Errata

Title & Document Type: **140A Oscilloscope Operating and Service Manual**

Manual Part Number: **00140-90904**

Revision Date: **May 1967**

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Agilent Technologies

OPERATING AND SERVICE MANUAL

H/P Part No. 00140-90904

MODEL 140A
OSCILLOSCOPE

SERIALS PREFIXED: 721-

(For Instruments with Other Serial Prefixes,
See Section I and Appendix I.)

01638-4

PRINTED: MAY 1967

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Table 1-1. Specifications

PLUG-IN COMPARTMENTS

Upper Compartment, horizontal axis:
Accepts horizontal plug-ins, Models 1420 to 1425 or, if desired, amplifier plug-ins, Models 1400 to 1414. Plug-in operates directly into horizontal deflection plates in Model 140A.

Lower Compartment, vertical axis:
Accepts plug-in amplifiers, Models 1400 to 1414 or, if desired, horizontal plug-ins, Models 1420 to 1425. Plug-in operates directly into vertical deflection plates in Model 140A.

Combined:
Dividing shield can be removed; compartment accepts single large plug-in units. Models 1415 to 1419.

CATHODE-RAY TUBE

Type:
Post-accelerator, 7300 volt accelerating potential, aluminized P31 phosphor standard; for other phosphors, see Modifications; etched safety glass face plate reduces glare.

Graticule:
10 x 10 cm parallax-free internal graticule, marked in centimeter squares; subdivisions of 2 mm on major horizontal and vertical axes, and second and tenth horizontal graticule lines.

Intensity Modulation:
AC coupled; +20-volt pulse will blank trace of normal intensity; input terminals on rear panel.

Writing Rate:
(Using hp Model 197A Camera with f/1.9 lens and Polaroid ® 3000 speed film).
P31 Phosphor: 300 cm/μsec.
P11 Phosphor: 430 cm/μsec.

CALIBRATOR

Type:
Line-frequency rectangular signal, approximately 0.5 μsec rise time.

Voltage:
Two outputs: 1 volt and 10 volts peak-to-peak, ±1% from 15° C to 35° C; ±3%, 0° C to 55° C.

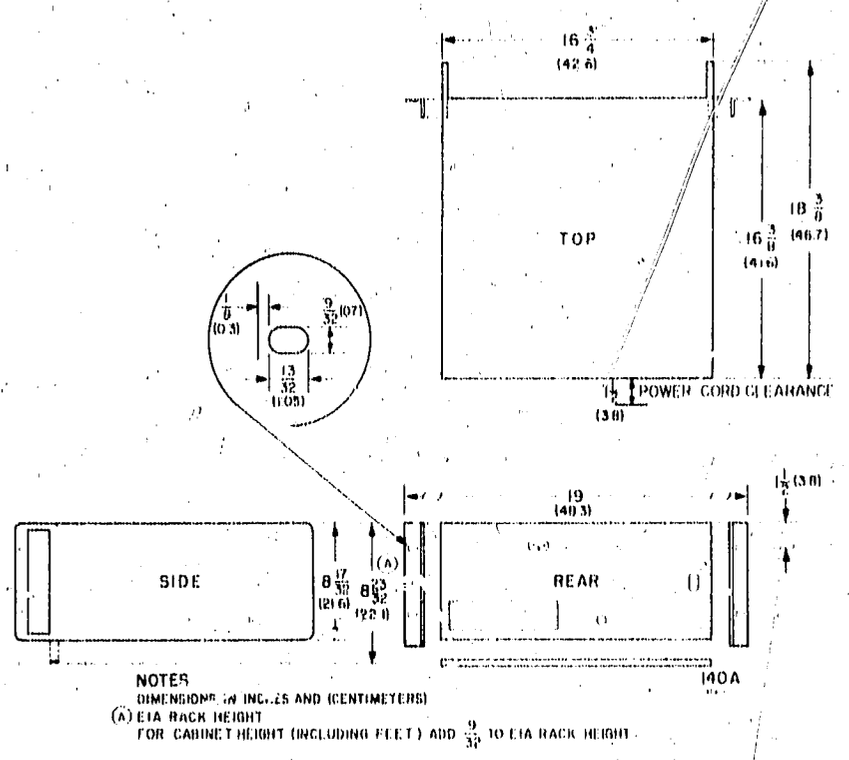
BEAM FINDER

Pressing BEAM FINDER control brings trace on CRT screen, regardless of settings of horizontal or vertical POSITION or INTENSITY controls.

GENERAL

Power Requirements:
115 or 230 volts ±10% AC, 50 to 60 Hz, normally less than 285 watts (varies with plug-in units used).

Dimensions:



Weight: (without plug-ins)
Net, 37 lbs (16, 7 kg); Shipping, 49 lbs (20 kg).

Modifications:
CRT Phosphors: (Specify by phosphor number)
P31 standard. P2, P7 and amber filter, P11 available.

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The hp Model 140A Figure 1-1, is a general purpose plug-in Oscilloscope. The deflection amplifiers are of the plug-in type and the Oscilloscope contains only the power supply, calibration and CRT circuits. The plug-in amplifiers operate directly into the CRT, therefore the characteristics of the Oscilloscope are dependent upon the plug-ins used. Presently available plug-ins make possible high sensitivity, wide bandwidth, and single, dual or four trace measurements in combination with normal, single, or delayed sweeps. Double-sized plug-ins are also available for special applications such as time domain reflectometry and swept frequency indication.

1-3. The Model 140A provides power for the plug-ins and line-frequency square wave calibrating voltages of 10 volts and 1 volt peak-to-peak which are available on the front panel. The primary power switch and all CRT controls are on the Model 140A front panel, and the terminals and switch for Z-axis modulation are on the rear panel.

1-4. CATHODE RAY TUBE.

1-5. The Model 140A uses an internal graticule CRT which eliminates parallax error in observing the display. The CRT is equipped with a nonglare safety face plate.

1-6. A type P31 aluminized phosphor CRT is normally furnished with the Model 140A, however, P2 phosphor (general purpose), P7 phosphor (long persistence) with amber filter, and P11 (fast writing rate), are also available at no extra cost.

1-7. CATHODE RAY TUBE WARRANTY.

1-8. The CRT used in the Model 140A is covered by a warranty separate from the instrument warranty. The CRT warranty is included at the back of the manual for your use in the event of CRT failure during the warranty period listed thereon.

1-9. ASSOCIATED EQUIPMENT.

1-10. Some of the plug-ins available for the Model 140A Oscilloscope are listed in Table 1-2. The Model 140A normally is used with a vertical amplifier in the lower compartment and a sweep plug-in in the upper compartment. Arrangement of plug-ins can be chosen to suit special applications; i.e. vertical amplifier and sweep plug-ins may be reversed so that the sweep is vertical and signal deflection is horizontal; a vertical plug-in can be used in each compartment to make X-Y measurements. Double sized plug-ins such as the Model 1415A or 1416A can be inserted into the compartment after removal of the divider shield between the upper and lower compartments. Blank

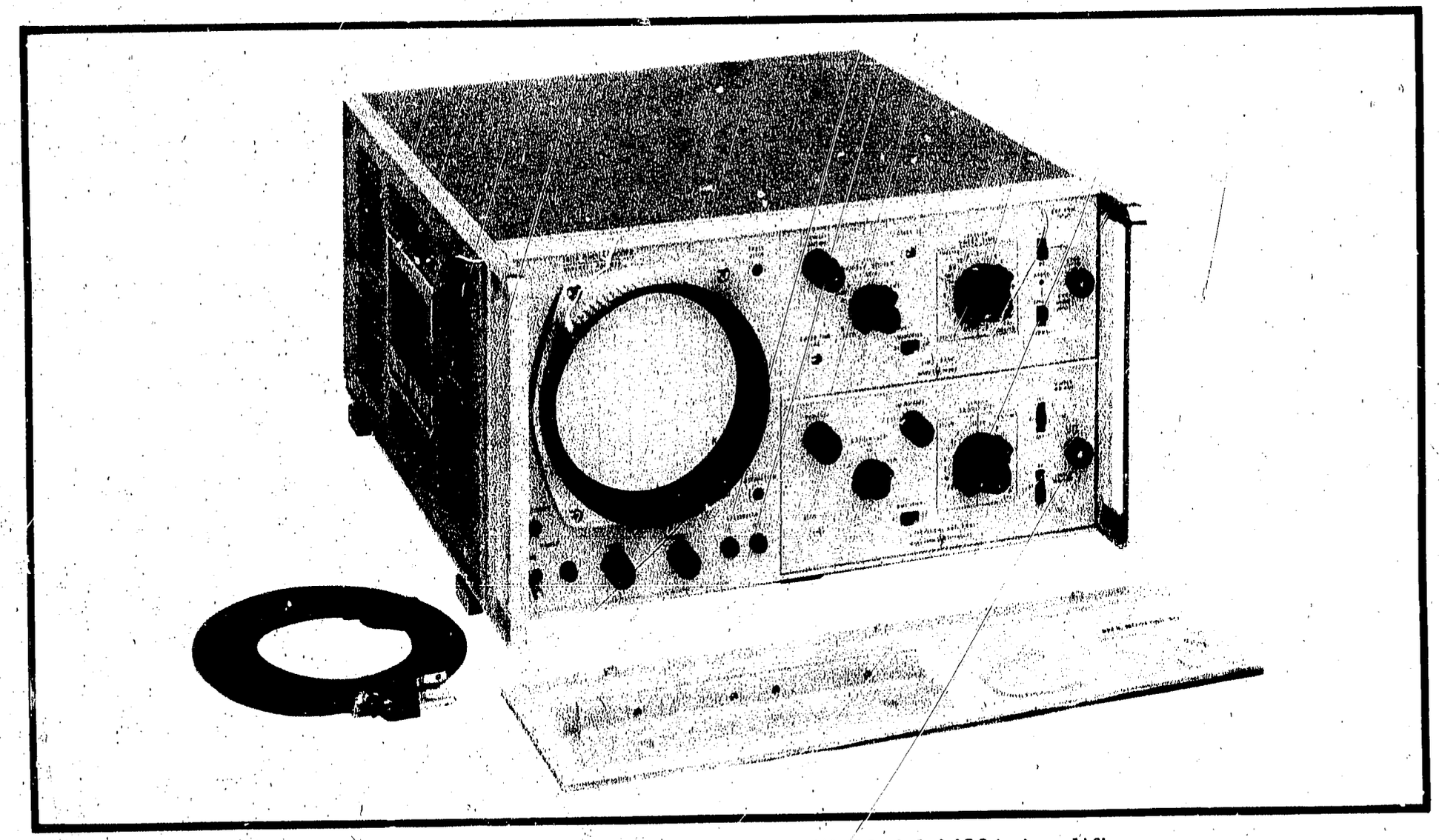


Figure 1-1. Model 140A Oscilloscope with Model 1400A Amplifier and Model 1420A Time Base Plug-In Units

plug-ins, both single and double size, are available for customer fabrication of specialized amplifier and sweep plug-ins. See Table 4-1 for power supply current limitations.

1-11. All hp Model 1400-series plug-ins can be used with the Model 140A Oscilloscope. Plug-in model numbers are grouped according to function as follows:

a. Models 1400 to 1414 - Plug-ins normally used for vertical deflection.

b. Models 1415 to 1419 - Double or full-sized plug-ins for special applications.

c. Models 1420 to 1425 - Plug-ins normally used for sweep (horizontal) deflection.

d. Model 1430 to 1432 - Sampling heads used in conjuction with sampling (vertical) plug-ins.

1-12. MANUAL IDENTIFICATION.

1-13. Information in this manual applies directly to Model 140A instruments with serial prefix of 721-. The serial prefix is the first 3 digits of the eight digit serial number (000-00000) used to identify each Hewlett-Packard instrument. If the serial prefix of a Model 140A is not 721, a change sheet supplied with the manual, or Appendix I will define the difference between that Model 140A and the one described in this manual, or a different manual may provide the information. Correction to this manual due to any errors which existed when this manual was printed, are called Errata and appear only on the change sheet supplied. For information pertaining to change sheets, contact the nearest Hewlett-Packard Sales/Service Office.

1-14. SCOPE OF MANUAL.

1-15. This manual supplies operating and maintenance instructions for the Model 140A Oscilloscope. This information is supplemented by the information contained in the 1400-series plug-in manuals. For information on the operation and manitenance of plug-in units, refer to the manual for that particular instrument.

Table 1-2. Plug-ins for Model 140A Oscilloscope*

FUNCTION	hp MODEL NUMBER	CAPABILITIES: Wide Band	Sampling	High Gain Differential	Dual Trace	X-Y	Delayed Sweep	No Drift	High CMR	Algebraic Addition	TDR**	Wide Band TDR	Swept Frequency
VERTICAL PLUG-INS	1400A			x		x							
	1401A				x	x				x			
	1402A	x			x	x				x			
	1403A			x		x			x				
	1405A	x			x	x				x			
	1406A			x		x		x	x				
	1407A			x		x		x	x				
	1410A		x		x	x				x			
	1411A		x		x	x				x		x	
	1430A		x									x	
	1431A		x										
	1432A		x										
COMPATIBLE TIME BASES	1420A	x		x	x			x	x	x			
	1421A	x		x	x		x	x	x	x			
	1422A			x	x			x	x	x			
	1423A	x		x	x			x	x	x			
	1424A		x		x					x		x	
	1425A		x		x		x			x		x	
DOUBLE SIZE PLUG-INS	1415A										x		
	1416A												x
BLANK PLUG-INS	10477A	Single-size for special purpose circuit.											
	10478A	Double-size for special purpose circuit.											

* Check latest literature for additional new plug-ins
** Time Domain Reflectometry.

SECTION II
INSTALLATION

2-1. INITIAL INSPECTION.

2-2. MECHANICAL CHECK. If external damage to the shipping carton is evident, ask the carrier's agent to be present when the instrument is unpacked. Check the instrument for external damage such as broken controls or connectors, and dents or scratches on the panel surface. If damage is evident, see Paragraph 2-4 for recommended claim procedure and repackaging information. If the shipping carton is not damaged, check the cushioning material and note any signs of severe stress as an indication of rough handling in transit. If the instrument appears undamaged, perform the electrical check (see Paragraph 2-3).

2-3. ELECTRICAL CHECK. Check the electrical performance of the Model 140A as soon as possible after receipt. Paragraphs 5-3 through 5-5 contain the performance check procedures which will verify instrument operation within the specifications listed in Table 1-1. This check is also suitable for incoming quality control inspection. If the Model 140A does not perform within the specifications when received, refer to Paragraph 2-4 for recommended claim procedure and repackaging information.

2-4. CLAIMS AND REPACKAGING.

2-5. If physical damage is evident, or if the instrument does not meet specifications when received, notify the carrier and the nearest Hewelett-Packard Sales/Service Office (see list at rear of manual). The Sales/Service Office will arrange for repair or replacement without waiting for settlement of a claim with the carrier.

2-6. The original shipping carton and packaging material, with the exception of accordion-pleated pads, should be used for reshipment. The accordion-pleated pads are fatigued with one use and are not reusable. The Hewlett-Packard Sales/Service Office will also provide information and recommendations on materials to be used if the original packaging material is not available or is not reusable. Materials used should include: (1) a double-walled carton (check with a freight carrier for test strength required), (2) heavy paper or sheets of cardboard to protect all instrument surfaces; use extra material around projecting parts of the instrument, (3) at least four inches of tightly packed shock-absorbing material surrounding the instrument. Close the carton securely with durable shipping tape. If the instrument is to be shipped to a Hewlett-Packard Sales/Service Office for repair, attach a tag showing owner, model, serial number and repairs required.

2-7. PREPARATION FOR USE.

2-8. POWER REQUIREMENTS.

2-9. The Model 140A Oscilloscope requires a power source of either 115 or 230 volts ac, ±10%, single phase, 50 to 60 Hz which can deliver approximately 300 watts. A rear panel switch provides selection of the line voltage to be used.

CAUTION

Be sure to set the rear panel switch for the line voltage to be used. The power supplies may be damaged if the switch is set to the wrong position.

2-10. 230 VOLT OPERATION.

2-11. If the instrument is to be operated from a 230-volt source, set the rear panel switch to 230. The line fuse, F401, is accessible by removing the bottom cover of the Model 140A. Remove the 4-amp slow-blow fuse and replace it with a 2-amp slow-blow fuse.

2-12. THREE CONDUCTOR POWER CABLE.

2-13. For the protection of operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. The Model 140A is equipped with a detachable, three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset (round) pin on the power cable connector is the ground pin. To preserve the protection feature when operating the Model 140A from a two-contact outlet, use a three-conductor to two-conductor adapter and connect the green lead on the adapter to ground at the power outlet.

2-14. COOLING.

2-15. VENTILATION REQUIREMENTS.

2-16. The Model 140A uses a forced-air cooling system to maintain reasonable operating temperatures within the cabinet. The air intake and filter are located on the rear of the instrument. Warm air is exhausted through the side panel perforations. When operating the Model 140A, choose a location that provides at least three inches of clearance around the rear and both sides of the instrument.

2-17. FAN AND AIR FILTER.

2-18. The fan requires periodic lubrication and the air filter should be clean as required to prevent clogging and restriction of air flow. See Paragraph 5-31 for lubricating and cleaning procedures.

2-19. INSTRUMENT MOUNTING.

2-20. MODULAR CABINET.

2-21. The Model 140A is shipped from the factory as a bench instrument with the tilt stand, feet, and plastic trim in place. The top and bottom panel covers can be removed, giving complete accessibility to all

components and adjustments. Sufficient space should be left around the cabinet for air circulation.

2-22. RACK MOUNTING.

2-23. Prepare the cabinet for rack mounting as illustrated in Figure 2-1. All necessary hardware is in the shipping carton with the instrument. After preparation, lift the instrument into place, and secure the mounting flanges to the rack with appropriate screws. Allow adequate ventilation for the instrument in the rack.

2-24. AMBER FILTER INSTALLATION.

2-25. An amber filter, Tip Part No. 120A-83A, is supplied with Oscilloscopes which have a CRT with type P7 phosphor. This filter improves visibility of displays such as single-shot or very low frequency phenomena. The filter improves the long persistency characteristics of the trace when making visual observations of this type display. To install the filter:

a. Remove front panel CRT bezel.

b. Set filter into bezel, align larger rectangular slots in edge of filter with metal guide posts of bezel casting.

c. Loosen clamp at CRT socket.

d. Carefully push CRT toward rear of instrument to provide clearance for thickness of amber filter, about 1/8 inch.

e. Replace bezel.

f. Slide CRT forward until light mask on front of CRT just lightly touches filter.

g. Tighten clamp just enough to prevent CRT from turning.

h. Check trace alignment, Paragraph 3-7.

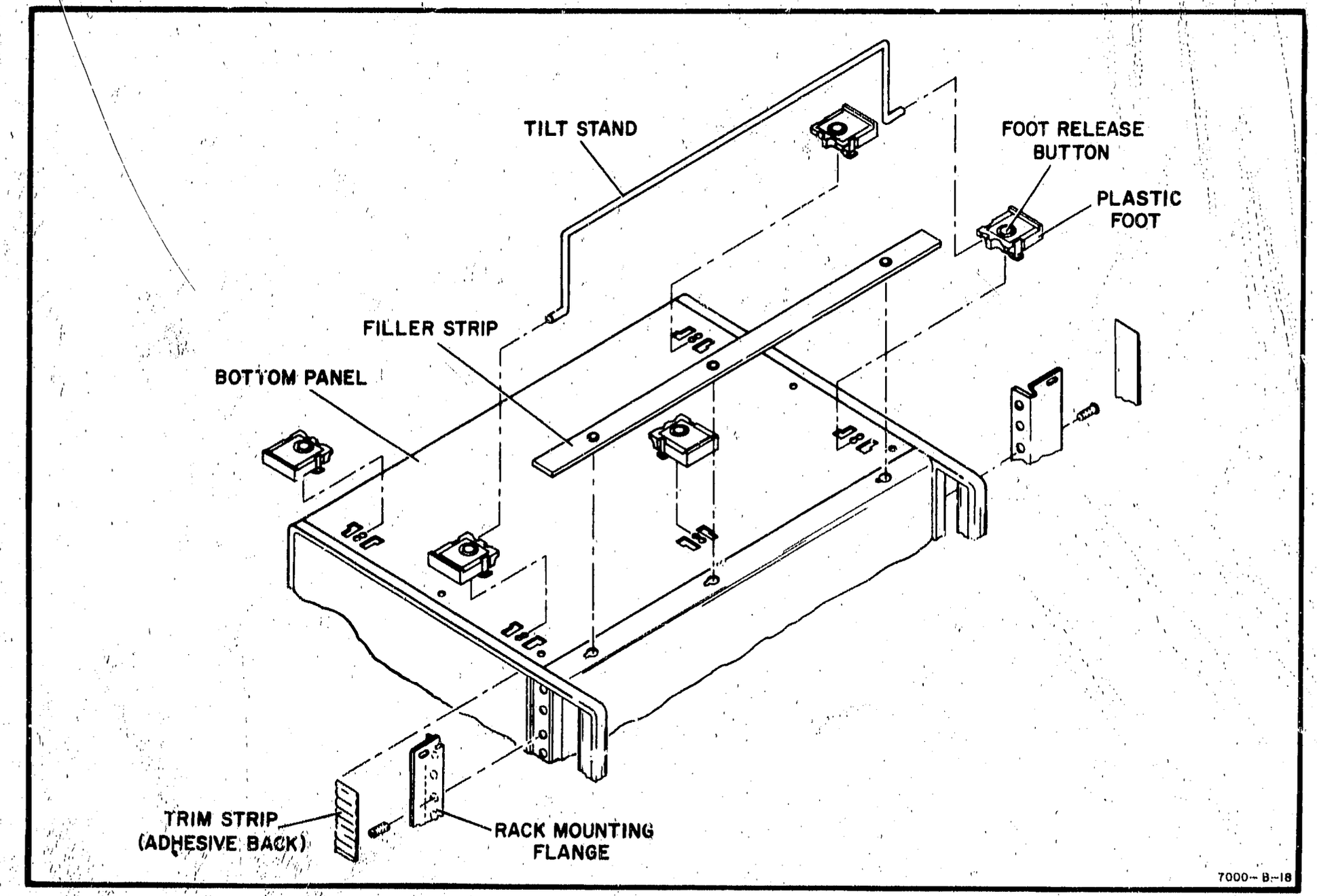


Figure 2-1. Rack Mounting Procedure

OPERATION

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. The Model 140A Oscilloscope is a plug-in oscilloscope, using a minimum number of functions on the main unit. Most of the controls are located on the plug-in units, and therefore detailed operating instructions are given in the manuals for the plug-in units. The Model 140A includes the cathode-ray tube and its associated controls, power supplies, and a calibrator which is used for vertical-sensitivity and sweep-time calibration as well as probe compensation.

3-3. CONTROLS AND INDICATORS.

3-4. FRONT PANEL.

3-5. Figure 3-1 identifies the front panel controls, indicators, and terminals, and provides a short description of their functions.

3-6. BEAM FINDER OPERATION. Frequently the CRT trace can be driven off the CRT screen by excessive DC input levels or by misadjustment of position or balance controls on plug-ins. When the BEAM FINDER switch is depressed, the beam is intensified and confined to the screen of the CRT. If the trace is centered with the position and/or balance control when the BEAM FINDER is depressed (see manual for plug-in for specific instruction), the trace will remain on screen when the BEAM FINDER is released.

NOTE

At high amplifier sensitivities a further slight adjustment of the balance control may be necessary. Failure of the BEAM FINDER to bring the trace on screen may generally be attributed to unusually high DC signal input. It should also be noted that when signal-sweep operation is used with a time base plug-in, the spot at the end of a single sweep will be blanked by termination of the gate.

3-7. TRACE ALIGN ADJUSTMENT. To compensate for slight manufacturing tolerances and external magnetic disturbances, a front panel screwdriver adjustment has been provided to align the trace with the graticule. Adjust TRACE ALIGN whenever realignment of the trace seems necessary. A check should be made after moving the instrument to a new operating location.

3-8. ASTIGMATISM ADJUSTMENT To provide uniform focus of the trace over the display area, the ASTIGMATISM control, a front panel screwdriver adjustment is used in conjunction with the FOCUS control. For correct adjustment, adjust both FOCUS and ASTIGMATISM for sharpest display of signal. Because different plug-ins will apply different DC potentials to the deflection plates, it will usually be necessary to readjust ASTIGMATISM whenever plug-ins are changed.

3-9. REAR PANEL.

3-10. 115/230. This switch, located at the bottom of the rear panel, must be set to the nominal line voltage before plugging the power cable into the service outlet.

3-11. Z-AXIS INPUT. The Z-AXIS INPUT terminals and selector switch are located on the rear panel of the instrument. To externally modulate the trace intensity, set the selector switch to EXT, and apply modulating signal to Z-AXIS INPUT terminals. The amplitude of modulating pulse required to blank the trace depends upon the level of beam intensity, and is about 20 volts positive for average intensities. Conversely, a negative pulse can be applied to the Z-AXIS INPUT to intensify the trace. When not using the terminals, be sure that the ground strap is in place. When the oscilloscope is used with a dual channel plug-in, the selector switch should be placed in the INT position. This will connect the chopper blanking pulse to the CRT cathode so that switching transients will be blanked out when the plug-in is being used in the chopped mode of operation.

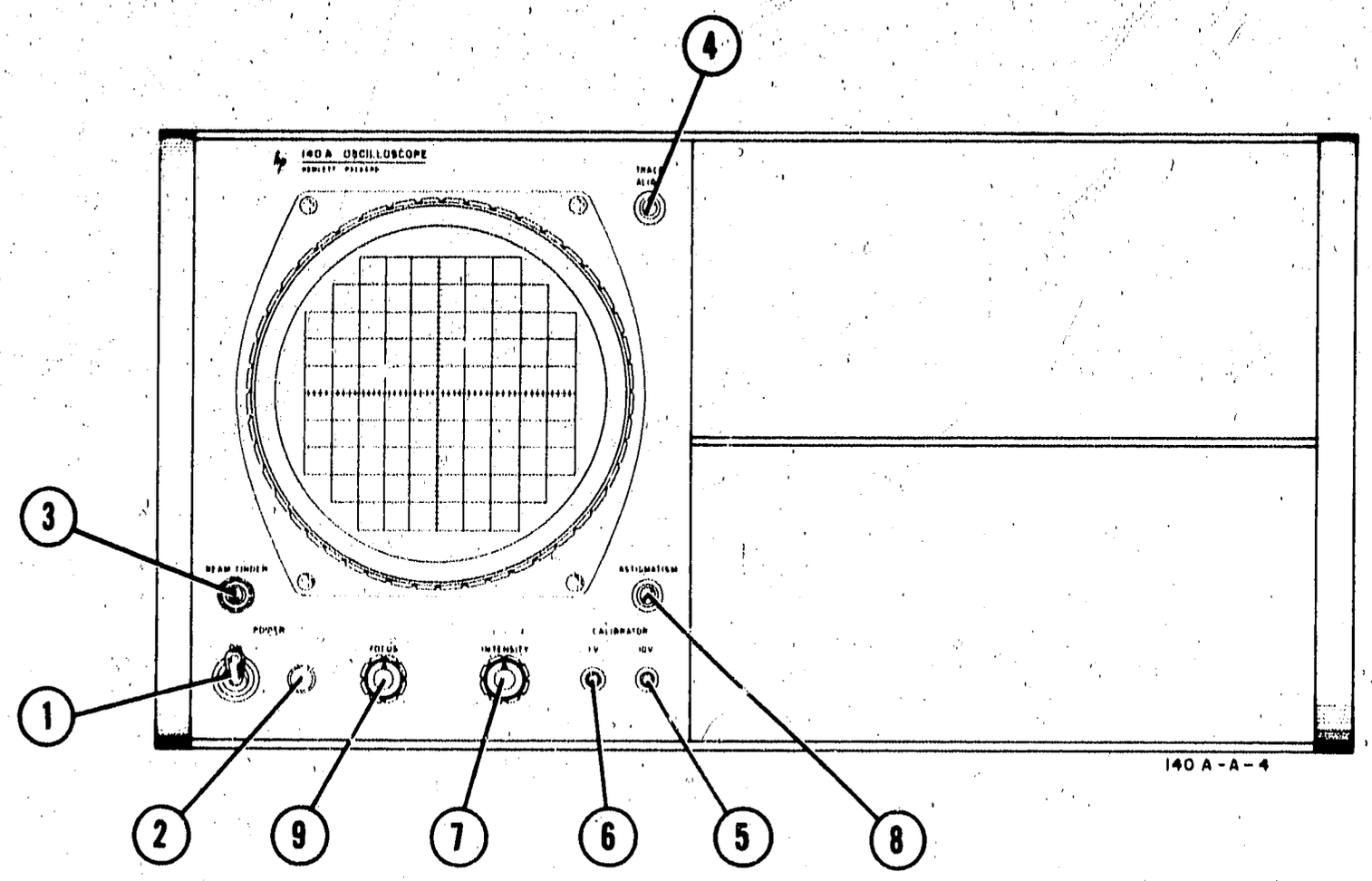
3-12. PLUG-IN UNITS.

3-13. INSTALLATION. Insert vertical amplifier (or other unit desired to produce vertical deflection) into the lower compartment, and lock in place. Insert a time base plug-in (or amplifier) into upper compartment, and lock in place. For double-sized plug-ins, remove the dividing shield, insert plug-in, and lock.

NOTE

For proper operation, make sure that the shield is in place when using standard size plug-ins.

3-14. GAIN. Because of differences in cathode-ray tube sensitivities, it will usually be necessary to readjust plug-in gain when units are interchanged or moved from one Model 140A to another.



(1) Applies AC line power to the instrument.

(2) Indicates that the instrument is on.

(3) Returns beam to CRT screen.

(4) Aligns trace with graticule.

(5) 10-volt peak-to-peak calibrating signal (line frequency square wave).

(6) 1-volt peak-to-peak calibrating signal (line frequency square wave).

(7) Controls intensity of CRT display.

(8) Controls roundness of spot.

(9) Adjusts focus of trace.

Figure 3-1. Model 140A Controls

THEORY

SECTION IV
PRINCIPLES OF OPERATION

4-1. OVERALL FUNCTIONAL DESCRIPTION.

4-2. Refer to the Block Diagram, Figure 4-1 for this explanation. The Model 140A Oscilloscope has three main circuits; a low-voltage supply, a high-voltage supply, and a calibrator circuit. The horizontal and vertical amplifier circuits are in the plug-in units and operate directly into the CRT.

4-3. LOW VOLTAGE SUPPLY. The low voltage supply uses 115 or 230 volts ac (rear panel switch), single phase, 50 - 60 Hz. Output voltages are -12.6, -100, +100 and +250 volts dc; all outputs are fused and are electronically regulated. Voltages are distributed to the high voltage supply, the calibrator circuit, and to the horizontal and vertical plug-ins. 6.3 vac is supplied from the low voltage transformer to the filament of the CRT and as a signal to the calibrator.

4-4. CALIBRATOR. The 6.3 vac applied to the calibrator circuit is shaped into a square wave (of line frequency) and applied to two front panel connectors, 10V and 1 V (peak-to-peak amplitude). The 1 volt output is also applied to the vertical and horizontal plug-ins for sensitivity calibration. Accuracy of the calibrating signal is ±1%.

4-5. HIGH VOLTAGE SUPPLY. A transistorized oscillator and a step-up transformer are used to generate negative and positive high voltages for the CRT. Both the +5000 volt and -2350 volt supplies are electronically regulated.

4-6. CIRCUIT DESCRIPTION.

4-7. LOW-VOLTAGE SUPPLY.

4-8. The low voltage supply consists of an independent -100 volt and three dependent supplies (-12.6, +100 and +250). The -100 volt supply is a reference for the other three supplies. The +250 volts is obtained by stacking a +150 volt supply on the +100v supply.

4-9. Figure 4-2 is a simplified block diagram of regulator used in the low voltage supply. The series regulator acts as a variable resistance in the regulated output. A sensor (or differential amplifier) compares the output voltage with a reference voltage (dc return for the supply). The driver (emitter

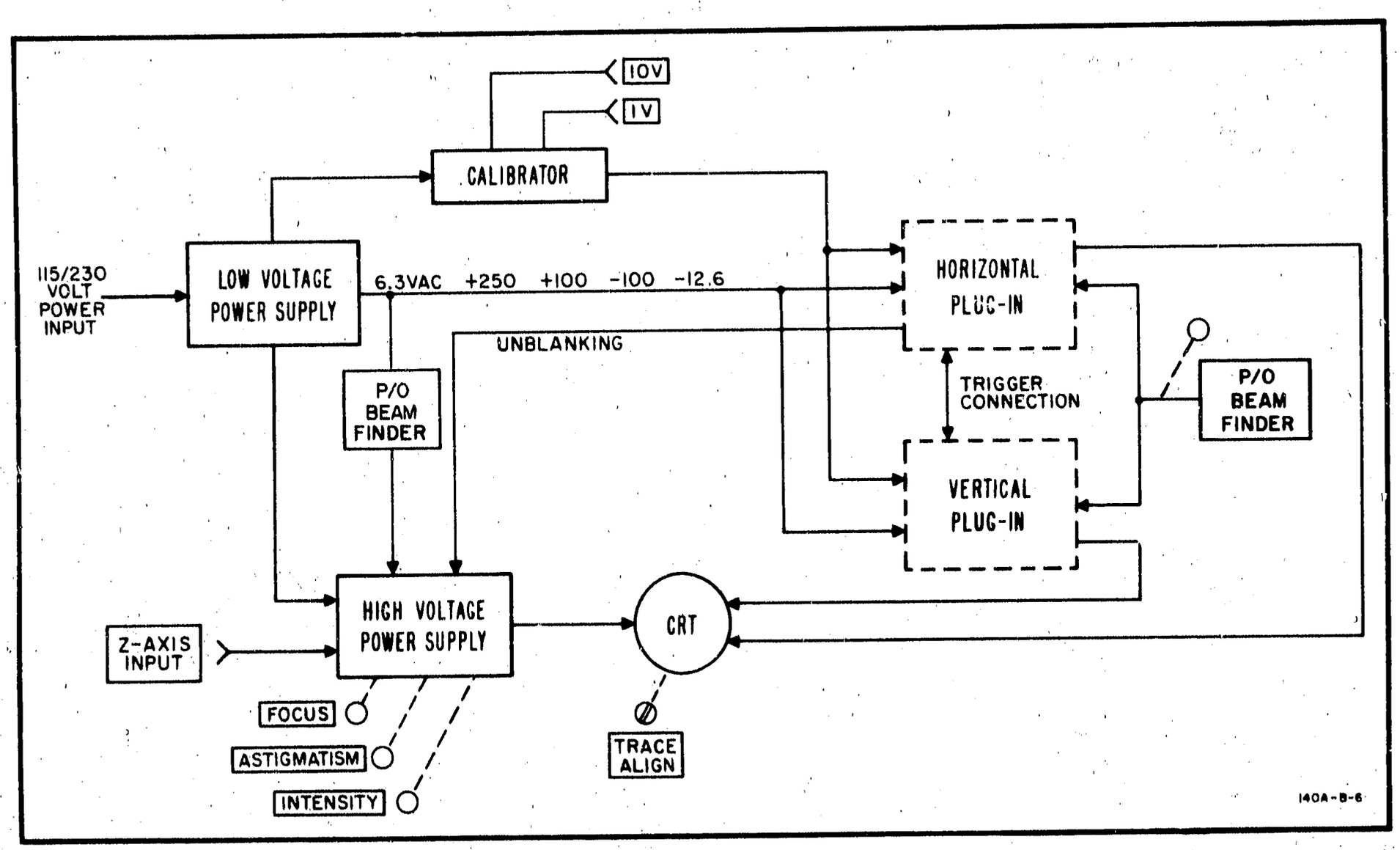


Figure 4-1. Model 140A Block Diagram

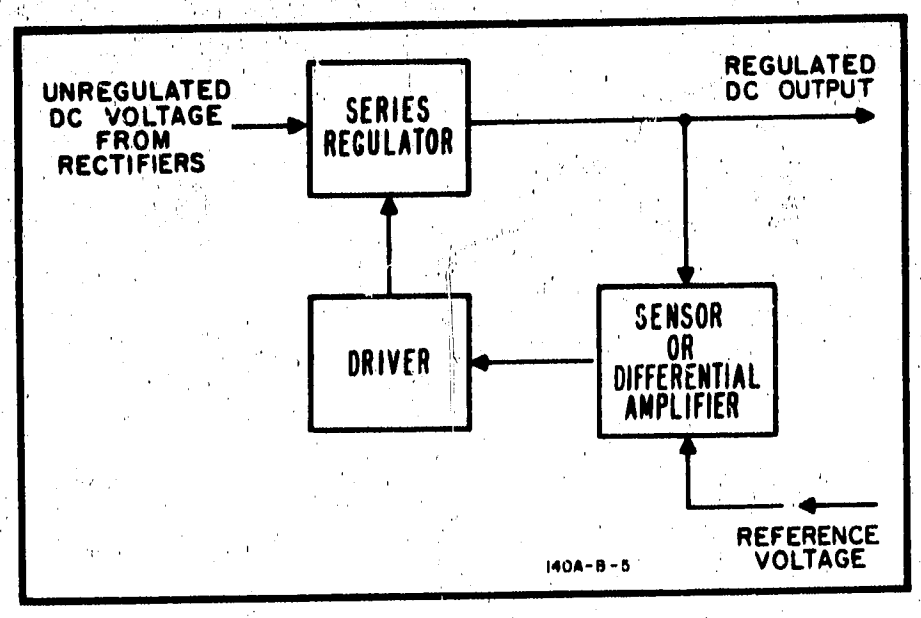


Figure 4-2. Regulated Power Supply Block Diagram

follower or amplifier) controls the bias on the series regulator, which effectively controls the series resistance. Any change in output voltage is fed back to the series regulator. The change in series resistance and the resulting voltage drop is opposite to the output voltage change; thus the output voltage is maintained at a constant level.

4-10. Figure 5-6 is a schematic diagram of the low voltage supply. The primary winding of transformer T401 is wired through a rear panel switch for quick conversion to either 115 or 230 vac operation. Line voltage is applied to the primary of T401 through an on-off switch, a fuse and a thermal switch. A pilot lamp is provided to indicate when power is applied to T401. Two shunt resistors are connected to the +250 volt supply to reduce series regulator power dissipation when high-current plug-ins are used. The shunts are wired one to each rear panel plug and the internal wiring of the plug-in determines whether the shunt is or is not used.

4-11. -100 VOLT SUPPLY. Since all low voltage supplies are referenced to the -100 volt supply, any change in the -100 volt supply is reflected in the other supplies. The ac voltage from the secondary of T401 is rectified by CR461-464 and partially filtered by C461, C462 and R461. The resulting dc voltage is applied through series regulator, Q461, to the output. Additional filter circuits are used in the plug-ins. Differential Amplifier Q463/464 compares the voltage across reference tube V461 with a sample of the output voltage, the magnitude of which is set by the -100 adjust, R471. The output of the Differential Amplifier is applied to the base of Q462, the Driver emitter follower, which controls the bias on Series Regulator Q461. Any tendency of the output voltage to change, is fed back through the amplifier and driver to the series regulator. The Series Regulator compensates for the change in output voltage by its change in series resistance. The -100 volt output is adjusted by R471 and fuse F461 provides overload protection for the circuit.

4-12. -12.6 VOLT SUPPLY. Sensor Amplifier Q484 senses any variation of output voltage with respect to -100 volts and applies the error voltage to Driver Amplifier Q482. The Driver increases signal current to the level required to control Series Regulator Q481. The -12.6 volt output is adjusted by R488. Current Limiter, Q483, a protective circuit for the series regulator, is normally biased off. If a short occurs across the -12.6 volt output, the base of Q483 goes negative by the voltage drop across R483 minus the forward breakdown voltage of CR483, thus turning Q483 on. The increased positive voltage on the collector of Q483 is applied through Q482 to the base of series regulator Q481, biasing it off. The current which then flows through the external short is limited to the current required to keep Q483 on. Additional overload protection is provided by fuse F481.

4-13. +100 VOLT SUPPLY. Differential Amplifier Q443/Q444 in the +100 volt supply senses any variation in output voltage with respect to -100 volts. The error voltage is applied through Driver Q442, to Series Regulator Q441, as corrective bias. Regulation of the output is accomplished in the same manner as in the -100 volt supply. R453 adjusts the +100 volt output and fuse F441 provides overload protection.

4-14. +250 VOLT SUPPLY. Sensor Amplifier Q423 in the +250 volt supply senses any variation in the output voltage, with respect to -100 volts. The error voltage is amplified by Driver, Q422 which applies corrective bias to Series Regulation Q421. R432 adjusts the +250 volt output and fuse F421 provides overload protection.

4-15. CALIBRATOR.

4-16. The schematic diagram of the Calibrator circuit is shown in Figure 5-6. The circuit consists of three parts: a tunnel diode square wave generator, a transistor switch and a calibration network.

4-17. 6.3 volts ac is applied through R491 to tunnel diode CR490, which generates a square wave at line frequency. Transistor switch Q490 is off during the time of the positive half cycle of the square wave (when the voltage at the base is close to zero), and the collector voltage is thus at a level set by dc voltage divider R493, 495 and 496. When the negative-going portion of the square wave is applied to the base of Q490, the transistor conducts heavily, effectively shorting the collector to ground. The output of the calibrator is thus zero volts. At the end of the negative input half cycle, the bias of Q490 returns to zero, the transistor is switched off, and the output returns to its previous value.

4-18. Tunnel diode bias current is supplied through R492. The bias current sets an operating level for the diode which affects the symmetry of the square wave output. Cal Adj R494 is used to set the dc voltage at the collector of Q490 to -10 volts when the transistor is off. Breakdown diode CR491 reduces the output impedance, and provides temperature compensation for the circuit. Voltage divider R495/R496 reduces the 10 volt output to 1 volt. Both 10 and 1 volt outputs are available on the front panel of the Model 140 and the 1 volt output is available to both plug-ins.

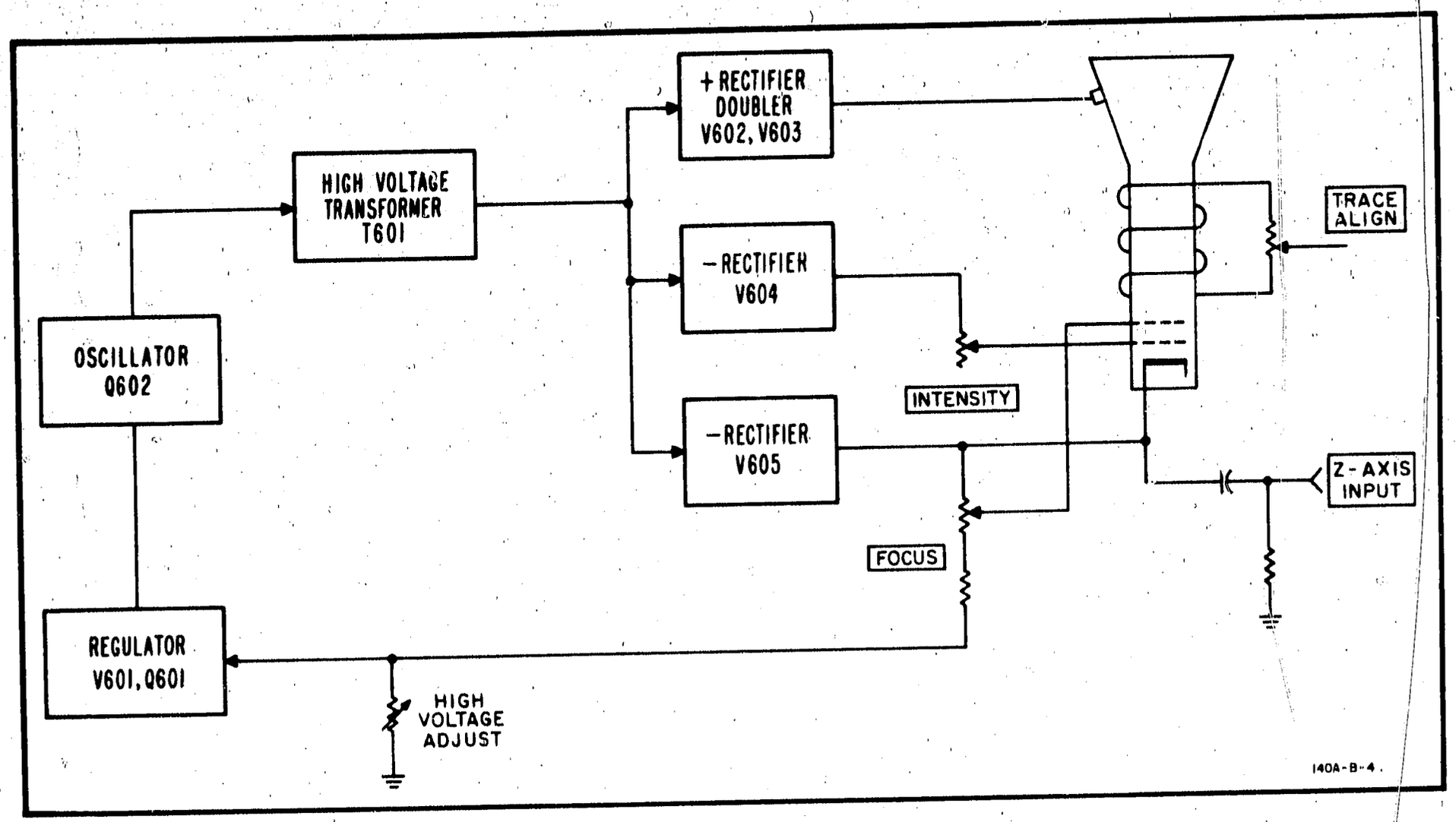


Figure 4-3. High-Voltage Power Supply Block Diagram

4-19. HIGH-VOLTAGE SUPPLY.

4-20. Figure 4-3 is a block diagram of the high voltage supply. The output of a regulated transistor oscillator is stepped up in voltage and applied to a series of high voltage rectifiers. The positive output of the voltage doubler is connected to the post-accelerator of the CRT. The negative output voltages are used in the gun assembly of the CRT and its associated controls. The Z-axis input can be used to apply intensity modulating signals to the CRT.

4-21. Figure 5-7 is a schematic diagram of the high voltage supply and the CRT. Oscillator Q602 operates at a frequency of approximately 32 kHz. Any change in the output voltage is applied to the grid of V601, which converts the voltage change to a current change. This current change is applied by emitter follower Q601 to the base of the oscillator transistor. The amplitude of oscillations is changed in such a direction as to oppose the original output voltage change. High Voltage Adjust R619 sets the amplitude of oscillation to produce the correct output voltage.

4-22. Two separate negative supplies are used, one for the control grid of the CRT, and one to provide CRT cathode and focusing voltages. Both supplies use half wave rectifiers (V604 and V605). The unblanking gate from the horizontal plug-in (pin 1, J2) is applied to the return side of the grid supply, and changes the negative grid voltage by about +50 volts to unblank the trace. A positive pulse of about 20 volts will blank the trace when applied to Z-axis input. When Z-axis input is not used, S601 is set to INT to receive chopped blanking from a dual-trace plug-in.

4-23. The voltage doubler circuit, V602/V603 provides the 5-kv post-accelerating voltage applied to the CRT.

4-24. The ASTIGMATISM adjustment, R641, affects the roundness of the spot, and the Geometry adjustment, R643, is used to optimize pattern shape.

4-25. TRACE ALIGN.

4-26. The trace align coil, L602 is located around the CRT near the screen. Adjustment of Trace Align R650A/B varies the magnitude and direction of current through the coil, which has the effect of rotating the trace. In this way the trace is brought into alignment with the CRT graticule.

4-27. PLUG-IN KIT FABRICATION.

4-28. The hp Model 10477A and Model 10478A Accessory Plug-ins are blank plug-in units for the Model 140 Oscilloscope. These two units permit the user of the Oscilloscope to design his own special-purpose circuits. Current available from each of the Model 140 power supply voltages is shown in Table 4-1. Power requirements for user-designed circuits should not exceed the capabilities shown in the table.

Table 4-1. Current Capability

Supply Voltage	Current Available At Each Jack (J1 and J2)
+250 vdc	0-100 ma
+100 vdc	137.5 ma
-100 vdc	10-200 ma
-12.6 vdc	0-0.9 amp
6.3 vac	0-3.25 amp

MAINTENANCE

Table 5-1. Equipment Required for Tests and Adjustments

Recommended Instrument	Model	Required For	Ref Para	Required Characteristics
Voltmeter Calibrator	ℌ 738AR or 738BR	Calibrator check; High Voltage Adjustment; Calibrator Adjustment	5-5 5-13 5-17	Outputs of 1v and 10v pk-pk; -300v DC; ±0.2%
DC Voltmeter	ℌ 412A	Low-Voltage Adjustments	5-11	-100 to +100 volts, ±1%
DC VTVM	ℌ 410B	High-Voltage Adjustment	5-13	May be adapted for high voltage (-2.5 kv) measurement. Provision for altering calibration.
Voltage Divider	ℌ 11044A	High-Voltage Adjustment	5-13	Provide 100:1 division for vtvm (item 3); 2.5 kv rating.
Audio Oscillator	ℌ 200CD	Geometry Adjustment	5-16	400 kHz output.

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section covers maintenance, trouble-shooting, and adjustment of the Model 140A Oscilloscope. A performance check is included which may be used at incoming inspection or after adjustments have been made to verify that the instrument meets its specifications.

5-3. PERFORMANCE CHECK.

5-4. CRT CONTROLS.

a. Install a single large plug-in or two small plug-in units in the Model 140A (vertical plug-in in the lower compartment, horizontal in the upper compartment).

b. Set: POWER . . . . . ON
AMPLIFIER coupling (if present) . AC
POSITION controls . . . . . Centered

c. If a time base plug-in is being used,

set: SWEEP TIME . . . . . 1 MSEC/CM
TRIGGER SOURCE . . . . . +INT
LEVEL . . . . . FREE RUN
NORMAL/SINGLE . . . . . NORMAL

d. A trace should be on screen. If necessary, turn INTENSITY control clockwise.

e. Remove trace from screen with POSITION controls. Depress BEAM FINDER. The trace should appear on screen.

f. The INTENSITY control should vary the intensity of the display from extinguished to brighter than normal intensity.

g. The FOCUS and ASTIGMATISM controls should defocus the display at the extreme of each control, and focus the display at approximately midrange. Adjust FOCUS and ASTIGMATISM for sharpest overall display.

h. Adjust TRACE ALIGN to set the trace parallel to the horizontal graticule lines. If the horizontal plug-in is not a time base, connect the calibrator signal to the horizontal amplifier input to produce a straight-line trace.

5-5. CALIBRATOR.

a. Set: Vertical SENSITIVITY . . . . 0.05 V/CM
INPUT coupling . . . . . DC

b. Connect 1 VOLT P-P from the Voltmeter Calibrator to vertical INPUT.

c. Adjust vertical VERNIER for exactly 10 cm deflection.

d. Disconnect the Voltmeter Calibrator and connect the 1V CALIBRATOR output to the vertical INPUT.

e. Deflection should be 10 cm ±0.1 cm.

f. Repeat steps a through e, using 0.5 V/CM vertical SENSITIVITY and 10 volts from the Voltmeter Calibrator.

5-6. ADJUSTMENTS.

5-7. The following paragraphs (5-11 through 5-17) give a complete adjustment procedure for the Model 140A Oscilloscope. A condensed procedure is given in Table 5-3. If difficulty is encountered in making any adjustment, refer to Paragraph 5-18 for trouble-shooting procedures.

5-8. EQUIPMENT NEEDED FOR ADJUSTMENTS. Test equipment recommended for the adjustment procedure is listed in Table 5-1. Similar instruments having the listed characteristics may be substituted.

5-9. LOCATION OF ADJUSTMENTS. Figure 5-1 shows the location of all internal adjustments in the Model 140A.

5-10. PRELIMINARY PROCEDURE. Plug-ins should be installed in both compartments whenever power supply voltage measurements are made; proper regulation may not occur if insufficient loading is provided. Set line voltage to 115 volts (230 volts if the 115/230 volt switch is in the 230-volt position).

5-11. ADJUSTMENTS OF LOW-VOLTAGE SUPPLIES.

5-12. Measure the output of each low-voltage supply, and adjust it to the value shown in Table 5-2. Measurement may be made on any wire bearing the indicated color code.

Table 5-2. Low-Voltage Adjustments

Supply (Volts)	Wire Color Code	Adjustment
-12.6	White/Violet	-12.6V Adj R488
-100	Violet	-100V Adj R471
+100	White/Red	+100V Adj R453
+250	Red	+250V Adj R432

5-13. ADJUSTMENTS OF HIGH-VOLTAGE SUPPLY.

a. Connect a Model 11044A 100:1 Voltage Divider to the DC probe of a Model 410B Voltmeter.

b. Set Voltmeter to 3-volt -DC range.

c. Set the Voltmeter Calibrator for -300 volts DC output, and connect divider tip to the output.

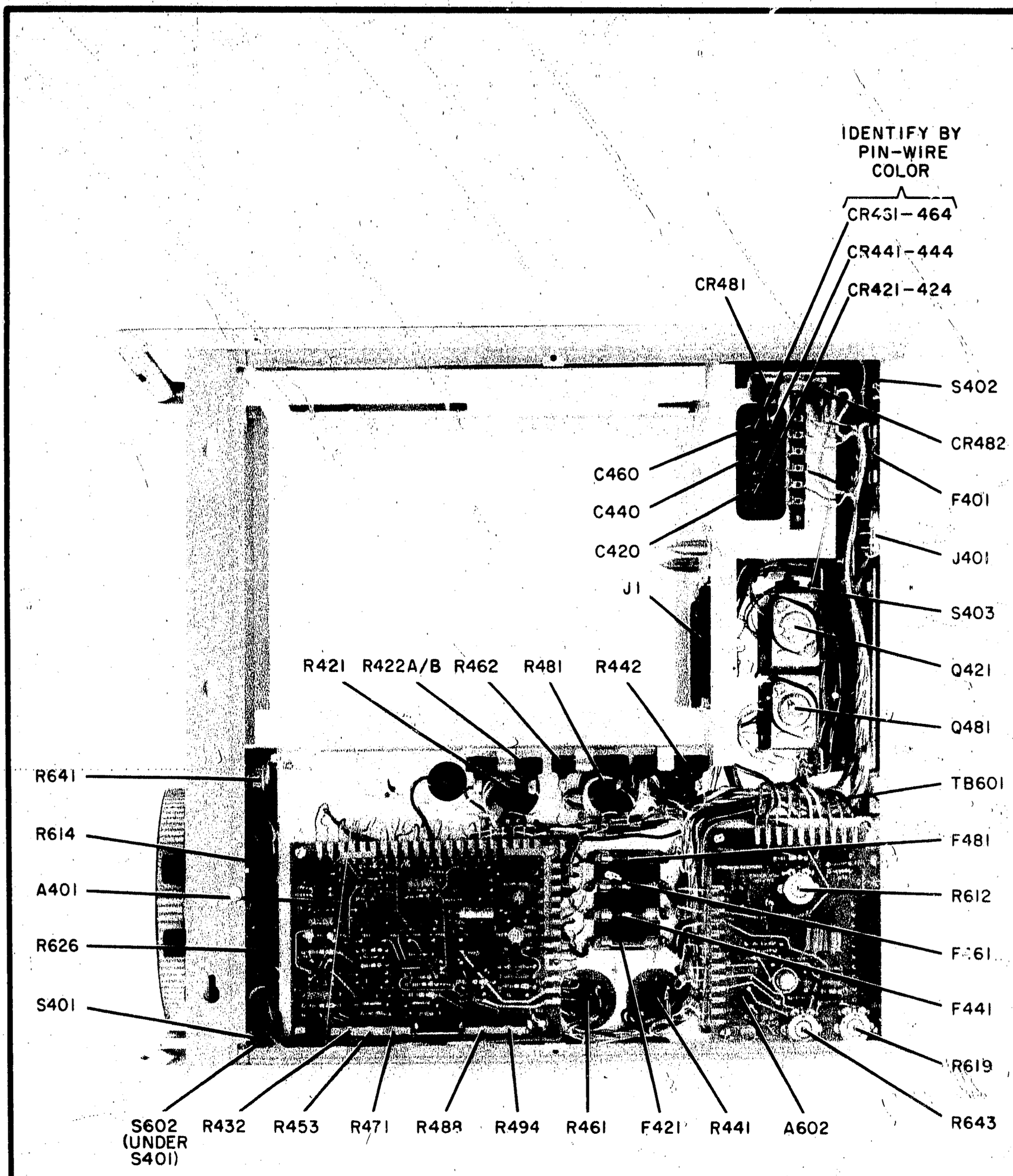


Figure 5-1. Component Locations, Bottom View

d. Set the gain adjustment of the Model 410B (located at the rear of the instrument) for a reading of exactly 3 volts.

e. Set the Voltmeter to the 30-volt range, and measure the high voltage supply. This may be done at the junction of R651 and R652.

f. Set High Voltage Adjust R619 for -2350 volts.

g. Recalibrate the Model 410B.

5-14. INTENSITY LIMIT ADJUSTMENT.

a. Center a defocused spot on the CRT. (Remove horizontal plug-in if necessary).

b. Set INTENSITY to 10 o'clock.

c. Adjust Intensity Limit R612 until spot is just extinguished.

5-15. ASTIGMATISM ADJUSTMENT.

a. Center a low-intensity spot on the CRT.

b. Adjust FOCUS and ASTIGMATISM for a small, round, sharply-focused spot.

5-16. GEOMETRY ADJUSTMENT.

a. Set: TRIGGER LEVEL . . . . . .AUTO
SWEEP TIME . . . . . 0.2 MSEC/CM

b. Connect a 400-kHz signal from the Audio Oscillator to the vertical INPUT of the amplifier plug-in.

c. Adjust vertical and horizontal controls to obtain a pattern 8 cm high.

d. Adjust Geometry R643 to obtain the straightest possible edges on the rectangular pattern.

5-17. CALIBRATOR ADJUSTMENT.

a. Connect a 10 VOLT P-P signal from the Voltmeter Calibrator to the vertical amplifier INPUT.

b. Set amplifier SENSITIVITY to 0.5V/CM, INPUT coupling to DC.

c. Adjust vertical VERNIER for exactly 10 cm deflection.

d. Disconnect the Voltmeter Calibrator, and connect the 10V CALIBRATOR output to the amplifier INPUT.

e. Set Cal Adj R494 for exactly 10 cm deflection.

Table 5-3. Condensed Adjustment Procedure

Test	External Equipment Required	Procedure	Adjust
Low Voltage Supplies	DC Voltmeter	Measure: -12.6v (White/Violet) -100v (Violet) +100v (White/Red) +250v (Red)	 R488 R471 R453 R432
High Voltage Supply	DC VTVM; 100:1 Divider; Voltmeter Calibrator	a. Calibrate Divider - Voltmeter combination. b. Measure -2350v	R619 for -2350 volts
Intensity Limit	None	a. Center a defocused spot. b. Set INTENSITY to 10 o'clock.	R612 until spot is just extinguished.
Astigmatism	None	Center a low-intensity spot.	FOCUS and ASTIGMATISM for sharp spot.
Geometry	Audio Oscillator	a. TRIGGER LEVEL: . . . . AUTO SWEEP TIME: . . 0.2 MSEC/CM b. Connect 400-kHz sine wave to vertical INPUT. c. Obtain pattern 8 cm high.	R643 for straightest edges.
Calibrator	Voltmeter Calibrator	a. SENSITIVITY: . . . . 0.5 V/CM b. Apply 10v pk-pk from Voltmeter Calibrator to vertical INPUT. c. Adjust vertical VERNIER for 10 cm deflection. d. Connect 10V CALIBRATOR to vertical INPUT.	Cal Adj. R494 for 10 cm deflection.

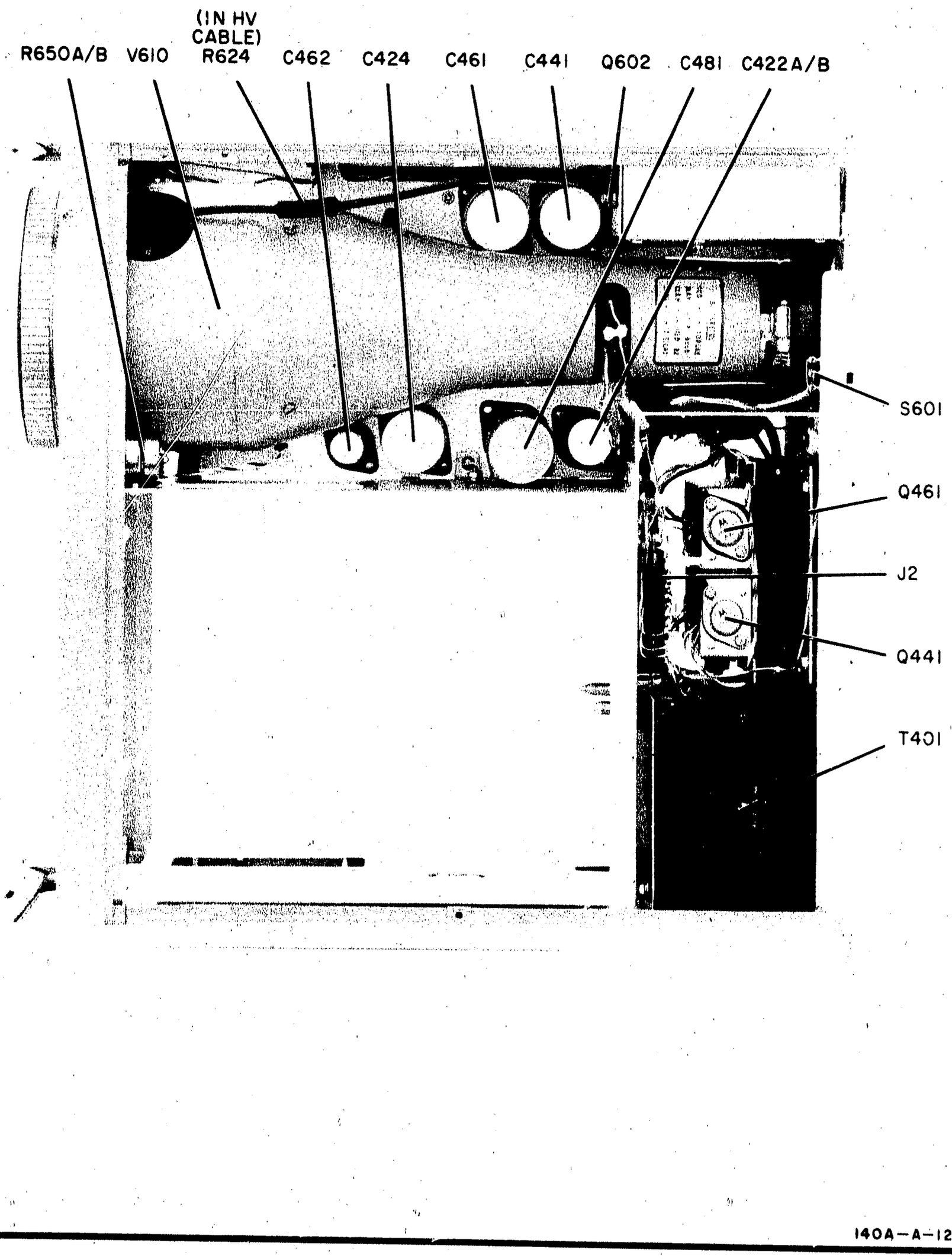


Figure 5-2. Component Locations, Top View

Table 5-4. Troubleshooting the Low-Voltage Supply

SUPPLY SYMPTOM				PROBABLE CAUSE OF TROUBLE
-12.6	-100	+100	+250	
No current limiting				Q483 open (B - E short)
Q421 not protected				CR425 open
ok	ok	119	280	Q444 open (B - E short)
ok	ok	117	282	Q443 short (B - E - C)
ok	ok	111	194	Q423 open (B - E short)
ok	ok	110	200	CR426 short
ok	ok	106	218	CR425 short
ok	ok	ok	198	Q422 open (removed)
ok	ok	96	274	Q421 open (green lead open)
ok	ok	94	292	CR426 open
ok	ok	93	295	CR445 open (cause Q421 short)
ok	ok	93	294	Q421 short (E - C)
ok	ok	93	286	Q422 short (E - C)
ok	ok	92	295	Q423 short (E - C)
ok	ok	81	55	Q421 open (removed)
ok	ok	80	55	F421 open
ok	ok	75	200	Q442 open (B - E short)
ok	ok	28	114	Q441 open (base disconnected)
22	ok	ok	ok	Q481 short (C - E causes Q484 B - E short)
22	ok	ok	ok	Q482 short (C - E causes Q484 to fail)
22	ok	ok	ok	Q484 open (removed)
0	ok	ok	ok	Q482 open (removed)
0	ok	ok	ok	Q482 short (B - E)
0	ok	ok	ok	Q481 open (base lead open)
0	ok	ok	ok	Q483 short (C - E)
0	ok	ok	ok	Q484 short (C - E)
18	142	144	344	Q461 short (C - E)
17	136	135	335	Q462 short (C - E)
0	0	0	0	Q464 open (E - B short blows F461)
14	113	145	342	Q441 short (C - E)
14	110	140	327	Q443 open (B - E short)
9	69	75	184	Q462 open (B - E short)
0	0	0	0	Q463 short (B - E blows F461)
5	63	77	185	Q463 short (C - E)
4	29	75	167	+100v removed from -100v supply
1	12	75	163	Q461 open (base lead open)
0	60	77	168	Q461 open (removed)

5-18. TROUBLESHOOTING.

5-19. LOW-VOLTAGE SUPPLIES.

5-20. TRANSISTORS. The series regulator transistors are located on the fan assembly. Each is easily replaced by removing the two screws and pulling the transistor from its sockets. All other low voltage power supply transistors are located on the low-voltage circuit board.

5-21. DC voltages shown on the low voltage schematic diagram were measured, to ground, with Model 1402A and 1421A plug-ins installed. Voltages may vary slightly when other plug-ins are used. Correct voltages for points not marked for voltage are generally obvious by being connected (direct or indirectly) to a supply output. Transistor base voltage in most cases should not measurably differ from emitter voltages when measured with respect to ground. Voltage drops across breakdown diodes are indicated on the schematic.

5-22. EXCESSIVE RIPPLE. The cause of excessive 120-Hertz ripple on any of the supplies can be isolated to input filter or regulator circuits by comparing ripple voltages at the rectifier outputs with the values given on the schematic. If ripple at these points is excessive, check capacitors C421, C422, C441, C461, or C481. If ripple is high and is 60 Hz, one of the rectifiers is probably open. If normal, the cause is most likely low gain in the amplifier transistors.

5-23. FUSES. If the -12.6, -100, +100, or +250 volts supply should be accidentally shorted to ground, the fuse for that particular supply will blow. This cuts off current in the supply and protects the transistors.

5-24. The -12.6 volt supply is fused, and employs a current limiter, Q483, for protection against brief shortings of the output to ground. The supply should immediately function normally upon removal of the short, provided the fuse has not blown.

5-25. SPECIFIC TROUBLES. Table 5-4 lists troubles which may occur in the low voltage supplies and the probable cause of each trouble. Voltage measurements given in the table should be taken with plug-ins installed in both compartments. If voltage measurements not shown in the table are encountered, use the voltage substitution procedure below.

a. Disconnect R468 from the +100 volt supply and connect an external, regulated +100 volts to the disconnected end; if the -100 volt supply does not check ok, the trouble is in the -100 volt circuit; if the -100 volt supply checks ok, reconnect R468 and proceed to step b.

b. Disconnect R450 from the +250 volt supply and connect an external, regulated +250 volts to the disconnected end; if the +100 volt supply is not ok, the trouble is in the +100 volt circuit. The -12.6 volt supply will also show defective when the +100 volt supply is defective. If the +100 volt supply checks ok, the trouble is in the +250 volt supply.

c. When the defective supply is located, check that circuit for defective components.

5-26. HIGH-VOLTAGE SUPPLY.

5-27. If one high-voltage supply output is zero but other outputs are normal, look for the unlit filament of a bad rectifier (V602 thru V605). Normal DC voltages are given on the high voltage schematic.

5-28. If there is no high-voltage output and none of the filaments are lit, observe the waveforms at the collector of Q603 (blue wire). If an approximately 30-kHz 20-volt peak-to-peak sine wave appears for short intervals, the trouble is probably a defective component in the rectifier filter/divider networks. If no waveform appears, use Table 5-5.

5-29. If the high-voltage output is incorrect and cannot be adjusted to the correct value, use Table 5-6.

5-30. If the -2350 volt supply seems to be operating properly, the +5 kv post-accelerator potential may be checked by removing the left side instrument cover and measuring the 5-kv voltage at the board termination of the thick red lead.

5-31. PERIODIC MAINTENANCE.

5-32. ELECTRICAL MAINTENANCE.

5-33. Perform the electrical adjustments once every 6 months and after repair or component replacement.

5-34. MECHANICAL MAINTENANCE.

5-35. Inspect the air filter at the rear of the instrument and clean it before it becomes clogged and restricts air flow. To clean the filter, wash it thoroughly in warm water and detergent. Dry the filter thoroughly before installing it on the instrument. Oil the motor (one point) with light machine oil, once every 6 months.

5-36. INSTRUMENT REPAIR.

5-37. All components in the Model 140A are identified by reference designation in Figures 5-1 to 5-5 and 5-8. Components mounted on circuit boards are shown in the shaded area of the schematic diagrams, Figures 5-6 and 5-7. Components not shown in the shaded areas are on the front panel or chassis of the instrument.

5-38. Figure 6-1 is an exploded-view drawing of the Model 140A frame. All parts are identified by description and hp part number.

5-39. MAJOR COMPONENT REPAIR.

5-40. CRT REMOVAL AND REPLACEMENT. To remove the CRT, proceed as follows:

WARNING

To prevent personal injury, always wear a face mask or goggles and gloves when handling the CRT. Handle the CRT carefully.

a. Remove top cover of instrument. (Top view drawing of Model 140A shown on inside of top cover.)

b. Disconnect the post-accelerator lead by lifting one side of the rubber cap and compressing the spring contact until the lead comes free.

c. Disconnect the clip-on leads from the neck of the CRT.

Table 5-5. Troubleshooting High Voltage Supply, No Voltage

1. Check Q602, L601, and the associated transformer primary for open circuits or shorts. Replace any bad components.		
Procedure	**Indication**	**Conclusion**
2. Remove the edge-on connector which goes to the emitter of Q601 (yellow wire). Connect this lead through a 2K resistor to -12.6 volts (any white-violet wire).	Rectifier (V302-V305) filaments light. Filaments don't light.	Proceed to step 3. Proceed to step 4.
3. Replace edge-on connector, and change V601.	Filaments light. Filaments don't light.	Q601 was bad. Check biasing circuitry of V601. Then check Q601 and associated circuitry.
4. Check T601 and rectifier load circuit for opens or shorts. Then lift one lead of C613, C614, C615, C616, C617, C621, and turn instrument on again.	Filaments light. Filaments don't light.	Put capacitors back one at a time until the bad one causes filaments to go out. Trouble probably with transformer T601.

d. Remove the CRT bezel from the front panel of the instrument.

e. Loosen the clamp at the CRT socket.

f. Remove the socket from the CRT base; pry loose carefully.

g. Place one hand on the CRT face and, with the other hand, slide the CRT forward and out of the instrument.

h. To replace the CRT, reverse the procedure.

i. Check the trace alignment and geometry adjustments, Paragraphs 3-7 and 5-16 respectively.

5-41. FAN REMOVAL AND REPLACEMENT. Use the following procedure for removing and reverse the procedure for replacing the cooling fan.

a. Remove the top and bottom covers of the Model 140A.

b. Disconnect the white-gray and white-green-gray wires from the fan terminals.

c. Remove all transistor heat sinks from the fan assembly and push them out of the way.

d. Remove the four fan mounting nuts on the rear panel of the instrument.

e. Lift out the fan assembly.

5-42. H-V DECK REMOVAL AND REPLACEMENT. Most of the components on the high voltage deck can be replaced without removing the assembly. Other components can be removed and replaced by removing the deck part way out (without disconnecting wires). Refer to Figure 5-3 for mounting screw and wire identification; use the following procedure for removing the high voltage deck.

a. Remove the left side and top covers.

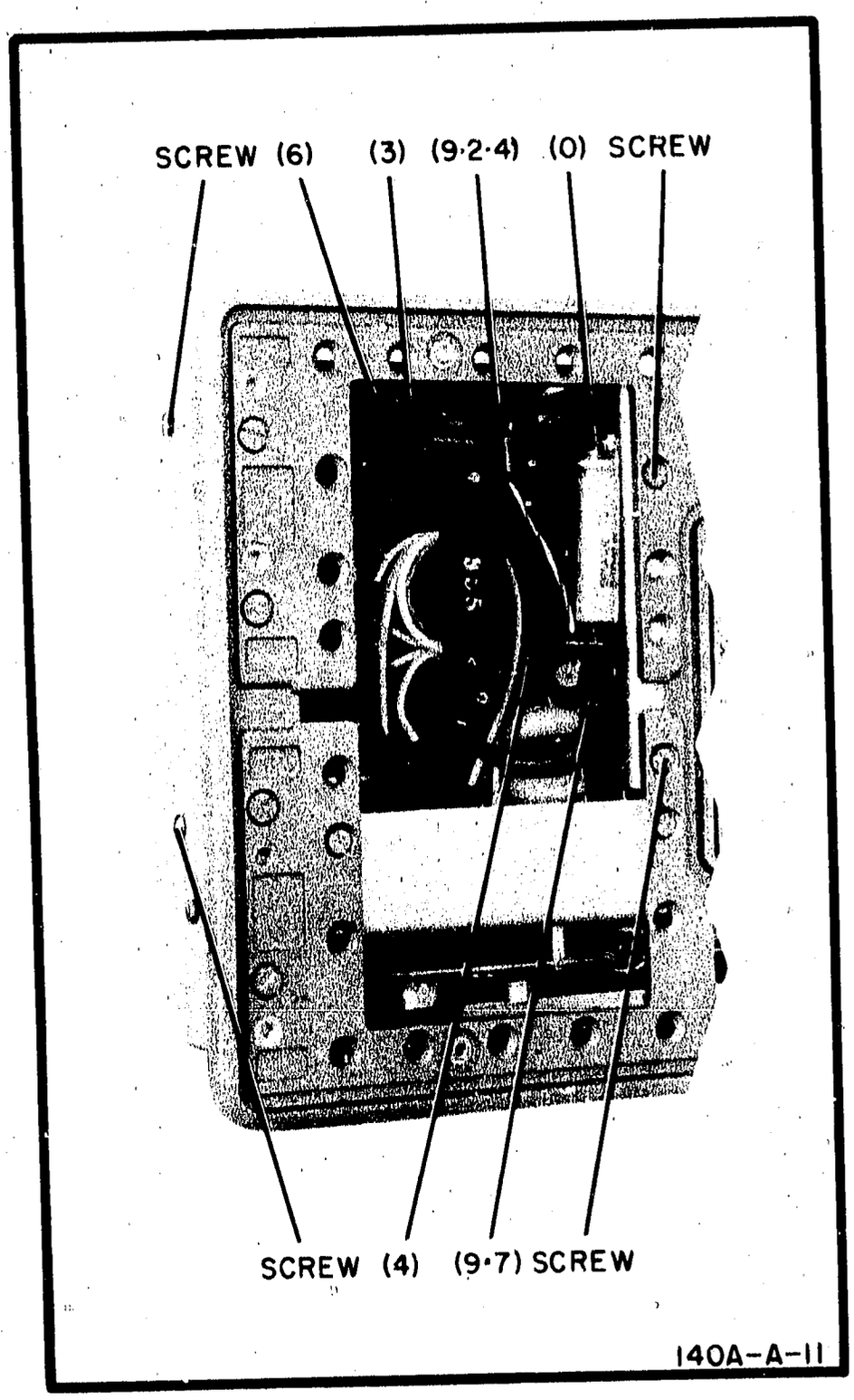


Figure 5-3. High Voltage Rectifier Deck Removal

b. Disconnect the 6 wires from the board and remove the 4 mounting screws; see Figure 5-3 for wire and screw identification.

c. Disconnect the post-accelerator lead from the CRT as described in Paragraph 5-40 b.

d. Push the wires aside, tilt the deck away from the left side of the instrument and lift it out.

5-43. SERVICING CIRCUIT BOARD.

5-44. The Model 140A has three circuit boards of the plated-through type. When servicing this type board, components can be removed and replaced by applying a soldering iron tip to the component connection on either side of the board. When removing a component with multiple leads, such as potentiometers, move the soldering iron tip from lead to lead while applying moderate pressure to the component to lift it from the board. Excess solder can be removed by applying heat and rotating a wooden toothpick in the hole. Hewlett-Packard Service Note M-20D contains additional information on the repair of circuit boards; important considerations are as follows:

a. Do not apply excessive heat.

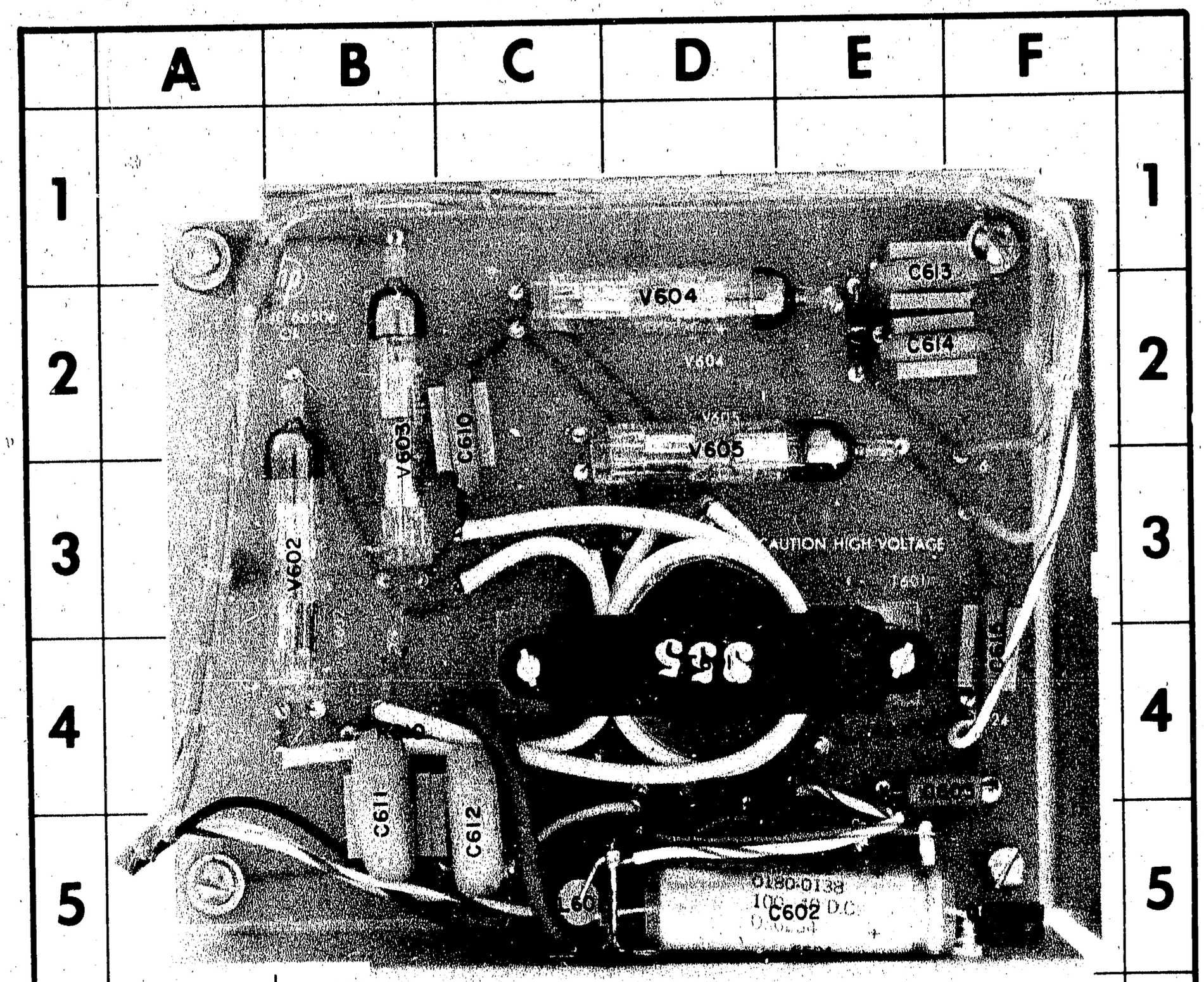
b. Apply heat to component leads and remove component with a straight pull away from the board.

c. Do not force replacement component leads into the hole.

5-45. If the metal conductor lifts from the board, it can be cemented back with a quick-drying acetate base cement having good insulating properties. If the metal conductor is broken, solder a good conducting bare wire to the conductor so it bridges the break.

Table 5-6. Troubleshooting High-Voltage Supply, Incorrect Voltage

Procedure	Effect	Conclusion
1. Remove Nuvistor V601 from its socket.	Output drops to zero.	Proceed to step 2.
	Output remains at an incorrect value.	Q601 shorted
2. Replace V601 in its socket, and lift one end of R601.	Output drops.	Trouble probably in the resistor divider network R611, R619 - R634.
	Output remains at an incorrect value.	V601 bad.



REF DESIG	GRID LOC	REF DESIG	GRID LOC
C602	E5	Q602	F5
C603	E4	R610	B4
C610	C2	R611	E2
C611	B5	T601	D4
C612	C5	V602	B3
C613	E1	V603	B2
C614	E2	V604	D2
C615	E4	V605	D3
L601	C5		

140A—A—8

Figure 5-4. High-Voltage Rectifier Deck, A601

Table 5-7. Schematic Diagram Notes

Conditions for DC Voltage Measurement

DC Voltages shown on the schematic diagrams were measured, to ground, using a vacuum tube Voltmeter, with a Model 1421A and a Model 1402A installed. Voltages shown are typical, ±10%.

Refer to MIL-STD-15-1A for schematic symbols not listed in this table.

Unless otherwise indicated:
capacitance in picofarads
inductance in microhenries
resistance in ohms

= Etched circuit board

= Front panel marking

= Rear panel marking

= Front panel control

= Screwdriver Adjustment

CW = Clockwise end of variable resistor

= Primary signal path

= Feedback path

= Waveform test point (with number)

= Common point (with letter)

= Avalanche (zener) diode

= Tunnel diode

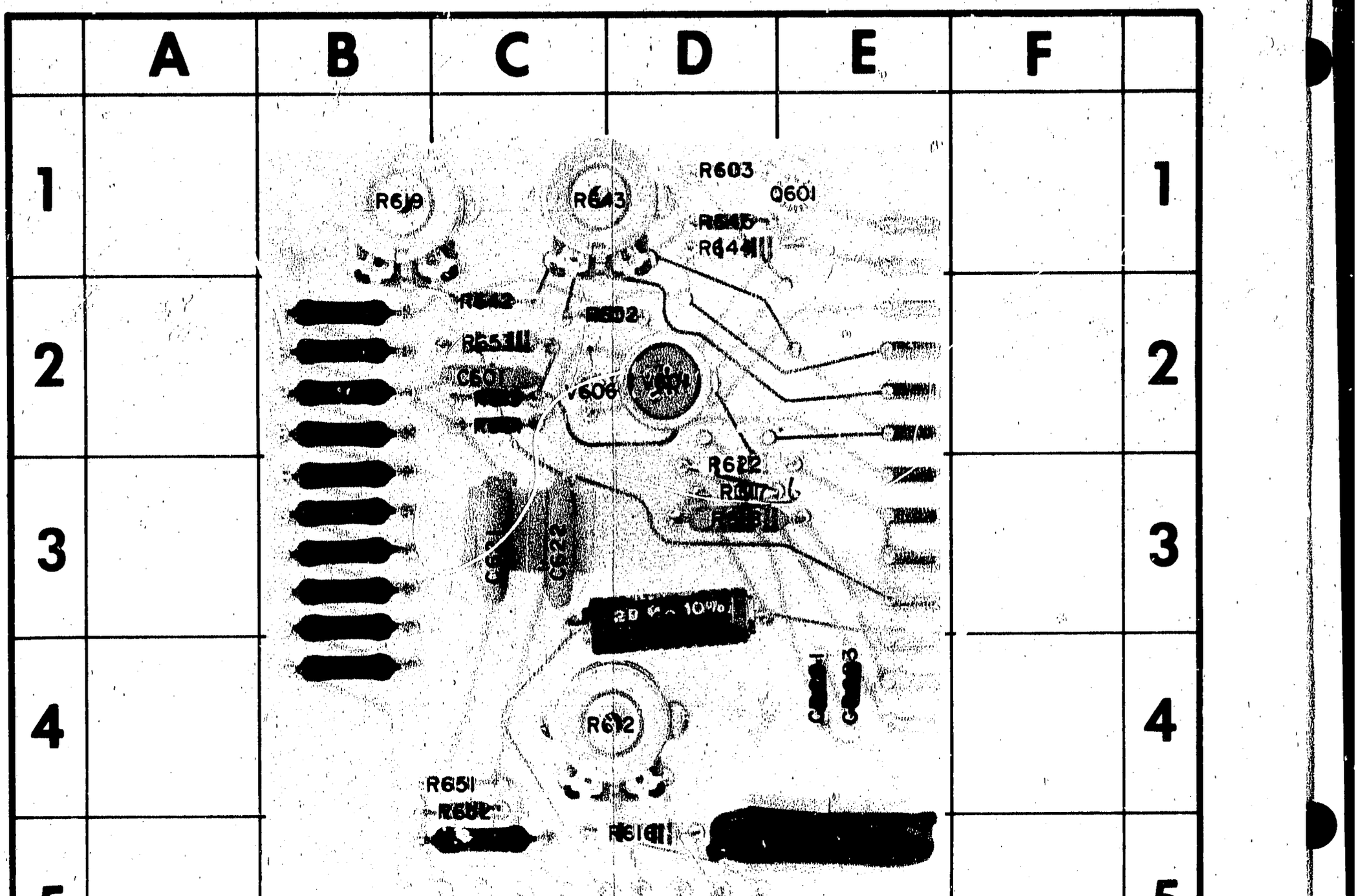
= Step recovery diode

Numbers in parentheses indicate wire color using resistor color code, e.g. WHT-RED-GRN is (9·2·5).

0 - Black	5 - Green
1 - Brown	6 - Blue
2 - Red	7 - Violet
3 - Orange	8 - Gray
4 - Yellow	9 - White

P/O = Part of

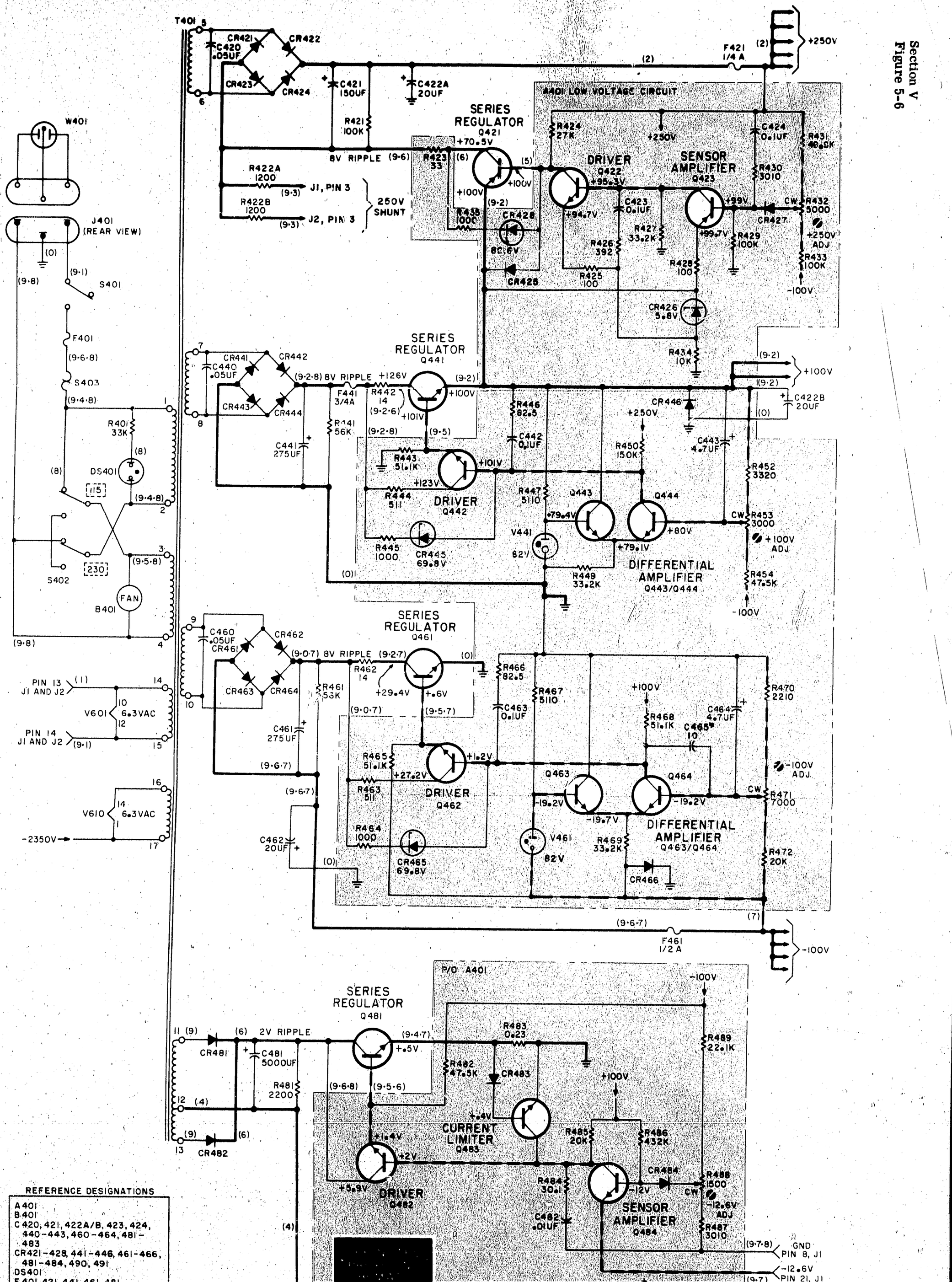
* = Optimum value selected at factory, average value shown; part may have been omitted.



REF DESIG	GRID LOC	REF DESIG	GRID LOC
C601	C2	R622	D3
C616	E5	R625	C5
C621	C3	R627	B4
C622	C3	R628	B3
CR601	E4	R629	B3
CR603	E4	R630	B3
Q601	E1	R631	B3
R617	D3	R632	B3
R601	C2	R633	B2
R602	D2	R634	B2
R603	D1	R642	C2
R612	D4	R643	C1
R613	C2	R644	D1
R615	D3	R645	D1
R616	D5	R651	C4
R618	D3	R652	C4
R619	B1	R653	C2
R620	B2	V601	D2
R621	B2	V606	C2

140A-A-10

Figure 5-5. Component Identification High-Voltage Regulator Board



REFERENCE DESIGNATIONS

A401
B401
C420, 421, 422A/B, 423, 424, 440-443, 460-464, 481-483
CR421-428, 441-446, 461-466, 481-484, 490, 491
DS401
F401, 421, 441, 461, 481

Figure 5-6. Low Voltage Schematic Diagram

REFERENCE DESIGNATIONS

A401
B401
C420, 421, 422A/B, 423, 424, 440-443, 460-464, 481-483
CR421-428, 441-446, 461-466, 481-484, 490, 491
DS401
F401, 421, 441, 461, 481
J401-403
Q421-423, 441-444, 461-464, 481-484, 490
R401, 421, 422A/B, 423, 434, 435, 441-447, 449, 450, 452-454, 461-472, 491, 496
S401
T401
V441, 461
W401

SERIES REGULATOR Q481

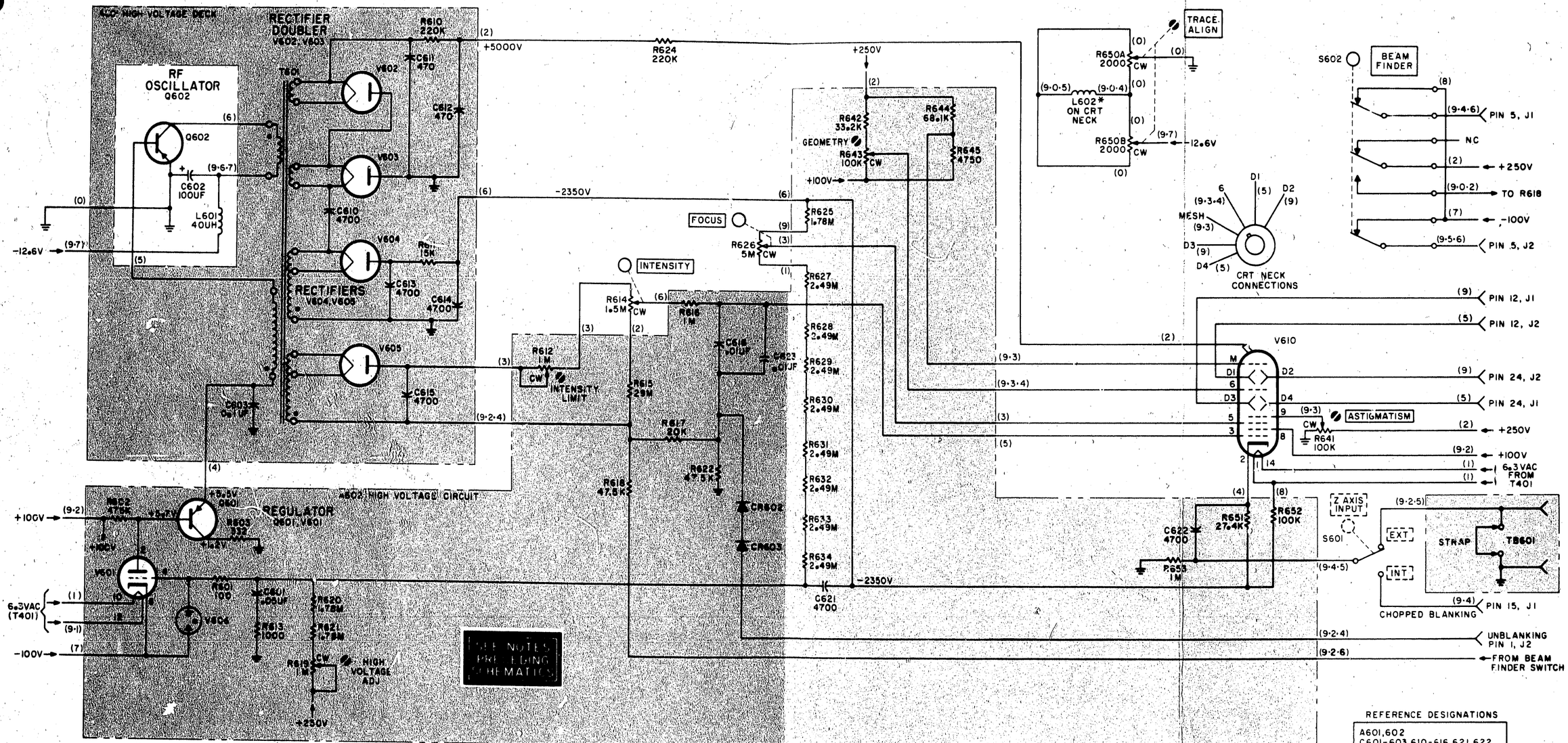
11 (9)
12 (4)
13 (9)
CR481
CR482
(6)
2V RIPPLE
C481 5000UF
R481 2200
(9·4·7)
+.5V
(9·6·8)
(9·5·6)
R482 47.5K
R483 0.23
CR483
+100V
R489 22.1K
-100V
+.9V
CURRENT LIMITER Q485
+1.4V
+2V
R485 20K
R486 432K
DRIVER Q482
+5.9V
R484 30.1
CR484
-12V
CW
R488 1500
-12.6V ADJ
C482 .01UF
SENSOR AMPLIFIER Q484
R487 3010
(4)
(9·7·8)
GND PIN 8, J1
(9·7)
-12.6V PIN 21, J1
C483 47UF
R490 0.23
(9·7)
F481 3A
-12.6V

P/O A401

CALIBRATOR Q490

6.3 VAC FROM T401, PIN 14 (1)
R491 825
-.2V
R492 1620
-12.6V
CR490
R493 16.2K
-100V
CR491 7.5V
CW
R494 1500 CAL ADJ
R495 4437
R496 493
J402
(9·3·4)
10V
CALIBRATOR
J403
(9·1·5)
1V
(9·1·5)
PIN 19 J1 AND J2

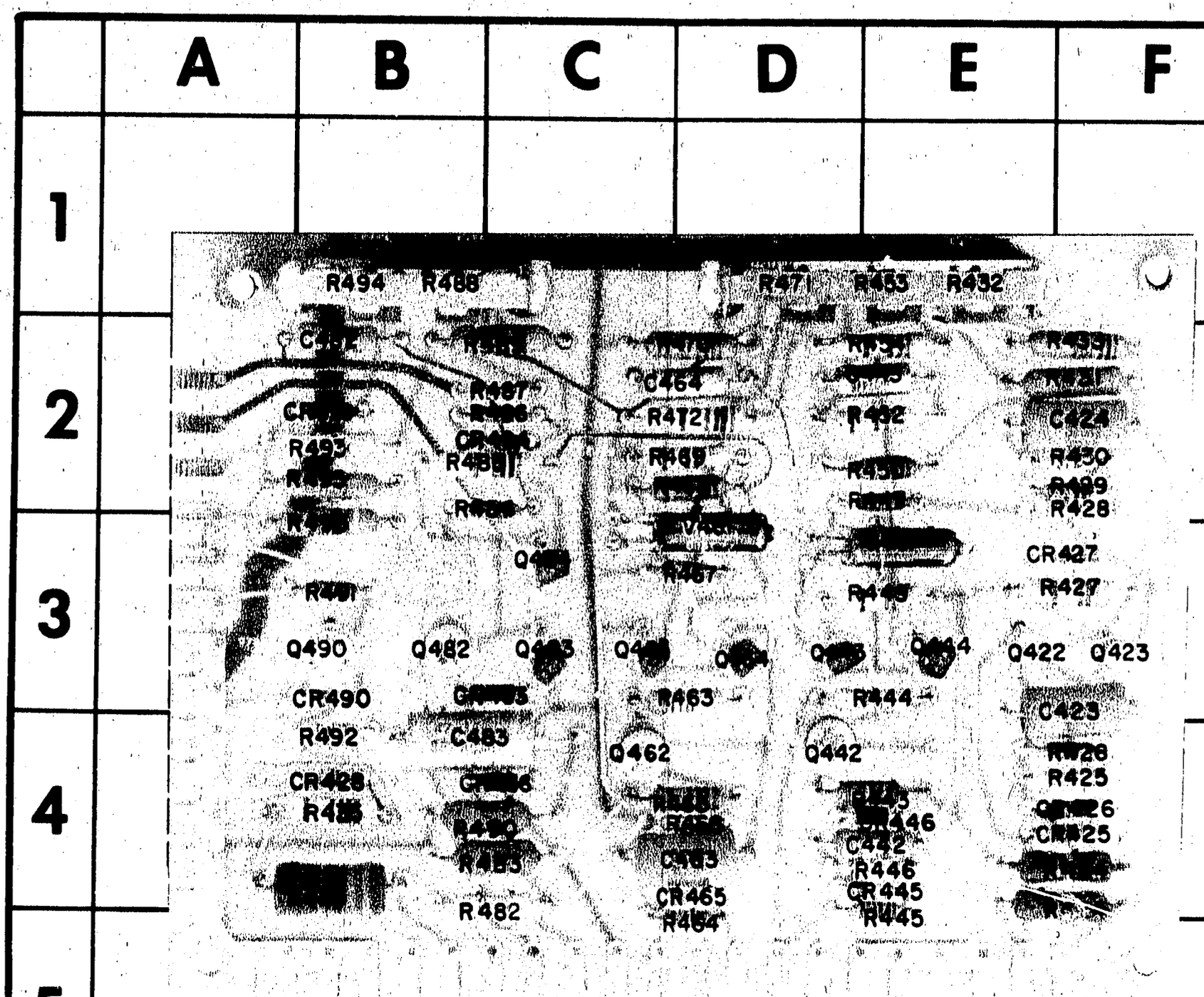
140A-L.V.P.S - 721



REFERENCE DESIGNATIONS

A601,602
C601-603,610-616,621,622
CR601-603
L601
Q601,602
R601-603,610-622,624-634, 641-645,650-653
S601,602
T601
TB601
V601-606,610,615

DELETED:



REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC
C423	F-3	Q423	F-3	R433	F-2	R470	D-2
C424	F-2	Q442	D-4	R434	F-4	R471	D-1
C442	E-4	Q443	D-3	R435	B-4	R472	D-2
C443	E-2	Q444	E-3	R443	E-4	R482	C-5
C463	D-4	Q462	C-4	R444	E-3	R483	C-4
C464	C-2	Q463	C-3	R445	E-5	R484	C-2
C482	B-2	Q646	D-3	R556	E-4	R485	B-2
C483	C-4	Q482	B-3	R447	E-2	R486	C-2
CR425	F-4	Q483	C-3	R449	E-3	R487	C-2
CR426	F-4	Q484	C-3	R450	E-2	R488	B-1
CR427	F-3	Q490	B-3	R452	E-2	R489	C-2
CR428	B-4	R423	B-4	R453	E-1	R490	C-4
CR445	E-4	R424	F-4	R454	E-2	R491	B-3
CR446	E-4	R425	F-4	R463	D-3	R492	B-4
CR465	D-4	R426	F-4	R464	D-5	R493	B-2
CR466	C-4	R427	F-3	R465	D-4	R494	B-1
CR483	C-3	R428	F-2	R466	D-4	R495	B-2
CR484	C-2	R429	F-2	R467	D-3	R496	B-3
CR490	B-3	R430	F-2	R468	D-2	V441	E-3
CR491	B-2	R431	F-2	R469	D-2	V461	D-3
Q422	E-3	R432	E-1				

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Figure 5-8. Component Identification Low-Voltage Board

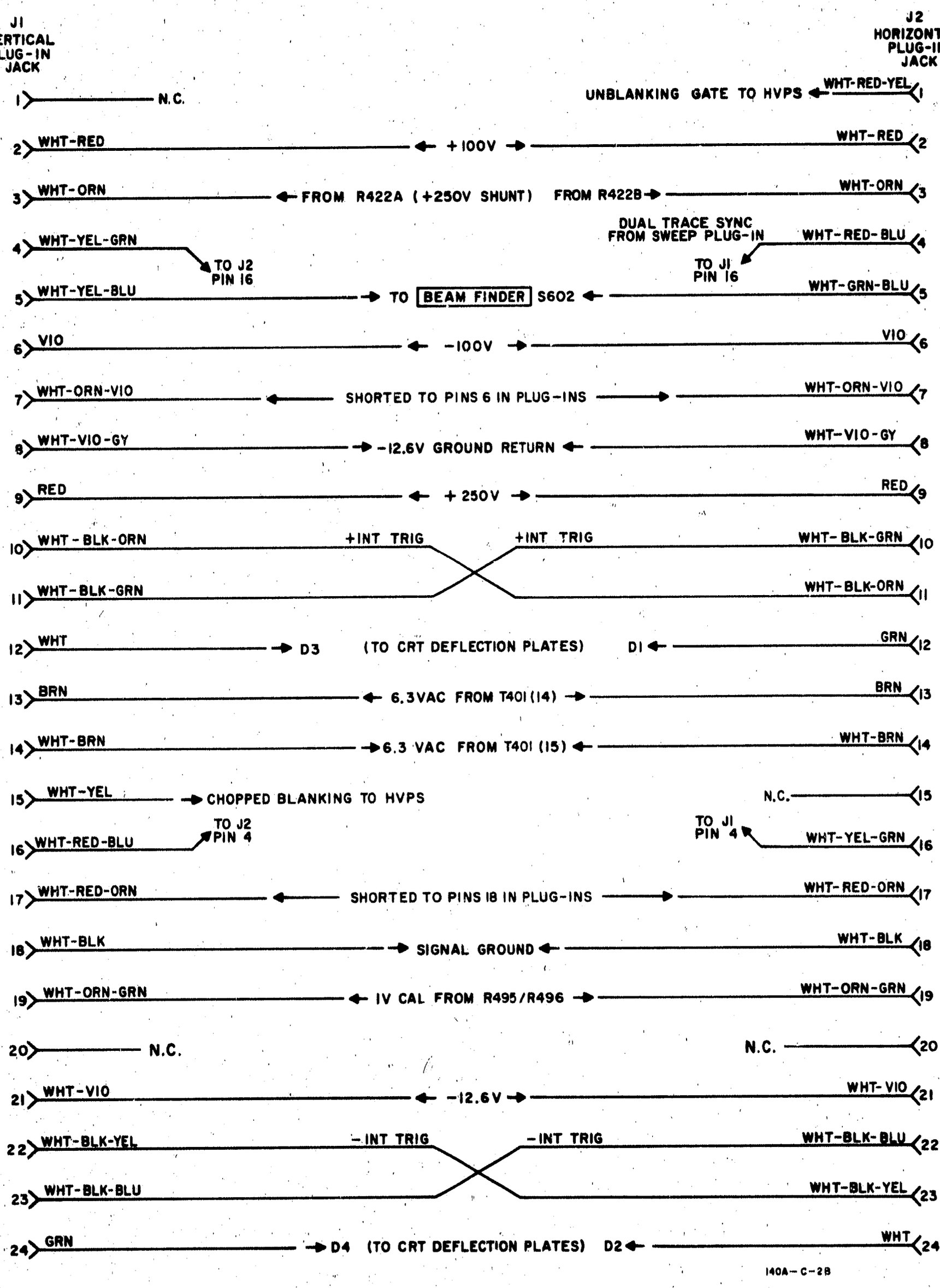
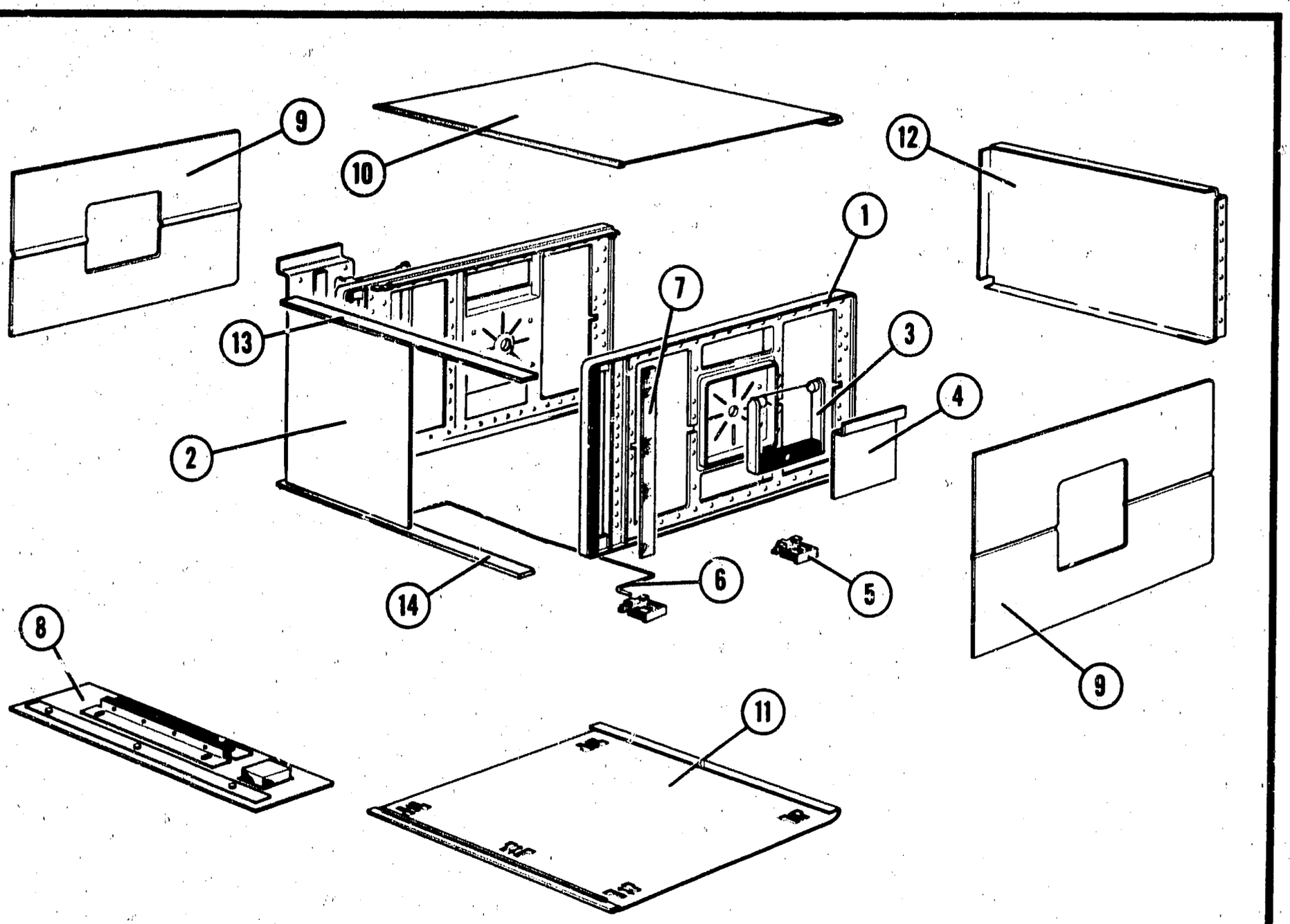


Figure 5-9. Plug-In Jack Connections

PARTS LIST



Part	Part Number	Quantity
1. Frame Assembly	5060-0736	2
2. Front Panel	00140-00204	1
3. Side Handle Assembly	5060-0763	2
4. Handle Retainer	5060-0765	2
5. Foot Assembly	5060-0767	5
6. Tilt Stand	1490-0030	1
7. Plastic Trim	6980-0004	2
8. Rack Mount Kit	5060-0777	1
9. Side Cover	5000-0747	2
10. Top Cover Assembly	5060-0740	1
11. Bottom Cover Assembly	00140-04402	1
12. Rear Panel	00140-00202	1
13. Top Panel Support	00140-24701	1
14. Bottom Panel Support	00140-24702	1

Figure 6-1. Cabinet Parts, Exploded View

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replaceable parts for the instrument. Table 6-2 lists the parts in alpha-numerical order of their reference designations and provides the following information for each item:

a. hp Part number.

b. Total quantity (TQ) used in instrument; given only first time a part number is listed.

c. Description of part; see Table 6-1 for list of reference designators and abbreviations.

d. Typical manufacturer of part in a five-digit code, except for Hewlett-Packard Company; see code list of manufacturers, Table 6-3, for name.

e. Manufacturer's part number.

6-3. Parts not identified by a reference designation are listed at the end of Table 6-2, under miscellaneous. Cabinet parts and the rack-mounting kit for the instrument are shown in Figure 6-1 and are identified by part number.

6-4. ORDERING INFORMATION.

6-5. To order a replacement parts from the Hewlett-Packard Company, address the order or iquiry to the nearest Hewlett-Packard Sales/Service Office (list in rear of manual) and supply the following information:

a. hp Part number of item(s).

b. Model number and eight-digit serial number of instrument.

6-6. To order a part not listed in the table, provide the following information:

a. Model number and eight-digit serial number of instrument.

b. Description of part including function and location.

6-7. To order a part from a manufacturer other than the Hewlett-Packard Company, provide the complete part description and the manufacturer's part number from the table.

Table 6-1. List of Reference Designators and Abbreviations

REFERENCE DESIGNATORS

A = assembly	E = misc electronic part	MP = mechanical part	TB = terminal board
B = motor	F = fuse	P = plug	TP = test point
C = capacitor	FL = filter	Q = transistor	V = vacuum tube, neon bulb, photocell, etc.
CP = coupling	J = jack	R = resistor	
CR = diode	K = relay	RT = thermistor	W = cable
DL = delay line	L = inductor	S = switch	X = socket
DS = device signaling (lamp)	M = meter	T = transformer	Y = crystal

ABBREVIATIONS

A = amperes	GE = germanium	N/C = normally closed	RMO = rack mount only
A.F.C = automatic frequency control	GL = glass	NE = neon	RMS = root-mean-square
AMPL = amplifier	GRD = ground(ed)	NI PL = nickel plate	
	H = henries	N/O = normally open	S-B = slow-blow
B.F.O. = beat frequency oscillator	HEX = hexagonal	NPO = negative positive zero (zero temperature coefficient)	SCR = screw
BE CU = beryllium copper	HG = mercury		SE = selenium
BH = binder head	hp = Hewlett-Packard		SECT = section(s)
BP = bandpass	HR = hour(s)	NRFR = not recommended for field replacement	SEMICON = semiconductor
BRS = brass	IF = intermediate freq		SI = silicon
BWO = backward wave oscillator	IMPG = impregnated	NSR = not separately replaceable	SIL = silver
	INCD = incandescent		SL = slide
CCW = counter-clockwise	INCL = include(s)		SPL = special
CER = ceramic	INS = insulation(ed)	OBD = order by description	SST = stainless steel
CMO = cabinet mount only	INT = internal	OH = oval head	SR = split ring
COEF = coefficient		OX = oxide	STL = steel
COM = common	K = kilo = 1000		
COMP = composition		P = peak	TA = tantalum
CONN = connector	LIN = linear taper	PC = printed circuit	TD = time delay
CP = cadmium plate	LK WASH = lock washer	PF = picofarads = 10^{-12} farads	TGL = toggle
CRT = cathode-ray tube	LOG = logarithmic taper		TI = titanium
CW = clockwise	LPF = low pass filter	PH BRZ = phosphor bronze	TOL = tolerance
		PHL = Phillips	TRIM = trimmer
DEPC = deposited carbon	M = milli = 10^{-3}	PIV = peak inverse voltage	TWT = traveling wave tube
DR = drive	MEG = meg = 10^{6}	P/O = part of	
	METFLM = metal film	POLY = polystyrene	U = micro = 10^{-6}
ELECT = electrolytic	MFR = manufacturer	PORC = porcelain	
ENCAP = encapsulated	MINAT = miniature	POS = position(s)	VAR = variable
EXT = external	MOM = momentary	POT = potentiometer	VDCW = dc working volts
	MTG = mounting	PP = peak-to-peak	
F = farads	MY = "mylar"	PT = point	W/ = with
FH = flat head		RECT = rectifier	W = watts
FIL H = fillister head	N = nano (10^{-9})	RF = radio frequency	WW = wirewound
FXD = fixed		RH = round head	W/O = without

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Table 6-2. Replaceable Parts

Ref Desig	hp Part No.	RS	TQ	Description (See Table 6-1.)	Mfr	Mfr Part No.
A401	00140-66504		1	A: low voltage supply board	hp	
A402	2100-1589		1	A: r var type v, 3 sect 7k, 3k, 5k ohms 20%	hp	
A403	2100-1588		1	A: r type v 2 sects 1.5k 30% (each)	hp	
A601	00140-60402		1	A: high voltage rectifier deck	hp	
A602	00140-66505		1	A: high voltage regulator board	hp	
B401	3160-0056		1	B: fan	hp	
C420	0150-0052		4	C: fxd cer 0.05 µf 20% 400vdcw	56289	33C17A
C421	0180-0147		1	C: fxd elect 150 µf -10 +50% 250vdcw	00853	PLI
C422	0180-0012		1	C: fxd elect 2 x 20 µf 450vdcw	56289	D32440
C423	0160-0168		5	C: fxd my 0.1 µf 10%	hp	
C424	0160-0168			C: fxd my 0.1 µf 10%	hp	
C425 - C439				Not assigned		
C440	0150-0052			C: fxd cer 0.05 µf 20% 400vdcw	56289	33C17A
C441	0180-0214		2	C: fxd elect 275 µf -10 +50% 200vdcw	56289	30D208G006DF4
C442	0160-0168			C: fxd my 0.1 µf 10% 200vdcw	hp	
C443	0180-0100		2	C: fxd elect 4.7 µf 10% 35vdcw	56289	150D475X9035B2
C444 - C459				Not assigned		
C460	0150-0052			C: fxd cer 0.05 µf 20% 400vdcw	56289	33C17A
C461	0180-0214			C: fxd elect 275 µf -10 +50% 200vdcw	56289	30D208G006DF4
C462	0180-0093			C: fxd elect 20 µf 150vdcw	56289	D33193
C463	0160-0168			C: fxd my 0.1 µf 10%	hp	
C464	0180-0100			C: fxd elect 4.7 µf 10% 35vdcw	56289	150D475X9035B2
C465	0160-2257		1	C: fxd cer 10 pf 5% 500 vdcw	72982	301-000-C0H0-10CJ
C466 - C467				Not assigned		
C468	0180-0093		1	C: fxd elect 20 µf 150vdcw	56289	D33193
C469 - C480				Not assigned		
C481	0180-0213		1	C: fxd elect 5000 µf 25vdcw	00853	PLI
C482	0160-0207		1	C: fxd my 0.01 µf 5% 200vdcw	hp	
C483	0180-0097		1	C: fxd elect 47 µf 10% 35vdcw	56289	150D476X9035S
C484 - C600				Not assigned		
C601	0160-0052			C: fxd cer 0.05 µf 20% 400vdcw	56289	33C17A
C602	0180-0138		1	C: fxd elect 100 µf -10 +100% 40vdcw	56289	D36254
C603	0160-0168			C: fxd my 0.1 µf 10% 200vdcw	hp	
C604 - C609				Not assigned		
C610	0160-0151		6	C: fxd cer 4700 pf -80 +20% 400vdcw	71590	DA172Z097CB
C611	0150-0036		2	C: fxd cer 470pf 20% 6kv	91418	S6KV470 20Z
C612	0150-0036			C: fxd cer 470 pf 20% 6kv	91418	S6KV470 20Z
C613	0160-0151			C: fxd cer 4700 pf -80 +20% 4000vdcw	71590	DA172-097CB
C614	0160-0151			C: fxd cer 4700 pf -80 +20% 4000vdcw	71590	DA172-097CB
C615	0160-0151			C: fxd cer 4700 pf -80 +20% 4000vdcw	71590	DA172-097CB
C616	0160-0907		2	C: fxd cer 0.01 µf -80 +20% 5000vdcw	hp	
C617 - C620				Not assigned		
C621	0160-0151			C: fxd cer 4700 pf -80 +20% 4000vdcw	71590	DA172-097CB
C622	0160-0151			C: fxd cer 4700 pf -80 +20% 4000vdcw	71590	DA172-097CB
C623	0160-0907			C: fxd cer 0.01 µf -80 +20% 5000vdcw	hp	

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.	RS	TQ	Description (See Table 6-1.)	Mfr	Mfr Part No.
CR421	1901-0028		12	CR: si	hp	
CR422	1901-0028			CR: si	hp	
CR423	1901-0028			CR: si	hp	
CR424	1901-0028			CR: si	hp	
CR425	1910-0015		3	CR: ge	hp	
CR426	1902-0034		1	CR: 5.8 v 10% 400mw	hp	
CR427	1901-0096		3	CR: si	hp	
CR428	1902-3402		1	CR: avalanche 80.6 v	hp	
CR429-CR440				Not assigned		
CR441	1901-0028			CR: si	hp	
CR442	1901-0028			CR: si	hp	
CR443	1901-0028			CR: si	hp	
CR444	1901-0028			CR: si	hp	
CR445	1902-3385		2	CR: si 69.8 v 5%	hp	
CR446	1901-0026			CR: si	hp	
CR447 - CR460				Not assigned		
CR461	1901-0028			CR: si	hp	
CR462	1901-0028			CR: si	hp	
CR463	1901-0028			CR: si	hp	
CR464	1901-0028			CR: si	hp	
CR465	1902-3385			CR: si 69.8 v 5%	hp	
CR466	1901-0026			CR: si	hp	
CR467 - CR480				Not assigned		
CR481	1901-0032		2	CR: rectifier si 15 amp	04713	1N3209
CR482	1901-0032			CR: rectifier si 15 amp	04713	1N3209
CR483	1901-0025		1	CR: si	hp	
CR484	1910-0015			CR: ge	hp	
CR485 - CR489				Not assigned		
CR490	1912-0006		1	CR: ge	03508	1N3718 Special
CR491	1902-0064		1	CR: si	hp	
CR492 - CR601				Not assigned		
CR602	1901-0487		2	CR: si	hp	
CR603	1901-0487			CR: si	hp	
DS401	1450-0048		1	DS: neon	hp	
F401	2110-0014		1	F: cartridge 4 amp 125v slow	71400	MDXZ4
	2110-0006		1	F: cartridge amp 125v slow	71400	MDL2
F402 - F420				Not assigned		
F421	2110-0004		1	F: cartridge 1/4 amp 250v	75915	AG-CAT J 312J250
F422 - F440				Not assigned		
F441	2110-0033		1	F: 0.75 amp 250v	79515	FO2GR750A
F442 - F460				Not assigned		
F461	2110-0012		1	F: cartridge 1/2 amp 250v	75915	312500

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.	RS	TQ	Description (See Table 6-1.)	Mfr	Mfr Part No.
F462 - F480				Not assigned		
F481	2110-0003		1	F: cartridge 3 amp 3 AG	75915	312003
J1	1251-0054		2	J: 24 contact	hp	
J2	1251-0054			J: 24 contact	hp	
J3 - J400				Not assigned		
J401	1251-0148			J: receptacle ac power	hp	
J402	1251-0202		2	J: calibrator	83330	221B
J403	1251-0202			J: calibrator	83330	221B
L601	9140-0171		1	L: fxd 40 μh 10% 1 amp	78526	HZ9897
L602	5060-0408		1	L: alignment	hp	
Q421	1850-0422		1	Q: ge pnp	hp	
Q422	1854-0005		1	Q: si npn	07263	2N708
Q423	1853-0036		1	Q: si pnp 2N3906	hp	
Q424 - Q440				Not assigned		
Q441	1854-0294		3	Q: si npn	hp	
Q442	1854-0090		2	Q: si npn	04713	SM8158
Q443	1854-0071		5	Q: si npn	03508	4JX16A1014
Q444	1854-0071			Q: si npn	03508	4JX16A1014
Q445 - Q460				Not assigned		
Q461	1854-0294			Q: si npn	hp	
Q462	1854-0090			Q: si npn	04713	SM8158
Q463	1854-0071			Q: si	03508	4JX16A1014
Q464	1854-0071			Q: si	03508	4JX16A1014
Q465 - Q480				Not assigned		
Q481	1854-0294			Q: si npn	hp	
Q482	1854-0039		1	Q: si	02735	2N3053
Q483	1854-0215		1	Q: si npn 2N3904	hp	
Q484	1854-0071			Q: si npn	03508	4JX16A1014
Q485 - Q489				Not assigned		
Q490	1850-0062		2	Q: ge pnp	hp	
Q491 - Q600				Not assigned		
Q601	1850-0062			Q: ge pnp	hp	
Q602	1850-0143		1	Q: ge spl	hp	
R401	0687-3331		1	R: fxd comp 33k ohms 10% 1/2w	01121	EB 3331
R402 - R420				Not assigned		
R421	0687-1041		1	R: fxd comp 100k ohms 10% 1/2w	01121	EB 1041
R422A/B	0815-0031		1	R: fxd ww 2400 ohms CT 5%	35434	CHE10-2400
R423	0764-0033		1	R: fxd met ox 33 ohms 5% 2w	hp	
R424	0761-0007		1	R: fxd met ox flm 27k ohms 5% 1w	hp	
R425	0757-0401		3	R: fxd metflm 100 ohms 1% 1/8w	hp	
R426	0757-0413		1	R: fxd metflm 392 ohms 1% 1/8w	hp	
R427	0757-0044		1	R: fxd metflm 33.2k ohms 1% 1/2w	hp	

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.	RS	TQ	Description (See Table 6-1.)	Mfr	Mfr Part No.
R428	0757-0401			R: fxd metflm 100 ohms 1% 1/8w	hp	
R429	0757-0465		2	R: fxd metflm 100k ohms 1% 1/8w	hp	
R430	0757-0273		2	R: fxd metflm 3.01k ohms 1% 1/8w	hp	
R431	0757-0370		1	R: fxd metflm 49.9k ohms 1% 1/2w	hp	
R432	2100-1589		1	NSR: p/o A402		
R433	0757-0367		1	R: fxd metflm 100k ohms 1% 1/2w	hp	
R434	0761-0006		1	R: fxd metflm 10k ohms 5% 1w	hp	
R435	0757-0338		1	R: fxd metflm 1k ohms 1% 1/4w	hp	
R436 - R440				Not assigned		
R441	0687-5631		2	R: fxd comp 56k ohms 10% 1/2w	01121	EB 5631
R442	0811-2030		2	R: fxd ww 14 ohms 5% 10w	hp	
R443	0757-0769		3	R: fxd metflm 51.1k ohms 1% 1/4w	hp	
R444	0757-0726		2	R: fxd metflm 511 ohms 1% 1/4w	hp	
R445	0757-0280		3	R: fxd metflm 1k ohms 1% 1/8w	hp	
R446	0757-0399		2	R: fxd metflm 82.5 ohms 1% 1/8w	hp	
R447	0757-0438		2	R: fxd metflm 5.11k ohms 1% 1/8w	hp	
R448				Not assigned		
R449	0757-0764		3	R: fxd metflm 33.2k ohms 1% 1/4w	hp	
R450	0757-0779		1	R: fxd metflm 150k ohms 1% 1/4w	hp	
R451				Not assigned		
R452	0757-0193		1	R: fxd metflm 3320 ohms 1% 1/2w	hp	
R453	2100-1589			NSR: p/o A402		
R454	0757-0852		1	R: fxd metflm 47.5k ohms 1% 1/2w	hp	
R455 - R460				Not assigned		
R461	0687-5631			R: fxd comp 56k ohms 10% 1/2w	01121	EB 5631
R462	0811-2030			R: fxd ww 14 ohms 5% 10w	hp	
R463	0757-0726			R: fxd metflm 511 ohms 1% 1/8w	hp	
R464	0757-0280			R: fxd metflm 1k ohms 1% 1/8w	hp	
R465	0757-0769			R: fxd metflm 51.1k ohms 1% 1/4w	hp	
R466	0757-0399			R: fxd metflm 82.5 ohms 1% 1/8w	hp	
R467	0757-0438			R: fxd metflm 5.11k ohms 1% 1/8w	hp	
R468	0757-0769			R: fxd metflm 51.1k ohms 1% 1/4w	hp	
R469	0757-0764			R: fxd metflm 33.2k ohms 1% 1/4w	hp	
R470	0757-0825		1	R: fxd metflm 2.21k ohms 1% 1/2w	hp	
R471	2100-1589			NSR: p/o A402		
R472	0757-0190		2	R: fxd metflm 20k ohms 1% 1/2w	hp	
R473 - R480				Not assigned		
R481	0687-2221		1	R: fxd comp 2200 ohms 10% 1/2w	01121	EB 2221
R482	0757-0768		1	R: fxd metflm 47.5k ohms 1% 1/4w	hp	
R483	0811-1746		2	R: fxd ww 0.36 ohms 5% 2w	81483	BWH
R484	0757-0388		1	R: fxd metflm 30.1 ohms 1% 1/8w	hp	
R485	0757-0190			R: fxd metflm 20k ohms 1% 1/2w	hp	
R486	0757-0480		1	R: fxd metflm 432k ohms 1% 1/8w	hp	
R487	0757-0273			R: fxd metflm 3.01k ohms 1% 1/8w	hp	
R488	2100-1588		1	NSR: p/o A403		
R489	0757-0846		1	R: fxd metflm 22.1k ohms 1% 1/2w	hp	
R490	0811-1746			R: fxd ww 0.36 ohms 5% 2w	81483	BWH
R491	0757-0421		1	R: fxd metflm 825 ohms 1% 1/8w	hp	

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.	RS	TQ	Description (See Table 6-1.)	Mfr	Mfr Part No.
R492	0757-0428		1	R: fxd metflm 1.62k ohms 1% 1/8w	hp	
R493	0757-0844		1	R: fxd metflm 16.2k ohms 1% 1/2w	hp	
R494	2100-1588			NSR: p/o A403		
R495	0698-3555		1	R: fxd metflm 4.43k ohms 1/2% 1/2w	hp	
R496	0698-3554		1	R: fxd metflm 493 ohms 1/2% 1/2w	hp	
R497 - R600				Not assigned		
R601	0757-0401			R: fxd metflm 100 ohms 1% 1/8w	hp	
R602	0757-0481		1	R: fxd metflm 475k ohms 1% 1/8w	hp	
R603	0757-0411		1	R: fxd metflm 332 ohms 1% 1/8w	hp	
R604 - R609				Not assigned		
R610	0683-2245		1	R: fxd comp 220k ohms 5% 1/4w	01121	EB 2245
R611	0683-1535		1	R: fxd comp 15k ohms 5% 1/2w	01121	EB 1535
R612	2100-0096		2	R: var comp 1 megohm 30% lin 1/5w	hp	
R613	0757-0280			R: fxd metflm 100 ohms 1% 1/8w	hp	
R614	2100-0756		1	R: var comp 1.5 megohm	hp	
R615	0836-0003		1	R: fxd depc 29 megohms 10% 1w	77764	Type BBF
R616	0757-0344		2	R: fxd metflm 1.00 megohms 1% 1/4w	hp	
R617	0757-0449		1	R: fxd metflm 20k ohms 1% 1/8w	hp	
R618	0757-0768		2	R: fxd metflm 47.5k ohms 1% 1/4w	hp	
R619	2100-0096			R: var comp 1 megohm 30% lin 1/5w	hp	
R620	0727-0845		3	R: fxd car flm 1.78 megohms 1% 1/2w	hp	
R621	0727-0845			R: fxd car flm 1.78 megohms 1% 1/2w	hp	
R622	0757-0768			R: fxd metflm 47.5k ohms 1% 1/4w	hp	
R623				Not assigned		
R624	0687-2241		1	R: fxd comp 220k ohms 10% 1/2w	01121	EB 2241
R625	0727-0845			R: fxd car flm 1.78 megohms 1% 1/2w	hp	
R626	2100-0374		1	R: var comp 5 megohms 30% lin 0.5w	hp	
R627	0698-3553		8	R: fxd car flm 2.49 megohms 1% 1/2w	hp	
R628	0698-3553			R: fxd car flm 2.49 megohms 1% 1/2w	hp	
R629	0698-3553			R: fxd car flm 2.49 megohms 1% 1/2w	hp	
R630	0698-3553			R: fxd car flm 2.49 megohms 1% 1/2w	hp	
R631	0698-3553			R: fxd car flm 2.49 megohms 1% 1/2w	hp	
R632	0698-3553			R: fxd car flm 2.49 megohms 1% 1/2w	hp	
R633	0698-3553			R: fxd car flm 2.49 megohms 1% 1/2w	hp	
R634	0698-3553			R: fxd car flm 2.49 megohms 1% 1/2w	hp	
R635 - R640				Not assigned		
R641	2100-0212		1	R: var comp 100k ohms 10% lin 2w	hp	
R642	0757-0454		1	R: fxd metflm 33.2k ohms 1% 1/8w	hp	
R643	2100-0095		1	R: var comp 100k ohms 30% lin 1/5w	hp	
R644	0757-0772		1	R: fxd metflm 68.1k ohms 1% 1/4w	hp	
R645	0757-0437		1	R: fxd metflm 4.75k ohms 1% 1/8w	hp	
R646 - R649				Not assigned		
R650A/B	2100-0445		1	R: var comp 2 x 2k ohms 30% lin	hp	
R651	0757-0452		1	R: fxd metflm 27.4k ohms 1% 1/8w	hp	
R652	0757-0465			R: fxd metflm 100k ohms 1% 1/8w	hp	
R653	0757-0344			R: fxd metflm 1.00 megohms 1% 1/4w	hp	
S401	3101-0030		1	S: wafer	hp	
S402	3101-0033		1	S: slide	hp	
S403	3103-0009		1	S: wafer	hp	
S404 - S600				Not assigned		

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.	RS	TQ	Description (See Table 6-1.)	Mfr	Mfr Part No.
S601	3101-0011			S: slide	hp	
S602	3101-0048		1	S: wafer	hp	
T401	9100-0184		1	T: power	hp	
T402 - T600				Not assigned		
T601	00140-86001		1	T: high voltage	hp	
V441	1940-0013		2	V: reference 82.0 ±1.0v	74276	Z82R7
V442 - V460				Not assigned		
V461	1940-0013			V: reference 82.0 ±1.0v	74276	Z82R7
V462 - V600				Not assigned		
V601	1921-0013		1	V: 6CW4	86684	6CW4
V602	1920-0001		4	V: 5642	93332	5642
V603	1920-0001			V: 5642	93332	5642
V604	1920-0001			V: 5642	93332	5642
V605	1920-0001			V: 5642	93332	5642
V606	2140-0008		1	V: neon NE2	24455	NE2
V607 - V609				Not assigned		
V610	5083-0652		1	V: cathode ray	hp	
W401	8120-0078		1	W: power 7J5FTJ	70903	KH4147
XV601	1200-0086		1	XV: nuvistor 5 pin	71785	133-75-11-026
				MISCELLANEOUS		
120A-20A			1	Bezel: crt	hp	
175A-91			2	Spring: crt contact	hp	
0360-0362			1	Strip: diode terminal	71785	Type 6-170
0370-0084			2	Knob: intensity and focus w/arrow	hp	
0510-0123			1	Clamp: pilot light	78553	C12008-014-4
0905-0050			1	Gasket: felt	85471	OBDS
1200-0037			1	Socket: crt	72825	97097
1200-0043			4	Insulator: anodized aluminum	76530	294457
1200-0050			7	Pin: crt socket	72825	9553
1200-0063			2	Clip: transistor	hp	
1200-0085			1	Cover: crt socket	72825	9109-1
1200-0088			4	Insulator: anodized aluminum	76530	293201
1251-0207			45	Connector: edge-on, 1/16"	00779	42587-5
1520-0042			4	Mount: vibration	hp	
2950-0034			2	Nut: hex, 11/16"	hp	
4320-0007			7	Extrusion: rubber	hp	
5000-0408			3	Bracket: coil	hp	
5040-0400			4	Support: cap	hp	
5040-0401			4	Support: cap	hp	
5040-0402			2	Mount: transformer	hp	

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.	RS	TQ	Description (See Table 6-1.)	Mfr	Mfr Part No.
	5040-0421		2	Insulator: potentiometer	hp	
	5040-0440		1	Cover: crt socket access	hp	
	5040-0466		1	Retainer: crt shield	hp	
	5060-0428		1	Filter: air	hp	
	7123-0092		1	Lable: crt shield	hp	
	8159-0001		1	Lead: electrical crt anode	03801	OBDS
	00140-00601		1	Shield: plug-in	hp	
	00140-00102		1	Deck: vertical	hp	
	00140-00103		1	Gusset: center	hp	
	00140-00104		1	Gusset: side	hp	
	00140-00106		1	Deck: main	hp	
	00140-01201		1	Bracket: latch	hp	
	00140-01202		1	Bracket: diode	hp	
	00140-01206		2	Bracket: fan	hp	
	00140-01208		4	Bracket: panel	hp	
	00140-01209		2	Bracket: gusset	hp	
	00140-01210		2	Bracket: transistor	hp	
	00140-24703		4	Support: panel bracket	hp	
	00140-44701		2	Spacer: cable	hp	
	00140-44702		5	Spacer: cable	hp	
	00140-60601		1	Shield: crt	hp	
	00140-61606		1	Cable: high voltage	hp	
	00140-61607		1	Cable: power	hp	

Table 6-3. Code List of Manufacturers

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 Handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00144	ADC Products Inc. Subsidiary of Magnetic Controls Co	Minneapolis, Minn.
00213	Sage Electronics Corp.	Rochester, N.Y.
00287	Cemco Inc.	Danielson, Conn.
00334	Humidial	Colton, Calif.
00348	Micro1ion Co., Inc.	Valley Stream, N.Y.
00373	Garlock Inc., Electronics Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass
00779	Amp. Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Co., Pickens Div.	Pickens, S.C.
00866	Gae Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
00929	Micro1ab Inc.	Livingston, N.J.
01002	General Electric Co Capacitor Dept	Gainsville, Fla
01009	Alden Products Co.	Brockton, Mass.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc., Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Rubber and Plastics Inc.	Sunnyvale, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Prod. Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electric Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N.J.
03954	Singer Co., Diehl Div. Finderne Plant	Somerville, N.J.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04222	Hi-Q Division of Aerovox	Myrtle ch, S.C.
04354	Precision Paper Tube Co.	C. go, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Products, Microwave Device Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P.M. Motor Company	Westchester, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp. Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05397	Union Carbide Corp. Linde Division Kemet Dept.	Cleveland, Ohio
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co	Roslyn Heights, Long Island, N.Y.
05729	Metro-Tel Corp.	Westbury, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	Bassick Co., The	Bridgeport, Conn.
06090	Raychem Corp.	Redwood City, Calif.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06407	E.T.A. Products Co. of America	Chicago, Ill.
06540	Amatom Electronic Hardware Co., Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Semcor Div. Components Inc.	Phoenix, Ariz.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
06980	Varian Assoc. Eimac Div.	San Carlos, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Culver City, Calif.
07263	Fairchild Camera & Inst. Corp. Semiconductor Div.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	Britcher Corp., The	Monterey Park, Calif.
07700	Technical Wire Products Inc.	Cranford, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Mfg. Co. Semiconductor Div.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Hewlett-Packard Co., Boonton Radio Div.	Rockaway, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08664	Bristol Co., The	Waterbury, Conn.
08717	Sloan Company	Sun Valley, Calif.
08718	ITT Cannon Electric Inc., Phoenix Div.	Phoenix, Arizona
08792	CBS Electronics Semiconductor Operations, Div of C.B.S. Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays Div.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atohm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11242	Bay State Electronics Corp.	Waltham, Mass.
11312	Teledyne Inc., Microwave Div.	Palo Alto, Calif.
11534	Duncan Electronics Inc.	Costa Mesa, Calif.
11711	General Instrument Corp., Semiconductor Div., Products Group	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N.J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12881	Metex Electronics Corp.	Clark, N.J.
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
12954	Dickson Electronics Corp.	Scottsdale, Arizona
13103	Thermalloy	Dallas, Texas
13396	Telefunken (GmbH)	Hanover, Germany
13835	Midland-Wright Div. of Pacific Industries, Inc.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14433	ITT Semiconductor, A Div. of Int. Telephone & Telegraph Corp.	West Palm Beach, Fla.
14493	Hewlett-Packard Company	Loveland, Colo.
14655	Cornell Dublier Electric Corp.	Newark, N.J.
14674	Corning Glass Works	Corning, N.Y.
14752	Electro Cube Inc.	So. Pasadena, Calif.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co.	New York, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15558	Micron Electronics	Garden City, Long Island, N.Y.
15566	Amprobe Inst. Corp.	Lynbrook, N.Y.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15818	Amelco Inc.	Mt. View, Calif.
15909	Daven Div. Thomas A. Edison Ind. McGraw-Edison Co.	Long Island City, N.Y.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16179	Omni-Spectra Inc.	Detroit, Ill.
16352	Computer Diode Corp.	Lodi, N.J.
16688	Weal Prec. Meter Co., Inc. De Jur Meter Div.	Brooklyn, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Inc.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
17675	Hamlin Metal Products Corp.	Akron, Ohio
17745	Angstrohm Prec. Inc.	No. Hollywood, Calif.
18042	Power Design Pacific Inc.	Palo Alto, Calif.
18476	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
18486	TRW Elect. Comp. Div.	Des Plaines, Ill.
18583	Curtis Instrument, Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
18911	Durant Mfg. Co.	Milwaukee, Wis.
19315	Bendix Corp., The Eclipse-Pioneer Div.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19644	LRC Electronics	Horseheads, N.Y.
19701	Electra Mfg. Co.	Independence, Kansas
20183	General Atronics Corp.	Philadelphia, Pa.
21226	Executone, Inc.	Long Island City, N.Y.
21335	Fafnir Bearing Co., The	New Britain, Conn.
21520	Fansteel Metallurgical Corp.	N. Chicago, Ill.
23783	British Radio Electronics Ltd.	Washington D.C.
24455	G.E. Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Coil Products Ltd.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co. Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.

00015-42
Revised: July, 1966

From: FSC. Handbook Supplements
H4-1 Dated JULY 1965
H4-2 Dated NOV 1962

Table 6-3. Code List of Manufacturers (Cont'd)

Code No.	Manufacturer	Address
44655	Ohmite Mfg. Co.	Skokie, Ill.
46384	Penn Eng. & Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer & Inst. C.	Southampton, Pa.
49956	Microwave & Power Tube Div.	Waltham, Mass.
52090	Rowan Controller Co.	Westminster, Md.
52983	Sanborn Company	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Raytheon Co. Commercial Apparatus & Systems Div.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
59730	Thomas & Betts Co.	Elizabeth, N.J.
60741	Triplett Electrical Inst. Co.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Inc. Weston-Newark	Newark, N.J.
66295	Wiltek Mfg. Co.	Chicago, Ill.
66346	Revere Wollansak Div. Minn. Mining & Mfg. Co.	St. Paul, Minn.
70276	Allen Mfg. Co.	Hartford, Conn.
70318	Allmetal Screw Product Co., Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	Union City, N.J.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Q cy, Mass.
71218	Bud Radio, Inc.	Willoughby, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Cardwell Condenser Corp.	Lindenhurst L.I., N.Y.
71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71447	Calif. Spring Co., Inc.	Pico-Rivera, Calif.
71450	CTS Corp.	Elkhart, Ind.
71468	ITT Cannon Electric Inc.	Los Angeles, Calif.
71471	Cinema Plant, Hi-Q Div. Aerovox Corp.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	Cornish Wire Co., The	New York, N.Y.
71707	Coto Coil Co., Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast Co., Div. Victoreen Instr. Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	Indiana General Corp., Electronics Div.	Keasby, N.J.
72699	General Instrument Corp., Cap. Div.	Newark, N.J.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Technological Products, Inc.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Inst., Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73586	Circle F Mfg. Co	Trenton, N.J.
73682	George K. Garrett Co., Div. MSL Industries Inc.	Philadelphia, Pa.
73734	Federal Screw Products Inc.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	General Industries Co., The	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Corp.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75378	CTS Knights Inc.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel.	San Francisco, Calif.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Cinch-Monadnock, Div. of United Carr Fastener Corp.	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76703	National Union	Newark, N.J.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Corp., The Bendix Pacific Div.	N. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phanostran Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine & Foundry Co. Potter & Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77638	General Instrument Corp., Rectifier Div.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	San Gabriel, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79136	Waldes Kohinoor Inc.	Long Island City, N.Y.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products Co.	Elizabeth, N.J.
80130	Times Telephoto Equipment	New York, N.Y.
80131	Electronic Industries Association. Any brand Tube meeting EIA Standards	Washington, DC
80207	Unimax Switch, Div. Maxon Electronics Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Controls Co.	Columbus, Ohio
80486	All star Products Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80583	Hammarlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments Inc.	Orange, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Elec. Div. Litton Ind., Inc.	Oakville, Conn.
81349	Military Specification	
81483	International Rectifier Corp.	El Segundo, Calif.
81541	Airpax Electronics, Inc.	Cambridge, Mass.
81860	Barry Controls, Div. Barry Wright Corp.	Watertown, Mass.
82042	Carter Precision Electric Co.	Skokie, Ill.
82047	Sperti Faraday Inc., Copper Hewitt Electric Div.	Hoboken, N.J.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Fairchild Camera & Inst. Corp., Defense Prod. Division	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod Inc. Electronic Tube Division	Emporium, Pa.
82376	Astron Corp.	East Newark, Harrison, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals & Controls Inc. Spencer Products	Attleboro, Mass.
82768	Phillips-Advance Control Co.	Joliet, Ill.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfg. Co.	Los Angeles, Calif.
83058	Carr Fastener Co	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	General Instrument Corp., Capacitor Div.	Darlington, S.C.
83148	ITT Wire and Cable Div.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co. Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp. Electronic Tube Div.	Plainfield, N.J.
83740	Union Carbide Corp. Consumer Prod. Div.	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
83942	Aeronautical Inst. & Radio Co.	Lodi, N.J.
84171	Arco Electronics Inc.	Great Neck, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	TRW Capacitor Div.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.

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Table 6-3. Code List of Manufactures (Cont'd)

Code No.	Manufacturer	Address
85471	A.B. Boyd Co.	San Francisco, Calif.
85474	R.M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	Hamden, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products Co., Inc.	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, Electronic Comp. & Devices Div.	Harrison, N.J.
87034	Marco Industries	Anaheim, Calif.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	San Francisco, Calif.
87930	Tower Mfg. Corp.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88421	Federal Telephone & Radio Corp.	Clifton, N.J.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89665	United Transformer Co.	Chicago, Ill.
90179	US Rubber Co., Consumer Ind. & Plastics Prod. Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Willow Grove, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91886	Malco Mfg. Co., Inc	Chicago, Ill
91929	Honeywell Inc., Micro Switch Div.	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92367	Elgeet Optical Co. Inc.	Rochester, N.Y.
92196	Universal Industries, Inc.	City of Industry, Calif.
92607	Tensolite Insulated Wire Co., Inc.	Tarrytown, N.Y.
93332	Sylvania Electric Prod Inc. Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93929	G.V. Controls	Livingston, N.J.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.
94148	Scientific Electronics Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp. Electronics Div.	East Paterson, N.J.
94222	South Chester Corp.	Chester, Pa.
94310	Tru-Ohm Products Memcor Components Div.	Huntington, Ind.
94330	Wire Cloth Products, Inc.	Bellwood, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
94696	Magnecraft Electric Co.	Chicago, Ill.
95023	George A. Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	Long Island, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95984	Siemon Mfg. Co.	Wayne, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Div. of Aerovox Corp.	Olean, N.Y.
96256	Thordarson-Meissner Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic & Precision Mfg.	Englewood, N.J.
97979	Reon Resistor Corp.	Yonkers, N.Y.
97983	Litton System Inc., Adler-Westrex Commun. Div.	New Rochelle, N.Y.
98141	R-Troncis, Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Hewlett-Packard Co., Moseley Div.	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98376	Zero Mfg. Co.	Burbank, Calif.
98731	General Mills Inc., Electronics Div.	Minneapolis, Minn.
98734	Paeco Div. of Hewlett-Packard Co.	Palo Alto, Calif.
98821	North Hills Electronics, Inc.	Glen Cove, N.Y.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99378	Allee Corp.	Winchester, Mass.
99515	Marshall Ind. Elect. Products Div.	San Marino, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Electronics Corp. Semiconductor Div.	El Monte, Calif.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

THE FOLLOWING HP VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000AB	ETA	England
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Mfg. Co.	San Jose, Calif.
000QQ	Cooltron	Oakland, Calif.
000WW	California Eastern Lab.	Burlington, Calif.
000YY	S.K. Smith Co.	Los Angeles, Calif.

06486	North American Electronics, Inc	Lynn, Mass.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
78526	Stanyck Winding Co.	Newburgh, N.Y.

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BACK DATING MANUAL CHANGES

APPENDIX 1
MANUAL CHANGES

This appendix contains information on changes required to adapt this manual to an instrument with a serial prefix listed in the table below. Check for your instrument serial prefix and make the changes indicated. Note that these changes adapt the manual to cover a particular instrument, as manufactured, and therefore will not apply to an instrument subsequently modified in the field. Refer to Section I for information on errata in this manual and on any other instrument serial prefix not covered in this appendix.

Instrument Serial Prefix	Make Numbered Changes
626-	1
602-	1, 2
546-	1 thru 3
542-	1 thru 4
540-	1 thru 5
520-	1 thru 6

CHANGE 1

Page 5-12, Figure 5-6,
C442: Change value to 0.01 µf.
C465: Delete
V441, V461: Change value to 81 V.
Table 6-2,
C442: Change to hp Part No. 0160-0207; C: fxd, my, 0.01 µf, 5%, 200vdcw; Mfr hp.
C465: Delete.
V441, V461: Change to hp Part No. 1940-0013; V: voltage regulator, 81 V; Mfr 73445; Mfr Part No. 8228/ZZ1000.

CHANGE 2

Page 5-12, Figure 5-6,
CR428: Delete.
R435: Delete.
Table 6-2,
CR428: Delete.
R435: Delete.

CHANGE 3

Page 5-13, Figure 5-7,
C603: Change value to 0.039 µf.
Table 6-2,
C603: Change to hp Part No. 0160-0164; C: fxd, my, 0.039 µf, 10%, 200vdcw; Mfr hp.

CHANGE 4

Page 5-13, Figure 5-7,
C623: Delete.
R617: Change value to 51.1k.
R618: Change value to 68.1k.
R622: Change value to 33.2k.
Table 6-2,
C623: Delete.
R617: Change to hp Part No. 0757-0458; R: fxd, metflm, 51.1k ohms, 1%, 1/8w; Mfr hp.
R618: Change to hp Part No. 0757-0855; R: fxd, metflm, 68.1k ohms, 1%, 1/2w; Mfr hp.
R622: Change to hp Part No. 0757-0764; R: fxd, metflm, 33.2k ohms, 1%, 1/4w; Mfr hp.

CHANGE 5

Page 5-12, Figure 5-6,
Add:
CR477 between base of Q444 and wiper of R453.
R451, 39k ohms between base and collector of Q444.
R452: Change value to 5110 ohms.
V441: Delete and replace with R448, 20k ohms.
Table 6-2,
Add:
CR447: hp Part No. 1910-0015; CR: ge; Mfr hp.
R448: hp Part No. 0757-0760; R: fxd metflm, 20k ohms, 1%, 1/4w; Mfr hp.
R451: hp Part No. 0757-0787; R: fxd metflm, 392k ohms, 1%, 1/4w; Mfr hp.
R452: Change to hp Part No. 0757-0833; R: fxd metflm, 5.11k ohms, 1%, 1/5w; Mfr hp.
V441: Delete.

CHANGE 6

Page 5-12, Figure 5-6,
R431: Change value to 51.1k ohms.
Table 6-2,
R431: Change to hp Part No. 0757-0853; R: fxd metflm, 51.1k ohms, 1%, 1/2w; Mfr hp.