

AC VOLTMETER

400E/400EL



HEWLETT  PACKARD

HP 400E/400EL



OPERATING AND SERVICE MANUAL

MODELS 400E/400EL AC VOLTMETER

Serial Prefixed: 1208A

**See Section VIII
Manual Backdating Changes**

WARNING

To help minimize the possibility of electrical fire or shock hazards, do not expose this instrument to rain or excess moisture.

-hp- Manual Part No. 00400-90020

Microfiche Part No. 00400-90067

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

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

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This Hewlett-Packard product is warranted against defects in material and workmanship for a period of one year from date of shipment [,except that in the case of certain components listed in Section I of this manual, the warranty shall be for the specified period] . During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

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Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

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

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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT.

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE.

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS.

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE.

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DANGEROUS PROCEDURE WARNINGS.

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

WARNING

Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.

Table 1-1. Specifications

Models 400E/400EL	
<p>Voltage Range: 1mV full scale to 300V full scale in 12 ranges; dB scale -10 to +2dB, 10dB between ranges.</p> <p>Frequency Range: 10Hz to 10MHz.</p> <p>Calibration: Responds to absolute average value of applied signal, calibrated in rms volts.</p> <p>Input Impedance: 10 megohms shunted by less than 25pF on the 1mV-1V ranges and 10 megohms shunted by less than 12pF on the 3V-300V ranges.</p> <p>Amplifier AC Output: 150mV rms for full scale meter indication; output impedance 50 ohms, 10Hz to 10MHz (105mV on the 1mV range). Accuracy: $\pm 10\%$, 10Hz to 4MHz.</p> <p>AC-DC Converter Output: 1Vdc output for full scale meter deflection (linear output for Model 400E/EL).</p>	<p>Output Resistance: 1000 ohms $\pm 5\%$ Response Time: 1 second to within 1% of final value for a step change.</p> <p>AC Power: 115 or 230 volts $\pm 10\%$, 48 to 440 Hz, 10 watts.</p> <p>Temperature Range: 0 to +55° C (except where noted on accuracy charts).</p> <p>External Battery Operation: Terminals are provided on rear panel; positive and negative voltages between 35V and 55V are required. current drain from 50 to 75mA.</p> <p>Weight: Net: 6 lbs. (2,7 kg). Shipping: 8 lbs. (4 kg).</p> <p>Dimensions: 6-1/2 in. high, 5-1/8 in wide, 11 in deep (165, 1 X 130, 2 x 279, 4 mm).</p>

Models 400E/400EL						
Accuracy: \pm (% of full scale + % of Reading)						
Range	10 Hz	40 Hz	Frequency		4 MHz	10 MHz
			500 kHz	2 MHz		
.001 V†	$\pm (2.5 + 2.5)$	$\pm (1 + 0)$	$\pm (2.5 + 2.5)$		/ / / / / / / / / /	
.003 V	$\pm (2.5 + 2.5)$		$\pm (1 + 0)$	$\pm (1.5 + 1.5)$	$\pm (2.5 + 2.5)$	
.01 V – 3 V	$\pm (2.5 + 2.5)$		$\pm (1 + 0)$	$\pm (1.5 + 1.5)$	$\pm (3.0 + 2.0)**$	
10 V – 30 V	$\pm (2.5 + 2.5)$		$\pm (1 + 0)$	$\pm (1.5 + 1.5)$	$\pm (3.5 + 3.5)$	
100 V – 300 V	$\pm (2.5 + 2.5)$		$\pm (1 + 0)$	$\pm (1.5 + 1.5)$	/ / / / / / / / / /	

** Accuracy for the 3 V range at 1/3 full scale and below, 6 MHz to 10 MHz is: $\pm (3.75 + 3.75)$.
† Accuracy applies to 1/3 full scale to full scale only.

AC to DC Converter Output							
Range	10 Hz	20 Hz	Frequency				10 MHz
			100 Hz	500 kHz	1 MHz	4 MHz	
.001 V†	$\pm (2.5 + 2.5)$	$\pm (1 + 1)$	$\pm (0.4 + 0.1)*$	$\pm (1 + 1)$	$\pm (2.5 + 2.5)$	/ / / / / / / / / /	
.003 V	$\pm (2.5 + 2.5)$	$\pm (1 + 1)$	$\pm (0.25 + 0.25)*$	$\pm (0.5 + 0.5)$	$\pm (2.5 + 2.5)$		
.01 V – 3 V	$\pm (2.5 + 2.5)$	$\pm (1 + 1)$	$\pm (0.25 + 0.25)*$	$\pm (0.5 + 0.5)$	$\pm (2.5 + 2.5)$	$\pm (3.0 + 2.0)$	
10 V – 30 V	$\pm (2.5 + 2.5)$	$\pm (1 + 1)$	$\pm (0.25 + 0.25)$	$\pm (0.5 + 0.5)$	$\pm (2.5 + 2.5)$	$\pm (3.5 + 3.5)$	
100 V – 300 V	$\pm (2.5 + 2.5)$	$\pm (1 + 1)$	$\pm (0.25 + 0.25)$	$\pm (0.5 + 0.5)$	$\pm (2.5 + 2.5)$	/ / / / / / / / / /	

* Accuracy applies for a temperature of 15°C to 40°C on the 1 mV to 1 V ranges only.

SECTION I

GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The -hp- Models 400E and 400EL are versatile ac voltmeters and dB meters. Both models can be used as ac to dc converters or wideband amplifiers. The Model 400E is primarily intended for voltage measurements, whereas the Model 400EL is primarily a dB meter. However, both meters indicate both volts and dB. The 400E has a linear ac scale with a logarithmic dB scale underneath, and the 400EL has a linear dB scale with a logarithmic ac scale underneath. Since the difference in scales is the only difference between the two instruments, this manual will use the term 400E/EL in reference to both instruments.

1-3. Figure 1-1 shows both the Model 400E and the Model 400EL. Table 1-1 is a list of specifications.

1-4. OPTIONS AVAILABLE.

1-5. OPTION 01 (400E ONLY).

1-6. Option 01 places the dB scale uppermost for greater resolution when making dB measurements.

1-7. OPTION 02.

1-8. Option 02 adds a relative reference adjustment to the 400E/EL. The REL. REF. control allows a continuous reduction in sensitivity by a maximum of 3 dB in order to make relative voltage or dB measurements.

1-9. INSTRUMENT AND MANUAL IDENTIFICATION.

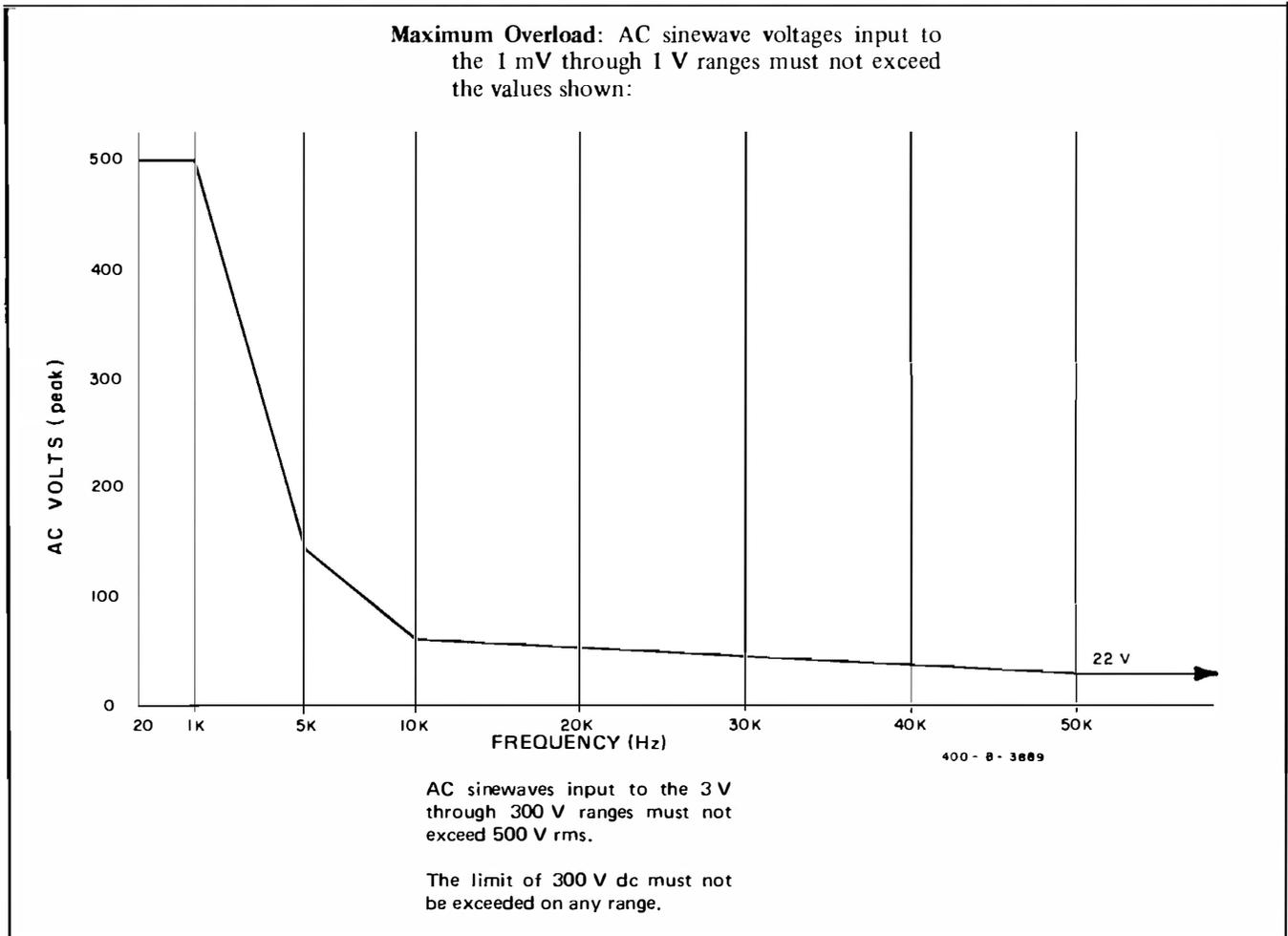
1-10. Hewlett-Packard instruments are identified by a two-section, eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and Model 400E/EL described in this manual.

1-11. If a letter prefixes the serial number, the instrument was manufactured outside the United States.



Figure 1-1. Models 400E and 400EL AC Voltmeters

Table 1-2. Performance Characteristics



SECTION II

INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary for the installation and shipping of the Model 400E and 400EL Voltmeters. 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 marks 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 5-7. 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 400E/EL can be operated from any source of 115 or 230 volts at 48 to 440 Hz 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 10 watts maximum.



Before applying ac power to the 400E or 400EL, be sure it is set for the proper line voltage.

2-7. POWER CORDS.

2-8. Figure 2-1 illustrates the standard power plug configurations that are used throughout the United States and in other countries. The -hp- part number directly below each drawing is the part number for a 400E/EL power cord equipped with a power plug of that configuration. If the appropriate power cord is not included with the instrument, notify the nearest -hp- Sales and Service Office and a replacement cord will be provided.

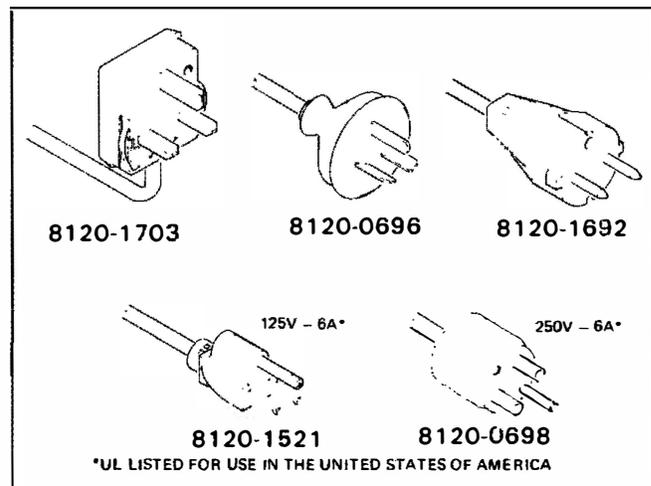


Figure 2-1. Power Cords.

2-9. GROUNDING REQUIREMENTS.

2-10. 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.

WARNING

For operator protection during battery operation, connect chassis terminal (MP26) to earth ground.

2-11. INSTALLATION.

2-12. The Model 400E/EL 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%.

2-13. BENCH MOUNTING.

2-14. The Model 400E/EL is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument.

2-15. INSTRUMENT CASE.

2-16. The 400E/EL can be placed in a rugged, high impact plastic case (-hp- 11076A). The instrument can be operated, stored or carried in this splash-proof case. A dual purpose tilt stand also serves as a carrying handle. Storage space is located at the rear of the case and in the front lid.

2-17. RACK MOUNTING.

2-18. The Model 400E/EL 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. It can be rack mounted only. For additional information, address inquiries to your -hp- Sales and Service Office. (See Appendix B for office locations.)

2-19. COMBINATION MOUNTING.

2-20. The Model 400E/EL 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, the combining case can be bench or rack mounted and is analogous to any full-module instrument.

2-21. REPACKAGING FOR SHIPMENT.

2-22. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-23 if the original container is to be used; 2-24 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.

2-23. If original container is to be used, proceed as follows:

- a. Place instrument in original container if available. If original container is not available, a suitable container can be purchased from your nearest -hp- Sales and Service Office.
- b. Ensure that container is well sealed with strong tape or metal bands.

2-24. 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.

SECTION III OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. The Model 400E/EL is primarily an ac voltmeter and dB meter, but it can be used as an ac to dc converter or as a wide band amplifier.

3-3. This section explains the controls of the 400E/EL and outlines the operating procedures for each mode of operation.

3-4. LOCATION OF CONTROLS AND INDICATORS.

3-5. Figure 3-2 shows the location of each of the 400E/EL controls and explains the function of each.

3-6. OPERATING INSTRUCTIONS.

3-7. STANDARD 400E/EL.

3-8. AC Voltmeter.

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	0.033	0.003
	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	1.380

* Depends on phase relationship between harmonic and fundamental.

NOTE

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

- a. Ensure that 115/230 V ac slide switch on the rear panel matches line voltage used, and connect power to the instrument. Mechanically zero the instrument using the procedure outlined in Paragraph 5-5.
- b. To operate the Model 400E/EL with battery power, connect two 35 to 55 volt batteries as shown in Figure 3-1. Since the front panel LINE switch has no effect during battery operation, the switch in Figure 3-1 can be used as a convenient method of disconnecting the batteries when the instrument is not in use. Two 35 volt batteries will deliver approximately 75 mA and two 55 volt batteries will deliver approximately 50 mA.

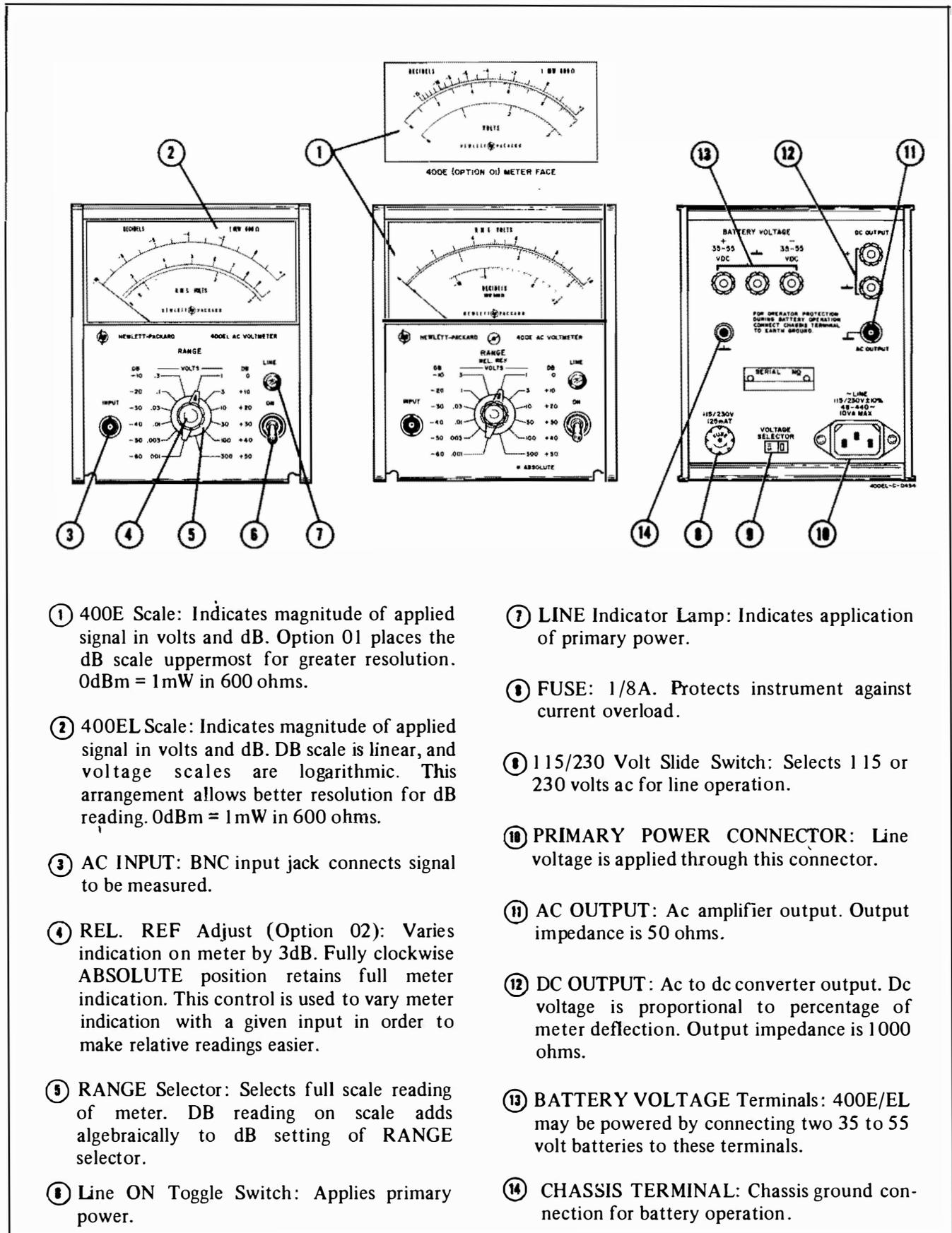
WARNING

For operator protection during battery operation, connect chassis terminal (MP26) to earth ground.

- c. Turn line ON toggle switch to up position. LINE lamp will glow.
- d. Select approximate range of signal to be measured.

CAUTION

Do not apply more than 500 volts ac to input. Do not overload the .001 through 1 volt ranges. Consult Table 1-2 for overload limits. If any of these overloads are exceeded, the instrument may be damaged.



- ① 400E Scale: Indicates magnitude of applied signal in volts and dB. Option 01 places the dB scale uppermost for greater resolution. $0\text{dBm} = 1\text{mW}$ in 600 ohms.
- ② 400EL Scale: Indicates magnitude of applied signal in volts and dB. DB scale is linear, and voltage scales are logarithmic. This arrangement allows better resolution for dB reading. $0\text{dBm} = 1\text{mW}$ in 600 ohms.
- ③ AC INPUT: BNC input jack connects signal to be measured.
- ④ REL. REF Adjust (Option 02): Varies indication on meter by 3dB. Fully clockwise ABSOLUTE position retains full meter indication. This control is used to vary meter indication with a given input in order to make relative readings easier.
- ⑤ RANGE Selector: Selects full scale reading of meter. DB reading on scale adds algebraically to dB setting of RANGE selector.
- ⑥ Line ON Toggle Switch: Applies primary power.
- ⑦ LINE Indicator Lamp: Indicates application of primary power.
- ⑧ FUSE: 1/8A. Protects instrument against current overload.
- ⑨ 115/230 Volt Slide Switch: Selects 115 or 230 volts ac for line operation.
- ⑩ PRIMARY POWER CONNECTOR: Line voltage is applied through this connector.
- ⑪ AC OUTPUT: Ac amplifier output. Output impedance is 50 ohms.
- ⑫ DC OUTPUT: Ac to dc converter output. Dc voltage is proportional to percentage of meter deflection. Output impedance is 1000 ohms.
- ⑬ BATTERY VOLTAGE Terminals: 400E/EL may be powered by connecting two 35 to 55 volt batteries to these terminals.
- ⑭ CHASSIS TERMINAL: Chassis ground connection for battery operation.

Figure 3-2. Location of Controls and Indicators

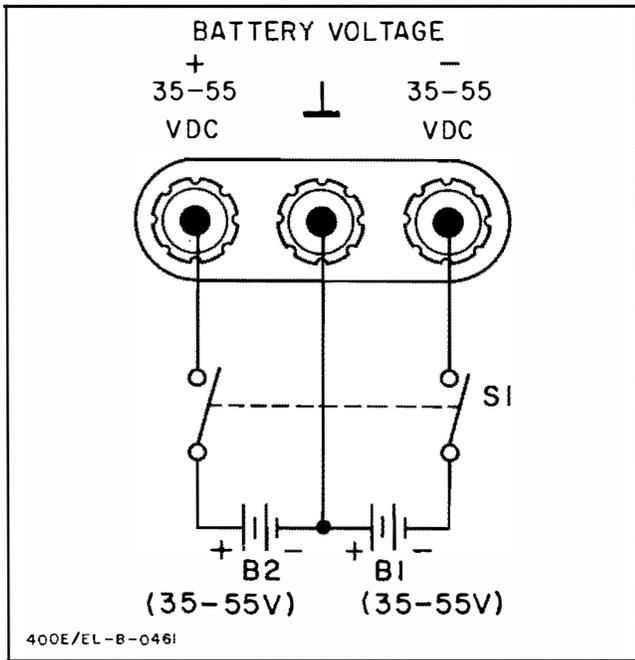


Figure 3-1. External Battery Connection

- e. Connect signal to be measured to INPUT terminals, and read the rms voltage on the scale.

3-9. DB Meter.

- a. To make a dB or dBm measurement, follow steps a through e in Paragraph 3-8, and add the scale reading to the RANGE setting. For example: If the scale reading is +1.5 and the RANGE is -30dB, the final measurement is -28.5dB.
- b. The 400E/EL dB scale is calibrated in dBm. 0dBm is equivalent to 1 milliwatt dissipated by a 600 ohm load. Consequently, any dBm measurements must be made across a total impedance of 600 ohms. Measurements across other impedances will be in dB, but not dBm.
- c. To convert a dB reading to dBm, use the Impedance Correction Graph (Figure 3-3). For example: To convert a +30dB reading made across 50 ohms to dBm, locate the load impedance on the bottom of the graph. Follow the impedance line to the heavy black line and read the meter correction at that point. The correction for 50 ohms is +10.5dBm, and the corrected reading is +40.5dBm.

3-10. Ac to Dc Converter.

- a. Follow steps a through e in Paragraph 3-8.
- b. Connect the rear panel DC OUTPUT terminals to a dc measuring device with a high input impedance. The dc output resistance is 1000 ohms; and if it is loaded, the dc output signal will be inaccurate.
- c. The dc output is a 0 to 1 volt signal proportional to the percentage of 400E/EL meter deflection.

3-11. Wide Band Ac Amplifier.

- a. Follow turn-on steps a through c in Paragraph 3-8.
- b. Select approximate range of input on RANGE switch.
- c. Connect SIGNAL to be amplified to INPUT terminals.
- d. When using an ac power source, ground loops can be eliminated by connecting the 400E/EL to an adequate isolation transformer. This will open the power line ground circuit as shown in Figure 3-3.

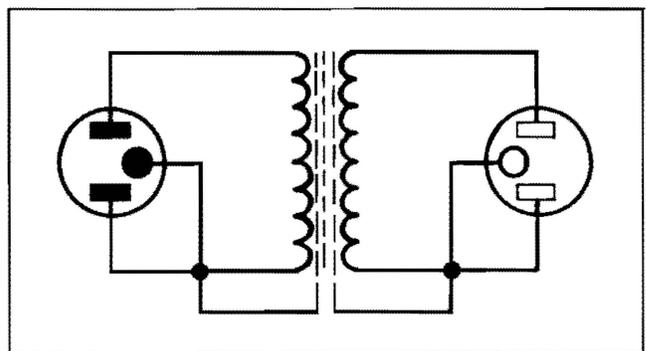


Figure 3-3. Isolation Transformer.

NOTE

Place a 1 kilohm shielded load across the DC OUTPUT, if it is not being used, when using the AC OUTPUT. This is especially necessary on low ranges.

- e. The gain of the amplifier depends on the RANGE selection. On the 0.1 volt range and below, the 400E/EL amplifies the input; and

on the 0.3 volt range and above, it attenuates the input. On the 0.001 volt ranges, the maximum output is 105mV. On all other ranges, the maximum output is 150mV. Table 3-2 shows the ac amplifier gain for each range setting.

Table 3-2. AC Amplifier Gain

RANGE	GAIN	RANGE	GAIN
0.001	+40dB	1	-16dB
0.003	+34dB	3	-26dB
0.01	+24dB	10	-36dB
0.03	+14dB	30	-46dB
0.1	+4dB	100	-56dB
0.3	-6dB	300	-66dB

3-12. 400E WITH OPTION 01.

3-13. Operation of the 400E with Option 01 is essentially the same as operation of the standard 400E; The dB scale reads from -15 to +2 instead of from -12 to +2, and is placed at the top of the scale for better resolution.

3-14. 400E/EL WITH OPTION 02.

3-15. Option 02 adds a relative reference adjustment to the 400E/EL. This adjustment allows a meter indication to be varied by 3dB. Use the REL. REF adjustment to set the meter at any reference (0dB for example) in order to make relative readings easier. When the REL. REF adjustment is in the fully clockwise ABSOLUTE position, it has no effect on the meter accuracy.

3-16. In all other respects, operation of a Option 02 instrument is the same as operation of a standard Model 400E/EL.

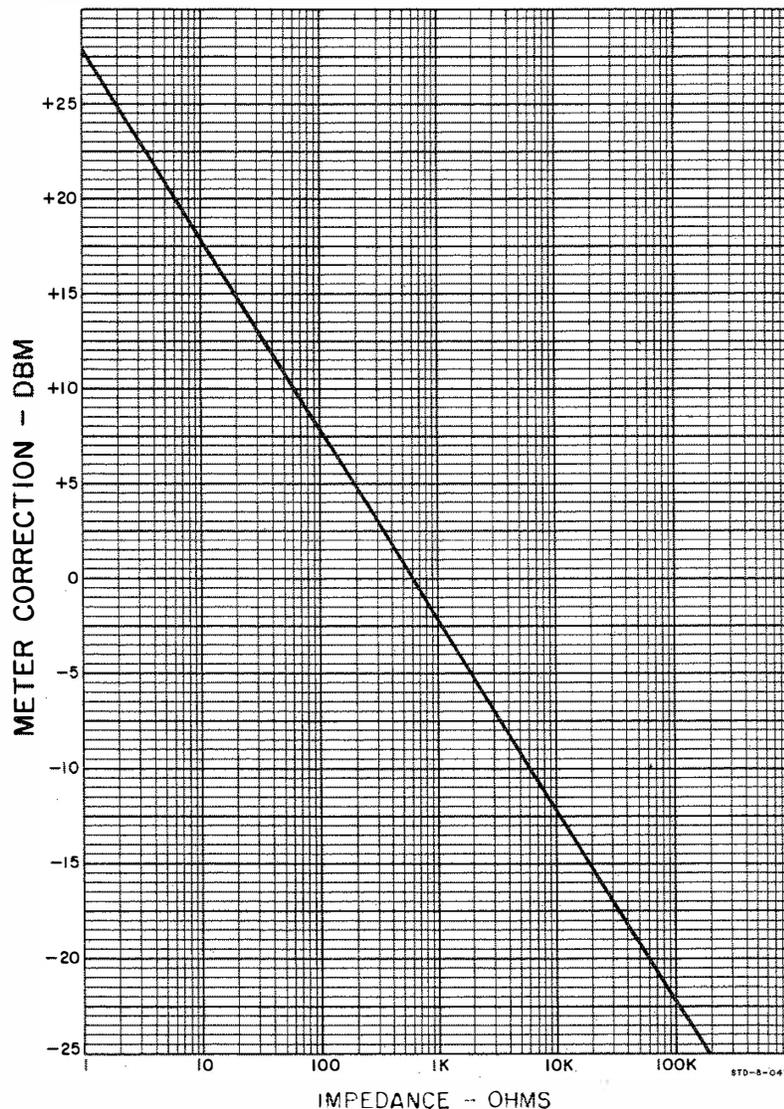


Figure 3-4. Impedance Correction Graph.

SECTION IV

THEORY OF OPERATION

4-1. GENERAL.

4-2. The 400E/EL is a solid state, average responding, rms calibrated voltmeter. It also has applications as an ac to dc converter and a wide band amplifier. Figure 4-1 shows a simplified block diagram of the instrument.

4-3. When relay K1 is closed, the input is not attenuated; when K1 is open and K2 is closed, the input is attenuated by 50 dB. On the 0.001 through 1 volt ranges, K1 is closed and K2 is open. K2 is closed and K1 is open on the 3 through 300 volt ranges. The entire Input Attenuator assembly is shielded, and the relays are operated remotely by voltages applied through the RANGE switch. Variable capacitor A1C2 is adjusted on the 3 volt range with a 3 volt 100 kHz input in order to shape the frequency response of the Input Attenuator.

4-4. The signal from the input attenuator is applied to the impedance converter. The impedance converter is a unity gain, feedback stabilized amplifier that matches the high Impedance of the Input Attenuator to the much lower impedance of the Post Attenuator.

4-5. The Post Attenuator attenuates the output of the Impedance Converter by 10dB for each step of the RANGE switch. On the 3 volt range, the Post

Attenuator is switched back to the 30dB position, and then it attenuates 10dB per step on the higher ranges. Variable capacitor S2C2 is adjusted on the .003 volt range with a 3mV, 8MHz input to adjust the 8MHz response of the .003 volt range. With a full scale input on any range except the .001 volt range, the output of the Post Attenuator should be 3mV. On the .001 volt range, the output should be 1mV.

4-6. The Meter Amplifier is a four-stage, high-gain amplifier utilizing both ac and dc feedback for gain stabilization. The Meter Bridge, connected in the ac feedback path of the meter amplifier, converts the ac output of the amplifier to a dc voltage proportional to its average value. This dc voltage drives the meter. A2C28 and A2R38 adjust the gain of the amplifier so that the meter will read rms volts. A2R38 is adjusted at 400Hz, and A2C28 is adjusted at 10MHz.

4-7. The DC Output is a 0-1 volt level that is proportional to meter deflection. R2 is adjusted to calibrate the dc output. The AC Amplifier samples the ac feedback and generates 0 to 150mV ac output that is directly proportional to meter deflection.

4-8. SCHEMATIC DESCRIPTION.

(See Figure 7-1).

4-9. IMPEDANCE CONVERTER.

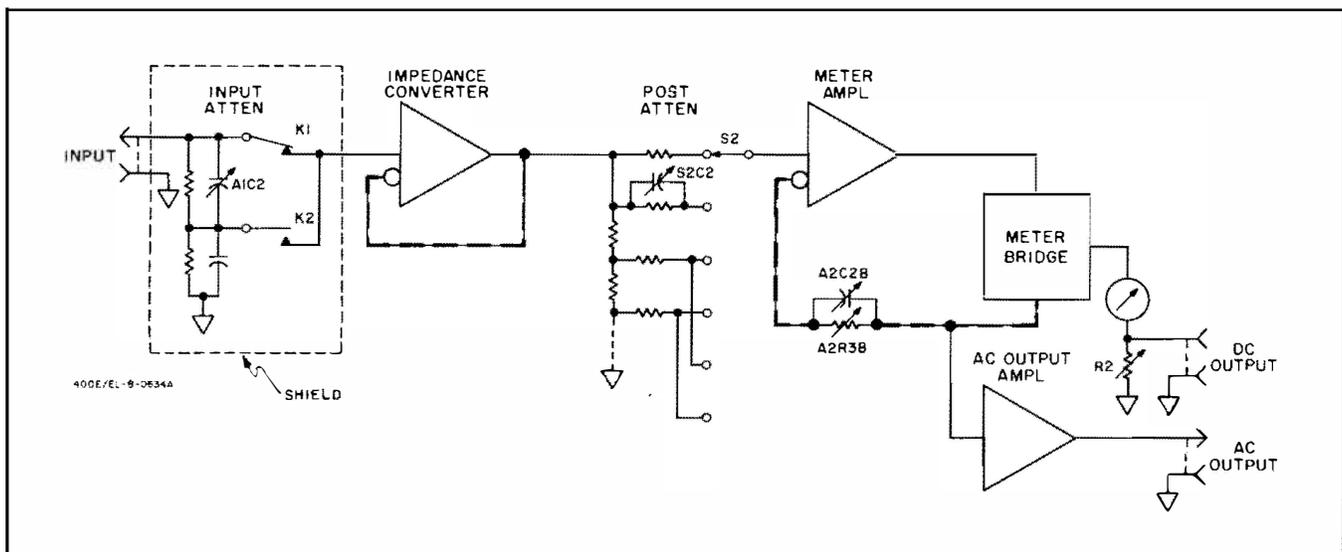


Figure 4-1. Simplified Block Diagram

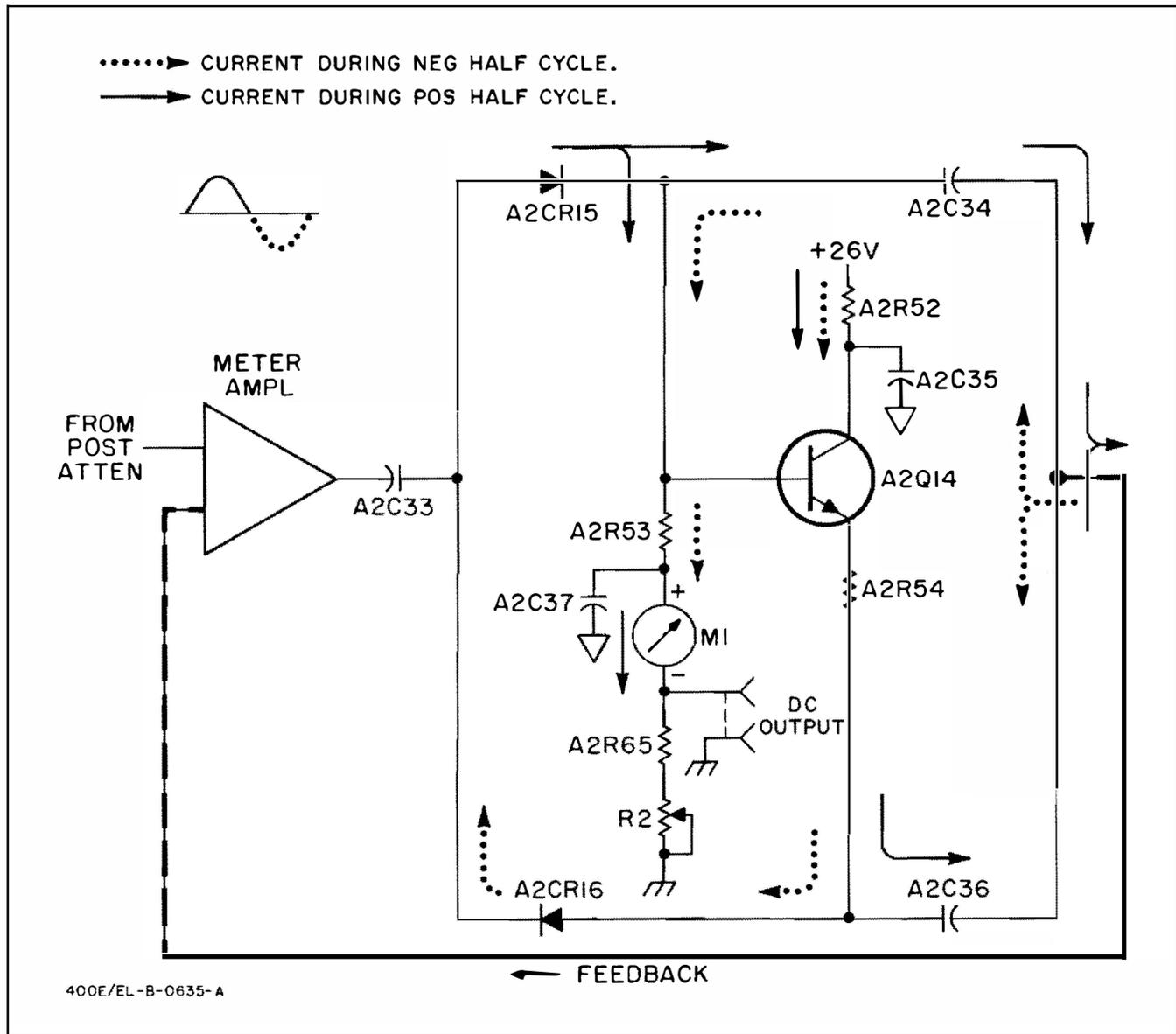


Figure 4-2. Meter Bridge

4-10. The impedance converter, located on the main voltmeter board (A2), matches the high impedance of the input attenuator to the relatively low impedance of the Post Attenuator. Breakdown diodes A2CR17 and A2CR18 bias diodes A2CR9 and A2CR10 at +5 and -5 volts respectively. A2CR9 and A2CR10 limit the input to 10 volts peak-to-peak, providing overload protection. Breakdown diodes A2CR20 and A2CR21 stabilize the bias voltages on A2Q5. Fuse A2F1 protects the instrument against destructive overloads.

4-11. A field-effect transistor (A2Q5) is used in the input stage of the impedance converter because of its characteristically high input impedance and good frequency response. A2R17 adjusts the dc bias of the

impedance converter. The output is taken from the emitter circuit of A2Q7 and applied to the post attenuator and then applied to the meter amplifier. The solid black lines on the schematic show the signal path, and the broken lines show the feedback paths.

4-12. METER AMPLIFIER.

4-13. The meter amplifier amplifies its input signal by a fixed gain on all ranges except the .001 volt range. The amplifier itself is a four-stage, dc coupled amplifier with a cascade-coupled final stage (A2Q12 and A2Q13). DC feedback is coupled from the emitter of A2Q12 back to the base of A2Q9. Breakdown diodes A2CR12, A2CR13 and A2CR14 establish fixed dc bias levels in the amplifier.

4-14. The output from the collector of A2Q13 is coupled through the Meter Bridge and fed back to the emitter of A2Q9. A2C28 in the feedback circuit adjusts the amount of feedback at the high end of the frequency range, and A2R38 adjusts the feedback at the low end. This calibrates the amplifier gain at both ends of the frequency range. A2R44, 45 and 72 are switched into the feedback circuit on the 0.001 volt range, boosting the gain on that range. A2R44 adjusts the gain on the 1mV range with a 400Hz input. A2R31 adjusts the dc bias level of the amplifier.

4-15. METER BRIDGE.

4-16. Figure 4-2 shows a partial schematic of the Meter Bridge. The meter bridge rectifies the ac amplifier output and supplies the dc current to drive the meter. In order to use part of the meter bridge output as the rear terminal dc output, the meter has to be referenced to ground. Transistor A2Q14 references the meter to ground.

4-17. During the positive half cycle, A2CR15 conducts. Part of the current (solid line) goes through A2C34 into the feedback path, and part of the current goes through A2R53 and the meter to ground. The current through A2R53 turns on A2Q14, and A2Q14 draws current from the positive supply. The current from A2Q14 goes through A2C36 into the feedback path. The current through A2Q14 and A2C36 is equal to the current drawn through the meter, so the current out of the bridge is equal to the current into the bridge.

4-18. During the negative half cycle, A2CR16 conducts and draws current from the feedback path (dotted line). Part of the current goes through A2C36

and A2CR16 into the amplifier, and part goes through A2R53 and the meter to ground. The current through A2R53 turns on A2Q14, and the current from A2Q14 goes through A2R54 and A2CR16 to the amplifier. Again the current through the meter equals the current through A2R54, and the current into the bridge equals the current out.

4-19. Transistor A2Q14 replaces current drawn by the meter, so the meter bridge is kept floating while the meter is referenced to ground. The dc output, taken across A2R65 and R2, is also referenced to ground.

4-20. AC OUTPUT CIRCUIT.

4-21. The ac output circuit isolates the meter bridge and amplifier from the ac output load. It consists of two emitter followers (A2Q15 and Q16) connected in cascade. A2R59 in the base circuit of A2Q15 zeroes the output dc level at the ac output.

4-22. POWER SUPPLY.

4-23. The power supply produces regulated +26 volts and -26 volts. Breakdown diode A2CR7 establishes a reference voltage of 6.98 volts. Part of the power supply output is applied to the base of A2Q2, and A2Q2 senses the difference between the supply output and the reference. If the output voltage changes, the emitter to base voltage of A2Q2 will change; and the output of A2Q2 will change the current through A2Q1, the regulator.

4-24. The negative regulator, A2Q3 and A2Q4, uses the +26 volt output as a reference. Consequently, the negative supply is dependent upon the positive supply.

WARNING

Maintenance described herein is performed with power supplied to the instrument, and protective covers removed. Such maintenance should be performed only by service-trained personnel who are aware of the hazards involved (for example, fire and electrical shock). Where maintenance can be performed without power applied, the power should be removed.

Table 5-1. Required Test Equipment

INSTRUMENT TYPE	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
AC Calibrator	Accuracy: 0.022% to 0.205% Voltage Ranges: 0.1mV to 300V Frequency Range: 10Hz to 110kHz	-hp- Model 745A/746A AC Calibrator
Test Oscillator	Frequency Range: 10Hz to 10MHz Output: 3.0 volts rms max. Distortion: less than 1% Frequency Response: adjustable to 0.25% (652A)	-hp- Model 651B or 652A Test Oscillator
AC/DC Voltmeter	Range: 0 to 100 volts Sensitivity: 100 microvolts Accuracy: greater than 0.1%	-hp- Model 3450B Multi-Function Meter with Option 001
DC Null Meter	Range: ± 3 microvolts full scale to 10mV full scale Accuracy: 2% of full scale	-hp- Model 419A DC Null Voltmeter
Thermal Converters	a. Input: 3 volts rms. $R = 200$ ohms/volt Output: 7mV dc b. Input: 1 volt and 0.45 volt rms Output: 7mV dc Accuracy: 0.2% or better Frequency Range: dc to 10MHz	a. -hp- Model H02-11049A (600 ohms input) b. -hp- Model 11050A and 11051A Thermal Converters (50 ohms input)
DC Standard	Output: Adjustable to 0.45V, 1V and 3V Accuracy: 0.1% or better	-hp- Model 740B DC Standard Differential Voltmeter
0-10 MV Reference Supply	See Figure 5-2 for schematic. a. Resistor: fxd, 6500 ohms $\pm 1\%$ b. Resistor: var, 500 ohms $\pm 5\%$, 10-turn c. Resistor: var, 50 ohms $\pm 5\%$, 10-turn d. Battery: 1.34 volts	a. -hp- Part No. 0811-0392 b. -hp- Part No. 2100-0324 c. -hp- Part No. 2100-1481 d. Mallory RM42R
AC/DC Voltmeter Ohmmeter	Accuracy: $\pm 3\%$ Input Capacity: < 1.5 pF Input Impedance: > 10 M Ω	-hp- Model 410C Electronic Voltmeter
Resistors	Fxd, 100 kilohms $\pm 1\%$ Fxd, 1 kilohm $\pm 1\%$ Var, 15 kilohms, ww $\pm 5\%$, 10-turn	-hp- Part No. 0757-0465 -hp- Part No. 0757-0280 -hp- Part No. 2100-0896
Voltmeter Calibrator	Voltage Accuracy: $\pm .25\%$ at 400Hz Output: 0 to 3 volts	-hp- Model 738BR Voltmeter Calibrator
Termination	Feed-through, 50 ohm impedance	-hp- Model 11048C 50 ohm Feed-through Termination
Coaxial Attenuators	50 dB attenuation ± 0.01 dB dc to 10 MHz 40 dB attenuation ± 0.01 dB dc to 10 MHz	Weinschel Engineering Models 50-40S and 50-50S Coaxial Attenuators
Wideband AC Voltmeter	Frequency Range: 10 Hz to 4 MHz Accuracy: Greater than $\pm 1\%$.	-hp- Model 3403C True RMS Voltmeter

SECTION V

MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains information necessary to maintain the Model 400E/EL. The following paragraphs describe the Performance Checks, the Calibration Procedures, and the Troubleshooting Procedures.

5-3. REQUIRED EQUIPMENT.

5-4. Table 5-1 is a list of the equipment required to properly maintain the Model 400E/EL. If the model recommended in Table 5-1 is not available, a substitute may be used as long as it meets the required specifications.

5-5. MECHANICAL ZERO ADJUST (400E Only).

5-6. Before any performance checks or calibration is begun, complete the mechanical zero adjustment in the following steps:

- a. Be sure the meter has been off for at least one minute, or momentarily short the meter terminals.
- b. Rotate mechanical adjustment screw **CLOCKWISE** until meter pointer is to the left of zero and moving upscale toward zero.
- c. Continue to rotate adjustment screw clockwise. **STOP** when needle is exactly on zero. If needle overshoots, repeat step b.
- d. When pointer is exactly over zero, rotate adjustment screw slightly **COUNTERCLOCKWISE** to relieve tension on suspension. If the pointer moves to the left, repeat whole procedure, but make counterclockwise rotation less.

5-7. PERFORMANCE CHECKS.

5-8. The performance checks are "in cabinet" tests that compare the 400E/EL with its specifications. These procedures can be used both for incoming inspection and periodic inspection. The performance checks should be conducted before any attempt is made to calibrate the instrument. A Performance Check Test Card is provided at the end of this section for recording the performance of the instrument during the performance checks. The card can be removed from the manual and used as a permanent record of the incoming inspection or of a routine performance check.

5-9. ACCURACY AND FREQUENCY RESPONSE TESTS.

5-10. The accuracy and frequency response tests compare the Model 400E/EL with its accuracy specifications. Three methods are given in the following paragraphs. Any one of the three procedures can be used dependent upon the test equipment available and the desired accuracy to which the 400E/EL is to be checked. The procedure using the -hp- 745A AC Calibrator and the 746A Amplifier is the simplest and most accurate for all voltages at frequencies from 10Hz to 110kHz. From 110kHz to 10MHz, the 652A Test Oscillator can be used for the 3 and 1 volt ranges with an accuracy of 0.25% (0.75% for lower ranges). The Thermal Converter Method is more time consuming and subject to burn-out; but it has an accuracy uncertainty of 0.04% to 0.18%. The E02-738BR can be used to check all ranges at 400Hz to a minimum of .3 millivolts. The accuracy at 400Hz is 0.2% at 300 volts and 0.3% using the attenuator. The frequency response can be checked with a maximum of 3 volts with the 652A Test Oscillator. The 654A Test Oscillator can be used below 1 volt output from 10Hz to 10MHz with a flatness of 0.5%. This flatness is without adjusting the amplitude at each change of frequency.

5-11. Accuracy Check from 10Hz to 110kHz.

5-12. The test setup in Figure 5-1 uses the 745A AC Calibrator System. This calibrator can produce any voltage level from 0.1mV to 100 volts in a seven digit readout for frequencies from 10Hz to 110kHz. The accuracy is from 0.022% to 0.205%. The 746A Amplifier can be used for voltages above 100 volts with the same accuracy.

NOTE

For optimum performance, let the 400E/EL and the 745A/746A warmup for at least one-half hour.

- a. Place the 400E/EL on the 3 volt range and position the 745A to read 3.00000 volts at 400Hz.
- b. Connect the test setup as shown in Figure 5-1. Set the 745A SENSE switch to LOCAL or if more accuracy is desired place the SENSE switch to REMOTE and connect the sense terminals to the input of the 400E/EL.

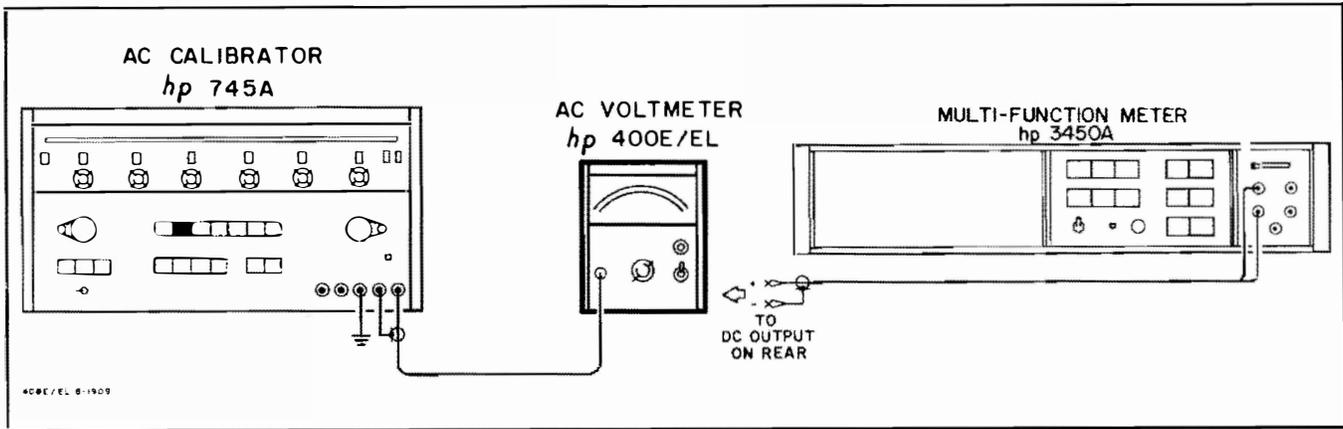


Figure 5-1. Accuracy Test Setup

- c. Set the error range to X1 and turn the marker to zero position. Read the dc output on the digital voltmeter. The dc output should read within the tolerances listed in Table 5-2. With some test setups, it may be necessary to connect a 500 microfarad capacitor across the 400E/EL output to obtain the required resolution at 10 Hz.
- d. Adjust the 745A error control until the 400E/EL reads exactly the applied voltage. Read the 400E/EL error directly in % from the 745A. Where the meter error exceeds $\pm 3\%$, return the 745A error control to zero, bring the 400E/EL to the required reading with the 745A voltage controls and calculate the error. Any error should be within the tolerance listed in Table 5-2 under Meter.
- e. Repeat steps c and d for each 745A frequency and voltage listed in Table 5-2 and 5-3. Connect the precision 40 dB attenuator between the 745A and the 400E/EL to calibrate the 1 mV and 3 mV ranges. If the 400E/EL is not within the tolerances listed in Table 5-2 and 5-3 refer to Paragraph 5-32 Alignment and Calibration Procedure.
- c. Change the frequency to those in Table 5-2 and 5-3. Adjust the 652A AMPLITUDE control until 0 is read on the expanded scale of the meter. The dc output of the 400E/EL should be within tolerances listed in Table 5-2 or 5-3 for range, voltage and frequency settings. Change the fine adjust on the 652A until the 400E/EL meter reads exactly the voltage applied. Read error on the 652A Meter. Where the meter error exceeds $\pm 2.5\%$, readjust the 652A AMPLITUDE control for 0 on the expanded scale of the meter and read the error on the 400E/EL. The error should be within the tolerances listed in Table 5-2 and 5-3 for range, voltage and frequency settings. If out of tolerance refer to Paragraph 5-32 Alignment and Calibration Procedure.

NOTE

For accuracy of voltage tracking not listed in Table 5-2 and 5-3 refer to the Accuracy Graphs Table 5-4. Obtain the percentage of accuracy from the specifications Table 1-1. Select the proper graph for the percentage of accuracy. Find the point on the curve for any tracking point from full scale to less than 1/3 full scale. Horizontally locate the error in percent of reading.

5-13. Frequency Response Check from 110kHz to 10MHz.

- a. For frequencies from 110kHz to 10MHz adjust the 652A (using the 50 ohm output and a 50 ohm load) to the same reading on the 400E/EL at 1kHz as read with the 745A. 3 and 1 volt only can be used on the expanded scale. (3 and 1 volt can be attenuated by the 652A range switch at less accuracy.)
- b. Turn the 652A to the expanded scale and adjust the REF SET control for 0% or 0dB.

5-14. Accuracy Check Using Thermal Converters.

5-15. The test setup in Figure 5-2 uses a thermal converter with a null circuit to adjust the frequency response of the test oscillator to within 0.2% over its entire band. Construct the 0 to 10mV Reference Supply shown in Figure 5-2 and allow it at least 24 hours to stabilize.

Table 5-2. Accuracy Tolerances

Frequency (Hz)	3 Volt Range			1 Volt Range Δ		
	Voltage Input	Meter (% of reading)	DC OUTPUT (Volts)	Voltage Input	Meter (% of reading)	DC OUTPUT (Volts)
10	3	3.00 \pm 5%	0.949 \pm 0.047	1.0	1.00 \pm 5%	1.00 \pm 0.05
	2	2.00 \pm 6.3%	0.633 \pm 0.040	0.5	0.50 \pm 7.5%	0.50 \pm 0.038
	1	1.00 \pm 10%	0.316 \pm 0.032	0.3	0.30 \pm 10.8%	0.30 \pm 0.033
40	3	3.00 \pm 1%	0.949 \pm 0.010	1.0	1.00 \pm 1%	1.00 \pm 0.010
	2	2.00 \pm 1.5%	0.633 \pm 0.010	0.5	0.50 \pm 2%	0.50 \pm 0.010
	1	1.00 \pm 3%	0.316 \pm 0.01	0.3	0.30 \pm 3.3%	0.30 \pm 0.010
100 or 400	3	3.00 \pm 1%	0.949 \pm 0.010	1.0	1.00 \pm 1%	1.00 \pm 0.01
	2	2.00 \pm 1.5%	0.633 \pm 0.010	0.5	0.50 \pm 2%	0.50 \pm 0.01
	1	1.00 \pm 3%	0.316 \pm 0.010	0.3	0.30 \pm 3.3%	0.30 \pm 0.01
500k	3	3.00 \pm 1%	0.949 \pm 0.010	1.0	1.00 \pm 1%	1.00 \pm 0.01
	2	2.00 \pm 1.5%	0.633 \pm 0.010	0.5	0.50 \pm 2%	0.50 \pm 0.01
	1	1.00 \pm 3%	0.316 \pm 0.010	0.3	0.30 \pm 3.3%	0.30 \pm 0.01
1 M	3	3.00 \pm 1%	0.949 \pm 0.010	1.0	1.00 \pm 1%	1.00 \pm 0.01
	2	2.00 \pm 1.5%	0.633 \pm 0.010	0.5	0.50 \pm 2%	0.50 \pm 0.01
	1	1.00 \pm 3%	0.316 \pm 0.010	0.3	0.30 \pm 3.3%	0.30 \pm 0.01
4 M	3	3.00 \pm 3%	0.949 \pm 0.029	1.0	1.00 \pm 3%	1.00 \pm 0.03
	2	2.00 \pm 3.8%	0.633 \pm 0.024	0.5	0.50 \pm 4.5%	0.50 \pm 0.023
	1	1.00 \pm 6%	0.316 \pm 0.019	0.3	0.30 \pm 6.5%	0.30 \pm 0.020
10 M	3	3.00 \pm 5%	0.949 \pm 0.0475	1.0	1.00 \pm 5%	1.00 \pm 0.05
	2	2.00 \pm 6.5%	0.633 \pm 0.0411	0.5	0.50 \pm 8%	0.50 \pm 0.04
	1	1.00 \pm 15%	0.316 \pm 0.0348	0.3	0.30 \pm 12%	0.30 \pm 0.036

Δ These tolerances can also be used on the following ranges: 10 mV, 100 mV,

NOTE

The test oscillator used must have very low distortion (less than 1%). A thermal converter and an average responding circuit react differently to distortion, and any distortion present would create a calibration error.

Figure 5-2. Set switch S1 to position A connecting the dc standard output to the thermal converter input. The reference supply and the thermal converter are sensitive to variations in ambient temperature. Ensure that the ambient temperature variations are less than $\pm 2.0^\circ$ C.

NOTE

If a 400E/EL Option 02 instrument is used, set the REL. REF adjustment to the fully clockwise ABSOLUTE position before making accuracy check.

5-16. Reference Supply Calibration.

5-17. Use the following procedure to calibrate the thermal converter and reference supply.

- a. Connect the dc standard, the 400E/EL, the null voltmeter, the reference supply, and a 3 volt thermal converter (H02-11049A with 600 ohm input impedance) as shown in

- b. Set the dc standard output to +3.000 volts dc.

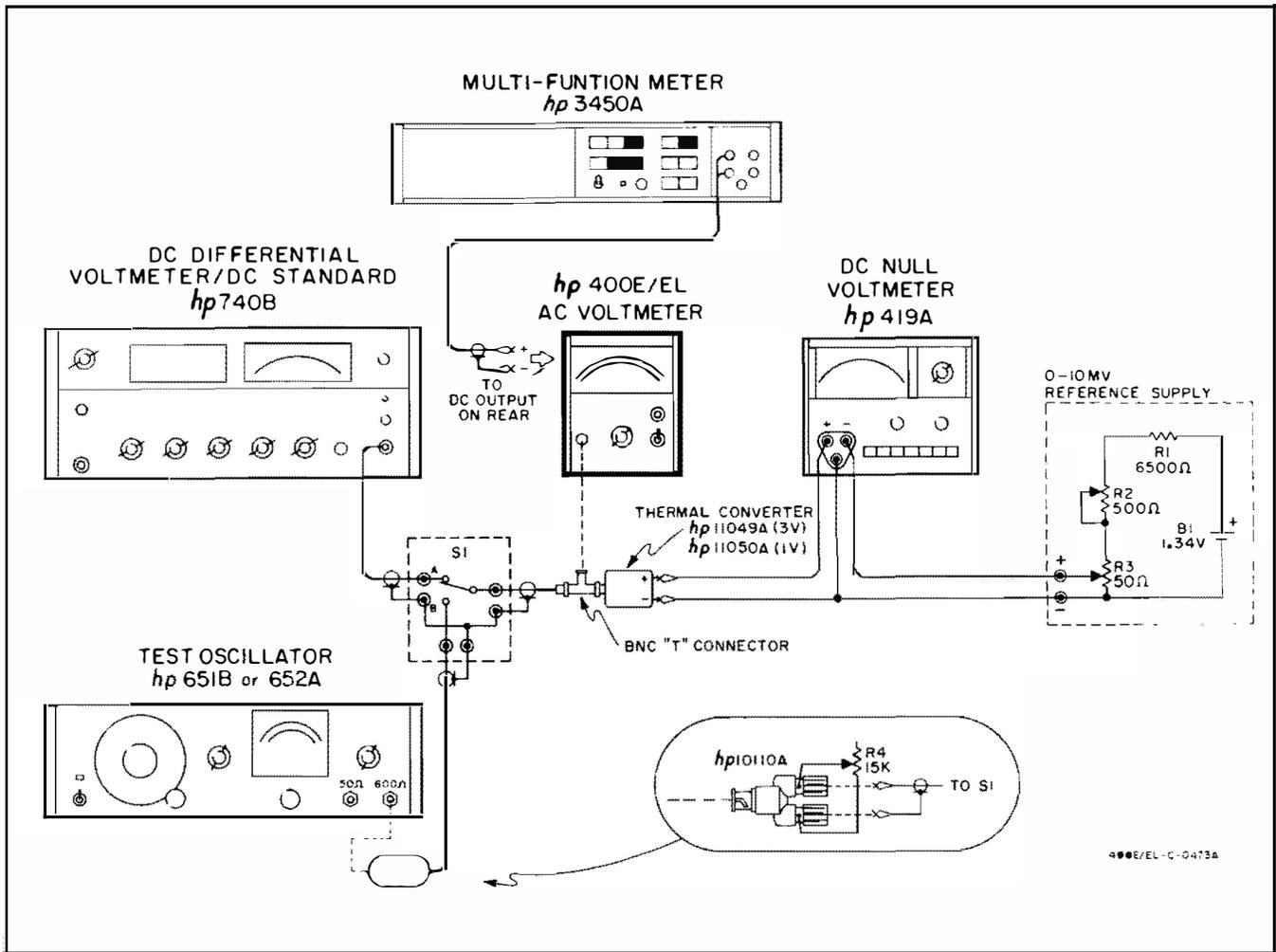


Figure 5-2. Accuracy and Frequency Response Test Setup

Table 5-3. Calibration Tolerances

Frequency (Hz)	1 Millivolt Range Only.			Frequency (Hz)	1 Millivolt Range Only.		
	Voltage Input	Meter (mV) (% of reading)	DC Output (Volts)		Voltage Input	Meter (mV) (% of reading)	DC Output (Volts)
10	1.00mV	1.00 ± 5%	1.00 ± 0.05	100k	1.00mV	1.00 ± 1%	1.00 ± 0.005
	0.5mV	0.50 ± 7.6%	0.50 ± 0.038		0.5mV	0.50 ± 2%	0.50 ± 0.0045
	0.3mV	0.30 ± 10.8%	0.30 ± 0.033		0.3mV	0.30 ± 3.3%	0.30 ± 0.0043
40	1.00mV	1.00 ± 1%	1.00 ± 0.02	500k	1.00mV	1.00 ± 1%	1.00 ± 0.02
	0.5mV	0.50 ± 2%	0.50 ± 0.015		0.5mV	0.50 ± 2%	0.50 ± 0.015
	0.3mV	0.30 ± 3.3%	0.30 ± 0.013		0.3mV	0.30 ± 3.3%	0.30 ± 0.013
100 or 400	1.00mV	1.00 ± 1%	1.00 ± 0.005	4M	1.00mV	1.00 ± 5%	1.00 ± 0.05
	0.5mV	0.50 ± 2%	0.50 ± 0.0045		0.5mV	0.50 ± 7.6%	0.50 ± 0.038
	0.3mV	0.30 ± 3.3%	0.30 ± 0.0043		0.3mV	0.30 ± 10.8%	0.30 ± 0.033

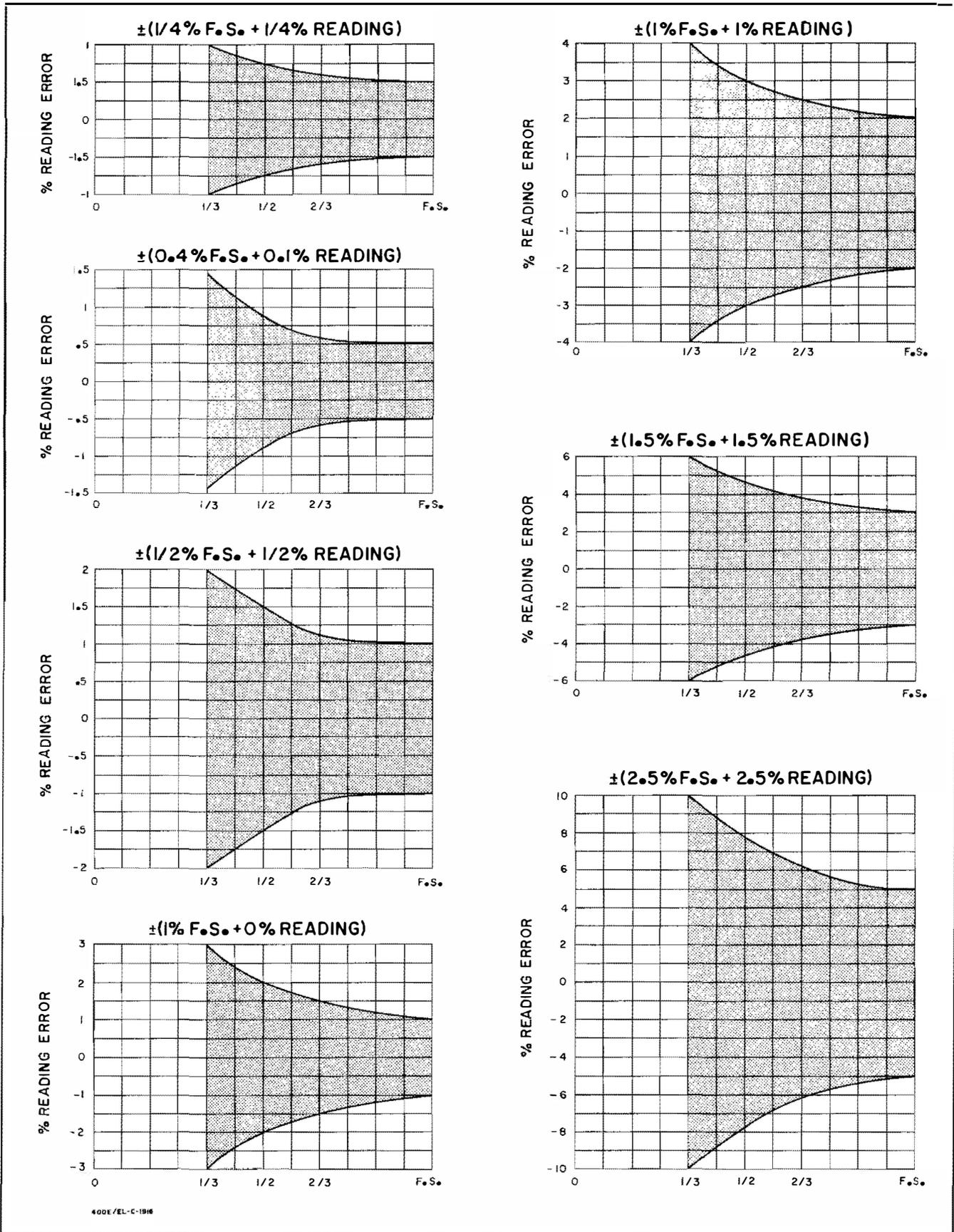


Table 5-4. Calibration Accuracy Graphs

- c. Using the null voltmeter, adjust the reference supply until its output is within ± 1.5 microvolts of the thermal converter output.

5-18. 3 Volt and 1 Volt Accuracy Test.

5-19. Check the 400E/EL accuracy and frequency response on the 3 volt and 1 volt ranges according to the following steps.



SET TEST OSCILLATOR OUTPUT TO MINIMUM BEFORE CONNECTING. REDUCE OSCILLATOR OUTPUT BEFORE CHANGING FREQUENCY RANGE. DO NOT ALLOW OSCILLATOR OUTPUT TO EXCEED RATED INPUT OF THERMAL CONVERTER. ANY OVERLOAD MAY DESTROY THERMAL CONVERTER.

- a. Set switch S1 in Figure 5-2 to position B, connecting the test oscillator's 600 ohm output to the thermal converter input. Connect the digital voltmeter to the 400E/EL DC OUTPUT terminals.
- b. Set the 400E/EL Range Switch to 3 volts and set the oscillator frequency to 10Hz. Connect the BNC "T" connector directly to the 400E/EL INPUT.
- c. Using the oscillator amplitude control as coarse adjustment and resistor R4 (Figure 5-2) as fine adjustment, increase the oscillator amplitude until the thermal converter output nulls the reference supply. Observe the 400E/EL meter indication and dc output.
- d. Repeat step c for each frequency listed in Table 5-2. If the 400E/EL is within specifications, the meter indication and the dc output will be within the tolerances listed in Table 5-2.
- e. Recalibrate the 10mV reference supply according to the procedure in Paragraph 5-17 using a 1 volt thermal converter and a 1 volt output from the dc standard.

- f. Repeat steps a through d in this paragraph using the one volt thermal converter and the 50 ohm output of the test oscillator. Set the 400E/EL to the 1 volt range.

5-20. Range Tracking Test.

5-21. The range tracking test checks the accuracy of the 400E/EL with a 1/3 scale input over its entire frequency range.

5-22. After verifying the full scale calibration with the accuracy test in Paragraph 5-19, check the range tracking with the following procedures.

- a. Recalibrate the 10mV reference supply according to the procedure in Paragraph 5-17. Use a 600 ohm input, 3 volt thermal converter and 3 volt output from the dc standard.



SET TEST OSCILLATOR OUTPUT TO MINIMUM BEFORE CONNECTING. REDUCE OSCILLATOR OUTPUT BEFORE CHANGING FREQUENCY RANGE. DO NOT ALLOW OSCILLATOR OUTPUT TO EXCEED RATED INPUT OF THERMAL CONVERTER. ANY OVERLOAD MAY DESTROY THERMAL CONVERTER.

- b. Set S1 in Figure 5-2 to position B, connecting the test oscillator 600 ohm output to the thermal converter input. Connect the digital voltmeter to the 400E/EL DC OUTPUT terminals.
- c. Set the 400E/EL switch to 10 volts and the oscillator to 10Hz. Connect the BNC "T" connector directly to the 400E/EL INPUT.
- d. Using the oscillator amplitude control as coarse adjustment and resistor R4 as a fine adjustment, set the oscillator output so that the thermal converter output nulls the reference supply output.
- e. Repeat step d for each frequency listed in Table 5-2. If the 400E/EL is within specifications, the meter indication and the dc output will be within the tolerances listed in the table.

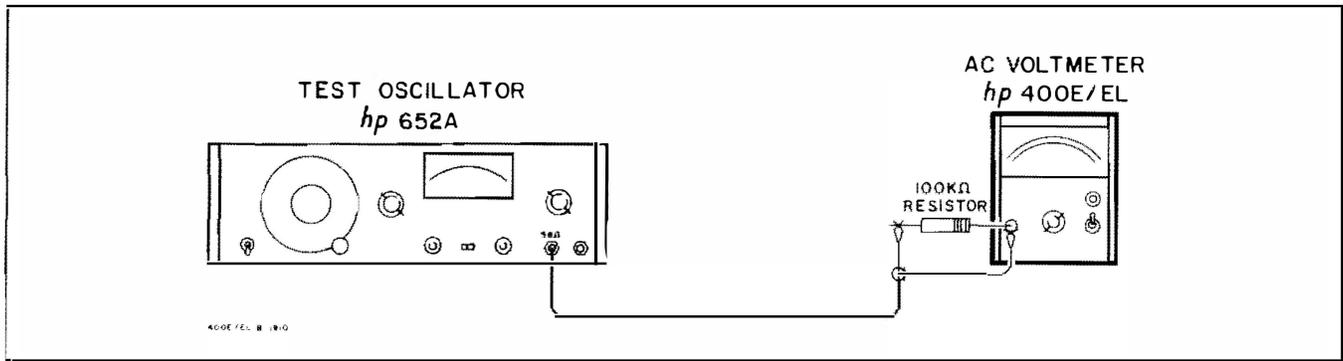


Figure 5-3. Input Impedance Check

- f. Repeat steps a through e in this paragraph using a 50 ohm input, 1 volt thermal converter and a +1.000 volt dc output from the dc standard. Set the 400E/EL to the 3 volt range and use the 50 ohm output of the test oscillator.

5-23. 3mV and 1mV Range Accuracy Test.

- a. Recalibrate the 10mV reference supply according to the procedures in Paragraph 5-17 using a 0.45 volt thermal converter and a 0.3000 volt output from the dc standard.
- b. Set S1 in Figure 5-2 to position B, connecting the test oscillator output to the thermal converter input. Connect the digital voltmeter to the 400E/EL DC OUTPUT terminals.

CAUTION

SET TEST OSCILLATOR OUTPUT TO MINIMUM BEFORE CONNECTING. REDUCE OSCILLATOR OUTPUT BEFORE CHANGING FREQUENCY RANGE. DO NOT ALLOW OSCILLATOR OUTPUT TO EXCEED RATED INPUT OF THERMAL CONVERTER. ANY OVERLOAD MAY DESTROY THERMAL CONVERTER.

- c. Set the 400E/EL RANGE switch to 3 millivolts (.003 volts) and the oscillator to 10Hz. Connect a precision 40dB coaxial attenuator between the BNC "T" connector and the 400E/EL INPUT.
- d. Using the oscillator amplitude control as coarse adjustment and resistor R4 as a fine

adjustment, set the oscillator output so that the thermal converter output nulls the reference supply output.

- e. Repeat step d for each frequency listed in Table 5-2. If the 400E/EL is within specifications, the meter indication and the dc output will be within the tolerances listed in the table.

- f. Recalibrate the 10mV reference supply according to the procedures in Paragraph 5-17 using a 0.45 volt thermal converter and a 0.3162 volt output from the dc standard.

CAUTION

SET TEST OSCILLATOR OUTPUT TO MINIMUM BEFORE CONNECTING. REDUCE OSCILLATOR OUTPUT BEFORE CHANGING FREQUENCY RANGE. DO NOT ALLOW OSCILLATOR OUTPUT TO EXCEED RATED INPUT OF THERMAL CONVERTER. ANY OVERLOAD MAY DESTROY THERMAL CONVERTER.

- g. Set the 400E/EL RANGE switch to .001 volts and set the test oscillator to 10Hz. Connect a precision coaxial 50dB attenuator between the BNC "T" and the 400E/EL INPUT.
- h. Using the oscillator amplitude control as coarse adjustment and resistor R4 (Figure 5-2) as fine adjustment, increase the oscillator amplitude until the thermal converter output nulls the reference supply. Observe the 400E/EL meter indication and dc output.

- i. Repeat step h for each frequency listed in Table 5-3. If the 400E/EL is within specifications, the meter indication and the dc output will be within the tolerances listed in Table 5-3.
- j. Place the 400E/EL RANGE switch to .003V and repeat step h at 1/3 scale using the frequencies listed in Table 5-2.

—————NOTE—————

Refer to paragraph 5-46 for an alternate calibration accuracy check.

5-24. INPUT IMPEDANCE CHECK.

5-25. Input Resistance Check.

- a. Connect the 50 ohm output of the test oscillator to the input of the 400E/EL.
- b. Set the test oscillator and the 400E/EL to the 3 volt range. Set the oscillator output to 40Hz, and adjust the output for a full scale indication.
- c. Connect a 100 kilohm resistor between the test oscillator output and the 400E/EL input as shown in Figure 5-3.
- d. The 400E/EL indication should not drop more than one small scale division from full scale. This verifies an input resistance of 10 megohms.

5-26. Input Capacitance

- a. Connect a test oscillator, a 100 kilohm resistor, and the 400E/EL as shown in Figure 5-3. Insert the resistor lead directly into the BNC connector on the 400E/EL, and connect the ground lead to the outer shield of the 400E/EL input connector. Do not use an adapter, as any adapter will add input capacity.
- b. With the 400E/EL on the 3 volt range, adjust the test oscillator for 3 volt reading on the 400E/EL at 40Hz.
- c. Increase the test oscillator frequency until the 400E/EL indication drops to 2.12 volts. This should occur at a frequency of 132kHz or greater, verifying an input capacity of 12pF or less on the 3 volt range.

- d. Repeat steps a and b with the 400E/EL on the 1 volt range.
- e. Increase the test oscillator frequency until the 400E/EL indication drops to 0.707 volts. This should occur at a frequency of 63.5kHz or greater, verifying an input capacity of 25pF or less on the 1 volt range.

5-27. AC TO DC CONVERTER OUTPUT IMPEDANCE CHECK.

5-28. Proceed as follows:

- a. Connect an -hp- 651B or 652A Test Oscillator through a 50 ohm load to the input of the 400E/EL.
- b. Connect a dc digital voltmeter to the dc output of the 400E/EL located on the rear panel. Set the 400E/EL to the 3 volt RANGE.
- c. Set the oscillator frequency to 100kHz and the OUTPUT ATTENUATOR to 3 volts.
- d. Adjust the oscillator amplitude to read 1.000 volts on the digital voltmeter at the dc output.
- e. Place a 1000 ohm $\pm 1\%$ metal film resistor (-hp- part number 0757-0280) across the dc output of the 400E/EL. The voltage should read between 0.475 and 0.525 volts. This verifies that the dc output impedance is 1000 ohms $\pm 5\%$.

5-29. AC OUTPUT VOLTAGE CHECK.

5-30. Proceed as follows:

- a. Connect an oscillator (651B or 652A) to the input of the 400E/EL through a 50 ohm load. Connect an ac digital voltmeter (-hp- (3403C) to the ac output of the 400E/EL.
- b. Place the 400E/EL and the oscillator on the one volt range.
- c. Adjust the oscillator's amplitude for full scale deflection on the 400E/EL meter. The ac digital voltmeter should read 150 mV $\pm 10\%$ from 10 Hz to 4 MHz.
- d. Decrease the range of the oscillator and 400E/EL to 100 mV and 10 mV, repeating Step c for each voltage.

- e. Place the oscillator and the 400E/EL on the 1 mV range. Increase the oscillator's amplitude for full scale deflection on the 400E/EL meter. The ac digital voltmeter should read $105\text{mV} \pm 10\%$.

5-31. CONCLUSION OF PERFORMANCE CHECKS.

NOTE

When the 400E/EL has passed these checks it has met its specifications listed in Table 1-1.

5-32. ALIGNMENT AND CALIBRATION PROCEDURE.

NOTE

The location of adjustments on A2 depends on the applicable board revision (see Pages 7-2 and 7-3).

5-33. The calibration adjustments are "cover off" procedures to adjust the 400E/EL to its performance specifications. If the instrument cannot be properly adjusted, refer to the Troubleshooting Procedures (Paragraph 5-48). Figure 5-4 shows the location of all the internal adjustments.

5-34. COVER REMOVAL.

5-35. To remove the top or bottom covers, remove the Phillips screws holding the cover, slide the cover about 1 inch to the rear, and lift it off. To replace the cover, reverse the removal procedure. If it is necessary to remove a side cover, remove the four Phillips screws and lift it off.

NOTE

Connect a dc voltmeter to TP1. The voltage should be $+26 \pm 2\text{V}$. Connect a dc voltmeter to TP2. The voltage should read $-26 \pm 2\text{V}$. If these voltages are not correct refer to Troubleshooting Paragraph 5-48.

5-36. BIAS ADJUST.

5-37. Connect a dc voltmeter to TP3 and adjust A2R17 for $-6.0 \pm 0.25\text{Vdc}$. Connect a dc voltmeter to TP4 and adjust A2R31 for $+10.0 \pm 1\text{Vdc}$.

5-38. AC OUTPUT ZERO.

5-39. Connect a dc voltmeter to TP5 and adjust A2R59 for $0.0 \pm 0.050\text{Vdc}$.

5-40. CALIBRATION.

NOTE

If a 400E/EL Option 02 is to be

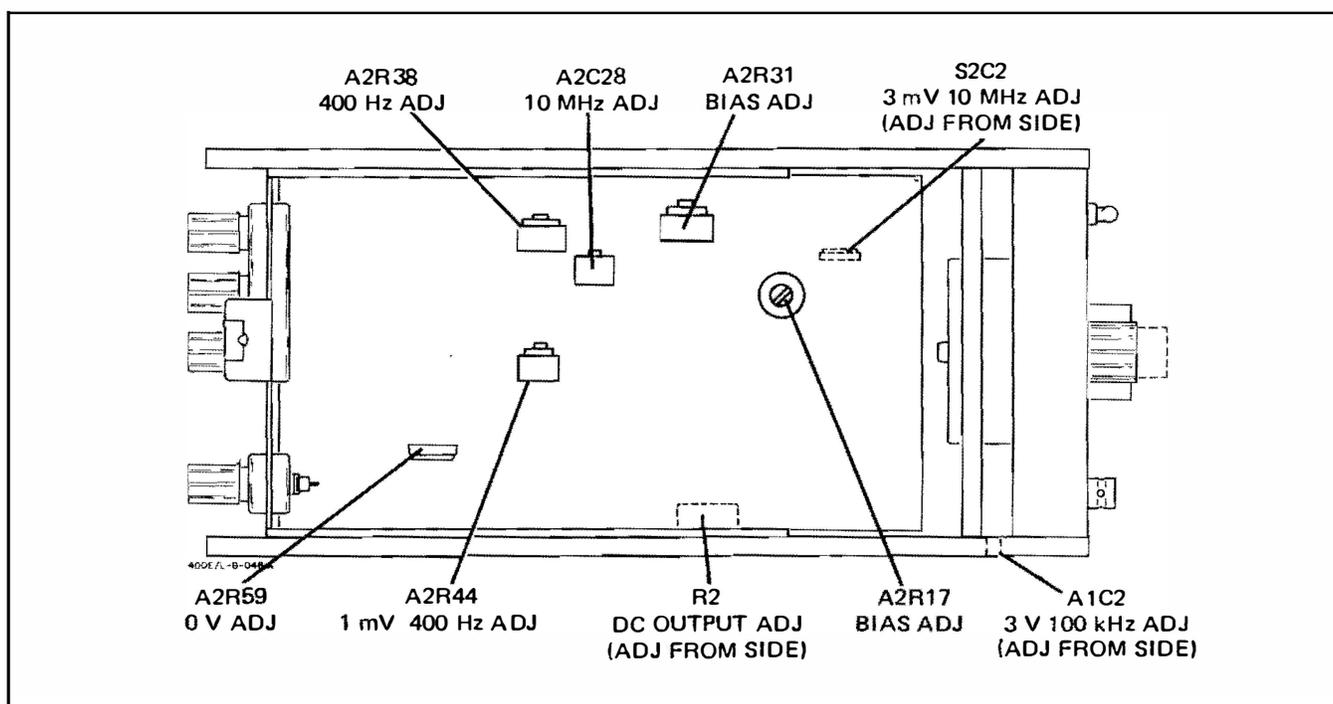


Figure 5-4. Location of Internal Adjustments

calibrated, set the REL. REF adjustment to the fully clockwise ABSOLUTE position before beginning the calibration. Always check and set the bias levels first before calibration.

5-41. Accuracy and Frequency Response Calibration.

- a. Calibrate the reference supply in Figure 5-2 with a 1 volt thermal converter according to the steps in Paragraph 5-17.
- b. Disconnect the standard and connect the test oscillator, the 400E/EL, and the digital voltmeter as shown in Figure 5-2. Connect a precision 40dB coaxial attenuator between the BNC "T" connector and the 400E/EL INPUT. When the thermal converter and reference supply outputs are nulled, the input to the 400E/EL will be 10mV. Set the oscillator frequency to 400Hz and the 400E/EL to the 0.01 volt range. Using the amplitude control as coarse adjustment and R4 as fine adjustment, increase the oscillator output until the thermal converter output nulls the reference supply.
- c. Adjust A2R38 for a 400E/EL meter reading of 10mV ± 0.1 mV or less.
- d. Adjust R2 for a digital voltmeter display of 1.000 ± 0.005 Vdc or less.
- e. Lower test oscillator output and set frequency to 10MHz. Readjust oscillator amplitude until thermal converter output nulls reference supply.
- f. Adjust A2C28 for digital voltmeter display of 1.000 ± 0.04 or less.
- g. Lower test oscillator output and set the frequency to 10 MHz. Disconnect the precision 40 dB attenuator and connect a precision 50 dB attenuator in its place. When the thermal converter and the reference supply are nulled, the input to the 400E/EL will be 3.162 mV. Set the 400E/EL RANGE to 0.003 volts.
- h. Using the amplitude control as a coarse adjustment and R4 (Figure 5-2) as a fine adjustment, increase the oscillator output until the thermal converter exactly nulls the reference supply output.

- i. Adjust S2C2 for a digital voltmeter indication of 1.000 ± 0.04 Vdc. The 400E/EL should read 3.16 ± 0.158 mV.

NOTE

Check at 6 and 4MHz. Amplitude can be lowered at 4MHz by moving A2C11 and C13 closer together.

- j. Lower the test oscillator output and set the frequency to 400Hz. Replace the 1 volt thermal converter with a 0.45 volt thermal converter, and calibrate it according to the procedure in Paragraph 5-17 using a 0.3162 volt output from the dc standard.
- k. Disconnect the dc standard and connect the test oscillator to the thermal converter as shown in Figure 5-2. Set the 400E/EL range switch to 0.001 volts. Using the amplitude control as a coarse adjustment and R4 as a fine adjustment, increase the oscillator output until the thermal converter output exactly nulls the reference supply output. At null, the input to the 400E/EL will be 1 mV at 400Hz.
- m. Adjust A2R44 for a digital voltmeter display of 1.000 ± 0.005 Vdc.

NOTE

The voltage at TP 4 affects frequency response. If the frequency response is low at 10 and 20 Hz decrease voltage at TP4 (extreme limits 8 to 12 volts). After changing voltage at TP4, check high and low frequency response.

- n. If the accuracy and frequency response can not be brought into specifications with the preceding adjustments, refer to Table 5-11 Factory Selected Components.

5-42. Calibration Procedure Using -hp- 745A/746A Calibrator.

5-43. Calibrate the 400E/EL for frequencies from 10Hz to 110kHz with the test setup shown in Figure 5-1.

- a. Set the 745A to the voltage levels and frequencies listed in Table 5-5, Alternate Calibration Procedure (omit steps 2 and 3). Select the proper 400E/EL range.

Table 5-5. Alternate Calibration Procedure

STEP	400E/EL RANGE	CALIBRATION SIGNAL	ADJUSTMENT	400E/EL INDICATION	
				METER	DC OUTPUT
1	0.01V	10mV 400Hz	A2R38	10mV \pm 0.1mV	
			R2		1.000 \pm 0.005Vdc
2	0.01V	10mV 10MHz	A2C28	10mV \pm 0.5mV	1.000 \pm 0.05Vdc
3	0.003V	3 mV 10 MHz	S2C2	3mV \pm 0.15mV	0.949 \pm 0.047Vdc
4	0.001V	1mV 400Hz	A2R44	1mV \pm 0.01mV	1.000 \pm 0.005Vdc
5	3V	3V 100kHz	A1C2	3V \pm 0.03V	0.949 \pm 0.004Vdc

b. With the adjustment components listed in Table 5-5 adjust within the specified error. For steps 2 and 3 the adjustment procedure in Paragraph 5-41 or 5-47 must be used because of frequency.

c. If the accuracy can not be brought into specifications refer to Table 5-11 Factory Selected Components.

5-44. Attenuator Alignment.

- Use the setup shown in Figure 5-2 to align the attenuator. Calibrate the reference supply according to the procedures in Paragraph 5-17 using a 3 volt thermal converter.
- Disconnect the dc standard and connect the test oscillator and 400E/EL as shown in Figure 5-2. Set the oscillator frequency to 100kHz and the 400E/EL to the 3 volt range. Using the amplitude control as coarse adjustment and R4 as fine adjustment, increase the oscillator output until the thermal converter output nulls the reference supply.
- Adjust A1C2 in the 400E/EL for a meter reading of 3.00 \pm 0.03 volts or less.

5-45. Alternate Calibration and Performance Check.

5-46. The following alternate procedure can be used for both a Performance Check and for calibration. The alternate procedure uses an -hp- Model 738BR voltmeter calibrator to generate a 400 Hz signal from 300 volts to .3 millivolts. The accuracy of this calibrator is 0.2% at 300 volts and 0.3% using the attenuator. For greater accuracy the calibrator output can be monitored by the ac differential voltmeter and the

AC INTERNAL CALIBRATION adjustment can be used to adjust the calibrator output to the accuracy of the ac differential voltmeter. Each time the calibrator voltage range is changed the output must be monitored and adjusted. Do not readjust the calibrator below the 50 millivolt range.

5-47. This 400 Hz voltage is used as a reference to set up the 652A for a frequency response test from 10 Hz to 10 MHz at voltages up to 3 volts.

- Connect the circuit as in Figure 5-5 position A. Place the ac differential voltmeter to 300 volts (maximum sensitivity) and place the calibrator to 400Hz rms, 300 volts.
- Adjust the AC INTERNAL CALIBRATION for an exact reading on the differential voltmeter.
- Connect the circuit as in Figure 5-5 position B. The 400E/EL should read 300 volts \pm 1% or \pm 3 volts. The dc output should be .949 \pm 0.0047.
- Change the calibrator and ac differential voltmeter to 100 volts. Connect as in Figure 5-5 position A. Adjust the AC INTERNAL CALIBRATION for an exact reading on the differential voltmeter.
- Connect the circuit as in position B with the 400E/EL on the 300V range. The 400E/EL meter and dc output should read within the tolerances in Table 5-2 for 1 volt input on the 3 volt range.
- Change the 400E/EL to the 100 volt range. Use the tolerances in Table 5-2 for 1 volt input on the 1 volt range.

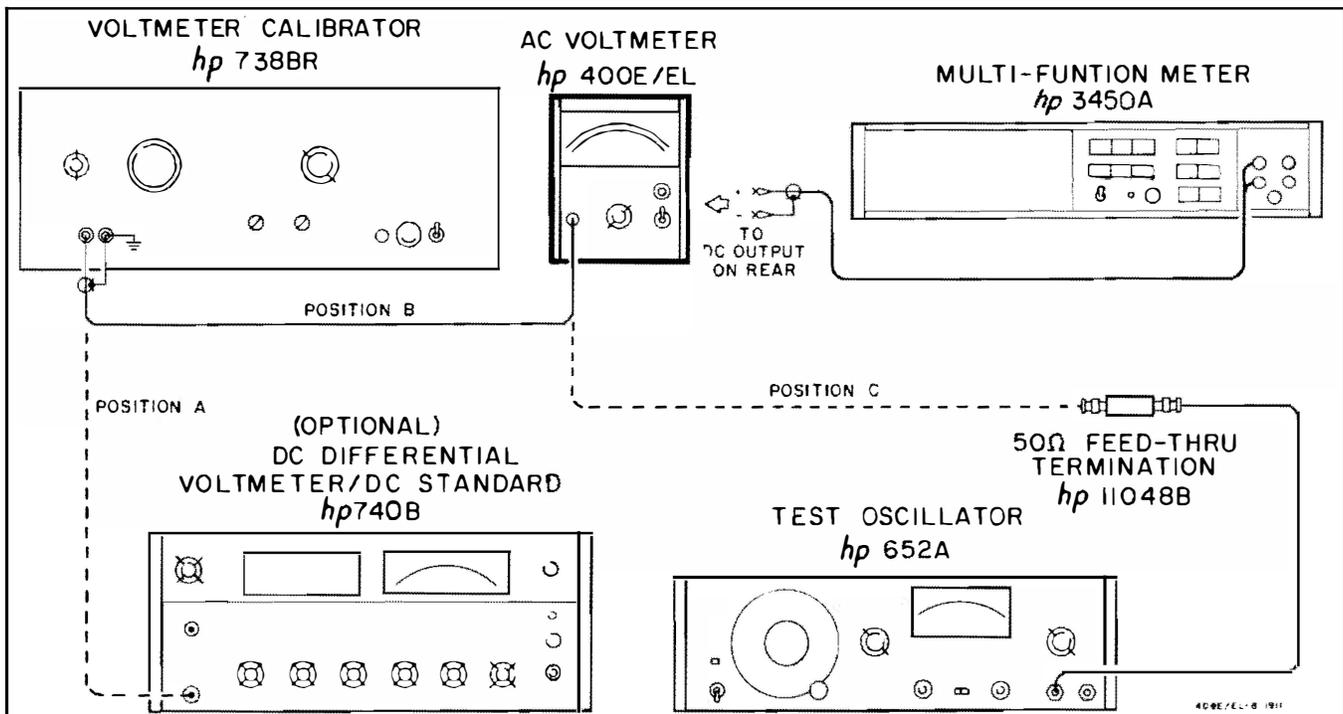


Figure 5-5. Alternate Calibration and Frequency Test Setup

- g. Repeat steps d and e for each range of the 400E/EL checking full scale and 1/3 full scale for each descending range.
- h. On the 3 volt range record the reading on the 400E/EL meter and dc output.
- i. Connect the circuit as in Figure 5-5 position C.
- j. Adjust the amplitude of the test oscillator at 400Hz to the value recorded in step h.
- k. Set the test oscillator to the EXPAND scale position and adjust the REF. SET for a 0% or 0dB reading on the meter.
- m. Change the frequency to those in Table 5-2 and readjust the oscillator AMPLITUDE to 0% or 0dB. The 400E/EL dc output should read within the tolerance for that frequency, range and voltage input. Adjust the oscillator's fine control for an exact meter reading on the 400E/EL. The % reading on the oscillator's meter should be within tolerance.
- n. Repeat steps h thru m for descending ranges at full scale and 1/3 full scale using the appropriate tables for tolerances. Below 50mV do not use Figure 5-5 position A as the calibrator is more accurate than the differential voltmeter at these low voltages.
- p. For checking the accuracy of the 1 mV range of the 400E/EL use tolerances listed in Table 5-3.
- q. 1 mV 4MHz is calibrated by dressing the white/orange/yellow jumper wire between the second attenuator and input to the meter amp. Moving the jumper wire towards the deck lowers the response. Set RESPONSE 1.5% high with the bottom cover off. The installation of the cover will lower the response by 1.5%. See Figure 6-2 for location of the white/orange/yellow jumper wire.
- r. If the 400E/EL is out of specifications at a frequency, adjust the component listed in Table 5-5 for a 400E/EL meter and dc output reading within the proper tolerance. Use the range specified for adjustment.

NOTE

The 654A Test Oscillator can be used in place of the 652A Test Oscillator for an output of 1 volt or less. The accuracy is 0.5% without readjusting the amplitude at each change of frequency.

Table 5-6. Troubleshooting Tips

SYMPTOM	PROBABLE TROUBLE
1. No response to input signal	1. Fuse A2F1 open. Check power supply voltages. Check AC signal according to Paragraphs 5-53 through 5-55 to isolate the area of trouble.
2. Low B+ voltage at TP1 or Low B- voltage at TP2	2. Disconnect jumper wire. Measure resistance to ground at both jumper terminals. If 10 ohms on the meter side, C16 or C19 is shorted, if 100 ohms, C35 or C29 is shorted; if zero, C8 or C9 is shorted. Disconnect R20 and R28 to isolate the Impedance Converter. If low resistance is on power supply side refer to Paragraph 5-51 and Table 5-7.
3. Low gain at high frequencies	3. Check A2C22 for open if 10% low. Lift A2C39 and check for oscillations; if no oscillations check A2Q15 and 16.
4. High gain at high frequencies	4. Check A2C30 for an open.
5. Low full scale readings	5. Check A2CR15 and A2CR16.
6. Instrument will not range above 1 volt but works OK at 1 volt and below	6. Relay A1 K1 stuck in closed position.
7. Instrument will not range below 3 volts but works OK on 3 volt range and above	7. Relay K2 stuck in closed position.
8. TP3 voltage can not be adjusted properly	8. Extreme condition: check A2Q5, Q6 and Q7. Small variation: change value of A2R18*. (Refer to Table 5-11).
9. TP5 voltage can not be adjusted properly	9. AC output circuit. Check A2Q15 and Q16. Refer to Paragraph 5-58 and Table 5-11.
10. TP4 voltage can not be adjusted properly	10. Meter Amplifier Circuit. Check A2Q8 thru Q13.
11. TP4 voltage varies and meter needle wobbles	11. Isolate by shorting A2C17 to ground. If voltage at TP4 still varies the trouble is in the Meter Amplifier. Refer to Paragraph 5-54 and Table 5-9. If voltage is constant the trouble is in the Impedance Converter. Refer to Paragraph 5-55 and Table 5-8.
12. Low line transients	12. Check A2Q3 and Q4. (If an old instrument change A2Q4, A2R73 and R74 to current part number). Check A2CR20 and CR21.
13. Transients on range change (1V to 3V)	13. Match reverse resistance of A2CR9 and CR10. Check S2CR1 and S2CR2. Check relays.
14. Peaking at 5MHz (10%)	14. Isolate by disconnecting orange wire to switch. Voltage at pin 21 should be same as input. Refer to Paragraph 5-55 or 5-56.
15. Voltage slightly low on 1mV range	15. Change value of A2R72* (refer to Table 5-11).
16. Low voltage (10 and 20Hz) near full scale	16. Check A2Q13. Change value of A2C31* (Table 5-11). Check A2C10 and C20.

5-48. TROUBLESHOOTING.

5-49. These procedures should only be performed when the 400E/EL can not be calibrated according to procedures in Paragraphs 5-32 through 5-47. If the

400E/EL is slightly out of specifications and can not be corrected by the proper adjustment, refer to Table 5-11 Factory Selected Values. If the 400E/EL is inoperative or completely out of specifications proceed as follows:

- a. Check the instrument for any obvious evidence of trouble, such as loose or broken wires or broken connectors. Check for burnt or loose components or separations or cracks in the printed circuit boards. Ensure that all pins are clean.
- b. Isolate the trouble to a particular circuit using the block diagram Figure 4-1 and the schematic Figure 7-1. Then refer to the troubleshooting steps for that circuit. Table 5-6 gives some probable troubles for specific symptoms.

NOTE

Test voltages in this section and on the schematic are nominal. A tolerance of ± 10% is allowable and more when stated.

5-50. POWER SUPPLY.

5-51. Check with a dc voltmeter (3450B) at TP1 and TP2 for + 26 volts and - 26 volts respectively. If the TP voltages are improper, check the voltages listed in Table 5-7. If the voltage for a given component is wrong, the trouble is probably in that component or its associated circuit.

Table 5-7. Power Supply Voltages

COMPONENT	VOLTAGE
Collector Q1	+39V
Collector Q2	+26.5V
Emitter Q2	+6.98V
Base Q3	-0.6V
Collector Q3	-23.5V
Collector Q4	-39V

5-52. AMPLIFIERS.

5-53. Set the 400E/EL to the 1 volt range, and connect a full scale input. With a sensitive ac voltmeter, monitor the ac amplifier output at the negative side of A2C34 or A2C36. The output should be 150mV. If it is not 150mV, measure the ac voltage at A2 pin 22. The voltage at pin 22 should be 3mV. If these two voltage readings are correct, the meter amplifier and meter bridge are operating properly.

5-54. If the voltage at pin 22 is low, pull the wht/orn/yel wire from pin 22, and measure the ac signal at the wire. It should be 3mV. If the voltage on the wire is proper, the trouble is in the meter

amplifier. If it isn't correct, the trouble is either in the Post Attenuator or the Impedance Converter.

5-55. To check the Impedance Converter, measure the ac voltage at its output (A2 pin 21). The output voltage should be very close to the input voltage since the Impedance Converter is a unity gain amplifier. With a 1 volt input, the output should be 0.98 volts ±0.02 volts.

5-56. Both the Impedance Converter and the meter amplifier are internally dc coupled. If the dc voltages anywhere in the amplifier are incorrect, the amplifier won't operate properly. Consequently a check of the dc voltages is a good check of the amplifiers.

5-57. Tables 5-8 and 5-9 contain the dc voltages on all of the transistors in the meter amplifier and the Impedance Converter. If the measured voltage on a given transistor is wrong, the trouble is probably in that transistor or its associated circuit.

NOTE

Measure these dc voltages with the input shorted. A dc voltmeter with low input capacitance and very high input resistance must be used. The -hp- Model 3450B is recommended. All dc voltages are ± 10% except where otherwise stated.

Table 5-8. Impedance Converter Voltages

TRANSISTOR	E	B	C
Q5	(S) -6V	(G)*	(D) -14.6V
Q6	-15.3V	-14.6V	-7.4V
Q7	-6.7V	-7.4V	-21.5V
*Cannot be measured.			

Table 5-9. Meter Amplifier Voltages

TRANSISTOR	E	B	C
Q8	+19V ±20%	19.5V ±20%	+25.5V
Q9	+0.02V	+0.57V	+8.5V
Q10	+8.2V	+8.5V	+1.8V
Q11	+0.9V	+1.9V	+8.5V
Q12	+9V	+8.5V	+0.7V
Q13	+0.7V	0	-4.6V
Q14*	+3V	+3.5V	+26V
*In bridge circuit.			

5-58. AC OUTPUT CIRCUIT.

5-59. To check the ac output circuit, measure the dc voltages at the points shown in Table 5-10. If a given measured voltage is incorrect, the trouble is probably in that component or its associated circuit.

Table 5-10. AC Voltage Output Circuit.

TRANSISTOR	E	B	C
Q15	+ 0.62 V	+ 1.3 V	+ 5 V
Q16	0	+ 0.62 V	+ 5 V

5-60. ADJUSTMENT OF FACTORY SELECTED COMPONENTS.

5-61. Certain components within the Model 400E/EL are individually selected in order to compensate for slightly varying circuit parameters. These components are denoted by an asterisk (*) on the schematic, and the typical value is shown. Table 5-11 describes the function of the factory selected components and gives instructions for their selection. Normally, these components do not need to be changed unless another associated component is changed. Replacement of a transistor, for example, may require the changing of a factory selected component.

Table 5-11. Factory Selected Components.

COMPONENT	FUNCTION AND SELECTION
A1R4*	29 to 45.3 ohms. Adjusts high frequency response on the 3 volt range. For low readings on the 3 volt range at high frequencies, increase resistance.
A2C24*	0 to 24 pF. Adjust 8 and 10 MHz frequency response. Normally not loaded. Used to raise response. 5 pF 0160-0763 12 pF 0140-0201 24 pF 0160-0196
A2C31*	18 to 22 μ F. Adjusts 10 and 20 Hz frequency response on all ranges. Increasing the capacitance increases the response.
A2C32*	39pF to zero. Affects 10 MHz response.
A2R18*	36 kilohms to 68 kilohms. Adjusts the bias level at A2Q5 due to FET variables. When A2R17 will not adjust voltage at TP3 to - 6 volts. If the voltage at TP3 is too negative, increase the resistance of R18*.
A2R22*	294 ohms. Adjust high frequency response at 4 MHz. For high readings at 4 MHz increase the resistance of R22.
A2R50*	2320 to 3320 ohms. Adjusts low frequency response on the 1 and 3 mV ranges. For high readings at 10 and 20 Hz on the 1 and 3 mV ranges decrease the resistance of R50. Also affects high frequency response.
A2R51*	133 to 187 ohms. Adjusts frequency response at 10 MHz.
S2C1*	10 pF to 24 pF 500 V. Adjusts the high frequency response on the .01 V and 3 V ranges.
S2C3*	5 pF or 10 pF 500 V. Adjust the high frequency response on the 1 V and 300 V ranges.
A2R72*	110 - 182 ohms. Adjusts to range of the 1 mV, 400 Hz adjustment, A2R44. If readings are low and A2R44 will not bring the amplitude within specifications, decrease the resistance of R72.
S2C4*	1.8 to 6.8 μ F, 35 vdcw. Adjusts 10 Hz frequency response on the 1 mV and 3 mV ranges. Increasing capacitance increases response.

PERFORMANCE CHECK TEST CARD

hp Model 400E/EL

Test performed by: _____

AC Voltmeter

Date: _____

Serial No. _____

1. Accuracy Check

INPUT SIGNAL		SPECIFICATION		INDICATION		
Range	Voltage	Frequency	Meter (V)	DC Output (V)	Meter	DC Output
3 V	300 V	10 Hz 400 Hz 100 kHz 1 MHz 4 MHz 10 MHz	3.00 ± 0.15 ± 0.03 ± 0.03 ± 0.03 ± 0.09 3.00 ± 0.15	0.949 ± 0.047 ± 0.0047 ± 0.0047 ± 0.0095 ± 0.047 0.949 ± 0.047		
3 V	1.00 V	10 Hz 400 Hz 100 kHz 1 MHz 4 MHz 10 MHz	1.00 ± 0.10 ± 0.03 ± 0.03 ± 0.03 ± 0.06 1.00 ± 0.15	0.316 ± 0.032 ± 0.0032 ± 0.0032 ± 0.0063 ± 0.032 0.316 ± 0.032		
1 V	1.00 V	10 Hz 400 Hz 100 kHz 1 MHz 4 MHz 10 MHz	1.00 ± 0.05 ± 0.01 ± 0.01 ± 0.01 ± 0.03 1.00 ± 0.05	1.00 ± 0.05 ± 0.005 ± 0.005 ± 0.010 ± 0.05 1.00 ± 0.05		
1 V	0.30 V	10 Hz 400 Hz 100 kHz 1 MHz 4 MHz 10 MHz	0.30 ± 0.032 ± 0.01 ± 0.01 ± 0.01 ± 0.02 0.30 ± 0.032	0.30 ± 0.033 ± 0.0033 ± 0.0033 ± 0.0065 ± 0.033 0.30 ± 0.033		
3 V	0.30 V	10 Hz 400 Hz 100 kHz 1 MHz 4 MHz 10 MHz	0.30 ± .015 ± .003 ± .003 ± .003 ± .009 0.30 ± .015	0.949 ± 0.047 ± 0.0047 ± 0.0047 ± 0.0095 ± 0.047 0.949 ± 0.047		
3 V	0.10 V	10 Hz 400 Hz 100 kHz 1 MHz 4 MHz 10 MHz	.100 ± .01 ± .003 ± .003 ± .003 ± .006 .100 ± .01	0.316 ± 0.032 ± 0.0032 ± 0.0032 ± 0.0063 ± 0.032 0.316 ± 0.032		

INPUT SIGNAL		SPECIFICATION		INDICATION		
Range	Voltage	Frequency	Meter Reading (V)	DC Output (V)	Meter	DC Output
.1 V	0.10 V	10 Hz 400 Hz 100 kHz 1 MHz 4 MHz 10 MHz	.100 ± .005 ± .001 ± .001 ± .001 ± .003 .100 ± .005	1.00 ± 0.05 ± 0.005 ± 0.005 ± 0.010 ± 0.05 1.00 ± 0.05		
.001 V	0.001 V	10 Hz 400 Hz 100 kHz 1 MHz 4 MHz	.001 ± .00005 ± .00001 ± .00001 ± .00005 .001 ± .00005	1.00 ± 0.05 ± 0.005 ± 0.005 ± 0.02 ± 0.05		
.001 V	0.0003 V	10 Hz 400 Hz 100 kHz 1 MHz 4 MHz	.0003 ± .000032 ± .00001 ± .00001 ± .000032 .0003 ± .000032	0.30 ± 0.033 ± 0.0043 ± 0.0043 ± 0.013 ± 0.033		

SECTION VI

REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-3 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.

6-3. Miscellaneous parts are listed at the end of Table 6-3.

6-4. ORDERING INFORMATION.

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office. (See Sales and Service for list of office locations.) Identify parts by their Hewlett-Packard part numbers.

6-6. NON-LISTED PARTS.

6-7. 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.

Table 6-1. Standard Abbreviations.

ABBREVIATIONS			
Ag	silver	Hz	hertz (cycles per second)
Al	aluminum	ID	inside diameter
A	ampere(s)	imp	impregnated
Au	gold	incd	incandescent
C	capacitor	ins	insulation(s)
cer	ceramic	kΩ	kiloohm(s) = 10 ⁺³ ohms
coef	coefficient	kHz	kiloherzt = 10 ⁺³ hertz
com	common	L	inductor
comp	composition	lin	linear taper
conn	connection	log	logarithmic taper
dep	deposited	mA	milliampere(s) = 10 ⁻³ amperes
DPDT	double-pole double-throw	MHZ	megahertz = 10 ⁺⁶ hertz
DPST	double-pole single throw	MΩ	megohm(s) = 10 ⁺⁶ ohms
elect	electrolytic	metfilm	metal film
encap	encapsulated	mfr	manufacturer
F	farad(s)	ms	millisecond
FET	field effect transistor	mtg	mounting
fxd	fixed	mV	millivolt(s) = 10 ⁻³ volts
GaAs	gallium arsenide	μF	microfarad(s)
GHz	gigahertz = 10 ⁺⁹ hertz	μs	microsecond(s)
gd	guarded	μV	microvolt(s) = 10 ⁻⁶ volts
Ge	germanium	my	Mylar
gnd	grounded	nA	nanoampere(s) = 10 ⁻⁹ amperes
H	henry(ies)	NC	normally closed
Hg	mercury	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
		pA	picoampere(s)
		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
		vcw	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
			® Dupont de Nemours
DESIGNATORS			
A	assembly	FL	filter
B	motor	HR	heater
BT	battery	IC	integrated circuit
C	capacitor	J	jack
CR	diode or thyristor	K	relay
DL	delay line	L	inductor
DS	lamp	M	meter
E	misc electronic part	MP	mechanical part
F	fuse	P	plug
		Q	transistor
		QCR	transistor-diode
		R(p)	resistor(pack)
		RT	thermistor
		S	switch
		T	transformer
		TB	terminal board
		TC	thermocouple
		TP	test point
		TS	terminal strip
		U	microcircuit
		V	vacuum tube, neon bulb, photocell, etc.
		W	wire
		X	socket
		XDS	lampholder
		XF	fuseholder
		Y	crystal
		Z	network

Table 8-2. Code of Manufacturers.

Mfr. No.	Manufacturer Name	Address
00853	Sangamo Elec Co	Pickens, SC 29671
01121	Allen-Bradley Co	Milwaukee, WI 53204
01281	TRW Semiconductors, Inc.	Lawndale, CA 90260
03292	Corning Glass Work	Bradford, PA 16701
03877	Transitron Electric Corp	Wakefield, MA 01880
03888	Pyrofilm Resistor Co, Inc	Whippany, NJ 07981
04062	Arco Electronic Inc	Great Neck, NY 11022
04200	Sprague Electric Co	North Adams MA 01247
04713	Motorola Semiconductor Prod Div	Phoenix AZ 85062
05820	Wakefield Engineering Inc	Wakefield, MA 01880
06486	Kaurz-Kasch Inc	Daton, OH 45401
07263	Fairchild Semiconductor Div	Mountain View, CA 94042
07910	Continental Device Corp	Hawthorne, CA 90250
11236	Cts of Berne, Inc	Berne, IN 46711
14433	ITT Semiconductor Div	West Palm Beach FL 33480
16299	Elec Component Div	Raleigh, NC 27604
19701	Mepco/Electra Corp	Mineral Wells, TX 76067
24446	General Electric Co	Schenectady, NY 12305
26365	Gries Reproducer Corp	New Rochelle, NY 10804
28480	Hewlett-Packard Co	Palo Alto, CA 94304
56289	Sprague Electric Co	North Adams MA 01247
70563	Amperite Co, Inc	Union City, NJ 07083
70903	Belden Mfg Co	Chicago, IL 60622
71400	Bussmann Mfg Div	St. Louis, MO 63121
72136	Electro-Motive Mfg Co Inc	Willimantic, CT 06226
72982	Erie Technological Products, Inc	Erie, PA 16512
73138	Beckman Instruments Helipot Div	Fullerton, CA 92634
75042	TRW Inc Philadelphia Div	Philadelphia, PA 19108
75915	Littlefuse, Inc	Des Plaines, IL 60016
78189	Illinois Tool Works Shakeproof Div	Elgin, IL 60120
78553	Tinnerman Products, Inc	Cleveland, OH 44141
81856	Kemlite Laboratories	Chicago, IL 60622
82142	Jeffers Electronics Division	Du Bois, PA 15801
82389	Switchcraft, Inc	Chicago, IL 60630
83385	Central Screw Co	Chicago, IL 60622
86684	RCA Electronic Corp & Devices Div	Harrison, NJ 07029
90201	Mallory Capacitor Div	Indianapolis, IN 46206
91418	Radio Materials Co	Chicago, IL 60622
93332	Semiconductor Div Sylvania Elec	Waburn MA 02158
95712	Dage Electric Co., Inc	Franklin, IN 46131

Table 6-3. Replaceable Parts.

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1	00400-66521	1	PC Board Ass'y:input attenuator	-hp-	
C1	0150-0024	1	C: fxd cer 20,000pF +80% -20% 600vdcw	72982	841-000-D5 203Z
C2	0121-0168	1	C: var 0.25 - 1.5 pF 600 Vdcw	72982	530-007
C3	0160-2208	1	C: fxd mica 330 pF 5%	72136	obd
C4	0140-0198	2	C: fxd mica 200pF ±5%	00853	RDM15F201J3C
C5,C6	0160-3847	2	C: fxd cer 0.01 μF +100 -0% 25 vdcw	-hp-	0160-3847
R1	0683-1005	1	R: fxd comp 10 ohms ±5% 1/4W	01121	CB1005
R2	0698-4128	1	R: fxd prec met flm 10.0 megohm ±1/4% 1/2W	03888	PME70
R3	0698-4129	1	R: fxd prec met flm 31723 ohms ±0.1% 1/2W	19701	MF5C T-3
R4*	0757-0388	1	R: fxd flm 30.1 ohms ± 1% 1/8W 3W	-hp-	0757-0388
R5,R6	0684-1021	1	R: fxd comp 1000 ohms ± 10% 1/4W	01121	CB1021
K1	0490-1205	1	Switch Assy: Reed and Coil	28480	0490-1205
K2	0490-1203	1	Switch Assy: Reed and Coil	28480	0490-1203
A2	00400-66521	1	PC Board Ass'y	-hp-	
C1,C2	0180-0149	2	C: fxd Al elect 65uF +100% -10% 60 vdcw	56289	Type 30D D36978
C3	0150-0050	2	C: fxd cer 1000pF 600 vdcw	01281	Type E
C4	0180-0142	2	C: fxd Al elect 20uF +100% -10% 25 vdcw	56289	Type 40D D36039
C5	0180-0061	1	C: fxd elect 100uF +100% -10% 15 vdcw	56289	30D107G015DD4
C6	0180-0100	5	C: fxd Ta elect 4.7uF ±20% 35 vdcw	14433	SM4 7NF
C7	0180-0142	3	C: fxd Al elect 20uF +100% -10% 25 vdcw	56289	Type 40D D36039
C8,C9	0180-0101	3	C: fxd Ta elect 1.8uF ±20% 35 vdcw	14433	SM1.8NF
C10	0150-0084	1	C: fxd cer 0.1uF +80% -20% 50 vdcw	72982	845-222Y5V0104Z
C11	0180-0119	1	C: fxd elect 1uF +75% -10% 25 vdcw	56289	30D105G025BA2-DSM
C12	0140-0193	1	C: fxd mica 82pF ±5%	04062	RDM15E820J3C
C13	0180-0137	2	C: fxd Ta elect 100uF ±20% 10 vdcw	81856	K100J108
C14	0180-0059	1	C: fxd elect 10uF +100% -10% 25 vdcw	56289	30D106G025BB4
C15	0140-0190	2	C: fxd mica 39pF ±5%	00853	RDM15E390J3C
C16	0180-1735	2	C: fxd Ta elect 0.22uF +10% 35 vdcw	56289	150D224X9035A2
C17	0180-1780	1	C: fxd Al elect 500uF +75% -10% 10 vdcw	56289	39D507G010EJ4
C18*	0180-0373	1	C: fxd Ta elect .68 μF ± 10% 35vdcw	04200	150D68rX9035A2
C19	0150-0121	1	C: fxd cer. 0.1 μF + 80 -20% 50 vdcw	56289	5C50BIS-CML
C20*	0180-1793	1	C: fxd Al elect 450uF +30% -10% 3 vdcw	56289	30D595 DSM
C21	0150-0093	2	C: fxd cer durez coated disc 0.01uF +80% -20% 10 vdcw	91418	TA
C22	0180-0100	1	C: fxd Ta elect 4.7uF ±10% 35 vdcw	14433	SM4.7NF
C23	0140-0198	1	C: fxd mica 200pF ±5%	00853	RDM15F201J3C
C24*		1	See Table 5-11		
C25	0150-0015	1	C: fxd TiO 2.2pF ±10% 500 vdcw	82142	Type JM
C26	0150-0093	1	C: fxd cer durez coated disc 0.01uF +80% -20% 100 vdcw	91418	TA
C27			Not assigned		
C28	0121-0036	1	C: var cer 5 - 18 pF	72982	538-006 5.5 - 18
C29	0180-0100	1	C: fxd Ta elect 4.7uF ±10% 35 vdcw	14433	SM4.7NF
C30	0140-0202	1	C: fxd mica 15pF ±5%	00853	RDM15C150J5C
C31*	0180-1779	2	C: fxd Ta elect 18 μF 35 vdcw	56289	150D186X9035R2
C32*	0140-0203	2	C: fxd mica 30pF ±5% 500 vdcw	72136	DM15E300J0500WV1CR
C33	0180-1779	2	C: fxd Ta elect 18uF 35 vdcw	56289	150D186X9035R2
C34	0180-0354	2	C: fxd Ta elect 40uF ±5% 10 vdcw	56289	150D406X5010B2
C35	0150-0093	1	C: fxd cer durez coated disc 0.01uF +80% -20% 100 vdcw	04062	RDM15E820J3C
C36	0180-0354	1	C: fxd Ta elect 40uF ±5% 10 vdcw	56289	150D406X5010B2
C37	0180-0137	1	C: fxd Ta elect 100uF ±20% 10 vdcw	81856	K100J108

Table 6-3. Replaceable Parts (Cont'd).

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
C38	0180-0100		C: fxd Ta elect 4.7uF ±10% 35 vdcw	14433	SM4. 7NF
C39	0180-0155	1	C: fxd Ta elect 2.2uF ±20% 20 vdcw	56289	150D225X0020A2
C40	0180-0064	1	C: fxd elect 35uF +100% -10% 6 vdcw	56289	30D346G006BB4
C41	0180-0100		C: fxd Ta elect 4.7uF ±10% 35 vdcw	14433	SM4. 7NF
C42,C43	0150-0122	2	C: fxd cer 2000pF ±20% 500 vdcw	72982	801-000-Y5S-202M
C44	0150-0050		C: fxd cer 1000pF 600 vdcw	01281	Type E
C45*	0140-0199		C: fxd mica 240 pF 5%	00853	obd
C46*	0140-020*		C: fxd 12 pF 500 V	72136	obd
CR1 thru CR6	1901-0033	6	Diode: Si 100mA at 1V 180 wiv 13pF	93332	D6238
CR7	1902-3125	1	Diode: Si breakdown 6.98V ±2% 400mW	06486	
CR8	1901-0025	3	Diode: Si 100mA at +1V 100 piv 12pF	93332	D3072
CR9,CR10	1901-0044	2	Diode: Si 20mA at 1V 10mA at -10V 50 wiv 2pF	07910	SF42
CR11	1901-0025		Diode: Si 100mA at 1V 100 piv 12pF	93332	D3072
CR12	1902-3222	3	Diode: Si breakdown 17.4V ±5% 400mW	06486	SZ10939-251
CR13	1902-0182	1	Diode: breakdown 20.5V ±5% 400mW	06486	
CR14	1902-3179	1	Diode: Si breakdown 11.8V ±5% 400mW	06486	obd
CR15,CR16	1901-0347		Diode: Si 20mA at +1V 1.5pF	-hp-	
CR17,CR18	1902-3090	2	Diode: breakdown 4.99V	04713	SZ10939-94
CR19	1902-0677		Diode: breakdown 15V ±5% 100pF 400mW	07263	FZ1641
CR20,CR21	1902-3222		Diode: breakdown 17.4V ±5%	068486	SZ10939-251
CR22	1901-0025		Diode: Si 100mA at 1V 100 piv 12pF	93332	D3072
F1	2110-0301		Fuse: .125A 125V	28480	2110-0301
Q1	1854-0030	1	TSTR: Si NPN 2N3053	04713	2N3053
Q2	1205-0033	2	Heat disapator semiconductor for A2Q1	05820	NF-207
Q3	1854-0033	2	TSTR: Si NPN 2N3391	24446	2N3391
Q4	1853-0062	1	TSTR: Si PNP 2N3645	07263	2N3645
Q5	1853-0006	1	TSTR: Si PNP 2N3134	04713	2N3134
Q6	1205-0033		Heat disapator semiconductor for A2Q4	05820	NF-207
Q7	1855-0082	1	TSTR: Si FET P-Channel	-hp-	
Q8	1854-0073	2	TSTR: Si NPN 2N3478	86684	2N3478
Q9	1853-0009	2	TSTR: Si PNP**	-hp-	
Q10	1205-0018	1	Heat disapator semiconductor for A2Q7	05820	NF-203
Q11	1854-0033		TSTR: Si NPN 2N3391	24446	2N3391
Q12,Q13	1854-0272	1	TSTR: Si NPN**	-hp-	
Q14 thru Q16	1853-0009		TSTR: Si PNP**	-hp-	
R1	1854-0073		TSTR: Si NPN 2N3478	86684	2N3478
R2,R3	1853-0010	2	TSTR: Si PNP**	-hp-	
R4	1854-0057	3	TSTR: Si NPN**	-hp-	
R5	0757-0794	2	R: fxd prec met flm 68 1 ohms ±1% 1/2W	75042	CEA T-O
R6	0683-2025	5	R: fxd comp 2000 ohms ±5% 1/4W	01121	CB2025
R7	0683-6825	1	R: fxd comp 6800 ohms ±5% 1/4W	01121	CB6825
R8	0698-4121	1	R: fxd prec met flm 11.3 kilohms ±1% 1/8W	19701	MF5C T-O
R9	0698-3155	1	R: fxd prec met flm 4640 ohms ±1% 1/8W	75042	CEA T-O
R10	0683-2025	5	R: fxd comp 2000 ohms ±5% 1/4W	01121	CB2025
R11	0757-0794		R: fxd prec met flm 68.1 ohms ±1% 1/2W	75042	CEA T-O
R12	0757-0447	1	R: fxd prec met flm 16.2 kilohms ±1% 1/8W	75042	CEA T-O
R13	0698-3156	1	R: fxd prec met flm 14.7 kilohms ±1% 1/8W	75042	CEA T-O
R14	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R15	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R16	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R17	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R18*	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R19	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R20	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R21	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R22*	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R23	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R24	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R25	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R26	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R27	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R28	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R29	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R30	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R31	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R32	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R33	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R34	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R35	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R36	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R37	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R38	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R39	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R40	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R41	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R42	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R43	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R44	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R45	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R46	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R47	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R48	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R49	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R50	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R51	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R52	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R53	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R54	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R55	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R56	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R57	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R58	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R59	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R60	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R61	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R62	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R63	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R64	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R65	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R66	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R67	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R68	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R69	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R70	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R71	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R72	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R73	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R74	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R75	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R76	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R77	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R78	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R79	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R80	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R81	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R82	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R83	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R84	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R85	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R86	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R87	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R88	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R89	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R90	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R91	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R92	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R93	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R94	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R95	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R96	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R97	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R98	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R99	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R100	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R101	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R102	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R103	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R104	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R105	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R106	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R107	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R108	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R109	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R110	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R111	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R112	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R113	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R114	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R115	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R116	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R117	0683-1215		R: fxd 120 ohms ±5% 1/4W	01121	CB1215
R118	0683-1215		R: fxd 120 ohms ±5% 1/4W		

Table 6-3. Replaceable Parts (Cont'd).

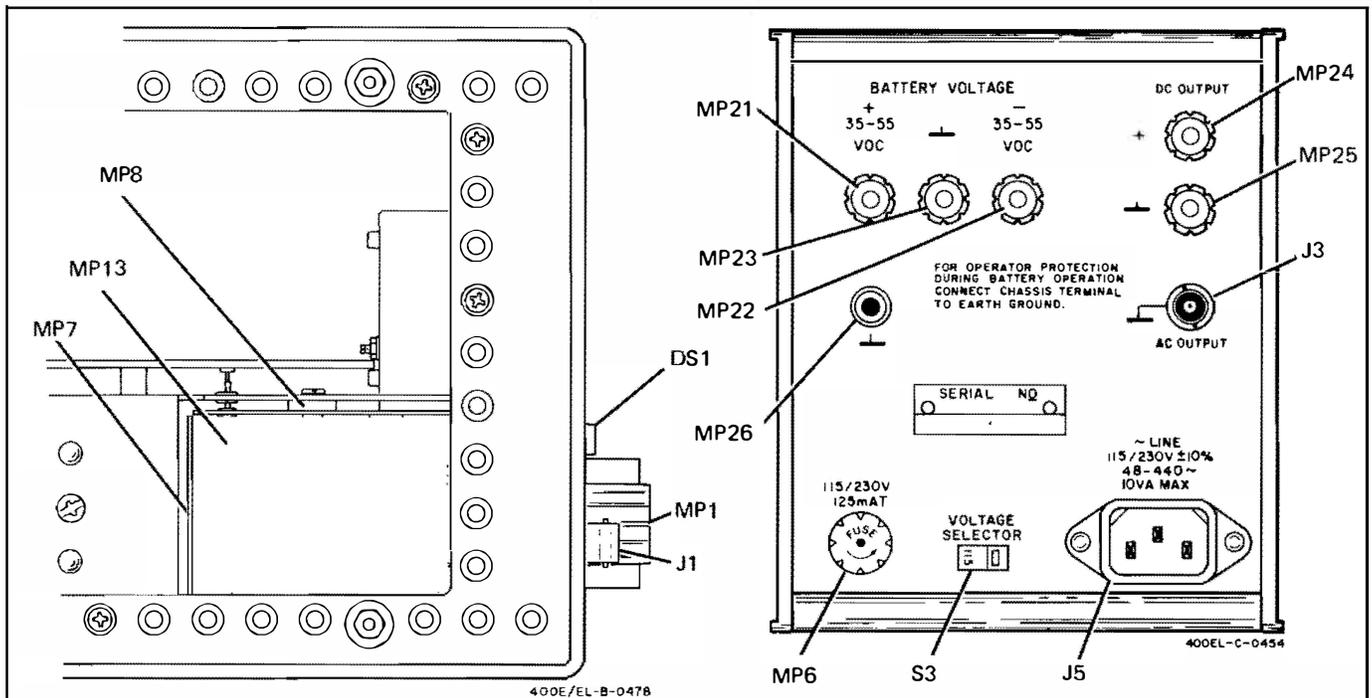
REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
R23,R24	0757-0434	2	R: fxd prec met flm 3650 ohms $\pm 1\%$ 1/8W	75042	CEA T-O obd
R25	0683-3915	2	R: fxd comp 390 ohms $\pm 5\%$ 1/4W	01121	C83915
R26	0698-4123	1	R: fxd prec met flm 499 ohms $\pm 1\%$ 1/8W	19701	MFFC T-O obd
R27	0683-2225	1	R: fxd comp 2200 ohms $\pm 5\%$ 1/4W	01121	CB2225
R28	0684-1001	1	R: fxd comp 10 ohms $\pm 10\%$ 1/4W	01121	CB1001
R29	0698-4422		R: fxd comp 1270 ohms $\pm 5\%$ 1/4W	03292	C4-1/8-TO-1271-F
R30	0698-2353	1	R: fxd met flm 196 kilohm $\pm 1\%$ 1/8W	75042	CEA obd
R31	2100-2522	1	R: var pot lin 10 kilohms $\pm 20\%$ 1/2 W	73138	62-227-1 obd
R32	0684-4721	1	R: fxd comp 4700 ohms $\pm 10\%$ 1/4W	01121	CB4721
R33	0757-0442	1	R: fxd met flm 10 kilohms $\pm 1\%$ 1/8W	75042	CEA T-O obd
R34	0698-3260	1	R: fxd met flm 464 kilohms $\pm 1\%$ 1/8W	75042	CEA T-O obd
R35	0757-0401	2	R: fxd met flm 100 ohms $\pm 1\%$ 1/8W	75042	CEA T-O obd
R36	0698-3179	1	R: fxd met flm	75042	CEA T-O obd
R37	0684-1011	3	R: fxd comp 100 ohms $\pm 10\%$ 1/4W	01121	CB1011
R38	2100-2632	1	R: var pot lin 100 ohms $\pm 10\%$ 1/2 W	73138	62-221-1 obd
R39	0757-0346	1	R: fxd met flm 10 ohms $\pm 1\%$ 1/8W	19701	MF5C T-O obd
R40	0698-3434	1	R: fxd met flm 34.8 ohms $\pm 1\%$ 1/8W	75042	CEA T-O obd
R41	0698-3147	1	R: fxd met flm 191 ohms $\pm 1\%$ 1/8W	75042	CEA obd
R42	0698-4126	1	R: fxd met flm 35.7 ohms $\pm 1\%$ 1/8W	19701	MF7C T-O obd
R43	0698-3262	1	R: fxd met flm 40.2 ohms $\pm 1\%$ 1/8W	75042	CEA T-O obd
R44	2100-2632	1	R: var lin 100 ohms $\pm 10\%$ 1/2 W	73138	62-221-1 obd
R45	0757-0381	1	R: fxd met flm 15 ohms $\pm 1\%$ 1/8W	75042	CEA T-O obd
R46	0757-0273	2	R: fxd met flm 3010 ohms $\pm 1\%$ 1/8W	75042	CEA obd
R47	0757-0410	1	R: fxd met flm 301 ohms $\pm 1\%$ 1/8W	75042	CEA T-O obd
R48	0757-0407	1	R: fxd met flm 200 ohms $\pm 1\%$ 1/8W	75042	CEA T-O obd
R49	0757-0273		R: fxd met flm 3010 ohms $\pm 1\%$ 1/8W	75042	CEA T-O obd
R50*	0698-4434	1	R: fxd met flm 2320 ohms $\pm 1\%$ 1/8W	75042	CEA obd
R51*	0757-0284	1	R: fxd met flm 150 ohms $\pm 1\%$ 1/8W	75042	CEA obd
R52	0684-1011		R: fxd comp 100 ohms $\pm 10\%$ 1/4W	01121	CB1011
R53	0757-0283	1	R: fxd met flm 2000 ohms $\pm 1\%$ 1/8W	75042	CEA obd
R54	0698-3358	1	R: fxd met flm 1000 ohms $\pm 1\%$ 1/8W	75042	CEA T-O obd
R55	0683-2025		R: fxd comp 2000 ohms $\pm 5\%$ 1/4W	01121	CB2025
R56	0698-4497	1	R: fxd met flm	19701	MF5C T-O obd
R57	0757-0428	1	R: fxd met flm 1620 ohms $\pm 1\%$ 1/2W	75042	CEA T-O obd
R58	0683-1035	1	R: fxd comp 10 kilohms $\pm 5\%$ 1/4W	01121	CB1035
R59	2100-0962	1	R: var comp pot lin 3000 ohms $\pm 30\%$ 1/4W	90201	MTC-1 obd
R60	0757-0459	2	R: fxd met flm 56.2 kilohms $\pm 1\%$ 1/8W	19701	MF4C obd
R61	0683-3335	1	R: fxd comp 33 kilohms $\pm 5\%$ 1/4W	01121	CB3335
R62	0757-0393	1	R: fxd met flm 47.5 ohm $\pm 1\%$ 1/8W	75042	CEA T-O obd
R63	0757-0401	1	R: fxd met flm 100 ohms $\pm 1\%$ 1/8W	75042	CEA T-O obd
R64	0757-0824		R: fxd met flm 2000 ohms $\pm 1\%$ 1/2W	75042	CEC T-O obd
R65	0698-4125	1	R: fxd met flm 953 ohms $\pm 1\%$ 1/8W	19701	MF5C T-O obd
R66	0757-0400	1	R: fxd met flm 90.9 ohms $\pm 1\%$ 1/8W	75042	CEA T-O obd
R67	0757-0413	1	R: fxd met flm 392 ohms $\pm 1\%$ 1/8W	19701	MF4C obd
R68,R69	0683-4325	2	R: fxd comp 4.3 kilohms $\pm 5\%$ 1/4W	01121	CB4325
R70	0757-0457	1	R: fxd met flm 47.5 kilohms $\pm 1\%$ 1/8W	75042	CEA T-O obd
R71	0757-0459		R: fxd met flm 56.2 kilohms $\pm 1\%$ 1/8W	75042	CEA T-O obd
R72*	0757-0402	1	R: fxd met flm 110 ohms $\pm 1\%$ 1/8W	19701	MF4C obd
R73,R74	0683-1525	2	R: fxd comp 1500 ohms $\pm 5\%$ 1/4W	01121	CB1525
R75	0684-1011		R: fxd comp 100 ohms 10% 1/4 W	01121	CB1011
	8150-3375	2	Shorting Wire: 22AWG, FORMED	75042	ZEROHM
CHASSIS MOUNTED COMPONENTS					
C1	0180-2151	1	C: fxd 500 μ F + 75% - 10%	56289	30D1610
DS1	1450-0574	1	DS: pilot indicator NE-2E neon in white plastic body	28480	1450-0574
F1	2110-0318	1	Fuse: 0.125 A 250 V slow blow	71400	MDL 1/8

Table 6-3. Replaceable Parts (Cont'd).

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
J1 J2 J3 J4 J5	1250-0118 1250-0118 1251-2357	2 1	Connector: BNC input front panel Connector: DC output(See Figure 6-1 for parts) Connector: BNC AC output rear panel Connector: battery (See Figure 6-1 for parts) Connector: power cord	95712 95712 82389	30384-1 30384-1 EAC-301
M1 M1 M1	1120-0919 1120-0902 1120-0908	1 1 1	Meter: Log (400EL and 400EL Option 02) Meter: Linear (400E and 400E Option 02) Meter: Linear (400E Option 01 only)	-hp- -hp- -hp-	
R1 R2	0687-3331 2100-0021		R: fxd comp 33 kilohms +10% 1/2W R: var ww 100 ohms +20% 1-1/2W	01121 11236	E B3331 112 obd
S1	3101-2147	1	S: tog SPST 3A 250 V ac-dc	28480	3101-2147
S2	00400-61901		Switch Ass'y: RANGE	-hp-	
C1* C2 C3* C4*	0160-0205 0130-0014 0160-0205 0180-0100		C: fxd 10 pF 500 V C: var cer 5-25pF C: fxd 10pF 500V C: fxd Ta elect 4.7 μ F + 10% 35 vdcw	72136 72982 72136 14433	557-062 COPO 39R SM4.7NF obd obd
CR1,CR2	1901-0040		Diode: 30mA at +1V 30 piv 2pF 2ns	03877	SC5050
R1 R2 R3 R4 R5	0757-0715 0757-0069 0757-0178 0698-4119 0698-4118		R: fxd met flm 150 ohms \pm 1% 1/4W R: fxd met flm 121 ohms \pm 1% 1/4W R: fxd met flm 100 ohms \pm 1% 1/4W R: fxd met flm 410.26 ohms \pm 0.1% 1/4W R: fxd met flm 277.48 ohms \pm 0.1% 1/4W	75042 75042 75042 19701 75042	CEA T-O CE8 T-O CEB T-O MF6C T-3 CEA T-O obd obd obd obd obd
R6 R7 R8 R9 R10	0698-4119 0698-4118 0698-4119 0698-4118 0698-4119		R: fxd met flm 410.26 ohms \pm 0.1% 1/4W R: fxd met flm 277.48 ohms \pm 0.1% 1/4W R: fxd met flm 410.26 ohms \pm 0.1% 1/4W R: fxd met flm 277.48 ohms \pm 0.1% 1/4W R: fxd met flm 410.26 ohms \pm 0.1% 1/4W	19701 75042 19701 75042 19701	MF6C T-3 CEA T-O MF6C T-3 CEA T-O MF6C T-3 obd obd obd obd obd
R11 R12 R13 R14	0698-4118 0698-4119 0698-4117 0683-4735		R: fxd met flm 277.48 ohms \pm 0.1% 1/4W R: fxd met flm 410.26 ohms \pm 0.1% 1/4W R: fxd met flm 189.72 ohms \pm 0.1% 1/4W R: fxd comp 47 kilohms \pm 5% 1/4W	75042 19701 75042 01121	CEA T-O MF6C T-3 CEA T-O CB4735 obd obd obd
S2	00400-61902	1	Switch Ass'y: RANGE (for Option 02 only) (Same as 00400-61901 with S4 added)	-hp-	
S3	3101-1234	1	Switch: slide DPDT 115/230 V rated 6A 259 VAC	82389	11A-1242A
S4 R1	2100-1723		P/O 00400-61902 ass'y R: var 200 kilohms \pm 20% log dB taper (Option 02 only)	-hp- 01121	Type V obd

Table 6-3. Replaceable Parts (Cont'd).

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
T1	9100-1321		Transformer: line	-hp-	
W1	8120-1348		Assy: cable AC power cord set	70903	KHS-7041
MECHANICAL PARTS (See Figure 6-1)					
MP1	0370-0112	1	Knob: bar w/one arrow black	-hp-	
MP2	0370-0113	1	Knob: bar (Option 02 only) 3/4 inch diam black	-hp-	
MP3	0370-0114	1	Knob: round red (Option 02 only) 5/8 inch diam	-hp-	
MP4			Not assigned		
MP5			Not assigned		
MP6	1400-0084	1	Holder: fuse extractor post type black	75915	342014
MP7	00400-05501	1	Shield box: attenuator	-hp-	
MP8	5040-4503	1	Grommet: insulator plastic	-hp-	
MP9	1490-0031	1	Stand: 1/3 module tilt	-hp-	
MP10	00400-00211	1	Panel: rear	-hp-	
MP11	00400-00217	1	Panel: front (400E and 400E Option 01)	-hp-	
MP11	00400-00220	1	Panel: front (400EL and 400EL Opt 01)	-hp-	
MP11	00400-00219	1	Panel: front (400E Opt 02)	-hp-	
MP11	00400-00221	1	Panel: front (400EL Opt 02)	-hp-	
MP12	5020-6852	1	Meter Trim: 1/3 module	-hp-	
MP13	00400-04101	1	Cover: shield box (attenuator)	-hp-	
MP14	5060-0703	2	Frame: 6 X 11 sub module	-hp-	
MP15	5060-0727	2	Foot Ass'y: 1/3 module	-hp-	
MP16	0590-0052	2	Nut: Tinnerman	78553	C-8020-632-24B
MP17	5000-5838	2	Bracket: cover retainer	-hp-	
MP18	00400-64103	1	Cover: top with handle	-hp-	
MP19	5000-8565	2	Cover: side 6 X 11 SM	-hp-	
MP20	5000-8571	1	Cover: bottom 5 X 11 SM	-hp-	
MP21, MP22	1510-0091		Bdg Post-Assy (grey/red)	-hp-	
MP23, MP24	1510-0107		Bdg Post-Assy (grey/black)	-hp-	
MP25	1510-0090		Bdg Post-Assy (grey)	-hp-	
MP26	1510-0038		Bdg Post-Single	-hp-	
MP27			Not Assigned		
MP28	5040-0700	1	Hinge: tilt stand 1/3 module	-hp-	
MP29	2190-0047	2	Lock washer: top cover	78189	1506-00
MP30	2370-0013	4	Screw: top and bottom cover phillips head 6-32	83385	obd
MISCELLANEOUS					
	0340-1512	4	Insulator: feed-thru	28480	0340-1512
	0380-0059	5	Spacer: captive (for PC board)	28480	0380-0059
	0360-0480		Terminal: pin matches with 1200-0162	70563	61038-1
	4330-0496	10	Beads: seed component standoff	000LP	215B
	1200-0162		Connector: pin receptical	70563	60804-1
	00400-01201	1	Ground strap	-hp-	
	00400-61602	1	Cable: power	-hp-	
	00400-64101	0	Kit: for cover with handle (includes hardware)	-hp-	
	7120-4609	1	Label-Warning 'Warning for Operator Protection'	-hp-	
	2950-0144	5	Nut-Hex-Dbi-Cham	26365	913891



LEFT SIDE VIEW

BACK VIEW

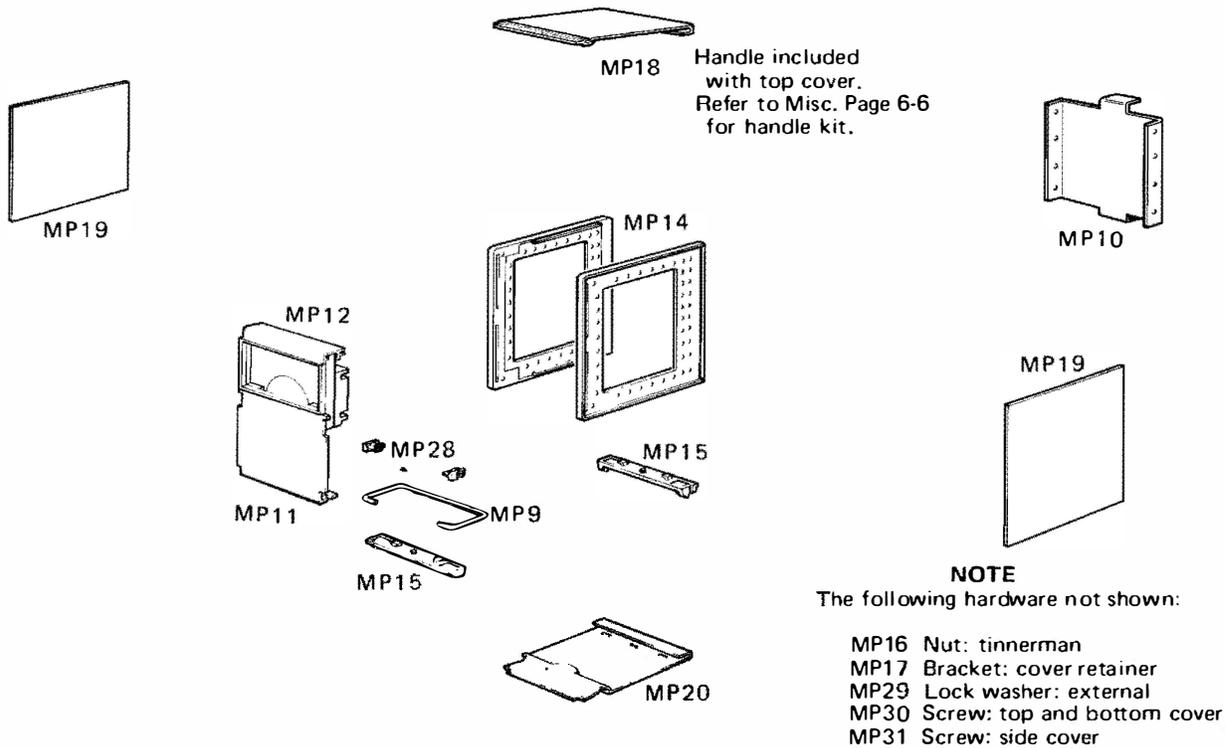


Figure 6-1. Mechanical Parts

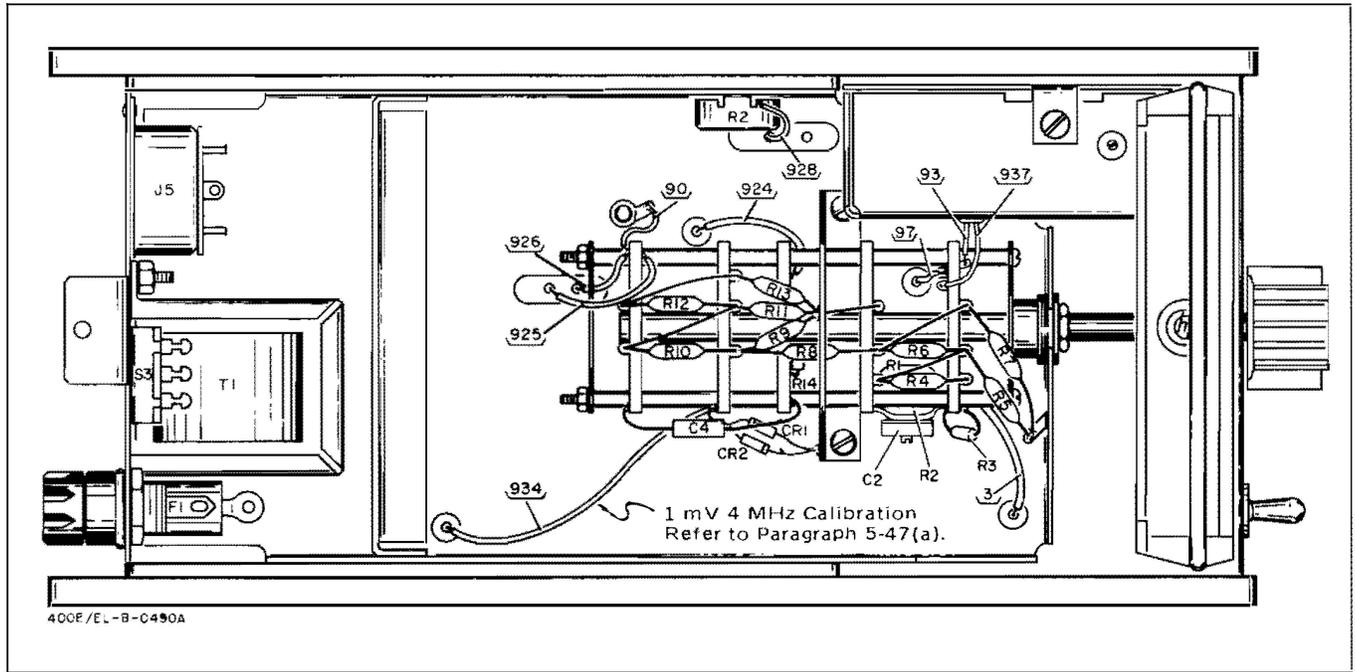


Figure 6-2. Chassis and Switch Components.

SECTION VII

CIRCUIT DIAGRAMS

7-1. INTRODUCTION.

7-2. This section contains a schematic diagram, component locator, and a PC board component

layout to be used for maintenance and operation of the 400 E/EL.

7-3 An explanation of terms and symbols used as reference designators is given in the Schematic Notes.

SCHEMATIC NOTES

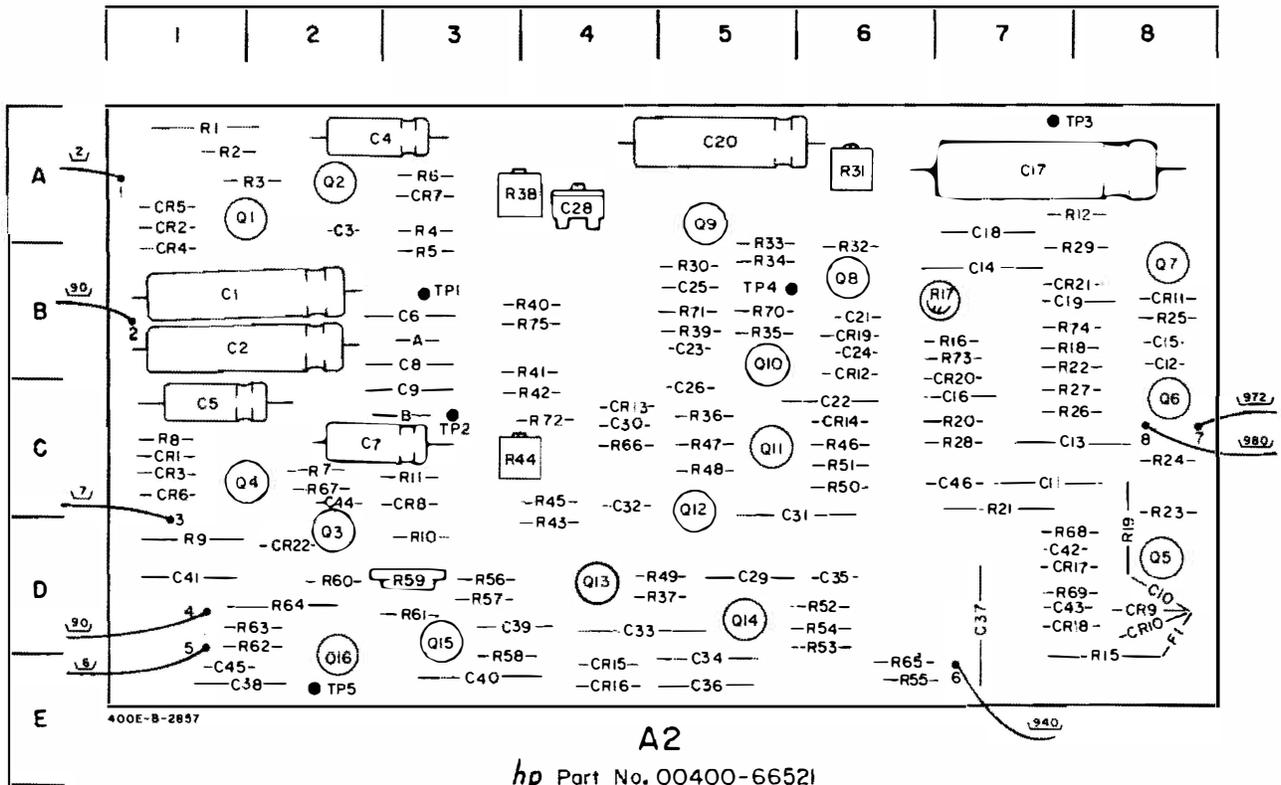
1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN: PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.
2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED:

RESISTANCE IN OHMS

CAPACITANCE IN MICROFARADS
3.  DENOTES ASSEMBLY.
 DENOTES MAIN SIGNAL PATH.
 DENOTES MAIN FEEDBACK PATH.
4. ALL DC VOLTAGES ARE $\pm 10\%$ EXCEPT THE BASE AND EMITTER OF Q8 WHICH IS $\pm 20\%$.
5. * AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY.
6. † REFER TO BACKDATING CHANGES IN APPENDIX C.
7. 918 DENOTES WIRE COLOR USING STANDARD COLOR CODE.
(e.g. 918 = WHITE, BROWN, GRAY)
8.  DENOTES POWER LINE GROUND.
9.  DENOTES CHASSIS GROUND.
10.  DENOTES CIRCUIT GROUND (ASSEMBLY).

A2 Board
Component Locations

	C	CR	Q	R	F		C	R		R
1	B1	C1	A1	A1	D8	26	C5	C7	51	C6
2	B1	A1	A2	A1		27	---	C7		
3	A2	C1	D2	A2					52	D6
4	A2	B1	C1	A3		28	A4	C7	53	F6
5	C1	A1	D8	B3		29	D5	B8	54	A7
6	B3	C1	C8	A3		30	C4	B5		
7	C2	A3	B8	C2		31	D5	A6	55	E6
8	B3	C3	B6	C1		32	C4	B6	56	D3
9	C3	D8	A5	D1		33	D4	B5	57	D3
10	D8	D8	B5	D3		34	E5	B5	58	E3
11	C7	B8	C5	C3		35	D6	B5	59	D3
12	B8	B6	C5	A7		36	E5	C5	60	D2
13	C7	C4	D4	---		37	D7	D4	61	D3
14	B7	C6	D5	---		38	E1	A3	62	D2
15	B8	E4	D3	E8		39	D3	B5	63	D2
16	C7	E4	E2	B7		40	E3	B4	64	D2
17	A7	D7		B7		41	D1	B4	65	E6
18	A7	D7		B7		42	D7	C4	66	C4
19	B8	B6		D8		43	D7	D4	67	C2
20	A5	C7		C7		44		C3	68	D7
21	B6	B7		C7		45	E1	C4	69	D7
22	C6	D2		B7		46		C6	70	B5
23	B5			C8		47		C5	71	B5
24	B6			C8		48		C5	72	C4
25	B5			B8		49		D4	73	B7
						50		C6	74	B7
									75	B4



SECTION VIII

MANUAL BACKDATING CHANGES

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 backdatingsheet, should be replaced using the part number given in the manual.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
536-00101 to -01100	1 thru 12, 14	All	12
536-01101 to -01350	2 thru 12, 14	1150A12354 to 1208A12853	13
536-01351 to -02403	3 thru 12, 14	1131A12603 and Earlier	14
536-02404 to -04253	4 thru 12, 14	400E 1208A07332 & Earlier 400EL 1208A16379 & Earlier	15
536-04254 to -04854	5 thru 12, 14	1208A18153 to 1131A12604	16
536-04855 to -05503	6 thru 12, 14	1208A18968 & Earlier	17
536-05504 to -08353	7 thru 12, 14	400E 1208A21368 & Earlier 400EL 1208A21319 & Earlier	18
536-08354 to -09153	8 thru 12, 14	400E 1208A21489 thru 23849 400EL 1208A21549 thru 23898	19
536-09154 to -09553	9 thru 12, 14	400E 1208A23848 & Earlier 400EL 1208A23898 & Earlier	20
949-09554 to -09753	10 thru 12, 14	400E 1208A24068 & Earlier 400EL 1208A24118 & Earlier	21
0949A11853 & Earlier	11, 12, 14	400E 1208A24128 & Earlier 400EL 1208A24168 & Earlier	22

CHANGE NO. 1 Transformer mounting and pin receptacles are different but current parts should be used.

Section VI Replaceable Parts and Figure 7-1 Schematic Diagram:

Change S2C2 to C: fxd 30 pF ± 5%; -hp- Part Number 0160-0181.

CHANGE NO. 2 Section VI Replaceable Parts and Figure 7-1 Schematic Diagram:

NOTE

If any of the parts listed in Change 2 are changed to values shown in Table 6-1 and Schematic Figure 7-1, app parts should be changed.

Change A2R44 to R*: fxd met flm 150 ohms \pm 1%; -hp- Part Number 0757-0284.

Change A2R16 to R: fxd comp 82 kilohms \pm 5%; -hp- Part Number 0683-8235.

Delete A2R72, A2R73, A2R74, A2CR20, A2CR21, A2C44.

Change A2Q3 to TSTR: Si PNP 2N3638; -hp- Part Number 1853-0016.

Change A2Q4 to TSTR: Ge PNP 2N1183; -hp- Part Number 1850-0064.

Change A2R67 to R: fxd comp 390 ohms \pm 5%; -hp- Part Number 0683-3915 and delete A2CR22.

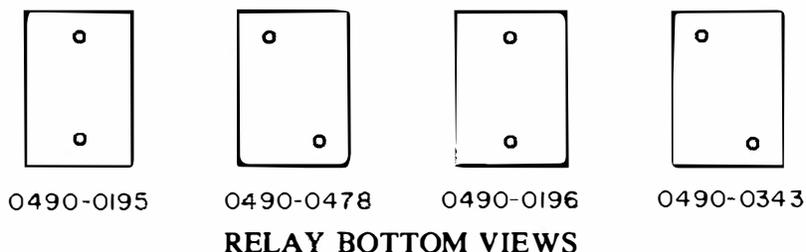
CHANGE NO. 3 Section VI Replaceable Parts and Figure 7-1 Schematic Diagram

Delete: A2R67 and A2CR22.

Change A2C12 to C: fxd 110 pF \pm 5%; -hp- Part Number 0140-0194.

CHANGE NO. 4 Section VI Replaceable Parts

00400-66502 printed circuit board has different location for relay connections: A1K1 and A1K2. Check configuration of relay connections and order part numbers shown according to location of relay terminals.



CHANGE NO. 5 Table 6-1 Replaceable Parts and Figure 7-1 Schematic:

Change A2Q5 to -hp- Part Number 1855-0068 and A2R16 to 82 kilohms \pm 5%, -hp- Part Number 0683-8325. If A2Q5 should be defective, replace both A2Q5 and A2R16 with latest part numbers to reduce noise.

CHANGE NO. 6 Table 6-1 Replaceable Parts and Figure 7-1 Schematic

Change A2R73, R74 to 4.7 kilohms, -hp- Part Number 0683-4725. Replace with latest part numbers to reduce noise produced by A2CR20 and CR21.

CHANGE NO. 7 Table 6-1 Replaceable Parts and Figure 7-1 Schematic.

Delete: A2R75.

CHANGE NO. 8 Table 6-1 Replaceable Parts and Figure 7-1 Schematic.

Delete: A2C45.

CHANGE NO. 9 Table 6-1 Replaceable Parts.

Change J5 connector power cord to -hp- Part Number 1251-0148.

Change Panel rear to 00400-00202.

Change Cord Assy power to 8120-0078.

- CHANGE NO. 10** Table 6-1 Replaceable Parts.
- Change S3 rear panel switch DPDT 115 V/230 V to -hp- Part Number 3101-0033.
- CHANGE NO. 11** Table 6-1:
- Change A2 Part Number to 00400-66501.
 Change A2C28 to 0130-0016 C: var cer 5-25 pF.
 Change A2R17 to 2100-0093 R: var comp 20 K \pm 20% 0.1 W.
 Change A2R31 to 2100-0092 R: var comp 10 K \pm 20% 0.15 W.
 Change A2R38 to 2100-0277 R: var comp 100 Ω \pm 20% 0.15 W.
 Change A2R44 to 2100-1836 R: var comp 100 Ω \pm 20% 0.1 W.
 Change MP27 to 00400-00603
- Page 7-3:
 Change the affected to reflect the above values.
- CHANGE NO. 12** The covers, panel and trim listed on Page 6-6 are for newer brown instruments. Parts for older blue instruments are listed below.
- MP11 00400-00201 Panel: front (400E and 400E Option 01)
 MP11 00400-00203 Panel: front (400EL and 400EL Option 01)
 MP11 00400-00204 Panel: front (400E Option 02)
 MP11 00400-00205 Panel: front (400EL Option 02)
 MP12 5020-5388 Meter trim: 1/3 module
 MP18 00400-64102 Cover: top with handle
 MP19 5000-0703 Cover: side 6 x 11 SM
 MP20 5000-0711 Cover: bottom 5 x 11 SM
- CHANGE NO. 13** Instruments that fall within this band of serial numbers have a 500 μ F capacitor across the output terminals. This capacitor made the meter response too slow and is no longer being used.
- CHANGE NO. 14** Table 6-1
- Change A1 to -hp- Part Number 00400-66502.
 Change A1C2 to 0121-0407; C: var 0.7 -3 pF.
 Change A1C3 to 0140-0149; C: fxd mica 470 pF \pm 5%.
 Change A1CR1, CR2 to A1C5, C6; 0150-0093; C: fxd cer 0.01 μ F.
 Change relays to: A1K1 0490-0194 Relay, Reed and A1K2 0490-0366 Relay, Reed.
 Delete coils for K1, K2.
 Change A2 to 00400-66511 PC Board Assembly (see drawings on Page 7-3).
 Change A2R22* to 0698-3510 R: fxd 453 ohms 1%.
 Delete S2C1, C3.
- CHANGE NO. 15** Page 6-3, Table 6-1. Delete A2R12.
 Page 7-2. Delete A2R12.
 Page 7-3, Figure 7-1. Delete A2R12. A2Q6 collector is directly connected to A2Q7 base.
- CHANGE NO. 16** Page 7-3, Figure 7-1. Delete the blue (6) jumper from A1 00400-66512 component locator drawing.

hp MANUAL CHANGES

-hp- MODEL 400E/EL

AC VOLTMETER

Manual Part Number 00400-90020

► New or Revised Item

Page 5-4, Table 5-3. Replace Table 5-3, Calibration Tolerances, with Table MC1 of this Change Sheet.

Table MC 1.

Frequency (Hz)	1 Millivolt Range Only			Frequency (Hz)	1 Millivolt Range Only		
	Voltage Input	Meter (mV) (% of reading)	DC Output (Volts)		Voltage Input	Meter (mV) (% of reading)	DC Output (Volts)
10	1.00 mV	1.00 ± 5%	1.00 ± 0.05	100 k	1.00 mV	1.00 ± 1%	1.00 ± 0.005
	0.5 mV	0.50 ± 7.6%	0.50 ± 0.038		0.5 mV	0.50 ± 2%	0.50 ± 0.0045
	0.3 mV	0.30 ± 10.8%	0.30 ± 0.033		0.3 mV	0.30 ± 3.3%	0.30 ± 0.0043
40	1.00 mV	1.00 ± 1%	1.00 ± 0.02	500 k	1.00 mV	1.00 ± 1%	1.00 ± 0.02
	0.5 mV	0.50 ± 2%	0.50 ± 0.015		0.3 mV	0.30 ± 3.3%	0.30 ± 0.013
	0.3 mV	0.30 ± 3.3%	0.30 ± 0.013				
100 or 400	1.00 mV 0.5 mV 0.3 mV	1.00 ± 1% 0.50 ± 2% 0.30 ± 3.3%	1.00 ± 0.005 0.50 ± 0.0045 0.30 ± 0.0043	4 M	1.00 mV 0.3 mV	1.00 ± 5% 0.30 ± 10.8%	1.00 ± 0.05 0.30 ± 0.033

CHANGE NO. 5 applies to all serial numbers.

Table 5-1. Required Test Equipment should have the following changes made:

- a. The AC Calibrator recommended model should be a Fluke 5200A and 5215A.
- b. The AC/DC Voltmeter recommended model should be an -hp- Model 3466.
- c. The DC Standard recommended model should be a Systron Donner Model M107A
- d. The Voltmeter Calibrator should be deleted from the table.

Page 5-2. Figure 5-1. Accuracy Test Setup, should be altered to show the use of the Fluke 5200A ACk Calibrator rather than the -hp-Model 745A.

Page 5-4. Figure 5-2. Accuracy and Frequency Response Test Setup, should be altered to show the use of the Systron Donner Model M107 DC Standard rather than the -hp- Model 740A.

Page 5-11. Figure 5-2. Delete paragraphs 5-45, 5-46, and 5-47.

Page 5-12. Delete Figure 5-5, Alternate Calibration and Frequency Test Setup.

hp MANUAL CHANGES

-hp- MODEL 400E/EL

AC VOLTMETER

Manual Part Number 00400-90020

Page 5-4, Table 5-3. Replace Table 5-3, Calibration Tolerances, with Table MC1 of this Change Sheet.

Table MC 1.

Frequency (Hz)	1 Millivolt Range Only			Frequency (Hz)	1 Millivolt Range Only		
	Voltage Input	Meter (mV) (% of reading)	DC Output (Volts)		Voltage Input	Meter (mV) (% of reading)	DC Output (Volts)
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	0.5 mV	0.50 ± 7.6%	0.50 ± 0.038		0.5 mV	0.50 ± 2%	0.50 ± 0.0045
	0.3 mV	0.30 ± 10.8%	0.30 ± 0.033		0.3 mV	0.30 ± 3.3%	0.30 ± 0.0043
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	0.3 mV	0.30 ± 3.3%	0.30 ± 0.013				
100 or 400	1.00 mV	1.00 ± 1%	1.00 ± 0.005	4 M	1.00 mV	1.00 ± 5%	1.00 ± 0.05
	0.5 mV	0.50 ± 2%	0.50 ± 0.0045		0.3 mV	0.30 ± 10.8%	0.30 ± 0.033
	0.3 mV	0.30 ± 3.3%	0.30 ± 0.0043				

CHANGE NO. 5 applies to all serial numbers.

Table 5-1. Required Test Equipment should have the following changes made:

- The AC Calibrator recommended model should be a Fluke 5200A and 5215A.
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- The DC Standard recommended model should be a Systron Donner Model M107A
- The Voltmeter Calibrator should be deleted from the table.

Page 5-2, Figure 5-1. Accuracy Test Setup, should be altered to show the use of the Fluke 5200A ACk Calibrator rather than the -hp-Model 745A.

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Page 5-11, Figure 5-2. Delete paragraphs 5-45, 5-46, and 5-47.

Page 5-12. Delete Figure 5-5, Alternate Calibration and Frequency Test Setup.

ERRATA

Page 6-3, Table 6-3 (Replaceable Parts). Change the -hp- Part Number of the A1 Assembly from "00400-66521" to "00400-66522".

CHANGE NO. 6. 400E: Applies to Serial Numbers 1208A28944 and Above.

400EL: Applies to Serial Numbers 1208A29014 and Above.

Section jVI, Table 6-3 (Replaceable Parts). Do the following changes in the table:

Ref. Des.	-hp- Part Number	Description
A2C47	0180-0100	Add 4.7µF 35V Capacitor
A2Q17	1853-0010	Add SM4713 PNP Transistor
A2Q18	1855-0093	Add F1748 N Channel JFET
A2R76	0683-1045	Add 100K ohms 5% 1/4W Resistor
A2R77*	0757-0274	Add 1.12K ohms 1% 1/8W Resistor
A2R77*	0698-3700	Add 715 ohms 1% 1/8W Resistor
A2R77*	0698-0410	Add 301 ohms 1% 1/8W Resistor
A2R78	0698-3458	Add 348K ohms 1% 1/8W Resistor

Section VII, Figure 7-1 (400 E/EL Schematic Diagram and Location of Components). Do the following changes in the figure.

Change the Meter Bridge to the bridge shown in Figure C-1.

Change the component locator of the A2 Assembly (-hp- Part Number 00400-66521) to the one shown in Figure C-2.

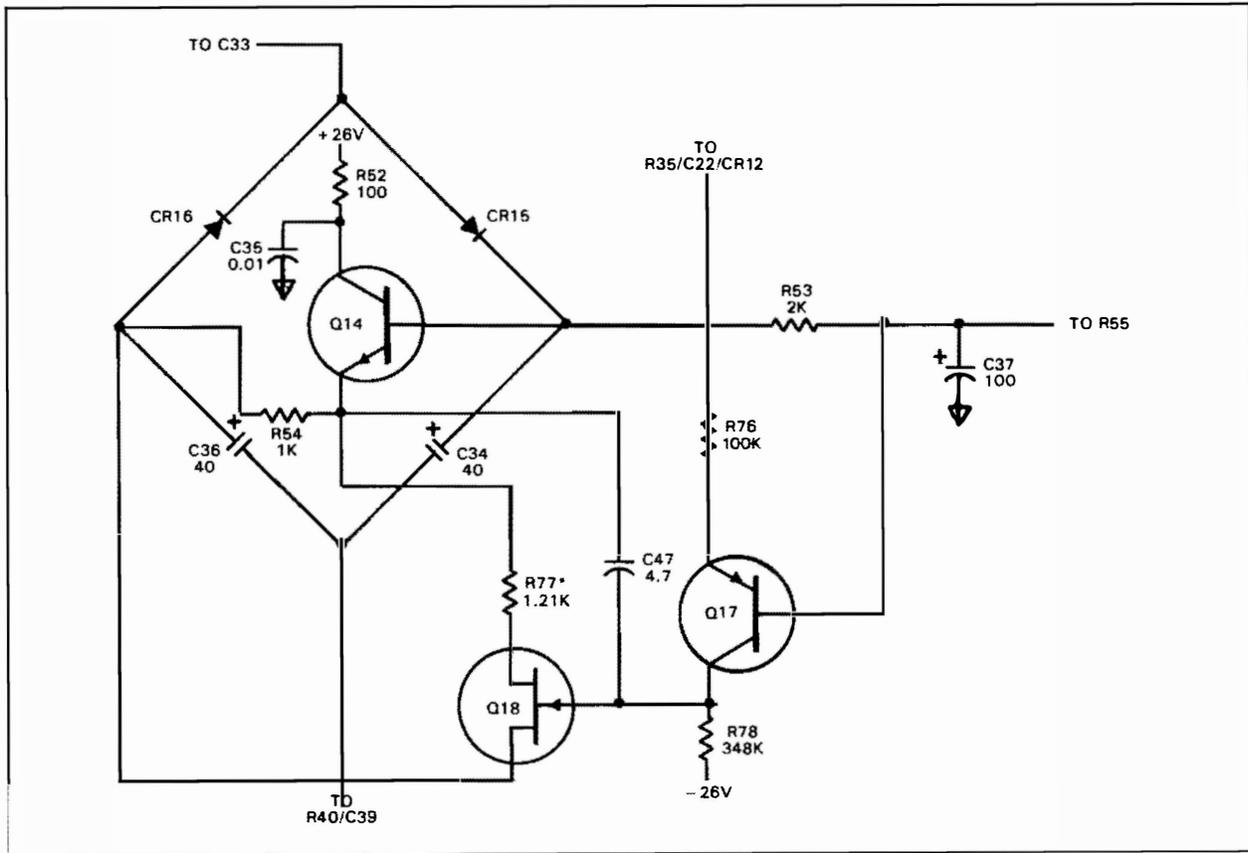


Figure C-1. Schematic Diagram Changes (Change #6)

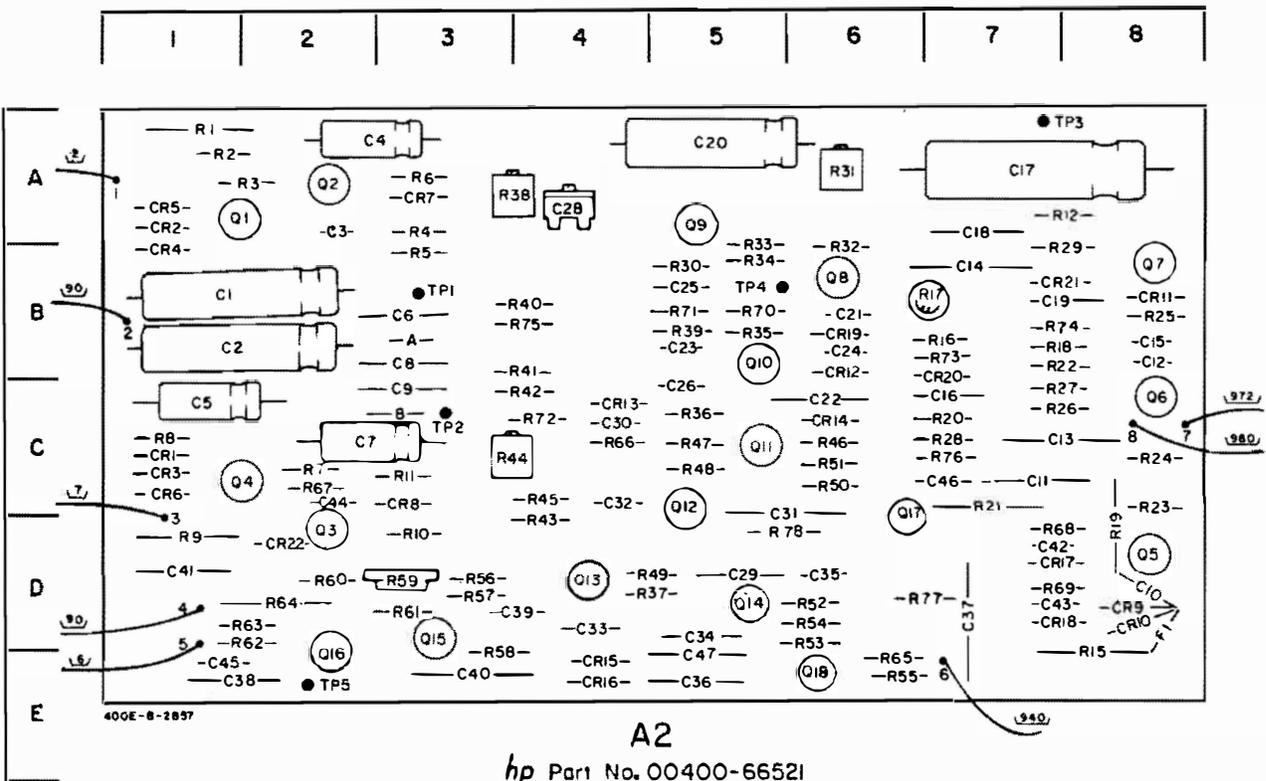


Figure C-2. A2 Assembly Component Locator Changes (Change #6)