HEATHKIT® MANUAL

for the

5 MHz PORTABLE OSCILLOSCOPE

Model IO-4541

595-1977-02

HEATH COMPANY • BENTON HARBOR, MICHIGAN

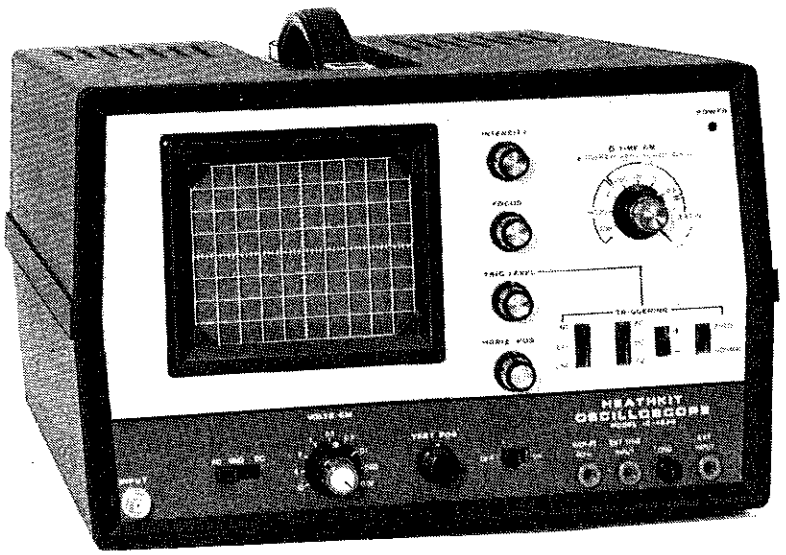
Heathkit® Manual

for the

5 MHz PORTABLE OSCILLOSCOPE

Model IO-4541

595-1977-02



HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

Copyright © 1976
Heath Company
All Rights Reserved
Printed in the United States of America

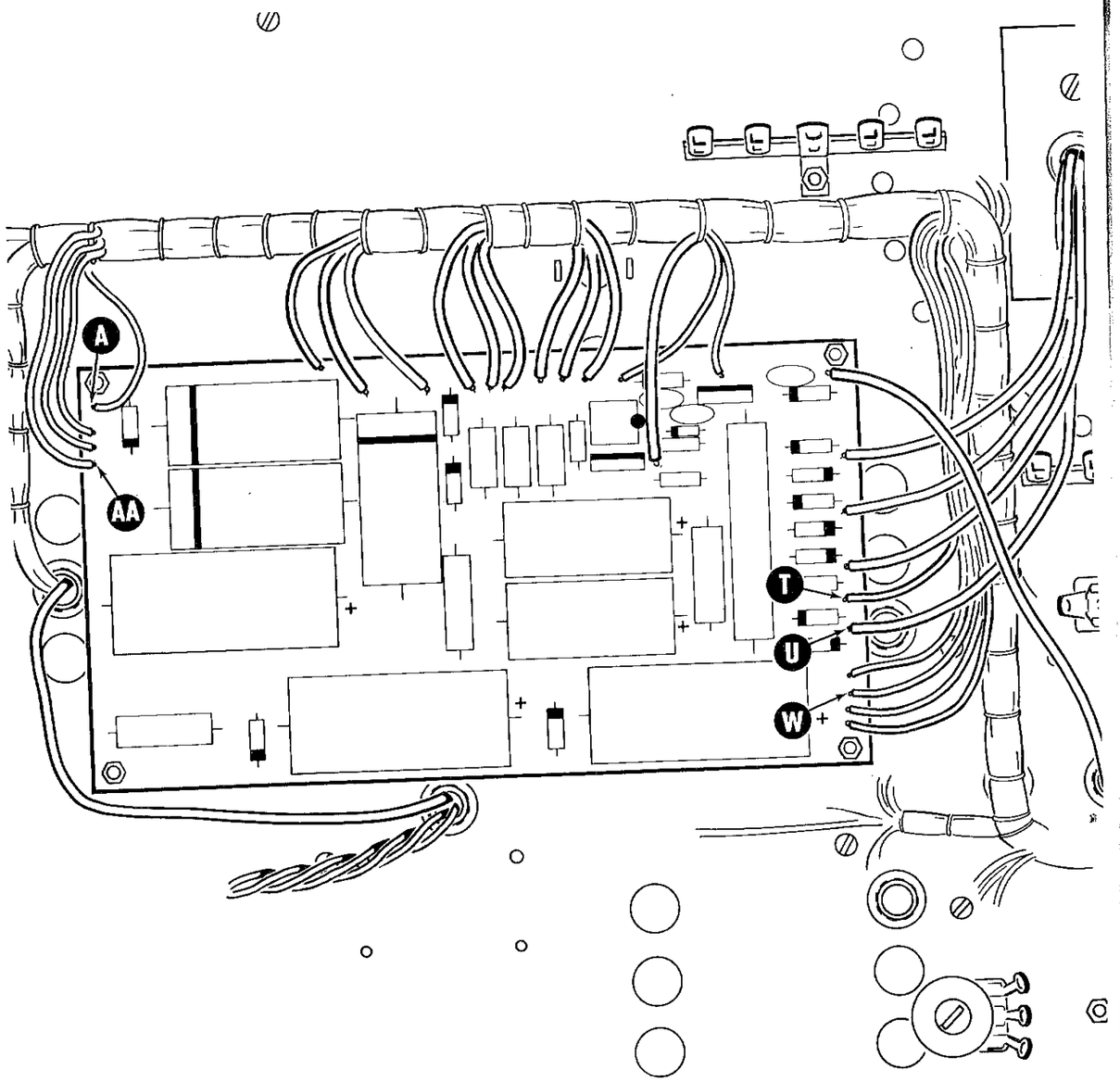


Figure 1-1

INITIAL TESTS

RESISTANCE MEASUREMENTS

( ) If an ohmmeter is available, measure the resistance between each flat plug prong and the round prong on the line cord. In both measurements you should obtain an infinite indication. Be sure the test probe is not touching the chassis or any connection.

If you do not obtain infinite indications, recheck all wiring and make sure no fine wire strands at any connection are touching another connection.

Use an ohmmeter to make the following resistance measurements before you apply power to the Oscilloscope. This will insure that the power supply will not be damaged due to a wiring error or some incorrectly installed or faulty part. If you do not get the proper indication in a step, check the wiring and installation of the parts listed in the "Possible Cause" column for that step. You may also refer to the "In Case of Difficulty" section of the Manual (Page 129). Be sure you obtain the correct resistance reading before proceeding.

Refer to Figure 1-1 for the following steps.

( ) Position the Oscilloscope bottom side up.

( ) Place the power ON-OFF switch in OFF position.

( ) Connect the negative ohmmeter lead to the chassis of the Oscilloscope. Then touch the positive meter lead to the points indicated in the following chart.

NOTE: Not all ohmmeters are polarized the same. Therefore, if you do not get the correct meter reading the first time, connect the positive meter lead to the chassis and touch the negative meter lead to the point indicated in the chart. If this produces the correct indication, cross out the word "positive" in the heading of the first column and write in "negative."

NOTE: The ohmmeter that was used to make the following measurements was powered by a 1.5 volt battery and set on the RX100 range.

Make all of the following measurements on the power supply circuit board.

POSITIVE METER LEAD TO:	APPROXIMATE METER READING	POSSIBLE CAUSE
( ) White wire at hole T.	700-1200 Ω	1. Capacitor C25. 2. Check power supply wiring, especially around C25. 3. Transformer T2.
( ) Red wire at hole U.	1000-4000 Ω	4. Diodes D404,D405,D406, and D407.
( ) Orange wire at hole W.	500-1000 Ω	1. Capacitor C407, C408, C409, C411, or C412. 2. Diodes ZD413,ZD414,ZD415,D408, D409,D410, or D411.
( ) Violet wire at hole AA.	50-300 Ω	1. Capacitor C408. 2. Diode ZD414,D408,D409,D410, or D411. 3. Resistor R409.
( ) Green wire at hole A.	500-1000 Ω	1. Capacitor C409 or C411. 2. Diode ZD413.

This completes the Initial Tests. Proceed to "Calibration."

CALIBRATION

In this section you will set the circuit board and front panel controls of your Oscilloscope for proper operation. To do this you will need a high input impedance voltmeter. Perform the adjustments exactly as instructed and DO NOT connect the line cord to an AC outlet until you are instructed to do so.

Equipment needed: High input impedance voltmeter.

Refer to Pictorial 10-8 in the Illustration Booklet for the following steps.

Set the front panel controls as follows:

( ) INTENSITY: Full clockwise.

NOTE: The intensity will tend to come on quickly at one point of the control's rotation. This is normal.

( ) FOCUS: Center of rotation.

( ) TRIG LEVEL: Center of rotation.

( ) HORIZ POS: Center of rotation.

( ) TIME/CM: X10.

( ) SWEEP VAR/HORIZ GAIN: Full clockwise.

( ) VOLTS/CM: .02.

( ) VARIABLE: Full clockwise.

( ) VERT POS: Center of rotation.

( ) AC-GND-DC: GND.

( ) OFF-ON switch: OFF.

( ) INT-EXT-LINE switch: INT.

( ) AC-DC-TV switch: AC.

( ) POSITIVE (+) NEGATIVE (–) switch: +.

( ) AUTO-NORMAL switch: AUTO.

( ) Set the ASTIGMATISM control on the chassis (see Figure 1-2 in the Illustration Booklet) to the center of its rotation.

Set the following controls on the vertical amplifier circuit board as follows:

( ) DC LEVEL: Center of rotation.

( ) POS ADJ: Center of rotation.

( ) PLATE VOLTS ADJ: Center of rotation.

( ) VERT CAL: Center of rotation.

( ) DC BAL: Center of rotation.

( ) TRIMMER C107: Turn the screw down until it is snug. Then turn the screw counterclockwise 3/4 of a turn.

Set the following controls on the horizontal amplifier circuit board as follows:

( ) SWEEP LENGTH: Center of rotation.

( ) PLATES VOLTS ADJ: Center of rotation.

( ) DC BAL: Center of rotation.

Set the following controls on the sweep-trigger circuit board as follows:

( ) SWEEP CALIBRATE: Center of rotation.

( ) LEVEL SET: Center of rotation.

CAUTION: AC and DC voltages in some areas of the Oscilloscope may exceed 1300 volts. Be very careful when you make the following adjustments. Make sure the Oscilloscope is setting on a nonmetallic surface and is not within reach of a water pipe or other ground conductor. The dangerous voltage areas are shown on Pages 150 and 151.

( ) Connect the Oscilloscope line cord to an AC outlet.

( ) Connect the negative voltmeter lead to the chassis of the Oscilloscope.

( ) Set the voltmeter to measure 1.5 volts DC.

NOTE: If you do not get the proper results in the following steps, recheck the steps to make sure you have adjusted the correct controls. If you still do not get the indicated results, turn the Oscilloscope off and refer to the "In Case of Difficulty" section on Page 129.

( ) Set the ON-OFF switch on the Oscilloscope to the ON position. The red POWER lamp should light. Allow the Oscilloscope at least one minute to warm up.

VERTICAL AMPLIFIER ADJUSTMENTS

Perform the following adjustments on the vertical amplifier circuit board.

Refer to Figure 1-2 for the following steps.

( ) Touch the meter probe to the front lug of the VERT CAL control and adjust the DC BAL (DC Balance) control to obtain a zero volt reading.

( ) Set the voltmeter to measure 150 volts DC.

( ) Alternately measure the voltage on the metal tab on top of transistor Q109 and Q110. Adjust the POS ADJ (Position Adjust) control until both transistor voltages are the same. (As the voltage on one transistor decreases, the voltage on the other transistor will increase.) NOTE: If you cannot quite achieve this adjustment using the POS ADJ control on the circuit board, turn the VERT POS control on the front panel.

( ) Again measure the voltage on the metal tab on top of transistors Q109 and Q110. Turn the PLATE VOLTS ADJ control to obtain 80 volts on the metal tabs. NOTE: If the voltage on both transistor tabs is not the same, repeat the previous step and then return to this step.

Vertical Balance Adjustment

( ) Turn the VARIABLE control on the front panel full counterclockwise.

( ) Using the VERT POS (Vertical Position) control on the front panel, position the dot on the CRT so it is on one of the horizontal graticule lines.

( ) Now turn the VARIABLE control full clockwise. If the dot moved up or down, adjust the DC BAL control on the vertical amplifier circuit board to reposition the dot back on the line.

( ) Repeat the previous three steps until there is no movement.

NOTE: Because of the normal ageing of your Oscilloscope, you may have to repeat this adjustment periodically. To determine if the adjustment is necessary, turn the VARIABLE control from one end to the other and see if the dot or trace moves up or down. The trace should remain in the same place.

HORIZONTAL AMPLIFIER ADJUSTMENTS

Perform the following adjustments on the horizontal amplifier circuit board.

( ) Set the voltmeter to measure 1.5 volts DC.

Refer to Figure 1-2 (in the Illustration Booklet) for the following steps.

( ) Touch the meter probe to the collector (C) lead of transistor Q202 and adjust the DC BAL (DC Balance) control to obtain a zero volt reading.

( ) Set the voltmeter to measure 150 volts.

( ) Alternately measure the voltage on the metal tab on top of transistors Q207 and Q208. Adjust the HORIZ POS (Horizontal Position) control on the front panel until they are equal. NOTE: As the voltage on one transistor decreases, the voltage on the other transistor will increase.

( ) Again measure the voltage on the metal tab on top of transistors Q207 and Q208. Turn the PLATE VOLTS ADJ control to obtain 90 volts on the metal tabs. NOTE: If the voltage on both transistor tabs is not the same, repeat the previous step and then return to this step.

Horizontal Balance Adjustment

( ) Turn the SWEEP VAR/HORIZ GAIN control full counterclockwise.

( ) Using the HORIZ POS (Horizontal Position) control on the front panel, position the dot on the CRT so it is on one of the vertical graticule lines.

( ) Now turn the SWEEP VAR/HORIZ GAIN control full clockwise. If the dot moves left or right, adjust the DC BAL control on the horizontal amplifier circuit board to reposition the dot back on the line.

( ) Repeat the previous three steps until there is no movement.

NOTE: Because of the normal ageing of your Oscilloscope, you may have to repeat this adjustment periodically. To determine if the adjustment is necessary, turn the SWEEP VAR/HORIZ GAIN control from one end to the other and see if the dot or trace moves up or down. The trace should remain in the same place.

TRIGGER CIRCUITS

Make the following adjustments on the front panel.

Refer to Pictorial 10-8 for the following steps.

( ) Turn the FOCUS control to obtain the smallest, sharpest spot of light on the CRT.

( ) Turn the ASTIGMATISM control on the chassis (see Figure 1-2) to obtain the smallest, sharpest spot of light on the CRT.

( ) Set the TIME/CM selector to the 2 mS position.

( ) Make sure that the VARIABLE control on the TIME/CM selector is turned fully clockwise.

Refer to Figure 1-2 (in the Illustration Booklet) for the following steps.

( ) Set the voltmeter to measure 1.5 volts DC.

( ) Touch the meter probe to the S (source) lead of transistor Q301 on the sweep-trigger circuit board and turn the LEVEL SET control to obtain a zero volt reading.

( ) Disconnect the voltmeter and set it aside.

( ) Inspect the trace on the CRT to see if it is parallel with the horizontal lines on the graticule. If it is, proceed to step 2. If the trace is not parallel to the graticule lines, complete all of the following steps.

1. ( ) Grasp the CRT just back from the front panel and turn the tube to make the trace parallel with the graticule lines.

2. ( ) Make sure the CRT is positioned all the way forward. Then tighten the CRT clamp screws. Tighten these screws only enough to keep the CRT from moving.

( ) Set the TIME/CM selector to the .2 μS position.

( ) Adjust the HORIZ POS control on the front panel so the trace starts at the left vertical line of the graticule.

( ) Adjust the SWEEP LENGTH control on the horizontal amplifier circuit board so that the trace ends at the right vertical line of the graticule (10 centimeters long). If the trace is longer than 10 centimeters it is alright.

( ) Connect a wire from the 1V (P-P) 60 Hz jack on the front panel to the vertical INPUT on the front panel of the Oscilloscope, or if you have a signal generator capable of producing a 60 Hz sine wave, connect it to the vertical INPUT.

( ) Set the TIME/CM selector to the 2 mS position.

( ) Set the VOLTS/CM (volts per centimeter) control on the front panel to the 1 position. Make sure that the VARIABLE control remains fully clockwise.

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

NOTE: In the next step it is not necessary to have the full sine wave displayed on the CRT. Only the leading part of the trace (on the left side of the CRT) will be used in this adjustment.

( ) Set the amplitude of the generator to produce a 6 centimeter vertical display on the CRT. NOTE: If you are using the 1V (P-P) 60 Hz jack on the front panel, disregard this step.

( ) Adjust the TRIG LEVEL (trigger level) control on the front panel to obtain a stable display.

( ) Center the display on the CRT by adjusting the VERT POS control.

( ) Now adjust the TRIG LEVEL control to obtain a trace that starts on the center horizontal line. (Make sure the display is centered on the CRT.)

( ) Set the AC-DC-TV switch to DC.

( ) Adjust the DC LEVEL control on the vertical amplifier circuit board to obtain a stable display with a trace that begins on the center horizontal line on the CRT.

( ) Now switch the AC-DC-TV switch back and forth between the AC and DC positions. The display should remain stable and the trace should begin at the same place in both positions. Repeat the DC LEVEL adjustment if necessary.

Trimmer Preset

Refer to Figure 1-3 (in the Illustration Booklet) for the following steps.

( ) Disconnect the line cord from the AC outlet.

( ) Position the Oscilloscope on its right side (transformer cage side) for the following steps.

NOTE: In the following steps, you must insert the screwdriver through the holes in the shield to reach the trimmer screws.

( ) Turn the screw in trimmer C2-A out exactly 3/4 turn.

( ) Turn the screw in trimmer C2-B out exactly 3/4 turn.

( ) Turn the screw in trimmer C2-C out exactly 3/4 turn.

Trigger Circuits Continued

NOTE: To complete the following calibration procedure, you will need a signal generator capable of producing 500 Hz sine waves and square waves at 500 Hz, 1000 Hz, and 100 khz, or an oscilloscope calibrator. If you do not have such a generator, proceed to "Vertical Calibration" on Page 118.

( ) Position the Oscilloscope right-side-up. Then reconnect the line cord to the AC outlet.

( ) Connect the signal generator or oscilloscope calibrator to the vertical INPUT of the Oscilloscope (if it is not already connected), and set it to produce a 500 Hz square wave. NOTE: If your oscilloscope calibrator is not capable of producing 500 Hz, use 1000 Hz.

NOTE: In the following steps, the term "signal generator" will also apply to your oscilloscope calibrator if you are using one.

( ) Adjust the output of your signal generator to obtain a 4-centimeter vertical display.

( ) Adjust the SWEEP CAL (sweep calibrate) control on the sweep-trigger circuit board to obtain a one-cycle-per-centimeter display on the CRT. Make sure you include the upper and lower part of the square wave. NOTE: If you are using 1000 Hz as your generator frequency, adjust the control to obtain two cycles per centimeter. NOTE: After you have done this step, check the length of the trace. If it is less than 10cm, slightly readjust the SWEEP LENGTH control on the horizontal amplifier circuit board. Then repeat this step. Because these controls interact, we suggest that you repeat this procedure three or four times.

( ) Set the signal generator to produce a 500 Hz sine wave. If your generator will not produce a sine wave, place the AC-GND-DC switch on the Oscilloscope in the GND position.

( ) Adjust the transformer cage (by turning it) for the sharpest, clearest trace on the CRT.

( ) Turn the Oscilloscope off, disconnect the signal generator, and disconnect the line cord from the AC outlet.

( ) Turn the Oscilloscope over.

( ) Refer to Figure 1-4 in the Illustration Booklet and move the transformer cage so that a screw hole in the cage lines up with a hole in the chassis. Then install a 6-32 x 1/4" hex head sheet metal screw in the hole to keep the transformer cage from moving. Also tighten the four screws in the grommet plate.

( ) Turn the Oscilloscope over and connect the line cord to an AC outlet.

VERTICAL COMPENSATION

( ) Connect the signal generator to the vertical INPUT on the front of the Oscilloscope.

( ) Set the signal generator to produce a 100 kHz square wave.

( ) Set the VOLTS/CM selector on the front panel to the .1 position.

( ) Turn the Oscilloscope on.

( ) Set the TIME/CM selector to 2 μS.

( ) Adjust the signal generator to produce a 4-centimeter display.

( ) Turn the screw in the VERTICAL COMPENSATION trimmer (C107) on the vertical amplifier circuit board (see Figure 1-2) until the waveform appears as shown in Figure 1-5 (shown in the Illustration Booklet).

( ) Set the VOLTS/CM selector to the 1 position.

( ) Set the TIME/CM switch to 200 μS.

( ) Set the signal generator to produce a 1000 Hz square wave.

( ) Set the amplitude of the signal generator to produce a 4-centimeter display.

( ) Disconnect the line cord from the AC outlet and position the Oscilloscope on its left side. Then reconnect the line cord.

( ) Turn the screw in trimmer C2-B (see Figure 1-3 in the Illustration Booklet) to obtain a waveform that appears like the one shown in Figure 1-5. Use an insulated screwdriver.

( ) Turn the VOLTS/CM switch to the 2 position.

( ) If possible, increase the amplitude of the signal generator to produce a 4-centimeter display on the CRT.

( ) Turn the screw in trimmer C2-C to obtain a waveform that appears like the one shown in Figure 1-5.

( ) Repeat all of the "Vertical Compensation" adjustments until there is no further improvement.

NOTE: If you have a low capacity probe, perform the following steps under "With Low Capacity Probe." If you do not have a low capacity probe, disregard the following steps and proceed to "Without Low Capacity Probe."

With Low Capacity Probe

( ) Connect the low capacity probe to the vertical INPUT on the Oscilloscope and to the signal generator.

( ) Set the signal generator to produce a 1000 Hz square wave signal to the Oscilloscope.

( ) Turn the VOLTS/CM selector on the Oscilloscope to the .02 position.

( ) Set the amplitude of the signal generator to produce a 4 centimeter vertical display on the CRT.

( ) Adjust the trimmer capacitor on the X10 low capacity probe to produce a waveform as shown in Figure 1-5.

( ) Turn the VOLTS/CM selector to the .2 position.

( ) If possible, increase the amplitude of the signal generator to produce a vertical display of 4 centimeters.

( ) Refer to Figure 1-3 and turn the screw in trimmer C2-A to produce a waveform as shown in Figure 1-5.

( ) Disconnect the low capacity probe and reconnect the signal generator to the vertical INPUT.

This completes the low capacity probe adjustment. Proceed to "Vertical Calibration."

Without Low Capacity Probe

( ) Refer to Figure 1-3 and turn the screw in trimmer C2-A in until it is just snug. Be careful that you do not overtighten the screw. Then turn the screw out 1/4 turn.

VERTICAL CALIBRATION

( ) Set the TIME/CM selector to the 2 mS position.

( ) Set the VOLTS/CM selector to the 0.2 position. Make sure the VARIABLE is full clockwise.

( ) Set the signal generator or oscilloscope calibrator to produce a IV(P-P), 60 Hz waveform. If your generator output is not calibrated or cannot be measured, connect instead a wire from the IV(P-P), 60 Hz jack on the Oscilloscope front panel to the vertical INPUT connector.

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

( ) Adjust the SWEEP VAR/HORIZ GAIN (Sweep Variable/Horizontal Gain) control to produce several cycles on the CRT.

( ) Refer to Figure 1-2 and turn the VERT CAL (Vertical Calibration) control, on the vertical amplifier circuit board, to obtain 5 centimeters of vertical deflection.

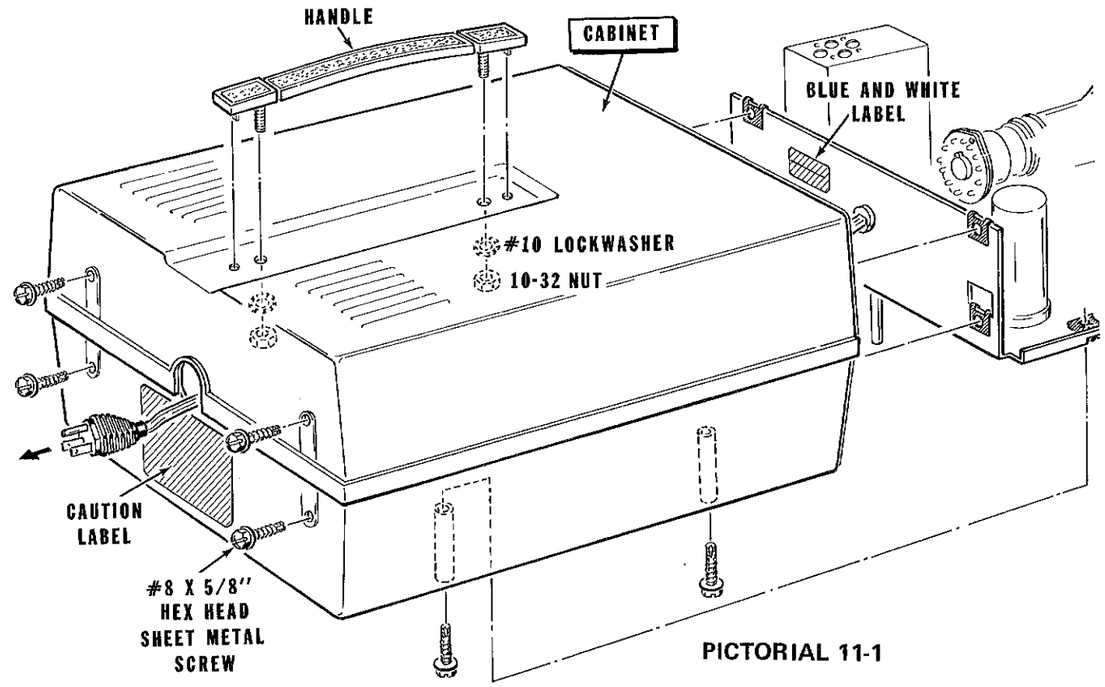
( ) Turn the Oscilloscope off and disconnect the line cord from the AC outlet.

( ) Disconnect the signal generator from the Oscilloscope.

NOTE: It is suggested that you repeat the "Calibration" after your Oscilloscope has operated several hours, and periodically thereafter. Each time, allow sufficient warm-up time (at least 30 minutes) before you start calibration.

This completes the calibration. Proceed to "Final Assembly."

FINAL ASSEMBLY



PICTORIAL 11-1

Refer to Pictorial 11-1 for the following steps.

( ) Locate the blue and white label. Be sure to refer to the numbers on this label in any communications you may have with the Heath Company about this kit.

( ) Remove the protective paper backing from the blue and white label. Then affix the label to the rear chassis panel.

( ) Locate the cabinet and handle. Mount the handle to the top of the cabinet with two #10 external lockwashers and two 10-32 nuts.

( ) Route the line cord into the cabinet and out the hole in the back of the cabinet. Then slide the cabinet over the chassis.

( ) Secure the cabinet to the chassis with eight #8 x 5/8" hex head sheet metal screws.

( ) Locate the "Caution" label and remove the protective paper backing. Then affix the label to the back of the cabinet in the space provided.

This completes the assembly of your Oscilloscope. Proceed to "Operation."

TROUBLESHOOTING PRECAUTION AND NOTES

WARNING: The full AC line voltage and high DC voltage is present at several places in the Oscilloscope. (See Pages 150 and 151.) Be careful to avoid electrical shock when you work on the Oscilloscope.

1. Be cautious when you test transistors and integrated circuits. Although they have almost unlimited life when used properly, they are easily damaged by excessive voltage and current.

2. Be careful so you do not short any terminals to ground when you make voltage measurements. If the probe should slip, for example, and short out a bias or voltage supply point, it may damage one or more components.

3. DO NOT remove any components while the Oscilloscope is turned on.

4. When you make repairs to the Oscilloscope, make sure you eliminate the cause as well as the effect of the trouble. If, for example, you should find a damaged resistor, be sure you find out what caused the resistor to become damaged. If the cause is not eliminated, the replacement resistor may also become damaged when the Oscilloscope is turned on again.

5. Refer to the "X-Ray Views," and the "Schematic Diagram," to locate various components.

6. When the oscilloscope Trigger Selector is in the "LINE" position, a trace may not be visible on the CRT above 20 μsec. The Oscilloscope will still be triggered, but the writing speed will be too fast to light the CRT.

TROUBLESHOOTING CHARTS

The "Troubleshooting Charts" are designed to pinpoint a trouble through a series of tests. The following symbols and procedures are used in the charts.

YES — Follow the "YES" arrow when you obtain the correct measurement or condition.

NO — Follow the "NO" arrow when you do not obtain the correct measurement or condition.

≈ — This symbol in a step means that the voltage listed immediately after the symbol may vary as much as ±20%. For example: If the step says, "≈ 100 volts DC," it means that the voltage could be 80 to 120 volts DC.

Components are listed in the order in which failure or a problem is most likely to occur.

All voltage measurements were made with a high impedance voltmeter with a nominal line voltage of 120 volts AC.

Set the front panel controls as follows:

INTENSITY: Center of rotation.

FOCUS: Center of rotation.

TRIGGER LEVEL: Center of rotation.

HORIZ POS: Center of rotation.

TIME/CM: X10 (full clockwise).

SWEEP VAR/HORIZ GAIN: CAL (full clockwise.

INT-EXT-LINE: INT

AC-DC-TV: AC

POSITIVE (+)-NEGATIVE (–): Positive (+)

AUTO-NORMAL: Normal

AC-GND-DC: GND

VOLTS/CM: 0.05

VARIABLE: CAL (full clockwise).

VERT POS: Center of rotation

OFF-ON: OFF

Do not change the position of any control or switch unless you are instructed in a step to do so.

Connect the line cord to an AC outlet and turn the Oscilloscope on.

Perform the ±9 and +5 volt power supply test (Test #1) in the Illustration Booklet to verify the operation of the power supplies before you proceed. These power supplies must operate properly before you attempt any further troubleshooting. After you have completed Tests #1, proceed to the "Trouble Locator Chart."

TROUBLE LOCATOR CHART

Alternately measure the collector voltages of Q109 and Q110. Adjust the VERT POS control (on the front panel) until these voltages are ≈ 80 volts DC.
- NO → A problem exists in the vertical deflection circuits. Proceed to Test #2.
- YES ↓

Alternately measure the collector voltages of Q207 and Q208. Adjust the HORIZ POS control until these voltages are equal at ≈ 90 volts DC.
- NO → A problem exists in the horizontal deflection circuits. Proceed to Test #3.
- YES ↓

Turn the INTENSITY control fully clockwise. A spot of light should be visible on the CRT.
- NO → A problem exists in the blanking and/or CRT circuits. Proceed to Test #4.
- YES ↓

Set the IN-EXT-LINE switch to LINE: Then turn the TIME/CM selector through all of its positions. A trace should appear on all positions except X1 and X10. Then turn the selector to the 200 μS position.
- NO → A problem exists in the trigger or sweep circuits. Proceed to Test #5 and #6.
- YES ↓

The major Oscilloscope circuits are operating properly. If a problem still exists, proceed to the test that most closely associates with the particular problem.

Accelerating Potential	Approximately 1.5 kV.
Graticule	Screened, 8 x 10 centimeters.
Power requirements	110-130 VAC or 220-260 VAC, 50/60 Hz, 35 watts.
Overall Dimensions	13" wide, 8" high, 17" deep.
Net Weight	14 lbs.

The Heath Company reserves the right to discontinue products and to change specifications at any time without incurring any obligation to incorporate new features in products previously sold.

CIRCUIT DESCRIPTION

Refer to the Schematic Diagram and the Block Diagram in the Illustration Booklet while you read the following circuit description.

To help you locate specific parts in the Oscilloscope or on the Schematic, the resistors, capacitors, transistors, and diodes are numbered in the following groupes:

1- 99	Parts on the chassis.
101-199	Parts on the vertical amplifier circuit board.
201-299	Parts on the horizontal amplifier circuit board.
301-399	Parts on the sweep-trigger circuit board.
401-499	Parts on the power supply circuit board.

VERTICAL AMPLIFIER

A signal applied to the vertical Input connector on the front panel of the Oscilloscope is coupled through the frequency-compensated attenuator network. Capacitor C1 blocks the DC when switch SW1 is in the AC position. From the attenuator circuit, a portion of the input signal is coupled through resistor R101 and capacitor C101 to the gate of transistor Q101. Diodes ZD101 and ZD102 are transistors connected to provide a zener action. Resistor R101 and these diodes limit the input signal to approximately ±9 volts, which protects Q101 from excessively high gate voltage. Capacitor C101 improves high frequency response by forming a high frequency path around R101.

Transistor Q101 is a field-effect transistor (FET) which is connected as a source follower. This type of transistor provides the high impedance input necessary to prevent loading of the attenuator.

Transistor Q102 is a constant current source for input transistor Q101. Since the base voltage of transistor Q102 is held constant by divider R105, R106, and the emitter voltage is dependent upon the base voltage, the emitter voltage will remain constant. This constant emitter voltage is across emitter resistor R103; therefore, the current through R103 is constant. Resistor R103 is adjusted so the source voltage of Q101 is zero when an input signal is not present.

A signal applied to the gate of Q101 will cause only voltage changes at the source because the current through Q101 is constant. These voltage variations are applied across resistors R102, R4, R5, R6, R7, and a portion of this signal is applied to the gate of source follower Q103.

Transistor Q104 forms a constant current source for transistors Q105 and Q106. Since the emitters of both transistors are connected to this constant current source, the current source serves as a common emitter resistance and sets the operating point for the following steps.

The output from source follower transistor Q103 is amplified by transistor Q105. A portion of the signal applied to the base of Q105 appears at its emitter. Because transistors Q105 and Q106 have a common emitter resistance, the signal present at the emitter of transistor Q105 is effectively coupled to the emitter of transistor Q106.

Transistor Q106 operates as a common base amplifier whose base is held constant by Vertical Position control R8. This control positions the trace by applying a controllable DC voltage to the base of transistor Q106, thus providing a controllable DC balance in the vertical amplifier. When the collector output voltage of Q105 decreases, its emitter voltage will increase. An increased emitter voltage at Q106 reduces its forward bias and increases its collector output voltage. The signal at the collector of transistor Q106 is 180 degrees out of phase with the signal at the collector of transistor Q105, forming a "push-pull" amplifier to drive the CRT deflection plates. Capacitor C104 is an emitter bypass capacitor to boost the gain at high frequencies.

Driver transistors Q107 and Q108 are common emitter amplifiers. In addition to providing gain, they also isolate transistors Q105 and Q106 from the output stages. Capacitor C105 AC bypasses the emitter resistors of Q107 and Q108 at high frequencies and improves the high frequency response. Output amplifiers Q109 and Q110 again amplify the differential signal and drive the vertical plates in the CRT. Transistor Q111 operates as an emitter follower and provides the trigger signal to the sweep circuit.

HORIZONTAL AMPLIFIER

Operation of the horizontal amplifier is similar to that of the vertical amplifier. The major difference is that the horizontal amplifier does not have a PNP amplifier stage (transistors Q107 and Q108 in the vertical amplifier).

The positive-going ramp voltage (sawtooth) from the sweep generator is amplified and applied to the horizontal plates of the CRT. This increasing voltage causes the electron beam to sweep across the face of the CRT, producing a visible trace.

SWEEP-TRIGGER CIRCUITS

Switch SW3 selects the source of the trigger signal (internal, external, or line) and couples this signal to switch SW4. Switch SW4 selects the type of coupling (AC, DC, or TV) that will be used to couple the signal to the triggering circuits. In the AC position, the signal is coupled through capacitor C6 to the triggering circuits. In the DC position the signal is coupled direct, and in the TV position the signal is coupled through capacitor C6, C7, resistor R12, and diode D1. The circuit composed of capacitor C7, resistor R12, and diode D1 forms a low-pass filter and DC restorer. This circuit allows the triggering circuits to be synchronized to the vertical frame rate of a complex video TV signal.

The triggering signal is coupled through resistor R302 to the gate (G) of transistor Q301. Resistor R301 determines the input resistance to Q301. ZD301 and ZD302 are transistors connected to provide a zener action. This diode configuration protects the input of Q301 by preventing the triggering signal from going greater than ±9 volts.

From transistor Q301, the signal is applied to differential amplifier transistors Q304 and Q305. From here the amplified signal is coupled through transistors Q306 and Q307 to slope switch SW8. This switch selects either the positive (+) or negative (–) slope of the waveform.

Transistor Q302 is the current source for Q301, and Q303 is the current source for Q304, and Q305. The trigger level control sets the amount of current that is allowed to flow through transistor Q302, which varies the DC level at the source (S) of transistor Q301. This change is coupled to and affects transistors Q304 and Q305 and, in turn, is coupled to transistors Q306 and Q307, which vary the voltage on lugs 1 and 3 of switch SW8.

The amplified signal (either positive or negative slope as is selected by switch SW8) is coupled to pin 9 of IC301C. IC301A, IC301B, IC301C, and IC301D are Schmitt input gates. That is to say, that at a specific positive level of the input signal the gate switches on, and at a specific level as the signal decreases the gate switches off. This switching on and off produces a pulse at the output of the gate.

As the signal is coupled to pin 9 of IC301C, it switches, and a negative pulse is produced at pin 8. This is coupled to pin 12 of IC303, causing IC303 to switch and produce a negative pulse at pin 8 and a positive pulse at pin 6. The pulse from pin 6 is coupled through resistor R318 to AC blanking transistor Q401, while the pulse from pin 8 is coupled through resistor R319 to DC blanking transistor Q308 and also to pin 12 of IC301D.

Two CRT blanking circuits (one AC coupled and one DC coupled) are employed in this Oscilloscope. The DC blanking circuit is more efficient at lower sweep frequencies. At higher sweep frequencies, the AC blanking is more efficient. In the following paragraphs both types of blanking will be discussed.

BLANKING

It is desirable to turn off the CRT during periods of "no signal" and also between successive sweeps so that the retrace lines are not visible. The CRT can be turned off (blanked) or on (unblanked) by a controlling voltage between the cathode and grid in the CRT. As the grid voltage becomes more positive with respect to the cathode, the trace will become brighter. The CRT is completely cut off when a sufficiently negative voltage is applied to the grid.

This Oscilloscope uses two blanking schemes: AC coupling to the grid, and DC coupling to the cathode of the CRT. The AC coupled system is operational all of the time; while the DC system is held off for frequencies over 60 Hz, due to the long on-off time of the device by capacitor C306 and R321. For frequencies less than 60 Hz, the AC system is unable to keep the tube blanked for long periods of time. The DC system is then used to keep the CRT blanked for the longer period of time.

Assume that the sweep generator is sweeping normally across the CRT. At this time, pin 8 of IC303 is high and pin 6 is low. (A low constitutes 0.5 volts or less and a high constitutes 2.5 volts or more.) With this condition, the AC and DC blanking systems are turned off. When the sweep voltage reaches a predetermined level, IC304 will change state and this causes IC303 to change state.

When IC303 changes state, pin 6 goes high which turns on transistor Q401 and causes the grid to go more negative, thus blanking the CRT. At the same time, pin 8 goes low and causes IC301D pin 11 to go high and turn on transistor Q310. Q310 shorts the sweep generator voltage back to zero volts. Transistor Q308 turns off and Q309 turns on at this time, which turns on the optical isolator (IC-401). The optical isolator turns off transistor Q402, which causes the cathode of the CRT to go more positive again, blanking the CRT.

The blanking and sweep circuits stay in this state until a trigger pulse is applied to IC303 and causes it to change state, and the sequence repeats itself again.

RAMP GENERATOR

The ramp generator is composed of transistor Q1, resistors R15, R16, and R17, and capacitors C8, C9, C11, C12, and C13. Transistor Q1 provides constant current to the timing resistors and capacitors which are selected by section A and C of switch SW6. When transistor Q310 is biased off, the selected timing capacitor (for example, we will use C8) begins to charge. This causes an increase or "ramp" of voltage that is coupled through resistor R327 to the gate of transistor Q311.

The ramp voltage is coupled through transistors Q311 and Q312 to pin 5 of IC304. Q311 and Q312 provide isolation to the ramp generator. When the ramp voltage increases to 1.2 volts, pin 1 of IC304 produces a pulse, which is coupled through diode D308 to pin 2 of IC303. This cancels the pulse on pins 6 and 8 of IC303 and allows the CRT to become blanked again.

With the pulse gone from pin 8 of IC303, transistor Q310 begins to conduct and the charge on capacitor C8 rapidly decays to zero. Thus, a sawtooth waveform has been formed by the charging of capacitor C8 and its rapid discharge. This sawtooth voltage is coupled through section C of switch SW6 to the horizontal amplifier circuit board.

IC301B is an anti-latch-up circuit. It is possible for a random pulse to be generated somewhere in the sweep circuits and cause IC303 or IC304 to miss their triggering pulse from IC302. If this should happen, the ramp voltage will increase until it reaches approximately 2 volts. This voltage is coupled through resistor R329 to pin 5 of IC301B. This causes a pulse to be produced at pin 6 of IC301B which is coupled through diode D309 to pin 2 of IC303, and IC303 reacts normally, as though it received the pulse from IC304.

POWER SUPPLY

Line voltage is connected through the fuse and the On-Off switch to the primary windings of power transformers T1 and T2. The dual primary windings of these transformers may be connected in parallel for 120 volt operation or in series for 240 volt operation. 240 volt operation is common outside the U.S.A.

The secondary windings of transformer T1 are connected to the voltage doubler circuit consisting of diodes D401, D402, and capacitors C405 and C406. Capacitor C404 filters this negative high voltage which is fed through resistor R27 to the grid of CRT. The intensity and focusing voltages are also supplied to the CRT from the voltage divider network consisting of resistors R28, R405, R403, R23, and R24. A separate 6.3 volt winding supplies the CRT filament voltage.

Optimum focus is obtained when the CRT deflection plates and the astigmatism grid are at the same potential. Since the vertical deflection plate voltages (collectors of Q109 and Q110) are adjusted to 80 volts DC by constant-current source Q104, the astigmatism voltage is also adjusted to approximately 80 volts DC.

The secondary windings of low voltage transformer T2 are connected to the full-wave bridge rectifier circuit which consists of diodes D408, D409, D410, and D411. Capacitor C412 filters the rectified DC. This DC voltage is regulated by zener diodes ZD413, ZD414, and ZD415. By connecting equal loads from each side of the supply to ground, separate supplies are obtained: These separate supplies are, +9 volts DC, −9 volts DC, and 5 volts DC.

Another secondary winding of transformer T2 is connected to another full-wave rectifier circuit which consists of diodes D404, D405, D406, and D407. Capacitor C25 filters the rectified DC voltage. A voltage divider circuit composed of resistors R32 and R33 provide 180 and 150 volt DC supplies.

A third secondary winding on transformer T2 supplies 1 volt peak-to-peak AC voltage to the front panel output jack.

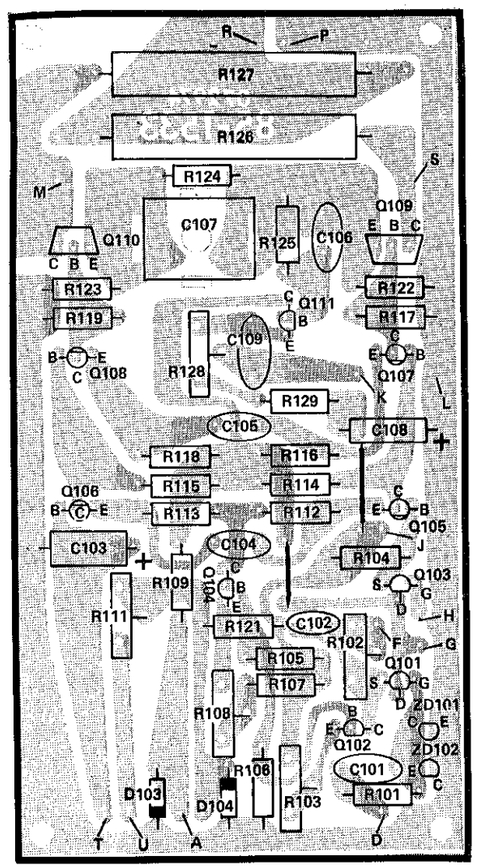
CIRCUIT BOARD X-RAY VIEWS

NOTE: To find the PART NUMBER of a component for the purpose of ordering a replacement part:

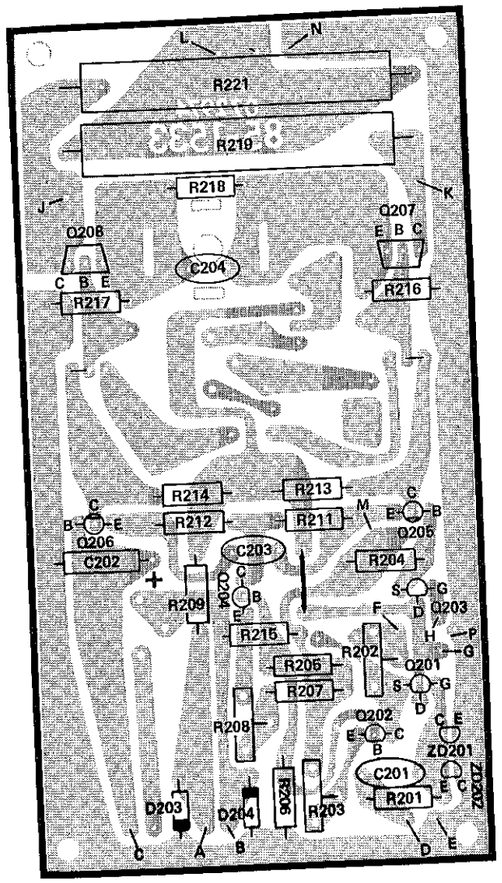
A. Find the circuit component number (R5, C3, etc.) on the X-Ray View.

B. Locate this same number in the "Circuit Component Number" column of the proper "Parts List."

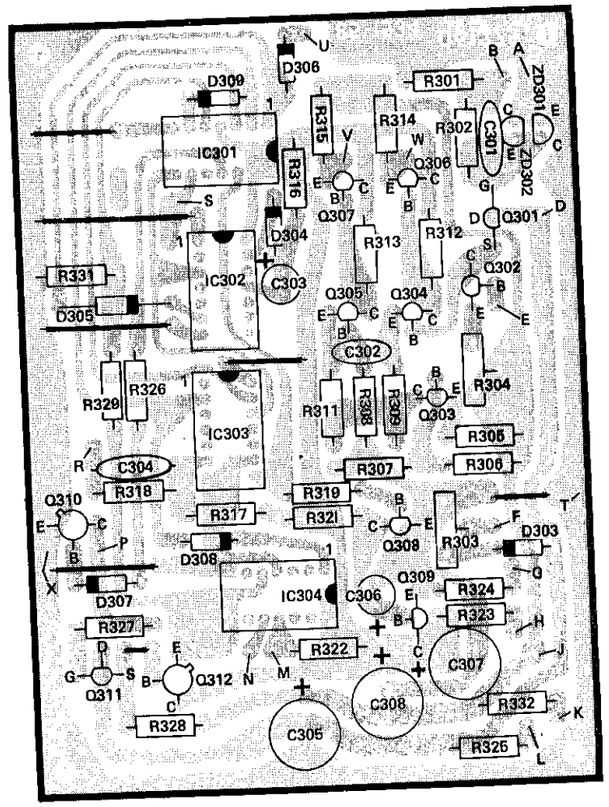
C. Adjacent to the circuit component number, you will find the PART NUMBER and DESCRIPTION which must be supplied when you order a replacement part.



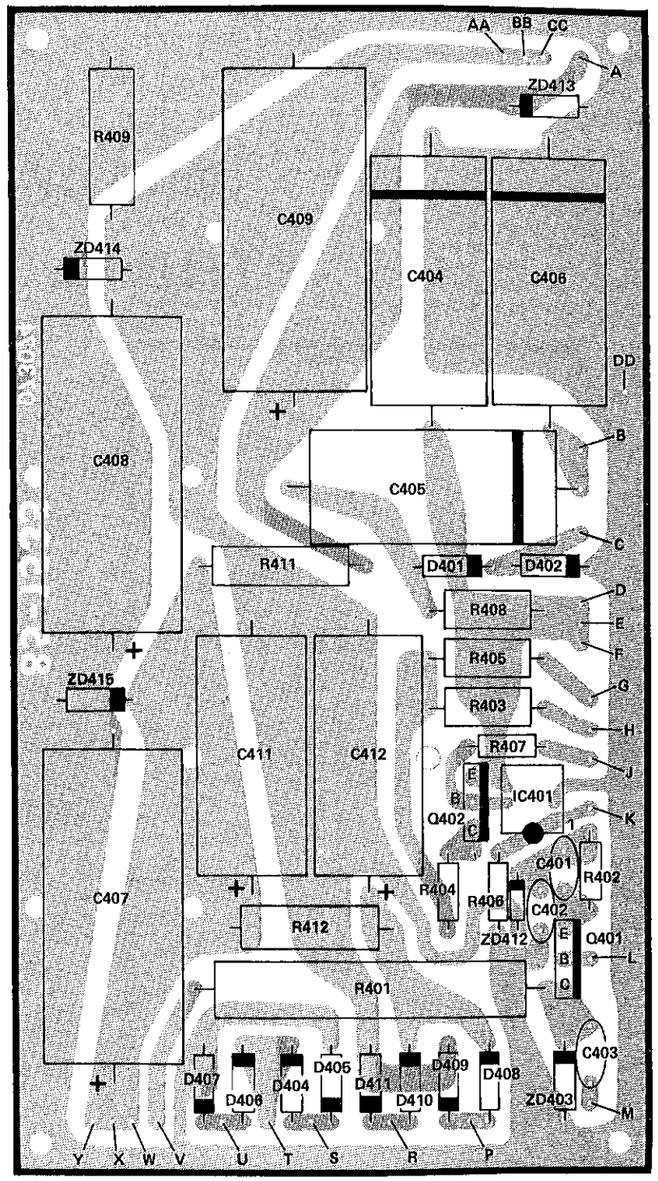
VERTICAL AMPLIFIER CIRCUIT BOARD
(Viewed from component side)



HORIZONTAL AMPLIFIER CIRCUIT BOARD
(Viewed from component side)

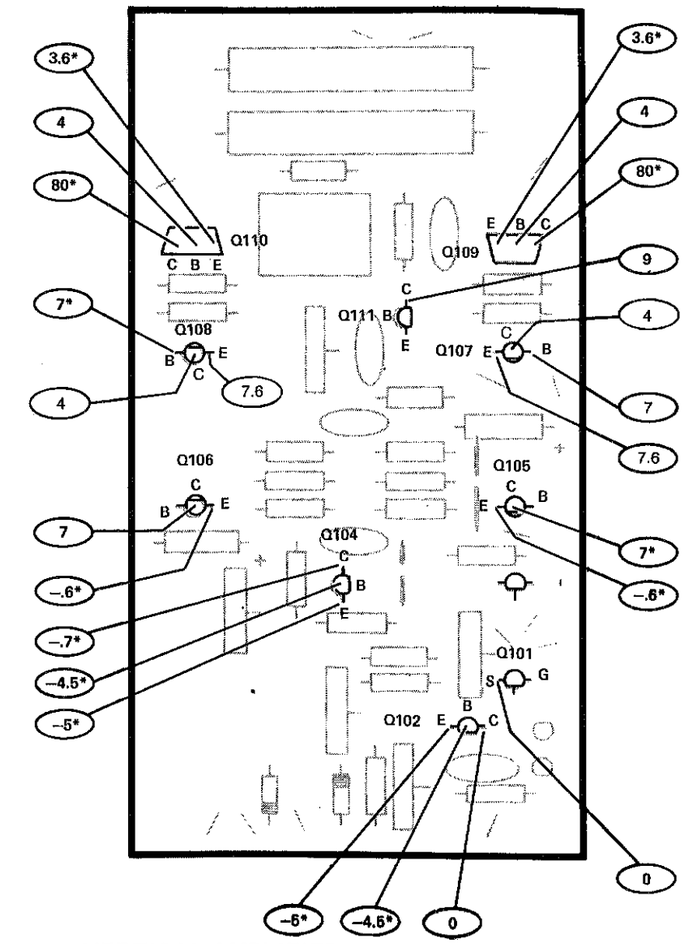


SWEEP TRIGGER CIRCUIT BOARD
(Viewed from component side)



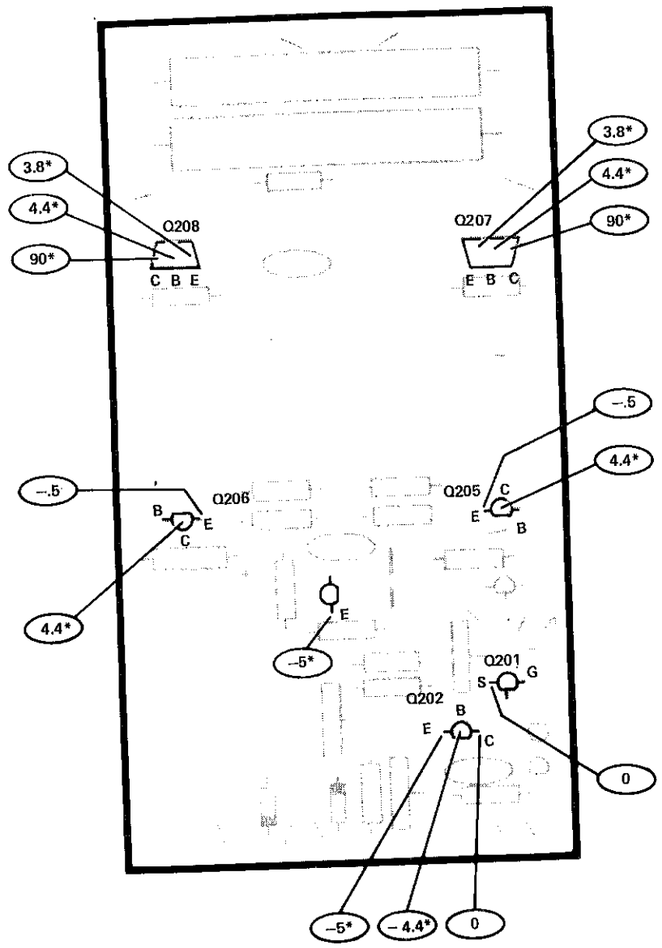
POWER SUPPLY CIRCUIT BOARD
(Viewed from component side)

CIRCUIT BOARD VOLTAGE CHARTS



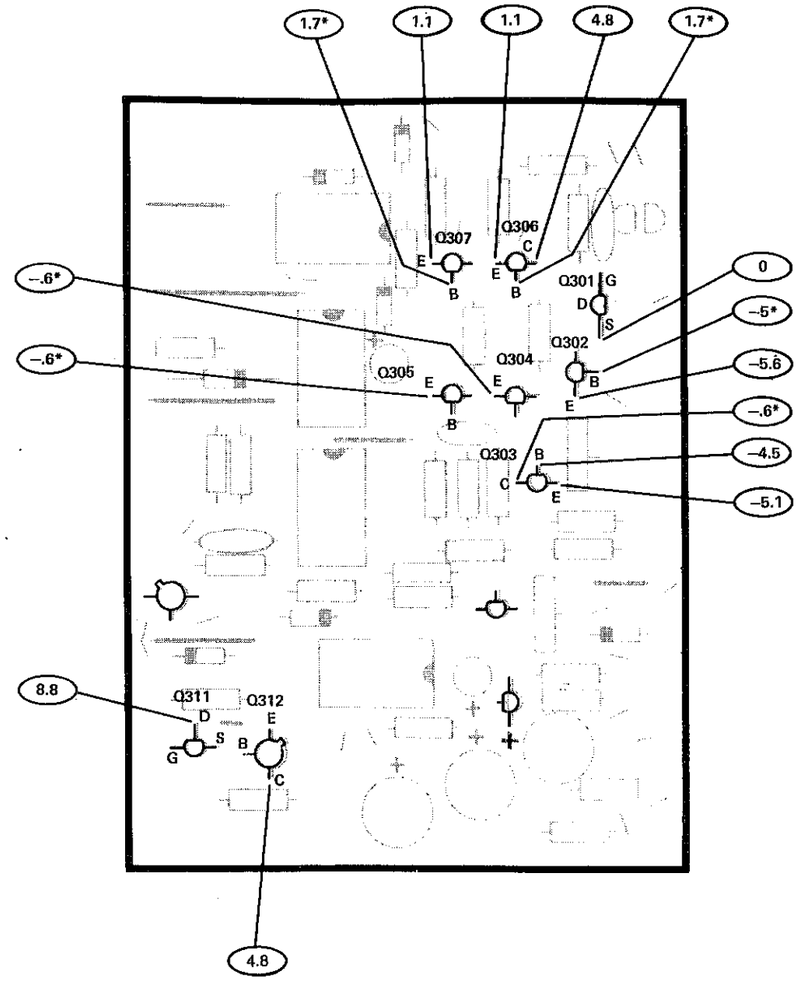
VERTICAL AMPLIFIER CIRCUIT BOARD
(Viewed from component side)

*Indicates a voltage that will change with an associated control setting change.



HORIZONTAL AMPLIFIER CIRCUIT BOARD
(Viewed from component side)

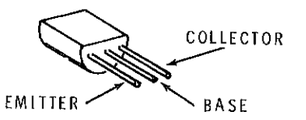
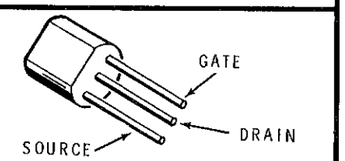
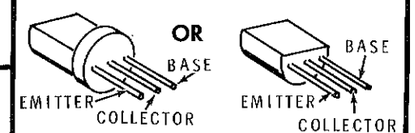
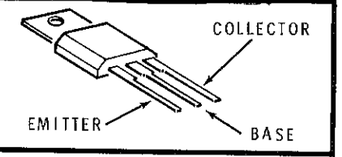
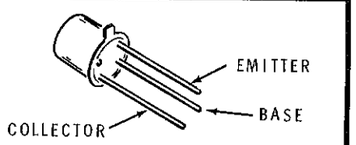
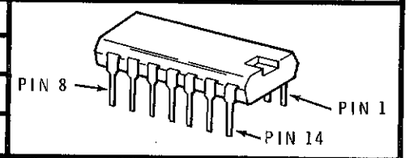
*Indicates a voltage that will change with an associated control setting change.



SWEEP-TRIGGER CIRCUIT BOARD
(Viewed from component side)

*Indicates a voltage that will change with an associated control setting change.

IDENTIFICATION CHART

CIRCUIT DESIGNATION	PART NUMBER	MANUFACTURE TYPE NUMBER	LEAD IDENTIFICATION
ZD101, ZD102, Q101, Q104, Q111, ZD201, ZD202, Q201, Q204, Q302, Q303, Q304, Q305, Q306, Q307, Q308, Q309, ZD301, ZD302.	417-801	MPSA20	
Q101, Q103, Q201, Q203, Q301, Q311.	417-241	EL131	
Q105, Q106, Q205, Q206.	417-83	L842	
Q107, Q108, Q1.	417-201	X29A829	
Q109, Q110, Q209, Q210, Q401, Q402.	417-834	MPSU10	
Q310, Q312.	417-154	2N2369	
IC304	443-22	SN74121	
IC301	443-625	SN74132	
IC302	443-23	SN74122	
IC303	443-4	SN7472	
IC401	443-631	TIL115