HEWLETT-PACKARD
COMPANY

450A

AMPLIFIER

SERIALS PREFIXED: 010-

OPERATING AND SERVICING MANUAL

hp

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00001-1

OPERATING AND SERVICING MANUAL

MODEL 450A

SERIALS PREFIXED: 010 -

AMPLIFIER

00001-1 Printed: JAN 1961

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LIST OF ILLUSTRATIONS

GAIN:	40 ± 1/8 db (100X), 20 ± 1/8 db (10X) at 1000 cps.
FREQUENCY RESPONSE:	For 40 db gain (open circuit): 5 cps to 2 megacycles, within ± 1 db; 10 cps to 1 megacycle, within ± 1/2db. For 20 db gain (open circuit): 2 cps to 1.2 megacycles, within ± 1 db; 5 cps to 1 megacycle, within ± 1/2 db.
STABILITY:	± 2% with line voltage changes (115/230 volts ± 10%) and normal changes in tube characteristics.
IMPEDANCE:	Input: 1 megohm shunted by approximately 15 pf. Output: 150 ohms maximum over full frequency range.
OUTPUT LEVEL:	10 volts maximum into 3000 ohms or higher resistive load.
DISTORTION:	Less than 1% distortion from 2 cps to 100 kc at rated output and load resistance; less than 2% above 100 kc.
NOISE:	For 40 db gain: Equivalent to 40 microvolts at input terminals. For 20 db gain: Equivalent to 250 microvolts at input terminals.
POWER:	115/230 volts ± 10%, 50 to 1000 cps ac, 50 watts.
DIMENSIONS:	Cabinet Mount: 8-5/8 in. wide, 5-1/2 in. high, 10-3/4 in. deep. Rack Mount: 19 in. wide, 5-7/32 in. high, 10-9/16 in. deep.
WEIGHT:	Cabinet Mount: Net 10 lbs; shipping 14 lbs. Rack Mount: Net 11 lbs; shipping 24 lbs.
ACCESSORIES AVAILABLE:	AC-16A Cable Assembly (terminates in dual banana plugs 44 in. long). AC-16B Cable Assembly (dual banana plug to BNC male 45 in. long).

Figure 1-1. Table of Specifications

Figure 1-2. Model 450A Amplifier

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The Model 450A is a general-purpose, stabilized, fixed-gain amplifier for use with low-level signals from 2 cps to 2 mc. It provides two calibrated gain factors, 10X (20 db) and 100X (40 db), selectable by a toggle switch on the front panel. Each gain factor is accurate to within ±1/8 db in the audio frequency range; frequency response is given in the table of specifications (figure 1-1). Principal characteristics: stable gain with smooth attenuation beyond rated frequency range, wide frequency range, low distortion.

1-3. Typical uses include increasing the sensitivity of ac test equipment (voltmeters, oscilloscopes, bridges, etc), obtaining larger signals across lower impedances in test bench setups and permanent system installations. An electronically-regulated power supply and large amounts of degenerative feedback around the entire amplifier circuit provide very reliable and stable operation in case of changing line voltage, load resistance, or tube characteristics.

1-4. The amplifier is constructed on a single chassis with removable cover and bottom plate. A leather carrying handle is provided on the left side of the cabinet model. The front panel is finished in light grey enamel; the rest of the cabinet is finished in dark grey wrinkle paint. Operating controls and terminals consist of toggle-type power and gain switches and binding post type input and output terminals on the front panel. Binding posts are spaced 3/4 inch on-centers to receive dual banana-plug connectors. The power cable is permanently attached to the rear of the amplifier and is terminated in a 3-prong, grounding-type plug. A fuse is provided on the rear and can be replaced externally.

1-5. APPLICABLE LITERATURE.

1-6. This handbook contains complete operating and servicing instructions for the 450A Amplifier and conforms to the format specified in MIL-M-5474C.

SECTION II
OPERATING INSTRUCTIONS

2-1. INCOMING INSPECTION.

2-2. MECHANICAL. When unpacking the amplifier, inspect it for any sign of physical damage. If the cabinet is damaged, remove cover and bottom plate and inspect chassis parts for further damage. Report all damage to the carrier and keep amplifier intact for inspection by carrier and insurer. All instruments shipped by the Hewlett-Packard Company are insured against shipping damage. See Warranty at rear of manual.

2-3. ELECTRICAL. Electrical inspection consists of testing certain electrical characteristics of the amplifier to determine that it functions normally after having been stored or transported. Only one test is required; full instructions are given in paragraph 4-20 steps a through f.

2-4. INSTALLATION.

2-5. INPUT CONNECTIONS. The amplifier can be connected to a signal source through either twisted pair leads or shielded cable. Keep input leads as short as possible to avoid excessive capacitive shunting of the signal source. If necessary, use coaxial cable to prevent unwanted signal pickup from stray electric and magnetic fields. DO NOT connect the amplifier input to circuit potentials greater than 400 volts unless an external 1-μf capacitor having sufficient voltage rating is used in series with the input terminals.

2-6. OUTPUT CONNECTIONS. The amplifier output can be connected through any convenient lead set or cable. The low output impedance of 150 ohms permits shielded cable to be used freely without capacitive loading in the audio range and permits twisted pair leads to be used with much less effect from stray fields. The amplifier is designed to be used with resistive loads of 3000 ohms or more. Loads below 3000 ohms reduce amplifier gain bandwidth, and maximum output voltage available. For higher frequencies, the load must have small capacitive reactance to preserve full output signal quality and stability. DO NOT connect the output terminals to dc potential of more than +50 or -300 volts, or output capacitor ratings will be exceeded.

2-7. CONSIDERATION FOR LOW SIGNAL LEVELS. When amplifying low-level signals it may be necessary to eliminate an electrical ground loop formed by the power cable ground lead and signal ground lead between two instruments. If this electrical path is completed (typically a combination of the signal ground and power line ground leads do), line frequency currents flow in the signal ground lead and develop voltages across the leads which are in series with the desired signal. To avoid this situation, select one ground path from a group of instruments connected together, and permit no other ground path to the power line ground. Grounding one of the instruments may give less ripple trouble than grounding any other; or ungrounding all instruments may give lowest line-frequency modulation of the desired signal.

2-8. POWER CABLE. The plug on the power cable has a round grounding terminal combined with standard, 2-prong plug. If the ac outlet will not accommodate this plug, an adapter must be used. The round pin on this plug grounds the amplifier chassis. When the adapter is used, the chassis connection is a pigtail lead extending from the adapter, which should be connected to a grounded ac outlet mounting box to ground the chassis.

2-9. POWER LINE VOLTAGE. The amplifier is shipped from the factory for operation on 115-volt ac power, unless otherwise specified. The power transformer can be reconnected for use on 230-volt power by connecting its dual primary windings in series as shown on the schematic diagram, note 1. After such conversion, replace the 0.8-ampere fuse with an 0.4-ampere slow-blow fuse.

2-10. OPERATING PROCEDURE.

2-11. The only operating precaution to be kept in mind are the instructions in paragraphs 2-5 and 2-6 regarding excessive dc voltages. For operation in undesirable atmospheric conditions, provide any physical protection possible to prevent mechanical damage, and operate amplifier as usual. Do not obstruct ventilating louvers. The power cord may be left connected to the power source during periods of non-operation.

SECTION III
THEORY OF OPERATION

3-1. AMPLIFIER CIRCUIT OPERATION.

3-2. The amplifier circuit consists of two stages of high-gain voltage amplification and a cathode follower output stage connected as shown in the schematic diagram. Pentode tubes are used in all three stages for wide bandwidth with low noise. The triode connected cathode follower presents a relatively low source impedance at the OUTPUT terminals. Degenerative feedback is carried around the entire amplifier to stabilize gain. The amount of degenerative feedback is adjusted by the GAIN switch to obtain 20 or 40 db amplification. The resistive feedback circuit is shunted by a small adjustable capacitor for gain compensation at high frequencies. Resistance-capacitance coupling is used between each stage. Cathode bias is used at each stage.

3-3. Degenerative feedback is taken from the amplifier output through a resistive divider consisting of R3 and R6 to the cathode of the first stage V1. The R3A portion of the divider is shorted by the GAIN switch S1 to decrease feedback and increase gain to 40 db. Resistor R6 provides fine adjustment of gain for calibration purposes. Capacitors C11 and C12 provide gain compensation at high frequencies.

3-4. REGULATED POWER SUPPLY OPERATION.

3-5. The power supply for the amplifier is electronically regulated to stabilize operation during changes in line voltage and to minimize line frequency modulation of the output signal. The regulated supply consists of power transformer T1, rectifier V4, series regulator tube V5, regulator amplifier V6 and voltage reference V7. The series regulator is a cathode follower whose cathode supplies the regulated voltage to the load consisting of V1, V2 and V3. The series regulator serves as an adjustable impedance controlled by amplified feedback from V6. Amplifier V6 samples the regulated voltage and amplifies any difference between it and the reference voltage provided by V7. Voltage comparison is accomplished by applying the sample voltage to V6 grid and the reference voltage to V6 cathode. If the regulated voltage tends to rise, V6 amplifies this increase and applies it to the grid of V5 causing the impedance of V5 to increase, thus instantly and exactly counteracting the original tendency to increase. This grid control automatically holds the series regulator cathode voltage constant. The high plate resistance of the series regulator tube assisted by amplifier feedback attenuates ripple and stabilizes the output voltage during changes in line voltage and rectifier output. The high transconductance of V5, assisted by the same feedback, stabilizes the cathode voltage during changes in load current. The sample of the regulated output is obtained from resistive divider R24 and R26. Resistor R25 is selected to adjust the value of the regulated voltage to +210 volts.

3-6. DC HEATER SUPPLY.

3-7. DC voltage is supplies to the heaters of V1, V2 and V3 to prevent line-frequency modulation of the output signal through heater-cathode leakage in the tubes. This voltage is obtained from a 9-volt winding on the transformer rectified by a full-wave bridge rectifier CR1. The rectified voltage is filtered by C7. Resistor R27 provides adjustment of the heater voltage to accommodate aging changes in rectifier resistance.

SECTION IV
SERVICE INSTRUCTIONS

4-1. WARNINGS AND CAUTIONS.

4-2. The amplifier contains a selenium rectifier. When selenium rectifiers burn out due to overheating, poisonous fumes are released. Ventilate immediately, and do not inhale these fumes. Do not handle the rectifier until it has cooled.

4-3. Do not remove V1 or V2 with the amplifier turned on. These tubes are supplied with unregulated dc heater voltage. If V1 or V2 is removed with the amplifier operating, the heater voltage on the remaining tube will rise sharply and possibly damage it.

4-4. EQUIPMENT REQUIRED FOR MAINTENANCE.

4-5. General troubleshooting requires an electronic multimeter such as the Hewlett-Packard Model 410B. Other multimeters can be used if they have 20,000 ohm/volt sensitivity or greater. To calibrate the gain of the amplifier requires an ac signal source and an accurate ac voltmeter of the required frequency range, such as the Hewlett-Packard Model 650A Oscillator and 400D Voltmeter. Other test instruments can be used if they provide the necessary frequency range and accuracy. To measure distortion from the amplifier requires a signal source producing a signal with less than 0.5% distortion and a distortion meter such as the Hewlett-Packard Model 202C Oscillator and 330B Distortion Analyzer. The frequency range of the 330B is considered adequate for this application. Measurement of distortion at higher and lower frequencies requires rejection filters not readily available. A variable line transformer is required to produce line voltages from 100 to 130 volts.

4-6. TROUBLESHOOTING.

4-7. The first step in servicing a defective amplifier is to inspect for any sign of overheating, physical damage, or wear. The second step is to attempt operation to see if the fuse blows, pilot lamp lights, and if the amplifier can be operated without damage. There are two sets of operational tests: power supply checks (see paragraphs 4-10, 4-12 and 4-18) and amplifier checks (see paragraphs 4-15, 4-20 and 4-22). Suspect electron tube failure first, then associated circuitry. Look for intermittent and marginal malfunctions. These types of failures can sometimes be found while troubleshooting, by physical shock and by applying low and high line voltages while making the tests.

4-8. TUBE REPLACEMENT.

4-9. The best way to test a tube is to replace it with a new one, noting any change in amplifier performance while measuring noise and distortion in the amplifier output. If the replacement tube does not improve performance, return original tube to socket to avoid complicating the troubleshooting procedure. Make the test at low and high line voltage to see if malfunction is marginal. If a tube tester is used to check tubes, consider its indication semi-final if it shows "good", final if it shows "bad". Tube testers do not measure second order effects such as excessive change in transconductance, plate current and grid current with changes in heater voltage, noise, microphonics, heater-cathode leakage, etc, which may be important in certain circuits. Remember that most tube failures occur during the first hundred hours of operation. After this period tubes age slowly and should not be replaced prematurely as part of routine maintenance.

4-10. LOCATING SHORTS IN POWER CIRCUITS.

4-11. Check the amplifier for shorts whenever application of line power causes the fuse to burn out, or whenever operation causes the power transformer or other part to overheat. Proceed as follows:

a. Replace blown fuse, remove V5 and again attempt operation. If the amplifier no longer blows fuses, the trouble is located in the circuits which follow the regulated power supply; check C8C, C8D, C2 and C4.

b. If amplifier continues to blow fuses with V5 removed, remove V4 also and again attempt operation. If the amplifier no longer blows fuses, the trouble is located in the power supply filter; check C8A and C8B.

c. If the amplifier continues to blow fuses with V4 removed, the trouble lies either in the tube filament circuit, power transformer windings, or in the transformer primary circuit. The resistance of each transformer winding is as follows:

WINDING	COLOR	RESISTANCE
Pri. #1	Black-Black/yellow	8 ohms
Pri. #2	Black/red-Black/green	8 ohms
Fil.#1 (6.3 v)	Brown-Brown	0.14 ohm
Fil.#2 (5 v)	Yellow-Yellow	0.06 ohm
Fil.#3 (9 v)	Green-White	0.18 ohm
*Fil.#4 (6.3 v)	Green-Red	0.12 ohm
H. V. #1	Red-Yellow	105 ohms
H. V. #2	Yellow-Red	105 ohms

*Fil. #4 part of winding for Fil. #3.

4-12. TESTING POWER SUPPLY OPERATION.

4-13. The amplifier employs an electronically-regulated power supply with very low line-frequency ripple. To test operation of the supply, proceed as follows:

a. Connect the amplifier to an adjustable line transformer which can supply from 100 to 130 volts.

b. Remove the amplifier bottom plate and connect the negative leads of the multimeter and ac voltmeter to the amplifier chassis.

c. Set the line voltage to 115, turn amplifier on and allow 3-minute warmup.

d. Measure the ac and dc volts at V5 pin 5. The dc voltage must be about 15 volts less than that measured in step g; the ac voltage must be about 1/10 that measured in step g. Excessive dc voltage drop indicates excessive current being drawn by the amplifier circuits or filter capacitors. Insufficient attenuation of ripple indicates filter capacitors low in capacity.

e. Measure ac and dc voltage at V5 pin 8. The dc voltage must be between 205 and 215 volts; the ac voltage must be less than 3 millivolts. The value of R25 can be selected to obtain exactly +210 volts.

f. Increase the line voltage to 127 volts; the dc voltage must remain within 1 volt of that read in step d; the ac voltage must not increase above that in step d.

g. Decrease line voltage to 103 volts; the dc voltage must remain within 1 volt of that read in step d; the ac voltage must not increase.

h. With line voltage set to 115 volts, measure the ac and dc volts at V4 pin 8. The dc voltage must be close to +390, the ac voltage less than 3 volts.

4-14. Possible trouble symptoms in electronic voltage regulators include rectifier tube which does not deliver full voltage to the series regulator tube, which in turn prevents good regulation at low line voltages. The same symptom may be observed with a weak series regulator tube. Another indication of this same trouble is increasing line-frequency ripple as the line voltage is decreased. Incorrect or unstable voltage level can be due to incorrect or unstable reference voltage obtained from V7. High ripple at all line voltages is an indication of poor electrolytic filters or weak V6.

4-15. MEASURING AMPLIFIER STAGE GAIN.

4-16. The typical amplification factor for each stage in the amplifier is given below. Gain is measured by applying 0.01 rms volts at 1000 cps to the amplifier INPUT terminals with the amplifier GAIN switch set to 40 DB. The 400D Voltmeter is then used to measure the resultant signal level at the input and output of each stage, each time dividing the output by the input voltage.

V1			V2			V3		
E_{in}	E_{out}	Gain	E_{in}	E_{out}	Gain	E_{in}	E_{out}	Gain
0.01	0.043	4.3	0.43	1.1	25.6	1.1	1.0	0.91

4-17. AMPLIFIER ADJUSTMENTS.

4-18. The amplifier contains three adjustable components which are used to obtain specified amplifier performance with the normal variations in replacement tubes and parts values. Resistor R27 adjusts the dc heater voltage applied to V1 and V2. Resistor R6 adjusts amplifier gain at middle frequencies. Capacitor C11 adjusts amplifier gain at high frequencies. Instructions for making each adjustment are given in the following paragraphs.

4-19. ADJUSTING V1 & V2 HEATER VOLTAGE.

4-20. The heater of V1 and V2 are supplied with dc power to reduce line-frequency ripple in the amplifier output. The power is obtained from a full-wave selenium rectifier bridge through an adjustable series resistor, R27. Resistor R27 permits resetting the heater voltage as the rectifier ages and its internal resistance increases. The adjustment must be made at six-month intervals and when the rectifier is replaced. To adjust R27 proceed as follows:

a. Remove amplifier bottom plate; connect amplifier to power source, turn on and allow 3-minute warmup.

b. Measure the dc voltage from the positive terminal of C7 to chassis. This voltage must be 6.3 volts when the line voltage is 115 volts.

c. If necessary, adjust R27 to obtain 6.3 volts. After a 24-hour run-in, recheck voltage to see that it has settled.

d. Measure the ac voltage across C7. If it is greater than 150 millivolts, check the capacity of C7.

e. The adjustment is completed; replace amplifier bottom plate and return amplifier to normal service.

4-21. ADJUSTING AMPLIFIER GAIN.

4-22. Amplifier gain at low and middle frequencies for both the 20 and 40 db positions of the GAIN switch is set by a potentiometer on top of the amplifier chassis. The adjustment permits setting the gain of either range exactly, or dividing any small error equally between the two ranges. Amplifier gain at high frequencies for both the 20 and 40 db settings is set by a trimmer capacitor on the bottom of the amplifier chassis. This adjustment permits setting the gain of either range at some selected high frequency to equal the low-frequency gain, or permits dividing any small error between the ranges, and frequencies. Both adjustments are required after replacement or aging of V1, V2, V3, R3 or C12. To adjust the gain of the amplifier proceed as follows:

a. Connect amplifier and test equipment as shown in figure 4-1 using the 400D Voltmeter to alternately measure the input and output signal voltage levels from the amplifier.

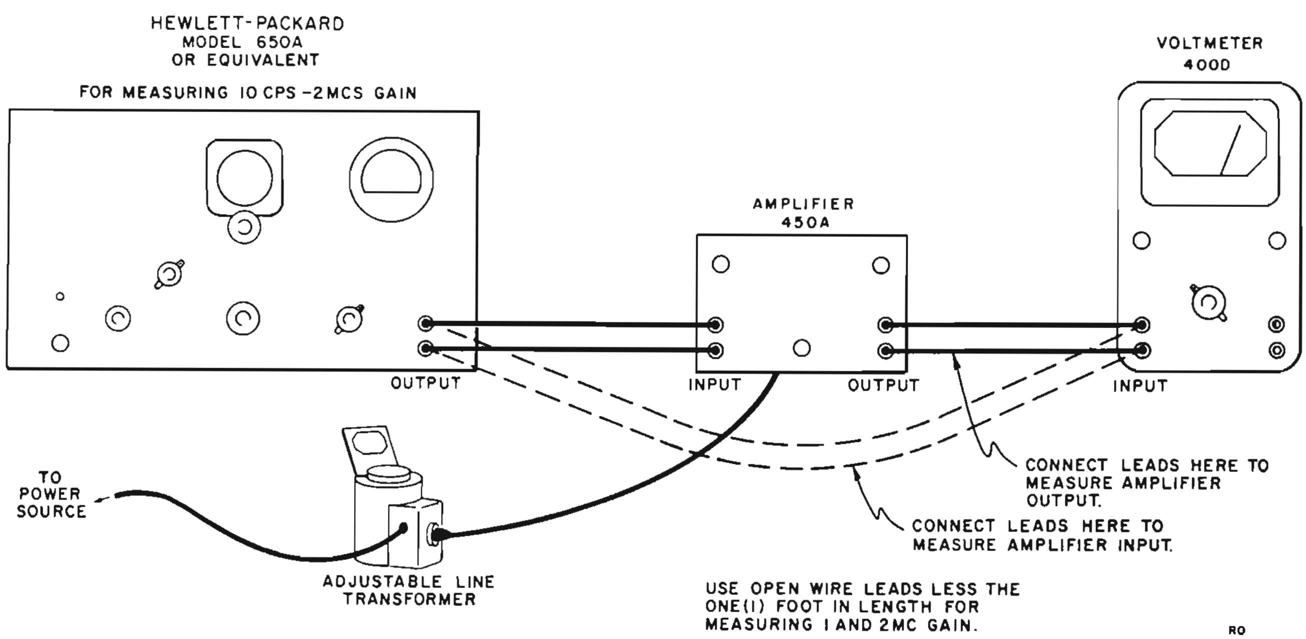


Figure 4-1. Test Setup for Measuring Amplifier Gain

b. Set the oscillator output to any convenient frequency between 100 and 10,000 cps and the output voltage to exactly -20 db as read on the 400D Voltmeter connected to the oscillator output.

c. Set the amplifier to 40 DB and measure the open-circuit output signal level with the 400D Voltmeter.

d. If necessary adjust R6 to obtain a reading of exactly +20 db on the voltmeter. Vary line voltage between 104 and 127 volts to be sure gain remains within specifications.

e. Set the amplifier to 20 DB and increase the oscillator output voltage to 0 db as read on the 400D Voltmeter connected to the amplifier input.

f. Measure the open-circuit output level from the amplifier which must be within 1/4 db of the reading obtained in step d.

g. Adjust R6 so that the difference between the 20 and 40 db gains is divided equally about +20 db on the voltmeter scale. The gain tolerance is ±1/8 db on each range. If the gain difference is greater than the specified tolerance, R3 in the amplifier or the voltage range switch in the voltmeter is inaccurate, or V1 or V2 may be defective.

h. Repeat steps b and c using an oscillator frequency of 2 mc.

i. If necessary adjust C11 to obtain an output voltage within ±1 db of +20 db. Vary line voltage from 104 to 127 volts to be sure gain remains within specifications.

j. Set the amplifier to 20 DB, set the oscillator frequency to 1 mc and increase the oscillator output voltage to 0 db as read on the 400D Voltmeter connected to the amplifier input.

k. Measure the open-circuit output voltage from the amplifier. If necessary refine the adjustment of C11 so the output level is within ±1/2 db of +20 db on the voltmeter.

m. Recheck the 40 db gain at 2 mc. If a satisfactory compromise cannot be reached for these high frequency gain measurements, the value of C12 may require adjustment. Increasing C12 increases the gain of the amplifier at high frequency.

n. In the same manner, amplifier gain at low frequency may be checked using a voltmeter such as the Model 403A. If the low-frequency gain is below that specified, check the coupling capacitors and tubes.

p. The gain adjustment is completed; replace amplifier cover and return amplifier to normal service.

4-23. NOISE AND DISTORTION MEASUREMENT.

4-24. Distortion in the amplifier output is measured by applying a pure sine-wave signal to the amplifier input and measuring the harmonics of this signal in the amplifier output after rejecting the fundamental frequency. The Model 330B Distortion Analyzer is an electronic ac voltmeter preceded by an electronic frequency-rejection filter which is adjustable from 20 cps to 20,000 cps. After the fundamental frequency is rejected by the filter, the total level of all remaining signals is measured by the voltmeter. This level consists of random noise, line-frequency ripple, and all harmonics of the applied signal frequency including those in the applied signal. To measure distortion and noise, proceed as follows:

a. Connect the test equipment as shown in figure 4-2, turn on and allow a ten-minute warmup of all instruments.

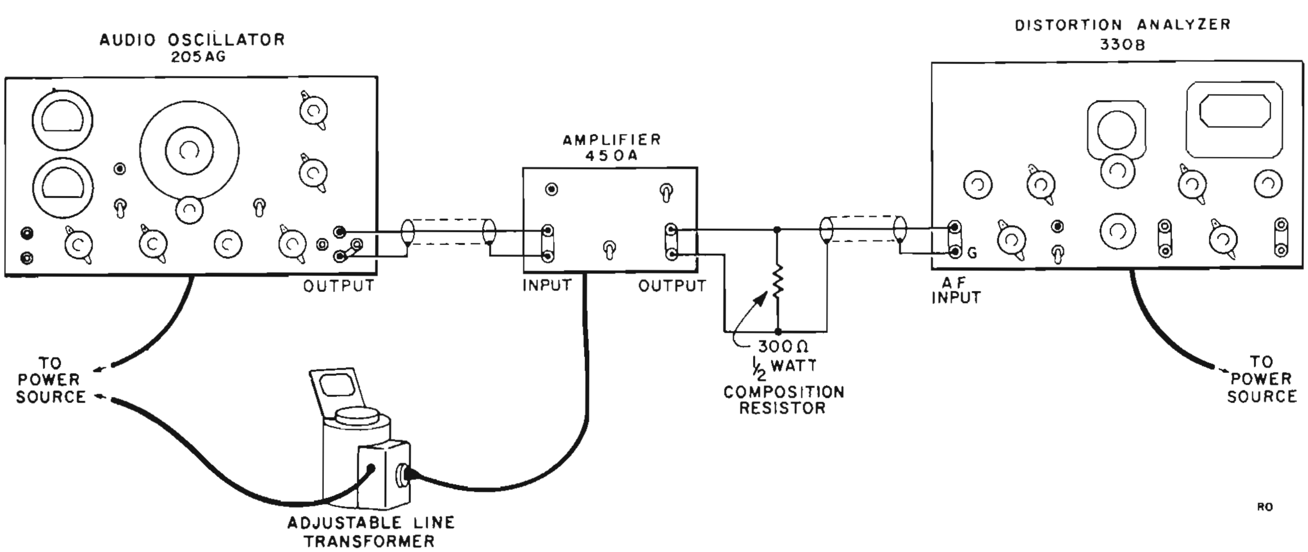


Figure 4-2. Test Setup for Measuring Amplifier Distortion and Noise

b. Set the front-panel controls on the amplifier as follows:

POWER switch - - - - - - - - - - - - - - ON
GAIN switch - - - - - - - - - - - - - - - - 40 DB

c. Set the front-panel controls on the oscillator as follows:

FREQUENCY dial - - - - - - - - - - - - - - 20
FREQUENCY range - - - - - - - - - - - - - X1
OUTPUT ATTENUATOR (upper) - - - - - - - 30
OUTPUT ATTENUATOR (lower) - - - - - - - 5
AMPLITUDE - - - - - - - - - - - - - - - - 0
IMPEDANCE - - - - - - - - - - - - - - - - 600
POWER - - - - - - - - - - - - - - - - - - ON
LOAD - - - - - - - - - - - - - - - - - - OFF

d. Set the front-panel controls on the distortion analyzer as follows:

INPUT SENSITIVITY- - - - - - - - - - - - MIN
FREQUENCY range - - - - - - - - - - - - - X1
FREQUENCY dial - - - - - - - - - - - - - - 20
Function switch - - - - - - - - - - - - - METER
Meter Range switch - - - - - - - - - - - .10 VOLT
AF-RF selector - - - - - - - - - - - - - - AF
Power switch - - - - - - - - - - - - - - - - ON

e. After a 10-minute warmup connect the amplifier INPUT terminals to the METER INPUT terminals on the analyzer, and adjust the AMPLITUDE CONTROL on the oscillator to obtain exactly 0.1 volt on the analyzer.

f. Set the analyzer function switch to SET LEVEL; meter range switch to 100% (10 VOLT) and connect the analyzer AF INPUT terminals to the amplifier OUTPUT terminals. Adjust the analyzer INPUT sensitivity control to obtain a full scale reading on the 0-1 scale on the analyzer meter.

g. Set the analyzer function selector to DISTORTION and tune FREQUENCY dial for a dip. Reduce setting of the meter range switch as necessary and tune analyzer FREQUENCY and BALANCE controls for a minimum reading. The final reading in distortion must be less than 1%. If it is higher than this, measure the distortion in the oscillator output alone which should be less than 0.5%.

h. Repeat above procedure using an oscillator frequency of 20,000 cps. Again, distortion must be below 1%.

i. Disconnect oscillator from amplifier INPUT terminals, and short the input terminals together with a wire jumper.

j. Set the analyzer function switch to SET LEVEL and set the INPUT sensitivity control to MAX; set the meter range switch to the 0.03 range. The actual voltage input is now only 0.1 that indicated on the meter scale. The input voltage must not exceed 4 millivolts.

k. Set the amplifier GAIN switch to 20 DB. The analyzer voltmeter should indicate less than 2.5 millivolts using the same X10 factor used in step j.

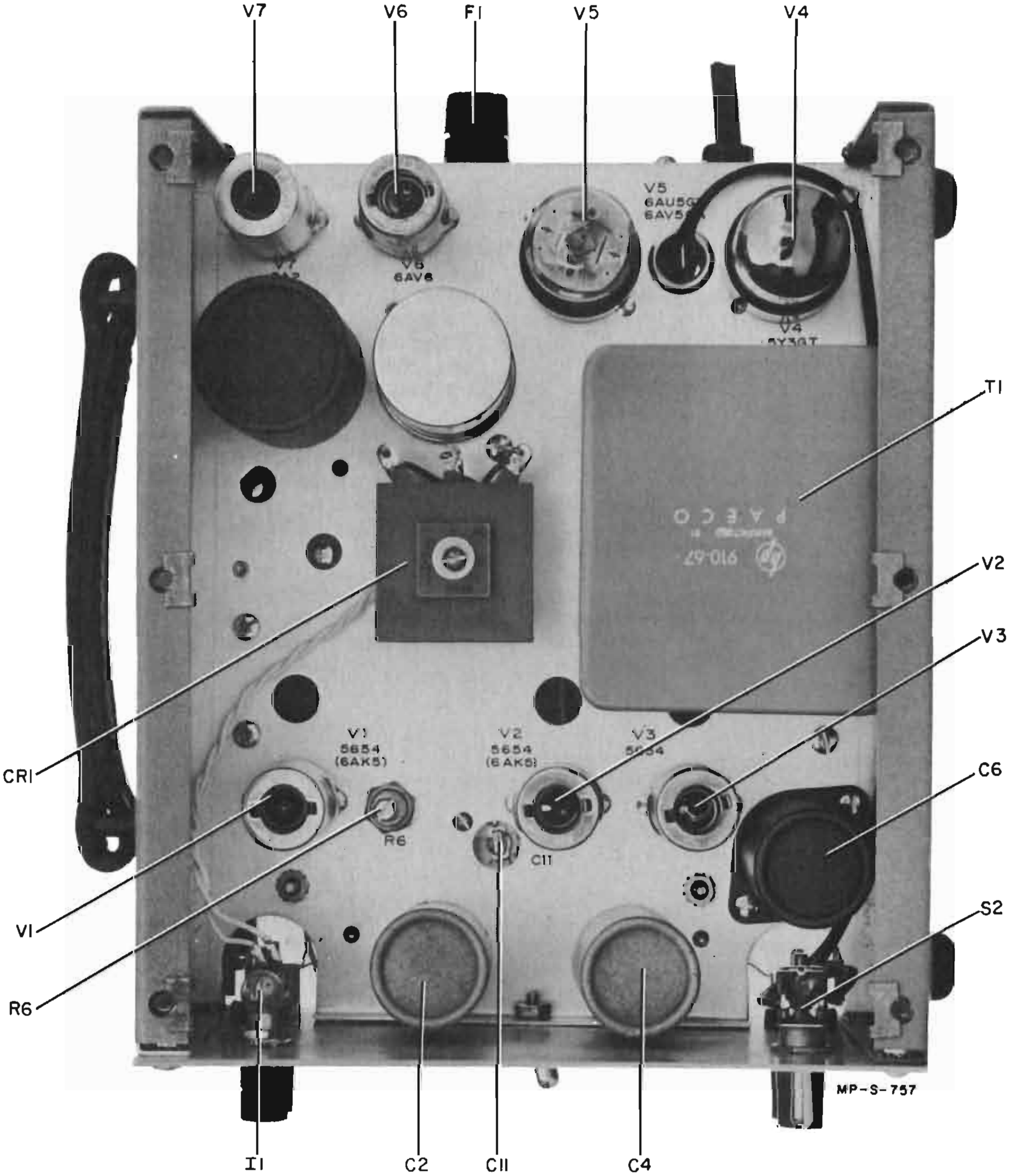


Figure 4-3. Top View of Model 450A

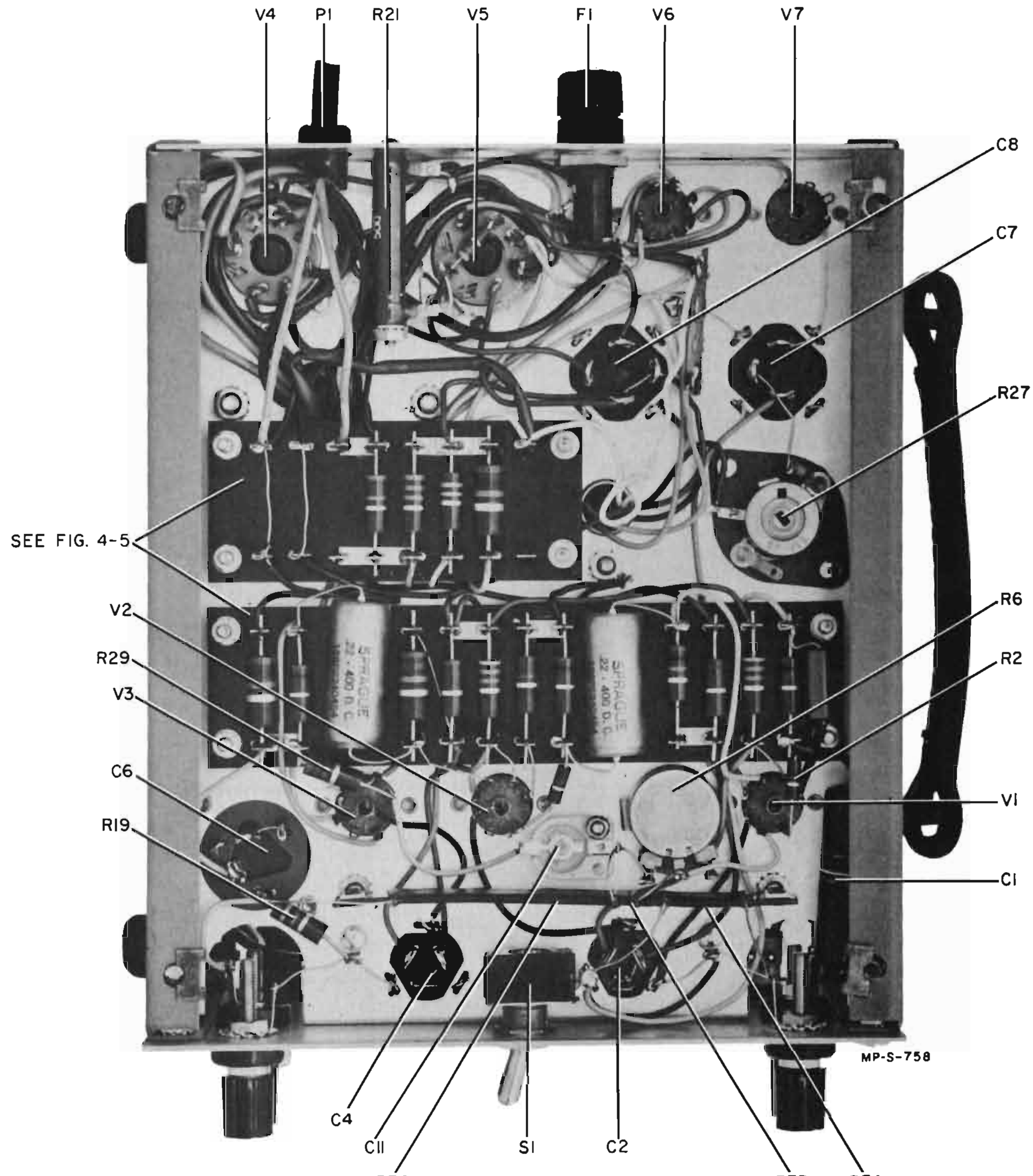
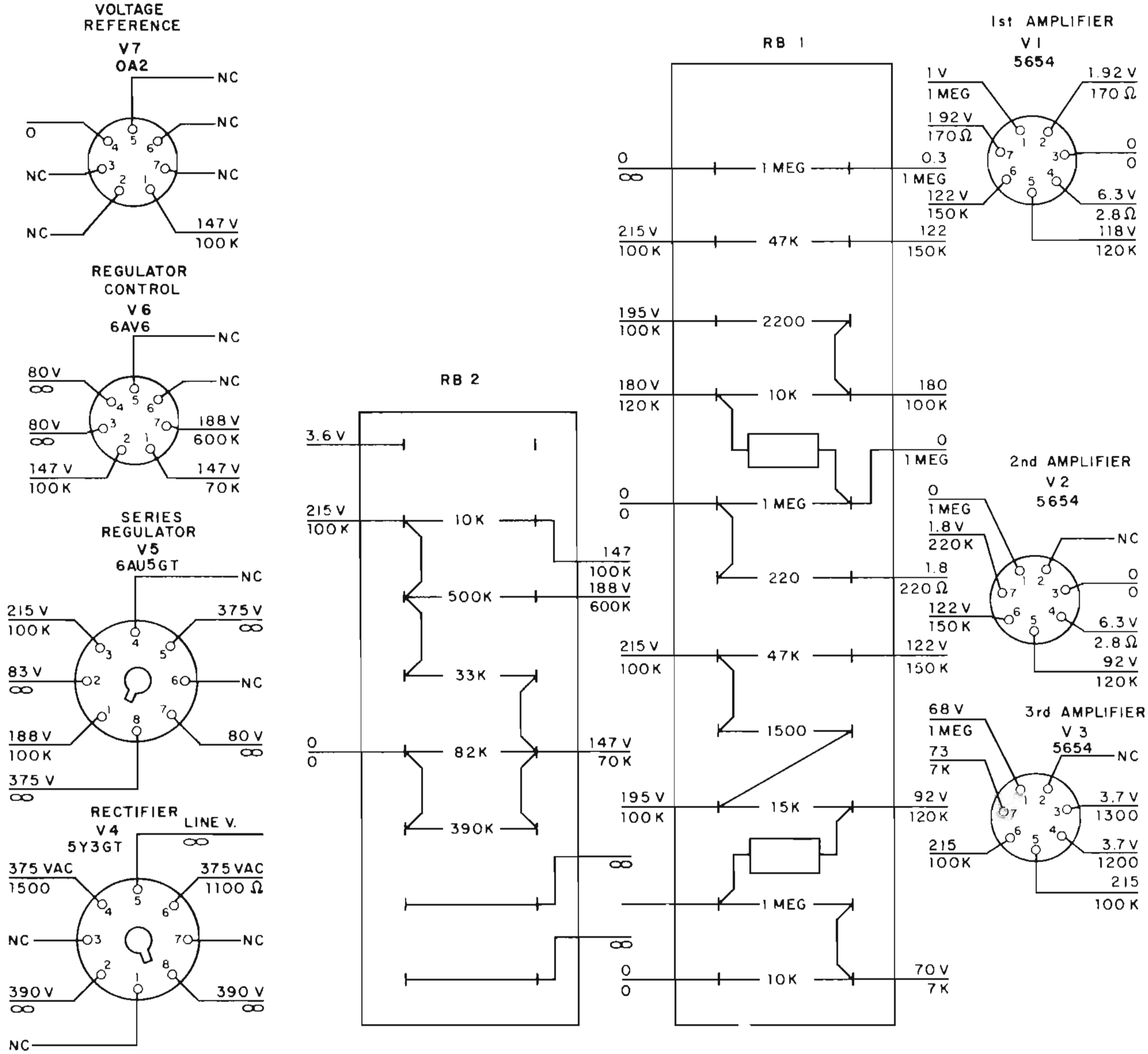


Figure 4-4. Bottom View of Model 450A



NOTES

UNLESS OTHERWISE NOTED, VOLTAGES ARE DC, MEASURED TO GROUND BY A VTVM WITH 100 MEGOHM INPUT IMPEDANCE.

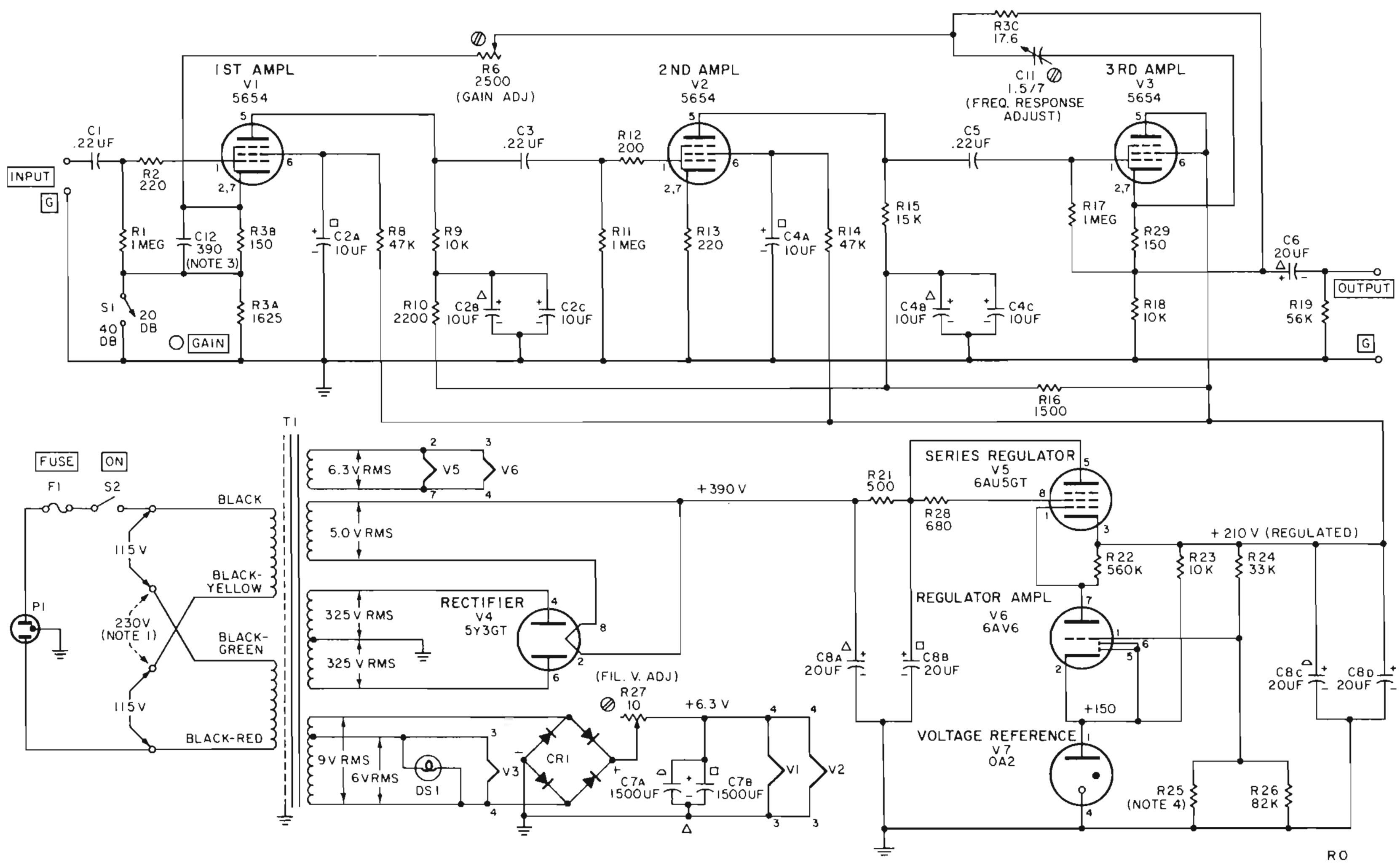
LINE VOLTAGE SET TO 115 VOLTS, 60 CPS

INPUT TERMINALS SHORTED.

GAIN SET TO 40 DB.

RO

Figure 4-5. Voltages and Resistances on Tube Sockets and Terminal Boards



NOTE 1. FOR OPERATION ON 230 VOLT LINES, REMOVE 115 VOLT JUMPERS AND ADD 230 VOLT JUMPER.

NOTE 2. UNLESS OTHERWISE INDICATED, RESISTANCE IS IN OHMS, CAPACITY IN UUF.

NOTE 3. ELECTRICAL VALUE SELECTED FOR BEST HIGH FREQUENCY RESPONSE.

NOTE 4. ELECTRICAL VALUE SELECTED FOR +210V ±5V REGULATED B+.

Figure 4-6. Schematic Diagram Model 450A

SECTION V
REPLACEABLE PARTS

5-1. INTRODUCTION.

5-2. This section contains information for ordering replacement parts for the Model 450A Amplifier.

5-3. ORDERING INFORMATION.

5-4. To order a replacement part, address order or inquiry either to your local Hewlett-Packard representative or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

5-5. Specify the following information on the part:

a. Model and serial number of instrument.
b. Hewlett-Packard stock number.
c. Circuit reference designator.
d. Description.

5-6. Parts not listed in table 5-1 can be ordered by giving a complete description of part including its function and location in the circuit.

5-7. Recommended spare parts for complete maintenance during one year of isolated service are listed in the "RS" column of the parts list.

Circuit Ref.	Description	Mfr. *	hp Stock No.	TQ	RS		
C1	Capacitor: fixed, paper, .22 μf ±10%, 400 vdcw, 125°C	56289	0160-0018	1	1		
C2ABC	Capacitor: fixed, electrolytic, 3 sections, 10 μf/sect., 450 vdcw	00656	0180-0016	2	1		
C3	Capacitor: fixed, paper, .22 μf ±20%, 400 vdcw	56289	0160-0017	2	1		
C4ABC	Same as C2						
C5	Same as C3						
C6	Capacitor: fixed, electrolytic, 20 μf, 450 vdcw	56289	0180-0011	1	1		
C7	Capacitor: fixed, electrolytic, 2 sections, 1500 μf/sect., 15 vdcw	56289	0180-0028	1	1		
C8ABCD	Capacitor: fixed, electrolytic, 4 sections, 20 μf/sect., 450 vdcw	56289	0180-0025	1	1		
C9, 10	Not assigned						
C11	Capacitor: variable, ceramic, 1.5-7 pf, 500 vdcw	72982	0130-0003	1	1		
C12	Capacitor: fixed, mica, 390 pf ±5%, 500 vdcw	00853	0140-0016	1	1		

* Refer to " List of Manufacturers".
TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

Figure 5-1. Replaceable Parts (Sheet 1 of 4)

Circuit Ref.	Description	Mfr. *	(hp) Stock No.	TQ	RS		
CR1	Rectifier, metallic	84970	1882-0002	1	1		
DS1	Lamp, incandescent: 6.3V, .15 amp, 2 pin base, GE #12	24455	2140-0012	1	1		
F1	Fuse, cartridge: 0.8 amp, slow-blow, 115V operation	75915	2110-0020	1	10		
	Fuse, cartridge: 0.4 amp, slow-blow, 230V operation	75915	2110-0019				
P1	Power Cable	70903	8120-0050	1	1		
R1	Resistor: fixed, composition, 1 megohm ±10%, 1 W	01121	0690-1051	3	1		
R2	Resistor: fixed, composition, 220 ohms ±10%, 1/2 W	01121	0687-2211	2	1		
R3	Resistor: fixed, wirewound, 1625, 150, 17,600 ohms	28480	45A-26A	1	1		
R4, 5	Not assigned						
R6	Resistor: variable, composition, 2500 ohms ±20%, 1/2 W	71590	2100-0067	1	1		
R7	Not assigned						
R8	Resistor: fixed, composition, 47,000 ohms ±10%, 1 W	01121	0690-4731	2	1		
R9	Resistor: fixed, composition, 10,000 ohms ±10%, 1 W	01121	0690-1031	1	1		
R10	Resistor: fixed, composition, 2200 ohms ±10%, 1 W	01121	0690-2221	1	1		
R11	Same as R1						
R12	Same as R2						
R13	Resistor: fixed, composition, 220 ohms ±10%, 1 W	01121	0690-2211	1	1		
R14	Same as R8						
R15	Resistor: fixed, composition, 15,000 ohms ±10%, 2 W	01121	0693-1531	1	1		
R16	Resistor: fixed, composition, 1500 ohms ±10%, 1 W	01121	0690-1521	1	1		

* Refer to "List of Manufacturers".
TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

Figure 5-1. Replaceable Parts (Sheet 2 of 4)

Circuit Ref.	Description	Mfr.*	hp Stock No.	TQ	RS		
R17	Same as R1						
R18	Resistor: fixed, composition, 10,000 ohms ±10%, 2 W	01121	0693-1031	2	1		
R19	Resistor: fixed, composition, 56,000 ohms ±10%, 1 W	01121	0690-5631	1	1		
R20	Not assigned						
R21	Resistor: fixed, wirewound, 500 ohms ±10%, 10 W	35434	0816-0003	1	1		
R22	Resistor: fixed, composition, 560,000 ohms ±10%, 1 W	01121	0690-5641	1	1		
R23	Same as R18						
R24	Resistor: fixed, composition, 33,000 ohms ±10%, 1 W	01121	0690-3331	1	1		
R25	Resistor: Optimum value selected at factory.						
R26	Resistor: fixed, composition, 82,000 ohms ±10%, 1 W	01121	0690-8231	1	1		
R27	Resistor: variable, wirewound, linear taper, 10 ohms	28480	M-77	1	1		
R28	Resistor: fixed, composition, 680 ohms ±10%, 1/2 W	01121	0687-6811	1	1		
R29	Resistor: fixed, composition, 150 ohms ±10%, 1 W	01121	0690-1511	1	1		
S1, 2	Switch, toggle	04009	3101-0001	2	1		
T1	Transformer, power	28480	9100-0016	1	1		
V1, 2, 3	Tube, electron: 5654	86684	1923-0001	3	3		
V4	Tube, electron: 5Y3GT	86684	1930-0010	1	1		
V5	Tube, electron: 6AU5GT	33173	1923-0020	1	1		
V6	Tube, electron: 6AV6	82219	1939-0001	1	1		
V7	Tube, electron: OA2	97966	1940-0004	1	1		

* Refer to " List of Manufacturers"
TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

Figure 5-1. Replaceable Parts (Sheet 3 of 4)

Circuit Ref.	Description	Mfr. *	Stock No.	TQ	RS		
	MISCELLANEOUS						
	Binding Post Assembly: black	28480	AC-10C	2	1		
	Binding Post Assembly: red	28480	AC-10D	2	1		
	Holder, fuse	75915	1400-0007	1	1		
	Insulator, binding post	28480	AC-54A	2	0		
	Insulator, binding post: (single)	28480	AC-54D	2	0		
	Lamp holder for DS1	72765	1450-0022	1	0		
	Jewel for lampholder	72765	1450-0020	1	0		
	Shield, tube: 1-3/8" long	71785	1220-0011	3	0		

* Refer to " List of Manufacturers".
TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

Figure 5-1. Replaceable Parts (Sheet 4 of 4)

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
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00656	Aerovox Corp.	New Bedford, Mass.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Co., Cap. Div.	Marion, Ill.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Semiconductor Components Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02777	Hopkins Engineering Co.	San Francisco, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04404	Dymec Inc.	Palo Alto, Calif.
04651	Special Tube Operations of Sylvania Electronic Systems	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04777	Automatic Electric Sales Corp.	Northlake, Ill.
05624	Barber Colman Co.	Rockford, Ill.
05783	Stewart Engineering Co.	Soquel, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06812	Torrington Mfg. Co., West. Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08733	Camloc Fastener Corp.	Los Angeles, Calif.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
10646	Carborundum Co.	Niagara Falls, N.Y.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G. E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
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.
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.
44655	Ohmite Mfg. Co.	Skokie, Ill.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
54294	Shallcross Mfg. Co.	Selma, N.C.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
70119	Advance Electric and Relay Co.	Burbank, Calif.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70563	Amperite Co., Inc	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	Chicago Telephone Supply Co.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Div. 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.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	Industrial Products Co.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Mfg. Co., Inc.	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.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Corp., Bendix Pacific Div.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Inc.	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77634	Radio Essentials Inc.	Mt. Vernon, N.Y.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80130	Times Facsimile Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80411	Acro Manufacturing Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Tube Division	Quincy, Mass.

From: F.S.C. Handbook Supplements
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H4-2 Dated July 1960

LIST OF MANUFACTURERS

CONTINUED

CODE NO.	MANUFACTURER	ADDRESS
81483	International Rectifier Corp.	El Segundo, Calif.
82042	Carter Parts Co.	Skokie, Ill.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Spencer Thermostat, Div. of Texas Instruments, Inc.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82893	Vector Electronic Co.	Glendale, Calif.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Products, Inc.	Columbus, Neb.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91929	Micro-Switch Div. of Minneapolis Honeywell Regulator Co.	Freeport, Ill.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Receiving Tube Div.	Quincy, Mass.
94145	Raytheon Mfg. Co., Semi-conductor Div.	Newton, Mass.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	Carlstadt, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98291	Sealectro Corp.	New Rochelle, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
99313	Varian Associates	Palo Alto, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99957	Technology Instruments Corp. of Calif.	No. Hollywood, Calif.

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

CODE NO.	MANUFACTURER	ADDRESS
0000A	Amp, Inc.	Hawthorne, Calif.
0000B	Chicago Telephone of Calif.	S. Pasadena, Calif.
0000C	Connor Spring Mfg. Co.	San Francisco, Calif.
0000D	Connex Corp.	Oakland, Calif.
0000E	Fisher Switches, Inc.	San Francisco, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000G	Microwave Engineering Co.	Palo Alto, Calif.
0000H	Philco Corp. (Lansdale Tube Division)	Lansdale, Pa.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000J	Ti Tal, Inc.	Berkeley, Calif.
0000K	Transitron Electronic Sales Corp.	Wakefield, Mass.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.

From: F.S.C. Handbook Supplements
H4-1 Dated July 1960
H4-2 Dated July 1960

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Klystron tubes as well as other electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Hewlett-Packard instruments should be made via Truck or Railway Express. The instruments should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

HEWLETT-PACKARD COMPANY

Laboratory Instruments for Speed and Accuracy

1501 Page Mill Road   Palo Alto, California

CABLE "HEWPACK"