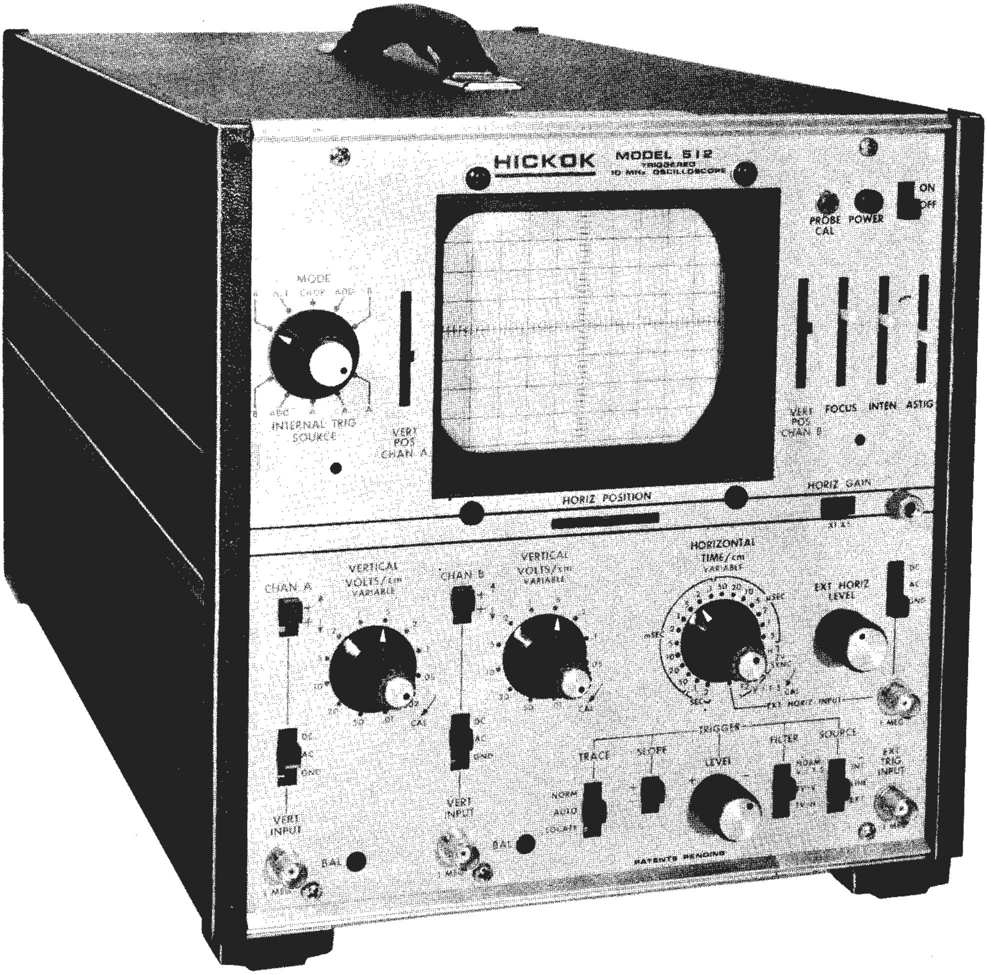

MODEL 512

10 MHz SOLID STATE TRIGGERED

OSCILLOSCOPE

INSTRUCTION MANUAL

(Stock No. 2490-648)

The Hickok Electrical Instrument Company

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF ILLUSTRATIONS

SECTION 1
GENERAL INFORMATION

1-1 DESCRIPTION

The Hickok Oscilloscope covered by this instruction manual has been especially designed to fulfill the need for a highly stable, triggered sweep, solid state oscilloscope for general purpose industrial use. Due to many unique features, it is also ideally suited for use by television, audio and radio service technicians.

Special features of this instrument which are essential for testing and servicing modern electronic equipment are:

a. The vertical system has dual channel amplifiers which allows two waveforms to be displayed simultaneously to compare their time or phase relationship. The two channels can be displayed separately, simultaneously or added together algebraically.

b. Each of the two vertical channels includes a step attenuator, to provide calibrated input voltage ranges, and a variable gain control, to permit adjustment between steps or ranges. Vertical input may be either AC or DC coupled. Special circuitry provides minimal overshoot, ringing and drift in the amplifier.

c. The horizontal amplifier system provides for either AC or DC coupled inputs and includes a variable gain control. The X1 - X5 gain switch permits expanding the display for easy viewing.

d. A digital type trigger circuit offers very stable triggering with minimum jitter to 15MHz without the use of high frequency sync adjustments. This permits the oscilloscope to be used to full bandwidth.

e. Calibrated sweep speeds in 18 steps with continuous adjustment between steps.

f. Special circuitry and control settings for viewing TV horizontal lines, vertical frames and vertical interval test signals (VITS) field 1 or field 2.

g. Overload protection on all ranges to protect the equipment from accidental application of excessive input voltage.

h. Regulated power supply for increased stability and accuracy.

i. Z axis blanking is provided by a Z Axis Input connector located on the back panel of the oscilloscope.

j. A trace locator circuit actuated by a momentary push switch permits rapid location of off-screen traces which may then be centered on the screen by the positioning controls.

1-2. SPECIFICATIONS AND REFERENCE DATA

Specifications for the oscilloscope are as follows:

SPECIFICATIONS AND REFERENCE DATA

CATHODE RAY TUBE

Type	5DEP31F
Accelerating Potential	2.5 kV
Usable Viewing Area	8 cm X 10 cm
Phosphor	P31 (green)

VERTICAL DEFLECTION SYSTEM

Display Modes	Channel A only Alternate: the signal on channel B is displayed alternately with that on channel A. Internal triggering is taken from channel A at all times. Chopped: the display is switched between channels at approximately 100kHz. Internal triggering is taken from channel A at all times. A + B: the signal on channel B is added to that on channel A. Internal triggering is taken from a composite of A and B. Channel B only: internal triggering is taken from channel B.

Deflection Sensitivity	10 mV/cm to 50 V/cm in 12 calibrated steps, accuracy ± 3%. A variable control (uncalibrated) provides continuous adjustment between steps and extends the range to 5 mV/cm.
Input	AC or DC coupled or grounded amplifier input selected by switch.
Input Impedance	1 megohm ± 1% shunted by approximately 30 pF.
Bandwidth	AC coupled 5 Hz to 10 MHz. DC coupled, DC to 10 MHz.
Rise Time	35 nanoseconds
Overshoot	5% or less
Max Input Voltage	600 volts DC plus AC peak

HORIZONTAL AMPLIFIER

Deflection Sensitivity	Continuously variable from 0.5 volts/cm to 50 volts/cm with X1 - X5 multiplier.
Input	AC or DC coupled or grounded amplifier input selected by switch.
Input Impedance	1 megohm (nominal) shunted by approximately 40 pF.
Bandwidth (with Horizontal Level Control full CW)	AC coupled, 5 Hz to 1 MHz. DC coupled DC to 1 MHz.

TIME BASE GENERATOR

Sweep Rates	0.5μ sec/cm to 0.2 sec/cm in 18 calibrated steps. Accuracy ± 5%. A variable control (uncalibrated) permits continuous adjustment between steps and extends the range to 1 sec/cm. In X5 multiplier position, max sweep rate is 100 ns/cm.
Linearity	Better than 1% through full horizontal sweep.

TRIGGERING SYSTEM

Source	Internal, external or line frequency signals may be selected as the triggering source.
Trace	Normal or automatic trace modes are provided.
Slope	Either the positive or negative slope of the input waveform may be selected to start the sweep.
Level	Adjustable by front panel control.
TV Sync	Sync filter circuits provide horizontal or vertical sync pulses from the composite video signal to sync the oscilloscope. Normal, TV Horizontal or TV Vertical synchronization are selected by panel controls.
VITS Sync	Separate positions on the time base switch permit viewing TV Vertical interval test signals (VITS), field 1 or field 2, on the oscilloscope.

Sensitivity, Internal	1/2 division of deflection at 4 MHz and 1/2 to 2 divisions from 4 MHz to 15 MHz.
External	200mV to 5V p to p.
Input Impedance (External Trigger)	1 megohm (nominal) shunted by approximately 30 pF.

Z AXIS BLANKING

Input Signal	T^2L input "0" blanks trace (0 volts at 1.6 ma). T^2L input "1" unblanks (+2.8 volts or open circuit).
Max Input Repetition Rate	100 kHz.

MISCELLANEOUS SPECS

Probe Calibration Voltage	Approximately 7.5V p to p, 1 kHz squarewave.
Power Requirements	105 to 125V, 50 to 60 Hz, 40 watts, for standard model. 205 to 260V, 50 to 60 Hz model available from factory when specified by customer.
Overall Dimensions (Excluding Handle and Knobs)	11" H x 10-1/2" W x 18-1/2" D (27.9 cm x 26.6 cm x 47 cm).

SECTION 2
PRELIMINARY INSTRUCTIONS

WARNING

Upon receipt the oscilloscope should be visually inspected for physical damage. The shipping carton should be saved since it is designed to prevent damage to the cathode ray tube during shipment. DO NOT ATTEMPT TO RE-SHIP WITHOUT A PROPER CARTON.

DO NOT ATTEMPT TO OPERATE THIS OSCILLOSCOPE UNTIL THE SECTION OF THIS MANUAL ON OPERATION HAS BEEN READ AND IT IS CERTAIN THAT THE LINE VOLTAGE IS WITHIN SPECIFIED LIMITS.

REFER TO SPECIFICATION FOR INPUT LIMITS.

IF A THIRD WIRE GROUNDED POWER SOURCE OUTLET IS NOT AVAILABLE AN APPROVED ADAPTER WITH GROUNDING LEAD SHOULD BE USED AND THE LEAD CONNECTED TO A SUITABLE GROUND TO PREVENT A POSSIBLE SHOCK HAZARD TO THE OPERATOR.

2-1 GENERAL

In order to use the oscilloscope properly and effectively, it is essential that the operator be thoroughly familiar with the various controls, connections and accessories. Read the following paragraphs carefully before operating the equipment.

2-2 CONTROLS AND THEIR USES

a. The various controls and connectors are described in the following subparagraphs together with their functions. For location of the controls and connectors, refer to figure 2-1. The index numbers on figure 2-1 correspond to the subparagraph number.

(1) PROBE CAL tip jack. Provides a square wave voltage of approximately 7.5 volts peak to peak at 1 kHz for calibrating high impedance voltage divider probes when used with the oscilloscope.

(2) POWER indicator. Lights when power is ON.

(3) ON-OFF power switch. Controls power line input to the oscilloscope.

(4) FOCUS control. Adjusts focus of CR tube beam to control sharpness of trace.

(5) INTEN control. Adjusts brightness of trace.

(6) ASTIG control. Used in conjunction with FOCUS control to provide maximum sharpness of trace.

(7) HORIZ POSITION control. Permits horizontal positioning of trace on CR tube screen.

(8) HORIZ GAIN, X1 - X5 switch. Permits increasing the horizontal gain by a factor of 5 to expand the display for easier viewing.

(9) Ground binding post. Provides an external ground connection to the chassis of the oscilloscope.

(10) HORIZONTAL TIME/cm switch.

(a) Coarse horizontal sweep selector. Selects sweep time of 0.5 μsec/cm to 0.2 sec/cm in 18 calibrated steps when VARIABLE horizontal gain control (11) is set to the CAL position.

(b) Selects proper sweep rates for composite video waveforms in the TV SYNC H (horizontal) and TV SYNC V (vertical) position.

(c) Selects internal circuitry for viewing TV vertical interval test signals. (VITS field 1 and field 2) in positions VITS F1 and VITS F2.

(d) Selects EXT HORIZ INPUT in full clockwise position.

(11) HORIZONTAL VARIABLE control.

(a) Permits fine sweep time adjustment (uncalibrated) between the steps of HORIZONTAL TIME/cm switch (10).

(b) When this control is set in its extreme clockwise position (CAL) the sweep time is calibrated.

(12) EXT HORIZ INPUT switch DC AC GND. Selects DC coupled, AC coupled or grounded amplifier inputs for signals from EXT HORIZ INPUT connector (14).

(13) EXT HORIZ LEVEL control. Adjusts magnitude of external horizontal input signals when the TIME/cm switch (10) is in the EXT HORIZ INPUT position.

(14) EXT HORIZ INPUT connector. Coaxial input terminal for horizontal amplifier. 1 MEG nominal impedance.

(15) EXT TRIGGER INPUT connector. Coaxial input terminal for application of external trigger signals. 1 MEG nominal impedance.

(16) TRIGGER SOURCE switch. Selects trigger signal.

(a) INT - Waveform being observed provides trigger.

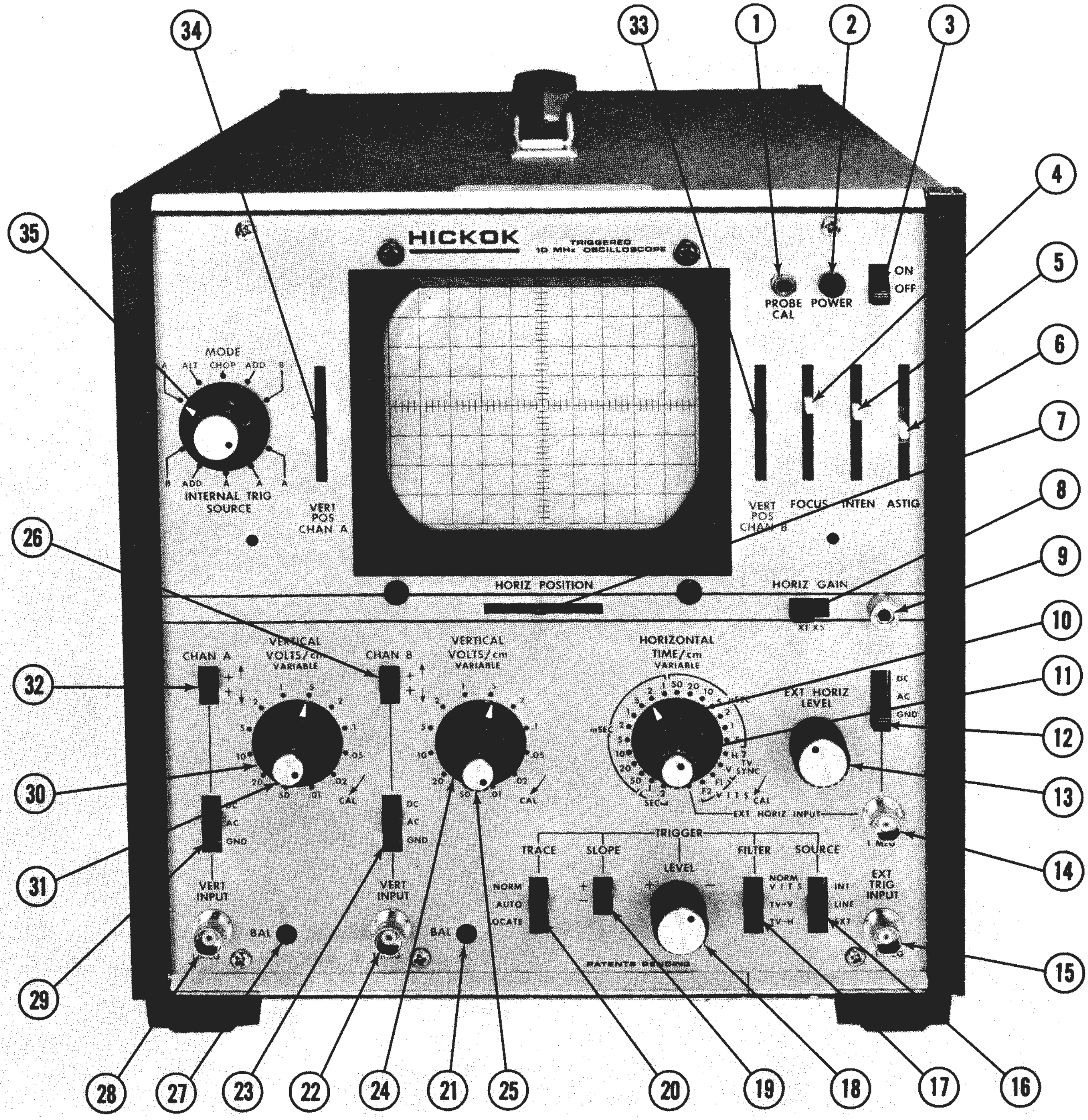


Figure 2-1. Controls and Their Locations

(b) LINE - Trigger signal taken from 50 - 60 Hz power line.

(c) EXT - Signal input at EXT TRIGGER INPUT connector (15) is used as the trigger signal.

(17) TRIGGER FILTER Switch.

(a) NORMAL - VITS position is used for conventional operation and when viewing field 1 and field 2 VITS.

(b) TV-V and TV-H positions switch in special filter circuits for displaying the composite video waveform at either vertical or horizontal rates.

(18) TRIGGER LEVEL control. Adjustment determines starting point of sweep on waveform slope.

(19) TRIGGER SLOPE switch, + and -. Selects either the positive or negative slope of the input waveform for start of trace.

(20) TRIGGER TRACE switch.

(a) NORMAL position permits adjustment of starting point of sweep on the waveform slope by TRIGGER LEVEL control (18).

(b) AUTO position automatically provides a base line when the sweep is not triggered.

(c) LOCATE. A momentary switch in this position actuates a beam finder circuit to locate off screen traces and indicates necessary positioning adjustments to return the trace to a usable portion of the screen. Switch should be placed in the NORM position for TV-V, TV-H and VITS triggering.

(21) BAL control (Channel B). Adjusts the offset of the B vertical amplifier so that the trace does not move when the VOLTS/cm switch (24) is changed from one position to another.

(22) VERT INPUT connector (Channel B). Coaxial input terminal for B vertical amplifier. 1 MEG ± 1% impedance.

(23) VERT INPUT switch DC AC GND (Channel B). Selects DC coupled, AC coupled or grounded amplifier inputs for VERT INPUT connector (22).

(24) VERTICAL VOLTS/cm switch (Channel B). Vertical attenuator. Provides coarse adjustment of vertical sensitivity in 12 calibrated steps from 0.01 to 50 volts per cm when VARIABLE vertical gain control (25) is in the CAL position.

(25) VERTICAL VARIABLE gain control (Channel B). Permits fine adjustment of vertical sensitivity (uncalibrated) between the steps of the VOLTS/cm switch (24). With this control set in the extreme clockwise (CAL) position the vertical attenuator steps are calibrated.

(26) $^{+}_{+}\updownarrow$ Trace Inverter Switch (Channel B). Permits the inversion of positive or negative vertical input signals so that they can be displayed in the same orientation of the screen. Note that this control also inverts the direction in which the VERT POS control moves the trace.

(27) BAL control (Channel A). Adjusts the offset of the A vertical amplifier so that the trace does not move when the VOLTS/cm switch (30) is changed from one position to another.

(28) VERT INPUT connector (Channel A). Coaxial input terminal for vertical amplifier A. 1 Meg ± 1% impedance.

(29) VERT INPUT switch DC AC GND (Channel A). Selects DC coupled, AC coupled, or grounded A amplifier inputs for VERT INPUT connector (28).

(30) VERTICAL VOLTS/cm switch (Channel A). Vertical attenuator. Provides coarse adjustment of A vertical sensitivity in 12 calibrated steps from 0.01 to 50 volts per cm when VARIABLE vertical gain control (31) is in the CAL position.

(31) VERTICAL VARIABLE gain control (Channel A). Permits fine adjustment of A vertical sensitivity (uncalibrated) between the steps of the VOLTS/cm switch (30). With this control set in the extreme clockwise (CAL) position the vertical attenuator steps are calibrated.

(32) $^{+}_{+}\updownarrow$ Trace Inverter Switch (Channel A). Permits the inversion of positive or negative A vertical input signals so that they can be displayed in the same orientation on the screen. For proper triggering of video signals this control should be set so the sync tips point down. Note that this control also inverts the direction in which the VERT POS control moves the trace.

(33) VERT POS control (Channel B). Permits vertical positioning of the B channel trace.

(34) VERT POS control (Channel A). Permits vertical positioning of the A channel trace.

(35) MODE INTERNAL TRIG SOURCE switch. Selects any of five basic modes of operation of the A and B vertical channels and indicates the signal source on which the trace triggers.

(a) A mode. Voltages connected to the A input will be displayed on screen. Trigger voltage is taken from the A channel input voltage.

(b) ALT mode. Voltages which are connected to A and B inputs will appear alternately on screen during successive sweeps. Trigger voltage is taken from the A channel input voltage.

(c) CHOP mode. Voltages which are connected to A and B inputs will appear simultaneously on screen by internally switching the CRT beam at a 100kHz rate between the A and B channels. Trigger voltage is taken from A channel input voltage.

(d) ADD mode. Voltages at the A and B inputs can be added together or subtracted from each other when used in conjunction with the A and B trace inverter ($^{+}_{+}\updownarrow$) switch. Trigger voltage is taken from a composite of the A and B input voltage.

(e) B Mode. Voltages connected to the B input will be displayed on the screen. Trigger voltage is taken from B input voltage.

SECTION 3
OPERATING INSTRUCTIONS

3-1 GENERAL

The oscilloscope is an instrument for the instantaneous graphing of voltages. The vertical axis of the graph is controlled by the vertical controls. These controls have green panel nomenclature. The horizontal axis of the graphs are controlled by the horizontal controls which have blue nomenclature. This oscilloscope displays two different types of graphs.

a. Voltage vs Voltage Graphing

With the voltage vs voltage graphing input signals are applied to the VERT INPUT and EXT HORIZ INPUT, amplified by the vertical and horizontal amplifiers, and applied to the vertical and horizontal deflection plates in the cathode ray tube. This mode of operation is useful for graphing the relationship between two voltages. Common applications are lissajous patterns for frequency comparison and vector scope measurements in television servicing.

b. Voltage vs Time Graphing

With voltage vs time graphing the input signal is applied to the VERT INPUT, amplified by the vertical amplifier, and applied to the vertical deflection plates. The horizontal amplifier is connected to a triggered time-to-voltage generator which is internally contained in the oscilloscope. The function of this generator is to develope an output voltage whose magnitude is linearly related to the elapsed time after the generator was triggered. This produces a display which is voltage vs time.

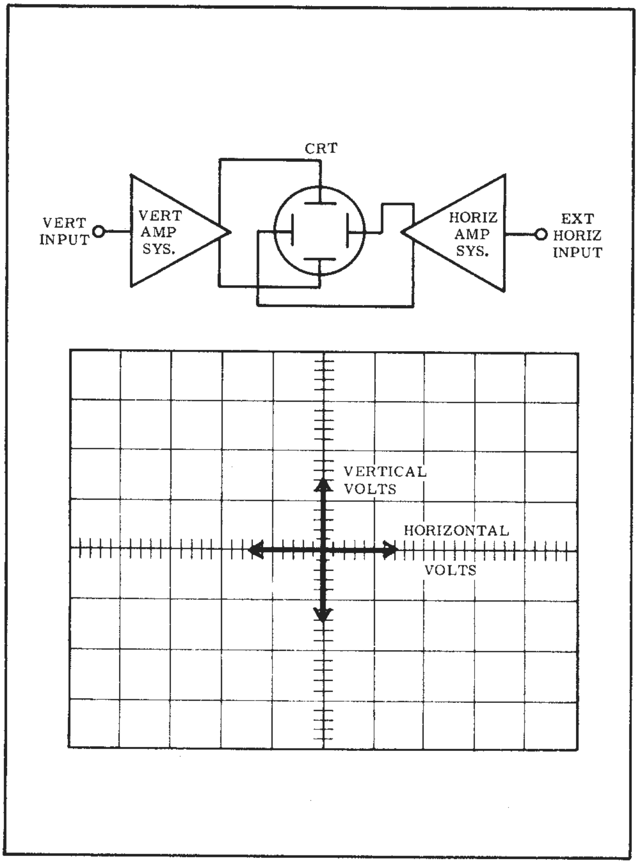


Figure 3-1. Voltage vs Voltage Diagram

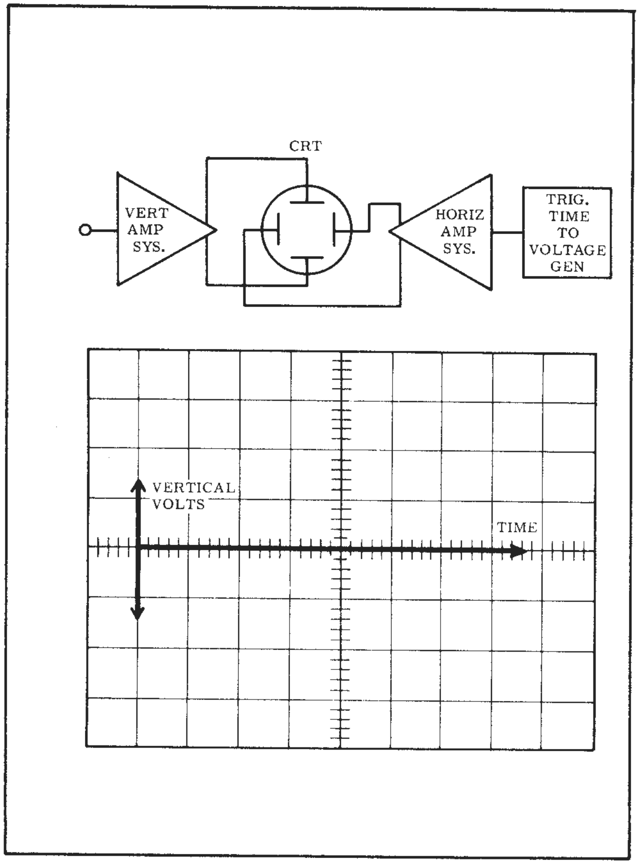


Figure 3-2. Voltage vs Time Diagram

3-2 OPERATIONAL CHECK (CHANNEL A)

a. To check the oscilloscope for proper operation plug the power cord into the power line using a third wire ground connection.

Set the front panel controls as follows:

POWER	OFF
VERT POS	Centered
INTEN	Maximum (Top)
HORIZ POSITION	Centered
HORIZ GAIN	X 1
MODE	A
VERTICAL VOLTS/cm Switch (Channel A and B)	1 V
VERTICAL VOLTS/cm VARIABLE (Channel A and B)	CAL (Clockwise)
VERT INPUT (Channel A and B)	AC
+ ↑ + ↓ Trace Invert (Channel A and B)	+ ↑ (Up)
TRACE	AUTO
SLOPE	+
LEVEL	Centered
FILTER	NORM
SOURCE	INT
HORIZONTAL TIME/cm	2M SEC
HORIZONTAL TIME/cm VARIABLE	CAL (Clockwise)

With the controls set as above, move power switch to ON and allow three minutes for warm up. A bright horizontal line should be observed. Using the HORIZ POSITION control, position the trace so that the beginning of the sweep occurs at the first line at the left of the graticule. Reduce INTEN control setting and adjust FOCUS and ASTIG for a sharp display.

b. Cathode Ray Tube (CRT) Alignment

Place the oscilloscope in its intended operating location away from transformers or motors. If the trace is horizontal then no adjustment of the crt is necessary. If the trace tilt is unacceptable note the amount of tilt. Move the power switch to off and remove the line plug from its socket. Remove the four plastic side trim pieces from the front and rear of the oscilloscope by removing the eight Phillips head screws. The bottom cover of the instrument can now be removed.

Note the two allen head screws which mount the CRT bracket at the bottom rear of the CRT. See figure 3-3.

Loosen these allen screws and grasp the CRT around the bell. Rotate the CRT in the proper direction such that the CRT rotates in the four rubber mounts at the front of the graticule bezel. Place the instrument back in its intended operating position, plug in and check operation. Continue adjusting until the trace is horizontal.

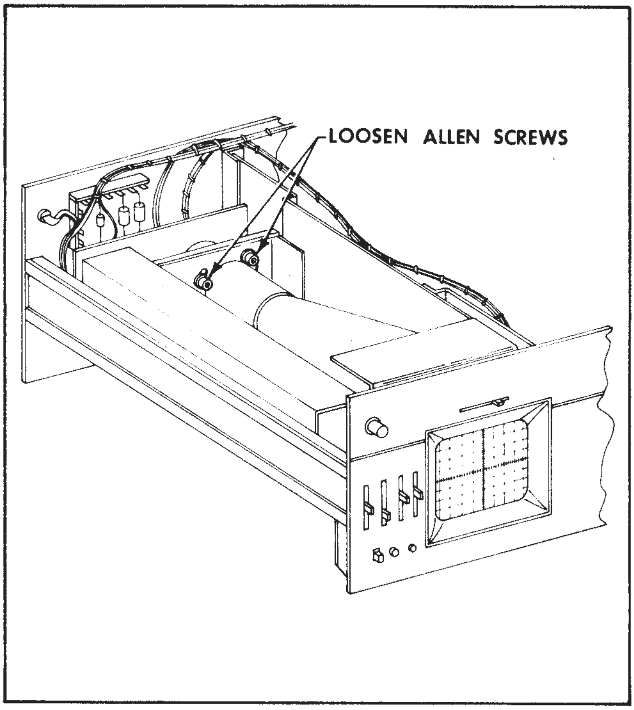


Figure 3-3. Alignment of Cathode Ray Tube

CAUTION

DO NOT ATTEMPT TO ADJUST TILT WHILE INSTRUMENT IS CONNECTED TO THE AC LINE.

When tilt is satisfactory retighten the allen screws and reinstall the bottom cover and plastic trim.

3-3 VERTICAL DC BALANCE ADJUST (CHANNEL A)

Set controls as in Paragraph 3-2a.

a. With an insulated screw driver carefully adjust BAL until the trace is on the center graticule line.

b. Move VERTICAL VOLTS/cm control to the 5 V range. If the trace has moved from the center graticule line recenter it with the VERT POS control.

c. Move VERTICAL VOLTS/cm control back to the 1 V range. If the trace has moved adjust BAL until the trace is again on the center graticule line.

d. Continue to adjust the VERT POS when the VERTICAL VOLTS/cm switch is on the 5 V range and adjust the BAL control when the VERTICAL VOLTS/cm switch is on the 1V range until trace shift is acceptable.

With careful adjustment of the BAL control the trace will remain centered as the VERTICAL VOLTS/cm control is rotated, however proper operation of the instrument is maintained as long as the trace moves less than 1cm when switching between the 1 V cm and 5 V/cm positions.

3-4 PROBE CALIBRATION VOLTAGE

With controls set as in Paragraph 3-2a connect the PROBE CAL output to the VERT INPUT connector. Center the display using the VERT POS and HORIZ POSITION controls. This display should be as in figure 3-4.

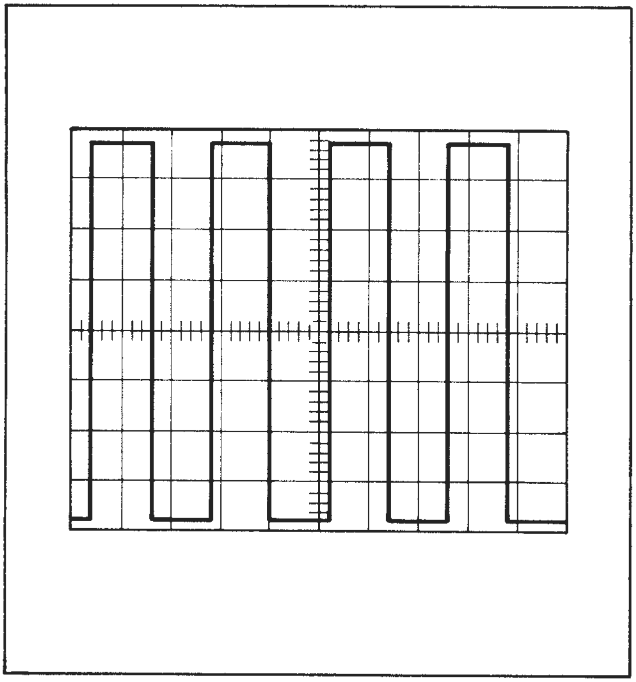


Figure 3-4. Calibrator Output Voltage Display

To obtain familiarity with the instrument, the controls may be manipulated as desired and the effects observed. Note that no combination of control positions can cause any damage to the instrument.

3-5 USE OF PROBES

a. Attenuator probes are frequently used to reduce resistive and capacitive loading of the circuit under test. The Hickok Style 100-155 or any standard probe which is capable of adjusting to a 30 pF Oscilloscope input capacity can be used. When making measurements with a probe, multiply the observed amplitude by the probe attenuation factor. The Hickok probe has a factor of 10.

b. To assure the accuracy of high frequency and pulse measurements, probe adjustment is necessary. To make this adjustment, proceed as follows:

(1) Set the VERTICAL VOLTS/cm switch to 1V, and the slide switch to DC, and connect the probe to the PROBE CAL output connector.

(2) Set the HORIZONTAL TIME/cm switch to .5 mSEC and adjust the trigger controls for a stable display.

(3) Adjust the probe for sharp rise and best flatness of the positive peak.

3-6 OPERATION OF VERTICAL CONTROLS

The controls marked in green nomenclature control the deflection of the spot in the vertical direction.

a. The VERTICAL VOLTS/cm control and its concentric VARIABLE control allow continuous adjustment of the input sensitivity of the instrument from .005 to 50 volts/cm. With the VARIABLE control in its most clockwise position, the instrument is calibrated, with 12 voltages ranges in a 1, 2, 5 sequence. Regardless of the position of the controls the input impedance of the VERT INPUT connector remains constant.

b. The VERT INPUT switch selects the type of coupling into the vertical amplifiers. In the DC position the amplifier is direct coupled from the VERT INPUT connector through the vertical amplifier to the deflection plates in the CRT. In the AC coupled position this vertical amplifier has a capacitor inserted in series with its input which blocks any DC voltages and allows AC voltages to pass. This position is very useful for viewing AC voltages which ride on DC levels such as power supply ripple.

c. In the GND position the VERTICAL INPUT is disconnected from the amplifier input for easy determination of the zero voltage input level.

d. The VERT POS control is used to move the display up and down on the vertical axis. The VERT POS control has a positioning range of + and - one additional screen. This extra positioning range is useful for viewing the small details on the tops and bottoms of waveforms.

e. +↑ +↓ Trace Inverter Switch

This control determines the direction that a positive voltage will move the trace. In the +↑ position positive input voltages move the trace up on the face of the crt. In the +↓ position positive input voltages move the trace down.

3-7 OPERATIONAL CHECK (CHANNEL B)

Set MODE switch to B. Repeat Steps 3-3, 3-4, and 3-6 for the B Channel.

3-8 ALTERNATE, CHOP

a. Set controls as in Paragraph 3-2a. Set HORIZONTAL TIME/cm to 50mSec. Position trace to upper half of the screen. Set MODE switch to B and position trace to lower half of screen. Set MODE switch to ALT. The trace should alternate between the top and bottom half of the screen.

b. Set MODE switch to CHOP. The upper and lower traces shall sweep simultaneously.

c. Set A and B VERTICAL VOLTS to 2V/cm. Connect the PROBE CAL to the A and B VERT INPUTS. Set B TRACE INVERT switch to +↓. Set MODE switch to ADD. The amplitude of the display should be less than 1 cm.

3-9 TRIGGERING CONTROLS

The red nomenclature markings on the front panel identify the controls which affect the triggering of the time-to-voltage or sweep generator. It is these controls and their associated circuitry that distinguish the triggered oscilloscope from the recurrent sweep type. An understanding of the TRIGGER controls is essential for using the oscilloscope to its maximum capabilities.

The function of the trigger circuit is to initiate the sweep when the input voltage to the trigger amplifier crosses an adjustable level on a selected slope.

a. SLOPE

The slope is selected by the SLOPE switch on the front panel. (Positive slopes are rising edges negative slopes are falling edges.)

b. LEVEL

Selection of the voltage level at which the sweep starts is adjusted by rotating the LEVEL Control.

c. SOURCE

The SOURCE switch determines which of three signals is used as the trigger circuit input voltage. In the INT position this signal is the same signal which is displayed on the crt face. This position is used for viewing most waveforms. In the LINE position the signal applied is a signal at the AC line frequency. This signal is useful when observing power supply ripple and other signals that occur at the line frequency. In the EXT position, the input to the trigger circuitry is made accessible at the EXT TRIG INPUT. Signals which are applied to this input should be in the .5 to 5 volt range.

d. FILTER: NORM, TV-V, TV-H

These filters are used in separating the vertical and horizontal sync pulses from a composite video waveform, and applying these pulses to the trigger amplifier. Because of the unique characteristics of the video waveform an active sync stripper is used. This circuit strips the most negative information from the video input signal. See figure 3-6.

Because of this stripping function the waveform <u>must</u> be applied with the sync at the most negative part of the waveform. With the SOURCE switch in the INT mode this is accomplished by the ‡↕ trace inverter switch. If the display on the crt is adjusted using the ‡↕ switch so that the sync pulse points down, the signal applied to the sync stripper will be of the proper polarity. Hence whenever these positions are used the sync must be at the bottom of the waveform.

When using the EXT TRIG INPUT position of the SOURCE switch for video signals the sync tips must be the most negative part of the waveform for stable triggering.

NOTE: Whenever the TV-V or TV-H position is used the TRACE control should be moved to the NORM position.

e. TRACE

(1) The function of the AUTO circuit is to produce a trace in the absence of the trigger signal. It is useful for providing a baseline when there is no input signal to the oscilloscope. When an input signal of sufficient amplitude is applied to the trigger input the auto circuit is automatically disabled. Whenever difficulty is experienced in triggering at low screen deflection, at frequencies below 20 Hz, or on a very narrow pulses the TRACE control should be placed in the NORM position. The trace control should be in the NORM position for all video or VITS triggering.

f. LOCATE

(1) The LOCATE position is used to find and orient the trace. The trace may be off the screen due to misadjustment of the position control, an excessive DC input level or incorrect trigger signal. When the TRACE control is moved to the LOCATE position the sweep is automatically triggered and the crt display area is lowered so the trace must be on the screen.

(2) To familiarize the operator with the use of the control set the controls as in Paragraph 3-2a and obtain a trace. Move the HORIZ POSITION control to its far left position. Move the VERT POS control to its lowest position and notice that the trace is no longer on screen. Move the TRACE control to the LOCATE position. Note that the display is now in the lower left position of the screen.

(3) Recenter the trace while holding the TRACE switch in the LOCATE position and then let the switch return to the AUTO position. The trace will now be on screen.

<u>NOTE</u>

The LOCATE position will not function in the VITS positions unless the sweep is triggered.

3-10. HORIZONTAL TIME/cm CONTROLS

a. HORIZONTAL TIME/cm switch determines the rate at which the spot moves across the face of the crt. With the HORIZONTAL TIME/cm VARIABLE control in the CAL position the spot will move across the screen at a rate of .2 second/cm to .5μs/cm in 18 calibrated ranges.

b. With the HORIZ GAIN switch in the X5 position each sweep position is approximately 5 times faster.

c. The HORIZONTAL TIME/cm VARIABLE allows fine adjustment between these calibrated ranges and extends the slowest range to greater than 1 second/cm.

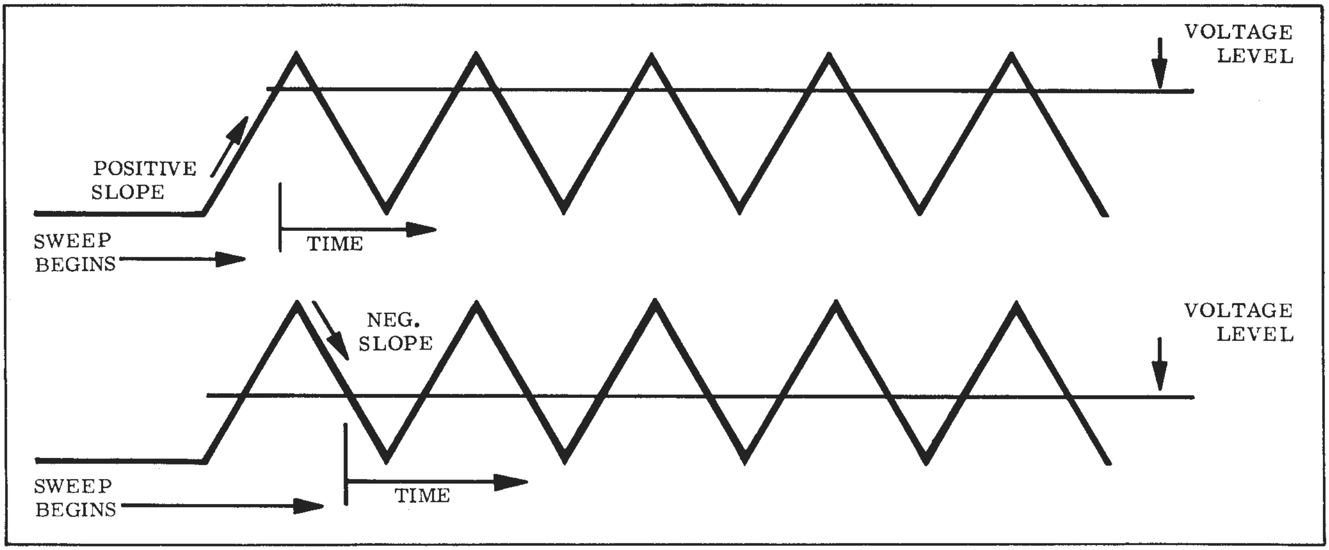


Figure 3-5. Positive and Negative Trigger Slopes

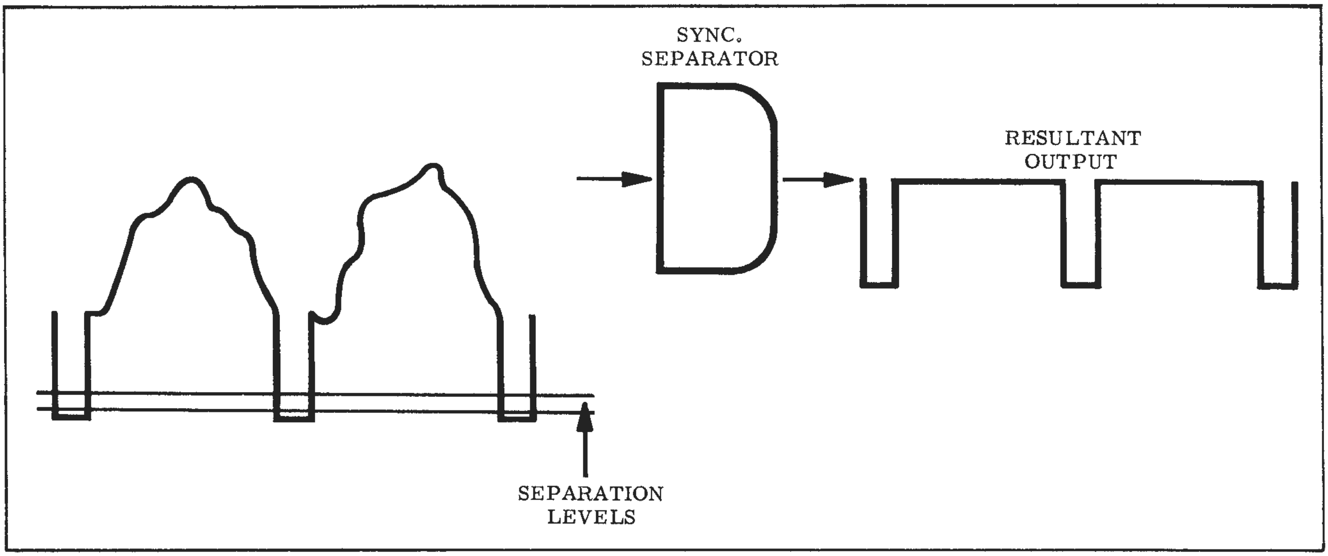


Figure 3-6. Action of Sync Stripper Circuit

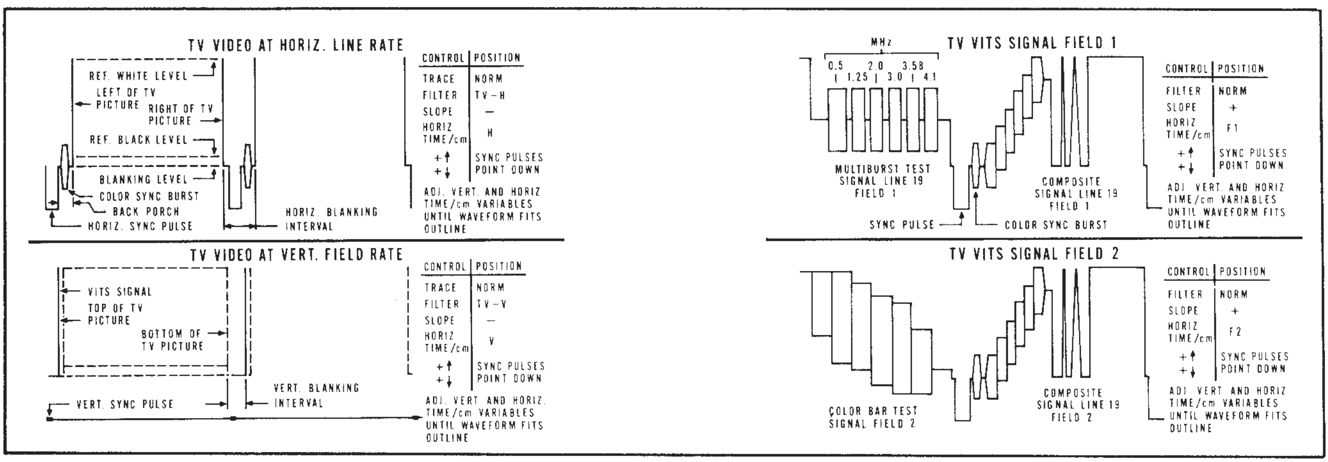


Figure 3-7. Outlines and Control Settings for Video Waveforms

d. TV SYNC

These positions are very useful for observing waveforms in television receivers and also in comparing these waveforms with those which appear on television schematics.

(1) The V position is calibrated to display 2 vertical fields or two cycles of information occurring at 60 Hz.

(2) The H position is calibrated to display two horizontal lines or 2 cycles of information occurring at 15.75 kHz.

e. VITS positions

(1) The F1 and F2 positions on the HORIZ TIME/cm switch are used to separate and view the specially transmitted information which occurs after the FIELD 1 or FIELD 2 vertical sync pulse in standard video broadcasts. These signals are used for measuring many different types of distortion which affect the picture quality of the video transmission. The presence of these signals can be determined by adjusting the Vertical Hold control on a standard television receiver until the picture falls out of sync. The VITS can then be seen as a thin line of white dots at the top of the picture below the black vertical blanking bar.

(2) The action of the internal VITS circuitry is to inhibit the trigger circuitry except during the interval immediately after the selected field 1 or field 2 vertical sync pulse. Further, only one sweep can occur during this period. As with the TV-V and TV-H trigger positions the sync tips of the video waveform must point down when the oscilloscope is triggered in the internal position.

(3) The FCC specified VITS outlines are shown in figure 3-7 along with the oscilloscope control settings.

(4) Because the oscilloscope CRT is swept only for a brief interval each frame and is dark during the rest of the frame, the display is quite dim during the VITS display. For this reason a high brightness CRT and considerable level of intensity has been built into the instrument. Hence when viewing the VITS the INTEN control should be moved to its maximum brightness position until the VITS is obtained and then lowered as is required for good focus. The use of a viewing hood also aids in viewing the VITS in areas of high ambient light.

f. INTERNAL TRIGGERING OF VITS

(1) Before triggering on the VITS signal the oscilloscope should be used to determine the presence of the composite video and sync. Set the oscilloscope controls as in the outline drawing titled TV VIDEO AT VERT FIELD RATE in figure 3-7. (In television receivers a good place to view the VITS is at the video detector output.)

(2) Adjust the TRIGGER LEVEL control to obtain a display. When the proper display is obtained the VITS will appear as a spike after the vertical sync pulse. After verifying the presence of the VITS set the controls as in the outline drawing titled TV VITS SIGNAL FIELD 1. Move the INTEN control to MAX and adjust the TRIGGER LEVEL control to obtain the F1 VITS display.

g. EXTERNAL TRIGGERING OF VITS

Triggering of the VITS signal with the TRIGGER SOURCE switch in the EXT position is possible as long as two input signal requirements are met.

(1) Video signals applied to the EXT TRIG INPUT connector must be of peak to peak amplitude greater than .5 but less than 5V peak to peak.

NOTE

If signals are too high in amplitude a 10:1 probe can be used to divide the signal. When using the 10:1 probe, signals should be in the 5 to 50V p to p range.

(2) The sync pulses must be on the negative part of the waveform.

External triggering of VITS is quite useful for viewing the VITS signal as it passes through various stages in both video and chroma circuitry. External VITS triggering allows the VITS to be observed in areas where the circuitry of the receiver adds large blanking pulses which prevent the VITS circuitry from triggering, as in the video output circuit of some television receivers. This technique is also useful at the chroma demodulators where the vertical sync pulses have been removed.

h. EXT HORIZ INPUT

In this position the sweep circuitry is disabled and the instrument functions in the X vs Y mode. As with the VERT INPUT switch, the DC AC GND EXT HORIZ INPUT switch controls the type of coupling used in the horizontal amplifier. (For television vectorscope use this switch should be placed in the AC position.) Because of the 1 MEG input impedance a 10:1 divider probe may be used with this input to lower the loading of circuitry. With the use of the HORIZ GAIN switch and the EXT HORIZ LEVEL control the input sensitivity is variable from .5 to 50 Volts/cm.

SECTION 4
APPLICATIONS

In this section of the instruction manual, the basic procedure and techniques for making measurements will be described. This is not meant to be a comprehensive text covering all possible uses of the oscilloscope but is intended to familiarize the user with some of the basic applications and techniques. Familiarity with the techniques and the operation of the controls will enable the operator to employ the instrument in a wide variety of applications.

4-1 TYPICAL VOLTAGE MEASUREMENTS

a. AC Component Measurement

(1) Set the VERT INPUT selector switch to the AC position. In this position, only the ac components of the signal are displayed on the crt. (It should be noted, however, that if the frequency of the ac component is very low the DC position should be used.) If the trace is off screen use the VERT POS control in conjunction with the VOLTS/cm switch to obtain a trace on screen.

(2) To make peak to peak measurements of the ac component of the waveform, perform the following steps. The AUTO position should be used and the sweep set to 1 ms/cm, or some other more appropriate rate, dependent upon the frequency of the viewed waveform.

(a) Adjust the VERTICAL VOLTS/cm switch for the largest on-screen display.

(b) Adjust the HORIZONTAL TIME/cm so that several cycles of the waveform are displayed.

(c) Use the VERT POS and HORIZ POSITION controls to position the waveform to a point on the crt where the amplitude can be easily determined. As an example, position the waveform so that one of the negative peaks coincides with one of the lower horizontal graticule lines and the positive peak occurs on the divided center vertical line.

(d) Measure the vertical deflection in centimeters and multiply this result by the VERTICAL VOLTS/cm setting (and by the probe attenuation factor, if used). As an example of this method, assume that 5.2 centimeters of deflection is obtained, that the VERTICAL VOLTS/cm switch is set to .1 VOLTS/cm and that a 10:1 probe is used. The calculation of the voltage amplitude is as follows:

VERT. DEFL. in CM		VERT. VOLTS/CM SETTING		PROBE ATTEN. FACTOR		VOLTS P-P
5.2	X	.1	X	10	=	5.2 V p-p

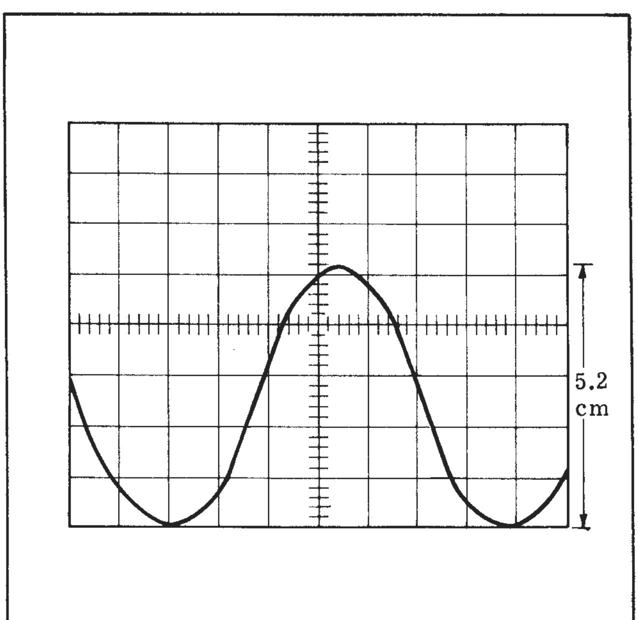


Figure 4-1. Measurement of AC Component Amplitude

b. DC Level Measurements. To measure the dc level or a dc voltage level at a given point on a waveform, use the following procedure:

(1) Set the HORIZONTAL TIME/cm to 1 MS/cm and move the TRACE switch to AUTO.

(2) Adjust the VERTICAL VOLTS/cm switch so that the voltage applied to the input connector is no more than eight times the VERTICAL VOLTS/cm switch setting.

(3) Set the AC-DC-GND, and using the VERT POS control, position the trace so that it coincides with the bottom horizontal graticule line. This point will be used as the zero voltage reference. (Note if the signal to be measured is negative, one of the top horizontal graticule lines should be used.) Do not move the VERT POS control after it has been set.

(4) Set the AC-DC-GND switch to DC.

(5) Adjust the HORIZONTAL TIME/cm and trigger controls for a stable trace if there is an ac component present.

(6) Using the HORIZ POSITION control, position the point on the waveform to be measured on the center vertical graticule line.

(7) Measure the distance from the base reference line to the point on the waveform which crosses the center vertical graticule line and convert this reading to a voltage by the following relationship:

$$\text{Deflection in cm} \times \text{VERTICAL VOLTS/cm setting} \times \text{probe attenuation factor} = \text{Volts DC}$$

4-2 TYPICAL TIME MEASUREMENTS

To measure the time duration of a pulse or the period of a waveform, the following procedure is used.

a. Measurement of Pulse Duration

Generally, when measuring the width of a pulse the measurement is made from the 10% of amplitude points. Since the procedure for measuring pulse width and pulse duration differ only in the reference point on the waveform, the more complex or pulse width measurement is outlined below.

(1) Adjust the VERT VOLTS/cm switch for a deflection near full scale and note the exact amplitude in divisions.

(2) Divide this measurement by 10 and, using the VERT POS control, position the trace bottom exactly this amount under the center horizontal graticule line. As an example: assume that the deflection height is 4.5 centimeters. Dividing this by 10 yields .45 centimeters or 2-1/4 minor divisions. Position the bottom edge of the waveform this distance below the graticule horizontal center line. Do not adjust the VERTICAL POS control after this point.

(3) Set the HORIZONTAL TIME/cm switch so that the pulse width is no more than 10 times the TIME/cm switch setting.

(4) Using the HORIZ POSITION control, position the leading edge of the pulse to a convenient vertical graticule line, at the point where it crosses the horizontal center line, at the left-hand side of the screen.

(5) Measure the distance (in centimeters) between the point where the leading edge crosses the center horizontal graticule line and the trailing edge crosses the center horizontal graticule line.

(6) Multiply this distance by the time indicated by the setting of the HORIZONTAL TIME/cm switch to obtain the pulse width in units of time.

b. Measuring The Period of Periodic Waveforms

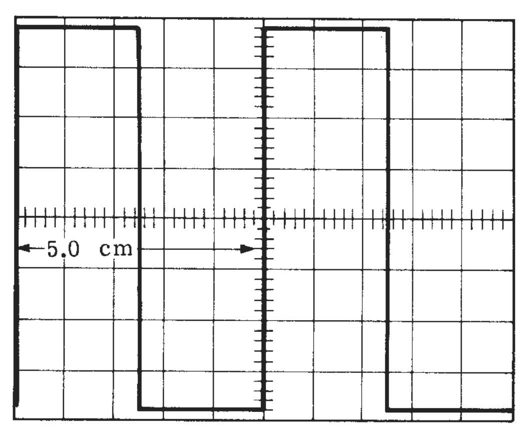
(1) Adjust the VERTICAL VOLTS/cm and VERT POS control to give a trace centered about the horizontal centerline of the graticule.

(2) Adjust the sweep rate and trigger controls to obtain one or more cycles of the waveform on screen.

(3) Using the HORIZ POS control, position the waveform so that it crosses the junction point of a vertical graticule line on the left-hand side of the screen and the center horizontal graticule line. Note the direction in which the waveform crosses the center horizontal graticule line.

(4) Measure the distance (in centimeters) from the junction point described above to where a comparable point of the next cycle of the waveform again crosses the center horizontal graticule line in the same direction as in 3. above.

(5) Multiply this distance by the setting of the HORIZONTAL TIME/cm switch to obtain the time duration of the period (T). This technique is demonstrated in figure 4-2.



T = 5.0cm x 1mSec/cm = 5.0 mSec

Figure 4-2. Measurement of Period Duration

SECTION 5
THEORY OF OPERATION

5-1 POWER SUPPLY (see schematic diagram figure 8-1)

a. The line voltage is half wave rectified by diode CR101 and filtered by capacitor C102. The resultant dc voltage varies with the line potential from approximately 130 to 170V DC. This voltage is regulated at 123V DC by the series regulator which uses Q103 as its series pass element. This regulated voltage appears across capacitors C105 and C110. This voltage is then chopped at approximately 18 kHz by transistors Q104 and Q105. These transistors act as two switches as shown in figure 5-1.

b. The resultant square wave is applied through a coupling capacitor C111 to the primary of T102. It is also supplied to the primary of the saturated switching transformer T101. This transformer determines the frequency of the oscillations which drive Q104 and Q105.

c. Oscillations are initiated by a pulse to the base of Q104. Initially capacitor C106 is uncharged. At the closure of the power switch, the voltage begins to rise across C110. When the voltage reaches the breakdown point of neon DS101 capacitor C106 is charged through the base of Q104. The flow of current through Q104 starts the oscillations.

d. The square wave which appears across the primary of T102 is stepped up or down by the various transformer windings and is applied to the half wave diodes CR108 through CR114. The resultant voltages are filtered by capacitors C112 through C120. The filament voltage for the CRT is also supplied by transformer T102.

5-2 VERTICAL PREAMPS (see schematic 8-2 and 8-3).

a. The A and B channel premaps are identical, with only one exception, the internal trigger pickoff which will be discussed later. Therefore any discussion of the A channel preamp can be applied to the B channel also.

b. Input signals from VERT INPUT connector J2201 are applied to the VERT INPUT switch S2202. In the AC position, signal-flow is through C2201 eliminating dc levels. In the DC position, C2201 is short circuited and the input is directly coupled to the VERTICAL VOLTS/cm attenuator.

c. In the .01, .02, and .05 volt positions of the VERTICAL VOLTS/cm switch the unattenuated input signals are applied directly to the input of the vertical preamplifier at A. In the .1, .2, and .5 positions, the input signals are attenuated by a factor of 10 and applied to the preamplifier. The attenuation factor for the 1, 2 and 5 volt positions is 100 and for the 10, 20 and 50 positions the factor is 1000. Protection circuitry, between A and the gate of field effect transistor Q2202, prevents damage to Q2202 under input overload conditions. CR2201 is a special diode type featuring low leakage and low capacity.

d. Q2202 and Q2201 are selected field effect transistors which are stacked as a thermally balanced source follower. The DC Bal potentiometer adjusts the voltage at junction of R2211 and Q2201. This voltage is properly adjusted when voltages at the emitters of Q2203 and Q2204 are equal.

e. The gain of the 6 transistor differential cascode amplifier is determined by the resistors in the emitters of Q2203 and Q2204. In the .05, .5, 5, and 50 volt ranges, these are precision 1% resistors. In the .02, .2, 2, and 20V ranges, the gain is calibrated by R2221 which is connected, by S2201, in parallel with R2223 and R2228. Likewise in the highest gain settings (.01, .1, 1, 10) the gain is adjusted by R2222. It is this gain changing used in conjunction with the decade attenuators which provide all 12 calibrated ranges.

f. AR2201E serves as a current generator which fixes the total current flowing through the entire differential cascode amplifier. Positioning is accomplished by sinking various amounts of this fixed current away from the output. More current is taken from one output than the other as R2217 is set which causes a DC difference at the outputs resulting in a corresponding shift of the trace.

g. Polarity inversion is also accomplished in this stage. AR2201 A, B, C and D are connected to outputs points A4 and A5. Switch S2203 is used to switch in and out a differential pair having opposite polarity signals at their emitter. The on pair allow their signal currents to flow into the loads at points A4 and A5.

5-3 VERTICAL SWITCHING (see schematic 8-4)

a. The differential outputs from AR2201 of channel A and AR2202 of channel B are fed into a diode matrix at points A4, A5, A8 and A9 respectively. The matrix used in conjunction with the MODE switch and the multivibrator of Q2214 and Q2215 selects which channel or channels are allowed to be fed into the vertical final drivers through the load resistors R2279 and R2280.

b. CR2212 and CR2213 are biased off and CR2211 and CR2210 are allowed to turn on with the MODE switch in position A allowing the channel A signal to reach the drivers. The opposite happens when the MODE switch is in position B.

c. The MODE switch, in ALT position, biases the multivibrator into the bi-stable state which receives a trigger pulse at the end of each sweep from the sweep circuitry through Q2216. The bi-stable multi-

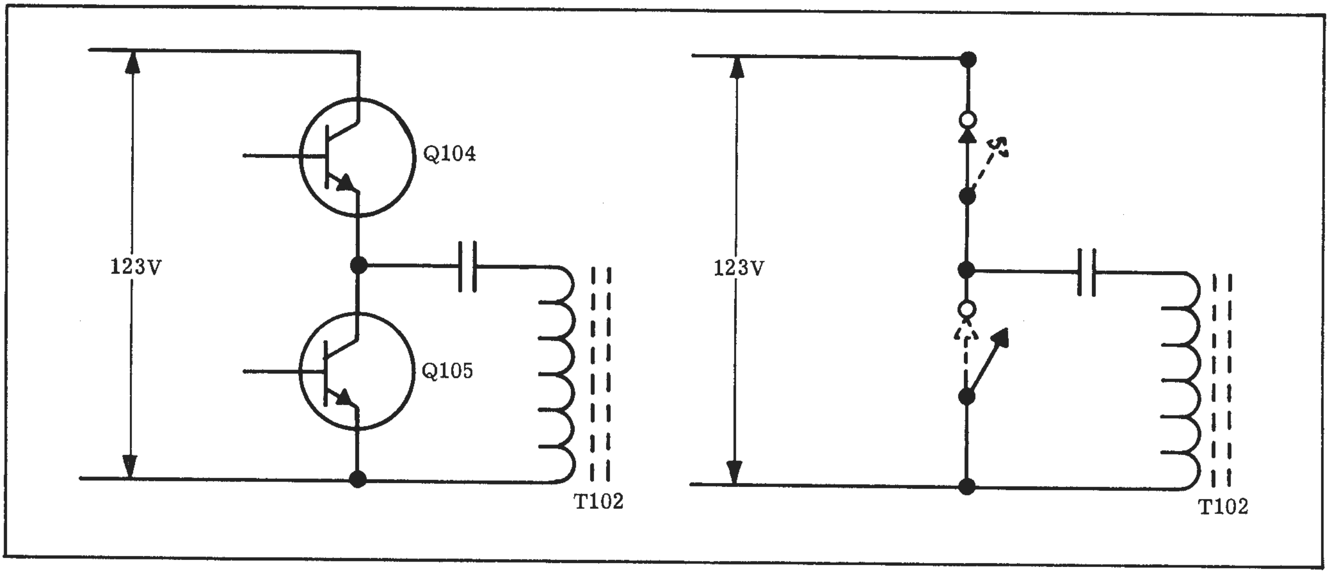


Figure 5-1. Simplified Transistor Switching Diagram

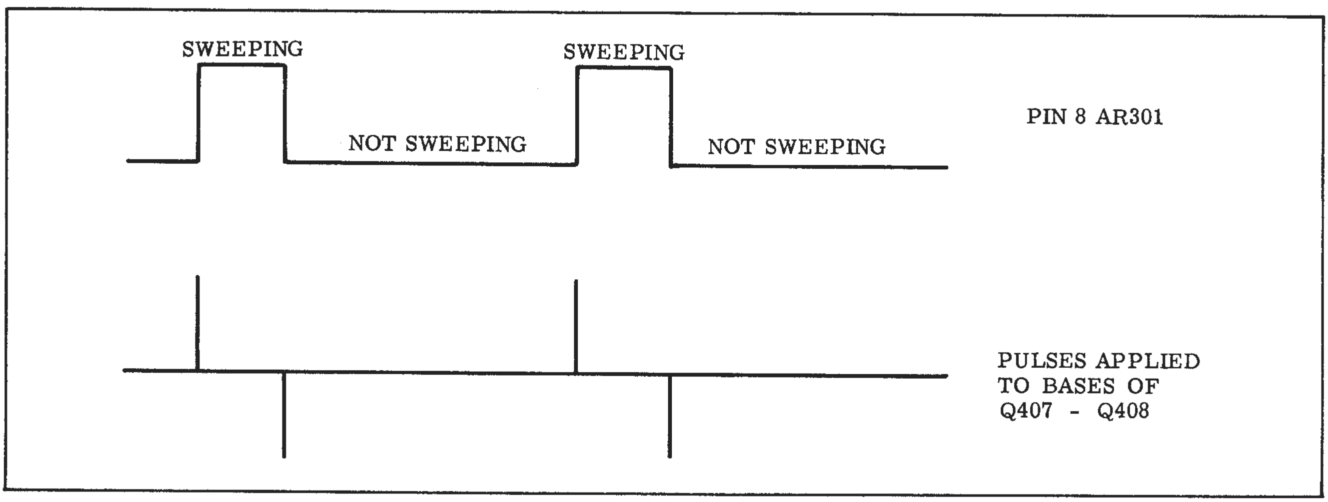


Figure 5-2. Blanking Control Pulse Waveform

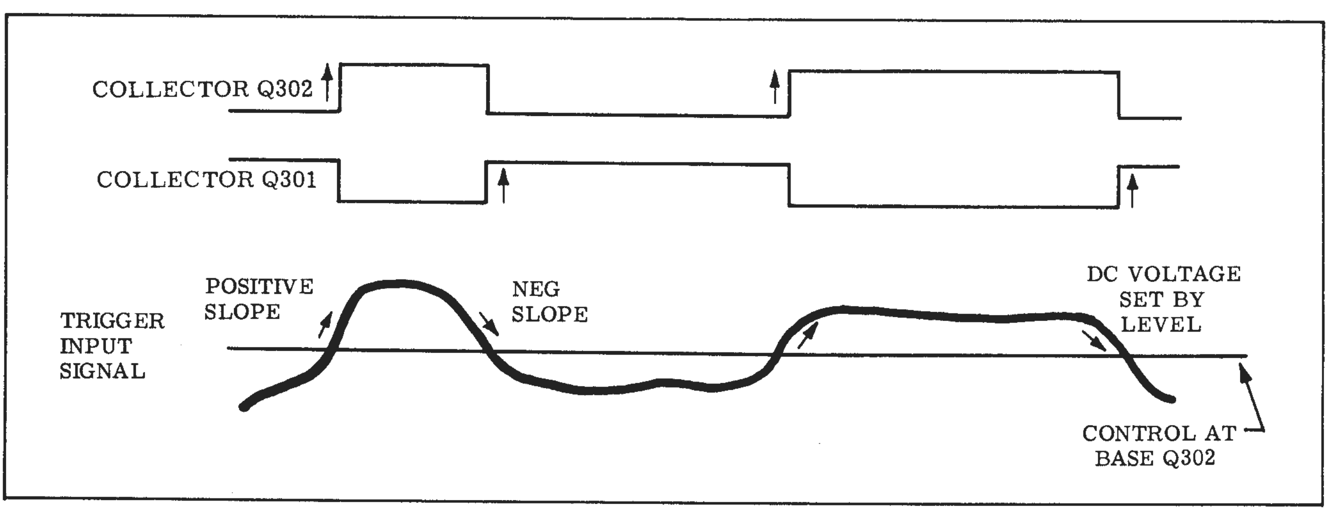


Figure 5-3. Trigger Amplifier Waveforms

vibrator biases each set of diodes on and off allowing channel A and B signals to alternately reach the drivers.

d. The MODE switch, in CHOP, biases the multivibrator into a 100 kHz astable condition allowing the A and B channel signals to appear at the drivers at a 100 kHz rate.

e. The MODE switch, in ADD, biases both sides of the multivibrator off allowing CR2210, CR2211, CR2212 and CR2213 to turn on which passes both the A and B signals (as a composite) to the bases of the drivers.

5-4 VERTICAL FINAL (see schematic 8-4 and 8-5)

a. The vertical final takes the voltage between the base of Q2205 and Q2208 and transforms it into a difference current which flows through the VERTICAL FINAL Q213 and Q214. Q2209 is a current generator and R2236 adjusts the current through the final for a proper operating level at the collectors of Q213 and Q214.

b. The overall gain of the VERTICAL DRIVER - FINAL amplifier is adjusted by R2232. The differential current signal developed by the drivers flows through Q213 and Q214 and developes a differential voltage across R241 and R247 which drives the CRT. The inductors at the collectors of Q213 and Q214 match the output impedance of vertical final to the CRT deflection plates giving an improved overall response.

5-5 TRIGGER PICKOFF (see schematic 8-4 and 8-2)

a. The trigger signal is taken from the proper stage of the vertical amplifier and fed in the proper polarity to the input of the trigger amplifier Q314 for each setting of the MODE switch.

b. The trigger signal for MODE switch settings of B and ADD is picked off the vertical final driver stage through CR2204 and fed through one of the analog gates in AR2203 to the trigger amplifier. This gate is biased on by the MODE switch for only settings of B and ADD.

c. The trigger signal for the MODE switch settings of A, ALT, and CHOP is taken from a differential amplifier made up of Q2217 and Q2218 in the A channel preamp.This amplified differential trigger signal is fed from the collectors of Q2217 and Q2218 to two analog gates of AR2203. Each of these gates is controlled by the A polarity switch (S2203) which in turn receives V1 (+15V) from the MODE switch. The polarity switch turns on the proper gate which lets one side or the other of the differential signal through to the trigger amplifier.

5-6 BLANKING CIRCUIT (see schematic diagram figure 8-5)

a. The blanking circuit is an edge triggered flip flop that controls the grid potential at the cathode ray tube. Triggering of this flip flop is accomplished through a coupling-pulse transformer. Pin 8 of nand gate AR301 is high whenever the horizontal circuitry is sweeping, and low when it is not. The pulse transformer differentiates these changes of state as shown in figure 5-2.

b. Note that the pulses are positive going at the beginning of each sweep and negative going at the end. The pulses are applied to the bases of Q407 and Q408. Pulses which forward bias the base emitter junction of one of the stacked pair will automatically reverse bias the base emitter junction of the other. When Q407 conducts the voltage level reached at the grid (pin 2) is limited, due to the saturation of Q407, by the setting of the INTEN control.

c. It is the function of Q407 and Q408 to conduct heavily during the period when the pulses from T401 are applied to their bases. This causes the grid voltage to change state very rapidly. Once this new voltage level is reached Q407 and Q408 cease conduction and the new voltage level is maintained by the output level of Q406.

d. Q405 and Q406 form a low power high voltage flip flop. Positive and negative pulses developed by Q407 and Q408 are coupled through R429 and C406 to the base of Q405. A positive pulse applied to the base of Q405 causes the voltage at the output of the flip flop, the collector of Q406, to go to the most positive state. Negative pulses at the base of Q405 cause this output voltage to change to the most negative state. This change of state is coupled through R427 and the secondary of T401 to hold the grid in either the high or low state.

5-7. TRIGGER AMPLIFIER (see schematic diagram figure 8-7)

a. The SOURCE switch S305 selects one of the three possible trigger signals. The selected signal then appears at the gate of Q314. Q314 serves as a source follower and signals at its gate are reproduced at R349. In all positions of the Source switch these signals are connected to the base of Q315 in the Television Sync separator. With the SOURCE switch in the NORM position, these signals are also coupled through C318 and CR302 to the input of the trigger level comparator amplifier.

b. Input signals at the base of Q301 are compared to the dc voltage set by the LEVEL control, at the base of Q302. When the input signal swings more positive than this dc level Q301 conducts while Q302 does not. When the input signal swings below this level Q302 conducts and Q301 does not. This is shown in figure 5-3 along with the resultant collector waveforms.

c. Because the trigger gate AR302 initiates the sweep only on positive slopes, negative slopes are turned into positive slopes at the collector of Q301. These two signals are then connected to S302, the SLOPE select switch. The selected signal is then amplified further by Q303 and Q304 and presented to the trigger gate, AR302.

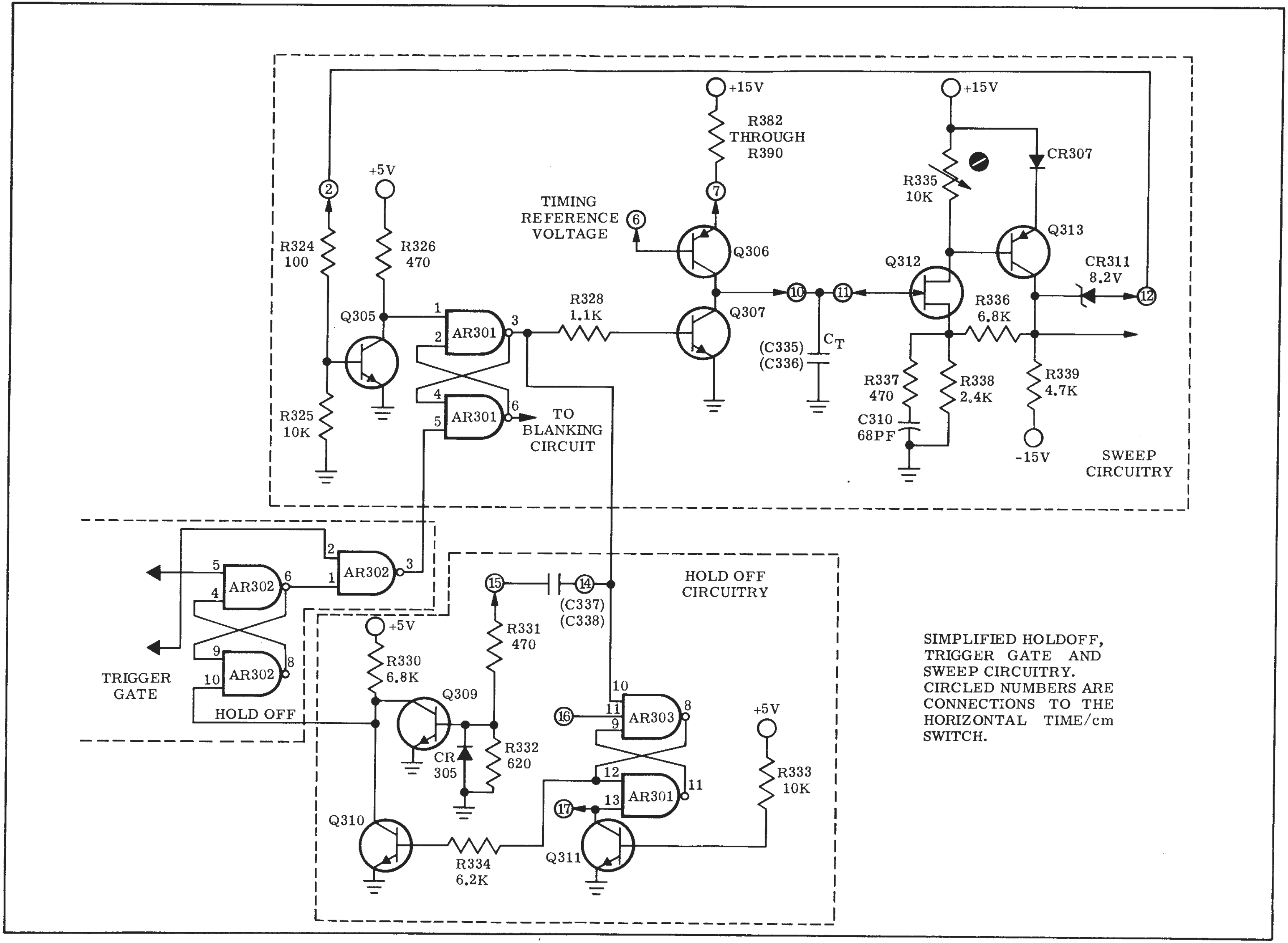


Figure 5-4. Simplified Diagram of Hold Off, Trigger Gate and Sweep Circuitry

5-8 AUTO GATE (see schematic diagram figure 8-7)

a. Q308 functions as the AUTO gate. In the AUTO mode of the TRACE control, in the absence of a trigger signal, transistor Q308 is turned on through R320 and R321. This causes the collector of Q308 to be at approximately 0 volts. Pulses from unijunction oscillator Q318 are coupled into the emitter of Q308. These pulses cause Q308 to turn off. The collector then is at + 15 volts during these pulses. The resultant collector pulses are then coupled through C304 into the base of Q304 and appear at the trigger gate.

b. When a trigger signal appears at the collector of Q301 this signal is rectified and filtered by CR303, CR304 and C303. This rectified, filtered, negative voltage causes Q308 to shut off and its collector rises. Under these conditions Q308 is off continuously and pulses from Q318 have no effect on the collector voltage. The trigger gate then acts on the input trigger signal and not on the auto pulses.

5-9 TRIGGER GATE (see schematic diagram figure 8-7 and simplified schematic figure 5-4).

a. In order to understand the operation of the trigger gate the concept of hold off will be introduced. When the sweep is initiated by the trigger circuitry no further trigger pulses are desired until the spot has been deflected horizontally across the crt and returned. A hold off signal is used to prevent triggering until some time after the spot has returned, otherwise, a trigger pulse could appear in the middle of the retrace of the spot, and sweep could start again in the middle of the display.

b. Two different transistors control hold off. Q310 causes hold off immediately after sweep is triggered and during the sweep interval. Q309 in conjunction with its series hold off timing capacitors C337 and C338 cause hold off during, and for a brief period after retrace.

c. In order that the sweep starts at precisely the same point on the trigger wave form a digital trigger gate is used. Trigger input signals are applied to Pins 2 and 5 of AR302, and the hold off signal is applied to Pin 10. When the hold off is low Pin 3 is high regardless of the state of the trigger input signal. After the hold off goes high the trigger signal must go low and on the next low to high transition Pin 3 of AR302 will go low. It is only when pin 3 goes low that the sweep is initiated.

5-10 SWEEP CIRCUIT (see schematic diagram figure 8-7 and simplified schematic figure 5-4).

The sweep circuitry used in this instrument relies on the fact that a fixed current into a capacitor produces a linear time-to-voltage ramping waveform. Q306 is a current generator and the magnitude of the current through its collector is determined by the voltage at the base, and the resistor in the emitter. By changing the resistor, 9 sweep ranges are produced for each sweep capacitor (C_T). Two different capacitors are used, C335 for the .2 second to .5mSEC ranges and C336 for the .2mSEC to .5μSEC ranges. These capacitors and resistors (R282 through R390) are located on the HORIZONTAL TIME/cm switch. Calibration of these sweep times for various capacitors is accomplished by adjusting the reference voltage at the base of Q306 with R344 and R345. The HORIZONTAL TIME/cm VARIABLE control R348 also varies this voltage to produce variable sweep times.

The current from Q306 can flow into one of two paths. When sweeping, Q307 is off and current flows in C_T. When not sweeping, Q307 is on and current flows into Q307.

When sweeping, the voltage across C_T is amplified by field effect transistor Q312 and transistor Q313. When the voltage at the collector of Q313 reaches the zener voltage of CR311 current begins to flow through the zener into the base of Q305. When Q305 conducts Pin 1 of AR301 is pulled low. This causes the sweep set-reset-flip-flop output at Pin 3 to go high which turns on Q307. This discharges C_T and returns the spot to the left side of the display to await the next trigger pulse into Pin 5 of AR301.

5-11 TELEVISION SYNC SEPARATOR (see schematic diagram figure 8-7)

a. Transistor Q315 and Q316 form an active sync stripper. The action of this circuit is to separate signals which occur around the most negative level of the trigger input signal. When video signals of the proper polarity are applied, the sync pulses are at the most negative level. See figure 3-6.

b. A negative going edge applied to the base of Q315 causes this transistor to conduct which causes Q316 to conduct. As the collector of Q316 is pulled towards the -15 volt supply, diode CR308 begins to conduct. This causes the voltage on capacitor C319 to be pulled towards a level which tends to shut Q315 back off. Equilibrium is reached when the final voltage on C319 is approximately .7 volts more positive than the most negative level of the input signal. When the input signal rises on a positive edge, Q315 and Q316 stop conducting immediately. This causes the collector voltage of Q316 to rise to approximately the + 15V level. CR310 clamps this swing to approximately 5.8 volts. As soon as Q315 and Q316 cease conduction the voltage at the C319 - R352 junction begins to rise; however, this rate of rise is quite slow compared to the time between two sync pulses. Hence Q315 begins to conduct again on the next negative going edge and thus holds this capacitor voltage around the negative level of the input signal. Hence Q315 and thus Q316 can only conduct for voltages around the negative signal level. This effectively strips sync from video for a wide range of input amplitudes. The signal at the collector of Q316 is used as the TV-H trigger signal. The clamped sync which appears across CR310 is coupled to the unijunction oscillator Q318 through R359 and C326 and synchronizes this oscillator at the horizontal line frequency. R357 and C323 serve as a low pass filter which separates the vertical sync pulse from the composite sync. This signal is the TV-V trigger signal.

5-12 VITS CIRCUITRY (see schematic diagram figure 8-7)

a. The VITS appears as the first video information after the video vertical sync pulse. To separate this information, triggering is inhibited by the hold off circuitry until after the FIELD 1 or FIELD 2 Vertical sync pulse is detected. Once the sweep has been triggered, the retrace pulse inhibits any further triggering until the next selected sync pulse is detected. Thus only one sweep per frame is possible and this sweep will display the first video information after the selected vertical sync pulse.

b. Unijunction transistor Q318 is syncronized at the horizontal line rate by the sync separator. The equilization pulses and the serrations of the vertical sync pulse of the composite sync signal maintain this oscillator in sync during the vertical blanking and vertical sync interval. In FIELD 1 the last edge of the vertical sync pulse and the pulse from the synchronized oscillator are coincident. In field two they are not.

c. The last edge of the vertical sync pulse of FIELD 1 and FIELD 2 are detected by Q317. The component values of R358, R357, C323 and C324 have been selected such that Q317 conducts for a very brief period at the end of each vertical sync pulse. The outputs of Q318 and Q317 are connected to nand gate pins 3, 4 and 5. The output of the nand gate will only be low when the field 1 sync pulse occurs. This pulse is stretched by Q319. The edge of vertical sync pulse from Q317 is also fed to AR303 pins 1, 2, 13. The output at Pin 12 goes low for each sync pulse. The output at the emitter of Q319 goes low for each field 1 sync pulse.

d. In the FIELD 1 and FIELD 2 positions of the HORIZONTAL TIME/cm switch Q311 is turned off. In the FIELD 1 position 19 is connected to 17. Thus the FIELD 1 pulse removes hold off after each FIELD 1 vertical sync pulse. In the FIELD 2 position 20 is connected to 17 and 19 is connected to 16. Under these conditions the vertical sync pulses remove hold off after each vertical sync pulse but the FIELD 1 pulse restores hold off on FIELD 1. Thus the oscilloscope can trigger only after the FIELD 2 sync pulse.

5-13 EXT. HORIZONTAL SYSTEM (see schematic diagram figure 8-5 and 8-8)

a. Signals which are applied to EXT HORIZ INPUT are divided in amplitude by compensated divide R340, R341, C312, C313. Signal input amplitude is determined by potentiometer R341, the EXT HORIZ LEVEL control. In this position of the HORIZ. TIME/cm switch 13 is connected to 11 and 12 is disconnected from 2. Input signals are amplified by Q312 and Q313 and then connected to the horizontal driver.

b. Circuitry for the horizontal driver is shown on schematic figure 8-8. It is the function of this driver to transform the input voltage into a differential current which flows to the horizontal final amplifier. Circuitry for the horizontal final is shown on schematic figure 8-5. The total current through this stage is adjusted by R371. The overall X1 gain of the horizontal driver-horizontal final amplifier is determined by the emitter resistor R367 and R368. In the X5 position these resistors are paralleled by R369 which increases the gain. Positioning of this stage is accomplished by changing the voltage at the base of Q321 which changes the ratio of the average current through Q320 and Q321. The signal current which is generated by the horizontal driver developes a voltage at the collectors of Q323 and Q324. The inductors L303, L304 and capacitors C332 and C333 are used to better match the amplifier to the horizontal deflection plates and improve the frequency response.

SECTION 6
CALIBRATION PROCEDURE

The Hickok oscilloscope is designed to provide many years of stable, trouble free operation. However, should it be necessary to replace any of the component parts, it is recommended that the overall calibration be checked and, if necessary, adjusted, before attempting to use the instrument. Refer to figures 6-2, 6-3 and 6-4 for parts location.

6-1 CALIBRATION EQUIPMENT REQUIRED

a. Electronic Multimeter (battery operated preferred) capable of measuring 0 to 260 volts dc and 0 to 2 volts ac at 400 Hz with an accuracy of ±1%. Hickok Model 3300A or equal.

b. Source of 20 Hz and 20 kHz square waves with a frequency accuracy of ±1%, or a source of broadcast video signals.

c. Source of 10 kHz and 1 MHz square waves.

d. Source of 400 Hz sine waves with adjustable output from .2 to 1.5 V rms.

e. Low input capacitance voltage divider probe. Hickok Style 100-155 or equal.

6-2 POWER SUPPLY CALIBRATION

WARNING

The high-voltage power supply produces dangerous potentials in excess of 2,500 volts. These voltages are present on the FOCUS and INTENSITY control circuits behind the front panel, on the blanking PC board at the base of the cathode ray tube and within the power supply itself.

a. Place the oscilloscope upside down on a service bench with the cathode ray tube at the bottom. Remove the four (4) corner screws which secure the rear trim strips and the top and bottom covers to the instrument and remove the covers.

CAUTION

Be sure the line plug is disconnected from the power source.

b. Remove the four (4) screws which secure the rear panel to the side rails.

c. Lay the rear panel and power supply on the bench behind the equipment. The power supply leads are long enough to permit removal without applying strain to the wiring. See figure 6-1.

WARNING

Whenever the power supply is disconnected from the side rails, a temporary ground must be connected between the power supply and the main equipment before power is applied. This can be accomplished by connecting the clip leads from the grounded lugs on the power supply terminal strip to the side rails or frame of the main equipment.

d. The low voltage power supplies are connected to a terminal strip on the rear panel. The voltages at these terminals when measured with respect to chassis ground should be within the limits specified in table 6-1.

Table 6-1. Voltage Limits for Low Voltage Supply

Wire Color	Voltage to Chassis Ground
Red-White	+240 to 260V dc
Orange-White	+120 to 128.5V dc
Red	+4.5 to +5.5V dc
Orange	+14.10 to +15.45 V dc
Blue	-14.10 to -15.45 V dc

e. If the terminal voltages are not within the specified limits proceed as follows:

(1) A battery operated multimeter capable of reading 123 volts to within ±0.5 volt is desired. If a battery operated meter is not available, this calibration can be accomplished by using an isolation transformer between the power line and the oscilloscope.

(2) Remove the eleven (11) screws which secure the power supply cover and remove the cover.

(3) Adjust the multimeter to measure 123 volts dc and connect it across capacitor C105 of the power supply.

(4) Turn the regulator adjust control R103 until the voltage across C105 reads 123 volts ± 0.5 volt.

(5) Measure the voltages again as in paragraph d above and table 6-1.

(6) If the voltages are not within the specified limits, adjust the symmetry control R108 until proper readings are obtained. Note that an adjustment of R108 which causes an increase in the 125 volt supply will cause a decrease in the other low voltage supplies.

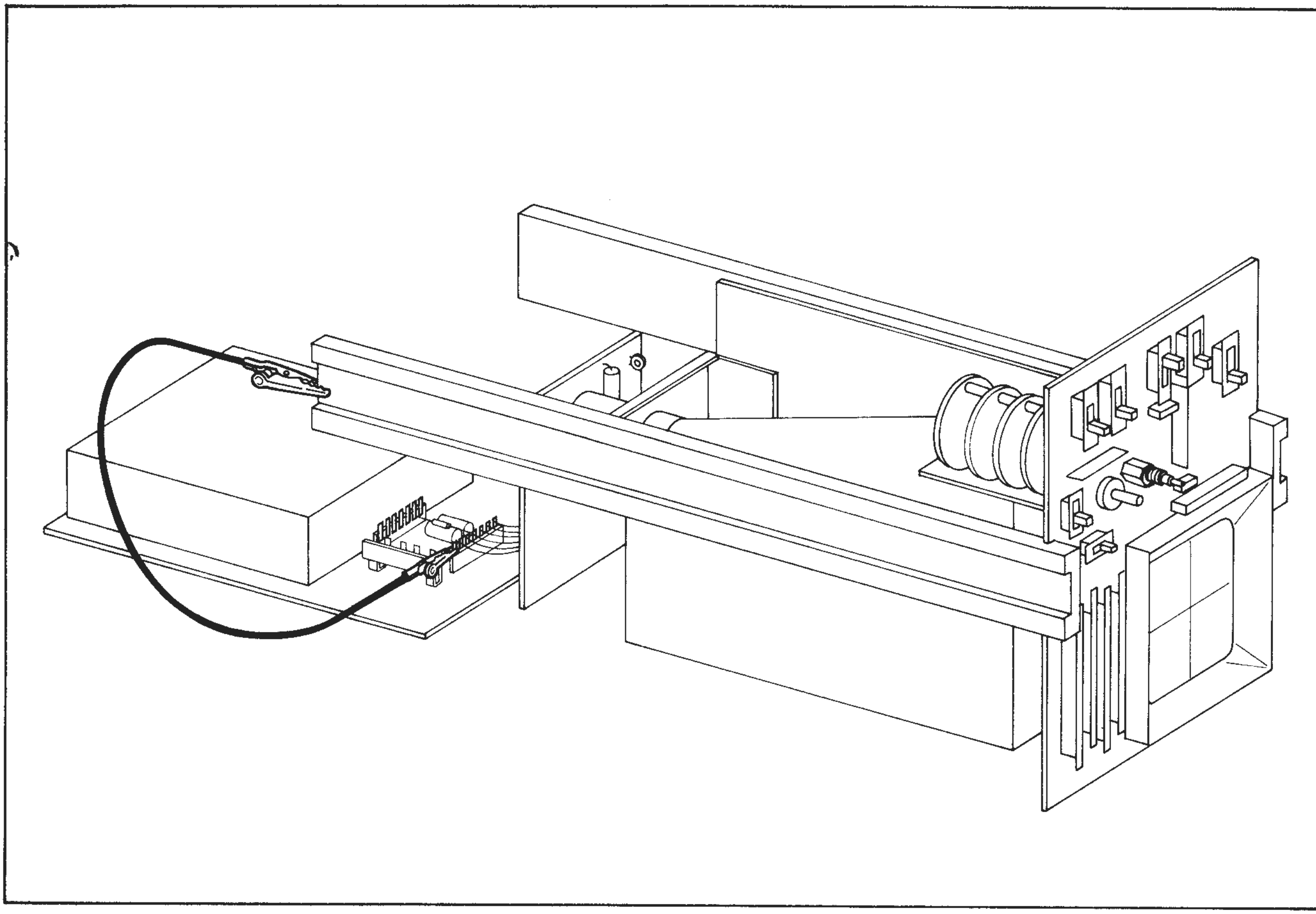


Figure 6-1. Clip Lead Ground Connections Required for Calibration and Service

6-3 HORIZONTAL PREAMPLIFIER CALIBRATION (This adjustment controls the length of trace.)

a. Connect the multimeter between the junction of Q313 and R339 and chassis ground.

b. Set the HORIZONTAL TIME/cm switch in the EXTERNAL HORIZONTAL INPUT position.

c. Adjust the horizontal preamp balance control R335 to obtain a voltage reading between 0 and -0.1 volt.

6-4 VERTICAL FINAL CURRENT ADJUST

a. Set MODE switch to A. Slide the VERT POS control to its lowest position and use the multimeter to measure the voltage between the collector of vertical output transistor Q214 and chassis ground.

b. Adjust the vertical current limit control R2236 for a reading of 24 volts ± 0.5 volt and note this reading as voltage "A". The trace should be off screen.

c. Slide the VERT POS control to its highest position and measure the voltage from the other vertical output transistor Q213 to chassis ground and note this reading as voltage "B".

d. If voltage "B" is more positive than voltage "A" no further adjustment is required. However, if voltage "B" is less positive than "A" it will be necessary to reset the vertical current limit control R2236 so that voltage "B" reads 24 volts ±0.5 volt. The trace should still be off screen.

e. Position the trace in the center of the screen and allow fifteen minutes for stabilization.

f. Repeat the procedures in paragraphs 6-4a. through 6-4b. while checking voltages "A" and "B" on the collectors of Q214 and Q213 respectively and adjusting R2236 as needed.

6-5 HORIZONTAL FINAL CURRENT ADJUST

a. Make the following front panel control settings.

Control	Setting or Position
HORIZ GAIN switch	Set to X5
VERT POS control	Set in center position
HORIZONTAL TIME/ cm switch	Set to EXT HORIZ INPUT

b. Slide the HORIZ POSITION control to its extreme right hand position and measure the collector to ground voltage of horizontal output transistor Q323.

c. Adjust the horizontal current limit control R371 for a reading of 23 volts ± 2 volts and note this reading as voltage "C". The spot should be off screen.

d. Slide the HORIZ POSITION control to its extreme left position and measure the collector to ground voltage of the other horizontal output transistor Q324 and note this as voltage "D".

e. If voltage "D" is more positive than voltage "C" adjust horizontal current limit control R371 so that voltage "D" reads 23 volts ± 2 volts. The spot should still be off the screen.

6-6 SWEEP TIMING CALIBRATION

a. Set front panel controls as follows:

Control	Setting or Position
MODE switch	Set to A
A and B VERT INPUT switches	Set to DC
A and B VERTICAL VOLTS/cm switches	Set to .5
TRACE switch	Set to NORM
SLOPE switch	Set to negative (-) slope
FILTER switch	Set to NORM
SOURCE switch	Set to INT
HORIZ GAIN switch	Set to X1
HORIZONTAL TIME/cm switch	Set to 10 mSEC
A and B VERTICAL VARIABLE controls	Set to CAL.
HORIZ VARIABLE control	Set to CAL.

b. Connect a 20 Hz square wave signal to the VERT INPUT connector of the oscilloscope and adjust the signal level for approximately 4 centimeters of deflection. Adjust the TRIGGER LEVEL control for a stable display starting on a low level.

c. Adjust the sweep timing resistor R344 such that with the second falling edge on the 5th vertical graticule line of the cathode ray tube the third falling edge is within ± 1/4 of a minor division of the 10th vertical graticule line.

d. Connect a 20 kHz square wave signal to the VERT INPUT CONNECTOR and move the HORIZONTAL TIME/ cm switch to 10 SEC.

e. Adjust the sweep timing resistor R345 in the same manner as R344.

NOTE

The sweep timing can also be adjusted using video signals as a frequency source. The procedure is as outlined in the following subparagraphs.

f. Apply composite video signals to the VERT INPUT connector of the oscilloscope and move the FILTER switch to TV-V. With the HORIZONTAL TIME/cm switch in the 10 mSEC position adjust R344 such that six vertical fields occupy 10 centimeters horizontally.

g. Move the HORIZONTAL TIME/cm switch to the 10μ SEC position and the FILTER switch to the TV-H position. Adjust R345 such that one horizontal line occupies 63.5μ SEC.

6-7 VERTICAL AMPLIFIER GAIN ADJUST

a. Connect a 400 Hz sine wave signal to the VERT INPUT connector and adjust triggering for a stable display.

b. Connect a multimeter or ac voltmeter having an accuracy of 1% of less across the vertical input to monitor the output of the sine wave generator.

c. Adjust the monitored voltage input to the oscilloscope to 1.414 volts rms. Set the VERTICAL VOLTS/cm switch at .5. Adjust R2232 for exactly 8 centimeters peak to peak deflection.

d. Adjust input voltage to 0.566V rms. Set the VOLTS/cm switch to .2 and adjust R2221 for exactly 8 cm peak to peak deflection.

e. Adjust input to 0.283V rms. Set the VOLTS/cm switch at .1 and adjust R2222 for exactly 8 cm peak to peak deflection.

f. Set MODE switch to B. Connect 400 Hz sine wave and meter to B input. Repeat steps c, d, and e adjusting R2274, 2264, and 2265 respectively.

6-8 ATTENUATOR COMPENSATION

a. Set the MODE switch to A.

b. Connect a 10 kHz square wave signal to the A VERT INPUT connector and adjust the trimmers for maximum flatness of the square wave display at the settings of the VERTICAL VOLTS/cm switch as listed below:

CHANNEL A VERT. VOLTS/cm Setting	Adjust	Note
.2	C2204	Trimmer C204, C208 and C212 are located toward the rear of the A VOLTS/cm switch.
2	C2208	
10	C2212	

c. Connect a 10:1 voltage divider probe (Hickok No. 100-155 or equal) from the VERT INPUT connector to the output of the square wave generator. With the VERTICAL VOLTS/cm switch in the .05 position set the signal level for approximately full screen deflection and adjust the probe for maximum flatness of the square wave.

d. Without disturbing the probe adjustment, move the VERTICAL VOLTS/cm switch to the setting listed below and adjust the corresponding trimmer capacitors for maximum flatness of the square wave. Increase the square wave generator output for usable deflection on each range.

CHANNEL A VERT. VOLTS/cm Setting	Adjust	Note
.2	C2202	Trimmers C2202, C2206
2	C2206	and C2210 are located
10	C2210	toward the front of the A VERT. VOLTS/cm switch.

e. Set the MODE switch to B, connect a 10kHz square wave to the B VERT INPUT connector and adjust the trimmers for maximum flatness of the waveform using the following chart.

CHANNEL B VERT. VOLTS/cm Setting	Adjust	Note
.2	C2221	These trimmers are lo-
2	C2225	cated toward the rear of
10	C2229	the B VOLTS/cm switch.

f. Repeat Steps c and d above for Channel B using the following chart.

CHANNEL B VERT. VOLTS/cm Setting	Adjust	Note
.2	C2219	These trimmers are
2	C2223	located toward the front
10	C2227	of the B VOLTS/cm switch.

6-9 CRT CAPACITY BALANCE AND INTENSITY LIMIT ADJUSTMENTS

The cathode ray tube capacity balance adjustment C218 and the intensity limit adjustment R425 are factory calibration controls which should not be tampered with in the field.

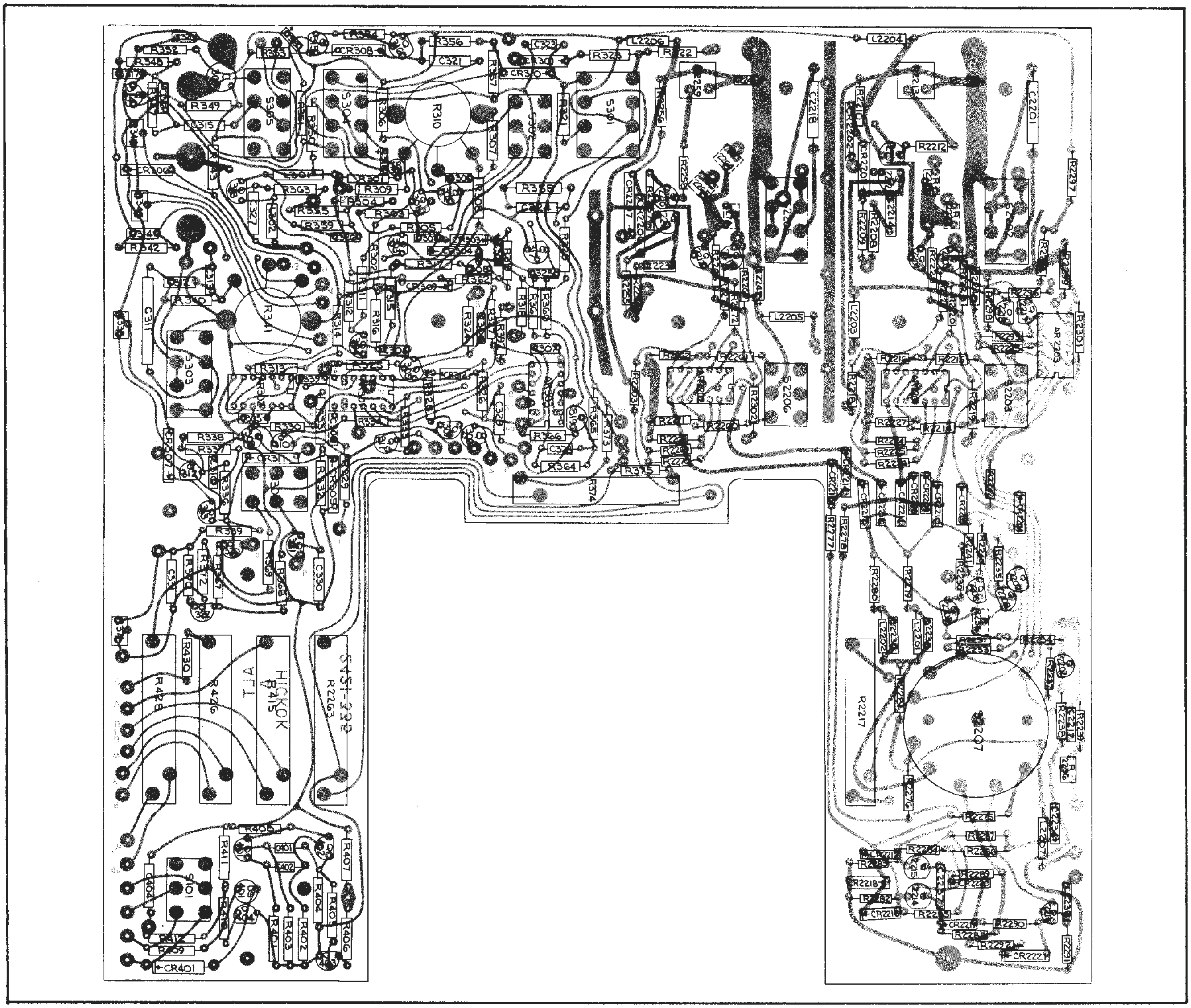


Figure 6-2. Main PC Board, Parts Location

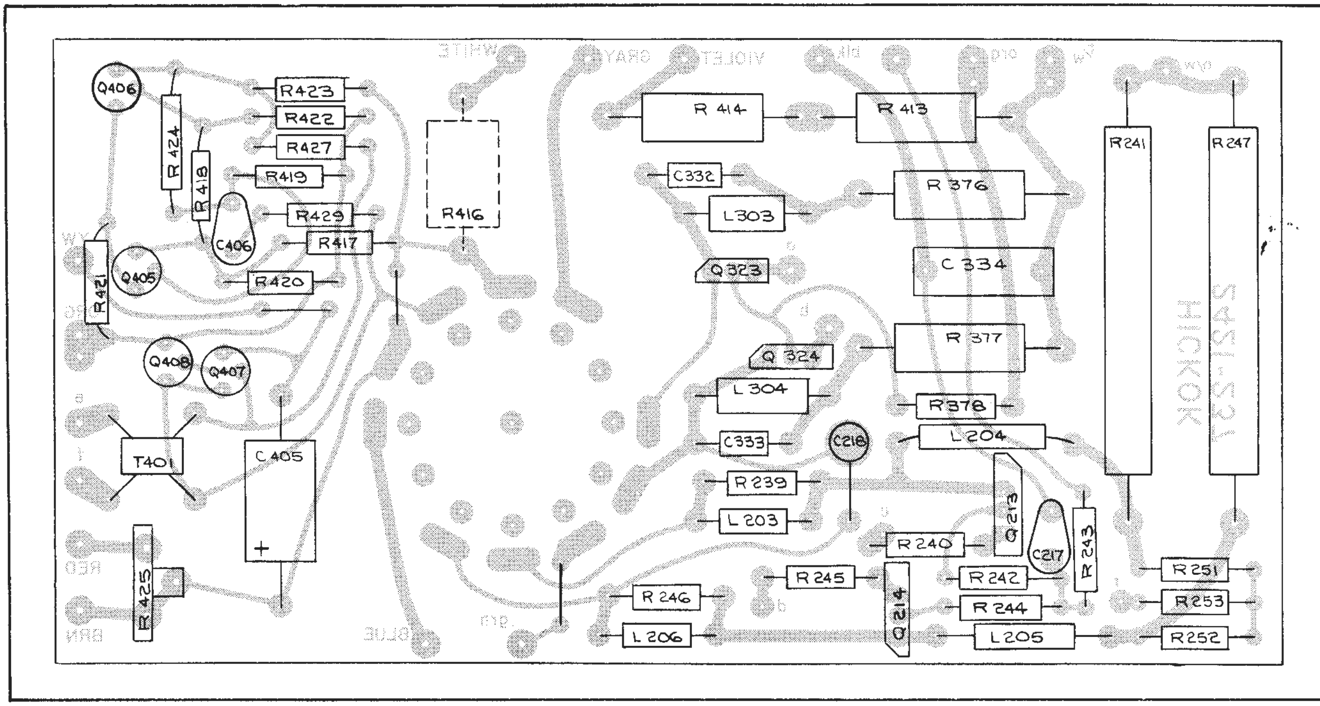


Figure 6-3. Final Amplifier and Blanking Circuit PC Board, Parts Location

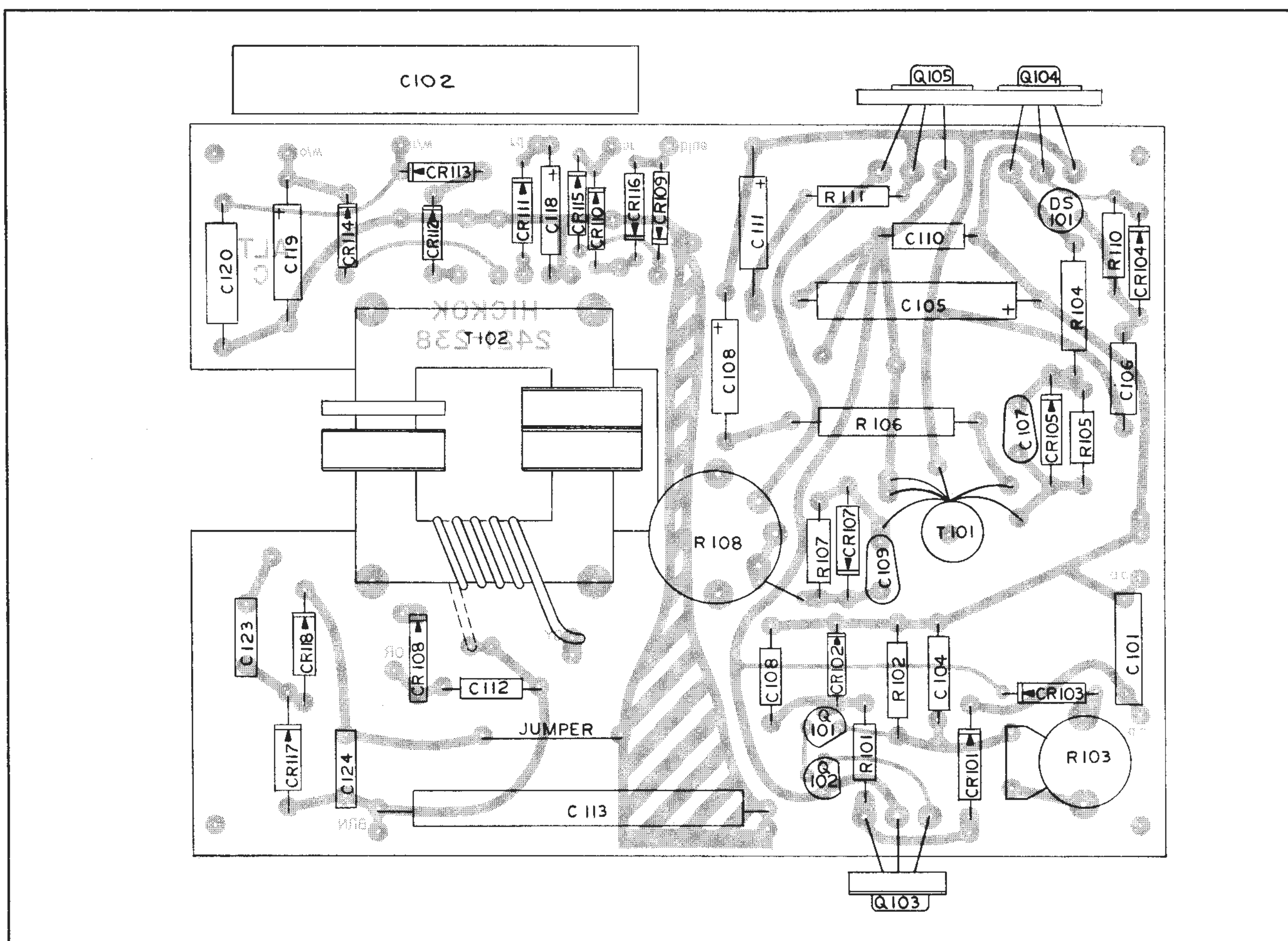


Figure 6-4. Power Supply PC Board, Parts Location

SECTION 7
SERVICING

7-1 GENERAL

a. Under normal operating conditions and with reasonable care this oscilloscope will provide trouble free operation for extended periods of time with no other service than an occasional check and, if necessary, adjustment of the calibration circuits. If major repairs or adjustments become necessary they should only be undertaken by qualified persons who are thoroughly familiar with the operation of transistors and their associated circuitry.

b. The Hickok Electrical Instrument Company maintains a complete factory service department, supported by authorized factory repair stations, to assure prompt and reliable service for all Hickok products. If major repairs or adjustments are needed it is recommended that the equipment be returned for service.

c. Should it be necessary to repair the oscilloscope in the field, it is imperative that service personnel read and understand the "Theory of Operation" and "Calibration Procedure", Sections 5 and 6 of this manual before attempting to service the equipment.

d. It is important that a logical approach be used to localize circuit failures, as indiscriminate replacement of components could cause damage to the equipment or to perfectly good components. The Procedure for Replacing Components in Printed Circuit Boards, outlined in figure 7-1 should be followed rigorously in order to prevent damage to components or printed circuit boards.

7-2 PRECAUTIONS TO BE OBSERVED WHEN SERVICING THE OSCILLOSCOPE

WARNING

The high-voltage power supply produces dangerous potentials in excess of 2,500 volts. These voltages are present on the FOCUS and INTENSITY control circuits behind the front panel, on the blanking PC board at the base of the cathode ray tube and within the power supply itself.

CAUTION

Before removing the power supply and rear panel or the front panel from the oscilloscope for servicing, make sure that the line cord is disconnected from the power line. When servicing the power supply an isolation transformer must be used between the power line and the oscilloscope to prevent dangerous electrical shock and destruction of components in the equipment.

a. Before operating the oscilloscope with the front panel removed, ground connections MUST be made between the side rails and circuit ground. This is most easily accomplished by connecting clip leads between the case of VERT INPUT switch S202 and the left side rail and between the case of the SOURCE switch S305 and the right side rail.

b. When the rear panel and power supply are removed from the side rails, grounds MUST be connected between the side rails and circuit ground before power is applied. Connect clip leads between the side rails and the grounded lugs on the power supply terminal strip.

c. When removing the rear panel and power supply, the oscilloscope should be placed upside down on the service bench with the cathode ray tube at the bottom. In this position the leads are long enough to allow the rear panel and power supply to rest on the bench without applying strain to the interconnecting wiring. See figure 6-1.

7-3 SERVICING AND TROUBLESHOOTING PROCEDURES

a. Preliminary Test Procedure. When trouble develops check the obvious causes first such as the following possibilities.

(1) Be sure the line cord is plugged in and there is power at the receptacle.

(2) Turn the POWER switch ON. If the POWER indicator does not light, check for a blown fuse.

NOTE

A 2 ampere slow-blow fuse F101, mounted in an in-line type holder, is located in the laced cable beside the CRT housing.

(3) Be sure all front panel controls are set properly for the desired operation and display.

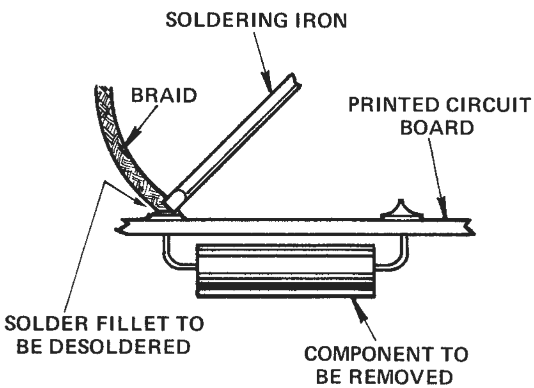
b. The first step in repair of the unit should be to localize the problem to a general area of the circuitry, such as the vertical amplifier, trigger circuitry, etc. This can generally be accomplished by observation of the performance of the unit. As an aid to the localization of the problem area, it is helpful to think of the unit as divided into seven major areas of circuitry. These are as follows:

1. Trigger Circuitry
2. Sweep Generator
3. Blanking Circuit
4. Ext. Horizontal Circuitry
5. Vertical Amplifier
6. Power Supplies
7. Calibrator

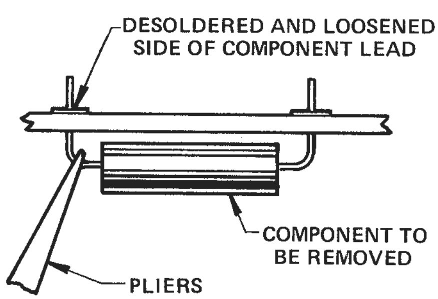
PROCEDURE FOR REPLACING COMPONENTS IN PRINTED CIRCUIT BOARDS

1. Place printed circuit in the horizontal position with the soldered side up*. Take a length of fine braid or fine stranded wire either tinned or not tinned. Braid is preferable. Dip the end of the braid in resin flux (London Chemical Co. type #77-33-TA or equivalent). Placed the fluxed end of the braid on a solder fillet of the component to be removed. Press the braid on to the fillet using the clean tip of the soldering iron. Do not overheat the board or component. Only heat the solder fillet sufficient to melt the solder. The solder will "wick" up the braided wire removing the solder from the joint. Continue this process until all leads of the component to be removed are free of solder.

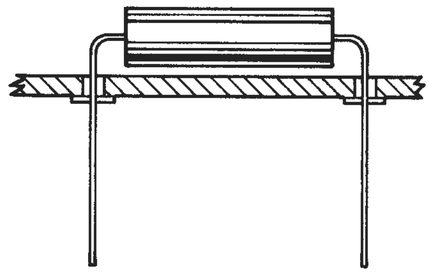
*A SOLDAPULLT desoldering tool, manufactured by Edsyn Inc., can be used in place of standard wire.



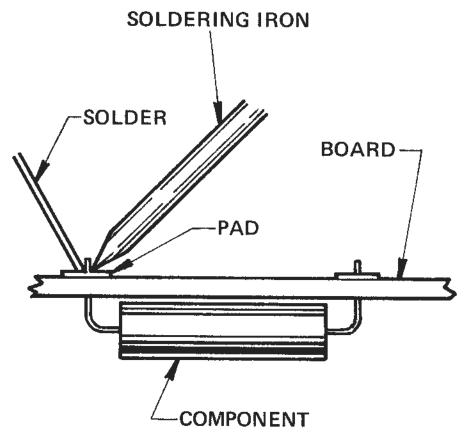
2. Using a pair of needle nose pliers "wiggle" each lead of the component to be removed to be sure it is free of the land area to which it was soldered. Place the needle nose pliers on the component lead and remove the lead. Continue the procedure with each component lead until the component is removed. Do not force the leads. If a lead can not be removed touch the lead on the soldered side of the board with the soldering tip.



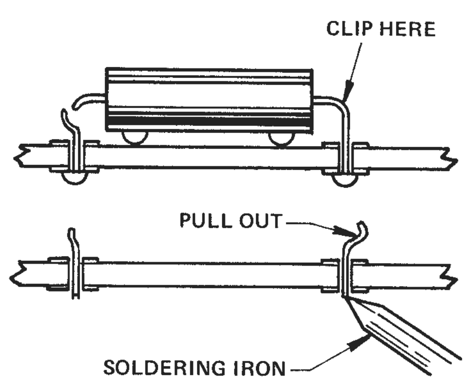
3. Bend clean tinned leads of new component and carefully insert in holes. (Do not force component. If it does not insert easily reheat pad and clean as before).



4. Hold part to board and solder leads from print side of board. Do not leave a large blob of solder on pad. The correct amount can be determined by observing other connections made in production.



Clean holes with a piece of .020 stainless steel wire by melting the solder and poking the wire through.'



The above should be carefully followed or extensive damage to the printed circuit board will result.

Figure 7-1. Servicing Etched Circuit Board

c. Adjust the panel controls through their range and observe the operation in an attempt to localize the problem to a particular section of the circuitry. The normal or abnormal operation of a particular control will aid in localizing the trouble.

d. The oscilloscope as with all highly accurate instruments will require periodic recalibration checks in order to insure a high degree of accuracy. It also should be noted that on occasion, circuits out of calibration may cause apparent trouble symptoms. For this reason, the calibration of the unit should be checked before proceeding with a detailed trouble analysis; also, a calibration check will greatly aid in localizing circuit failures. The calibration procedure is found in Section 6 of this instruction book.

e. After the trouble has been isolated to a particular circuit, perform a complete visual check of that circuit for faulty components. If a visual check of the circuit fails to detect the trouble, it will be necessary to check the circuit for its electrical operating characteristics.

f. When it has ascertained that the unit requires repair the first step is to measure the power supply voltages as described in the calibration procedure. Should any voltage read below its expected value by more than 10% a shorted component should be suspected. The oscilloscope should be turned off and the short eliminated before further investigation. Operating the unit with a shorted supply can cause extensive damage to the power supply.

g. Since this oscilloscope is an extremely complex instrument, a comprehensive troubleshooting procedure is beyond the scope of this text. In general, troubleshooting an instrument can be divided into two parts; isolating or localizing the trouble to a particular circuit, and the actual location of the defective component. Reference to the following troubleshooting chart and the theory of operation Section 5 will aid in localizing the trouble.

7-4 TROUBLESHOOTING CHART

The following chart will help to correlate the symptoms of improper operation with the area of circuitry involved.

Table 7-1. Trouble Shooting Chart

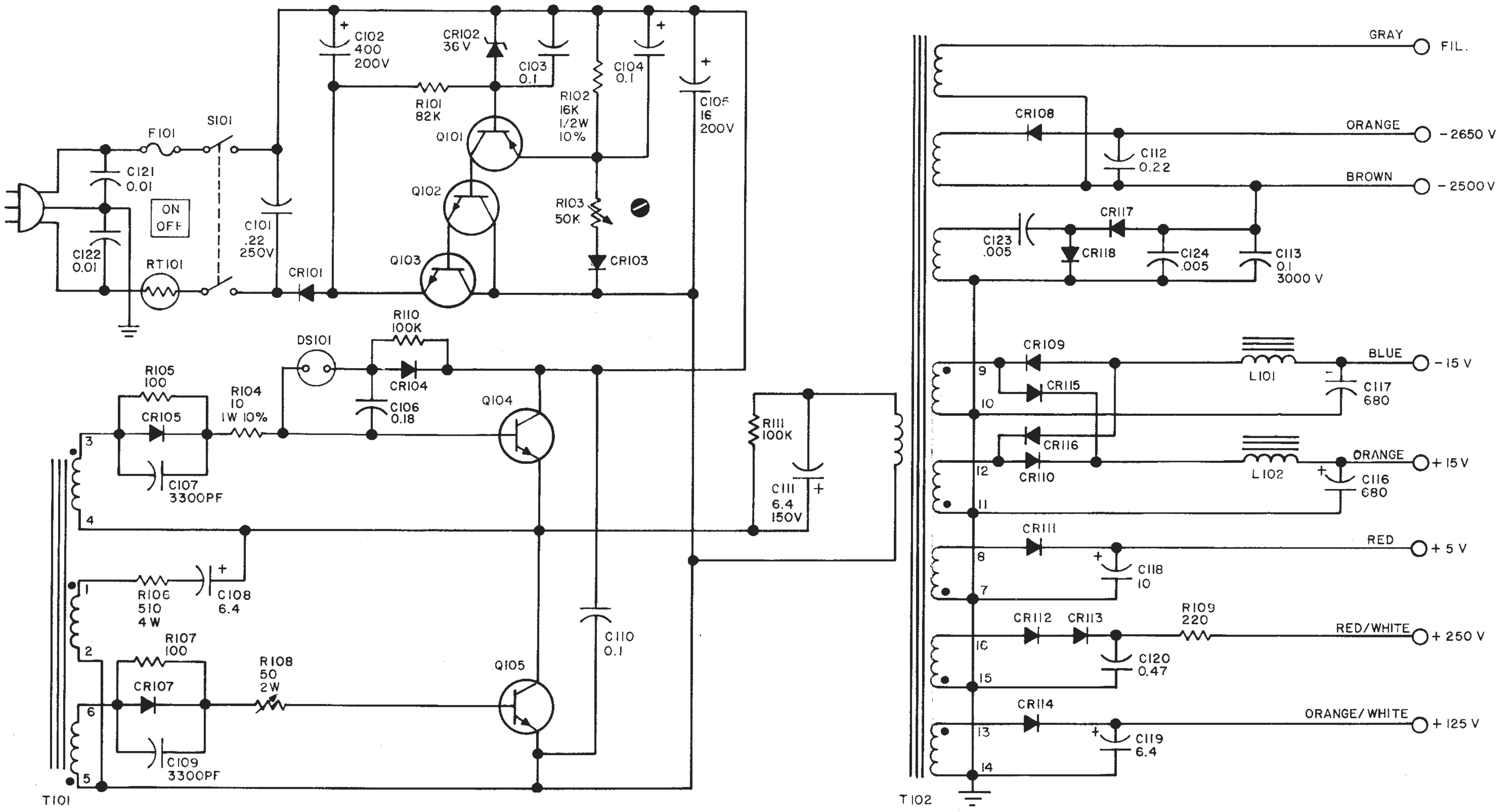
SYMPTOMS	POSSIBLE REASONS	COMPONENTS TO BE CHECKED
Pilot light does not light unit does not operate	Blown fuse due to overload to supplies, improper line voltage	F101, RT101, C102, Q101, Q102, Q103, CR101 thru CR114
Pilot light lights unit power supplies read 0, voltage across C105 approx. 123 volts	Supply will not oscillate	T101, Q104, Q105, DS101, CR104, C111, C108
Power supply voltages to high R103 has no effect	Failure of series regulator or associated circuitry	Series regulator semiconductors Q101, Q102, Q103, CR102, CR103
Power supply voltages OK no trace in any control position	Blanking circuit inoperative. Trace off screen due to amplifier failure. See Note 1, at end of table.	Q407, Q408, Q405, Q406. Check components in VERTICAL AMPLIFIER Q201 thru Q214, CR201, CR202 and Horizontal Amplifier components Q312, Q313, Q320 thru Q324.
Trace only in locate position	Amplifier failure	See Note 1 at end of table.
No triggering on INT EXT or LINE position. Trace appears in AUTO and LOCATE mode.	Trigger amplifier failure	Semiconductor to be checked Q314, Q301, Q302, Q303, Q304.
AUTO does not function. Trigger OK in INT, EXT, LINE	AUTO pulses not reaching Q304.	Q308, Q318, CR303, CR304, CR309.
No sweep in any position. Operation correct in EXT HORIZ mode.	No sweep	AR301, AR302, AR303, Q305, Q309, Q310, Q306, Q307, Q311
Poor triggering on certain sweep ranges. Trace seems occasionally to start in the center of screen.	No hold off	Q309, Q310, AR302. CR305

Table 7-1. Troubleshooting Chart (con't)

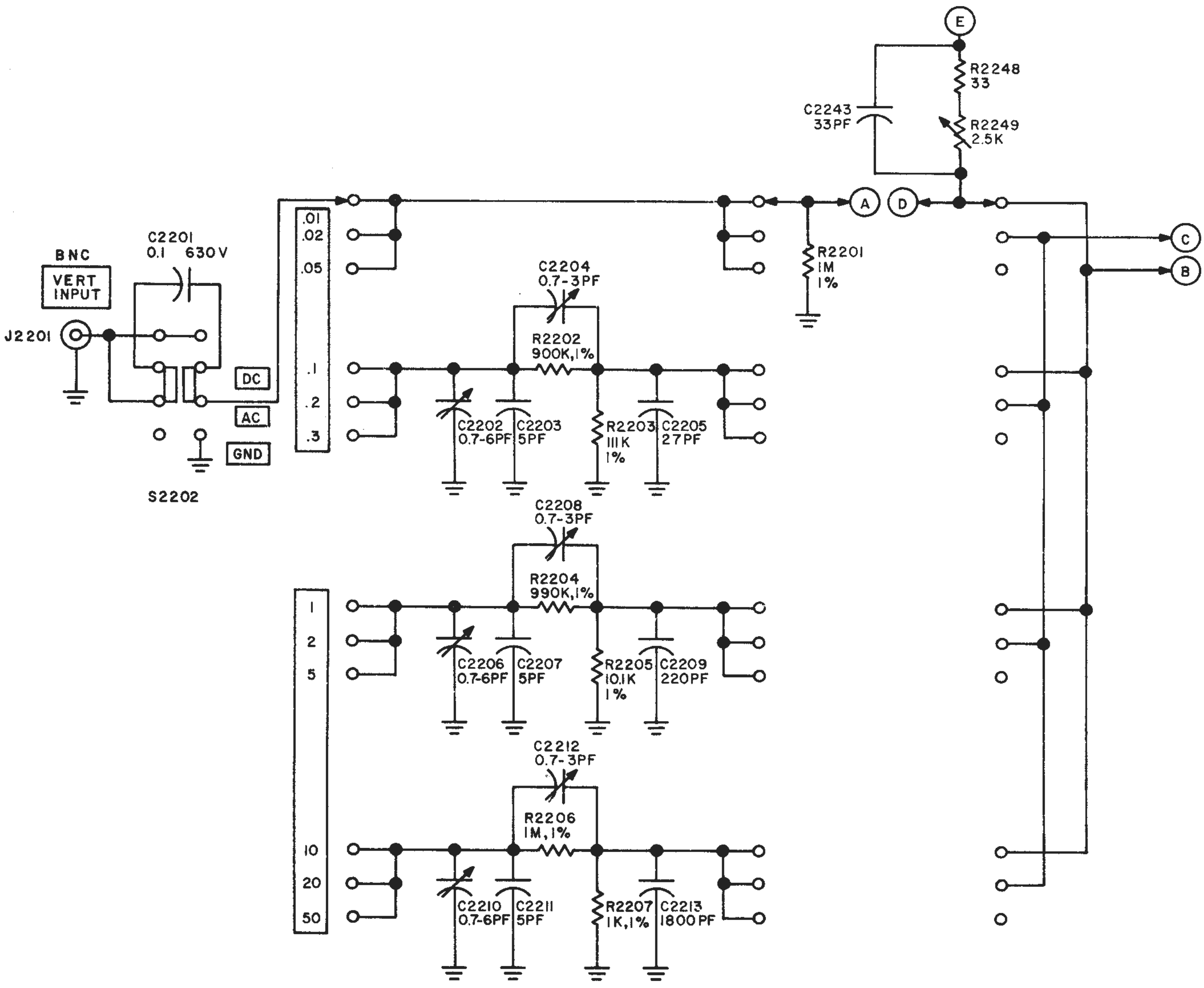
SYMPTOMS	POSSIBLE REASONS	COMPONENTS TO BE CHECKED
Poor or absent TV-V, TV-H VIT triggering	Sync separator failure	Q315, Q316, CR308, CR310
No VIT triggering, or continuous triggering on both fields. TV-V and TV-H OK	VIT circuit failure	Q317, Q318, AR303, Q319, Q311, AR301, Q310
No line trigger	Pilot light defective. Defective photo transistor	CR401, DS401, Q404
No PROBE CAL output	Defective PROBE CAL oscillator	Q401, Q402, Q403
Horizontal trace linearity poor at high sweep speeds	R371 out of CAL. Excessive horizontal driver current	Q322
Vertical distortion at high frequencies	R2236 out of CAL. Excessive vertical driver current.	Q2209

NOTE 1

In order to determine which if either amplifier has failed, perform the following test. Set controls as in Section 3-2. Connect a clip lead between the collectors of the two horizontal (Q324, Q323) or vertical (Q213, Q214) final amplifiers. These collectors are accessible at the tabs on the tops of the transistors. If shorting the vertical output transistor collectors together brings a trace on screen then the vertical amplifier is at fault. If shorting the horizontal output transistor collectors together brings a spot on to the screen then the horizontal amplifier has failed. CAUTION: Connect the clip lead with the power off to avoid shock.



F101
S101
ON
OFF
C121
0.01
C122
0.01
RT101
C101
.22
250V
CR101
C102
400
200V
CR102
36 V
R101
82K
C103
0.1
R102
16K
1/2W
10%
C104
0.1
C105
16
200V
Q101
Q102
Q103
R103
50K
CR103
R110
100K
DS101
CR104
C106
0.18
R105
100
CR105
C107
3300PF
R104
10
1W 10%
Q104
R111
100K
C111
6.4
150V
R106
510
4 W
C108
6.4
R107
100
CR107
C109
3300PF
R108
50
2W
Q105
C110
0.1
T101
GRAY
FIL.
CR108
ORANGE
- 2650 V
C112
0.22
BROWN
- 2500 V
C123
.005
CR117
CR118
C124
.005
C113
0.1
3000 V
CR109
CR115
L101
BLUE
- 15 V
C117
680
CR116
CR110
L102
ORANGE
+ 15 V
C116
680
CR111
RED
+ 5 V
C118
10
CR112
CR113
R109
220
RED/WHITE
+ 250 V
C120
0.47
CR114
ORANGE/WHITE
+ 125 V
C119
6.4
T102



NOTES:

UNLESS OTHERWISE SPECIFIED, ALL RESISTOR
CAPACITOR VALUES ARE IN MICROFARADS.

CIRCLED LETTERS (A) SHOW INTER-CONNECTION
FRONT P.C. BOARD.

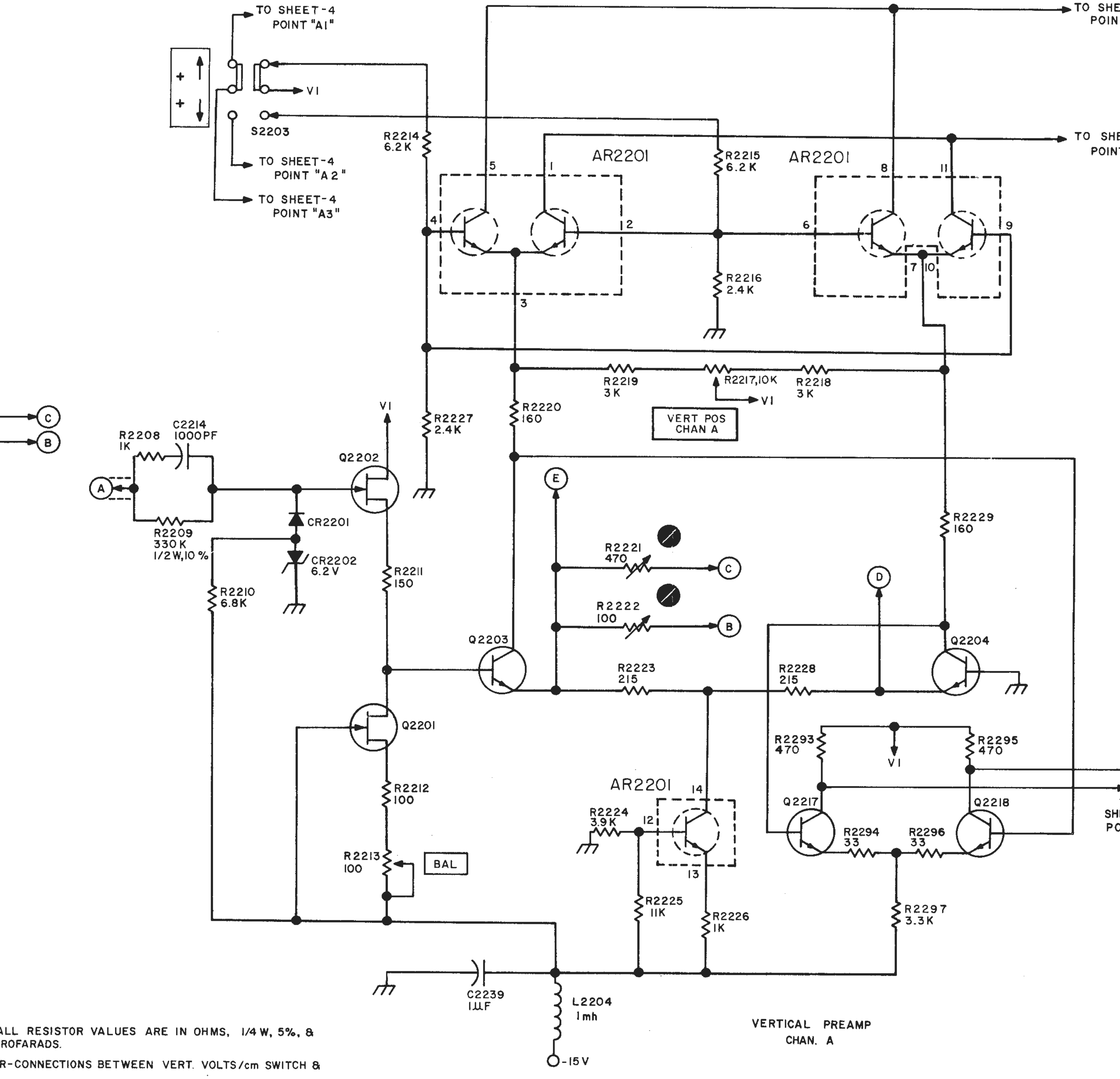
+ NO CONNECTION.

● DENOTES CONNECTION.

☐ FRONT PANEL NOMENCLATURE.

⊘ INTERNAL SCREWDRIVER ADJUSTMENT.

ALT.	DRAWING
	902-5



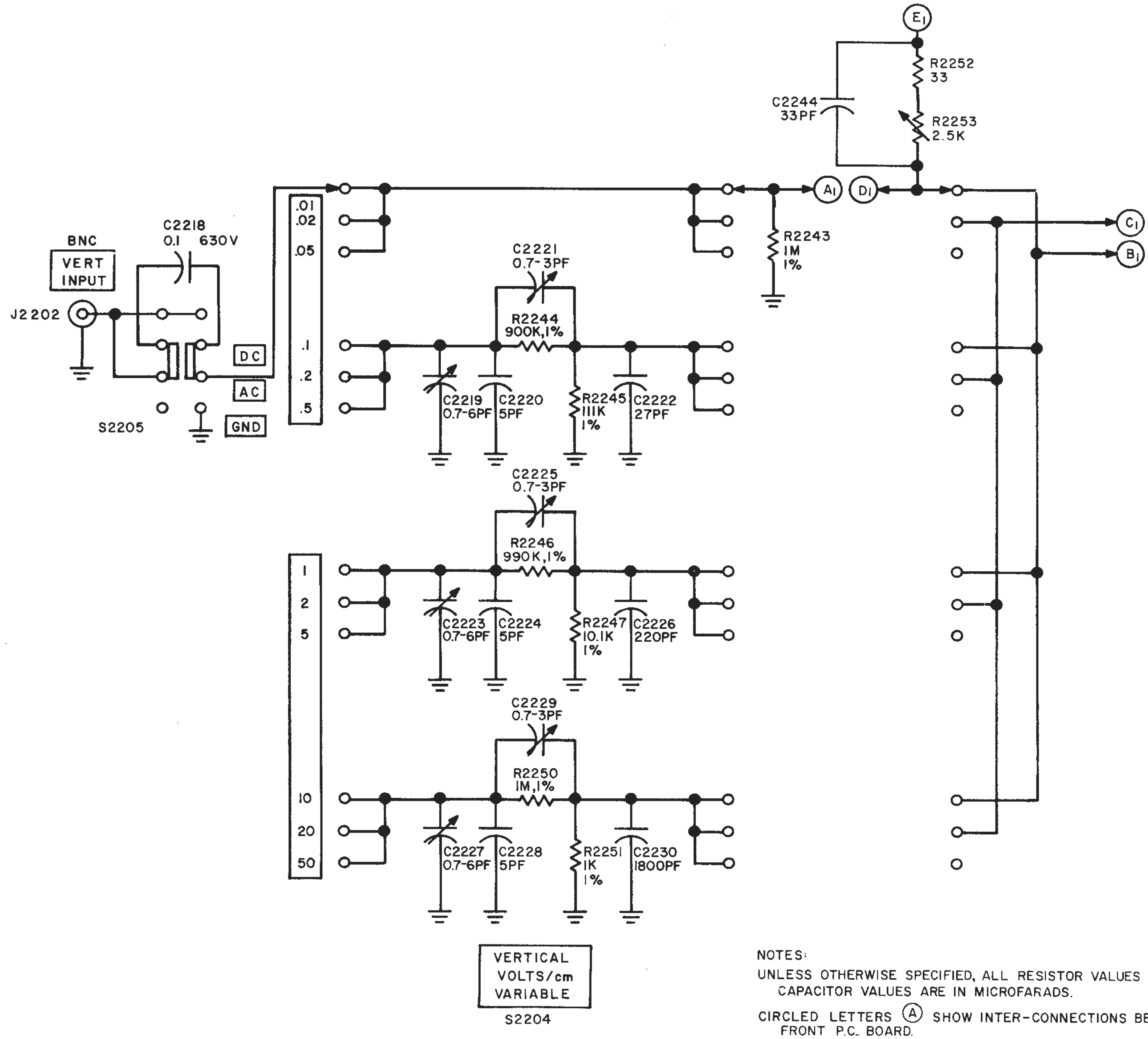
ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, 5%, &
ROFARADS.

R-CONNECTIONS BETWEEN VERT. VOLTS/cm SWITCH &

RE.

STMENT.

FIG. 8-1 SHEET 2, SCHEMATIC WIRING DIA



NOTES:

UNLESS OTHERWISE SPECIFIED, ALL RESISTOR VALUES ARE
CAPACITOR VALUES ARE IN MICROFARADS.

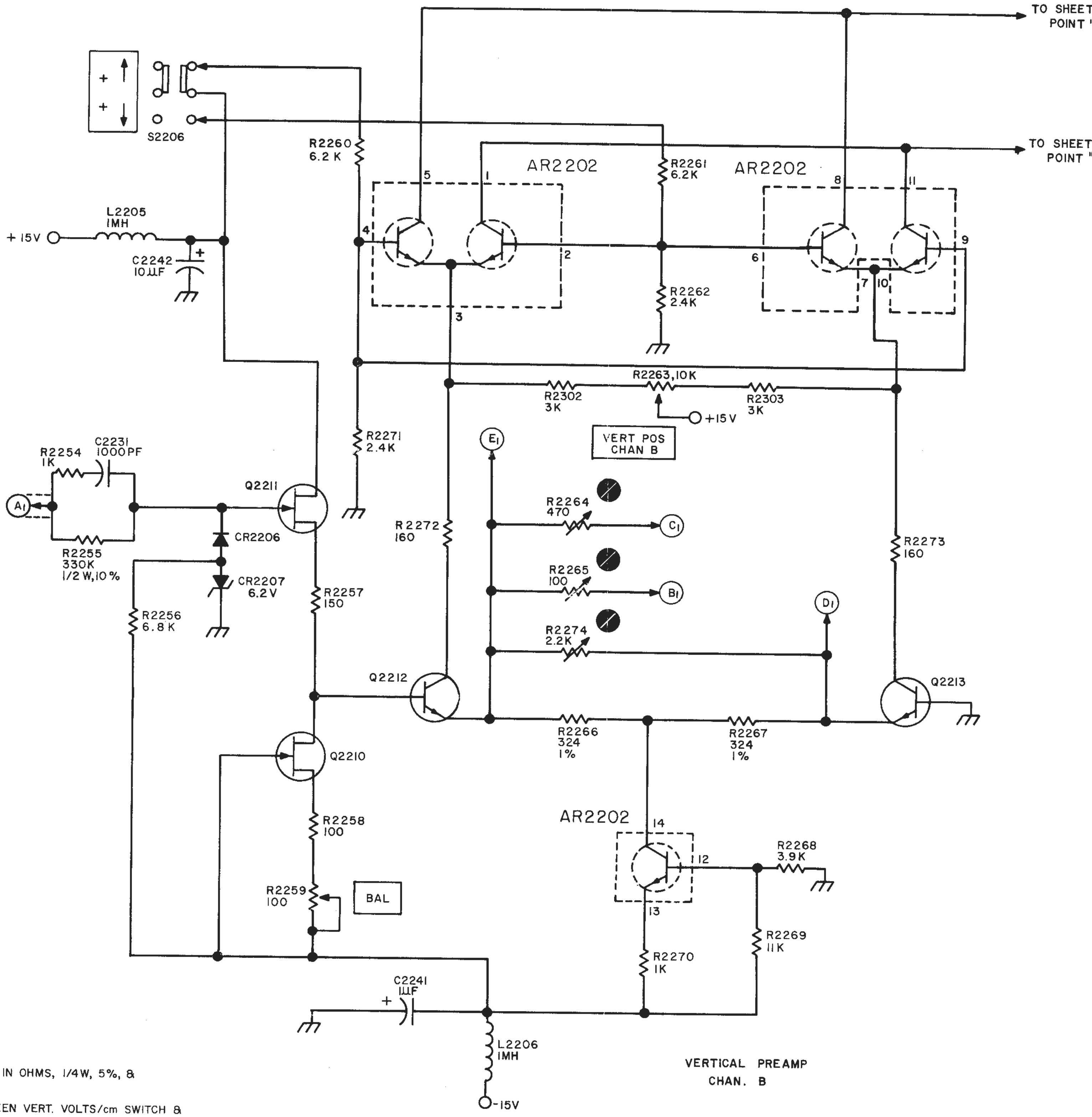
CIRCLED LETTERS (A) SHOW INTER-CONNECTIONS BETW
FRONT P.C. BOARD.

+ NO CONNECTION.

◆ DENOTES CONNECTION.

▭ FRONT PANEL NOMENCLATURE.

● INTERNAL SCREWDRIVER ADJUSTMENT.



VALUES ARE IN OHMS, 1/4W, 5%, &

TIONS BETWEEN VERT. VOLTS/cm SWITCH &

FIG. 8-1 SHEET 3, SCHEMATIC WIRING DIAG

NOTES:

UNLESS OTHERWISE SPECIFIED, ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 5%, & CAPACITOR VALUES ARE IN MICROFARADS.

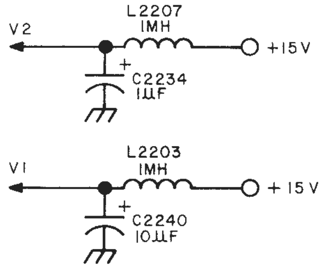
CIRCLED LETTERS (A) SHOW INTER-CONNECTIONS BETWEEN VERT. VOLTS/cm SWITCH & FRONT P.C. BOARD.

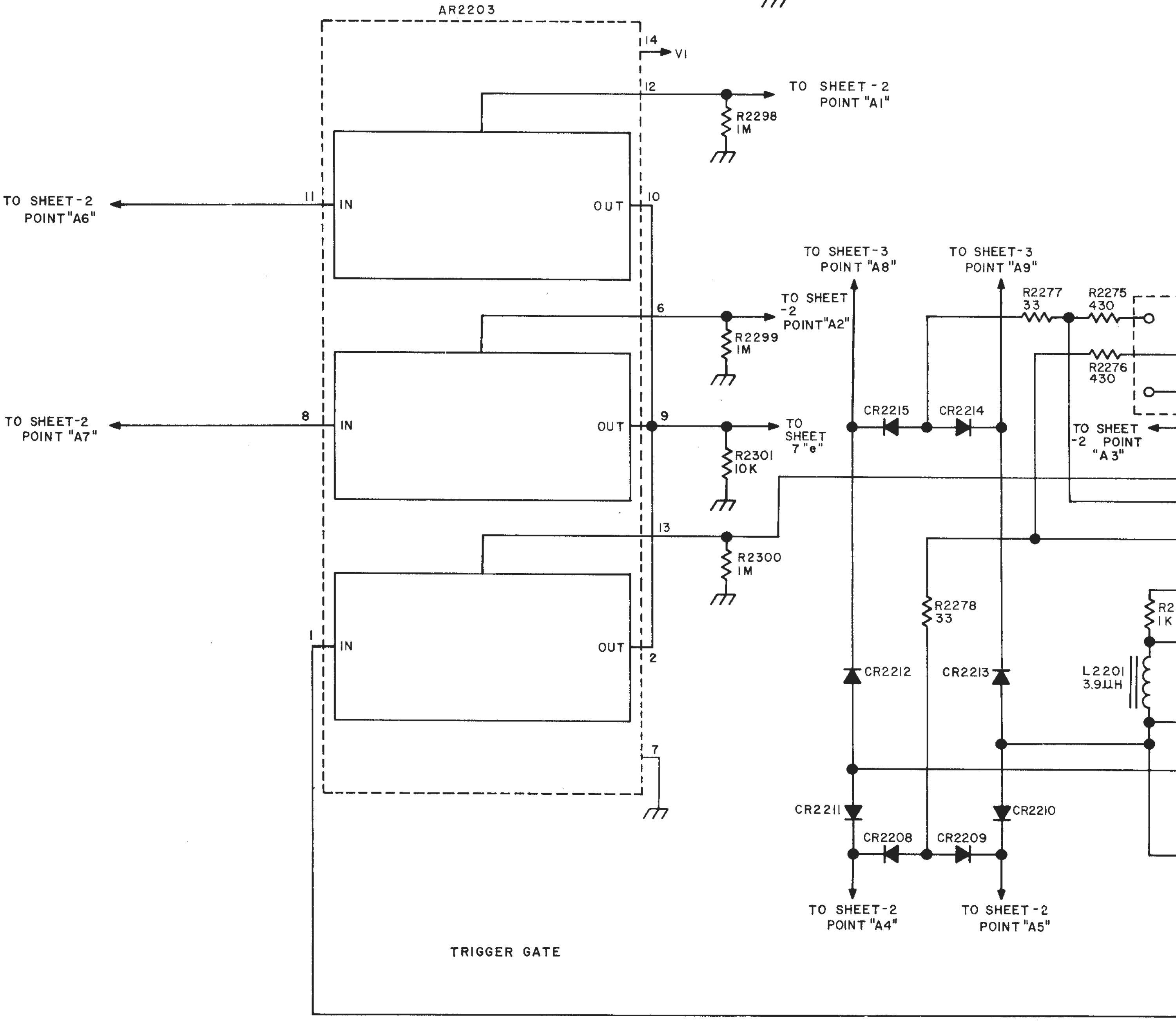
┼ NO CONNECTION.

◆ DENOTES CONNECTION.

▭ FRONT PANEL NOMENCLATURE.

● INTERNAL SCREWDRIVER ADJUSTMENT.





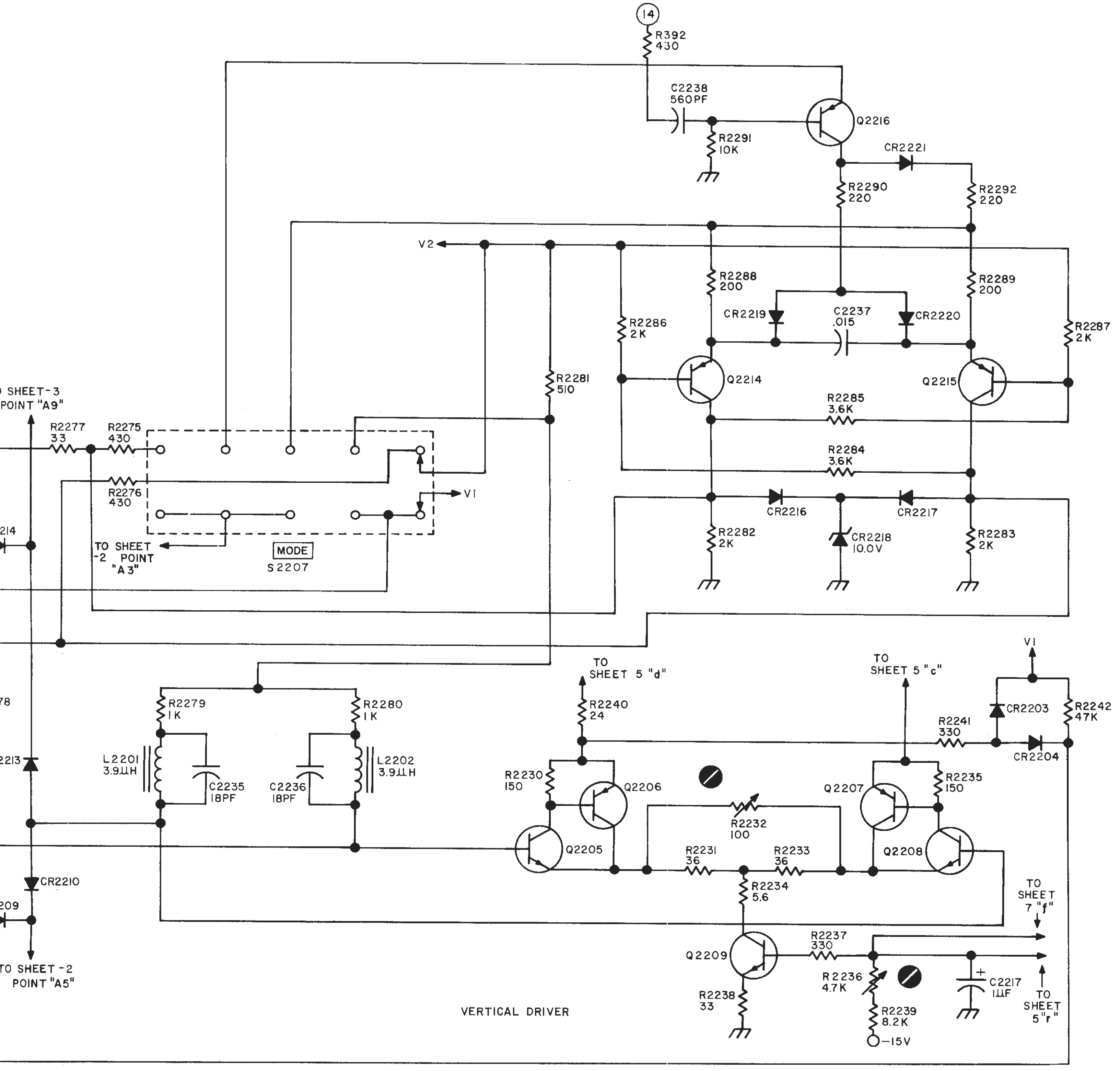
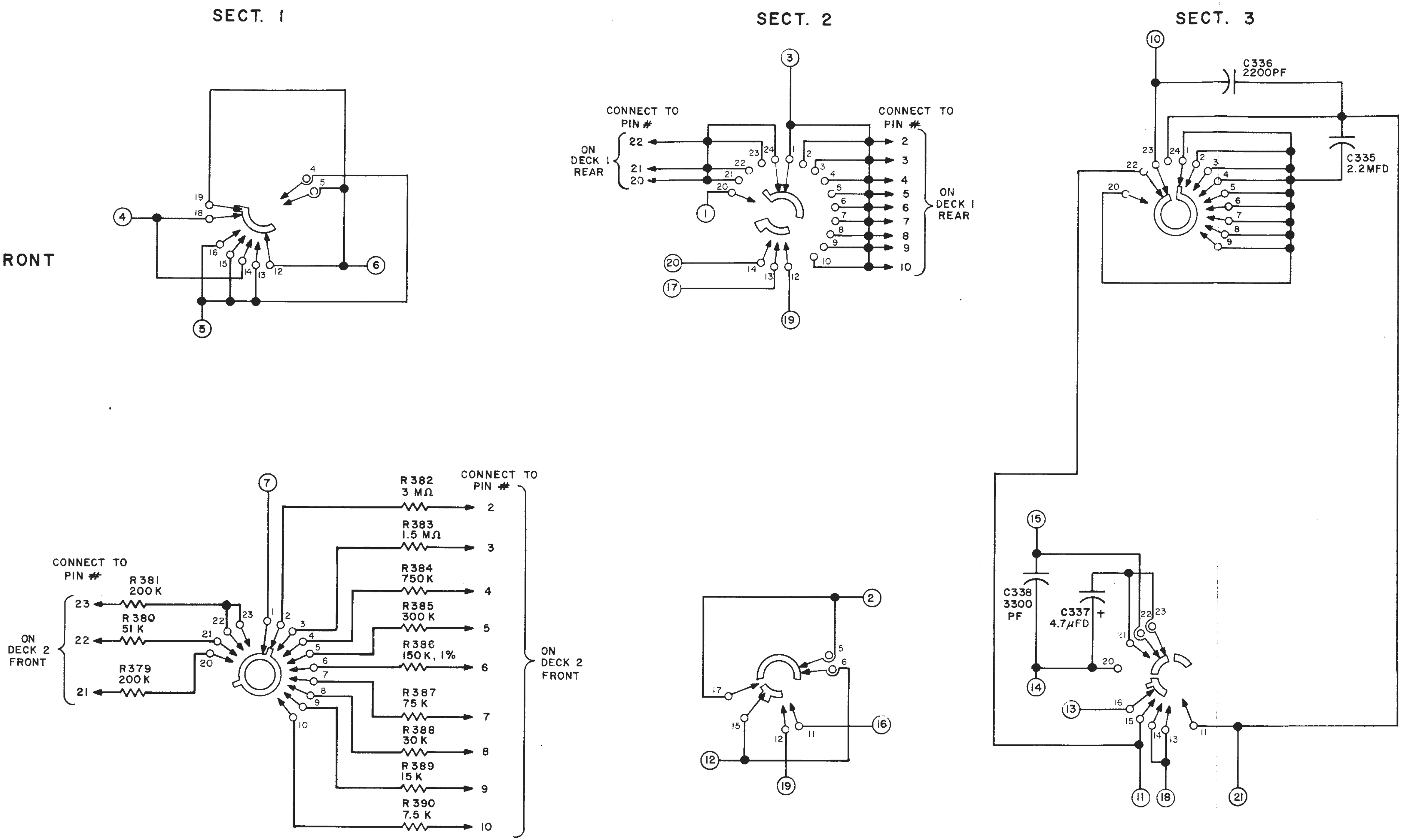
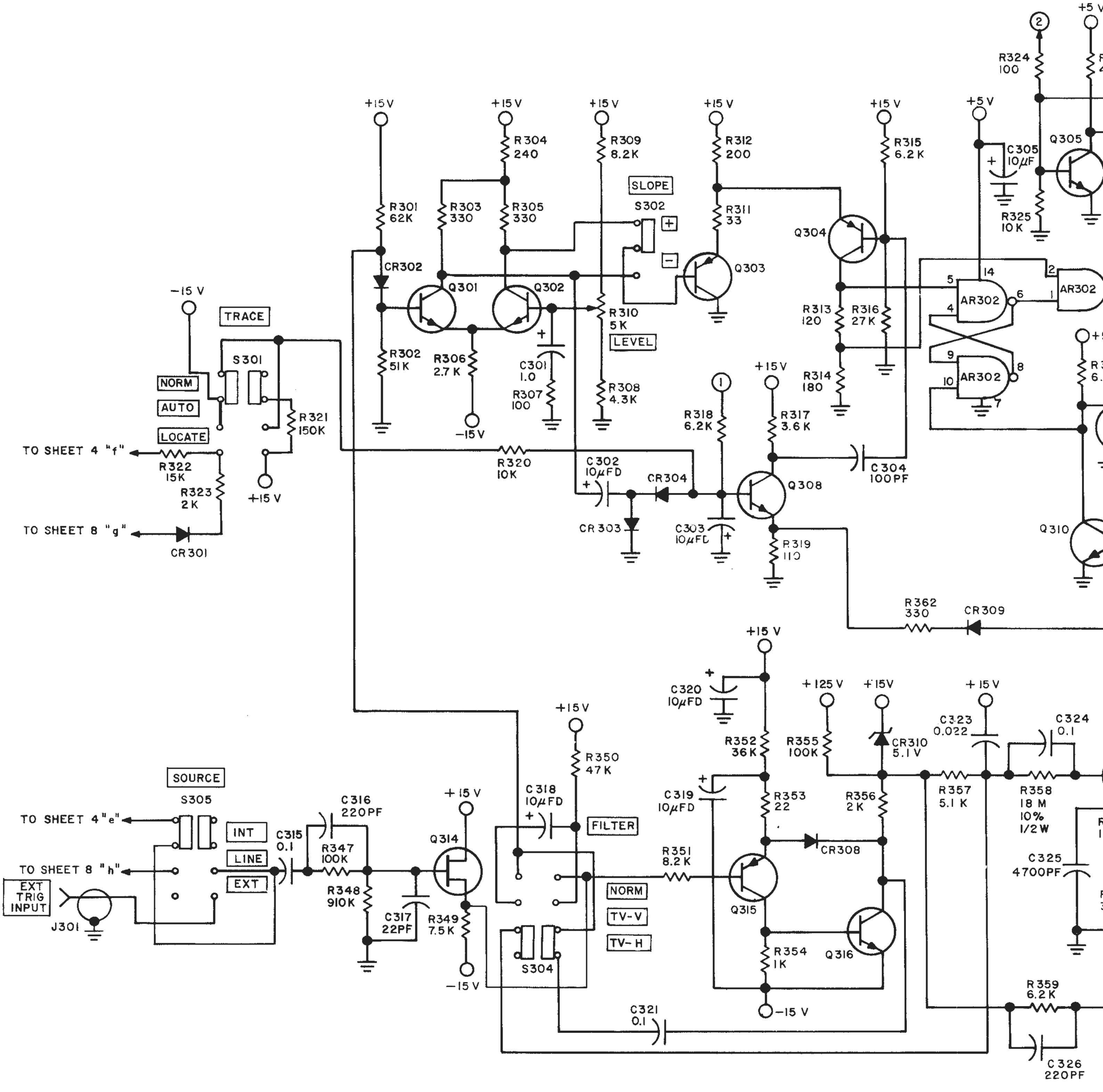


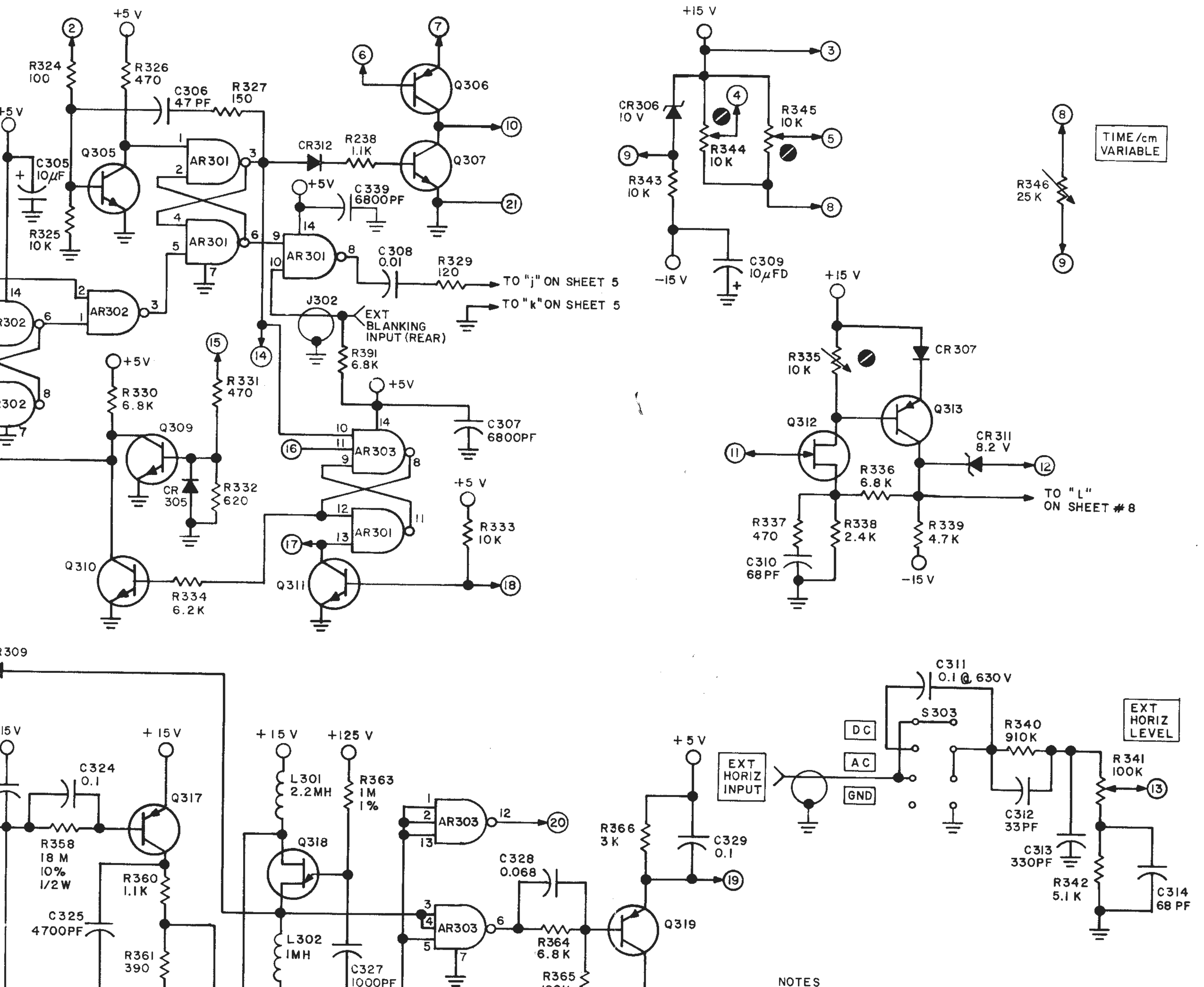
FIG. 8-1 SHEET 4, SCHEMATIC WIRING DIA

FRONT


SECT. 1
SECT. 2
SECT. 3
CONNECT TO PIN #
ON DECK 1 REAR
CONNECT TO PIN #
ON DECK 1 REAR
C336 2200PF
C335 2.2MFD
CONNECT TO PIN #
R382 3 MΩ
R383 1.5 MΩ
R384 750K
R385 300K
R386 150K, 1%
R387 75K
R388 30K
R389 15K
R390 7.5K
ON DECK 2 FRONT
CONNECT TO PIN #
R381 200K
R380 51K
R379 200K
ON DECK 2 FRONT
C338 3300 PF
C337 4.7μFD



TRIGGER & HORIZONTAL PREA



NOTES

UNLESS OTHERWISE SPECIFIED, ALL RESISTOR VALUES ARE IN OHMS 1/4 W, 5%, & CAPACITOR VALUES ARE IN MICROFARADS.

CIRCLED NUMBERS (15) SHOW INTER-CONNECTIONS BETWEEN HORIZ TIME/cm SWITCH (SHEET 4) & FRONT P. C. BOARD.

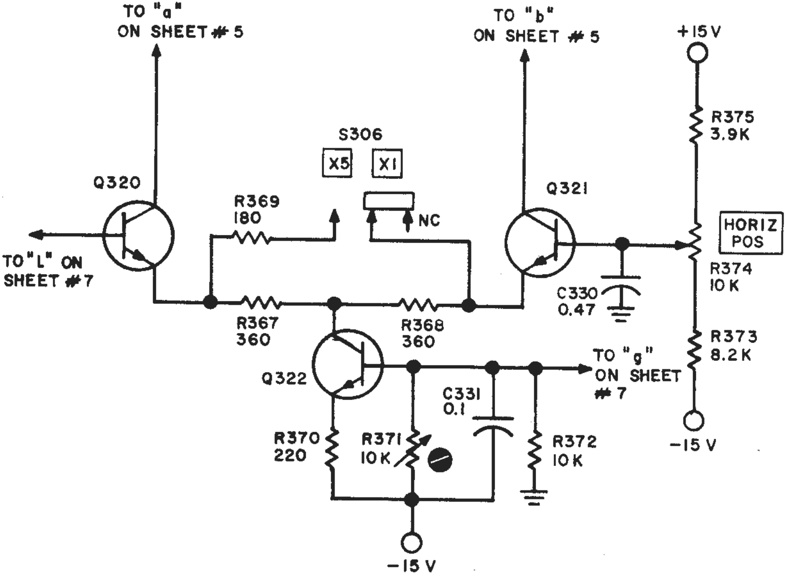
+ NO CONNECTION ━●━ DENOTES CONNECTION.

▭ FRONT PANEL NOMENCLATURE.

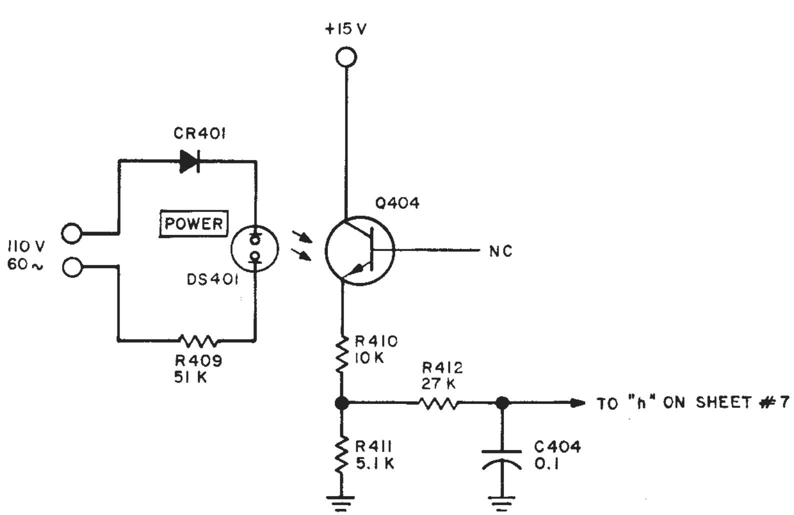
● INTERNAL SCREWDRIVER ADJUSTMENT.

ONTAL PREAMP

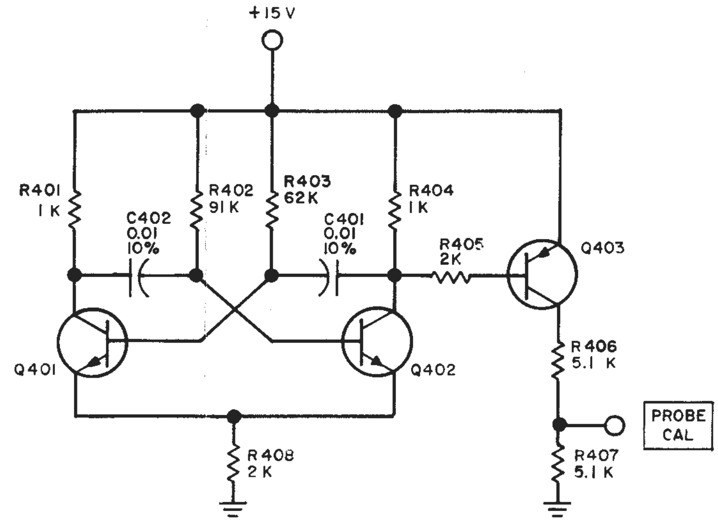
FIG. 8-1 SHEET 7, SCHEMATIC WIRING DIAGRAM



HORIZONTAL DRIVER



LINE TRIGGER

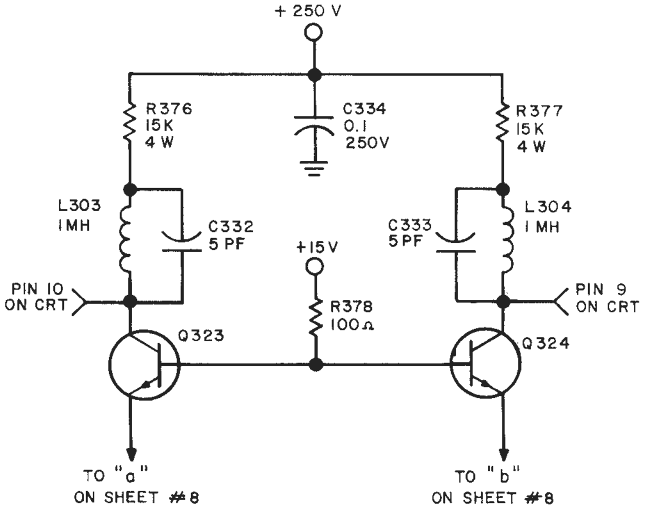


PROBE CALIBRATOR

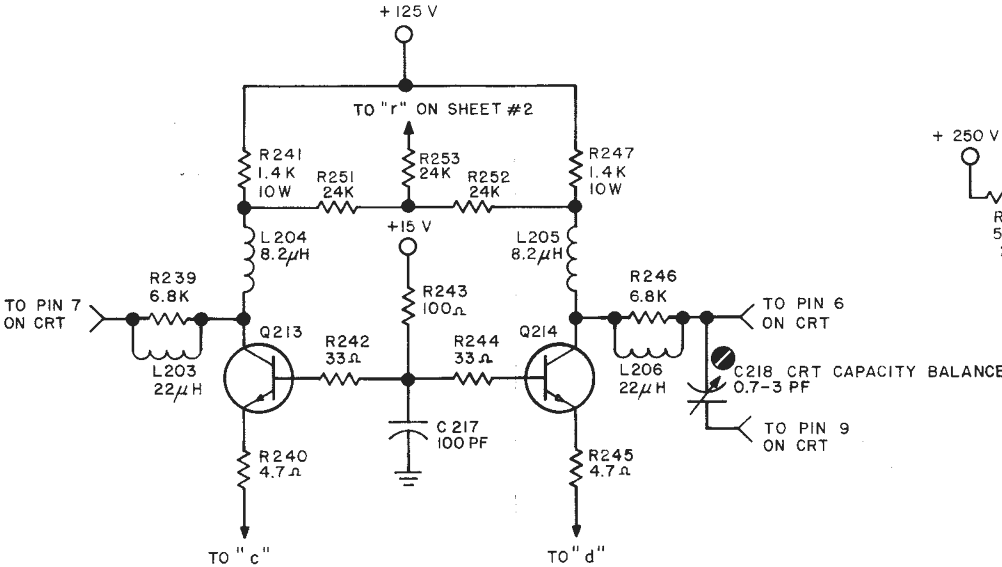
NOTES

UNLESS OTHERWISE SPECIFIED, ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, 5 %, & CAPACITOR VALUES ARE IN MICROFARADS.

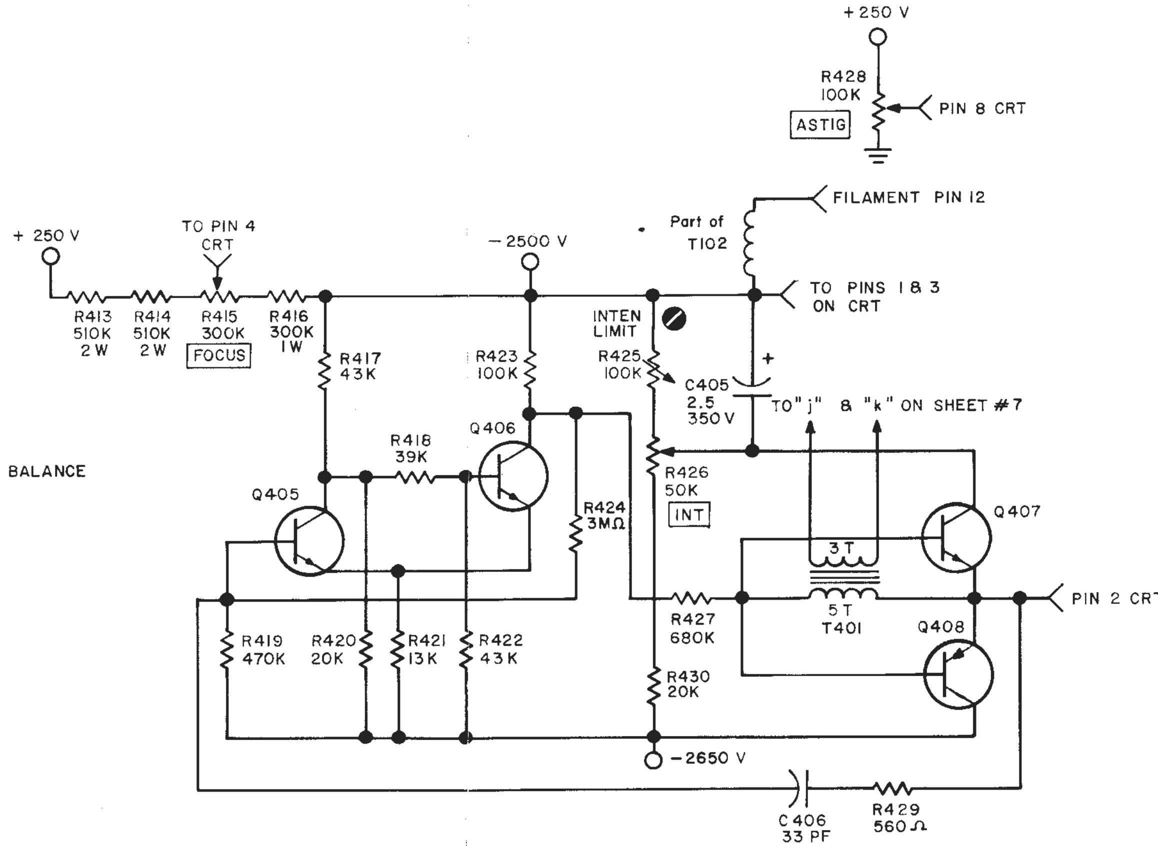
- NO CONNECTION
- DENOTES CONNECTION
- FRONT PANEL NOMENCLATURE
- INTERNAL SCREWDRIVER ADJUSTMENT


+ 250 V
R376
15K
4 W
C334
0.1
250V
R377
15K
4 W
L303
1MH
C332
5 PF
+15V
C333
5PF
L304
1 MH
PIN 10
ON CRT
R378
100Ω
PIN 9
ON CRT
Q323
Q324
TO "a"
ON SHEET #8
TO "b"
ON SHEET #8

HORIZ FINAL



VERTICAL FINAL



BLANKING CIRCUIT

NOTES

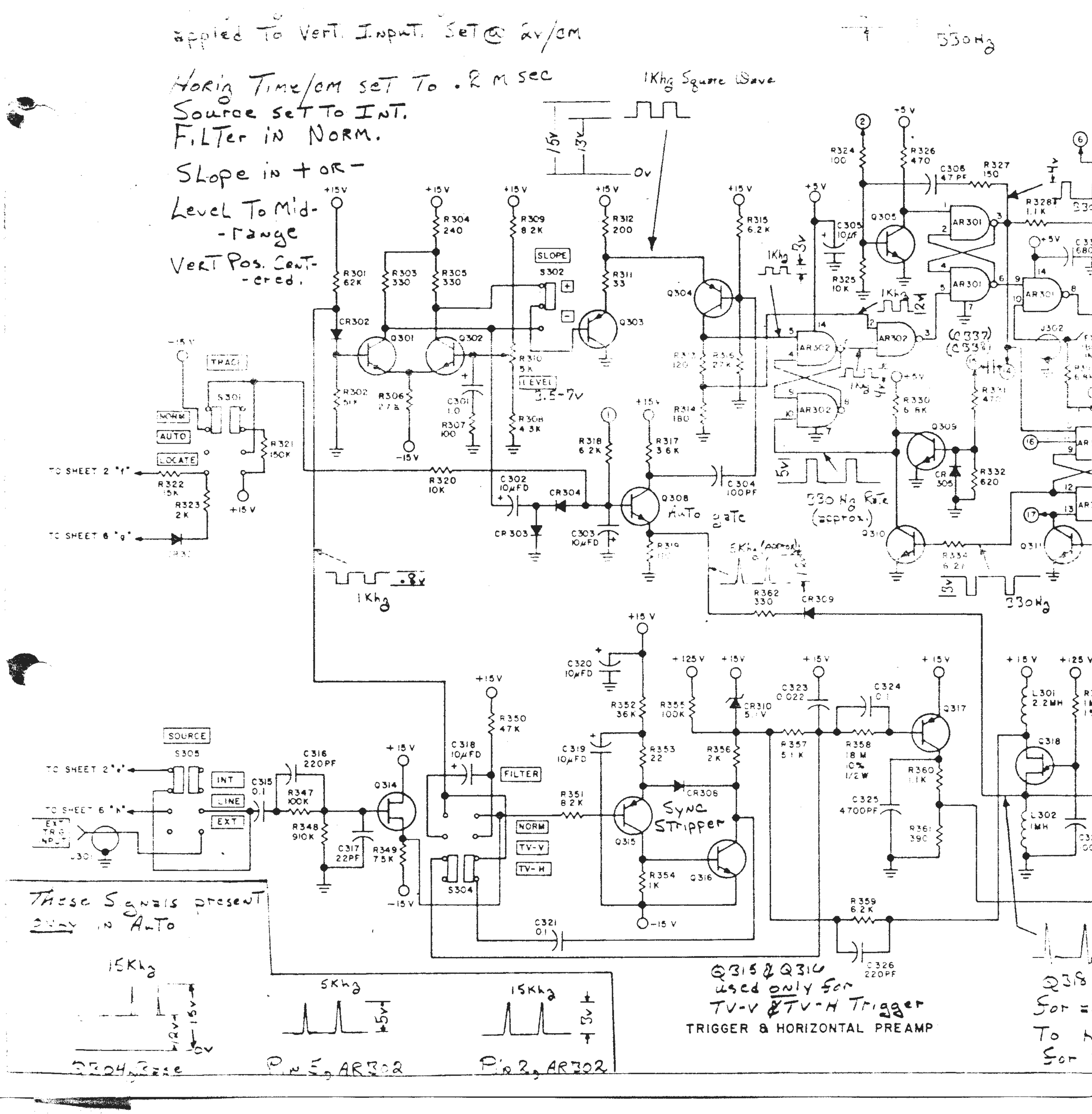
UNLESS OTHERWISE SPECIFIED, ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, 5%, & CAPACITOR VALUES ARE MICROFARADS.

┼ NO CONNECTION

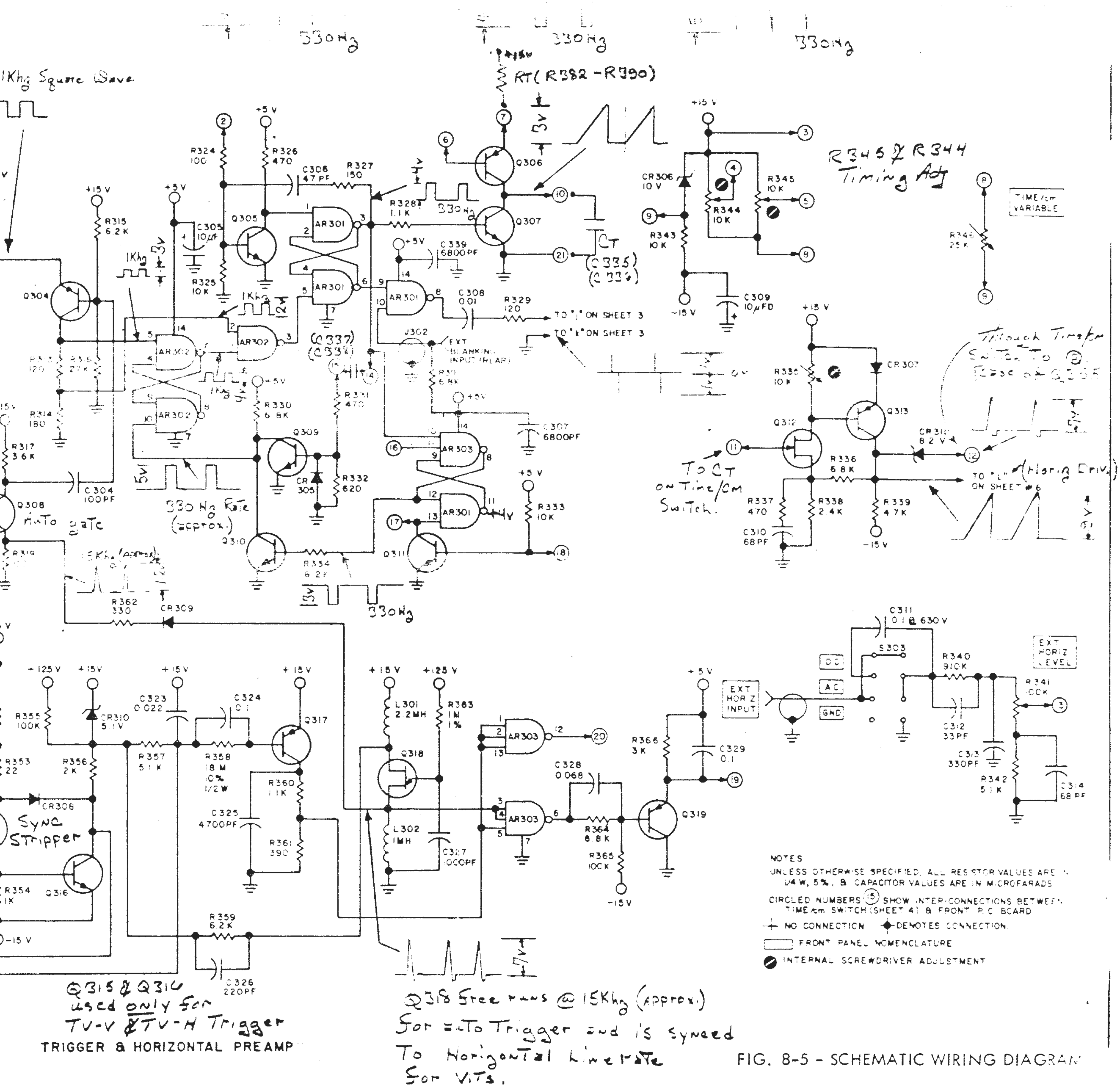
✦ DENOTES CONNECTION

▭ FRONT PANEL NOMENCLATURE

⊘ INTERNAL SCREWDRIVER ADJUSTMENT.



TRIGGER & HORIZONTAL PREAMP



TRIGGER & HORIZONTAL PREAMP

FIG. 8-5 - SCHEMATIC WIRING DIAGRAM

ADDENDUM
SERIES 511 OSCILLOSCOPES

Your Series 511 Oscilloscope includes additional circuitry that generates trace unblanking pulses when the "TRACE LOCATE" switch is activated.

This circuitry is used in "EXT. HORIZ." position of the sweep switch when the internal sweep generator and blanking circuits are deactivated.

If the trace is blanked (not visible) in the "EXT. HORIZ." position one or two actuations of the "TRACE LOCATE" switch should restore the blanking circuitry to the unblanked mode.

This factory installation is equivalent to field modification No. 100-179.

SECTION 8
PARTS LIST

When ordering parts always state the model and serial number of the equipment. Also, be sure to give the reference designation, description, and Hickok part number as shown in the parts list. There is a minimum billing charge of $5.00 for all parts orders.

The following notes apply to certain parts as indicated in the "NOTES" column of the parts list.

NOTES:

1. Part not replaceable in field. Return equipment to Hickok factory or authorized repair station.
2. Q201 and Q202 are selected and matched as a pair. Order replacement from Hickok factory only.
3. Selected part. Order replacement from Hickok factory only.

REF. DESIG.	NOTES	DESCRIPTION	HICKOK PART NO.
AR301		INTEGRATED CIRCUIT: TTL, DM/SN7400N	9800-65
AR302		Same as AR301	
AR303		INTEGRATED CIRCUIT: DTL, MC862P	9800-38
AR2201		INTEGRATED CIRCUIT: CA3086	9800-121
AR2202		Same as AR2201	
AR2203		INTEGRATED CIRCUIT: MC14016CL	9800-112
C101		CAPACITOR, FIXED, METALLIZED MYLAR: .22 uf, 250 volts	3090-104
C102		CAPACITOR, FIXED, ELECTROLYTIC: 400 uf, 200 volts	3085-432
C103		CAPACITOR, FIXED, METALLIZED MYLAR: .1 uf, 250 volts	3090-103
C104		Same as C103	
C105		CAPACITOR, FIXED, ELECTROLYTIC: 16 uf, 200 volts	3085-477
C106		CAPACITOR, FIXED, METALLIZED MYLAR: .18 uf, 250 volts	3090-111
C107		CAPACITOR, FIXED, CERAMIC: 3300 pf, +50%, -20%, 500 volts	3111-525
C108		CAPACITOR, FIXED, ELECTROLYTIC: 6.4 uf, 150 volts	3085-476
C109		Same as C107	
C110		Same as C103	
C111		Same as C108	
C112		Same as C101	
C113		CAPACITOR, FIXED, POLYESTER FILM: .1 uf, 20%, 3000 volts	3103-67
C114		Not Used	
C115		Not Used	
C116		CAPACITOR, FIXED, ELECTROLYTIC: 680 uf, 16 volts	3085-446
C117		Same as C116	
C118		Same as C114	
C119		Same as C108	
C120		CAPACITOR, FIXED, METALLIZED MYLAR: .47 uf, 250 volts	3090-105
C121		CAPACITOR, FIXED, POLYESTER FILM: .01 uf, 10%, 400 volts	3103-124
C122		Same as C121	
C123		CAPACITOR, FIXED, CERAMIC: .005 uf, 3,000 volts	3110-281
C124		Same as C123	
C217		CAPACITOR, FIXED, CERAMIC: 100 pf, 20%, 500 volts	3111-516
C218		CAPACITOR, VARIABLE: .7-3 pf, trimmer	3115-85
C301		CAPACITOR, FIXED, ELECTROLYTIC: tantalum, 1 uf, 35 volts	3085-433
C302		CAPACITOR, FIXED, ELECTROLYTIC: bead tantalum, 10 uf, 25V	3085-480
C303		Same as C302	
C304		Same as C217	
C305		Same as C302	
C306		CAPACITOR, FIXED, CERAMIC: 47 pf, 20%, 500 volts	3111-514
C307		CAPACITOR, FIXED, CERAMIC: 6800 pf, +50%, -20%, 125 volts	3110-324
C308		CAPACITOR, FIXED, POLYESTER FILM: .01uf, 10%, 200 volts	3092-201

REF. DESIG.	NOTES	DESCRIPTION	HICKOK PART NO.
C309		Same as C302	
C310		CAPACITOR, FIXED, CERAMIC: 68 pf, 20%, 500 volts	3111-515
C311		CAPACITOR, FIXED, METALLIZED POLYCARBONATE: .1 uf, 630 volts	3092-613
C312		CAPACITOR, FIXED, CERAMIC: 33 pf, 20%, 500 volts	3111-513
C313		CAPACITOR, FIXED, CERAMIC: 330 pf, 20%, 500 volts	3111-519
C314		Same as C310	
C315		Same as C103	
C316		CAPACITOR, FIXED, CERAMIC: 220 pf, 20%, 500 volts	3111-518
C317		CAPACITOR, FIXED, CERAMIC: 22 pf, 20%, 500 volts	3111-512
C318		Same as C302	
C319		Same as C302	
C320		Same as C302	
C321		Same as C103	
C322		Not Used	
C323		CAPACITOR, FIXED, METALLIZED MYLAR: .022 uf, 250 volts	3090-108
C324		Same as C103	
C325		CAPACITOR, FIXED, CERAMIC: 4700 pf, +50% -20%, 500 volts	3111-526
C326		Same as C316	
C327		CAPACITOR, FIXED, POLYSTYRENE: 1000 pf, 5%, 125 volts	3103-106
C328		CAPACITOR, FIXED, METALLIZED MYLAR: .068 uf, 250 volts	3090-109
C329		Same as C103	
C330		CAPACITOR, FIXED, METALLIZED POLYCARBONATE: .47 uf, 10%, 100 volts	3103-108
C331		Same as C103	
C332		CAPACITOR, FIXED, COMPOSITION: 5 pf, 10%, 500 volts	3116-17
C333		Same as C332	
C334		Same as C103	
C335		CAPACITOR, FIXED, METALLIZED POLYESTER FILM: 2.2 uf, 100 volts	3103-105
C336		CAPACITOR, FIXED, POLYSTYRENE: 2200 pf, 5%, 125 volts	3103-107
C337		CAPACITOR, FIXED, ELECTROLYTIC: 4.7 uf, 35 volts	3085-481
C338		CAPACITOR, FIXED, POLYSTYRENE: 3300 pf, 63 volts	3103-126
C339		Same as C307	
C401		CAPACITOR, FIXED, METALLIZED MYLAR: .01 uf, 250 volts	3090-101
C402		Same as C401	
C403		Not Used	
C404		Same as C103	
C405		CAPACITOR, FIXED, ELECTROLYTIC: 2.5 uf, 350 volts	3085-475
C406		Same as C312	
C2201		Same as C311	
C2202		CAPACITOR, VARIABLE: .7-6 pf, trimmer	3115-86
C2203		Same as C332	
C2204		Same as C218	
C2205		CAPACITOR, FIXED, DIPPED MICA: 27 pf, 5%, 500 volts	3096-511
C2206		Same as C2202	
C2207		Same as C332	
C2208		Same as C218	
C2209		CAPACITOR, FIXED, DIPPED MICA: 220 pf, 5%, 500 volts	3096-533
C2210		Same as C2202	
C2211		Same as C332	
C2212		Same as C218	
C2213		CAPACITOR, FIXED, POLYSTYRENE: 1800 pf, 63 volts	3103-125
C2214		CAPACITOR, FIXED, CERAMIC: 1000 pf, +50% -20%, 500 volts	3111-522
C2215		Not Used	
C2216		Not Used	
C2217		Same as C301	
C2218		Same as C311	
C2219		Same as C2202	
C2220		Same as C332	
C2221		Same as C218	
C2222		Same as C2205	

REF. DESIG.	NOTES	DESCRIPTION	HICKOK PART NO.
C2223		Same as C2202	
C2224		Same as C332	
C2225		Same as C218	
C2226		Same as C2209	
C2227		Same as C2202	
C2228		Same as C332	
C2229		Same as C218	
C2230		Same as C2213	
C2231		Same as C2214	
C2232		Not Used	
C2233		Not Used	
C2234		Same as C301	
C2235		CAPACITOR, FIXED, COMPOSITION: 18 pf, 10%, 500 volts	3116-26
C2236		Same as C2235	
C2237		CAPACITOR, FIXED, METALLIZED MYLAR: .015 uf, 250 volts	3090-112
C2238		CAPACITOR, FIXED, DIPPED MICA: 560 pf, 5%, 500 volts	3096-543
C2239		Same as C301	
C2240		Same as C302	
C2241		Same as C301	
C2242		Same as C302	
C2243		CAPACITOR, FIXED, DIPPED MICA: 33 pf, 5%, 500 volts	3096-513
C2244		Same as C2243	
CR101		SEMICONDUCTOR DEVICE: BY127 rectifier	3870-233
CR102		SEMICONDUCTOR DEVICE: diode 1N5749B, 36 volts	3870-318
CR103		SEMICONDUCTOR DEVICE: diode BY187	3870-313
CR104		SEMICONDUCTOR DEVICE: diode 1N4003	3870-329
CR105		Same as CR104	
CR106		Same as CR104	
CR107		Same as CR104	
CR108		SEMICONDUCTOR DEVICE: diode BA148	3870-316
CR109		SEMICONDUCTOR DEVICE: diode DT230F	3870-317
CR110		Same as CR109	
CR111		Same as CR109	
CR112		Same as CR108	
CR113		Same as CR108	
CR114		Same as CR108	
CR115		Same as CR109	
CR116		Same as CR109	
CR117		SEMICONDUCTOR DEVICE: diode SEM50, 5 KV	3870-197
CR118		Same as CR117	
CR301 thru CR305		SEMICONDUCTOR DEVICE: diode 1N914	3870-175
CR306		SEMICONDUCTOR DEVICE: diode 1N5736B, 10 volts, 5%	3870-319
CR307		Same as CR301	
CR308		Same as CR301	
CR309		Same as CR301	
CR310		SEMICONDUCTOR, DEVICE: diode 1N5729B, 5.1 volts, 5%	3870-320
CR311		SEMICONDUCTOR DEVICE: 1N5734B, 8.2 volts, 5%	3870-312
CR312		Same as CR301	
CR401		Same as CR104	
CR2201		SEMICONDUCTOR DEVICE: diode FD333	3870-332
CR2202		SEMICONDUCTOR DEVICE: zener diode 1N5731B, 6.2V ± 5%, 400MW	3870-302
CR2203		Same as CR301	
CR2204		Same as CR301	
CR2205		Not Used	
CR2206		Same as CR2201	
CR2207		Same as CR2202	
CR2208		Same as CR301	
CR2209		Same as CR301	
CR2210		Same as CR301	
CR2211		Same as CR301	
CR2212		Same as CR301	

REF. DESIG.	NOTES	DESCRIPTION	HICKOK PART NO.
CR2213		Same as CR301	
CR2214		Same as CR301	
CR2215		Same as CR301	
CR2216		Same as CR301	
CR2217		Same as CR301	
CR2218		Same as CR306	
CR2219		Same as CR301	
CR2220		Same as CR301	
CR2221		Same as CR301	
DS101		LAMP: NE-83	12270-96
DS401		Same as DS101	
F101		FUSE: 1 Amp, SLO-BLO	6900-77
J301		CONNECTOR: coaxial type BNC, UG-1094/U	3475-303
J302		Same as J301	
J401		JACK: red nylon body	10300-55
J402		JACK: phone, single	10300-81
J2201		Same as J301	
J2202		Same as J301	
L101		COIL: 8 ampere, R.F. choke, 5%, 300 microhenries, 1.06 ohms dc resistance	3320-374
L102		Same as L101	
L203		COIL: 22 uh	3320-369
L204		COIL: 8.2 uh	3320-370
L205		Same as L204	
L206		Same as L203	
L301		COIL: 2.2MH	3320-373
L302		COIL: 1MH	3320-372
L303		Same as L302	
L304		Same as L302	
L2201		COIL: 3.9 uh	3320-377
L2202		Same as L2201	
L2203		Same as L302	
L2204		Same as L302	
L2205		Same as L302	
L2206		Same as L302	
L2207		Same as L302	
Q101		TRANSISTOR: 2N4888, silicon, PNP, high voltage	20861-182
Q102		TRANSISTOR: 2N6220, silicon NPN, high voltage	20861-320
Q103		TRANSISTOR: 2N4240NPN	20861-385
Q104		Same as Q103	
Q105		Same as Q103	
Q213		TRANSISTOR: D40P1, silicon, NPN	20861-325
Q214		Same as Q213	
Q301	3	TRANSISTOR: selected, 2N3563	20861-331
Q302		TRANSISTOR: 2N3563, silicon, NPN	20861-196
Q303		TRANSISTOR: BC309, silicon, PNP	20861-321
Q304		Same as Q303	
Q305		TRANSISTOR: A139, silicon, NPN, high beta	20861-316
Q306		TRANSISTOR: EN3962, silicon, PNP	20861-322
Q307		TRANSISTOR: 2N5134, silicon, NPN	20861-323
Q308		TRANSISTOR: can be either A139 or A137 or A138	20861-316 or 20861-328 or 20861-329
Q309		Same as Q308	
Q310		Same as Q308	
Q311		Same as Q308	
Q312		TRANSISTOR: 2N5245 FET	20861-185
Q313		TRANSISTOR: 2N5139, PNP	20861-181
Q314		Same as Q312	
Q315		Same as Q303	

REF. DESIG.	NOTES	DESCRIPTION	HICKOK PART NO.
Q316		Same as Q308	
Q317		Same as Q303	
Q318		TRANSISTOR: 2N4870, silicon, unijunction	20861-144
Q319		Same as Q303	
Q320		Same as Q308	
Q321		Same as Q308	
Q322		Same as Q305	
Q323		TRANSISTOR: D40N1, silicon, NPN	20861-324
Q324		Same as Q323	
Q401		Same as Q305	
Q402		Same as Q305	
Q403		Same as Q303	
Q404		TRANSISTOR: 2N5780, NPN, silicon	20861-326
Q405		Same as Q305	
Q406		Same as Q102	
Q407		Same as Q102	
Q408		Same as Q101	
Q2201	2	TRANSISTOR: selected, FET	20861-330
Q2202	2	Same as Q2201	
Q2203		Same as Q301	
Q2204		Same as Q302	
Q2205		Same as Q302	
Q2206		TRANSISTOR: 2N3638 silicon, PNP	20861-65
Q2207		Same as Q2206	
Q2208		Same as Q302	
Q2209		TRANSISTOR: 2N3566, silicon, NPN	20861-122
Q2210		Same as Q2201	
Q2211		Same as Q2201	
Q2212		Same as Q301	
Q2213		Same as Q302	
Q2214		Same as Q303	
Q2215		Same as Q303	
Q2216		Same as Q303	
Q2217		Same as Q308	
Q2218		Same as Q308	
R101		RESISTOR, FIXED, DEPOSITED CARBON: 82K ohms, 5%, 1/4 watt	18470-823
R102		RESISTOR, FIXED, COMPOSITION: 16K ohms, 5%, 1/2 watt	18413-161
R103		RESISTOR, VARIABLE: miniature, 50K ohms, .25 watt	16925-784
R104		RESISTOR, FIXED, COMPOSITION: 10 ohms, 10%, 1 watt	18420-102
R105		RESISTOR, FIXED, DEPOSITED CARBON: 100 ohms, 5%, 1/4 watt	18470-101
R106		RESISTOR, FIXED, METAL OXIDE: 510 ohms, 5%, 4 watt	18575-539
R107		Same as R105	
R108		RESISTOR, VARIABLE: wire wound, 50 ohms, 20%, 2 watt	16925-636
R109		RESISTOR, FIXED, DEPOSITED CARBON: 220 ohms, 5%, 1/4 watt	18470-221
R110		RESISTOR, FIXED, DEPOSITED CARBON: 100K ohms, 5%, 1/4 watt	18470-104
R111		Same as R110	
R239		RESISTOR, FIXED, DEPOSITED CARBON: 6.8K ohms, 5%, 1/4 watt	18470-682
R240		RESISTOR, FIXED, DEPOSITED CARBON: 4.7 ohms, 5%, 1/4 watt	18555-80
R241		RESISTOR, FIXED, METAL OXIDE: 1.4K ohms, 5%, 10 watt	18575-622
R242		RESISTOR, FIXED, DEPOSITED CARBON: 33 ohms, 5%, 1/4 watt	18470-330
R243		Same as R105	
R244		Same as R242	
R245		Same as R240	
R246		Same as R239	
R247		Same as R241	
R251		RESISTOR, FIXED, DEPOSITED CARBON: 24K ohms, 5%, 1/4 watt	18470-243
R252		Same as R251	
R253		Same as R251	
R301		RESISTOR, FIXED, DEPOSITED CARBON: 62K ohms, 5%, 1/4 watt	18470-623
R302		RESISTOR, FIXED, DEPOSITED CARBON: 51K ohms, 5%, 1/4 watt	18470-513
R303		RESISTOR, FIXED, DEPOSITED CARBON: 330 ohms, 5%, 1/4 watt	18470-331
R304		RESISTOR, FIXED, DEPOSITED CARBON: 240 ohms, 5%, 1/4 watt	18470-241
R305		Same as R303	
R306		RESISTOR, FIXED, DEPOSITED CARBON: 2.7K ohms, 5%, 1/4 watt	18470-272

REF. DESIG.	NOTES	DESCRIPTION	HICKOK PART NO.
R307		Same as R105	
R308		RESISTOR, FIXED, DEPOSITED CARBON: 4.3K ohms, 5%, 1/4 watt	18470-432
R309		RESISTOR, FIXED, DEPOSITED CARBON: 8.2K ohms, 5%, 1/4 watt	18470-822
R310		RESISTOR, VARIABLE: rotary, 5K ohms, 30%	16925-777
R311		Same as R242	
R312		RESISTOR, FIXED, DEPOSITED CARBON: 200 ohms, 5%, 1/4 watt	18470-201
R313		RESISTOR, FIXED, DEPOSITED CARBON: 120 ohms, 5%, 1/4 watt	18470-121
R314		RESISTOR, FIXED, DEPOSITED CARBON: 180 ohms, 5%, 1/4 watt	18470-181
R315		RESISTOR, FIXED, DEPOSITED CARBON: 6.2K ohms, 5%, 1/4 watt	18470-622
R316		RESISTOR, FIXED, DEPOSITED CARBON: 27K ohms, 5%, 1/4 watt	18470-273
R317		RESISTOR, FIXED, DEPOSITED CARBON: 3.6K ohms, 5%, 1/4 watt	18470-362
R318		Same as R315	
R319		RESISTOR, FIXED, DEPOSITED CARBON: 110 ohms, 5%, 1/4 watt	18470-111
R320		RESISTOR, FIXED, DEPOSITED CARBON: 10K ohms, 5%, 1/4 watt	18470-103
R321		RESISTOR, FIXED, DEPOSITED CARBON: 150K ohms, 5%, 1/4 watt	18470-154
R322		RESISTOR, FIXED, DEPOSITED CARBON: 15K ohms, 5%, 1/4 watt	18470-153
R323		RESISTOR, FIXED, DEPOSITED CARBON: 2K ohms, 5%, 1/4 watt	18470-202
R324		Same as R105	
R325		Same as R320	
R326		RESISTOR, FIXED, DEPOSITED CARBON: 470 ohms, 5%, 1/4 watt	18470-471
R327		RESISTOR, FIXED, DEPOSITED CARBON: 150 ohms, 5%, 1/4 watt	18470-151
R328		RESISTOR, FIXED, DEPOSITED CARBON: 1.1K ohms, 5%, 1/4 watt	18470-112
R329		Same as R313	
R330		Same as R239	
R331		Same as R326	
R332		RESISTOR, FIXED, DEPOSITED CARBON: 620 ohms, 5%, 1/4 watt	18470-621
R333		Same as R320	
R334		Same as R315	
R335		RESISTOR, VARIABLE: miniature, 10K ohms, 20%, .1 watt	16925-779
R336		Same as R239	
R337		Same as R326	
R338		RESISTOR, FIXED, DEPOSITED CARBON: 2.4K ohms, 5%, 1/4 watt	18470-242
R339		RESISTOR, FIXED, DEPOSITED CARBON: 4.7K ohms, 5%, 1/4 watt	18470-472
R340		RESISTOR, FIXED, DEPOSITED CARBON: 910K ohms, 5%, 1/4 watt	18470-914
R341		RESISTOR, VARIABLE: rotary, 100K ohms, 30%	16925-778
R342		RESISTOR, FIXED, DEPOSITED CARBON: 5.1 K ohms, 5%, 1/4 watt	18470-512
R343		Same as R320	
R344		Same as R335	
R345		Same as R335	
R346		Part of S307	
R347		RESISTOR, FIXED, DEPOSITED CARBON: 100K ohms, 5%, 1/4 watt	18470-104
R348		Same as R340	
R349		RESISTOR, FIXED, DEPOSITED CARBON: 7.5K ohms, 5%, 1/4 watt	18470-752
R350		RESISTOR, FIXED, DEPOSITED CARBON: 47K ohms, 5%, 1/4 watt	18470-473
R351		Same as R309	
R352		RESISTOR, FIXED, DEPOSITED CARBON: 36K ohms, 5%, 1/4 watt	18470-363
R353		RESISTOR, FIXED, DEPOSITED CARBON: 22 ohms, 5%, 1/4 watt	18470-220
R354		RESISTOR, FIXED, DEPOSITED CARBON: 1K ohms, 5%, 1/4 watt	18470-102
R355		Same as R347	
R356		Same as R323	
R357		Same as R342	
R358		RESISTOR, FIXED, COMPOSITION: 18 megohms, 10%, 1/2 watt	18416-182
R359		Same as R315	
R360		Same as R328	
R361		RESISTOR, FIXED, DEPOSITED CARBON: 390 ohms, 5%, 1/4 watt	18470-391
R362		Same as R303	
R363		RESISTOR, FIXED, METAL FILM: 1 megohm, 1%, 1/4 watt	18555-35
R364		Same as R239	
R365		Same as R347	
R366		RESISTOR, FIXED, DEPOSITED CARBON: 3K ohms, 5%, 1/4 watt	18470-302
R367		RESISTOR, FIXED, DEPOSITED CARBON: 360 ohms, 5%, 1/4 watt	18470-361
R368		Same as R367	

REF. DESIG.	NOTES	DESCRIPTION	HICKOK PART NO
R369		Same as R314	
R370		Same as R109	
R371		Same as R335	
R372		Same as R320	
R373		Same as R309	
R374		RESISTOR, VARIABLE: 10K ohms, 30%, 1 watt	16925-773
R375		RESISTOR, FIXED, DEPOSITED CARBON: 3.9K ohms, 5%, 1/4 watt	18470-392
R376		RESISTOR, FIXED, METAL OXIDE: 15K ohms, 5%, 4 watt	18575-582
R377		Same as R376	
R378		Same as R105	
R379		RESISTOR, FIXED, DEPOSITED CARBON: 200 K ohms, 5%, 1/4 watt	18470-204
R380		Same as R302	
R381		Same as R379	
R382		RESISTOR, FIXED, DEPOSITED CARBON: 3 megohms, 5%, 1/4 watt	18470-305
R383		RESISTOR, FIXED, DEPOSITED CARBON: 1.5 megohms, 5%, 1/4 watt	18470-155
R384		RESISTOR, FIXED, DEPOSITED CARBON: 750K ohms, 5%, 1/4 watt	18470-754
R385		RESISTOR, FIXED, DEPOSITED CARBON: 300K ohms, 5%, 1/4 watt	18470-304
R386		RESISTOR, FIXED, METAL FILM: 150K ohms, 1%, 1/4 watt	18555-179
R387		RESISTOR, FIXED, DEPOSITED CARBON: 75K ohms, 5%, 1/4 watt	18470-753
R388		RESISTOR, FIXED, DEPOSITED CARBON: 30K ohms, 5%, 1/4 watt	18470-303
R389		Same as R322	
R390		Same as R349	
R391		Same as R239	
R392		RESISTOR, FIXED, DEPOSITED CARBON: 430 ohms, 5%, 1/4 watt	18470-431
R401		Same as R354	
R402		RESISTOR, FIXED, DEPOSITED CARBON: 91K ohms, 5%, 1/4 watt	18470-913
R403		Same as R301	
R404		Same as R354	
R405		Same as R323	
R406		Same as R342	
R407		Same as R342	
R408		Same as R323	
R409		Same as R302	
R410		Same as R320	
R411		Same as R342	
R412		Same as R316	
R413		RESISTOR, FIXED, COMPOSITION: 510K ohms, 5%, 2 watt	18434-511
R414		Same as R413	
R415		RESISTOR, VARIABLE: 300K ohms, 30%, 1 watt	16925-776
R416		RESISTOR, FIXED, COMPOSITION: 300K ohms, 5%, 1 watt	18424-301
R417		RESISTOR, FIXED, DEPOSITED CARBON: 43K ohms, 5%, 1/4 watt	18470-433
R418		RESISTOR, FIXED, DEPOSITED CARBON: 39K ohms, 5%, 1/4 watt	18470-393
R419		RESISTOR, FIXED, DEPOSITED CARBON: 470K ohms, 5%, 1/4 watt	18470-474
R420		RESISTOR, FIXED, DEPOSITED CARBON: 20K ohms, 5%, 1/4 watt	18470-203
R421		RESISTOR, FIXED, DEPOSITED CARBON: 13K ohms, 5%, 1/4 watt	18470-133
R422		Same as R417	
R423		Same as R347	
R424		Same as R382	
R425		RESISTOR, VARIABLE: miniature, 100K ohms, .25 watt	16925-785
R426		RESISTOR, VARIABLE: 50K ohms, 30%, 1 watt	16925-774
R427		RESISTOR, FIXED, DEPOSITED CARBON: 680K ohms, 5%, 1/4 watt	18470-684
R428		RESISTOR, VARIABLE: 100K ohms, 30%, 1 watt	16925-775
R429		RESISTOR, FIXED, DEPOSITED CARBON: 560 ohms, 5%, 1/4 watt	18470-561
R2201		Same as R363	
R2202		RESISTOR, FIXED, METAL FILM: 900K ohms, 1%, 1/4 watt	18555-69
R2203		RESISTOR, FIXED, METAL FILM: 111K ohms, 1%, 1/8 watt	18554-128
R2204		RESISTOR, FIXED, METAL FILM: 990K ohms, 1%, 1/4 watt	18555-112
R2205		RESISTOR, FIXED, METAL FILM: 10.1K ohms, 1%, 1/8 watt	18554-129
R2206		Same as R363	
R2207		RESISTOR, FIXED, METAL FILM: 1K ohms, 1%, 1/8 watt	18554-125
R2208		Same as R354	
R2209		RESISTOR, FIXED, COMPOSITION: 330K ohms, 10%, 1/2 watt	18414-332

REF. DESIG.	NOTES	DESCRIPTION	HICKOK PART NO.
R2210		Same as R239	
R2211		Same as R327	
R2212		Same as R105	
R2213		RESISTOR, VARIABLE: miniature, 100 ohms, 0.5 watt	16925-837
R2214		Same as R315	
R2215		Same as R315	
R2216		Same as R338	
R2217		Same as R374	
R2218		Same as R366	
R2219		Same as R366	
R2220		RESISTOR, FIXED, DEPOSITED CARBON: 160 ohms, 5%, 1/4 watt	18470-161
R2221		RESISTOR, VARIABLE: miniature, 470 ohms, 20%, .1 watt	16925-781
R2222		RESISTOR, VARIABLE: miniature, 100 ohms, 20%, .1 watt	16925-780
R2223		RESISTOR, FIXED, METAL FILM: 215 ohms, 1%, 1/4 watt	18555-180
R2224		Same as R375	
R2225		RESISTOR, FIXED, DEPOSITED CARBON: 11K ohms, 5%, 1/4 watt	18470-113
R2226		Same as R354	
R2227		Same as R338	
R2228		Same as R2223	
R2229		Same as R2220	
R2230		Same as R327	
R2231		RESISTOR, FIXED, DEPOSITED CARBON: 36 ohms, 5%, 1/4 watt	18470-360
R2232		Same as R2222	
R2233		Same as R2231	
R2234		RESISTOR, FIXED, DEPOSITED CARBON: 5.6 ohms, 5%, 1/4 watt	18555-126
R2235		Same as R327	
R2236		RESISTOR, VARIABLE: miniature, 4.7K ohms, 20%, .1 watt	16925-806
R2237		Same as R303	
R2238		Same as R242	
R2239		Same as R309	
R2240		RESISTOR, FIXED, DEPOSITED CARBON: 24 ohms, 5%, 1/4 watt	18470-240
R2241		Same as R303	
R2242		Same as R350	
R2243		Same as R363	
R2244		Same as R2202	
R2245		Same as R2203	
R2246		Same as R2204	
R2247		Same as R2205	
R2248		Same as R242	
R2249		Part of S2201	
R2250		Same as R363	
R2251		Same as R2207	
R2252		Same as R242	
R2253		Part of S2204	
R2254		Same as R354	
R2255		Same as R2209	
R2256		Same as R239	
R2257		Same as R327	
R2258		Same as R105	
R2259		Same as R2213	
R2260		Same as R315	
R2261		Same as R315	
R2262		Same as R338	
R2263		Same as R374	
R2264		Same as R2221	
R2265		Same as R2222	
R2266		RESISTOR, FIXED, METAL FILM: 324 ohms, 1%, 1/4 watt	18555-197
R2267		Same as R2266	
R2268		Same as R375	
R2269		Same as R2225	
R2270		Same as R354	
R2271		Same as R338	

REF. DESIG.	NOTES	DESCRIPTION	HICKOK PART NO.
R2272		Same as R2220	
R2273		Same as R2220	
R2274		RESISTOR, VARIABLE: miniature, 2.2K ohms, 20%, .1 watt	16925-815
R2275		Same as R392	
R2276		Same as R392	
R2277		Same as R242	
R2278		Same as R242	
R2279		Same as R354	
R2280		Same as R354	
R2281		RESISTOR, FIXED, DEPOSITED CARBON: 510 ohms, 5%, 1/4 watt	18470-511
R2282		Same as R323	
R2283		Same as R323	
R2284		Same as R317	
R2285		Same as R317	
R2286		Same as R323	
R2287		Same as R323	
R2288		Same as R312	
R2289		Same as R312	
R2290		Same as R109	
R2291		Same as R320	
R2292		Same as R109	
R2293		Same as R326	
R2294		Same as R242	
R2295		Same as R326	
R2296		Same as R242	
R2297		RESISTOR, FIXED, DEPOSITED CARBON: 3.3K ohms, 5%, 1/4 watt	18470-332
R2298		RESISTOR, FIXED, DEPOSITED CARBON: 1 megohm, 5%, 1/4 watt	18470-105
R2299		Same as R2298	
R2300		Same as R2298	
R2301		Same as R320	
R2302		Same as R366	
R2303		Same as R366	
RT101		RESISTOR: thermistor	18682-55
S101		SWITCH: slide, dpdt	19911-130
S301		SWITCH: slide, dptt	19911-132
S302		Same as S101	
S303		SWITCH: slide, dptt	19911-131
S304		Same as S303	
S305		Same as S303	
S306		Same as S101	
S307		SWITCH: rotary, horizontal sweep	19912-679
S2201		SWITCH: rotary, vertical attenuator	19912-680
S2202		Same as S303	
S2203		Same as S101	
S2204		Same as S2201	
S2205		Same as S303	
S2206		Same as S101	
S2207		SWITCH: rotary, 1 deck, phenolic, 5 positions	19912-695
T101	1	TRANSFORMER: driver	20800-402
T102	1	TRANSFORMER: power	20800-401
T401	1	TRANSFORMER: coupling	20800-403
V101		TUBE: CRT, 5DEP31F	20875-291

CALIBRATION PROCEDURE
MODEL 512 OSCILLOSCOPE

Equipment required.

1. Hickok Model 3300 DVM
2. Hickok Model CRO 5000
3. Krohn-Hite Model 4100 Oscillator
4. Tektronix Type 105 Square Wave Generator
5. Hewlett-Packard 738AR Voltmeter Calibrator
6. Tektronix LC Meter 130
7. Line Auto Transformer with AC Voltmeter, ±1% and Wattmeter, 50 watts full scale, accuracy ± 1 watt.

NOTE 1: Units to be calibrated should go to the calibrators with front panels mounted by two #8 screws through the front panel and into the side extrusions, four #6 screws through the front panel into the bottom 3 spacers and the left hand corner spacer, and the 3 bottom rotary switch mounting nuts.

NOTE 2: Units which have passed calibration should have the front panels mounted by the calibrator as specified in Note 1. This greatly reduces the chances of adjustments being moved when the covers are being installed.

NOTE 3: When operating the unit without the front panel, ground MUST be connected between the side extrusions and circuit ground. This is most easily accomplished by connecting four 6 inch clip leads between either side extrusion and the four spacers mentioned in Note 1.

NOTE 4: CAUTION: Whenever power supply and rear panel are being removed from unit, make sure that line cord is removed from powerline until the ground connection has been made.

When removing the power supply unit to adjust the CRT capacity balance the unit should be upside down with the CRT at the bottom. The power supply leads are long enough to allow the power supply to rest on the bench without applying strain to its interconnecting wiring.

NOTE 5: Whenever the power supply is removed from the side extrusions, ground MUST be connected between the side extrusions and circuit ground before the power is applied. This is most easily accomplished by connecting a 6 inch clip lead from either side extrusion to the chassis of the power supply.

NOTE 6: CAUTION. This unit contains 2.5kV. These voltages are found at the front of the unit on the FOCUS and INTEN pots and their associated tapes and wiring on the rear board on the INT LIMIT adjust pot and all the associated blanking circuitry, and in the power supply on the transformer and the 2650V and 2500V filters.

Pre-Calibration Fire Up

1. Power Supply

a. Before applying power measure the resistance from each of the power supply terminals to the chassis using a 3300 with power switch ON and not plugged in.

Supply	Wire	Resistance Approx.
+ 250V	R/W	greater than 30K
+ 125V	OR/W	greater than 30K
+ 5V	RED	100K
+ 15V	ORG	700Ω
- 15V	BLUE	700Ω
+2500V	3KV BRW	1.7 MegΩ
+2650V	3KV ORG	1.7 MegΩ

Also check the line cord terminals to chassis resistance with the power switch in the on position. This reading should be greater than 1000MΩ.

b. Center all internal potentiometers except for the Intensity limit pot R425 which should be adjusted fully counter clockwise, and the horiz. preamp balance R335 which will be adjusted as the unit is fired up.

Set Front Panel Controls as indicated:

MODE	A
A&B VERT INPUT	GND
A&B VERTICAL VOLTS/CM	10V
TRACE	AUTO
SLOPE	+
FILTER	NORM
SOURCE	INT
HORIZ GAIN	X1
HORIZ TIME/CM	1 M Sec
A&B VERT VARIABLE	CAL
HORIZ VARIABLE	CAL

2. Power Supply Calibration

a. Dress all leads away from the rear of the CRT mounted board.

b. Connect the 512 line cord to the Variac and move the 512 power switch to the on position. Slowly increase the Variac while watching the wattmeter. At 117V AC, the power drawn should not exceed 45 watts.

c. Measure the power supply voltages. They should fall within the limits of Chart A.

Chart A

Wire Color	Supply MIN	Supply MAX
Red/White	240	260
Or/White	120	128.5
Red	4.5	5.5
Orange	+ 14.10	+ 15.45
Blue	- 14.10	- 15.45

3. Horizontal Pre-Amp Calibration

Connect the CRO 5000 probe at the output of the horiz pre-amp, junction of Q313 and R339. Set the CRO 5000 to 5 ms/div. Adjust the horiz. pre-amp balance pot. R335 so that the ramp shown on the CRO 5000 starts at 0 volts ± .1 volt. (Adjust the CRO 5000 attenuator as is necessary to view this ramp.)

4. Vert Balance Adjust

a. Center the HORIZ POS and the A CHAN VERT POS controls. Adjust the INTEN control to approximately 3/8 of an inch from the top of its travel. With an insulated screw driver adjust A BAL R2213 until the trace is centered. Adjust FOCUS and ASTIG for the best display. Set A VERTICAL VOLTS/CM to the 50 volt range and readjust VERT POS so the trace is centered. Continue to alternate the VERTICAL VOLTS/cm switch. Adjust the BAL pot when on the 10V range and the VERT POS post on the 50V range until the trace moves less than 1 major division when switched between 50V and 10V/cm. (The BAL pot is quite critical.) The VERTICAL POS control should be within 1/4 inch of center with the trace centered. Slowly rotate the TRIGGER LEVEL control. The trace should remain over the entire range of the control.

b. Set MODE switch to B and repeat Step 4a for channel B, adjusting B BAL R2259.

5. Preliminary Vertical Final Current Adjust

Position the B VERTICAL POS control to its lowest position. Connect the DC voltmeter to the collector of Vertical output transistor Q214. Adjust the Vertical current limit pot R2236 to 24.0 ± .5V. The trace should be off screen. Position the VERTICAL POS control to its highest position. The trace should move upwards until off screen.

6. Horizontal Final Current Adjust

Switch HORIZ GAIN to X5.
Recenter VERT POS control.
Switch HORIZ TIME/cm to EXT.

Position the HORIZONTAL POS control to its extreme right position. Connect the DC Voltmeter to the collector of Horizontal output transistor Q323. Adjust the Horizontal current limit pot R371 to 23V ± 2V this is Voltage C. The dot should be off screen. Position the HORIZONTAL POS control to its extreme left position. Check the collector of the other Horizontal output transistor Q324 this is Voltage D. If Voltage D is more positive than C then no further adjustment is required. If Voltage D is less positive than Voltage C adjust Horizontal current limit pot R371 so Voltage D reads 30V ± 2V. The dot should still be off screen.

Repeat the procedure again setting the HORIZONTAL POS pot to the extreme right and the extreme left positions and checking Voltage C and D on collectors of Q323 and Q324 respectively. The difference between Voltage C and D should be less than 20 Volts.

7. Vertical Amplifier Gain Adjust, CHAN A

a. Set MODE switch to A. Connect the 738AR to the A VERTICAL INPUT BNC. Set the 738AR output selector to 400 ~ PTP and function to calibration. Set the A VERT INPUT switch to AC. Set the A VERTICAL VOLTS/CM switch to the 5V range, and the HORIZ TIME/cm switch to 5/ms.

b. Set the 738AR MULTIPLIER to 10. Set the 738AR range setting to 3. Adjust the TRIGGER LEVEL control for a stable pattern. Adjust the INTEN control for a dim display. Adjust FOCUS and ASTIG for the best display.

c. Adjust the X1, X2, X5 gain in the order shown below:

738AR MULTIPLIER	RANGE	VERTICAL VOLTS/CM	ADJUST	SCOPE DEFLECTION
10	3	5	R2232 (X5)	30 ± 1/4 minor div.
10	1	2	R2221 (X2)	25 ± 1/4 minor div.
10	.5	1	R2222 (X1)	25 ± 1/4 minor div.

d. Check the accuracy of the rest of the ranges following the chart below:

.1	.5	.01		25 ± 3/4 minor div.
.1	1	.02		25 ± 3/4 minor div.
.1	3	.05		30 ± 1 minor div.
1	.5	.1		25 ± 3/4 minor div.
1	1	.2		25 ± 3/4 minor div.
1	3	.5		30 ± 1 minor div.
100	.5	10		25 ± 3/4 minor div.
100	1	20		25 ± 3/4 minor div.
100	3	50		30 ± 1 minor div.

8. Vertical Amplifier Gain CHAN B

a. Set MODE switch to B. Connect the 738AR to the B VERT INPUT. Set the B Vertical and Horizontal controls as in steps 7a and 7b.

b. Adjust the X1, X2, X5 gain in order shown below:

738AR MULTIPLIER	RANGE	VERTICAL VOLTS/CM	ADJUST	SCOPE DEFLECTION
10	3V	5	R2274	30 ± 1/4 minor div.
10	1V	2	R2264	25 ±1/4 minor div.
10	.5V	1	R2265	25 ± 1/4 minor div.

c. Check the accuracy of the rest of the ranges following the chart below:

.1	.5	.01		25 ± 3/4 minor div.
.1	1	.02		25 ± 3/4 minor div.
.1	3	.05		30 ± 1 minor div.
1	.5	.1		25 ± 3/4 minor div.
1	1	.2		25 ± 3/4 minor div.
1	3	.5		30 ± 1 minor div.
100	.5	10		25 ± 3/4 minor div.
100	1	20		25 ± 3/4 minor div.
100	3	50		30 ± 1 minor div.

d. Set Front Panel controls as follows:

A&B VERT INPUT	AC
TRACE	AUTO
SLOPE	+
FILTER	NORM
SOURCE	INT
HORIZ GAIN	X1
HORIZ TIME/CM	20μ SEC
A&B VERT VARIABLE	CAL
HORIZ VARIABLE	CAL

9. Attenuator Compensation CHAN B

a. Connect the specified generator to the B VERT INPUT BNC. Adjust the output level for full screen deflection ± 1/4 major division. Adjust the specified trimmer for less than 1/4 minor division of tilt.

	VERTICAL VOLTS/CM	ADJUST
Krohn-Hite Square Wave Output 10kHz	.2V	C2221
Tektronix 105 10kHz	2V	C2225
Tektronix 105 10kHz	10V	C2229

b. Check the rest of the ranges for flatness of ± 1/2 minor division of tilt at full screen deflection using generators as below:

GENERATOR	VERTICAL VOLTS/CM
Krohn-Hite Square Wave	.01
	.02
	.05
	.1
	.5
Tektronix 105 10kHz	1V
	5V

The 20 and 50V ranges can not be checked for flatness at full screen. Check them at 2 major divisions of deflection. There should be little noticeable tilt.

10. Input Capacity CHAN B

Measure the input capacity at the B VERT INPUT of the .02 Volt range using the Tektronix 130 LC Meter. Set the VERTICAL VOLTS/cm switch for the .2. Adjust C2219 for the same input capacity as the .02 position. Set the VERTICAL VOLTS/cm switch to the 2 and the 20 position adjusting C2223 and C2227 respectively for the same input capacity as the .02 position. Rotate the VERTICAL VOLTS/cm control through all its ranges. The input should not vary by more than ± 1 pF.

11. Attenuator Compensation CHAN A

a. Set MODE switch to A. Connect specified generator to A VERT INPUT. Adjust the output level for full screen deflection ± 1/4 major division. Adjust the specified trimmer for less than ± 1/4 minor division of tilt.

	VERTICAL VOLTS/CM	ADJUST
Krohn-Hite 10kHz sq. wave	.2V	C2204
Tektronix 105 10kHz sq. wave	2V	C2208
Tektronix 105 10kHz sq. wave	10V	C2212

b. Check the rest of the ranges for flatness of ± 1/2 minor division of tilt at full screen deflection using generators as below:

GENERATORS	VERTICAL VOLTS/CM
Krohn-Hite Square Wave	.01
	.02
	.05
	.1
	.5
Tektronix 105 10kHz	1V
	5V

12. Input Capacity CHAN A

a. Measure the input capacity at the A VERT INPUT of .02V range using the Tektronix 130 LC Meter set the VERTICAL VOLTS/cm switch to .2. Adjust C2202 for the same input capacity as the .02V position.

b. Set the VERTICAL VOLTS/cm switch to 2 and 20 positions adjusting C2206 and C2210 respectively for the same input capacity as the .02 position. The input capacity should not vary by more than ± 1 pF.

13. Alternate, Chop and Add

Set Front Panel controls as shown:

A&B VERT INPUT	DC
A&B VERTICAL VOLTS/cm	.5
TRACE	AUTO
SLOPE	-
FILTER	NORM
SOURCE	INT
HORIZ. GAIN	X1
HORIZ TIME/cm	50mSec
VERT VARIABLE	CAL
HORIZ VARIABLE	CAL
A&B $+\uparrow$ $+\downarrow$	$+\uparrow$

a. Set MODE switch to A. Position trace into the upper half of screen. Set MODE switch to B and position trace to lower half of screen. Set MODE switch to ALT. The trace should alternate in top and bottom half of the screen.

b. Set MODE switch to CHOP. The upper and lower trace shall appear simultaneously.

c. Connect 1kHz SQ. WAVE from Krohn-Hite to the A and B VERT INPUT. Set MODE switch to B and adjust Krohn-Hite for 2 cm of display. Set MODE switch to ADD. The display shall be 4 cm ± 1.5 minor div.

14. Sweep Timing Adjust

Set MODE switch to A. Set HORIZ TIME/cm to 10mSec. Set the Krohn-Hite to 20.0 Hz. Adjust the Krohn-Hite for about 4 cm of deflection. Adjust the TRIGGER LEVEL control for a stable display starting on a low level. Adjust sweep timing pot R344 such that with the second falling edge on the 5th Vertical graticule line of the CRT the third falling edge is within ± 1/4 a minor division of the 10th Vertical graticule line.

Set the Krohn-Hite to 20 kHz and the frequency vernier control on the Krohn-Hite to the Cal position, and the HORIZONTAL TIME/cm control to 10μSec. Adjust sweep timing pot R345 in the same manner as R344.

15. Vertical Bandwidth Check CHAN A

a. Connect the Tektronix Type 190A Generator to the A VERT INPUT. Set the VERTICAL VOLTS/cm to the .5 volts range. Set the output adjust of 190 for 5 major division at 50 kHz

b. Adjust TRIGGER LEVEL as is necessary. Adjust the Tektronix 190 to 10 MHz. The amplitude on the screen shall be greater than 2.6 major divisions.

16. Vertical Bandwidth CHAN B

Set Mode Switch to B. Connect 190A to B VERT INPUT. Repeat Steps 15a and b.

Set Front Panel controls as indicated.

POWER SWITCH	OFF
VERT INPUT	AC
VERTICAL VOLTS/CM	.5
TRACE	AUTO
SLOPE	-
FILTER	NORM
SOURCE	INT
HORIZ GAIN	X5
HORIZ TIME/CM	EXT HORIZ INPUT
VERT VARIABLE	CAL
HORIZ VARIABLE	CAL
EXT HORIZ LEVEL	FULLY CLOCKWISE

17. CRT Capacity Balance

CAUTION: See Notes 4 and 5.

Move power switch to on position. Connect the square wave output of the Krohn-Hite to the B VERT INPUT. Set the Krohn-Hite for 999 kHz. Adjust for full 8 cm of deflection and adjust FOCUS INTEN and ASTIG for a dim trace. Using an insulated screw driver adjust trimmer C218 for 1 Vertical line. Move power switch to off position and remove line cord. Remount power supply.

18. Intensity Limit Adjust

Move power switch to on.

Set the Krohn-Hite to 1 kHz. Adjust the HORIZ POSITION control to set the pattern to the center of screen. Adjust FOCUS, INTEN, and ASTIG controls for 2 dim spots of the smallest diameter possible.

Adjust the amplitude of the Krohn-Hite and VERT POS so that the spots fall exactly on the 3rd and 7th major horizontal division lines from the bottom. Move the INTEN control to max intensity and reposition the center of the resulting lower dot on the 3rd major horizontal division line. The center of the upper dot should be 1.75 minor division above the 7th horizontal division line. Using an insulated screw driver, adjust the Intensity limit control R425 such that with the lower dot centered on the 3rd major horizontal division line, the center of the upper dot is 1.75 minor divisions above the 7th horizontal division line. If the range of R425 is such that the upper dot can not be set to 1.75 minor divisions above the 7th horizontal line, then set R425 to its extreme counter clockwise position.

19. The following tests should be run to insure proper operation of circuitry which has no calibration adjustments.

a. Check power consumption: Should be 40 watts ± 3.5 watts at 117V line with intensity at minimum.

b. Check trigger sensitivity: TRACE IN NORM POSITION.

Internally: Less than 2 minor divisions with a 1kHz square wave. Test performed on CHAN A and CHAN B.

Externally: Less than 200mV p to p at 1kHz square wave. Less than 500mV p to p at 10MHz sine wave.

c. Calibrator: Calibrator output voltage should be approximately 7.5 volts p to p and flat to ± 1/2 minor division of full screen deflection.

d. Video:

Perform the following tests to insure the operation of the TV triggering systems.

Connect the Video Signal to the VERT INPUT. Set the VERTICAL VOLTS/CM control and adjust TRIGGER LEVEL as necessary. Use ‡↕ switch to point sync tips downward.

Set the HORIZ TIME/CM switch to V. Set the FILTER switch to TV-V. Adjust the TRIGGER LEVEL control for 2 frames. Triggering should be quite stable.

Set the HORIZONTAL TIME/CM switch to H. Set the FILTER switch to TV-H. Adjust the TRIGGER LEVEL control for 2 lines. Triggering should be quite stable.

Adjust INTEN control to max. Connect the VITS generator to the VERT INPUT. Adjust the VERTICAL VOLTS/cm for approximately 1/2 screen of display. Use the ‡↕ switch to point sync tips downward. Set the HORIZONTAL TIME/cm switch to F1. Set the FILTER switch to NORM. Adjust the TRIGGER LEVEL control to obtain the F1 test signal.

Set the HORIZONTAL TIME/CM switch to F2. Adjust the TRIGGER LEVEL control as necessary to obtain the F2 test signal.

VERT INPUT	DC
SLOPE	-

e. Horizontal Timing

Using the Krohn-Hite square wave output check each range as shown in the accompanying chart centering the first rising edge on the 5th vertical major division line and noting the position of the falling edge with respect to the 10th major division line. All the falling edges should fall within ± 2 minor divisions of this line. Adjust TRIGGER LEVEL as necessary to maintain trace.

HORIZONTAL TIME/CM	FREQ.
V	30 Hz
H	7.8 kHz
.5 μ sec	200 kHz
1 μ sec	100 kHz
2 μ sec	50 kHz
5 μ sec	20 kHz
20 μ sec	5 kHz
50 μ sec	2 kHz
.1 msec	1 kHz
.2 msec	500 Hz
.5 msec	200 Hz
1 msec.	100 Hz
2 msec.	50 Hz
5 msec.	20 Hz
20 msec.	5 Hz
50 msec.	2 Hz
.1 sec	1 Hz
.2 sec	.5 Hz

With the HORIZONTAL TIME/CM switch at .2 sec, adjust the HORIZ TIME/CM variable fully counter clockwise. The spot should continue to move across the screen at faster than 2 sec/cm.

Set controls as below:

VERT INPUT	DC
VERTICAL VOLTS/CM	1V
TRACE	NORM
SLOPE	+
FILTER	NORM
SOURCE	INT
HORIZ GAIN	X5
HORIZ TIME/CM	EXT HORIZ.
VERT VARIABLE	CAL
HORIZ VARIABLE	CAL
EXT HORIZ LEVEL	FULLY CLOCKWISE
HORIZ INPUT	AC

f. Check Horiz Bandwidth

Adjust the HORIZ POSITION control until the spot is centered on the screen. Connect the sine wave output of the Krohn-Hite to the EXT HORIZ INPUT BNC. Set the Krohn Hite at 1kHz. Adjust the RMS volts control of the Krohn-Hite for 10 cm of deflection. Set the Krohn-Hite for 999 kHz. The resulting deflection should be greater than 6 major division.

Rotate the EXT HORIZ LEVEL control fully counter clockwise. The resulting deflection should be approximately 1 major division.

Remove the cable from the EXT HORIZ INPUT and connect to the vertical input of the 5000 Oscilloscope. Set the 5000 to the 1V range. The peak to peak amplitude should be between 3. 5 and 6. 5 major divisions.

g. Check operation of the slop switch on the 1 kHz square wave.

h. Check the 1 MHz square wave response on both channels: Aberritions and ringing in the trace should not exceed 3 minor divisions for full screen deflectio

i. Check operation of the line trigger, by touching the Vertical Input with the finger and adjusting TRIGGER LEVEL for stationary trace.

j. Check operation of the trace locate switch:

Hold TRACE switch in the LOCATE position. The CRT display should shrink such that it cannot be positioned off screen. Release TRACE switch. It should return to AUTO position. Reposition trace to center of screen.

Final Vertical Final Current Adjust

Position the VERTICAL POS control to its lowest position. Connect the voltmeter to the collector of Q214. Allow three minutes for the voltages to stabilize. Set this voltage to 21.0 Volts ± .3V.

Position the VERTICAL POS control to its highest position and allow two minutes for stabilization. If the voltage at the collector of Q213 is 20.7 Volts or greater then no further adjustment is required. If the voltage is below 20.7 volts, adjust this voltage to 21 ± .3 volts with R2236.