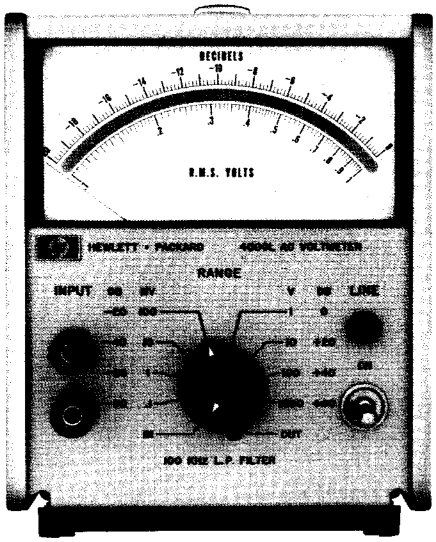
HP 400GL

OPERATING AND SERVICE MANUAL

AC VOLTMETER

400GL



HEWLETT hp PACKARD

HP 400GL

September '69

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

For any assistance contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

OPERATING AND SERVICE MANUAL

(HP PART NO. 00400-90008)

MODEL 400GL
AC VOLTMETER

SERIALS PREFIXED: 628-, 737-, 943-

See MANUAL BACKDATING CHANGES Appendix C

P. O. Box 301, Loveland, Colorado, 80537 U. S. A.

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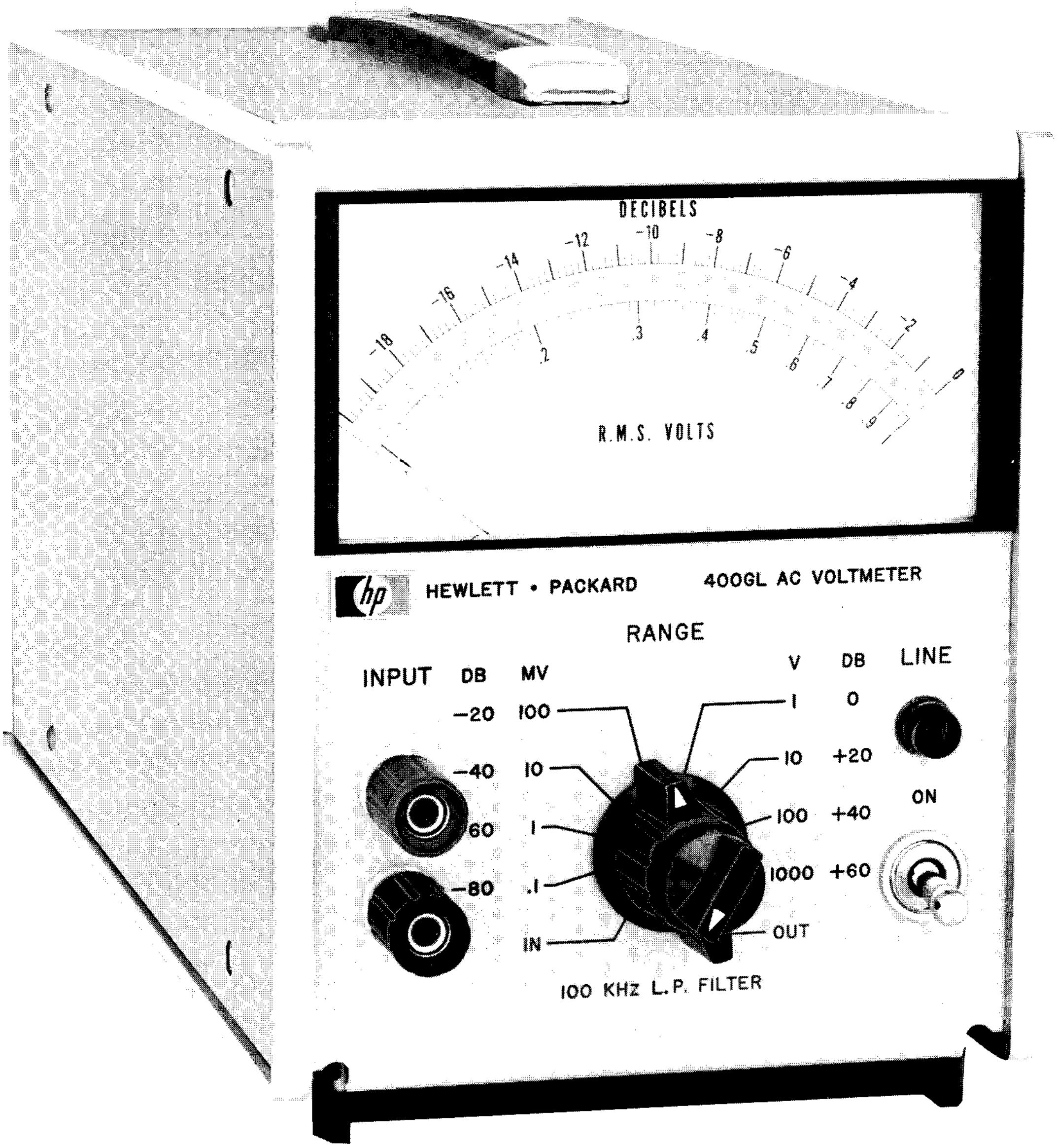


Figure 1-1. Model 400GL AC Voltmeter

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The -hp- Model 400 GL is a versatile instrument designed for measuring ac voltages from 100μV to 1000 V rms, over a frequency range of from 20Hz to 4 MHz. The instrument has eight voltage ranges, divided in steps of 20 dB each, to correspond with the 20 dB logarithmic meter scale. A 100 kHz low pass filter is provided to reduce the effect of high frequency noise signals, when low frequency signals are being measured. The filter is effective on all voltage ranges, but is especially useful on the more sensitive ranges.

1-3. The Model 400GL may be used as a wideband ac amplifier, with a maximum open circuit gain of 80dB. The instrument has an ac output of 1 V rms (for full scale meter deflection) into an open circuit, or 0. 5V rms into 600 ohms. The output is proportional to the meter indication on the voltage scale.

1-4. See Table 1-1 on next page for specifications.

1-5. ACCESSORIES.

1-6. Accessories available with the Model 400GL are the Model 11074A Voltage Divider Probe with Model 10111A banana post-to-BNC Adapter, and Model 11076A Instrument Case. See Figures 1-2 and 1-3. The specifications for the Model 11074A are listed below:

Input Impedance: 10 megohms shunted by 10 pF
Division Ratio: 10:1
Division Accuracy: ±2%
Bandwidth: DC to 10 MHz
Maximum Input Voltage: 1000 V rms

1-7. INSTRUMENT AND MANUAL IDENTIFICATION.

1-8. Hewlett-Packard instruments are identified by a two-section, eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 400GL described in this manual.

1-9. If the first three digits of the two-section eight-digit serial number are prefixed with an E or G, your instrument was produced in Europe. An E000-00000 serial number indicates that the instrument was manufactured in England; a G000-00000 serial number indicates that the instrument was manufactured in Germany.

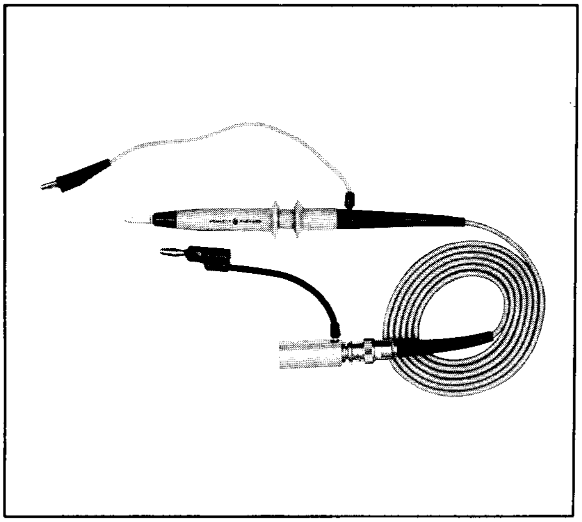


Figure 1-2. Model 11074A Voltage Divider Probe

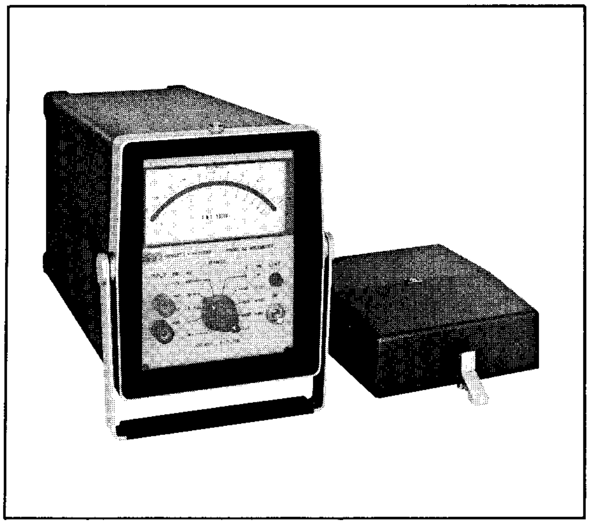


Figure 1-3. Model 11076A Instrument Case

Table 1-1. SPECIFICATIONS

ACCURACY (% of reading):

1 mV - 1000 V* ranges:

20 Hz – 40 Hz	40 Hz – 500 kHz	500 kHz – 2 MHz	2 MHz – 4 MHz
±0.4 dB	±0.2 dB	±0.4 dB	+0.2 dB -0.8 dB

100 μV range:

30 Hz – 60 Hz	60 Hz – 100 kHz	100 kHz – 500 kHz
±0.4 dB	±0.2 dB	+0.2 dB -0.8 dB

* For input voltages greater than 300 volts, the high frequency range is limited to 100 kHz.

VOLTAGE RANGE: 100 μV to 1000 V full scale, eight ranges.

FREQUENCY RANGE: 20 Hz to 4 MHz.

CALIBRATION: Responds to average value of input waveform; calibrated in rms value of a sine wave. Linear dB scale, 100 divisions from -20 to 0 dB. Logarithmic voltage scale; 0 dB = 1 V.

NOISE REFERRED TO INPUT (1000 ohm termination):

Range	Filter In	Filter Out
1 mV - 1000 V	< 5 μV	< 30 μV
100 μV	< 5 μV	< 15 μV

Note: Noise adds to the signal approximately according to the relation:

$$\text{Reading} = \sqrt{(\text{signal})^2 + (\text{noise})^2}$$

RECOVERY FROM OVERLOAD: < 2 sec for 80 dB overload (1200 V max input).

INPUT IMPEDANCE:

Resistance: 10 MΩ, all ranges.
Capacitance: < 30 pF for 100 μV to 100 mV ranges.
< 15 pF for 1 V to 1000 V ranges.

AMPLIFIER AC OUTPUT: 1 V rms open circuit (for full scale deflection), proportional to meter indication on voltage scale. Frequency response 20 Hz to 4 MHz on 1 mV to 1000 V range; 30 Hz to 100 kHz on 100 μV range. 100 kHz filter in the "in" position on 100 μV range.

AC POWER: 115 or 230 volts ±10%, 50 to 400 Hz, 5 watts.

EXTERNAL BATTERY OPERATION: Terminals are provided on rear panel; positive and negative voltages between 35 V and 55 V are required; current drain from each battery is approximately 45 mA. (External switching and on/off monitoring should be used for battery operation).

WEIGHT: Net 6 lbs (2,7 kg); shipping 8 lbs (3,6 kg).

OVERALL DIMENSIONS: 6 1/2" high; 5 1/8" wide; 11 11/16" deep.

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary for the installation and shipping of the Model 400GL voltmeter. Included are initial inspection procedures, power and grounding requirements, installation information, and instructions for repackaging for shipment.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be physically free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also check for supplied accessories, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-5. If there is damage or deficiency, see the warranty on the inside front cover of this manual.

2-5. POWER REQUIREMENTS.

2-6. The Model 400GL can be operated from any source of 115 or 230 volts at 50 to 1000 cycles or from two 35 to 55 volt batteries connected to the rear panel BATTERY terminals. The 115/230 V slide switch on the rear panel selects the desired line voltage. Power dissipation is 5 watts maximum.

2-7. GROUNDING REQUIREMENTS.

2-8. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. All Hewlett-Packard instruments are equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground wire.

2-9. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

2-10. INSTALLATION.

2-11. The Model 400GL is fully transistorized; therefore, no special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 55° C (131°F) or the relative humidity exceeds 95%.

2-12. BENCH MOUNTING.

2-13. The Model 400GL is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument.

2-14. RACK MOUNTING.

2-15. The Model 400GL may be rack mounted by using an adapter frame (-hp- Part No. 5060-0797). The adapter frame is a rack frame that accepts any combination of submodular units. The adapter frame is used only for rack mounting. For additional information, address inquiries to your -hp- Sales and Service office. (See Appendix B for office location.)

2-16. COMBINATION MOUNTING.

2-17. The Model 400GL may be mounted in combination with other submodular units by using a Combining Case (-hp- Model 1051A or 1052A). The Combining Case is a full-module unit which accepts various combinations of submodular units. Being a full-module unit, it can be bench or rack mounted and is analogous to any full-module instrument.

2-18. REPACKAGING FOR SHIPMENT.

2-19. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-20 if the original container is to be used; 2-21 if it is not. If you have any questions, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished; include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number, serial number, and serial number prefix.

2-20. If original container is to be used, proceed as follows:

a. Place instrument in container. If original container is not available, a suitable one can be purchased from your nearest -hp- Sales and Service Office.

b. Ensure that container is well sealed with strong tape or metal bands.

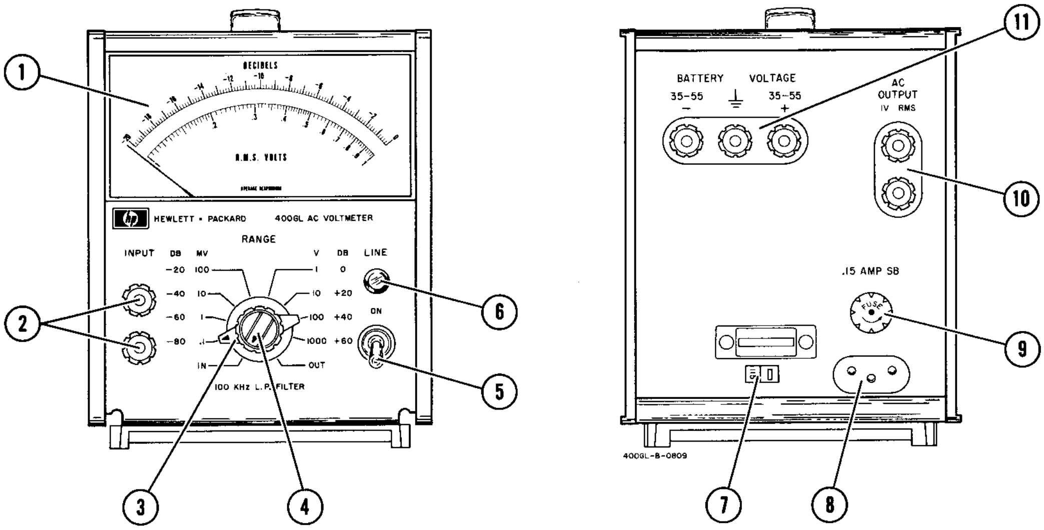
2-21. If original container is not to be used, proceed as follows:

a. Wrap instrument in heavy paper or plastic before placing in an inner container.

b. Place packing material around all sides of instrument and protect panel face with cardboard strips.

c. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.

d. Mark shipping container with "DELICATE INSTRUMENT", "FRAGILE" etc.



(1) 400GL Scale: Indicates magnitude of applied signal in volts and dBm.

(2) INPUT Terminals: Connects signal to be measured to 400GL.

(3) RANGE Selector (S1): Selects full scale reading of meter. Dbm reading on scale adds algebraically to dB setting of RANGE selector.

(4) 100 KHz LP FILTER Switch (S2): Switches 100 KHz filter either in or out of circuit.

(5) Line ON Toggle Switch (S3): Applies primary power.

(6) LINE Indicator Lamp: Indicates application of primary power.

(7) 115/230 Volt Slide Switch (S4): Sets 400GL to operate from either 115 V or 230 V, ac power source.

(8) Primary Power Connector: Connects primary power to 400GL.

(9) FUSE: Protects instrument against current overload.

(10) AC OUTPUT: Ac amplifier output; output impedance is 600 Ω.

(11) BATTERY VOLTAGE Terminals: 400GL may be powered by connecting two 35 to 55 volt batteries to these terminals.

Figure 3-1. Location of Controls and Indicators

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This section contains instructions and information necessary for the operation of the 400GL AC Voltmeter. Included is identification of controls, indicators and connectors, turn on procedures, and operating instructions.

3-3. CONTROLS, INDICATORS AND CONNECTORS.

3-4. Each control, indicator, and connector on the 400GL is identified and described in Figure 3-1.

3-5. TURN ON PROCEDURES.

a. If line voltage is used, ensure that the 115/230 Vac switch (located on the rear panel) is in the correct position. Set the line ON toggle switch to the ON position. The LINE lamp will glow, indicating that line power is applied.

b. If batteries are used, connect two 35 to 55 volt batteries as shown in Figure 3-2. The line ON switch is not in the circuit when batteries are used, therefore an external DPST switch should be used to provide a means for disconnecting the batteries when the instrument is not in use.

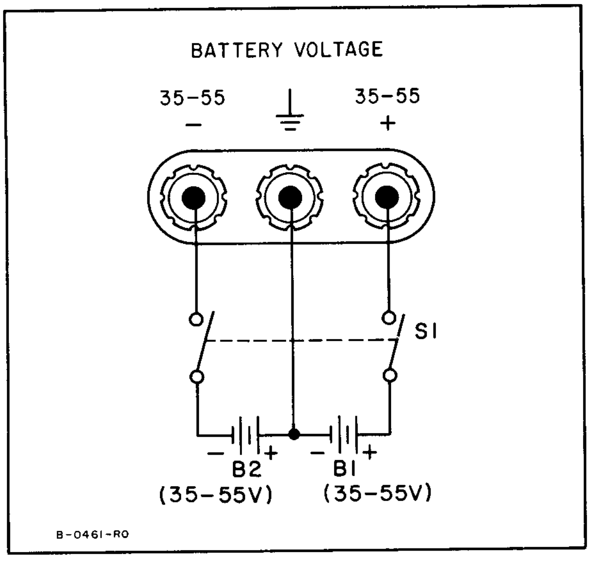


Figure 3-2. External Battery Connection

3-6. DB MEASUREMENTS.

a. Perform the steps listed under Paragraph 3-5.

b. Set the meter RANGE switch to the approximate range of the voltage to be measured.

CAUTION

DO NOT APPLY MORE THAN 1200 VOLTS TO INPUT. DO NOT OVERLOAD THE .1 MV THROUGH 100 MV RANGES WITH MORE THAN 300 VOLTS AT FREQUENCIES BELOW 300 KHz OR WITH MORE THAN 64 VOLTS AT FREQUENCIES ABOVE 300 KHz. IF ANY OF THESE OVERLOADS ARE EXCEEDED, THE INSTRUMENT MAY BE DAMAGED.

c. If the signal to be measured is a frequency less than 100 kHz, the 100 KHz LP FILTER may be switched in to filter out all frequency components above 100 kHz.

d. Connect the signal to be measured to the INPUT terminals.

e. The dB measurement is equal to the algebraic sum of the meter indication and the RANGE setting. For example: if the RANGE setting is +20dB, and the meter reading is -3dB, the actual dB measurement is +17dB.

3-7. AC VOLTAGE MEASUREMENTS.

NOTE

Since the 400GL is average responding and rms calibrated, any distortion will affect the accuracy of the measurement. Table 3-1 shows the errors caused by distortions.

Table 3-1

Effect of Distortion on Average Responding Meter

HARMONIC	%DISTORTION	% ERROR (* Fundamental)	
		MAX. POSITIVE	MAX. NEGATIVE
Any even	0.1	0.000	
	0.5	0.001	
	1.0	0.005	
	2.0	0.020	
Third	0.1	0.003	0.033
	0.5	0.168	0.167
	1.0	0.338	0.328
	2.0	0.687	0.667
Fifth	0.1	0.020	0.020
	0.5	0.101	0.099
	1.0	0.205	0.195
	2.0	0.420	0.380

*Depends on phase relationship between harmonic and fundamental.

a. Perform steps a through d of Paragraph 3-6.

b. The meter will indicate the rms voltage amplitude of the sinusoidal input signal.

3-8. WIDE BAND AC AMPLIFIER.

CAUTION

EXTREME CARE SHOULD BE TAKEN TO AVOID COMMON GROUND PATHS BETWEEN THE INPUT AND OUTPUT SIGNALS. BECAUSE OF THE HIGH GAIN OF THE INSTRUMENT ON THE MORE SENSITIVE RANGES (80 DB ON .1 MV RANGE, ETC.), COMMON GROUND PATHS CAN CAUSE OSCILLATIONS AT HIGHER FREQUENCIES.

a. Perform the steps listed in Paragraph 3-5.

b. Set the meter RANGE switch to the approximate range of the input signal.

c. When signals of frequencies less than 100 kHz are being amplified, the 100 KHz L. P. FILTER may be switched in to reduce high frequency noise and lessen the possibility of oscillations.

d. Connect the input signal to the INPUT terminals, and connect the load to the AC OUTPUT terminals.

e. Table 3-2 shows the gain factor for each range of the 400GL, into an open circuit.

Table 3-2. AC Amplifier Gain Factors

RANGE	GAIN	RANGE	GAIN
1000 V	-60dB	100 mV	+20dB
100 V	-40dB	10 mV	+40dB
10 V	-20dB	1 mV	+60dB
1 V	0dB	.1 mV	+80dB

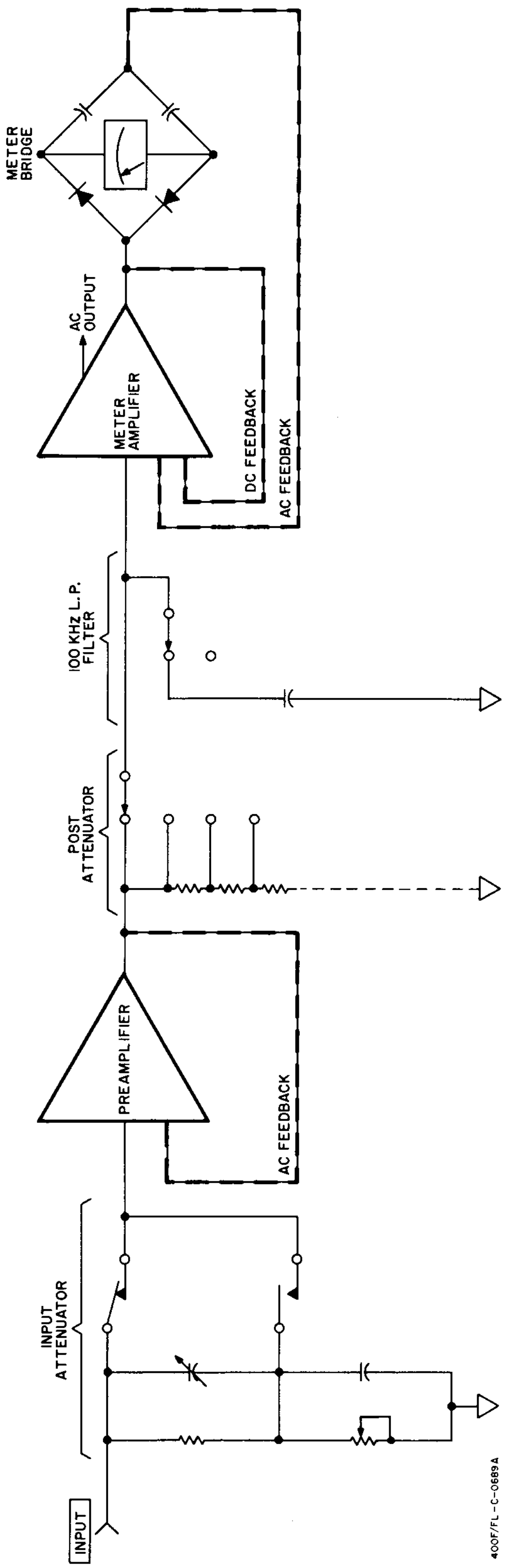


Figure 4-1. Functional Circuit Diagram

SECTION IV
THEORY OF OPERATION

4-1. GENERAL.

4-2. The 400GL is a solid state, average responding, rms calibrated ac voltmeter. It may also be used as a wide band ac amplifier, with switchable gain and switchable bandwidth. Refer to Figure 4-1 for a functional circuit diagram of the instrument.

4-3. BLOCK DIAGRAM DESCRIPTION.

4-4. The voltage to be measured is applied to the input attenuator, where it is either attenuated by 60 dB, or coupled directly to the preamplifier. The preamplifier provides 10dB of gain for the input signal and applies it to the post attenuator. The signal goes from the post attenuator to the 100 KHz Low Pass filter, which may be switched in to limit the bandwidth to signals from 20Hz to 100kHz. The meter amplifier then amplifies the signal, couples it to the meter bridge, and supplies a signal to the AC OUTPUT terminal. The meter bridge rectifies the ac signal and applies it to meter M1, which indicates the rms value of the input voltage. The meter bridge also provides the ac feedback to the meter amplifier.

4-5. SCHEMATIC THEORY.

4-6. Refer to Figure 6-3 for the following discussion.

4-7. INPUT ATTENUATOR.

4-8. The input attenuator consists of an rc voltage divider and two reed relays. On the .1 mV through 100 mV ranges, reed relay A1K1 is energized by -26 V from wafer (A) of the RANGE switch, S1, routing the input signal directly to the preamplifier. On all other ranges, the -26 V is applied to relay A1K2. When A1K2 is closed, the input signal is attenuated 60dB by the rc divider and coupled to the preamplifier.

4-9. PREAMPLIFIER.

4-10. The preamplifier is a three stage ac amplifier that amplifies the signal from the input attenuator by 10dB. It also functions as an impedance matcher to match the high impedance of the input attenuator to the much lower impedance of the post attenuator.

4-11. Capacitor A2C5 blocks dc transients and couples the ac signal to the preamplifier. The input signal is limited to 5.4 volts peak-to-peak by diodes A2CR2 and A2CR4, which are biased at +2.7 V and -2.7 V respectively, by zener diodes A2CR1 and A2CR5. A field effect transistor, A2Q1, is used as the input stage of the preamplifier because of its low noise characteristics and high input impedance. The signal is taken from the drain of A2Q1 and is further amplified by A2Q2 and A2Q3.

4-12. Feedback from the emitter of A2Q2 bootstraps the value of A2R9, the drain load of A2Q1. Feedback from the source of A2Q1 bootstraps the input impedance of the preamplifier and keeps it at a high level over all ranges of inputs. Gain stability and linearity of the preamplifier are maintained by feedback from the emitter of A2Q3. A2R6 provides a bias adjustment for the field effect transistor, A2Q1.

4-13. POST ATTENUATOR.

4-14. The post attenuator is a precision resistive voltage divider that operates as a function of the RANGE switch. On the lowest voltage range, the signal from the preamplifier is applied through two resistors (S1R1 and S1R17) to the 100 KHz LP FILTER, and receives no attenuation. A precision resistive divider circuit provides signal attenuation in progressive steps of 20dB for the seven higher ranges.

4-15. 100 KHz LOW PASS FILTER.

4-16. The 100 KHz LP FILTER is a 0.01 μF capacitor (S2C1) which may be switched into or out of the circuit by switch S2. When the filter is in the circuit, the bandwidth of the instrument is from 20 Hz to 100 kHz. If the filter is switched out of the circuit, the bandwidth is increased to 4 MHz. Refer to Figure 4-2 for a graph of the filter attenuation characteristics.

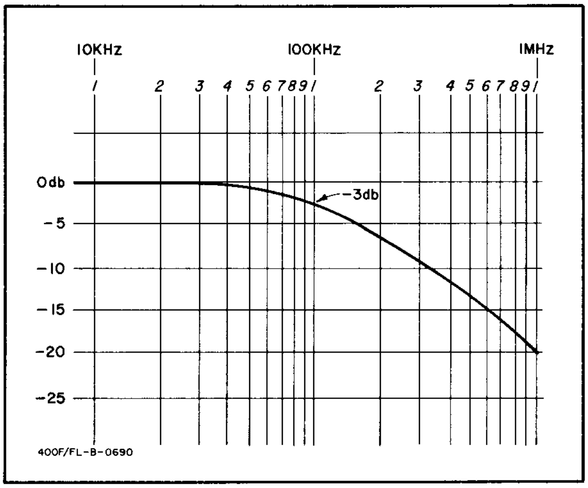


Figure 4-2. Filter Attenuation Characteristics

4-17. METER AMPLIFIER.

4-18. The meter amplifier is a four stage, direct coupled voltage and power amplifier. The first stage is a differential amplifier, A2Q10 and A2Q12, which amplifies the difference between the input signal and the feedback signal on the base of A2Q12. The three other stages of amplification are provided by A2Q11, A2Q13, and A2Q15.

4-19. The ac feedback from the meter bridge is adjustable at 4 MHz (A2C36) and 400 Hz (A2R62) on the -40dB range. On the -80dB range, A2R64, A2R67, and A2R68 are switched into the circuit to increase

the gain of the amplifier by 10dB and to allow a 400 Hz gain adjustment to be made.

4-20. The dc feedback from the collector of A2Q15 is adjustable at 20 Hz (A2R59) on the -40dB range. A2R58 is switched into the circuit on the -80dB range to provide a feedback adjustment at 30 Hz. These adjustments provide overall amplifier gain stability for the entire voltage and frequency range of the instrument.

4-21. A2Q14 isolates the AC OUTPUT circuit from the meter amplifier and the meter bridge. It is an independent current source which will supply a signal to the OUTPUT terminal that is identical to the signal applied to the meter bridge. That is, for a 1 V rms signal for full scale meter deflection, A2Q14 will provide a 1 V rms signal at the AC OUTPUT terminal, into an open circuit.

4-22. METER BRIDGE.

4-23. Refer to Figure 4-3 for a simplified diagram of the metering circuit.

4-24. The meter bridge is a full wave rectifier that converts the ac signal from the meter amplifier into dc. It supplies current to drive the meter and provides an ac feedback signal to the meter amplifier.

4-25. Transistor A2Q16 provides a large output impedance for the meter amplifier, and is the current drive source for the meter bridge circuit. The collector output of A2Q16 is applied to the meter bridge, and is rectified by diodes A2CR22 and A2CR23. The ac components of the bridge signal are coupled into the feedback loop by capacitors A2C38 and A2C39. Transistor A2Q17 bootstraps the resistance of A2R69 to a high value, so that current is driven through the bridge, keeping the meter circuit response linear to large variations in signal amplitude.

4-26. The meter, M1, is a current driven device that utilizes a taut-band movement. It responds to the average value of the rectified meter amplifier output, which is proportional to the rms value of the sinusoidal signal being measured. The meter indicates the rms value of the input signal in volts and dB. The meter scale is calibrated so that 0dB corresponds to 1 volt. The meter is protected from circuit transients and overloads by capacitor C1.

4-27. POWER SUPPLY.

4-28. The power supply provides both a positive and negative 26 V regulated output. It may be operated by external batteries (+35 V to 55 V and -35 V to 55V) or line power (115 V or 230 V, 50 Hz to 1000 Hz).

4-29. The line input is converted to dc by a diode rectifier network consisting of A2CR6 through A2CR9. The positive output of the rectifier is applied to series regulator A2Q4, which regulates the +26 V supply. Control transistor A2Q6 has a constant emitter reference voltage supplied by zener diode A2CR13. Capacitor A2C16 couples any change in the +26 V output

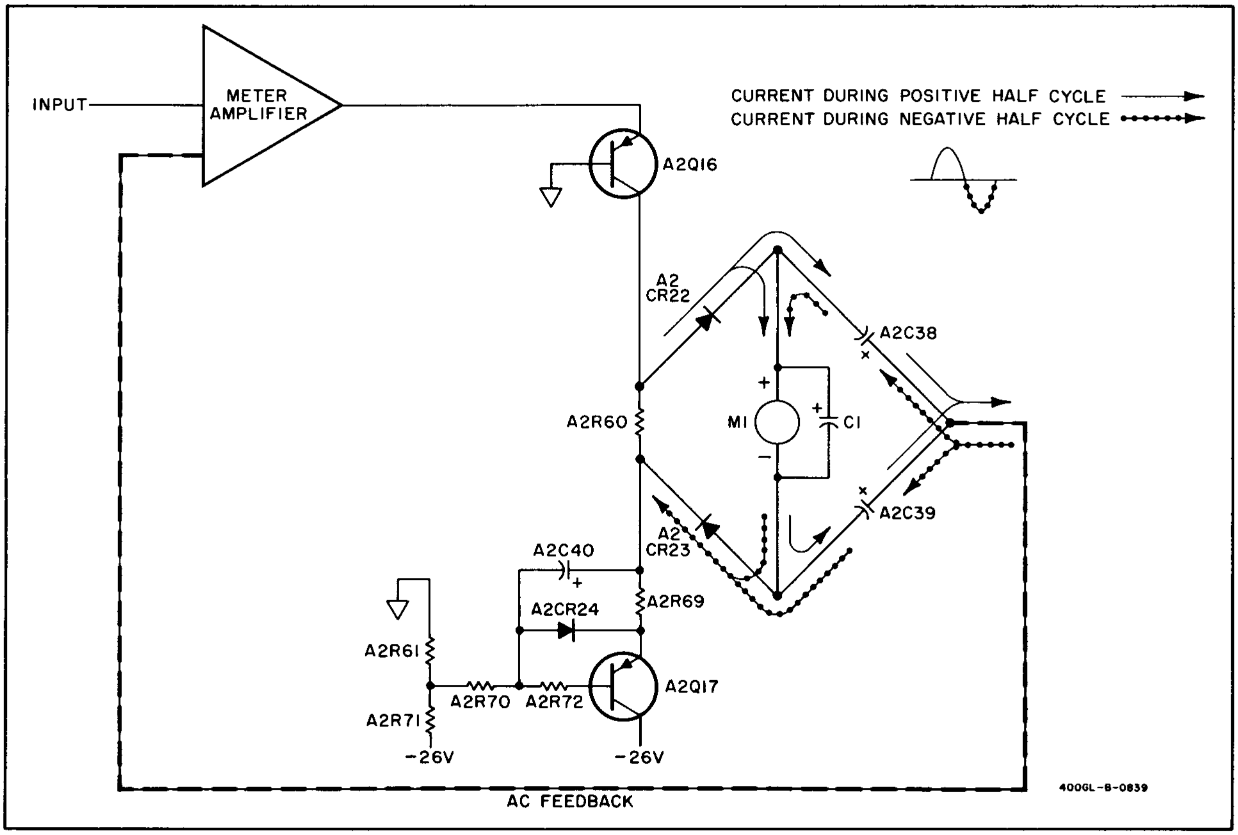


Figure 4-3. Simplified Diagram of Metering Circuit

to the base of A2Q6, which will supply a signal proportional to the change in output voltage to A2Q5. A2Q5 will then amplify the signal and couple it to the base of the regulator A2Q4, causing it to regulate the output by either increasing or decreasing conduction.

4-30. The -26 V supply is regulated in the same manner, the only difference being that the control transistor A2Q7 is referenced to the +26 V output, instead of the zener diode.

Table 5-1. Test Equipment

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
AC Voltmeter Calibrator	Accuracy: 0.2% at 400 Hz Range: 5 mV to 1 V	Performance Checks and Calibration	-hp- Model 738BR Voltmeter Calibrator
Test Oscillator	Output: 5 mV to 1 V Frequency Range: 20 Hz to 4 MHz Distortion: < 1% Flatness: ±0.25%	Performance Checks and Calibration	-hp- Model 652A Test Oscillator or Combination -hp- Model 739AR Frequency Response Test Set and -hp- Model 200SR Oscillator
AC/DC Voltmeter/Ohmmeter	Volts Accuracy: 2% Ohms Accuracy: 5%	Troubleshooting	-hp- Model 427A Voltmeter
Resistor	Fxd, 100 KΩ ±1%	Performance Checks	-hp- Part No. 0757--0465
Resistor	Fxd, 200 KΩ ±1%	Performance Checks	-hp- Part No. 0757-0128
Terminating Resistance	Feed-through, 50 Ω impedance	Performance Checks and Calibration	-hp- Part No. 11048B Feed-through Termination
Crystal Socket (with Terminals shorted)	Size: 1/2 inch	Performance Checks and Calibration (Shorting Test Points)	-hp- Part No. 1200-0028

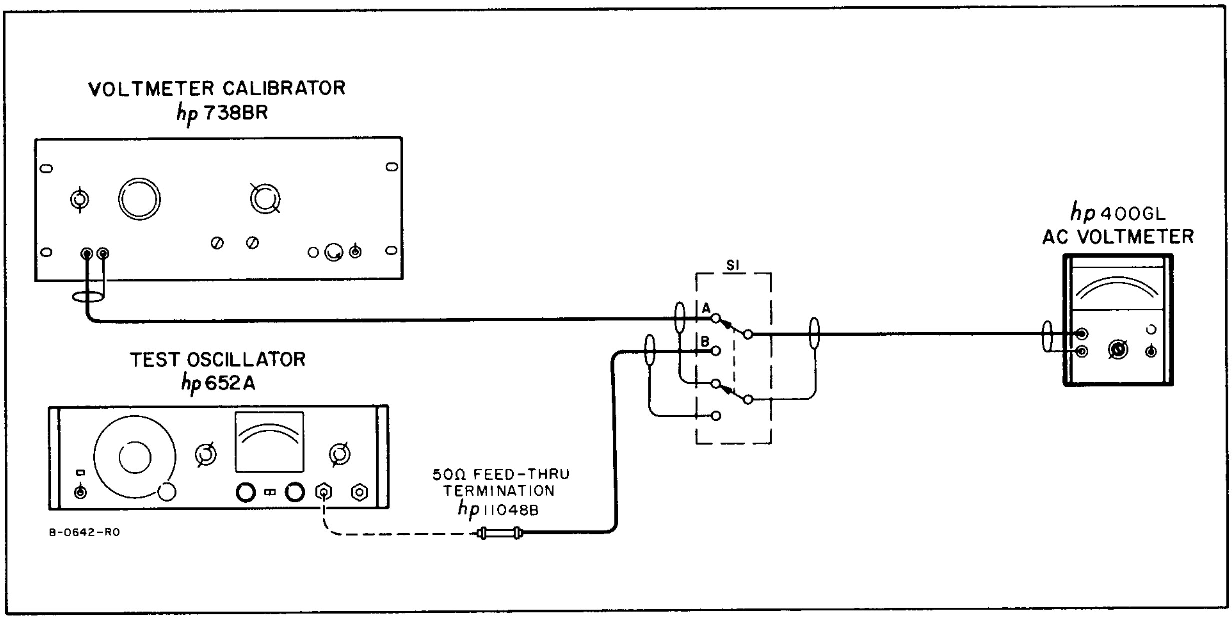


Figure 5-1. Accuracy and Frequency Response Check Setup

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains maintenance and service information for the Model 400GL AC Voltmeter. Included are Performance Checks, Alignment and Calibration Procedures, and Troubleshooting Procedures.

5-3. TEST EQUIPMENT REQUIRED.

5-4. The equipment required to properly maintain the 400GL is listed in Table 5-1. The table lists the type of equipment to be used, the specification requirements, and the recommended commercially available test equipment.

5-5. PERFORMANCE CHECKS.

5-6. The following Performance Checks compare the 400GL with its accuracy specifications (Table 1-1). These checks may be used for incoming inspection, periodic maintenance, and for specification checks after a repair. A highly accurate and stable voltage reference that is variable from 20 Hz to 4 MHz is required for the performance checks. The -hp- 738BR Voltmeter Calibrator produces a 400 Hz signal that is within less than 0.2% of the indicated output. The -hp- 652A Test Oscillator can be referenced to the output of the 738BR and can be adjusted to within 0.25% of the set reference voltage from 20 Hz to 4 MHz.

5-7. If the -hp- 652A Test Oscillator is not available, the -hp- 739AR Frequency Response Test Set and 200SR Oscillator combination may be used. This combination can be adjusted to within 0.5% of a set voltage reference from 20 Hz to 4 MHz. (The -hp- 739AR, -hp- 200SR, and -hp- 738BR are available in a rack mounted configuration designated -hp- K02-738BR VTVM Calibration System.)

5-8. The following procedures specify the use of the -hp- 652A and the -hp- 738BR. If the K02-738BR calibration system is used, follow the same general procedures.

5-9. Figure 5-1 shows the test setup for using the -hp- 652A and -hp- 738BR combination. Figure 5-2 shows the test setup for using the K02-738BR VTVM Calibration System.

NOTE

The -80dB (0.1 mV) range of the 400GL may be checked for accuracy by verification of the additional 10dB of gain that is provided by the meter amplifier on that range. In order to verify the gain, the top cover of the instrument must be removed to gain access to TP1 through TP4.

5-10. TOP COVER REMOVAL.

5-11. To remove or replace the top cover, follow the procedures outlined in Paragraph 5-25.

5-12. ACCURACY AND FREQUENCY RESPONSE CHECKS.

5-13. The accuracy and frequency response checks compare the 400GL with its accuracy specifications over the entire frequency range of the instrument.

5-14. Connect the voltmeter calibrator and the test oscillator to the 400GL as shown in Figure 5-1. An external switch (S1) should be used to facilitate switching from one test instrument to the other.

5-15. -40dB RANGE.

a. Set 400GL RANGE switch to -40dB (10mV) and set 100 KHz L. P. FILTER switch to OUT.

b. Set switch S1 to position A.

c. Adjust voltmeter calibrator for a 5 mV rms output, at 400 Hz.

d. Note 400GL meter indication. If meter indication is not within tolerances listed in Table 5-2, perform the meter calibration (Paragraph 5-30).

e. Set switch S1 to position B. Set test oscillator to 400 Hz, and adjust amplitude controls until 400GL meter indication is the same as in step d of this paragraph. Set a reference on meter of test oscillator, and use amplitude controls to maintain the set reference whenever frequency of oscillator is varied.

f. Repeat step d of this paragraph for each frequency listed in Table 5-2.

5-16. -20dB RANGE (-80dB RANGE CHECK.)

a. Set 400GL RANGE switch to -20dB (100mV), and set 100 KHz L. P. FILTER switch to OUT.

b. Set switch S1 to position A.

c. Adjust voltmeter calibrator for a 10 mV rms output, at 400 Hz.

d. Short TP1 to TP4, and short TP2 to TP3. (A shorting device, such as a crystal socket with its terminals shorted together, should be used to avoid pickup of noise.) The meter should indicate -10dB ±0.2dB, verifying the additional 10dB of gain that is provided by the meter amplifier on the -80dB range (0.1 mV). Note meter indication.

e. Set switch S1 to position B.

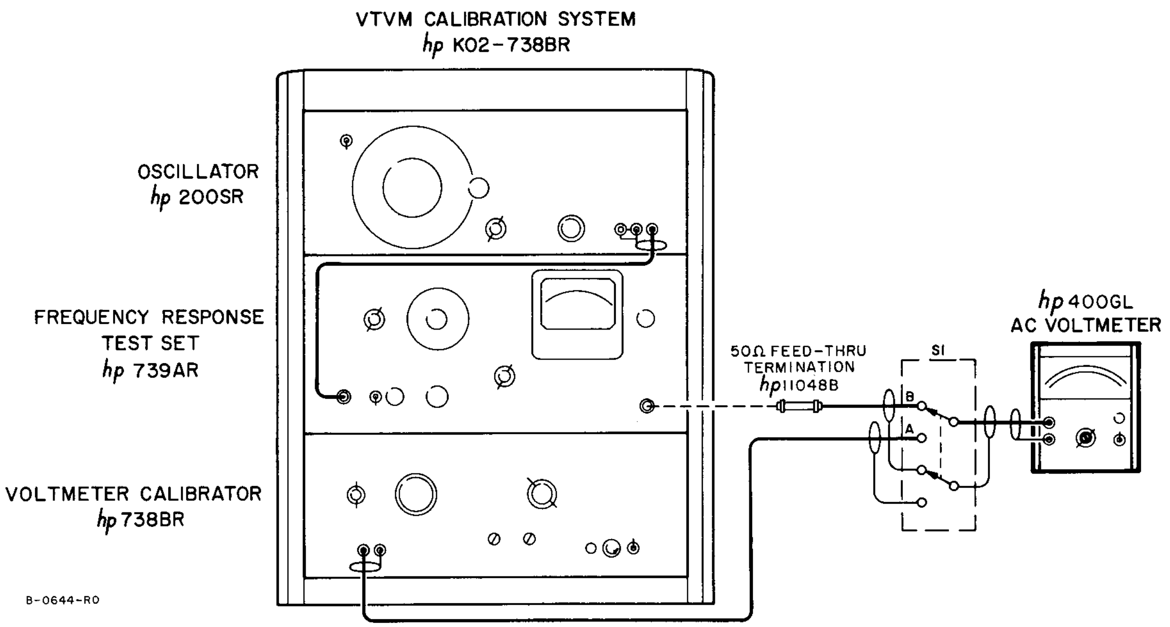


Figure 5-2. Alternate Accuracy and Frequency Response Check Setup

f. Set test oscillator to 400 Hz, and adjust amplitude controls until 400GL indication is same as in step d of this paragraph. Set a reference on meter of test oscillator, and use amplitude controls to maintain set reference whenever frequency of oscillator is changed.

g. Set test oscillator to each frequency listed in Table 5-2, and observe the 400GL meter indication for each different frequency. If each meter indication is not within the tolerances listed in Table 5-2, perform the Meter Calibration (Paragraph 5-30).

h. Remove shorting device from test points.

5-17. 0dB RANGE.

a. Set 400GL RANGE switch to 0dB (1V), and set 100 KHz L. P. FILTER switch to OUT.

b. Set switch S1 to position A.

c. Adjust voltmeter calibrator for a 0.5 V rms output at 400 Hz.

d. Note 400GL meter indication. If meter indication is not within tolerances listed in Table 5-2, perform the meter calibration (Paragraph 5-30).

e. Set switch S1 to position B. Set test oscillator to 400 Hz, and adjust amplitude controls until 400GL meter indication is same as in step d of this paragraph. Set a reference on meter of test oscillator, and use amplitude controls to maintain set reference, whenever frequency of oscillator is changed.

f. Repeat step d of this paragraph for each frequency listed in Table 5-2.

5-18. RANGE TRACKING CHECK.

5-19. The following procedures are used to verify the tracking accuracy of the 400GL on two voltage ranges, over the entire frequency range of the instrument. Use the test setup shown in Figure 5-1 for the range tracking check.

a. Set 400GL RANGE switch to -20dB (100mV), and set 100 KHz L. P. FILTER switch to OUT.

b. Set switch S1 to position A.

c. Adjust voltmeter calibrator for a 30 mV rms output, at 400 Hz.

d. Note 400GL meter indication. If meter indication is not within tolerances listed in Table 5-3, perform the meter calibration (Paragraph 5-30).

e. Set switch S1 to position B. Set test oscillator to 400 Hz, and adjust amplitude controls until 400GL meter indication is same as in step d of this paragraph. Set a reference on meter of test oscillator, and use amplitude controls to maintain the set reference whenever frequency of oscillator is varied.

f. Repeat step d of this paragraph for each frequency listed in Table 5-3.

g. Set switch S1 to position A.

h. Adjust voltmeter calibrator for a 15 mV rms output at 400 Hz.

i. Repeat steps d, e, and f of this paragraph.

j. Set 400GL RANGE switch to 0dB (1 V).

Table 5-2. Meter Calibration Tolerances

-40 dB RANGE			-20 dB RANGE (-80dB Range Check)			0dB RANGE		
FREQ.	METER INDICATION(dB)		FREQ.	METER INDICATION(dB)		FREQ.	METER INDICATION(dB)	
	MIN.	MAX.		MIN.	MAX.		MIN.	MAX.
20	-6.4	-5.6	30	-10.4	-9.6	20	-6.4	-5.6
40	-6.4	-5.6	60	-10.4	-9.6	40	-6.4	-5.6
400	-6.2	-5.8	400	-10.2	-9.8	400	-6.2	-5.8
1000	-6.2	-5.8	1000	-10.2	-9.8	1000	-6.2	-5.8
10 K	-6.2	-5.8	10 K	-10.2	-9.8	10 K	-6.2	-5.8
100 K	-6.2	-5.8	100 K	-10.2	-9.8	100 K	-6.2	-5.8
1 M	-6.4	-5.6	300 K	-10.8	-9.8	1 M	-6.4	-5.6
2 M	-6.4	-5.6	500 K	-10.8	-9.8	2 M	-6.4	-5.6
4 M	-6.8	-5.8				4 M	-6.8	-5.8

Table 5-3. Range Tracking Tolerances

FREQ.	-20 dB RANGE				0dB RANGE			
	30 mV INPUT METER INDICATION(dB)		15 mV INPUT METER INDICATION(dB)		0.3 V INPUT METER INDICATION(dB)		0.15 V INPUT METER INDICATION(dB)	
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
20	-10.9	-10.1	-16.9	-16.1	-10.9	-10.1	-16.9	-16.1
40	-10.9	-10.1	-16.9	-16.1	-10.9	-10.1	-16.9	-16.1
400	-10.7	-10.3	-16.7	-16.3	-10.7	-10.3	-16.7	-16.3
1000	-10.7	-10.3	-16.7	-16.3	-10.7	-10.3	-16.7	-16.3
1 K	-10.7	-10.3	-16.7	-16.3	-10.7	-10.3	-16.7	-16.3
100 K	-10.7	-10.3	-16.7	-16.3	-10.7	-10.3	-16.7	-16.3
1 M	-10.9	-10.1	-16.9	-16.1	-10.9	-10.1	-16.9.	-16.1
2 M	-10.9	-10.1	-16.9	-16.1	-10.9	-10.1	-16.9	-16.1
4 M	-11.3	-10.3	-17.3	-16.3	-11.3	-10.3	-17.3	-16.3

k. Set switch S1 to position A.

l. Adjust voltmeter calibrator for a 0.3 V rms output at 400 Hz.

m. Repeat steps d, e, and f of this paragraph.

n. Set switch S1 to position A.

o. Adjust voltmeter calibrator for a 0.15 V rms output at 400 Hz.

p. Repeat steps d, e, and f of this paragraph.

5-20. INPUT IMPEDANCE CHECK.

5-21. INPUT RESISTANCE CHECK.

a. Connect 50 Ω output of test oscillator to 400GL.

b. Set 400GL RANGE switch to 0dB(1V), and set 100 KHz L. P. FILTER switch to OUT.

c. Set test oscillator output for full scale meter deflection of 400GL at 400 Hz.

d. Connect resistor R1 between test oscillator and 400GL as shown in Figure 5-3. (R1 = 200 KΩ).

e. 400GL meter indication should not drop more than 0.2 dB from full scale. This verifies an input resistance of 10 MΩ.

5-22. INPUT CAPACITY CHECK.

a. Connect test oscillator and resistor R1 to 400GL as shown in Figure 5-3. (R1 = 100 KΩ). Connect resistor lead directly to GR connector.

b. Set 400GL RANGE switch to 0dB (1V), and set 100 KHz L. P. FILTER switch to OUT.

c. Set test oscillator output for full scale deflection of 400GL meter at 400 Hz.

d. Increase frequency of test oscillator until 400 GL indication drops to -3dB. This should

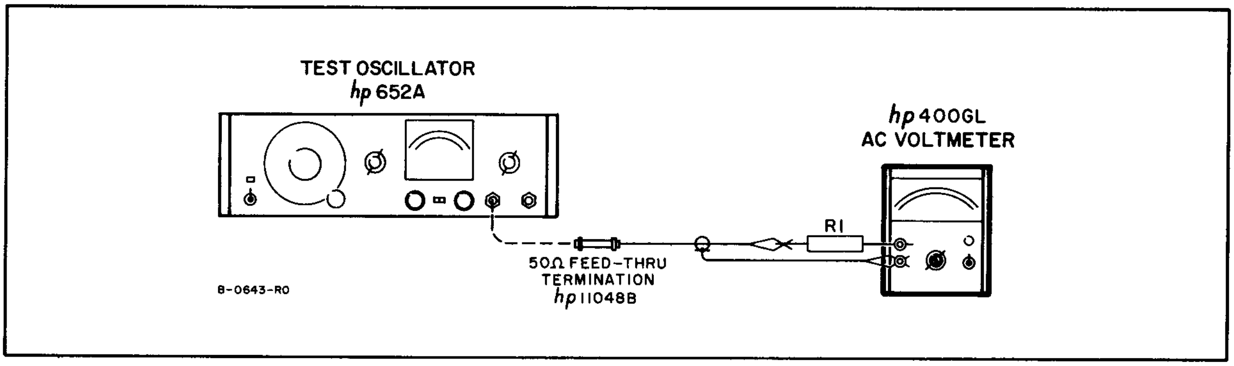


Figure 5-3. Input Impedance Check Setup

occur at a frequency of 106 kHz or greater, verifying an input capacity of 15 pF or less on the 0dB range.

e. Set 400GL RANGE switch to -20 dB (100 mV).

f. Set frequency response test set output for full scale deflection of 400GL meter at 400 Hz.

g. Increase frequency of test oscillator until 400 GL indication drops to -3 dB. This should occur at a frequency of 53 kHz or greater, verifying an input capacity of 30 pF or less on the -20 dB range.

5-23. ALIGNMENT AND CALIBRATION PROCEDURES.

5-24. The alignment and Calibration Procedures should be performed only if it has been determined by the Performance Checks that the 400GL is not within specifications. The following procedures specify the use of an -hp- 738BR Voltmeter Calibrator and an -hp- 652A Test Oscillator. However, an -hp- K02-738BR VTVM Calibration System may be substituted if the same general procedures are followed. If the instrument cannot be properly adjusted, refer to Paragraph 5-41, Troubleshooting Procedures. Refer to Figure 5-4 for the location of internal adjustments.

5-25. COVER REMOVAL AND REPLACEMENT.

5-26. Removal of the top cover exposes circuit areas for routine checks and adjustments. Removal of the bottom and side covers exposes circuit areas for operations such as soldering and component replacement.

5-27. TOP OR BOTTOM COVERS.

a. Remove screw at rear of cover; also remove two screws on side of top cover. Slide cover about 1 inch to rear, and lift it off.

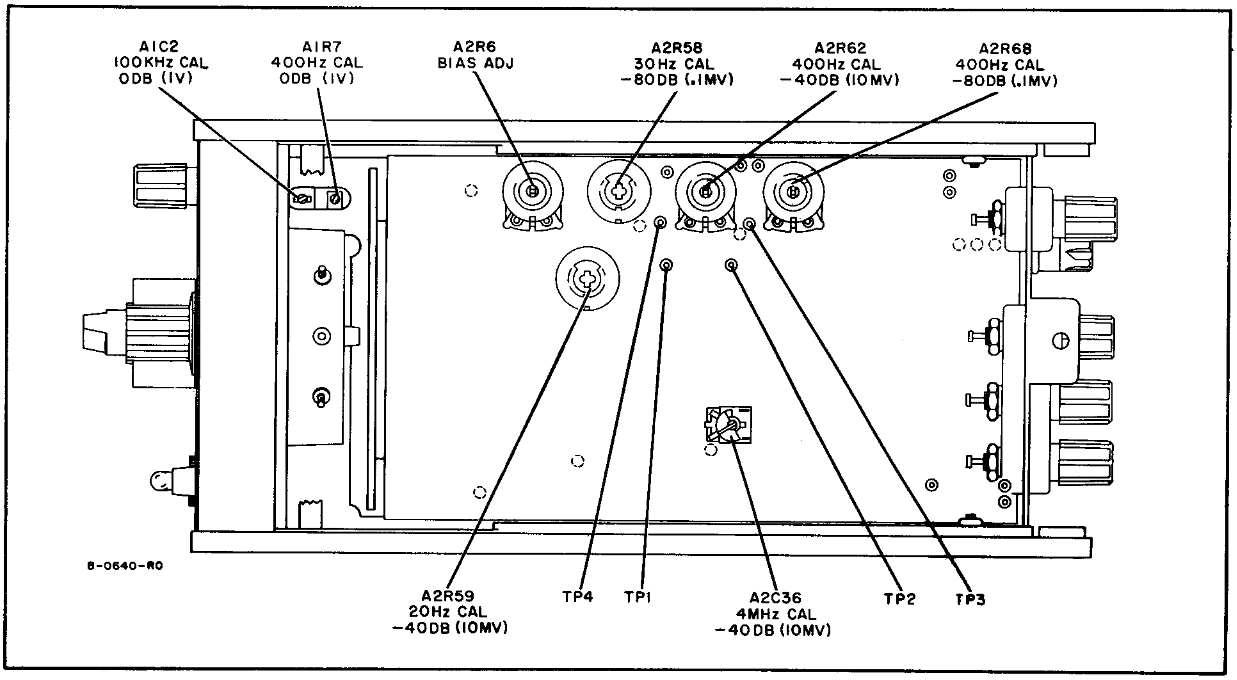


Figure 5-4. Location of Internal Adjustments

b. To replace cover reverse the removal procedure.

5-28. SIDE COVER.

5-29. Remove the four screws from side cover, and lift it off.

5-30. METER CALIBRATION.

5-31. The following procedures are used to adjust the gain of the meter amplifier on two voltage ranges at five different frequencies. Proper gain adjustments will assure accurate meter indications over the entire voltage and frequency range of the instrument. Use the test setup shown in Figure 5-1 for the meter calibration.

5-32. Meter Calibration, -40dB RANGE.

a. Set switch S1 to Position A.

b. Set 400GL RANGE switch to -40 dB (10 mV), and set 100 KHz L. P. FILTER switch to OUT.

c. Set voltmeter calibrator for 10 mV output at 400 Hz.

d. Adjust A2R62 for a 400GL full scale meter indication.

e. Set switch S1 to Position B.

f. Adjust test oscillator for a 400GL full scale meter indication at 400 Hz. Set a reference on meter of test oscillator and use amplitude controls to maintain reference whenever frequency of oscillator is changed.

g. Set test oscillator to 20 Hz.

h. Adjust A2R59 for a 400GL full scale meter indication.

i. Set test oscillator to 4 MHz.

j. Adjust A2C36 for a 400GL full scale meter indication.

5-33. METER CALIBRATION, -80dB RANGE.

NOTE

The -80dB range meter calibration is performed on a higher range. This is done by shorting test points which provide the amplifier with the additional 10dB of gain that normally is switched in only on the -80dB range.

a. Set switch S1 to Position B.

b. Set 400GL RANGE switch to -40dB (10 mV) and set 100 KHz L. P. FILTER switch to OUT.

c. Set test oscillator to 400 Hz, and adjust for a 400GL meter indication of -10dB.

d. Short TP1 to TP4 and short TP2 to TP3. (This increases the gain of the meter amplifier by 10dB, as if the instrument were on the -80dB range.)

e. Adjust A2R68 for a 400GL full scale meter indication. Remove shorting device from test points.

f. Set test oscillator to 30 Hz, and adjust for a 400GL meter indication of -10dB.

g. Short TP1 to TP4 and short TP2 to TP3.

h. Adjust A2R58 for a 400GL full scale meter indication.

5-34. ATTENUATOR ALIGNMENT.

5-35. The following procedures are used to properly align the input attenuator of the 400GL at both high and low frequencies. Use the test setup shown in Figure 5-1 for the attenuator alignment.

a. Set switch S1 to Position A.

b. Set 400GL RANGE switch to 0dB (1V), and set 100 KHz L. P. FILTER switch to OUT.

c. Adjust voltmeter calibrator for a 1 volt output at 400 Hz.

d. Adjust A1R7 for a 400GL full scale meter indication.

e. Set switch S1 to position B.

f. Set test oscillator for a 400GL full scale meter indication, at 400 Hz.

g. Set test oscillator to 100 kHz, maintaining a constant amplitude.

h. Adjust A1C2 for a 400GL full scale meter indication. If more than a 0.2 dB adjustment is needed, repeat the 400 Hz adjustment.

5-36. A2Q1 BIAS ADJUSTMENT.

5-37. A2R6 provides a bias adjustment for field effect transistor A2Q1.

a. Monitor voltage at junction between A2R5 and A2R3 with a dc voltmeter.

b. Adjust A2R6 for a +6 V (-6 V for Ser. No. below 737-00456) indication at the junction.

5-38. REPLACEMENT OF A2C37*.

5-39. The value of A2C37 is individually selected to compensate for varying circuit parameters within the instrument. Certain Model 400GL instruments may not have a capacitor in this location.

5-40. If an instrument cannot be properly calibrated on the -40dB range at 4 MHz, A2C37 should be changed. Increase the value of A2C37 if the instrument meter indication is high and cannot be adjusted low enough; decrease the value of A2C37 if the instrument meter indication is low and cannot be adjusted high enough.

5-41. TROUBLESHOOTING PROCEDURE.

5-42. If the 400GL is operating improperly, it either needs to be calibrated or has a circuit that is malfunctioning. Troubleshoot the instrument only after it has been determined that the malfunction cannot be corrected by performing the Alignment and Calibration Procedures in Paragraph 5-23.

Table 5-4 Troubleshooting Guide

MALFUNCTION INDICATION	PROBABLE TROUBLE
Instrument will not operate on line voltage, and LINE ON lamp will not light.	Fuse F1 open.
Instrument will not uprange above -20dB (100mV), but works on -20dB range and below.	Relay A2K1 stuck closed, or A2K2 stuck open.
Instrument will not downrange below 0dB(1V), but works on 0dB range and above.	Relay A2K1 stuck open, or A2K2 stuck closed.
Voltage at A2R8 cannot be properly adjusted.	Impedance Converter Circuit (A2Q1, A2Q2 and A2Q3).
No voltage at A2L1.	Jumper wire #1 broken.
Power supply output unregulated.	A2Q6, A2Q7 or Zener diode A2CR13.
No ac output.	A2R33 shorted, or A2C26 open.
Instrument operates improperly with inputs above 100 kHz, but works with inputs of lower frequencies.	Filter switch S2.
Instrument will not operate properly on -80dB range (0.1 mV).	Range switch S1, wafer D.
Meter deflection on all ranges with no input.	A2Q15, A2Q16, A2Q17. A2C38, A2C39 or A2C40.
Meter remains at zero with any input on any range.	Capacitor C1 shorted.

5-43. When a malfunction occurs, remove power from the 400GL and visually inspect for loose or broken wires and connectors. Also check for overheated or loose components and similar conditions that could be a source of trouble.

5-44. The checks outlined in this section were not designed to measure all circuit parameters, but to localize the malfunction. Therefore, it is probable that additional checks and measurements will be required to completely isolate the faulty component.

5-45. Refer to Table 5-4 for a list of possible malfunctions and their probable causes.

NOTE

All the voltage measurements in this section should be made with the 400GL input shorted and the RANGE switch set to 0dB (1V).

5-46. POWER SUPPLY.

5-47. Measure the power supply outputs at jumper wires #1 and #2 for +26 V and -26 V respectively. If both outputs are incorrect, first check the components in the +26 V section of the power supply, because the control transistor in the -26 V supply is referenced to the +26 V output. Consequently, if the +26 V becomes unregulated, the -26 V will also be unregulated. Refer to Table 5-5 for a list of check point voltages in the power supply.

Table 5-5. Power Supply Voltages

CHECK POINT	VOLTAGE
Emitter Q4	+26.0 V ±1 V
Collector Q4	+41.5 V ±5 V
Collector Q6	+27.5 V ±1 V
Emitter Q8	-26.0 V ±1 V
Emitter Q9	-43.5 V ±5 V

5-48. AMPLIFIERS.

5-49. Both the preamplifier and the meter amplifier are internally dc coupled. If the dc voltages anywhere in the amplifiers are incorrect, the amplifiers will not operate properly. Measure the dc voltages in the amplifiers at the check points listed in Tables 5-6 and 5-7.

Table 5-6. Preamplifier Voltages

CHECK POINT	VOLTAGE
Source Q1	+2.3 V ±0.5 V
Drain Q1	+17.0 V ±2.0 V
Collector Q2	+7.5 V ±0.5 V
Collector Q3	+21.4 V ±1.0 V

NOTE: Preamplifier voltages are negative for Serial Numbers below 737-00456.

Table 5-7. Meter Amplifier Voltages

CHECK POINT	VOLTAGE
Emitter Q10	-0.64 V ±0.1 V
Collector Q10	+9.20 V ±2.0 V
Collector Q11	+0.97 V ±0.2 V
Collector Q12	+22.00 V ±2.0 V
Collector Q13	+11.00 V ±1.0 V
Collector Q15	+2.30 V ±0.5 V

5-50. METER BRIDGE.

5-51. Measure the dc voltages on the transistors in the meter bridge and compare the readings with those given in Table 5-8. Also measure the voltages at the meter terminals. The meter should be floating at approximately -9 volts, ±2 volts, with respect to circuit ground.

Table 5-8. Meter Bridge Voltages

CHECK POINT	VOLTAGE
Collector Q16	-9 V ±2 V
Base Q17	-17 V ±1 V

5-52. ETCHED CIRCUIT BOARD REPAIR.

5-53. The Model 400GL uses plated-through, double-sided, etched circuit boards. To prevent damage to the circuit board and components, observe the following rules when soldering:

a. Use a low-heat (25 to 50 watts) soldering iron with a small tip (1/16" to 3/32" diameter).

b. To remove a component, clip a heat sink (long nose pliers, commercial heat sink tweezers, etc.) on the component lead as close to the component as possible. Place the soldering iron directly on the component lead, and pull up on the lead. If a component is obviously damaged or faulty, clip the leads close to the component and then remove the leads from the board.

CAUTION

EXCESSIVE OR PROLONGED HEAT CAN LIFT THE CIRCUIT FOIL FROM THE BOARD OR CAUSE DAMAGE TO COMPONENTS.

c. Clean the component lead holes by heating the solder in the hole, quickly removing the soldering iron, and inserting a pointed, non-metallic object such as a toothpick.

d. To mount a new component, shape the leads and insert them in the holes. Clip a heat sink on the component, heat with the soldering iron, and add solder as necessary to obtain a good electrical connection.

e. Clip excess leads off after soldering and clean excess flux from the connection and adjoining area, using type TF Freon (-hp- Part No. 8500-0232).

SECTION VI
CIRCUIT DIAGRAMS

6-1. INTRODUCTION.

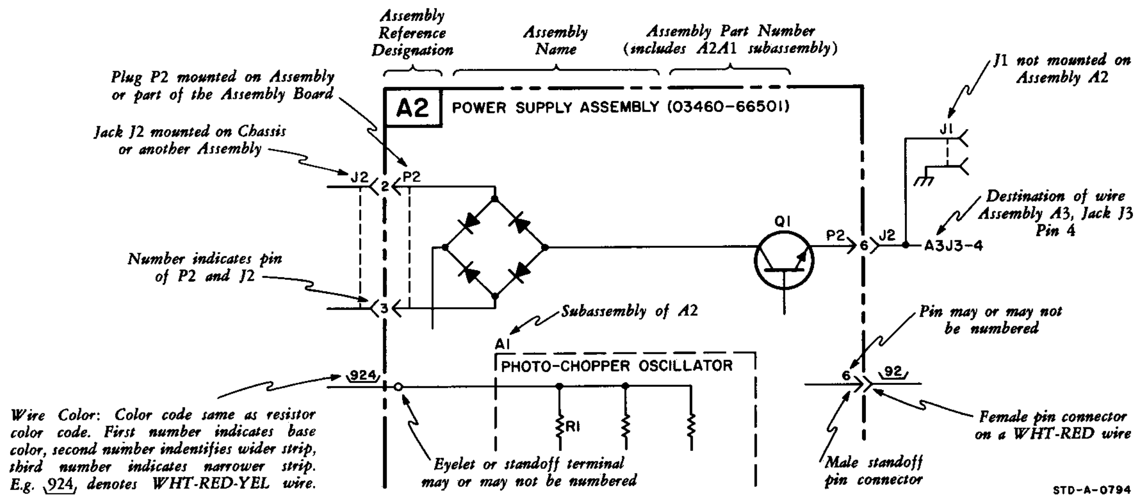
6-2. This section contains the schematic and component location diagrams for the Model 400GL. Figure 6-1 shows a flattened view of the RANGE switch and part of the internal wiring data. Figure 6-2 shows the component location on the A1 and A2 printed circuit boards, and the location of chassis components. Figure 6-3 is the schematic diagram of the 400GL.

An explanation of terms and symbols used as reference designators is given below.

REFERENCE DESIGNATIONS

PARTIAL REFERENCE DESIGNATIONS ARE SHOWN: PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.

ASSEMBLY	SUBASSEMBLY	COMPONENT	COMPLETE DESIGNATION
A2	NONE	Q1	A2Q1
A2	A1	R1	A2A1R1
NONE	NONE	J1	J1



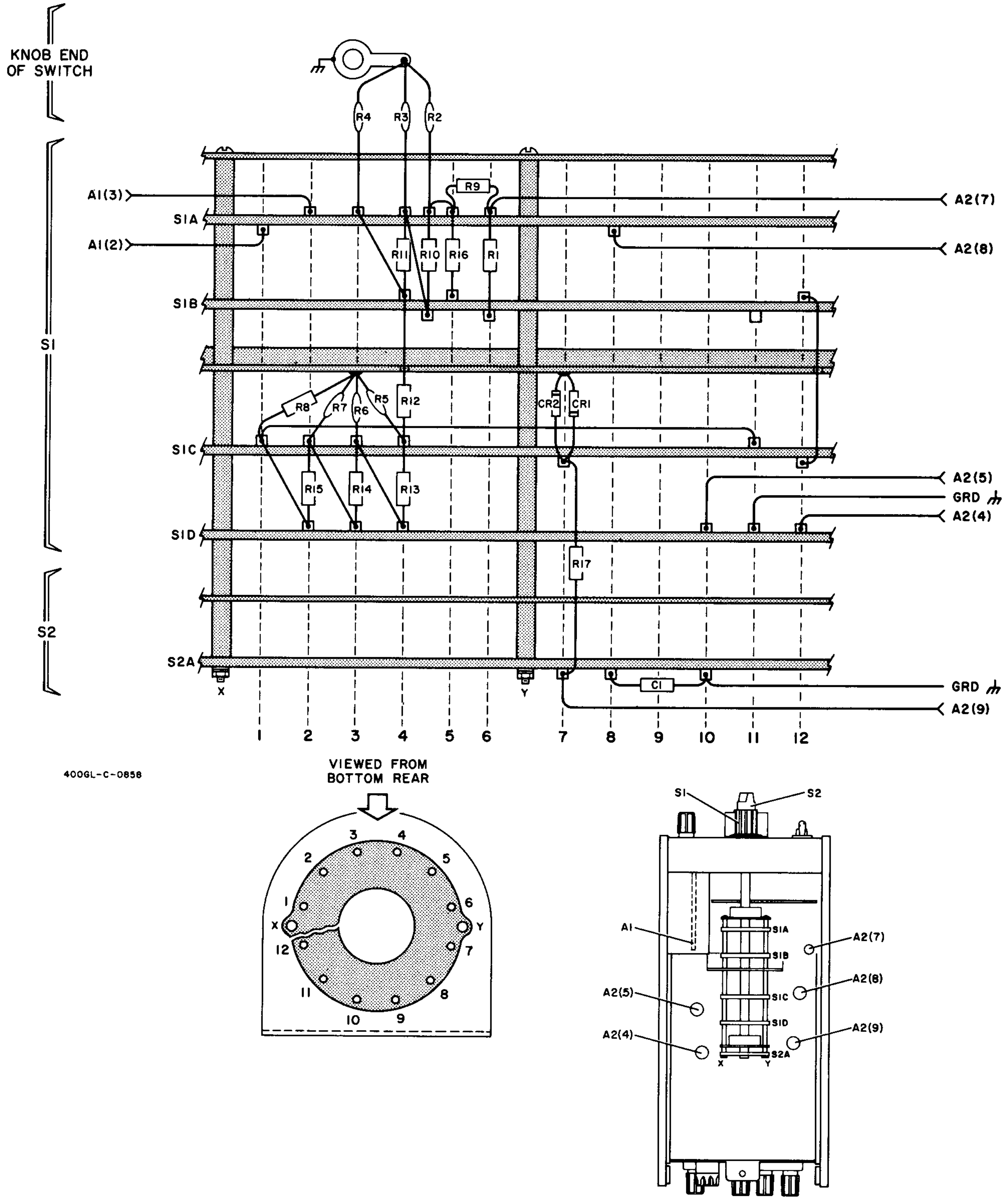
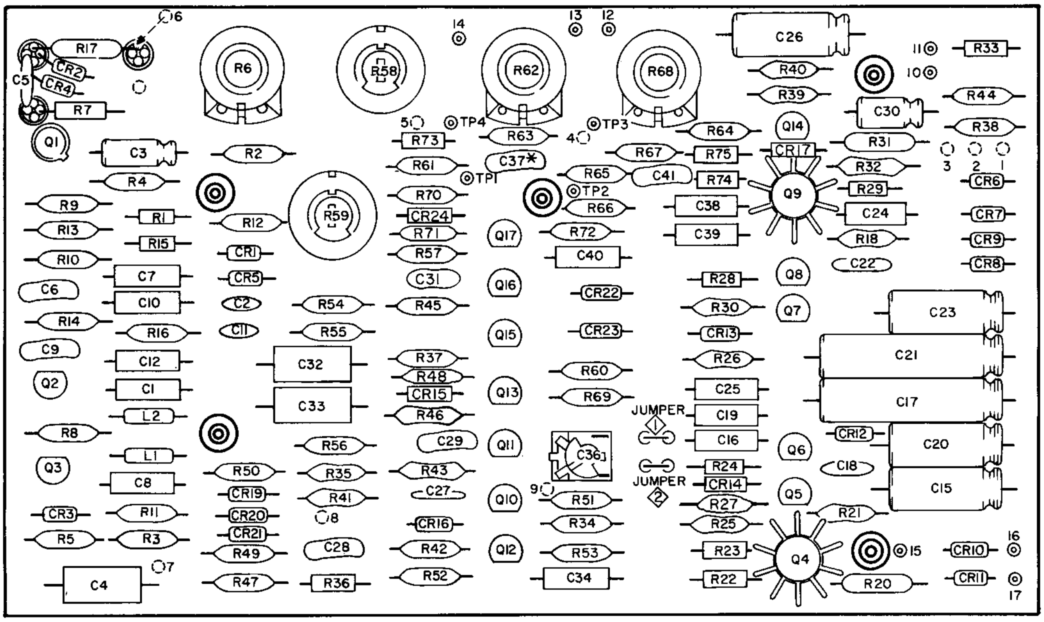
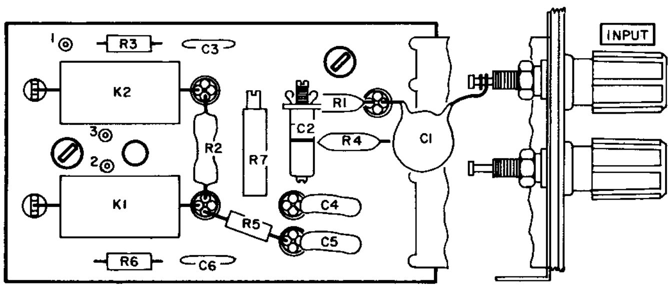


Figure 6-1. Model 400GL Range Switch



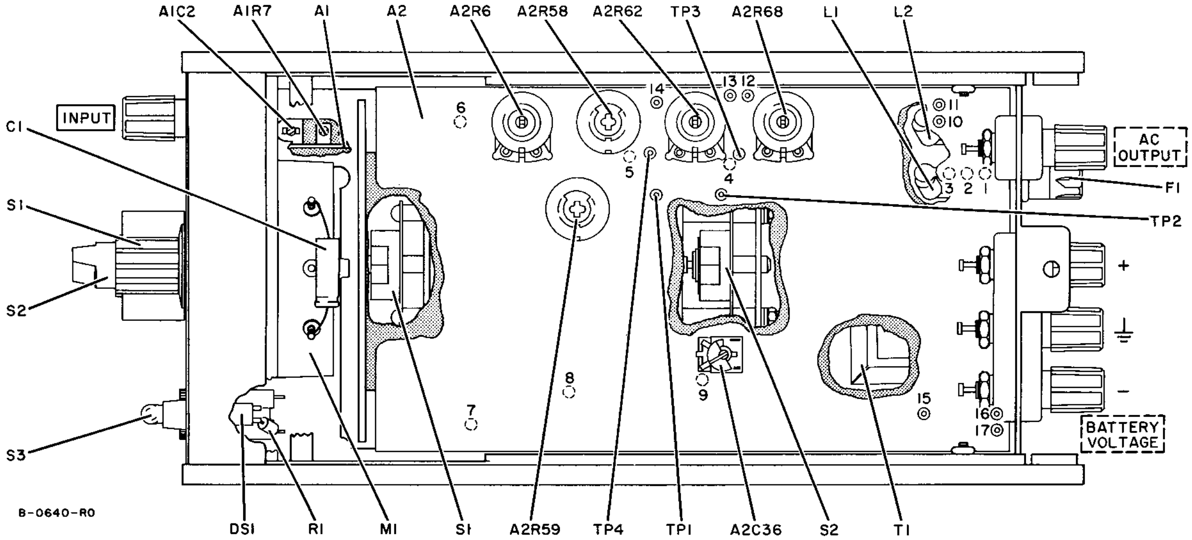
400F/FL-B-0645A

A2 ASSEMBLY



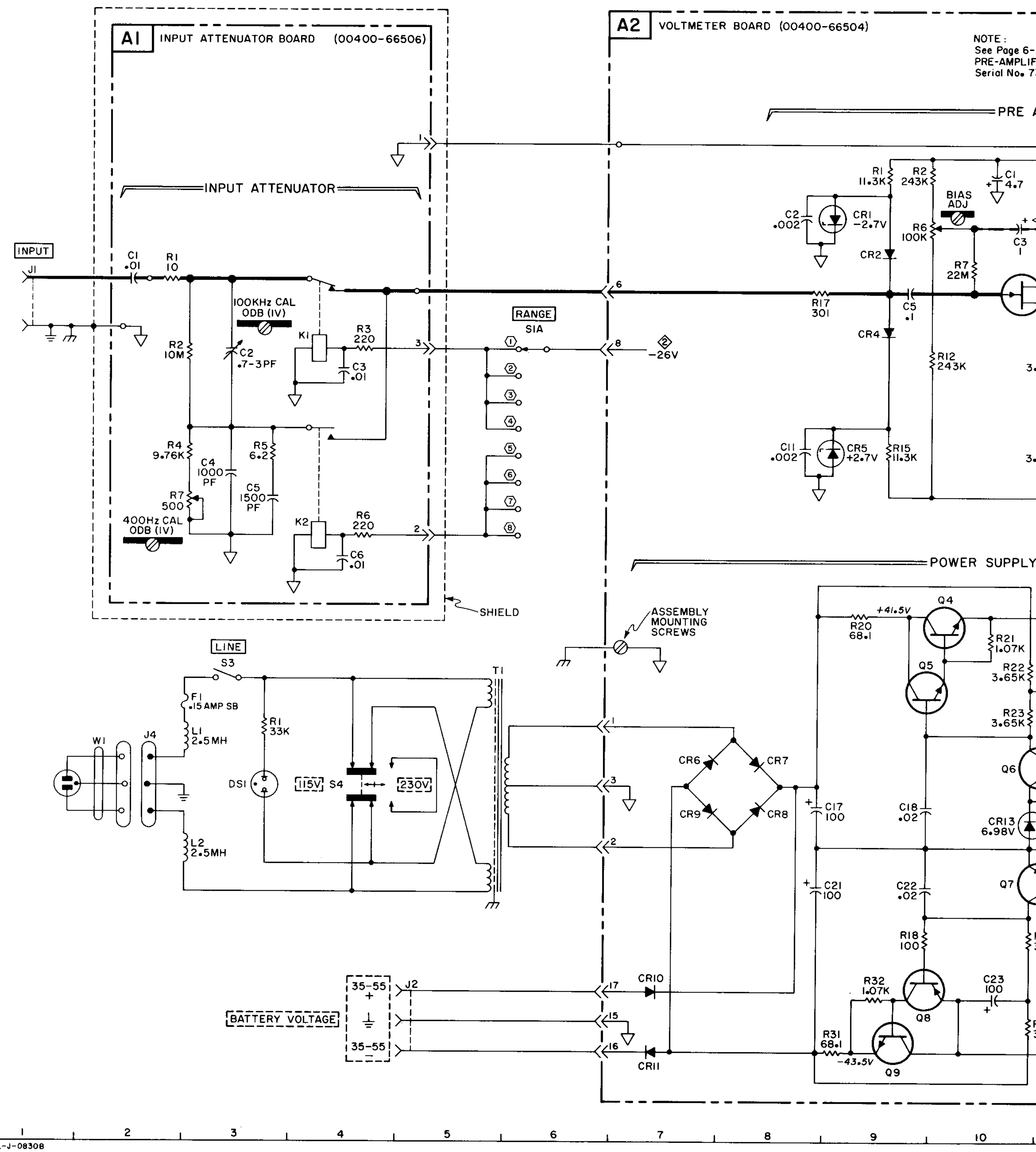
400F/FL-B-0646

A1 ASSEMBLY



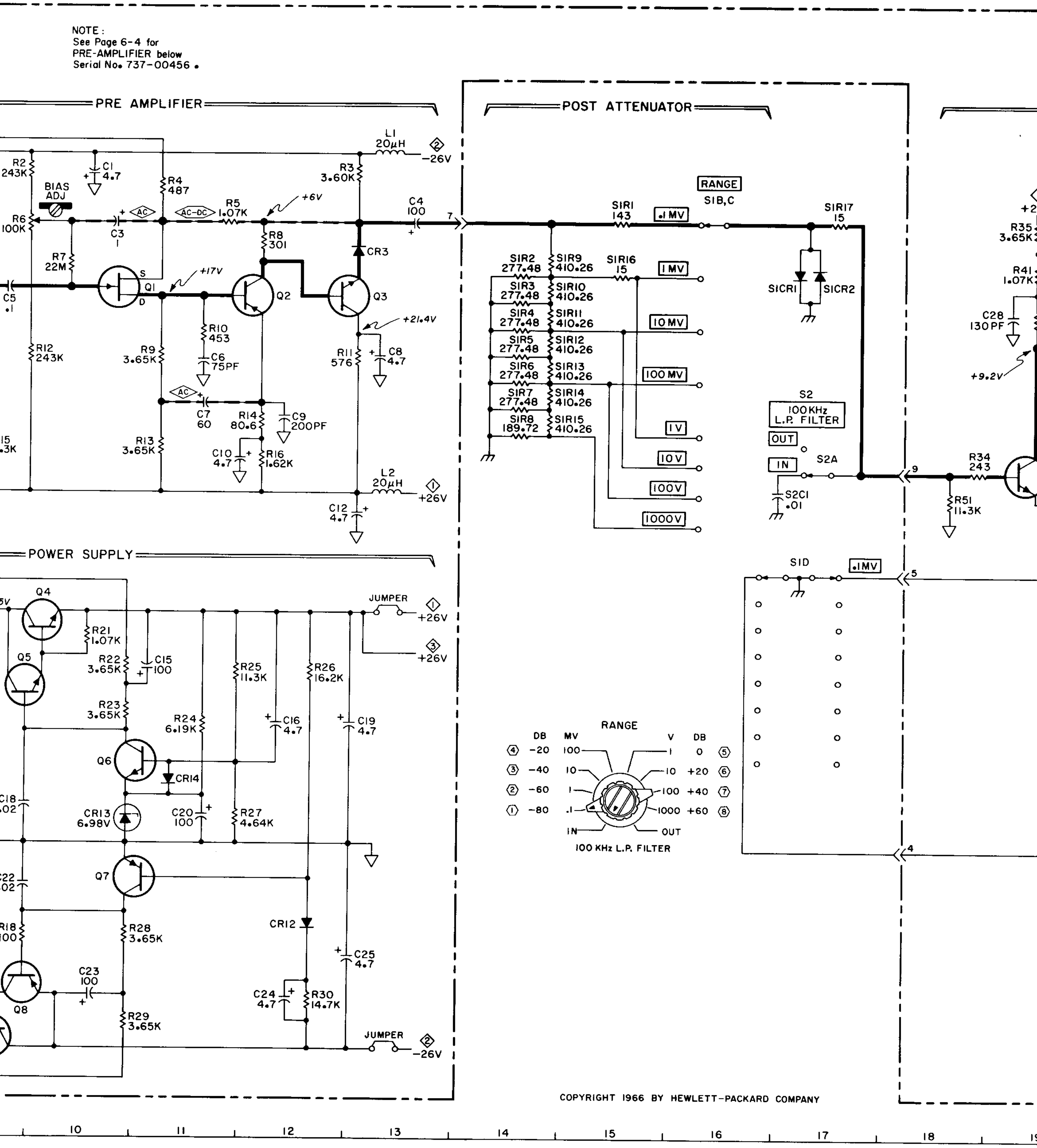
CHASSIS COMPONENT LOCATIONS

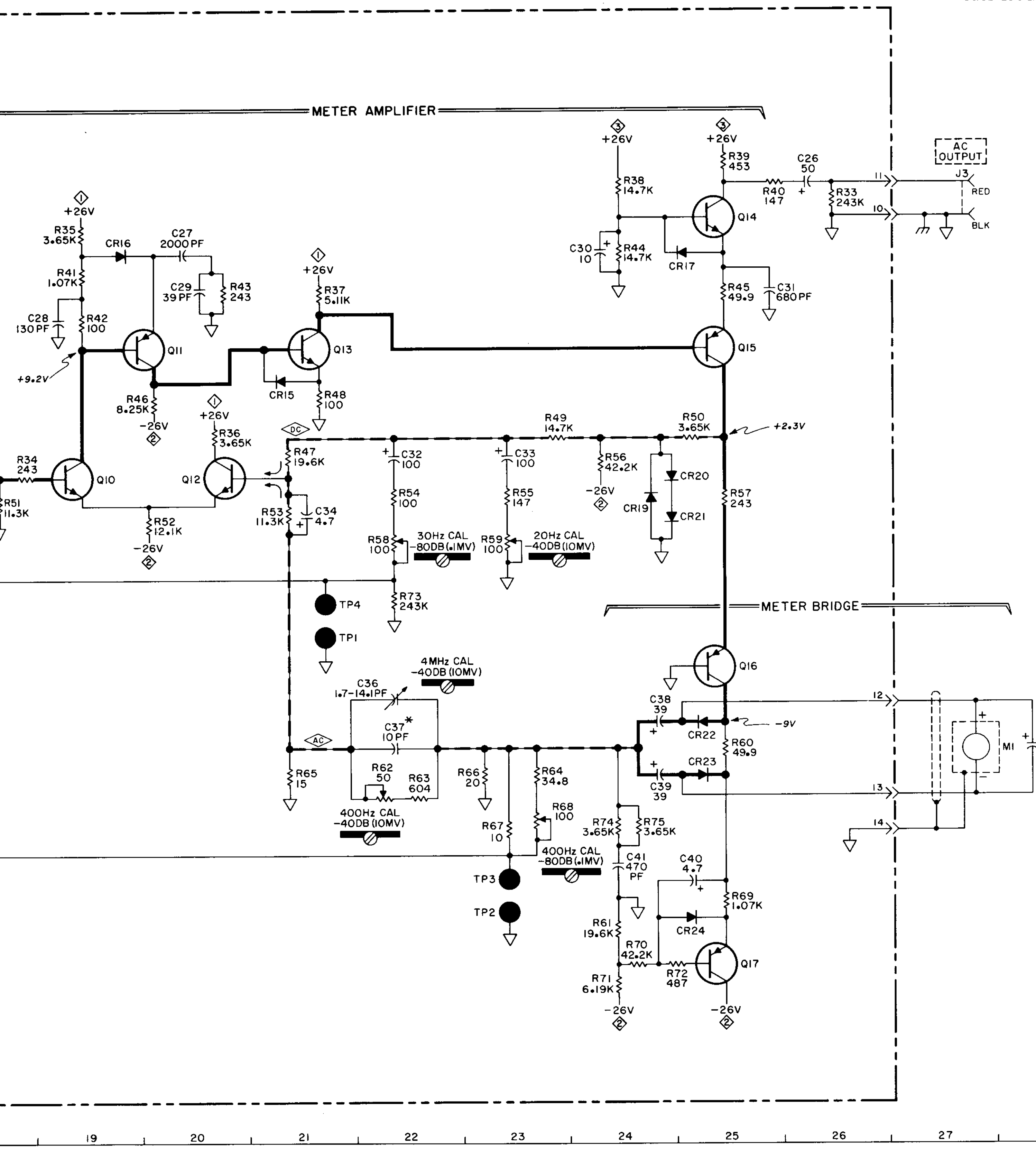
Figure 6-2. Model 400GL Component Location



A1 INPUT ATTENUATOR BOARD (00400-66506)
INPUT ATTENUATOR
INPUT
J1
C1 .01
R1 10
R2 10M
100KHz CAL ODB (IV)
C2 .7-3PF
K1
R3 220
C3 .01
R4 9.76K
C4 1000 PF
R5 6.2
C5 1500 PF
R7 500
400Hz CAL ODB (IV)
K2
R6 220
C6 .01
SHIELD
RANGE
S1A
-26V
A2 VOLTMETER BOARD (00400-66504)
NOTE:
See Page 6-
PRE-AMPLIF
Serial No. 7
PRE A
R1 11.3K
R2 243K
C1 4.7
BIAS ADJ
C2 .002
CR1 -2.7V
R6 100K
C3 1
CR2
R7 22M
R17 301
C5 .1
CR4
R12 243K
C11 .002
CR5 +2.7V
R15 11.3K
POWER SUPPLY
ASSEMBLY MOUNTING SCREWS
LINE
S3
T1
F1 .15 AMP SB
L1 2.5MH
R1 33K
W1
J4
DS1
115V
S4
230V
L2 2.5MH
CR6
CR7
CR9
CR8
C17 100
C21 100
+41.5V
Q4
R20 68.1
R21 1.07K
Q5
R22 3.65K
R23 3.65K
Q6
C18 .02
CR13 6.98V
Q7
C22 .02
R18 100
35-55 +
35-55 −
J2
BATTERY VOLTAGE
CR10
CR11
R32 1.07K
Q8
C23 100
R31 68.1
-43.5V
Q9
1 2 3 4 5 6 7 8 9 10
-J-08308

NOTE:
See Page 6-4 for
PRE-AMPLIFIER below
Serial No. 737-00456.




METER AMPLIFIER
METER BRIDGE
AC OUTPUT
J3
RED
BLK
+26V
-26V
+9.2V
+2.3V
-9V
R35 3.65K
CR16
C27 2000PF
R41 1.07K
C29 39PF
R43 243
C28 130PF
R42 100
Q11
Q13
R37 5.11K
CR15
R48 100
R46 8.25K
R36 3.65K
R34 243
Q10
Q12
R51 11.3K
R52 12.1K
R47 19.6K
R53 11.3K
C34 4.7
DC
AC
C32 100
C33 100
R49 14.7K
R50 3.65K
R56 42.2K
CR20
CR19
CR21
R54 100
R55 147
R57 243
R58 100
30Hz CAL -80DB(.1MV)
R59 100
20Hz CAL -40DB(10MV)
R73 243K
TP4
TP1
R38 14.7K
R39 453
C26 50
R40 147
R33 243K
Q14
C30 10
R44 14.7K
CR17
R45 49.9
C31 680PF
Q15
Q16
4MHz CAL -40DB(10MV)
C36 1.7-14.1PF
C37* 10PF
R62 50
R63 604
400Hz CAL -40DB(10MV)
R65 15
R66 20
R64 34.8
R68 100
R67 10
400Hz CAL -80DB(.1MV)
TP3
TP2
C38 39
CR22
R60 49.9
C39 39
CR23
R74 3.65K
R75 3.65K
C41 470 PF
C40 4.7
R69 1.07K
CR24
R61 19.6K
R70 42.2K
R72 487
Q17
R71 6.19K
M1
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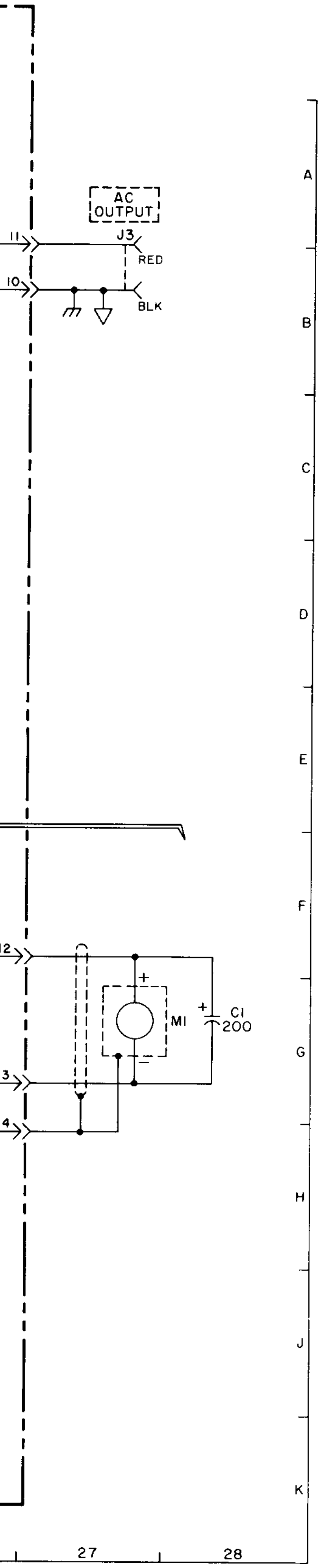

NOTES

1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN. PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.
2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED.
   RESISTANCE IN OHMS
   CAPACITANCE IN MICROFARADS
3. DENOTES POWER LINE GROUND.
   DENOTES CHASSIS GROUND.
   DENOTES SIGNAL COMMON.
4. DENOTES ASSEMBLY.
   DENOTES MAIN SIGNAL PATH.
   DENOTES FEEDBACK PATH.
5. DENOTES FRONT PANEL MARKING.
   DENOTES REAR PANEL MARKING.
6. DENOTES SCREWDRIVER ADJUST.
7. * AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY.

A2 SCHEMATIC COMPONENT LOCATIONS

	C	CR	Q	R	L		R
1	A10	B9	C11	A9	A13	43	B20
2	B8	B9	C12	A9	D13	44	B24
3	B10	B13	C13	A13		45	B25
4	B13	C9	E10	B11		46	D19
5	C9	D9	F9	B11		47	D21
6	C11	G7	G10	B9		48	C21
7	D11	G8	H10	B10		49	D23
8	C13	G8	J9	B12		50	D25
9	D12	G7	K9	C11		51	D18
10	D11	J7	D19	C11		52	E20
11	D8	K7	C20	C13		53	E21
12	E12	H12	D20	C10		54	D22
13	--	G10	C21	D11		55	D23
14	--	G11	B25	D12		56	D24
15	F11	C21	C25	D9		57	D25
16	G12	B19	F25	D12		58	E22
17	G9	B25	J25	C8		59	E23
18	G9	C25		J9		60	G25
19	G13	E24		--		61	H24
20	G11	D25		F9		62	G22
21	H9	E25		F10		63	G22
22	H9	G25		F10		64	G23
23	J10	G25		F10		65	G21
24	J12	J25		G11		66	G23
25	J13			F12		67	H23
26	A26			F12		68	G23
27	B20			G12		69	H25
28	C19			J11		70	J24
29	B20			J11		71	J24
30	B24			J12		72	J24
31	B26			J9		73	E22
32	D22			J9		74	G24
33	D23			B26		75	G24
34	E21			D18		76	
35	--			B19		77	
36	F22			D20		78	
37	G22			C21		79	
38	F24			A24		80	
39	G24			A25		81	
40	H25			B25		82	
41	H24			B19		83	
42				C19		84	

Figure 6-3. Model 400GL Schematic Diagram

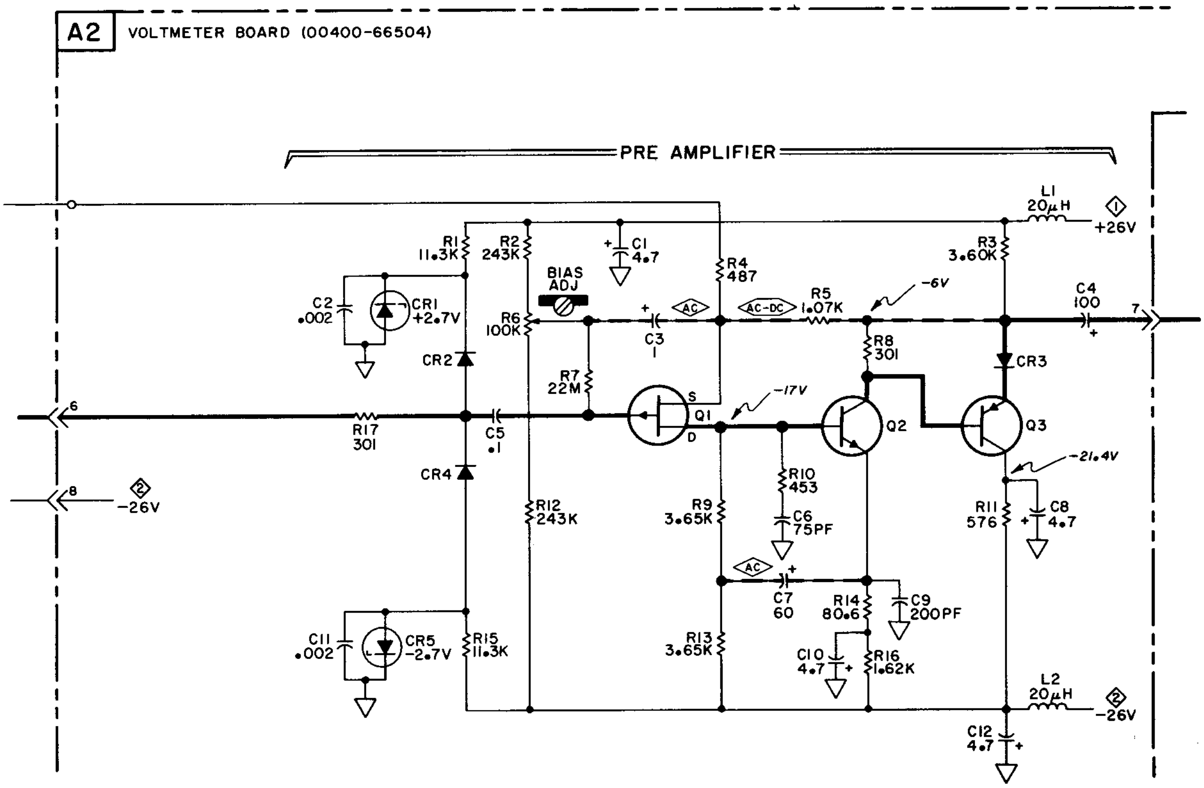

Figure 6-4. Pre Amplifier below Serial No. 737-00456

01799-1

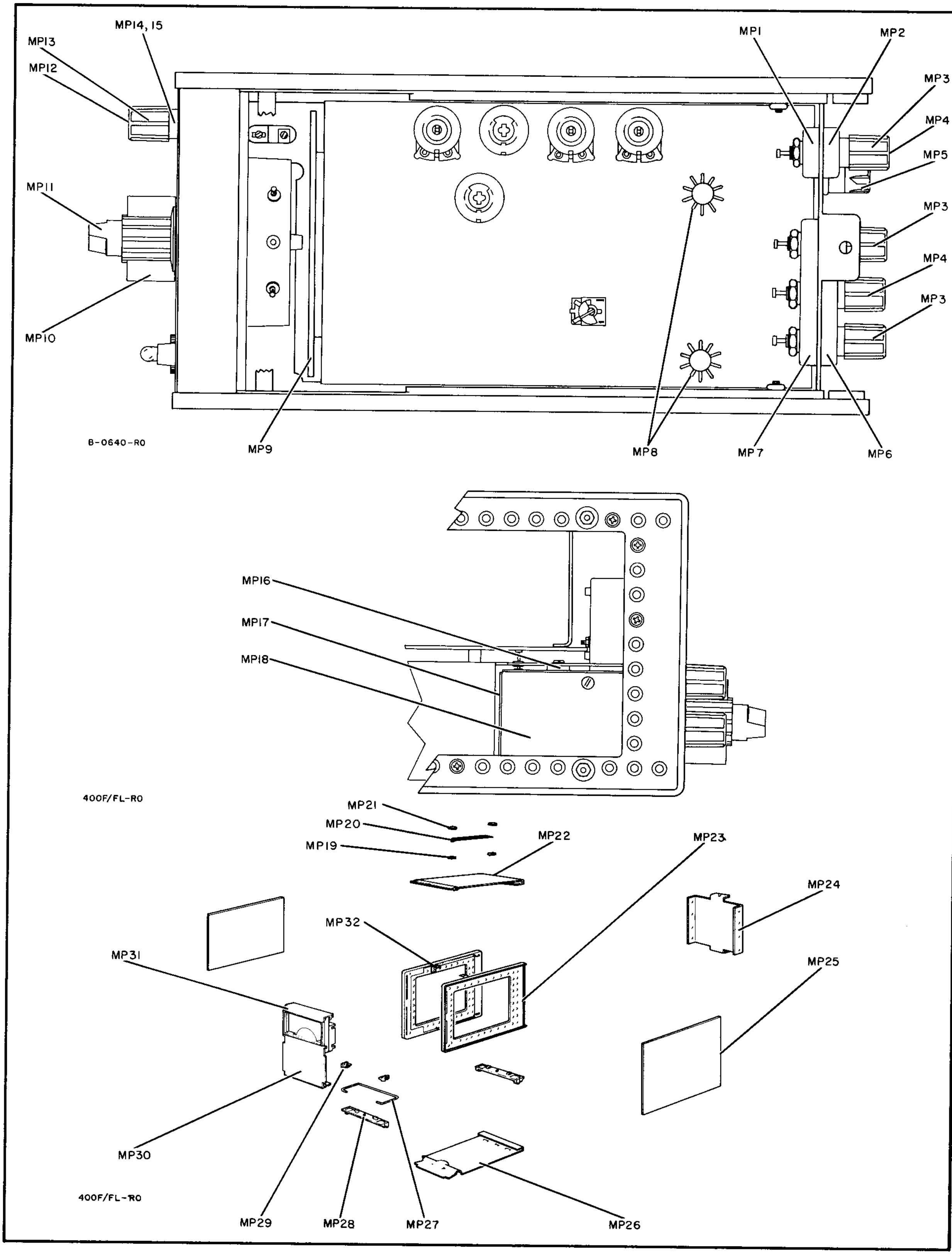

Figure 7-1. Location of Important Mechanical Parts

SECTION VII
REPLACEABLE PARTS

7-1. INTRODUCTION.

7-2. This section contains information for ordering replacement parts. Table 7-1 lists parts in alphameric order of their reference designators and indicates the description, -hp- part number of each part, together with any applicable notes, and provides the following:

a. Total quantity used in the instrument (TQ column). The total quantity of a part is given the first time the part number appears.

b. Description of the part. (See list of abbreviations below.)

c. Typical manufacturer of the part in a five-digit code. (See Appendix A for list of manufacturers.)

d. Manufacturer's part number.

7-3. Miscellaneous parts are listed at the end of Table 7-1.

7-4. ORDERING INFORMATION.

7-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office. (See Appendix B for list of office locations.) Identify parts by their Hewlett-Packard part numbers. Include instrument model and serial numbers.

7-6. NONLISTED PARTS.

7-7. To obtain a part that is not listed, include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

DESIGNATORS

A	= assembly	F	= fuse	MP	= mechanical part	TC	= thermocouple
B	= motor	FL	= filter	P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
BT	= battery	HR	= heater	Q	= transistor		
C	= capacitor	IC	= integrated circuit	QCR	= transistor-diode	W	= cable
CR	= diode	J	= jack	R	= resistor	X	= socket
DL	= delay line	K	= relay	RT	= thermistor	XDS	= lampholder
DS	= lamp	L	= inductor	S	= switch	XF	= fuseholder
E	= misc electronic part	M	= meter	T	= transformer	Z	= network

ABBREVIATIONS

Ag	= silver
Al	= aluminum
A	= ampere (s)
Au	= gold
C	= capacitor
cer	= ceramic
coef	= coefficient
com	= common
comp	= composition
conn	= connection
dep	= deposited
DPDT	= double-pole double-throw
DPST	= double-pole single-throw
elect	= electrolytic
encap	= encapsulated
F	= farad (s)
FET	= field effect transistor
fxd	= fixed
GaAs	= gallium arsenide
GHz	= gigahertz = 10^{+9} hertz
gd	= guard (ed)
Ge	= germanium
grd	= ground (ed)
H	= henry (ies)
Hg	= mercury
Hz	= hertz (cycle (s) per second)
ID	= inside diameter
impg	= impregnated
incd	= incandescent
ins	= insulation (ed)
kΩ	= kilohm (s) = 10^{+3} ohms
kHz	= kilohertz = 10^{+3} hertz
L	= inductor
lin	= linear taper
log	= logarithmic taper
m	= milli = 10^{-3}
mA	= milliampere (s) = 10^{-3} amperes
MHz	= megahertz = 10^{+6} hertz
MΩ	= megohm (s) = 10^{+6} ohms
met flm	= metal film
mfr	= manufacturer
mtg	= mounting
mV	= millivolt (s) = 10^{-3} volts
μ	= micro = 10^{-6}
μV	= microvolt (s) = 10^{-6} volts
my	= Mylar ®
nA	= nanoampere (s) = 10^{-9} amperes
NC	= normally closed
Ne	= neon
NO	= normally open
NPO	= negative positive zero (zero temperature coefficient)
ns	= nanosecond (s) = 10^{-9} seconds
nsr	= not separately replaceable
Ω	= ohm (s)
obd	= order by description
OD	= outside diameter
p	= peak
pc	= printed circuit
pF	= picofarad (s) = 10^{-12} farads
piv	= peak inverse voltage
p/o	= part of
pos	= position (s)
poly	= polystyrene
pot	= potentiometer
p-p	= peak-to-peak
ppm	= parts per million
prec	= precision (temperature coefficient, long term stability, and/or tolerance)
R	= resistor
Rh	= rhodium
rms	= root-mean-square
rot	= rotary
Se	= selenium
sect	= section (s)
Si	= silicon
sl	= slide
SPDT	= single-pole double-throw
SPST	= single-pole single-throw
Ta	= tantalum
TC	= temperature coefficient
TiO_2	= titanium dioxide
tog	= toggle
tol	= tolerance
trim	= trimmer
TSTR	= transistor
V	= volt (s)
vacw	= alternating current working voltage
var	= variable
vdcw	= direct current working voltage
W	= watt (s)
w/	= with
wiv	= working inverse voltage
w/o	= without
ww	= wirewound
*	= optimum value selected at factory, average value shown (part may be omitted)
**	= no standard type number assigned (selected or special type)

REV 6

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Table 7-1. Replaceable Parts

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1	00400-66506		1	Board: etched circuit input assembly	28480	00400-66506
	00400-66505			(below Serial Number 737-00456)	28480	00400-66505
A1C1	0150-0012		1	C: fxd cer 0.01 μF ±20% 1000 vdcw	56289	29C214A3
A1C2	0121-0407		1	C: var trim 0.7 to 3 pF	72982	536-016
A1C3	0150-0093			C: fxd cer 0.01 μF +80% -20% 100 vdcw	91418	TA obd
A1C4	0140-0179		1	C: fxd mica 1000 pF ±2%	04062	RDM19F102G3C
A1C5	0140-0156		1	C: fxd mica 1500 pF ±2%	04062	RDM19F152G3C
A1C6	0150-0093		2	C: fxd cer 0.01 μF +80% -20% 100 vdcw	91418	TA obd
A1K1	0490-0479		1	Relay reed: high voltage K1	28480	0490-0479
	0490-0478			(below Serial Number 737-00456)	28480	0490-0478
	0490-0195			(below Serial Number 628-00151)	28480	0490-0195
A1K2	0490-0343		1	Relay reed: low voltage K2	28480	0490-0343
A1R1	0757-0346		1	R: fxd prec met flm 10.0 Ω ±1% 1/8 W	19701	MF5C T-O obd
A1R2	0698-4128		1	R: fxd met flm 10.0 MΩ ±0.25% 1/2 W	03888	PME70-T-2 obd
A1R3	0684-2211		2	R: fxd comp 220 Ω ±10% 1/4 W	01121	CB 2211 obd
A1R4	0698-4475		1	R: fxd prec met flm 9760 Ω ±1% 1/8 W	19701	MF5C T-O obd
A1R5	0683-0625		1	R: fxd comp 6.2 Ω ±5% 1/4 W	01121	CB-62G5 obd
A1R6	0684-2211			R: fxd comp 220 Ω ±10% 1/4 W	01121	CB2211 obd
A1R7	2100-1799		1	R: var pot ww 500 Ω ±10% 1 W	89709	2600 Series obd
A2	00400-66504		1	Board: etched circuit assembly	28480	00400-66504
A2C1	0180-0100		10	C: fxd Ta 4.7 μF ±10% 35 vdcw	56289	150D475X9035B2
A2C2	0150-0122		3	C: fxd cer 0.002 μF ±20% 500 vdcw	72982	Style 801-000-Y5S-202M
A2C3	0180-0119		1	C: fxd Al elect 1 μF +75% -10% 25 vdcw	56289	30D105GO25BA2-DSM
A2C4	0180-0137		3	C: fxd Ta elect 100 μF 10 vdcw	56289	150D107X0010R2
A2C5	0150-0084		1	C: fxd cer 0.1 μF +80% -20% 50 vdcw	56289	33C41 obd
A2C6	0160-2024		1	C: fxd mica 75 pF ±5% 500 vdcw	04062	RDM15E750J5S
A2C7	0180-0106		1	C: fxd Ta elect 60 μF ±20% 6 vdcw	56289	150D606X0006B2
A2C8	0180-0100			C: fxd Ta 4.7 μF ±10% 35 vdcw	56289	150D475X9035B2
A2C9	0140-0198		1	C: fxd mica 200 pF ±5%	04062	RDM15F201J3C
A2C10	0180-0100			C: fxd Ta 4.7 μF ±10% 35 vdcw	56289	150D475X9035B2
A2C11	0150-0122			C: fxd cer 0.002 μF ±20% 500 vdcw	72982	Style 801-000-Y5S-202M
A2C12	0180-0100			C: fxd Ta 4.7 μF ±10% 35 vdcw	56289	150D475X9035B2
A2C13, A2C14				Not assigned		
A2C15	0180-0061		3	C: fxd Al elect 100 μF +75% -10% 15 vdcw	56289	30D107G015DC2-DSM
A2C16	0180-0100			C: fxd Ta 4.7 μF ±10% 35 vdcw	56289	150D475X9035B2
A2C17	0180-1819		2	C: fxd Al elect 100 μF +75% -10% 50 vdcw	56289	30D107G050DH2-DSM
A2C18	0150-0024		2	C: fxd cer 0.02 μF +80% -20% 600 vdcw	71590	841-000-Z5U-203Z
A2C19	0180-0100			C: fxd Ta 4.7 μF ±10% 35 vdcw	56289	150D475X9035B2
A2C20	0180-0061			C: fxd Al elect 100 μF +75% -10% 15 vdcw	56289	30D107G015DC2-DSM
A2C21	0180-1819			C: fxd Al elect 100 μF +75% -10% 50 vdcw	56289	30D107G050DH2-DSM
A2C22	0150-0024			C: fxd cer 0.02 μF +80% -20% 600 vdcw	71590	841-000-Z5U-203Z
A2C23	0180-0061			C: fxd Al elect 100 μF +75% -10% 15 vdcw	56289	30D107G015DC2-DSM
A2C24, A2C25	0180-0100			C: fxd Ta 4.7 μF ±10% 35 vdcw	56289	150D475X9035B2
A2C26	0180-0058		1	C: fxd Al elect 50 μF +75% -10% 25 vdcw	56289	30D506GO25CC2-DSM
A2C27	0150-0122			C: fxd cer 0.002 μF ±20% 500 vdcw	72982	Style 801-000-Y5S-202M
A2C28	0140-0195		1	C: fxd mica 130 pF ±5%	04062	RDM15F131J3C
A2C29	0140-0190		1	C: fxd mica 39 pF ±5%	04062	RDM15E390J3C
A2C30	0180-0224		1	C: fxd Al elect 10 μF +75% -10% 15 vdcw	56289	30D106G015BA4

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2C31	0140-0208		1	C: fxd mica 680 pF ±5%	04062	RDM15F681J3C
A2C32, A2C33	0180-0137			C: fxd Ta elect 100 μF 10 vdcw	56289	150D107X0010R2
A2C34	0180-0100			C: fxd Ta 4.7 μF ±10% 35 vdcw	56289	150D475X9035B2
A2C35				Not assigned		
A2C36	0121-0127		1	C: var air trim 1.7 to 14.1 pF	74970	189-505-5
A2C37	0160-0205		1	C: fxd mica 10 pF ±5%	04062	RDM15C100J5S
A2C38, A2C39	0180-0393		2	C: fxd Ta 39 μF ±10% 10 vdcw	56289	150D396X9010B2
A2C40	0180-0100			C: fxd Ta 4.7 μF ±10% 35 vdcw	56289	150D475X9035B2
A2C41	0140-0149		1	C: fxd mica 470 pF ±5%	04062	RDM15F471J3S
A2CR1	1902-0022		2	Diode: 2.67 V ±10%	04713	SZ10939-16
A2CR2	1901-0044		2	Diode: Si 20 mA at +1V 10 nA at 10Vreverse current 50 wiv 2 pF	03877	SG5178 obd
A2CR3	1901-0040		10	Diode: Si 30 wV 30 mA 2 pF	03877	SG5050 obd
A2CR4	1901-0044			Diode: Si 20 mA +1 V 10 nA 10 V 50 wiv 2 pF	03877	SG5178 obd
A2CR5	1902-0022			Diode: 2.67 V ±10%	04713	SZ10939-16
A2CR6 thru A2CR11	1901-0033		6	Diode: Si 100 mA at +1V 180 wiv 13 pF	03877	SG3396 obd
A2CR12	1901-0040			Diode: Si 30 wV 30 mA 2 pF	03877	SG5050 obd
A2CR13	1902-3125		1	Diode: Si breakdown V 6.98 V ±2%	07263	obd
A2CR14, A2CR15	1901-0040			Diode: Si 30 wV 30 mA 2 pF	03877	SG5050 obd
A2CR16	1901-0040			Diode: Si 30 wV 30 mA 2 pF	03877	SG5050 obd
A2CR17	1901-0040			Diode: Si 30 wV 30 mA 2 pF	03877	SG5050 obd
A2CR19 thru A2CR21	1901-0040			Diode: Si 30 wV 30 mA 2 pF	03877	SG5050 obd
A2CR22, A2CR23	1901-0027		2	Diode: Si 1 pF 10 wiv	73293	obd
A2CR24	1901-0040			Diode: Si 30 wV 30 mA 2 pF	03877	SG5050 obd
A2L1, A2L2	9140-0047		2	Inductor: fxd 20 μH ±10%	99848	H51074020
A2Q1	1855-0033		1	TSTR: Si 2N3684	07256	FN576
	1855-0029			TSTR: F5035 FET** (below Ser. No. 737-00456)	28480	1855-0029
A2Q2	1853-0036		7	TSTR: Si PNP 2N3906	04713	SPS-3612
	1854-0215			TSTR: Si NPN 2N3904 (below Ser. No. 737-00456)	04713	2N3904 obd
A2Q3	1854-0314		7	TSTR: Si NPN 2N3904	04713	MPS6521-5
	1853-0036			TSTR: Si PNP 2N3906 (below Ser. No. 737-00456)	04713	2N3906
A2Q4	1854-0039		2	TSTR: Si NPN 2N3053	04713	2N3053 obd
A2Q5, A2Q6	1854-0215			TSTR: Si NPN 2N3904	04713	2N3904 obd
A2Q7, A2Q8	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906 obd
A2Q9	1854-0039			TSTR: Si NPN 2N3053	04713	2N3053 obd
A2Q10	1854-0215			TSTR: Si NPN 2N3904	04713	2N3904 obd
A2Q11	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906 obd
A2Q12 thru A2Q14	1854-0215			TSTR: Si NPN 2N3904	04713	2N3904 obd
A2Q15 thru A2Q17	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906 obd
A2R1	0698-4121		5	R: fxd prec met flm 11.3 KΩ ±1% 1/8 W	19701	MF5C T-O obd
A2R2	0757-0474		4	R: fxd prec met flm 243 KΩ ±1% 1/8 W	75042	CEA T-O obd
A2R3	0686-3625		12	R: fxd 3.60 kΩ ±5% 1/2 W	01121	EB3625
A2R4	0698-3178		2	R: fxd prec met flm 487 Ω ±1% 1/8 W	19701	MF5C T-O obd
A2R5	0698-4196		5	R: fxd prec met flm 1070 Ω ±1% 1/8 W	19701	MF5C T-O obd
A2R6	2100-0095		1	R: var pot comp 100 KΩ ±30% 0.10 W	11236	UPM70RE(-hp-)obd
A2R7	0686-2265		1	R: fxd comp 22 MΩ ±5% 1/2 W	01121	EB2265 obd
A2R8	0757-0410		1	R: fxd prec met flm 301 Ω ±1% 1/8 W	19701	MF5C T-O obd
A2R9	0757-0434			R: fxd prec met flm 3650 Ω 1/8 W	19701	MF5C T-O obd
A2R10	0698-3510		2	R: fxd prec met flm 453 Ω ±1% 1/8 W	19701	MF5C T-O obd
A2R11	0698-4457		1	R: fxd prec met flm 576 Ω ±1% 1/8 W	19701	MF5C T-O obd

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A2R12	0757-0474			R: fxd prec met flm 243 KΩ ±1% 1/8 W	75042	CEA T-O	obd
A2R13	0757-0434			R: fxd prec met flm 3650 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R14	0698-4396		2	R: fxd prec met flm 80.6 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R15	0698-4121			R: fxd prec met flm 11.3 KΩ ±1% 1/8 W	19701	MF5C T-O	obd
A2R16	0757-0428		1	R: fxd prec 1620 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R17	0757-0808		1	R: fxd prec met flm 301 Ω ±1% 1/2 W	75042	CEC T-O	obd
A2R18	0757-0401		5	R: fxd prec met flm 100 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R19				Not assigned			
A2R20	0757-0794		2	R: fxd prec met flm 68.1 Ω ±1% 1/2 W	75042	CEA T-O	obd
A2R21	0698-4196			R: fxd prec met flm 1070 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R22, A2R23	0757-0434			R: fxd prec met flm 3650 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R24	0757-0290		2	R: fxd prec met flm 6.190 Ω ±1% 1/8 W	75042	CEA T-O	obd
A2R25	0698-4121			R: fxd prec met flm 11.3 KΩ ±1% 1/8 W	19701	MF5C T-O	obd
A2R26	0757-0447		1	R: fxd prec met flm 16.2 KΩ ±1% 1/8 W	19701	MF5C T-O	obd
A2R27	0698-3155		1	R: fxd prec met flm 4640 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R28, A2R29	0757-0434			R: fxd prec met ılm 3650 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R30	0698-3156		4	R: fxd prec met flm 14.7 KΩ ±1% 1/8 W	75042	CEA T-O	obd
A2R31	0757-0794			R: fxd prec met flm 68.1 Ω ±1% 1/2 W	75042	CEA T-O	obd
A2R32	0698-4196			R: fxd prec met flm 1070 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R33	0757-0474			R: fxd prec met flm 243 KΩ ±1% 1/8 W	75042	CEA T-O	obd
A2R34	0757-0408			R: fxd prec met flm 243 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R35, A2R36	0757-0434			R: fxd prec met flm 3650 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R37	0757-0438		1	R: fxd prec met flm 5110 Ω ±1% 1/8 W	75042	CEA T-O	obd
A2R38	0698-3156			R: fxd prec met flm 14.7 KΩ ±1% 1/8 W	75042	CEA T-O	obd
A2R39	0698-3510			R: fxd prec met flm 453 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R40	0698-3438		2	R: fxd prec met flm 147 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R41	0698-4196			R: fxd prec met flm 1070 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R42	0757-0401			R: fxd prec met flm 100 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R43	0757-0408		2	R: fxd prec met flm 243 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R44	0698-3156			R: fxd prec met flm 14.7 KΩ ±1% 1/8 W	75042	CEA T-O	obd
A2R45	0757-0277		1	R: fxd prec met flm 49.9 Ω ±1% 1/8 W	75042	CEA T-O	obd
A2R46	0757-0441		1	R: fxd prec met flm 8250 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R47	0698-3157		2	R: fxd prec met flm 19.6 KΩ ±1% 1/8 W	19701	MF5C T-O	obd
A2R48	0757-0401			R: fxd prec met flm 100 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R49	0698-3156			R: fxd prec met flm 14.7 KΩ ±1% 1/8 W	75042	CEA T-O	obd
A2R50	0757-0434			R: fxd prec met flm 3650 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R51	0698-4121			R: fxd prec met flm 11.3 KΩ ±1% 1/8 W	19701	MF5C T-O	obd
A2R52	0757-0444		1	R: fxd prec met flm 12.1 KΩ ±1% 1/8 W	19701	MF5C T-O	obd
A2R53	0698-4121			R: fxd prec met flm 11.3 KΩ ±1% 1/8 W	19701	MF5C T-O	obd
A2R54	0757-0401			R: fxd prec met flm 100 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R55	0698-3438			R: fxd prec met flm 147 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R56	0698-3450		2	R: fxd prec met flm 42.2 KΩ ±1% 1/8 W	19701	MF5C T-O	obd
A2R57	0757-0408			R: fxd prec met flm 243 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R58, A2R59	2100-0290		2	R: var ww 100 Ω ±20% 1-1/2 W	11237	110	obd
A2R60	0757-0277			R: fxd prec met flm 49.9 Ω ±1% 1/8 W	91637	MF-1/10-32	
A2R61	0698-3157			R: fxd prec met flm 19.6 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R62	2100-0240		1	R: var ww 50 Ω ±20% 1-1/2 W	11237	110	obd
A2R63	0757-0161		1	R: fxd prec met flm 604 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R64	0698-3434		1	R: fxd prec met flm 34.8 Ω ±1% 1/8 W	75042	CEA T-O	obd
A2R65	0757-0381		1	R: fxd prec met flm 15 Ω ±1% 1/8 W	75042	CEA T-O	obd
A2R66	0757-0384		1	R: fxd prec met flm 20 Ω ±1% 1/8 W	75042	CEA T-O	obd
A2R67	0757-0346		1	R: fxd prec met flm 10 Ω ±1% 1/8 W	75042	CEA T-O	obd
A2R68	2100-0277		1	R: var comp lin 100 Ω ±20% 0.3 W	11236	Type UPE65CV	obd
A2R69	0698-4196			R: fxd 1070 Ω ±1% 1/8 W	19701	MF5C T-O	obd
A2R70	0698-3450			R: fxd prec met flm 42.2 KΩ ±1% 1/8 W	19701	MF5C T-O	obd
A2R71	0757-0290			R: fxd prec met flm 6190 Ω ±1% 1/8 W	75042	CEA T-O	obd
A2R72	0698-3178			R: fxd prec met flm 487 Ω ±1% 1/8 W	19701	MF5C T-O	obd

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2R73	0757-0474			R: fxd prec met flm 243 KΩ ±1% 1/8 W	75042	CEA T-O obd
A2R74, A2R75	0757-0434			R: fxd prec met flm 3650 Ω ±1% 1/8 W	19701	MF5C T-O obd
C1	0180-0060		1	C: fxd Al elect 200 μF +75% -10% 3 vdcw	56289	30D207G003CC2-DSM
DS1	1450-0048		1	Lamp: pilot 1" red transparent	72765	599-124 obd
F1	2110-0017		1	Fuse: 15 A slow-blow 115 V - 230 V	75915	313.150 obd
L1, L2	9140-0041		2	Inductor: fxd 30 Ω or less 2.5 mH ±10%	95265	SA-2500-I obd
M1	1120-0928			Meter	28480	1120-0928
MP1	0340-0090		1	Insulator: 2 hole front with locating key	28480	0340-0090
MP2	0340-0086		1	Insulator: 2 hole rear	28480	0340-0086
MP3	1510-0010		3	Binding post assembly: red	28480	1510-0010
MP4	1510-0011		2	Binding post assembly: black	28480	1510-0011
MP5	1400-0084		1	Holder: fuse	75915	342014 obd
MP6	0340-0087		1	Insulator: 3 hole rear	28480	0340-0087
MP7	0340-0091		1	Insulator: 3 hole front	28480	0340-0091
MP8	1205-0033		2	Heat dissipator: semiconductor for TO-5	05820	NF-207 obd
MP9	00400-00605			Shield: meter	28480	00400-00605
MP10	0370-0113		1	Knob: bar with one arrow	28480	0370-0113
MP11	0370-0115		1	Knob: bar red w/ pointer	28480	0370-0115
MP12	1510-0035		1	Binding post assembly: black	28480	1510-0035
MP13	1510-0036		1	Binding post assembly: red	28480	1510-0036
MP14	0340-0099		2	Insulator: single binding post	28480	0340-0099
MP15	0340-0100		1	Insulator: single binding post	28480	0340-0100
MP16	0340-0109		6	Insulator: 6-32 nylon 0.437"	000LA	212-160402-00-0101
MP17	00400-05502		1	Can: shield input	28480	00400-05502
MP18	00400-04102		1	Cover: input attenuator	28480	00400-04102
MP19	1440-0050		2	Plate: handle plated steel	12136	Part 3 of 3 assy # 1875-376-370
MP20	1440-0049		2	Cap: handle brushed cadmium	12136	Part 2 of 3 assy # 1875-376-370
MP21	1440-0048		1	Strap: handle black vinyl	12136	Part 1 of 3 assy # 1875-376-370
MP22	5060-6020		1	Cover assembly: top 5 x 11 sub module	28480	5060-6020
MP23	5060-0703		2	Frame assembly: 6 x 11 sub module	28480	5060-0703
MP24	00400-00210		1	Panel: rear	28480	00400-00210
	00400-00206			(below Serial Number 943-01016)	28480	00400-00206
MP25	5000-0703		2	Side cover 6 x 11 sub module	28480	5000-0703
MP26	5000-0711		1	Cover assembly: bottom 5 x 11 sub module	28480	5000-0711
MP27	1490-0031		1	Stand: 1/3 module tilt	91260	obd
MP28	5060-0727		2	Foot assembly: 1/3 module	28480	5060-0727
MP29	5040-0700		2	Hinge: mold	28480	5040-0700
MP30	00400-00209		1	Panel: front	28480	00400-00209
MP31	5020-0704		1	Meter trim: third module	28480	5020-0704
R1	0687-3331		1	R: fxd comp 33 KΩ ±10% 1/2 W	01121	EB3331 obd
S1	00400-61904			Switch: assembly range	28480	00400-61904
S1C1	0160-0207		1	C: fxd my 0.01 μF ±5% 200 vdcw	56289	192P10352-pts
S1CR1, S1CR2	1901-0040		2	Diode: Si	03877	SG5050 obd
S1R1	0757-0167		1	R: fxd prec met flm 143 Ω ±1% 1/4 W	19701	MF6C T-O obd
S1R2 thru S1R7	0698-4118		6	R: fxd prec met flm 277.48 Ω ±0.1% 1/4 W	75042	obd
S1R8	0698-4117		1	R: fxd prec met flm 189.72 Ω ±0.1% 1/4 W	75042	obd
S1R9 thru S1R15	0698-4119			R: fxd prec met flm 410.26 Ω ±0.1% 1/4 W	75042	obd
S1R16, S1R17	0687-1501		2	R: fxd comp 15 Ω ±10% 1/2 W	01121	EB1501 obd

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
S3	3101-0036		1	Switch: toggle 3 amps 250 V AC-DC	88140	8928K61
S4	3101-0033		1	Switch: slide 115/230	82389	11A-1009 obd
T1	00400-86901		1	Transformer	28480	00400-86901
W1	8120-1348 8120-0078			Cord: power, external (below Serial Number 943-01016)	70903 70903	obd obd
J4	1251-2357 1251-0148			Jack: rear panel, power (below Serial Number 943-01016)	28480 28480	1251-2357 1251-0148
				MISCELLANEOUS		
	0340-0039		2	Bushing: insulator	00866	HP-3000T-1
	00400-61602		1	Cable 1: power	28480	00400-61602
	00400-61603		1	Cable 2: meter	28480	00400-61603
	0340-0060		3	Insulator: feed thru	98291	FT-E-15 obd
	0340-0060		7	Insulator: feed thru	92891	FT-E-15 obd
	0340-0059		2	Post: terminal	00866	obd
	0360-0435		4	Post: terminal	00677	1012-3 obd
	0380-0059		1	Spacer: captive	00866	obd
	0380-0111		5	Spacer: captive	00866	0380-0111
	00400-01202		1	Strap: ground	28480	00400-01202

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.
00213	Sage Electronics Corp.	Rochester, N.Y.
00287	Cemco Inc.	Danielson, Conn.
00334	Humidial	Colton, Calif.
00348	Microtron Co., Inc.	Valley Stream, N.Y.
00373	Garlock Inc.	Cherry Hill, 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	Goe Engineering Co.	City of Industry, Cal.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
00929	Microlab Inc.	Livingston, N.J.
01002	General Electric Co., Capacitor Dept.	Hudson Falls, N.Y.
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.
01670	Gudebrod Bros. Silk Co.	New York, N.Y.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02116	Wheelock Signals, Inc.	Long Branch, N.J.
02286	Cole Rubber and Plastics Inc.	Sunnyvale, Calif.
02660	Amphenol-Borg Electronics Corp.	Broadview, 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.
02875	Hudson Tool & Die Co.	Newark, N.J.
03508	G.E. Semiconductor Prod. Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	Compton, Calif.
03818	Parker Seal Co.	Los Angeles, Calif.
03877	Transitron Electric Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N.J.
03954	Singer Co., Diehl Div. Finderne Plant	Sumerville, N.J.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04062	Arco Electronic Inc.	Great Neck, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04354	Precision Paper Tube Co.	Wheeling, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Products, Microwave Device Div.	Mountain View, Calif.
04673	Dakota Engr. Inc.	Culver City, 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.
04919	Component Mfg. Service Co.	W. Bridgewater, Mass.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05245	Components Corp.	Chicago, Ill.
05277	Westinghouse Electric Corp. Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05397	Union Carbide Corp., Elect. Div.	New York, N.Y.
05574	Viking Ind. Inc.	Canoga Park, Calif.
05593	Icore Electro-Plastics Inc.	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., Div. of Stewart Warner Corp.	Bridgeport, Conn.
06090	Raychem Corp.	Redwood City, Calif.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	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	Components Inc., Ariz. Div.	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.
07256	Silicon Transistor Corp.	Carle Place, N.Y.
07261	Avnet Corp.	Culver City, Calif.
07263	Fairchild Camera & Inst. Corp. Semiconductor Div.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	Birtcher Corp., The	Monterey Park, Calif.
07397	Sylvania Elect. Prod. Inc., Mt. View Operations	Mountain View, Calif.
07700	Technical Wire Products Inc.	Cranford, N.J.
07829	Bodine Elect. Co.	Chicago, Ill.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, 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
08524	Deutsch Fastener Corp.	Los Angeles, Calif.
08664	Bristol Co., The	Waterbury, Conn.
08717	Sloan Company	Sun Valley, Calif.
08718	ITT Cannon Electric Inc., Phoenix Div.	Phoenix, Arizona
08727	National Radio Lab. Inc.	Paramus, N.J.
08792	CBS Electronics Semiconductor Operations, Div of C.B.S. Inc.	Lowell, Mass.
08806	General Electric Co. Miniat. Lamp Dept.	Cleveland, Ohio
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays Div.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Tech. Ind. Inc. Atohm Elect.	Burbank, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09353	C & K Components Inc.	Newton, Mass.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09922	Burndy Corp.	Norwalk, Conn.
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.
11314	National Seal	Downey, Calif.
11453	Precision Connector Corp.	Jamaica, N.Y.
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.
12040	National Semiconductor	Danbury, Conn.
12136	Philadelphia Handle Co.	Camden, N.J.
12361	Grove Mfg. Co., Inc.	Shady Grove, Pa.
12574	Gulton Ind. Inc. Data System Div.	Albuquerque, N.M.
12697	Clarostat Mfg. Co.	Dover, N.H.
12728	Elmar Filter Corp.	W. Haven, Conn.
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	Thermolloy	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.	San Gabriel, Calif.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co.	New York, N.Y.
15287	Scionics Corp.	Northridge, Calif.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15558	Micron Electronics	Garden City, Long Island, N.Y.
15566	Amprobe Inst. Corp.	Lynbrook, N.Y.
15631	Cabletronics	Costa Mesa, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15801	Fenwal Elect. Inc.	Framingham, Mass.
15818	Amelco Inc.	Mt. View, Calif.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16179	Omni-Spectra Inc.	Farmington, Mich.
16352	Computer Diode Corp.	Lodi, N.J.
16585	Boots Aircraft Nut Corp.	Pasadena, Calif.
16688	Ideal Prec. Meter Co., Inc. De Jur Meter Div.	Brooklyn, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokoma, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
17554	Components Inc.	Biddeford, Ma.
17675	Hamlin Metal Products Corp.	Akron, Ohio
17745	Angstrohm Prec. Inc.	No. Hollywood, Calif.
17870	McGraw-Edison Co.	Manchester, N.H.
18042	Power Design Pacific Inc.	Palo Alto, Calif.
18083	Clevite Corp., Semiconductor Div.	Palo Alto, Calif.
18324	Signetics Corp.	Sunnyvale, 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.
18612	Vishay Instruments Inc.	Malvern, Pa.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
18911	Durant Mfg. Co.	Milwaukee, Wis.
19315	The Bendix Corp., Navigation & Control Div.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19589	Concoa	Baldwin Park, Calif.
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.
23042	Texscan Corp.	Indianapolis, Ind.
23783	British Radio Electronics Ltd.	Washington, D.C.
24455	G.E. Lamp Division	Nela Park, Cleveland, Ohio

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
24655	General Radio Co.	West Concord, Mass.
24681	Memcor Inc., Comp. Div.	Huntington, Ind.
24796	Parelco Inc.	San Juan Capistrano, Calif.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26851	Compac/Hollister Co.	Hollister, Calif.
26992	Hamilton Watch Co.	Lancaster, Pa.
27251	Specialities Mfg. Co., Inc.	Stratford, Conn.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
30817	Instrument Specialties Co., Inc.	Little Falls, N.J.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Coil Products Ltd.	Hawkesbury, Ontario, Canada
36287	Cunningham, W.H. & Hill, Ltd.	Toronto 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.
44655	Ohmite Mfg. Co.	Skokie, Ill.
46384	Penn Eng. & Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer & Inst. Co.	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 Corp.	Tulsa, Okla.
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	Wittek Mfg. Co.	Chicago, Ill.
66346	Minnesota Mining & Mfg. Co. Revere Mincom Div.	St. Paul, Minn.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control	New York, N.Y.
70318	Allmetal Screw Product Co., Inc.	Garden City, N.Y.
70417	Amplex, Div. of Chrysler Corp.	Detroit, Mich.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	Union City, N.J.
70674	ADC Products Inc.	Minneapolis, Minn.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71034	Bliley Electric Co., Inc.	Erie, Pa.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionics Corp.	Cambridge, Mass.
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, 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.
71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
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.	Harwood Heights, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72962	Elastic Stop Nut Corp.	Union, N.J.
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 Elect Co.	Hicksville, L.I., 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.
73957	Groov-Pin Corp.	Ridgefield, N.J.
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.
75263	Keystone Carbon Co., Inc.	St. Marys, 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.
76433	General Instrument Corp., Micamold Division	Newark, N.J.
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	The Bendix Corp., Electrodynamics 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.
78277	Sigma	So. Braintree, Mass.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78424	Speciality Leather Prod. Co.	Newark, 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.
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 Label Co.	Monrovia, Calif.
80583	Hammarlund Co., Inc.	Mars Hill, N.C.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
80813	Dimco Gray Co.	Dayton, Ohio
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, Maryland
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.
82116	Electric Regulator Corp.	Norwalk, Conn.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Fairchild Camera & Inst. Corp. Space & Defense System Div.	Paramus, 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.
83014	Hartwell Corp.	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 Eng. Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83324	Rosan Inc.	Newport Beach, Calif.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83332	Tech Labs	Palisade's Park, N.J.
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.
85471	A.B. Boyd Co.	San Francisco, Calif.
85474	R.M. Bracamonte & Co.	San Francisco, Calif.

From: FSC. Handbook Supplements

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
85660	Koiled Kords, Inc.	Hamden, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86174	Fafnir Bearing Co.	Los Angeles, Calif.
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.
86928	Seastrom Mfg. Co.	Glendale, Calif.
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.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89473	G. E. Distributing Corp.	Schenectady, N.Y.
89665	United Transformer Co.	Chicago, Ill.
90030	United Shoe Machinery Corp.	Beverly, Mass.
90179	US Rubber Co., Consumer Ind. & Plastics Prod. Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91146	ITT Cannon Elect, Inc., Salem Div.	Salem, Mass.
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.
92607	Tensolite Insulated Wire Co., Inc.	Tarrytown, N.Y.
92702	IMC Magnetics Corp.	Wesbury Long Island, N.Y.
92966	Hudson Lamp Co.	Kearney, N.J.
93332	Sylvania Electric Prod. Inc. Semiconductor Div.	Woburn, Mass.
93369	Robbins & Myers Inc.	Palisades Park, N.J.
93410	Stemco Controls, Div. of Essex Wire Corp.	Mansfield, Ohio
93632	Waters Mfg. Co.	Culver City, Calif.
93929	G. V. Controls	Livingston, N.J.
94137	General Cable Corp.	Bayonne, N.J.
94142	Phelps Dodge	Yonkers, N.Y.
94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.
94148	Scientific Electronics Products, Inc.	Loveland, Colo.
94154	Wagner Elect. Corp., Tung-Sol Div.	Newark, N.J.
94197	Curtiss-Wright Corp. Electronics Div.	East Paterson, N.J.
94222	South Chester Corp.	Chester, Pa.
94330	Wire Cloth Products, Inc.	Bellwood, Ill.
94375	Automatic Metal Products Co.	Brooklyn, N.Y.
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.,	Dania, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	Long Island, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Rolling Meadows, Ill.
95566	Arnold Engineering Co.	Marengo, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95984	Siemon Mfg. Co.	Wayne, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Microwave Assoc., West Inc.	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.
96306	Microswitch, Div. of Minn.-Honeywell	Freeport, Ill.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
96733	San Fernando Elect. Mfg. Co.	San Fernando, Calif.
96881	Thomson Ind. Inc.	Long Is., N.Y.
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.
98410	Etc Inc.	Cleveland, Ohio
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	Atlee Corp.	Winchester, Mass.
99515	Marshall Ind., Capacitor Div.	Monrovia, 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.
99928	Branson Corp.	Whippany, N.J.
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.

Code No.	Manufacturer	Address
0000F	Malco Tool and Die	Los Angeles, Calif.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AB	ETA	England
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CS	Hewlett-Packard Co., Colorado Springs	Colorado Springs, Colorado
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.

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TWX: 910-950-1282

5737 East Broadway
Tucson 85716
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TWX: 910-952-1162

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1430 East Orangethorpe Ave.
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North Hollywood 91604
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TWX: 910-499-2170

1101 Embarcadero Road
Palo Alto 94303
Tel: (415) 327-6500
TWX: 910-373-1280

2591 Carlsbad Avenue
Sacramento 95821
Tel: (916) 482-1463
TWX: 910-367-2092

1055 Shafter Street
San Diego 92106
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TWX: 910-335-2000

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Englewood 80110
Tel: (303) 771-3455
TWX: 910-935-0705

CONNECTICUT
508 Tolland Street
East Hartford 06108
Tel: (203) 289-9394
TWX: 710-425-3416

111 East Avenue
Norwalk 06851
Tel: (203) 853-1251
TWX: 710-468-3750

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Wilmington 19807
Tel: (302) 655-6161
TWX: 510-666-2214

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9999 N.E. 2nd Avenue
Miami Shores 33153
Tel: (305) 754-4565
TWX: 810-848-7262

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Tel: (813) 391-0211
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GEORGIA
P.O. Box 28234
450 Interstate North
Atlanta 30328
Tel: (404) 436-6181
TWX: 810-766-4890

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5500 Howard Street
Skokie 60076
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INDIANA
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TWX: 810-955-5524

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Tel: (301) 944-5400
TWX: 710-862-0850

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2 Choke Cherry Road
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TWX: 710-828-9684

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TWX: 710-326-6904

MICHIGAN
24315 Northwestern Highway
Southfield 48075
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TWX: [illegible]0-232-1532

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2459 University Avenue
St. Paul 55114
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TWX: 910-563-3734

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9208 Wyoming Place
Kansas City 64114
Tel: (816) 333-2445
TWX: 910-771-2087

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St. Louis 63144
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TWX: 910-760-1670

NEW JERSEY
W. 120 Century Road
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TWX: 710-990-4951

1060 N. Kings Highway
Cherry Hill 08034
Tel: (609) 667-4000
TWX: 710-892-4945

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82 Washington Street
Poughkeepsie 12601
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TWX: 510-248-0012

39 Saginaw Drive
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TWX: 510-253-5981

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Roslyn, Long Island 11576
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TWX: 510-223-0811

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Syracuse 13211
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1923 North Main Street
High Point 27262
Tel: (919) 882-6873
TWX: 510-926-1516

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Cleveland 44145
Tel: (216) 835-0300
TWX: 810-427-9129

3460 South Dixie Drive
Dayton 45439
Tel: (513) 298-0351
TWX: 810-459-1925

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Oklahoma City 73112
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Westhills Mall, Suite 158
4475 S.W. Scholls Ferry Road
Portland 97225
Tel: (503) 292-9171
TWX: 910-464-6103

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2500 Moss Side Boulevard
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TWX: 710-797-3650

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11745 Jasper Ave.
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TWX: 610-831-2431

BRITISH COLUMBIA
Hewlett-Packard (Canada) Ltd.
304-1037 West Broadway
Vancouver 9
Tel: (604) 738-5301
TWX: 610-922-5059

MANITOBA
Hewlett-Packard (Canada) Ltd.
511 Bradford Ct.
St. James
Tel: (204) 786-7581

NOVA SCOTIA
Hewlett-Packard (Canada) Ltd.
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Hewlett-Packard (Canada) Ltd.
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TWX: 610-492-2382

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275 Hymus Boulevard
Pointe Claire
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TWX: 610-422-3022
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MANUAL BACKDATING CHANGES

Model 400GL

AC VOLTMETER

This manual backdating sheet makes this manual applicable to earlier instruments. Instrument-component values that differ from those in the manual, yet are not listed in the backdating sheet, should be replaced using the part number given in the manual.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
Below 628-00151	CHANGE #1		
Below 737-00456	CHANGE #2		

CHANGE #1: Part No. of A1K1 is 0490-0195.

CHANGE #2: Preamplifier is as shown on Page 6-4.
Part No. of A1 is 00400-66505.
Part No. of A1K1 is 0490-0478 except as listed in CHANGE #1.

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00400-90008

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