K4XL's  BAMA

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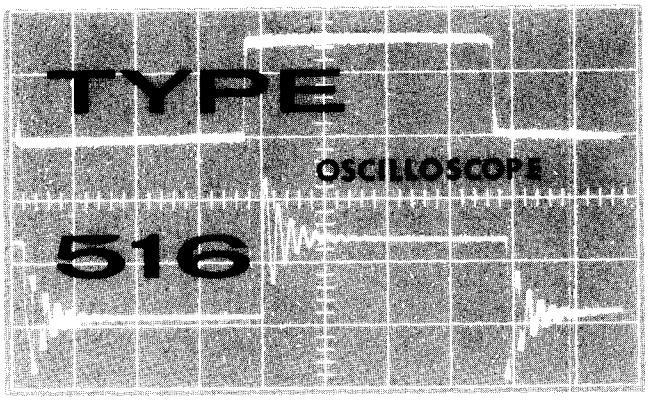
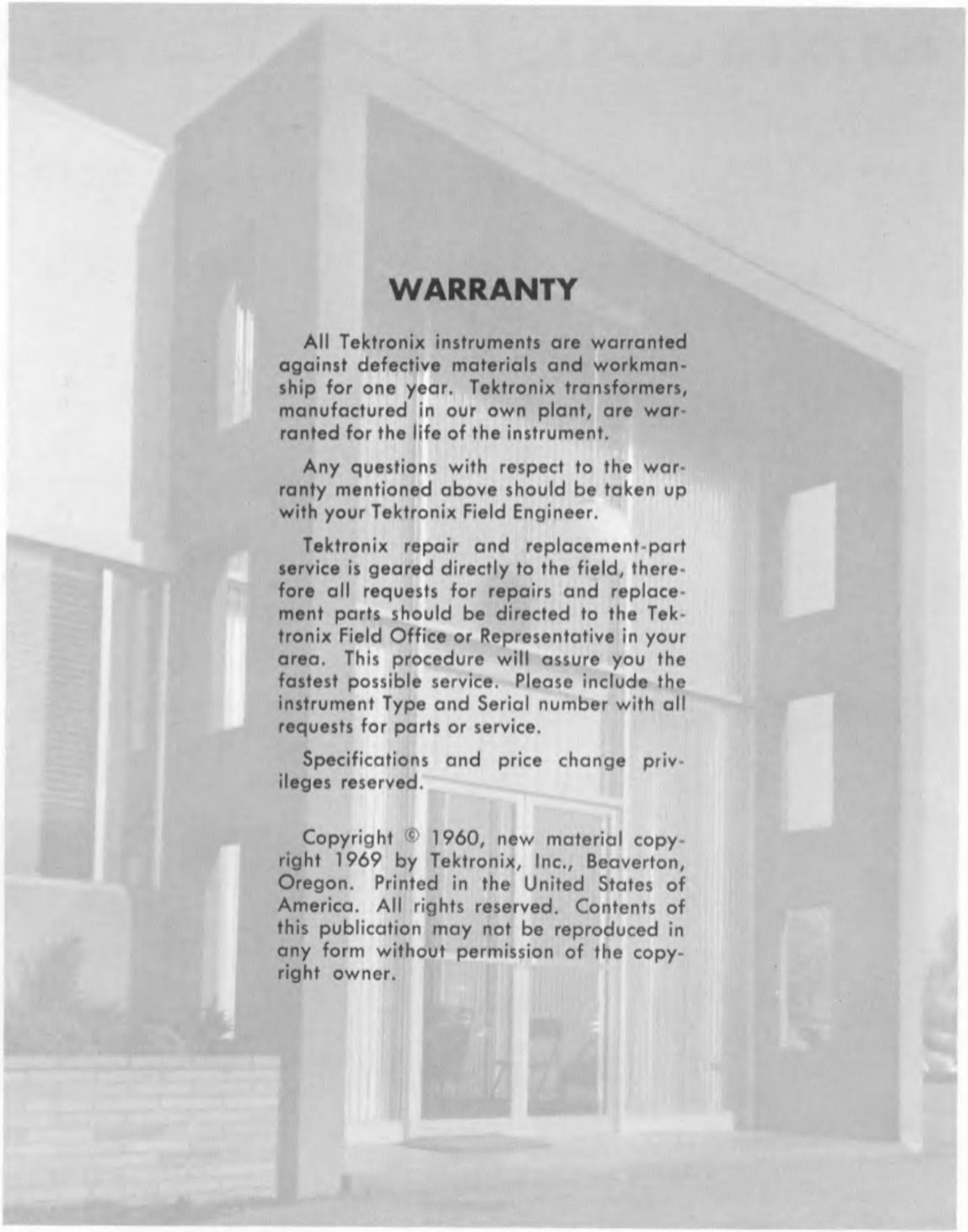
INSTRUCTION MANUAL

Serial Number _____



Tektronix, Inc.
S.W. Millikan Way ● P. O. Box 500 ● Beaverton, Oregon 97005 ● Phone 644-0161 ● Cables: Tektronix

070-0225-01



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.

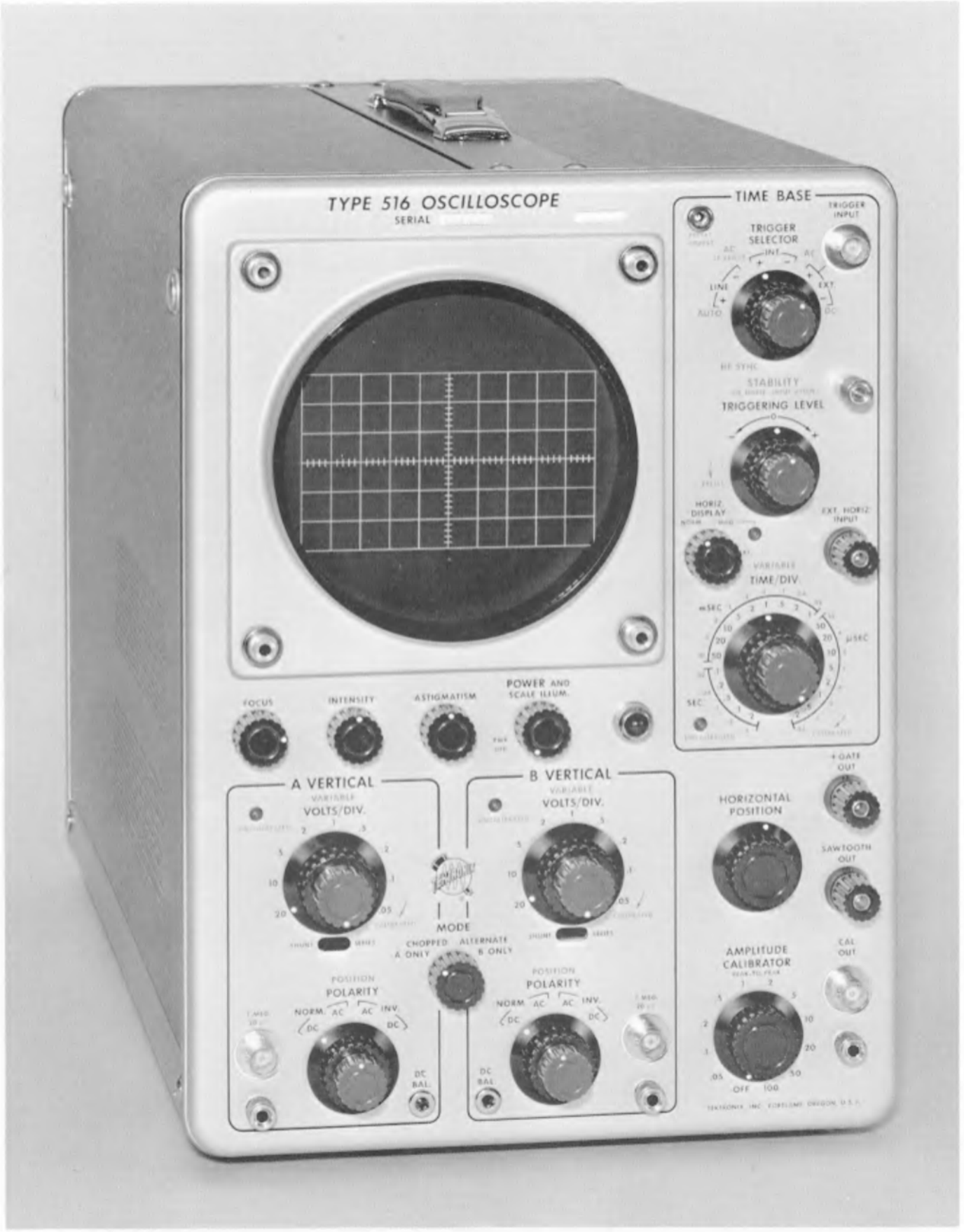
Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

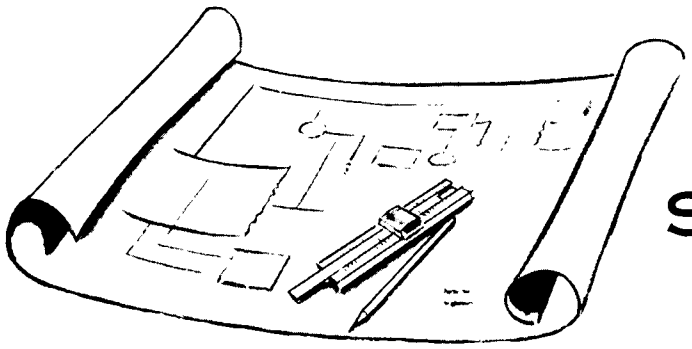
Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or Representative in your area. This procedure will assure you the fastest possible service. Please include the instrument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

Specifications and price change privileges reserved.

CONTENTS

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


TYPE 516 OSCILLOSCOPE
SERIAL
TIME BASE
TRIGGER INPUT
TRIGGER SELECTOR
INT
EXT
LINE
AUTO
STABILITY
TRIGGERING LEVEL
HORIZ. DISPLAY
EXT. HORIZ. INPUT
VARIABLE
TIME/DIV.
mSEC
μSEC
SEC
FOCUS
INTENSITY
ASTIGMATISM
POWER AND SCALE ILLUM.
A VERTICAL
VARIABLE
VOLTS/DIV.
B VERTICAL
VARIABLE
VOLTS/DIV.
MODE
CHOPPED
ALTERNATE
A ONLY
B ONLY
POSITION
POLARITY
NORM
AC
DC
INV
DC BAL.
+GATE OUT
HORIZONTAL POSITION
SAWTOOTH OUT
AMPLITUDE CALIBRATOR
CAL OUT
OFF



SECTION 1

SPECIFICATIONS

Introduction

The Tektronix Type 516 Oscilloscope is a dual-trace general purpose laboratory oscilloscope with a bandpass of dc to 15 megahertz. Dual-trace operation is provided by two identical vertical input channels; signals may be applied to either or both input channels at the same time. Switching between the two channels takes place at the end of each sweep of the beam or at a free-running rate of approximately 150 kHz. Either channel may be used separately to provide single-trace operation when desired.

Vertical Deflection System, Both Channels

Bandpass . . . DC to 15 MHz (response not more than 3 dB down within these limits).

Risetime. . . 23 nanoseconds or less.

Sensitivity. . 0.05 volt/div. to 20 volts/div. in 9 calibrated steps; accuracy with 3%. Continuously variable from 0.05 volt/div. to at least 50 volts/div., uncalibrated.

Input Impedance. . . 1 megohm paralleled by 20 picofarads.

Operating Modes . . . Channel A only, Channel B only, electronic switching at approximately 150 kHz (chopped), or electronic switching on alternate sweeps.

Maximum Voltage Input. . . 600 volts, combined dc- and ac-voltage.

Triggering

Type. . . Amplitude-level selection with preset or manual stability control.

Modes. . . Automatic, ac-coupled, dc-coupled, and high-frequency synchronized.

Source. . . Internal from vertical signal, external from triggering signal, or line frequency.

Slope. . . Plus (rising slope of triggering waveform), or minus (falling slope of triggering waveform).

Signal Requirements . . . Internal-AC: 2 mm of display at 1 kHz increasing to 5 mm at 2 MHz. Low frequency response is 3 dB down at approximately 16 Hz. AUTO: 5 mm of display from 50 Hz to 1 kHz increasing to 1 cm at 2 MHz. DC: 5 mm of display from DC to 1 kHz increasing to 2 cm at 2 MHz. AC LF REJECT: Attenuates frequencies below 16 kHz. HF SYNC: 2 cm of display at 20 MHz. External-AC: 0.5 V at 1 kHz increasing to 1.5 V at 2 MHz. Low frequency response is 3 dB down at approximately 16 Hz. AUTO: 1 V from 50 Hz to 1 kHz increasing to 3 V at 2 MHz. DC: 0.5 V from DC to 1 kHz increasing to 1.5 V at 2 MHz. AC LF REJECT: Attenuates frequencies below 16 kHz. HF SYNC: 2 V at 20 MHz. Line-AC LF REJECT: Attenuates frequencies between 16 kHz.

Sweep

Type. . . Miller Integrator.

Sweep Rates. . . 0.2 μsec/div. to 2 sec/div. in 22 calibrated steps. Accuracy typically within 1% of full scale; in all cases, within 3% of full scale.

Continuously variable sweep rates are available from 0.2 μsec/div. to 6 sec/div., uncalibrated.

Magnifier. . . Expands center portion of sweep 5 times. Extends fastest sweep rate to 0.04 μsec/div; accuracy within 5%.

External Horizontal Input

Bandpass . . . DC to 500 kHz (response not more than 3 dB down within these limits).

Deflection Factor. . . 1.5 volts/div.

Amplitude Calibrator

Waveform. . . Square-waves at approximately 1,000 cycles.

Amplitude. . . 0.05 volt to 100 volts, peak-to-peak, in eleven fixed steps; accuracy within 3% of indicated amplitude.

Cathode-Ray Tube

Type. . . T55P31

P1, P2, P7 and P11 phosphors optional; other phosphors furnished on special order.

Accelerating Potential. . . 4,000 volts.

Unblanking. . . Cutoff type, dc-coupled.

Z-Axis Modulation. . . External terminal permits RC coupling to crt cathode.

Deflection Factors at plates

Vertical-6 to 7½ volts per centimeter.

Horizontal-19 to 23 volts per centimeter.

Output Waveforms Available

Positive gate, coincident with sweep, at least 20 volts peak-to-peak.

Positive-going sawtooth, coincident with sweep, at least 150 volts peak-to-peak.

Graticule

Illumination...Variable edge lighting.

Display Area...Marked in 6 vertical and 10 horizontal divisions. Each major division divided into 5 parts on centerlines.

Power Supplies

Electronically regulated for stable operation with widely varying line voltages and loads (see Section 2 of this manual).

Power...Approximately 310 watts.

Ventilation

Forced filtered air. Thermal relay interrupts instrument power if the internal temperature rises above 137°F.

Mechanical Specifications

Construction...Aluminum alloy chassis and cabinet.

Finish...Photo-etched anodized front panel, blue vinyl-finish cabinet.

Dimensions...13½" high, 9¾" wide, 21½" deep.

Accessories

2 . . . P6006 Probe, 010-0127-00

2 . . . Instruction Manuals, 070-0225-01

1 . . . 3- to 2-wire Adapter, 103-013-00

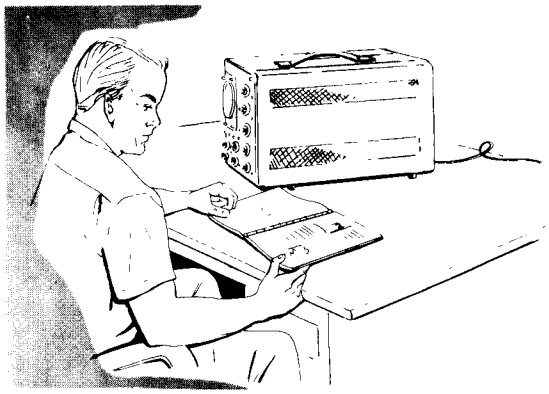
1 . . . BNC to BNC Patch Cord, 012-0087-00

1 . . . BNC to Banana Patch Cord, 012-0091-00

1 . . . BNC to Post Jack, 012-0092-00

1 . . . 3-conductor Power Cord, 161-0010-03

1 . . . Green Light Filter, 378-0567-00



SECTION 2

PRELIMINARY INFORMATION

Power Requirements

The Type 516 Oscilloscope line transformer can be wired for proper operation of the instrument on nominal line voltages of 110, 117, 124, 220, 234, and 248 volts at line frequencies of 50 to 60 Hz. Fig. 2-1 shows the transformer primary connections to be made for each line voltage.

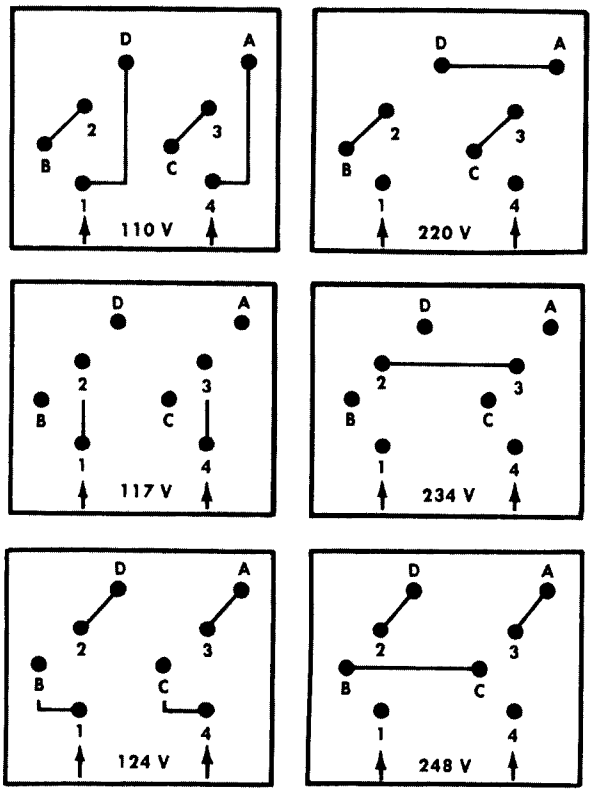


Fig. 2-1. Power Transformer primary connections.

Proper regulation of the oscilloscope power supplies will be maintained at line voltages between 105 and 125 volts when the instrument is wired for a nominal voltage of 117 volts, and within proportionate limits when it is wired for the other nominal line voltages.

When the Type 516 is supplied with a dc fan and the associated rectifiers (circuit D646 on the Power Supply circuit diagram), it can be operated at any line frequency from 50 Hz to 400 Hz, although slightly higher line voltages are required at the higher line frequencies. Normally, the Type 516 Oscilloscope with the dc fan will operate satisfactorily on a 400-Hz line voltage of 117 volts when the primary of the line transformer is connected for 110-volt, 50-to-60 Hz operation, as shown in Fig. 2-1. For maximum dependability and longest life, is is recommended that the line voltage be kept at or slightly below the nominal.

Fuse Requirements

When the Type 516 Oscilloscope is connected for 110-, 117-, or 124-volt operation, a 3.2-amp slow-blowing type fuse should be used. When the instrument is connected for 220-, 234-, or 248-volt operation, a 1.6-amp slow-blowing type fuse should be used.

Cooling

Your Type 516 Oscilloscope will last much longer if you keep it as cool as possible whenever it is being operated. A fan provides cooling by drawing air in through a filter at the rear of the instrument and blowing it over the internal components. The instrument must be placed such that the air intake is not blocked, and the air filter must be kept clean to permit adequate air circulation. Instructions for replacing and cleaning the air filter are given in Section 5 of this manual.

Furthermore, the side panels of the Type 516 Oscilloscope are designed to promote maximum air circulation over the internal components where the most heating takes place. For this reason, the instrument should not be operated for long periods of time with the side panels off. Also, there are differences between the right-hand side panel and the left-hand side panel, so they must be mounted on the proper sides. Fig. 2-2 shows the two sides of the oscilloscope with the side panels correctly mounted.

If the temperature inside the instrument should become so high that it might cause immediate damage to components, a thermal cutout switch will disconnect the power. When the temperature drops to a safe level, the switch will again close automatically; no manual reset is necessary.

Fan Connections

The manner in which the fan is wired in the Type 516 Oscilloscope depends upon the line voltage for which the instrument is wired. For 110-, 117-, and 124-volt operation, the black fan lead should be connected to the third notch of the 11-notch ceramic terminal strip at the right rear of the

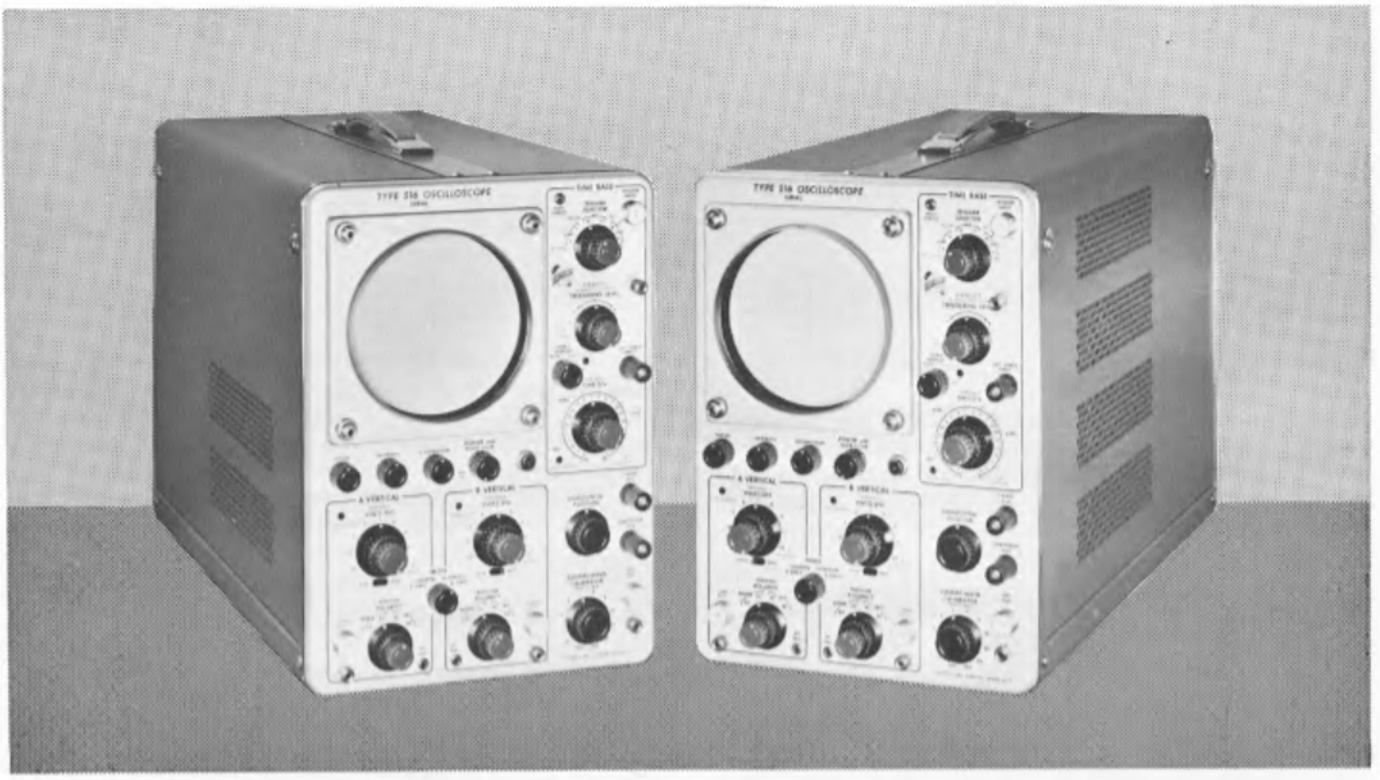
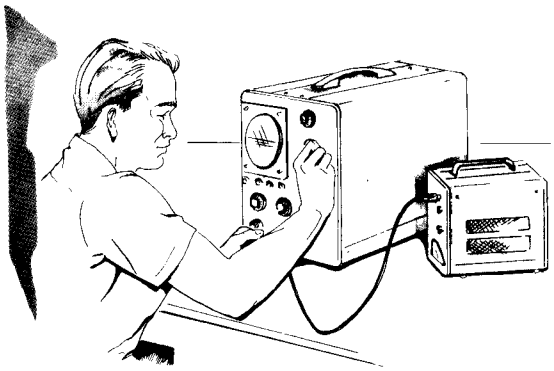


Fig. 2-2. Type 516 Oscilloscope, showing side panels properly mounted.

bottom of the instrument. For 220-, 234-, and 248-volt operation, it should be connected to the second notch of the same ceramic strip.

Note that when a dc fan is used, no change in fan connections is necessary with changes in nominal operating voltage.



SECTION 3

OPERATING INSTRUCTIONS

Introduction

This section of the manual is divided into three parts. The first part, Preliminary Instructions, is a step-by-step procedure designed to acquaint a "first-time" operator of a Tektronix oscilloscope with the basic operation of the Type 516. The second part, Operating Information, which starts on page 3-5, covers all phases of the operation of the Type 516 Oscilloscope in detail. The third part, Applications, which starts on page 3-8, describes techniques which can be used for certain basic applications of the Type 516 Oscilloscope.

Preliminary Instructions

The front panel of the Type 516 Oscilloscope is shown in Fig. 3-1. Functions of all front panels controls, indicators, and connectors are described in Table 3-1.

TABLE 3-1

TRIGGER SELECTOR (black knob)	Selects source of triggering signal and slope on which triggering occurs.
TRIGGER SELECTOR (red knob)	Selects triggering mode.
TRIGGER INPUT	Coaxial connector for application of external triggering signal when black TRIGGER SELECTOR control is in the EXT. position.
PRESET STABILITY	Sets triggering stability level when red TRIGGER SELECTOR control is in the AUTO. position, or when STABILITY control is in the PRESET position.
TRIGGERING LEVEL	Selects the voltage point on the triggering waveform at which the horizontal sweep is triggered.
STABILITY OR HORIZ.-INPUT ATTEN. (red knob)	Sets Time-Base Generator for triggered or free-running operation. Also serves as attenuation control for signals applied through EXT. HORIZ. INPUT when HORIZ. DISPLAY switch is in the EXT. position.
HORIZ. DISPLAY	Sets horizontal sweep for normal or magnified (X5) presentation. Also provides for application of external signal to Horizontal Amplifier.
TIME/DIV.	Selects the desired horizontal sweep rate from 22 calibrated steps.
VARIABLE TIME/DIV. (red knob)	Provides a continuous range of sweep rates between the fixed steps selected by the TIME/DIV. control. (The sweep rates are calibrated only when the VARIABLE control is in the CALIBRATED position.)
UNCALIBRATED lamp	Lights when VARIABLE TIME/DIV. control is not in the CALIBRATED position.
	A VERTICAL
VOLTS/DIV.	Selects the sensitivity of the A VERTICAL Channel from nine calibrated steps.
VARIABLE VOLTS/DIV. (red knob)	Provides a continuous range of sensitivity values between the fixed calibrated steps selected by the VOLTS/DIV. control. (Sensitivity is calibrated only when the VARIABLE control is in the CALIBRATED position.)
UNCALIBRATED lamp	Lights when VARIABLE VOLTS/DIV. control is not in the CALIBRATED position.
SHUNT and SERIES adjustments	Compensation adjustments for attenuator. (See Calibration Section.)
POLARITY	Selects ac or dc coupling of signal applied to A VERTICAL input connector, and normal or inverted presentation on the screen.
POSITION (red knob)	Controls vertical positioning of A VERTICAL Channel signal on the crt screen.
DC. BAL.	Provides for vertical stability of no-signal trace for all positions of the A VERTICAL VOLTS/DIV. control.

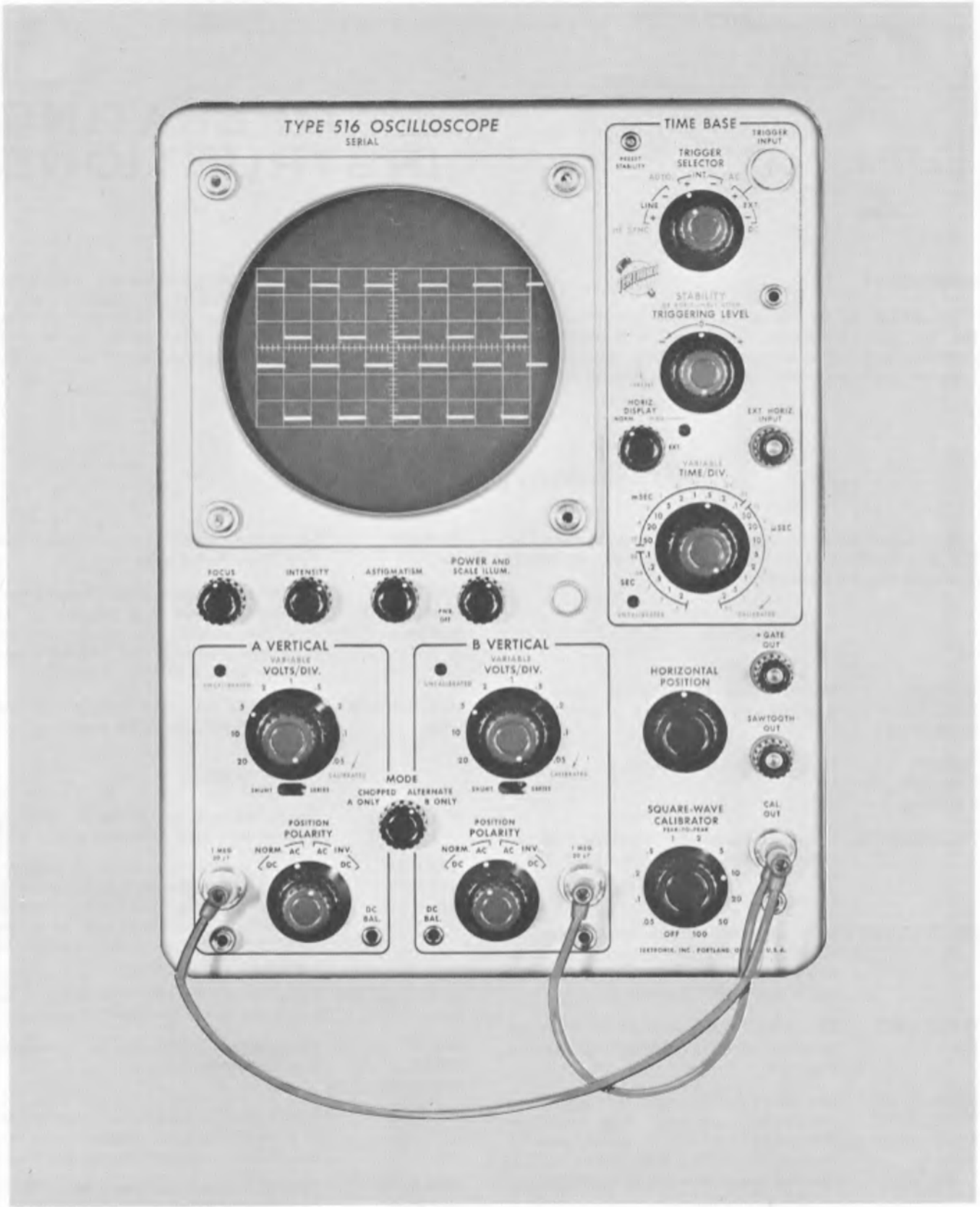


Fig. 3-1. Type 516 Oscilloscope front panel.

Input connector	Input connector for signal through A VERTICAL Channel.

B VERTICAL

(All controls in the B VERTICAL Channel are the same as those in the A VERTICAL Channel except that they control the signal applied through the B VERTICAL Channel input connector.)

OTHERS

FOCUS	Focuses the trace or spot on the screen.
INTENSITY	Controls the brightness of the trace or spot on the screen.
ASTIGMATISM	Controls the roundness of the spot on the screen.
POWER AND SCALE ILLUM.	Turns the instrument on and off, and controls graticule illumination.
MODE	Provides for display of signal in A VERTICAL Channel or B VERTICAL Channel independently, or both channels either on alternate sweeps of the trace or alternately at 150-kHz rate.
HORIZONTAL POSITION	Controls horizontal positioning of both A and B VERTICAL Channel signals on the crt screen.
+GATE OUT connector	Provides +25-volt (approximate) positive gate coincident with sweep time.
SAWTOOTH OUT connector	Provides +150-volt (approximate) sawtooth waveform coincident with sweep time.
AMPLITUDE CALIBRATOR*	Selects amplitude of square-wave available at CAL. OUT connector from 11 calibrated steps.
CAL. OUT connector	Coaxial connector for supplying Amplitude Calibrator output.

* On some instruments, this control is labeled SQUARE-WAVE CALIBRATOR.

INITIAL OPERATION

The following paragraphs describe a simple procedure by which you can become acquainted, in a general way, with the controls of the Type 516 Oscilloscope and the effect they have on its operation.

Initial Setup

To initially set up the Type 516 Oscilloscope for operation, proceed as follows:

1. Connect jumper wires from the CAL. OUT connector to the A and B VERTICAL Channel input connectors and set the oscilloscope controls as shown in Fig. 3-1.

2. Adjust the FOCUS, INTENSITY, and ASTIGMATISM controls to obtain sharply defined traces of useful brightness.

3. Center one waveform in the upper half of the graticule with the A VERTICAL Channel POSITION control and the other waveform in the lower half of the graticule with the B VERTICAL Channel POSITION control.

Functions of Controls

With the oscilloscope set up as described, turn the MODE switch through each of its positions. Note that in the A ONLY and B ONLY positions only one waveform is displayed, and in the ALTERNATE and CHOPPED positions, both waveforms are displayed. (When the MODE switch is in the CHOPPED position, the display may not be stable.) The difference between the ALTERNATE and CHOPPED positions is described later in this section of the manual. Set the MODE switch to the A ONLY position.

Set the red TRIGGER SELECTOR control to AC. Move the TRIGGERING LEVEL control throughout its range, noting that the waveform appears when the control is set toward the middle of its range and disappears as it is set toward either end of its range. Set the AMPLITUDE CALIBRATOR control to 5. Move the TRIGGERING LEVEL control throughout its range again, noting that the waveform is present during a narrower portion of its range than before. Set the AMPLITUDE CALIBRATOR control to 2. Note that the waveform appears during still less of the range of the TRIGGERING LEVEL control.

Set the AMPLITUDE CALIBRATOR control to 10 and the A VERTICAL VOLTS/DIV. control to 10, and then to 20, adjusting the TRIGGERING LEVEL control as described in the previous paragraph at each step. Note that the adjustment of the TRIGGERING LEVEL control becomes more critical as the triggering signal is reduced, whether by actual reduction of the signal or reduction of vertical sensitivity. (Changing the vertical sensitivity affects the amplitude of the triggering signal only when an internal triggering signal is used.)

Set the AMPLITUDE CALIBRATOR control to 2 and the A VERTICAL VOLTS/DIV. control to 10. Set the STABILITY and TRIGGERING LEVEL controls fully clockwise. Turn the STABILITY control counterclockwise until the trace disappears. Then set the TRIGGERING LEVEL control for a stable display. This is the method to use if a stable display is not present when the red TRIGGER SELECTOR control is in the AUTO. position, or cannot be obtained by means of the TRIGGERING LEVEL control alone with the STABILITY control set in the PRESET position.

Set the AMPLITUDE CALIBRATOR control to 1 and the A VERTICAL VOLTS/DIV. control to 2, then to 5, then to 10, and then to 20. At each setting of the A VERTICAL VOLTS/DIV. control, adjust the STABILITY and TRIGGERING LEVEL controls, as described in the previous paragraph, for a stable display. Note that as the vertical deflection on the screen becomes less, stable triggering becomes more difficult to obtain, until at the higher settings of the VOLTS/DIV. control, it may be impossible to obtain. This is because the setting of the VOLTS/DIV. control also affects the amplitude of the internal triggering signal. Normally, vertical deflection of at least one-fifth of a major graticule division is required for proper triggering from an internal signal.

Remove the jumper wire from the B VERTICAL input connector and connect it from the CAL. OUT connector to the

TRIGGER INPUT connector (leave the jumper wire connected from the CAL. OUT connector to the A VERTICAL input connector). Set the black TRIGGER SELECTOR control to +EXT. You have now set up the oscilloscope for external triggering, with the Calibrator supplying the external triggering signal as well as the displayed signal.

Set the A VERTICAL VOLTS/DIV. control to 1 and the AMPLITUDE CALIBRATOR control to 1, then to .5, then to .2, then to .1, and then to .05. At each setting of the AMPLITUDE CALIBRATOR control, set the STABILITY and TRIGGERING LEVEL controls for a stable display, if possible. Note that at the lowest settings of the AMPLITUDE CALIBRATOR control, stable triggering becomes very difficult or impossible to obtain. This is because there is not sufficient triggering signal being applied to the Time-Base Trigger. Normally, an external triggering signal of about 0.5 volt peak-to-peak amplitude is required for proper triggering.

Set the AMPLITUDE CALIBRATOR control to 1 again. Turn the A VERTICAL VOLTS/DIV. control counterclockwise. Note that no matter how small the deflection on the crt becomes, the display continues to be triggered. This is because the setting of the VOLTS/DIV. control has no effect on an external triggering signal.

Set the AMPLITUDE CALIBRATOR control to 20 and the A VERTICAL VOLTS/ DIV. control to 5. Set the black TRIGGER SELECTOR control to +INT., and set the STABILITY and TRIGGERING LEVEL control for a stable display. Rotate the TRIGGERING LEVEL control back and forth and note the vertical variation in the starting point of the square wave at the left-hand edge of the screen. (It may be necessary to move the display slightly to the right with the HORIZONTAL POSITION control to observe this.) Note also that the display starts on a positive-going portion of the waveform. Set the black TRIGGER SELECTOR control to —INT. and rotate the TRIGGERING LEVEL control as before. Note that the display now starts on a negative-going portion of the square-wave.

With the A VERTICAL POSITION control, move the display up and down on the screen. Note that the point at which the waveform starts at the left-hand edge of the screen remains fixed relative to the top and bottom of the waveform as the display moves. This is because when the red TRIGGER SELECTOR control is set to AC, triggering occurs at a given level relative to the average dc level of the entire signal. Set the red TRIGGER SELECTOR control to DC, and move the display up and down on the screen with the A VERTICAL POSITION control. (If the display disappears, turn the A VERTICAL POSITION control in the opposite direction to make it reappear.) Note that the point at which the waveform starts at the left-hand edge of the screen remains approximately fixed relative to the graticule. This is because when the red TRIGGER SELECTOR control is set to DC, triggering occurs at a specific dc level with respect to ground.

Set the AMPLITUDE CALIBRATOR control to 10 and the red TRIGGER SELECTOR control to AUTO. Switch the TIME/-DIV. and VARIABLE TIME/DIV. controls through their ranges and note the effect on the display. Note that the associated UNCALIBRATED lamp lights when the VARIABLE TIME/DIV. control is moved away from the CALIBRATED position. Return the TIME/DIV. control to the .5μSEC position and the VARIABLE TIME/DIV. control to the CALIBRATED position. With the HORIZONTAL POSITION control, position the display horizontally so that one of the vertical portions of the waveform coincides with the center graticule line. Set the HORIZ. DISPLAY switch to the MAG. position. Note that the center portion of the waveform has been expanded. Specifically, the portion of the waveform which occupied the center two divisons horizontally when the HORIZ. DISPLAY switch was in the NORM. position now occupies the entire graticule. Return the HORIZ. DISPLAY switch to the NORM. position.

Switch the A VERTICAL POLARITY switch to the NORM. DC position. Note the change in the position of the waveform on the screen. This is because the dc component of the square wave is now included in the display whereas, in the AC position, the display showed only the variation around the average dc level of the square wave.

To see the effect of the INV. positions of the POLARITY switch, set the black TRIGGER SELECTOR control to +EXT. (The jumper wire must still be connected from the CAL. OUT connector to the TRIGGER INPUT and A VERTICAL input connectors.) Now move the A VERTICAL POLARITY switch back and forth between NORM. DC and INV. DC. Note that as the switch moves from the NORM. positions to the INV. positions, the square wave becomes inverted on the screen. Note further that the position of the bottom of the square wave on the screen when the switch is at NORM. DC corresponds to the position of the top of the square wave on the screen when the switch is at INV. DC. This is because the negative portion of the Calibrator square wave is at dc ground and the signal is being inverted about the dc ground potential point.

The effect of all of the preceding operations is the same when the MODE switch is in the B ONLY position except that the B VERTICAL Channel controls must be used instead of the A VERTICAL Channel controls. The effect of the operations with the MODE switch in the ALTERNATE or CHOPPED positions is approximately the same, except that external triggering should be used for best results.

Graticule Illumination

Graticule illumination can be adjusted to suit the lighting conditions of the room by means of the POWER AND SCALE ILLUM. control. Turning the control clockwise increases the graticule illumination. It is possible to extinguish the graticule illumination completely by turning the control counterclockwise.

The graticule of the Type 516 Oscilloscope can be illuminated so that it appears to have either red or white graticule markings. The markings can be changed from white to red or red to white simply by removing the graticule cover and inverting the graticule. As a general rule, white graticule lines are superior to red for photographic purposes.

Operating Information

Input Coupling

The Type 516 Oscilloscope is provided with two input connectors to the Vertical Amplifier. Signals may be connected to both of these input connectors at the same time and, by means of the MODE switch, they may be displayed one at a time or both together on the crt screen. When only one signal is to be displayed, it may be connected to either input connector.

Polarity Switches

Input signals to both channels may be either ac or dc coupled and may be displayed either normally or inverted on the crt screen by placing the corresponding POLARITY switches to the appropriate positions. Dc coupling applies both the ac and dc components of the input signal to the amplifier circuits. This permits you to measure the dc voltage level as well as the amplitude of the ac component. However, it is sometimes neither necessary nor desirable to display the dc component, and in such cases ac coupling should be used. Placing the POLARITY switch to either of the AC positions inserts a capacitor in series with the input connector. This capacitor blocks the dc component while allowing the ac component to be displayed.

MODE Switch

When the MODE switch is in the A ONLY position or the B ONLY position, only the signal which is applied to the corresponding vertical channel will be displayed on the crt. When the MODE switch is in the ALTERNATE position, the oscilloscope will display the signals in each of the channels on alternate sweeps of the trace. When the MODE switch is in the CHOPPED position, the oscilloscope will display the signals alternately at about a 150-kHz rate; in other words, the signal in the A Channel is displayed for about $3\frac{1}{3}$ microseconds and then the signal in the B Channel is displayed for about $3\frac{1}{3}$ microseconds. At the faster sweep rates, the CHOPPED mode of operation causes the traces to take on a dotted appearance. At the slower sweep rates, the ALTERNATE mode of operation causes the alternate appearance of the traces to become quite noticeable which makes it difficult to compare the two. Therefore, in general, the ALTERNATE mode of operation is most useful at the faster sweep rates and the CHOPPED mode of operation is most useful at the slower sweep rates.

DC Balance Adjustment

Occasionally, there is need for adjustment of the dc balance of one or both input channels. This need is indicated by a vertical shift in the position of a no-signal trace as the VARIABLE VOLTS/DIV. control is rotated.

To make this adjustment, set the MODE switch to ALTERNATE. With no signal connected to the input connectors, set the STABILITY control fully clockwise and position the two free-running traces on the screen. Rotate each VARIABLE VOLTS/DIV. control back and forth, and simultaneously adjust the corresponding DC BAL. adjustment until the trace position is no longer affected by rotation of the VARIABLE VOLTS/DIV. control.

Input Connections

Certain precautions must be observed in connecting the oscilloscope to the signal source to prevent errors due to stray electric or magnetic coupling in the leads. Shielded cables shoula 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, it should be kept as short as possible.

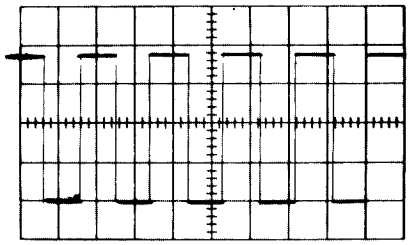
In broadband applications, it might be necessary to terminate a coaxial input cable with a resistor or an attenuating pad presenting a resistance equal to the characteristic impedance of the cable. This is to prevent resonance effects and "ringing" (high-frequency damped oscillation). It becomes more necessary to terminate the cable properly as the length of the cable is increased. The termination is generally placed at the oscilloscope end of the cable, although many sources require an additional termination at the source end of the cable as well.

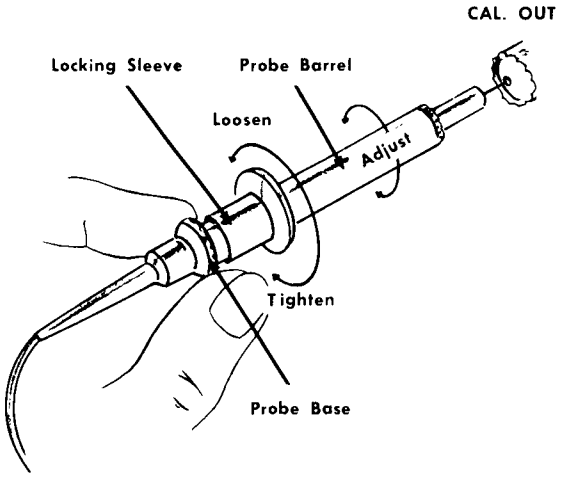
As nearly as possible, the actual operating conditions of the equipment being tested must be maintained. For example, the equipment should work into a load impedance equal to that which it will see in actual use. The input connectors of the Type 516 Oscilloscope present an input impendance of 1 megohm in parallel with 20 picofarads. With a few feet of shielded cable, the input capacitance may well be as much as 100 picofarads. In cases where the effects of these resistive and capacitive loads are significant in terms of the equipment being tested, you should use an attenuator probe as described in the next paragraph.

Use of Probes

Use of the attenuator probes furnished with the Type 516 Oscilloscope reduces the capacitive and resistive loading effect on the equipment under test and, at the same time, reduces sensitivity. Connected to the input connectors of the Type 516 and properly compensated, these probes present a characteristic input impedance of 10 megohms in parallel with 8 picofarads and have an attenuation ratio of 10:1. The maximum-voltage rating of the probes is 600 volts. Exceeding this rating, either in peak ac volts or dc volts, may result in damage to the probes.

When making amplitude measurements with an attenuator probe, be sure to multiply the observed amplitude by the attenuation factor of the probe. If the waveform being displayed contains fast-changing portions, it is generally necessary to clip the probe ground lead to the chassis of the equipment being tested.





Display several cycles of Calibrator waveform on crt screen. Hold probe barrel and loosen locking sleeve. Hold probe base and adjust probe barrel for flat-topped square waves. Hold probe barrel and carefully tighten locking sleeve.

Fig. 3-2. Probe compensation adjustment.

An adjustable capacitor in the probe body compensates for variations in the input capacitance from one instrument to another or between two input connectors of one instrument. To insure the accuracy of pulse and transient measurements, this adjustment should be checked frequently. Fig. 3-2 illustrates the method of adjusting the compensation of the probe.

TRIGGERED OPERATION

For most uses of your oscilloscope, you will need to get a stable display of some recurrent waveform. In order to obtain a stable display, it is necessary to start the horizontal sweep consistently at the same time relative to recurring cycles of the input waveform. The sweep therefore must be triggered by the input waveform itself or by some waveform which bears a fixed time relationship to the input waveform. The following instructions tell you how to select and use the proper triggering signal for various applications of the oscilloscope.

Selecting the Trigger Source

For most applications the sweep can be triggered by the input waveform. The only requirement is that the input signal be large enough to provide at least one-fifth of a major graticule division of deflection on the screen at the sensitivity level for which the VOLTS/DIV. control is set. To obtain triggering of the sweep from the input waveform, set the black TRIGGER SELECTOR control to either the +INT. or the —INT. position (the significance of the + and — will be explained in a later paragraph).

For dual-trace operation, it is usually advantageous to trigger the sweep with some external trigger. In this way, the true phase relationship of the two waveforms can be shown and triggering is obtained more easily. In order to obtain a stable display, it is necessary that the external triggering waveform bear a fixed time relationship to the input waveforms. The external triggering signal must be at least 0.2 volt in amplitude to assure proper triggering. To use an external waveform for triggering the horizontal sweep, connect the signal to the TRIGGER INPUT connector and set the black TRIGGER SELECTOR control to the +EXT. or —EXT. position. External triggering may also be used with single trace operation where desired.

When you are observing a waveform which bears a fixed time relationship to the ac line frequency, you may wish to trigger the sweep from the line-frequency waveform. To do this, place the black TRIGGER SELECTOR control in the +LINE or —LINE position.

When the black TRIGGER SELECTOR control is set to one of the + positions (+INT., +EXT., +LINE), the sweep is triggered on a positive slope of the triggering signal. When the control is set to one of the — positions (—INT., —EXT., —LINE), the sweep is triggered on a negative slope of the triggering signal. In most cases, selection of the triggering slope is not critical.

Selecting the Triggering Mode (HF SYNC, AUTO., AC, DC)

The most useful triggering mode is the automatic mode, obtained by setting the red TRIGGER SELECTOR control to the AUTO. position. The automatic mode of triggering provides a stable display with virtually any triggering signal from about 50 Hz to 2 MHz in frequency. No adjustment of the STABILITY or TRIGGERING LEVEL controls is necessary since these two functions are automatically set to their optimum values internally. (In the other triggering modes, it is necessary to set one or both of these controls to obtain a stable presentation.) In addition, the automatic mode of triggering provides a free-running trace on the screen in the absence of any triggering signal. This trace may be used, under certain conditions, as a base line from which to make dc measurements. It also gives a constant indication of the readiness of the oscilloscope to accept a triggering signal for the display of a stable waveform.

In the ac triggering mode, obtained by setting the red TRIGGER SELECTOR control in the AC position, suitable triggering can be obtained with signals from about 16 Hz to 5 MHz. When the ac triggering mode is used, it is usually

necessary to adjust the STABILITY and TRIGGERING LEVEL controls to obtain stable triggering. In this way, the point on the signal at which triggering will occur may be selected; in the automatic triggering mode, triggering occurs at the average dc level of the waveform.

The dc triggering mode, obtained by setting the red TRIGGER SELECTOR control in the DC position, is particularly useful in triggering from very low-frequency waveforms. The trigger pulses are generated when the signal reaches a given dc level relative to ground. Suitable triggering can be obtained from triggering signals from dc to about 5 MHz. In the dc triggering mode, as in the ac triggering mode, it is usually necessary to adjust the STABILITY and TRIGGERING LEVEL controls to obtain stable triggering.

The high-frequency synchronized mode, obtained by setting the red TRIGGER SELECTOR control in the HF SYNC position, should be used to display signals from about 5 MHz to 15 MHz. In this mode of operation, the Time-Base Trigger circuit is bypassed and the triggering signal itself, either internal or external, synchronzies the free-running operation of the Time-Base Generator. For this reason, neither the TRIGGERING LEVEL control nor the + and — feature of the black TRIGGER SELECTOR control have any effect on the display. The sweep will always be started on a negative-going slope of the signal. It is usually necessary to adjust the STABILITY control to obtain a stable display.

Adjusting the STABILITY and TRIGGERING LEVEL Controls

As mentioned previously, it is not necessary to adjust the STABILITY and TRIGGERING LEVEL controls as long as stable triggering can be obtained in the automatic mode of operation. However, if stable triggering cannot be obtained in the automatic mode, it will be necessary to use one of the other modes. In this case, it will usually be necessary to adjust the STABILITY control or the TRIGGERING LEVEL control, or both, to obtain a stable presentation.

Normally, in the ac and dc modes, the STABILITY control can be set in the PRESET position, and stable triggering obtained through use of the TRIGGERING LEVEL control only. When it is not possible to obtain stable triggering with the STABILITY control in the PRESET position, then you should use the following procedure in adjusting the STABILITY and TRIGGERING LEVEL controls:

1. Set both controls fully clockwise.
2. Turn the STABILITY control counterclockwise until the trace just disappears.
3. Set the TRIGGERING LEVEL control for a stable display.

When the TRIGGERING LEVEL control is set in the + region of its range, triggering of the sweep will take place at a point on the triggering signal above its average dc level. When the TRIGGERING LEVEL control is set in the — region of its range, triggering of the sweep will take place at a point on the triggering signal below its average dc level. With some signals it will be possible to obtain stable triggering at several positions of the TRIGGERING LEVEL control or throughout a considerable portion of its range. You should set the control where it produces the most favorable display for the purpose desired.

When the red TRIGGER SELECTOR control is in the HF SYNC position, the TRIGGERING LEVEL control has no effect and a stable display is obtained through the use of the STABILITY control only. In this case, rotate the STABILITY control through its range until the best display is obtained on the screen.

Setting the Sweep Rate

Throughout the operation of the oscilloscope, the TIME/DIV. control may be adjusted at any time to present the desired waveform on the crt. For most applications, the TIME/DIV. control is set to display several cycles of a recurring waveform. Sometimes, when it is desired to inspect some portion of a single cycle closely, it will be best to adjust the TRIGGERING LEVEL control so that the portion of the waveform to be inspected is at the extreme left-hand edge of the graticule and then set the TIME/DIV. control to the fastest sweep rate (smallest numercial setting) possible, still keeping the desired portion of the waveform on the screen. The black numbers in the inner ring around the TIME/DIV. control indicate the sweep rate when the HORIZ. DISPLAY switch is in the NORM. position.

Magnification of the Sweep

Any part of the trace may be expanded horizontally by a factor of 5 through the use of the HORIZ. DISPLAY switch. To expand a given portion of the sweep, first set that portion to the center of the graticule by means of the HORIZONTAL POSITION control. Then set the HORIZ. DISPLAY switch to the MAG. position. The magnified sweep feature is particularly useful for inspecting portions of the waveform which cannot be expanded sufficiently and still kept on the screen by the method described in the previous paragraph. The small blue numbers in the outer ring around the TIME/DIV. control give the true sweep rates when the HORIZ. DISPLAY switch is in the MAG. position.

FREE-RUNNING OPERATION

When the STABILITY control is set fully clockwise (and the red TRIGGER SELECTOR control is not in the AUTO. position), the Time-Base Generator free runs to produce a sweep independent of any synchronizing signal. The frequency of the sweep can be varied from about 0.012 Hz to 100 kHz by means of the TIME/DIV. control and the associated VARIABLE control.

Two outputs coincident with the sweep are available at front-panel connectors. A positive gate about 25 volts in amplitude is available at the +GATE OUT connector, and a positive-going sawtooth waveform, rising to a maximum amplitude of about 150 volts, is available at the SAWTOOTH OUT connector. Applications for free-running operation are discussed later in this section.

Applications

The following paragraphs describe procedures for making measurements of voltage, elapsed-time, and phase-shift with the Type 516 Oscilloscope. No attempt has been made to describe any but the most basic techniques. Familiarity with the instrument will enable the operator to apply the essence of these techniques to a wide variety of applications, depending upon the problem at hand.

Voltage Measurements

To measure the ac component of a signal, proceed as follows:

1. Display the waveform over as large a portion (vertically) of the screen as possible by adjusting the appropriate VOLTS/DIV. control.

2. With the aid of the graticule, measure the vertical distance (in graticule divisions) between the two points on the waveform at which the voltage measurement is desired. Make sure the appropriate VARIABLE VOLTS/DIV. control is in the CALIBRATED position. On small voltage measurements, the width of the trace can make up an appreciable part of the entire measurement. For this reason, it is important to take all readings in a given measurement from the same side of the trace.

3. Multiply the distance between the two points by the setting of the appropriate VOLTS/DIV. control and by the attenuation factor, if any, of the probe. This is the voltage between the two points of the waveform.

To measure the dc level at some point on a signal, proceed as follows:

1. Set the POLARITY switch of the channel to which the signal is applied to the NORM. DC position.

2. Set the corresponding VOLTS/DIV. control such that the expected voltage (at the oscilloscope input connector) is not more than six times the setting of the control. Make sure the VARIABLE VOLTS/DIV. control is in the CALIBRATED position.

3. Set the oscilloscope controls to produce a free-running trace.

4. Touch the oscilloscope probe tip to a ground point, and with the appropriate VERTICAL POSITION control position the trace so that it lies along one of the horizontal lines of the graticule. This line will be used as a ground reference line; its position in any given case will depend upon the polarity and amplitude of the input signal to be measured. Do not adjust the VERTICAL POSITION control after the reference line has been established.

5. Remove the probe tip from ground and connect it to the signal source. Adjust the triggering controls for a stable display.

6. Measure the distance, in graticule divisions, from the ground reference line established in step 4 to the point at which the dc voltage level is desired.

7. Multiply this distance by the setting of the appropriate VOLTS/DIV. control and the attenuation factor, if any, of the probe. This is the dc level of the point measured.

Time and Frequency Measurements

To measure the time interval between two points on a waveform, proceed as follows:

1. Apply the signal to either of the Vertical Channels and set the triggering controls for a stable display. Make sure the VARIABLE TIME/DIV. control is in the CALIBRATED position.

2. Measure the horizontal distance, in graticule divisions, between the two points whose interval you wish to find.

3. Multiply the distance measured by the setting of the TIME/DIV. control. (If the HORIZ. DISPLAY switch is in the MAG. position, use the blue numbers). This is the time interval between the two points measured.

To determine the frequency of a recurrent waveform, simply take the reciprocal of the time interval between corresponding points on two consecutive cycles of the waveform.

Phase-Shift Measurements

A phase comparison of two signals of the same frequency can be made by making use of the dual-trace feature of the Type 516 Oscilloscope. To make this comparison, proceed as follows:

1. Apply the two signals to the two input connectors and set the MODE switch to the CHOPPED or ALTERNATE position. (In general, the CHOPPED position is more suitable for low-frequency signals and the ALTERNATE position is more suitable for high-frequency signals). Apply one of the signals as an external trigger and set the triggering controls for a stable presentation. Center both signals vertically on the graticule.

2. Set the TRIGGERING LEVEL and HORIZONTAL POSITION controls so that the leading waveform starts exactly at the point where the horizontal centerline meets the vertical line at the left-hand edge of the graticule.

3. Measure the distance, in graticule divisions, from the left-hand edge of the graticule to the point where the other waveform crosses the horizontal centerline. For the most accurate measurement, use the fastest sweep rate possible. Make sure that the VARIABLE TIME/DIV. control is in the CALIBRATED position.

4. Multiply the distance measured in step 3 by the setting of the TIME/DIV. control and divide by the period of one cycle of the waveform. Multiply the result by 360°. This is the phase difference between the two signals.

Application of Free-Running Operation

Sometimes it is desired to display the output of a device which requires a triggering signal for each cycle of output, such as a monostable or bistable multivibrator. In this case, the Type 516 Oscilloscope can be used for triggering the device as well as displaying its output waveform. To set the oscilloscope up for this type of operation, proceed as follows:

1. Set the STABILITY control fully clockwise.

2. Connect a lead between either the +GATE OUT connector or the SAWTOOTH OUT connector and the input to the device under observation. (The signal at the +GATE OUT connector has an amplitude of about 25 volts and the signal at the SAWTOOTH OUT connector has an amplitude of about 150 volts; therefore, it may be necessary to scale these down by means of a voltage divider, depending upon the equipment with which they are to be used.)

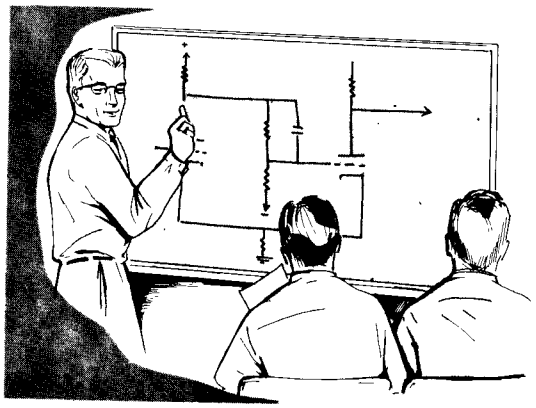
CAUTION

To avoid shorting out the +gate or sawtooth voltage from the oscilloscope, make the connection to the device under observation before connecting the lead to the oscilloscope connector. Do not connect a resistance of less than about 2k between the +GATE OUT connector and ground, or less than about 10k between the SAWTOOTH OUT connector and ground; to do so might damage components in the oscilloscope.

3. Connect the output of device under observation to the vertical input connector of the Type 516.

The output of the device will now be synchronized to the free-running sweep of the oscilloscope and will appear as a stable display on the screen.

NOTES



SECTION 4

CIRCUIT DESCRIPTION

GENERAL DESCRIPTION

A block diagram of the Type 516 Oscilloscope is shown in Fig. 4-1. In general, operation of the oscilloscope is as follows:

The signal or signals to be displayed are applied to the Vertical Amplifier through the A and/or B input connectors. The Vertical Amplifier amplifies the signals and applies them through the Delay Line to the vertical deflection plates of the cathode-ray tube. A sample of the signal is taken out at the Vertical Amplifier and applied to the Time-Base Trigger. The Time-Base Trigger generates a trigger pulse which bears a selected fixed time relationship to the incoming signal. This trigger pulse triggers the Time-Base Generator which generates a linear sawtooth waveform. The sawtooth waveform is applied through the Horizontal Amplifier to deflect the crt beam horizontally at a selected fixed rate. Provisions are also made for generating trigger pulses which bear a selected fixed time relationship to some external signal or to the ac line waveform. If desired, the Time-Base Generator may be disabled and an external signal applied directly to the Horizontal Amplifier. The Amplitude Calibrator provides an amplitude-calibrated square wave for use in calibrating the gain of the Vertical Amplifier and adjusting the compensa-

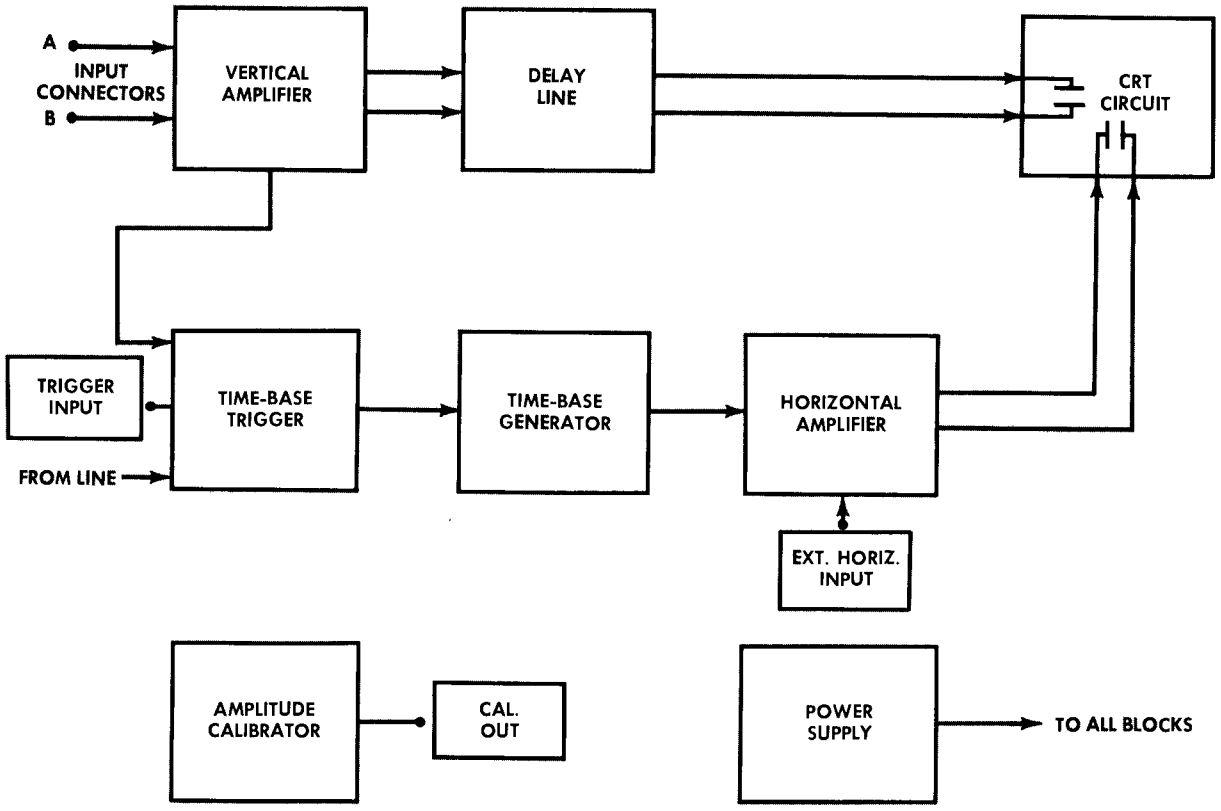


Fig. 4-1. Type 516 Oscilloscope block diagram.

tion of probes. The Power Supply supplies regulated voltages and currents as required throughout the oscilloscope.

The remainder of this section of the manual presents a more detailed description of the operation of each of the oscilloscope circuits. Throughout the discussion, you should refer to the circuit diagrams contained in the Diagrams section of this manual.

VERTICAL AMPLIFIER

The Vertical Amplifier of the Type 516 Oscilloscope contains two separate Input Amplifier Channels (A and B), a common Output Amplifier, and a Switching Circuit. Signals may be applied to both Input Amplifier Channels, and the Switching Circuit makes it possible to display one signal as a single trace on the crt or to display both signals as two separate traces. It does this by turning the outputs of the two Input Amplifier Channels alternately off and on, either on alternate sweeps of the trace or at a 150-kHz switching rate.

The Type 516 can also be used as a conventional single-channel oscilloscope with an input signal on one channel only.

A block diagram of the Vertical Amplifier is shown in Fig. 4-2.

Input Amplifier Channels

Since the two Input Amplifier Channels are identical, except for the CHANNEL A GAIN SET adjustment, the following discussion refers to the A Channel only. Operation of the B Channel is identical.

The signal to be displayed is applied through the POLARITY switch and the VOLTS/DIV. control to one of the grids of the Input Cathode Follower, V423. When the POLARITY switch is in either of the AC positions, the signal is coupled through C400 which prevents the dc component of the signal from being applied to the Input Cathode Follower grid. When the POLARITY switch is in one of the NORM. positions, the signal is applied to the grid of V423A and is displayed on the crt in the normal position, with the positive portions toward the top of the screen. When the POLARITY switch is in one of the INV. positions, the signal is applied to the grid of V423B and is displayed on the crt in the inverted position, with the positive portions toward the bottom of the screen.

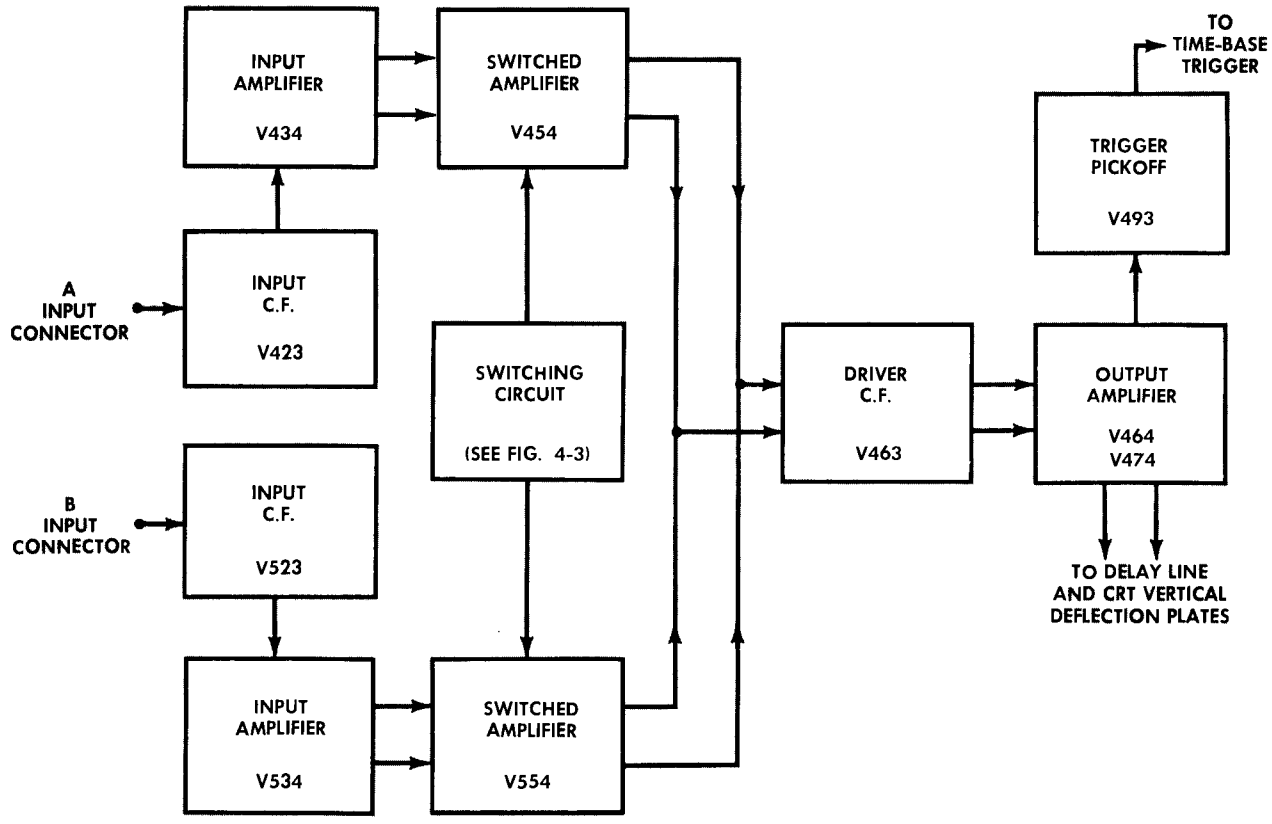


Fig. 4-2. Vertical Amplifier block diagram.

The basic sensitivity of the Vertical Amplifier is 0.05 volt per divison. In other words, 0.05 volt of signal at the grids of the Input Cathode Followers will produce one division of deflection on the crt. Changes in sensitivity of the oscilloscope are accomplished by attenuation of the input signal before it reaches the Input Cathode Followers. A "straight-through" position and eight different values of attenuation may be selected by the VOLTS/DIV. control to provide nine fixed calibrated sensitivities of 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, and 20 volts per division. The attenuators are resistance and capacitance dividers which provide constant attenuation throughout the frequency range of the instrument while maintaining a constant input impedance of 1 megohm and 20 picofarads at the input connectors.

The Input Amplifier, V434, is a cathode-coupled paraphase amplifier which converts the single-ended input from the Input Cathode Follower to a push-pull output. The gain of this stage can be adjusted by means of the VARIABLE VOLTS/DIV. control which varies the coupling resistance between the two cathodes. This control permits a continuous range of uncalibrated sensitivity values between the steps selected by the VOLTS/DIV. control and up to about 50 volts per division of deflection. Switch SW442, which switches the UNCALIBRATED lamp, B442, in and out of the circuit, is linked mechanically to the VARIABLE VOLTS/DIV. control. Thus, when the VARIABLE VOLTS/DIV. control is moved away from the CALIBRATED position (fully clockwise), the UNCALIBRATED lamp is energized to indicate that the vertical sensitivity is not calibrated.

The CHANNEL A GAIN SET is used to set the gain of the A Channel equal to that of the B Channel. This provides equal deflection with equal signals through both channels, provided both VOLTS/DIV. controls are set to the same position and both VARIABLE controls are in the CALIBRATED position.

The DC BAL. control in the cathode circuit of V423B is adjusted to place both cathodes of the Input Amplifier at the same potential so that under no-signal conditions there is no current flowing through R440 and R441. This provides vertical stability of the trace as the value of R441 is changed with the VARIABLE VOLTS/DIV. control.

The POSITION control varies the average dc level about which the signal moves at the grids of the Switched Amplifier, V454. Since the entire Vertical Amplifier is dc coupled, this varies the position of the trace on the screen. The POSITION control also affects the average dc plate voltage of the Input Amplifier and, therefore, can disturb the dc balance of that circuit. For this reason, a small portion of the positioning voltage at each plate is fed back to the opposite cathode (through R443 and R444) to counteract this effect.

The turning off and on of the two channels is accomplished in the Switched Amplifiers by the operation of the Switching Circuit, which will be discussed later in this section.

Output Amplifier

The push-pull output of the Switched Amplifier is applied to the Driver Cathode Followers, V463, which, in turn, drive the Output Amplifier, V464 and V474. The output of the Output Amplifier is connected through the Delay Line to the vertical deflection plates of the crt. The Delay Line delays the application of the signal to the deflection plates until the crt has been unblanked and the horizontal sweep started. This delay allows the leading edge of fast-rising pulses to be displayed.

The overall gain of the Vertical Amplifier is adjusted by varying the degeneration between the two cathodes of the Output Amplifier. This is done with the GAIN ADJ. potentiometer, R478.

The parallel network of D477, D478, and R477 lowers the effective resistance between the two cathodes as the dc potential between them exceeds about 0.2 volt. The purpose of this network is to compensate the compression of the crt display which might otherwise occur when the POSITION control is near the end of its range.

Trigger Pickoff

The output from V464 is also applied through two cathode followers, V493A and V493B, to the TRIGGER SELECTOR switch, SW10A. Thus, when SW10A is in either of the INT. positions, a portion of the output of the Output Amplifier is applied to the Time-Base Trigger to start the horizontal sweep.

B493 and B494 protect V493 against cathode-to-grid breakdown when the instrument is first turned on by holding the cathodes within a safe operating level of the grids until the heater has warmed up enough to allow the tube to conduct. After V493 starts conducting, B493 and B494 stop conducting and are therefore effectively removed from the circuit.

Switching Circuit

Selection of the input channel whose output is to be applied to the Driver Cathode Followers is accomplished by means of the Switching Circuit. A block diagram of the Switching Circuit is shown in Fig. 4-3.

The Switching Circuit may be operated in any one of four modes, depending upon the setting of the MODE switch, SW585. When the MODE switch is in the A ONLY position, the grid of V594A (one side of the Switching Amplifier) is at about ground potential and the grid of V594B is at about −96 volts. Therefore, V594A is conducting heavily, and V594B is cut off. The plate of V594A and the cathodes of the A Channel Switched Amplifier are at about +57 volts. The plate of V594B and the cathodes of the B Channel Switched Amplifier are at about +63 volts (they are prevented from going further positive by conduction through D554). The average dc potential of the grids of both Switched Amplifiers is about +56 volts. Therefore, with only about one volt of bias, the A Channel Switched Amplifier will conduct and amplify any signal applied to its grids. Meanwhile, with about 7 volts of bias, the B Channel Switched Amplifier will be cut off. So the signal in the A Channel is applied through the Driver Cathode Followers and the Output Amplifier to the crt deflection plates, and the signal in the B Channel is blocked at the B Channel Switched Amplifier.

When the MODE switch is in the B ONLY position, just the opposite set of conditions exists; the B Channel Switched Amplifier conducts and the A Channel Switched Amplifier is cut off. So the B Channel signal is displayed on the crt.

When the MODE switch is in the ALTERNATE position, the crt displays the signal in one channel for one sweep of

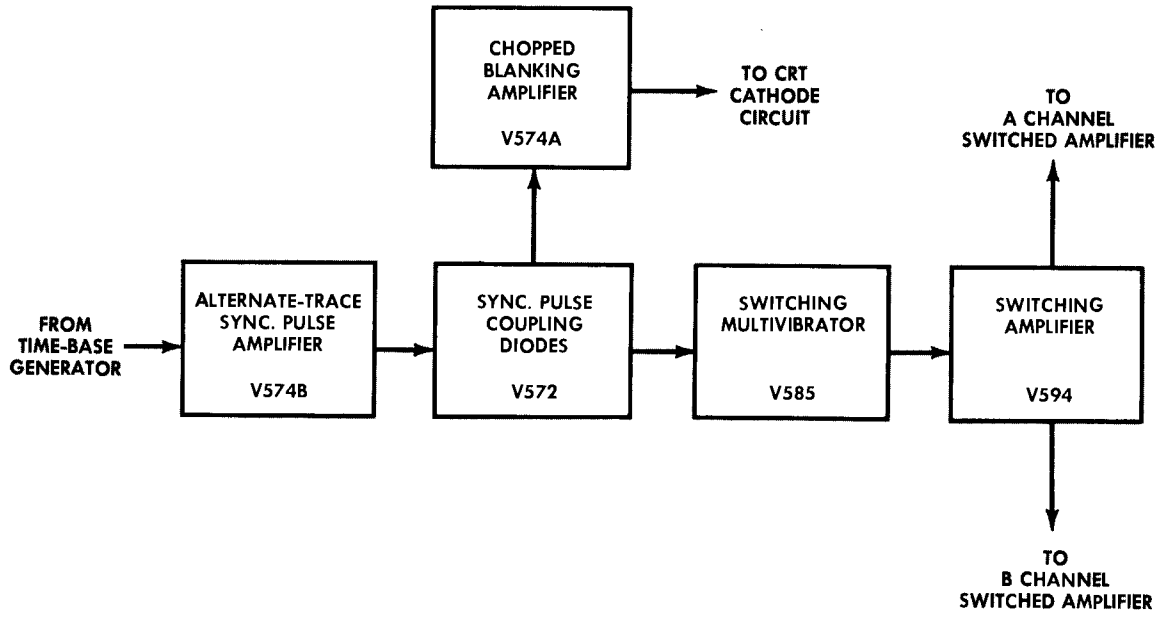


Fig. 4-3. Switching Circuit block diagram.

the beam, and then the signal in the other channel for the next sweep of the beam. In this mode of operation, V585 becomes a bistable Switching Multivibrator which is switched from one state to the other at the end of each sweep. When the Switching Multivibrator is in one state—say, with V585A conducting and V585B cut off—the low plate voltage on V585A is coupled to the grid of V594B. This cuts off V594B whose plate voltage then rises to about +63 volts, which cuts off the B Channel Switched Amplifiers. The high plate voltage of V585B is coupled to the grid of V594. This allows V594A to conduct which lowers its plate voltage and the voltage at the cathodes of the A Channel Switched Amplifiers to about +57 volts. Therefore, the A Channel Switched Amplifiers conduct. When the Switching Multivibrator is in the other state—V585B conducting and V585A cut off—the opposite set of conditions exists; the B Channel Switched Amplifiers conduct and the A Channel Switched Amplifiers are cut off.

The switching of the Switching Multivibrator in the ALTERNATE mode takes place as follows. At the end of each sweep, a positive spike is formed at the screen of V145A in the Time-Base Generator. This positive spike is applied to the grid of the Alternate Trace Sync Pulse Amplifier, V574B, and, since V574B is normally cut off, allows the tube to conduct. This allows current to flow also through the Sync Pulse Coupling Diodes, V572, and applies a negative spike to both grids of the Switching Multivibrator. Since one side of the multivibrator is already cut off, the negative spike will have no effect on that side. However, the negative spike will cut off the side which is conducting and cause the multivibrator to switch states.

When the MODE switch is in the CHOPPED position, V585 becomes an astable multivibrator with a frequency of about 150 kc. The outputs from the two sides of the Switching Multivibrator are applied to the two sides of the Switching Amplifier which turns the Switched Amplifiers off and on alternately at a 150-kc rate. This causes the signals in the two channels to be displayed on the crt alternately for a little over three microseconds at a time.

Since the POSITION controls of the two channels are normally set at different levels, it is necessary, in the CHOPPED mode, to turn off the crt beam as the switching between channels is taking place. This action takes place in the Chopped Blanking Amplifier, V574A. The negative-going pulses formed as the two sides of the Switching Multivibrator alternately come into conduction are differentiated and applied as negative spikes to the grid of V574A. V574A amplifies and inverts the spikes and applies them to the crt cathode via SW848. These positive spikes on the crt cathode, then, cut off the beam as switching is taking place.

TIME-BASE TRIGGER

The Time-Base Trigger consists basically of the Trigger Selector switches, SW10A and SW10B, the Trigger Input Amplifier, V24, and the Trigger Multivibrator, V45. The TRIGGER SELECTOR switches select the triggering source, the triggering slope, and the triggering mode. The Trigger Input Amplifier amplifies (and, when desired, inverts) the incoming triggering signal and applies it to the input of the Trigger Multivibrator. The Trigger Multivibrator is a Schmitt circuit which is switched from one state to the other by the signal at its input. Its square-wave output is differentiated to form negative and positive spikes which are applied to the Time-Base Generator where the negative spikes are used to start the horizontal sweep. The positive spikes are not used.

A block diagram of the Time-Base Trigger is shown in Fig. 4-4.

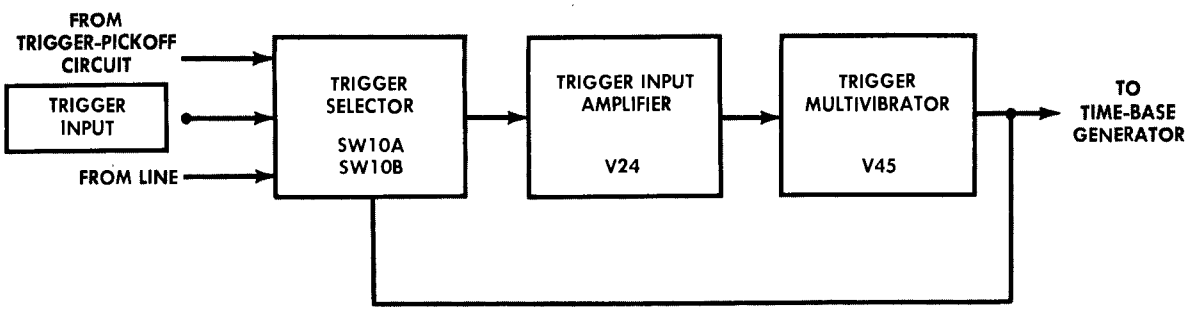


Fig. 4-4. Time-Base Trigger block diagram.

Trigger Input Amplifier

The input to the Trigger Input Amplifier, V24, may be selected from any one of three sources by means of the black TRIGGER SELECTOR control, SW10A. When SW10A is in one of the INT. positions, the signal is obtained from the Trigger Pickoff circuit in the Vertical Amplifier. When SW10A is in one of the EXT. positions, the signal may be obtained from an external source through the TRIGGER INPUT connector on the front panel. When SW10A is in one of the LINE positions, the signal is obtained from one of the 6.3-volt secondary windings of the line transformer.

The + and — positions of SW10A provide a means of inverting or not inverting, as desired, the triggering signal in the Trigger Input Amplifier. This is done so that the negative spike at the output of the Time-Base Trigger can be made to occur during either a positive-going or a negative-going portion of the triggering signal. (The negative spike occurs only when there is a negative-going signal at the input to the Trigger Multivibrator.)

When SW10A is in any of the —positions, the incoming triggering signal is applied to the grid of V24A, and V24 is a cathode-coupled amplifier. With this configuration, the signal at the plate of V24B (output of the Trigger Input Amplifier) is in phase with the incoming triggering signal. When SW10A is in any of the +positions, the incoming triggering signal is applied to the grid of V24B, and V24B is a plate-loaded amplifier. In this case, the signal at the plate of V24B is 180° out of phase with the incoming triggering signal.

The TRIGGERING LEVEL control, R17, varies the average dc level at the plate of V24B from about +60 volts to +100 volts. This is true whether SW10A is in a + position or a — position. The minimum level of +60 volts represents the point where V24B is taken into saturation by a sufficiently positive setting of R17 when SW10A is in a — position or by a sufficiently negative setting of R17 when SW10A is in a + position. The maximum level of +100 volts represents the point where V24B is taken into cutoff by a sufficiently negative setting of R17 when SW10A is in a — position or by a sufficiently positive setting of R17 when SW10A is in a + position. As will be seen later, the voltage at the plate of V24B must pass through the approximate center of this range (about +80 volts) in order to cause the Trigger Multivibrator to change states.

For small triggering signals, R17 is set such that the average dc level at the plate of V24B is close to the center of its range so that the small signal, as amplified by V24, is sufficient to carry the plate voltage through the +80-volt point. When a large triggering signal is applied and it is desired to trigger on an extreme positive or negative point of it, R17 is set such that V24B is well into saturation, or cutoff (depending upon whether triggering is desired at a more negative or more positive point on the signal and on a negative-going or positive-going slope). In this case, the triggering signal must be sufficient to overcome the saturation or cutoff of V24B and produce an additional 20 volts of swing at the plate of V24B in order to cause the Trigger Multivibrator to switch states.

It should be noted that the voltages given in the foregoing discussion are typical nominals only and will vary somewhat from instrument to instrument and with time.

Trigger Multivibrator

The Trigger Multivibrator is a two-state Schmitt circuit. When the voltage at its input grid (grid of V45A) is above a certain critical level (neglecting hysteresis), the Trigger Multivibrator is in one state, with V45A conducting and V45B cut off. When the Trigger Multivibrator is in this state, the voltage as its output (plate of V45B) is at 300 volts. When the voltage at the input grid is below the critical level (still neglecting hysteresis), the Trigger Multivibrator is in the other state, with V45A cut off and V45B conducting. When the Trigger Multivibrator is in this second state, the voltage at its output is about +290 volts. The transition from one

state to the other occurs very rapidly regardless of how slowly the voltage at the input grid passes the critical level. Thus the output of the Trigger Multivibrator is a 10-volt square wave. The negative-going transition occurs when the voltage at the input passes the critical level while moving in the negative direction, and the positive-going transition occurs when the voltage at the input passes the critical level while moving in the positive direction. As mentioned before, only the negative-going transistion is of significance time-wise, and, by means of the black TRIGGER SELECTOR control and the TRIGGERING LEVEL control, this point can be made to coincide with virtually any point on the incoming triggering signal.

The TRIG. LEVEL CENTERING adjustment, R39, varies the level of the grid of V45B with respect to the plate of V45A. Thus, it controls the input voltage at which the Trigger Multivibrator changes states. This level is normally set at the voltage which the plate of V24B assumes when both grids of V24 are at ground potential. In most instruments, this is within a volt or two of +80 volts.

Actually, the input voltage level at which the Trigger Multivibrator changes states on a negative-going signal is normally slightly lower than the input voltage level at which it changes states on a positive-going signal. The difference between the two input voltage levels at which the two changes in state occur is the hysteresis of the circuit. In order to obtain maximum triggering sensitivity, the hysteresis must be kept as small as possible. To reduce the hysteresis, resistance is introduced between the two cathodes by means of the TRIGGER SENSITIVITY adjustment, R47. Due to the drop across this resistance, the cathode voltage of the non-conducting tube is moved closer to its grid voltage, so that the grid will not have to move as far to bring the tube into conduction and cause the multivibrator to change states. Too much resistance between the cathodes causes the multivibrator to oscillate during transitions from one state to the other.

As will be seen in the discussion of the Time-Base Generator, not every negative trigger pulse from the Time-Base Trigger initiates a sweep. Negative trigger pulses which arrive at the Time-Base Generator during the time that a sweep is in progress will have no effect on the circuit. It is only after a sweep has been completed and all circuits have returned to their quiescent state that the Time-Base Generator will be retriggered by a trigger pulse from the Time-Base Trigger.

Triggering Mode

The red TRIGGER SELECTOR control, SW10B, selects the type, or mode, of triggering. In the DC position, the triggering signal is dc-coupled to the Trigger Input Amplifier, which in turn is dc-coupled to the input of the Trigger Multivibrator. R30 isolates the plate of V24B from the capacitance of the switch; R32 isolates the grid of V45A from the switch. It should be noted that with SW10A in the INT. position, and SW10B and the appropriate POLARITY switch in the DC position, complete dc-coupling exists from the input of the Vertical Amplifier to the Trigger Multivibrator.

In the AC position of SW10B, capacitor C10 is connected into the input circuit. This prevents the dc component of the triggering signal from reaching the Trigger Input Amplifier. The Trigger Input Amplifier, however, is still dc-coupled to the Trigger Multivibrator.

In the AUTO. position of SW10B, the Trigger Multivibrator is converted from a bistable configuration to an astable (free-running) configuration by the addition of feedback from the grid of V45B to the grid of V45A through R40. In addition, the dc coupling between the Trigger Input Amplifier and the Trigger Multivibrator is removed when the switch is in the AUTO. position.

To understand the operation of the Trigger Multivibrator in the free-running mode of operation, first assume that V45B is cut off and V45A is just being driven into cutoff by the charge on C31. The voltage at the plate of V45A starts to rise, carrying with it the voltage at the grid of V45B. V45B then starts to conduct, causing a negative step at its plate. Since the two grids are coupled through R40, the grid of V45A will start moving positively at the same time as the grid of V45B. However, the time constant of C31 and the resistances in the grid circuit of V45A is such that it takes about 0.01 second for the voltage at the grid of V45A to rise exponentially from its starting point, below cutoff, to a point where the tube will start conducting.

When V45A does start conducting, its plate voltage will drop, carrying with it the grid of V45B. V45B will cut off causing a positive step at its plate. At the same time that the grid of V45B goes negative, the grid of V45A will also start negative. Once again, it will take about 0.01 second for C31 to charge up sufficiently to cut V45A off. When V45A does cut off, the cycle starts over. Thus, the Trigger Multivibrator free runs at about 50 Hz.

During the automatic mode of operation, the total voltage change at the grid of V45A is about 3 volts. Since the grid of V45A is never more than 3 volts from cutoff, a triggering signal from the Trigger Input Amplifier 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 than 3 volts can drive the V45A grid into cutoff if they occur at a time when the exponentially changing grid voltage is approaching the cutoff level of the tube (relatively later in the time interval during which V45A is conducting).

Hence, in the absence of any triggering signal, the Trigger Multivibrator free runs at about 50 Hz. However, since the triggering signals are still coupled to the Trigger Multivibrator through C31, virtually any triggering signal over 50 Hz in frequency and of sufficient amplitude will produce synchronized operation of the Trigger Multivibrator. The 50-Hz free-running sweep produced in the absence of a triggering signal provides a base line from which to make voltage measurements and also indicates that the instrument is adjusted to display any signal that might be applied to the input.

The Trigger Multivibrator has a maximum switching frequency of about 5 MHz. Therefore, when it is desired to display signals above that frequency, the Time-Base Trigger is bypassed by placing SW10B in the HF SYNC position and the incoming signal is applied directly to the Time-Base Generator. The STABILITY control is advanced to produce a free-running sweep and the signal becomes a synchronizing signal, rather than a triggering signal, which synchronizes the free-running sweep to a submultiple of its frequency.

TIME-BASE GENERATOR

The Time-Base Generator, upon receipt of a negative trigger pulse from the Time-Base Trigger, produces a linearly rising (sawtooth) voltage which is applied through the Horizontal Amplifier to the crt horizontal deflection plates. This causes the spot to move from left to right on the crt screen and form the trace. The amplitude of the sawtooth voltage is about 150 volts. Its rate of rise is controlled by the values of the Timing Capacitor and Timing Resistor switched into the circuit by the TIME/DIV. control on the front panel.

The Time-Base Generator consists of three main circuits; the Sweep-Gating Multivibrator, the Miller Runup Circuit, and the Hold-Off Circuit. The Sweep-Gating Multivibrator consists of V135A, V135B, and V145A. The essential components of the Miller Runup Circuit are: The Miller Runup Tube, V161A; the Runup Cathode Follower, V161B; the Disconnect Diodes, V152A and V152B; the Timing Capacitor, C160; and the Timing Resistor, R160. The Hold-Off Circuit consists of the Hold-Off Cathode Followers, V183A and V183B; the Hold-Off Capacitor, C180; and the Hold-Off Resistors, R180A and R180B. Also considered a part of the Time-Base Generator are the Unblanking Cathode Follower, V145B, the + Gate-Out Cathode Follower, V193A, and the Sawtooth Out Cathode Follower, V193B.

A block diagram of the Time-Base Generator is shown in Fig. 4-5.

Sweep Generation

In the quiescent state—that is, when no sweep is being generated—V135A is conducting and V145A is cut off. (The STABILITY control, R110, or the PRESET STABILITY adjustment, R111, whichever is in the circuit, is set so that the grid of V135A is just above cutoff voltage.) The plate of V145A is

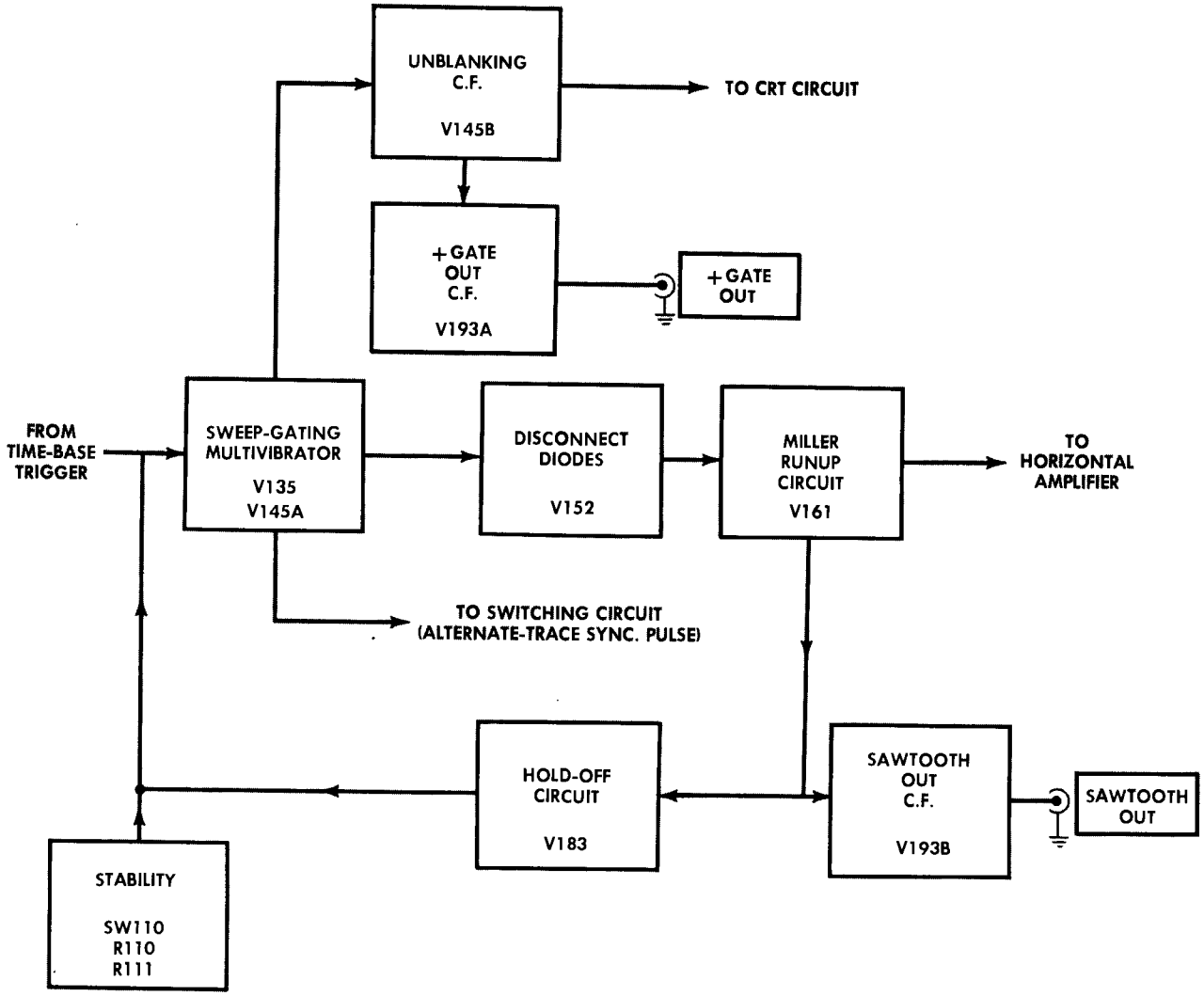


Fig. 4-5. Time-Base Generator block diagram.

at about —2.5 volts with respect to ground. The Disconnect Diodes are conducting and hold both sides of the Timing Capacitor at about —2.5 volts. With its cathode grounded and its grid at —2.5 volts, the Miller Runup tube, V161A, is conducting heavily and its plate is at about +30 volts.

A negative trigger pulse, arriving at the grid of V135A from the Time-Base Trigger, causes the Sweep-Gating Multivibrator to switch rapidly to its other state. That is, V135A cuts off and V145A conducts. V135A is held in cut off after the trigger pulse passes by a rise in voltage at the common cathode connection. As V145A conducts, its plate voltage goes down, cutting off the Disconnect Diodes. When the Disconnect Diodes cut off, the plates of the Timing Capacitor are no longer held at —2.5 volts, and the Timing Capacitor starts to charge toward the instantaneous potential difference between the —150-volt supply and the potential at the cathode of V161B. However, as the lower side of the Timing Capacitor starts to move in a negative direction, it takes the grid of V161A with it. This produces a positive swing at the plate of V161A which is coupled, through B167 and V161B, to the top of the Timing Capacitor. This increases the voltage to which the Timing Capacitor is trying to charge. The effect is to "straighten out" the charging curve by increasing the charging voltage with each increment of charge on the capacitor. The positive swing at the top of the Timing Capacitor also tends to prevent the lower side from swinging negatively. Since the gain of V161A is about 150, the potential at the top of the Timing Capacitor moves about 150 volts with respect to ground while the potential at the lower side moves about one volt. The result is an extremely linear sawtooth at the cathode of V161B, which is applied through the Horizontal Amplifier to the horizontal deflection plates of the crt. This sawtooth is also coupled through the cathode follower V193B to the SAWTOOTH OUT connector on the front panel.

Sweep Length

The length of the sweep—that is, the distance the spot moves across the crt—is determined by the setting of the SWP. LENGTH adjustment, R176. As the sweep voltage rises linearly at the cathode of V161B, there will be a proportionate rise in the voltage at the wiper arm of the SWP. LENGTH adjustment. This rise is coupled through the two Hold-Off Cathode Followers, V183A and V183B, to the grid of V135A. When the voltage rises to the point where V135A comes out of cutoff, the Sweep-Gating Multivibrator will rapidly revert to its original state with V135A conducting and V145A cut off. The voltage at the plate of V145A will then rise, carrying with it the voltage at the plates of the Disconnect Diodes.

V152B starts conducting and discharges the Timing Capacitor. This brings the grid of V161A quickly back up to its quiescent level. The rise in voltage at the grid causes the tube to conduct more, so the plate voltage drops, carrying with it the grid and cathode of V161B. When the voltage at the cathode of V161B returns to about —2.5 volts, V152A conducts, clamping the voltage at this point

The time during which the voltage at the plate of V161A and the cathode of V161B drops is the sweep trace interval. The trace is blanked during this time and during the hold-off time following it.

Hold-Off Circuit

The Hold-Off Circuit prevents the Time-Base Generator from being triggered following the completion of a sweep until after the Miller Runup Circuit has stabilized in the quiescent condition. It does this by holding the grid of V135A positive enough to prevent it from being taken into cutoff by the negative trigger pulses from the Time-Base Trigger.

When no sweep is being generated, the arm of the SWP. LENGTH potentiometer and, therefore, the grid of V183B are at about —90 volts. Normal operating bias on V183B is about 5 volts, so the Hold-Off Capacitor, C180 and/or C181, is charged to about 85 volts. During the sweep, the Hold-Off Capacitor discharges to about 45 volts through V183B as a result of the rise in voltage on the grid. At the end of the sweep, the voltage at the grid of V183B drops back to —90 volts. The cathode tries to follow but is held up by the charge on the Hold-Off Capacitor. The Hold-Off Capacitor starts to charge again exponentially toward 85 volts, carrying the grid of V183A negative. The cathode of V183A and the grid of V135A follow the grid of V183A. When the Hold-Off Capacitor charges to the point where V183A cuts off (V183A is normally cut off between sweeps), it loses control over the grid of V135A, which then returns to the level established by the setting of the STABILITY or PRESET STABILITY control.

The amount of hold-off time, then, is determined by the value of capacitance and/or resistance switched into the Hold-Off Circuit by the TIME/DIV. control. (See the Timing Switch circuit diagram.) The amount of hold-off time required is determined by the sweep rate. For this reason the TIME/DIV. control changes the time constant of the Hold-Off Circuit as well as that of the Timing Circuit.

Sweep Stability

The STABILITY control, R110, (or the PRESET STABILITY adjustment, R111, depending upon the mode of operation) regulates the dc level at the grid of V135A. This control is adjusted so that the voltage at the grid of V135A is just high enough to hold V135A out of cutoff. When the circuit is adjusted in this manner, a sweep will be produced only when a negative trigger pulse from the Time-Base Trigger drives V135A into cutoff. Turning the STABILITY control fully clockwise (when SW10B is in the DC, AC, or HF SYNC position) places a sufficiently negative voltage on the grid of V135A that V135A cuts off immediately upon decay of the hold-off voltage and initiates the next sweep without a trigger pulse. The result is a free-running sweep whose period is the total of the sweep time plus the hold-off time at any given setting of the TIME/DIV. control.

Unblanking

The positive rectangular pulse appearing at the cathode of V135B in the Sweep-Gating Multivibrator is coupled through the Unblanking Cathode Follower, V145B, to the grid circuit of the crt to unblank the crt during sweep time. This unblanking pulse is also coupled through the cathode follower V193A to the +GATE OUT connector on the front panel.

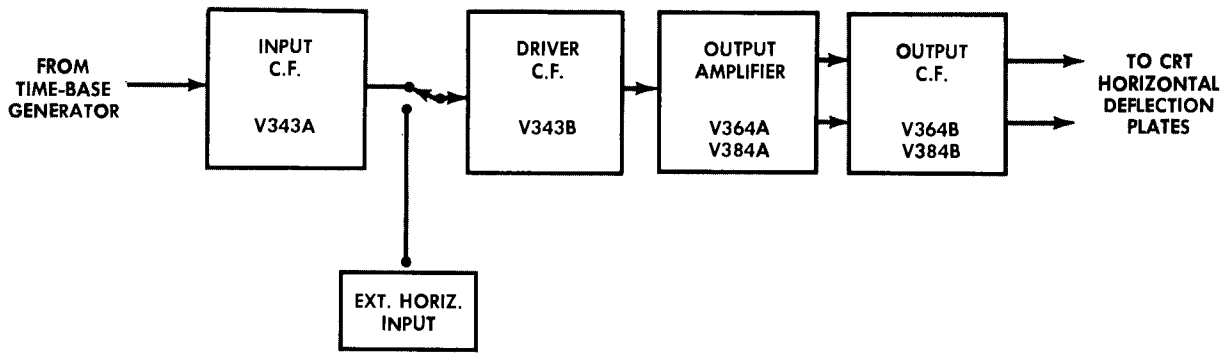


Fig. 4-6. Horizontal Amplifier block diagram.

HORIZONTAL AMPLIFIER

The Horizontal Amplifier consists of the Input Cathode Follower, the Driver Cathode Follower, the Output Amplifier, and the Output Cathode Follower stage. A block diagram of the Horizontal Amplifier is shown in Fig. 4-6.

The sweep waveform is coupled to the grid of the Input Cathode Follower, V343A, via the frequency-compensated voltage divider, R330-R332. The HORIZONTAL POSITION control, R333A, supplies a manually adjustable dc voltage to the grid of V343A for horizontal positioning of the crt beam. The C340-R340 network produces a small step at the start of the waveform at the faster sweep rates. This step is necessary to compensate for the bandpass-limiting effect of the stray capacitance in the amplifier. By its application the sweep will start linearly at the faster sweep rates. The Input Cathode Follower provides the necessary low impedance to drive the switch capacitances and the Driver Cathode Follower, V343B; the Driver Cathode Follower isolates the Output Amplifier from the HORIZONTAL DISPLAY switch.

In the MAG. position of the HORIZ. DISPLAY switch, the sweep waveform is coupled by the Driver Cathode Follower directly to the Output Amplifier, V364A-V384A. This stage is a cathode-coupled paraphase amplifier which converts the single-ended input to a push-pull output. The waveform is then coupled by the Output Cathode Follower stage, V364B-V384B, to the horizontal deflection plates. The MAG. GAIN ADJ., R259, varies the degeneration in the cathode circuit of the Output Amplifier and thus sets the gain of the stage. C260 reduces the degeneration at higher frequencies and thus compensates the amplifier for faster sweep rates. Bootstrap capacitors C364 and C384 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 B346 is connected in the circuit when the HORIZ. DISPLAY switch is in the MAG. position to indicate that the magnifier circuits are in operation.

In the NORM. position of the HORIZ. DISPLAY switch, the gain of the amplifier is reduced by a factor of five by negative feedback. The feedback, from the cathode of V364B, is developed across R225 and R347, which have been switched into the grid circuit of V343B. When the HORIZ. DISPLAY switch is in the NORM. position, both the MAG. GAIN ADJ. R259, and the SWP. GAIN ADJ., R225, will vary the gain of the Horizontal Amplifier; for this reason, the MAG. GAIN ADJ. is adjusted only when the HORIZ. DISPLAY switch is in the MAG. position.

The SWP./MAG. REGIS. adjustment, R358, sets the dc level at the grid of V343B so that the portion of the waveform at the horizontal center of the graticule will not shift as the HORIZ. DISPLAY switch is switched between the NORM. and MAG. positions.

In the EXT. position of the HORIZ. DISPLAY switch, the grid of the Driver Cathode Follower is connected to the EXT. HORIZ. INPUT connector on the front panel. With this arrangement, the horizontal signal is obtained from an external source rather than from the Time-Base Generator. The HORIZ.-INPUT ATTEN. control, R349 (ganged with the STABILITY control), provides adjustable attenuation of the externally applied signal. Horizontal positioning is provided by R333B rather than R333A when the HORIZ. DISPLAY switch is in the EXT. position.

Placing the HORIZ. DISPLAY switch in the EXT. position also disables the Time-Base Generator by opening the cathode circuit of the Sweep-Gating Multivibrator.

POWER SUPPLY

Plate and filament power for the tubes in the Type 516 Oscilloscope is furnished by a single transformer, T601. The primary has two equal tapped windings which are connected in parallel for 117-volt operation or in series for 234-volt operation. Two auxiliary windings are also provided to furnish aiding or bucking currents, as desired, for certain other primary source voltages (see Section 2).

The three main full-wave power supplies furnish regulated voltages of −150, +100, and +300 volts. The +300-volt supply also has an unregulated output of about 400 volts

for the high-voltage supply for the crt. It is unnecessary to regulate this supply as the high-voltage supply has its own regulating circuit.

Reference voltage for the —150-volt supply is established by a gas diode, VR tube V609. This tube, which has a constant voltage drop, establishes a fixed potential of about —84 volts at one grid of the Difference Amplifier, V634. The grid potential for the other half of the Difference Amplifier is obtained from a voltage divider consisting of R615, R616 and R617. The setting of the —150 ADJ., R616, determines the percentage of the total output voltage that appears at the grid of V634B and thus determines the total voltage across the divider. When this adjustment is properly set, the output voltage of the —150-volt supply will lie somewhere between —147 volts and —153 volts.

Should the loading on the supply tend to change the output voltage, the potential at the grid of V634B will change in proportion, and an error voltage will exist between the two grids of the Difference Amplifier. The error signal is amplified by V634A, whose plate is dc-coupled to the grid of the Series Tube, V627. The error voltage appearing at the grid of V627 will change the bias and, hence, the effective resistance of V627. This will allow more or less current, as required, to flow through the load to bring the output voltage back toward its original level. C617 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 both the +100-volt and +300-volt supplies. In the +100-volt supply, the voltage divider R650-R651 establishes a voltage of essentially zero at the grid of the Amplifier, V654. (The actual voltage at this grid will be equal to the bias voltage required by the tube.) 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, V667A. The cathode of V667A will follow the grid, and thus the output voltage will be returned to its established value of +100 volts. C650 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 V654 through R657. This ripple signal appearing at the screen (which acts as an injector grid) will produce a ripple component at the grid of V667A which is opposite in polarity to the ripple appearing at the plate of V667A. This tends to cancel the ripple at the cathode of V667A, 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 8 and 9 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 output of about 400 volts for the crt high-voltage supply.

CRT CIRCUIT

A 60-kHz Hartley oscillator circuit furnishes energy for the three power supplies that provide accelerating voltages for the crt. The main components of the oscillator are V800 and the primary of T801 tuned by C808.

The rectifier circuits are the half-wave type, with capacitor-input filters. Separate supplies are required for the grid and cathode circuits in order to provide dc-coupled unblanking to the grid supply.

V822 supplies —1675 volts for the cathode of the crt. V842 supplies +2325 volts for the post-anode acceleration. This provides an accelerating voltage of 4000 volts for the crt beam. V832 supplies about —1750 volts for the grid of the crt (the actual voltage depends upon the setting of the INTENSITY control, R826).

In order to maintain a constant deflection sensitivity in the crt, and thereby maintain the calibration of the oscilloscope, it is necessary that the accelerating potentials in the crt remain constant. This is accomplished by regulating the three supplies by comparing a "sample" of the high voltage to the regulated —150-volt supply. The "sample" voltage, obtained from the arm of the HV ADJ., R841, is applied to the grid of V814B; the cathode of this tube is connected to the regulated —150-volt supply. The error signal is amplified by V814B and V814A; the output of V814A varies the screen voltage of the oscillator tube, thereby controlling the amplitude of its output.

Unblanking

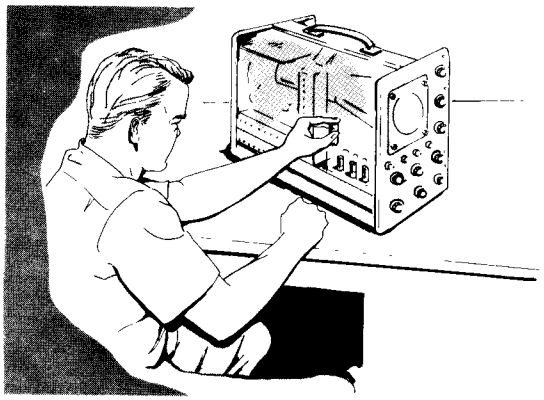
As mentioned previously, dc-coupled unblanking is accomplished by employing separate high-voltage supplies for the grid and cathode. The cathode supply is tied to the +100-volt supply via the decoupling network, R801-C801A. The grid supply, on the other hand, is not tied to any other supply, and is therefore "floating". The unblanking pulses from the Time-Base Generator are transmitted to the grid of the crt via the floating grid supply.

The stray capacitance in the circuit makes 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 C827, R827, and R828 is employed. By this arrangement, the fast leading edge of the unblanking pulse is coupled directly to the grid of the crt via C827. For short-duration unblanking pulses (at the faster sweep rates), the power supply itself is not appreciably moved. For longer unblanking pulses (at the slower sweep rates), however, the stray capacitance of the circuit is charged through R827. This holds the grid at the unblanked potential for the duration of the unblanking pulse.

AMPLITUDE CALIBRATOR

The Amplitude Calibrator is a square-wave generator whose output is available at the CAL. OUT connector on the front panel. It consists of an astable multivibrator, V885A and V875, connected so as to switch the Cal. Out Cathode Follower, V885B, between two operating states, cutoff and conduction, at approximately 1 kHz.

During the negative portion of the multivibrator waveform, the grid of V885B is driven well below cutoff and the cathode rests at ground potential. The CAL. ADJ. potentiometer, R879, is adjusted so that the voltage at the cathode of V885B (CAL. TEST PT.) rises to exactly +100 volts during the positive portion of the mutivibrator waveform. The tapped cathode resistor provides eleven calibrated outputs, from 0.05 volt to 100 volts, which are used for calibrating the gain of the Vertical Amplifier and adjusting the compensation of attenuator probes.



SECTION 5

MAINTENANCE

Preliminary Instructions

PREVENTIVE MAINTENANCE

Visual Inspection

Every few months, the oscilloscope should be visually inspected for possible circuit defects. These defects may include such things as loose or broken connections, damaged binding posts, improperly seated tubes, scorched wires or resistors, missing tube shields, and broken terminal strips. For most visual troubles the remedy is apparent; however, particular care must be taken when heat-damaged components are detected. Overheating of parts is often the result of other, less apparent, defects in the circuit. It is essential to determine the cause of overheating, before replacing heat-damaged parts, in order to prevent further damage.

Calibration

The Type 516 Oscilloscope is a stable instrument which should provide many hours of trouble-free operation. However, to insure the reliability of measurements we suggest that you calibrate the instrument after each 500 hours of operation (or every six months if used intermittently). A complete step-by-step procedure for calibrating the instrument is presented in Section 6 of this manual.

Air Filter

The Type 516 Oscilloscope is cooled by forced, filtered air. This instrument is equipped with a washable air filter, constructed of aluminum wool coated 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 briskly, from the dirty side, with hot water. Or, if preferred, it may be washed with hot, soapy water. After rinsing and drying, the filter should then be coated with "Handi-Coater" or "Filter-coat", products of the Research Products Corporation. These products are generally available from air-conditioner suppliers.

Fan Motor

The bearings in the fan motor are sintered bronze oilite bearings and do not require oiling.

REMOVAL AND REPLACEMENT OF PARTS

General Information

Procedures required for replacement of most parts in the Type 516 Oscilloscope are obvious. Detailed instructions for their removal are therefore not required. Other parts, however, can best be removed if a definite procedure is followed. Instructions for the removal of some of these parts are contained in the following paragraphs. Parts ordering information is included in the Parts List Section.

Because of the nature of the instrument, replacement of certain parts will require recalibration of sections of the oscilloscope to insure proper operation.

Removal of Side Panels

The side and bottom panels of the Type 516 Oscilloscope are held in place by small screwhead fasteners. To remove the panels, use a screwdriver to rotate the fasteners approximately two turns counterclockwise and pull the panels away from the instrument (see Fig. 5-1). In replacing the side panels, be sure that they are fitted properly at the bottom before fitting the top portion into place. The two side panels are perforated differently to promote proper air flow within the instrument. They should not be interchanged. Fig. 2-2 shows the two side panels correctly mounted.

Replacement of the Cathode-Ray Tube

To remove the cathode-ray tube, first disconnect the tube socket and the five leads connected to the neck of the tube. Remove the graticule cover, spacer washers, graticule, and graticule light shield. Loosen the tube clamp at the base of

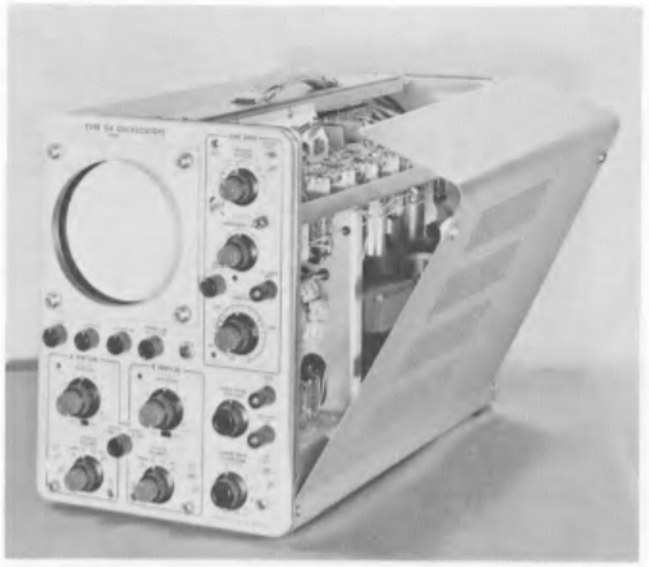


Fig. 5-1. Removing the oscilloscope side panels.

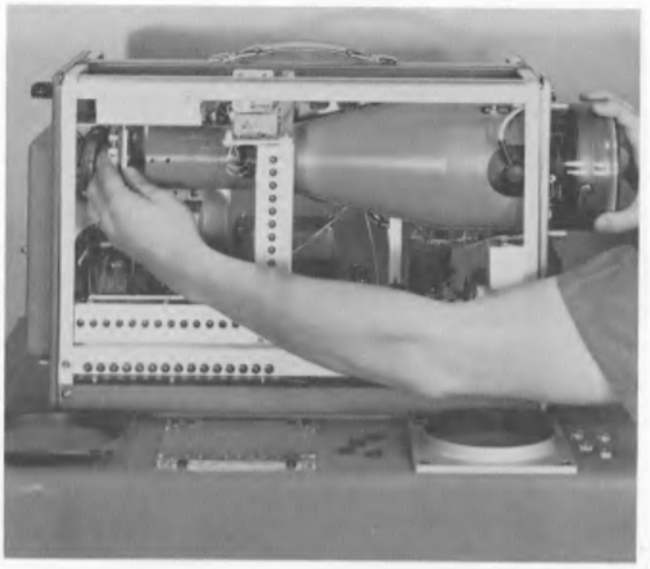


Fig. 5-2. Removing the cathode-ray tube.

the crt. Remove the crt by pushing forward on the tube base and then pulling the tube straight out through the front panel (see Fig. 5-2).

When the new crt is in place, the leads can be properly connected to the neck of the tube by following the color code information provided on the tube shield. After replacement of the crt, it may be necessary to calibrate certain portions of the oscilloscope. Special attention should be given to calibration of the sweep timing and the Vertical Amplifier gain.

Replacement of Switches

Methods for removal of defective switches are, for the most part, obvious and only a normal amount of care is required. Single wafers are normally not replaced on the switches used in the instrument. If one wafer is defective, the entire switch should be replaced. Switches can be ordered from Tektronix either wired or unwired, as desired.

Tube Replacement

Care should be taken both in preventive and corrective maintenance that tubes are not replaced unless they are actually causing trouble. Often during routine maintenance it will be necessary to remove tubes from their sockets. It is important that these tubes be returned to their original sockets unless they are actually defective. Unnecessary replacement or switching of tubes will often necessitate calibration of the instrument. If tubes do require replacement, it is recommended that they be replaced by previously checked, high-quality tubes.

Soldering Precautions

In the production of Tektronix instruments, a special silver-bearing solder is used to establish a bond to the ceramic terminal strips. This bond can be broken by repeated use of ordinary tin-lead solder, or by the application of too much heat. However, occasional use of ordinary solder will not break the bond if too much heat is not applied.

It is advisable to have a stock of solder containing about 3% silver if you frequently perform work on Tektronix instruments. This type of solder is used frequently in printed circuitry and should be readily available. It may also be purchased directly from Tektronix in one-pound rolls (order by Tektronix Part Number 251-0514-00).

Because of the shape of the terminals on the ceramic terminal strips, it is advisable to use a wedge-shaped tip on your soldering iron when installing or removing parts from the strips. A wedge-shaped tip allows you to apply heat directly to the solder in the terminals and reduces the amount of heat required. It is important to use as little heat as possible.

Ceramic Terminal Strips

Damaged ceramic terminal strips are most easily removed by unsoldering all connections, then using a plastic or hard

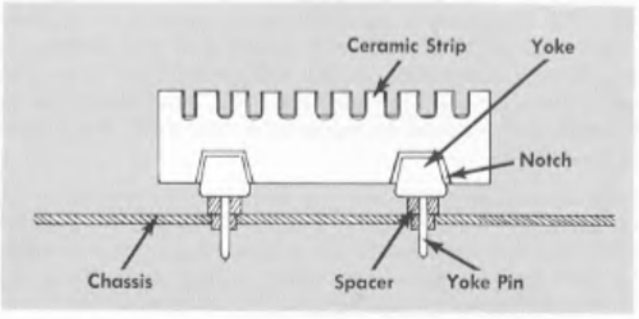


Fig. 5-3. Installation of ceramic terminal strips.

rubber mallet to knock the yokes out of the chassis. This can be done by pounding on the ends of the yoke protruding through the chassis. This removes both the strip and the yoke assembly.

When the damaged strip and yoke assembly have been removed, place the spacers for the new strip into the holes in the chassis. Snap the ceramic strip into the yokes and place the tip of the yoke pins into the spacers. Using a plastic or hard rubber mallet, tap the ceramic strip lightly above the yokes to drive the yoke pins down through the spacers. Be certain that the yoke pins are driven completely through. Using a pair of diagonal cutters, cut off the excess length of the yoke pins protruding beyond the spacers. Fig. 5-3 illustrates the way that the parts fit together.

Troubleshooting

The Troubleshooting section is divided into two parts, Circuit Isolation and Circuit Troubleshooting. When a trouble occurs in the instrument, refer first to the Circuit Isolation section for instructions on how to isolate the trouble to a given circuit. After determining which circuit is at fault, refer to the Circuit Troubleshooting section, where procedures for troubleshooting each circuit are given. Before attempting to troubleshoot the Type 516 Oscilloscope, however, make sure that any apparent trouble is actually due to a malfunction within the instrument and not due to improper control settings. Operating instructions are contained in Section 3 of this manual.

Apparent trouble may be due to improper calibration of one or more circuits. One of the first steps in any troubleshooting procedure should be to check the calibration of the suspected circuit.

Power-supply output voltages should be checked whenever any type of trouble occurs in the instrument. Due to the circuit configurations employed in the Type 516, it is possible for an incorrect power-supply voltage to affect one circuit more than others. When all but one circuit in the oscilloscope is functioning properly, there is a tendency to overlook the Power Supply as a source of the trouble and to concentrate on the circuit where the trouble apparently exists. In cases of this type, valuable time may be saved by checking the power supplies first. If the output and ripple voltages of the regulated power supplies are correct, the power supplies can be assumed to be operating correctly.

When the trouble has been isolated to a definite circuit, perform a complete visual check on that circuit. Many troubles can be found easily by visual means. If the visual check fails to reveal the cause of the trouble, check the tubes by substitution. Do not depend on tube testers to adequately indicate the suitability of a tube for use in the instrument. The criterion for usability of a tube is whether or not it works satisfactorily in the instrument. Be sure to return good tubes to the same sockets from which they were removed.

Separate circuit diagrams for each circuit are contained in the Diagrams section of this manual. In addition, a block diagram provides an overall picture of instrument operation. The reference designation of each electronic component of the instrument is shown on the circuit diagrams. The following chart lists the reference designation numbers associated with each circuit.

All numbers less than 100	Time-Base Trigger
All 100 numbers	Time-Base Generator
All 200 and 300 numbers	Horizontal Amplifier
All 400 and 500 numbers	Vertical Amplifier
All 600 numbers	Power Supply
All 800 numbers	Crt Circuit and Calibrator

Switch wafers shown in the circuit diagrams are coded to indicate the position of the wafer on the switch. The number portion of the code refers to the wafer number on the switch assembly. Wafers are numbered from the front of the switch to the rear. The letters F and R indicate whether the front or the rear of the wafer is used to perform the particular switching function.

CIRCUIT ISOLATION

This portion of the Troubleshooting procedure lists some of the troubles that can be caused by a circuit failure in the Type 516 Oscilloscope. It also describes checks that can be made to isolate the faulty circuit or circuits. In some cases simple front panel checks can determine which circuit is defective, but in other cases internal checks and/or measurements are required.

The crt display can often be used to isolate the trouble to one particular circuit. If there is no vertical deflection, for example, when the intensity and horizontal deflection appear to be normal, an open condition probably exists in the Vertical Amplifier and this circuit should be investigated first.

Although the Type 516 Oscilloscope is a complex instrument, it can be thought of as consisting of six main circuits in addition to the Calibrator Circuit. These are:

1. Power Supply
2. Crt Circuit
3. Time-Base Generator
4. Time-Base Trigger
5. Vertical Amplifier
6. Horizontal Amplifier

Whenever any trouble occurs in the instrument, first check the voltages at the points shown in Fig. 6-4, at the —1675- and +2325-volt checkpoints at the top rear of the instrument, and at the center arm of the INTENSITY potentiometer, R826. If all of these voltages are approximately as indicated (the voltage at the center arm of the INTENSITY potentiometer should be about —1700 volts when the INTENSITY control is set fully clockwise), proceed to the troubleshooting procedures described under the appropriate symptom. If the low voltages (—150, +100, and +300) are not as indicated, refer to the paragraphs on Troubleshooting the Power Supply. If the low voltages are as indicated but the high voltages (—1675, +2325, and INTENSITY potentiometer voltage) are not, refer to the paragraphs on Troubleshooting the Crt Circuit.

WARNING

Be careful of the power-supply voltages. The low-voltage Power Supply can cause more harm than the high-voltage supply (in the CRT Circuit) due to the higher current capabilities of the circuit. When you reach into the instrument to measure the voltage, do not touch the metal frame. If possible, stand on an insulated surface and use insulated tools and measuring probes.

The following troubleshooting information is divided according to the symtoms presented to the operator. Upon detecting an apparent trouble, use the symptoms to determine which circuit is at fault. Then refer to the Circuit Troubleshooting information, where the procedure for troubleshooting within the circuit is given.

No Trace on the Crt Screen

Normally, you should obtain two traces on the crt screen when the STABILITY control is set for a free-running sweep (fully clockwise), the MODE switch is set to the ALTERNATE position, the HORIZ. DISPLAY switch is set to NORM., and the POSITION controls are set to about midrange. If one of the two traces is missing under these conditions, there is an unbalance in the vertical input channel for which there is no trace. (The channel which controls the displayed trace can be determined by noting which VERTICAL POSITION control moves the trace up and down.) In this case, adjust the DC BAL. control of the faulty channel. If the trace is obtained, try to set the DC BAL. control according to the procedure given in the Calibration section of this manual. If a trace is not obtained, or if it is not possible to set the control as described, turn to the instructions for troubleshooting the Vertical Amplifier later in this section of the manual.

If only two spots are present when the controls are set as described in the previous paragraph, and the spots can be moved with the HORIZONTAL POSITION control, then the trouble is in the Time-Base Generator. If the spots cannot be moved with the HORIZONTAL POSITION control, then the trouble is in the Horizontal Amplifier.

If no spot or trace at all is present on the face of the crt, the trouble may be in the Power Supply, the Vertical Amplifier, the Horizontal Amplifier, the Time-Base Generator, or the Crt Circuit. To determine which circuit is at fault in this case, set all POSITION controls to midrange, the HORIZ. DISPLAY switch to the EXT. position, and turn the INTENSITY control clockwise. If a spot now appears on the screen, either the Time-Base Generator or the first stage of the Horizontal Amplifier is at fault.

If a spot does not appear, short the vertical deflection plates together at the neck pins of the crt.

CAUTION

Be careful not to short the deflection plates to the metal shield around the crt, or to the GEOM. neck pin. Also be ready to turn the INTENSITY control down quickly when a spot does appear so as not to burn the crt screen.

If a spot now appears on the screen, either the Vertical Amplifier or the Delay Line is at fault. If no spot appears, remove the shorting strap from the vertical deflection plate pins and short the horizontal deflection plates together. If a spot now appears, the trouble is in the Horizontal Amplifier.

If no spot or trace appears during any of the previous checks, a defect in the Crt Circuit, possibly in the crt itself, is indicated.

Insufficient or No Vertical Deflection, or Waveform Distortion

These troubles are all caused by a defective Vertical Amplifier and/or Delay Line. Refer to the instructions for troubleshooting these circuits. If there is reduced deflection sensitivity both vertically and horizontally, the trouble is probably in the Crt Circuit.

Insufficient Horizontal Deflection

This condition can be produced by the Time-Base Generator or the Horizontal Amplifier.

The operation of the Time-Base Generator can be checked from the front panel. Set the HORIZ. DISPLAY switch to the NORM. position, the TIME/DIV. switch to .5 SEC, and adjust the STABILITY control for a free-running sweep (fully clock-

wise). Connect a voltmeter between the SAWTOOTH OUT connector and ground. If the voltage varies between zero and +150 volts ±15%, as the Miller circuit runs up and back, the Time-Base Generator is operating correctly. This means that the trouble is in the Horizontal Amplifier. No voltage variation at this point, or a variation of significantly less than 150 volts, indicates trouble in the Time-Base Generator circuit.

Nonlinear Horizontal Sweep

The linearity of the horizontal deflection circuit can be checked by connecting a marker generator or the Calibrator output to the Vertical input of the oscilloscope. Set the MODE switch to correspond to the Vertical Channel being used, and adjust the Time-Base controls for a stable display. If the displayed markers, or the square waves produced by the Calibrator, are not symmetrically spaced across the crt, a nonlinear sweep is indicated. This condition can be caused by nonlinear amplification in the Horizontal Amplifier, or by the generation of a nonlinear sawtooth in the Time-Base Generator.

To determine which circuit is at fault, connect a jumper wire from one of the Vertical input connectors to the SAWTOOTH OUT connector.

CAUTION

To avoid shorting the 150-volt sawtooth to the chassis, connect the jumper wire to the input connector before connecting it to the SAWTOOTH OUT connector.

Set the appropriate VOLTS/DIV. switch to 20, and adjust the STABILITY control for a free running sweep (fully clockwise). If the TIME/DIV. control is set to a rate of 1 mSEC or faster, a steady diagonal trace will be seen on the crt. This trace is the sweep portion of the sawtooth voltage produced by the Time-Base Generator. If the slope of the trace is constant, the nonlinearity is being produced in the Time-Base Generator. If the slope of the trace is not constant, the nonlinearity is being produced in the Horizontal Amplifier. Refer to the instructions for troubleshooting the Horizontal Amplifier.

Improper Sweep Timing

If the sweep timing is off in some, but not all, positions of the TIME/DIV. control, one of the timing resistors or timing capacitors has changed in value. By comparing the switch positions in which the timing is incorrect with the Timing Switch diagram, you will be able to tell which components are common to these positions.

If the timing is off in all positions of the TIME/DIV. control, the Horizontal Amplifier is probably the circuit at fault. However, it is important that the Power Supply voltages be checked first. Check to see if the timing circuits can be calibrated in accordance with the instructions presented in the Calibration section of this manual. If the circuits cannot be adjusted for correct timing, then refer to the instructions for troubleshooting the Horizontal Amplifier.

Improper Triggering

The most probable cause of poor triggering (as compared with no triggering at all) is lack of calibration of the Time-Base Trigger. The first thing to check in the event of poor or erratic triggering, then, is the calibration of the Time-Base Trigger. Procedures for calibration are given in Section 6.

If the oscilloscope will not trigger at all, and yet a free-running trace can be produced by turning the STABILITY control fully clockwise, trouble exists in the Trigger Pickoff circuit of the Vertical Amplifier or in the Time-Base Trigger itself. If only the internal triggering is absent, the trouble is in the Trigger-Pickoff circuit or in SW10A in the Time-Base Trigger. If all triggering (internal, external, and line) is absent, then the trouble is in the Time-Base Trigger.

If stable triggering cannot be obtained and the free-running trace cannot be turned off with the STABILITY control, the trouble lies in the Sweep-Gating Multivibrator of the Time-Base Generator.

CIRCUIT TROUBLESHOOTING

This portion of the Troubleshooting procedure contains information for locating a defective stage within a given circuit. Once the stage at fault is known, the component or components causing the trouble can be located by tube and component substitution or by voltage and resistance measurements.

Tube failure is the most prevalent cause of circuit failure. For this reason, the first step in troubleshooting any circuit is to check for defective tubes, preferably by direct substitution.

If replacement of a defective tube does not correct the trouble, then check to see whether components, through which the tube draws current, have been damaged. Shorted tubes will often overload plate-load and cathode resistors. These components can often be located by a visual inspection of the circuit. If damaged components are not apparent, it will be necessary to make measurements or other checks within the circuit to locate the trouble.

Troubleshooting the Power Supply

Proper operation of every circuit in the Type 516 Oscilloscope depends upon proper voltages from the Power Supply. The voltages must remain within their specified tolerances for the instrument to maintain its calibration.

The regulated supply voltage busses are identified by color-coded wires, following the standard color code. The —150-volt bus is coded brown-green-brown; the +100-volt bus is coded brown-black-brown; and the +300-volt bus orange-black-brown. The widest stripe always identifies the first color in the code.

No Output Voltage. If there are no output voltages from the Power Supply, note whether the graticule lamps are lighted. If they are, then the trouble is in the Power Supply.

If the graticule lamps are not lighted and the fan is not going, check the power cord connections, the fuse, and the source of power. If your instrument is wired for 220-, 234-, or 248-volt operation, also check the Thermal Cut-Out Switch by checking the continuity through it with an ohmmeter. If your instrument is wired for 110-, 117-, or 125-volt operation and the fan is running but the graticule lamps are not lighted, check the Thermal Cut-Out Switch. If none of the above checks reveals the trouble, then the primary of T601 is probably open.

Failure to Regulate at the Correct Voltage. If any of the supplies fail to regulate, the first thing to check is the line voltage. The supplies are designed to regulate at line voltages between 105 and 125 volts at a nominal line voltage of 117 volts and within proportionate limits at the other nominal line voltage for which the instrument can be wired. Improper line voltages may cause the supply voltages to be off.

If the line voltage is the correct value, the next step is to turn the instrument off and measure the resistance between the Power Supply test points, shown in Fig. 6-4, and ground. The —150-volt test point should measure approximately 4500 ohms to ground, the +100-volt test point should measure approximately 4000 ohms to ground, and the +300-volt test point should measure approximately 12,000 ohms to ground.

If these values check out, the next step is to check the tubes. Then check the rms voltage across each secondary winding of the transformer. The voltage between terminals 8 and 9 should be about 195 volts ac; between terminals 15 and 16, about 125 volts ac; and between terminals 5 and 6, about 180 volts, ac. If these voltages are correct, check the rectified voltage at the input to each regulator. The voltage at the plate of V667 should be about +410 volts; at the plate of V667A, about +175 volts; and at the plate of V627, about +72 volts. If these voltages are all correct, check for open or leaky capacitors and improper resistance values, especially in the dividers. If it becomes necessary to adjust the —150 ADJ. potentiometer, it will be necessary to recalibrate the instrument.

The material that follows may be used as a quick index to troubleshooting the low voltage Power Supply.

If the output voltage is high with excessive ripple, check:

1. For high line voltage.
2. The amplifier tubes (V634, V654, V674).
3. For insufficient loading.

(Proper loading of the supplies can be checked by measuring the voltage drop across the 10-ohm resistors, R640, R642, and R644, in each supply. With the AMPLITUDE CALIBRATOR control set to OFF and the STABILITY control set so that no sweep is being produced (counterclockwise but not to PRESET), the drop across the resistors should be as follows: R640, 1.65 volts ±0.1 volt; R642, 1.4 volts ±0.1 volt; R644, 1.75 volts ±0.1 volt.)

If the output voltage is high with normal ripple, check for proper resistance values in the dividers (R615, R616, and R617; R650 and R651; R670 and R671).

If the output voltage is low with excessive ripple, check:

1. For low line voltage.
2. The series tubes (V667, V627).
3. For excessive loading.
4. Open or leaky filter capacitors.
5. Bad diode rectifiers.

If the output voltage is low with normal ripple, check:

1. The resistance values in the dividers.
2. The capacitors across the dividers.

Troubleshooting the CRT Circuit

If the trouble has been isolated to the Crt Circuit, first check the voltages at the —1675-volt test point and the +2325-volt test point at the top rear of the oscilloscope. If there is no voltage at either of these points, remove the high-voltage shield containing the two test point openings.

WARNING

Always turn the instrument off before removing or replacing either high-voltage shield.

Check for heater glow in the three high-voltage rectifier tubes, V822, V832, and V842. If there is no heater glow in any of these tubes, the high-voltage oscillator circuit is not oscillating. If there is heater glow in any or all of the three rectifier tubes, measure the voltage at the grid of the Oscillator tube, V800. If this voltage is about —55 volts, the oscillator is operating properly. If it is significantly less than —55 volts, the oscillator is not operating properly.

If the oscillator is not operating properly, and replacement of V814 and V800 does not correct the trouble, check the other components associated with the circuit, including the primary and secondary of T801.

If there is no voltage at either of the high-voltage test points, but the high-voltage Oscillator is found to be operating properly, then the trouble lies in the secondary of T801 or in one of the high voltage rectifiers. If this is the case, measure the voltage at the plate of V832. (This is the high-voltage rectifier tube nearest the centerline of the instrument; the plate is the connection at the forward end of the tube.) The voltage at this point should be in the vicinity of —1775 volts. If it is not, then trouble exists in some part of the circuit common to all three high-voltage supplies. If the voltage at the plate of V832 is in the vicinity of —1775 volts, then trouble exists in some part of the circuit peculiar to the —1675- and +2325-volt supplies.

If there are voltages present at the —1675-volt test point and the +2325-volt test point, but they are not of the proper value and cannot be brought to the proper value by adjustment of the HV ADJ. (R841), the regulator circuit (V814) is probably faulty, or the supply is being loaded down by a short somewhere in the circuit.

If the high-voltage supplies are normal but no spot is visible on the crt, check the continuity of the cathode circuit. Also, check the ASTIGMATISM control, R864, for proper re-

sistance and voltage. If a badly distorted spot or trace is visible on the crt, check the GEOMETRY ADJ. adjustment, R861, and its connection to the neck pin on the crt.

If the Crt Circuit checks out satisfactorily, but trouble still exists, replace the crt.

Troubleshooting the Vertical Amplifier

No Spot or Trace. If a trace or spot is visible when the vertical deflection plates are externally shorted together, but disappears when the short is removed, the vertical deflection system is in a state of dc unbalance. This could be caused by an open inductor in one side of the Delay Line, by an open peaking coil in the Vertical Amplifier, or by a faulty tube. To check for this condition, short the plates of the Output Amplifier together (V464 pin 6 and V474 pin 6). If the trace does not appear, one side of the circuit, between the Output Amplifier and the crt, is open. A continuity check with an ohmmeter is perhaps the best way to determine which side is open.

If the trace does appear, however, when the plates of the Output Amplifier stage are shorted together, the circuit is all right between this point and the crt. This means that the trouble lies somewhere ahead of the plate circuit of the Output Amplifier. Short the grids of the Driver Cathode Follower stage together (pins 2 and 7 of V463). If a trace does not appear, the trouble is in the Driver Cathode Follower stage or in the grid circuit of the Output Amplifier. Check tubes, peaking coils, resistors, and capacitors in the circuit.

If a trace does appear when the grids of the Cathode Follower are shorted together, check L455, L555, R455, and R555 in the grid circuit of the Driver Cathode Follower.

If a spot or trace appears on one vertical channel and not on the other, a dc unbalance condition exists in the defective channel. In this case, set the MODE switch to correspond to the defective vertical channel and use a shorting strap as follows to locate the defective stage. Short between corresponding points on opposite sides of the circuit, starting at the plates of the Switched Amplifier, V454 or V554, and working back toward the input connector. When a point is reached where the trace no longer appears as opposite sides of the circuit are shorted together, the stage immediately following this point is the stage in which the unbalance is being produced. (When the grids of the Input Amplifier or the cathodes of the Input Cathode Follower are shorted together, the VERTICAL POSITION control may have to be adjusted to bring the trace into view.) The trouble may be a defective tube, a shorted capacitor, a defective resistor, or a broken lead.

Insufficient or No Vertical Deflection. Insufficient vertical deflection indicates a change in the gain of the Vertical Amplifier. If the change is slight, the Vertical Amplifier can usually be recalibrated to allow for it. Refer to Section 6 of this manual for this procedure.

If the change in gain is more pronounced, or if there is no vertical deflection at all, check the tubes first. Then check components which can affect the gain but not the dc balance of the circuit; for example, the VARIABLE controls, the GAIN ADJ. potentiometer, plate-dropping resistors R422, R522, R432, R457, and R489, and the screen resistor, R468.

If gain trouble exists in only one vertical channel, then one of the first two stages (Input Cathode Follower or Input Amplifier) is probably at fault. If the gain trouble exists in both vertical channels then a Driver Cathode Follower and/or the Output Amplifier is probably at fault.

Waveform Distortion. Waveform distortion can be divided into two categories—low frequency and high frequency. High-frequency distortion normally appears as "overshoot" or "undershoot" at the leading edge of a high-frequency square wave, while low-frequency distortion is normally characterized by a "tilt" to the top and bottom of a low-frequency square wave.

The first thing to check, if waveform distortion is detected, is the adjustment of the probe. The procedure for adjusting a probe is described in Section 3 (see Fig. 3-2).

Faulty tubes are the most common cause of low-frequency distortion. Even though the vertical deflection system is dc-coupled from the attenuators to the crt, if certain tubes (depending on their grid circuits) start drawing grid current, a time-constant network can be established which will affect the low-frequency response of the circuit. If low-frequency distortion is observed, change the tubes in the suspected circuits.

Three types of high-frequency distortion are illustrated in Fig. 5-4. Insufficient high frequency peaking, which limits the risetime and consequently the bandwidth, will produce the "undershoot" type of distortion shown in Fig. 5-4 (a). This condition can be caused by tubes, particularly when

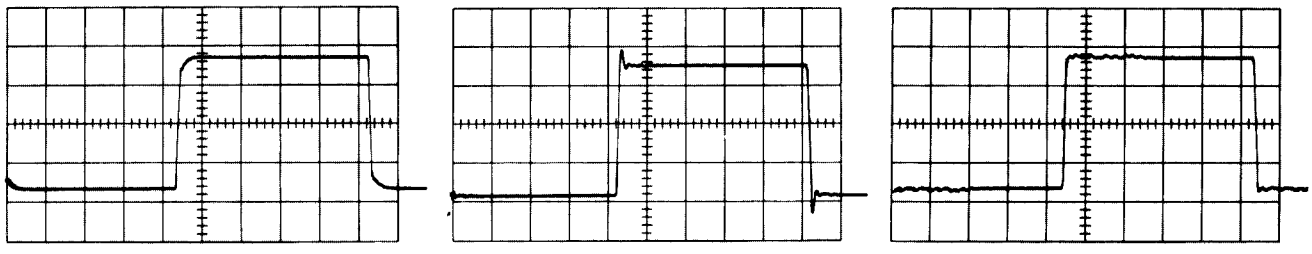


Fig. 5-4. Three types of high-frequency distortion. A 450-kHz square wave with a risetime of less than 0.020 microsecond was used for these pictures.

used as cathode followers working into peaking circuits. Shorted, or partially shorted, peaking coils are another common source; hot solder spilled on a peaking coil can cause this condition.

An "overshoot" such as shown acccentuated in Fig. 5-4 (b), is the result of excessive high-frequency peaking. This can be caused by a type of tube distortion known as cathode interface. The first thing to check, therefore, for this type of distortion is the tubes. If tube replacement does not correct the trouble, the variable peaking coils in the Vertical Amplifier may need adjusting. Refer to the Calibration section of this manual for the adjustment procedure.

The "wrinkle" condition, illustrated in Fig. 5-4 (c), is produced by an improperly adjusted Delay Line. Refer to the Delay Line Adjustment procedure in the Calibration section.

Improper Triggering. If the Time-Base Generator triggers normally in the EXT. and LINE position (+ or —), but does not trigger properly in the INT. position, a defect in the Trigger Pick-Off Circuit is indicated. In this case, the trouble would be either a defective Trigger Cathode Follower, V493, or a defective resistor in the circuit.

Troubleshooting the Time-Base Trigger

If the sweep cannot be triggered, and if the Trigger-Pickoff circuit in the Vertical Amplifier has been eliminated as the source of trouble, the Time-Base Trigger is at fault. (This assumes that the trace can be turned on and off with the STABILITY control.) The first thing to do is to replace both tubes in the Time-Base Trigger and try to recalibrate the circuit according to the procedure given in the Calibration section of this manual. If this does not correct the trouble, then trouble in the circuitry is indicated.

To check the quiescent state of the circuit, set the red TRIGGER SELECTOR control to AC, the black TRIGGER SELECTOR control to —INT., and the TRIGGERING LEVEL control to 0. Next, connect a jumper wire between the junction of R19, R20, and R21 and ground (see Fig. 6-6). This fixes the voltage at the grid of V24B at ground potential. Then measure the voltage at the plate of V24B (pin 1); it should be about +80 volts. If this voltage does not measure close to +80 volts, replace tube V24 again. Then, if necessary, check for such things as off-value resistors, broken leads, and poor switch contacts.

The next step is to measure the voltage difference between the two grids of V45 (pins 2 and 7). Since connecting a voltmeter at the grid of V45A (pin 2) may produce an adverse loading effect, it is recommended that this measurement be made between the plate (pin 1) of V24B and the grid (pin 7) of V45B. With the TRIG. LEVEL CENTERING adjustment, you should be able to bring the voltage at the grid of V45B to within 4 or 5 volts of the voltage at the plate of V24B. This indicates that the hysteresis of the Trigger Multivibrator can be set at the proper level with respect to the grid of V45A.

If the voltage at the grid of V45B cannot be brought to within 4 or 5 volts of the voltage at the plate of V24B with the TRIG. LEVEL CENTERING adjustment, trouble in the Trigger Multivibrator is indicated. In this case, replace V45 again; then, if necessary, check the rest of the circuit for off-value resistors or other troubles.

Remove the jumper wire between the junction of R19, R20, and R21 and ground.

Troubleshooting the Time-Base Generator

No Horizontal Sweep. If the Time-Base Generator is not producing a sawtooth waveform when the STABILITY control is set fully clockwise, some defect in the circuit is causing the output to remain at some fixed voltage. A clue to the cause of this trouble can be obtained by measuring the plate voltage of the Miller tube, V161A pin 6.

NOTE

All voltages in this section should be measured with a 20,000-ohms-per-volt voltmeter or a vacuum-tube voltmeter.

The voltage reading obtained at the plate of V161A will probably be approximately +260 volts, or approximately +30 volts. A reading of +260 volts indicates that the Miller Runup Circuit has run up and has not been reset, while a reading of +30 volts indicates that the Miller Runup Circuit is not being allowed to run up. The condition that exists will depend on the type of trouble. The two conditions of plate voltage will be handled separately in the following paragraphs.

High voltage at the plate of the Miller tube, V161A, indicates that the tube is cut off. If this is the case, momentarily ground the grid of the tube while monitoring the plate voltage. If the tube is good, the plate voltage will drop to about +10 volts. Remove the ground as soon as the reading is taken. If the Miller tube is found to be good, measure the voltage at its grid. If this voltage is more than 20 volts negative, V152B is probably not conducting. In this case, check V152, R147, and R148.

If the voltage at the grid of V161A is not more negative than —20 volts (it should be about —5 volts), measure the voltage at the cathode of V161B. If this voltage is approximately +200 volts, the Runup Cathode Follower stage may be assumed to be operating correctly. If this voltage is significantly lower than +200 volts, the stage is defective, and its grid and cathode circuits should be checked.

If the Runup Cathode Follower is found to be operating properly, measure the voltage at the cathode of V183A. If this voltage is more positive than —45 volts, the trouble is in the Sweep-Gating Multivibrator. Check the tubes and resistors in this circuit. The voltage divider network in the cathode circuit of V135B is particularly critical.

If the voltage at the cathode of V183A is more negative than —55 volts, check the tube in the Hold-Off Circuit, the Hold-Off capacitors, and the resistors in the cathode circuits of the tube.

Low voltage at the plate of the Miller tube indicates that the tube is conducting quite heavily and is not being allowed to perform its normal run-up operation. If this trouble exists on only a few ranges of the TIME/DIV. control, the trouble is probably an open timing resistor. If the trouble exists on all ranges of the TIME/DIV. control, the trouble is probably due to a defective Sweep-Gating Multivibrator.

Check the voltage at the grid (pin 2) of V135A. If the voltage at this point is in the vicinity of —65 volts or lower (more negative), the Sweep-Gating Multivibrator is faulty. In this case, replace V135 and V145. If this does not remedy the trouble, check the rest of the circuit by voltage and resistance measurements.

If the voltage at the grid of V135A is more positive than —60 volts, measure the voltage at the grid (pin 2) of V183B. If the voltage at this point is —70 volts or lower (more negative), the Hold-Off Circuit is faulty. In this case, replace V183, and if this does not remedy the trouble, check the rest of the circuit by voltage and resistance measurements. (The cathode of V183B and the grid of V183A should be about 5 to 7 volts more positive than the grid of V183B. However, there should be a considerably greater voltage differential between the grid and cathode of V183A.) If the voltage at the grid of V183B is more positive than about —70 volts, the Runup Cathode Follower circuit is faulty. If this case, replace V161, and if this does not remedy the trouble, check the rest of the circuit by voltage and resistance measurements.

Nonlinear Sweep. A nonlinear sweep will be generated if the current charging the Timing Capacitor does not remain constant. If the nonlinearity occurs at all sweep rates, a defective Miller Tube is probably the cause. If the nonlinearity occurs only at certain sweep rates, a leaky timing Capacitor is probably the cause. A defective C165 can also cause the sweep to be nonlinear at the faster sweep rates.

Constant Free-Running Trace. If the free-running trace cannot be turned off with the STABILITY control, the Sweep-Gating Multivibrator is at fault. The most probable cause is a change in resistance in either of the grid circuits or in the cathode circuit.

Insufficient Horizontal Deflection. If the horizontal trace starts at the left-hand side of the screen, but does not extend to the right-hand side, the Hold-Off Circuit is resetting the Sweep-Gating Multivibrator before the sweep is complete. If the sweep cannot be adjusted to normal length with the SWP. LENGTH adjustment, R176, the resistances in the cathode circuit of V161B should be checked.

Troubleshooting the Horizontal Amplifier

No Spot or Trace. If a spot is visible when the horizontal deflection plates are externally shorted together, but disappears when the short is removed, the horizontal deflection system is in a state of unbalance. The procedure for locating the defective stage in the Horizontal Amplifier is somewhat the same as that described for the Vertical Amplifier. That is, the shorting strap should be removed from the deflection plates, and connected between the grids of the Output Cathode Follower, V364B and V384B. If no spot then appears, the Output Cathode Follower stage is at fault.

If the spot does appear, however, the shorting strap should then be moved back to the grids of the Output Amplifier, V364A and V384A. No spot on the crt when these points are shorted together indicates trouble in the Output Amplifier stage. Check for open resistors in the cathode and plate circuits.

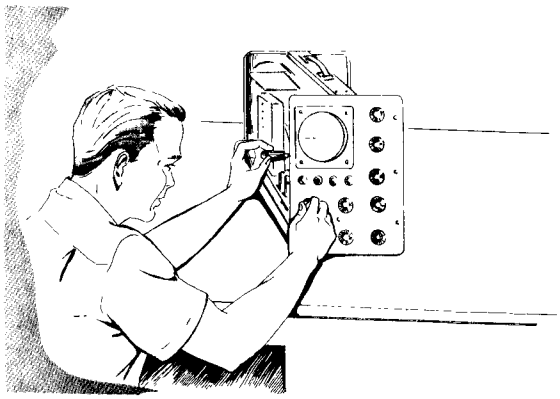
If the spot appears when the grids of the Output Amplifier are shorted together, the trouble lies ahead of the Output Amplifier.

Insufficient or no Horizontal Deflection. If the gain of the Horizontal Amplifier decreases, the timing will no longer correspond to the calibrated values indicated by the TIME/DIV. control.

If the change in gain is only slight, as indicated by improper timing and a slightly decreased horizontal sweep, the amplifier can usually be recalibrated. However, since the gain of the Horizontal Amplifier regulates the timing of the sweep, care must be taken to insure that the gain adjustments are accurately made. Refer to the Calibration section if it is necessary to adjust the gain of the Horizontal Amplifier.

If the decrease in gain of the Horizontal Amplifier is more pronounced, or if there is no horizontal deflection at all, check for defective components that can affect the gain but not the dc balance of the circuits. Such components, in addition to the tubes, would be the R225, (SWP. GAIN ADJ.), R347, R377, and R259 (MAG. GAIN ADJ.).

NOTES



SECTION 6

CALIBRATION

INTRODUCTION

We recommend that the Type 516 Oscilloscope be calibrated after each 500 hours of operation or every six months, whichever comes sooner. It should not require more frequent calibration. However, whenever tubes or other circuit components are replaced, the calibration of the circuit involved should be checked and, if necessary, readjusted.

Also, apparent troubles in the instrument can be caused by improper calibration of one or more circuits. Consequently, this section of the manual should be used in conjunction with the Maintenance section during troubleshooting work. If a trouble occurs in the instrument, you should be sure that it is not due to improper calibration before proceeding with more detailed troubleshooting.

In the instructions that follow, the steps are arranged in the proper sequence for a complete calibration of the instrument. However, any single step may be performed individually or out of order as long as the entire step is performed, including references to other steps or adjustments, with certain exceptions. Due to interaction between adjustments in the Horizontal and Vertical Amplifiers and the sweep timing circuits of the Time-Base Generator, single adjustments in these circuits cannot be made. When amplifier adjustments are re-required, the entire amplifier should be recalibrated. In addition, if the —150-volt Power Supply is adjusted, the entire instrument should be recalibrated. Front-panel controls not mentioned in a given step are assumed to be set at the positions they were in at the end of the previous step.

Figs. 6-1, 6-2, and 6-3 show the location of the internal adjustments referred to in the Calibration procedures.

EQUIPMENT REQUIRED

The following equipment is necessary for a complete calibration of the Type 516 Oscilloscope:

1. DC voltmeter (sensitivity of at least 5000 Ω/volt calibrated for an accuracy of 1% or better at 100 volts, 150 volts, and 300 volts, and for an accuracy of 3% or better at 1675 volts.

2. Accurate rms-reading ac voltmeter, having a range of at least 0-125 volts (0-250 volts for 234-volt instruments).

3. Variable autotransformer having a rating of at least 3 amperes at 125 volts (or 1.5 amperes at 250 volts for 234-volt instruments).

4. Time-Mark Generator, Tektronix Type 184 or equivalent. Time-Mark Generator used must have markers at 1 μsec, 10 μsec, 100 μsec, 1 msec, 5 msec, 10 msec, 100 msec, 1 sec, and a sine-wave output of 20 megahertz; accuracy of at least 1%.

5. Square-Wave Generator, Tektronix Type 106 or equivalent. Required specifications are: (1) Output frequencies of 1 kHz and 450 kHz, (2) risetime of 15 nanoseconds or less, and (3) output amplitude variable from approximately 40 millivolts to 100 volts.

6. Constant-Amplitude Sigal Generator, Tektronix Type 191 or equivalent. Required specifications are: (1) output amplitude 200 millivolts and equal at all frequency settings, and (2) output frequency variable from 1 MHz to over 15 MHz.

7. 52-ohm termination resistor, Tektronix Type B52-R or equivalent.

8. 52-ohm 10-1 "L" pad, Tektronix Type B52-L10 or equivalent.

9. Coaxial cable suitable for applying the outputs of the square-wave generator and the time-mark generator to the inputs of the Type 516, Tektronix Type P52 Coaxial Cable or equivalent.

10. 20 pF Input Capacitance Normalizer, Tektronix Calibration Fixture 067-0538-00.

11. Low-capacitance calibration tools: Tektronix Part Numbers 003-0000-00, 003-0301-00 and 003-0007-00 or equivalent.

CALIBRATION PROCEDURE

Preliminary

Remove the side covers from the Type 516 Oscilloscope. Set the front panel controls as follows (controls not listed may be left in any position):

TIME BASE	
TRIGGER SELECTOR (black)	+INT.
TRIGGER SELECTOR (red)	AC
STABILITY	fully counterclockwise but not PRESET
TRIGGERING LEVEL	0
HORIZ DISPLAY	NORM.

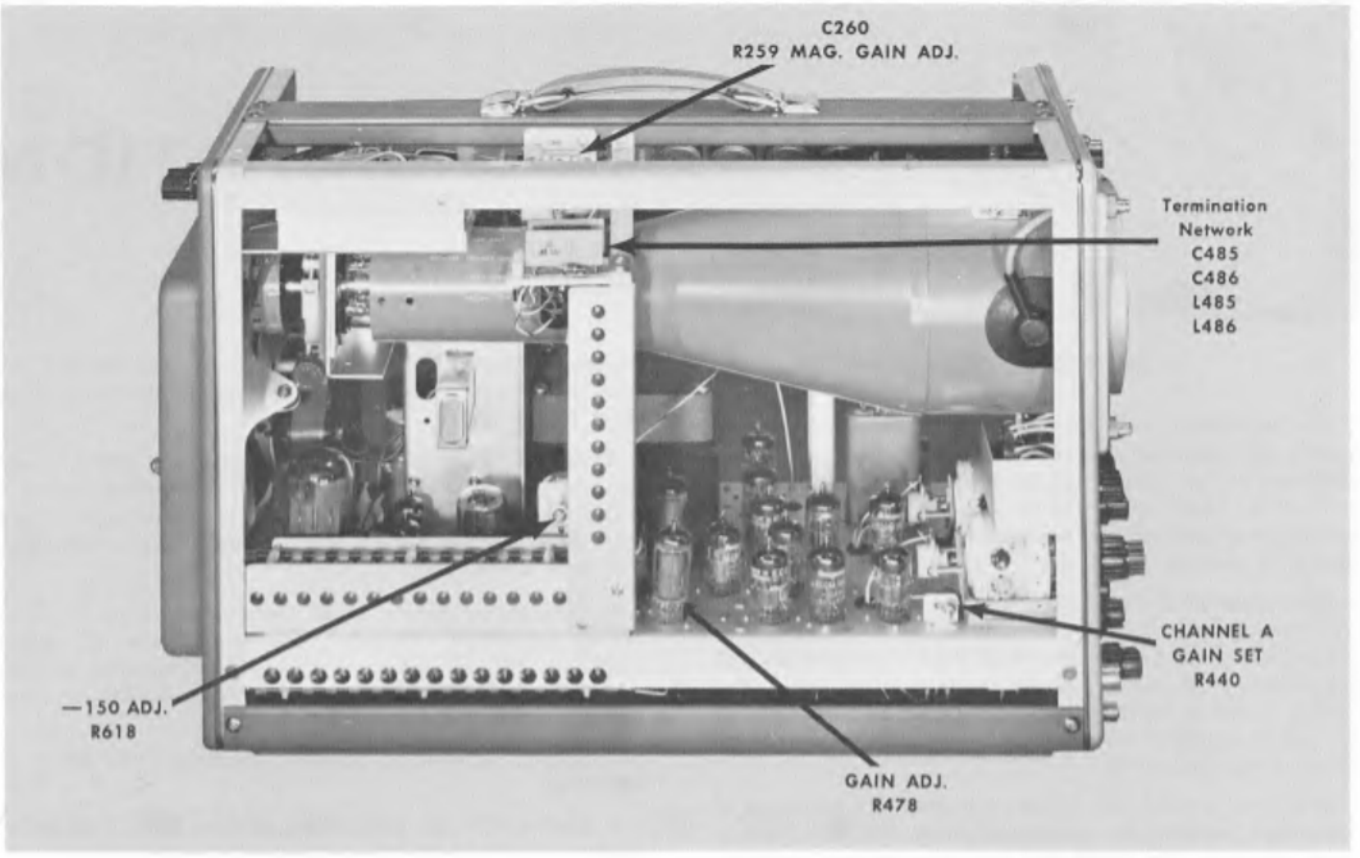


Fig. 6-1. Left side of Type 516 Oscilloscope, showing location of internal adjustments.

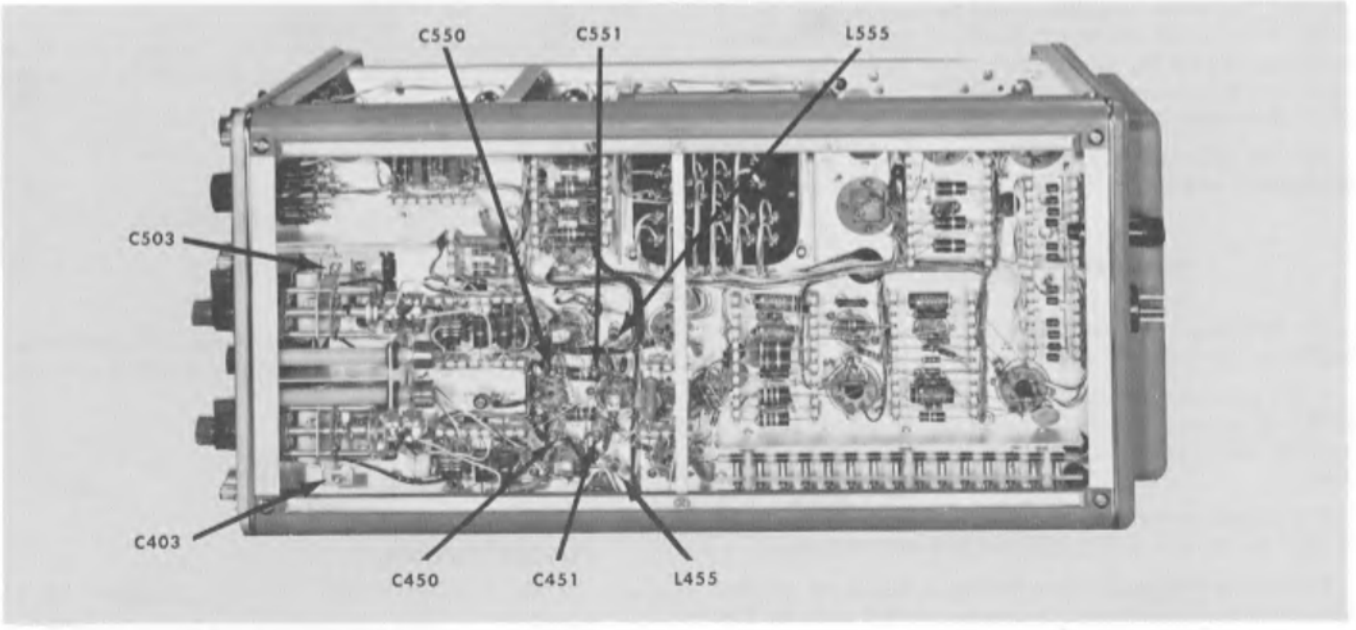


Fig. 6-2. Bottom of Type 516 Oscilloscope, showing location of internal adjustments.

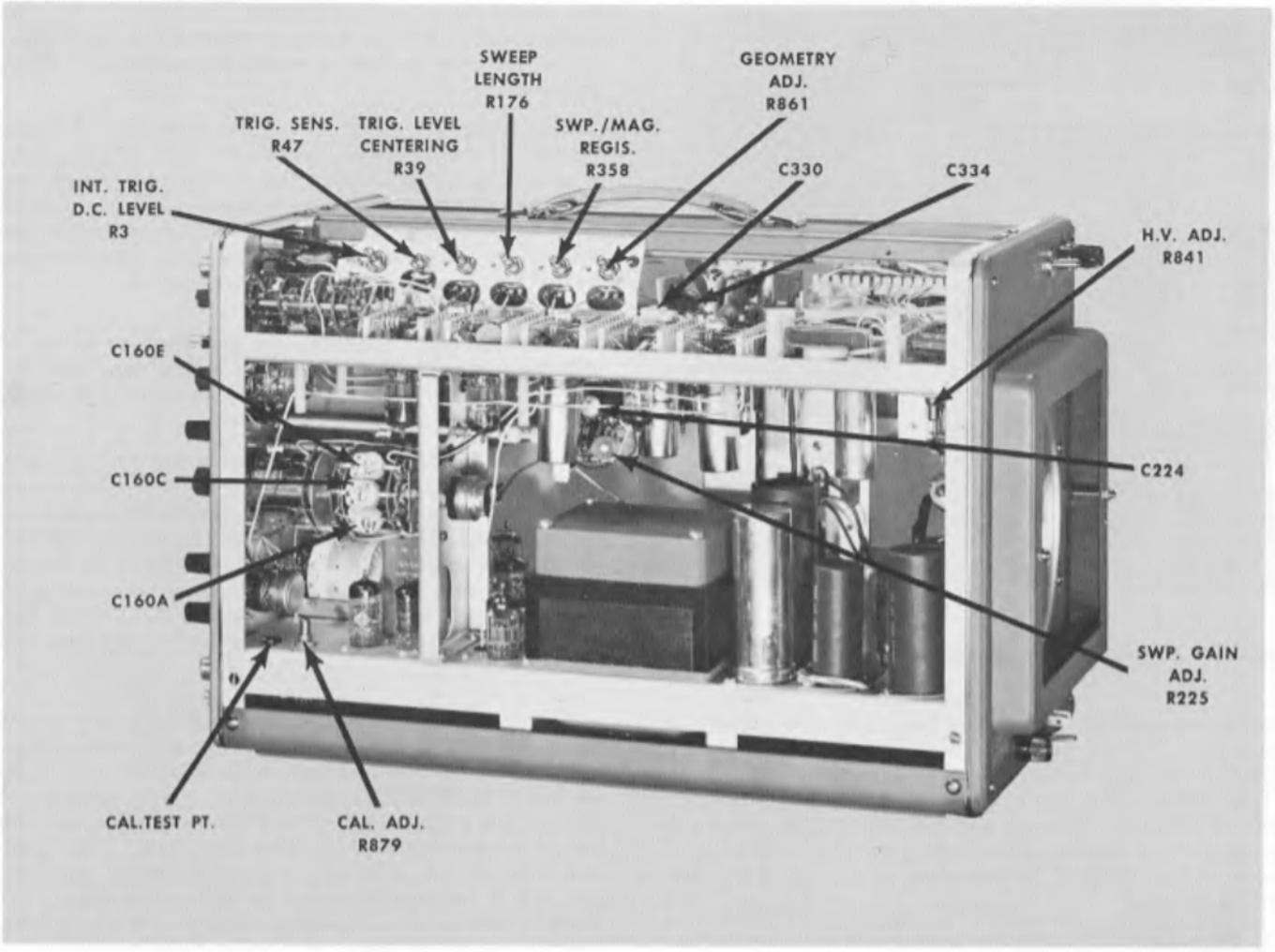


Fig. 6-3. Right side of Type 516 Oscilloscope, showing location of internal adjustments.

TIME/DIV.	1 mSEC
VARIABLE TIME/DIV.	CALIBRATED
INTENSITY	counterclockwise
POWER	PWR. OFF
A VERTICAL	
VOLTS/DIV.	1
VARIABLE VOLTS/DIV.	CALIBRATED
POLARITY	NORM. AC
POSITION	centered
B VERTICAL	
VOLTS/DIV.	1
VARIABLE VOLTS/DIV.	CALIBRATED
POLARITY	NORM. AC
POSITION	centered
MODE	A ONLY
HORIZONTAL POSITION	centered
AMPLITUDE CALIBRATOR	OFF

Connect the Type 516 Oscilloscope to the autotransformer, and turn on all equipment. Set the output of the autotransformer to the nominal voltage for which your instrument is wired. Allow the instrument to warm up for at least 5 minutes before proceeding.

Power Supply

Proper operation of every circuit in the Type 516 Oscilloscope is dependent on correct power supply voltages. Since the regulated —150-volt supply serves as the reference for the other regulated supplies it is very important that this supply be properly adjusted.

1. —150 ADJ. (R616). Measure the output voltage of the —150-volt, the +100-volt and the +300-volt supplies at the

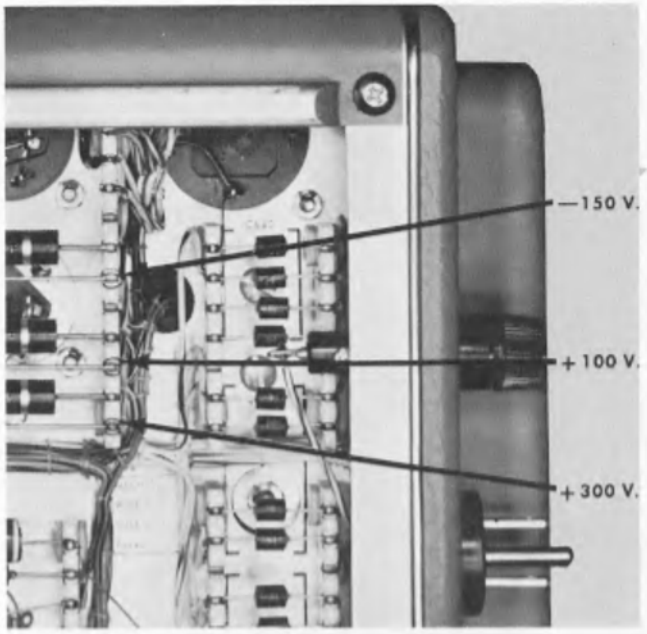


Fig. 6-4. Location of Power Supply test points.

points indicated in Fig. 6-4. Set the —150 ADJ. control so that the —150-volt supply is within 2% and the other supplies within 3% of their rated values. Do not adjust the —150 ADJ. control unless one or more of the supplies is actually out of tolerance or unless you are planning to perform a complete recalibration of the instrument. The calibration of most of the circuits of the instrument will change if this control is adjusted.

2. Regulation. To check the operation of the regulator circuits, vary the output voltage from the autotransformer between the limits specified in Section 2 of this manual, at the same time observing the required voltages. All of the voltages should remain essentially constant and within specified tolerances over this range of line voltage.

Amplitude Calibrator

3. CAL. ADJ. R879. 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. TEST PT. jack and ground, turn the AMPLITUDE CALIBRATOR control 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 fall to between 45 and 55 volts when the calibrator is turned on (to any of the output voltage settings). Readings outside of this range are generally caused by unbalanced multivibrator tubes V875 or V885.

CRT Circuit

4. HV ADJ. R841. The adjustment that sets the high voltage determines the total accelerating voltage on the crt and thus affects the deflection sensitivity. Do not adjust the high voltage unless it is actually of tolerance or unless you are planning to perform a complete recalibration of the instrument.

Measure the voltage at the —1675 ADJ. TEST PT. at the top rear of the instrument. Set the HV ADJ. adjustment for a reading of —1675 volts. This voltage should not vary more than 10 volts between the following limits: line voltage set at its lower limit (see Section 2) and the INTENSITY control set fully clockwise; line voltage set at its upper limit and the INTENSITY control set fully counterclockwise.

5. Crt Alignment. Check to see that the face of the crt rests snugly against the graticule. If it does not, loosen the crt clamp and move the tube forward by pushing on the crt tube socket. Then tighten the crt clamp.

Set the STABILITY control clockwise to free run the sweep. Turn up the INTENSITY control until a trace is visible (it may be necessary to adjust the VERTICAL POSITION control) and adjust the FOCUS and ASTIGMATISM controls for the narrowest trace width. With the VERTICAL POSITION control, position the trace directly behind the center horizontal graticule line. If the trace is tipped relative to the graticule line, rotate the crt alignment knob until the trace coincides with the graticule line.

6. Graticule Alignment. To check the alignment of the graticule, obtain a free-running trace on the oscilloscope, as explained in the previous step. Next move the trace, with the VERTICAL POSITION control, to the top of the graticule until the trace disappears. Then move the trace to the bottom of the graticule until the trace disappears. If the graticule lines are not centered in the usable viewing area, the graticule is improperly aligned in the vertical plane. The graticule may be repositioned by means of a nylon adjusting cam, located in the lower left corner of the graticule.

To make this adjustment, remove the graticule cover and loosen the set screw that holds the positioning cam. By inserting a pointed tool (such as a scriber or center punch) into the small hole, the cam may be rotated until the graticule lines are centered in the usable viewing area. Then tighten the set screw that holds the nylon cam, and replace the graticule cover.

7. Crt GEOMETRY ADJ. R861. The geometry of the crt display is adjustable over a limited range by means of the GEOMETRY ADJ. potentiometer. To achieve optimum linearity, vertical lines are displayed on the crt and the GEOMETRY potentiometer is adjusted for minimum curvature in the lines. Nonlinearity is most noticeable at the edges of the graticule.

Connect a time-mark generator to the A VERTICAL input connector and adjust the TIME/DIV. control and the A VERTICAL VOLTS/DIV. control to obtain vertical lines as illustrated in Fig. 6-5. Adjust the oscilloscope controls to obtain a stable display. Adjust the GEOMETRY ADJ. potentiometer for straight vertical lines running parallel to the left and right edges of the graticule.

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.

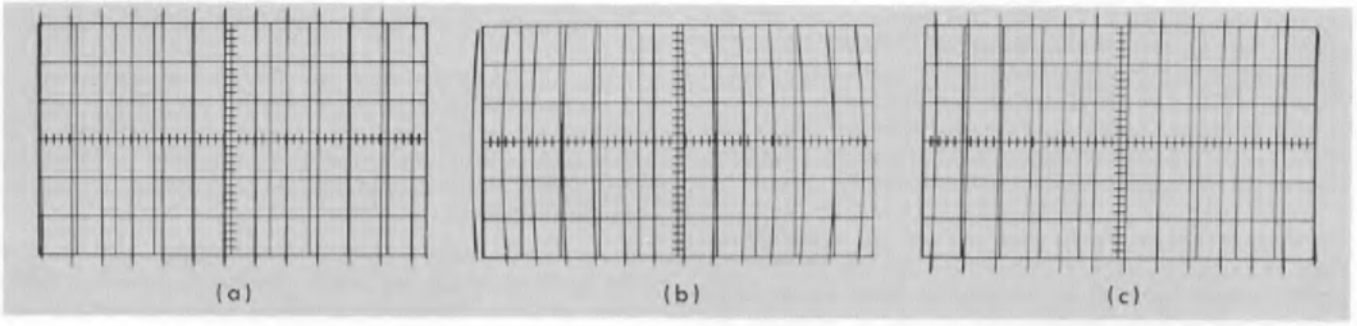


Fig. 6-5. Checking the geometry of the crt. When the GEOMETRY ADJ. is properly set, vertical lines will be parallel with the graticule lines, as shown in (a). If GEOMETRY ADJ. is not properly set, lines will appear as shown in (b) or (c).

Triggering Circuits

Set the front panel controls as follows:

TIME BASE	
TRIGGER SELECTOR (black)	+INT.
TRIGGER SELECTOR (red)	AC
STABILITY	Fully clockwise
TRIGGERING LEVEL	0
HORIZ. DISPLAY	NORM.
TIME/DIV.	.5 mSEC
A VERTICAL	
VOLTS/DIV.	1
VARIABLE VOLTS/DIV.	CALIBRATED
POLARITY	NORM. DC
MODE	A ONLY
AMPLITUDE CALIBRATOR	.2

Connect a test lead from the CAL. OUT connector to the A input connector; this should result in a free-running trace having an amplitude of one minor graticule division (one-fifth of major division). Center the trace vertically on the screen and adjust the INTENSITY, FOCUS and ASTIGMATIM controls for best definition. Then ground the junction of R19, R20, and R21 with a short clip lead. This junction is located on the Trigger switch (see Fig. 6-6).

8. TRIG. LEVEL CENTERING R39. Set the TRIG. SENS. control fully counterclockwise and the TRIG. LEVEL CENTERING control fully clockwise. Turn the STABILITY control counterclockwise until the trace just disappears from the crt screen, then two or three degrees further counterclockwise.

Rotate the TRIG. LEVEL CENTERING control slowly counterclockwise until the trace appears (it may just flicker), then back off the control approximately 2 degrees clockwise from that point.

Whenever you adjust the TRIG. LEVEL CENTERING adjustment you should also adjust the TRIG. SENS. as described in the following step.

9. TRIG. SENS. R47. (Always perform step 8 before this step). Leave the jumper wire and calibrator signal connected as in the previous step. Rotate the TRIG. SENS. control slowly clockwise until the sweep triggers. Rotate the TRIG. LEVEL CENTERING control until stable triggering is obtained with the black TRIGGER SELECTOR control in both the +INT, and —INT. position. Rotate the TRIG. SENS. control clockwise until unstable triggering occurs, then back off a few degrees into a stable region. Check that the sweep is triggered on the + slope of the calibrator waveform when the black TRIGGER SELECTOR control is set at +INT., and on the — slope when the switch is set at —INT. If the slopes are reversed, reset the TRIG. SENS. and TRIG. LEVEL CENTERING controls slightly until the slopes are correct and stable triggering is obtained. Perform the next step immediately.

10. INT. TRIG. DC LEVEL R3. Set the A VERTICAL VOLTS/DIV. control to the .5 position, center the display vertically,

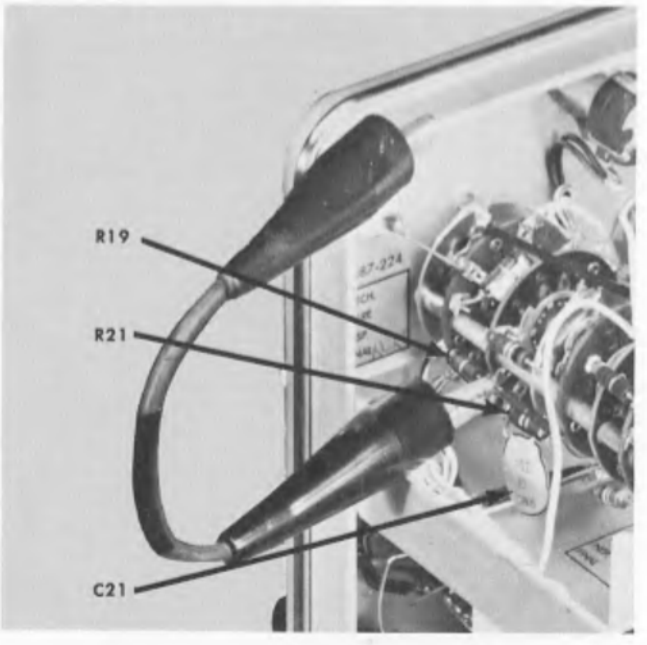


Fig. 6-6. Grounding the junction of R19, R20, and R21 to simplify the adjustment of the TRIG. LEVEL CENTERING and TRIG. SENS. adjustments.

and turn the red TRIGGER SELECTOR control to the DC position. Then, while switching the black TRIGGER SELECTOR control back and forth between +INT and —INT., adjust the INT. TRIG. DC LEVEL adjustment for stable triggering in both positions. It may be necessary to adjust the A VERTICAL POSITION control slightly to obtain stable triggering. Disconnect the jumper wire and the calibrator signal.

11. PRESET STABILITY R111.* Set the red TRIGGER SELECTOR control to the AUTO. position. Set the PRESET STABILITY control (screwdriver adjustment, front panel) to its fully counterclockwise position and connect a voltmeter between the center arm of the PRESET STABILITY potentiometer and ground (see Fig. 6-7). Next, advance the PRESET STABILITY control clockwise until a trace first appears on the crt. Note the voltmeter reading for this setting of the control. Then, advance the PRESET STABILITY control further clockwise until the trace brightens and note the voltmeter reading for this setting. Finally, back off the control until the voltmeter indicates a reading midway between the two previous readings. Disconnect the voltmeter.

* Although this control is shown on the Time-Base Generator circuit diagram, it is more closely associated with the triggering circuitry and its adjustment is therefore included in this section.

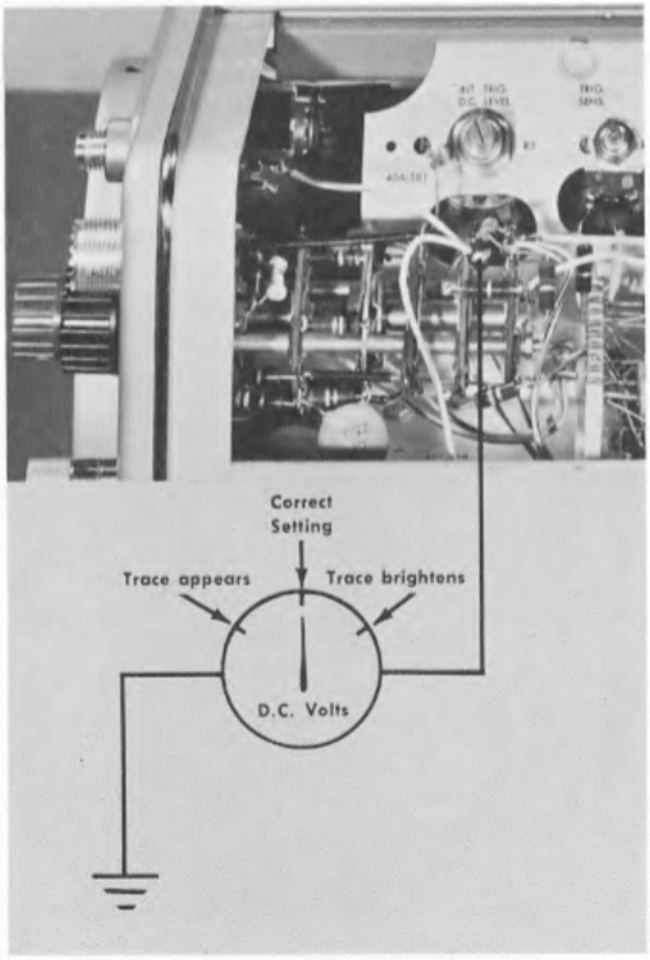


Fig. 6-7. Adjustment of the PRESET STABILITY control.

Time-Base Generator and Horizontal Amplifier

The time-base circuits of the Type 516 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 and can be recalibrated according to the following procedures.

Any nonlinearity present in the time base will generally be confined to the first major division of horizontal deflection. In these instructions, therefore, we recommend calibrating the time-base circuits on the basis of time markers appearing between the second and tenth vertical graticule lines (one division in from the left- and right-hand edges of the graticule).

In the instructions that follow, some of the adjustments interact to a degree. For this reason, it is important that you make the adjustments in the proper sequence.

Some of the Horizontal Amplifier adjustments affect the horizontal position of the crt display. As a result, it will be necessary to reposition the display with the HORIZONTAL POSITION control to keep the time markers properly positioned with respect to the graticule lines.

Set up the Type 516 front panel controls as follows:

TIME BASE	
TRIGGER SELECTOR (red)	AC
TRIGGER SELECTOR (black)	+INT.
STABILITY	PRESET
TRIGGERING LEVEL	0
HORIZ. DISPLAY	NORM.
TIME/DIV.	1 mSEC.
VARIABLE TIME/DIV.*	CALIBRATED
MODE	A ONLY

* Make sure the VARIABLE TIME/DIV. control stays in the CALIBRATED position during all timing adjustments.

12. MAG. GAIN ADJ. R259. Connect the output of the time-mark generator to the A VERTICAL input connector and set the time-mark generator controls for a 100-microsecond marker output. Adjust the Type 516 A VERTICAL VOLTS/DIV. control for a vertical deflection of about 3 major divisions. Center the display on the graticule with the POSITION controls.

To calibrate the magnifier circuit, turn the HORIZ. DISPLAY switch to the MAG. position and adjust the MAG. GAIN ADJ. so that there are two time markers per major division.

13. SWP. GAIN ADJ. R225. Turn the HORIZ. DISPLAY switch to the NORM. position, remove the 100-microsecond markers and apply 1000-microsecond (1-millisecond) markers to the A VERTICAL input connector of the oscilloscope. Adjust the SWP. GAIN ADJ. for one marker per major division.

14. SWP. LENGTH R176. With 1-millisecond markers applied to the Vertical Amplifier, adjust the SWP. LENGTH adjustment for a sweep length of 10.5 divisions.

15. SWP./MAG. REGIS. R358. Set the HORIZ. DISPLAY switch to the MAG. position and adjust the HORIZONTAL POSITION control to align the first marker with the vertical centerline of the graticule. Then set the HORIZ. DISPLAY switch to the NORM. position and adjust the SWP./MAG. REGIS. adjustment to again align the first marker with the center of the graticule. Repeat this step until the marker remains horizontally centered as the HORIZ. DISPLAY switch is changed from MAG. to NORM. Set the HORIZ. DISPLAY switch to the NORM. position.

16. Check Sweep Timing—2 seconds/div. to .1 millisecond/div. This step checks the accuracy of the sweep timing components for sweep rates between 2 seconds per division and .1 millisecond per division. There are no adjustments to be made. Table 6-1 lists the time markers to be applied for the indicated settings of the TIME/DIV. switch and the number of markers per division to be observed for each setting. When checking sweep rates between .1 SEC and 2 SEC, it will be necessary to adjust the STABILITY control for a stable display.

TABLE 6-1

TIME/DIV.	TIME MARKERS	OBSERVE
.1 mSEC	100 μsec	1 marker/div.
1 mSEC	1 msec	1 marker/div.
2 mSEC	1 msec	2 marker/div.
5 mSEC	5 msec	1 marker/div.
10 mSEC	10 msec	1 marker/div.
.1 SEC	100 msec	1 marker/div.
1 SEC	1 sec	1 marker/div.
2 SEC	1 sec	2 marker/div.

17. 1-, 2-, and 5-μsec/div. Sweep Rates. Capacitor C160C determines the sweep rate for the 1-, 2-, and 5-μsec positions of the TIME/DIV. control.

Set the oscilloscope controls as outlined at the beginning of the Time-Base Generator and Horizontal Amplifier section with the exception of the TIME/DIV. control and the HORIZ. DISPLAY switch. Set these controls to 5μSEC and MAG., respectively. The STABILITY control may have to be adjusted to obtain a stable display in the following timing adjustments.

Connect the time-mark generator to the A VERTICAL input connector and display 1-microsecond markers. With the HORIZONTAL POSITION control, position the display to the left so that the last ten timing markers are visible. Adjust C160C so that each time marker is directly coincident with a vertical graticule line. It will be necessary to adjust the HORIZONTAL POSITION control, as C160C is adjusted, to align the time markers with the graticule lines.

18. 1-, 2-, and 5-μsec/div. Linearity. Capacitor C330 compensates a voltage divider network at the input circuit of the Horizontal Amplifier, and affects the sweep rate of the early part of the display at the faster sweep rates.

With the controls unchanged from Step 17, position the display to the right until the first ten timing markers are visible. Adjust C330 to align each time marker with a vertical graticule line. Again, it will be necessary to adjust the HORIZONTAL POSITION control, as C330 is adjusted, to align the time markers with the graticule lines.

There is some interaction between C160C and C330. It may be necessary to go back and forth two or three times between steps 17 and 18 to obtain satisfactory calibration.

19. 10-, 20-, and 50-μsec/div. Sweep Rates. Capacitor C160E determines the sweep rate for the 10-, 20-, and 50-μsec positions of the TIME/DIV. switch. To make this adjustment, set the HORIZ. DISPLAY switch to NORM. and the TIME/DIV. switch to 10 μSEC. Display 10-microsecond markers from the time-mark generator.

Adjust C160E to obtain one time marker for each graticule line.

20. 2-μsec/div. Linearity. Capacitor C224 is one of three adjustments that determine the high-frequency response of the horizontal amplifier, and thereby the linearity of the crt display at the faster sweep rates. (The other two adjustments are C260 and C384). The time constants of these circuits are such as to permit adjustments at different sweep rates. C224 affects the response when the HORIZ. DISPLAY switch is in the NORM. position only, and is initially adjusted to provide the best linearity in the 2-μsec/div. range.

To make this adjustment, turn the TIME/DIV. control to 2 μSEC and display 1-microsecond markers from the time-mark generator. Adjust C224 so that two markers per division are displayed on the left half of the screen. You may ignore the linearity on the right half at this point.

21. .2- and .5-μsec/div. Sweep Rate. Capacitor C160A determines the sweep rate for the .2 and .5 μSEC positions of the TIME/DIV. control.

Continue displaying 1-microsecond markers, and turn the TIME/DIV. control to .5 μSEC. Make sure the VARIABLE TIME/DIV. control remains in the CALIBRATED position. Adjust C160A so that a time marker is aligned with every other graticule line.

22. .2-μsec/div. Linearity. At the .2-μsec/div. sweep rate the linearity of the crt display can be altered slightly by adjusting C260. In addition, the linearity adjustments for lower sweep rates become timing adjustments at the higher sweep rates. This is particularly true of C224 (step 20), which has a pronounced effect on the .2-μsec/div. sweep rate. To adjust C260 (which may require a readjustment of C224), set the oscilloscope controls as follows:

TRIGGER SELECTOR (red)	HF SYNC
TRIGGER SELECTOR (black)	+INT.
HORIZ. DISPLAY	NORM.
TIME/DIV.	.2 μSEC
VARIABLE TIME/DIV.	CALIBRATED

Set the time-mark generator for a 50 nanosecond sinewave output, and adjust the STABILITY and A VERTICAL VOLTS/

DIV. controls for a stable display of about five divisions of vertical deflection. Now, adjust C260 for the most linear display. If the initial adjustment of C224 was correct, there will be four cycles per division in the display. If this is not the case, readjust C224 to obtain two cycles per division.

If you find it necessary to adjust C224 in this step, repeat steps 21 and 22.

23. .04-μsec/div. Sweep Rate and Linearity. Capacitor C384 affects the sweep rate and linearity of the display when the TIME/DIV. control is set to .2 μSEC and the HORIZ. DISPLAY control is in the MAG. position (this increases the sweep rate five times from .2 μsec/div. to .04 μsec/div.).

Set the oscilloscope controls as outlined in step 22 with the exception of the HORIZ. DISPLAY control; set this control to the MAG. position. Display a 50 nanosecond sine wave from the time-mark generator and adjust C384 to obtain eight cycles within the entire 10 divisions of horizontal deflection.

Disconnect the time-mark generator.

Vertical Amplifier

This section contains instructions for adjusting the Vertical Amplifier in the Type 516 Oscilloscope. There is interaction between some of the vertical amplifier adjustments; for this reason, the adjustments should be made in the sequence that follows:

24. DC Balance. This adjustment is performed by the operator of the oscilloscope in the course of normal operation (it should be done every day). However, the maintenance technician must check the adjustment at this point before proceeding with the calibration of the vertical amplifier.

Misadjustment of the control is indicated if a free-running trace (no signal) shifts vertically as the VARIABLE VOLTS/DIV. controls are rotated. To perform this adjustment, it is necessary to obtain a reference trace on the crt. Set the STABILITY control to the clockwise (free run) position and the TIME/DIV. control to 1mSEC. Set the MODE switch to the ALTERNATE position. Two traces should be displayed on the crt, one controlled by the A VERTICAL POSITION control and one controlled by the B VERTICAL POSITION control. Adjust the A VERTICAL DC BAL. control (front panel) until there is no longer any vertical shift in the A Channel trace as the A VERTICAL VARIABLE control is rotated. Adjust the B VERTICAL DC BAL. control until there is no longer any vertical shift in the B Channel trace as the B VERTICAL VARIABLE control is rotated.

25. Amplifier Gain. Two adjustments, GAIN ADJ. and CHANNEL A GAIN SET, determine the gain of the vertical amplifiers and therefore the calibration of the VOLTS/DIV. controls.

To adjust the GAIN ADJ. adjustment (R478) set the oscilloscope controls as follows:

TIME BASE	
TRIGGER SELECTOR (red)	AUTO.
TRIGGER SELECTOR (black)	+INT.
STABILITY	not used in
TRIGGERING LEVEL	AUTO. mode.
HORIZ. DISPLAY	NORM.
TIME/DIV.	1 mSEC
VARIABLE TIME/DIV.	CALIBRATED
MODE	B ONLY
B VERTICAL	
VOLTS/DIV.	.05
VARIABLE TIME/DIV.	CALIBRATED
POLARITY	NORM. AC
AMPLITUDE CALIBRATOR	.2

Connect a jumper wire from the B VERTICAL input connector to the CAL. OUT connector, and adjust the INTENSITY, FOCUS, ASTIGMATISM and POSITION controls for a suitable display. Make sure the B VERTICAL VARIABLE control is in the CALIBRATED position, and adjust the GAIN ADJ. adjustment for a deflection of exactly four major divisions.

To adjust the CHANNEL A GAIN SET adjustment (R440), set the oscilloscope controls as follows. Controls not mentioned are left in the position they were in at the beginning of step 25.

MODE	A ONLY
A VERTICAL	
VOLTS/DIV.	.05
VARIABLE	CALIBRATED
POLARITY	NORM. AC
POSITION	midrange

Connect the jumper wire from the A VERTICAL input connector to the CAL. OUT connector. Make sure the A VERTICAL VARIABLE control is in the CALIBRATED position, and adjust the CHANNEL A GAIN SET adjustment for a deflection of exactly four major divisions. Remove the jumper wire.

25. Attenuator High Frequency Compensation. To adjust the high-frequency compensation of the attenuators, set the front-panel controls as follows:

TIME BASE	
TRIGGER SELECTOR (black)	+INT.
TRIGGER SELECTOR (red)	AUTO.
HORIZ. DISPLAY	NORM.
TIME/DIV.	.5 mSEC
VARIABLE TIME/DIV.	CALIBRATED
MODE	A ONLY
A and B VERTICAL AMPLIFIERS	
VOLTS/DIV.	.05
VARIABLE TIME/DIV.	CALIBRATED
POLARITY	NORM. AC
POSITION	midrange

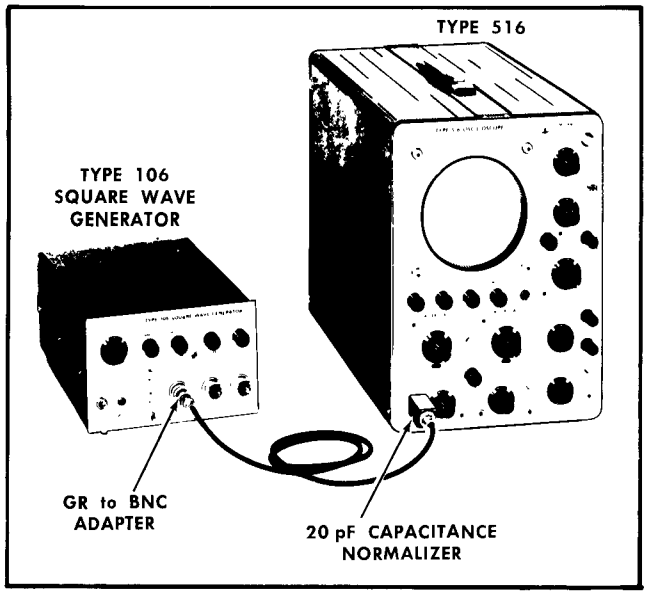


Fig. 6-8. Tektronix Type 106 Square-Wave Generator connected for attenuator high frequency compensation.

Connect the output of the square-wave generator through the 20-pF capacitance normalizer to the A VERTICAL input connector of the Type 516. Adjust the square-wave generator for an output frequency of 1 kHz. Fig. 6-8 shows the Tektronix Type 106 Square-Wave Generator connected for high-frequency compensation of the A Channel attenuator.

Set the A VERTICAL VOLTS/DIV. control to the .05 position and adjust the output amplitude of the square-wave generator to produce about 4 divisions of deflection on the crt screen. With the A VOLTS/DIV. switch set to the .05 position adjust the Output Amplitude control of the Type 106 to obtain 4 divisions of vertical deflection on the crt of the Type 516. If the signal can't be reduced to 4 divisions you may insert the 10XT/B52L10 attenuator. The attenuator should be placed between the Type 106 and the 20 pF capacitance normalizer.

Observing the top of the square wave adjust C403 for SN range 101-569, and C420 for SN 570 and up, for the best square wave response. For instruments with SN 570 or higher change the POLARITY switch to the INV. AC position. Observing the bottom of the square wave this time adjust C421 for the best square wave response. Then set the A VERTICAL VOLTS/DIV. control to each of its other settings, and at each setting adjust the two capacitors exposed in the SHUNT-SERIES opening below the A VERTICAL VOLTS/DIV. control for best square-wave response. In each case the SERIES capacitor (the adjustment on the right) affects the attenuator high-frequency compensation (see Fig. 6-9), and the SHUNT capacitor (the adjustment on the left) affects the attenuator input capacitance (see Fig. 6-10). Maintain about four divisions of vertical deflection on the crt screen by adjusting the output amplitude of the square-wave generator as you switch the VOLTS/DIV. control from one setting to the next. (With the Tektronix Type 106 Square-Wave Generator, the maximum vertical deflection will be less than four divisions when the VOLTS/DIV. control is in the 20 VOLTS/DIV. position. The square wave presentation should be checked in the NORM and INV. positions of the POLARITY switch. They should look the same in either position of the switch.

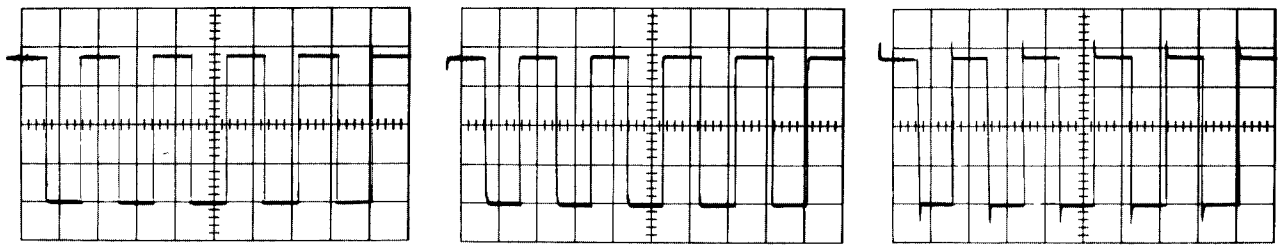


Fig. 6-9. Compensating the attenuator high-frequency response; (a) proper compensation, (b) undercompensation, and (c) overcompensation.

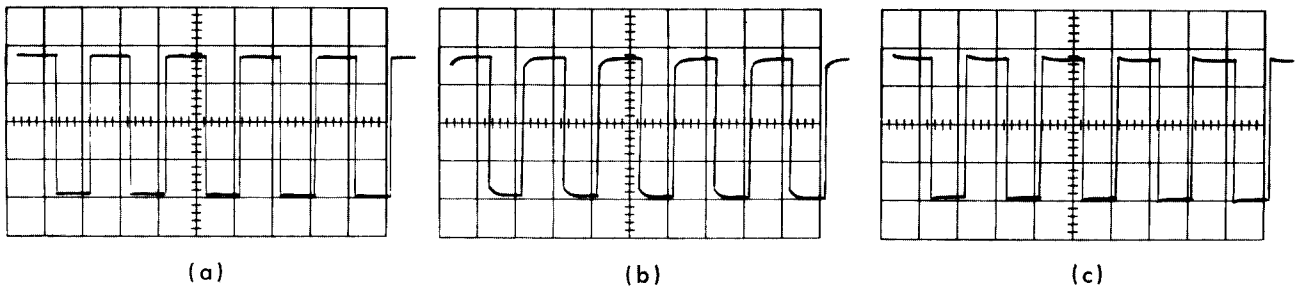


Fig. 6-10. Adjusting the input capacitance; (a) proper adjustment, (b) and (c) improper adjustment.

Adjustment of B channel is done in the same manner as outlined above. C503 is adjusted for instruments below SN 570 while C520 and C521 are adjusted for instruments above this serial number.

27. Switched Amplifier Interelectrode Capacitance Compensation. When a signal with fast-rising portions is applied to one of the input channels, and that input channel is "turned off" by the action of the Switching Circuit, the grid-to-plate capacitance of the Switched Amplifier in that channel tends to couple a part of the signal through to the Output Amplifier. When this happens, the coupled-through portions of the signal in the turned-off input channel appears as spikes on the signal in the other channel. To counteract this tendency, C450, C451, C550, and C551 must be adjusted to compensate for the grid-to-plate capacitance of their respective Switched Amplifier tubes.

To adjust C450 and C451, apply a 1-kHz square wave from the Type 106 Square-Wave Generator to the A VERTICAL input connector. Set the black TRIGGER SELECTOR control to EXT. and apply an external triggering signal from the square-wave generator to the TRIGGER INPUT connector. Set both VOLTS/DIV. controls to .05. Set the MODE switch to A ONLY and the TRIGGERING LEVEL and STABILITY controls for a stable display and several cycles of the square-wave signal. Set the amplitude control of the square-wave generator so that the peak-to-peak amplitude of the displayed square waves is slightly greater than the diameter of the face of the crt. Set the MODE switch to B ONLY. Inspect the trace very carefully for small negative and positive spikes along its length. Adjust C450 and C451 as necessary to reduce the amplitude of these spikes, if any, as much as possible. Try to adjust both capacitors approximately the same amount in order to maintain the balance of the channel. When the adjustment is completed, both adjusting screws should extend about the same distance above the capacitor bodies.

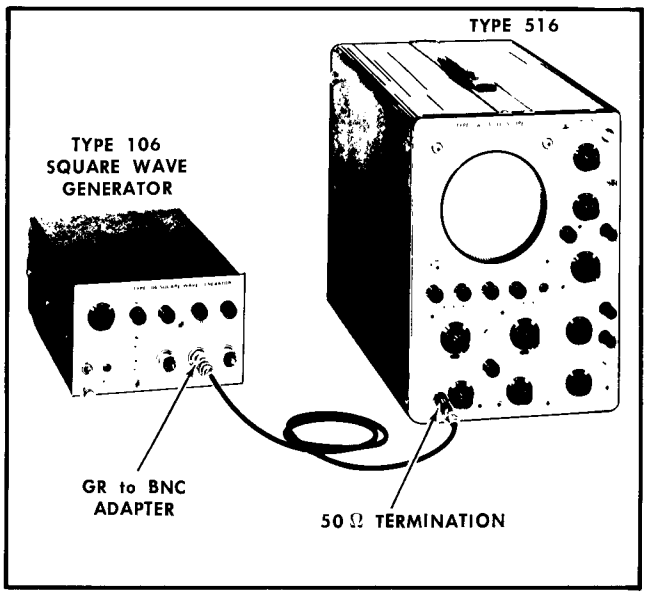


Fig. 6-11. Connecting the Tektronix Type 106 Square-Wave Generator to the Type 516 Oscilloscope for adjustment of the Delay Line.

To adjust C550 and C551, apply the output of the square-wave generator to the B VERTICAL input connector, and set the MODE switch to A ONLY. Then adjust C550 and C551 in the manner described for C450 and C451 in the previous paragraph.

These adjustments interact with the adjustment of the Delay Line described in the following paragraphs. Therefore, whenever you have changed the setting of any of these capacitors, you should check the adjustment of the Delay Line.

Delay Line and Vertical Amplifier High Frequency Compensation

Of all the adjustments you may be called upon to perform on the Type 516 Oscilloscope, the adjustment of the Delay Line and the high-frequency compensation of the Vertical Amplifier will be the most critical. This is due largely to the interaction between the adjustments. There are 42 variable capacitors and 2 variable inductors associated with the Delay Line, and 2 variable inductors and 4 variable capacitors in the Vertical Amplifier, and all of the adjustments interact to some degree.

Before making any of the adjustments decribed in this section, read the instructions carefully so that you will be sure of what is to be done. Study the photographs and illustrations carefully in order to obtain a clear understanding of the result of each adjustment. 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 whether the Delay Line is in need of adjustment, and to make the necessary adjustments, you will need to apply a square wave to the oscilloscope and observe the waveform displayed on the crt. The risetime of the square wave applied will affect the accuracy of the tuning of the Delay Line; the shorter the risetime of the applied square wave, the greater will be the ability to tune accurately. For this reason, the risetime of the square wave applied should be kept as short as possible; 15 nanoseconds or less may be considered satisfactory for most uses of the oscilloscope. Also, the waveform should be free of overshoot and irregularities.

The Type 106 Square-Wave Generator which has a risetime of 1 nanosecond or less when connected as shown in Fig. 6-11 is suitable for use in tuning the delay line of the Type 516 oscilloscope. All tuning should be done on the positive half-cycle of the waveform.

A square-wave frequency of about 450 kHz is optimum for tuning the Type 516 Oscilloscope. This frequency permits the broadest oscilloscope display while preventing the appearance of reflected aberrations from the preceding rise or fall of the waveform (these reflected aberrations can appear at frequencies over 500 kHz).

To check the response of the Vertical Amplifier and Delay Line, apply the 450-kHz square wave to the A VERTICAL input connector and set the front-panel controls of the Type 516 as follows:

TIME BASE	
TRIGGER SELECTOR (red)	AC

TRIGGER SELECTOR (black)	+INT.
STABILITY	PRESET
HORIZ. DISPLAY	NORM.
TIME/DIV.	2 μSEC
VARIABLE TIME/DIV.	CALIBRATED
MODE	A ONLY
A VERTICAL	
VOLTS/DIV.*	.05
VARIABLE TIME/DIV.	CALIBRATED
POLARITY	NORM. DC

***It is very important to bypass the effect of the attenuators in the procedure that follows. Make sure that the VOLTS/DIV. control is set to the .05 position and that the VARIABLE control remains in the CALIBRATED position.**

Adjust the TRIGGERING LEVEL control for a stable display and adjust the output amplitude control of the square-wave generator for approximately four divisions of vertical deflection. Position the display so that it is similar to Fig. 6-12. It may be necessary to adjust the frequency control of the square-wave generator slightly to obtain the desired number of cycles on the crt screen.

After obtaining the desired display you can begin your examination for waveform distortion. There are three general characteristics to appraise in determining the response of the Vertical Amplifier and the Delay Line. The first is the "level" of the display, the second is the amount of "wrinkle" in the flat portion of the display, and the third is the "squareness" of the leading edge and corner of the display.

Determining the Level of the Display. To determine the level of the display, position the waveform so that the flat top of the positive portion coincides with a horizontal graticule line. If the top of the waveform is coincident with the graticule line for the entire positive half-cycle, the display is level. If there is either an upward or a downward slope to the top of the waveform, the display is not level. When the Delay Line is properly adjusted the display will be level. Any departure from a level display is the result of a collective misadjustment of several Delay-Line capacitors. While it is possible to observe the level at a sweep rate of .2 μsec/div., the level is most easily obeserved at the 2 or 5 μSEC position of the TIME/DIV. control. A waveform that is level, and two waveforms that are not level, are shown in Fig. 6-13.

Determining the Amount of Wrinkle in the Display. There are two general types of "wrinkle conditions" that may appear in a display as a result of an improperly adjusted Delay Line. One type is that shown in Fig. 6-14 (a). This type of irregularity, which is most easily observed at a sweep rate of .2 μsec/div., is generally caused by the misadjustment of a group of capacitors. However, if there appears to be a certain rhythmic waviness or symmetry to the distortion, the condition may be caused by faulty adjustment in either the termination network or in the high-frequency compensation of the Vertical Amplifier.

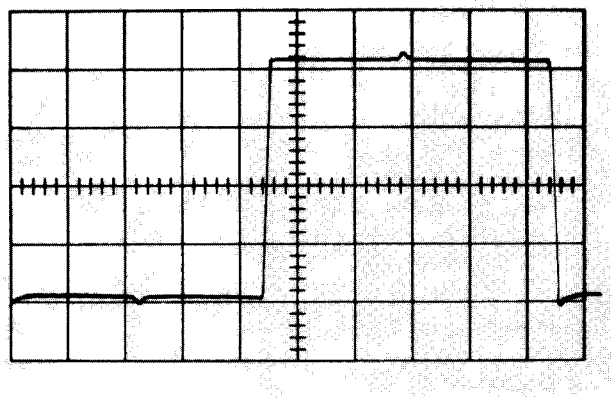


Fig. 6-12. 450-kHz square wave displayed on the Type 516 Oscilloscope at a sweep rate of 0.2 μsec/div. The termination bump has been accentuated for this photograph.

The second type of wrinkle to look for is shown in Fig. 6-14 (b). This condition, a single aberration in the waveform, is also most easily observed at a sweep rate of .2 μsec/div., and is caused by the misadjustment of a single Delay-Line capacitor.

Determining the Squareness of the Corner and Leading Edge. The risetime of the leading edge of the displayed square wave, and the squareness or sharpness of the corner at the top of the leading edge, are determined by the high-frequency response of the Delay-Line adjustments adjacent to the Vertical Amplifier. This condition is most easily observed at a sweep rate of .2 μsec/div. The corner at the leading edge of the waveform should be as sharp or square as possible, but must be free of overshoot and wrinkles. The

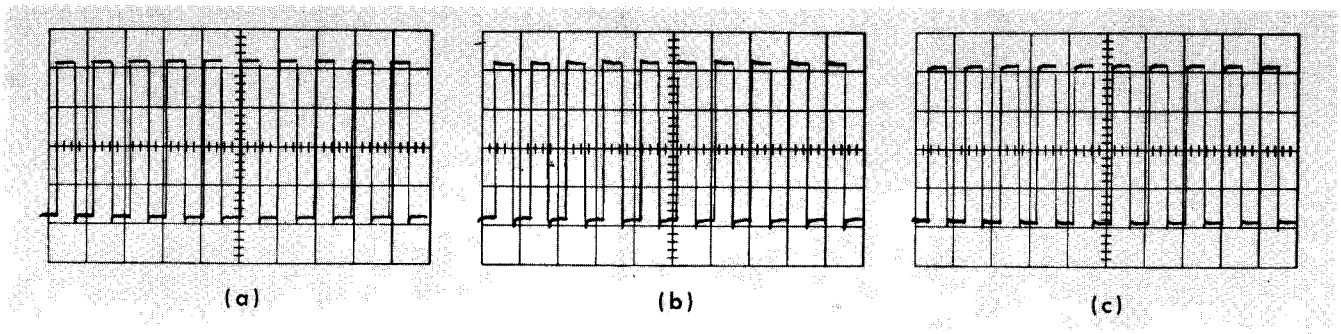


Fig. 6-13. Determining the level of the display. The frequency of the square wave is 450-kHz; the sweep rate is 2 μsec/div. (a) shows a level waveform, (b) shows an upward slope to the waveform, and (c) shows a downward slope to the waveform.

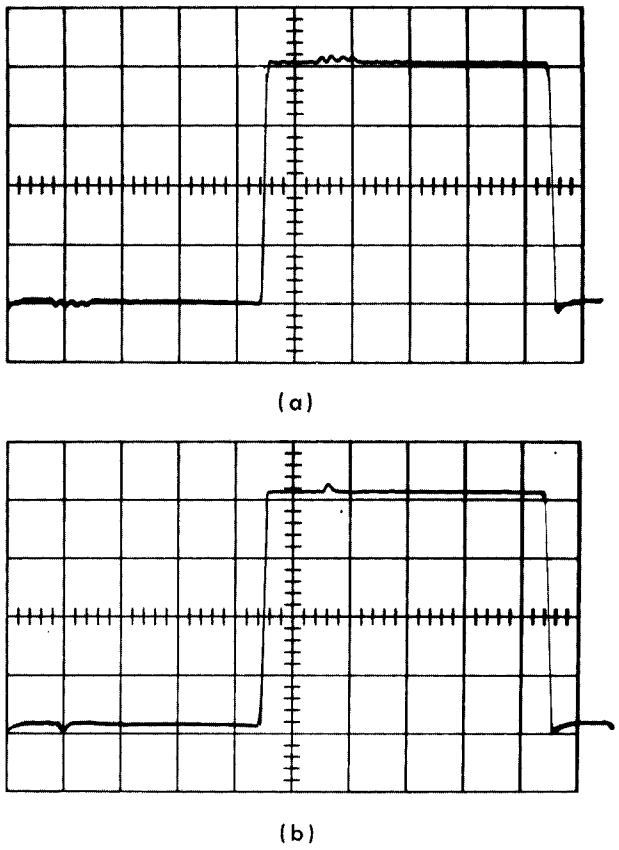


Fig. 6-14. Determining the amount of wrinkle in the display. The aberrations in (a) are caused by a misadjustment of a group of capacitors; the single bump in (b) is caused by the misadjustment of a single capacitor.

correct type of waveform is shown in Fig. 6-15 (a). The rounded-corner type of waveform, shown in Fig. 6-15 (b) is the result of insufficient high-frequency compensation, and the overshoot condition shown in Fig. 6-15 (c) is the result of overcompensation.

Delay Line Adjustment Procedure

There are four major steps in adjusting the Delay Line and the Vertical Amplifier in the Type 516 Oscilloscope. These are:

1. Presetting the adjustments
2. Establishing a level display
3. Removing the wrinkles
4. Compensating the amplifier

It may be necessary, in some instances, to perform all of the steps listed in these instructions. In other cases, and particularly where the degree of misadjustment is minor, the first step can usually be omitted.

Presetting the Adjustments. If the displayed square-wave on the crt indicates that the Vertical Amplifier and the Delay Line are considerably out of adjustment, presetting the controls before starting the adjustment procedure will generally render the best results.

The variable inductors, L455 and L555, in the Vertical Amplifier, should be preset so that the slugs are positioned deeper into the coil form than the windings of the coil extend. When the slugs are positioned below the coil windings, light can be observed between the top of the slugs and the bottom of the windings. Presetting the inductors in this manner reduces their effect in the circuit, and the adjustment of the Delay Line is simplified.

The variable capacitors in the Delay Line should be preset so that the top of the adjusting screw extends about one-quarter of an inch above the top of the contact springs. The important characteristic is that the tops of all the adjusting screws should be at about the same height, both after the preset procedure and after the final adjustment.

The inductors and the capacitors in the termination network (L485, L486, C485, C486) are the first to be adjusted in the adjustment procedure; for this reason it is not necessary to preset these controls. However, it is important to check the inductors for balance. The slugs in each inductor should be set to the same depth within the coil form.

Establishing a Level Display. The reference level for the displayed waveform is established by that portion of the

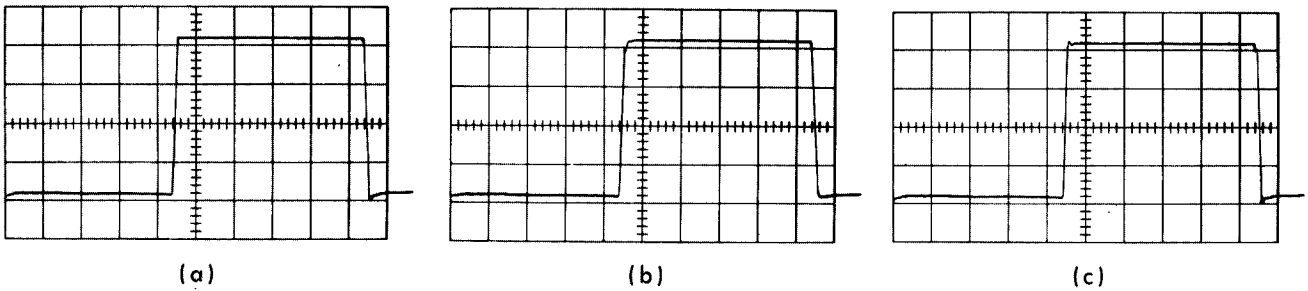


Fig. 6-15. Determining the squareness of the corner and leading edge. (a) shows the ideal waveform; the rounded corner in (b) is the result of insufficient high-frequency compensation in the amplifier; and the overshoot in (c) is the result of excessive high-frequency compensation.

square wave following the termination network. Make sure that the VOLTS/DIV. control is set to .05 and the VARIABLE control is set to the CALIBRATED position. Set the TIME/DIV. control to .2 μSEC. Observe the waveform closely in the region near the center of the positive portion, and adjust the two inductors and the two capacitors in the termination network for the minimum termination bump. Be sure to check the inductors for balance as described in the previous paragraph.

The level of that portion of the square wave preceding the termination bump is determined by the collective effect of all the Delay-Line capacitors. Set the TIME/DIV. control to 2 μSEC; this will produce narrow pulses on the crt screen and make it easy to ascertain any departure from a level display. Each capacitor must now be adjusted a small amount in a direction that will make the top of the square wave level. Start at the terminated end of the Delay Line and adjust each capacitor a small amount, carefully observing the top of the waveform for the result. Make sure that you retain a level top to the waveform as you progress toward the amplifier end of the line.

After you have been over the line once, and have established an average level for the waveform, advance the sweep rate to 1 μsec/div. and repeat the procedure. This time, try to adjust the capacitors for a smooth transition from bump to bump, at the same time maintaining the level. Do not try to obtain a wrinkle-free line at this time. Just try to reduce the amplitude of all the bumps the same amount. The important consideration is to maintain the level of the waveform.

Removing the Bumps and Wrinkles. After you have established a level display, and reduced the amplitude of the bumps a bit, you can start removing the wrinkles and bumps to a greater degree. Again, start at the terminated end of the line and work toward the amplifier end.

Set the TIME/DIV. control to .5 μSEC and adjust the termination network again to reduce the wrinkles in the vicinity of the termination bump. Do not try to achieve a perfectly straight line across the top of the waveform at this time. Just reduce the amplitude of the bumps by about one-half. Then advance to the first group (about 4 or 5) of the capacitors in the line and adjust them for a reasonably smooth line over that portion of the display they affect. Keep in mind that each capacitor will only require a slight adjustment, and that it is combined effect of a group of capacitors with which you must be concerned. As you advance along the line, from each group of capacitors to the next, turn the VARIABLE TIME/DIV. control full left from time to time; this will decrease the sweep rate and narrow the pulse width so that you may more easily check the level of the waveform. It is just as important to maintain the level of the waveform as it is to achieve a wrinkle-free display.

After you have traversed the entire length of the Delay Line, advance the sweep rate to .2 μsec/div. and repeat the process. (Adjust the VARIABLE TIME/DIV. control to obtain the entire positive half-cycle on the crt.) Be extremely careful in your adjustments at this time. Any capacitors that require adjusting will only need a slight "touch". Any overadjustment might nullify all of your efforts up to this point. From time to time switch back to a sweep rate of 2 μsec/div. to check the level.

Upon completing this portion of the adjustment procedure, the display on the oscilloscope should appear similar to Fig. 6-15 (b). That is, the display should be level and free from bumps and wrinkles, with a pronounced rolloff at the leading corner. The final step in the adjustment procedure, therefore, is to square up the corner.

Squaring up the Corner. With the TIME/DIV. control set to .2 μSEC, position the display so that you have a good view of the leading edge and corner. Then, adjust L455 and L555 in the Vertical Amplifier, being careful to adjust each inductor the same amount. Continue adjusting each inductor, maintaining balance, until the leading edge comes up to a sharp, square corner. This process will introduce some new wrinkles in the display, but these can be easily removed by adjusting the first few capacitors in the Delay Line. When the Vertical Amplifier and the Delay Line are in proper adjustment, the display should appear similar to Fig. 6-15 (a).

A slight readjustment of C450 and C451 may also improve the shape of the corner without seriously degrading the response for which they were adjusted in step 27 of the preceding procedure. If you find it necessary to adjust them more than a slight amount, you should go back and check the adjustment as described in step 27. The final setting will be a compromise between the squareness of the corner and the amount of feedthrough allowable; the most emphasis should be put upon the squareness of the corner, since feedthrough from one channel to the other will not be a problem in most applications of the oscilloscope.

Apply the 450-kHz output of the square-wave generator to the B VERTICAL input connector and set the MODE switch to B ONLY. Note the shape of the leading corner. You may wish to adjust C550 and C551 and/or the first few capacitors of the Delay Line to improve the response of the B Channel. The final setting will be a compromise between the response obtained through the A Channel and the response obtained through the B Channel. Usually, it is best to set up one of the channels for optimum square-wave response, even if it means degrading the response on the other channel slightly. Then all critical high-frequency observations can be made on the optimum channel.

Check Bandwidth of Vertical Amplifier. Connect the output cable from the constant-amplitude signal generator to the A VERTICAL input connector of the Type 516. Set up the front panel controls as follows:

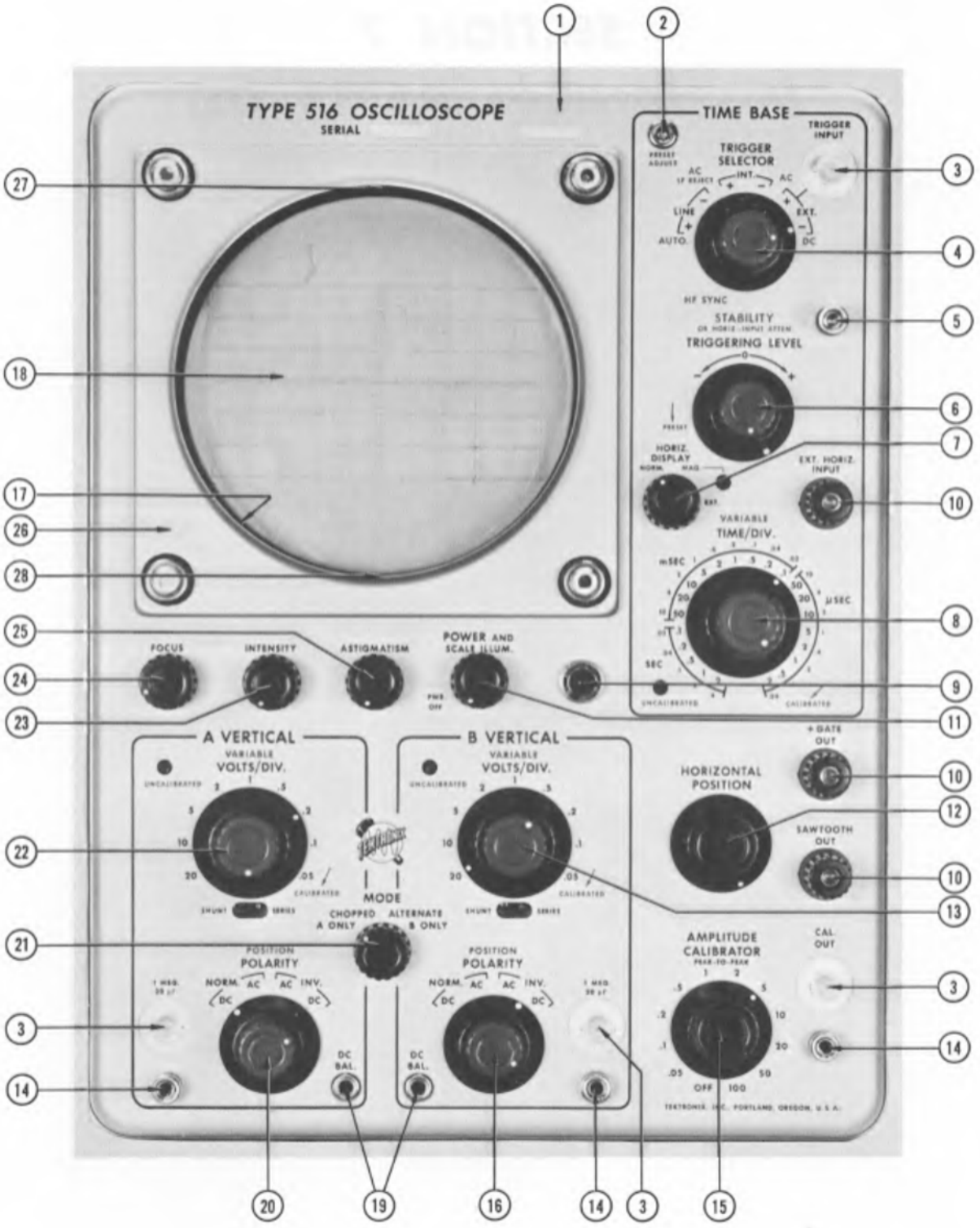
TIME BASE	
TRIGGER SELECTOR (red)	AC
TRIGGER SELECTOR (black)	+INT.
STABILITY	Fully clockwise (free run)
HORIZ. DISPLAY	NORM.
TIME/DIV.	1 mSEC
VARIABLE TIME/DIV.	CALIBRATED

MODE	A ONLY
A VERTICAL	
VOLTS/DIV.	.05
VARIABLE VOLTS/DIV.	CALIBRATED
POLARITY	NORM. DC

Set the frequency control on the signal generator for an output frequency of 1 megahertz, and adjust the amplitude control on the signal generator for a vertical deflection of exactly 4 major divisions. Center the display vertically on the crt with the A VERTICAL POSITION control.

Then increase the output frequency of the signal generator to 15 megahertz. The deflection should be at least 2.8 major divisions. This corresponds to an attenuation of 3 dB or less at 15 MHz as specified (see Section 1).

SECTION 7
MECHANICAL PARTS LIST


TYPE 516 OSCILLOSCOPE
SERIAL
TIME BASE
TRIGGER INPUT
TRIGGER SELECTOR
AC LF REJECT
INT.
AC
LINE
EXT.
AUTO.
DC
HF SYNC
STABILITY
TRIGGERING LEVEL
PRESET
HORIZ. DISPLAY
NORM.
MAG.
EXT.
EXT. HORIZ. INPUT
VARIABLE TIME/DIV.
mSEC
μSEC
SEC
UNCALIBRATED
CALIBRATED
FOCUS
INTENSITY
ASTIGMATISM
POWER AND SCALE ILLUM.
PWR OFF
A VERTICAL
B VERTICAL
VARIABLE VOLTS/DIV.
UNCALIBRATED
CALIBRATED
SHUNT
SERIES
MODE
CHOPPED
ALTERNATE
A ONLY
B ONLY
POSITION
POLARITY
NORM.
INV.
AC
DC
DC BAL.
+ GATE OUT
HORIZONTAL POSITION
SAWTOOTH OUT
AMPLITUDE CALIBRATOR
PEAK-TO-PEAK
OFF
CAL. OUT
TEKTRONIX, INC., PORTLAND, OREGON, U.S.A.
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FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5 Description
1	333-0603-00	101	269	1	PANEL, front
	333-0644-00	270		1	PANEL, front
	387-0224-00			1	PLATE, front subpanel
	- - - - - -			-	plate includes:
	354-0057-00			1	RING, ornamental
	355-0043-00			4	STUD, graticule (replacement)
	- - - - - -			-	each stud includes:
	212-0507-00			1	SCREW, 10-32 x 3/8 inch, PHS
	210-0010-00			1	LOCKWASHER, internal, #10
2	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
	210-0471-00			1	NUT, hex., 1/4-32 x 19/32 inch
	210-0223-00			1	LUG, solder, 1/4 ID x 7/16 inch OD, SE
	210-0046-00			1	LOCKWASHER, internal, 0.261 ID x 0.400 inch OD
3	131-0081-00	101	2029	4	CONNECTOR, coaxial, 1 contact, UHF
	131-0126-00	2030		4	CONNECTOR, coaxial, 1 contact, BNC
4	366-0031-00			1	KNOB, small red--TRIGGER SELECTOR
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	366-0029-00	101	3209	1	KNOB, large black--TRIGGER SELECTOR
	366-0142-00	3210		1	KNOB, large charcoal--TRIGGER SELECTOR
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	262-0333-00	101	269	1	SWITCH, wired--TRIGGER SELECTOR
	262-0402-00	270	1958	1	SWITCH, wired--TRIGGER SELECTOR
	262-0564-00	1959		1	SWITCH, wired--TRIGGER SELECTOR
	- - - - - -			-	switch includes:
	260-0332-00	101	269	1	SWITCH, unwired
	260-0377-00	270		1	SWITCH, unwired
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0013-00			1	LOCKWASHER, internal, 3/8 ID x 11/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
5	129-0020-00			1	ASSEMBLY, binding post
	- - - - - -			-	assembly includes:
	355-0503-00			1	STEM
	200-0072-00			1	CAP
	- - - - - -			-	mounting hardware: (not included w/assembly)
	210-0010-00			1	LOCKWASHER, internal, #10
	210-0445-00			1	NUT, hex., 10-32 x 3/8 inch
6	366-0032-00			1	KNOB, small red--STABILITY
	- - - - - -			-	knob includes:
	213-0004-00			1	LOCKWASHER, internal, #4
	366-0030-00	101	3209	1	KNOB, large black--TRIGGERING LEVEL
	366-0146-00	3210		1	KNOB, large charcoal--TRIGGERING LEVEL
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0013-00			1	LOCKWASHER, internal, 3/8 ID x 11/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch

FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
7	366-0033-00	101	3209	1	KNOB, small black--HORIZ DISPLAY
	366-0148-00	3210		1	KNOB, small charcoal--HORIZ DISPLAY
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	358-0029-00			1	BUSHING, hex., 3/8-32 x 13/32 inch
	- - - - - -			-	mounting hardware: (not included w/bushing)
	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
8	366-0038-00			1	KNOB, small red--VARIABLE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	366-0040-00	101	3209	1	KNOB, large black--TIME/DIV
	366-0160-00	3210		1	KNOB, large charcoal--TIME/DIV
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	- - - - - -			-	SEE RIGHT SIDE PAGE FOR SWITCH PARTS
8	366-0038-00			1	KNOB, small red--VARIABLE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	366-0040-00	101	3209	1	KNOB, large black--TIME/DIV
	366-0160-00	3210		1	KNOB, large charcoal--TIME/DIV
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	- - - - - -			-	SEE RIGHT SIDE PAGE FOR SWITCH PARTS
9	136-0031-00	101	4359	1	SOCKET, light, red
	136-0031-01	4360		1	SOCKET, light, green
	- - - - - -			-	socket includes:
	210-0021-00			1	LOCKWASHER, internal, 0.480 inch ID
	210-0414-00			1	NUT, hex., 15/32-32 x 9/16 inch
10	129-0036-00	101	3209	3	POST, binding
	129-0063-00	3210		3	POST, binding
	- - - - - -			-	mounting hardware for each: (not included w/post)
	358-0036-00	101	3209	1	BUSHING, binding post, black
	358-0169-00	3210		1	BUSHING, binding post, charcoal
	210-0445-00	101	2159	2	NUT, hex., 10-32 x 3/8 inch
	220-0410-00	2160		1	NUT, keps, 10-32 x 3/8 inch
	210-0010-00	101	2159X	1	LOCKWASHER, internal, #10
	210-0206-00	101	2159X	1	LUG, solder, SE #10
11	366-0033-00	101	3209	1	KNOB, small black--POWER & SCALE ILLUM
	366-0148-00	3210		1	KNOB, small charcoal--POWER & SCALE ILLUM
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0013-00			1	LOCKWASHER, interna, 3/8 ID x 11/16 inch OD
	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch

FRONT (cont)

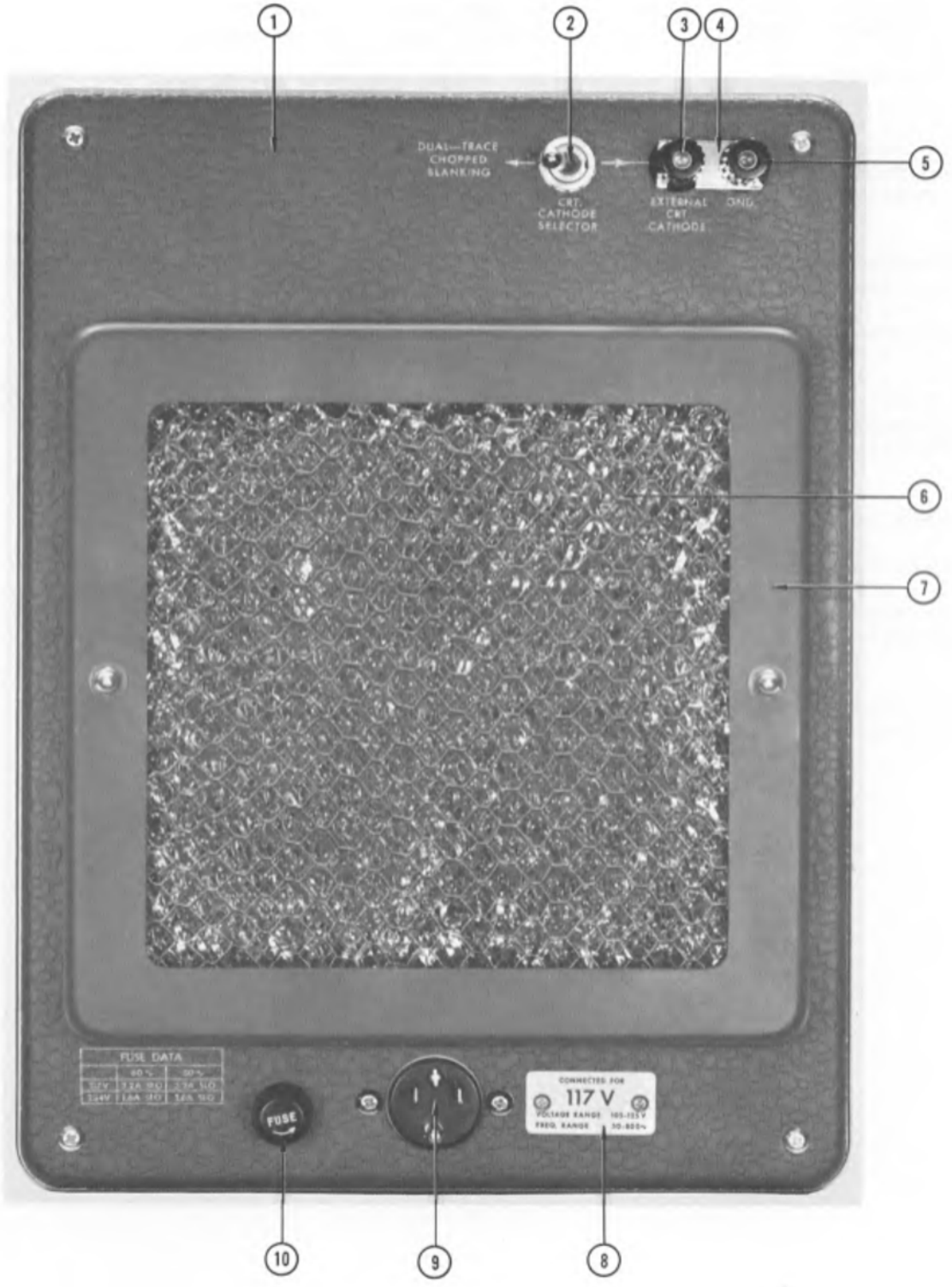
Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description
					1 2 3 4 5
12	366-0028-00	101	3209	1	KNOB, large black--HORIZONTAL POSITION
	366-0145-00	3210		1	KNOB, large charcoal--HORIZONTAL POSITION
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0013-00			1	LOCKWASHER, internal, 3/8 ID x 11/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
13	366-0038-00			1	KNOB, small red--VARIABLE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	366-0040-00	101	3209	1	KNOB, large black--VOLTS/DIV
	366-0160-00	3210		1	KNOB, large charcoal--VOLTS/DIV
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	- - - - - -			-	SEE TURRET ATTENUATOR PAGE FOR SWITCH PARTS
14	129-0035-00			3	ASSEMBLY, binding post
	- - - - - -			-	each assembly includes:
	355-0507-00			1	STEM
	200-0103-00			1	CAP
	210-0455-00			1	NUT, hex., 1/4-28 x 3/8 inch
	210-0046-00			1	LOCKWASHER, internal, 0.261 ID x 0.400 inch OD
15	366-0028-00	101	3209	1	KNOB, large black--AMPLITUDE CALIBRATOR
	366-0145-00	3210		1	KNOB, large charcoal--AMPLITUDE CALIBRATOR
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	262-0332-00			1	SWITCH, wired--AMPLITUDE CALIBRATOR
	- - - - - -			-	switch includes:
	260-0098-00			1	SWITCH, unwired
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0013-00			1	LOCKWASHER, internal 3/8 ID x 11/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
16	366-0031-00			1	KNOB, small red--POSITION
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	366-0029-00	101	3209	1	KNOB, large black--POLARITY
	366-0142-00	3210		1	KNOB, large charcoal--POLARITY
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	262-0337-00	101	569	1	SWITCH, wired--B VERTICAL POLARITY
	262-0433-00	570		1	SWITCH, wired--B VERTICAL POLARITY
	- - - - - -			-	switch includes:
	260-0326-00			1	SWITCH, unwired
	384-0213-00			1	ROD, extension
	376-0014-00			1	COUPLING
	210-0012-00			1	LOCKWASHER, internal 3/8 ID x 1/2 inch OD
	210-0413-00			2	NUT, hex., 3/8-32 x 1/2 inch
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0013-00			1	LOCKWASHER, internal, 3/8 ID x 11/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch

FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5	Description
17	401-0004-00			1		CAM, plastic (under cover)
	- - - - - -			-		mounting hardware: (not included w/cam)
	211-0025-00			1		SCREW, 4-40 x 3/8 inch, FHS
18	331-0037-00			1		GRATICULE, 5 inch, 6 cm vert. X10 cm horiz.
19	358-0054-00			3		BUSHING, banana jack
20	366-0031-00			1		KNOB, small red--POSITION
	- - - - - -			-		knob includes:
	213-0004-00			1		SCREW, set, 6-32 x 3/16 inch, HSS
	366-0029-00	101	3209	1		KNOB, large black--POLARITY
	366-0142-00	3210		1		KNOB, large charcoal--POLARITY
	- - - - - -			-		knob includes:
	213-0004-00			1		SCREW, set, 6-32 x 3/16 inch, HSS
	262-0344-00	101	569	1		SWITCH, wired--A VERTICAL POLARITY
	262-0432-00	570		1		SWITCH, wired--A VERTICAL POLARITY
	- - - - - -			-		switch includes:
	260-0331-00			1		SWITCH, unwired
	384-0213-00			1		ROD, extension
	376-0014-00			1		COUPLING
	210-0413-00			2		NUT, hex., 3/8-32 x 1/2 inch
	- - - - - -			-		mounting hardware: (not included w/switch)
	210-0013-00			1		LOCKWASHER, internal, 3/8 ID x 11/16 inch OD
	210-0413-00			1		NUT, hex., 3/8-32 x 1/2 inch
21	366-0033-00	101	3209	1		KNOB, small black--MODE
	366-0148-00	3210		1		KNOB, small charcoal--MODE
	- - - - - -			-		knob includes:
	213-0004-00			1		SCREW, set, 6-32 x 3/16 inch, HSS
	260-0325-00			1		SWITCH, unwired--MODE
	- - - - - -			-		mounting hardware: (not included w/switch)
	210-0012-00			1		LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0840-00			1		WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0413-00			1		NUT, hex., 3/8-32 x 1/2 inch
22	366-0038-00			1		KNOB, small red--VARIABLE
	- - - - - -			-		knob includes:
	213-0004-00			1		SCREW, set, 6-32 x 3/16 inch, HSS
	366-0040-00	101	3209	1		KNOB, large black--VOLTS/DIV
	366-0160-00	3210		1		KNOB, large charcoal--VOLTS/DIV
	- - - - - -			-		knob includes:
	213-0004-00			1		SCREW, set, 6-32 x 3/16 inch, HSS
	- - - - - -			-		SEE TURRET ATTENUATOR PAGE FOR SWITCH PARTS
23	366-0033-00	101	3209	1		KNOB, small black--INTENSITY
	366-0148-00	3210		1		KNOB, small charcoal--INTENSITY
	- - - - - -			-		knob includes:
	213-0004-00			1		SCREW, set, 6-32 x 3/16 inch, HSS
	- - - - - -			1		RESISTOR, variable
	- - - - - -			-		mounting hardware: (not included w/resistor)
	210-0013-00			1		LOCKWASHER, internal, 3/8 ID x 11/16 inch OD
	210-0840-00			1		WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0413-00			1		NUT, hex., 3/8-32 x 1/2 inch

FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
24	366-0033-00	101	3209	1	KNOB, small black--FOCUS
	366-0148-00	3210		1	KNOB, small charcoal--FOCUS
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0013-00			1	LOCKWASHER, internal, 3/8 ID x 11/16 inch OD
	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
25	366-0033-00	101	3209	1	KNOB, small black--ASTIGMATISM
	366-0148-00	3210		1	KNOB, small charcoal--ASTIGMATISM
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0013-00			1	LOCKWASHER, internal, 3/8 ID x 11/16 inch OD
	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
26	200-0382-00			1	COVER, graticule
	- - - - - -			-	cover includes:
	354-0116-00			1	RING, ornamental
	- - - - - -			-	mounting hardware: (not included w/cover)
	210-0816-00			4	WASHER, rubber
	210-0424-00			4	NUT, knurled, 3/8-24 x 9/16 inch
27	337-0187-00			1	SHIELD, graticule light (under cover)
28	124-0068-00			1	STRIP, felt (under cover)


1
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DUAL—TRACE CHOPPED BLANKING
CRT CATHODE SELECTOR
EXTERNAL CRT CATHODE
GND
FUSE DATA
FUSE
117 V

Ⓐ

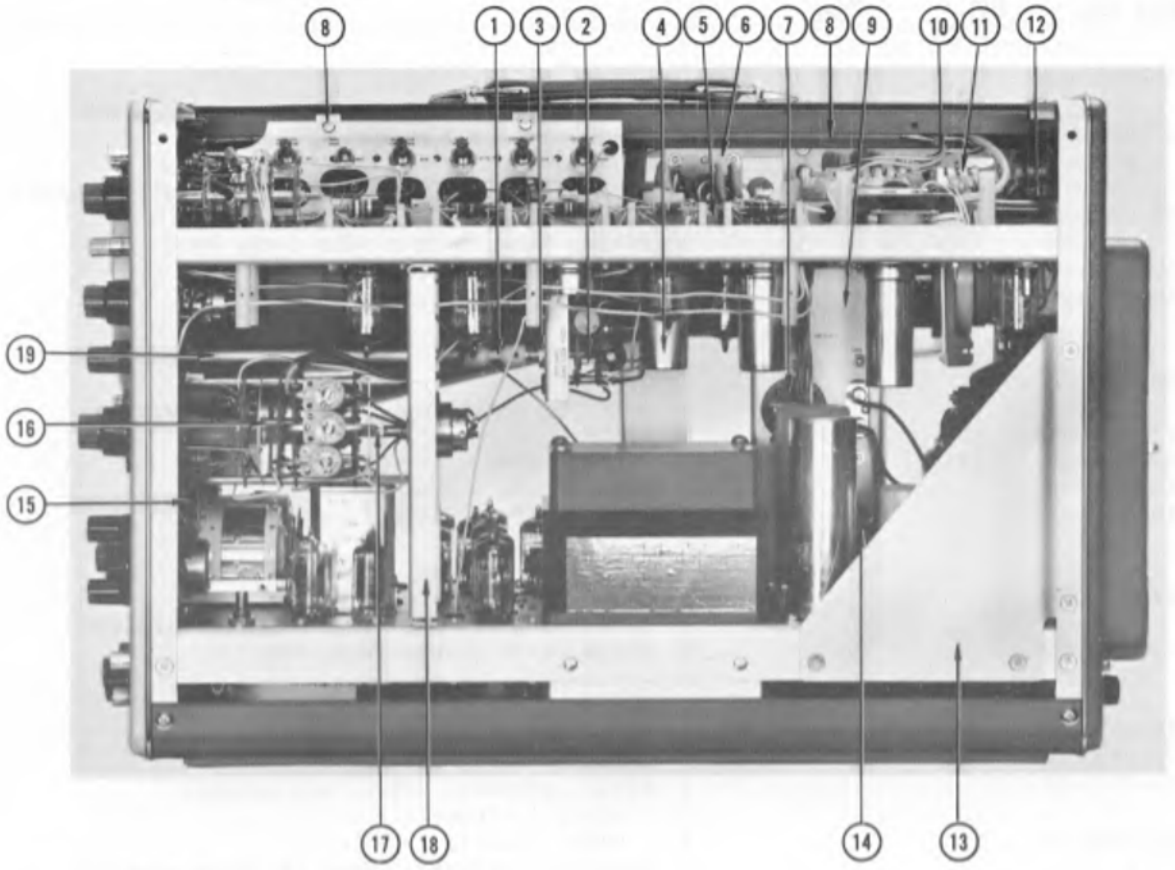
REAR (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description
1	387-0220-00			1	PLATE, rear overlay
	- - - - - -			-	mounting hardware: (not included w/plate)
	213-0104-00			4	SCREW, thread forming, #6 x 3/8 inch, THS
	387-0221-00			1	PLATE, rear sub-panel
	- - - - - -			-	plate includes:
	354-0057-00			1	RING, ornamental
2	260-0209-00			1	SWITCH, toggle -- CRT CATHODE SELECTOR
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0414-00			1	NUT, hex., 15/32-32 x 9/16 inch
	354-0055-00			1	RING, locking
	210-0902-00			1	WASHER, flat, 0.470 ID x 21/32 inch OD
	210-0473-00			1	NUT, 12 sided, 15/32-32 x 0.634 inch
3	129-0036-00	101	3209	1	POST, binding, black
	129-0063-00	3210		1	POST, binding, charcoal
	- - - - - -			-	mounting hardware: (not included w/post)
	358-0036-00	101	3209	1	BUSHING, binding post, black
	358-0169-00	3210		1	BUSHING, binding post, charcoal
	210-0445-00	101	2159	2	NUT, hex., 10-32 x 3/8 inch
	220-0410-00	2160		1	NUT, keps, 10-32 x 3/8 inch
	210-0010-00	101	2159X	1	LOCKWASHER, internal, #10
	210-0206-00	101	2159X	1	LUG, solder, SE #10
6	378-0010-00			1	FILTER, air
7	380-0017-00			1	HOUSING, air filter
	- - - - - -			-	mounting hardware: (not included w/housing)
	212-0031-00			2	SCREW, 8-32 x 1 1/4 inches, RHS
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
	210-0402-00			2	NUT, hex., 8-32 x 5/16 inch
8	334-0649-00			1	TAG, voltage rating
	- - - - - -			-	mounting hardware: (not included w/tag)
	213-0088-00			2	SCREW, thread forming, 4-40 x 1/4 inch, PHS
9	131-0102-00	101	3919	1	CONNECTOR, motor base, 3 wire
	131-0102-01	3920	4419	1	CONNECTOR, motor base, 3 wire
	131-0102-02	4420		1	CONNECTOR, motor base, 3 wire
	- - - - - -			-	connector includes:
	129-0041-00	101	3919	1	POST, ground
	129-0041-01	3920	4419	1	POST, ground
	200-0185-00	101	3919	1	COVER, plastic
	200-0185-01	3920	4419	1	COVER, plastic
	204-0335-00	4420		1	BODY, contact assembly
	210-0003-00	101	3919X	2	LOCKWASHER, external, #4
	210-0551-00	101	3919X	2	NUT, hex., 4-40 x 1/4 inch
	211-0132-00	X3920	4419	1	SCREW, sems, 4-40 x 1/2 inch, PHS
	211-0534-00	4420		1	SCREW, sems, 6-32 x 5/16 inch, PHS

REAR (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
	211-0015-00	101	3919	1	SCREW, 4-40 x 1/2 inch, PHS
	213-0088-00	3920	4419	1	SCREW, thread forming, 4-40 x 1/4 inch, PHS
	213-0146-00	4420		1	SCREW, thread forming, #6 x 0.312 inch, PHS
	214-0078-00			2	PIN, connecting
	377-0041-00	101	3919	1	INSERT, plastic
	377-0051-00	3920	4419	1	INSERT, plastic
	214-1016-00	4420		1	INSULATOR, connector
	386-0933-00	101	4419	1	PLATE, mounting
	386-1356-01	4420		1	PLATE, mounting
	- - - - - -			-	mounting hardware: (not included w/connector)
	211-0537-00			2	SCREW, 6-32 x 3/8 inch, THS
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
10	352-0002-00			1	ASSEMBLY, fuse holder
	- - - - - -			-	assembly includes:
	352-0010-00			1	HOLDER, fuse
	200-0582-00			1	CAP, fuse, black
	210-0873-00			1	WASHER, rubber, 1/2 ID x 11/16 inch OD
	- - - - - -			1	NUT

RIGHT SIDE



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	376-0011-00			1	COUPLING, plastic, insulating
	- - - - - -			-	coupling includes:
	213-0048-00			2	SCREW, set, 4-40 x 1/8 inch, HSS
2	262-0125-00	101	569	1	SWITCH, wired--HORIZ. DISPLAY
	262-0430-00	570		1	SWITCH, wired--HORIZ. DISPLAY
	- - - - - -			-	switch includes:
	260-0186-00			1	SWITCH, unwired
	- - - - - -			-	mounting hardware: (not included w/switch)
3	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
4	337-0008-00			3	SHIELD, tube
5	210-0204-00			1	LUG, solder, DE #6
	- - - - - -			-	mounting hardware: (not included w/lug)
	211-0038-00			1	SCREW, 4-40 x 5/16 inch, 100° csk, FHS
	210-0406-00			1	NUT, hex., 4-40 x 3/16 inch

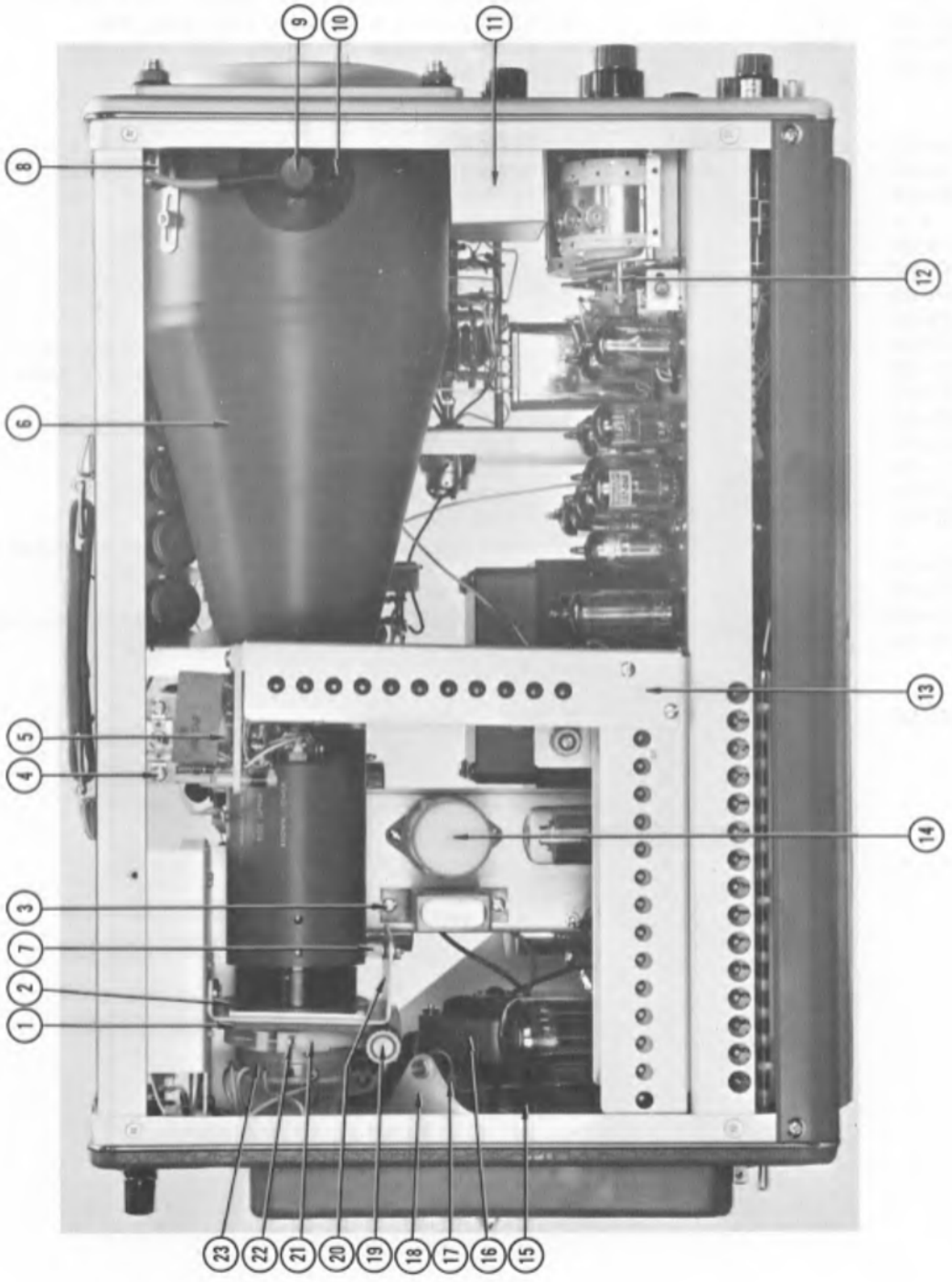
RIGHT SIDE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty 1 2 3 4 5	Description
6	386-0533-00			1	PLATE, white plastic
	- - - - - -			-	mounting hardware: (not included w/plate)
	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
7	386-0254-00	X140		1	PLATE, fiber
	211-0534-00	X140		2	SCREW, sems, 6-32 x 5/16 inch, PHS
	210-0006-00	X140		2	LOCKWASHER, internal, #6
	210-0407-00	X140		2	NUT, hex., 6-32 x 1/4 inch
8	166-0096-00			1	TUBE, conduit
	- - - - - -			-	mounting hardware: (not included w/tube)
	343-0015-00	101	1315	2	CLAMP
	343-0084-00	1316		2	CLAMP, strap
	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
	210-0803-00			2	WASHER, flat, 0.150 ID x 3/8 inch OD
9	387-0219-00			1	PLATE, vertical bulkhead
	- - - - - -			-	mounting hardware: (not included w/plate)
	211-0507-00			4	SCREW, 6-32 x 5/16 inch, PHS
10	179-0435-00	101	709	1	CABLE HARNESS, focus & intensity
	179-0132-00	710		1	CABLE HARNESS, focus & intensity
11	124-0092-00			1	STRIP, ceramic, 3/4 h, w/3 notches
	- - - - - -			-	strip includes:
	355-0046-00			1	STUD, plastic
	- - - - - -			-	mounting hardware: (not included w/strip)
	361-0009-00	101	709	1	SPACER, plastic, 0.406 inch long
	361-0008-00	710		1	SPACER, plastic, 0.281 inch long
12	348-0005-00			1	GROMMET, rubber, 1/2 inch diameter
13	406-0657-00	X201		1	BRACKET, chassis support
	- - - - - -			-	mounting hardware: (not included w/bracket)
	212-0040-00	X201		4	SCREW, 8-32 x 3/8 inch, 100° csk, FHS
	210-0458-00	X201		4	NUT, keps, 8-32 x 11/32 inch
14	- - - - - -			1	SWITCH, thermal cutout
	- - - - - -			-	mounting hardware: (not included w/switch)
	211-0503-00			2	SCREW, 6-32 x 3/16 inch, PHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
15	352-0008-00	101	3619	4	HOLDER, neon bulb, single, black
	352-0067-00	3620		4	HOLDER, neon bulb, single, gray

RIGHT SIDE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description
	378-0541-00	X3620		4	FILTER, lens, neon
	- - - - - -			-	mounting hardware for each: (not included w/holder)
	211-0031-00	101	3619	1	SCREW, 4-40 x 1 inch, 100° csk, FHS
	211-0109-00	3620		1	SCREW, 4-40 x 7/8 inch, 100° csk, FHS
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
16	262-0334-00	101	3929	1	SWITCH, wired--TIME/DIV
	262-0334-01	3930	4769	1	SWITCH, wired--TIME/DIV
	262-0334-02	4770		1	SWITCH, wired--TIME/DIV
	- - - - - -			-	switch includes:
	260-0329-00			1	SWITCH, unwired--TIME/DIV
17	384-0147-00			1	ROD, extension
	376-0014-00			1	COUPLING
	210-0413-00			2	NUT, hex., 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
18	406-0582-00			1	BRACKET
	348-0002-00			3	GROMMET, rubber, 1/4 inch
	348-0003-00			2	GROMMET, rubber, 5/16 inch
	348-0004-00			1	GROMMET, rubber, 3/8 inch
	211-0029-00			2	SCREW, 5-40 x 3/16 inch, PHS
	210-0202-00			1	LUG, solder, SE #6
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0803-00			4	WASHER, flat, 0.150 ID x 3/8 inch OD
	211-0507-00			4	SCREW, 6-32 x 5/16 inch, PHS
	210-0013-00			1	LOCKWASHER, internal, 3/8 ID x 11/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
19	384-0133-00			1	ROD, extension

LEFT SIDE



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LEFT SIDE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description
1	432-0022-00	101	5089	1	BASE, CRT rotator
	432-0022-02	5090		1	BASE, CRT rotator
	- - - - - -			-	mounting hardware: (not included w/base)
	211-0561-00			2	SCREW, 6-32 x 3/8 inch, FH cap
	210-0503-00			1	NUT, rotator securing
	386-1485-00	X5090		1	PLATE, retaining (not shown)
	- - - - - -			-	mounting hardware: (not included w/plate)
	211-0022-00			1	SCREW, 2-56 x 3/16 inch
2	354-0078-00	101	1319	1	RING, CRT rotator
	354-0178-00	1320		1	RING, CRT rotator
3	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
4	- - - - - -			1	CAPACITOR, variable
	- - - - - -			-	mounting hardware: (not included w/capacitor)
	211-0510-00			2	SCREW, 6-32 x 3/8 inch, PHS
	210-0802-00			2	WASHER, flat, 0.150 ID x 5/16 inch OD
	210-0803-00			2	WASHER, flat, 0.150 ID x 3/8 inch OD
	210-0202-00			2	LUG, solder, SE #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
5	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0465-00			1	NUT, hex., 1/4-32 x 3/8 inch
	210-0011-00			1	LOCKWASHER, internal, 1/4 ID x 15/32 inch OD
6	337-0088-00			1	SHIELD, CRT
	- - - - - -			-	mounting hardware: (not included w/shield)
	211-0559-00			5	SCREW, 6-32 x 3/8 inch, 100° csk, FHS
	406-0239-00			2	BRACKET
	210-0457-00			5	NUT, keps, 6-32 x 5/16 inch
7	211-0514-00			1	SCREW, 6-32 x 3/4 inch, PHS
	210-0006-00			1	LOCKWASHER, internal, #6
	385-0127-00			1	ROD, hex., 9/32 inch
	210-0803-00			2	WASHER, flat, 0.150 ID x 3/8 inch OD
	210-0811-00			2	WASHER, fiber, #6
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
8	136-0001-00			2	SOCKET, graticule light
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	211-0534-00			1	SCREW, sems, 6-32 x 5/16 inch, PHS
	210-0803-00			1	WASHER, flat, 0.150 ID x 3/8 inch OD
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch

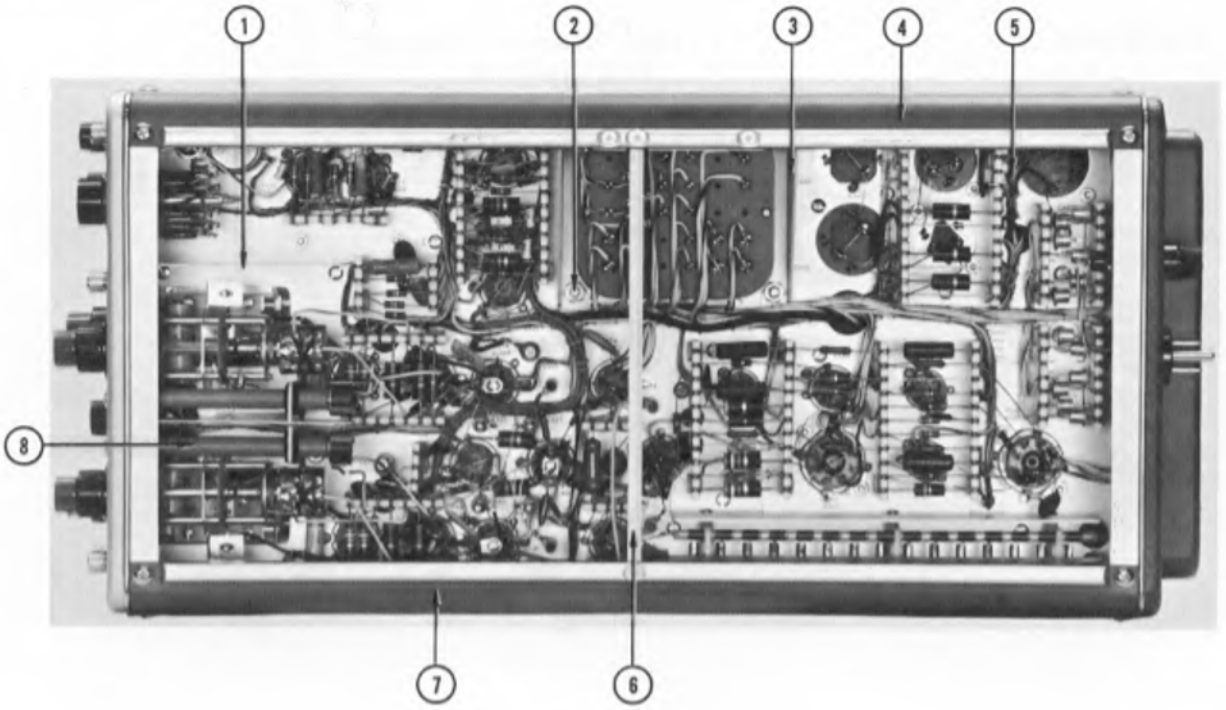
LEFT SIDE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty 1 2 3 4 5	Description
9	179-0435-00	101	709	1	CABLE HARNESS, focus & intensity
	179-0132-00	710		1	CABLE HARNESS, focus & intensity
	- - - - - -			-	cable harness includes:
	131-0086-00			1	CONNECTOR, cable, anode
	- - - - - -			-	connector includes:
	131-0073-00			1	CONNECTOR, CRT brush
	200-0110-00			1	CAP, CRT anode
	134-0031-00			1	PLUG, CRT contact (not shown)
10	200-0112-00			1	COVER, CRT anode & plate
	- - - - - -			-	cover includes:
	200-0111-00			1	COVER
	386-0647-00			1	PLATE
11	337-0371-00			1	SHIELD, variable resistor
12	- - - - - -			2	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
	211-0017-00			2	SCREW, 4-40 x 3/4 inch, RHS
	210-0004-00			2	LOCKWASHER, internal, #4
	166-0169-00			2	TUBE, spacer, 9/16 inch
13	- - - - - -			-	SEE DELAY LINE PAGE
14	200-0293-00	X140		1	COVER, capacitor
	635-0427-00			1	ASSEMBLY, fan motor
	- - - - - -			-	assembly includes:
15	369-0015-00			1	FAN, 5 1/2 inches, clockwise
16	147-0022-00			1	MOTOR, 115 V
	- - - - - -			-	mounting hardware: (not included w/motor)
	212-0022-00			2	SCREW, 8-32 x 1 1/2 inches, RHS
	166-0006-00			2	TUBE, spacer, 7/16 inch
	210-0008-00			2	LOCKWASHER, internal, #8
	210-0409-00			2	NUT, hex., 8-32 x 5/16 inch
17	426-0046-00			1	MOUNT, fan motor
	- - - - - -			-	mounting hardware: (not included w/mount)
	348-0008-00			3	SHOCKMOUNT
	210-0008-00			6	LOCKWASHER, internal, #8
	210-0409-00			6	NUT, hex., 8-32 x 5/16 inch
18	354-0051-00			1	RING, fan
	- - - - - -			-	mounting hardware: (not included w/assembly)
	213-0104-00			6	SCREW, thread forming, #6 x 3/8 inch, THS
19	366-0032-00			1	KNOB, small red
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
	355-0049-00			1	STUD, CRT rotator
20	406-0368-00	101	809	1	BRACKET, CRT support
	406-0729-00	810		1	BRACKET, CRT support
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
	210-0803-00			2	WASHER, flat, 0.150 ID x 3/8 inch OD

LEFT SIDE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
21	354-0103-00			1		RING, plastic, clamping
	- - - - - -			-		ring includes:
	210-0502-00			1		NUT, 10-32 x 3/8 inch
22	211-0560-00			1		SCREW, 6-32 x 1 inch, RHS
	210-0407-00			1		NUT, hex., 6-32 x 1/4 inch
23	136-0046-00	101	528	1		SOCKET, CRT
	387-0344-00	101	528	1		PLATE, socket back
	211-0038-00	101	528	2		SCREW, 4-40 x 5/16 inch, 100° csk, FHS
	136-0046-00	529		1		ASSEMBLY, CRT socket
	- - - - - -			-		assembly includes:
	136-0117-00			1		SOCKET, CRT
	131-0178-00			7		CONNECTOR, cable end
	387-0393-00			1		PLATE, back
	213-0087-00			2		SCREW, thread cutting, 2-32 x 1/2 inch, RHS

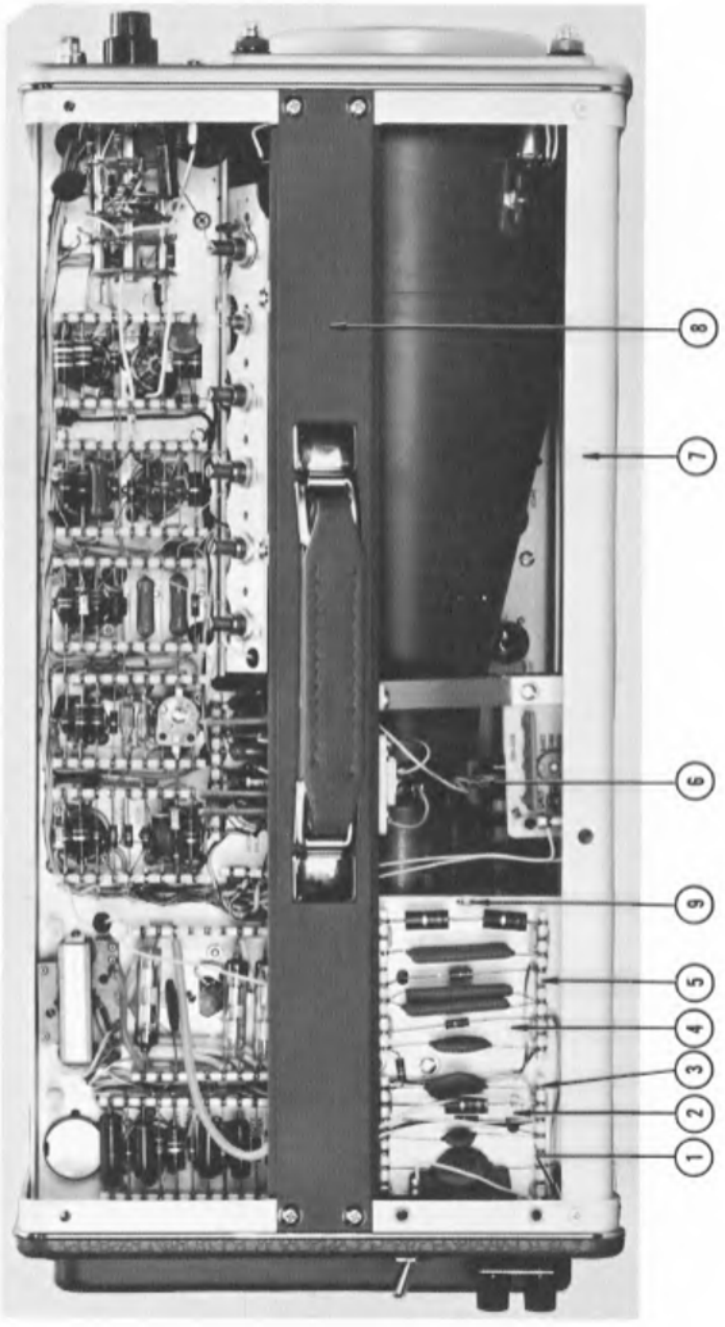
BOTTOM



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	337-0373-00			1	SHIELD, calibrator
	- - - - - -			-	mounting hardware: (not included w/shield)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
2	- - - - - -			1	TRANSFORMER
	- - - - - -			-	transformer includes:
	212-0545-00			4	SCREW, 10-32 x 4 inch, HHS
	210-0812-00			4	WASHER, fiber, #10
	- - - - - -			-	mounting hardware: (not included w/transformer)
	210-0010-00			4	LOCKWASHER, internal, #10
	210-0564-00			4	NUT, hex., 10-32 x 3/8 inch
3	406-0578-00	101	200	1	BRACKET, transformer support, left
	406-0579-00	101	200	1	BRACKET, transformer support, right
	406-0656-00	201		1	BRACKET, transformer support
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
	211-0522-00			2	SCREW, 6-32 x 5/16 inch, 100° csk, FHS
	210-0203-00			1	LUG, solder, SE #6 long
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch

BOTTOM (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
4	122-0085-00	101	200	1		ANGLE, frame, bottom rail, right
	122-0092-00	201		1		ANGLE, frame, bottom rail, right
	- - - - - -			-		mounting hardware: (not included w/angle)
	212-0039-00			4		SCREW, 8-32 x 3/8 inch, THS
	210-0458-00			4		NUT, keps, 8-32 x 11/32 inch
5	179-0428-00			1		CABLE HARNESS, 110 V
6	381-0133-00			1		BAR, support
	- - - - - -			-		mounting hardware: (not included w/bar)
	212-0043-00			2		SCREW, 8-32 x 1/2 inch, 100° csk, FHS
7	122-0086-00			1		ANGLE, frame, bottom rail, left
	- - - - - -			-		mounting hardware: (not included w/angle)
	212-0039-00			4		SCREW, 8-32 x 3/8 inch, THS
	210-0458-00			4		NUT, keps, 8-32 x 11/32 inch
8	384-0565-00			2		ROD, spacing, resistor mounting
	384-0194-00			2		ROD, extension (not shown)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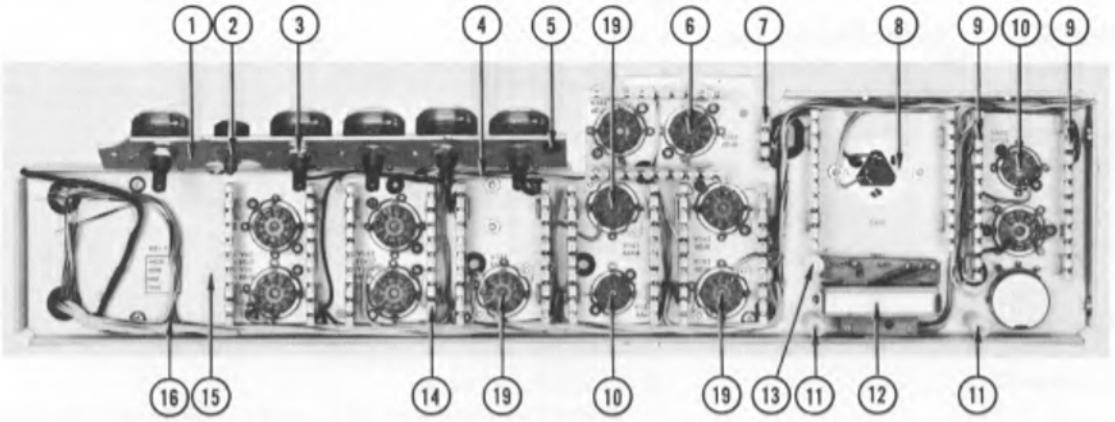
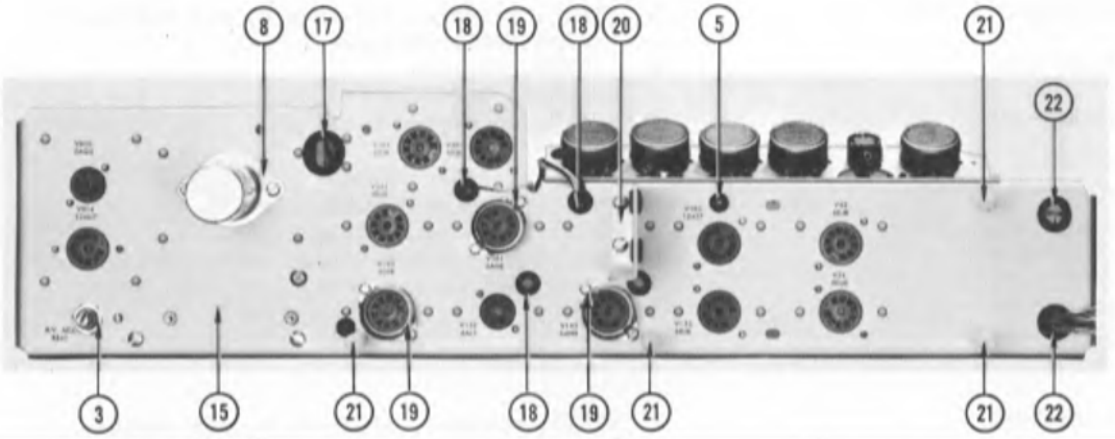
TOP (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty 1 2 3 4 5	Description
1	348-0002-00			1	GROMMET, rubber, 1/4 inch diameter
2	210-0202-00			1	LUG, solder, SE #6
	- - - - - -			-	mounting hardware: (not included w/lug)
	211-0504-00			1	SCREW, 6-32 x 1/4 inch, PHS
	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch
3	124-0093-00	101	709	2	STRIP, ceramic, 3/4 inch h, w/5 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
	124-0095-00	710		2	STRIP, ceramic, 3/4 inch h, w/9 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0008-00			2	SPACER, plastic, 0.281 inch long
4	441-0318-00	101	709	1	CHASSIS, focus & intensity
	441-0272-00	710		1	CHASSIS, focus & intensity
	- - - - - -			-	mounting hardware: (not included w/chassis)
	211-0559-00			1	SCREW, 6-32 x 3/8 inch, 100° csk, FHS
	211-0507-00			3	SCREW, 6-32 x 5/16 inch, PHS
	210-0803-00			3	WASHER, flat, 0.150 ID x 3/8 inch OD
5	124-0095-00			2	STRIP, ceramic, 3/4 inch h, w/9 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00	101	709	2	SPACER, plastic, 0.406 inch long
	361-0008-00		710	2	SPACER, plastic, 0.281 inch long
6	131-0049-00			5	CONNECTOR, cable end
7	122-0060-00			1	ANGLE, frame, top left
	- - - - - -			-	mounting hardware: (not included w/angle)
	211-0559-00			4	SCREW, 6-32 x 3/8 inch, 100° csk, FHS
	210-0457-00			4	NUT, keps, 6-32 x 5/16 inch
8	381-0176-00	101	1315	1	BAR, top support w/handle
	381-0199-00	1316		1	BAR, top support w/handle
	- - - - - -			-	mounting hardware: (not included w/bar)
	212-0039-00			4	SCREW, 8-32 x 3/8 inch, THS
	381-0073-00			2	BAR, retaining
9	337-0318-00			1	SHIELD, focus & intensity (not shown)
	- - - - - -			-	mounting hardware: (not included w/shield)
	211-0559-00			2	SCREW, 6-32 x 3/8 inch, 100° csk, FHS
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
	210-0803-00			1	WASHER, flat, 0.150 ID x 3/8 inch OD





REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	406-0581-00			1	BRACKET, variable resistor
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
	210-0803-00			2	WASHER, flat, 0.150 ID x 3/8 inch OD
2	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0011-00			1	LOCKWASHER, internal, 1/4 ID x 15/32 inch OD
	210-0465-00			1	NUT, hex., 1/4-32 x 3/8 inch
3	- - - - - -			6	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
	210-0207-00			1	LUG, solder, 3/8 ID x 5/8 inch OD, SE
	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
4	179-0455-00			1	CABLE HARNESS
5	348-0002-00			6	GROMMET, rubber, 1/4 inch diameter

SWEEP CHASSIS (cont)

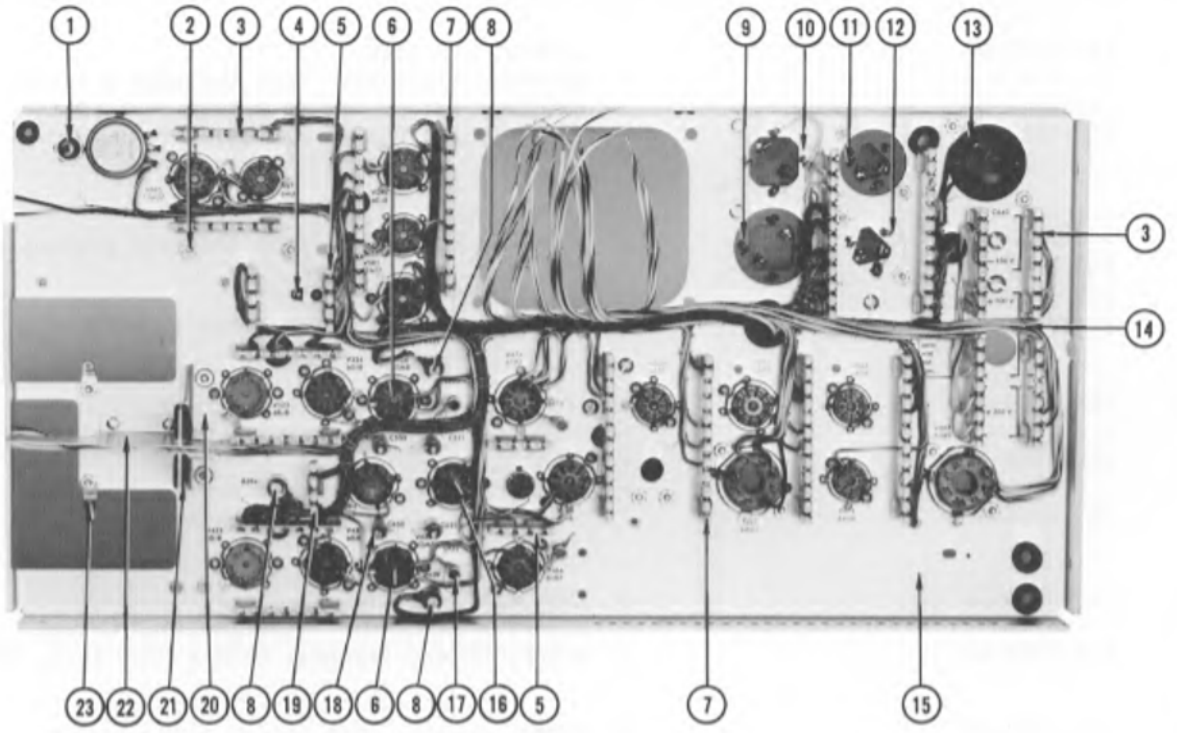
Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
6	136-0015-00			8		SOCKET, tube, 9 pin, w/ground lugs
	- - - - - -			-		mounting hardware for each: (not included w/socket)
	213-0044-00			2		SCREW, thread forming, 5-32 x 3/16 inch, PHS
7	124-0088-00			1		STRIP, ceramic, 3/4 inch h, w/4 notches
	- - - - - -			-		strip includes:
	355-0046-00			2		STUD, plastic
	- - - - - -			-		mounting hardware: (not included w/strip)
	361-0009-00			2		SPACER, plastic, 0.406 inch long
8	- - - - - -			1		CAPACITOR
	- - - - - -			-		mounting hardware: (not included w/capacitor)
	386-0253-00			1		PLATE, metal
	211-0534-00			2		SCREW, sems, 6-32 x 5/16 inch, PHS
	210-0006-00			2		LOCKWASHER, internal, #6
	210-0407-00			2		NUT, hex., 6-32 x 1/4 inch
9	124-0091-00			2		STRIP, ceramic, 3/4 inch h, w/11 notches
	- - - - - -			-		each strip includes:
	355-0046-00			2		SPACER, plastic
	- - - - - -			-		mounting hardware for each: (not included w/strip)
	361-0009-00			2		SPACER, plastic, 0.406 inch long
10	136-0008-00			2		SOCKET, tube, 7 pin, w/ground lugs
	- - - - - -			-		mounting hardware for each: (not included w/socket)
	213-0044-00			2		SCREW, thread forming, 5-32 x 3/16 inch, PHS
11	385-0060-00			2		ROD, plastic
	- - - - - -			-		mounting hardware for each: (not included w/rod)
	211-0507-00			1		SCREW, 6-32 x 5/16 inch, PHS
	337-0370-00			1		SHIELD, high voltage (not shown)
	- - - - - -			-		mounting hardware: (not included w/shield)
	211-0503-00			3		SCREW, 6-32 x 3/16 inch, PHS
	210-0803-00			3		WASHER, flat, 0.150 ID x 3/8 inch OD
	214-0210-00	X399		1		ASSEMBLY, solder spool
	- - - - - -			-		assembly includes:
	214-0209-00			1		SPOOL, w/o solder
	- - - - - -			-		mounting hardware: (not included w/assembly)
	361-0007-00			1		SPACER, plastic, 0.188 inch long
12	- - - - - -			1		TRANSFORMER
	- - - - - -			-		mounting hardware: (not included w/transformer)
	346-0001-00			1		STRAP, mounting
	210-0004-00			2		LOCKWASHER, internal, #4
	210-0406-00			2		NUT, hex., 4-40 x 3/16 inch

SWEEP CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty 1 2 3 4 5	Description
13	385-0076-00	101	339	1	ROD, plastic
	385-0138-00	340		1	ROD, plastic
	- - - - - -			-	mounting hardware: (not included w/rod)
	211-0507-00	101	339	1	SCREW, 6-32 x 5/16 inch, PHS
	213-0041-00	340		1	SCREW, thread cutting, 6-32 x 3/8 inch, THS
14	124-0090-00			14	STRIP, ceramic, 3/4 inch h, w/9 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
15	441-0319-00	101	4049	1	CHASSIS, sweep
	441-0319-01	4050		1	CHASSIS, sweep
	- - - - - -			-	mounting hardware: (not included w/chassis)
	212-0040-00			3	SCREW, 8-32 x 3/8 inch, 100° csk, FHS
	210-0458-00			1	NUT, keps, 8-32 x 11/32 inch
16	179-0427-00	101	629	1	CABLE HARNESS, sweep
	179-0569-00	630		1	CABLE HARNESS, sweep
17	348-0012-00			1	GROMMET, rubber, 5/8 inch diameter
18	348-0003-00			6	GROMMET, rubber, 5/16 inch diameter
19	136-0015-00			3	SOCKET, tube, 9 pin, w/ground lugs
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	211-0033-00			2	SCREW, sems, 4-40 x 5/16 inch, PHS
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
	337-0005-00			1	SHIELD, socket
20	406-0218-00			1	BRACKET, horizontal display switch
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
21	385-0096-00	101	339	4	ROD, plastic
	385-0136-00	340		4	ROD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/rod)
	211-0507-00	101	339	1	SCREW, 6-32 x 5/16 inch, PHS
	213-0041-00	340		1	SCREW, thread cutting, 6-32 x 3/8 inch, THS
22	348-0005-00			2	GROMMET, rubber, 1/2 inch diameter

POWER & VERTICAL AMPLIFIER CHASSIS

TOP



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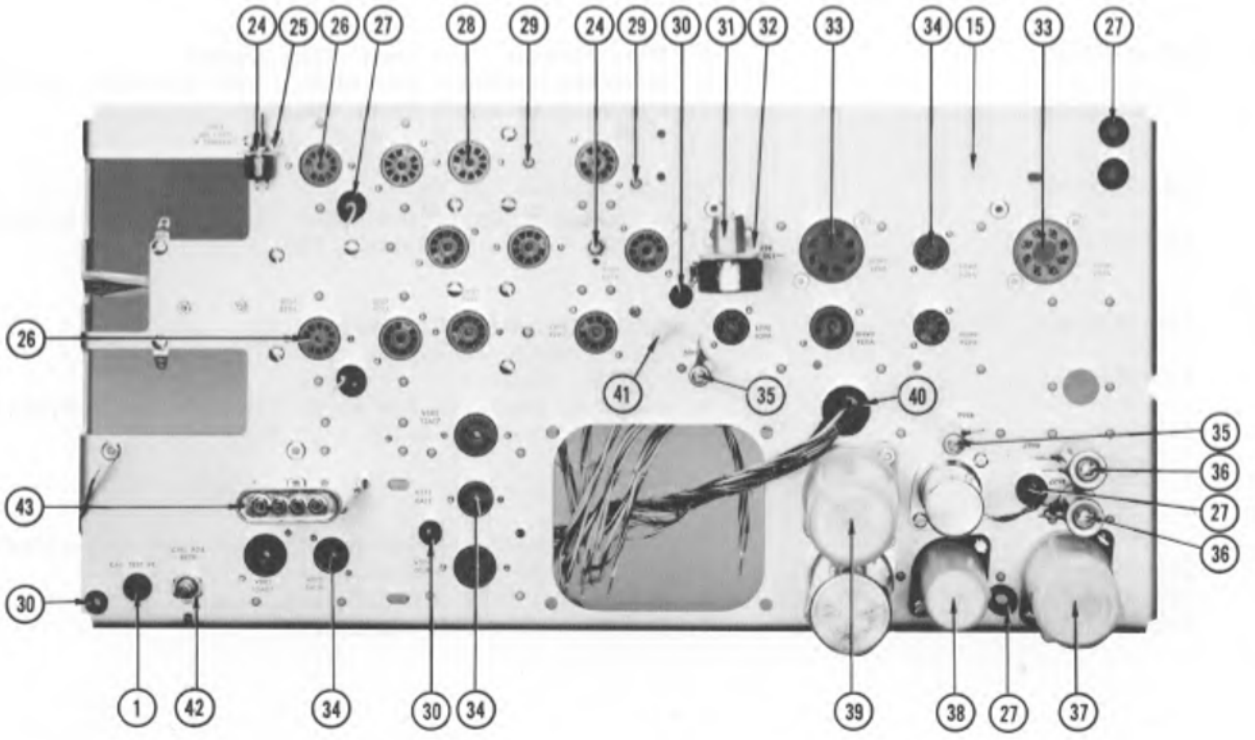


POWER & VERTICAL AMPLIFIER CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description
1	136-0037-00			1	SOCKET, tip jack
	- - - - - -			-	mounting hardware: (not included w/socket)
	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
2	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0803-00			2	WASHER, flat, 0.150 ID x 3/8 inch OD
3	124-0089-00			10	STRIP, ceramic, 3/4 inch h, w/7 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
4	210-0201-00			1	LUG, solder, SE #4
	- - - - - -			-	mounting hardware: (not included w/lug)
	213-0044-00			1	SCREW, thread forming, 5-32 x 3/16 inch, PHS
5	124-0088-00			4	STRIP, ceramic, 3/4 inch h, w/4 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
6	385-0107-00			2	ROD, plastic, 3/4 inch (not shown)
	- - - - - -			-	mounting hardware for each: (not included w/rod)
	211-0014-00			1	SCREW, 4-40 x 1/2 inch, PHS
	210-0201-00			2	LUG, solder, SE #4
	- - - - - -			-	mounting hardware for each: (not included w/lug)
	211-0011-00			1	SCREW, 4-40 x 5/16 inch, PHS
7	124-0091-00			8	STRIP, ceramic, 3/4 inch h, w/11 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
8	- - - - - -			3	RESISTOR
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
	211-0544-00			1	SCREW, 6-32 x 3/4 inch, THS
	210-0478-00			1	NUT, hex., 5/16 x 21/32 inch long
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS

POWER & VERTICAL AMPLIFIER CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty 1 2 3 4 5	Description
9	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
	386-0254-00			1	PLATE, fiber, large
	432-0044-00	X1600	3449X	1	BASE
	211-0543-00	101	1599	2	SCREW, 6-32 x 5/16 inch, RHS
	211-0514-00	1600	3449	2	SCREW, 6-32 x 3/4 inch, PHS
	211-0543-00	3450		2	SCREW, 6-32 x 5/16 inch, RHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
10	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
	386-0255-00			1	PLATE, metal
	211-0534-00			2	SCREW, sems, 6-32 x 5/16 inch, PHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
11	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
	386-0252-00			1	PLATE, fiber
	211-0534-00			2	SCREW, sems, 6-32 x 5/16 inch, PHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
12	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
	386-0253-00			1	PLATE, metal
	211-0534-00			2	SCREW, sems, 6-32 x 5/16 inch, PHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
13	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
	386-0254-00			1	PLATE, fiber
	211-0543-00			2	SCREW, 6-32 x 5/16 inch, RHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
14	179-0426-00			1	CABLE HARNESS, power
15	441-0320-00	101	4329	1	CHASSIS, power & vertical amplifier
	441-0320-01	4330		1	CHASSIS, power & vertical amplifier
	- - - - - -			-	mounting hardware: (not included w/chassis)
	212-0040-00			8	SCREW, 8-32 x 3/8 inch, 100° csk, FHS
	210-0458-00			8	NUT, keps, 8-32 x 11/32 inch
16	385-0107-00			1	ROD, plastic, 3/4 inch (not shown)
	- - - - - -			-	mounting hardware: (not included w/rod)
	211-0014-00			1	SCREW, 4-40 x 1/2 inch, PHS

POWER & VERTICAL AMPLIFIER CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description
	210-0204-00			1	LUG, solder, DE #6
	- - - - - -			-	mounting hardware: (not included w/lug)
	211-0011-00			1	SCREW, 4-40 x 5/16 inch, PHS
17	276-0506-00			2	CORE, iron, threaded, 10-32 x 5/16 inch
18	384-0542-00			4	ROD, plastic, capacitor mounting
	- - - - - -			-	mounting hardware for each: (not included w/rod)
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
19	124-0087-00			1	STRIP, ceramic, 3/4 inch h, w/3 notches
	- - - - - -			-	strip includes:
	355-0046-00			1	STUD, plastic
	- - - - - -			-	mounting hardware: (not included w/strip)
	361-0009-00			1	SPACER, plastic, 0.406 inch
20	406-0577-00			1	BRACKET, support
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
21	348-0005-00			2	GROMMET, rubber, 1/2 inch
22	337-0372-00			1	SHIELD, polarity
	- - - - - -			-	mounting hardware: (not included w/shield)
	211-0008-00			2	SCREW, 4-40 x 1/4 inch, PHS
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
23	210-0202-00			2	LUG, solder, SE #6
	- - - - - -			-	mounting hardware for each: (not included w/lug)
	211-0504-00			1	SCREW, 6-32 x 1/4 inch, PHS
	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch
24	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0011-00			1	LOCKWASHER, internal, 1/4 ID x 15/32 inch OD
	210-0465-00			1	NUT, hex., 1/4-32 x 3/8 inch
25	406-0576-00			1	BRACKET, variable resistor
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0008-00			2	SCREW, 4-40 x 1/4 inch, PHS
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
26	136-0015-00	101	1699	2	SOCKET, tube, 9 pin, w/ground lugs
	136-0145-00	1700		2	SOCKET, tube, 9 pin, w/ground lugs
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS

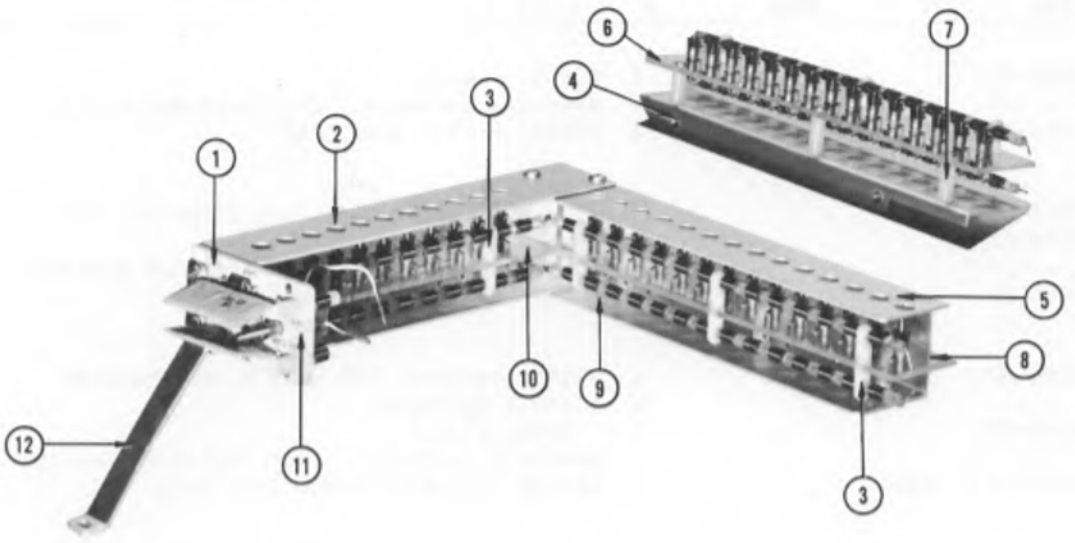
POWER & VERTICAL AMPLIFIER CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty 1 2 3 4 5	Description
27	348-0044-00			6	GROMMET, rubber, 3/8 inch diameter
28	136-0015-00			13	SOCKET, tube, 9 pin, w/ground lugs
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS
29	- - - - - -			2	COIL
	- - - - - -			-	mounting hardware for each: (not included w/coil)
	213-0035-00			1	SCREW, thread cutting, 4-40 x 1/4 inch, PHS
30	348-0003-00			4	GROMMET, rubber, 5/16 inch diameter
31	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0444-00			1	NUT, hex., 3/8-32 x 1/2 inch
32	406-0024-00			1	BRACKET, variable resistor
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
33	136-0011-00			2	SOCKET, tube, 8 pin
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	211-0538-00			2	SCREW, 6-32 x 5/16 inch, 100° csk, FHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
34	136-0008-00			5	SOCKET, tube, 7 pin, w/ground lugs
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS
35	- - - - - -			2	RESISTOR
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
	211-0553-00			1	SCREW, 6-32 x 1 1/2 inches, RHS
	210-0601-00			1	EYELET
	210-0478-00			1	NUT, hex., 5/16 x 21/32 inch long
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
36	- - - - - -			2	RESISTOR
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
	212-0037-00			1	SCREW, 8-32 x 1 3/4 inches, FIL HS
	210-0809-00	101	5169	1	WASHER, centering
	210-0808-00	5170		1	WASHER, centering
	210-0008-00			1	LOCKWASHER, internal, #8
	210-0462-00			1	NUT, hex., 8-32 x 1/2 x 23/64 inch
	212-0004-00			1	SCREW, 8-32 x 5/16 inch, PHS

POWER & VERTICAL AMPLIFIER CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description
37	200-0258-00			1	COVER, capacitor
38	200-0257-00			1	COVER, capacitor
39	200-0261-00	101	1599	1	COVER, capacitor, 4 1/16 inches
	200-0259-00	1600	3199	1	COVER, capacitor, 3 9/16 inches
	200-0293-00	3200	3449	1	COVER, capacitor, 2 9/16 inches
	200-0258-00	3450		1	COVER, capacitor, 3 1/32 inches
40	348-0006-00	101	5069	1	GROMMET, rubber, 3/4 inch diameter
	348-0050-00	5070		1	GROMMET, plastic, 3/4 inch diameter
41	385-0092-00	101	339	1	ROD, plastic
	385-0137-00	340		1	ROD, plastic
	- - - - - -			-	mounting hardware: (not included w/rod)
	211-0507-00	101	339	1	SCREW, 6-32 x 5/16 inch, PHS
	213-0041-00	340		1	SCREW, thread cutting, 6-32 x 3/8 inch, THS
42	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
43	- - - - - -			1	CAPACITOR
	- - - - - -			-	capacitor includes:
	407-0277-00	X3930		1	BRACKET, capacitor
	124-0187-00	X3930		1	STRIP, ceramic, 7/16 inch h, w/5 notches
	- - - - - -			-	strip includes:
	355-0046-00			2	STUD, plastic
	124-0187-01	X3930		1	STRIP, ceramic, 7/16 inch h, w/5 notches & silver band
	- - - - - -			-	strip includes:
	355-0046-00			2	STUD, plastic
	361-0007-00	X3930		4	SPACER, plastic, 0.188 inch long

DELAY LINE

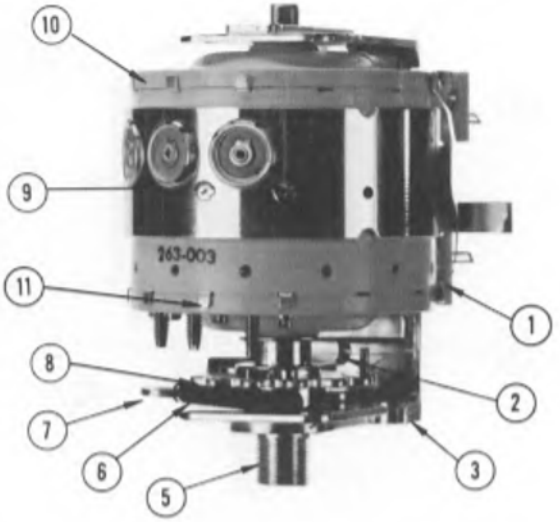


REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	386-0488-00			1	PLATE, white plastic
	- - - - - -			-	mounting hardware: (not included w/plate)
	211-0510-00			2	SCREW, 6-32 x 3/8 inch, PHS
	210-0803-00			2	WASHER, flat, 0.150 ID x 3/8 inch OD
2	441-0131-00			1	CHASSIS
	- - - - - -			-	mounting hardware: (not included w/chassis)
	211-0504-00			4	SCREW, 6-32 x 1/4 inch, PHS
3	352-0016-00			8	HOLDER, coil form, w/o pin
	352-0017-00			8	HOLDER, coil form, w/pin
4	337-0368-00			1	SHIELD
	- - - - - -			-	mounting hardware: (not included w/shield)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
5	441-0129-00			1	CHASSIS
	- - - - - -			-	mounting hardware: (not included w/chassis)
	211-0507-00			3	SCREW, 6-32 x 5/16 inch, PHS
6	386-0487-00			1	PLATE, plastic
	- - - - - -			-	mounting hardware: (not included w/plate)
	211-0011-00			3	SCREW, 4-40 x 5/16, PHS
7	384-0531-00			8	ROD, spacing, plastic
	- - - - - -			-	mounting hardware for each: (not included w/rod)
	211-0011-00			1	SCREW, 4-40 x 5/16 inch, PHS

DELAY LINE

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
8	386-0486-00			1		PLATE, plastic
	- - - - - -			-		mounting hardware: (not included w/plate)
	211-0011-00			2		SCREW, 4-40 x 5/16, PHS
9	348-0002-00			1		GROMMET, rubber, 1/4 inch diameter (not shown)
10	386-0485-00			1		PLATE, plastic
	- - - - - -			-		mounting hardware: (not included w/plate)
	211-0011-00			3		SCREW, 4-40 x 5/16 inch, PHS
11	124-0086-00	X140		1		STRIP, ceramic, 3/4 inch h, w/2 notches
	- - - - - -			-		strip includes:
	355-0046-00			1		STUD, plastic
	- - - - - -			-		mounting hardware: (not included w/strip)
	361-0009-00	X140		1		SPACER, plastic, 0.406 inch long
12	406-0220-00			1		BRACKET, support
	- - - - - -			-		mounting hardware: (not included w/bracket)
	211-0504-00			1		SCREW, 6-32 x 1/4 inch, PHS
	210-0803-00			1		WASHER, flat, 0.150 ID x 3/8 inch OD

s/n 101 - 2240



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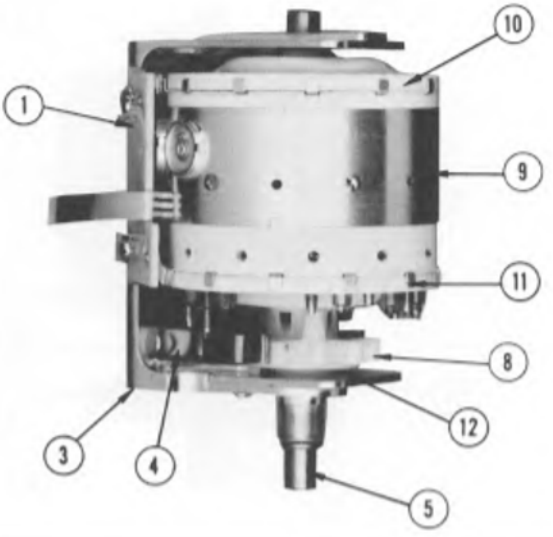
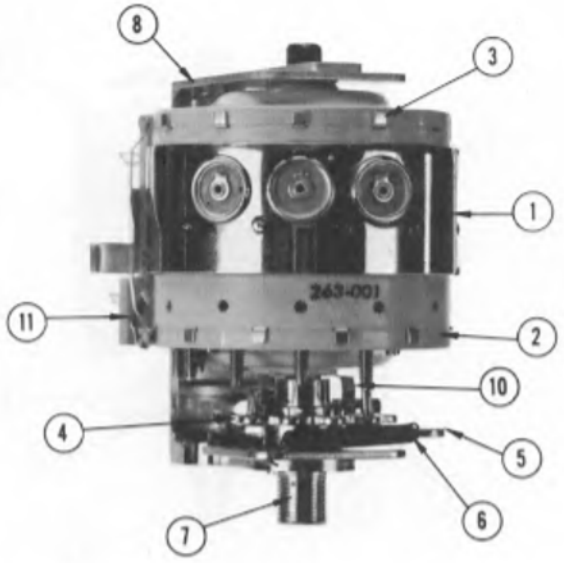


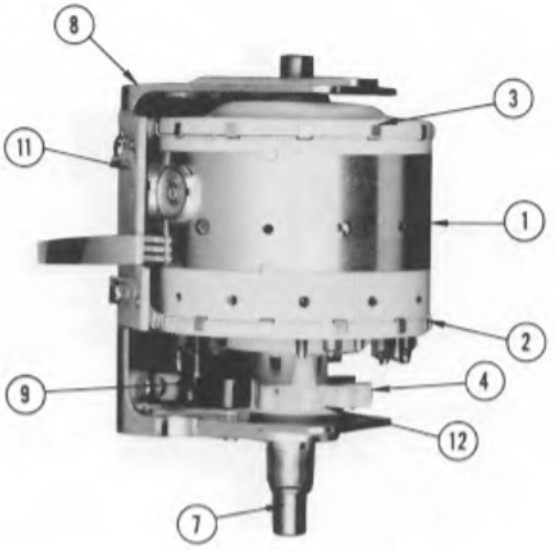
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
	263-0003-00			1	SWITCH, wired--VOLTS/DIV CHANNEL "B"
	- - - - - -			-	switch includes:
1	387-0421-00	101	2059	1	PLATE, turret contact
	387-0692-00	2060		1	PLATE, turret contact
	- - - - - -			-	mounting hardware: (not included w/plate)
	211-0007-00			2	SCREW, 4-40 x 3/16 inch, PHS
	210-0003-00			2	LOCKWASHER, external, #4
2	214-0134-00	101	2240X	1	SPRING, thrust
3	426-0076-00	101	2059	1	FRAME, turret
	426-0189-00	2060	2240	1	FRAME, turret
	426-0195-00	2241		1	FRAME, turret
	- - - - - -			-	frame includes:
4	214-0324-00	X2241		1	SPRING, detent
	211-0097-00	X2241		1	SCREW, 4-40 x 5/16 inch, PHS
	210-0589-00	X2241		1	NUT, locking, 4-40 x 1/4 inch
5	384-0235-00			1	ROD, shaft
6	214-0088-00	101	2240X	1	SPRING, extension
7	214-0189-00	101	2240X	1	CARRIER, detent
	- - - - - -			-	mounting hardware: (not included w/carrier)
	211-0563-00			1	SCREW, 6-32 x 9/32 inch, CRS shoulder
8	401-0017-00	101	2059	1	WHEEL, detent
	401-0025-00	2241		1	WHEEL, detent
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
9	204-0068-00	101	2059	1	BODY, wired turret assembly
	204-0129-00	2060		1	BODY, wired turret assembly
	- - - - - -			-	body includes:
10	200-0191-00			2	CAP, end
11	204-0024-00	101	2059	18	BODY, capacitor barrel
	204-0127-00	2060		18	BODY
12	354-0206-00	X2241		1	RING, stop, detent
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0419-00			1	NUT, hex., 3/8-32 x 1/2 inch

TURRET ATTENUATOR-A

s/n 101 - 2240

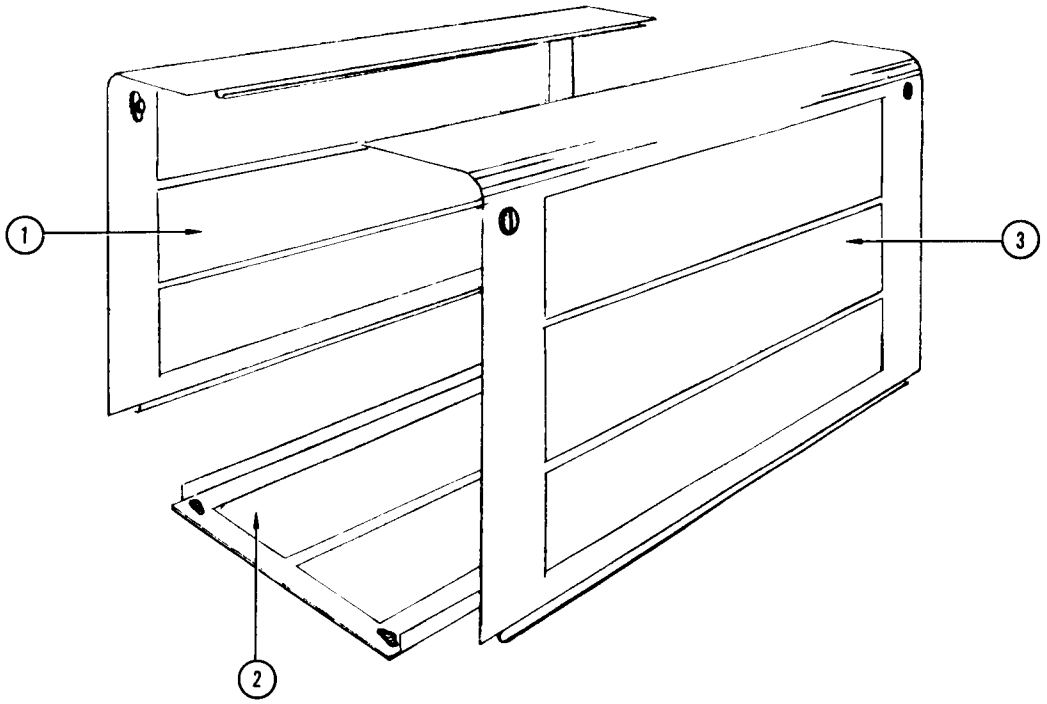


s/n 2241 - up



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY	DESCRIPTION
	263-0001-00			1	SWITCH, wired -- VOLTS/DIV, CHANNEL "A"
	- - - - - -			-	switch includes:
1	204-0068-00	101	2059	1	BODY, wired turret assembly
	204-0129-00	2060		1	BODY, wired turret assembly
	- - - - - -			-	body includes:
2	200-0191-00			2	CAP, end
3	204-0024-00	101	2059	18	BODY, capacitor barrel
	204-0127-00	2060		18	BODY, capacitor barrel
4	401-0017-00	101	2240	1	WHEEL, detent
	401-0025-00	2241		1	WHEEL, detent
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
5	214-0189-00	101	2240X	1	CARRIER, detent assembly
	- - - - - -			-	mounting hardware: (not included w/carrier)
	211-0563-00			1	SCREW, 6-32 x 9/32 inch, CRS shoulder
6	214-0088-00	101	2240X	1	SPRING, extension
7	384-0235-00			1	ROD, shaft
8	426-0076-00	101	2059	1	FRAME, turret
	426-0189-00	2060	2240	1	FRAME, turret
	426-0195-00	2241		1	FRAME, turret
	- - - - - -			-	frame includes:
9	214-0324-00	X2241		1	SPRING, detent
	211-0097-00	X2241		1	SCREW, 4-40 x 5/16 inch, PHS
	210-0589-00	X2241		1	NUT, locking, 4-40 x 1/4 inch
10	214-0134-00	101	2240X	1	SPRING, thrust
11	387-0420-00	101	2059	1	PLATE, turret contact
	387-0691-00	2060		1	PLATE, turret contact
	- - - - - -			-	mounting hardware: (not included w/plate)
	211-0007-00			2	SCREW, 4-40 x 3/16 inch, PHS
	210-0003-00			2	LOCKWASHER, external, #4
12	354-0206-00	X2241		1	RING, stop, detent
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0419-00			1	NUT, hex., 3/8-32 x 1/2 inch

CABINET



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	387-0222-00			1	PLATE, cabinet side, left
	- - - - - -			-	plate includes:
	214-0057-00			2	FASTENER, cabinet latch assembly
	- - - - - -			-	fastener includes:
	105-0007-00			1	STOP
	210-0480-00			1	NUT, latch
	210-0847-00			1	WASHER, plastic, 0.164 ID x 0.500 inch OD
	213-0033-00			1	SCREW, 8-32 x 1/2 inch
2	387-0067-00			1	PLATE, cabinet bottom
	- - - - - -			-	plate includes:
	214-0057-00			4	FASTENER, cabinet latch assembly
	- - - - - -			-	fastener includes:
	105-0007-00			1	STOP
	210-0480-00			1	NUT, latch
	210-0847-00			1	WASHER, plastic, 0.164 ID x 0.500 inch OD
	213-0033-00			1	SCREW, 8-32 x 1/2 inch
3	387-0223-00			1	PLATE, cabinet side, right
	- - - - - -			-	plate includes:
	214-0057-00			2	FASTENER, cabinet latch assembly
	- - - - - -			-	fastener includes:
	105-0007-00			1	STOP
	210-0480-00			1	NUT, latch
	210-0847-00			1	WASHER, plastic, 0.164 ID x 0.500 inch OD
	213-0033-00			1	SCREW, 8-32 x 1/2 inch

Ⓐ

STANDARD ACCESSORIES

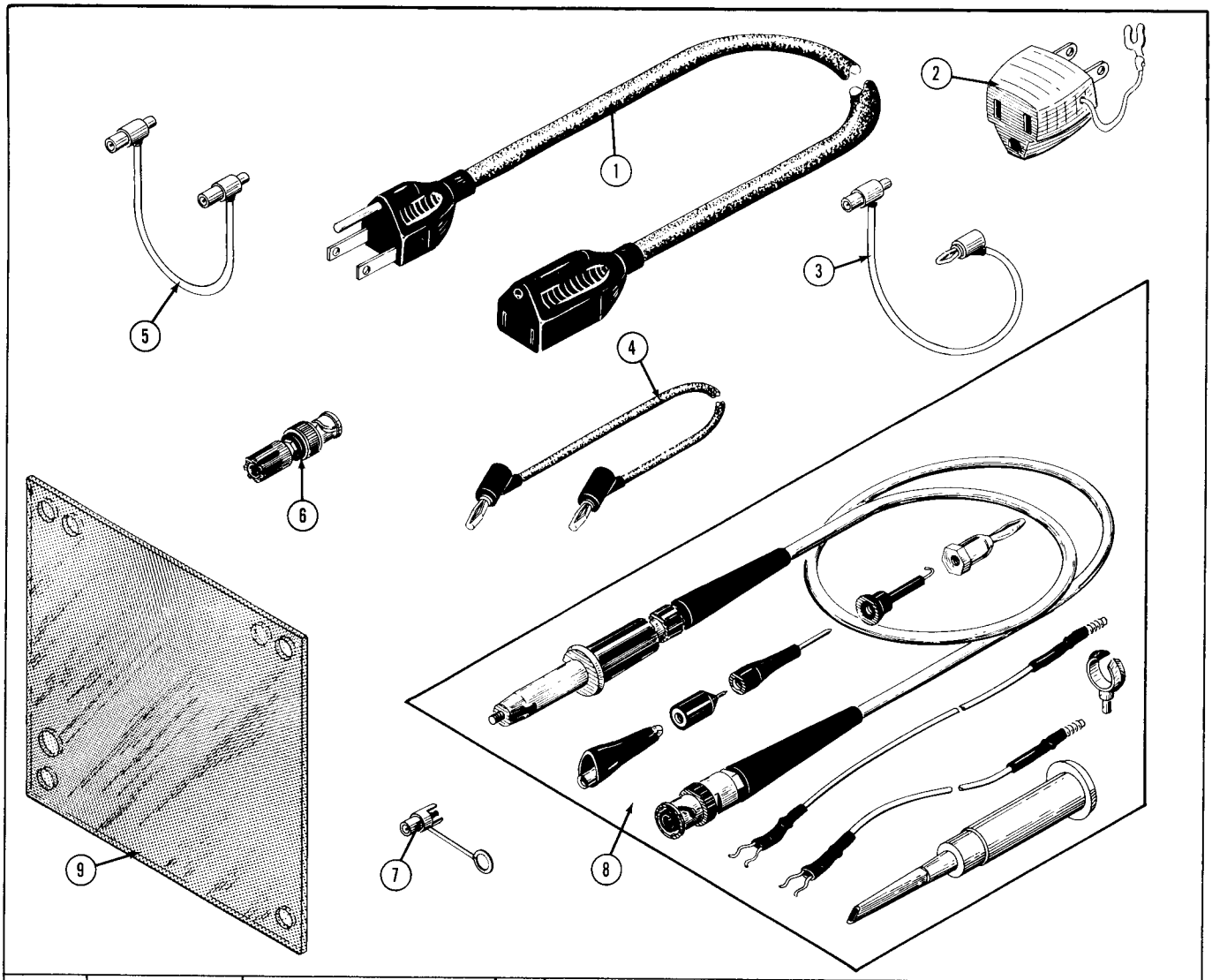


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
1	161-0010-00	101	4129	1	CORD, power, 16 guage, 8 foot, 3 wire
	161-0010-03	4130		1	CORD, power, 16 guage, 8 foot, 3 wire
2	103-0013-00			1	ADAPTER, power cord, 3 to 2 wire
3	012-0091-00	X3050		1	CORD, patch, BNC to banana, red, 18 inches long
4	012-0031-00	X2270	3049	1	CORD, patch-banana, 18 inches, red
5	012-0087-00			1	CORD, patch, BNC to BNC, red, 18 inches long
6	013-0004-00	101	2029	2	ADAPTER, binding post
	103-0033-00	2030	3049X	2	ADAPTER, BNC to binding post
7	012-0092-00	X3050		1	JACK, BNC
8	010-0127-00			2	PROBE, P6006, 10 MEG, 10X, 42 inches, BNC
9	378-0514-00	101	3519	1	FILTER, light, plastic, 5 inches, green, w/cam hole
	378-0567-00	3520		1	FILTER, light, smoke gray
	070-0225-01			2	MANUAL, instruction (not shown)

PARTS LIST ABBREVIATIONS

BHB	binding head brass
BHS	binding head steel
cap.	capacitor
cer	ceramic
comp	composition
conn	connector
CRT	cathode-ray tube
csk	countersunk
DE	double end
dia	diameter
div	division
elect.	electrolytic
EMC	electrolytic, metal cased
EMT	electrolytic, metal tubular
ext	external
F & I	focus and intensity
FHB	flat head brass
FHS	flat head steel
Fil HB	fillister head brass
Fil HS	fillister head steel
h	height or high
hex.	hexagonal
HHB	hex head brass
HHS	hex head steel
HSB	hex socket brass
HSS	hex socket steel
ID	inside diameter
incd	incandescent
int	internal
lg	length or long
met.	metal
mtg hdw	mounting hardware
OD	outside diameter
OHB	oval head brass
OHS	oval head steel
PHB	pan head brass
PHS	pan head steel
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
prec	precision
PT	paper, tubular
PTM	paper or plastic, tubular, molded
RHB	round head brass
RHS	round head steel
SE	single end
SN or S/N	serial number
SW	switch
TC	temperature compensated
THB	truss head brass
thk	thick
THS	truss head steel
tub.	tubular
var	variable
w	wide or width
WW	wire-wound

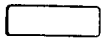
PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number
00X	Part removed after this serial number
*000-0000-00	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.
Use 000-0000-00	Part number indicated is direct replacement.
	Screwdriver adjustment.
	Control, adjustment or connector.

SECTION 8
ELECTRICAL PARTS LIST

Values fixed unless marked variable.

Bulbs

Ckt. No.	S/N Range	Description	Tektronix Part Number
B160W	101-3619	NE23	Use 150-027
B160W	3620-up	NE-2V	150-0030-00
B167		NE23	Use 150-027
B171		NE23	Use 150-027
B346	101-3619	NE23	Use 150-027
B346	3620-up	NE-2V	150-0030-00
B364		NE23	Use 150-027
B384		NE23	Use 150-027
B442	101-3619	NE23	Use 150-027
B442	3620-up	NE-2V	150-0030-00
B493		NE23	Use 150-027
B494		NE23	Use 150-027
B542	101-3619	NE23	Use 150-027
B542	3620-up	NE-2V	150-0030-00
B590	X3150-3340X	NE23	150-0027-00
B594	X3150-3340X	NE23	150-0027-00
B601		Graticule Light	150-001
B602		Graticule Light	150-001
B603		Pilot Light Assembly	136-031

Capacitors

Tolerance ±20% unless otherwise indicated.

C1		4.7 pf	Cer.		500 v	±1 pf	281-501
C2	X1959-up	.1 μf	Cer.		500 v		283-008
C10		.01 μf	MT		400 v		285-510
C11	X270-up	100 pf	Cer.		350 v		281-523
C15		.001 μf	Discap		500 v		283-000
C21		.01 μf	MT		500 v		283-002
C24		100 pf	Cer.		350 v		281-523
C25		.001 μf	Discap		500 v		283-000
C31		.01 μf	Hi-Kap		150 v		283-003
C37		18 pf	Cer.		500 v	10%	281-542
C44		27 pf	Cer.		500 v	±5.4 pf	281-513
C47		.005 μf	Discap		500 v		283-001
C134		8 pf	Cer.		500 v	±0.5 pf	281-503
C138		.01 μf	Discap		500 v		283-002
C141		5.6 pf	Cer.		500 v	±10%	281-544
C149		.005 μf	Discap		500 v		283-001
C150		56 pf	Cer.		500 v	±5.6 pf	281-521
C160A		3-12 pf	Cer.	Var			281-007
C160B		82 pf	Mica		500 v	5%	283-534
C160C		4.5-25 pf	Cer.	Var.			281-010
C160D		82 pf	Mica		500 v	5%	283-534
C160E		4.5-25 pf	Cer.	Var.			281-010

Capacitors *(cont)*

Ckt. No.	S/N Range		Description				Tektronix Part Number
C160F	101-3929	.001 μf	Mylar			±½%	*291-008
C160G C160H C160J	101-3929	.01 μf .1 μf 1 μf	Mylar Timing Series			±½%	*291-007
C160F C160G C160H C160J	3930-up	0.001 μf 0.01 μf 0.1 μf 1 μf	Timing Capacitor Assembly				*295-0095-00
C165		470 pf	Cer.		500 v	±94 pf	281-525
C167		.001 μf	Discap		500 v		283-000
C180A		180 μf	Mica		500 v	10%	283-509
C180B		.0022 μf	MT		400 v	5%	285-543
C180C		.022 μf	MT		400 v		285-515
C180D		.1 μf	MT		400 v		285-526
C180E		.1 μf	MT		400 v		285-526
C181	101-4769	39 pf	Cer.		500 v	±3.9 pf	281-516
C181	4770-up	22 pf	Cer.		500 v	10%	281-0511-00
C190		12 pf	Cer.		500 v	±1.2 pf	281-506
C196		.001 μf	Discap		500 v		283-000
C224		3-12 pf	Cer.	Var.			281-009
C260		9-180 pf	Mica	Var.			281-023
C330		4.5-25 pf	Cer.	Var.			281-010
C340		15 pf	Cer.		500 v	±1.5 pf	281-509
C355		1.5 pf	Cer.		500 v	±0.5 pf	281-526
C364		6.8 pf	Cer.		500 v	10%	281-541
C381		.01 μf	Discap		500 v		283-002
C384		3-12 pf	Cer.	Var.			281-009
C400		.1 μf	MT		600 v		285-587
C403	101-569X	.7-3 pf	Tub.	Var.			281-027
C404		.005 μf	Discap		500 v		283-001
C420	X570-up	.7-3 pf	Tub.	Var.			281-027
C421	X570-up	.7-3 pf	Tub.	Var.			281-027
C422		.1 μf	PTM		200 v		285-572
C430	X124-up	1.8 pf	Cer.		500 v		281-557
C431	X124-up	1.8 pf	Cer.		500 v		281-557
C450		.7-3 pf	Tub.	Var.			281-027
C451		.7-3 pf	Tub.	Var.			281-027
C454		.005 μf	Discap		500 v		283-001
C457		.01 μf	Discap		500 v		283-002
C462		.001 μf	Discap		500 v		283-000
C472		.001 μf	Discap		500 v		283-000
C480A-C484L		.7-3 pf	Tub.	Var.			(40) 281-037
C485		.7-3 pf	Tub.	Var.			281-037
C486		3-12 pf	Cer.	Var.			281-031
C488A,B	X140-up	2 x 40 μf	EMC		350 v		Use 290-027
C489		.01 μf	Discap		500 v		283-002
C491		.01 μf	Discap		500 v		283-002
C500		.1 μf	MT		600 v		285-587
C503	101-569X	.7-3 pf	Tub.	Var.			281-037
C504		.005 μf	Discap		500 v		283-001

Capacitors *(cont)*

Ckt. No.	S/N Range		Description				Tektronix Part Number
C520	X570-up	.7-3 pf	Tub.	Var.			281-027
C521	X570-up	.7-3 pf	Tub.	Var.			281-027
C522		.1 μf	PTM		200 v		285-572
C530	X124-up	1.8 pf	Cer.		500 v		281-557
C531	X124-up	1.8 pf	Cer.		500 v		281-557
C550		.7-3 pf	Tub.	Var.			281-027
C551		.7-3 pf	Tub.	Var.			281-027
C571		.01 μf	Discap		500 v		283-002
C580		10 pf	Cer.		500 v	±1 pf	281-504
C581		47 pf	Cer.		500 v	±4.7 pf	281-519
C584		.005 μf	Discap		500 v		283-001
C585		10 pf	Cer.		500 v		281-504
C586		47 pf	Cer.		500 v	±4.7 pf	281-519
C588		.005 μf	Discap		500 v		283-001
C594		12 pf	Cer.		500 v	±1.2 pf	281-506
C597		.01 μf	Discap		500 v		283-002
C601		2 μf	PMC		236 v		285-588
C610		.01 μf	PTM		400 v		285-510
C617		.01 μf	PTM		400 v		285-510
C627		2 x 20 μf	EMC		450 v		Use 290-010
C640		125 μf	EMC		350 v		Use 290-016
C642		2 x 125 μf	EMC		350 v		Use 290-130
C644		2 x 125 μf	EMC		350 v		Use 290-130
C650		.01 μf	PTM		400 v		285-510
C666A,B		2 x 20 μf	EMC		450 v		Use 290-010
C670		.01 μf	PTM		400 v		285-510
C680		.02 μf	Discap		600 v		283-006
C681		.02 μf	Discap		600 v		283-006
C684		.01 μf	Discap		500 v		283-002
C801A,B		2 x 20 μf	EMC		450 v		Use 290-010
C803		.001 μf	MT		600 v		285-501
C807		.001 μf	MT		1,000 v		285-502
C808		.001 μf	MT		1,000 v		285-502
C821	101-709	.015 μf	Discap		2,500 v		283-030
C821	710-up	.015 μf	Discap		3,000 v		283-042
C827A,B	101-709	.01 μf	Discap		2,000 v		283-011
C827A,B	710-up	.015 μf	Discap		3,000 v		283-042
C831	101-709	.01 μf	Discap		2,000 v		283-011
C831	710-up	.0068 μf	Discap		3,000 v		283-043
C832	101-169	.0068 μf	PTM		3,000 v		Use 283-034
C832	170-up	.005 μf	Cer.		4,000 v		283-034
C841		.047 μf	MT		400 v		285-519
C842	101-709	.015 μf	Discap		2,500 v		283-030
C842	710-up	.0068 μf	Discap		3,000 v		283-043
C844	101-269	.01 μf	Discap		2,000 v		Use 283-044
C844	270-up	.001 μf	Discap		3,000 v		283-044
C846	X710-up	.0068 μf	Discap		3,000 v		283-043
C848	101-709	.015 μf	Discap		2500 v		283-030
C848	710-up	.015 μf	Discap		3,000 v		283-042

Capacitors *(cont)*

Ckt. No.	S/N Range	Description			Tektronix Part Number
C863		.01 μf	Discap	500 v	283-002
C864		.01 μf	Discap	500 v	283-002
C871		330 pf	Mica	500 v 10%	283-518
C874		330 pf	Mica	500 v 10%	283-518
C885		27 pf	Cer.	500 v	281-513

Fuses

F601		3.2 Amp 3 AG	Slo-Blo	117 V Operation	159-026
		1.6 Amp 3 AG	Slo-Blo	234 V Operation	159-003

Inductors

LR149	101-4709	850 μh	Fixed	*108-058
LR149	4710-up	1.2 mh	Fixed	*108-0164-00
L455		6.8-14.6 μh	Var.	core 276-506 *114-080
L460	101-123	1.4 μh	Fixed	108-095
L460	124-up	.5 μh	Fixed	*108-170
L464		7 μh	Fixed	*108-137
L470	101-123	1.4 μh	Fixed	108-095
L470	124-up	.5 μh	Fixed	*108-170
L474		7 μh	Fixed	*108-138
L480A,B		15 Section Delay Line		*108-108
L481A,B		2.2 μh	Fixed	*108-147
L482A,B		14 Section Delay Line		*108-107
L484A,B		11 Section Delay Line		*108-106
L485		7.3-16 μh	Var.	core 276-506 *114-054
L486		7.3-16 μh	Var.	core 276-506 *114-054
L555		6.8-14.6 μh	Var.	core 276-506 *114-080

Resistors

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

R1		1 meg	½ w		Comp. 5%	301-105
R2		560 k	½ w		Comp. 5%	301-564
R3		50 k		Var.	Comp. DC Level Adj.	311-023
R4		100 k	½ w		Comp. 10%	302-104
R5	X1959-up	10 meg	½ w		Comp. 10%	302-106
R13		1 meg	½ w		Comp. 10%	302-105
R14	X270-up	100 k	½ w		Comp. 10%	302-104
R15		470 k	½ w		Comp. 10%	302-474
R16		100 k	½ w		Comp. 10%	302-104
R17[1]		100 k		Var.	Comp. Trig. Level	311-099
R19		1 meg	½ w		Comp. 10%	302-105
R20		3.9 meg	½ w		Comp. 10%	302-395
R21		820 k	½ w		Comp. 10%	302-824
R22		100 Ω	½ w		Comp. 10%	302-101
R23		100 Ω	½ w		Comp. 10%	302-101

[1]R17 concentric with R110, R349 & SW110, furnished as a unit.

Resistors *(cont)*

Ckt. No.	S/N Range		Description				Tektronix Part Number
R24		3.9 k	½ w		Comp.	10%	302-392
R25		27 Ω	½ w		Comp.	10%	302-270
R26		3.9 k	½ w		Comp.	10%	302-392
R28		39 k	2 w		Comp.	10%	306-393
R29		39 k	2 w		Comp.	10%	306-393
R30		100 k	½ w		Comp.	10%	302-104
R31		100 Ω	½w		Comp.	10%	302-101
R32		220 k	½ w		Comp.	10%	302-224
R34		1 k	½ w		Comp.	10%	302-102
R35	101-399	2.2 k	½ w		Comp.	10%	Use 301-222
R35	400-up	2.2 k	½ w		Comp.	5%	301-222
R37		150 k	½ w		Comp.	10%	302-154
R38		120 k	½ w		Comp.	10%	302-124
R39		100 k		Var.	Comp.	Trig. Level Centering	311-026
R40		2.2 meg	½ w		Comp.	10%	302-225
R41		100 Ω	½ w		Comp.	10%	302-101
R43		820 Ω	½ w		Comp.	10%	302-821
R44		1 meg	½ w		Comp.	10%	302-105
R46		22 k	1 w		Comp.	10%	304-223
R47		500 Ω	.2 w	Var.	Comp.	Trig. Sensitivity	311-066
R48		22 k	1 w		Comp.	10%	304-223
R110[2]		500 k		Var.	Comp.	Stability	311-099
R111		100 k		Var.	Comp.	Preset Stability	311-173
R114		100 k	½ w		Comp.	10%	302-104
R131		4.7 k	½ w		Comp.	10%	302-472
R132		100 Ω	½ w		Comp.	10%	302-101
R133		3.6 k	1 w		Comp.	5%	303-362
R134		3.6 k	1 w		Comp.	5%	303-362
R135		100 Ω	½ w		Comp.	10%	302-101
R138		100 Ω	½ w		Comp.	10%	302-101
R140		47 Ω	½ w		Comp.	10%	302-470
R141		43 k	1 w		Comp.	5%	303-433
R143		33 k	1 w		Comp.	5%	303-333
R144		10 k	5 w		WW	5%	308-054
R146		47 Ω	½ w		Comp.	10%	302-470
R147		1 k	½ w		Comp.	10%	302-102
R148		150 k	1 w		Comp.	10%	304-154
R150		680 Ω	½ w		Comp.	10%	302-681
R152	X3870-up	6.8 meg	½ w		Comp.	10%	302-0685-00
R160A		100 k	½ w		Prec.	1%	309-045
R160B		200 k	½ w		Prec.	1%	309-051
R160C		500 k	½ w		Prec.	1%	309-003
R160D		1 meg	½ w		Prec.	1%	309-014
R160E		2 meg	½ w		Prec.	1%	309-023
R160F		5 meg	½ w		Prec.	1%	309-087

[2]R110 concentric with R17, R349 & SW110, furnished as a unit.

Resistors *(cont)*

Ckt. No.	S/N Range	Description			Tektronix Part Number
R160G		10 meg	½ w	Prec. 1%	309-095
R160H		10 meg	½ w	Prec. 1%	309-095
R160J		10 meg	½ w	Prec. 1%	309-095
R160W		100 k	½ w	Comp. 10%	302-104
R160X		8.2 k	½ w	Comp. 10%	302-822
R160Y		20 k	Var.	WW Time/Div.	311-108
R161		100 Ω	½ w	Comp. 10%	302-101
R165		47 k	1 w	Comp. 10%	304-473
R166		47 k	1 w	Comp. 10%	304-473
R167		1.5 meg	½ w	Comp. 10%	302-155
R168		470 k	½ w	Comp. 10%	302-474
R171		100 Ω	½ w	Comp. 10%	302-101
R173		10 k	5 w	WW 5%	308-054
R174		2.2 k	1 w	Comp. 10%	304-222
R176		2 k	Var.	Comp. Sweep Length	311-008
R178		6 k	5 w	WW 5%	308-052
R180A		470 k	½ w	Comp. 10%	302-474
R180B		4.7 meg	½ w	Comp. 10%	302-475
R181		4.7 meg	½ w	Comp. 10%	302-475
R183		100 Ω	½ w	Comp. 10%	302-101
R184		39 k	½ w	Comp. 5%	301-393
R185		27 k	½ w	Comp. 5%	301-273
R190		12 k	1 k	Comp. 10%	304-123
R191		22 k	2 w	Comp. 10%	306-223
R192		47 Ω	½ w	Comp. 10%	302-470
R194		10 k	½ w	Comp. 10%	302-103
R196		100 k	½ w	Comp. 10%	302-104
R197		47 Ω	½ w	Comp. 10%	302-470
R198		47 Ω	½ w	Comp. 10%	302-470
R199		100 k	½ w	Comp. 10%	302-104
R225		50 k	.1 w	Var. Comp. Sweep Gain Adjust	311-078
R259		2.5 k	.5 w	Var. Comp. Mag. Gain Adjust	311-086
R330		1.84 meg	½ w	Prec. 1%	309-021
R332		1.5 meg	½ w	Prec. 1%	309-017
R333A,B		2 x 20 k	Var.	Comp. Horiz. Position	311-090
R340		560 Ω	½ w	Comp. 10%	302-561
R341		47 Ω	½ w	Comp. 10%	302-470
R345		47 k	2 w	Comp. 10%	306-473
R346		100 k	½ w	Comp. 10%	302-104
R347		120 k	½ w	Prec. 1%	309-091
R349[3]		100 k	Var.	Comp. Horiz. Input Atten.	311-099
R351		100 Ω	½ w	Comp. 10%	302-101
R353		68 k	2 w	Comp. 10%	306-683
R355		400 k	½ w	Prec. 1%	309-126
R356		250 k	½ w	Prec. 1%	309-109

[3]R349 concentric with R17, R110 & SW110, furnished as a unit.

Resistors *(cont)*

Ckt. No.	S/N Range	Description				Tektronix Part Number
R358		50 k		Var.	Comp. Sweep Mag. Regis.	311-023
R361		47 Ω	½ w		Comp. 10%	302-470
R364		6—30 k	7 w		Mica 1%	*310-507
R366		47 Ω	½ w		Comp. 10%	302-470
R368		41.5 k	8 w		WW ½%	Use *310-614
R373		15 k	1 w		Comp. 10%	304-153
R376		15 k	1 w		Comp. 10%	304-153
R377		10 k	5 w		WW 5%	308-054
R380	101-5289	22 k	1 w		Comp. 10%	304-223
R380	5290-up	24 k	1 w		Comp. 5%	303-0243-00
R381	101-5289	5.6 k	½ w		Comp. 10%	302-562
R381	5290-up	5.6 k	½ w		Comp. 5%	301-0562-00
R382	101-5289	100 k	½ w		Comp. 10%	302-104
R382	5290-up	100 k	½ w		Comp. 5%	301-0104-00
R383		47 Ω	½ w		Comp. 10%	302-470
R384		7—35 k	7 w		Mica 1%	*310-524
R386		47 Ω	½ w		Comp. 10%	302-470
R388		270 k	1 w		Comp. 10%	304-274
R403		1 meg	½ w		Prec. 1%	309-014
R404		100 k	½ w		Comp. 10%	302-104
R420		47 Ω	½ w		Comp. 10%	302-470
R421		47 Ω	½ w		Comp. 10%	302-470
R422		220 Ω	½ w		Comp. 10%	302-221
R423		100 Ω	½ w		Comp. 10%	302-101
R424		39 k	1 w		Comp. 10%	304-393
R426		39 k	1 w		Comp. 10%	304-393
R427		200 Ω		Var.	Comp. D.C. Balance	311-158
R430		47 Ω	½ w		Comp. 10%	302-470
R432		1 k	5 w		WW 5%	308-106
R433		600 Ω	2 w		Mica Plate 1%	*310-567
R434		8.2 k	2 w		Comp. 5%	305-822
R437		8.2 k	2 w		Comp. 5%	305-822
R438		600 Ω	2 w		Mica Plate 1%	*310-567
R439		3.5 k	5 w		WW 5%	308-080
R440		100 Ω	½ w	Var.	Comp. Gain Set, Channel A	311-169
R441		550 Ω		Var.	WW Volts/Div	Use *311-287
R442		100 k	½ w		Comp. 10%	302-104
R443		180 k	½ w		Comp. 10%	302-184
R444		180 k	½ w		Comp. 10%	302-184
R446		27 k	½ w		Comp. 10%	302-273
R447		2 x 50 k		Var.	Comp. Position	311-111
R448		27 k	½ w		Comp. 10%	302-273
R450		47 Ω	½ w		Comp. 10%	302-470
R451		47 Ω	½ w		Comp. 10%	302-470
R454		47 Ω	½ w		Comp. 10%	302-470

Resistors *(cont)*

Ckt. No.	S/N Range		Descripition				Tektronix Part Number
R455		670 Ω	½ w		Prec.	1%	309-082
R456		47 Ω	½ w		Comp.	10%	302-470
R457		4.7 k	2 w		Comp.	10%	306-472
R458		12 k	2 w		Comp.	10%	306-123
R460		47 Ω	½ w		Comp.	10%	302-470
R462		100 k	½ w		Comp.	10%	302-104
R463		3 k	5 w		WW	5%	308-062
R468	101-106	3.3 k	2 w		Comp.	10%	Use 303-222
R468	107-up	2.2 k	1 w		Comp.	5%	303-222
R470		47 Ω	½ w		Comp.	10%	302-470
R472		100 k	½ w		Comp.	10%	302-104
R473		3 k	5 w		WW	5%	308-062
R477		27 Ω	½ w		Comp.	10%	302-270
R478		100 Ω	½ w	Var.	Comp.	Gain Adjust	311-169
R485		1 k	7 w	Mica Plate		1%	*310-523
R486		1 k	7 w	Mica Plate		1%	*310-523
R487		470 Ω	½ w		Comp.	10%	302-471
R488A,B	X140 up	33 k	½ w		Comp.	10%	(2) 302-333
R489		750 Ω	10 w		WW	5%	308-016
R490		680 Ω	½ w		Comp.	10%	302-681
R491		100 Ω	½ w		Comp.	10%	302-101
R494		39 k	2 w		Comp.	10%	306-393
R496		1 k	½ w		Comp.	10%	302-102
R497		100 Ω	½ w		Comp.	10%	302-101
R498	101-2169	39 k	2 w		Comp.	10%	306-393
R498	2170-up	15 k	5 w		WW	5%	308-108
R503		1 meg	½ w		Prec.	1%	309-014
R504		100 k	½ w		Comp.	10%	302-104
R520		47 Ω	½ w		Comp.	10%	302-470
R521		47 Ω	½ w		Comp.	10%	302-470
R522		220 Ω	½ w		Comp.	10%	302-221
R523		100 Ω	½ w		Comp.	10%	302-101
R524		39 k	1 k		Comp.	10%	304-393
R526		39 k	1 k		Comp.	10%	304-393
R527		200 Ω		Var.	Comp.	D.C. Bal	311-158
R530		47 Ω	½ w		Comp.	10%	302-470
R533		600 Ω	2 w		Mica Plate	1%	*310-567
R534		8.2 k	2 w		Comp.	5%	305-822
R537		8.2 k	2 w		Comp.	5%	305-822
R538		600 Ω	2 w		Mica Plate	1%	*310-567
R539		3.5 k	5 w		WW	5%	308-080
R540	101-4851	27 Ω	½ w		Comp.	10%	302-270
R540	4852-up	47 Ω	½ w		Comp.	5%	301-0470-00
R541		550 Ω		Var.	WW	Volts/Div.	Use *311-287
R542		100 k	½ w		Comp.	10%	302-104

Resistors *(cont)*

Ckt. No.	S/N Range		Descripition				Tektronix Part Number
R543		180 k	½ w		Comp.	10%	302-184
R544		180 k	½ w		Comp.	10%	302-184
R546		27 k	½ w		Comp.	10%	302-273
R547		2 x 50 k		Var.	Comp.	Position	311-111
R548		27 k	½ w		Comp.	10%	302-273
R550		47 Ω	½ w		Comp.	10%	302-470
R551		47 Ω	½ w		Comp.	10%	302-470
R555		670 Ω	½ w		Prec.	1%	309-082
R556		47 Ω	½ w		Comp.	10%	302-470
R558		12 k	2 w		Comp.	10%	306-123
R571		47 Ω	½ w		Comp.	10%	302-470
R572		1.2 k	1 w		Comp.	10%	304-122
R573		220 k	½ w		Comp.	10%	302-224
R576		56 k	½ w		Comp.	10%	302-563
R577		1.5 meg	½ w		Comp.	10%	302-155
R578		10 k	½ w		Comp.	10%	302-103
R580		18 k	2 w		Comp.	10%	306-183
R581		180 k	½ w		Comp.	5%	301-184
R583		360 k	½ w		Comp.	5%	301-364
R584		120 k	½ w		Comp.	10%	302-124
R585		18 k	2 w		Comp.	10%	306-183
R586		180 k	½ w		Comp.	5%	301-184
R588		120 k	½ w		Comp.	10%	302-124
R589		360 k	½ w		Comp.	5%	301-364
R590		100 Ω	½ w		Comp.	10%	302-101
R591		220 k	½ w		Comp.	10%	302-224
R593		220 k	½ w		Comp.	10%	302-224
R594	101-299	10 k	5 w		WW	5%	Use 308-007
R594	300-up	8 k	5 w		WW	5%	308-007
R595		1.5 k	½ w		Comp.	10%	302-152
R596		27 k	½ w		Comp.	10%	302-273
R597		100 Ω	½ w		Comp.	10%	302-101
R601		50 Ω		Var.	WW	Scale Illum.	311-057
R603	X630-up	33 Ω	1 w		Comp.	10%	304-330
R609		33 k	½ w		Comp.	10%	302-333
R615		68 k	½ w		Prec.	1%	309-042
R616		10 k		Var.	WW	—150 Adjust	311-015
R617		50 k	½ w		Prec.	1%	309-090
R618		1 meg	½ w		Comp.	10%	302-105
R623		1 k	½ w		Comp.	10%	302-102
R627		750 Ω	25 w		WW	5%	308-147
R633		470 k	½ w		Comp.	10%	302-474
R635		18 k	1 w		Comp.	10%	304-183
R638		120 k	½ w		Comp.	10%	302-124
R639		10 k	½ w		Comp.	10%	302-103

Resistors *(cont)*

Ckt. No.	S/N Range		Description				Tektronix Part Number
R640		10 Ω	2 w		Comp.	10%	306-100
R642		10 Ω	2 w		Comp.	10%	306-100
R644		10 Ω	2 w		Comp.	10%	306-100
R650		333 k	½ w		Prec.	1%	309-053
R651		490 k	½ w		Prec.	1%	309-002
R653		1 meg	½ w		Comp.	10%	302-105
R657		330 k	½ w		Comp.	10%	302-334
R658		47 k	½ w		Comp.	10%	302-473
R659		33 k	½ w		Comp.	10%	302-333
R663		1 k	½ w		Comp.	10%	302-102
R664		1 k	½ w		Comp.	10%	302-102
R666		1 k	10 w		WW	5%	308-089
R667		1.25 k	25 w		WW	5%	308-102
R670		610 k	½ w		Prec.	1%	309-006
R671		300 k	½ w		Prec.	1%	309-125
R673		1 meg	½ w		Comp.	10%	302-105
R677	X4852-up	560 k	½ w		Comp.	5%	301-0564-00
R678	101-4851	270 k	1 w		Comp.	10%	Use 304-274
R678	4852-up	560 k	½ w		Comp.	5%	301-0564-00
R679	101-4851	47 k	½ w		Comp.	10%	302-473
R679	4852-up	56 k	½ w		Comp.	5%	301-0563-00
R680		100 k	½ w		Comp.	10%	302-104
R684		180 k	½ w		Comp.	10%	302-184
R685		47 k	½ w		Comp.	10%	302-473
R801		1 k	½ w		Comp.	10%	302-102
R802		390 Ω	1 w		Comp.	10%	304-391
R803		68 k	2 w		Comp.	10%	306-683
R806		47 k	½ w		Comp.	10%	302-473
R807		1.5 k	½ w		Comp.	10%	302-152
R814		470 k	½ w		Comp.	10%	302-474
R815		47 Ω	½ w		Comp.	10%	302-470
R824	101-709	6.8 meg	1 w		Comp.	10%	304-685
R824	710-up	6.8 meg	2 w		Comp.	10%	306-685
R825	101-709	6.8 meg	1 w		Comp.	10%	304-685
R825	710-up	6.8 meg	2 w		Comp.	10%	306-685
R826	101-4449	1 meg		Var.	Comp.	Intensity	311-041
R826	4450-up	1 meg		Var.	Comp.	Intensity	311-0041-02
R827		33 k	½ w		Comp.	10%	302-333
R828	101-709	1 meg	¼ w		Comp.	10%	316-105
R828	710-up	1 meg	½ w		Comp.	10%	302-105
R840		2.2 meg	½ w		Comp.	10%	302-225
R841		2 meg		Var.	Comp.	HV Adjust	311-042
R842	101-709	3.3 meg	1 w		Comp.	10%	304-335
R842	710-up	3.3 meg	2 w		Comp.	10%	306-335
R844	101-4449	2 meg		Var.	Comp.	Focus	311-043

Resistors *(cont)*

Ckt. No.	S/N Range		Description				Tektronix Part Number
R844	4450-up	2 meg		Var.	Comp.	Focus	311-0043-02
R845		1 meg	½ w		Comp.	10%	302-105
R846	101-709	10 k	¼ w		Comp.	10%	316-103
R846	710-up	10 k	½ w		Comp.	10%	302-103
R847		27 k	½ w		Comp.	10%	302-273
R848		1 meg	½ w		Comp.	10%	302-105
R861		100 k		Var.	Comp.	Geom. Adjust	311-026
R862		100 k	½ w		Comp.	10%	302-104
R863		120 k	½ w		Comp.	10%	302-124
R864		100 k		Var.	Comp.	Astigmatism	311-026
R870		150 k	½ w		Comp.	10%	302-154
R871		2.7 meg	½ w		Comp.	10%	302-275
R872		1 k	½ w		Comp.	10%	302-102
R874	101-339	3.3 meg	½ w		Comp.	10%	302-335
R874	340-up	3.9 meg	½ w		Comp.	10%	302-395
R875		68 k	½ w		Comp.	10%	302-683
R876		1 k	½ w		Comp.	10%	302-102
R878		33 k	½ w		Comp.	10%	302-333
R879		10 k		Var.	Comp.	Cal. Adjust	311-076
R880	101-339	100 k	½ w		Comp.	10%	302-104
R880	340-up	68 k	½ w		Comp.	10%	302-683
R883		100 Ω	½ w		Comp.	10%	302-101
R885		10 k	½ w		Prec.	1%	309-100
R886		6 k	½ w		Prec.	1%	309-099
R887		2 k	½ w		Prec.	1%	309-098
R888		1 k	½ w		Prec.	1%	309-115
R889		600 Ω	½ w		Prec.	1%	309-097
R890		200 Ω	½ w		Prec.	1%	309-073
R891		100 Ω	½ w		Prec.	1%	309-112
R892		60 Ω	½ w		Prec.	1%	309-067
R893		20 Ω	½ w		Prec.	1%	309-064
R894		10 Ω	½ w		Prec.	1%	309-096
R895		10 Ω	½ w		Prec.	1%	309-096

Switches

			Wired	Unwired
SW10A,B,	101-269	Trigger Selector	*262-333	*260-332
SW10A,B	270-1958	Trigger Selector	Use *050-107	*260-377
SW10A,B	1959-up	Trigger Selector	*262-564	*260-377
SW110		Preset W/R17, R110 & R349		311-099
SW160	101-3929	Time/Division	*262-334	*260-329
SW160	3930-4769	Time/Division	*262-0334-01	260-0329-00
SW160	4770-up	Time/Division	*262-0334-02	260-0329-00
SW348	101-569	Horizontal Display	*050-027	*260-186
SW348	570-up	Horizontal Display	*262-430	*260-186
SW400	101-569	Polarity "A"	*050-046	*260-331

Switches *(cont)*

Ckt. No.	S/N Range	Description	Tektronix Part Number
SW400	570-up	Polarity "A"	*262-432 *260-331
SW410		Volts/Division "A" turret atten complete	*263-003
SW500	101-569	Polarity "B"	Use *050-047 *260-326
SW500	570-up	Polarity "B"	*262-433 *260-326
SW510		Volts/Division "B" turret atten complete	*263-001
SW585		Mode	*260-325
SW601		Power W/R601	311-057
TK601		Thermo Cutout 137°	260-120
SW848		CRT Cathode Selector	*260-209
SW870		Square Wave Calibrator	*262-332 *260-098

Diodes

D131		Germanium, T12G			152-008
D152	X3800-up	Silicon, Low Leakage	0.25 w	40 V	152-0246-00
D454		Germanium, T12G			152-008
D477		Germanium, Tek Spec			Use *152-0075-00
D478		Germanium, Tek Spec			Use *152-0075-00
D554		Germanium, T12G			152-008
D594	X4330-up	Silicon Replaceable by 1N4152			*152-0185-00
D640A,B,C,D	101-3799	1N2862			Use 152-047
D640A,B,C,D	3800-up	Silicon, 1N3194			152-0066-00
D642A,B,C,D	101-3799	1N2862			Use 152-047
D642A,B,C,D	3800-up	Silicon, 1N3194			152-0066-00
D644A,B,C,D	101-3799	1N2862			Use 152-047
D644A,B,C,D	3800-up	Silicon, 1N3194			152-0066-00

Transformers

T601	Power (All Voltages)	*120-142
T801	CRT Supply	*120-079

Electron Tubes

V24	6DJ8	154-187
V45	6DJ8	154-187
V135	6DJ8	154-187
V145	101-4049	6AN8	154-078
V145	4050-up	EFC-80/6BL8	154-0278-00
V152	101-3799	6AL5 Selected	Use *157-0104-01
V152	3800-up	6AL5	154-0016-00
V161		6AN8	154-078
V183		12AT7	154-039
V193		6DJ8	154-187
V343		6DJ8	154-187
V364		6DJ8	154-187
V384		6DJ8	154-187
V423		6DJ8	154-187
V434		6DJ8	154-187

Electron Tubes *(cont)*

Ckt. No.	S/N Range	Description	Tektronix Part Number
V454		6GM8 (ECC86)	Use *157-068
V463		6DJ8	154-187
V464		6197	154-146
V474		6197	154-146
V493		6DJ8	154-187
V523		6DJ8	154-187
V534		6DJ8	154-187
V554		6GM8 (ECC86)	Use *157-068
V572		6AL5	154-016
V574		6DJ8	154-187
V585		12AT7	154-039
V594	101-4329	6DJ8	154-187
V594	4330-up	7119	154-0340-00
V609		5651	154-052
V627		6AU5	154-021
V634		6AN8	154-078
V654		6AU6	154-022
V667		6080	154-056
V674		6AU6	154-022
V800		6AQ5	154-017
V814		12AU7	154-041
V822		5642	154-051
V832		5642	154-051
V842		5642	154-051
V859		T0550-31 CRT Standard Phosphor	Use *154-344
V875		6AU6	154-022
V885	101-339	12AT7	154-039
V885	340-up	12AU7	154-041

Type 516 Turret Attenuator

Values fixed unless marked variable.

Capacitors

Tolerance ±20% unless otherwise indicated.

C407C	82 pf	Cer.	500 v	10%	281-528
C408B				Adjusting Slug	use 214-142
C408C				Adjusting Slug	use 214-142
C408D	5.6 pf	Cer.	500 v	10%	281-544
C409B				Adjusting Slug	use 214-142
C409C				Adjusting Slug	use 214-142
C410B				Adjusting Slug	use 214-142
C410C				Adjusting Slug	use 214-142
C410E	22 pf	Cer.	500 v	10%	281-511
C411B				Adjusting Slug	use 214-142

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Turret Attenuator (cont)

Capacitors *(cont)*

Ckt. No.	S/N Range		Description			Tektronix Part Number
C411C					Adjusting Slug	use 214-142
C411E		47 pf	Cer.	500 v	10%	281-519
C412A	X3300-up	Selected		Nominal value 2.2 pf		281-0500-00
C412B					Adjusting Slug	use 214-142
C412C					Adjusting Slug	use 214-142
C412E		100 pf	Cer.	500 v	10%	281-530
C413A	X3300-up	Selected		Nominal value 2.2 pf		281-0500-00
C413B					Adjusting Slug	use 214-142
C413C					Adjusting Slug	use 214-142
C413E[4]		250 pf	Mica	500 v	10%	283-0539-00
C414A	X3300-up	Selected		Nominal value 2.2 pf		281-0500-00
C414B					Adjusting Slug	use 214-142
C414C					Adjusting Slug	use 214-142
C414E[4]		500 pf	Mica	500 v	10%	283-0541-00
C415A		Selected		Nominal Value 2.2 pf		281-500
C415E[4]		625 pf	Mica	500 v	10%	283-0547-00
C415B					Adjusting Slug	use 214-142
C415C					Adjusting Slug	use 214-142

Resistors

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

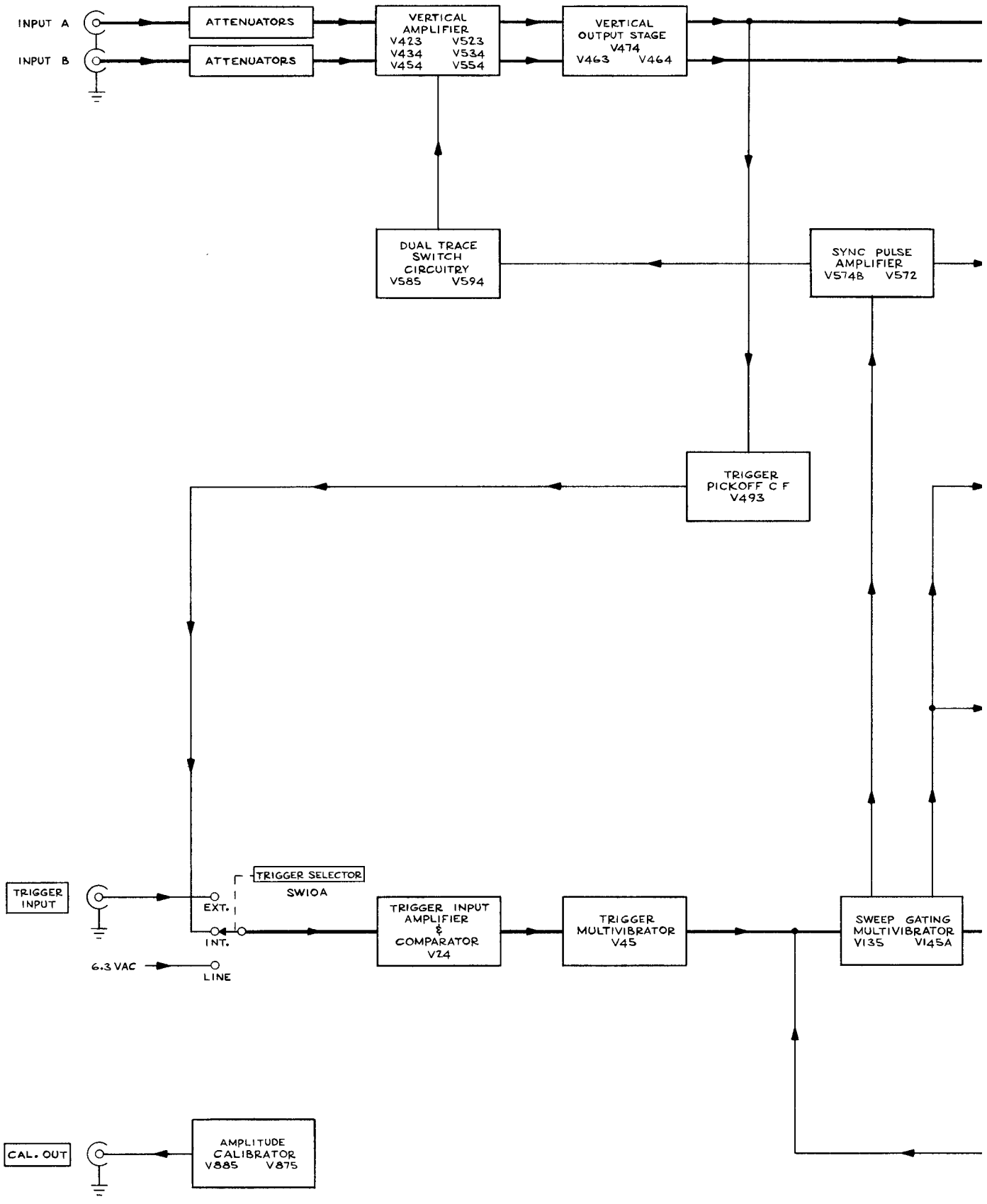
R407C		82 Ω	¼ w			316-820
R407E		47 Ω	¼ w			316-470
R408C	101-5235	500 k	½ w	Prec.	1%	309-140
R408C	5236-up	500 k	¼ w	Prec.	½%	322-0610-01
R408E	101-5235	1 meg	⅛ w	Prec.	1%	318-004
R408E	5236-up	1 meg	¼ w	Prec.	½%	322-0481-01
R409C	101-5235	750 k	½ w	Prec.	1%	309-141
R409C	5236-up	750 k	½ w	Prec.	½%	323-0655-00
R409E	101-5235	333 k	⅛ w	Prec.	1%	318-005
R409E	5236-up	333 k	⅛ w	Prec.	½%	321-0628-01
R410C	101-5235	900 k	½ w	Prec.	1%	309-142
R410C	5236-up	900 k	½ w	Prec.	½%	323-0611-01
R410E	101-5235	111 k	⅛ w	Prec.	1%	318-006
R410E	5236-up	111 k	⅛ w	Prec.	½%	321-1389-01
R411C	101-5235	950 k	½ w	Prec.	1%	309-143
R411C	5236-up	950 k	½ w	Prec.	½%	323-0612-01
R411E	101-5235	52.6 k	⅛ w	Prec.	1%	318-007
R411E	5236-up	52.6 k	⅛ w	Prec.	½%	321-0616-01
R412C	101-5235	975 k	½ w	Prec.	1%	309-144
R412C	5236-up	975 k	½ w	Prec.	½%	323-0757-01

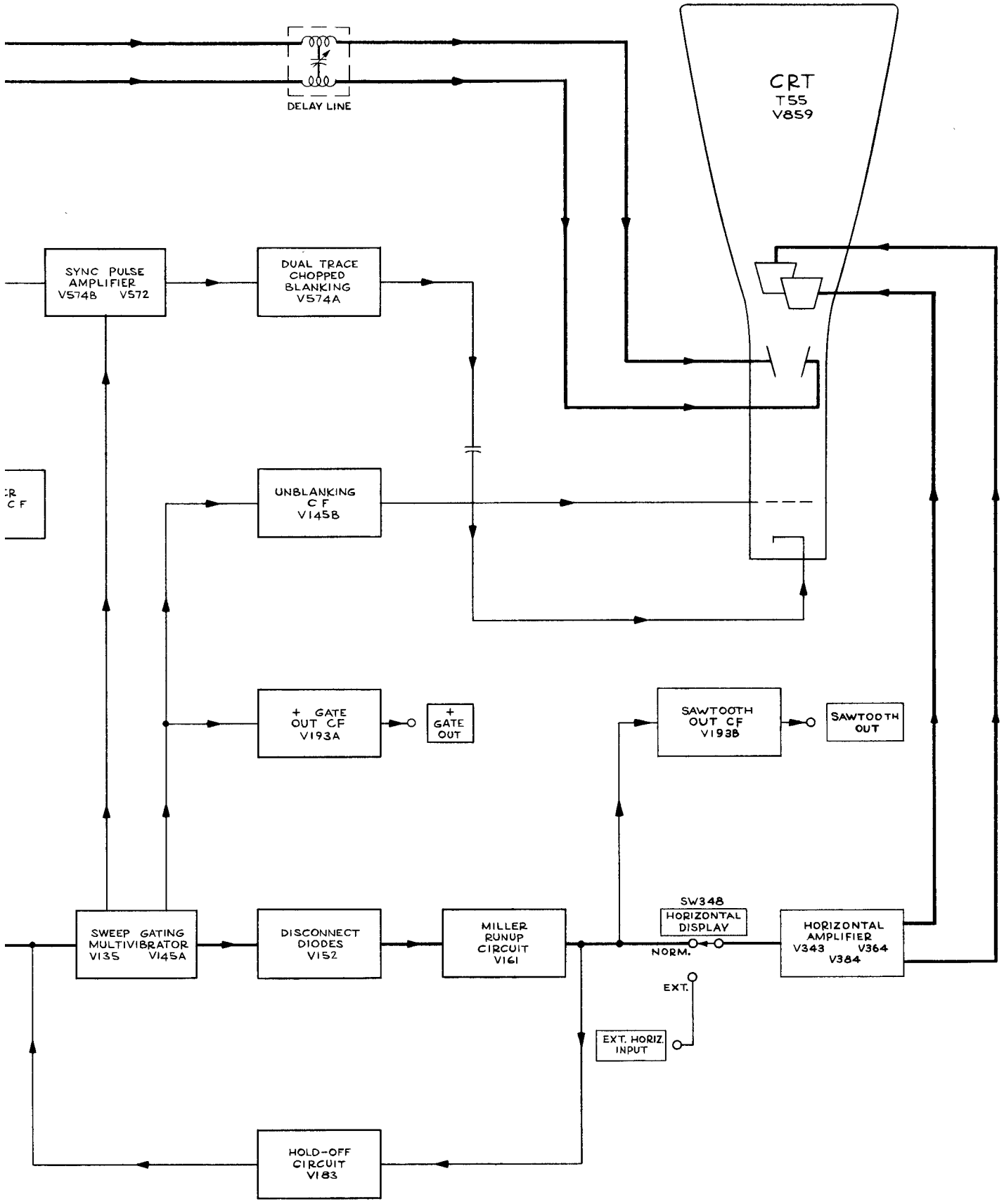
[4]These capacitors are installed at the factory by a special process. If replacement is necessary, order a wired turret body, part number *204-0129-00 (S/N 2060-up). Below S/N 2060 order *263-0001-00 or *263-0003-00 for wired turret body.

Turret Attenuator (cont)

Resistors *(cont)*

Ckt. No.	S/N Range		Description			Tektronix Part Number
R412E	101-5235	25.6 k	1/8 w	Prec.	1%	318-008
R412E	5236-up	25.6 k	1/8 w	Prec.	1/2%	321-0627-01
R413C	101-5235	990 k	1/2 w	Prec.	1%	309-145
R413C	5236-up	990 k	1/2 w	Prec.	1/2%	323-0614-01
R413E	101-5235	10.1 k	1/8 w	Prec.	1%	318-009
R413E	5236-up	10.1 k	1/8 w	Prec.	1/2%	321-1289-01
R414C	101-5235	995 k	1/2 w	Prec.	1%	309-146
R414C	5236-up	995 k	1/2 w	Prec.	1/2%	323-0615-01
R414E	101-5235	5.03 k	1/8 w	Prec.	1%	318-010
R414E	5236-up	5.03 k	1/8 w	Prec.	1/2%	321-0613-01
R415C	101-5235	997.5 k	1/2 w	Prec.	1%	309-147
R415C	5236-up	997.5 k	1/2 w	Prec.	1/2%	323-0616-01
R415E	101-5235	2.51 k	1/8 w	Prec.	1%	318-011
R415E	5236-up	2.51 k	1/8 w	Prec.	1/2%	321-0626-01

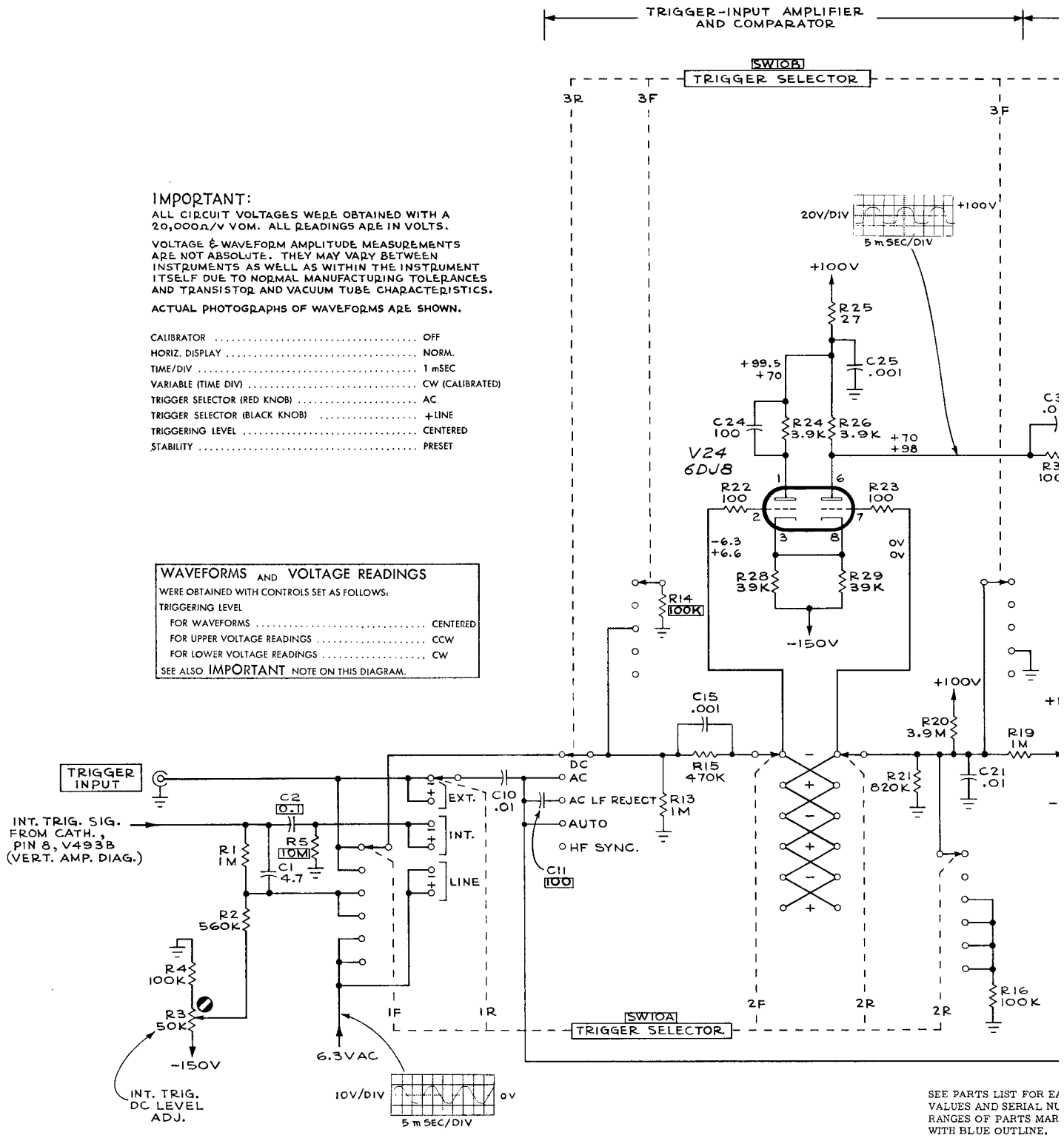

INPUT A
INPUT B
ATTENUATORS
ATTENUATORS
VERTICAL AMPLIFIER
V423 V523
V434 V534
V454 V554
VERTICAL OUTPUT STAGE
V474
V463 V464
DUAL TRACE SWITCH CIRCUITRY
V585 V594
SYNC PULSE AMPLIFIER
V574B V572
TRIGGER PICKOFF C F
V493
TRIGGER INPUT
EXT.
INT.
TRIGGER SELECTOR
SW10A
6.3 VAC
LINE
TRIGGER INPUT AMPLIFIER & COMPARATOR
V24
TRIGGER MULTIVIBRATOR
V45
SWEEP GATING MULTIVIBRATOR
V135 V145A
CAL. OUT
AMPLITUDE CALIBRATOR
V885 V875



10/26/62
TP

A1

BLOCK DIAGRAM



IMPORTANT:

ALL CIRCUIT VOLTAGES WERE OBTAINED WITH A 20,000Ω/V VOM. ALL READINGS ARE IN VOLTS.

VOLTAGE & WAVEFORM AMPLITUDE MEASUREMENTS ARE NOT ABSOLUTE. THEY MAY VARY BETWEEN INSTRUMENTS AS WELL AS WITHIN THE INSTRUMENT ITSELF DUE TO NORMAL MANUFACTURING TOLERANCES AND TRANSISTOR AND VACUUM TUBE CHARACTERISTICS.

ACTUAL PHOTOGRAPHS OF WAVEFORMS ARE SHOWN.

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

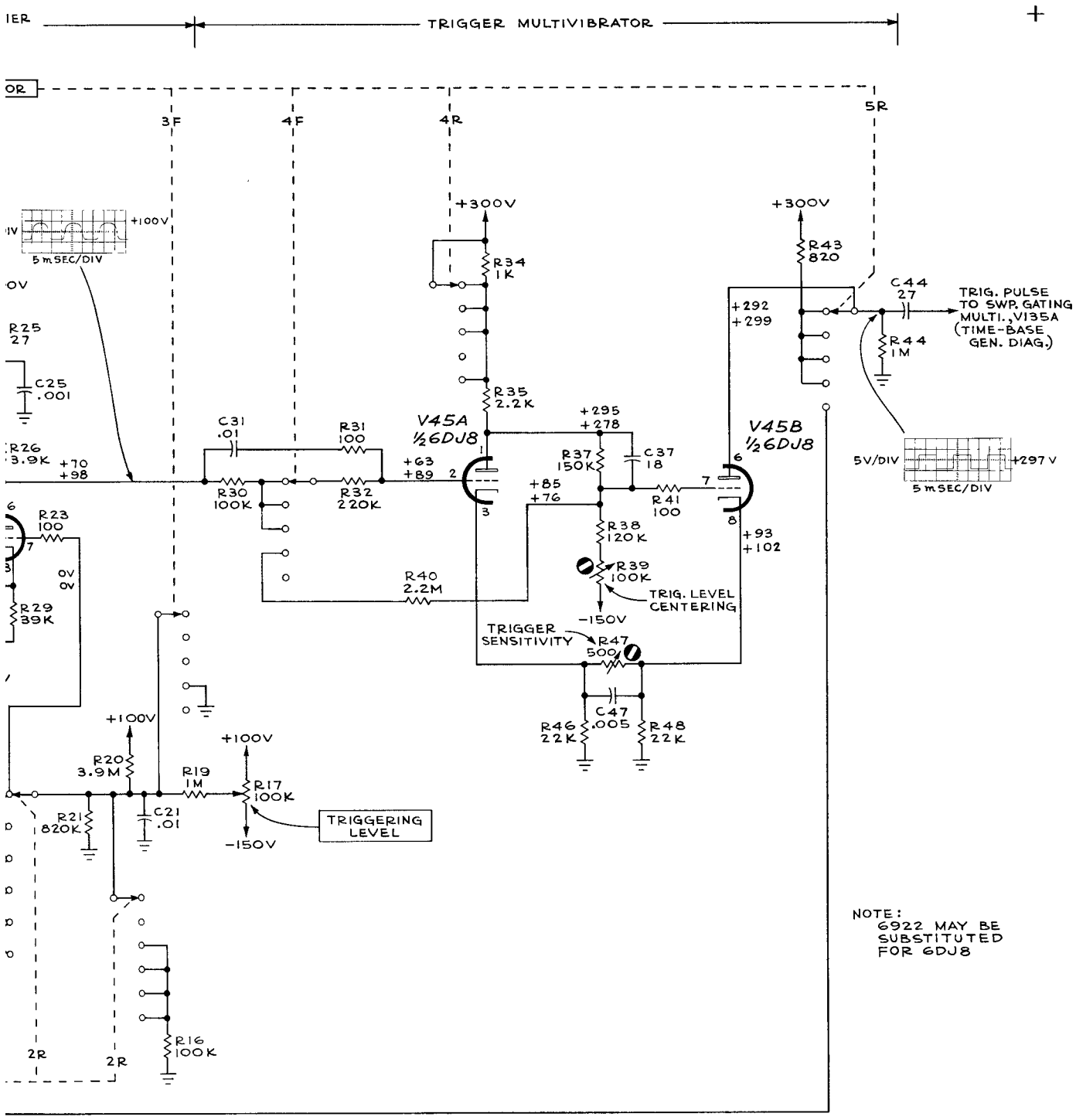
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

TRIGGERING LEVEL

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

SEE ALSO IMPORTANT NOTE ON THIS DIAGRAM.

SEE PARTS LIST FOR EA
VALUES AND SERIAL NU
RANGES OF PARTS MAR
WITH BLUE OUTLINE.



NOTE:
6922 MAY BE
SUBSTITUTED
FOR 6DJ8

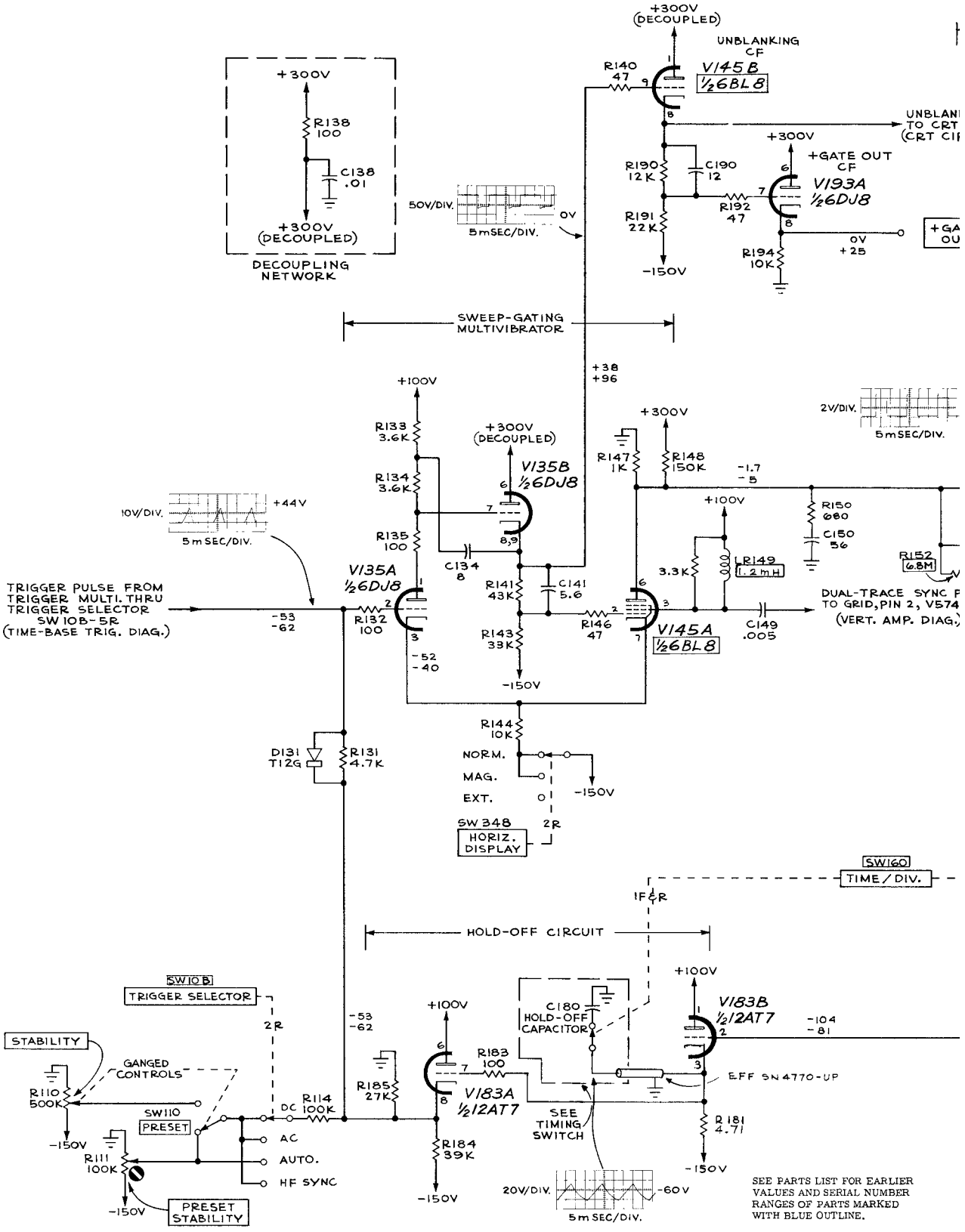
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

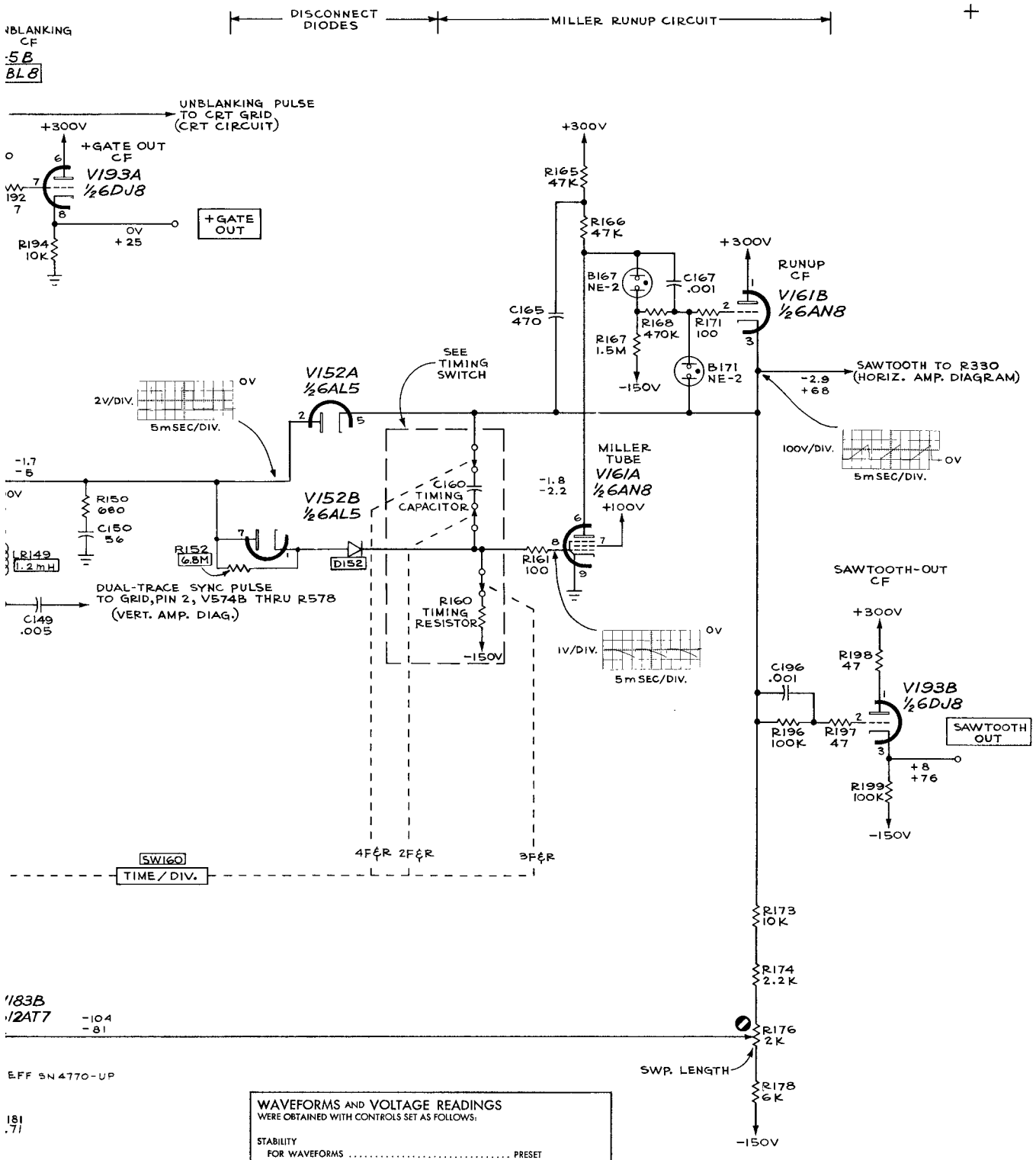
CIRCUIT NUMBERS
1 THRU 49

G∧B
664

TIME-BASE TRIGGER

C,


+300V (DECOUPLED)
UNBLANKING CF
V145B ½6BL8
R140 47
UNBLANK TO CRT (CRT CI
+300V
+GATE OUT CF
V193A ½6DJ8
R190 12K
C190 12
R192 47
R191 22K
R194 10K
0V +25
-150V
+GA OU
+300V
R138 100
C138 .01
+300V (DECOUPLED)
DECOUPLING NETWORK
50V/DIV.
0V
5mSEC/DIV.
SWEEP-GATING MULTIVIBRATOR
+38 +96
+100V
R133 3.6K
R134 3.6K
R135 100
+300V (DECOUPLED)
V135B ½6DJ8
C134 8
10V/DIV.
+44V
5mSEC/DIV.
V135A ½6DJ8
TRIGGER PULSE FROM TRIGGER MULTI. THRU TRIGGER SELECTOR SW 10B-5R (TIME-BASE TRIG. DIAG.)
-53 -62
R132 100
-52 -40
R141 43K
C141 5.6
R143 33K
-150V
R146 47
V145A ½6BL8
+300V
R147 1K
R148 150K
-1.7 -5
+100V
R149 1.2mH
3.3K
R150 680
C150 56
C149 .005
2V/DIV.
5mSEC/DIV.
R152 6.8M
DUAL-TRACE SYNC F TO GRID, PIN 2, V574 (VERT. AMP. DIAG.)
R144 10K
NORM.
MAG.
EXT.
SW 348 HORIZ. DISPLAY
2R
-150V
D131 T12G
R131 4.7K
SW160
TIME/DIV.
1F&R
HOLD-OFF CIRCUIT
SW10B
TRIGGER SELECTOR
2R
STABILITY
GANGED CONTROLS
R110 500K
SW110 PRESET
AC
AUTO.
HF SYNC
R111 100K
PRESET STABILITY
-150V
DC 100K
R114
-53 -62
+100V
R185 27K
R183 100
V183A ½12AT7
R184 39K
-150V
C180 HOLD-OFF CAPACITOR
+100V
V183B ½12AT7
-104 -81
EFF SN 4770-UP
SEE TIMING SWITCH
R181 4.7K
-150V
20V/DIV.
-60V
5mSEC/DIV.
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.



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

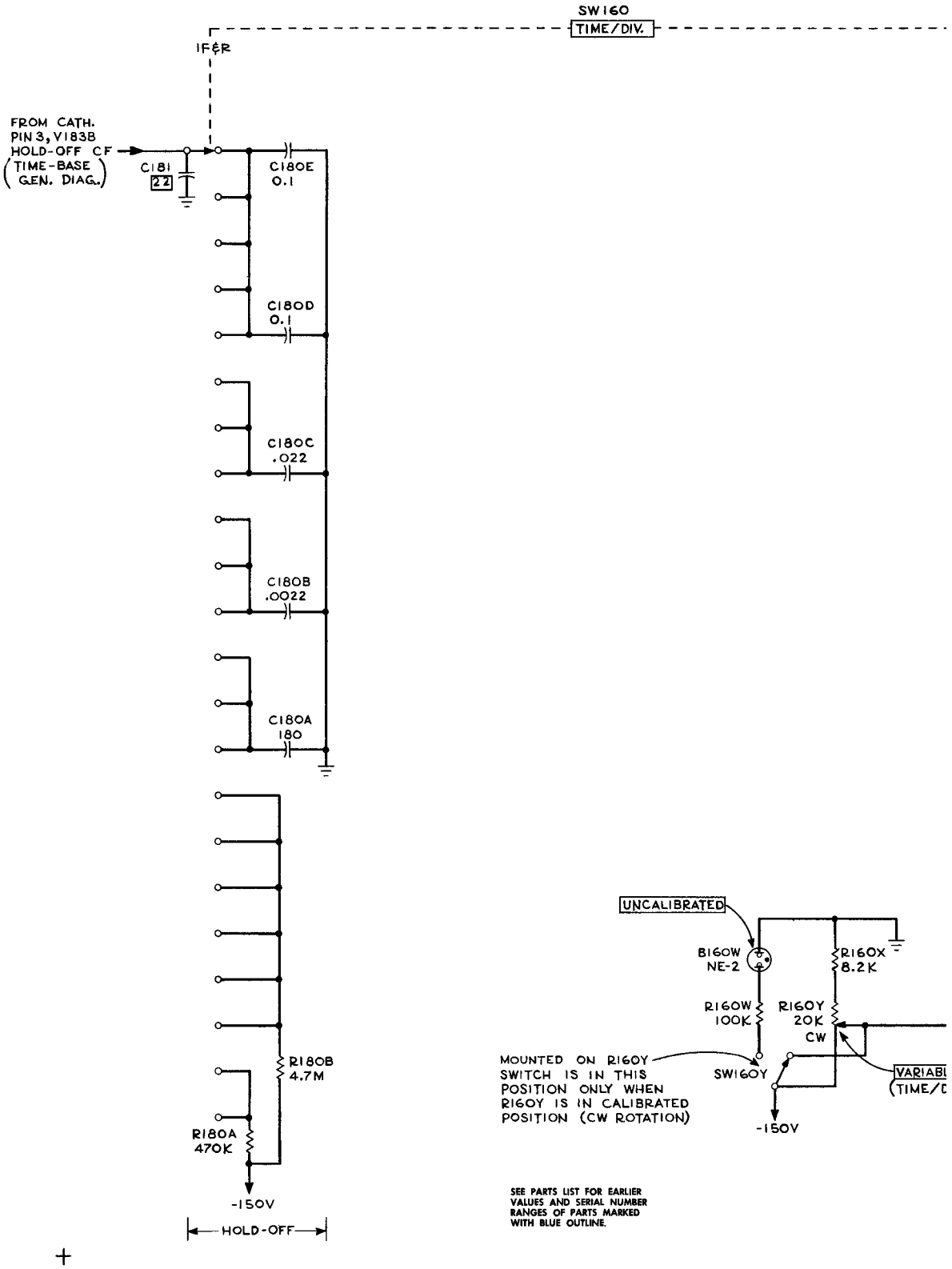
STABILITY
- FOR WAVEFORMS ..... PRESET
- FOR UPPER VOLTAGE READINGS (SWEEP IS DISABLED) ... CCW, BUT NOT SWITCHED TO PRESET
- FOR LOWER VOLTAGE READINGS (SWEEP FREERUNS) ... CW

SEE ALSO IMPORTANT NOTE ON SWEEP TRIGGER DIAGRAM.

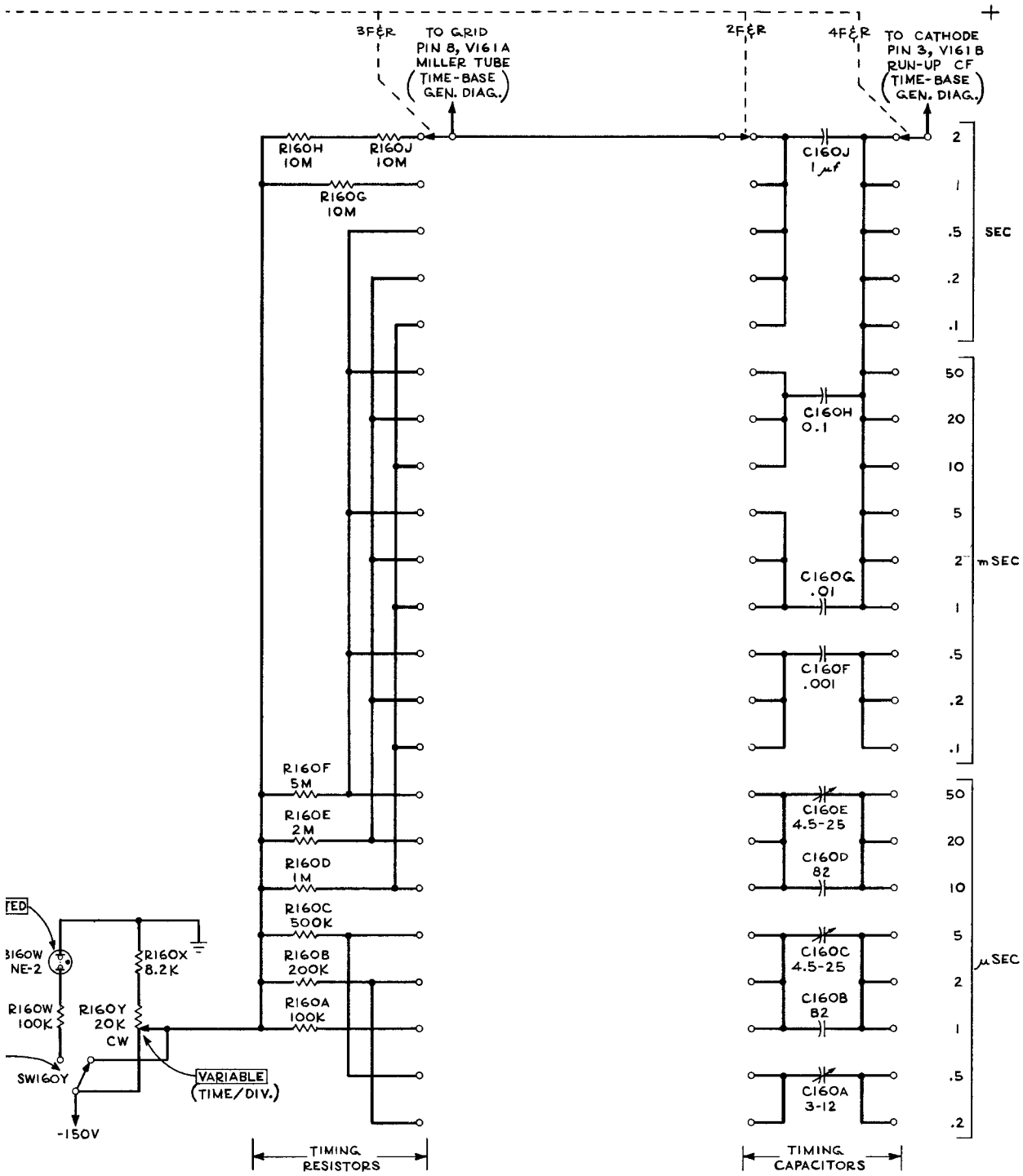
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

TIME-BASE GENERATOR

CIRCUIT NUMBERS 100 THRU 199

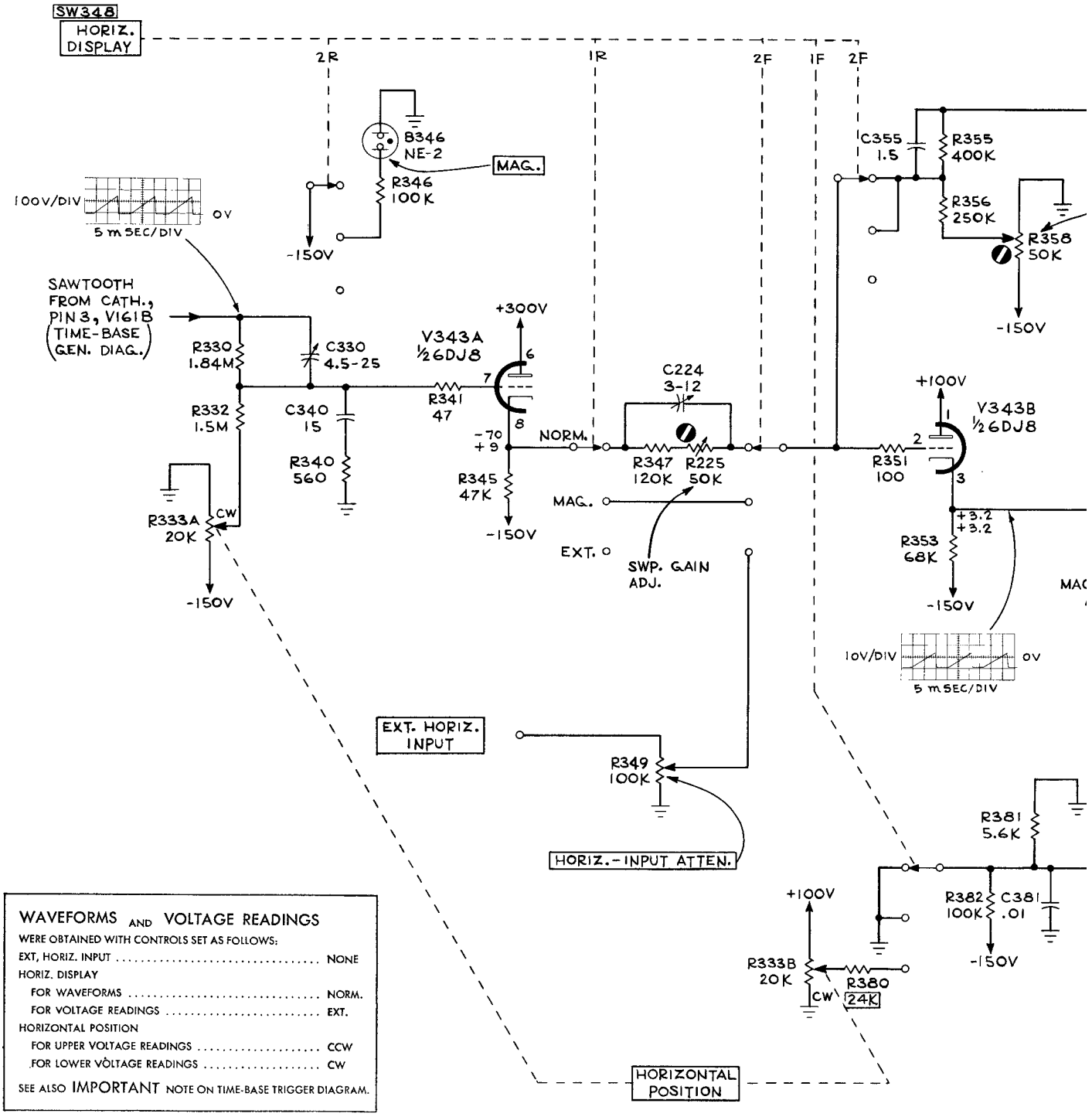


SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.



B

TIMING SWITCH



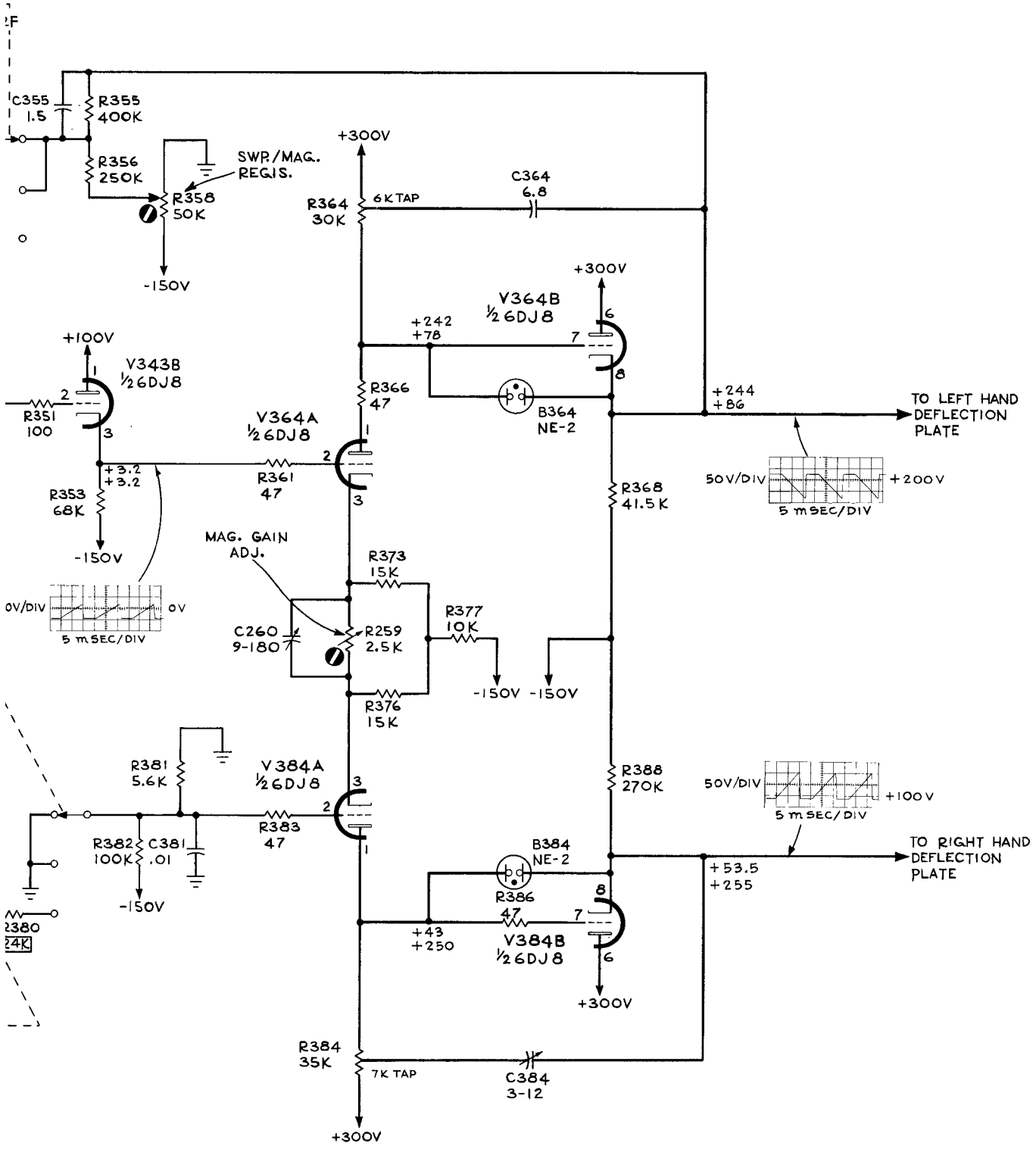
WAVEFORMS AND VOLTAGE READINGS

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

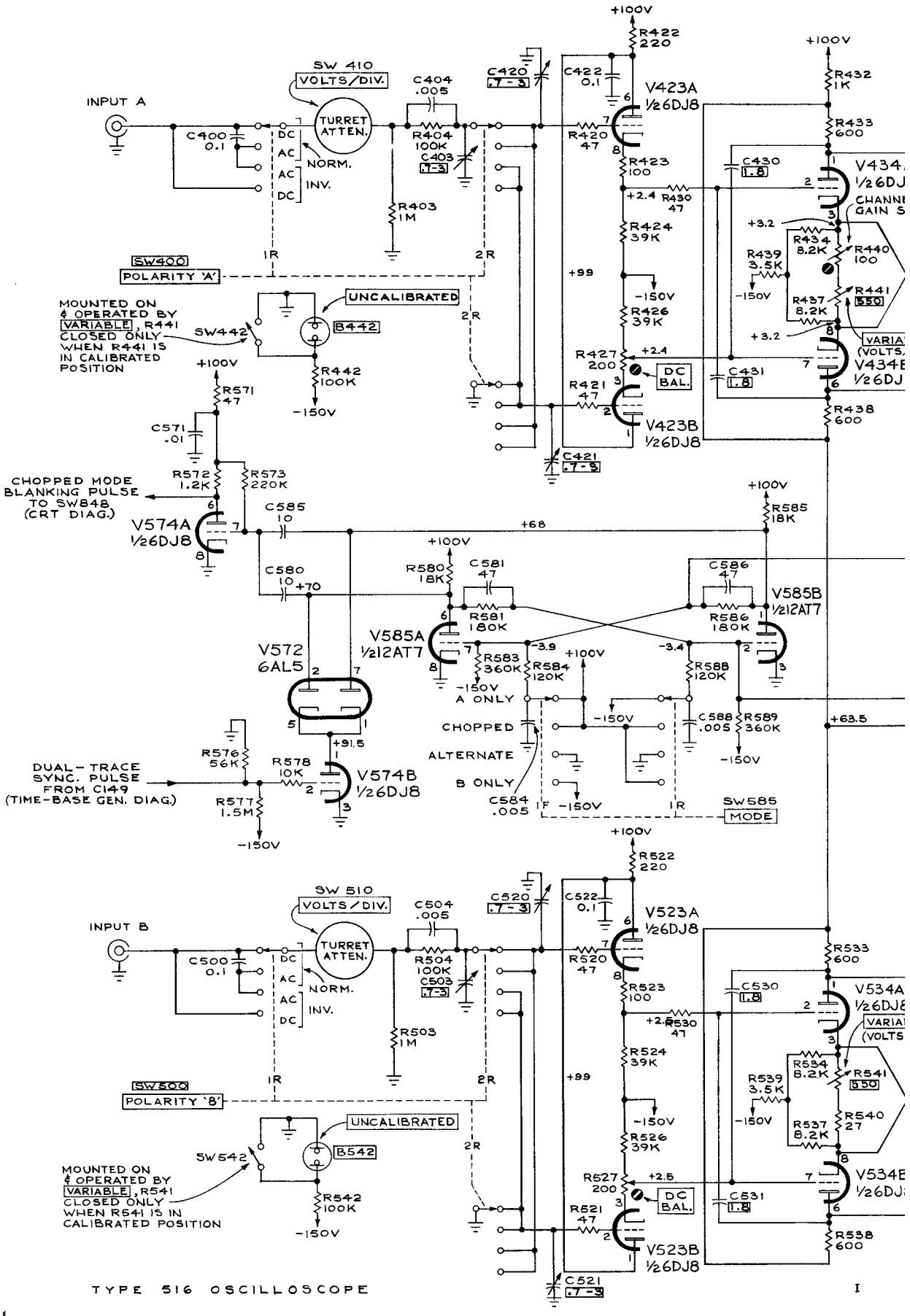
SEE ALSO IMPORTANT NOTE ON TIME-BASE TRIGGER DIAGRAM.

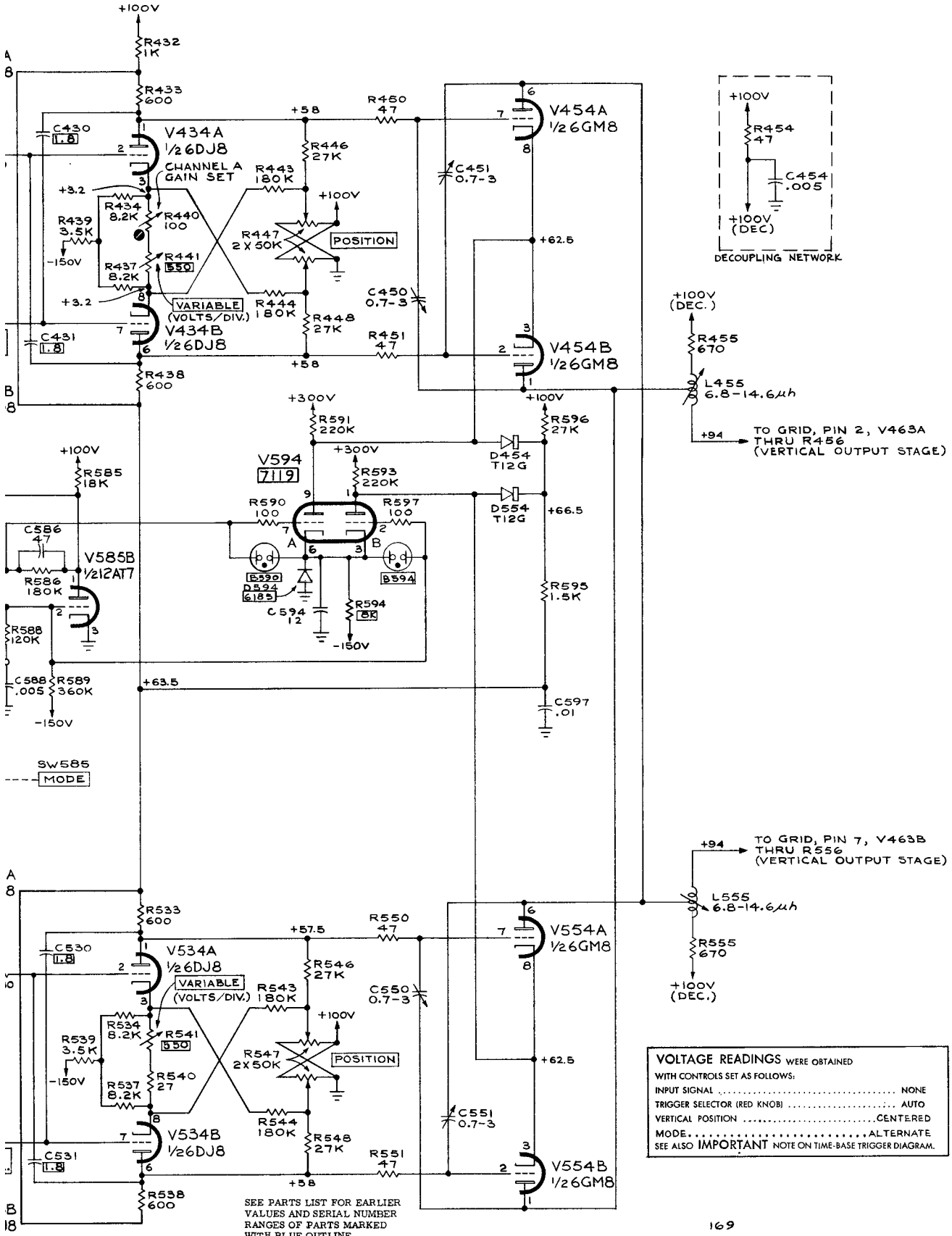
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.



CIRCUIT NUMBERS
225 THRU 389

HORIZONTAL AMPLIFIER


INPUT A
SW 410
VOLTS/DIV.
TURRET ATTEN.
C400 0.1
C404 .005
R404 100K
C403 .7-3
R403 1M
DC
AC
NORM.
AC
INV.
DC
1R
2R
SW400
POLARITY 'A'
UNCALIBRATED
B442
SW442
MOUNTED ON & OPERATED BY VARIABLE, R441 CLOSED ONLY WHEN R441 IS IN CALIBRATED POSITION
R442 100K
-150V
+100V
R571 47
C571 .01
R572 1.2K
R573 220K
CHOPPED MODE BLANKING PULSE TO SW848 (CRT DIAG.)
V574A 1/26DJ8
C585 10
+68
C580 10
+70
V572 6AL5
R576 56K
R578 10K
R577 1.5M
+91.5
V574B 1/26DJ8
DUAL-TRACE SYNC. PULSE FROM C149 (TIME-BASE GEN. DIAG.)
C420 .7-3
C422 0.1
V423A 1/26DJ8
R422 220
R420 47
R423 100
R424 39K
R426 39K
R427 200
DC BAL.
R421 47
V423B 1/26DJ8
C421 .7-3
+2.4
R430 47
+99
-150V
C430 1.8
C431 1.8
R438 600
R432 1K
R433 600
+3.2
R434 8.2K
R439 3.5K
R440 100
R441 550
R437 8.2K
V434A 1/26DJ8
V434B 1/26DJ8
CHANNEL GAIN S
VARIA (VOLTS/
R585 18K
R580 18K
C581 47
C586 47
V585A 1/2 12AT7
V585B 1/2 12AT7
R581 180K
R586 180K
R583 360K
R584 120K
R588 120K
-3.9
-3.4
A ONLY
CHOPPED
ALTERNATE
B ONLY
C584 .005
C588 .005
R589 360K
+63.5
SW585
MODE
SW 510
VOLTS/DIV.
INPUT B
C500 0.1
C504 .005
R504 100K
C503 .7-3
R503 1M
SW500
POLARITY 'B'
UNCALIBRATED
B542
SW542
MOUNTED ON & OPERATED BY VARIABLE, R541 CLOSED ONLY WHEN R541 IS IN CALIBRATED POSITION
R542 100K
C520 .7-3
C522 0.1
V523A 1/26DJ8
R522 220
R520 47
R523 100
R524 39K
R526 39K
R527 200
R521 47
V523B 1/26DJ8
C521 .7-3
+2.5
R530 47
C530 1.8
C531 1.8
R538 600
R533 600
R534 8.2K
R539 3.5K
R541 550
R540 27
R537 8.2K
V534A 1/26DJ8
V534B 1/26DJ8



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

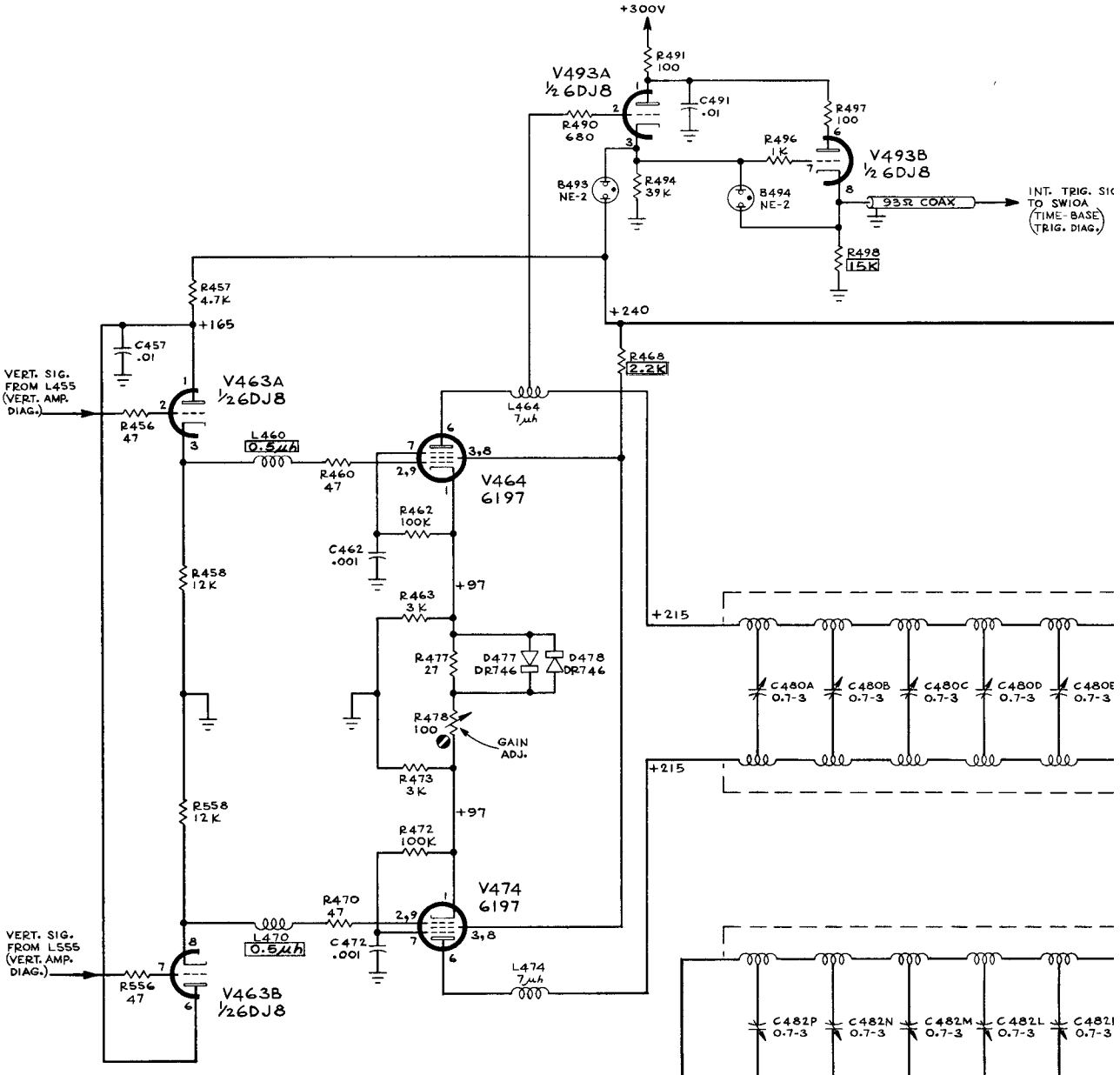
VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

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

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

VERTICAL AMPLIFIER

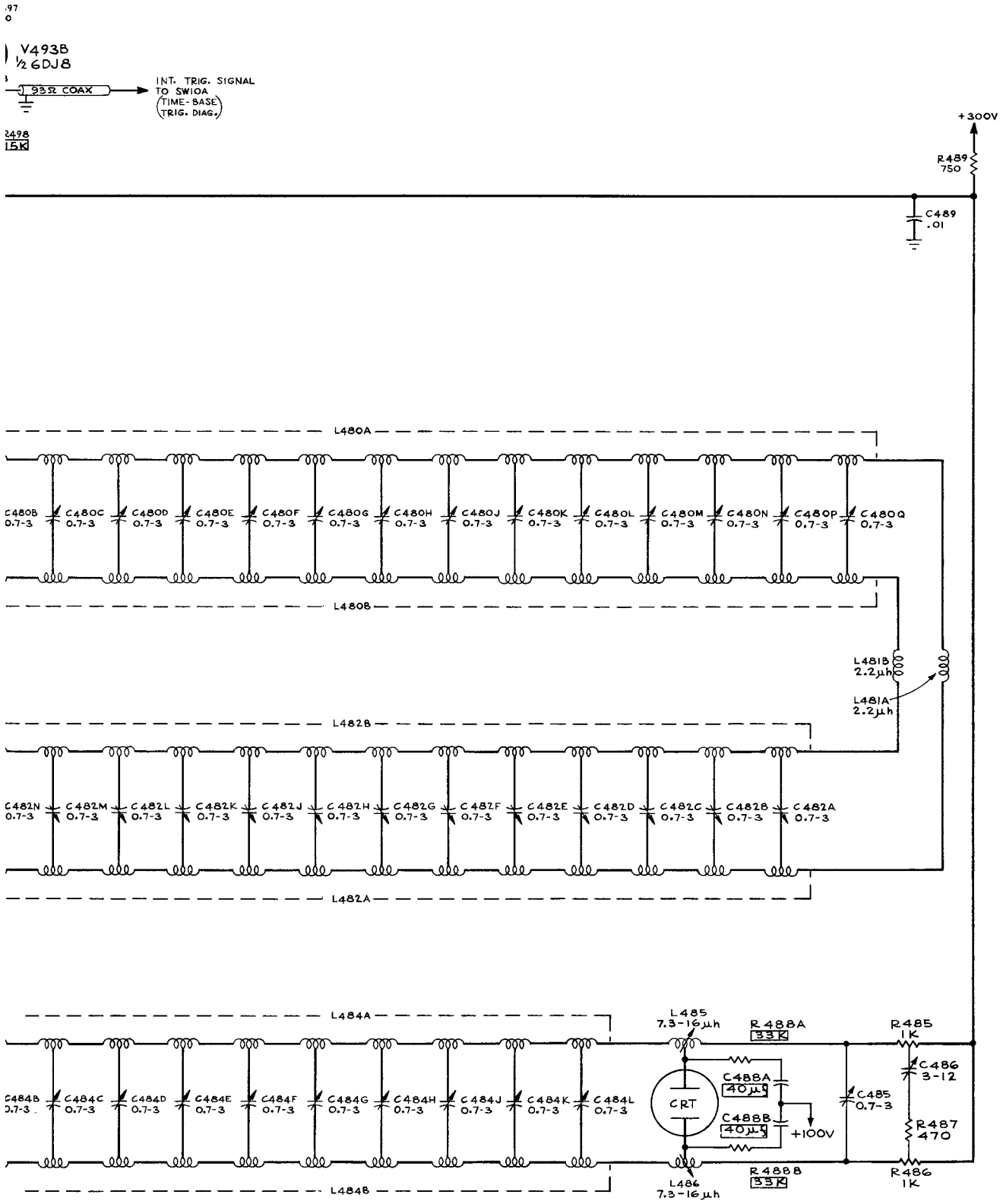
CIRCUIT NUMBERS 400 THRU 599



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

INPUT SIGNAL ..... NONE
TRIGGER SELECTOR (RED KNOB) ..... AUTO
VERTICAL POSITION .....CENTERED
MODE.....ALTERNATE
SEE ALSO IMPORTANT NOTE ON TIME-BASE TRIGGER DIAGRAM.

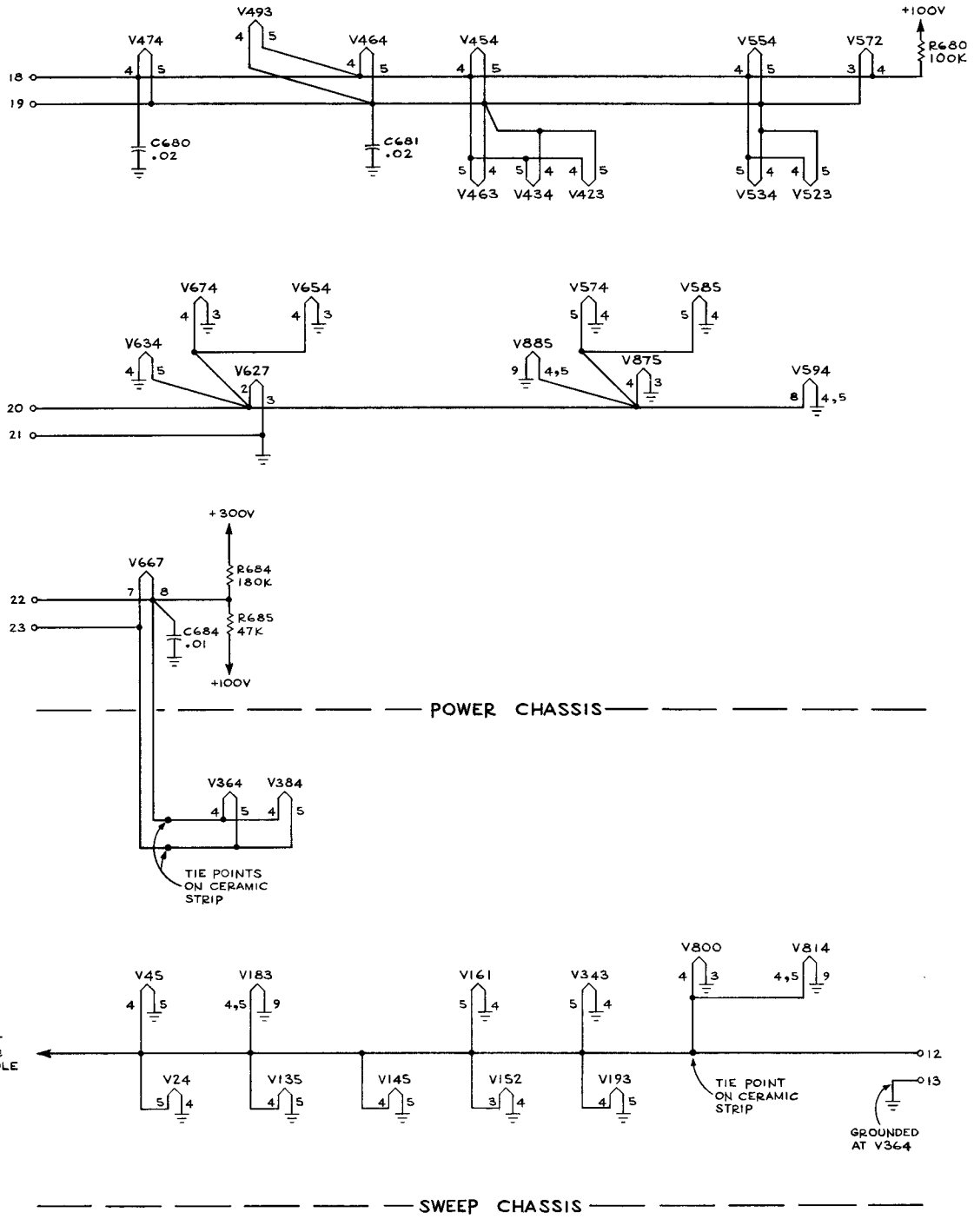


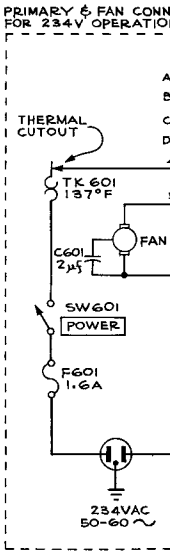
C1

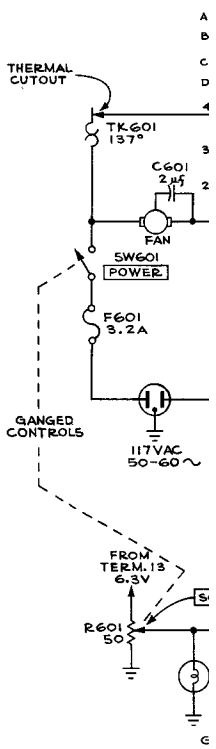
VERTICAL OUTPUT STAGE & DELAY LINE

CIRCUIT NUMBERS
450 THRU 499

664
TP



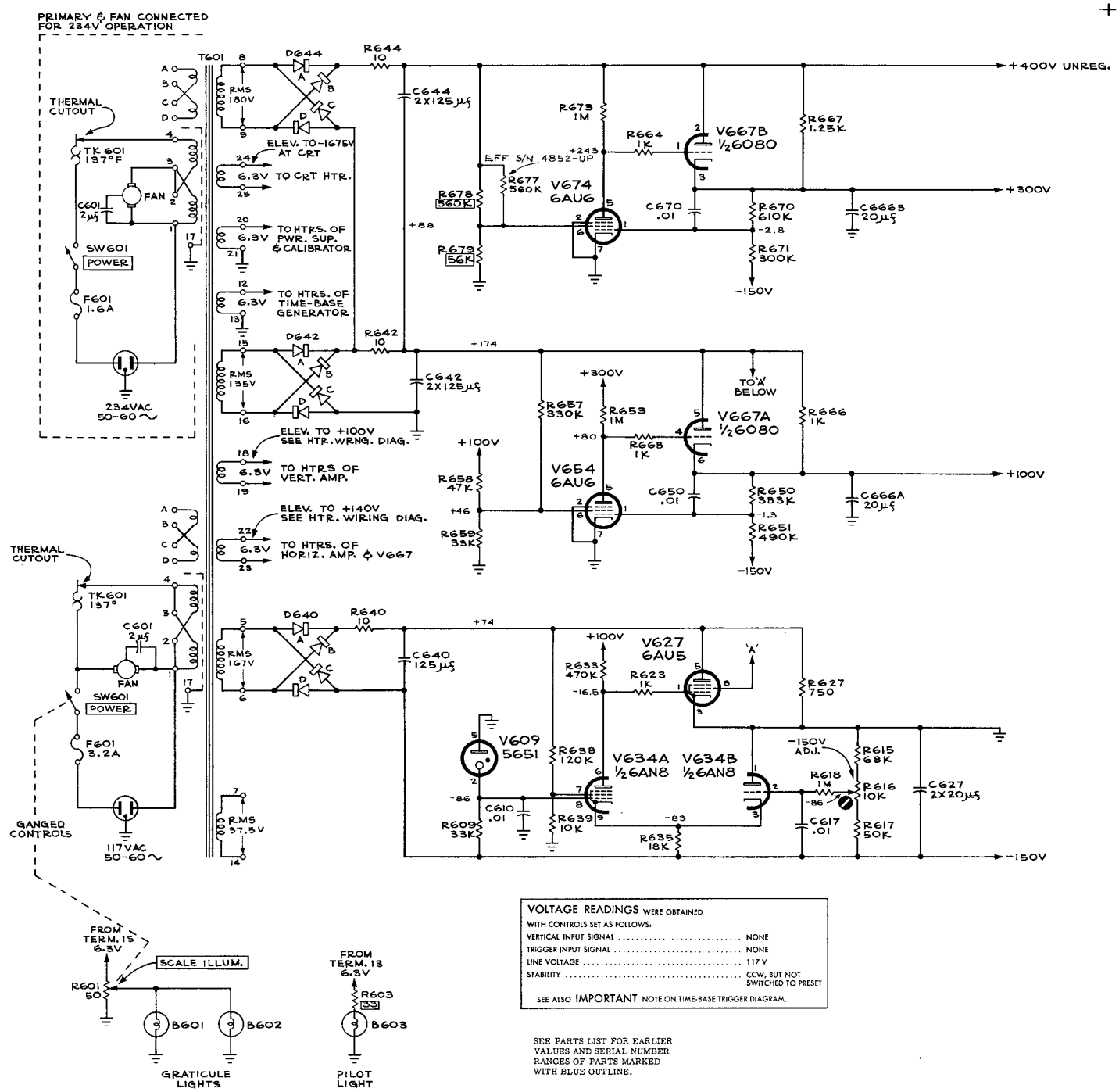




TYPE 516 OSCILLOSCOPE

HEATER WIRING DIAGRAM

E



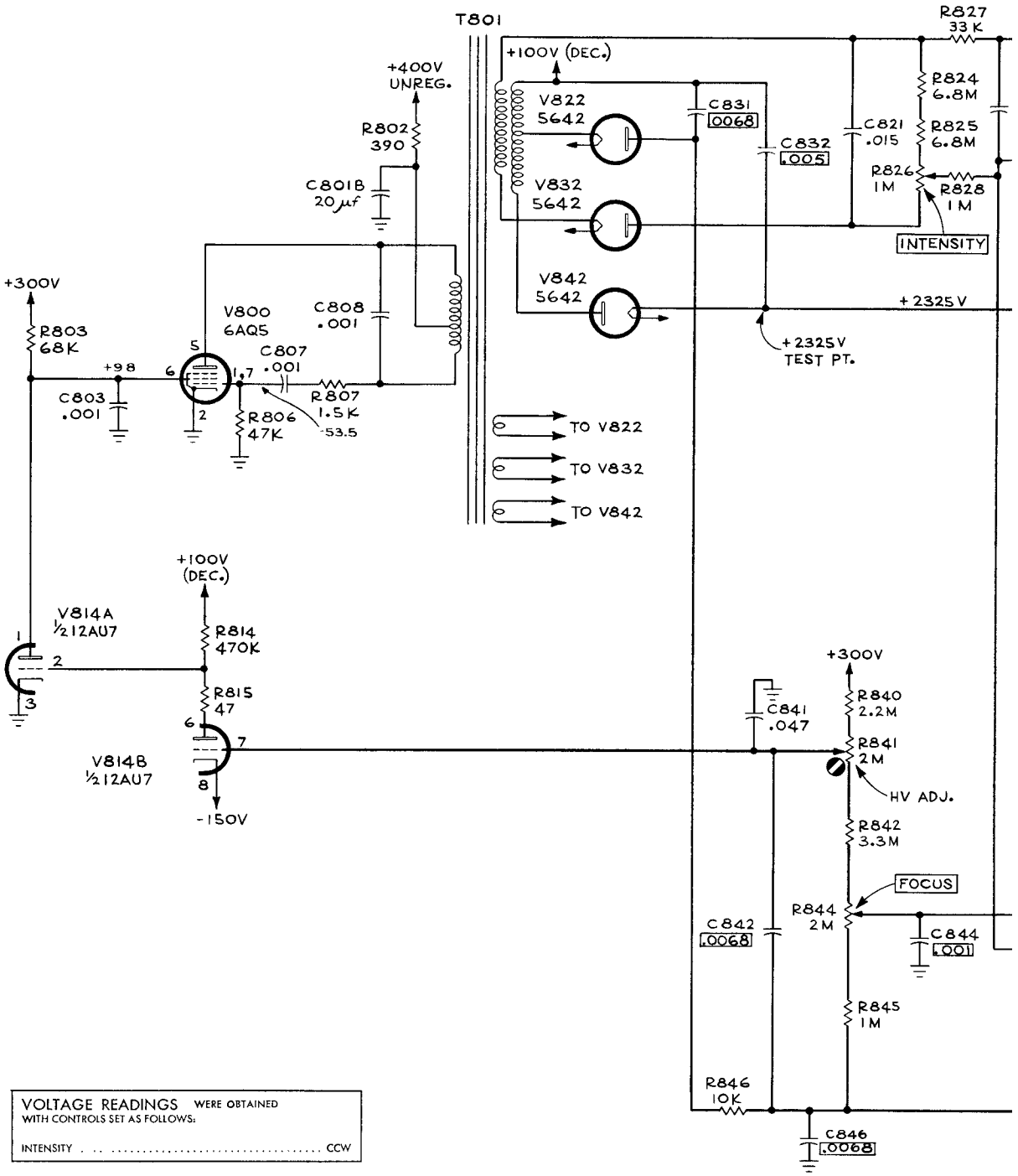
VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:	
VERTICAL INPUT SIGNAL	NONE
TRIGGER INPUT SIGNAL	NONE
LINE VOLTAGE	117 V
STABILITY	CCW, BUT NOT SWITCHED TO PRESET

SEE ALSO IMPORTANT NOTE ON TIME-BASE TRIGGER DIAGRAM.

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

CIRCUIT NUMBERS 600 THRU 679

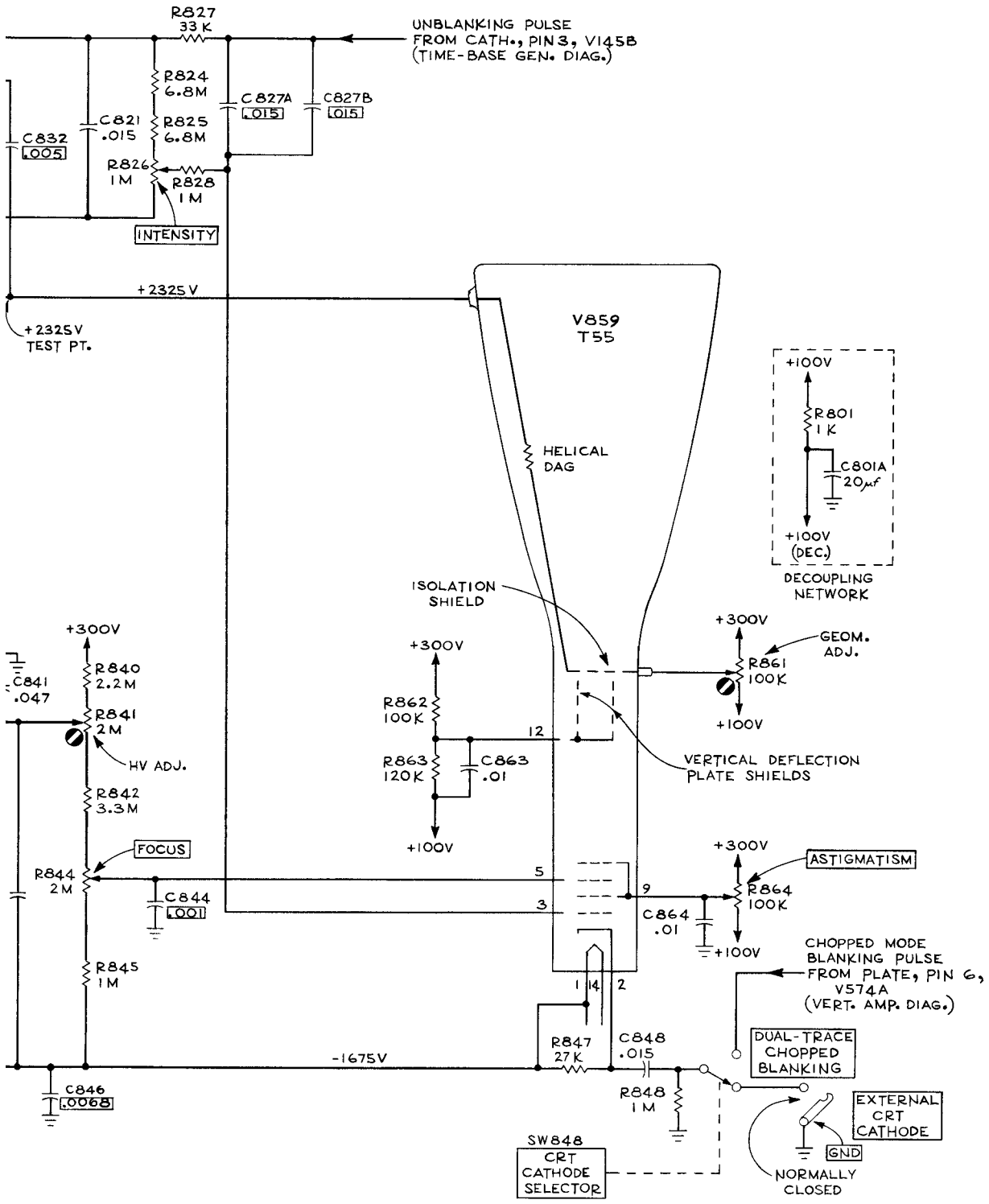
POWER SUPPLY



VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

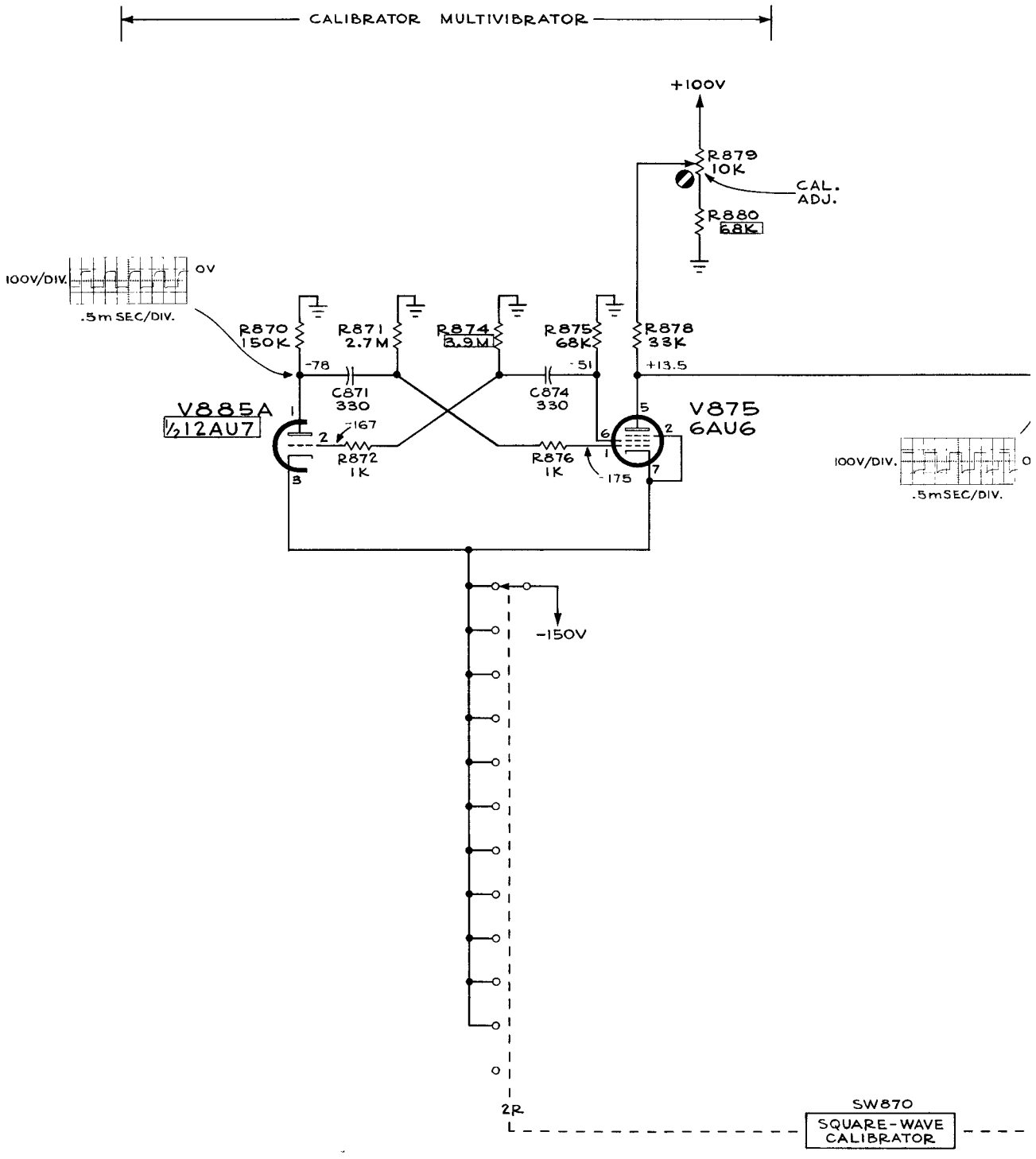
INTENSITY . . . . . CCW

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.



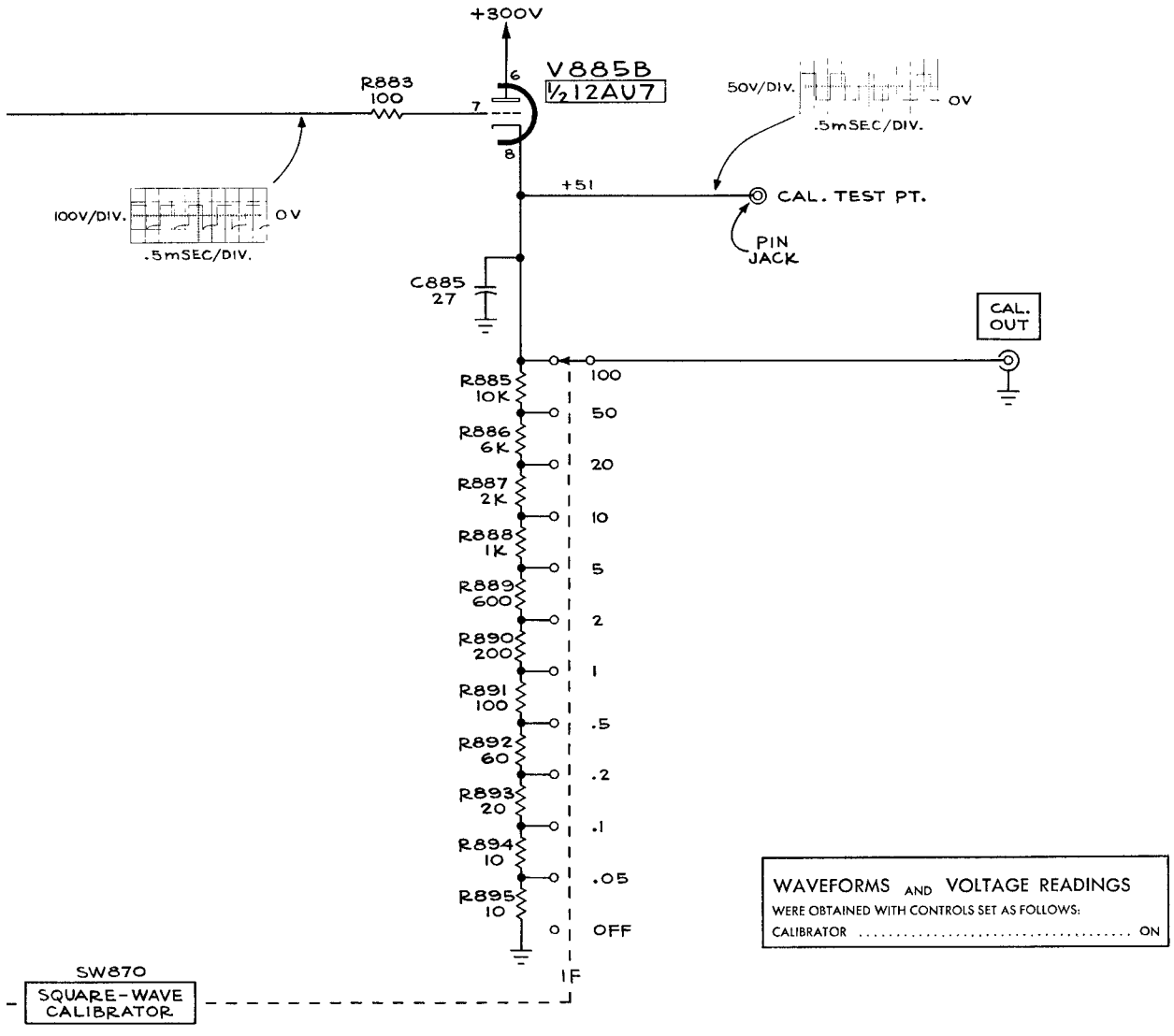
CIRCUIT NUMBERS
800 THRU 869

CRT CIRCUIT


CALIBRATOR MULTIVIBRATOR
+100V
R879
10K
CAL.
ADJ.
R880
68K
100V/DIV.
0V
.5m SEC/DIV.
R870
150K
R871
2.7M
R874
3.9M
R875
68K
R878
33K
-78
-51
+13.5
C871
330
C874
330
V885A
½12AU7
-167
R872
1K
R876
1K
-175
V875
6AU6
100V/DIV.
.5mSEC/DIV.
-150V
2R
SW870
SQUARE-WAVE
CALIBRATOR

CAL. OUT
CF

CAL.
ADJ.



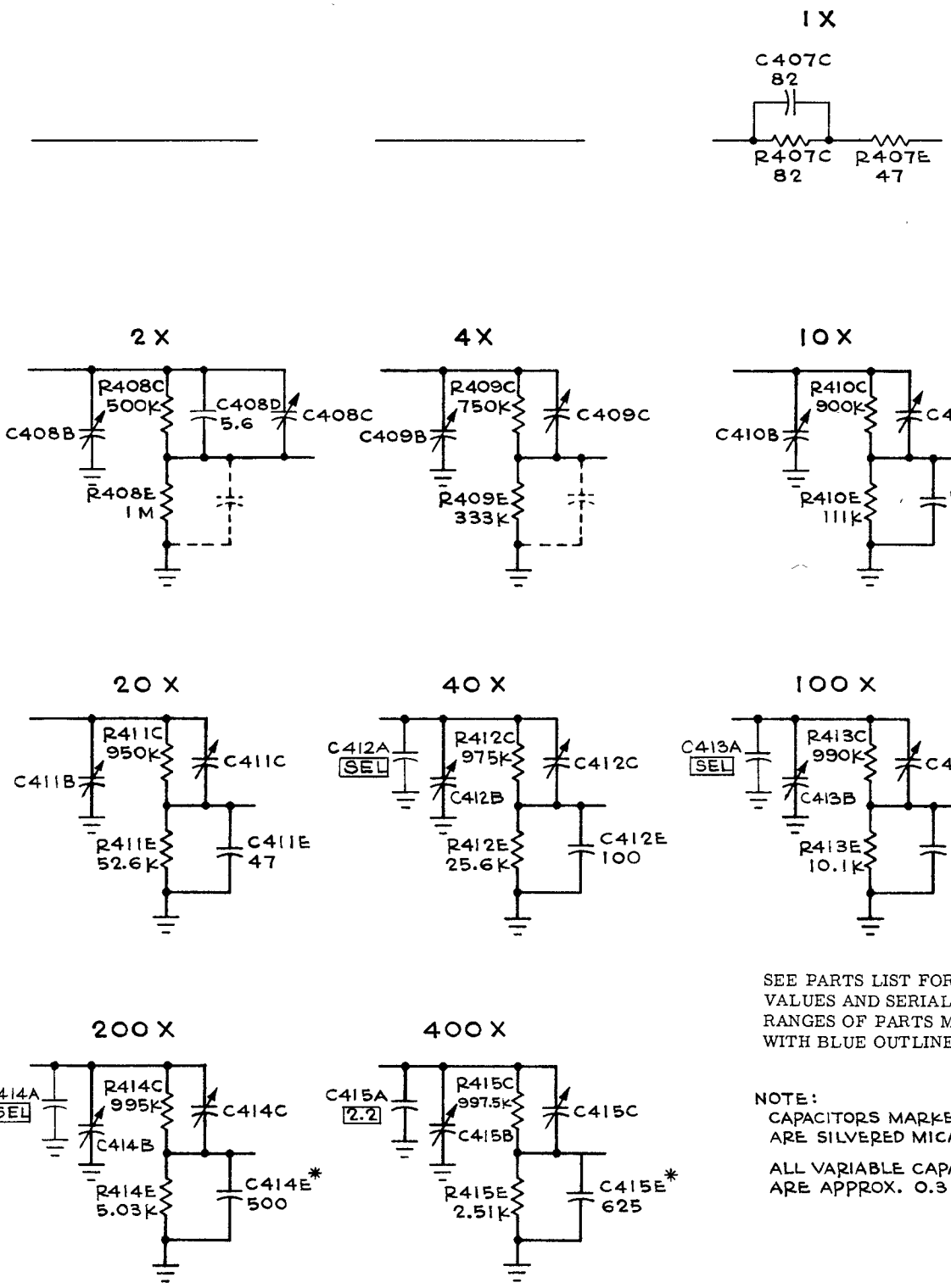
WAVEFORMS AND VOLTAGE READINGS
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:
CALIBRATOR ..... ON

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

CIRCUIT NUMBERS 870 THRU 899

GAB 664

CALIBRATOR



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

NOTE:
CAPACITORS MARKED WITH * ARE SILVERED MICA BUTTONS

ALL VARIABLE CAPACITORS ARE APPROX. 0.3-8 pf

TYPE 516

TURRET ATTENUATOR

865

C

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.

TYPE 516

TEXT CORRECTION

Section 6 Calibration

Page 6-8 Step 22, top of left column

CHANGE: "two cycles" to read "four cycles" in line five.

C3/269
(Rev. #1)

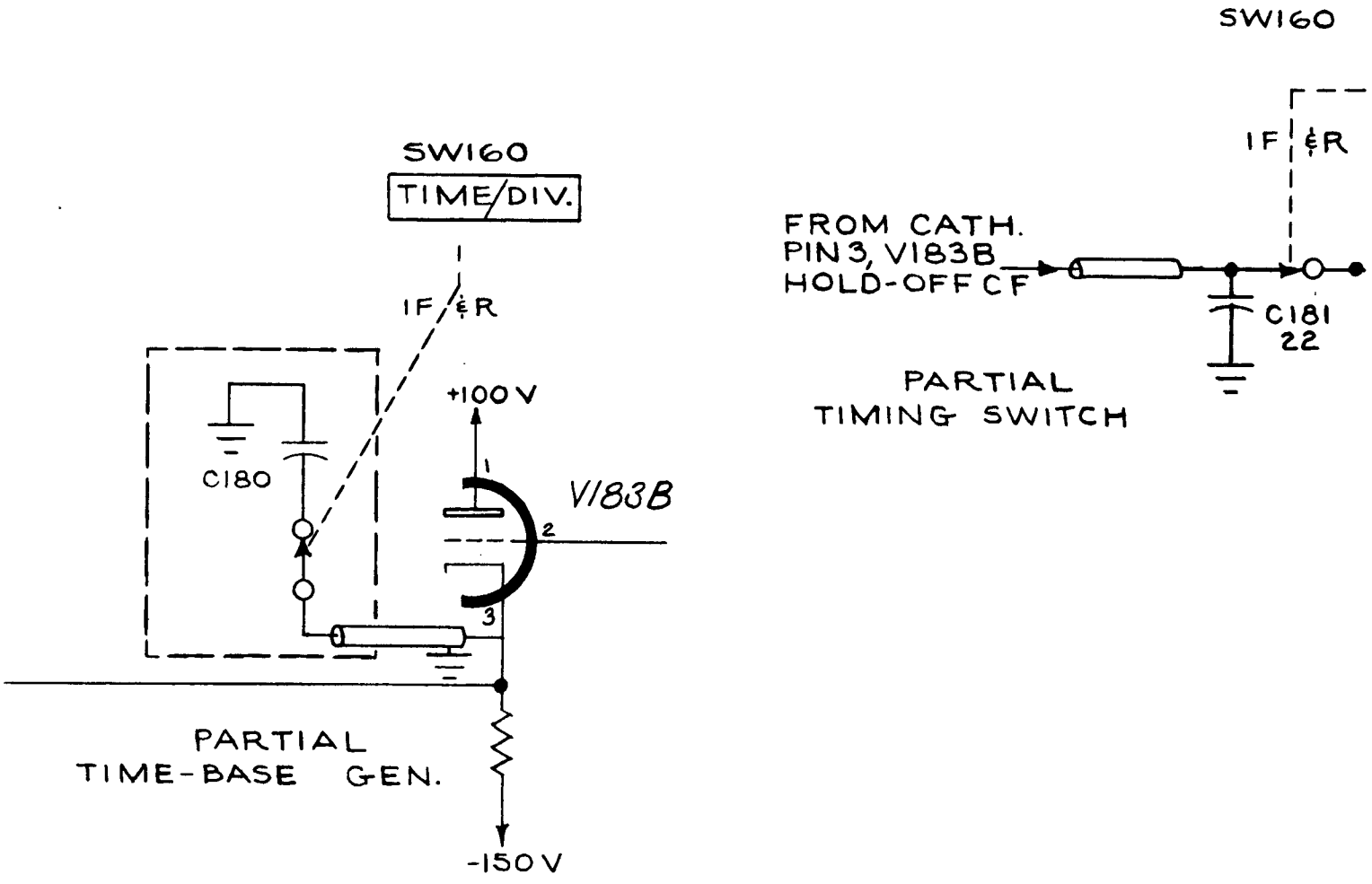
TYPE 516 TENT SN 4770

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

C181	281-0511-00	22 pF	Cer	500 V
SW160	262-0334-02	Time/Division		

SCHEMATIC CORRECTION



ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

L460	108-0170-01	0.5 μH
L470	108-0170-01	0.5 μH

TYPE 516

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

CHANGE TO:

R478	311-0097-00	200 Ω, Var

M16,675/870