INSTRUCTION MANUAL

TYPE 316 OSCILLOSCOPE

Tektronix, Inc.

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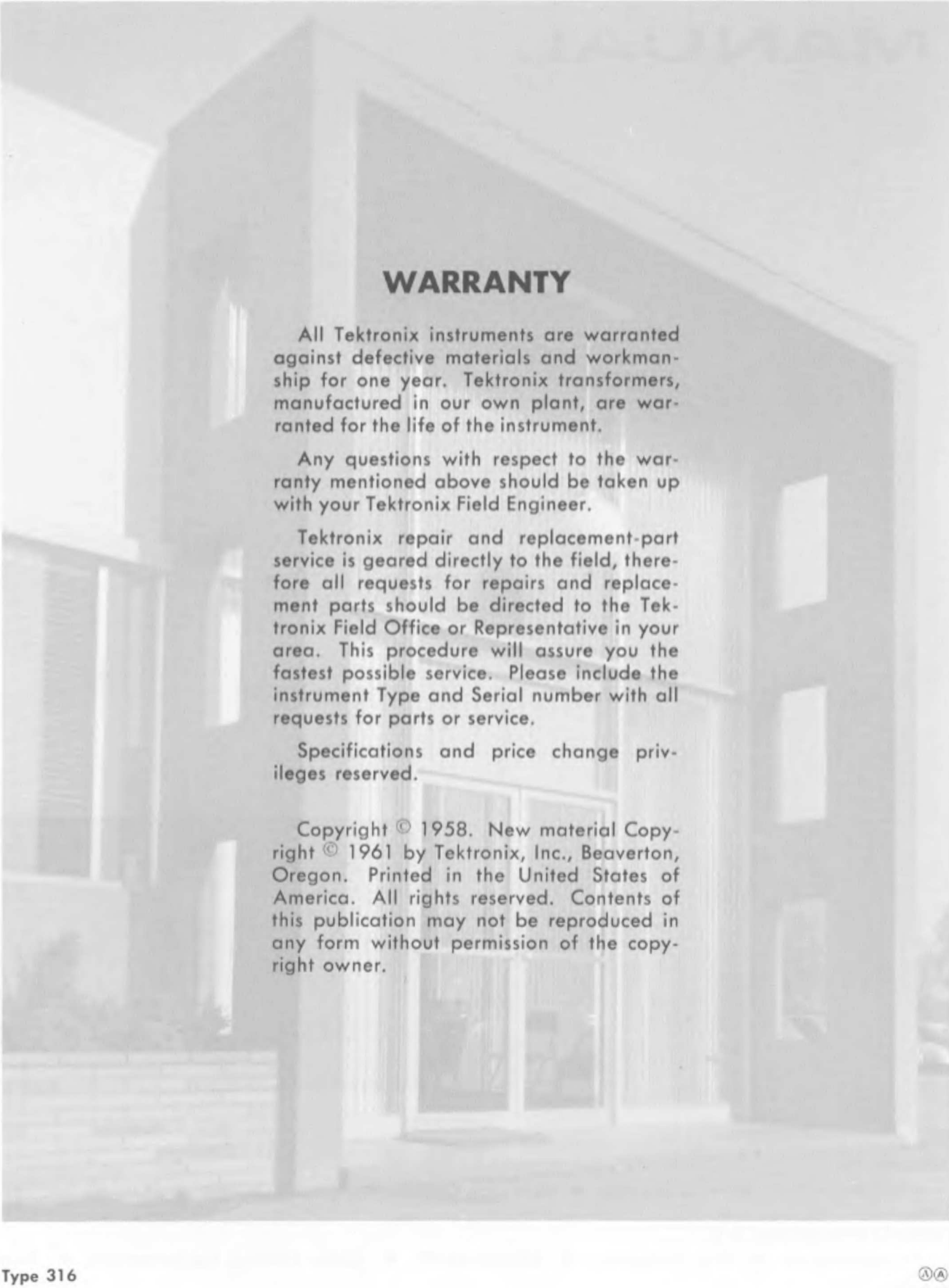

WARRANTY

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 number with all requests for parts or service.

Specifications and price change privileges reserved.

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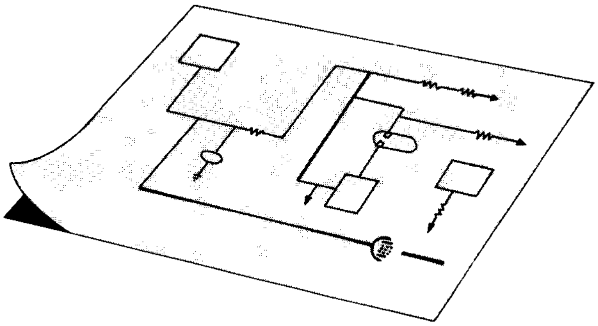
TEKTRONIX, INC.
PORTLAND, OREGON, U. S. A.

Type 316



SECTION 1

CHARACTERISTICS

General

The Type 316 Oscilloscope is a compact, general-purpose oscilloscope. The dc-coupled amplifier and wide range of sweep rates, combined with the size, make the Type 316 a versatile field or laboratory instrument.

VERTICAL-DEFLECTION SYSTEM

Input Characteristics

Direct connection-1 megohm, 38 pf.

With P510A Probe-10 megohm, 13 pf.

With P6017 Probe-10 megohm, 14 pf.

Deflection factor

Twelve-position switch provides calibrated deflection factors from .1 v/div to 50 v/div, dc coupled, and from .01 v/div to 50 v/div, ac coupled accurate within 3%.

Continuously variable deflection factors are available from .01 v/div to approximately 125 v/div.

Frequency response

.1 v/div to 50 v/div:

DC coupled-dc to 10 mc.

AC coupled-2 cps to 10 mc (.2 cps to 10 mc when a Type P510A or P6017 Attenuator Probe is used.)

.01 v/div to .05 v/div:

2 cps to 9 mc (1.3 cps to 9 mc when a Type P510A or P6017 Attenuator Probe is used.)

Risetime

.035 microseconds.

HORIZONTAL-DEFLECTION SYSTEM

Sweep rates

Twenty-two-position switch provides calibrated sweep rates from 2 sec/div to .2 μsec/div.

Accuracy typically within 1% of full scale; in all cases, within 3% of full scale.

Continuously variable sweep rates are available which will show the calibrated sweep rates down by a factor of approximately 2.5 X.

Magnifier

Expands sweep 5 times to the right and left of the crt-screen center. Extends the fastest sweep rate to .04 μsec/div.

Accuracy: within 5%.

Unblanking

DC coupled.

Triggering signal requirements

Internal-.2 major graticule division.

External-.2 v to 20 v, peak-to-peak.

Frequency range-dc to 15 mc.

Synchronizing frequency range

5 mc to 15 mc.

Horizontal input

Deflection factor-approx. 1.3 v/div.

Frequency response-dc to 500 kc.

OTHER CHARACTERISTICS

Cathode-ray tube

Type T316P2-P1, P7 and P11 phosphors optional.

Accelerating potential-1,850 volts.

Deflection factor at plates:

Vertical-approximately 8 v/div (32 v/in).

Horizontal-approx. 16.5 v/div (66 v/in).

Voltage calibrator

Square-wave output at approximately 1 kc.

Eleven fixed voltages from .05 volts to 100 volts, peak-to-peak.

Accuracy: ±3%.

Output waveforms available

Positive gate of same duration as sweep, approximately 20 volts.

Positive-going sweep sawtooth, approximately 150 volts.

Power requirements

Line voltage-100 to 130 or 200 to 260 v, 50-60 cycles.

Power-260 w at 117 v line voltage.

Mechanical Characteristics

Ventilation-filtered, forced-air.

Finish-photoetched, anodized panel. Blue, perforated cabinet.

Dimensions—8½" wide, 12" high, 19½" deep.

Weight-38 pounds.

Accessories included

1-P6017 Probe.

2-A510 binding-post adapters.

1-F510-5 green filter.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+GATE OUT
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MILLISEC
SEC
SAWTOOTH OUT
FOCUS
INTENSITY
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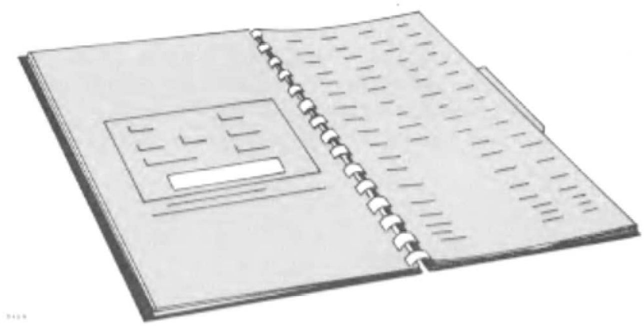


SECTION 2

OPERATING INSTRUCTIONS

General

The Type 316 Oscilloscope is an extremely versatile instrument which is adaptable to a great number of applications. However, to make full use of the instrument, it is important that you understand the operation and function of the various controls. This section of the Manual is designed to give you this information.

PRELIMINARY INSTRUCTIONS

Cooling

A fan maintains safe operating temperature in the Type 316 by circulating filtered air over the rectifiers and other components. When in operation, the instrument must be placed so that the air intake at the back is clear of any obstruction that might impede the flow of air. Side panels should also be in place for proper air circulation. The air filter should be kept clean, in accordance with cleaning instructions found in the Maintenance Section of the manual.

Under no circumstances should your Type 316 oscilloscope be operated without the fan running. Without the fan, inside temperature of the oscilloscope will rise to a dangerous level in five to ten minutes. In this event, the thermal cutout switch will disconnect the power and keep it disconnected until the temperature drops to a safe level.

Power Requirements

Unless tagged otherwise, this instrument is connected at the factory for operation at 100 to 130 volts. However, provisions are made for easy conversion to operation at 200 to 260 volts.

TRANSFORMER PRIMARY CONNECTIONS

LINE VOLTAGE OPERATING RANGE	NOMINAL LINE VOLTAGE	CONNECT JUMPER WIRE OR WIRES BETWEEN TERMINALS AS FOLLOWS
100 to 117	110	3 to 4 and 5 to 6
105 to 125	117	2 to 4 and 5 to 7
112 to 130	124	1 to 4 and 5 to 8
200 to 234	220	3 to 6
210 to 250	234	2 to 7
224 to 260	248	1 to 8

Fan Connections

The cooling fan is powered by a 117-volt ac motor. If the instrument is converted to operate from a 234-volt line, a change in the fan wiring must be made so that it operates from a 117-volt source.

The power connections for the fan are terminated on a ceramic strip directly in front of the fan and below the crt base. The correct connections for 100 to 130 volt operation are shown in Figure 2-1. To connect the fan for 200 to 260 volt operation, move the left-hand fan lead from the rear slot to connect with the black and white wire at the front end of the ceramic strip.

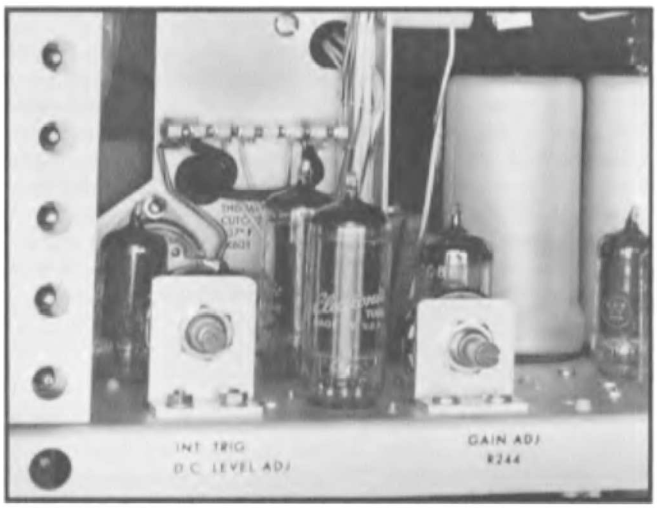


Fig. 2-1. Fan connections for 100- to 130-volt operation. Note wiring change needed for conversion to 200- to 260-volt operation.

Fuse Data

Fuse data is silk-screened on the rear panel of the instrument adjacent to the fuse holder. Use only the recommended fuses for maximum over-current protection.

OSCILLOSCOPE OPERATION INFORMATION

Initial control settings

Set the oscilloscope controls as follows:

FOCUS	centered
INTENSITY	full left (counterclockwise)

POWER	ON
VOLTS/DIV (black knob)	5
VARIABLE VOLTS/DIV. (red knob)	CALIBRATED (full right)
AC-DC	AC
TRIGGER SELECTOR (black knob)	+INT.
TRIGGER SELECTOR (red knob)	AUTO.
STABILITY	PRESET
TRIGGERING LEVEL	full right or full left
DISPLAY	NORM.
TIME/DIV. (black knob)	.5 MILLISEC (black numbers)
VERTICAL POSITIONING	centered
HORIZONTAL POSITIONING	centered
CALIBRATOR	10

Focus and Astigmatism Controls

The FOCUS and ASTIGMATISM controls operate in conjunction with each other to allow you to obtain a sharp, clearly defined display. To adjust the FOCUS and ASTIGMATISM controls, put a signal in from the CAL OUT connector of about two major divisions. Now with the FOCUS and ASTIGMATISM controls adjust the displayed waveform for the sharpest vertical and horizontal trace lines available. The area of the display you should observe, is an area two divisions high and two divisions wide with its center where the center vertical and horizontal lines of the graticule meet. Keep the intensity at a level just high enough for you to see the waveform, during this adjustment. If you are using a green filter on your scope, make sure the adjustment is done at an intensity high enough to be seen through the filter.

Intensity Control

The INTENSITY control is used to adjust the brightness of the oscilloscope display. This permits you to compensate for changes in brightness resulting from changes in the sweep triggering rate. The INTENSITY control is rotated clockwise to increase brightness and counterclockwise to decrease it. Be careful when you use the INTENSITY control that the brightness is not turned up to where it will permanently damage the face of the cathode-ray tube. If brightness is turned up to the point where a halo forms around the spot, it should be turned down immediately.

Graticule Illumination Control

The graticule used with the Type 316 Oscilloscope is accurately marked with 10 horizontal and 8 vertical divisions. These graticule markings allow you to make time and voltage measurements from the oscilloscope screen.

The graticule is illuminated by two lamps located at the top edge of the graticule.

Graticule illumination is adjusted by the SCALE ILLUM. control located just under the oscilloscope screen. Rotating the control clockwise increases the brightness of the graticule markings, and turning it counterclockwise decreases brightness.

Positioning Controls

Two controls are used with the Type 316 for positioning the trace on the oscilloscope screen. One control is used to set horizontal positioning of the trace. This is located on the front panel of the instrument. The second control is used to set vertical positioning, and is located on the front panel of the scope.

The HORIZONTAL POSITION control causes the trace to move to the right when it is rotated in the clockwise direction and to the left when rotated counterclockwise.

The vertical positioning control has enough range to allow the trace to be positioned completely off the top or bottom of the screen or anywhere in between. The trace moves up when the control is turned clockwise and down when the control is turned counterclockwise.

Input Signal Connections

The electrical waveform to be observed is applied to the input connector. The waveform is then connected through the vertical-deflection system of the oscilloscope to cause the spot to be deflected vertically and to trace out the waveform on the screen of the crt. The vertical size of the displayed waveform is adjusted with the VOLTS/DIV. switch.

The VOLTS/DIV. switch is an accurately calibrated control which, when used with the graticule, allows you to make precise voltage measurements from the displayed waveforms.

Certain precautions must be taken when you are connecting the oscilloscope to the input signal source to insure that accurate information is obtained from the oscilloscope display. This is particularly true when you are observing low-level signals or waveforms containing high or extremely low frequency components. For applications where you are observing low-level signals, unshielded input leads are unsatisfatory because they tend to pick up stray signals which produce erroneous oscilloscope displays. Shielded cables should be used whenever possible, with the shield connected to the chassis of both the oscilloscope and the signal source. Regardless of the type of input lead used, keep them as short as possible.

Distortion of the input waveform may result if very low-frequency input signals are ac coupled into the oscilloscope, if high-frequency waveforms are not properly terminated, or if the input waveform contains high-frequency components which exceed the passband of the oscilloscope. You must be aware of the limitations of the instrument.

In analyzing the displayed waveform, you must consider the loading effect that the oscilloscope has on the input signal source. In most cases this loading effect is negligible, but in some applications, loading caused by the oscilloscope may materially alter the results obtained. In such cases you may want to use a probe to reduce the amount of loading.

VERTICAL AMPLIFIER OPERATION

Coupling

It is sometimes unnecessary or undesirable to display the dc level of the waveform. In the AC position of the AC-DC switch, a capacitor in series with the input blocks the dc component of the waveform so that only the ac component is displayed.

Deflection Sensitivity

The VOLTS/DIV switch inserts frequency-compensated attenuators ahead of the amplifier. The Variable control provides continuous adjustment of the deflection sensitivity (2.5 to 1 attenuation ratio) between the values indicated by the VOLTS/DIV. switch. The UNCALIBRATED light indicates when the VARIABLE control is not fully clockwise.

VARIABLE ATTEN. Balance Adjustment

After the scope has been in use for a period of time you will notice that the trace will change position as the VARIABLE control is rotated. This is caused by tube aging and the resultant shift in operating potentials. To correct this condition rotate the VARIABLE control back and forth and adjust the VARIABLE ATTEN. BAL control until the trace position is no longer affected by rotation of the VARIABLE control.

Use of Probes

Occasionally, connecting the input of an oscilloscope to a signal source loads the source enough to adversely affect both the operation of the source and the waveform displayed on the oscilloscope. When this occurs, both capacitive and resistive loading due to the oscilloscope can be reduced to a negligible value by using an attenuator probe.

In addition to providing isolation of the oscilloscope from the signal source, an attenuator probe also decreases the amplitude of the displayed waveform by the attenuation factor of the probe. Use of a probe allows you to increase the vertical deflection factors of the oscilloscope to look at large amplitude signals which are beyond the normal limits of the oscilloscope. Signal amplitudes, however, must be limited to the maximum allowable value of the probe used.

Before using a probe, you must check (and adjust if necessary) the compensation of the probe to prevent distortion of the applied waveform. To adjust the probe compensation, place the DISPLAY switch at NORMAL (X1), the TRIGGER SELECTOR (Red knob) switch at AUTO, and the TRIGGER SELECTOR (Black knob) switch at +INT. Turn up the intensity until the trace is visible and connect the probe tip to the CAL OUT connector. Set the CALIBRATOR for 2 major divisions of displayed signal. Set the TIME/DIV switch to display approximately 3 or 4 cycles of the Calibrator waveform and adjust the probe compensation control to obtain flat tops on the displayed Calibrator square waves as shown in Fig. 2-2.

The method of setting the compensation control depends on the probe in use. If your oscilloscope is equipped with a Type P510A probe, compensation is by means of a screwdriver adjustment through the hole near the nose end of the probe body. If a P6000 type probe is used, it is necessary

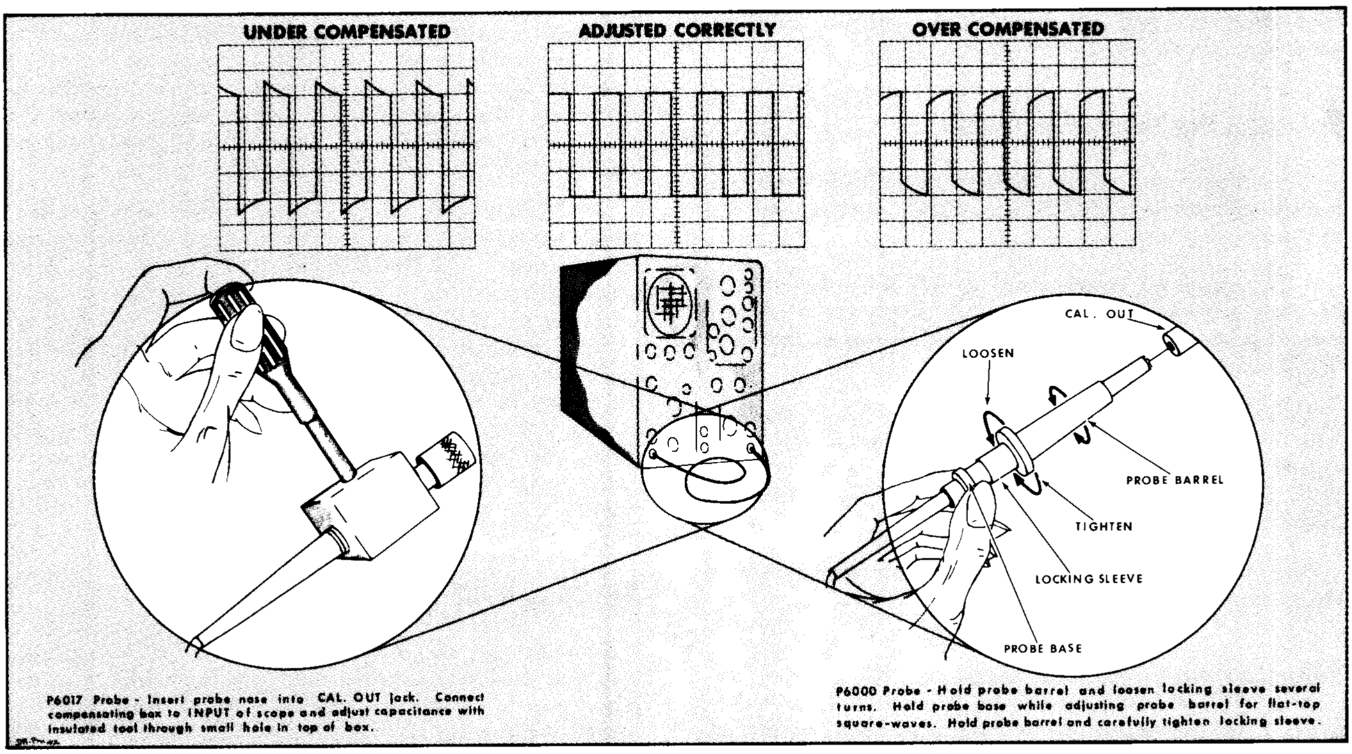


Fig. 2-2. When compensating the probe, it is adjusted to obtain an undistorted presentation of the Calibrator squarewave.

to first unlock the Locking Sleeve by turning it counterclockwise. The probe is then compensated by rotating the probe body while watching the oscilloscope display for the desired waveform. When compensation is completed, carefully turn the Locking Sleeve clockwise to lock it without disturbing the adjustment of the probe.

If a P6017 type probe is used it can be compensated by adjusting the capacitor mounted in the box which will be near the coax fitting for the scope. The capacitor can be reached through the hole in the box. See Fig. 2-2 for the different probes.

HORIZONTAL DEFLECTION SYSTEM

Trigger Operation

For most uses of the oscilloscope a stable display of some waveforms is required. To accomplish this the oscilloscope can be operated so that the horizontal sweep starts at a given point on the displayed waveform. This is known as "triggered" operation. For the present, we will refer to the starting of the sweep, at the left side of the graticule, as "triggering" the sweep.

Triggered operation is useful for observing a waveform which may occur only once, or which may occur at random intervals. For these uses, the oscilloscope can be used in such a way that each horizontal sweep is triggered by some waveform other than the one being observed, but which bears a time relationship to the observed waveform.

The waveform used to start the horizontal sweep is called the "triggering signal" whether it is the waveform being observed, or some other waveform. The instructions that follow tell you how to select this signal. They also contain information on triggering according to various modes, depending on the nature of the triggering signal.

Selecting the Triggering Signal

1. To trigger the sweep from the waveform being observed, set the black TRIGGER SELECTOR knob to INT. (+ or —).

2. To trigger the sweep from the powerline wave (as in the case when observing a waveform which has a time relationship to the powerline wave), set the black TRIGGER SELECTOR knob to LINE (+ or —).

3. To trigger the sweep from some external waveform (one having a time relationship to the waveform being observed), connect the source of the triggering signal to the TRIGGER INPUT connector and set the black TRIGGER SELECTOR knob to EXT. (+ or —).

Refer to Fig. 2-3 for a complete pictorial presentation of the various triggering source options.

Selecting the Triggering Slope

The horizontal sweep can be triggered on either the rising (+ slope) or falling (— slope) portion of the triggering waveform as determined by the position of the TRIGGER SELECTOR switch. When the switch is in one of the + positions, the sweep is triggered on the rising portion of the triggering waveform; when the TRIGGER SELECTOR switch is in one of the — positions, the sweep is triggered on the falling portion of the waveform. (See Fig. 2-4).

In many applications the triggering slope is not important, since triggering on either slope will provide a display which is suitable to the application. However, in many other cases such as pulse measurements, the triggering is very important. If, while using a fast sweep, you wish to see the rise of a pulse, it will be necessary for you to trigger the sweep on the rising portion of the waveform by placing the TRIGGER SELECTOR (black knob) switch in one of the + positions. To observe the fall of a pulse at a fast sweep speed, it will be necessary to trigger the sweep on the falling portion of the waveform by placing the TRIGGER SELECTOR (black knob) switch in one of the — positions. In either case, selection of the wrong triggering slope will make it impossible for you to see the portion of the waveform you want to check.

Using the STABILITY and TRIGGERING LEVEL Controls

Triggered operation in all modes except AUTOMATIC and HF SYNC may require proper setting of the STABILITY and TRIGGERING LEVEL controls. The TRIGGERING LEVEL control has no effect in either AUTOMATIC or HF SYNC modes.

The STABILITY control has a PRESET position at the fully counterclockwise setting of the control. This position permits proper triggering in many applications without necessitating additional adjustment of the STABILITY control. If it becomes difficult or impossible for you to obtain proper triggering with the STABILITY control at PRESET, you must then adjust the control. This is done with the TRIGGERING LEVEL control fully counterclockwise. The STABILITY control is rotated clockwise from the PRESET position until a trace appears on the screen. The proper Stability setting for a triggered display is then obtained by turning the knob slowly counterclockwise until the trace just disappears.

The TRIGGERING LEVEL control should then be turned slowly toward the 0 position until a stable display appears on the screen. The TRIGGERING LEVEL control also determines the exact point on the triggering waveform where triggering of the sweep occurs. Turning the control clockwise causes the sweep to trigger at more positive points on the waveform, while turning the control counterclockwise causes the sweep to trigger at more negative points. If the displayed waveform is vertically centered under the graticule, setting the TRIGGERING LEVEL control at 0 will cause the sweep to start at approximately the mid-voltage point of the waveform, except in DC mode.

Selecting the Triggering Mode

After selecting the triggering source and triggering slope, it is next necessary to select the triggering mode which will allow you to obtain the desired display. Four triggering modes are available. In the Type 316, they are DC, AC, AUTOMATIC and HIGH FREQUENCY SYNC.

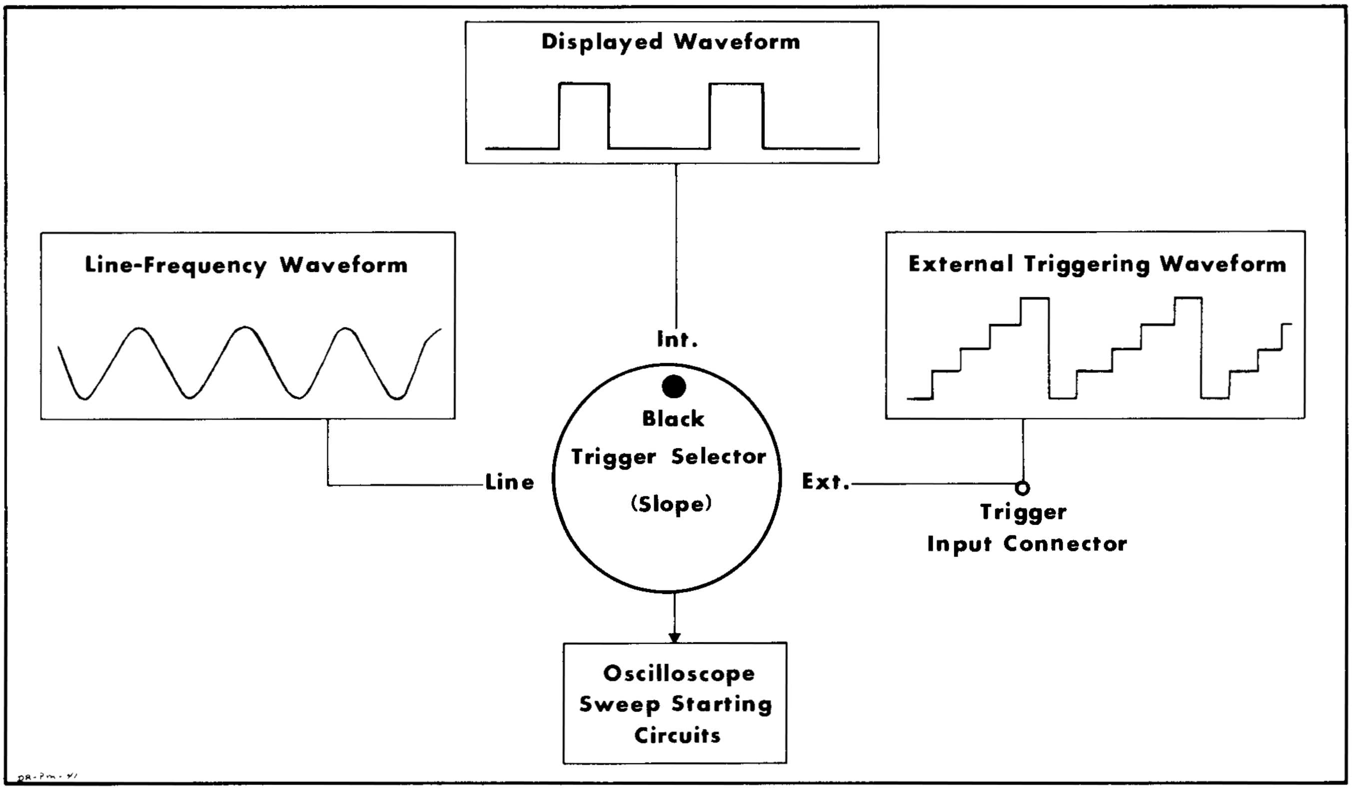


Fig. 2-3. The triggering signal is selected from three possible sources with the TRIGGER SLOPE control.

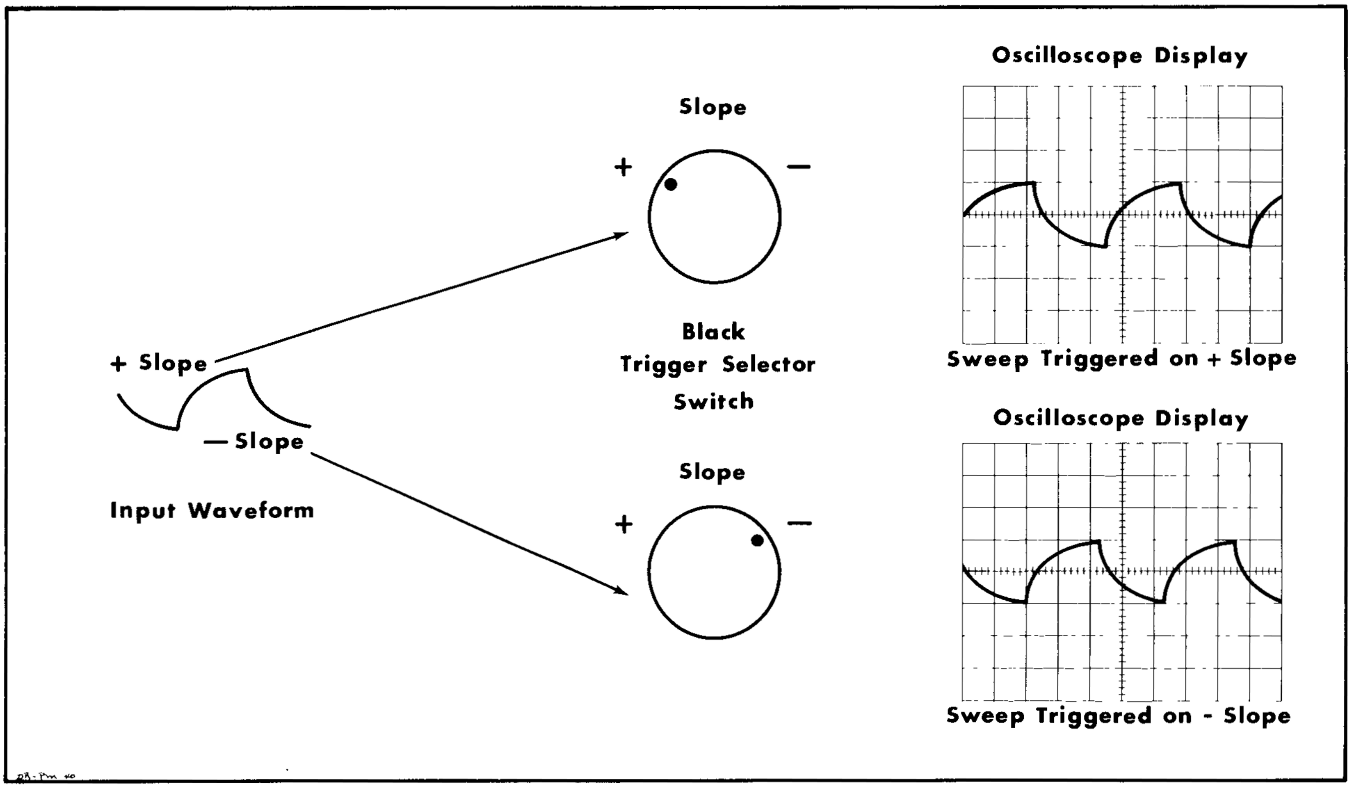


Fig. 2-4. Effects on the oscilloscope display produced by + and — settings of the TRIGGER SLOPE control.

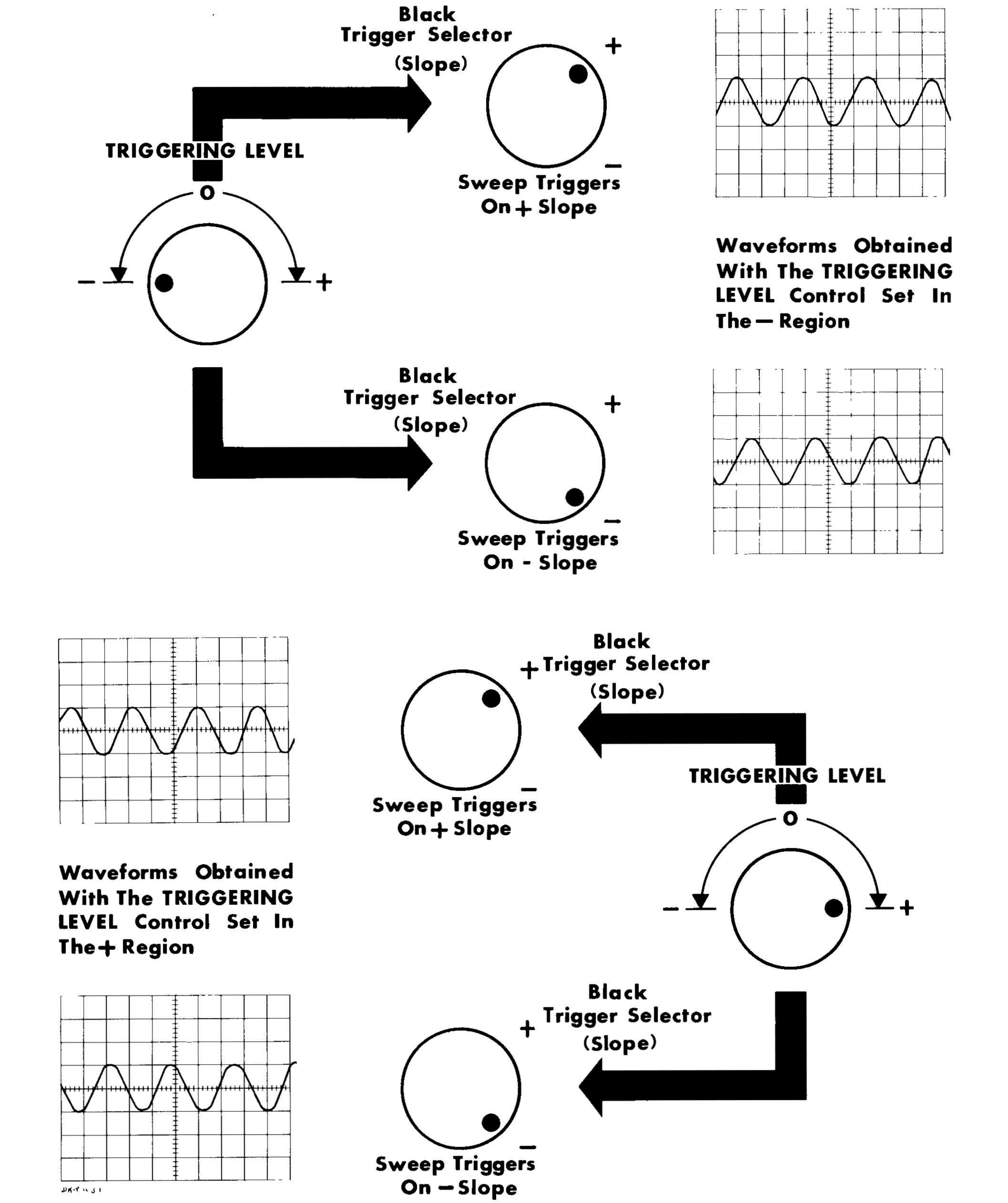


Fig. 2-5. Effects on the oscilloscope display produced by + and — settings of the TRIGGERING LEVEL control. When the TRIGGERING LEVEL control is set in the + region, the sweep is triggered on the upper portion of the input waveform; when it is set in the — region, the sweep is triggered on the lower portion of the input waveform. The TRIGGER SLOPE control determines whether the sweep is triggered on the rising portion or the falling portion of the input waveform.

Each of the triggering modes is designed to provide stable triggering from a certain type of waveform. For most applications however, several of the triggering modes will work equally well. For applications of this type, the triggering mode used is purely a matter of choice. The primary thing to consider in choosing the triggering mode is whether or not it allows you to obtain the display you want.

To determine the best mode of operation for a particular application, it is usually best to try each triggering mode in the application. The Automatic mode should be tried first since this triggering mode provides stable triggering in most applications without the necessity of setting the STABILITY or TRIGGERING LEVEL controls. If the Automatic mode does not provide the desired display, it will then be necessary for you to try one or more of the other triggering modes.

AUTOMATIC Triggering Mode

The AUTOMATIC mode is most frequently used because of its ease of operation. This mode is useful in obtaining stable triggering from waveforms with frequencies of from approximately 60 cycles to 2 megacycles. The principal advantage of this type of operation is that it is not necessary to adjust either the STABILITY or TRIGGERING LEVEL controls to obtain a stable display. This permits you to observe a large number of waveforms with different shapes and amplitudes without adjusting any of the triggering controls. In the absence of a triggering signal, the sweep continues to run to provide a convenient reference trace on the oscilloscope screen.

The AUTOMATIC triggering mode is selected by placing the TRIGGER SELECTOR (red knob) switch in the AUTO. position. The triggering source and slope is then selected and the input signal is applied to the oscilloscope. No other control adjustments are required. Since the TRIGGERING LEVEL control has no effect on the display when automatic triggering is used, it is impossible to select the point on the triggering waveform where the sweep is triggered. Each sweep is instead triggered at the average voltage point of the waveform.

DC Triggering Mode

In the DC mode, the sweep can be triggered from periodic signals in the range from dc to 5 mc. This mode is especially useful with trigger signals that change slowly, and is also useful when it is desired to trigger at a certain point (voltage level) on a waveform with respect to ground.

Another application of the DC triggering mode is to obtain a stable display of a random-pulse train. The average voltage of this type of signal is dependent upon the time duration and amplitude of each pulse and the time lapse between successive pulses. Since these are variable quantities in a random-pulse train, the average voltage will also vary. This is likely to cause unstable triggering in the AC mode. In the dc mode, however, the circuits are sensitive to the instantaneous voltage only. Changes in the average voltage do not alter the operation of the circuits. As a result, the TRIGGERING LEVEL control can be adjusted to initiate a sweep whenever a pulse reaches the desired voltage.

AC Triggering Mode

Selection of the AC triggering mode is made by placing the TRIGGER SELECTOR (red knob) switch in the AC position. This mode provides useful triggering in the frequency range of approximately 15 cycles to 5 mc. These frequency limits vary slightly depending upon the shapes and amplitude of the trigger waveform. In the AC mode, triggering is unaffected by the dc components of the triggering signal or by the vertical positioning of the trace. The triggering level can be selected to provide the desired display using the STABILITY and TRIGGERING LEVEL controls. These two controls are set as described for the DC mode.

HF SYNC Triggering Mode

The High Frequency Snychronization Mode permits stable displays of waveforms with frequencies higher than approximately 5 mc. Stability of the display is adjusted with the STABILITY control. The TRIGGERING LEVEL control is not used. To use the High Frequency Synchronization Mode, place the TRIGGER SELECTOR (red knob) switch in the HF SYNC position. Turn the STABILITY control clockwise until a trace appears. Continue to adjust the STABILITY control until a stable display is obtained.

Although the synchronization signal source is selected with the TRIGGER SELECTOR (black knob) control, the slope cannot be selected. Also you cannot use the PRESET position of the STABILITY Control in this mode.

Free-Running Sweep Operation

In the usual oscilloscope application, the sweep is triggered or synchronized by the input waveform. However, in some applications it may be more desirable to reverse the process and initiate the input waveform through use of a periodically recurrent waveform from the oscilloscope. In this type of application the sweep is caused to free-run and an output from either the +GATE OUT or SAWTOOTH OUT connectors is used to trigger or synchronize the input waveform. (See Fig. 2-6).

The sweep can be made to free run with any setting of the TRIGGER SELECTOR (black knob) switch by turning the STABILITY control fully clockwise. In all positions of the TRIGGER SELECTOR (red knob) switch except AUTOMATIC the number of sweeps per second is determined by the setting of the TIME/DIV controls. In the AUTOMATIC position, the sweep repetition rate remains at approximately 50 sweeps per second regardless of the setting of the TIME/DIV control.

In addition to providing the means of controlling an applied waveform, a free-running sweep also provides a convenient reference trace on the oscilloscope screen without requiring an input signal. This trace can then be used to position the sweep or to establish a voltage reference line.

Sweep Magnification

To magnify a particular part of a display, position that portion of the display with the HORIZONTAL POSITION control so that it appears near the center of the graticule.

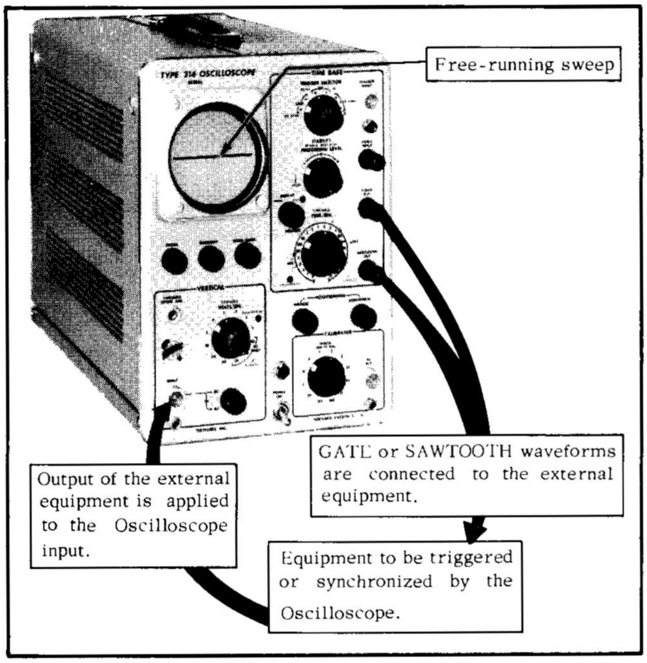


Fig. 2-6. Using the Gate or Sawtooth Output waveforms to synchronize or trigger external equipment.

Then turn the DISPLAY control to MAG. position. That part of the display which formerly occupied the middle section of the graticule will now be expanded. The apparent time calibration of the X (sweep) axis will be equal to the setting of the TIME/DIV control divided by 5.

External Horizontal Deflection

In some instances it may be necessary to deflect the beam horizontally by means of an externally derived waveform,

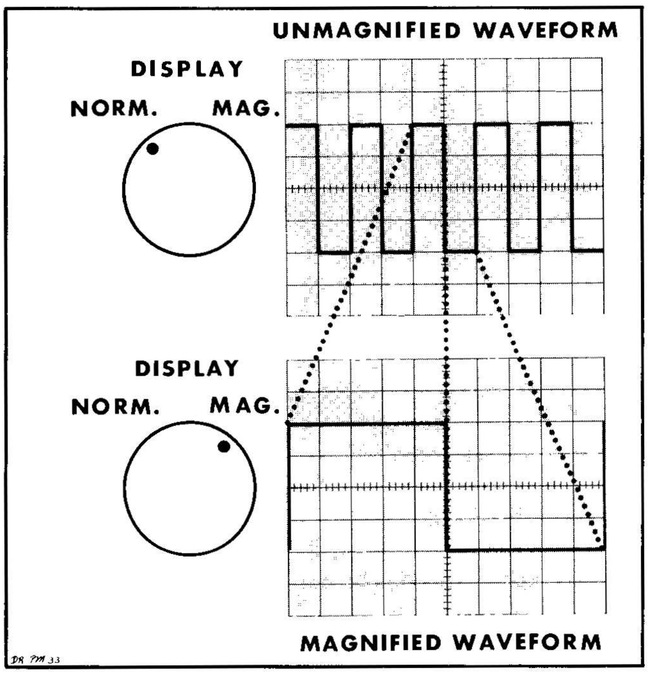


Fig. 2-7. Effects of the Sweep MAGNIFIER control.

rather than by means of the internal sweep. To accomplish this, set the DISPLAY switch to EXT. and connect the source of the waveform to the HORIZ. IN connector. Set the VARIABLE for the desired amount of horizontal deflection.

Output Waveform

The SAWTOOTH OUT waveform starts at about ground and rises linearly to a peak amplitude of about 150 volts.

The start and duration of the rising part of the sawtooth coincides with the start and duration of the horizontal sweep on the crt. The rate at which the sawtooth rises is determined by the setting of the TIME/DIV control.

A positive rectangular waveform is available at the + GATE OUT connector. This waveform starts at ground and rises to about 20 volts. The starting time and duration of each pulse coincides with the starting time and duration of the positive-going part of the sawtooth available at the SAWTOOTH OUT connector.

AUXILIARY FUNCTIONS

Calibrator

The calibrator provides a convenient source of square waves of known amplitude at a frequency of approximately 1 kc. The square-waves are used primarily to adjust probes and to verify the calibration of the vertical deflection system of the oscilloscope.

Calibrator square-waves are adjustable from .05 volts peak to peak, to 100 volts peak to peak, in 11 steps. The VOLTS PEAK TO PEAK knob controls the full range of 11 outputs, ranging in steps from .05 volts to 100 volts.

The peak to peak calibrator voltage is within 3 percent of the CALIBRATOR switch setting when the output is connected to a high impedance load.

Intensity Modulation

The crt display of the Type 316 Oscilloscope can be intensity modulated by an external signal to dislay additional information. This is done by disconnecting the grounding strap from the CRT CATHODE connector at the rear of the instrument and connecting the external signal to this terminal.

When you wish to make very accurate time measurements from the crt display, you can intensity modulate the beam with time markers presented on the screen. A positive signal of approximately 25 volts is required to cut off the beam from normal intensity.

Direct Connection to CRT Deflection Plates

The vertical deflection plate pins are located on the side of the crt neck. The horizontal deflection plate pins are located on the top. In some applications, it is advantageous to connect a signal directly to either one or both sets of these deflection plate pins—bypassing the internal oscilloscope amplifiers. Maintain the average dc voltage on the deflection plates between +150 and 200 volts. If the voltage is not within this range, the crt display may become defocused.

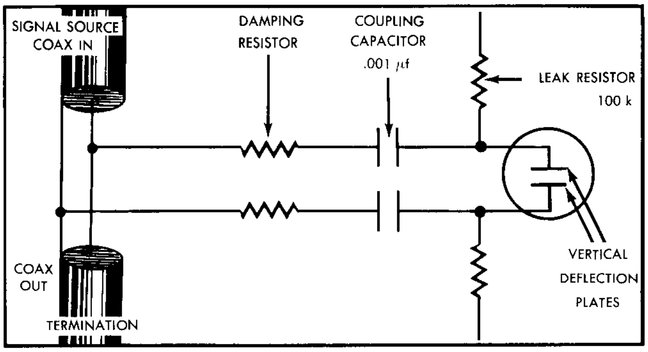


Fig. 2-8. Connecting to the crt deflection plates by AC coupling.

For dc coupling, it is necessary to supply positioning voltages from the signal source. These voltages should fall within the +150 to +300 volt range. When dc coupling the signal to the deflection plates, you should tape the ends of the wires you have removed from the crt pins. This prevents shorting to the chassis and damage to the amplifier. The external signal source is then connected to the crt.

In many applications, it is advantageous to use ac coupling. This is necessary for those signals which cannot be made to have the right dc voltage. Positioning is controlled through the vertical amplifier with its normal positioning control.

The usual direct deflection application is to make use of the ultimate rise-time capability of the crt in the oscilloscope. This requires careful connection to the deflection plates from coaxial cables through damping resistors, and physically small coupling capacitors. These leads should be set close to the crt pins, should be short, and should be rigid. Tie down the coax so that a pull on the coax will not break the crt.

Referring to Fig. 2-8, connect the damping resistor to the coax center conductor. Connect the other damping resistor to the coax outer conductor. The size of the damping resistors will depend upon the coaxial line impedance, the lead lengths, and the coupling capacitor type. The best value is found by passing a fast-rise signal through the coax and adjusting the resistance until the display is just short of overshoot. A good starting value is 68Ω for a 52-Ω coaxial cable. No damping resistors are needed for cables with impedance above approximately 200 Ω.

In order to realize the desired amount of deflection sensitivity in the Type T316 Cathode Ray Tube, the deflection plates have been placed as close as possible to the path of the electron beam. As a result, a small amount of current will flow in the deflection plate circuits. This current flow varies nonlinearly with the beam position, increasing rapidly in that plate toward which the beam is positioned. In the Type 316 oscilloscope, the effects of these currents are negligible. However, if the resistance is increased, these currents can cause objectionable voltage drops. For values of resistance greater than 110 k for the leak resistor, you may experience some difficulty from the current collected on the deflection plates. Some defocusing or distortion may be evident. These effects are most noticeable when the display is positioned close to the limits of the crt graticule.

The low frequency response required will determine the size of the coupling capacitor needed. The formula for the size of the coupling capacitor is

$$C = \frac{1}{2\pi RF}$$

where R is the leak resistor, and F is the desired low-frequency cutoff. For example, to find the coupling capacitor needed when the low frequency cutoff is 1600 cps and the leak resistor is 100 k, take the reciprocal of $2\pi RF$. The Coupling capacitor is .001 μf.

The coupling capacitor should be spaced about 1/4" to 3/8" from the damping resistor, and should be of the ceramic disc type, or equivalent, to preserve the fast-rise capability of the Type T316 crt.

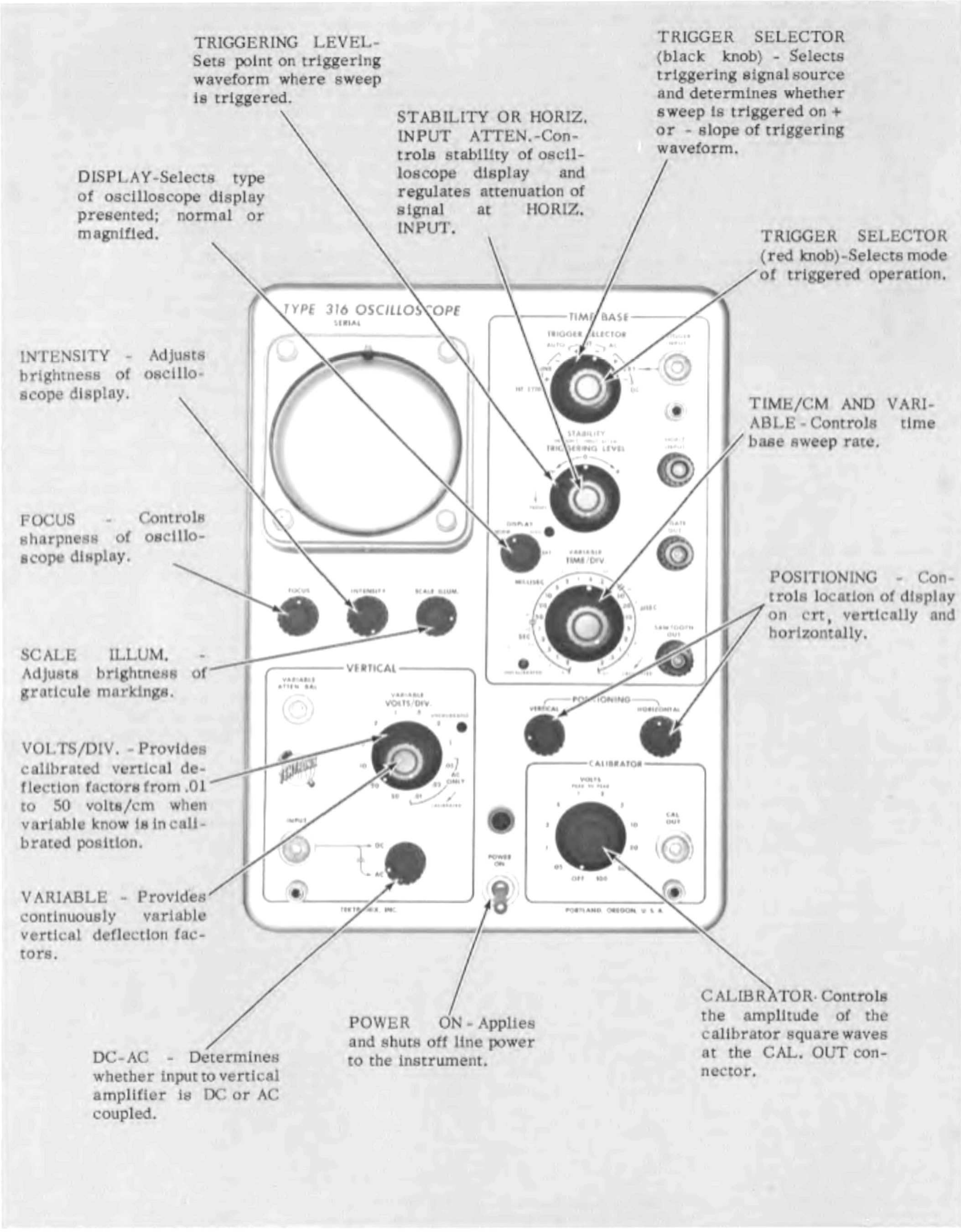
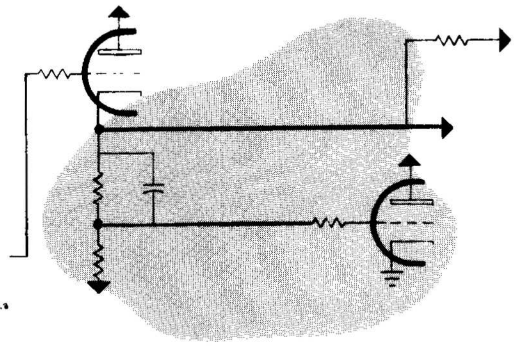


Fig. 2-9. Functions of the Type 316 Oscilloscope front panel controls.



SECTION 3

CIRCUIT DESCRIPTION

VERTICAL-DEFLECTION SYSTEM

Preamplifier

The Vertical Amplifier in the Type 316 Oscilloscope requires an input signal voltage of 0.1 v, peak-to-peak, to produce one division of calibrated deflection on the crt. In order to satisfy this condition, and to make the instrument applicable to a wide range of input voltages, a calibrated attenuation network and a Preamplifier are incorporated into the vertical-deflection system. When the VOLTS/DIV. switch (shown on the preamplifier circuit diagram) is in the .1 position, the signal is coupled through the X1 network—in which the attenuation is negligible—to the main Vertical Amplifier. The X1 network compensates for lead inductance in the input circuit. For settings of the VOLTS/DIV. switch between .2 and 50, the Attenuators are switched into the circuit, either singly or in tandem pairs, so that the input voltage to the main Vertical Amplifier is always .1 v for each division of the crt deflection when the VARIABLE knob is in the CALIBRATED position.

The Attenuators are frequency-compensated voltage dividers. For low-frequency signals they are resistive dividers, and the degree of attenuation is proportional to the ratio of the resistances. The reason for this is that the impedance of the capacitors, at low frequencies, is so high that their effect in the circuit is negligible. As the frequency of the input signals increases, however, the impedance of the capacitances decreases and their effect in the circuit becomes pronounced. For high-frequency signals the impedance of the capacitances is so low, compared to the resistance of the circuit, that the Attenuators become capacitive voltage dividers. For these frequencies, the degree of attenuation is inversely proportional to the ratio of the capacitances.

The variable capacitor at the input to each Attenuator (except for the X1 network) provides a means for adjusting the input capacity of the Attenuator to equal that of the main Vertical Amplifier. Similarily, C141 provides a method of adjusting the input capacity of the Preamplifier. In this manner the probe, connected to the INPUT connector, works into the same input capacity regardless of the setting of the VOLTS/DIV. switch. In the "straight through" (X1) position, the probe works directly into the main Vertical Amplifier, so no adjustment is required for this network.

By means of the AC-DC switch (SW101) the signal may be either ac-coupled or dc-coupled to the Vertical Amplifier. In the AC position the signal is coupled through C101; in the DC position, C101 is bypassed with a direct connection. When the VOLTS/DIV. switch is in any of the three positions marked AC ONLY, the AC-DC switch is electrically removed from the circuit and the signal is coupled through C101.

When working with very small voltages, greater sensitivity than furnished by the main Vertical Amplifier may be required or desired. To provide this, the Preamplifier can be switched into the circuit by turning the VOLTS/DIV. switch to any of the positions marked AC ONLY. The Preamplifier is used in conjunction, with either the X1, the X2 or the X5 Attenuator, depending on the setting of the switch, and provides three additional ranges of vertical sensitivity.

The Preamplifier, which has a calibrated signal gain of 10, consists of a single amplifier stage V154, a cathode follower output stage V163B, and a voltage-setting cathode follower V163A. The Voltage-Setting C.F. provides a +175-volt source for the plate and screen circuits of V154, and for the plate of V163B.

The gain of the Preamplifier is regulated by the setting of the PREAMP GAIN ADJ. R154. This control regulates the gain of V154 over an approximate range of 7 to 17 by varying the degeneration in its cathode circuit. For calibrated operation, however, this control must be set so that the gain is exactly 10. (See Calibration Procedure.)

High-frequency compensation for the Preamplifier is provided by a series-shunt peaking coil L150, and by series peaking coils L157 and L177. L150 and L177 provide a means for adjusting the circuit for optimum high-frequency response. R157 is included in the grid circuit of V163B to prevent parasitic oscillations that might occur.

Low-frequency accentuation for the Preamplifier is provided mainly by C146A in the plate circuit of V154. Together with R146 and R150, this circuit forms a low-frequency "boost" network to compensate for the attenuation in the cathode circuit, the screen circuit, and the rc coupling network between the Output C.F. and the Vertical Amplifier. The amount of compensation added to the circuit can however, be varied with the LOW FREQ. ADJ. control R175. (On some instruments this control is called LOW. FREQ. COMP.) By adjusting the amount of attenuation to equal that of the compensation, low frequency distortion in the amplifier is eliminated.

There are two protective devices incorporated in the design of the Preamplifier. One is the diode V142, which protects the electrolytic capacitor C154 from inverse voltage in the event the cathode circuit of V154 should go negative. This would occur, for example, if V154 were removed from its socket when the power was turned on. The other protective device is the neon lamp B163. This prevents the potential between the grid and cathode of V163B from exceeding the break-down rating of the tube in the interval from the time the instrument is first turned on and the time that V163B is warmed up to its operating condition.

Vertical Amplifier

The Vertical Amplifier consists of two stages of direct-coupled, push-pull amplification, each preceded by a cathode follower. V183 is the signal-input cathode follower when the VOLTS/DIV. switch is in any position other than those marked AC ONLY (in other words, when the Preamplifier is not connected into the circuit). R184, bypassed by C184, prevents the grid from drawing excessive current in the event the stage should be overdriven. R187 is a suppressor for parasitic oscillations.

The Input Amplifier stage, composed of V214 and V224, is a cathode-coupled phase inverter. That is, it converts a single-ended input signal to a push-pull output signal. The VARIABLE control, located between the two cathodes, regulates the gain of the stage over a $2\frac{1}{2}$ to 1 range by varying the amount of degeneration in the cathode circuit.

When the Preamplifier is not connected into the circuit, as mentioned previously, the Input Amplifier stage receives its signal voltage from V183. The opposite cathode follower, V203, couples a fixed dc voltage from the VAR. ATTEN BAL. control to the grid of V224. When this control is properly set, the cathode voltages at the two Input Amplifier tubes will be equal and no change in vertical trace positioning will occur as a result of any change in the setting of the VARIABLE gain control.

When the Preamplifier is connected into the circuit, by turning the VOLTS/DIV. switch to any of the positions marked AC ONLY, V203 becomes the signal-input cathode follower. This action removes V183 from the signal path by returning its grid circuit to ac ground through C182. The switching of Input C.F. tubes compensates for the 180-degree shift of signal polarity introduced by the Preamplifier. With this arrangement, positive-going portions of the input signal always produce an upward deflection of the crt beam.

Vertical positioning of the crt beam is accomplished through the action of the VERTICAL POSITIONING control R231. This is a dual control, connected between +300 volts and ground. It is connected electrically so that as the voltage between ground and the arm in one increases, the voltage between ground and the arm in the other decreases. When the potential at the arms of the controls is different than at the plate of the tubes to which they are connected, current will flow through the limiting resistors R230 and R232, and through the plate-load resistors R213 and R227. This current, flowing through the plate-load resistors, will change the voltage at the plate of the tubes. Rotation of the control will therefore cause the plate voltage at one tube to increase and the plate voltage at the other to decrease. Any change in plate voltage occuring in this stage, due to rotation of the VERTICAL POSITIONING control, will be reflected as a change in vertical deflection-plate voltage at the crt, since direct coupling is used between these two points.

The Input Amplifier stage, as well as all succeeding stages, contains high-frequency peaking coils to improve the high-frequency response of the amplifier. However, since direct-coupling is employed throughout, there is no low-frequency loss in the circuit and no low-frequency compensation is required.

The Input Amplifier is coupled to the Output Amplifier by the Driver C.F. V233. The GAIN ADJ. control, R244, sets the gain of the Output Amplifier to correspond with the front panel calibration when the VARIABLE control is turned full right to the CALIBRATED position.

Delay Line

The output signal from the Vertical Amplifier is coupled through the balanced Delay Line to the vertical-deflection plates of the crt. The function of the Delay Line is to retard the arrival of the waveform at the deflection plates until the crt has been unblanked and the horizontal sweep has been started. This delay insures that the very "front" of fast vertical signals can be observed. Because of the delay time and certain other characteristics, irregularities are introduced in the crt display when the delay line is misadjusted. And it is through analyzing the shape and position of these irregularities that we are able to effect the necessary adjustments.

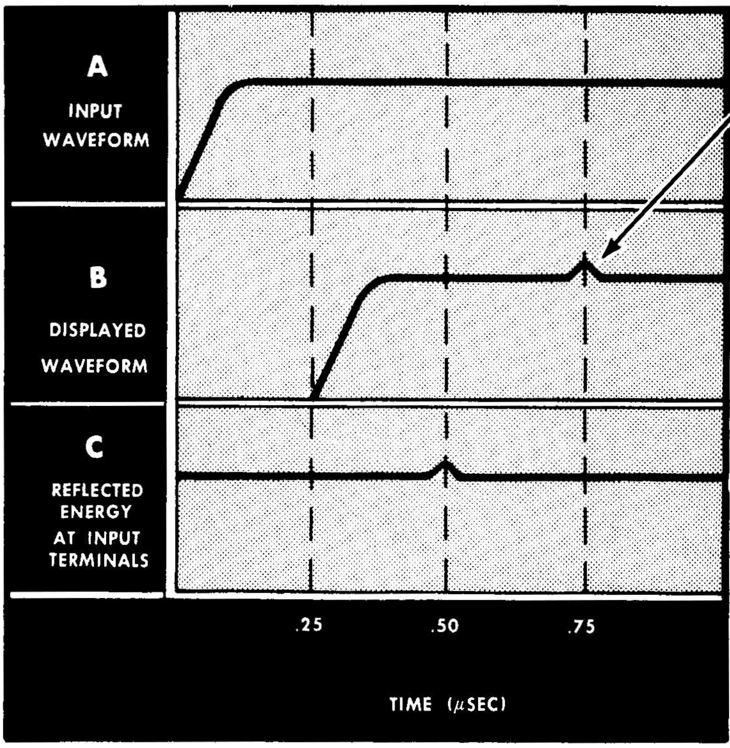
So that you will better understand the adjustment procedure (described in the Calibration Procedure, Section 5, we have outlined in the paragraphs that follow a brief description of the delay line operation and how it affects the crt display.

Consider the sequence of events when a step function is applied to the delay-line input terminals (waveforms A in Fig. 3-1). We'll assume for the moment that the delay line is in good adjustment except for two variable capacitors adjacent to the crt deflection plates.

Oen quarter microsecond after the application of the step function, the leading edge of the waveform will arrive at the crt deflection plates. The crt end of the delay line is terminated, and in normal operation the signal energy would be dissipated in the terminating resistors. However, the misadjustment of the two capacitors creates a slight impedance mismatch, resulting in the reflection of a small amount of signal energy. This reflected energy travels down the delay line toward the input terminals, while, at the same time, the original step function is being traced on the crt screen.

The reflected energy reaches the delay-line input terminals in 0.25 microseconds (the delay time of the delay line) and is once again reflected since there are no terminating resistors to absorb the energy (waveform C in Fig. 3-1). As a result, the reflected energy is present at the crt deflection plates 0.5 microseconds (twice the delay-line delay time) after it was initially reflected. This energy is manifest in the crt display as an irregularity occuring 0.5 microseconds after the leading edge of the step function (waveform B in Fig. 3-1). Because the reflected energy is the result of a misadjustment in the delay-line terminating network, we call the irregularity on the displayed waveform the Termination Bump. For ease of discussion in the following paragraphs, we shall refer to the lapsed time from leading edge to Termination Bump as time T.

Consider next the affect of a misadjustment located $\frac{1}{4}$ of the delay-line length from the input terminals. Because the velocity of propagation is uniform over the length of the



The reflected energy is caused initially by a slight misadjustment in the delay-line termination network. As a result, the irregularity in the displayed waveform is called the Termination Bump.

Fig. 3-1. Time relationship of delay-line signals.

delay line, the step function will reach the point of misadjustment ¼ of the delay-line delay time after application. This is equivalent to 1/8T. At this point, a small amount of energy is reflected back to the input terminals due to the impedance mismatch caused by the misadjustment. The reflected energy will reach the input terminals 1/8T after being reflected or ¼T after application of the step-function. This means, then, that the reflected energy will reach the crt deflection plates ¼T after the leading edge of the step function and will result in a bump located ¼ of the distance from the leading edge to the Termination Bump on the displayed waveform (see Fig. 3-2).

If the misadjustment of the previous paragraph were located elsewhere on the delay-line, it could be shown that its relative position between input terminals and termination network would correspond to the position of the resulting bump on the displayed waveform. It is this characteristic of the delay-line that allows us to locate and remedy a misadjustment.

Since the Delay Line is the load for the Vertical Output stage, it is elevated above ground by an amount equal to the plate voltage of the Output Amplifier stage. R293 and R294, in addition to terminating the line, are the plate-load resistors for the output stage.

When internal triggering of the Time Base Generator is desired (black TRIGGER SELECTOR knob is in either the + or —INT. position), a "sample" of the vertical output signal

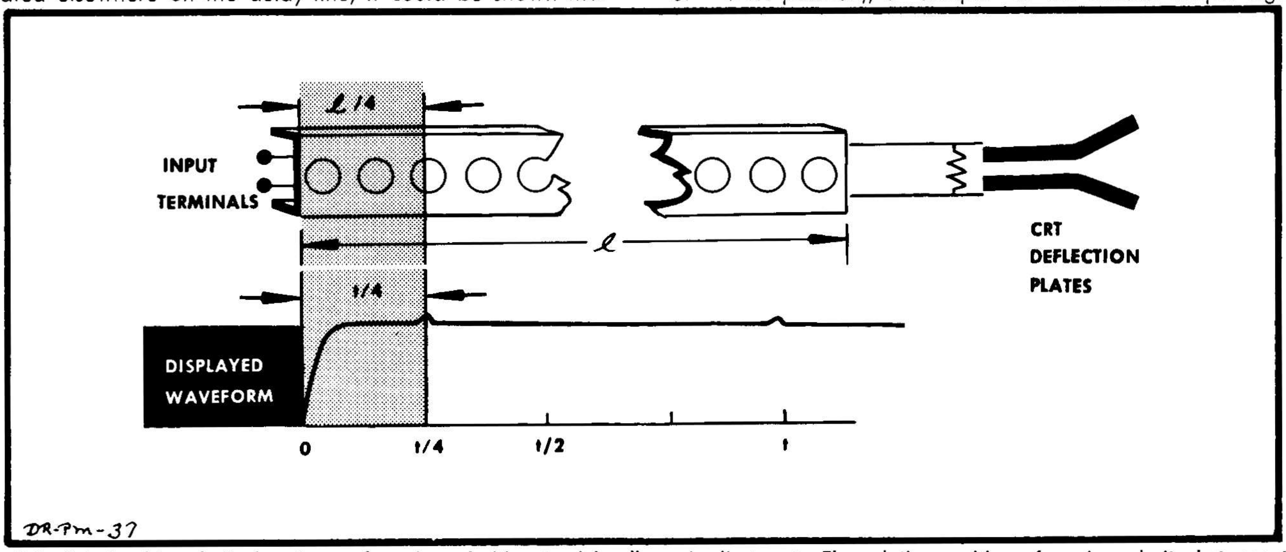


Fig. 3-2. Relationship of displayed waveform irregularities to delay-line misadjustment. The relative position of an irregularity between the start of the display and the Termination Bump corresponds to the relative position of the delay-line misadjustment between the input terminals and the terminating resistors.

is used to develop the triggering pulse. The "sample" is obtained from a tap on a coil at the input to the Delay Line. This point provides a signal suitable for good triggering action, yet presents minimum loading to the Output Stage and the Delay Line. The "triggering" signal is coupled to the Time-Base Trigger circuit by the Trigger C.F. V263, shown on the Vertical Amplifier circuit diagram.

HORIZONTAL-DEFLECTION SYSTEM

Time-Base Trigger

The function of the Time-Base Trigger circuitry is to develop a negative-going triggering pulse to trigger the Time-Base Generator in the proper time sequence. The signal from which the negative going triggering pulse is produced may emanate from one of three sources, as determined by the setting of the TRIGGER SELECTOR switch (black knob) SW420. When the switch is in the + or —EXT. position, an external signal is employed in the development of the triggering pulse. When the switch is in the + or —INT. position, the vertical signal itself is used to develop the triggering pulse. This was explained at the conclusion of the previous section. In the + or —LINE position of the switch, a voltage at the power line frequency is used to develop the triggering pulse.

In addition to selecting the source of the triggering voltage, switch SW420 (TRIGGER SELECTOR, black knob) also arranges the input circuit of the Trigger-Input Amplifier so that a negative-going pulse is always produced at the plate of V435B regardless of whether the switch is in a + or — position.

The Trigger-Input Amplifier V414 is a polarity-inverting, cathode-coupled amplifier. The output is always taken from the V414B plate, but the grid of either stage may be connected to the input-signal source. When the black TRIGGER SELECTOR knob is in the — position (EXT., INT. or LINE range), the V414A grid is connected to the input-signal source. The grid of V414B is connected to a dc bias source, adjustable by means of the TRIGGERING LEVEL control. This bias voltage establishes the quiescent voltage at the V414B plate. When the TRIGGER SELECTOR knob is in the + position (for any of the three ranges), the grid of V414B is connected to the input-signal source and V414A is connected to the bias source.

The voltage at the grid of V414A and the voltage at the plate of V414B are in phase with each other; that is, they both go through ac zero in the same direction at the same time. Therefore, when the switch is in any of the — positions (the signal applied to the V414A grid), the voltage at the plate of V414B is in phase with the input-signal voltage. By this arrangement, V414A acts as a cathode follower, having a gain of approximately unity, and the signal voltage developed across the cathode resistor becomes the input signal to the V414B section.

When the switch is moved to any of the + positions, the V414B grid is connected to the input-signal source. With this configuration, the voltage at the plate of V414B will be 180 degrees out of phase with the input-signal voltage. Thus, depending on the setting of the switch (+ or —), the V414B plate signal swing may be in phase, or 180 degrees out of phase, with the input signal voltage.

The Schmitt Trigger consists of V435, A and B, connected as a dc-coupled multivibrator. In the quiescent state. i.e., ready to receive a signal, V435A is conducting and its plate voltage is down. This holds the V435B grid below cutoff, since the two circuits are dc-coupled by the voltage divider R435, R436 and R437. With V435B in a state of cutoff, its plate voltage is up; hence no output is being developed.

A negative-going signal is required at the grid of V435A to drive the Schmitt Trigger into its other state in which the triggering pulse can be produced. However, the signal coupled to the V435A grid is a component of the vertical input signal, and therefore contains both negative- and positive-going voltages.

The negative-going portion will drive the V435A grid in the negative direction, and the cathodes of both tubes will follow the grid down. At the same time the V435A plate voltage starts rising, which causes the V435B grid voltage to rise. With the grid of V435B going up and its cathode going down, V435B starts conducting. The cathodes will no longer follow the V435A grid; hence the cathode voltages start going up. With the V435A grid down and its cathode up, it cuts off. As V435B conducts its plate voltage drops, creating a negative step at the output. This transition occurs very rapidly, regardless of how slowly the V435A grid signal falls.

When the signal at the grid of V435A starts in the positive direction, just the opposite will occur. That is, V435A will start conducting again, V435B will be cutoff, and the circuit will revert to its original state with the V435B plate voltage up. This completes the negative step voltage output from the Schmitt Trigger circuit.

The operation of the Schmitt Trigger circuit is exactly the same for both + and — positions of the black TRIGGER SELECTOR knob. However, since there is a reversal in signal polarity—between these two settings—triggering will occur at different points with respect to the signal being observed. For example, when the switch is in the + position, triggering will occur during the positive slope of the waveform. Conversely, when the switch is in the — position, the trace will start when the waveform is going in the negative direction.

The TRIGGER SELECTOR switch with the red knob, SW140, selects the type, or mode of triggering. In the DC position, the vertical-input signal is dc-coupled from the Trigger C.F. to the Trigger-Input Amplifier, which in turn is dc-coupled to the grid of V435A. R422 isolates the output circuit of V414B from the capacitance of the switch; R424 isolates the grid circuit of V435A from the switch.

In the AC position of the switch, capacitor C407 is connected into the input circuit; this, of course, removes any dc component of the input waveform. The Trigger-Input Amplifier, however, is still dc-coupled to the Schmitt Trigger stage.

In the AUTO. position of the switch, the Schmitt Trigger is converted from a bistable configuration to a recurrent configuration. This is accomplished by coupling the grid circuit of V435B to the grid circuit of V435A via R431. In addition, the dc-coupling between the Trigger-Input Amplifier and the Schmitt Trigger is removed when the switch is in this position.

The addition of R431 to the circuit causes the Schmitt Trigger to free-run in the absence of a vertical-input signal. For example, assume the grid of the V435A section is just being driven into cutoff. The voltage at the plate of V435A starts to rise, carrying with it the grid voltage of V435B. The grid of V435B is coupled to the grid of V435A through R431 and R424. This causes the grid voltage of V435A to start rising. The time constant of the rc network R431, R424 and C423 is such that it takes about .01 second for the V435A grid voltage to rise exponentially from its starting point, below cutoff, to a value where plate current can flow.

As V435A starts to conduct, its plate voltage drops, which in turn lowers the voltage at the V435B grid. The voltage at the V435A grid then starts dropping exponentially toward cutoff. When the grid of V435A reaches cutoff again, the circuit has completed one cycle of its approximately 50-cycle triangular waveform.

The range of voltage at the grid of V435A, between V435A cutoff and V435B cutoff, is about 3 volts when the circuit is used in the AUTO. mode (this is increased from about 0.5 volt, for the AC or DC mode, by the addition or R431 to the circuit). Since the V435A grid is never more than 3 volts from cutoff, a triggering signal with a peak-to peak amplitude of 3 volts or more can drive the grid to cutoff at any time and produce a trigger output. Smaller signals can also produce a trigger output, but only if they occur at a time when the sum of the signal voltage and the triangular grid voltage is sufficient to drive the V435A grid to cutoff. However, the duty cycle of operation is somewhat reduced when smaller triggering signals are being received.

With the circuit configuration just described, the horizontal sweep can be triggered with repetitive signals, over a wide range of frequencies, without readjustment. When not receiving triggers, the sweep continues at a 50-cycle rate. Thus, in the absence of any vertical signal, the sweep generates a base line which indicates that the oscilloscope is adjusted to display any signal that might be connected to the vertical-deflection system.

When switch SW410 is in the HF SYNC position, the Time-Base Trigger circuits are bypassed and the input "triggering" signal is applied directly to the Time-Base Generator. This signal now acts as a synchronizing signal, superimposed on the holdoff waveform (to be discussed in the section that follows). This synchronizes the Time-Base Generator at a submultiple of the triggering-signal frequency. This mode is useful for input signals in the range from 5 megacycles to 15 megacycles.

Time-Base Generator

The Time-Base Trigger produces a negative-going waveform which is coupled to the Time-Base Generator. This waveform is differentiated in the grid circuit of V25A to produce a sharp negative-going triggering pulse to trigger the Time-Base Generator. Positive-going pulses are also produced in the differentiation process, but they are not used in the operation of the Time-Base Generator.

The Time-Base Generator consists of three main circuits: a Bistable Multivibrator, a Miller Runup Circuit, and a Hold-Off Circuit. The Bistable Multivibrator consists of V25A, V35B and the cathode follower V25B. The essential components in the Miller Runup circuit are the Miller Tube V61B, the Runup C.F. V61A, the On-Off Diodes V52, the Timing Capacitor C160 and the Timing Resistor R160. The Hold-Off Circuit consists of the Hold-Off Divider V83A, the Hold-Off C.F. V83B, the Hold-Off capacitor C180 and the Hold-Off Resistor R181.

In the quiescent state, V25A is conducting and its plate voltage is down. This cuts off V35B through the cathode follower V25B, the voltage divider R26-R27, and the cathode resistors, R28 and R29.

The quiescent state of the Miller Tube is determined by a dc network between plate and grid. This network consists of the neon lamp B75, the Runup C.F. V61A, and the On-Off Diodes V52. The purpose of the dc network is to establish a voltage at the plate of the Miller Tube of such a value that the tube will operate above the knee, and thus over the linear region, of its characteristic curve.

In the quiescent state, the grid of the Miller Tube rests at about —2 volts. There is about a 1½-volt drop in the Runup On-Off Diodes, about 18.5 volts bias on the Runup C.F., and about a 55-volt drop across the neon lamp. This establishes a quiescent voltage of about +33 volts at the plate of the Miller Tube.

If the STABILITY control is now advanced, making the grid of V25A more negative, a point will be reached where a negative-going triggering pulse from the Schmitt Trigger stage will cause the Bistable Multivibrator to switch rapidly to its other state. That is, V25A will be cutoff and V35B will start to conduct. As V35B conducts, its plate voltage, and the voltage at the diode plates, drops. As a result the diodes are cutoff, which permits the grid of the Miller Tube and the cathode of the Runup C.F. to seek their own voltages. Any spiking that may occur, during this transition period, is attenuated by the R52-C52 network.

As there is no diode conduction at this time, the grid of the Miller Tube starts negative, since it is connected to —150 volts through the Timing Resistor R160. The plate of the Miller Tube then starts positive, carrying with it the grid and cathode of the cathode follower V61A. This raises the voltage at the top of the Timing Capacitor C160, which in turn raises the voltage at the grid of the Miller Tube and prevents it from going over ¾ of a volt negative. The gain of the Miller Tube, as a Class A amplifier, is approximately 200. This means that a 150-volt change in plate voltage will maintain the grid voltage constant within three-quarters of a volt.

The Timing Capacitor C160 starts charging with current from the —150-volt bus. Since the voltage at the grid of the Miller Tube remains essentially constant, the voltage drop across the Timing Resistor, and hence the charging current through it, remains essentially constant. Thus, C160 charges linearly, and the voltage at the cathode of the Runup C.F. V61A rises linearly. Any departure from a linear rise in the voltage at this point will produce a change in the voltage at the grid of the Miller Tube in such a direction as to correct for the error.

The linear rise of voltage at the cathode of V61A is used as the sweep time base. Timing Capacitor C160 and Timing Resistor R160 are selected by means of the TIME/DIV. switch (SW160). The Timing Resistor determines the current that charges the Timing Capacitor. By means of the TIME/DIV. switch, both the size of the capacitor being charged and the current charging the capacitor can be selected to cover a wide range of sawtooth slopes (sweep rates). For high-speed sweeps the bootstrap capacitor C72 helps supply current to charge the stray capacitance at the plate of the Miller Tube, which permits the plate voltage to rise at the required rate.

If uncalibrated sweep speeds are desired, the VARIABLE TIME/DIV. (red knob) control varies the sweep rate over a $2\frac{1}{2}$ to 1 range. Switch SW65 is ganged with the VARIABLE control in such a way that the UNCALIBRATED light comes on when the control is turned away from the CALIBRATED position.

As explained previously, the sweep rate is determined by the timing circuit C160 and R160. The length of the sweep is determined by the setting of the SWEEP LENGTH control R82. As the sweep voltage rises linearly at the cathode of V61A, there will be a linear rise in voltage at the arm of the SWEEP LENGTH control R82. This will increase the voltage at the grid and cathode of V83A, and at the grid and cathode of V83B. As the voltage at the cathode of V83B rises, the voltage at the grid of V25A will rise. When the voltage at this point is sufficient to bring V25A out of cutoff, the multivibrator circuit will rapidly revert to its original state with V25A conducting and V35B cutoff. The voltage at the plate of V35B rises, carrying with it the voltage at the diode plates. The diode then conducts and provides a discharge path for C160 through R37 and R38, and through the resistance in the cathode circuit of V61A. The plate voltage of the Miller Tube now falls linearly, under feedback conditions essentially the same as when it generated the sweep portion of the waveform except for a reversal of direction. The resistance through which C160 discharges is much less than that of the Timing Resistor (through which it charges). The capacitor current for this period will therefore be much larger than during the sweep portion, and the plate of the Miller Tube will return rapidly to its quiescent voltage. This produces the retrace portion of the sweep sawtooth, during which time the crt beam returns rapidly to its starting point.

The Hold-Off Circuit prevents the Time-Base Generator from being triggered during the retrace interval.

During the trace portion of the sweep sawtooth the Hold-Off Capacitor C180 charges through V83A, as a result of the rise in voltage at the cathode of V83A. At the same time, the grid of V25A is being pulled up, through the Hold-Off C.F. V83B, until V25A comes out of cutoff and starts conducting. As mentioned previously, this is the action that initiates the retrace. At the start of the retrace interval C180 starts discharging through the Hold-Off Resistor. The time constant of this circuit is long enough, so that during the retrace interval (and for a short period of time after the completion of the retrace) V180 holds the grid of V25A high enough so that it cannot be triggered. However, when C180 discharges to the point that V83B is cut off, it releases control of the grid of V25A and the grid returns to the level established by the STABILITY control. The hold-off time required is determined by the size of the Timing Capacitor. For this reason the TIME/DIV. switch changes the time constant of the Hold-Off Circuit simultaneously with the change of Timing Capacitors.

The STABILITY control R10 regulates the dc level at the grid of V25A. In use, this control is adjusted so that the grid voltage is just high enough to prevent the circuit from free-running. Adjusted in this manner, a sweep will only be produced when a negative-going triggering pulse from the Schmitt Trigger can drive the stage into cutoff. For convenience, a PRESET Stability control can be connected into the circuit via switch SW10. When in this position a fixed negative dc voltage is obtained from R11 and applied to the grid of V25A. Where triggering may be critical, however, the variable STABILITY control should be used.

The positive rectangular pulse appearing at the cathode of V25B is coupled through the Unblanking C.F. to the grid circuit of the crt. This pulse, whose start and duration are coincident with that of the sweep portion of the sawtooth, unblanks the crt and permits the trace to be observed.

The unblanking pulse is also coupled through another cathode follower, V43B, to a jack on the front panel labeled +GATE OUT. This is a positive pulse, which starts at ground and rises to approximately +20 volts.

The sweep sawtooth voltage at the cathode of V61A, in addition to being coupled to the Horizontal Amplifier, is also coupled through the cathode follower V43A to a jack on the front panel labeled SAWTOOTH OUT. This provides a 150-volt linear rise in voltage, starting at zero volts with respect to ground.

Horizontal Amplifier

The Horizontal Amplifier consists of an input cathode follower, a driver cathode follower, a push-pull amplifier and an output cathode follower stage.

The sweep waveform is coupled to the grid of the Input C.F. V313B via the frequency-compensated voltage divider R310-R311. The HORIZONTAL POSITIONING control R314A supplies a manually adjustable dc voltage to the grid of V313B for horizontal positioning of the crt beam. The R315-C315 network produces a small step at the start of the waveform at the faster sweep speeds. This step is necessary to compensate for the bandpass-limiting effect of the stray capacitance in the amplifier. By its application the waveform will start linearly at the faster sweep speeds. The Input C.F. V313B provides the necessary low impedance to drive the switch capacitances and the Driver C.F. V313A; the Driver C.F. isolates the Output Amplifier from the DISPLAY switch.

In the MAG. position of the DISPLAY switch, the waveform is coupled by cathode follower V313A to the Output Amplifier stage. This stage, V354A and V374A, a cathode-coupled phase inverter, converts the single-ended input to a push-pull output. The waveform is then coupled by the Output C.F. stage, V354B and V374B, to the horizontal-deflection plates. The MAG. GAIN ADJ. varies the degeneration in the cathode circuit of the Output Amplifier and thus sets the gain of the stage. C358 reduces the degeneration at higher frequencies and thus compensates the amplifier for faster sweep rates. Bootstrap capacitors C350 and C372 also improve the response at the faster sweep rates by supplying current from the output cathode followers to charge the stray capacitance at the plates of the Output Amplifier. Neon lamp B300 is connected in the circuit when the DISPLAY switch is in the MAG. position to indicate that the magnifier circuits are in operation.

In the NORM. position of the DISPLAY switch the gain of the amplifier is reduced by a factor of five by a feedback loop between the cathode circuit of V354B and the grid circuit of V313A. This loop consists of R333 shunted by C333, and R324 and R325 shunted by C324. The amount of feedback, and hence the gain of the amplifier, is adjusted by means of R325, the HORIZ. GAIN ADJ. In the normal position of the DISPLAY switch (NORM.) both the MAG. GAIN ADJ. and the HORIZ. GAIN ADJ. will vary the gain; for this reason the MAG. GAIN ADJ. must only be set when the DISPLAY switch is in the MAG. position.

The MAG. REGIS. control R335 adjusts the voltage at the grid of V313A to equal the voltage at the cathode of V313B when the spot is in the center of the screen and the DISPLAY switch is in the NORM. position. This insures that the portion of the waveform within the center two graticule divisions, will be expanded the full length of the graticule when the DISPLAY switch is set to the MAG. position.

In the EXT. position of the DISPLAY switch the Driver C.F. is connected to an external binding post on the front panel marked HORIZ. INPUT. With this arrangement the horizontal waveform is obtained from an external source rather than from the Time-Base Generator. The HORIZ. INPUT ATTEN. control R330 varies the input voltage so that the waveform may be adjusted for the desired amplitude. In the EXT. position, horizontal beam positioning is provided by R314B rather than by R314A.

POWER SUPPLY

Plate and filament power for the tubes in the Type 316 Oscilloscope is furnished by a single power transformer T600. The primary has two equal tapped windings; these may be connected in parallel for 100- to 130-volt operation, or in series for 200- to 260-volt operation. Silicon rectifiers are employed for the three separate full-wave, bridge-type, power supplies. The three supplies furnish regulated dc voltages of —150 volts, +100 volts and +300 volts. The +300-volt supply also has an unregulated output of about +420 volts for the oscillator tube in the high-voltage supply for the crt. It is unnecessary to regulate this supply as the high-voltage power supplies have their own regulation circuits.

Reference voltage for the —150-volt supply is established by a gas diode Voltage-Reference tube V609. This tube which has a constant voltage drop, establishes a fixed potential of about —84 volts at the grid of V606B, one-half of a Difference Amplifier. The grid potential for the other half of the Difference Amplifier, V606A, is obtained from a voltage divider consisting of R616, R617 and R618. R617, the —150 ADJ., determines the percentage of total voltage that appears at the grid of V606A and thus determines the total voltage across the divider. When this control is properly adjusted the output voltage is exactly —150 volts.

Should the loading on the supply tend to change the output voltage, the potential at the grid of V606A will change in proportion, and an error voltage will exist between the two grids of the Difference Amplifier. The error signal is amplified by V606B, whose plate is dc-coupled to the grid of the Series Tube V617B. The error voltage appearing at the grid of the Series Tube will change the voltage drop across the tube, and hence change the voltage at the plate of the tube. This change in voltage at the plate of the Series tube, which will be in a direction to compensate for the change in the output voltage, is coupled through the rectifiers and C601A to the output and thus pulls the output voltage back to its established value of —150 volts. C614 improves the ac gain of the feedback loop, and thus increases the response of the circuit to sudden changes in output voltage.

The —150-volt supply serves as a reference for the +100-volt supply. The voltage divider R641-R642 establishes a voltage of essentially zero at the grid of the Amplifier V636. If the loading should tend to change the output voltage, an error voltage will appear at the grid of the Amplifier. The error voltage will be amplified and will appear at the grid of the Series Tube V637. The cathode of V637 will follow the grid, and thus the output voltage will be returned to its established value of +100 volts. C638 improves the response of the regulator circuit to sudden changes in output voltage.

A small sample of the unregulated-bus ripple will appear at the screen of V636 through R635. This ripple signal appearing at the screen (which acts as an injector grid) will produce a ripple component at the grid of V637 which will be opposite in polarity to the ripple appearing at the plate of V637. This tends to cancel the ripple at the cathode of V637, and hence reduces the ripple on the +100-volt bus. This same circuit also improves the regulation of the circuit in the presence of line voltage variation.

The +300-volt supply functions in the same manner as the +100-volt supply. Rectified voltage from terminals 18 and 19 of the power transformer is added to the voltage supplying the +100-volt regulator to supply power for the +300-volt regulator. As mentioned previously, the +300-volt supply also provides an unregulated +420-volt output or the crt high-voltage supply.

CRT CIRCUIT

High Voltage Supply

A single 60-kilocycle Oscillator circuit furnishes energy for the two power supplies that provide accelerating voltages for the crt. The Oscillator is the Hartley type, whose main components are V810 and the Primary of T800 tuned by C811.

The rectifier circuits are of the half-wave type, with capacitor-input filter networks. Separate supplies are required for the grid and cathode circuits in order to provide dc-coupled unblanking to the grid supply. V822 supplies about —1850 volts for the grid of the crt (the actual voltage depends on the setting of the INTENSITY control). V832 supplies —1675 volts for the cathode. With the mean potential in the deflection area +175 volts and the cathode at —1675 volts, the accelerating potential for the crt beam is 1850 volts.

In order to provide a constant deflection sensitivity in the oscilloscope, and thereby maintain its calibration, it is necessary that the accelerating potentials in the crt remain constant. This is accomplished by regulating the grid and cathode supplies by comparing a sample of the high voltage to the regulated —150-volt supply. The "sample" voltage obtained from the arm of R841 (H.V. ADJ.), is applied to the grid of V806B; the cathode of this tube is connected to the regulated —150-volt supply. The error signal is amplified by V806B and V806A. The output of V806A varies the screen voltage of the Oscillator tube, thus controlling its output.

Unblanking

As mentioned previously, dc-coupled unblanking is accomplished by employing separate high-voltage supplies for the grid and cathode. The cathode supply is tied to the +100-volt supply via the decoupling network R832 and C832. The grid supply, on the other hand, is not tied to any other supply and is therefore "floating". The unblanking pulses from the Time-Base Generator are transmitted to the grid of the crt via the floating grid supply.

At the faster sweep speeds the stray capacitance in the circuit would make it difficult to move the floating supply fast enough to unblank the crt in the required time. To overcome this, an isolation network composed of C822, C826, R822 and R826 is employed. The fast leading edge of the unblanking pulse, at the faster sweep speeds, is coupled directly to the grid of the crt via C826 and C822; the power supply itself is not appreciably moved during this time due to the isolating resistors R822 and R826.

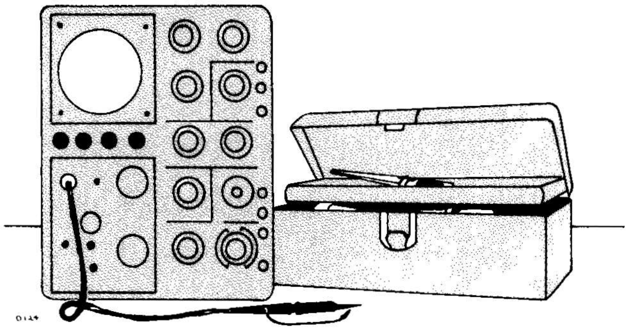
For longer unblanking pulses (at slower sweep speeds) the stray capacitance of the circuit is charged through R822; this holds the grid at the unblanked potential for the duration of the pulse.

CALIBRATOR

The Calibrator is a square-wave generator whose approximately 1-kilocycle output is available at a front-panel jack labeled CAL. OUT. It consists of a Multivibrator, V555A-V573, connected so as to switch the Cathode Follower V555B between two operating states—cutoff and conduction.

During the negative portion of the Multivibrator waveform the grid of V555B is driven well below cutoff and the cathode rests at ground potential. During the positive portion of the waveform the grid of V555B rises to slightly less than 100 volts. By means of the CAL. ADJ. R566, the grid voltage can be adjusted so that the voltage at the CAL. VOLT. CHECK jack (cathode) can be set to exactly 100 volts.

The Calibrator C.F. has a precision tapped voltage divider for its cathode resistor. By means of the VOLTS, PEAK TO PEAK switch, eleven calibrated voltages from .05 v to 100 v are available.



SECTION 4

MAINTENANCE

PREVENTIVE MAINTENANCE

Air Filter

Your Type 316 Oscilloscope is cooled by filtered, forced air. The instrument is equipped with a washable air filter, constructed of aluminum wool with an adhesive. If the filter becomes dirty it may restrict the flow of air and cause the instrument to overheat. The filter should be inspected, and cleaned or replaced if necessary, every three to four months.

To remove the loose dirt, the filter may be rapped gently on a hard surface. It should then be rinsed from the dirty side, with hot water. Or, if preferred, it may be washed with hot, soapy water. After rinsing and drying throughly, the filter should then be coated with "Handi-Koter" or "Filtercoat", products of the Research Products Corporation. These products are generally available from air-conditioner suppliers.

Fan Motor

The bearings in the fan motor should be oiled every three to four months. Use a good grade of light machine oil, and apply only a drop or two.

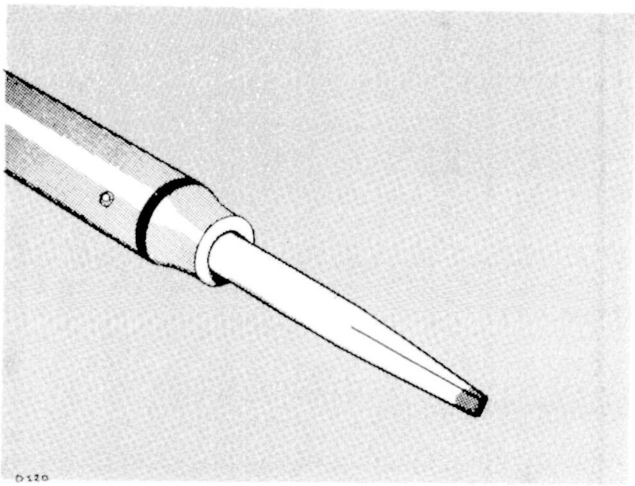


Fig. 4-1. Soldering iron tip properly shaped and tinned.

Soldering and Ceramic Strips

Many of the components in your Tektronix instrument are mounted on ceramic terminal strips. The notches in these strips are lined with a silver alloy. Repeated use of excessive heat, or use of ordinary tin-lead solder will break down the silver-to-ceramic bond. Occasional use of tin-lead solder will not break the bond if excessive heat is not applied.

If you are responsible for the maintenance of a large number of Tektronix instruments, or if you contemplate frequent parts changes, We recommend that you keep on hand a stock of solder containing about 3% silver. This type of solder is used frequently in printed circuitry and should be readily available from radio-supply houses. If you prefer, you can order the solder directly from Tektronix in one-pound rolls. Order by Tektronix part number 251-514.

Because of the shape of the terminals on the ceramic strips it is advisable to use a wedge-shaped tip on your soldering iron when you are installing or removing parts from the strips. Fig. 4-1 will show you the correct shape for the tip of the soldering iron. Be sure and file smooth all surfaces of the iron which will be tinned. This prevents solder from building up on rough spots where it will quickly oxidize.

When removing or replacing components mounted on the ceramic strips you will find that satisfactory results are obtained if you proceed in the manner outlined below.

1. Use a soldering iron of about 75-watt rating.
2. Prepare the tip of the iron as shown in Fig. 4-1.
3. Tin only the first $\frac{1}{16}$ to $\frac{1}{8}$ inch of the tip. For soldering to ceramic terminal strips tin the iron with solder containing about 3% silver.

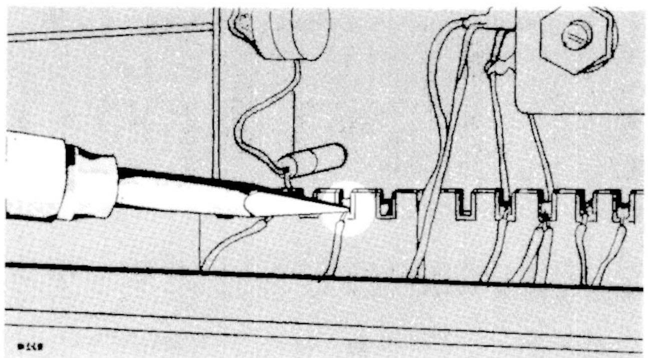


Fig. 4-2. Correct method of applying heat in soldering to a ceramic strip.

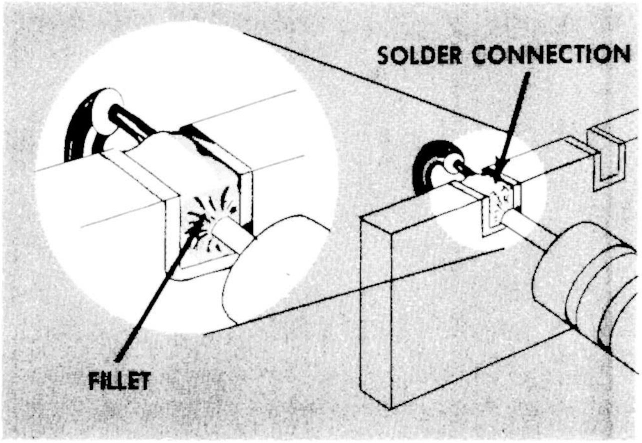


Fig. 4-3. A slight fillet of solder is formed around the wire when heat is applied correctly.

4. Apply one corner of the tip to the notch where you wish to solder (see Fig. 4-2).

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

6. 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 slight fillet on the wire as shown in Fig. 4-3.

In soldering to metal terminals (for example, pins on a tube socket) a slightly different technique should be employed. Prepare the iron as outlined above, but tin with ordinary tin-lead solder. Apply the iron to the part to be soldered as shown in Fig. 4-4. Use only enough heat to allow the solder to flow freely along the wire so that a slight fillet will be formed as shown in Fig. 4-4.

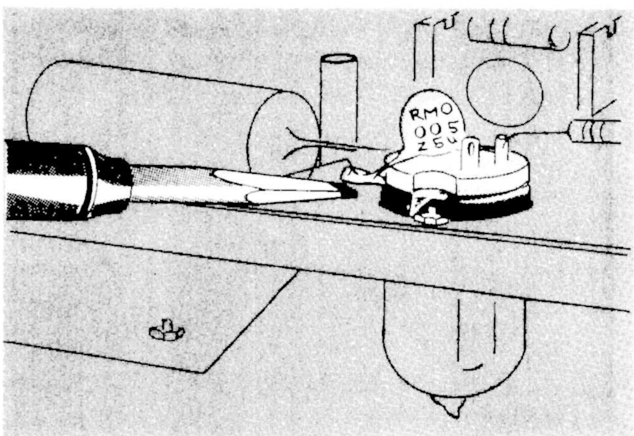


Fig. 4-4. Soldering to a terminal. Note the slight fillet of solder—exaggerated for clarity—formed around the wire.

General Soldering Considerations

When replacing wires in terminal slots clip the ends as close to the solder joint as possible. In clipping the ends of wires take care the end removed does not fly across the room as it is clipped.

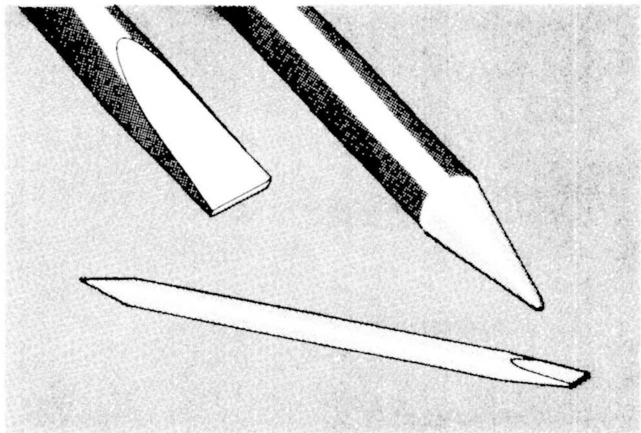


Fig. 4-5. A soldering aid constructed from a ¼ inch wooden dowel.

Occasionally you will wish to hold a bare wire in place as it is being soldered. A handy device for this purpose is a short length of wooden dowel, with one end shaped as shown in Fig. 4-5. In soldering to terminal pins mounted in plastic rods it is necessary to use some form of "heat sink" to avoid melting the plastic. A pair of long-nosed pliers (see Fig. 4-6) makes a convenient tool for this purpose.

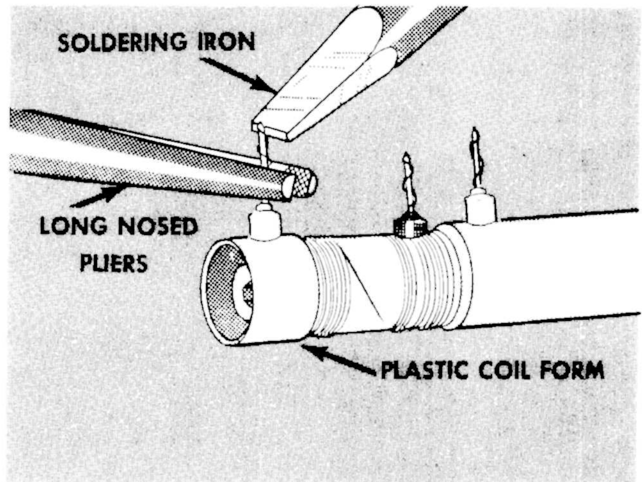


Fig. 4-6. Soldering to a terminal mounted in plastic. Note the use of the long-nosed pliers between the iron and the coil form to absorb the heat.

Ceramic Strips

Two distinct types of ceramic strips have been used in Tektronix instruments. The earlier type mounted on the chassis by means of #2-56 bolts and nuts. The later type is mounted with snap-in, plastic fittings. Both styles are shown in Fig. 4-7.

To replace ceramic strips which bolt to the chassis, screw a #2-56 nut onto each mounting bolt, positioning the nut so that the distance between the bottom of the nut and the ceramic strip equals the height at which you wish to mount the strip above the chassis. Secure the nuts to the bolts with a drop of red glyptal. Insert the bolts through the holes in the chassis where the original strip was mounted, placing a #2 starwasher between each nut and the chassis. Place a second set of #2 flatwashers on the protruding ends of the bolts, and fasten them firmly with another set of #2-56 nuts. Place a drop of red glyptal over each of the second set of nuts after fastening.

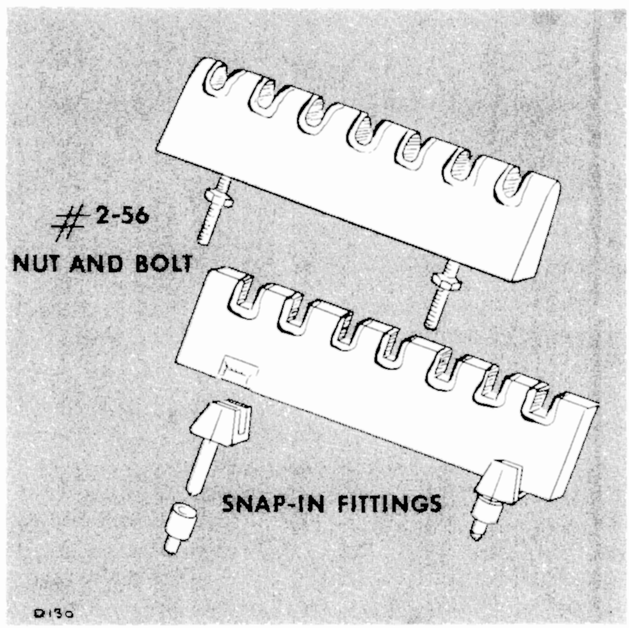


Fig. 4-7. Two types of ceramic strip mountings.

Mounting Later Ceramic Strips

To replace ceramic strips which mount with snap-in plastic fittings, first remove the original fittings from the chassis. Assemble the mounting post on the ceramic strip. Insert the nylon collar into the mounting holes in the chassis. Carefully force the mounting posts into the nylon collars. Snip off the portion of the mounting post which protrudes below the nylon collar on the reverse side of the chassis.

NOTE

Considerable force may be necessary to push the mounting rods into the nylon collars. Be sure that you apply this force to that area of the ceramic strip directly above the mounting rods.

TROUBLESHOOTING

General Information

If your Type 316 Oscilloscope fails to operate, make sure that it is properly connected to a source of power. If the pilot lamp on the front panel, and the fan at the rear of the instrument, do not come on when the instrument is turned on, check the source of power, the power cord connections and the fuse.

If the instrument is turned on, but no spot or trace is visible on the crt, check the POSITION and INTENSITY controls. Be sure that an input signal is not driving the beam off the screen.

Although your Type 316 Oscilloscope is a complex instrument, it can be conveniently divided into basic circuits, as shown on the Block Diagram. The first circuit to check, for practically any type of trouble, is the low-voltage power supply. Proper operation of every circuit in the Type 316 Oscilloscope depends on proper operation of the regulated power supplies.

The low-voltage supply can be checked at the points shown in Fig. 4-8. If an improper voltage reading is obtained at any of the indicated points, the first thing to suspect is the tubes. Make sure that any tubes found to be good, are returned to their original socket. Color-coded wires, following the standard RETMA code, are used to identify the regulated supply voltages. The —150-volt bus wire is coded brown, green, brown; the +100-volt bus is coded brown, black brown; and the +300-volt bus is coded orange, black brown. The widest stripe always identifies the first color in the code.

For any troubles involving the loss of vertical and/or timebase calibration, the high-voltage supply must also be checked. These voltages can be measured at the points shown in Fig. 4-9. The shield covering the high-voltage supply must be removed to make this check.

WARNING

Be careful of the power-supply voltages. The lower-voltage buses are considerably more dangerous than the high voltages in the crt circuit, due to the higher current capabilities and the larger filter capacitors used.

If the power supplies prove to be operating normally, the next step in troubleshooting an oscilloscope is to isolate the source of the trouble down to a particular circuit. The procedure for doing this is explained in the section that follows, entitled "Trouble Analysis and Circuit Isolation". Once the circuit at fault is known, you can then troubleshoot within this circuit to locate the component (or components) at fault. The Circuit Description for the circuit involved may prove useful when troubleshooting within a given circuit.

Circuit failure is often caused by tube failure. If replacement of a defective tube does not correct the trouble, then check that components through which the tube draws current have not been damaged. Shorted tubes will sometimes overload plate-load and cathode resistors.

NOTE

After servicing the Type 316 Oscilloscope, it is important to check its calibration. For this, refer to the Calibration Procedure section of this manual.

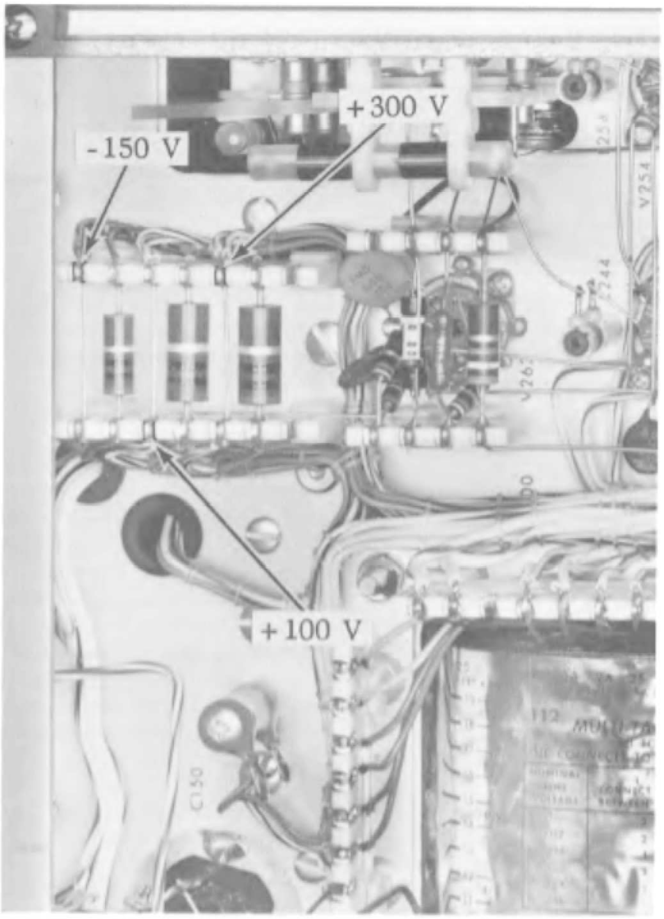


Fig. 4-8. Low voltage check points.

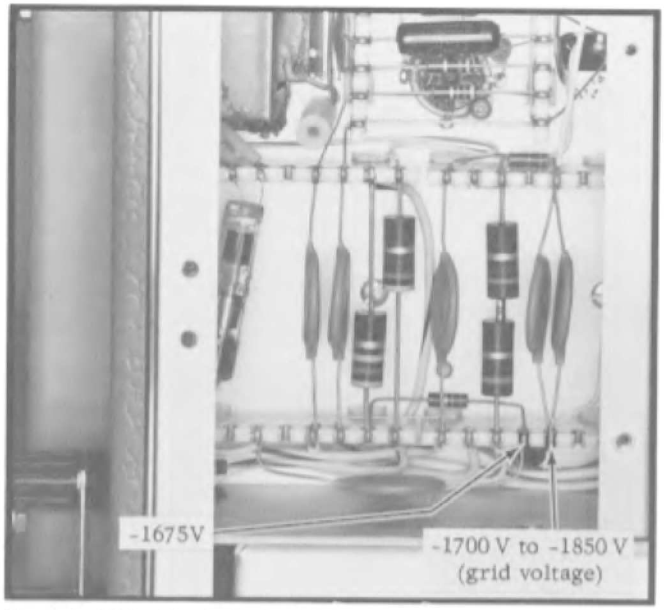


Fig. 4-9. High voltage check points.

TROUBLE ANALYSIS AND CIRCUIT ISOLATION

Troubles that may be produced by a circuit failure in the Type 316 Oscilloscope are as follows:

1. No spot or trace.
2. Insufficient or no vertical deflection.
3. Insufficient or no horizontal deflection.
4. Nonlinear horizontal sweep.
5. Improper sweep timing (horizontal sweep linear).
6. Improper triggering.
7. Waveform distortion.

As mentioned previously, the purpose of this section is to help you isolate the source of trouble to a particular section or circuit. Once the faulty circuit is known, the component (s) causing the trouble can be located by normal troubleshooting procedures; i.e., voltage and resistance measurements, tube and component substitution.

1. No spot or trace.

If the power supplies are operating normally, the following checks can be made to isolate the circuit causing the trouble. Short the vertical deflection plates together (at the neck pins on the crt) with a screwdriver. Adjust the HORIZONTAL POSITIONING control and see if the spot or trace appears on the crt. If so, a state of unbalance in the vertical-deflection system is indicated.

Next, short together the plates of the Output Amplifier (V244/V254). If the trace reappears, the Delay Line can be eliminated as the source of the trouble. The shorting strap can now be moved back, across correspondingly-opposite sides of the Vertical Amplifier, until a point is reached where the trace no longer appears. The stage immediately following this point will be the one in which the unbalance is being produced.

If the spot or trace does not appear during the previous check, turn the instrument off and remove the leads that connect to the horizontal-deflection plates (make sure that the metal clips on the end of each lead do not touch the chassis). Turn the instrument back on and adjust the VERTICAL POSITIONING control. If the spot now appears on the crt, either the Horizontal Amplifier or the Time-Base Generator is causing the trouble.

To determine which circuit is at fault, reconnect the leads to the horizontal-deflection plates and turn the DISPLAY switch to the EXT. position. If the spot now reappears, the Horizontal Amplifier is in balance, and the trouble is being caused by an inoperative condition in the Time-Base Generator. To troubleshoot this circuit, turn the DISPLAY switch to the NORM. position, and turn the STABILITY control to the free-running (full right) position. Next, turn the TIME/DIV. switch through its range. If a sweep or trace appears for some positions of the switch, the trouble will be occuring in the components associated with the Timing Switch.

If no trace appears in any position of the TIME/DIV. switch, replace the tubes in the Time-Base Generator one at a time. Make sure that all tubes found to be good are returned to their original socket. If this does not reveal the source of the trouble, the voltages throughout the circuit can be checked. In particular, check to see that the STABIL-

ITY control varies the voltage at the grid of V25A. Neon lamp B75 is an important part of the Time-Base circuit; check to see that it is not burned out.

It is important that you understand the operation of the Time-Base Generator before proceeding with any extensive investigation of the circuit. For this reason we suggest that you throughly study that portion of the circuit Description that pertains to this circuit.

If no spot appeared on the crt when the DISPLAY switch was turned to the EXT. position, the Horizontal Amplifier is causing the trouble. The faulty stage in this circuit can be isolated by shorting together correspondingly-opposite sides of the amplifier and checking for a spot or trace on the crt. This is the same procedure that was explained in trouble-shooting the Vertical Amplifier.

If none of the previous checks indicates the source of the trouble, a defective crt is indicated.

2. Insufficient or no vertical deflection.

If the trace can be moved with the VERTICAL POSITIONING control, the trouble is originating ahead of the control in one of the input stages to the Vertical Amplifier (Input C.F., Input Amplifier).

If the trace cannot be moved with the VERTICAL POSITIONING control, one of the stages following the control, or the Delay Line, is inoperative. In either of the above cases the tubes should first be replaced. If the trouble still exists, connect a voltmeter between the two plates of the Output Amplifier (V244-V254). If the voltage at this point varies as the VERTICAL POSITIONING control is rotated, the Delay Line is causing the trouble. If the voltage at this point does not vary, the voltmeter can be moved back, point by point, across opposite sides of the amplifier. The stage producing the trouble will be indicated when a point is reached where the voltage does vary as the VERTICAL POSITIONING control is adjusted.

If there is some vertical deflection on the crt, but not enough to correspond to the calibrated value, the Vertical Amplifier can be investigated for insufficient gain. If there is only a slight deficiency in the deflection, as will usually be the case, the amplifier can generally be recalibrated for gain. Refer to the Calibration Procedure for this. However, if the amplifier cannot be recalibrated, or if the decrease in gain is more pronounced, it will be necessary to check the tubes and circuit components.

If the trouble described in this section only appears when the VOLTS/DIV. switch is in one of the positions marked AC ONLY, the trouble is originating in the Preamplifier. Or, if the trouble only appears in one position of the VOLTS/DIV. switch, the Attenuator(s) associated with this setting of the switch will be at fault.

3. Insufficient or no horizontal deflection.

The operation of the Time-Base Generator can be checked from the front panel. Set the DISPLAY switch to NORM., the TIME/DIV. switch to .5 SEC., and adjust the STABILITY control for a free-running sweep (full right). Connect a voltmeter between the SAWTOOTH OUT connector and ground. If the voltage varies between zero and +150 volts, as the Miller circuit runs up and back, the Time-Base Generator is operating properly. No voltage variation at this jack indicates an inoperative Time-Base circuit.

When the trouble has been isolated to either the Time-Base Generator or the Horizontal Amplifier, the circuit at fault can be located by following the procedure outlined in Section 1.

If there is some horizontal deflection on the crt, but not enough to cover the ten-division length of the graticule, the trouble will either be due to insufficient output from the Time-Base Generator, or to insufficient gain in the Horizontal Amplifier.

The Time-Base Generator can be checked in the same manner as described previously. That is, by measuring for a 150-volt variation at the SAWTOOTH OUT connector, at a slow sweep rate. If this reading is not obtained, the Time-Base Generator is at fault, and its circuitry can be investigated. The SWEEP LENGTH control (R82) is very important in this respect, and its setting should be checked first. For the proper adjustment of this control, refer to the Calibration Procedure.

If a voltmeter indicates the proper reading at the SAWTOOTH OUT connector, the Horizontal Amplifier will be the circuit at fault. There are two gain adjustments in this circuit: the HORIZ. GAIN ADJ. (R325) and the MAG. GAIN ADJ. (R358). Any adjustment of these controls, will also affect the sweep timing. Be sure to refer to the Calibration Procedure before making any adjustments in the Horizontal Amplifier.

4. Nonlinear horizontal sweep

The linearity of the horizontal-deflection circuit can be checked by connecting a marker-generator to the VERTICAL INPUT connector and adjusting the Time-Base controls for a stationary display. If the display markers are not equally spaced across the graticule, a nonlinear sawtooth, at the horizontal deflection plates, is indicated. This can be caused by nonlinear amplification in the Horizontal Amplifier, or by nonlinear operation of the Time-Base Generator.

If another oscilloscope is available, the linearity of the Time-Base Generator can be checked by observing the sawtooth available at the SAWTOOTH OUT connector. If the slope of the trace portion of the sawtooth is constant, the Time-Base Generator is producing a linear sawtooth and the nonlinearity is being produced in the Horizontal Amplifier. If the slope of the trace is not constant, however, the nonlinearity is being produced by the Time-Base circuitry.

5. Improper sweep timing (horizontal sweep linear).

If the timing of the horizontal sweep appears to be improper, check to see if this is occuring in all positions, or just in certain positions, of the TIME/DIV. switch. If the timing appears to be off in all positions of the switch, the Horizontal Amplifier will probably be out of adjustment. Two adjustments, the HORIZ. GAIN ADJ. (R325) and the MAG. GAIN ADJ. (R358), affect the timing at all sweep rates. Refer to the Calibration Procedure for the adjustment of these controls.

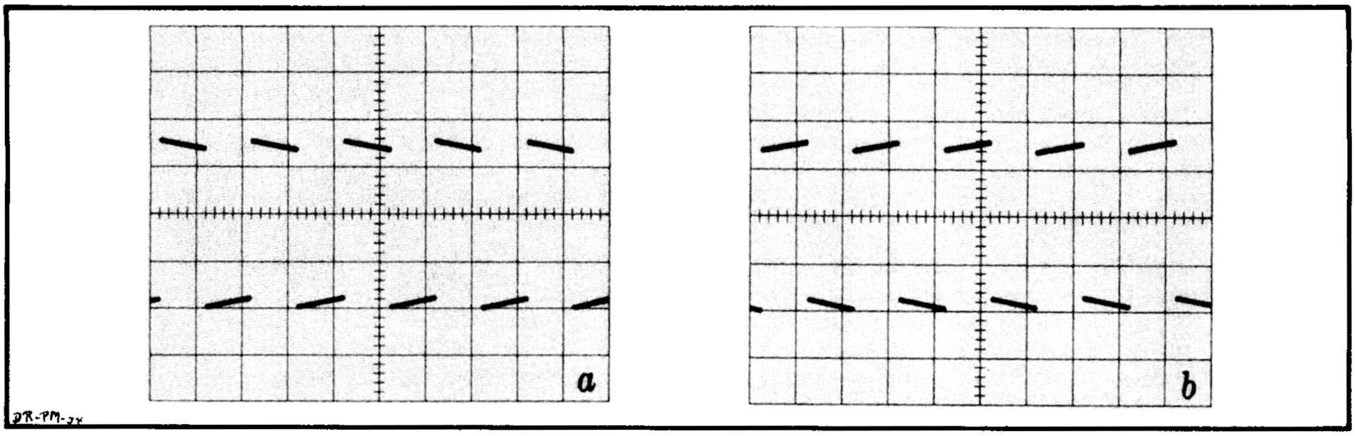


Fig. 4-10. Two types of low-frequency distortion.

If the timing is off in just one setting, or in just one group of settings, of the TIME/DIV. switch, one (or more) of the components associated with the Timing Switch have probably changed in value. There are three variable capacitors associated with this switch; C160A, C160C, C160E. These capacitors are additional timing adjustments at the faster sweep rates (μSEC range). These capacitors should be adjusted only if the aiming in the μSEC range appears to be off.

6. Improper triggering

The operation of the Trigger C.F. can be checked as follows: connect an external triggering signal (preferably the signal-input waveform) to the TRIGGER INPUT connector. Set the black TRIGGER SELECTOR knob to EXT. (+ or —). Check to see if the waveform can now be triggered If so, the Trigger C.F. stage V263 is at fault; it is not passing the internal signal that develops the triggering pulse.

If the waveform cannot be triggered on either the INT. or EXT. positions of the TRIGGER SELECTOR switch, some circuit in either the Time-Base Trigger or the Time-Base Generator is not operating properly. The Time-Base Generator can be eliminated if the trace can be turned off and on with the STABILITY control.

7. Waveform distortion

Waveform distortion can be divided into two categories; (1) low-frequency distortion, illustrated in Fig. 4-10 and (2) high-frequency distortion, illustrted in Fig. 4-11. Any low-frequency distortion apparent in the waveform will be produced by the Preamplifier. The main Vertical Amplifier is dc-coupled; therefore its response is flat down to dc.

Low-frequency attenuation will produce the type of distortion shown in Fig. 4-10(a). This is caused by the cathode- and screen-bypass capacitors, and by coupling capacitors. Before attempting any component replacement, however, be sure to check the adjustment of the LOW FREQ. ADJ. control (R175), as explained in the Calibration Procedure.

Over-compensation of low frequencies is illustrated in Fig. 4-10(b). This condition is produced by excessive low-frequency "boost". Refer to the Circuit Description for an explanation of how the "boost" circuit operates.

NOTE

Low-frequency distortion can also be produced by an improperly adjusted probe. Refer to the article on "Use of Probes", page 2-3.

High-frequency distortion can be produced in the Attenuators (shown on the Preamplifier diagram), the Preamplifiers, the main Vertical Amplifier, and the Delay Line. When the

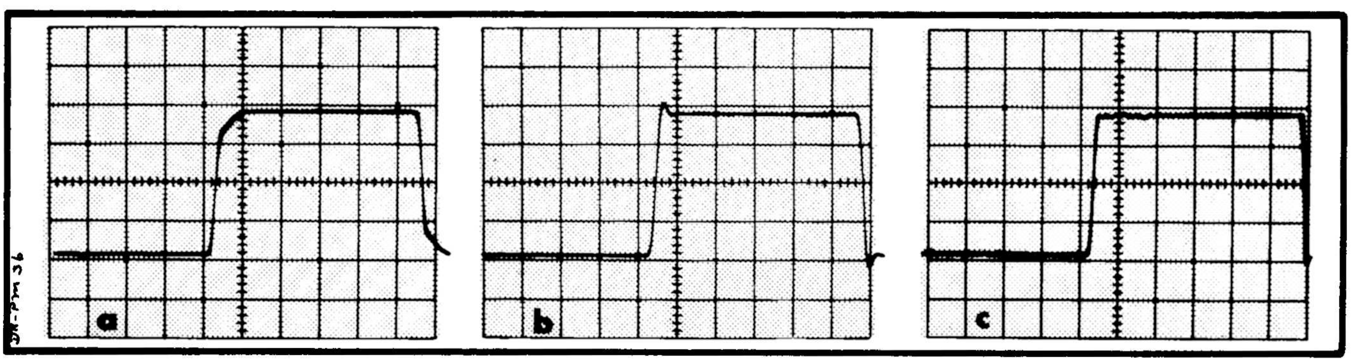
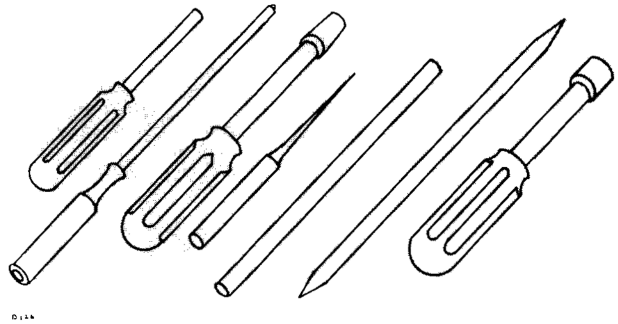


Fig. 4-11. Three types of high-frequency distortion.

VOLTS/DIV. switch is in the .1 (straight through) position, the Attenuators and the Preamplifier are bypassed. Any distortion observed in the waveform, when the switch is in this position, will be produced by either the Vertical Amplifier or the Delay Line.

Insufficient high-frequency peaking, which limits the risetime and consequently the bandwidth, will produce the type of distortion illustrated in Fig. 4-11(a). Tubes are often a cause of this type of distortion. Peaking coils are another common source.

The condition, illustrated in Fig. 4-11(b), is the result of excessive high-frequency peaking, and is produced by improperly adjusted peaking coils. The condition, shown in Fig. 4-11(c), is produced by an improperly adjusted Delay Line. Refer to the Calibration Procedure for the Delay Line tuning procedure.



SECTION 5

CALIBRATION PROCEDURE

The Type 316 Oscilloscope is a stable instrument and should not require frequent recalibration. However, it will be necessary to recalibrate certain parts of the instrument when tubes or components are changed, and a periodic recalibration is desirable. In the instructions that follow, the steps are arranged in the proper sequence for a full recalibration of the instrument. Each numbered step contains the information necessary to make one adjustment. If you are aware of the interaction between adjustments, you can refer to a particular adjustment procedure and make the adjustment without performing unnecessary steps.

Outline of Procedure

For purposes of recalibration, the Type 316 Oscilloscope can be divided into five distinct parts: (1) the power-supply and crt circuits, (2) the triggering circuits, (3) the horizontal-amplifier and time-base generator, (4) the vertical amplifier and (5) the delay line. Calibration adjustments made in any one of these categories will frequently affect another adjustment in the same category. For example, the HORIZ. GAIN ADJ., control affects the calibration of the time-base generator at all sweep speeds when the DISPLAY switch is in the NORMAL position, and therefore affects the adjustment of C160E, the 10-microsecond per division timing adjustment. On the other hand, calibration adjustments made in one category will usually have little or no effect on adjustments in another category. There are a few exceptions, the most notable being the power-supply voltage adjustments.

Interaction of Adjustments

If you find it necessary to effect a single adjustment without recalibrating the rest of the instrument, it is most important that you be fully aware of the interaction of adjustments. Generally speaking, the interaction of controls will be apparent in the schematic diagram. If you are in doubt, check the calibration of the entire section on which you are working. For example, if you make an adjustment in the horizontal-deflection system, check all of the adjustments listed under the heading in these instructions.

EQUIPMENT REQUIRED

The following equipment or its equivalent is necessary for a full recalibration of the Type 316 Oscilloscope.

1. DC voltmeter (at least 5000 ohms per volt) calibrated for an accuracy within 1% at 100 volts, 150 volts and 300 volts, and calibrated for an accuracy within 3% at 1675 volts. Be sure your meter is accurate.

2. Accurate rms-reading ac voltmeter, 0-150 volts (0-250 or 0-300 for 200- to 260-volt operation).

3. Variable autotransformer (Powerstat, Variac, etc.) having a rating of at least 3 amperes.

4. Time-Mark Generator, Tektronix Type 180 or Type 181. If neither of these instruments is available, it will be necessary to substitute a time-mark generator having output markers of 100, 10 and 1 microseconds, and a sine-wave output of 10 megacycles, with an accuracy of at least 1%.

5. Square-Wave Generator, Tektronix Type 105, with a Type B52-R Terminating Resistor, a Type B52-L10 "L" Pad and a Type P52 Coaxial Cable.

In these instructions, a Type 105 Square-Wave Generator is used to describe the technique of adjusting the amplifier high- and low-frequency compensation. If you do not have a Tektronix Type 105, it will be necessary to substitute a generator with the following specifications: (1) output of approximately 50 cycles, and 400 kilocycles, (2) risetime no more than 20 nanoseconds (when properly terminated) and (3) output amplitude variable from about 40 millivolts to 100 volts.

6. Constant-Amplitude Signal Generator, Tektronix Type 190 or Type 190A, 190B. In these instructions, a Type 190A is used to describe the techniques of measuring the bandwidth of the Type 316 Vertical Amplifier. To make this measurement, it is necessary to have available at the INPUT connector of the Type 316 a signal variable from one megacycle to over twelve megacycles, and having at least two amplitudes: 30 millivolts and 300 millivolts. It is also necessary that the output be adjustable (manually or automatically) for equal amplitude at all frequency settings.

7. Tektronix Type P510A or P6017 Probe.

8. Insulated alignment tools, see Fig. 5-1.
The tools can be purchased through your Tektronix Field Engineer or direct from factory.

POWER SUPPLY AND CRT CIRCUIT

In this section, you will find six calibration steps outlining the method of adjusting the power-supply voltages, the crt circuits and the internal calibrator. Two of these adjustments will affect the calibration of the entire instrument. They are Step 1, "Low-Voltage Supply" and Step 3, "High-Voltage

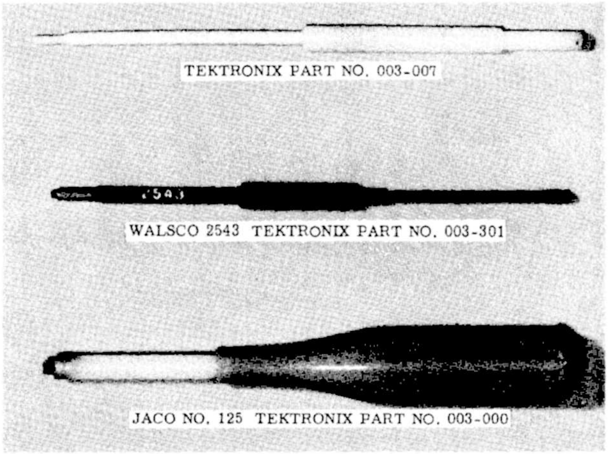


Fig. 5-1. Handtools necessary for calibrating the Type 316 Oscilloscope.

Supply." If you find it is necessary to make these adjustments, you will also have to check the calibration of the rest of the instrument. Therefore, before you adjust the controls, double check your meter readings to be sure the adjustment is needed. In the instructions that follow it is assumed that the power transformer is connected for a nominal line voltage of 117 volts.

Preliminary

Preset the front-panel controls of the Type 316 as follows:

POWER	OFF
INTENSITY	full counter clockwise
TRIGGER SELECTOR (black)	+INT.
TRIGGER SELECTOR (red)	AC
DISPLAY	NORM.
TRIGGERING LEVEL	centered
STABILITY	full clockwise
TIME/DIV. (black)	.5 MILLISEC
TIME/DIV. (red)	CALIBRATED (full clockwise)
VERTICAL POSITIONING	centered
HORIZONTAL POSITIONING	centered
VOLTS/DIV. (black)	1
VOLTS/DIV. (red)	CALIBRATED (full clockwise)
AC-DC	AC
CALIBRATOR	OFF

Remove the perforated side panels and the bottom plate from the Type 316 and connect the power cord and the ac meter to the output of the variable autotransformer. Switch the Type 316 on and adjust the autotransformer for a meter reading of 117 volts. Maintain the autotransformer output voltage at 117 volts during the calibration procedure. If the power transformer in your instrument is connected for 234-volt operation, adjust the autotransformer for a meter reading of 234 volts.

1. Low-Voltage Power Supply

Proper operation of your instrument is dependent upon correct power-supply voltages. Because the —150-volt supply is used as a reference for all of the other supplies, it is important that it is properly adjusted.

Measure the output voltage at the —150-volt, +100-volt and +300-volt supplies at the points indicated. Be sure your meter is accurate. The output voltage of the —150-volt supply must be between —147 and —153 volts, and the output voltages of the +100-volt and +300-volt supplies must be within 3% of their rated values. You should be able to set the —150 ADJ. control so that all of these voltages are within their entire instrument tolerances. Bear in mind that the calibration of the entire instrument is affected by changes in the power-supply voltages.

To check the operation of the voltage regulating circuits, vary the autotransformer output voltage from 105 to 125 volts (or from 210 to 250 volts if the power transformer is connected for 234 volt operation) while observing the effect on the regulated power-supply voltages. All of the voltages should remain essentially constant.

2. Internal-Calibrator Adjustment

When the CAL. ADJ. control is properly set, the calibrator output will be within 3% of the voltages indicated on the front panel. To make this adjustment, connect a voltmeter between the CAL. VOLT CHECK jack and ground, turn the CALIBRATOR switch to OFF and adjust the CAL. ADJ. control for a meter reading of exactly 100 volts. To assure suitable symmetry of the calibrator waveform, the voltage at this point should not be less than 45 volts nor greater than 55 volts when the calibrator is turned on. Readings outside of this range are generally caused by an unbalanced multivibrator tube.

3. High-Voltage Power Supply

This adjustment determines the total accelerating voltage on the crt and thus affects the deflection sensitivity.

Connect the voltmeter between ground and either connection on the two-terminal ceramic strip mounted on the underside of the top chassis, behind the crt socket. Adjust the H.V. ADJ. control for a meter reading of —1675 volts. This voltage should not vary more than 10 volts between the following limits:

Upper Limit: Line voltage—125 v; INTENSITY control turned full left.

Lower Limit: Line voltage—105 v; INTENSITY control turned full right.

NOTE

To avoid possible burning of the crt screen while performing this check, position the crt spot off the screen.

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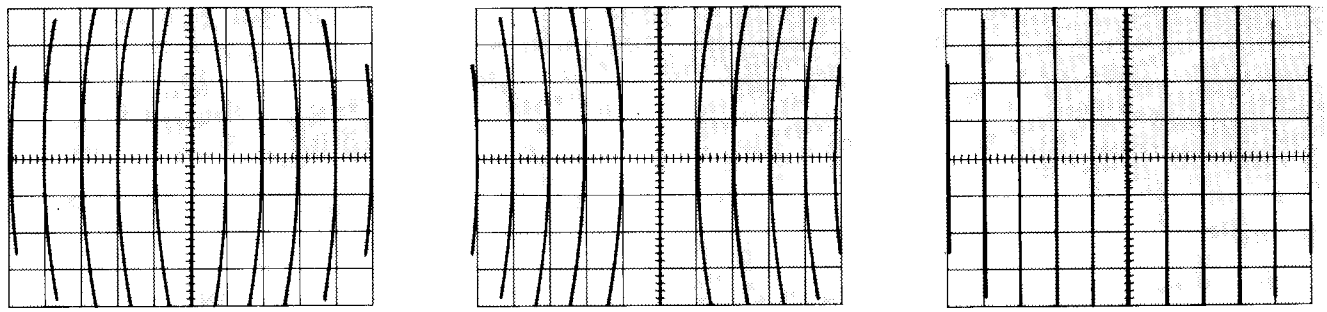


Fig. 5-2. Checking the crt geometry by displaying vertical lines. When the GEOM. ADJ. control is properly adjusted, the displayed lines will coincide with the vertical graticule lines as shown in the picture at the right.

4. CRT Alignment

The crt in the Type 316 is held in position by a single clamp around the tube base. If the instrument is subject to considerable handling, the clamp may loosen—permitting the crt to turn. This would cause the crt display to appear canted in relation to the graticule lines. Your job will be made easier if you align the crt point in the calibration procedure.

With no signal connected to the INPUT conector, free-run the Time-Base Generator by turning the STABILITY control full right. Position the free-running trace directly behind the center horizontal graticule line. If the trace and the graticule line do not coincide over the width of the graticule, it will be necessary to loosen the crt base clamp and rotate the crt until they do.

After you have aligned the crt trace with the graticule line, push the crt forward so that it rests snugly against the graticule. Then, tighten the crt base clamp. Recheck the alignment of the crt after tightening the clamp to be sure it didn't move while the clamp was being tightened.

5. CRT Astigmatism

Need for adjustment of the ASTIGMATISM control is indicated if the display appears to be defocussed and it is impossible to improve the focus with the front-panel controls.

Connect a jumper from the CAL. OUT connector to the VERTICAL INPUT connector and adjust the controls for a reasonably bright display of four or five square-waves having a vertical deflection of 2 or 3 major divisions. Now adjust the ASTIG. and FOCUS controls for the sharpest possible display. Changes in INTENSITY or ambient light conditions may require readjustment of these two controls.

6. CRT Geometry

The geometry of the crt display is adjustable over a limited range by means of the GEOM. ADJ. control. To achieve optimum linearity, vertical lines are displayed on the crt and the GEOM. ADJ. control is adjusted for minimum curvature in the lines. Nonlinearity is most noticeable at the edges of the graticule.

To make this adjustment, preset the oscilloscope controls as described at the beginning of this section with the exception of the TIME/DIV. and the VOLTS/DIV. controls. Set these controls to .2 MILLISEC and .2 volts respectively. Next, connect the Time-Mark Generator to the INPUT connector and display 100-microsecond markers. Position the base line of the timing comb below the bottom edge of the crt face so that it is not visible. The display should appear similar to one of the drawings in Fig. 5-2. Adjust the GEOM. ADJ. control for straight vertical lines.

The calibrator output waveform can be used in place of the Time-Mark Generator to make this adjustment, but due to the dimness of the trace, the adjustment is more difficult.

TRIGGERING CIRCUITS

In this section you will find a three-step procedure for adjusting the triggering circuits. These adjustments should not affect the calibration of any other part of the oscilloscope and therefore can be adjusted separately. Steps 7 and 8 interact, however, and these adjustments should be made in the order given.

7. Trigger Level Centering

When displaying a symmetrical waveform of small amplitude and with the red TRIGGER SELECTOR knob at AC, there should be a setting of the TRIGGERING LEVEL control where the display appears to invert as you switch the black TRIGGER SELECTOR knob from +INT. to —INT. without requiring readjustment of the TRIGGERING LEVEL control. Failure of the oscilloscope to perform in this manner indicates improper adjustment of the TRIG. LEVEL CENT. control.

To prepare the oscilloscope for this adjustment, connect a jumper from the CAL. OUT connector to the INPUT connector, and set the front-panel controls as follows:

TRIGGER SELECTOR (red)	AC
TRIGGER SELECTOR (black)	+INT.
TRIGGERING LEVEL	0
STABILITY	*PRESET

DISPLAY	NORM.
TIME/DIV. (black)	.5 MILLISEC
TIME/DIV (red)	CALIBRATED
VERTICAL POSITIONING	centered
HORIZONTAL POSITIONING	centered
CALIBRATOR	1
VOLTS/DIV. (black)	1
AC-DC	AC

*If your oscilloscope has not been calibrated for some time, it may be necessary to manually adjust the STABILITY control.

The control settings given above should result in a display of the calibrator waveform having a height of 1 major graticule division.

With a short clip lead, ground the junction of R426, R427, R428 and C425 (see Figure 5-3). Then, reduce the amplitude of the displayed signal with the VARIABLE VOLTS/DIV. control until the display disappears.

You will be able to return the display to the screen by slightly adjusting the TRIG. LEVEL CENT. control.

Continue to reduce the amplitude of the display until the vertical deflection is 2 minor divisions. Then, while switching the black TRIGGER SELECTOR knob back and forth between +INT. and —INT., slightly readjust the TRIG. LEVEL CENT., and TRIG SENS ADJ controls to get stable triggering for both positions of the switch.

Remove the clip lead from the TRIGGER SELECTOR switch and check for reliable triggering in both positions of the black TRIGGER SELECTOR switch with the TRIGGERING LEVEL control set at 0. If the triggering point occurs at other than the 0 position, it will be necessary to loosen the set screw of the TRIGGERING LEVEL knob and rotate the knob to the 0 position (without rotating the shaft).

8. Internal Trigger DC Level Centering

In the DC triggering mode, if the TRIGGERING LEVEL control is set at 0, the crt display should start at the center horizontal graticule marker when the black TRIGGER SELECTOR knob is set at +INT. or —INT. If this does occur, need for adjustment of the INT. TRIG. DC LEVEL ADJ. control is indicated.

To make this adjustment, set the oscilloscope controls as described in Step 7 with the exception of the red TRIGGER SELECTOR knob. Set this control to DC. Do not disturb the setting of the TRIGGERING LEVEL control established during the last part of Step 7.

As in Step 7, reduce the amplitude of the display with the VARIABLE VOLTS/DIV. control until the display disappears. This time, however, you must keep the display centered about the center horizontal graticule line as you decrease the amplitude. You will be able to return the display to the screen by slightly adjusting the INT. TRIG. DC LEVEL ADJ. control.

Continue to reduce the amplitude of the display until the vertical deflection is 3 minor divisions and the waveform is centered about the center horizontal graticule line. Then, while switching the black TRIGGER SELECTOR knob back and forth between +INT. and —INT. slightly readjust the INT. TRIG. DC LEVEL ADJ. control to get stable triggering for both positions of the switch.

9. Preset Stability

In the AUTO. mode of triggering, or when the STABILITY control is set at PRESET, the PRESET STAB. control provides

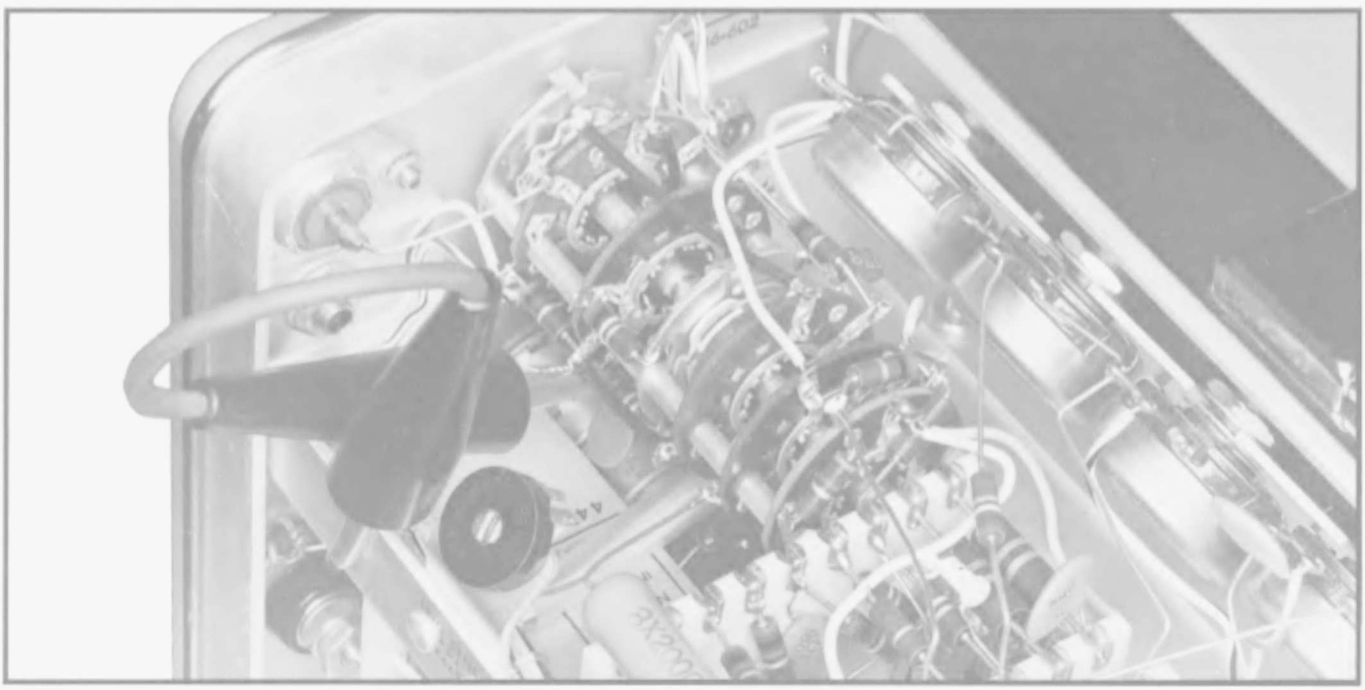


Fig. 5-3. Grounding the junction of R426, R427, R428 and C425.

a stability setting suitable for most triggering applications. If you cannot get reliable triggering, when the STABILITY control is set at PRESET, but experience no difficulty in manually setting the control, the trouble is probably due to faulty adjustment of the PRESET STAB. control.

To make this adjustment, set the oscilloscope controls as described in Step 7 with the exception of the red TRIGGER SELECTOR knob. Do not connect a jumper from the CAL. OUT connector to the INPUT connector. Set the red TRIGGER SELECTOR knob to AUTO. Turn, the PRESET STAB. control to its full-left (counterclockwise) position.

Now, slowly advance the PRESET STAB. control to the right until a trace appears on the crt screen. Note the position of the screwdriver slot. Then, turn the PRESET STAB. control further to the right until the trace brightens. Finally, set the control to a position midway between the points where the trace appeared and where it brightened.

NOTE

In the above example of trigger circuit adjustments, adjustment of the Trig. Level Cent. control is mentioned. On later models of the Type 316, it is necessary to adjust a Trig. Sens. Adj. pot along with the Trig. Level Cent. Be sure that in adjusting the Trig. Sens. Adj., you keep the circuit as insensitive as possible while still obtaining clean triggering.

TIME-BASE GENERATOR

The time-base circuits should not require frequent readjustment. As a general rule, if the need for adjustment is indicated, you should first check all of the time-base ranges before making any adjustments. Often only one control is misadjusted, yet it may be the control for the range in which you first noticed the trouble.

If nonlinearity is present in the time-base, it will generally be confined to the first major division of horizontal deflection. Therefore, in these instructions, we recommend calibrating the time-base generator on the basis of time markers appearing between the second and ninth vertical graticule lines.

In the 6-step instructions that follow, all but two of the adjustments interact to some degree. The two exceptions are Steps 12 and 13. For this reason, it is important that you make the adjustments in proper sequence.

Some of the horizontal amplifier adjustments described in the following section affect the horizontal position of the crt display. As a result, it will be necessary to reposition the display with the HORIZONTAL POSITIONING control to keep the time markers properly positioned with respect to the graticule lines.

10. Magnifier Gain

The MAG. GAIN ADJ. control determines the gain of the horizontal amplifier when the DISPLAY switch is in the MAG. position. To make this adjustment, set the front-panel controls as follows:

TRIGGER SELECTOR (red)	AC
TRIGGER SELECTOR (black)	+INT.
TRIGGERING LEVEL	0
STABILITY	PRESET
DISPLAY	NORM.
TIME/DIV. (black)	1 MILLISEC
TIME/DIV. (red)	CALIBRATED
VERTICAL POSITIONING	centered
HORIZONTAL POSITIONING	centered

Next, connect the Time-Mark Generator to the INPUT connector, set the controls for 100-microsecond marker output and adjust the oscilloscope VOLTS/DIV. controls for a vertical deflection of approximately 2 major divisions. Center the display on the graticule with the POSITIONING controls.

To calibrate the magnifier circuits, turn the DISPLAY switch to MAG. and adjust the MAG. GAIN ADJ. control so that there are two time markers for every major graticule line.The MAG. GAIN ADJ. control is located on the plastic plate above the crt.

11. Horizontal Amplifier Gain

The HORIZ. GAIN ADJ. control R325, is part of a feedback circuit that reduces the gain of the horizontal amplifier by a factor of five when the DISPLAY switch is in the NORM. position.

To make this adjustment, set the front-panel controls as described in Step 10 with the exception of the TIME/DIV. switch. Set the control to .1

Display 100 microsecond markers from the Time-Mark Generator and adjust the HORIZ. GAIN ADJ. control so that each time-marker coincides with a vertical graticule line.

12. Sweep Length

The SWEEP LENGTH control prevents the beam from hitting the sides of the crt when the display is centered on the screen.

To make this adjustment, free-run the time-base generator at any convenient sweep speed in the millisecond range and adjust the SWEEP LENGTH control for a sweep length of 10.5 major divisions.

13. Magnifier Registration

When the NORM/MAG. REGIS. control is properly set, that part of the display immediately under the center vertical graticule line will remain there as the DISPLAY switch is turned from NORM. to MAG.

Prepare the oscilloscope for making this adjustment by turning the STABILITY control as far left as possible without actuating the internal preset switch, and turn the red TRIGGER SELECTOR knob to any position other than AUTOMATIC. Next, turn the INTENSITY control to the right until a spot is just visible on the crt. With the POSITIONING controls, position the spot to the center of the crt.

Now, set the DISPLAY switch to MAG. and position the spot directly under the center graticule lines.

With the spot accurately centered on the crt screen, turn the DISPLAY switch to NORM. and adjust the NORM/MAG. REGIS. control to return the spot to the center of the screen.

14. Setting of Horizontal Amplifier Compensation

Set up your scope controls as explained in Step 10, except for the TIME/DIV. switch, which will be set at 50 μsec. Apply 10 μsec markers, 2 major divisions high, from your 180A Time-Mark Generator. Set the first left marker of the trace on the center graticule line. Now switch the TIME/DIV. switch to .1 msec and return the first left marker to the center line of the graticule by adjusting C310. Switch between 50 μsec and .1 msec until the first left marker no longer moves. If you wish this step may be done with the 5X Mag. on. This will make for a finer adjustment.

15. High Sweep Rate Adjustments

Time-Mark Generator	Time/ Div. Switch	Adjust	CRT Display	Display Switch
10 μsec*	10 μsec	C160E	1 mark/div.	NORM.
5 μsec	5 μsec	C160C	1 mark/div.	NORM.
1 μsec	2 μsec	C324 approximate adjustment	2 marks/div. (first major division only)	NORM.
1 μsec	.5 μsec	C160A	1 mark/every 2 div.	NORM.
**10 MC sine wave	.2 μsec	C324	2 cycles/div.	NORM.
**50 MC sine wave†	.2 μsec	C350 and C372	2 cycles/div.	NORM.

*Set C358 to maximum capacitance before starting this adjustment.

**Externally triggered adjustments with 100 μs markers from the Time Mark Generator.

†The 50 MC must be applied to one of the vertical plates of the CRT through a 100 μμf capacitor.

The above adjustments interact with each other.

VERTICAL AMPLIFIER

In this section you will find instructions on how to perform six adjustments to the vertical amplifier. One of the adjustments (VARIABLE ATTEN. BAL.) is explained in the Operating Instructions and is repeated here for completeness. Of the remaining five, Steps 17 and 18 are interacting, as are Steps 19 and 20. None of the adjustments listed in this section affect the operation of any other part of the oscilloscope.

16. Variable Attenuator Balance

This adjustment is performed by the operator of the oscilloscope during the course of normal operation. However, the maintenance technician must also make the adjustent before he can proceed to calibrate the vertical amplifier.

Misadjustment of the control is indicated if the entire crt display is positioned vertically as the variable attenuator control is rotated. To perform this adjustment, it is first necessary to get a horizontal reference trace on the crt. This can be done most easily by turning the red TRIGGER SELECTOR control to AUTO., and the TIME/DIV. switch to 1 MILLISEC.

With the trace vertically centered on the screen, adjust the VARIABLE ATTEN. BAL. control so that the trace remains stationary as the red VOLTS/DIV. control is turned back and forth through its range.

17. Amplifier Gain

This adjustment determines the gain of the vertical amplifier and therefore, the calibration of the VOLTS/DIV. control.

To adjust the GAIN ADJ. control, first set the oscilloscope front-panel controls as follows:

TRIGGER SELECTOR (red knob)	AUTO.
TRIGGER SELECTOR (black knob)	+INT.
TRIGGERING LEVEL	full left or right
STABILITY	PRESET
DISPLAY	NORM.
TIME/DIV. (black knob)	.5 MILLISEC
TIME/DIV. (red knob)	CALIBRATED
VERTICAL POSITIONING	centered
HORIZONTAL POSITIONING	centered
CALIBRATOR	.5
VOLTS/DIV. (black)	.1
VOLTS/DIV. (red)	CALIBRATED

Connect a jumper from the CAL. OUT connector to the VERTICAL INPUT connector.

Set the GAIN ADJ. control for five major divisions of vertical deflection.

18. Preamplifier Gain

The PREAMP. GAIN ADJ. control determines the gain of the preamplifier and therefore the calibration of the VOLTS/DIV. switch in the .01, .02 and .05 positions.

Set the oscilloscope controls as outlined in Step 17 with the exception of the VOLTS/DIV. and CALIBRATOR controls. Set these controls to .01 and .05 respectively. Connect a jumper from the CALIBRATOR connector to the VERTICAL INPUT connector.

Adjust the PREAMP. GAIN ADJ. control for exactly 5 major divisions of vertical deflection.

19. Attenuator High-Frequency Compensation (Square-Corner) and Input Capacitance (Flat Top).

Set the scope up as explained in Step 17 except AC-DC switch is set in DC position. Attach a probe cable to the scope's vertical INPUT connector. Now touch the end of the probe to the CAL OUT connector and hook the ground lead to the nearest ground. Adjust the VOLTS PEAK TO PEAK switch so that you display about 5 major divisions of signal. In the .1 position of the VOLTS/DIV. switch (black knob) adjust the compensation in the probe for a level top. The following table gives the adjustments, in the scope, for the other positions of the VOLTS/DIV. (black knob) switch.

VOLTS/DIV. Switch	Adjust For Optimum Square Corner	Adjust For Optimum Level Top
.2	C132	C130
.5	C126	C124
1	C118	C116
10	C112	C110
.02		C141

Check all the other ranges of the VOLTS/DIV. switch for the level top and square corner.

20. Preamplifier Low-Frequency Compensation

Need for the adjustment of the LOW. FREQ. COMP. control is indicated by a loss of low frequency response.

To make this adjustment, set the front-panel controls as outlined in Step 17 with the exception of the TIME/DIV. control—set this control to 10 MILLISEC. Connect a Type P510A or P6017 Probe to the VERTICAL INPUT connector. Set the Type 105 controls for a fifty-cycle output signal and connect a Type B52-R Terminating Resistor to the output connector. Connect the oscilloscope to the Type 105 by touching the probe tip to the center conductor of the coax connector on the Terminating Resistor and fastening the ground clip to the case of the Terminating Resistor. If excessive hum is encountered, reinstall the bottom plate on the oscilloscope.

Make sure the vertical AC-DC switch is in AC. Note the slant on the top of the square-wave. Now turn the VOLTS/DIV (black knob) to the .01 position and adjust the Low Freq. Comp. control for the same slant on the top of the square-wave.

DELAY LINE

Including Amplifier High-Frequency Compensation

Of all of the adjustments you may be called upon to perform on the Type 316, the adjustment of the delay line and the vertical-amplifier high-frequency compensation will be the most difficult. This is due largely to interaction between adjustments. There are 26 variable capacitors and 2 variable inductors associated with the delay line, and 6 variable inductors in the vertical amplifier. All of these adjustments interact to some degree.

Before attempting to perform any of the adjustments described in this section, read the instructions carefully until you are sure of what is to be done. Study the picture and drawings to gain a clear mental picture of the result of each adjustment. Refer to the Circuit Description of this manual for an explanation of the operation of the Delay Line (page 3-2). Attempts to adjust the delay line without adequate preparation frequently lead to a misadjustment more severe than the initial condition.

Displaying the Test Signal

To determine the extent of misadjustment of the delay line in your instrument, you will need to closely examine a displayed 400 kilocycle square wave. The square wave used to make this examination must have a risetime of no more than 20 nanoseconds and must also be free of waveform irregularities during the positive half of the cycle. A Tektronix Type 107 or Type 105 Square-Wave Generator is recommended.

By following the recommendations in these instructions for terminating resistors and cables, you should not experience any difficulty in arriving at the desired results. If,

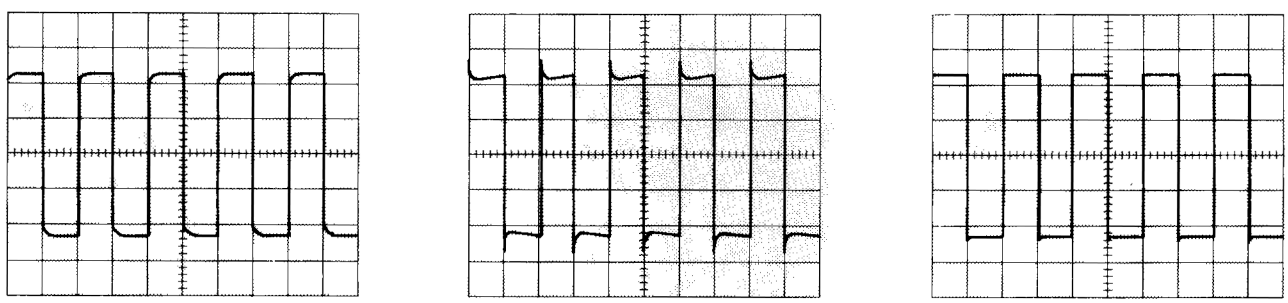


Fig. 5-4. Compensating the attenuator high-frequency response. When the attenuators are properly adjusted, the display of the Type 105 output waveform will be similar to the drawing at the right.

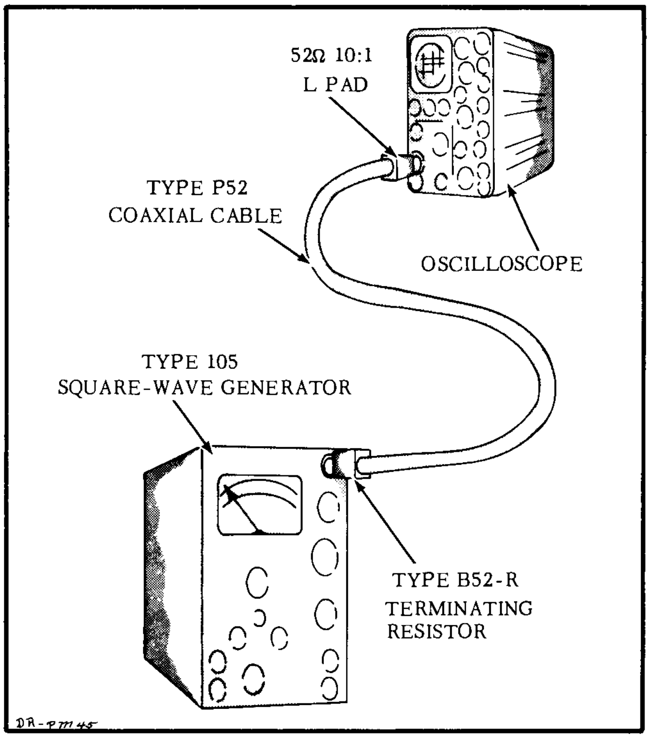


Fig. 5-5. Connecting the Type 105 Square-wave Generator to the oscilloscope.

however, it is necessary to use a signal generator other than a Type 105 or Type 107, you must exercise caution in connecting the instrument to the Type 316. A good check on the suitability of your test equipment is to display the output waveform on another Tektronix oscilloscope (of a type having a delay line) known to be in good adjustment.

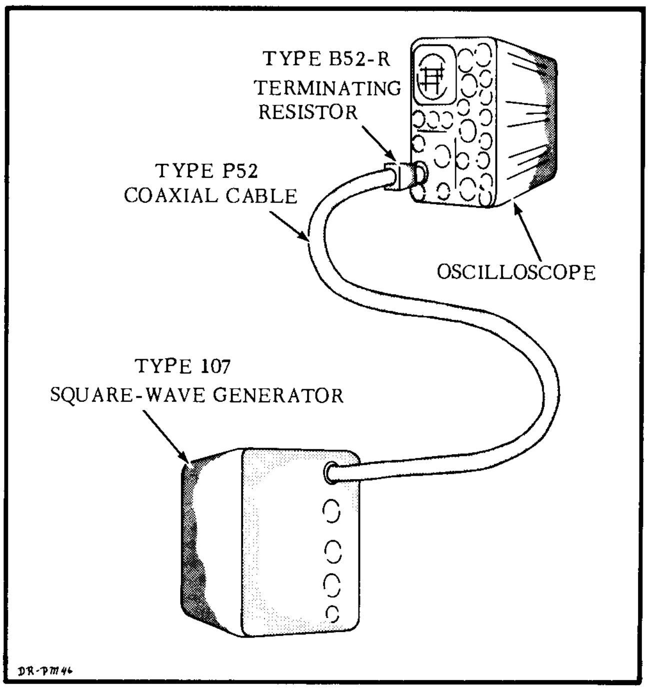


Fig. 5-6. Connecting the Type 107 Square-Wave Generator to the oscilloscope.

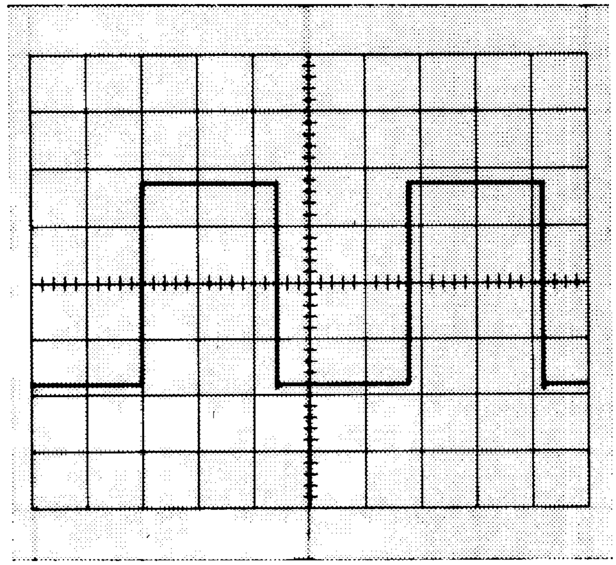


Fig. 5-7. The Type 107 output waveform displayed on a correctly adjusted Type 316.

Fig. 5-5 and Fig. 5-6, shows the desired methods for connecting either the Type 105 or the Type 107 Square-Wave Signal Generator to the Type 316 input connector.

To display a 400-kilocycle waveform, set the square-wave generator controls for a 400-kilocycle output (a few degrees away from full-left on the Type 107 APPROXIMATE FREQUENCY control) and set the oscilloscope front-panel controls as follows:

TRIGGER SELECTOR (red)	AC
TRIGGER SELECTOR (black)	—INT.
STABILITY	PRESET
DISPLAY	NORM.
TIME/DIV. (black)	.5 μSEC
TIME/DIV. (red)	CALIBRATED
VOLTS/DIV. (black)	1
VOLTS/DIV. (red)	CALIBRATED
AC-DC	DC

Adjust the TRIGGERING LEVEL control for a stable display and adjust the square-wave generator output-amplitude control for approximately 4 major divisions of vertical deflection. Position the display so that it is similar to the photograph of Fig. 5-7. You may have to adjust the square-wave-generator output-frequency control slightly to get the desired number of cycles displayed on the crt screen.

There are three general characteristics which you will have to appraise, and to do this you will need to use three different sweep rates. The first characteristic to look for is the "level" of the display; the second is the amount of "bumpiness" contained in the flat top of the displayed waveform; and the third is the "squareness" of the leading edge and corner of the displayed waveform.

Determining the "Level" of the Display

If the display of Fig. 5-7 were positioned on the screen so that the positive portion coincided with a graticule line, we

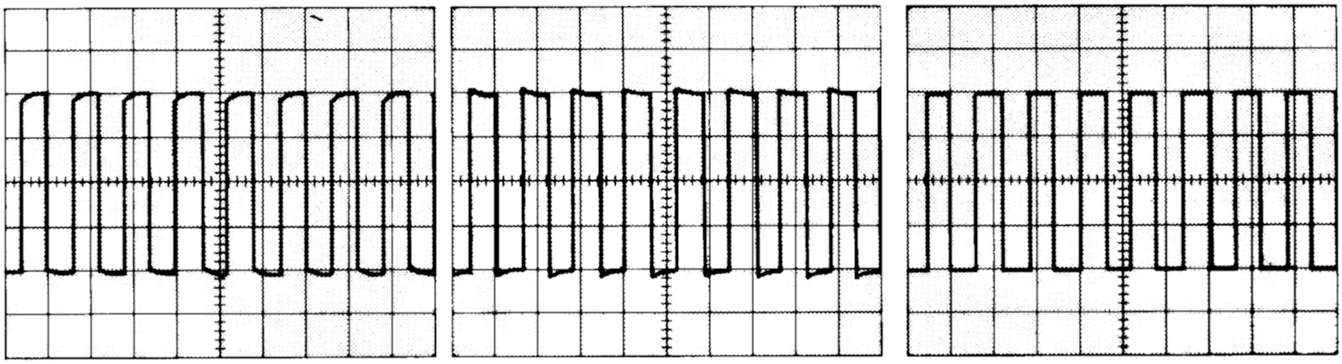


Fig. 5-8. Determining the "level" of a display.

would refer to the plane of the graticule line as the "level". If the leading corner of the waveform extended above the graticule line, we would say, "The display has an upward slope." Conversely, if the leading corner were to fall below the graticule line, we would say, "The display has a downward slope."

Fig. 5-8 shows the three conditions described in the previous paragraph. Although it is possible to observe an upward or downward slope at a sweep rate of .5 μsec/div, the "level" is most easily observed at 2 or 5 μsec/div.

Determining the "Bumpiness" of the Display

The next characteristic to look for in the displayed waveform is the "bumpiness" of the first half of the positive portion; that is, the portion that is affected by the delay-line adjustments. To make this observation, you will use two sweep rates: .5 μsec/div. and .2 μsec/div.

There are two general types of bumps to be found in a poorly adjusted delay line. They are shown in Fig. 5-9. The first type is the irregularity caused by the misadjustment of a group of capacitors. This type is most easily observed at a sweep rate of .5 μsec/div. If the bumps occur at random intervals along the delay line, they are probably due to misadjustment of the delay line and can usually be corrected by a few slight adjustments. However, if there is a certain rhythmic waviness or symmetry to their appearance, the trouble may be due to a faulty adjustment in the terminating network or in the high-frequency compensation of the amplifier and a detailed adjustment may be necessary.

The second kind of bump is caused by misadjustment of a single delay-line capacitor. Use a sweep rate of .2 μsec/div. to see bumps of this kind.

Determining the HF Response

The third characteristic to be investigated in the displayed waveform is the extreme leading edge and corner. This part of the waveform is affected by the vertical-amplifier HF peaking coils and the delay-line adjustments collectively, they determine the high-frequency response of the vertical-deflection system and for that reason are of the utmost importance.

The "squareness" of the leading corner is best observed by turning the TIME/DIV. switch to .2 μSEC. The corner should be as sharp as possible with no overshoot. Fig. 5-10 shows the three possibilities. While it is necessary that the corner be as sharp as possible for optimum frequency response, it is also necessary that there be no wrinkling or "bumpiness" in this portion of the display.

There is a good deal of similarity in the effect of the amplifier peaking coils and the delay-line adjustments. For this reason, it is sometimes difficult to ascertain which adjustments are faulty. Perhaps the simplest way to determine the source of misadjustment is to check the physical position of each adjustment and compare it to Fig. 5-11.

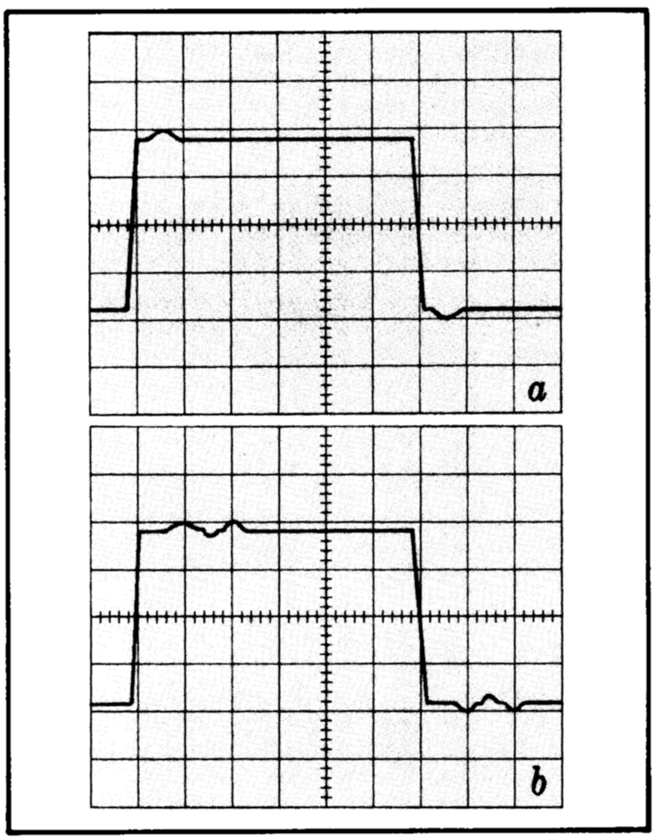


Fig. 5-9. Two types of "bumps" caused by delay-line misadjustment.

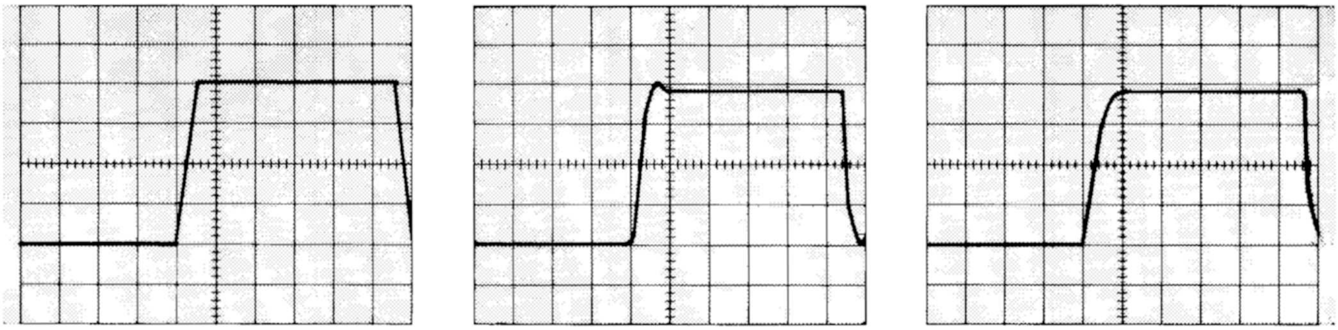


Fig. 5-10. Compensating the amplifier high-frequency response.

ADUSTMENT PROCEDURE

There are four major steps in adjusting the delay line and vertical amplifier of the Type 316. They are: (1) physically presetting the adjustments, (2) establishing a level display, (3) removing the bumps and wrinkles from the display and (4) adjusting the high-frequency compensation. In the instructions that follow, we outlined a method for performing these steps.

Physical Presetting

Perhaps the most important single bit of information for the novice is knowledge of the approximate positions of the various adjustments in a properly adjusted instrument. This knowledge will give him a good "starting" point. Later during the adjustment procedure, he can use the information as a check on his progress.

The variable inductors in the vertical amplifier can be preset according to Fig. 5-11. By positioning them as shown, you will reduce the effects of the inductors during the delay-line adjustment procedure.

If, in your preliminary investigation, you detected a cyclic waviness in the display, or if there was extreme overshoot at the leading edge, you will probably save yourself considerable time by presetting the variable inductors. Usually, turning the slugs too far out of the coil winding will only result in a rounding off of the leading edge. On the other hand, turning the slugs too far into the coil winding will result in severe wrinkles in the displayed square-wave—wrinkles which can frequently be reduced by misadjusting the delay line. This might give you the impression that the delay line was at fault instead of the high-frequency peaking coils.

The variable capacitors in the delay line will not, as a rule, require presetting. If the performance of the instrument has deteriorated as a result of normal use and handling, the delay line should require only "touching up," and the original physical positions of the capacitors should be very nearly correct. On the other hand if the instrument has been tampered with, or if it has been subject to severe vibration or rough handling, it may be desirable to preset the delay-line capacitors as described in the following paragraph.

In a properly adjusted delay line, the adjusting screw extends above the capacitor body about $^3/_8$ inch. The important characteristic is that the tops of all the delay-line adjusting screws be at about the same height. It is very important to keep this characteristic in mind as you adjust the delay line.

If you can observe a waviness in the heights of the adjusting screws (while, at the same time, the display is "level"), the trouble is probably due to misadjustment of the inductors in the vertical amplifier. In this event, you should recheck the physical positions of the slugs as described in the previous paragraphs.

The inductors and capacitor at the terminated (crt) end of the delay line are the first to be adjusted in the adjustment procedure and therefore are not usually preset. Should you have difficulty in adjusting the delay line, you can use the approximate positions shown in Fig. 5-11 as a guide to help you locate the source of trouble. The positions shown are typical of those in a properly adjusted instrument.

If, in the preliminary inspection, you noticed a bump following the Termination Bump (that is, on the portion of the delay line not normally affected by delay-line misadjustments), be sure to check the termination inductors for balance. The slugs in both inductors should be equidistant from the coil windings as shown in Fig. 5-11. When you adjust the slugs, be sure to adjust each slug the same amount.

As a final step in the Physical Presetting procedure, dress the leads to the crt vertical-deflection plates. They are to be uniformly spaced—both with respect to each other and with respect to the crt shield.

Establishing a "level" Display

The "level" of the flat top of the displayed square wave is determined by the collective effects of all of the delay-line capacitors. The characteristics to look for are described in the Preliminary Inspection section of these instructions.

To make the display "level", you will need to adjust each delay-line capacitor a small amount in a direction that will

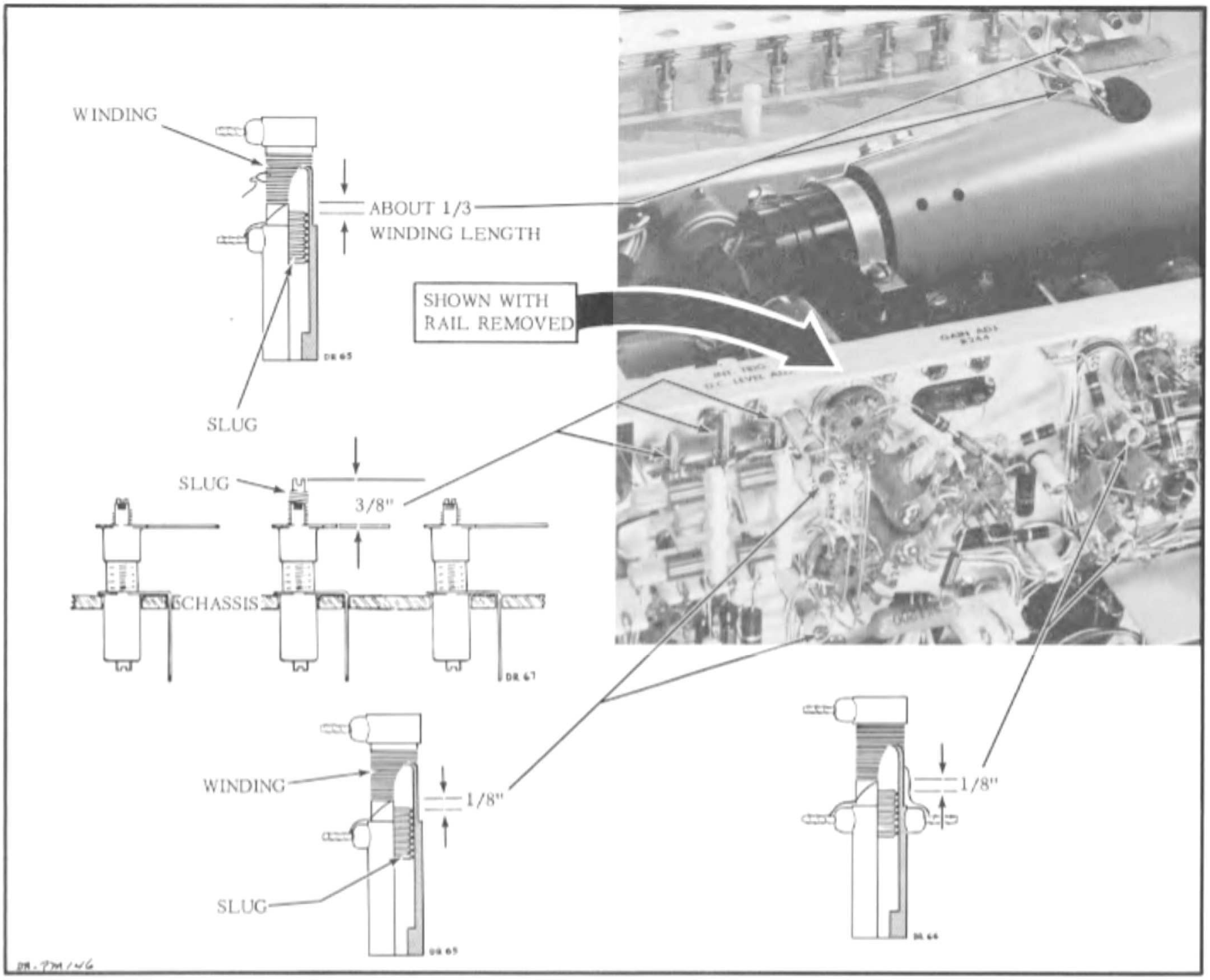


Fig. 5-11. Approximate physical positions of adjustments in a correctly adjusted instrument.

result in a "level" display. Start at the termination network by adjusting the two inductors and the capacitors (see Fig. 5-11) for minimum Termination Bump. Then advance from capacitor to capacitor on the delay line; working toward the amplifier end. During your first attempt, you will probably find it most convenient to use a sweep rate of 5 μsec/div. After you have adjusted all of the capacitors to gain an average "level" over the length of the flat top on the displayed square-wave, you can advance the sweep rate to 2 μsec/div. and repeat the procedure. This time, however, try to adjust the capacitors for a smooth transition from bump to bump while at the same time, maintaining a satisfactory "level". The important thing to remember is to reduce the amplitude of all of the bumps by the same amount and not to try to achieve a perfectly straight line at this time.

Removing the Bumps and Wrinkles

After you have established a "level" display with the amplitude of the bumps and wrinkles reduced to within a trace width of the "level" line, you can start to remove the wrinkles and bumps over smaller sections of the display.

Set the TIME/DIV. switch to .5 μSEC and proceed to remove the bumps caused by the termination network. Do not try to arrive at a perfectly straight line during your first attempt. Just reduce the bumps by one half. Then, advance to the first group of 4 or 5 capacitors in the delay line and adjust them for a smooth line over the portion of the display that they affect. Keep in mind that each capacitor will only require a slight adjustment—a mere "touch"— and that it is the combined effect of the group of capacitors that you should be concerned with.

While you are adjusting a group of capacitors to remove a bump or wrinkle, be sure to frequently turn to a sweep rate of 2 or 5 μsec/div. and check the level of the display.

Advance along the delay line from each group of capacitors to the next until you have traversed the entire length. Then, turn the TIME/DIV. switch to .2 μSEC and repeat the process. This time, however, you must be extra careful. The capacitors that require adjustment will only need a slight touch—to do otherwise might nullify all of your efforts up to the point. Be sure to check the "level" of the display frequently. It is very easy to concentrate on removing a particularly stubborn bump, and in so doing introduce an upward or downward slope in the display.

At this point in the adjustment procedure, it will not be necessary to adjust each capacitor. "Touching up" here and there will probably produce the desired results.

Adjusting the High-Frequency Compensation

If you have successfully completed the adjustment procedure up to this point, the display on your oscilloscope should appear similar to Fig. 5-7. During this final part of the adjustment procedure, you will strive for a square corner of the leading edge, while at the same time maintaining the proper "level" without introducing wrinkles or bumps.

Set the TIME/DIV. switch at .2 μSEC and position the display to afford a good view of the leading edge and corner. Each pair of inductors in the amplifier affect the same part of the display. It is very important that you adjust each inductor the same amount as its corresponding opposite. That is, the slug in L244 should be in the same position as the slug in L254 when you complete the adjustment. This is also true for the slugs in L213 and L227.

Adjust the inductors, in pairs, for a square corner on the display. It may be necessary to readjust the first two or three capacitors in the delay line to achieve a wrinkle-free corner.

L177 and L150 determine the high-frequency response of the preamplifier and must be adjusted separately. To do this, set the VOLTS/DIV. switch at .01 and reduce the output signal from the signal generator. If using a Type 107, substitute a Type B52L10 Pad for the B52R Terminating Resistor.

The coils are adjusted in the same manner as the coils in the main amplifier, however, do not adjust the delay-line capacitors. They are only to be adjusted when the VOLTS/DIV. switch is set at .1.

Main Amplifier Bandwidth

A good check on the completeness of your adjustments to the delay line and vertical amplifier is to measure the bandpass of the vertical-deflection system. To make this check, it is necessary to establish a reference deflection on the crt. Then, without altering the oscilloscope control settings or the amplitude of the input signal, increase the frequency of the input signal until the crt deflection is reduced to .71 of the reference deflection. The input signal frequency at this point will be the high-frequency 3-db-down point and represents the upper frequency limit of the bandpass.

To measure the bandpass of the main amplifier, connect the output of a Type 190A Constant-Amplitude Signal Generator to the Type 316 input connector through a Type B52R Terminating Resistor. Set the front-panel controls of the instruments as follows:

Type 316:

TRIGGER SELECTOR (red)	AUTO.
TRIGGER SELECTOR (black)	+INT.
STABILITY	PRESET
TRIGGERING LEVEL	full right or full left
DISPLAY	NORM.
TIME/DIV.	1 MILLISEC
TIME/DIV. VARIABLE	CALIBRATED
VOLTS/DIV.	.1
VOLTS/DIV. VARIABLE	CALIBRATED
AC-DC	AC

Type 190A:

RANGE SELECTOR	.35-.75 MC
RANGE IN MEGACYCLES	.50
ATTENUATOR	10
OUTPUT AMPLITUDE	See test

Adjust the Type 190A OUTPUT AMPLITUDE control for a vertical deflection of exactly four major divisions on the graticule. Then, turn the Type 190A RANGE SELECTOR to 9-21.

Next, without adjusting any other controls, advance the Type 190A RANGE IN MEGACYCLES control until you reach the point where the crt display is reduced to 2.8 major divisions. You may have to position the display with the VERTICAL POSITIONING control to make this measurement, but do not adjust any other controls.

With the vertical deflection reduced to 2.8 major divisions, read the high-frequency 3-db-down frequency directly from the dial of the Type 190A. Typically, this frequency should fall within the range from 10 megacycles to 11 megacycles.

Preamplifier Bandwidth

To measure the bandwidth of the preamplifier, set the front-panel controls as described in the previous step with the exception of the VOLTS/DIV. switch and the Type 190A ATTENUATOR switch. Set these controls to .01 and 1, respectively. Adjust the Type 190A OUTPUT AMPLITUDE control for four major divisions of vertical deflection,

Increase the frequency of the Type 190A output signal, just as you did in the previous step, until the vertical deflection falls to 2.8 major divisions of deflection. Read the 3-db-down frequency directly from the dial of the Type 190A. Typically, the upper frequency limit should be between 9 and 10.5 megacycles.

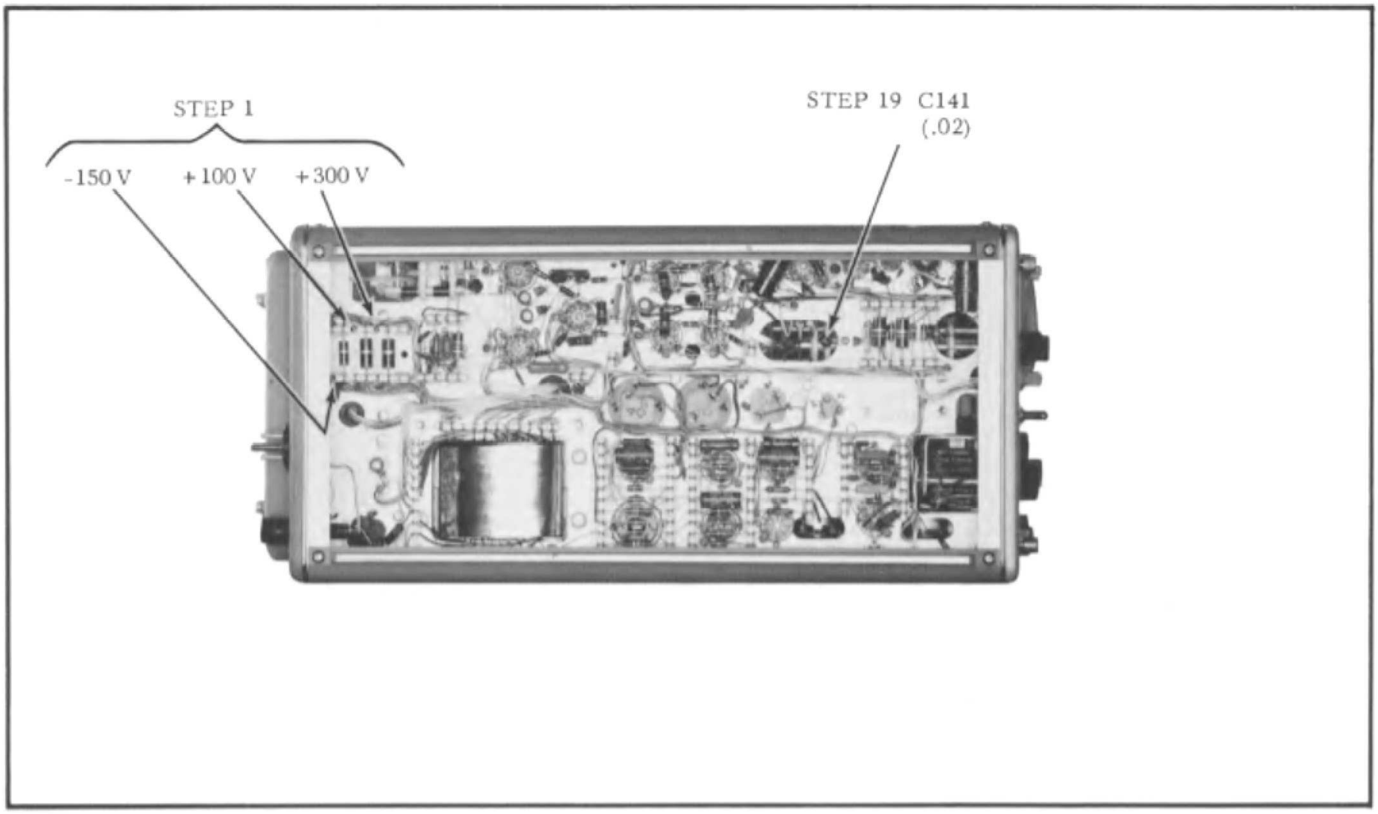


Fig. 5-12. Bottom view of the Type 316.

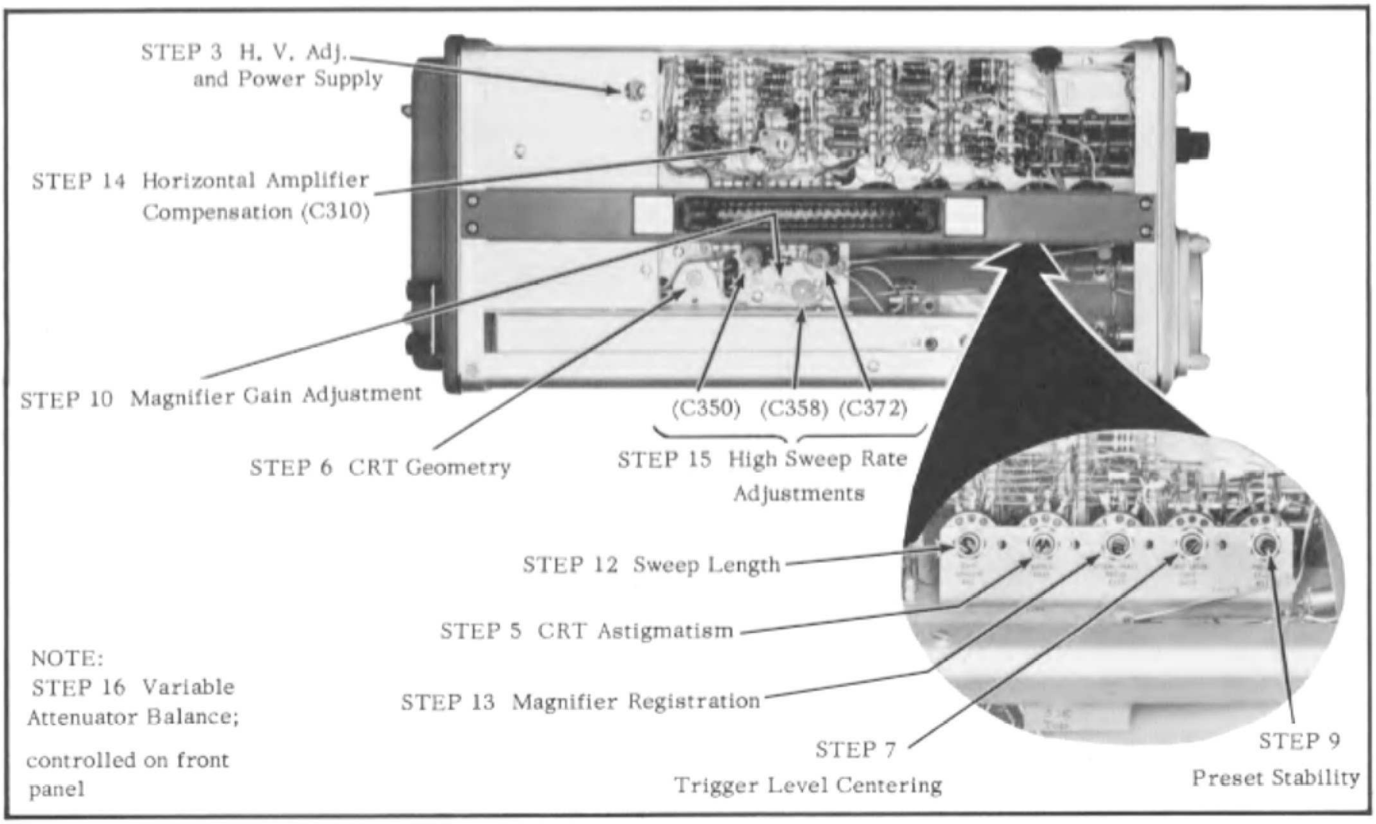


Fig. 5-13. Top View of the Type 316.

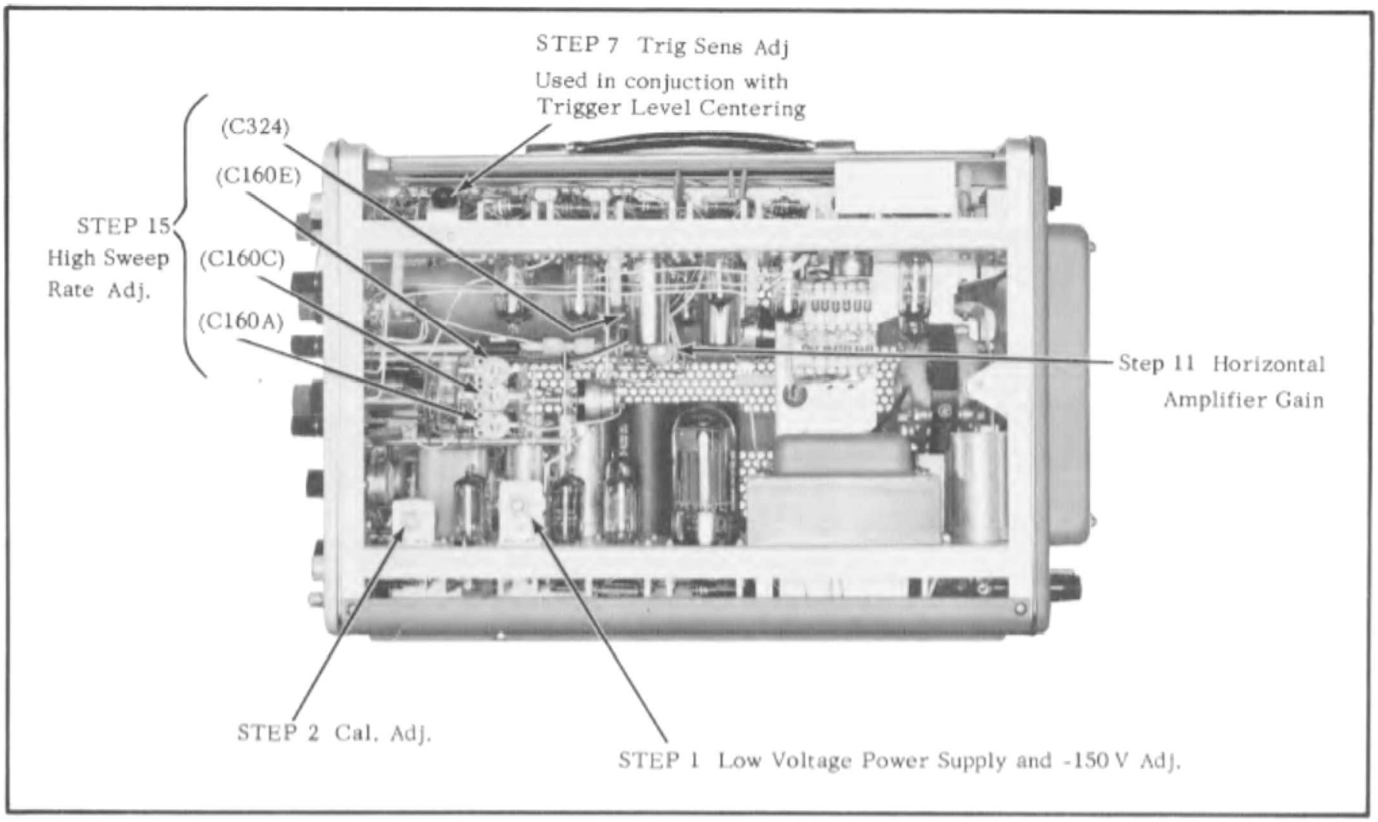


Fig. 5-14. Type 316, Right-Side View.

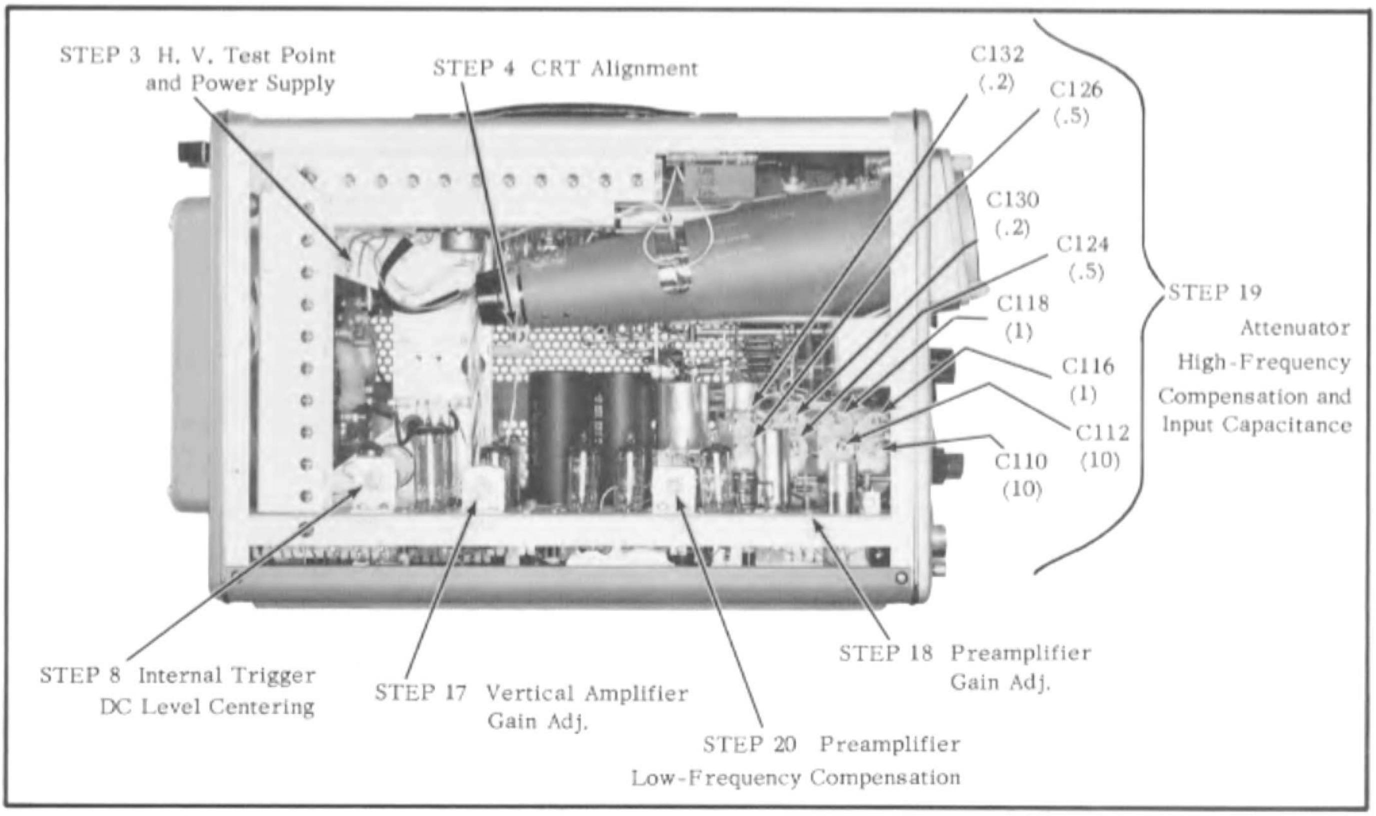
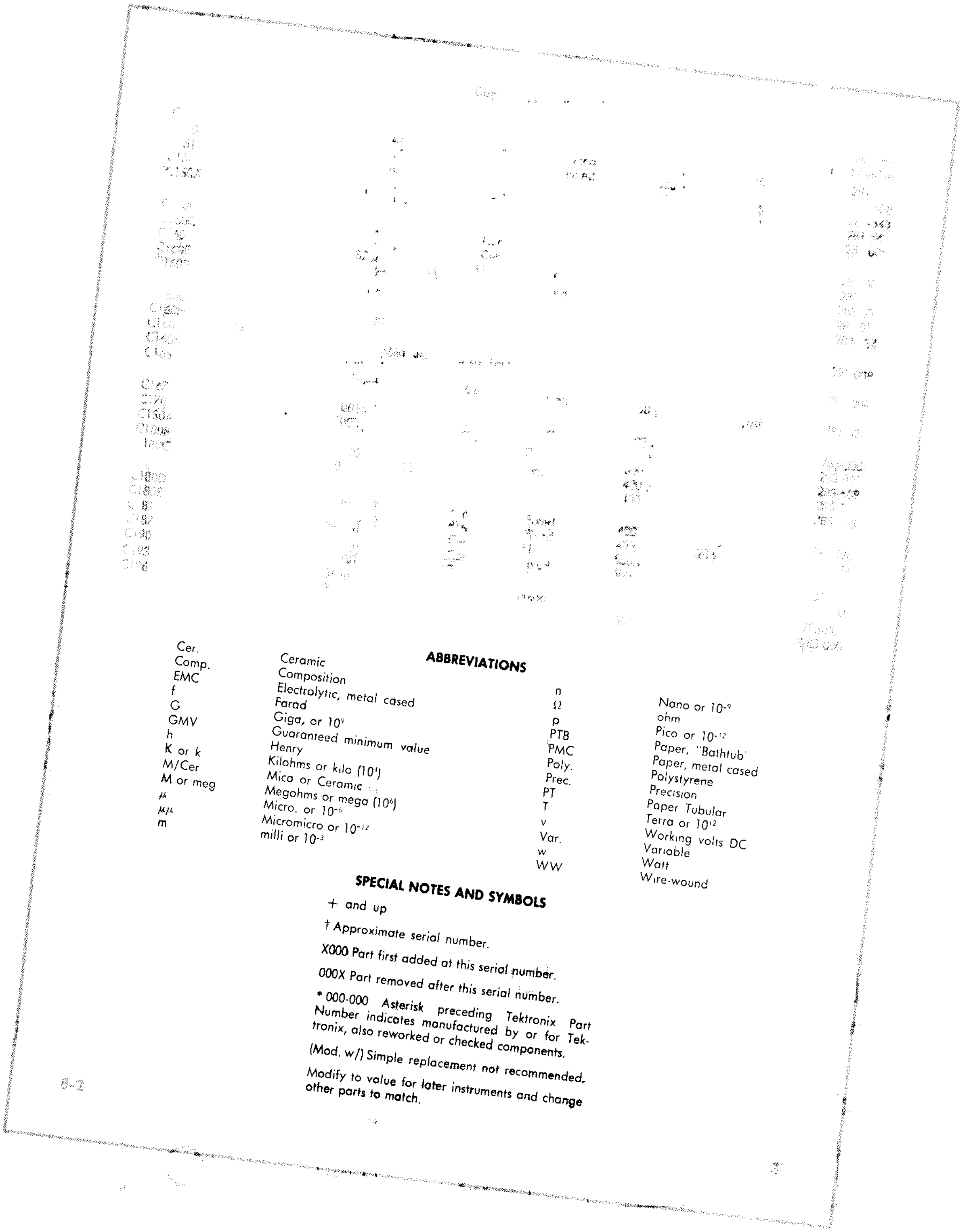


Fig. 5-15. Type 316, Left-Side View.

PARTS LIST *and* DIAGRAMS



ABBREVIATIONS

Cer.	Ceramic	n	Nano or 10^{-9}
Comp.	Composition	Ω	ohm
EMC	Electrolytic, metal cased	p	Pico or 10^{-12}
f	Farad	PTB	Paper, "Bathtub"
G	Giga, or 10^{9}	PMC	Paper, metal cased
GMV	Guaranteed minimum value	Poly.	Polystyrene
h	Henry	Prec.	Precision
K or k	Kilohms or kilo (10^{3})	PT	Paper Tubular
M/Cer	Mica or Ceramic	T	Terra or 10^{12}
M or meg	Megohms or mega (10^{6})	v	Working volts DC
μ	Micro, or 10^{-6}	Var.	Variable
μμ	Micromicro or 10^{-12}	w	Watt
m	milli or 10^{-3}	WW	Wire-wound

SPECIAL NOTES AND SYMBOLS

+ and up

† Approximate serial number.

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, also reworked or checked components.

(Mod. w/) Simple replacement not recommended. Modify to value for later instruments and change other parts to match.

8-2

MANUFACTURERS OF CATHODE-RAY OSCILLOSCOPES

HOW TO ORDER PARTS

Replacement parts are available through your local Tektronix Field Office.

Improvements in Tektronix instruments are incorporated as soon as available. Therefore, when ordering a replacement part it is important to supply the part number including any suffix, instrument type, serial number, plus a modification number where applicable.

If the part you have ordered has been improved or replaced, your local Field Office will contact you if there is a change in part number.

PARTS LIST

Values are fixed unless marked Variable.

Bulbs

Ckt. No.	Tektronix Part Number	Description		S/N Range
B68	150-002	Neon, Type NE-2	UNCALIBRATED	
B75	150-002	Neon, Type NE-2		
B77	150-002	Neon, Type NE-2		
B163	150-002	Neon, Type NE-2		
B217	150-002	Neon, Type NE-2	UNCALIBRATED	
B300	150-002	Neon, Type NE-2	MAG	
B359	150-002	Neon, Type NE-2		
B379	150-002	Neon, Type NE-2		
B600	150-004	Miniature Type #328	Pilot Light	
B601	150-001	Incandescent Type #47	Graticule Light	
B602	150-001	Incandescent Type #47	Graticule Light	

Capacitors

Tolerance ±20% unless otherwise indicated.

Tolerance of all electrolytic capacitors are as follows (with exceptions)

3V - 50V = —10% - +250%

51V - 350V = —10% - +100%

35V - 450V = —10% - +50%

C20	281-513	27 μμf	Cer.		500 v	
C22	283-001	.005 μf	Discap		500 v	GMV
C24	281-503	8 μμf	Cer.		500 v	±0.5 μμf
C26	281-544	5.6 μμf	Cer.		500 v	10%
C28	283-001	.005 μf	Discap		500 v	GMV
C33	281-504	10 μμf	Cer.		500 v	10%
C42	283-001	.005 μf	Discap		500 v	GMV
C46	283-000	.001 μf	Discap		500 v	GMV
C52	281-521	56 μμf	Cer.			10%
C72	281-525	470 μμf	Cer.		500 v	
C76	283-000	.001 μf	Discap		500 v	GMV
C101	Use *285-556	.1 μf	PTM		600 v	
C103	283-000	.001 μf	Discap		500 v	GMV
C110	281-010	4.5-25 μμf	Cer.	Var.		
C112	281-005	1.5-7 μμf	Cer.	Var.		
C114	283-543	250 μμf	Mica		500 v	5%
C116	281-010	4.5-25 μμf	Cer.	Var.		
C118	281-010	4 5-25 μμf	Cer.	Var.		
C120	283-544	150 μμf	Mica		500 v	10%
C124	281-010	4.5-25 μμf	Cer.	Var.		
C126	281-007	3-12 μμf	Cer.	Var.		
C130	281-007	3-12 μμf	Cer.	Var.		
C132	281-010	4.5-25 μμf	Cer.	Var.		
C136	281-543	270 μμf	Cer.	Var.	500 v	10%

Capacitors *(continued)*

Ckt. No.	Tektronix Part Number	Description					S/N Range
C141	281-005	1.5-7 μμf	Cer.	Var.			101-347
	281-027	.7-3 μμf	Tub.	Var.			348-up
C145	283-001	.005 μf	Discap		500 v	GMV	
C146A							
C146B	290-033	3 x 10 μf	EMC		450 v		
C146C †							
C150	290-050	2 x 1000 μf	EMC		15 v		
C151	283-004	.02 μf	Discap		150 v	GMV	X288-up
C154	290-030	500 μf	EMT		6 v		
C160A	281-007	3-12 μf	Cer.	Var.			
C160B	283-534	82 μμf	Mica		500 v	5%	
C160C	281-010	4.5-25 μμf	Cer.	Var.			
C160D	283-534	82 μμf	Mica		500 v	5%	
C160E	281-010	4.5-25 μμf	Cer.	Var.			
C160F	*291-008	.001 μf	Mylar			±½%	
C160G		.01 μf					
C160H	*291-007	0.1 μf	Mylar Timing			±½%	
C160J		1 μf	Series				
C165	283-001	.005 μf	Discap		500 v	GMV	
C166	283-001	.005 μf	Discap		500 v	GMV	
C171	285-526	.1 μf	PTM		400 v		
C180A	283-509	180 μμf	Mica		500 v	10%	
C180B	285-543	0022 μf	PTM		400 v		
C180C	285-515	.022 μf	PTM		400 v		
C180D	285-526	.1 μf	PTM		400 v		
C180E	285-526	.1 μf	PTM		400 v		
C181	281-516	39 μμf	Cer.		500 v	10%	
C182	283-000	.001 μf	Discap		500 v	GMV	
C183	281-501	4.7 μμf	Cer.		500 v	±1 μμf	101-347
	281-500	2.2 μμf	Cer.		500 v	±0.5 μμf	348-up
C184	283-001	.005 μf	Discap		500 v	GMV	
C190	283-001	.005 μf	Discap		500 v	GMV	
C194	283-002	.01 μf	Discap		500 v	GMV	
C207	283-002	.01 μf	Discap		500 v	GMV	
C256	281-547	2.7 μμf	Cer.		500 v	10%	101-1082
	281-526	1.5 μμf	Cer.		500 v	±0.5 μμf	1083-up
C262	283-001	.005 μf	Discap		500 v	GMV	
C267	281-027	.7-3 μμf	Tub.	Var.			
C268	281-534	3.3 μμf	Cer.			±0.25 μμf	
C269	281-027	.7-3 μμf	Tub.	Var.			
C271-293 (23)	281-037	.7-3 μμf	Tub.	Var.			
C295	281-027	.7-3 μμf	Tub.	Var.			
C310	281-010	4.5-25 μμf	Cer.	Var.			
C315	281-509	15 μμf	Cer.		500 v	10%	
C324	281-009	3-12 μμf	Cer.	Var.			
C333	281-526	1.5 μμf	Cer.		500 v	±0.5 μμf	

† This part shown on Power Supply Diagram.

Capacitors *(continued)*

Ckt. No.	Tektronix Part Number	Description					S/N Range
C350 †	Use 281-011	5-25 μμf	Cer.	Var.			
C358	281-013	8-50 μμf	Cer.	Var.			
C367	283-002	.01 μf	Discap.		500 v	GMV	
C372 †	Use 281-011	5-25 μμf	Cer.	Var.			
C407	285-510	.01 μf	PTM		400 v		
C410	283-000	.001 μf	Discap		500 v	GMV	
C413	Use 281-523	100 μμf	Cer.		350 v		
C414	283-000	.001 μf	Discap		500 v	GMV	
C423	283-003	.01 μf	Discap		150 v	GMV	
C425	283-003	.01 μf	Discap		150 v	GMV	
C435	281-542	18 μμf	Discap		500 v	10%	
C443	283-003	.01 μf	Discap		150 v	GMV	X1298-up
C554	283-518	330 μμf	Mica		500 v	10%	
C558	283-518	330 μμf	Mica		500 v	10%	
C576	281-513	27 μμf	Cer.		500 v		
C601A	290-060	160 μf	EMC		350 v		
C601B		10 μf					
C603	285-510	.01 μf	PTM		400 v		
C614	285-510	.01 μf	PTM		400 v		
C630A	290-061	160 μf	EMC		350 v		
C630B		10 μf					
C638	285-510	.01 μf	PTM		400 v		
C660	290-044	125 μf	EMC		350 v		
C668	285-510	.01 μf	PTM		400 v		
C690	283-000	.001 μf	Discap		500 v	GMV	101-224
	283-003	.01 μf	Discap		150 v	GMV	225-1154
	283-004	.02 μf	Discap		150 v	GMV	1155-up
C691	283-004	.02 μf	Discap		150 v	GMV	X1155-up
C801	283-000	.001 μf	Discap		500 v	GMV	
C805	285-515	.022 μf	PTM		400 v		
C810	283-002	.01 μf	Discap		500 v	GMV	
C811	285-502	.001 μf	PTM		1000 v		
C822	285-513	.015 μf	PTM		3000 v		101-1229
	283-011	.01 μf	Discap		2000 v		1230-up
C824	285-508	.0068 μf	PTM		3000 v		101-1294
	283-011	.01 μf	Discap		2000 v		1295-up
C826	283-011	.01 μf	Discap		2000 v		X1230-up
C832	283-002	.01 μf	Discap		500 v	GMV	
C833	285-513	.015 μf	PTM		3000 v		101-1229
	283-011	.01 μf	Discap		2000 v		1230-up
C834	285-508	.0068 μf	PTM		3000 v		101-1294
	283-011	.01 μf	Discap		2000 v		1295-up
C848	285-513	.015 μf	PTM		3000 v		101-1229
	283-011	.01 μf	Discap		2000 v		1230-up
C852	283-001	.005 μf	Discap		500 v	GMV	
C856	283-001	.005 μf	Discap		500 v	GMV	

Diodes

D18	152-008	Germanium Diode	X1298-up
D142	152-008	Germanium Diode	X1083-up
D152A,B	Use 152-047	Silicon Diode	X1083-up
D602A,B,C,D	Use 152-047	Silicon Diode	X1083-up
D632A,B,C,D	Use 152-047	Silicon Diode	X1083-up
D662A,B,C,D	Use 152-047	Silicon Diode	X1083-up

† S/N 101-1256 C350 and C372 have to be replaced at the same time.

Fuses

Ckt. No.	Tektronix Part Number	Description			S/N Range
F601	159-005	3 Amp Type 3 AG Slo-Blo 117 V. oper. 50 & 60 cycles			
	159-003	1.6 Amp Type 3 AG Slo-Blo 234 V. oper. 50 & 60 cycles			

Inductors

L150	*114-084	19-42 μh		Var.	101-224
	*114-086	23-55 μh		Var.	225-up
L157	*108-054	6.4 μh			
L177	*114-078	1.9-4 μh		Var.	101-224
	*114-051	.9-1.6 μh		Var.	225-up
L213	*114-076	15-30 μh		Var.	
L227	*114-076	15-30 μh		Var.	
L233	*108-088	3.2 μh			101-383X
L234	*108-088	3.2 μh			101-383X
L240	*108-105	1.8 μh			101-383
L240	*108-088	3.2 μh			384-1082
	*108-103	2.5 μh			1083-up
L244	*114-077	12-25 μh		Var.	
L250	*108-105	1.8 μh			101-383
	*108-088	3.2 μh			384-1082
	*108-103	2.5 μh			1083-up
L254	*114-077	12-25 μh		Var.	
L270	*108-123	Delay Line, 2-section			
L271	*108-123	Delay Line, 2-section			
L274	*108-125	Delay Line, 12-section			
L275	*108-125	Delay Line, 12-section			
L283	*108-103	2.5 μh			
L284	*108-103	2.5 μh			
L285	*108-124	Delay Line, 10-section			
L286	*108-124	Delay Line, 10-section			
L293	*114-075	17-34 μh		Var.	
L294	*114-075	17-34 μh		Var.	

Rectifiers †

SR150	*106-038	1-250 ma plate/leg	101-1082X
SR154	*106-037	1-100 ma plate/leg	101-1082X
SR601	*106-015	5-500 ma plate/leg	101-1082X
SR630	*106-031	5-250 ma plate/leg	101-1082X
SR660	*106-030	6-250 ma plate/leg	101-1082X

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R10††	311-099	500 k	½ w	Var.	STABILITY
R11	311-026	100 k	2 w	Var.	Preset Stability
R14	302-104	100 k	½ w		
R16	301-273	27 k	½ w		5%
R17	301-393	39 k	½ w		5%

† S/N 1083-up, see D142, D152 A, B, D602 A, B, C, D, D632 A, B, C, D, and D662 A, B, C, D. A kit is available to convert from Selenium Rectifiers to Silicon Diodes. Order Mod. Kit #040-212.

†† Furnished as a unit with SW10, R330 and R429.

Resistors *(continued)*

Ckt. No.	Tektronix Part Number	Description					S/N Range
R18	302-472	4.7 k	½ w				
R20	302-101	100 Ω	½ w				
R22	302-101	100 Ω	½ w				
R23	303-362	3.6 k	1 w			5%	
R24	303-362	3.6 k	1 w			5%	
R25	302-101	100 Ω	½ w				
R26	303-433	43 k	1 w			5%	
R27	303-333	33 k	1 w			5%	
R28	302-101	100 Ω	½ w				
R29	308-054	10 k	5 w		WW	5%	
R30	302-105	1 meg	½ w				
R31	302-470	47 Ω	½ w				
R33	Use 303-183	18 k	1 w			5%	
R34	Use 305-333	33 k	2 w			5%	
R36	302-470	47 Ω	½ w				
R37	302-681	680 Ω	½ w				101-1034
	302-102	1 k	½ w				1035-up
R38	304-154	150 k	1 w				
R41	302-470	47 Ω	½ w				
R42	302-470	47 Ω	½ w				
R43	302-103	10 k	½ w				
R46	302-104	100 k	½ w				
R47	302-470	47 Ω	½ w				
R48	302-470	47 Ω	½ w				
R49	304-104	100 k	1 w				
R52	302-681	680 Ω	½ w				
R64	302-822	8.2 k	½ w				
R65 †	311-083	20 k	2 w	Var.		VARIABLE	101-732
	311-108	20 k	2 w	Var.	WW	VARIABLE	733-up
R67	302-105	1 meg	½ w				X1260-up
R68	302-104	100 k	½ w				
R70	302-101	100 Ω	½ w				
R72	304-473	47 k	1 w				
R73	304-473	47 k	1 w				
R75	302-155	1.5 meg	½ w				
R76	302-224	220 k	½ w				
R77	302-101	100 Ω	½ w				
R80	308-054	10 k	5 w		WW	5%	
R81	304-222	2.2 k	1 w				
R82	311-008	2 k	2 w	Var.		Sweep Length	
R83	308-052	6 k	5 w		WW	5%	
R88	302-101	100 Ω	½ w				
R103	302-100	10 Ω	½ w				
R112	309-013	990 k	½ w		Prec.	1%	
R114	309-034	10.1 k	½ w		Prec.	1%	

† S/N 733-up mounted concentrically with SW160.

Resistors *(continued)*

Ckt. No.	Tektronix Part Number	Description					S/N Range
R118	309-111	900 k	½ w		Prec.	1%	
R120	309-046	111 k	½ w		Prec.	1%	
R122	302-270	27 Ω	½ w				
R126	309-110	800 k	½ w		Prec.	1%	
R128	309-109	250 k	½ w		Prec.	1%	
R132	309-003	500 k	½ w		Prec.	1%	
R134	309-014	1 meg	½ w		Prec.	1%	
R136	302-220	22 Ω	½ w				
R141 †	*312-583	1 meg	½ w		Prec.	0.1% (Selected)	
R143	302-470	47 Ω	½ w				
R144	302-223	22 k	½ w				
R145	302-101	100 Ω	½ w				
R146	306-123	12 k	2 w				
R150	*310-539	3 k	½ w		Mica Plate	1%	
R151	Use 307-015	3.3 Ω	1 w			5%	
R152	308-024	15 k	10 w		WW	5%	
R154	311-097	200 Ω	½ w	Var.		Preamp Gain Adj.	
R157	302-821	820 Ω	½ w				101-224
	302-470	47 Ω	½ w				225-up
R160A	309-045	100 k	½ w		Prec.	1%	
R160B	309-051	200 k	½ w		Prec.	1%	
R160C	309-003	500 k	½ w		Prec.	1%	
R160D	309-014	1 meg	½ w		Prec.	1%	
R160E	309-023	2 meg	½ w		Prec.	1%	
R160F	309-087	5 meg	½ w		Prec.	1%	
R160G	309-095	10 meg	½ w		Prec.	1%	
R160H	309-095	10 meg	½ w		Prec.	1%	
R160J	309-095	10 meg	½ w		Prec.	1%	
R163	306-223	22 k	2 w				
R165	302-470	47 Ω	½ w				
R166	302-102	1 k	½ w				
R167	301-154	150 k	½ w			5%	
R168	301-204	200 k	½ w			5%	
R171	304-822	8.2 k	1 w				
R174	302-394	390 k	½ w				
R175	311-042	2 meg	2 w	Var.		Low Freq. Comp.	
R180A	302-474	470 k	½ w				
R180B	302-475	4.7 meg	½ w				
R181	302-475	4.7 meg	½ w				
R183 †	*312-583	1 meg	½ w		Prec.	0.1% (Selected)	
R184	302-104	100 k	½ w				
R187	302-470	47 Ω	½ w				
R190	302-470	47 Ω	½ w				
R193	304-393	39 k	1 w				
R194	302-470	47 Ω	½ w				

† Furnished with R183 (matched pair).

Resistors *(continued)*

Ckt. No.	Tektronix Part Number	Description					S/N Range
R195	304-393	39 k	1 w				
R201	311-068	500 k	.2 w	Var.		Var. Atten. Bal.	
R203	302-394	390 k	½ w				
R205	302-475	4.7 meg	½ w				
R206	302-392	3.9 k	½ w				
R207	302-470	47 Ω	½ w				
R210	302-100	10 Ω	½ w				
R212	302-122	1.2 k	½ w				
R213	*310-533	1.8 k	½ w		Mica Plate	1%	
R216	Use *050-043						101-476
R216	*311-135	660 Ω			WW	VARIABLE	477-up
R217	302-104	100 k	½ w				
R219	304-103	10 k	1 w				
R220	304-103	10 k	1 w				
R223	308-007	8 k	5 w		WW	5%	
R225	302-100	10 Ω	½ w				
R227	*310-533	1.8 k	½ w		Mica Plate	1%	
R230	302-823	82 k	½ w				
R231	311-028	2 x 100 k	2 w	Var.		VERTICAL POSITIONING	
R232	302-823	82 k	½ w				
R233	302-100	10 Ω	½ w				X384-up
R234	302-100	10 Ω	½ w				X384-up
R235	303-153	15 k	1 w			5%	
R236	303-153	15 k	1 w			5%	
R240	302-470	47 Ω	½ w				101-383
	302-270	27 Ω	½ w				384-up
R244	311-003	100 Ω	2 w	Var.		Gain Adj.	101-1082
	311-004	200 Ω	2 w	Var.		Gain Adj.	1083-up
R245	308-082	3 k	5 w		WW	5%	
R246	308-082	3 k	5 w		WW	5%	
R248	308-063	1.2 k	5 w		WW	5%	101-1082
	302-221	220 Ω	½ w				1083-1179
	308-063	1.2 k	5 w		WW	5%	1180-up
R250	302-470	47 Ω	½ w				101-383
	302-270	27 Ω	½ w				384-up
R256	309-001	433 k	½ w		Prec.	1%	
R257	309-125	300 k	½ w		Prec.	1%	101-856
	309-053	333 k	½ w		Prec.	1%	857-1297
	Use 309-053	333 k	½ w		Prec.	1%	1298-up
R258	311-078	50 k	.1 w	Var.		Int. Trig. DC LEVEL ADJ.	101-460
	311-023	50 k	2 w	Var.		Int. Trig. DC LEVEL ADJ.	461-up
R260	302-470	47 Ω	½ w				
R262	302-470	47 Ω	½ w				
R264	304-393	39 k	1 w				
R293	*310-534	1.8 k	5 w		Mica Plate	1%	
R294	*310-534	1.8 k	5 w		Mica Plate	1%	
R297	308-089	1 k	10 w		WW	5%	101-1082
	308-086	1.2 k	10 w		WW	5%	1083-1179
	308-089	1 k	10 w		WW	5%	1180-up

Ckt. No.	Tektronix Part Number	Description					S/N Range
R300	302-104	100 k	½ w				
R310	309-021	1.84 meg	½ w		Prec.	1%	
R311	309-017	1.5 meg	½ w		Prec.	1%	
R314A,B	311-090	2 x 20 k	2 w	Var.	WW	HORIZ. POSITIONING	
R315	302-561	560 Ω	½ w				
R316	302-470	47 Ω	½ w				
R318	306-473	47 k	2 w				
R324	309-049	150 k	½ w		Prec.	1%	
R325	311-078	50 k	.1 w	Var.		Horiz. Gain Adj.	
R330 †	311-099	100 k	½ w	Var.		HORIZ. INPUT ATTEN.	
R333	309-126	400 k	½ w		Prec.	1%	
R334	309-109	250 k	½ w		Prec.	1%	
R335	311-023	50 k	2 w	Var.		Norm/Mag. Regis.	
R337	302-470	47 Ω	½ w				
R340	306-683	68 k	2 w				
R344	302-470	47 Ω	½ w				
R350	*310-507	6-30 k	5 w		Mica Plate		
R351	302-470	47 Ω	½ w				
R353	303-153	15 k	1 w			5%	
R354	308-054	10 k	5 w		WW	5%	
R356	303-153	15 k	1 w			5%	
R358	311-086	2.5 k	½ w	Var.		Mag. Gain Adj.	
R359	*310-512	41.5 k	5 w		Mica Plate	1%	
R365	304-223	22 k	1 w				
R366	302-104	100 k	½ w				
R367	302-562	5.6 k	½ w				
R370	302-470	47 Ω	½ w				
R372	*310-524	7-35 k	5 w		Mica Plate	1%	
R374	302-470	47 Ω	½ w				
R379	304-274	270 k	1 w				
R409	302-105	1 meg	½ w				
R410	302-474	470 k	½ w				
R412	302-101	100 Ω	½ w				
R413	302-392	3.9 k	½ w				X1298-1539
	302-472	4.7 k	½ w				1540-up
R414	302-270	27 Ω	½ w				
R415	302-562	5.6 k	½ w				101-1297
	302-392	3.9 k	½ w				1298-1539
	302-472	4.7 k	½ w				1540-up
R417	308-081	20 k	8 w		WW	5%	101-1297
	306-393	39 k	2 w				1298-up
R418	306-393	39 k	2 w				X1298-up
R419	302-101	100 Ω	½ w				
R422	302-104	100 k	½ w				
R423	302-101	100 Ω	½ w				
R424	302-224	220 k	½ w				
R425	302-104	100 k	½ w				

† Furnished as a unit with R10, R429 and SW10.

Resistors *(continued)*

Ckt. No.	Tektronix Part Number	Description					S/N Range
R426	302-395	3.9 meg	½ w				
R427	302-824	820 k	½ w				
R428	302-105	1 meg	½ w				
R429 †	311-099	100 k	½ w	Var.		TRIGGERING LEVEL	
R431	302-225	2.2 meg	½ w				
R432	302-102	1 k	½ w				
R433	301-332	3.3 k	½ w			5%	101-1297
	Use 301-222	2.2 k	½ w			5%	1298-up
R435	302-154	150 k	½ w				
R436	302-124	120 k	½ w				
R437	311-026	100 k	2 w	Var.		Triggering Level Cent.	
R439	302-101	100 Ω	½ w				
R440	302-821	820 Ω	½ w				
R441	302-105	1 meg	½ w				X498-1297
	316-105	1 meg	¼ w			5%	1298-up
R442	305-113	11 k	2 w			5%	101-1297
	304-223	22 k	1 w			5%	1298-up
R443	311-056	500 Ω	.1 w	Var.			X1298-up
R444	304-223	22 k	1 w				X1298-up
R550	302-154	150 k	½ w				
R552	302-102	1 k	½ w				
R554	302-335	3.3 meg	½ w				101-1082
	301-395	3.9 meg	½ w			5%	1083-up
R556	302-275	2.7 meg	½ w				101-1082
	301-245	2.4 meg	½ w			5%	1083-up
R558	302-102	1 k	½ w				
R562	302-683	68 k	½ w				
R564	304-333	33 k	1 w				
R566	Use 311-016	10 k	2 w	Var.		Cal. Adj.	
R567	302-104	100 k	½ w				101-1082
	302-683	68 k	½ w				1083-up
R572	302-101	100 Ω	½ w				101-1082
	302-102	1 k	½ w				1083-up
R577	309-100	10 k	½ w		Prec.	1%	
R578	309-099	6 k	½ w		Prec.	1%	
R579	309-098	2 k	½ w		Prec.	1%	
R580	309-115	1 k	½ w		Prec.	1%	
R581	309-097	600 Ω	½ w		Prec.	1%	
R582	309-073	200 Ω	½ w		Prec.	1%	
R583	309-112	100 Ω	½ w		Prec.	1%	
R584	309-067	60 Ω	½ w		Prec.	1%	
R585	309-064	20 Ω	½ w		Prec.	1%	
R586	309-096	10 Ω	½ w		Prec.	1%	
R587	309-096	10 Ω	½ w		Prec.	1%	
R599	302-100	10 Ω	½ w				X1280-up
R600	311-055	50 Ω	2 w	Var.	WW	SCALE ILLUM.	
R601	306-100	10 Ω	2 w				
R603	302-333	33 k	½ w				
R605	302-562	5.6 k	½ w				

† Furnished as a unit with R10, R330, and SW10.

Resistors *(continued)*

Ckt. No.	Tektronix Part Number	Description					S/N Range
R606	302-224	220 k	½ w				
R607	302-683	68 k	½ w				
R609	302-105	1 meg	½ w				
R610	302-102	1 k	½ w				
R612	302-183	18 k	½ w				
R614	302-105	1 meg	½ w				
R616	309-042	68 k	½ w		Prec.	1%	
R617	311-015	10 k	2 w	Var.	WW	—150V Adj.	
R618	309-090	50 k	½ w		Prec.	1%	
R620	308-102	1.25 k	25 w		WW	5%	
R630	304-100	10 Ω	1 w				
R632	302-473	47 k	½ w				
R633	302-333	33 k	½ w				
R635	302-105	1 meg	½ w				
R636	302-105	1 meg	½ w				
R638	302-102	1 k	½ w				
R639	308-082	3 k	5 w		WW	5%	
R641	310-056	333 k	1 w		Prec.	1%	
R642	310-057	490 k	1 w		Prec.	1%	
R660	306-100	10 Ω	2 w				
R662	304-274	270 k	1 w				
R663	Use 302-563	56 k	½ w				
R666	302-105	1 meg	½ w				
R668	302-102	1 k	½ w				
R669	308-102	1.25 k	25 w		WW	5%	
R671	309-014	1 meg	½ w		Prec.	1%	
R672	309-002	490 k	½ w		Prec.	1%	
R690	302-104	100 k	½ w				
R694	302-274	270 k	½ w				
R695	302-104	100 k	½ w				
R801	304-154	150 k	1 w				
R804	302-155	1.5 meg	½ w				
R808	302-473	47 k	½ w				
R810	302-472	4.7 k	½ w				
R822	302-683	68 k	½ w				101-1229
	302-333	33 k	½ w				1230-up
R823	306-565	5.6 meg	2 w				
R824	306-565	5.6 meg	2 w				
R825	311-041	1 meg	½ w	Var.		INTENSITY	
R826	302-155	1.5 meg	½ w				
R832	302-332	3.3 k	½ w				
R840	309-017	1.5 meg	½ w		Prec.	1%	
R841	311-042	2 meg	2 w	Var.		HV Adj.	
R842	306-395	3.9 meg	2 w				101-268
	306-475	4.7 meg	2 w				269-up
R843	311-043	2 meg	½ w	Var.		FOCUS	
R844	306-155	1.5 meg	2 w				101-268
	306-474	470 k	2 w				269-up
R846	302-273	27 k	½ w				
R848	302-105	1 meg	½ w				

Resistors *(continued)*

Ckt. No.	Tektronix Part Number	Description				S/N Range
R850	302-154	150 k	½ w			
R852	302-124	120 k	½ w			
R854	311-026	100 k	2 w	Var.	Geom. Adj.	
R856	311-023	50 k	2 w	Var.		

Switches

Ckt. No.	Unwired	Wired		Description	S/N Range
SW10†	311-099			PRESET	
SW101	*260-122		Rotary	AC/DC	
SW120	*260-187	*050-011	Rotary	VOLTS/DIV.	101-1539
	*260-187	*262-428	Rotary	VOLTS/DIV.	1540-up
SW160††	*260-150	*262-122	Rotary	TIME/DIV.	101-396
	*260-174	*262-122	Rotary	TIME/DIV.	397-732
	*260-226	*262-182	Rotary	TIME/DIV.	733-up
SW300	*260-186	*050-028	Rotary	DISPLAY	101-1539
SW300	*260-186	262-431			1540-up
SW410, SW420	*260-151	*262-167	Rotary	TRIGGER SELECTOR	101-1297
SW410, SW420	*260-151	Use *262-196	Rotary	TRIGGER SELECTOR	1298-up
SW555	*260-098	*262-120	Rotary	SQUARE WAVE CAL.	
SW600	260-134		Toggle	POWER ON	

Thermal Cutout

TK601	260-120	Thermal Cutout, 137° F ±5°	

Transformers

T600	*120-064	L. V. Power	101-1082
	*120-112	L. V. Power	1083-up
T800	*120-061	H. V. Power	

Electron Tubes

V25	154-028	6BQ7A	101-1297
	154-187	6DJ8	1298-up
V35	154-078	6AN8	
V43	154-028	6BQ7A	101-1297
	154-187	6DJ8	1298-up
V52	154-016	6AL5	
V61	154-078	6AN8	
V83	154-039	12AT7	101-1297
	154-187	6DJ8	1298-up
V154	154-030	6CB6	
V163	154-028	6BQ7A	101-1082
	154-187	6DJ8	1083-up
V183	154-022	6AU6	
V203	154-022	6AU6	
V214	154-022	6AU6	

† Furnished as a unit with R10, R330, and R429.

†† S/N 733-up, concentric with R65. Furnished as a unit.

Electron Tubes *(continued)*

Ckt. No.	Tektronix Part Number	Description	S/N Range
V224	154-022	6AU6	
V233	154-028	6BQ7A	101-1082
	154-187	6DJ8	1083-up
V244	154-031	6CL6	
V254	154-031	6CL6	
V263	154-022	6AU6	
V313	154-028	6BQ7A	101-1297
	154-187	6DJ8	1298-up
V354	154-028	6BQ7A	101-1297
	154-187	6DJ8	1298-up
V374	154-028	6BQ7A	101-1297
	154-187	6DJ8	1298-up
V414	154-033	6U8	101-1297
	154-187	6DJ8	1298-up
V435	154-033	6U8	101-1297
	154-187	6DJ8	1298-up
V555	154-033	6U8	101-1082
	154-041	12AU7	1083-up
V573	154-022	6AU6	
V606	154-078	6AN8	
V609	154-052	5651	
V617	154-056	6080	
V636	154-022	6AU6	
V637	154-044	12B4	
V666	154-022	6AU6	
V806	154-041	12AU7	
V810	154-017	6AQ5	
V822	154-051	5642	
V832	154-051	5642	
V859 †	Use *154-155	T316P2 (T32) CRT Standard Phosphor	

† For S/N 101-268 order Mod. Kit 040-151

Type 316
Mechanical Parts List

	Tektronix Part Number
ADAPTOR, MOLDER NYLON, COIL HOLDER	103-011
ADAPTOR, POWER CORD	103-013
ANGLE, FRAME $15\frac{7}{8}$ (Extrusion) Bottom, Blue Wrinkle (S/N 101-1294)	122-032
ANGLE, FRAME, $15\frac{7}{8}$ (Extrusion) Top	122-034
ANGLE, FRAME, $15\frac{7}{8}$ (Extrusion) Bottom, Blue Vinyl (S/N 1295-up)	122-064
BAR, EXTRUDED CHANNEL TOP SUPPORT Blue Wrinkle (S/N 101-1294)	381-079
BAR, ALUM., $\frac{3}{16} \times \frac{1}{2} \times 1$ W/2 6-32 Holes	381-084
BAR, ALUM. $\frac{3}{8} \times \frac{3}{8} \times 1\frac{25}{32}$ Tapped 10-32 and 6-32 (S/N 101-1109)	381-125
BAR, ALUM., $\frac{3}{8} \times \frac{3}{8} \times 1\frac{11}{16}$ Tapped 10-32 and 6-32 (S/N 1110-up)	381-142
BAR, ALUM., EXTRUDED CHANNEL TOP SUPPORT W/Handles Blue Vinyl (S/N 1295-up)	381-164
BOLT, SPADE 6-32 x $\frac{3}{8}$	214-012
BRACKET, ALUM., $.080 \times 1 \times 1\frac{1}{2} \times \frac{1}{2}$	406-022
BRACKET, ALUM., $.080 \times 1 \times 1\frac{1}{16} \times \frac{1}{2}$	406-109
BRACKET, ALUM., $.080 \times 1 \times 1\frac{1}{4} \times \frac{1}{2}$ (S/N 348-up)	406-230
BRACKET, ALUM., $.063 \times 2\frac{1}{2} \times 1\frac{3}{16}$ "U" Shaped	406-278
BRACKET, ALUM., $.080 \times 1\frac{1}{2} \times 2\frac{5}{8}$ Mag. Switch	406-279
BRACKET, ALUM., $.040 \times 2\frac{15}{16} \times 5\frac{15}{16} \times \frac{1}{2}$	406-283
BRACKET, ALUM., $.063 \times \frac{1}{2} \times 1\frac{1}{2} \times \frac{3}{8}$ Delay Line Plate	406-284
BRACKET, BRASS	406-286
BRACKET, ALUM., $.063 \times 2\frac{5}{8} \times 1\frac{1}{16} \times \frac{1}{2}$ Sw. Mtg. (S/N 1013-up)	406-481
BUSHING, HEX, $\frac{3}{8}$-32 x $\frac{13}{32}$ x .252 ID	358-029
BUSHING, NYLON	358-036
BUSHING, ALUM.	358-043
CABLE HARNESS, SWEEP	179-141
CABLE HARNESS, F & I	179-142
CABLE HARNESS, POWER (S/N 101-1082)	179-143
CABLE HARNESS, PRE-AMP.	179-148
CABLE HARNESS, 110 VOLT	179-156
CABLE HARNESS, L. V. POWER (S/N 1083-up)	179-346
CAP, FUSE, 3 AG, RAW	200-015
CAP, BINDING POST	200-103
CHASSIS, SWEEP (S/N 101-1297)	441-147
CHASSIS, VERT. POWER (S/N 101-1082)	441-156

	Tektronix Part Number
CHASSIS, DELAY LINE HOUSING (S/N 101-271)	441-159
CHASSIS, DELAY LINE HOUSING (S/N 271-up)	441-179
CHASSIS, POWER (S/N 1083-up)	441-215
CHASSIS, SWEEP (S/N 1298-up)	441-306
CLAMP, CABLE $1/2$", PLASTIC	343-006
CLAMP, CABLE $3/8$", PLASTIC	343-013
CLAMP, STAINLESS STEEL $1/2 \times 3/4$ Dia	343-036
CLAMP, STAINLESS STEEL $.037 \times 1\,7/16$ W/2 Mtg. Straps	343-038
CLIP, FUSE $1/4$"	348-002
CLIP, "KLIPZON" TIP, RAW	348-003
CLIP, ALLIGATOR, W/O EYELET	348-004
CLIP, ALLIGATOR, ASS'Y	348-005
CLIP, TEST (Gray Bill #2-0)	348-008
CONNECTOR, CHASSIS MT., 2 CONTACT, MALE (S/N 101-589)	131-010
CONNECTOR, CABLE, CRT, PIN	131-049
CONNECTOR, CHASSIS MT., 3 WIRE, MALE (S/N 590-up)	131-102
CORD, POWER	161-010
COUPLING, INSUL., NYLON ASS'Y	376-011
COUPLING, POT, WIRE STEEL	376-014
COVER, GRATICULE	200-073
EYELET, BRASS, TAPERED BARREL	210-601
FILTER, AIR $7 \times 7 \times 1$	378-015
FILTER, LIGHT, PLEX., GREEN	378-509
GRATICULE, 3", 8 VERT x 10 HORIZ.	331-042
HOLDER, NEON BULB, SINGLE	352-008
HOLDER, FUSE	352-010
HOLDER, $1/4$" DIA COIL FORM x $1\,1/8$"	352-012
HOLDER, $1/4$" DIA COIL FORM x $1\,19/64$	352-013
HOUSING, AIR FILTER BLUE WRINKLE (S/N 101-1294)	380-009
HOUSING, AIR FILTER BLUE VINYL (S/N 1295-up)	380-016
KNOB, LARGE BLACK, $1/4$ INSERT HOLE	366-028
KNOB, LARGE BLACK, $1/4$ INSERT HOLE, $1/4$ CONC. HOLE	366-029
KNOB, LARGE BLACK, $17/64$ INSERT HOLE, .265 CONC. HOLE	366-030
KNOB, SMALL RED, $1/8$ INSERT HOLE	366-031
KNOB, SMALL RED, $3/16$ INSERT HOLE	366-032
KNOB, SMALL BLACK, $1/4$ INSERT HOLE	366-033

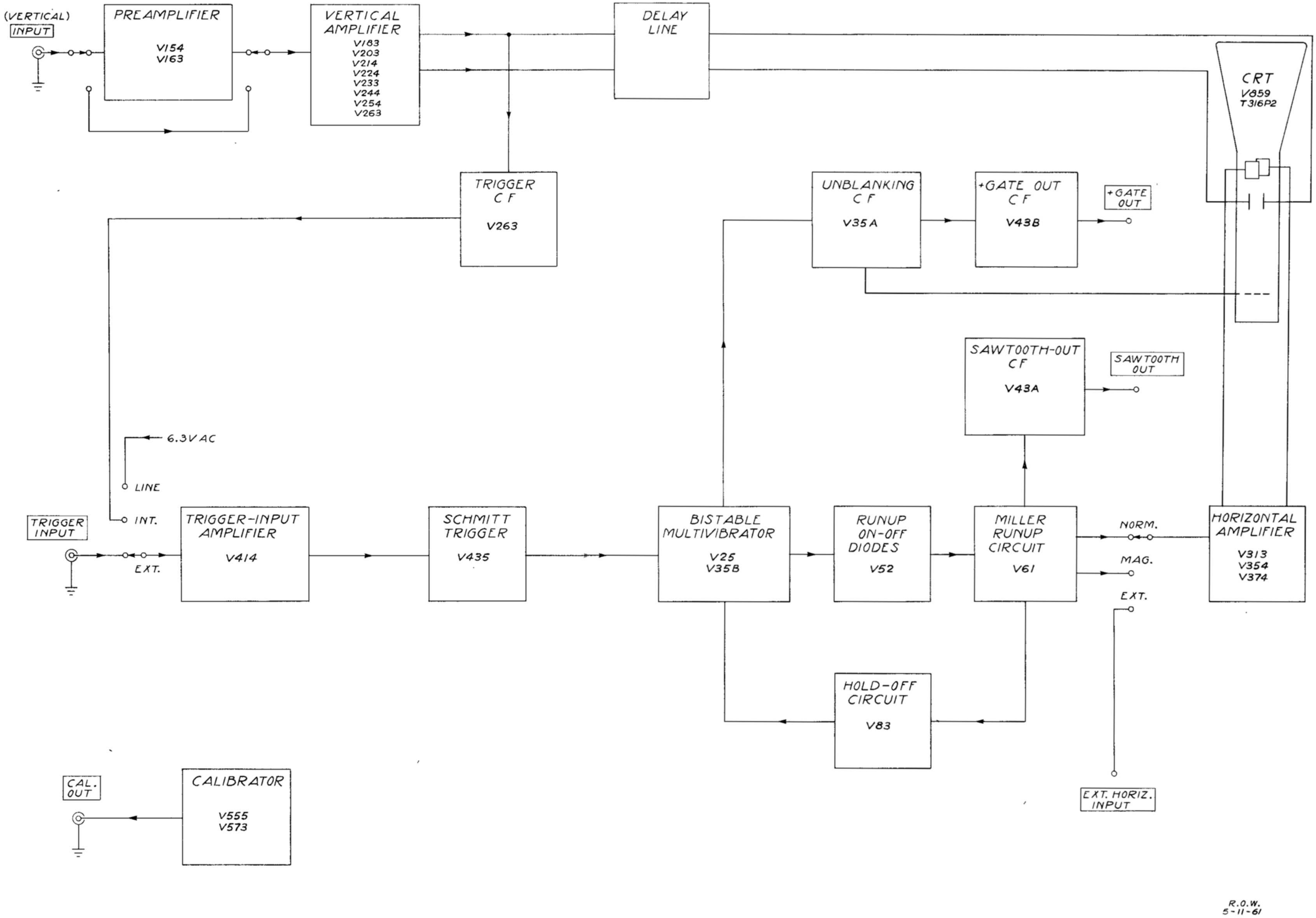
	Tektronix Part Number
KNOB, SMALL RED, 1/8 HOLE PART WAY	366-038
KNOB, LARGE BLACK, 1/4 HOLE THRU	366-040
LOCKWASHER, STEEL EXT. #2	210-002
LOCKWASHER, STEEL INT. #4	210-004
LOCKWASHER, STEEL INT. #6	210-006
LOCKWASHER, STEEL EXT. #8	210-007
LOCKWASHER, STEEL INT #8	210-008
LOCKWASHER, STEEL EXT. #10	210-009
LOCKWASHER, STEEL INT. #10	210-010
LOCKWASHER, STEEL INT. 1/4	210-011
LOCKWASHER, STEEL INT. POT 3/8 x 1/2	210-012
LOCKWASHER, STEEL INT. 3/8 x 11/16	210-013
LOCKWASHER, STEEL NO. 5 SPRING	210-017
LUG, SOLDER, SE4	210-201
LUG, SOLDER, SE 6 W/2 WIRE HOLES	210-202
LUG, SOLDER, SE 6 LONG	210-203
LUG, SOLDER, SE 8	210-205
LUG, SOLDER, POT, PLAIN, 3/8	210-207
LUG, SOLDER, SF 8 LONG	210-228
MOUNT, FAN MOTOR	426-046
NUT, HEX 2-56 x 3/16	210-405
NUT, HEX 4-40 x 3/16	210-406
NUT, HEX 6-32 x 1/4	210-407
NUT, HEX 8-32 x 5/16	210-409
NUT, HEX 10-32 x 5/16	210-410
NUT, HEX 3/8-32 x 1/2	210-413
NUT, SQUARE 10-24 x 3/8	210-416
NUT, KNURLED, GRATICULE	210-434
NUT, HEX, 1-72 x 5/32 (Received W/Pot)	210-438
NUT, HEX 1/2 x 5/8, 3/8-32 INT. THREAD (Pot)	210-444
NUT, HEX 5-40 x 1/4 or 3/16 W/SWITCH	210-449
NUT KEPS 6-32 x 5/16	210-457
NUT, HEX 8-32 x 1/2 x 23/64 (25 W Resistor Mtg.)	210-462
NUT, HEX 1/4-32 x 3/8 x 3/32 (For Miniature Pot)	210-465
NUT, SWITCH, 12 SIDED	210-473
NUT, HEX 6-32 x 5/16 x .194 (5-10 W Res Mtg.)	210-478

Mechanical Parts List *(continued)*

	Tektronix Part Number
PANEL, FRONT	333-323
PLATE, CRT GRND. STRAP (S/N 1295-up)	386-374
PLATE, BRASS .040 x $9/16$ x $1\,9/32$ (S/N 101-1294)	386-427
PLATE, SUB PANEL, FRONT	386-602
PLATE, CABINET BOTTOM BLUE WRINKLE (S/N 101-1294	386-605
PLATE, CABINET SIDES (S/N 101-530)	386-606
PLATE, SUB PANEL, BACK (S/N 101-1294)	386-615
PLATE, RECT. MTG. (S/N 101-1082)	386-621
PLATE, REAR OVERLAY BLUE WRINKLE (S/N 101-1294)	386-633
PLATE, PLEXIGLAS .100 x 2 x $2\,1/8$ DELAY LINE	386-634
PLATE, PLEXIGLAS .100 x $1\,1/2$ x $1\,9/16$ DELAY LINE	386-641
PLATE, PLEXIGLAS .100 x $2\,1/4$ x $11/16$ GAIN ADJ. POT MTG.	386-642
PLATE, ALUM. .050 x $3\,5/8$ x $4\,3/8$	386-645
PLATE, PLEXIGLAS .100 x $1\,7/16$ x $9\,3/8$ DELAY LINE	386-703
PLATE, PLEXIGLAS .100 x $1\,7/16$ x $7\,7/8$ DELAY LINE	386-704
PLATE, CABINET SIDES BLUE WRINKLE (S/N 531-1294)	386-735
PLATE, ALUM., .063 x $3/4$ x $7/8$ POT. MTG. (S/N 1298-up)	386-768
PLATE, ALUM., .063 x $4\,27/32$ x $7\,1/2$ x $7/16$ SILICON RECT. (S/N 1083-1499)	386-932
PLATE, ALUM., .063 x $4\,27/32$ x $7\,1/2$ x $7/16$ SILICON RECT. (S/N 1500-up)	387-411
PLATE, REAR SUB PANEL (S/N 1295-up)	386-971
PLATE, CAB. SIDES BLUE VINYL (S/N 1295-up)	387-051
PLATE, CAB. BOTTOM BLUE VINYL (S/N 1295-up)	387-052
PLATE, REAR OVERLAY BLUE VINYL (S/N 1295-up)	387-054
POST BINDING ASS'Y W/BUSHING	129-001
POST, CERAMIC CONNECTING, $1/2$ x $5/16$	129-009
POST, GROUND, ASS'Y	129-035
RING, FAN	354-051
RING, LOCKING SWITCH	354-055
ROD, EXTENSION, ALUM. $1/4$ x $5\,3/4$	384-010
ROD, EXTENSION, STEEL $1/8$ x $5\,13/16$	384-147
ROD, SPACING, NYLON $1/4$ x $17/32$ TAPPED 4-40 THRU (S/N 272-up)	384-536
ROD, NYLON $5/16$ x 1 TAPPED 6-32 THRU	385-016
ROD, NYLON $5/16$ x $3/4$ TAPPED 6-32 ONE END W/#44 HOLE	385-073
ROD, NYLON $5/16$ x1 TAPPED 6-32 ONE END W/#44 HOLE (S/N 1083-up)	385-074
ROD, NYLON $1/4$ x $1\,1/4$ TAPPED 6-32 ONE END W/3 #44 HOLES	385-096
ROD, NYLON $5/16$ x 2	385-097
SCREW 4-40 x $3/16$ BHS	211-007

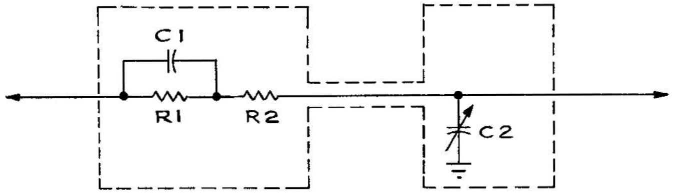
	Tektronix Part Number
SCREW 4-40 x 1/4 BHS	211-008
SCREW 4-40 x 5/16 BHS	211-011
SCREW 4-40 x 1/4 FHS	211-023
SCREW 4-40 x 1 FHS	211-031
SCREW 4-40 x 5/16 PAN HS W/Lockwasher	211-033
SCREW 4-40 x 5/16 FHS, Phillips	211-038
SCREW 4-40 x 1/4 BHS, Nylon	211-040
SCREW 6-32 x 3/16 BHS	211-503
SCREW 6-32 x 1/4 BHS	211-504
SCREW 6-32 x 5/16 BHS	211-507
SCREW 6-32 x 5/16 FHS	211-508
SCREW 6-32 x 3/8 BHS	211-510
SCREW 6-32 x 5/16 PAN HS W/Lockwasher	211-534
SCREW 6-32 x 3/8 TRUSS HS, Phillips	211-537
SCREW 6-32 x 5/16 FHS 100°, CSK Phillips	211-538
SCREW 6-32 x 3/4 TRUSS HS, Phillips	211-544
SCREW 6-32 x 1 1/2 RHS, Phillips	211-553
SCREW 8-32 x 5/16 BHS	212-004
SCREW 8-32 x 1 1/4 FHS, 100°	212-012
SCREW 8-32 x 1 1/4 RHS	212-031
SCREW 8-32 x 1 3/4 FIL. HS	212-037
SCREW 8-32 x 3/8 FHS, 100°, Phillips	212-040
SCREW 10-32 x 5/8 BHS	212-509
SCREW THREAD CUTTING 4-40 x 5/16 RHS, Phillips	213-034
SCREW THREAD CUTTING 4-40 x 1/4 PHS, Phillips	213-035
SCREW THREAD CUTTING 6-32 x 3/8 TRUSS HS, Phillips	213-041
SCREW THREAD CUTTING 6-32 x 5/16 PHS Phillips	213-054
SHIELD, SOCKET 29/32 ID	337-005
SHIELD, TUBE 7/8 W/SPRING 1 3/4 HI	337-007
SHIELD, TUBE 1 1/32 W/SPRING 1 15/16 HI	337-008
SHIELD, ALUM. .040 x 1 9/16 x 1 1/8	337-106
SHIELD, ALUM. .040 x 2 3/4 x 1 1/2	337-141
SHIELD, CRT 3"	337-170
SHIELD, ALUM. .040 x 4 1/2 x 6 x 1 1/4	337-174
SHIELD, ALUM. .040 x 1 3/4 x 8 5/16 W/two 214-012	337-177
SHIELD, ALUM. .040 x 2 5/8 x 1 5/8 F and I (S/N 1083-1230)	337-178

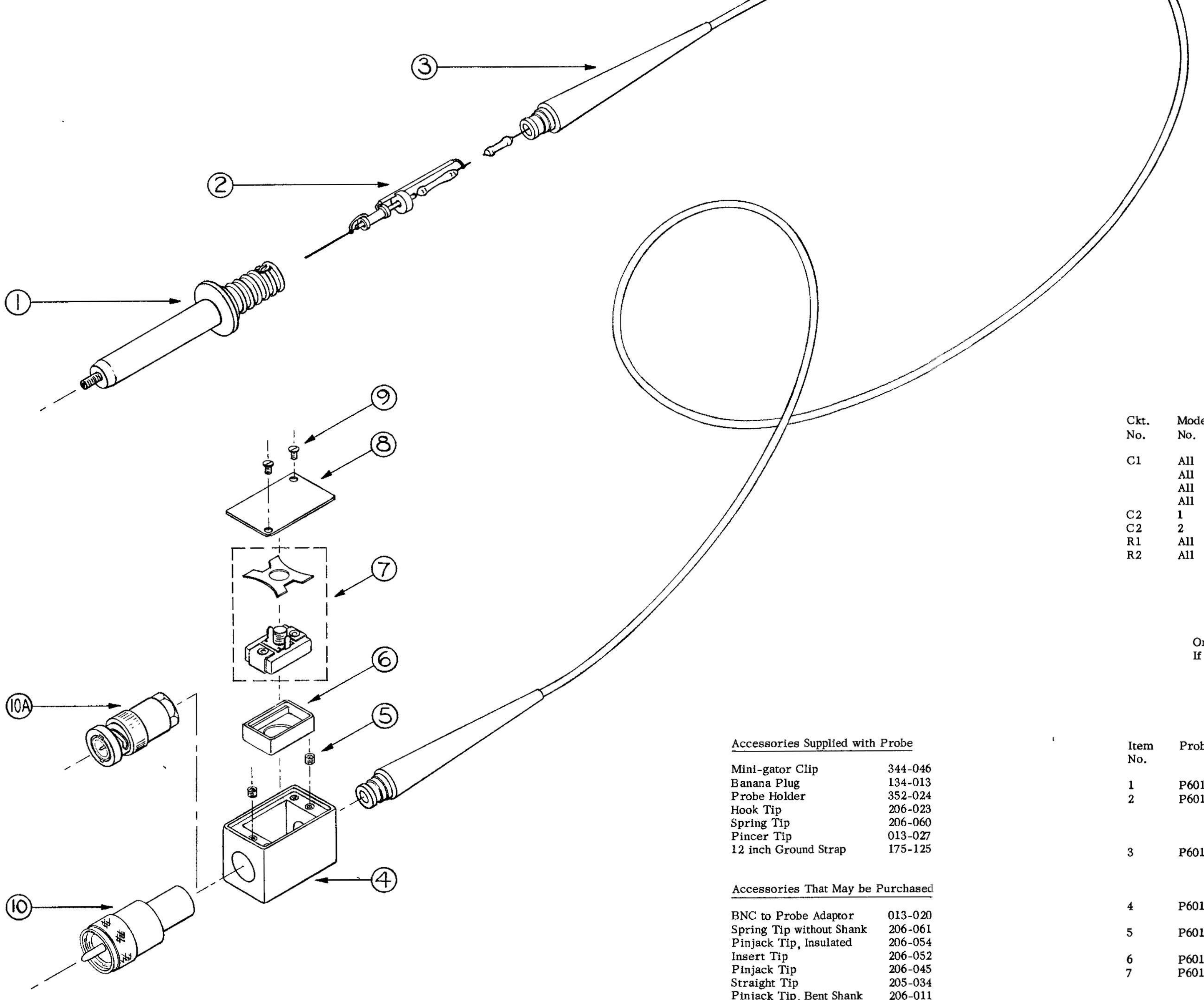
	Tektronix Part Number
SHIELD, PLEXIGLAS, CLEAR (S/N 1083-1230)	337-314
SHIELD, PLEXIGLAS, CLEAR (S/N 1500-up)	337-314
SOCKET, GRATICULE LAMP	136-001
SOCKET, STM7G	136-008
SOCKET, STM7, SHIELDED	136-009
SOCKET, STM8, GROUND	136-011
SOCKET, STM9G	136-015
SOCKET, LIGHT, RED JEWEL, ASS'Y W/#328 BULB 6V	136-031
SOCKET, TIP JACK, BLACK NYLON, $\frac{1}{2}$", THREADED $\frac{3}{8}$-32 x $\frac{1}{2}$	136-037
SOCKET, 3" CRT	136-053
SPACER, POT	361-003
SPACER, NYLON, MOLDED .156—.250 x .188 (S/N 1500-up)	361-008
STEM, BINDING POST ADAPTOR	361-507
STRIP, CERAMIC, $\frac{3}{4}$ x 2 NOTCHES, CLIP MOUNTED	124-086
STRIP, CERAMIC, $\frac{3}{4}$ x 4 NOTCHES, CLIP MOUNTED	124-088
STRIP, CERAMIC, $\frac{3}{4}$ x 7 NOTCHES, CLIP MOUNTED	124-089
STRIP, CERAMIC, $\frac{3}{4}$ x 9 NOTCHES, CLIP MOUNTED	124-090
STRIP, CERAMIC, $\frac{3}{4}$ x 11 NOTCHES, CLIP MOUNTED	124-091
STRIP, CERAMIC, $\frac{7}{16}$ x 7 NOTCHES, CLIP MOUNTED (S/N 1500-up)	124-094
STUD, STEEL 10-32 x $2\frac{7}{16}$, 2" Under Shoulder	355-044
TAG, SERIAL NO. INSERT	334-642
TAG, VOLTAGE RATING	334-649
TUBE, SPACER, ALUM. .180 x $\frac{1}{4}$ x $\frac{1}{4}$	166-031
TUBE, SPACER, ALUM. .196 x $\frac{5}{16}$ x $\frac{1}{8}$	166-084
TUBE, SPACER, ALUM. .180 x $\frac{1}{4}$ x $1\frac{23}{32}$ TAPPED 6-32 (S/N 1083-1230)	166-099
TUBE, COIL FORM	166-103
TUBING, PLASTIC INSUL. #20 BLACK (Skein)	162-504
TUBING, PLASTIC INSUL. #18 RED	162-509
WASHER, STEEL 6L x $\frac{3}{8}$ x .032	210-803
WASHER, STEEL 8S x $\frac{3}{8}$ x .032	210-804
WASHER, STEEL 10S x $\frac{7}{16}$ x .032	210-805
WASHER, BRASS, RES. CENTERING	210-809
WASHER, ALUM. $\frac{1}{4}$ x $\frac{1}{2}$ x .046 (Rectifier)	210-821
WASHER, STEEL .390 x $\frac{9}{16}$ x .020	210-840
WASHER, NEOPRENE $\frac{7}{32}$ x $\frac{3}{8}$ x $\frac{5}{64}$	210-844
WASHER, STEEL #2 FLAT .093 x $\frac{9}{32}$ x .020	210-850
WASHER, RUBBER $\frac{1}{2}$ x $\frac{11}{16}$ x $\frac{3}{64}$ (For Fuse Holder)	210-873



TYPE 316 OSCILLOSCOPE AA

BLOCK DIAGRAM





AA

PROBES THIS SHEET COVERS

P6017

43 inches	Tektronix Part No.	010-038
6 ft.		010-056
9 ft.		010-057
12 ft.		010-058

P6022

43 inches	Tektronix Part No.	010-064
6 ft.		010-066
9 ft.		010-067
12 ft.		010-068

Accessories Supplied with Probe

Mini-gator Clip	344-046
Banana Plug	134-013
Probe Holder	352-024
Hook Tip	206-023
Spring Tip	206-060
Pincer Tip	013-027
12 inch Ground Strap	175-125

Accessories That May be Purchased

BNC to Probe Adaptor	013-020
Spring Tip without Shank	206-061
Pinjack Tip, Insulated	206-054
Insert Tip	206-052
Pinjack Tip	206-045
Straight Tip	205-034
Pinjack Tip, Bent Shank	206-011
BNC Tip	206-015
5 inch Ground Strap	175-124
18 inch Ground Strap	175-184

TABLE I ELECTRICAL PARTS

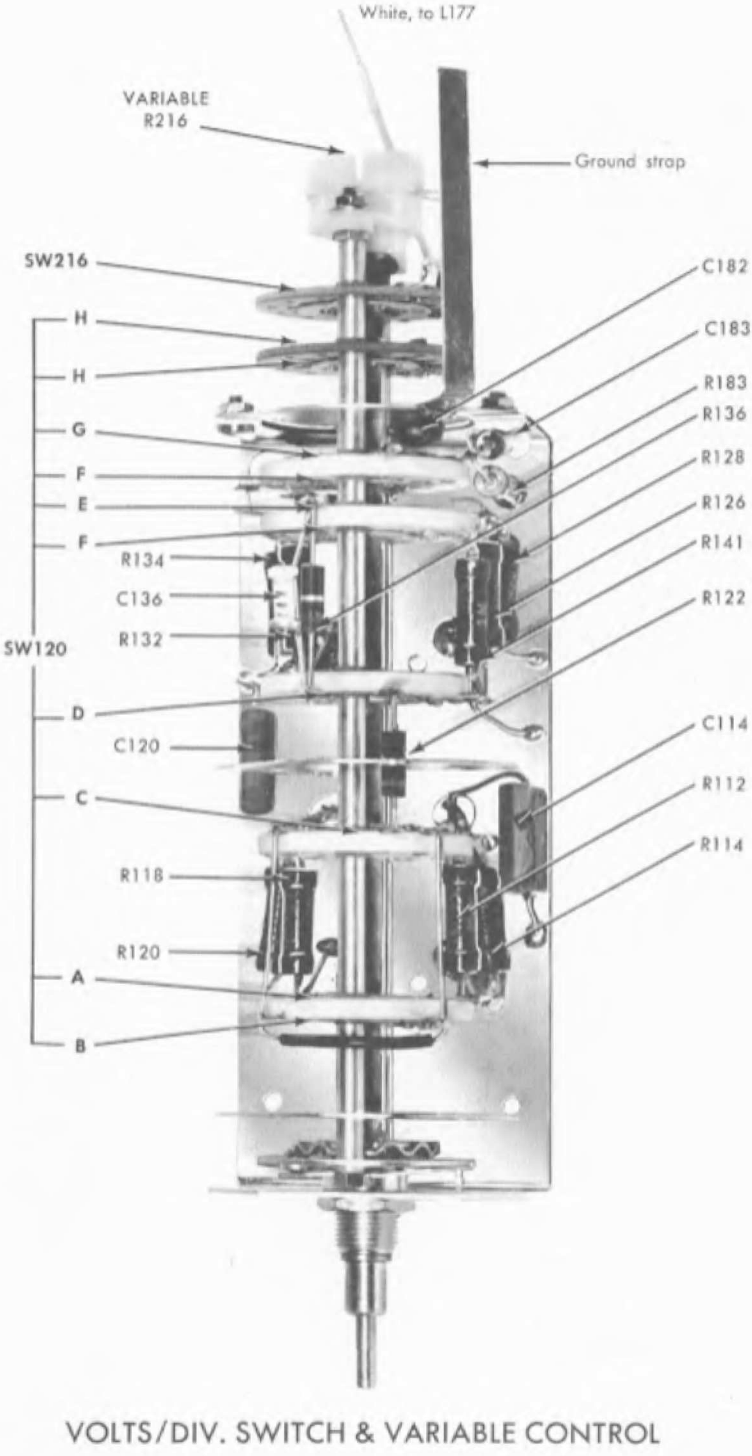
Ckt. No.	Model No.	Cable Length	Value	Description	Tektronix Part No.
C1	All	43 inches	$11\mu\mu f$	Cer. Fixed 500v +or- 5%	281-576
	All	6 ft.	$14\mu\mu f$		281-577
	All	9 ft.	$18\mu\mu f$		281-578
	All	12 ft.	$21\mu\mu f$		281-579
C2	1	All Lengths	$8\text{-}50\mu\mu f$	Cer. Var. 500v	281-013
C2	2	All Lengths	$5\text{-}80\mu\mu f$	Mica Var. 500v	281-062
R1	All	All Lengths	9 meg	1/2 w Fixed Prec. 2%	309-232
R2	All	All Lengths		Selected for proper cable termination. Furnished with cable.	

NOTE

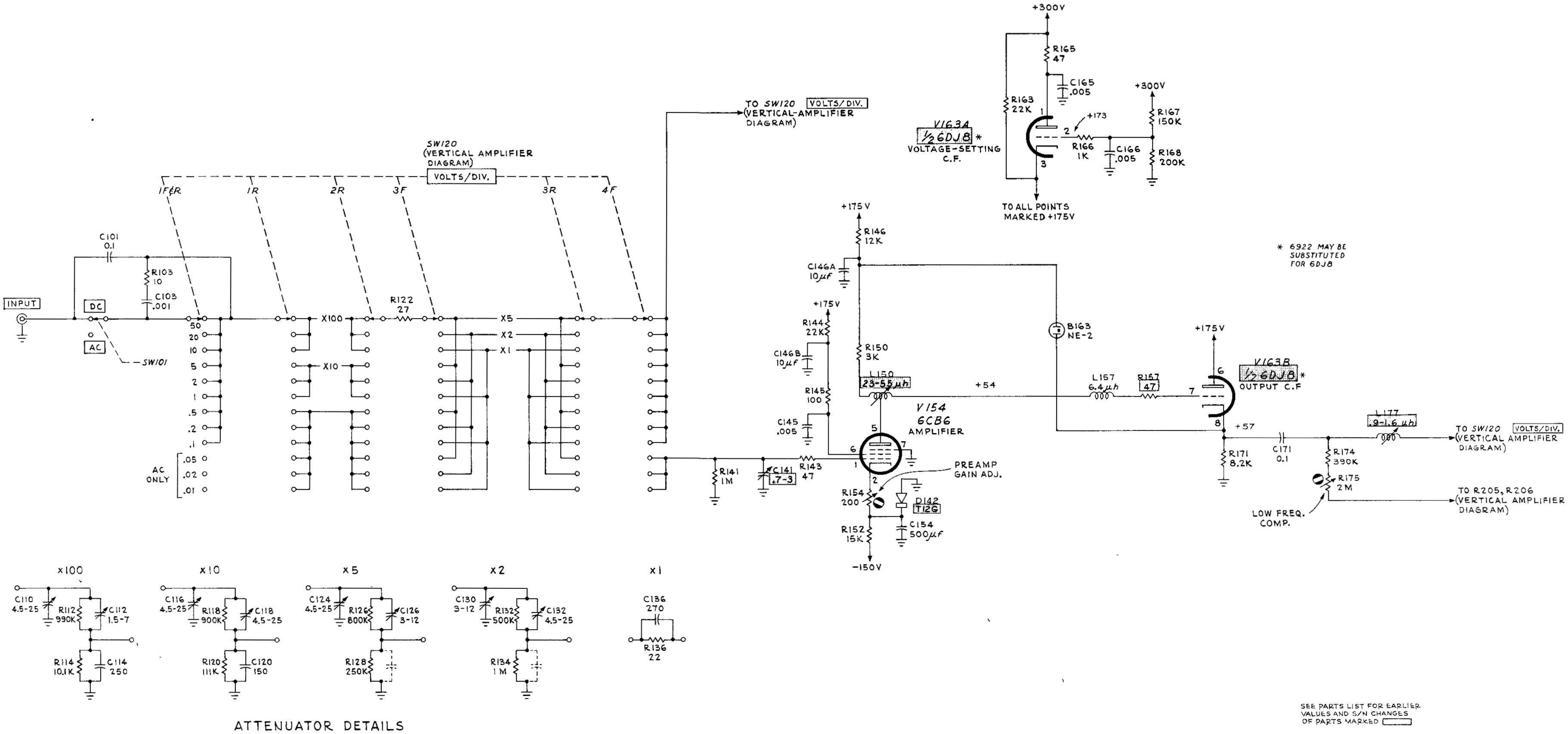
On the underside of the lid for the Compensation Box is the Model Number. If the probe shows no number it will be Model Number One.

TABLE II MECHANICAL PARTS

Item No.	Probe Type	Model No.	Cable Length	Part Title	Tektronix Part No.
1	P6017/P6022	All	All Lengths	Probe Body	204-054
2	P6017/P6022	All	43 inches	Attenuation Assembly	011-038
			6 ft.		011-037
			9 ft.		011-039
			12 ft.		011-040
3	P6017/P6022	All	43 inches	Cable Assembly	175-143
			6 ft.		175-185
			9 ft.		175-186
			12 ft.		175-187
4	P6017/P6022	1	All Lengths	Compensator Box	202-051
		2			202-068
5	P6017/P6022	All	All Lengths	Allen Set Screws 4-40 x 3/32	213-075
6	P6017/P6022	2 only	All Lengths	Positioning Insulator	200-098
7	P6017/P6022	1	All Lengths	Compensating Capacitor	281-013
		2		Compensating Capacitor and Spring Clip Assembly	281-059
8	P6017/P6022	All	All Lengths	Plate Cover	200-248
9	P6017/P6022	All	All Lengths	Thread Cutting Screw 4-40 x 1/4	213-035
10A	P6017	All	All Lengths	Connector, UHF	131-058
10	P6022	All	All Lengths	Connector, BNC	131-186



VOLTS/DIV. SWITCH & VARIABLE CONTROL



SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED ▭

VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS

INPUT SIGNAL	NONE
TRIGGER SELECTOR (RED KNOB)	AUTO
VERTICAL POSITION	TRACE CENTERED

SEE ALSO **IMPORTANT** NOTE ON TIME BASE TRIGGER DIAGRAM

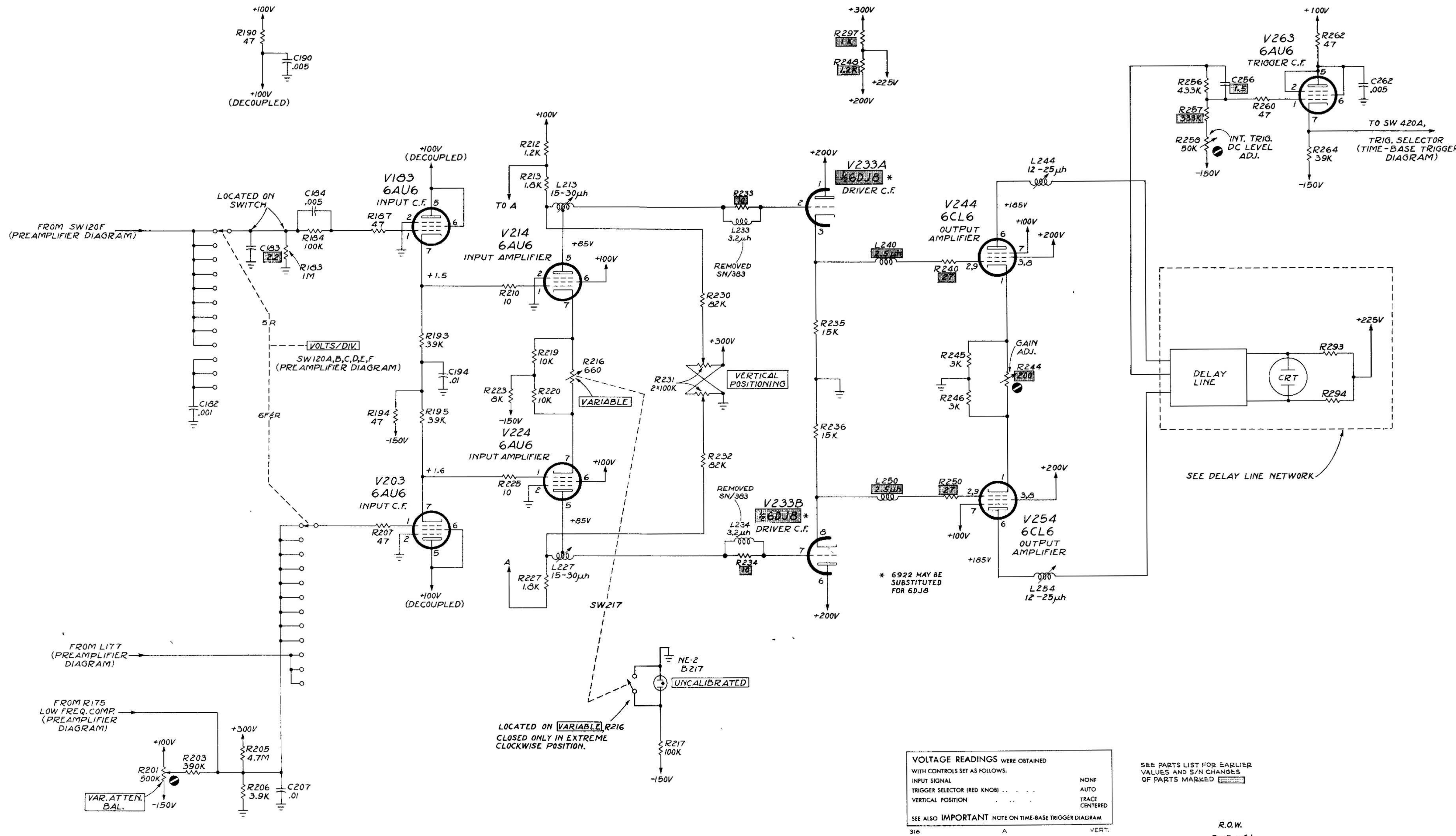
316 A PREAMP

RBH
5-8-61

TYPE 316 OSCILLOSCOPE

AA

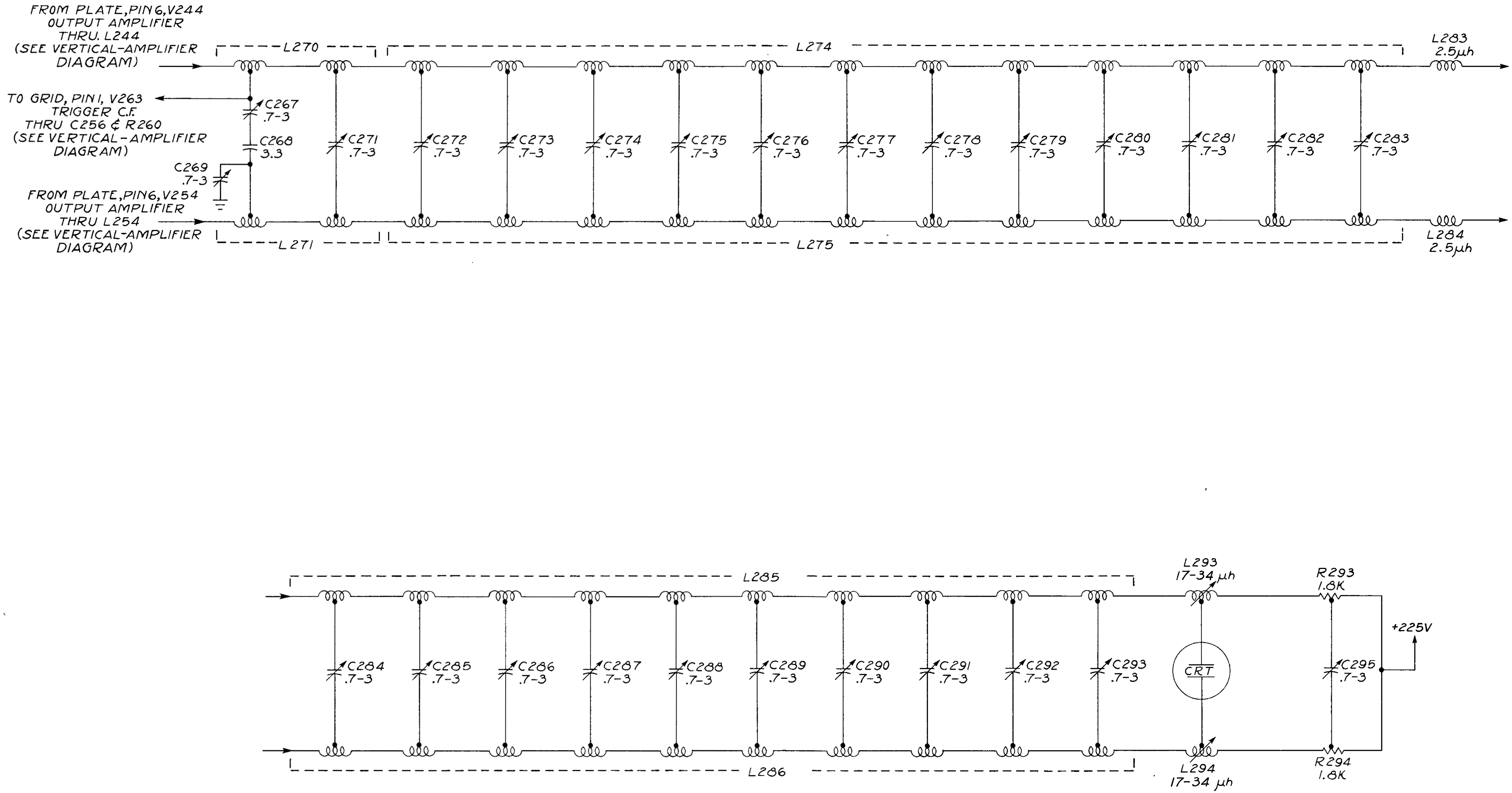
PREAMPLIFIER



TYPE 316 OSCILLOSCOPE

AA

VERTICAL AMPLIFIER

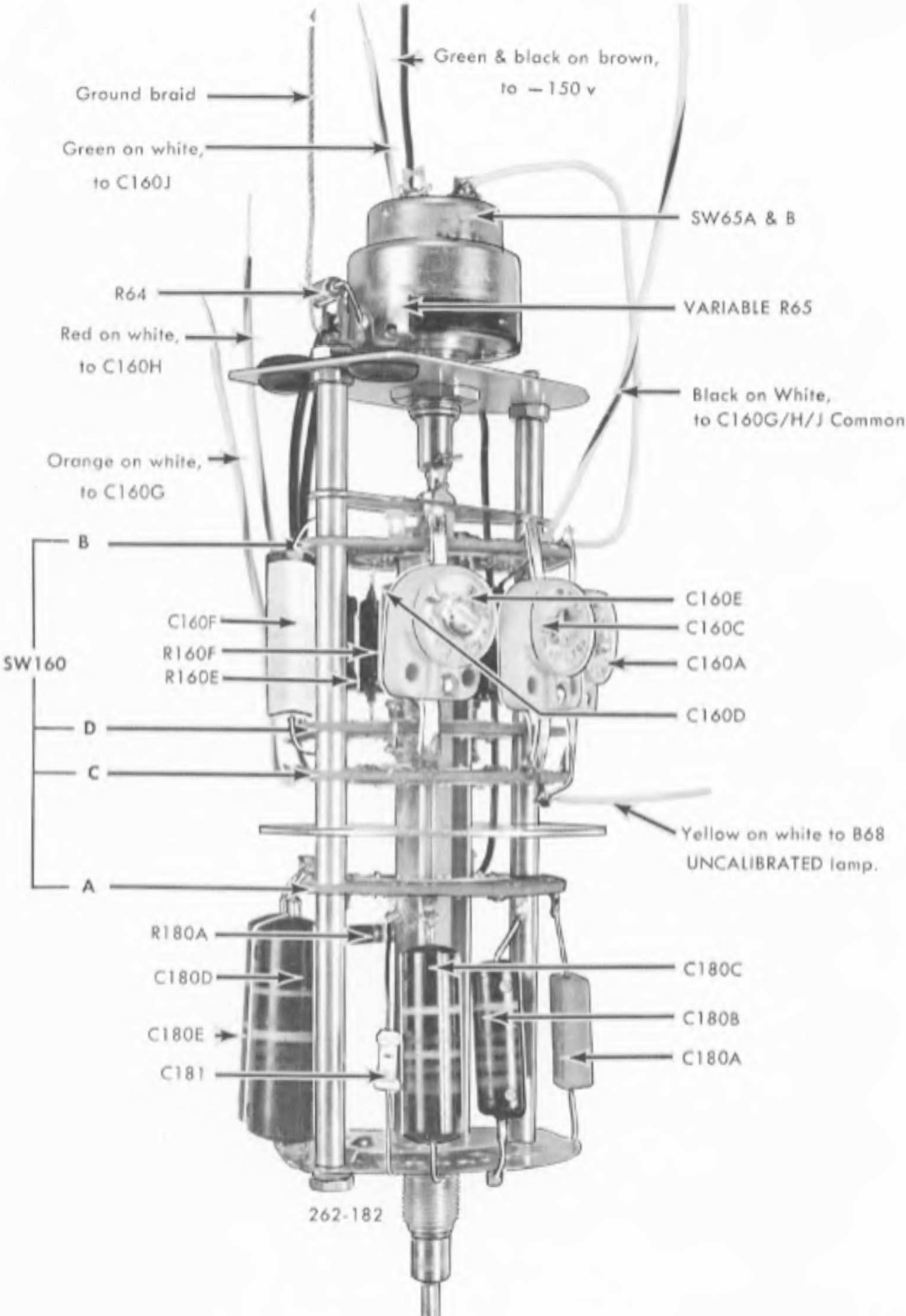


R.O.W.
5-8-61

TYPE 316 OSCILLOSCOPE

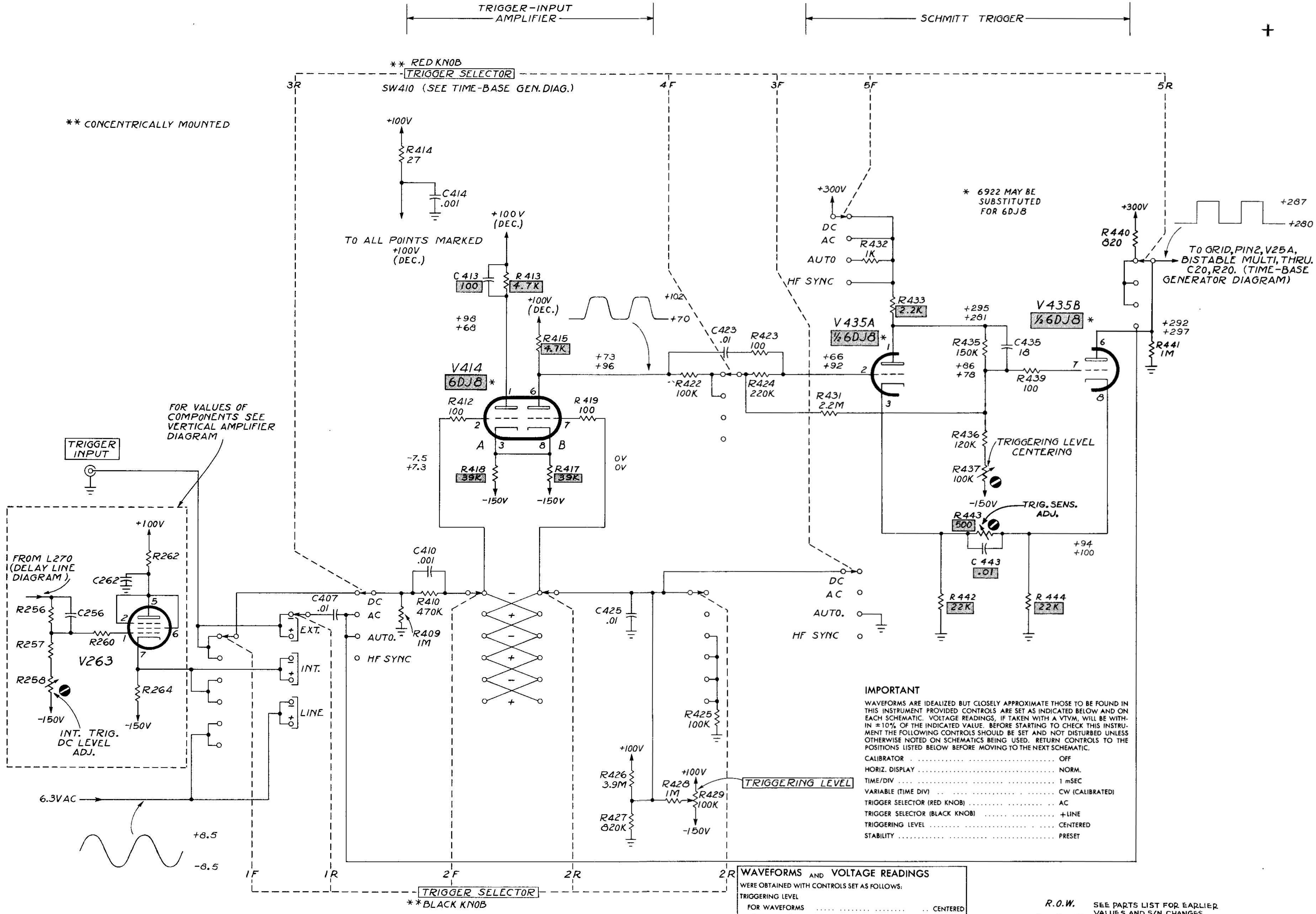
AA

DELAY LINE



TIME/DIV. SWITCH & VARIABLE CONTROL

Right-side view, rotated 30 deg.



IMPORTANT

WAVEFORMS ARE IDEALIZED BUT CLOSELY APPROXIMATE THOSE TO BE FOUND IN THIS INSTRUMENT PROVIDED CONTROLS ARE SET AS INDICATED BELOW AND ON EACH SCHEMATIC. VOLTAGE READINGS, IF TAKEN WITH A VTVM, WILL BE WITHIN ±10% OF THE INDICATED VALUE. BEFORE STARTING TO CHECK THIS INSTRUMENT THE FOLLOWING CONTROLS SHOULD BE SET AND NOT DISTURBED UNLESS OTHERWISE NOTED ON SCHEMATICS BEING USED. RETURN CONTROLS TO THE POSITIONS LISTED BELOW BEFORE MOVING TO THE NEXT SCHEMATIC.

CALIBRATOR	OFF
HORIZ. DISPLAY	NORM.
TIME/DIV	1 mSEC
VARIABLE (TIME DIV)	CW (CALIBRATED)
TRIGGER SELECTOR (RED KNOB)	AC
TRIGGER SELECTOR (BLACK KNOB)	+LINE
TRIGGERING LEVEL	CENTERED
STABILITY	PRESET

WAVEFORMS AND VOLTAGE READINGS
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:
TRIGGERING LEVEL

FOR WAVEFORMS	CENTERED
FOR UPPER VOLTAGE READINGS	CCW
FOR LOWER VOLTAGE READINGS	CW

SEE ALSO **IMPORTANT** NOTE ON THIS DIAGRAM.

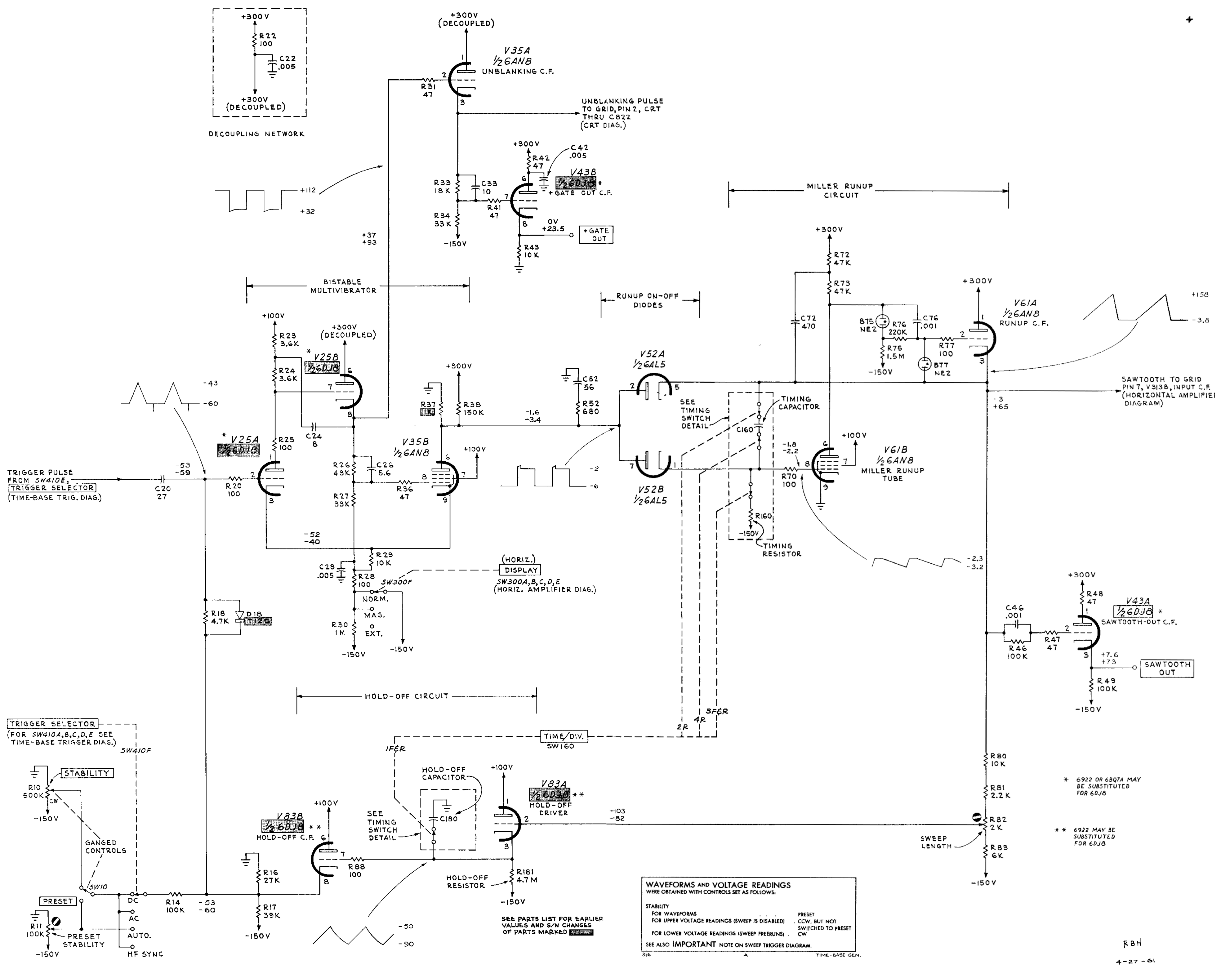
R.O.W.
5-8-61

SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED

TYPE 316 OSCILLOSCOPE

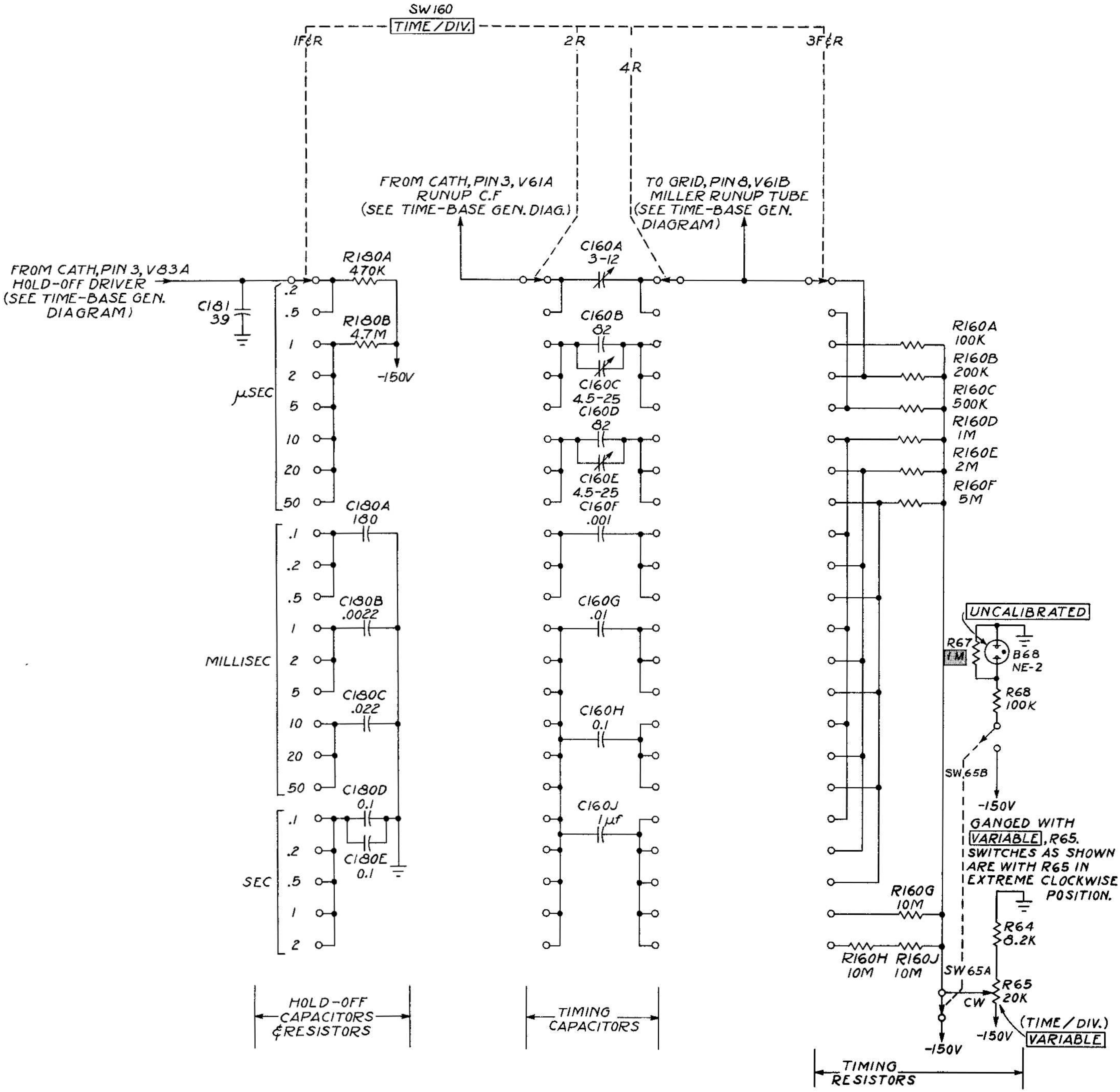
AA

TIME-BASE TRIGGER



TYPE 316 OSCILLOSCOPE AA

TIME-BASE GENERATOR

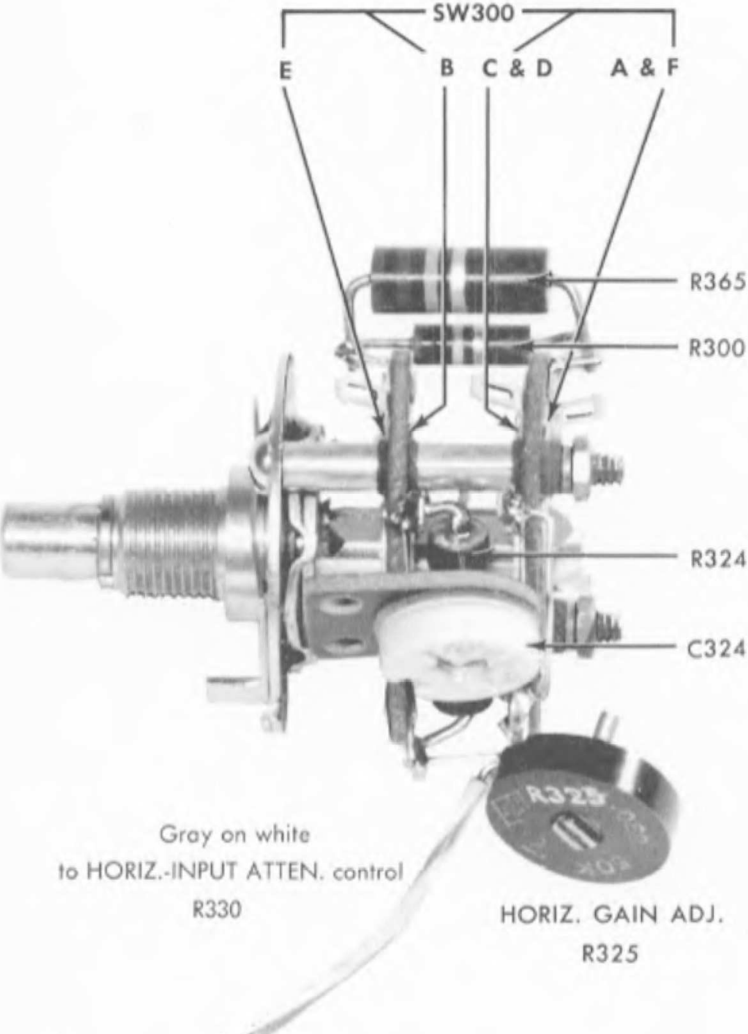


TYPE 316 OSCILLOSCOPE AA

SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED

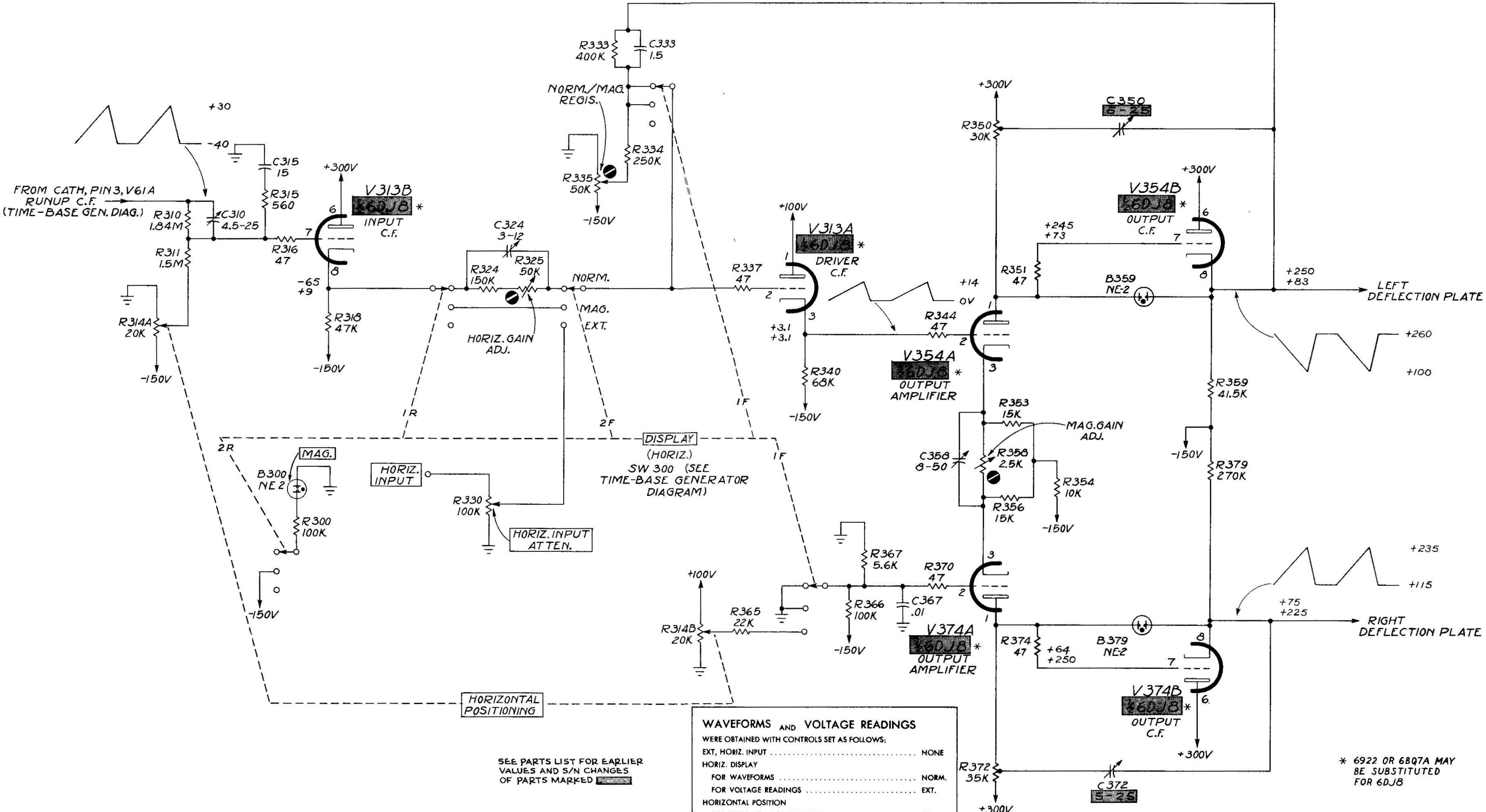
TIMING SWITCH
(TIME/DIV.)

R.O.W.
5-8-61



DISPLAY SWITCH

Right-side view, rotated 45 deg.



WAVEFORMS AND VOLTAGE READINGS

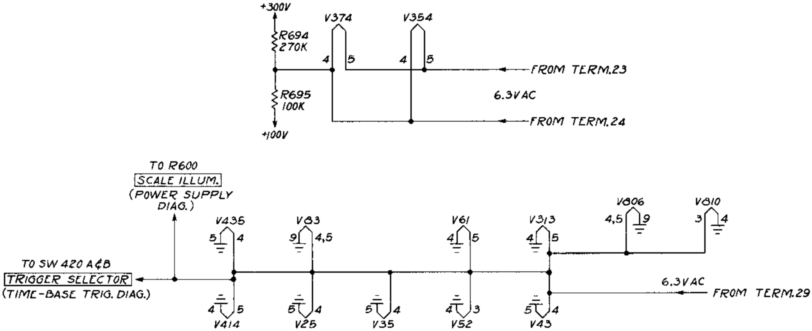
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

EXT, HORIZ. INPUT	NONE
HORIZ. DISPLAY	
FOR WAVEFORMS	NORM.
FOR VOLTAGE READINGS	EXT.
HORIZONTAL POSITION	
FOR UPPER VOLTAGE READINGS	CCW
FOR LOWER VOLTAGE READINGS	CW

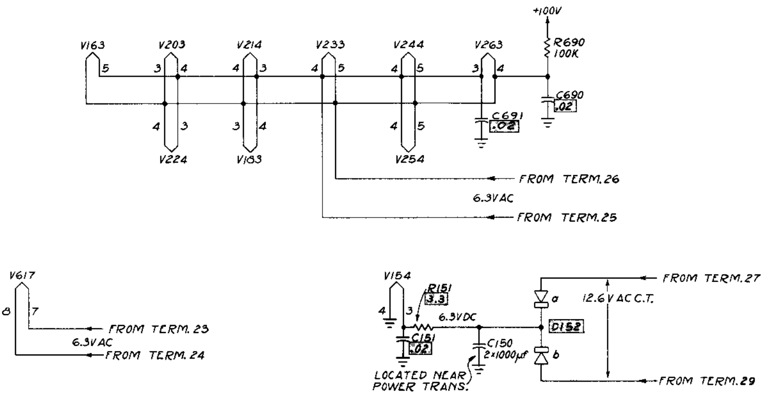
SEE ALSO **IMPORTANT** NOTE ON TIME-BASE TRIGGER DIAGRAM.

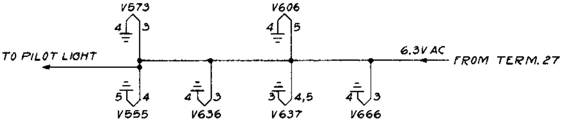
316 A HORIZ AMP

HORIZONTAL AMPLIFIER



TIME - BASE DECK





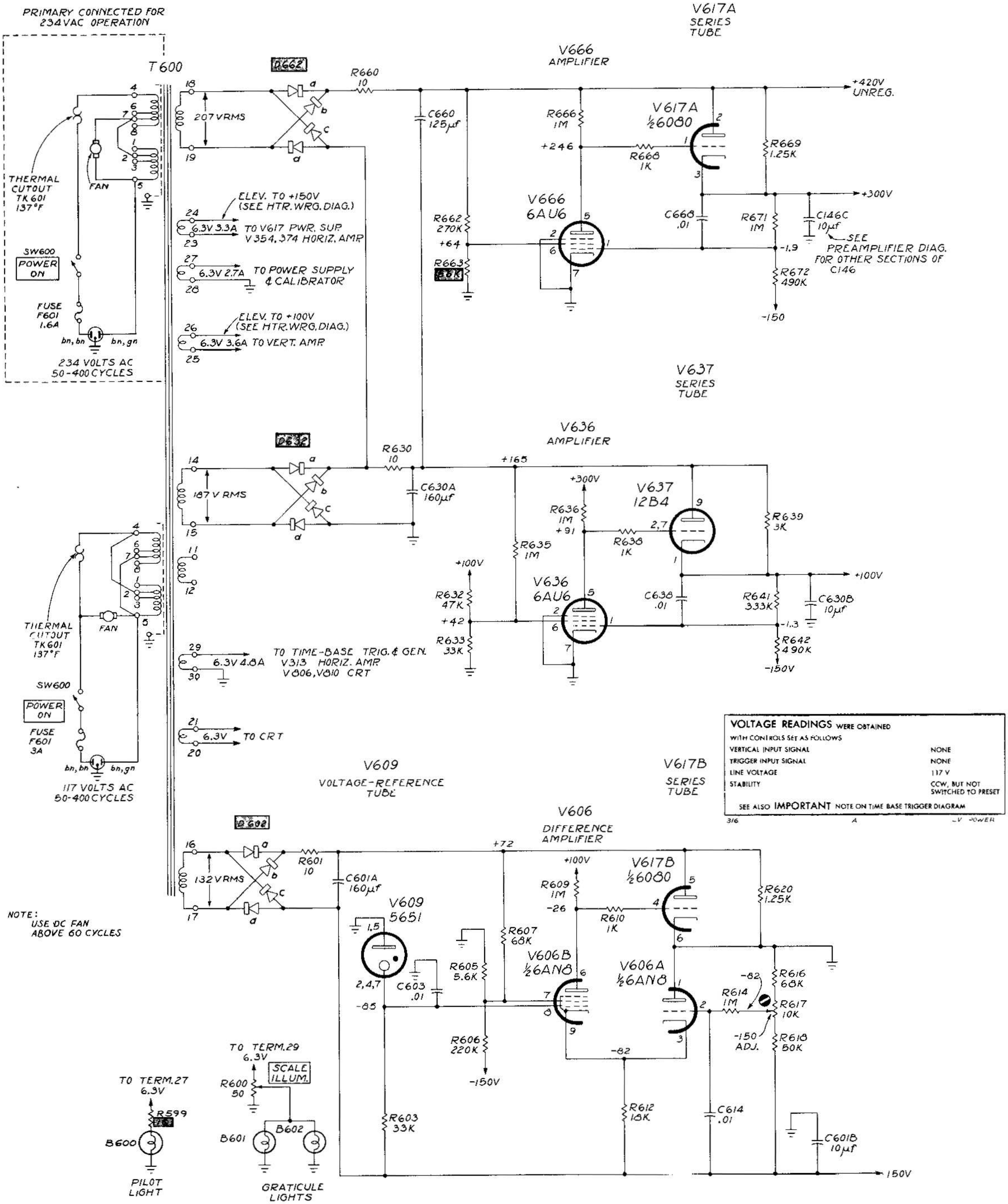
POWER DECK

R.O.W

5-5-61

TYPE 316 OSCILLOSCOPE

HEATER WIRING DIAGRAM



VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS	
VERTICAL INPUT SIGNAL	NONE
TRIGGER INPUT SIGNAL	NONE
LINE VOLTAGE	117 V
STABILITY	CCW, BUT NOT SWITCHED TO PRESET

SEE ALSO **IMPORTANT** NOTE ON TIME BASE TRIGGER DIAGRAM

316 A LV POWER

SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED

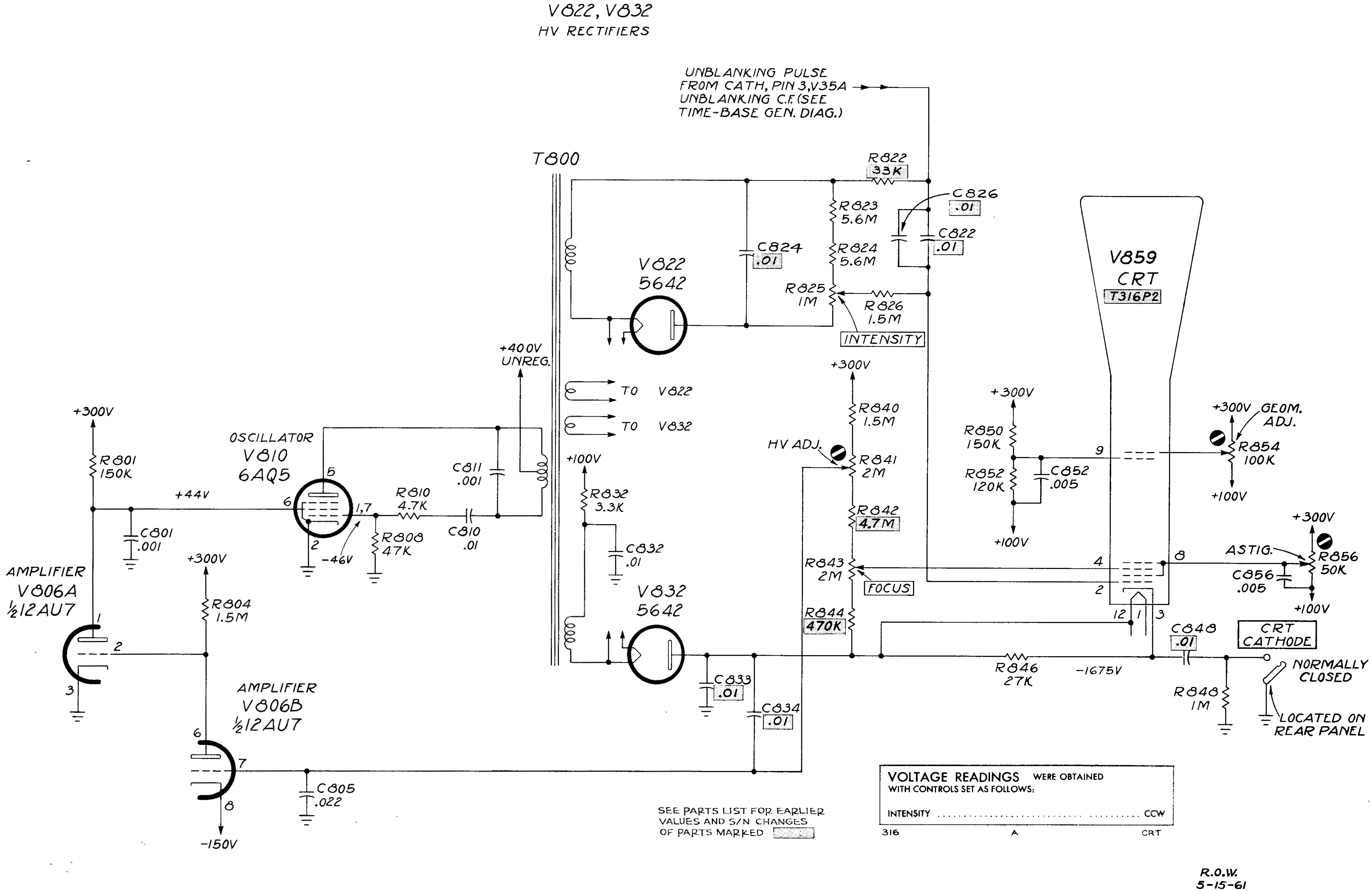
R. O. W.

5-5-61

TYPE 316 OSCILLOSCOPE

AA

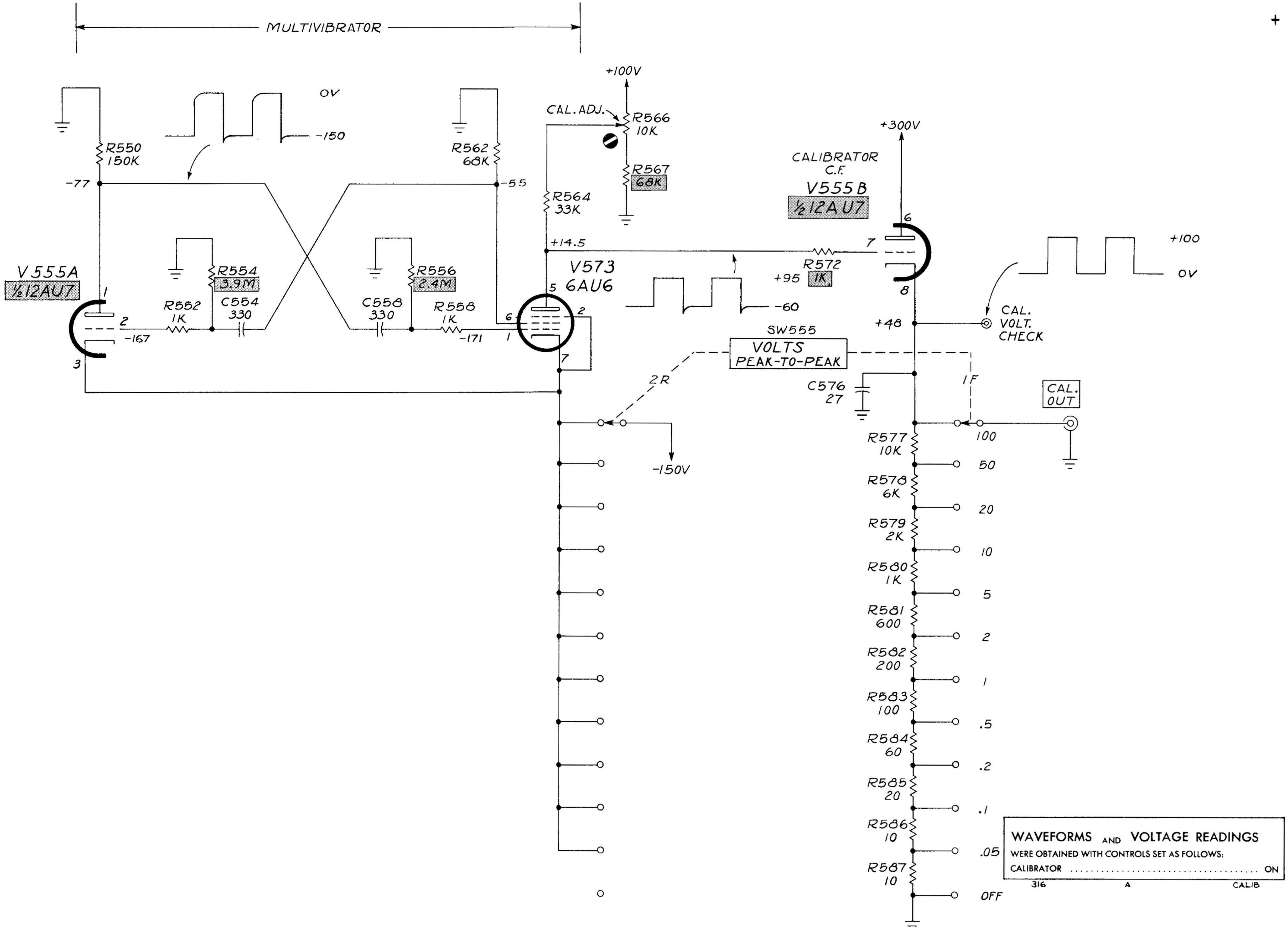
LV POWER SUPPLY



TYPE 316 OSCILLOSCOPE

AA

CRT CIRCUIT



WAVEFORMS AND VOLTAGE READINGS
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:
CALIBRATOR .... ON

316 A CALIB

TYPE 316 OSCILLOSCOPE AA

SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED

R.O.IV.
5-8-61

CALIBRATOR