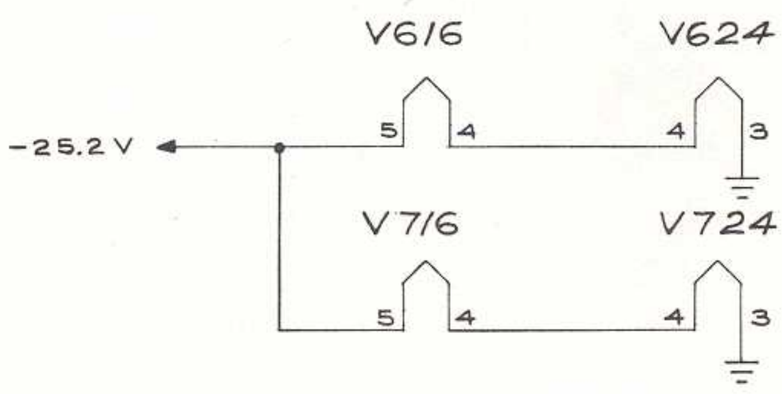
* SPOT POSITION CONTROLLED BY VERT. DC BAL. CONTROL

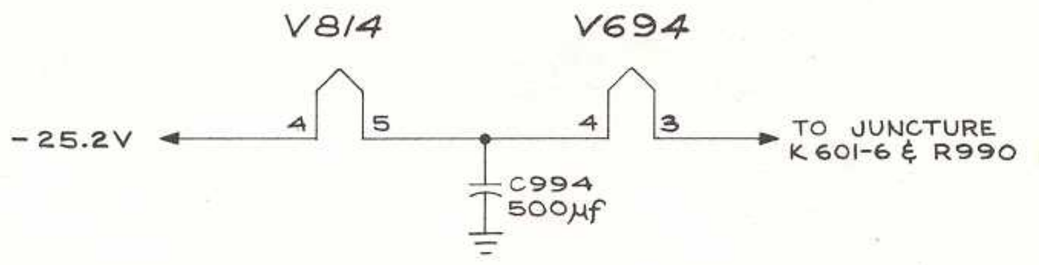
SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE

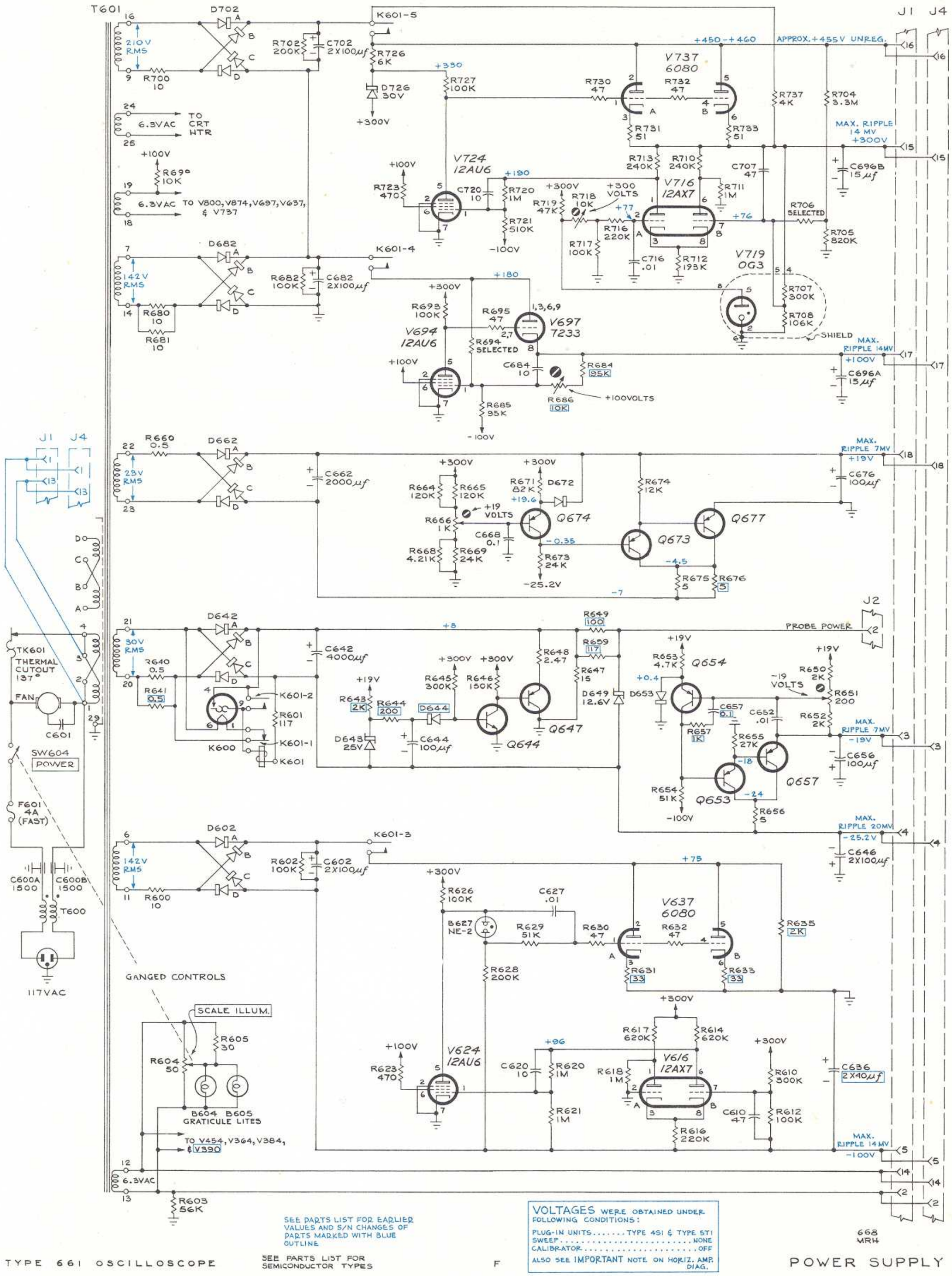
JN
265

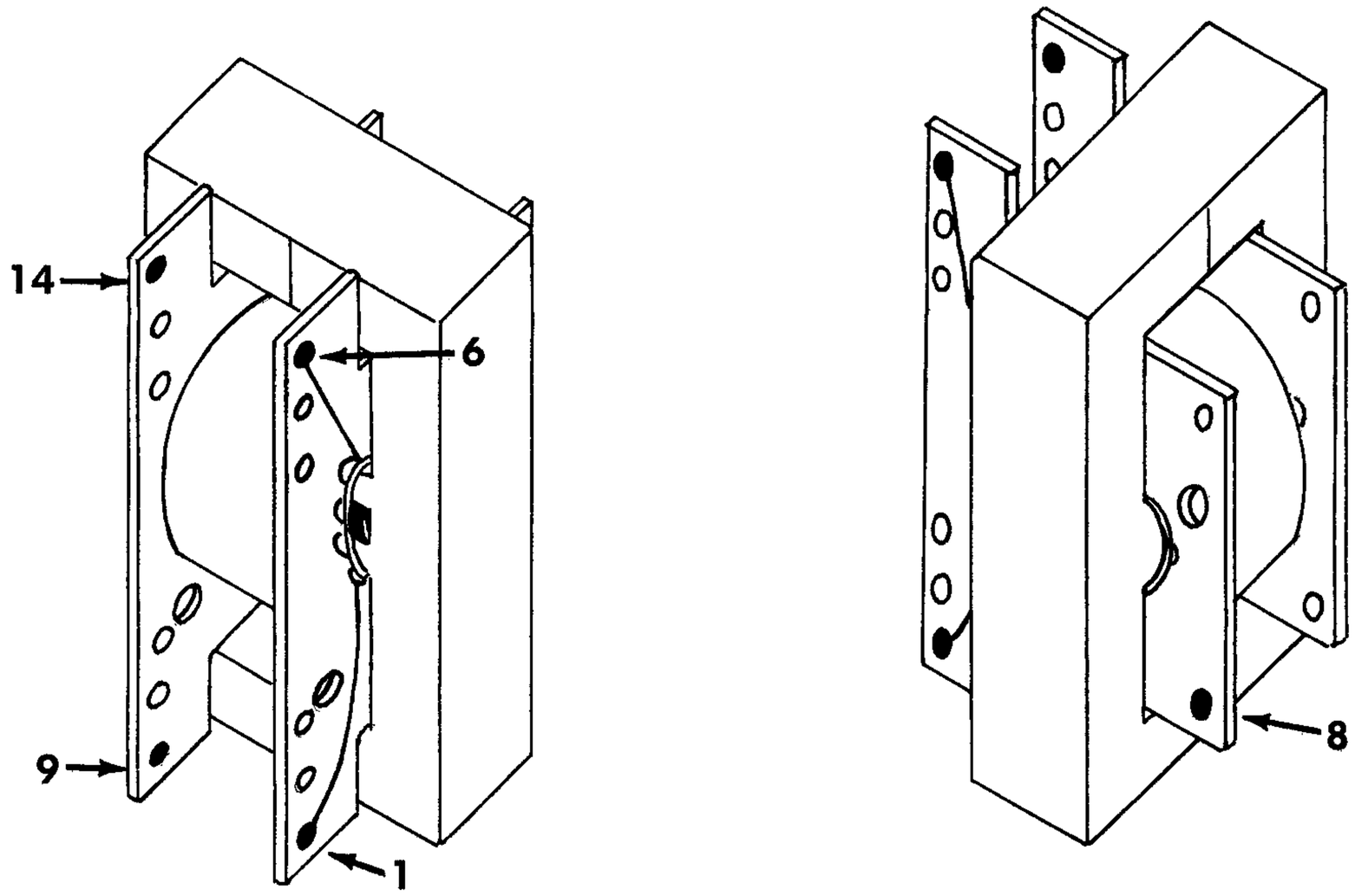

V384
V364
V454
TERM 12
6.3 V AC
TERM 13
4
4
4
5
5
5


V737
V637
V697
V800
V874
TERM 19
6.3V AC
TERM 18
8
8
4
4
4
9
9
5
5
5


V616
V624
-25.2 V
V716
V724
5
4
4
3
5
4
4
3

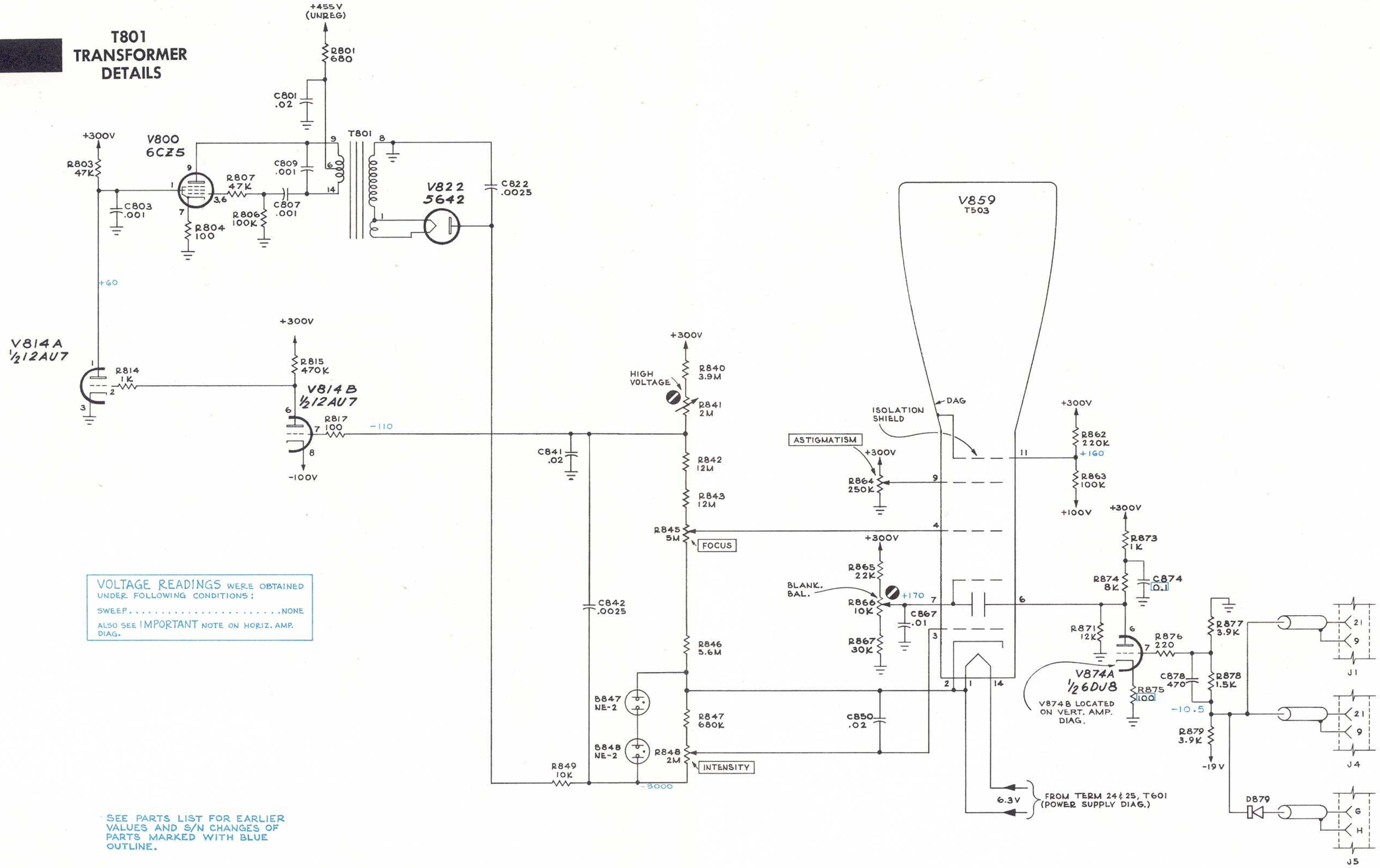

V814
V694
-25.2V
4
5
4
3
TO JUNCTURE
K601-6 & R990
C994
500μf


T601
D702
K601-5
J1 J4
210V RMS
R700 10
R702 200K
C702 2X100µf
R726 6K
D726 30V
+300V
+330
R727 100K
+450-+460
APPROX.+455V UNREG.
V737 6080
R730 47
R732 47
R731 51
R733 51
R737 4K
R704 3.3M
MAX. RIPPLE 14 MV +300V
C696B 15µf
24
6.3VAC TO CRT HTR
25
+100V
R690 10K
19
6.3VAC TO V800,V874,V697,V637, & V737
18
V724 12AU6
+190
R723 470
C720 10
R720 1M
R721 510K
-100V
R713 240K
R710 240K
C707 47
V716 12AX7
+300V
R719 47K
R718 10K
+300 VOLTS
+77
R716 220K
R717 100K
C716 .01
R712 193K
R711 1M
+76
R706 SELECTED
R705 820K
V719 OG3
R707 300K
R708 106K
SHIELD
D682
K601-4
7
142V RMS
14
R680 10
R681 10
R682 100K
C682 2X100µf
+180
R698 100K
V694 12AU6
R695 47
2,7
V697 7233
1,3,6,9
R694 SELECTED
C684 10
R684 95K
R686 10K
+100VOLTS
R685 95K
-100V
MAX. RIPPLE 14MV +100V
C696A 15µf
J1 J4
R660 0.5
D662
22
23V RMS
23
C662 2000µf
+300V
R664 120K
R665 120K
R671 82K
D672
+19.6
+19 VOLTS
R666 1K
C668 0.1
R668 4.21K
R669 24K
Q674
-0.35
R673 24K
-25.2V
Q673
Q677
-4.5
R674 12K
R675 5
R676 5
-7
MAX. RIPPLE 7MV +19V
C676 100µf
D
C
B
A
TK601 THERMAL CUTOUT 137°
FAN
C601
SW604 POWER
F601 4A (FAST)
C600A 1500
C600B 1500
T600
117VAC
D642
21
30V RMS
20
R640 0.5
R641 0.5
K601-2
R601 117
K601-1
K601
K600
+8
C642 4000µf
R649 100
R659 117
R647 15
D649 12.6V
R648 2.47
+300V
R645 300K
R646 150K
+19V
R643 2K
R644 200
D644
D643 25V
C644 100µf
Q647
Q644
PROBE POWER
J2
+19V
R653 4.7K
Q654
+0.4
D653
C657 0.1
R657 1K
C652 .01
R650 2K
-19 VOLTS
R651 200
R652 2K
R655 27K
-18
Q657
Q653
-24
R654 51K
-100V
R656 5
MAX. RIPPLE 7MV -19V
C656 100µf
MAX. RIPPLE 20MV -25.2V
C646 2X100µf
D602
6
142V RMS
11
R600 10
R602 100K
C602 2X100µf
K601-3
+75
+300V
R626 100K
C627 .01
B627 NE-2
R629 51K
R630 47
V637 6080
R632 47
R635 2K
R628 200K
R631 33
R633 33
GANGED CONTROLS
SCALE ILLUM.
R605 30
R604 50
B604 B605 GRATICULE LITES
TO V454,V364,V384, & V390
12
6.3VAC
13
R603 56K
+100V
R623 470
V624 12AU6
+96
C620 10
R620 1M
R621 1M
R617 620K
R614 620K
V616 12AX7
R618 1M
R616 220K
+300V
R610 300K
C610 47
R612 100K
C636 2X40µf
MAX. RIPPLE 14 MV -100V
5
14
2
SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE
SEE PARTS LIST FOR SEMICONDUCTOR TYPES
VOLTAGES WERE OBTAINED UNDER FOLLOWING CONDITIONS:
PLUG-IN UNITS.....TYPE 4S1 & TYPE 5T1
SWEEP.....NONE
CALIBRATOR.....OFF
ALSO SEE IMPORTANT NOTE ON HORIZ. AMP. DIAG.
668 MRH
TYPE 661 OSCILLOSCOPE
F
POWER SUPPLY



T801 TRANSFORMER DETAILS

T801 TRANSFORMER DETAILS

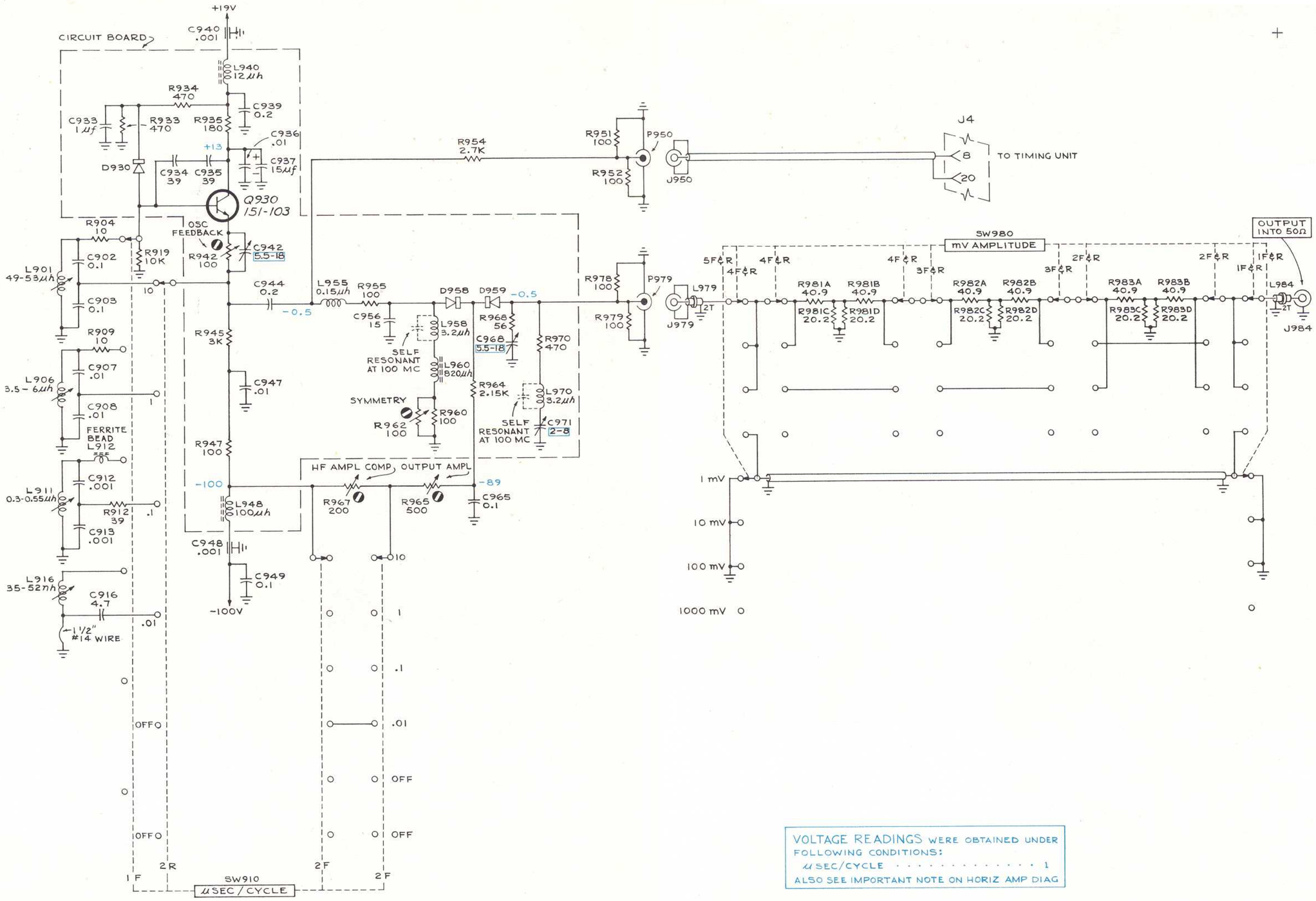


VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

SWEEP.....NONE

ALSO SEE IMPORTANT NOTE ON HORIZ. AMP. DIAG.

SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE.



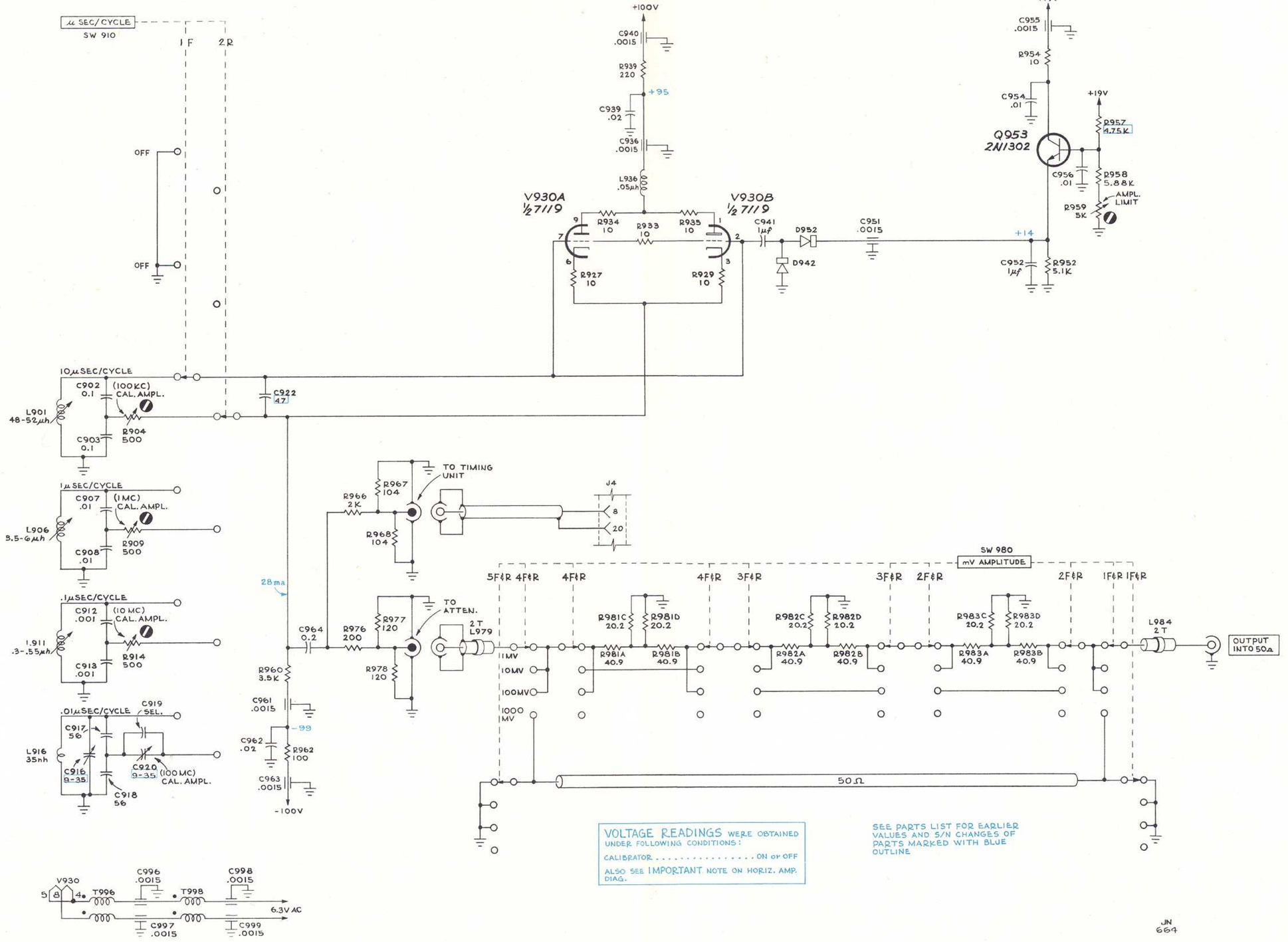
VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:
μSEC/CYCLE 1
ALSO SEE IMPORTANT NOTE ON HORIZ AMP DIAG

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

MRH
665

AMPLITUDE / TIME CALIBRATOR

S/N 2000 - UP



VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

CALIBRATOR . . . . . ON or OFF

ALSO SEE IMPORTANT NOTE ON HORIZ. AMP. DIAG.

SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE

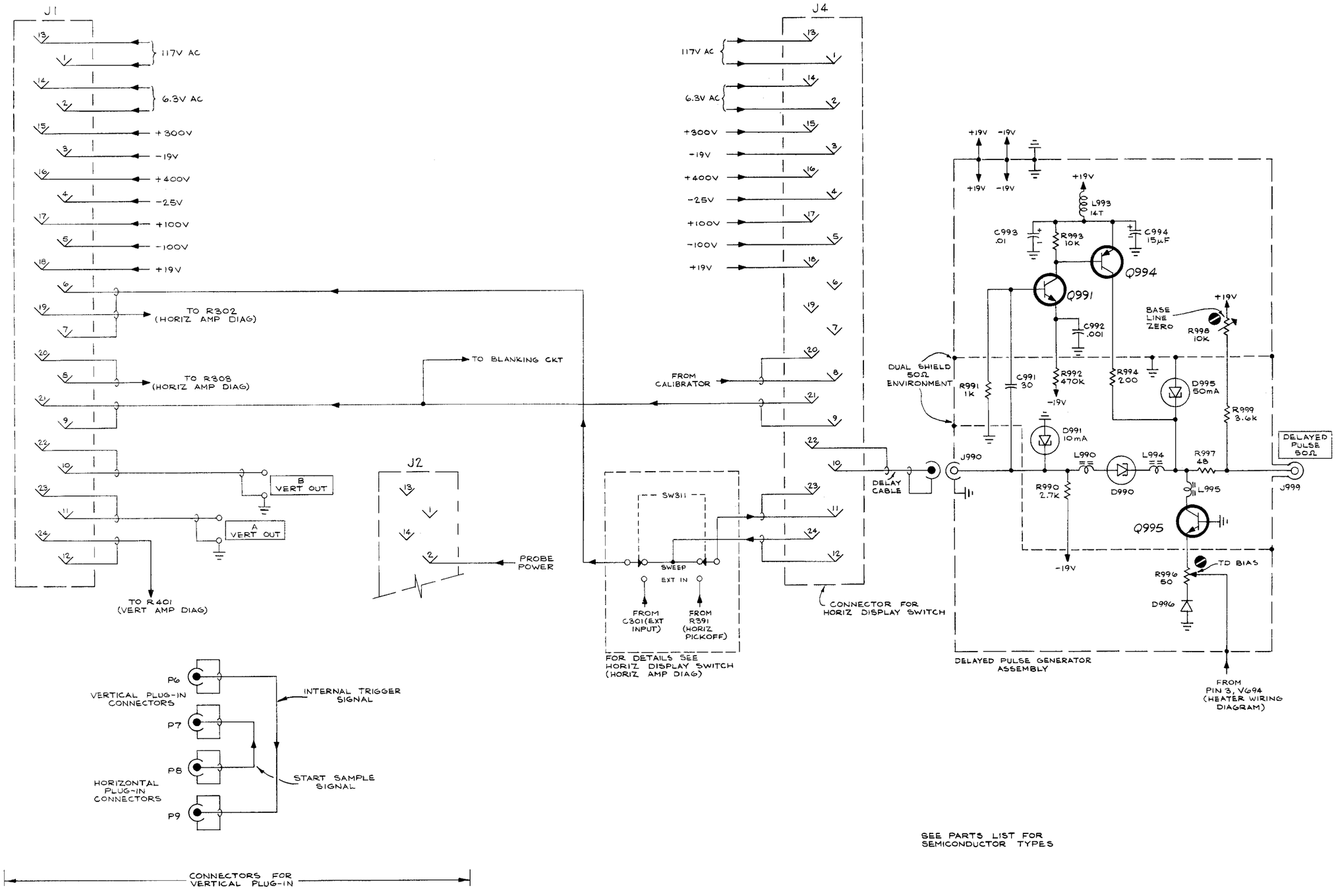
JN 664

AMPLITUDE/TIME CALIBRATOR

S/N 101 - 1999

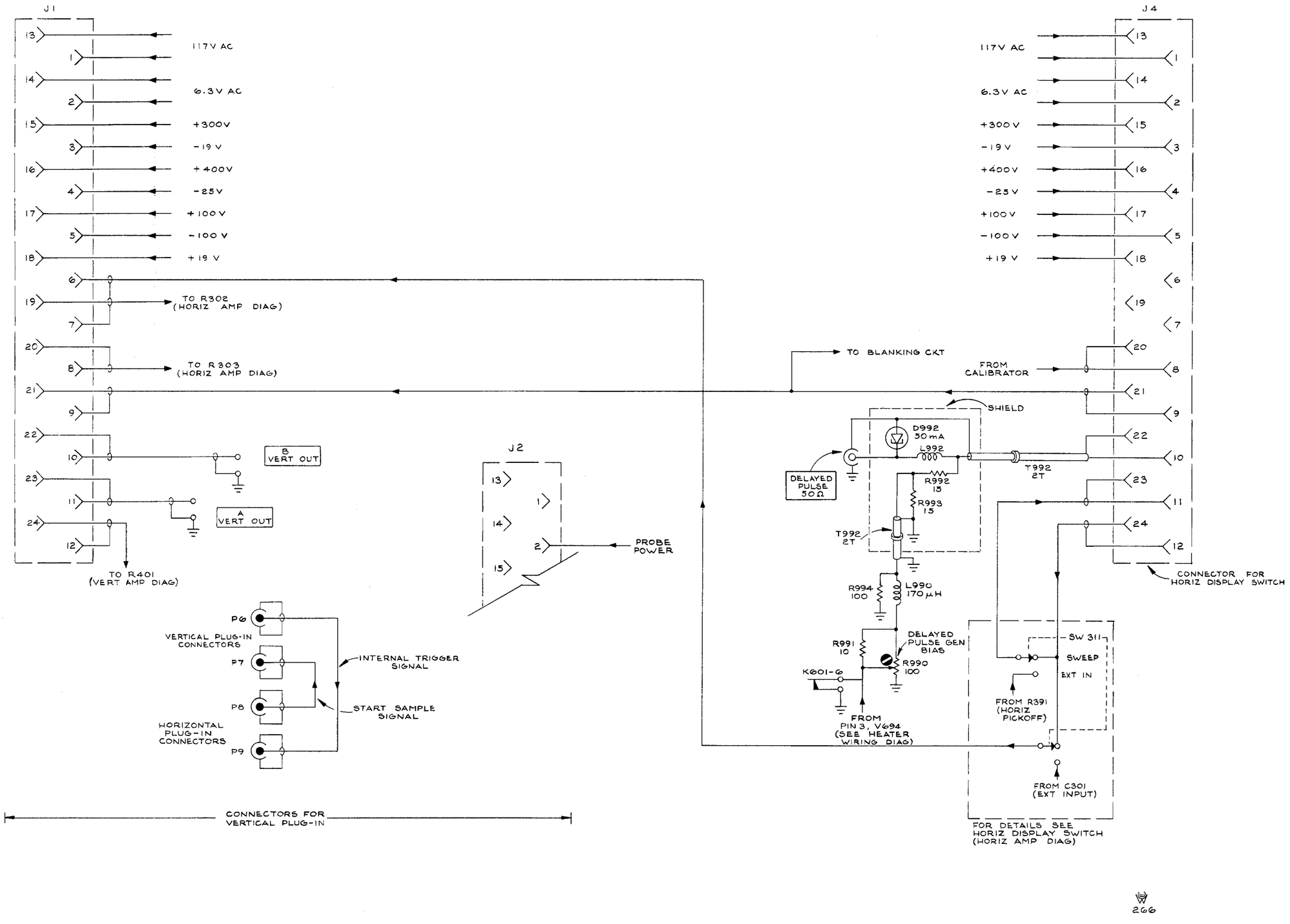
TYPE 661 OSCILLOSCOPE

A2



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

1167



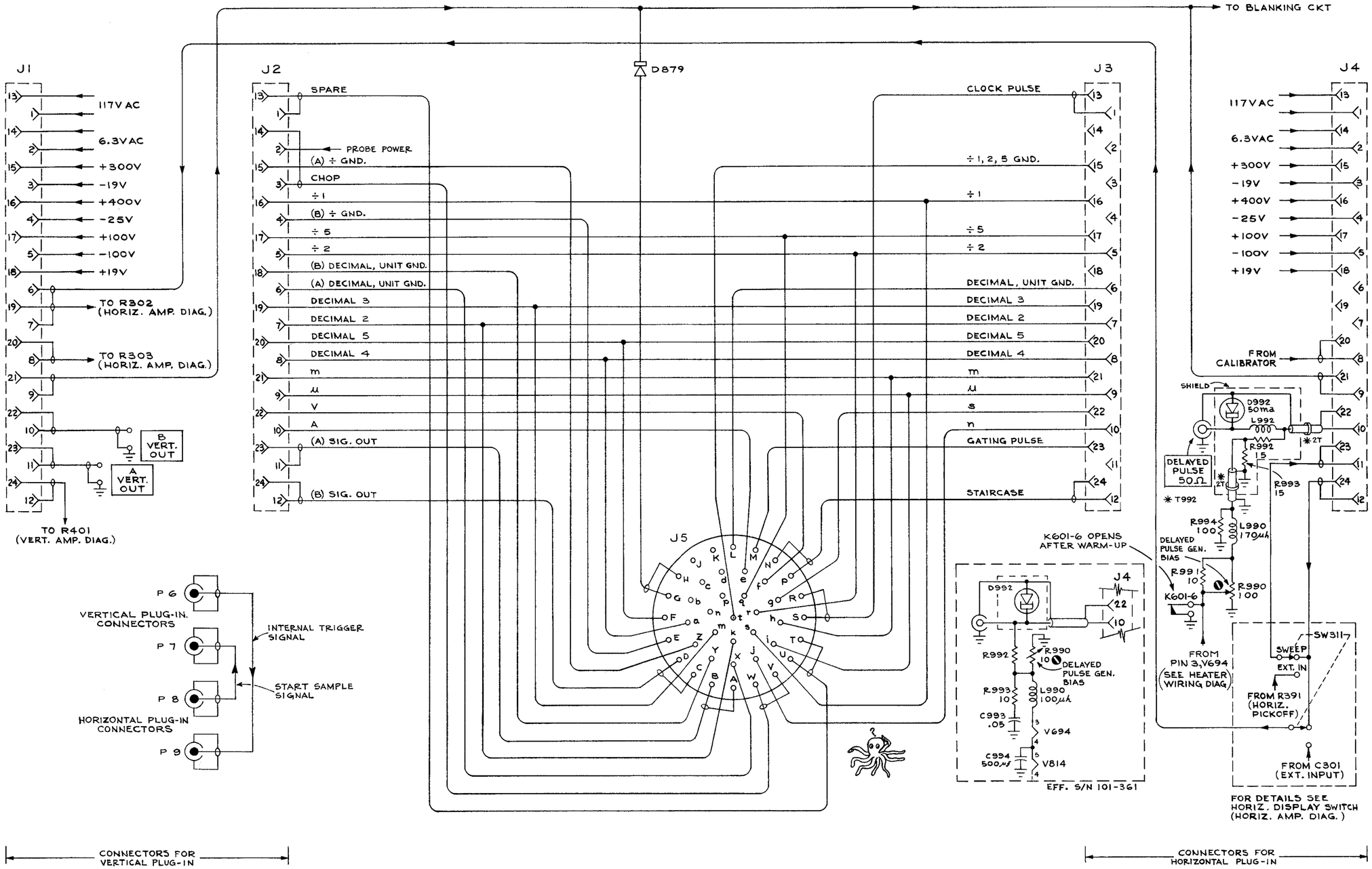
266

TYPE 661 OSCILLOSCOPE

D1

INTERCONNECTING SOCKETS

S/N 2830-3459



MRH
1064

TYPE 661 OSCILLOSCOPE

C

INTERCONNECTING SOCKETS
S/N 101-2829

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.

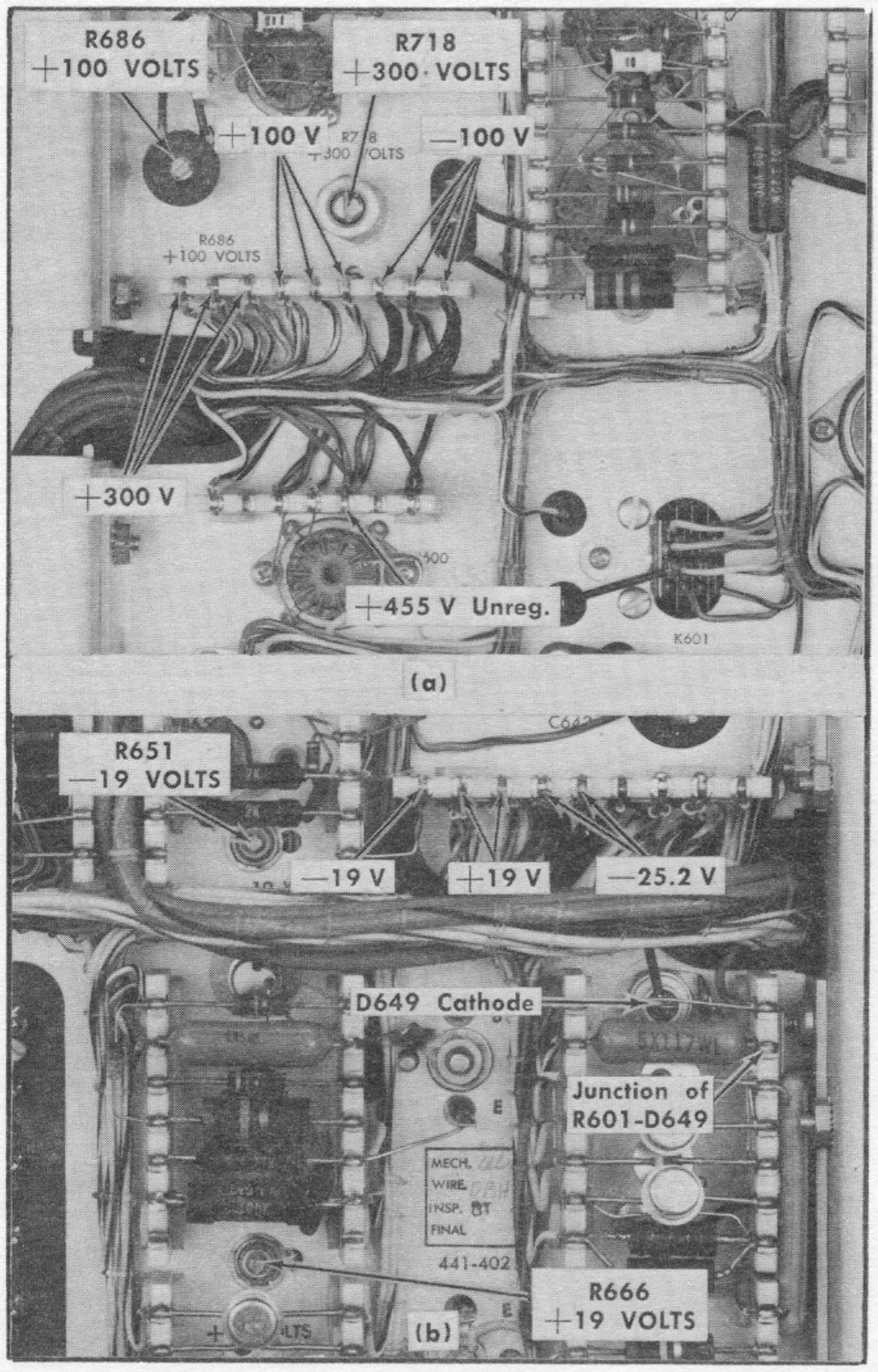
TYPE 661

TEXT CORRECTION

Section 6 Calibration

Page 6-6 Fig. 6-4

REPLACE: the present Fig. 6-4 with the one below:



Page 6-6 Step 7

CHANGE: the second paragraph in part a to read:

Connect the meter minus lead to the junction of R601-R649, and the plus lead to D649 cathode. See Fig. 6-4.

C1/369

TYPE 661 TENT SN 3580

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

D930	152-0141-02	Silicon	1N4152

M13,721/1068

TYPE 661 TENT SN 3510

PARTS LIST CORRECTION

CHANGE TO:

V624	154-0040-05	8426/12AU6
V694	154-0040-05	8426/12AU6
V724	154-0040-05	8426/12AU6

S13,300/268

CORRECTION

Delayed Pulse Generator Assembly

CHANGE: The circuit board marking of Q992 should be Q991.