OPERATING AND SERVICE MANUAL

VOLTMETER
427A

HEWLETT PACKARD

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OPERATING AND SERVICE MANUAL

MODEL 427A VOLTMETER

Serial Number 0947A16701 and greater

IMPORTANT NOTICE

Any changes made in instruments with serial numbers greater than those stated on this title page will be noted on a change sheet supplied with this manual. If the serial number of your instrument is lower than that stated above, the manual can contain revisions that do not apply to your instrument. Backdating information located in Appendix C adapts this manual to these instruments.

WARNING

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

Manual Part No. 00427-90008

Microfiche Part No. 00427-90058

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

Printed: June 1983

HEWLETT PACKARD

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.

WARRANTY

This Hewlett-Packard instrument product is warranted against defects in materials 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.

For warranty service or repair, this product must be returned to a service facility designated by -hp-. Buyer shall prepay shipping charges to -hp- and -hp- shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to -hp- from another country.

Duration and conditions of warranty for this instrument may be superceded when the instrument is integrated into (becomes a part of) other -hp- instrument products.

Hewlett-Packard warrants that its software and firmware designated by -hp- for use with an instrument will execute its programming instructions when properly installed on that instrument. Hewlett-Packard does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HEWLETT-PACKARD SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HEWLETT-PACKARD SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

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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HEWLETT PACKARD

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. This is a Safety Class 1 instrument.

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.

DO NOT OPERATE A DAMAGED INSTRUMENT

Whenever it is possible that the safety protection features built into this instrument have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the instrument until safe operation can be verified by service-trained personnel. If necessary, 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.

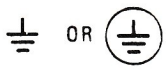
A

SAFETY SYMBOLS

General Definitions of Safety Symbols Used On Equipment or In Manuals.

Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.

Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).



Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating equipment.

Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of a fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating the equipment.

Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.

Alternating current (power line).

Direct current (power line).

Alternating or direct current (power line).

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, condition or the like, which,if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

NOTE: The NOTE sign denotes important information. It calls attention to procedure, practice, condition or the like, which is essential to highlight.

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION

1-2. The Hewlett-Packard Model 427A is a versatile, compact, self-contained voltmeter. It is capable of making dc measurements from 1 mV to 1000 volts, ac measurements from 0.3 mV to 300 volts at frequencies from 10 Hz to 1 MHz, and resistance measurements from 0.2 ohms to 500 megohms. With the 01 option, the Model 427A may be powered either by a 115 or 230 volt line or by an internal 22-1/2 volt dry cell battery.

1-3. The use of solid state components throughout gives the Model 427A both ruggedness and reliability. Battery operation makes the instrument ideal for field use or isolation from common mode ground loops.

1-4. Table 1-1 lists the specifications of the 427A which are the performance standards or limits against which the 427A can be tested.

1-5. BATTERY

1-6. The battery used in the Model 427A is a 22-1/2 volt dry cell, Eveready No. 763 or an RCA VS102. Typical battery life is more than 300 hours continuous operation or 700 hours intermittent operation.

1-7. INSTRUMENT AND MANUAL IDENTIFICATION

1-8. Instrument identification by serial number is located on the rear panel. Hewlett-Packard uses a two-section serial number consisting of a three or four-digit prefix and a five-digit suffix. These numbers may be separated by a letter designating the country in which the instrument was manufactured. (A = U.S.A.; G = West Germany; J = Japan; U = United Kingdom).

1-9. AVAILABLE ACCESSORIES

1-10. The following accessories are available to increase the test capabilities of the Model 427A.

1-11. Cables and Adapters

-hp- 11001A 45" test lead, dual banana to BNC male
-hp- 11002A 5' test lead-dual banana to alligator clips
-hp- 11003A 5' test lead-dual banana to pencil probe and alligator clip
-hp- 10111A shielded BNC female to banana plug adapter

1-12. Probes

-hp- Model 11074A 10:1 Voltage Divider Probe extends the voltage range of Model 427A by a factor of 10.
-hp- Model 11039A 1000:1 Capacitive Voltage Divider for measuring voltages up to 24 KV.
-hp- Model 11096B High Frequency Probe extends the frequency range of the 427A to 500 MHz. The voltage range is 0.25V to 30V.

1-13. OPTIONS

1-14. To obtain an additional Operating and Service Manual order Option 910.

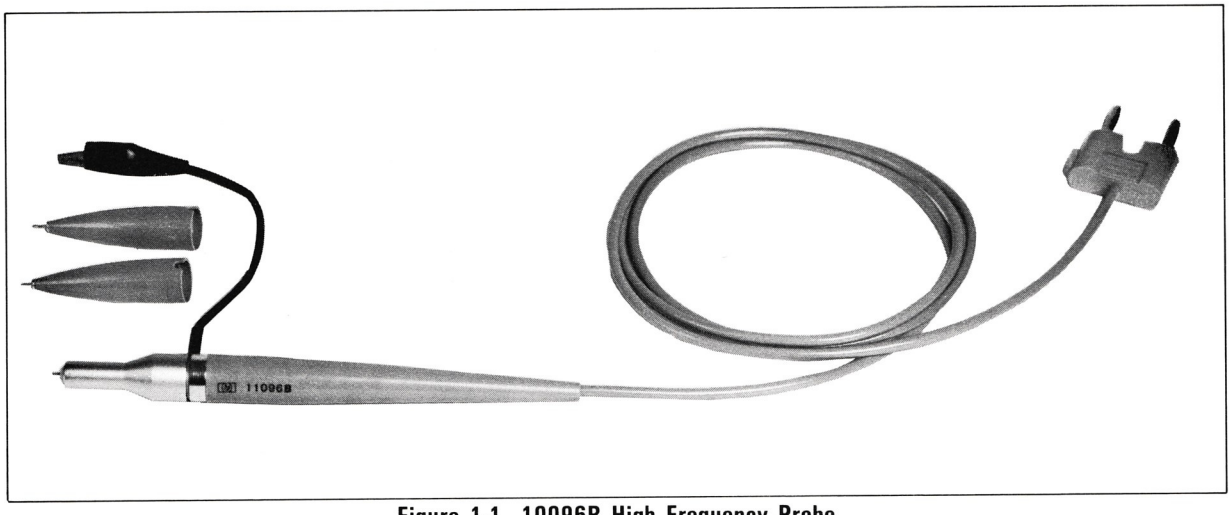


Figure 1-1. 10096B High Frequency Probe

Table 1-1. Specifications

DC VOLTMETER

Voltage Ranges: ±100 mV to ±1000 V full scale in a 1, 3, 10 sequence (9 ranges).

Accuracy: ±2% of full scale on any range (0°C to 50°C).

Input Resistance: 10 megohms on all ranges.

AC normal-mode rejection (ACNMR): ACNMR is the ratio of the ac normal-mode signal to the resultant error in readout.
50 Hz and above: >80 dB.

Maximum Input Voltage: 1000 V dc. (Volts terminal to chassis)

AC VOLTMETER

Voltage Ranges: 10 mV to 300 V rms full scale in a 1, 3, 10 sequence (10 ranges).

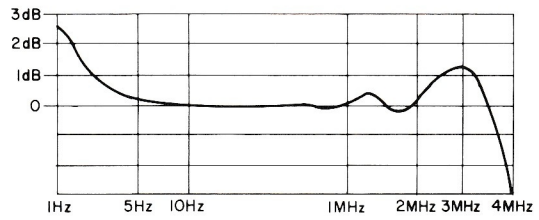
Frequency Range: 10 Hz to 1 MHz.

Response: responds to average value, calibrated in rms of sinusoid.

Accuracy:

Frequency	Range	
	0.01V - 30 V	100 V - 300 V
10 Hz - 100 kHz	2% of range	2% of range
100 kHz - 1 MHz		———

Frequency Response:



Frequency response 10 mV to 30 V ranges.

AC VOLTMETER (Cont'd)

Input Impedance: 10 megohms shunted by < 40 pF on 10 mV to 1 V ranges; < 20 pF on 3 V to 300 V ranges.

Overload: 300 V/rms momentarily, 2 V range and below.
425V/rms maximum above 1 V range.
(Maximum dc voltage from COM to chassis is ± 500 V).

OHMMETER

Resistance Ranges: 10 ohms center scale to 10 megohms center scale (7 ranges).

Accuracy: ±5% of reading from .3 to 3 on scale.

Source Current: (ohms terminal positive)

Range	Open Circuit Voltage	Short Circuit Current
X10	0.1 V	10 mA
X100	0.1 V	1 mA
X1K	1 V	1 mA
X10K	1 V	100 μA
X100K	1 V	10 μA
X1M	1 V	1 μA
X10M	1 V	0.1 μA

GENERAL

Floating Input: May be operated up to ± 500 Vdc COM terminal to chassis ground. (Ohms input open in any function except ohms--volts input open when instrument is in off position.)

Operating Temperature: 0°C to 50°C.

Power: 22 - 1/2 volt dry cell battery. (Eveready No. 763 or RCA VS102.) > 300 hr. operation per battery.
Option 01: Battery operation and ac line operation (selectable on rear panel). 115 or 230 V ± 20%, 48 Hz to 440 Hz, < 0.7 VA.

SECTION II
INSTALLATION

2-1. INTRODUCTION

2-2. This section contains information and instructions necessary for installation and shipping of Model 427A Voltmeter. Included are initial inspection procedures, power and grounding requirements, installation, and instructions for repackaging for shipment.

2-3. INITIAL INSPECTION

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

2-5. POWER REQUIREMENT

2-6. The Model 427A uses a 22.5 volt dry cell battery for its primary power source. However, if Option 01 is included, the Model 427A can be operated from any source of 115 or 230 volts (± 20%) at 48 to 440 Hz. With the instrument disconnected from the ac power source, move the slide switch (located on the rear panel) until the desired line voltage appears. Power dissipation is less than 0.7 VA.

2-7. GROUNDING REQUIREMENTS

2-8. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. The Option 01 427A is 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

When the 427A is powered from its dry cell battery, there is no ground return. Connect Chassis ground terminal on the rear panel to earth ground.

2-9. INSTALLATION

2-10. The Model 427A 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). For additional information, address inquires to your local -hp- Sales and Service Office. (See Appendix B for office locations.)

2-11. Bench Mounting

2-12. Model 427A is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument.

2-13. Rack Mounting

2-14. Model 427A 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.

2-15. Combination Mounting

2-16. The Model 427A may be mounted in combination with other submodular units by using a Combining Case (-hp- Model 1051A). If the 427A is equipped with a carrying handle, it will be necessary to remove the top cover on the 427A before inserting it into the Combining Case. The Combining Case is a full-module unit which accepts various combinations of submodular units. Being a full-module unit itself, it can be bench or rack mounted and is analogous to any full-module instrument.

2-17. REPACKAGING FOR SHIPMENNT

2-18. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-19 if the original container is to be used; 2-20 if it is not.

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.

2-19. If original container is to be used, proceed as follows:

a. Place instrument in original container. 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.

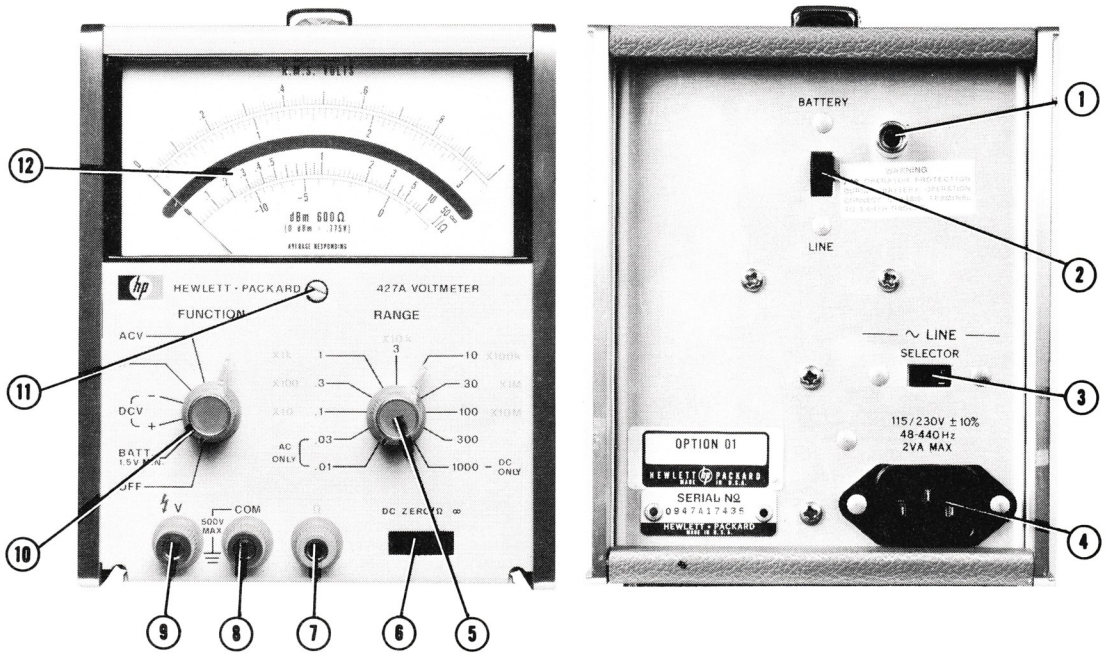
2-20. If original container is not to be used, proceed as follows:

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

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

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

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



(1) Chassis ground terminal

(2) BATT/LINE (option 01 only) slide switch: Selects either battery or line operation.

(3) 115/230 slide switch (option 01 only): Selects either 115 Vac or 230 Vac for line operation.

(4) Line input (option 01 only): Connects ac operating power to instrument.

(5) RANGE switch: Selects appropriate range of unknown input.

(6) DC ZERO/Ω ∞ thumbwheel: Used to electrically zero the instrument in DC mode and to infinity-set the instrument in OHMS mode.

(7) Ω terminal: Connect unknown resistance to instrument between this terminal and common.

(8) COM terminal: Connects to instrument common. (Common input for ACV, OHMS and DCV.)

(9) VOLTS terminal: Apply unknown ac or dc voltage to instrument between this terminal and common.

(10) FUNCTION switch: Selects mode of operation. Selections are OFF, BATT, +DC, −DC, OHMS and AC.

(11) Mechanical zero: Mechanically zeroes the meter.

(12) Meter face: Displays the magnitude of unknown resistance or voltage in ohms or volts respectively.

Figure 3-1. Location of Front Panel Controls and Indicators

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION

3-2. The Model 427A may be operated as a dc voltmeter, ac voltmeter, ohmmeter or dB meter. This section contains operating instructions for each mode of operation.

3-3. FRONT AND REAR PANEL DESCRIPTION

3-4. Figure 3-1 shows the location of all the Model 427A controls and indicators and explains the function of each. The Option 01 rear panel is shown. The standard rear panel is blank.

3-5. OPERATING INSTRUCTIONS

NOTE

To obtain maximum battery life, set the FUNCTION switch to OFF when the instrument is not in use.

3-6. Mechanical Zero Adjustment

3-7. Before any measurements are made, complete the Mechanical Zero Adjustment in the following steps.

a. Be sure instrument has been off for at least one minute.

b. Rotate Mechanical Zero 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 the counterclockwise rotation less.

3-8. Turn-On Procedure

3-9. Standard Instrument

a. Rotate the FUNCTION Switch to BATT/1.5 MIN position.

b. The meter should read 1.5 or higher on the 0-3 scale on any range, indicating that the battery voltage is 15 volts or higher. If the reading is below 1.5, replace the battery according to the steps in Paragraph 5-54.

3-10. Option 01 Instrument

a. Select either battery or line operation with the rear panel BATT/LINE slide switch. If battery operation is selected, check the battery according to Paragraph 3-9.

b. If line operation is selected, set the 115/230 slide switch to indicate the proper line voltage, and attach the line cord.

c. Rotate the FUNCTION switch to the desire function. During line operation, the BATT/1.5 MIN check position displays the output of the Option 01 power supply. The reading should be 1.5 or higher on the 0-3 scale on any range, indicating a power supply output of 17 volts or greater. This serves as a convenient check of the Option 01 power supply.

NOTE

The "OFF" position on the FUNCTION Switch is used to turn the 427A off (i.e., disconnects either the battery or the Option 01 ac power supply from the circuitry). The rear line switch does NOT turn the 427A off.

3-11. DC Measurements

a. Rotate the FUNCTION switch to +DCV or −DCV depending on the polarity of the input.

b. Short the VOLTS input to the COM input, rotate RANGE switch to 0.1, and adjust the DC ZERO/Ω∞ thumbwheel for zero meter deflection.

c. Select approximate range of input with RANGE switch.

d. Connect input across VOLTS and COM terminals and read magnitude of input on meter.

CAUTION

DO NOT APPLY MORE THAN 1000 VDC TO ANY DC RANGE.

3-12. Resistance Measurements

CAUTION

DAMAGE TO 427A INPUT CIRCUIT MAY RESULT IF DC OR AC VOLTAGE IS APPLIED TO OHMS TERMINAL.

a. Rotate the FUNCTION switch to Ω.

b. Select the approximate range with the RANGE switch; and with the input terminals open, adjust the DC ZERO/Ω∞ thumbwheel for an ∞ indication on the ohms scale. (Pointer should rest on the mark just to the left of ∞).

c. Connect the unknown resistance across the Ω and COM terminals. Read the resistance value on the ohms scale.

NOTE

For best accuracy, select an ohms range that will place the meter pointer near the center of the scale.

3-13. AC Measurements

3-14. The Model 427A responds to the average value of the ac input and is calibrated in rms volts for a sine wave input. Since the average value and the rms value of a non-sinusoidal signal are different, any distortion on the input will affect the accuracy of the reading. Table 3-1 shows the effect of harmonic distortion on a reading.

NOTE

The following table is universal in application since these errors are inherent in all average responding voltmeters. The error shown may vary with the phase relationship between the harmonic and fundamental.

3-15. Use the following steps to make an ac measurement.

a. Rotate FUNCTION switch to ACV.

NOTE

With the input shorted, there may be a zero offset of about two minor divisions. This is caused by the bias current through the meter bridge and does not affect the accuracy of ac measurements as the meter moves upscale.

b. Rotate RANGE switch to approximate range of input voltage.

Table 3-1. Effects of Harmonic Distortion

Input Voltage Characteristics	True RMS Value	Meter Indication
Fundamental = 100	100	100
Fundamental + 10% second harmonic	100.5	100
Fundamental + 20% second harmonic	102	100 - 102
Fundamental + 50% second harmonic	112	100 - 110
Fundamental + 10% third harmonic	100.5	96 - 104
Fundamental + 20% third harmonic	102	94 - 108
Fundamental + 50% third harmonic	112	90 - 116

CAUTION

DO NOT APPLY MORE THAN 425V RMS WHEN THE INSTRUMENT IS ON RANGES ABOVE 1 V, OR MORE THAN 300V RMS ON THE 1V RANGE AND BELOW.

c. Connect the signal to be measured to the VOLTS and COM terminals and read the magnitude on the voltage scale.

3-16. DB Measurements

a. Making a dB or dBm measurement is essentially the same as making an ac voltage measurement. Follow the steps in Paragraph 3-13, but read the magnitude on the dB scale.

b. The 1 volt position of the RANGE switch is the 0 dBm range. Each position above 1 volt is a 10 dB increase, and each position below 1 volt is a 10 dB decrease. Table 3-2 lists the dB value of each range.

Table 3-2. DB Range Identification

Range	DB	Range	DB
300	+50	1	0
100	+40	0.3	−10
30	+30	0.1	−20
10	+20	0.03	−30
3	+10	0.01	−40

c. A given dB reading is equal to the algebraic sum of the range and the meter reading. For example, if the

meter reading were −6 and the instrument were on the 10 volt (+20 dB) range, the final reading would be 20 dB - 6 dB = 14 dB.

d. The 427A meter is calibrated in dBm, 0 dBm is equivalent to 0.775 volt dropped across a 600Ω load. Consequently, any dBm measurements must be made across a total impedance of 600Ω. Measurements across other impedances will be in dB, not dBm.

e. To convert a dB reading to dBm, use the Impedance Correction Graph (Figure 3-2). For example, to convert a +30 dB reading made across a 50Ω load to dBm, locate the 50Ω 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 50Ω is +10.5 dBm, and the corrected reading is +40.5 dBm.

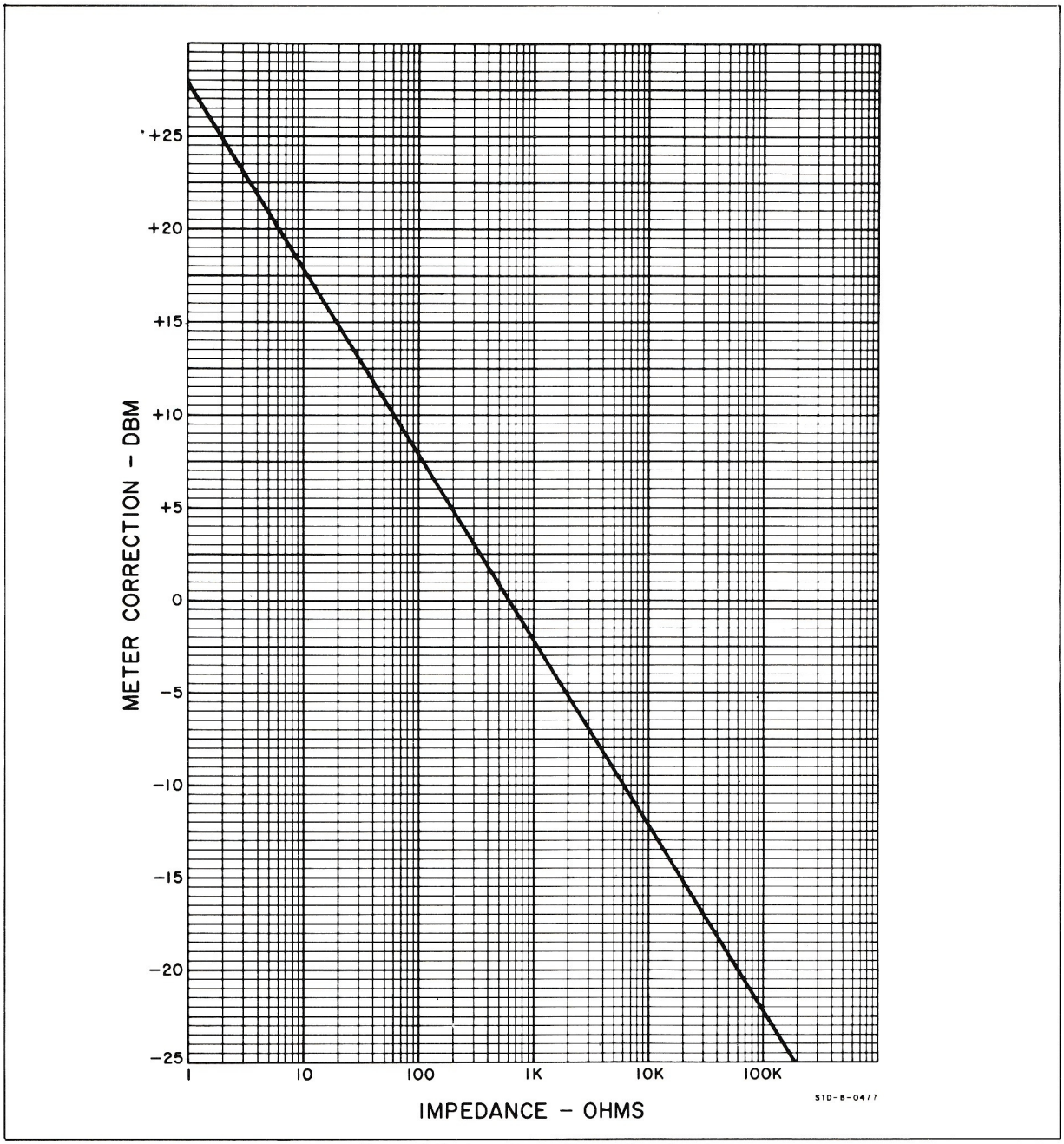


Figure 3-2. Impedance Correction Graph

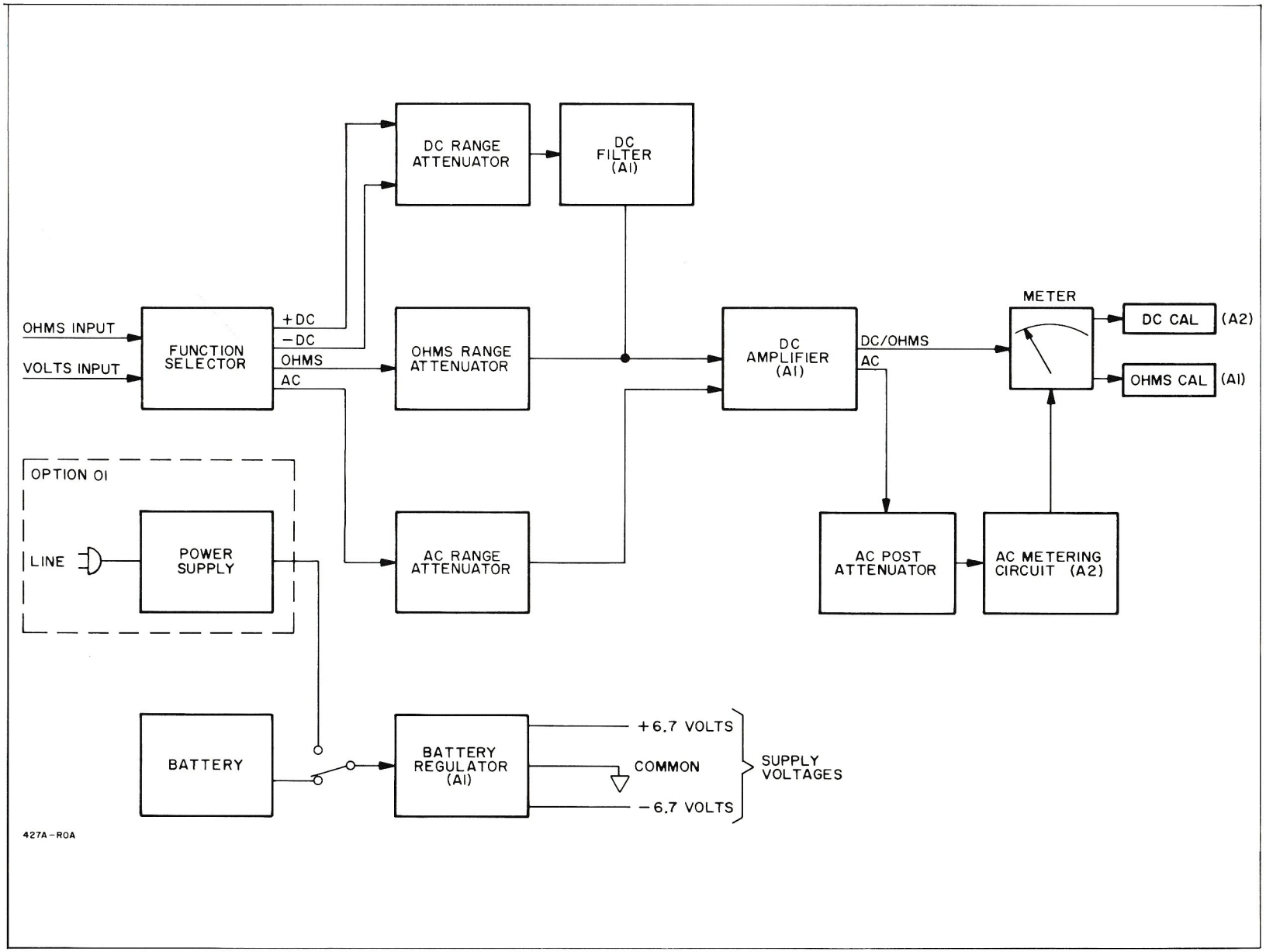


Figure 4-1. Simplified Block Diagram

SECTION IV

THEORY OF OPERATION

4-1. GENERAL

4-2. The Model 427A measures ac voltage, dc voltage, and resistance. It is battery operated, but with Option 01, can be powered by line voltage. Figure 4-1 shows a simplified block diagram of the 427A.

4-3. The Battery Regulator (A1) regulates the battery output and provides +6.7 and −6.7 volt bias supply to the amplifiers. The 427A uses two amplifiers, the DC Amplifier (A1) and the AC Metering Circuit (A2). The former is a high input impedance unity gain amplifier used to amplify dc and resistance inputs. It also serves as a preamplifier for ac signals. The AC Metering Circuit amplifies ac signals from the preamplifier, converts them to dc signals proportional to the average ac, and connects them to the meter. The meter is calibrated to display the rms value of the ac input.

4-4. The DC Offset Adjust (A2) compensates for leakage current from the dc amplifier, and DC CAL and OHMS CAL are resistive circuits used for calibration.

4-5. DC OPERATION

4-6. Figure 4-2 shows the Model 427A in the DC Mode of Operation. The dc input is first applied to the DC Range Attenuator where it is attenuated by 10 dB for each step of the attenuator. The dc signal from the attenuator goes to the DC Filter, and the filter rejects any ac superimposed noise that may be present on the input. The dc output of the filter goes to the DC Amplifier (A1) and then to the meter. The DC Amplifier matches the high impedance of the attenuator to the low impedance of the meter. The DC CAL circuits are resistive circuits in series with the meter used to adjust the meter current to calibrate the lower ranges.

4-7. OHMS OPERATION

4-8. Figure 4-3 is a block diagram of the Model 427A in the OHMS Mode of Operation. With the input open, R_a and R_b forms a voltage divider. The voltage across R_b causes full scale current to flow through the meter. The OHMS CAL circuit adjusts the meter current for an indication of ∞ with the input open. When R_x is equal to the parallel combination of R_a and R_b, the total resistance from the OHMS terminal to ground will be half the parallel combination of R_a and R_b, the voltage into the amplifier will be halved, and the meter indication will be half scale. The Model 427A is designed so that the full RANGE setting will be displayed in the center of the scale. For example, 10 Ω on the X10 range is a center scale reading.

4-9. AC OPERATION

4-10. Figure 4-4 shows a block diagram of the 427A in the AC Mode of Operation. The input signal goes to the AC Range Attenuator. On the 1 volt range and below, the signal is not afffected by the AC Range Attenuator; but on all the higher ranges, the signal is attenuated by 50 dB. Capacitor C3 adjusts the frequency response of the attenuator with a 3 volt 100 kHz input. The signal from the AC Range Attenuator goes through the DC amplifier to the AC Post Attenuator where it is attenuated by 10 dB for each step of the RANGE selector. The DC Amplifier matches the low impedance of the Post Attenuator to the high impedance of the Range Attenuator, acting as a preamplifier.

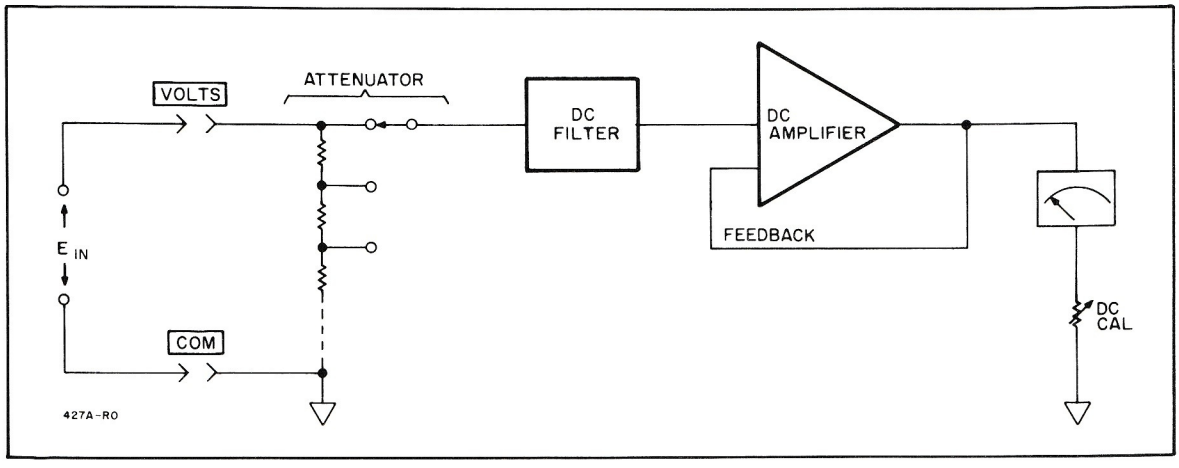


Figure 4-2. DC Operation

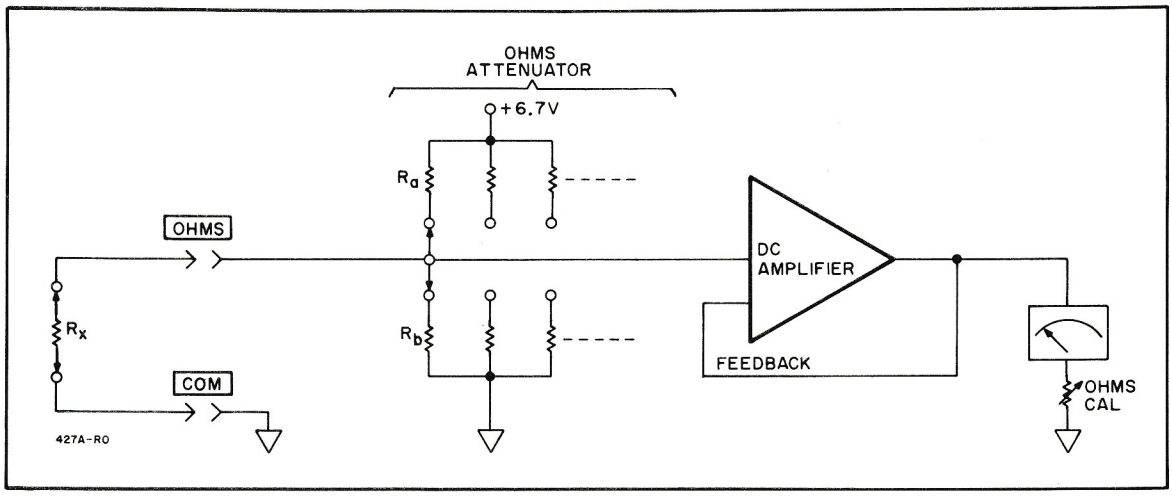


Figure 4-3. Ohms Operation

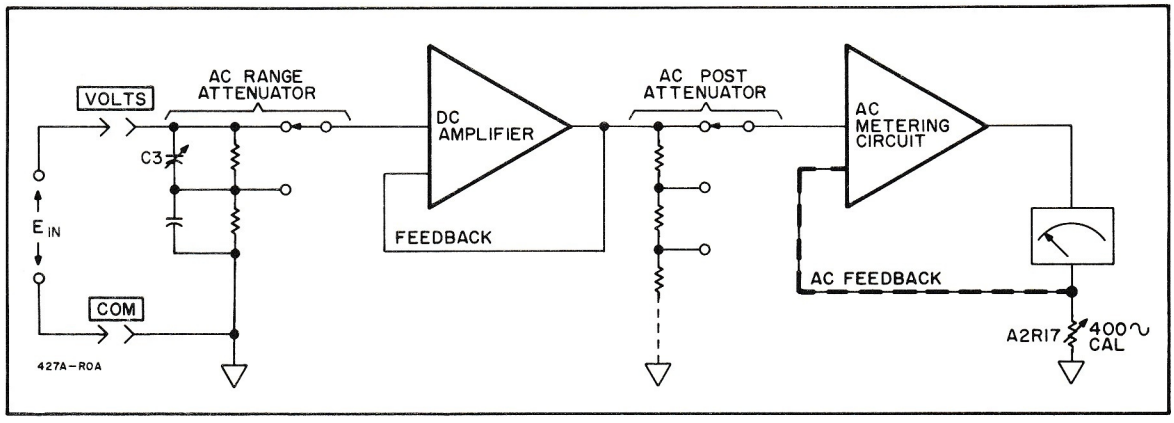


Figure 4-4. AC Operation

4-11. The AC Metering Circuit contains both a feedback stabilized ac amplifier and an averaging meter circuit. The meter circuit converts the ac signal to a dc voltage proportional to the average of the ac amplifier output. A2R17 adjusts the current through the meter so that the scale reading is in rms volts.

4-12. CIRCUIT DESCRIPTION

4-13. DC Amplifier (A1)

4-14. Figure 6-3 is the schematic diagram of the Model 427A. The input to the DC Amplifier (A1) is applied through Pin 2 to the impedance converter A1Q6. A field effect transistor is used as the impedance converter because of its characteristically high input impedance. Transistors A1Q7 and A1Q9 make up a two-stage amplifier, with A1Q9 as an emitter follower output stage. The signal from the emitter of A1Q9 is fed back to the base of A1Q7 for gain stabilization.

4-15. A1Q8 acts as a constant current source for A1Q6. The constant current from A1Q8 assures linearity in A1Q6 and helps minimize drift.

4-16. AC Metering Circuit (A2)

4-17. Figure 6-3 contains the schematic of the AC Metering Circuit. The ac input from the ac post attenuator is applied through A2C1 to the base of A2Q1. A2Q2 is an emitter follower that provides impedance matching to common emitter output stage A2Q3. Capacitor A2C4 provides an ac feedback path for gain stabilization.

4-18. The output from the collector of A2Q3 is rectified by A2CR3 and A2CR4 and applied to the meter movement.

4-19. Resistor A2R17 is used to calibrate the amplifier at low frequency and is adjusted for full scale meter deflection with a 10 mV, 400 Hz input. Capacitor A2C3 is used to calibrate the amplifier at high frequency. With a 10 mV, 1 MHz input, A2C3 is adjusted for full scale.

4-20. Battery Regulator A1 (See Figure 6-3)

4-21. The Battery Regulator regulates the dc voltage from the 22.5 volt battery or from the optional power supply.

The voltage drop across A1CR2 and the emitter-base junction of A1Q3 provides the −6.7 volt reference for the power supply and the −6.7 volt output. A1Q5 senses changes in the +6.7 volt output and controls A1Q2, the positive series regulator. A1Q1 is a current source for A1Q5, and diodes A1CR3, CR4, and CR5 provide temperature stabilization. Transistor A1Q4 provides a current shunt for A1CR2 to keep its voltage constant under heavy current loads.

Table 5-1. Required Test Equipment

Instrument Type	Required Characteristics	Recommended Model	Use
Meter Calibrator	Range: 0 to 300V Accuracy: ±.2%	Fluke Model 760A Meter Calibrator	PAT
Test Oscillator	Frequency: 400Hz to 1MHz Output: 0.01V to 3V ac	-hp- Model 652A Test Oscillator	PAT
Variable Line Transformer	Frequency: 50Hz to 60Hz Voltage: 0 to 120V	Powerstate Model 116B	PT
Decade Resistor	Range: 10 to 10M ohms Accuracy: ±.05%	General Radio Model 1432Z	PT
Multimeter	Range 0 to 50V dc/ac	-hp- Model 3468A Multimeter	T
Resistors	100K ohms ±1% 1M ohms ±.1%	-hp- No. 0757-0367 -hp- No. 0811-0473	P
P = Performance Test	A = Adjustment		T = Troubleshooting

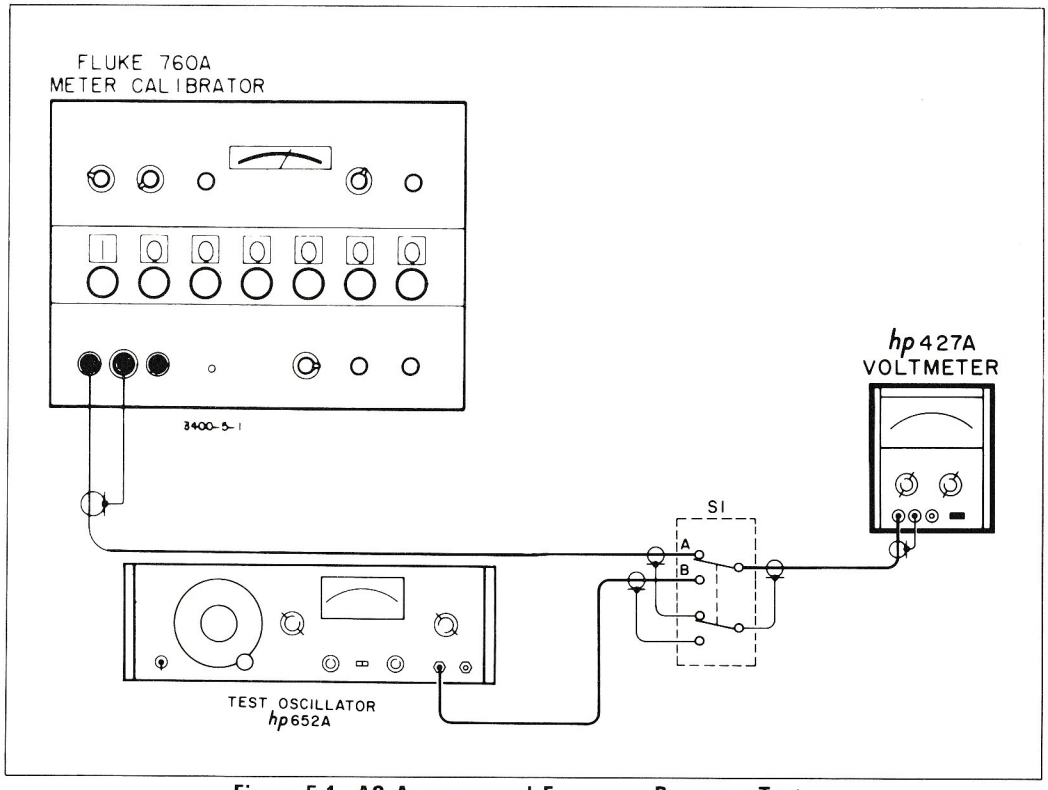


Figure 5-1. AC Accuracy and Frequency Response Test

SECTION V
MAINTENANCE

WARNING

These servicing instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing other than that contained in the operating instructions unless you are qualified to do so.

5-1. INTRODUCTION

5-2. This section contains information necessary to maintain the Model 427A. 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 needed to properly maintain the Model 427A. If the recommended model is not available, use any substitute that meets the required characteristics.

5-5. PERFORMANCE TESTS

5-6. The Performance Tests are "in cabinet" tests that compare the Model 427A with its specifications. These procedures can be used both for incoming inspection and periodic inspection. A performance Test Card is provided at the end of this section for recording the performance tests. The card can be removed from the manual and used as a permanent record of the incoming inspection or of a routine performance test. If the Model 427A does not meet its specifications, refer to the Adjustment and Calibration Procedures, Paragraph 5-25.

5-7. AC ACCURACY AND FREQUENCY RESPONSE

5-8. The AC Accuracy and Frequency Response Check requires a test oscillator that is flat within ± 0.5% from 10 Hz to 1 MHz. The absolute value of the applied voltage must be accurate within ± 0.2%. The meter calibrator produces a 400 Hz signal that is within less than 0.2% of the indicated output. The -hp- Model 652A Test Oscillator can be adjusted to within less than 0.25% of a desired reference from 10 Hz to 10 MHz.

NOTE

Before beginning the Performance Test, be sure to adjust the mechanical meter zero according to the steps in Paragraph 3-6.

5-9. AC Accuracy

5-10. Connect the meter calibrator and test oscillator to the 427A, as shown in Figure 5-1. In the figure, switch S1 is used to connect either the calibrator or the oscillator to the 427A without removing any cables from the 427A. A simple knife switch can be used for S1. If the switch is not available, connect the calibrator or oscillator directly to the 427A.

a. Set the voltmeter calibrator for an output of 0.01 volts at 400 Hz.

b. Set S1 in Figure 5-1 to position A.

c. Set the Model 427A FUNCTION to ACV and the range to 0.01.

d. The 427A should read 0.01 volts rms ± 2% (2 minor scale division).

e. Repeat steps a through d for each ac RANGE selection through 300 V by setting the voltmeter calibrator output to the full scale value for each range. The Model 427A indication should not vary from the known input by more than 2% on any range. 2% corresponds to 2 minor divisions on the 0-1 scale and 1-1/2 minor divisions on the 0-3 scale.

f. Set the Model 427A to the 1 volt range and apply 0.9, 0.8, 0.7, 0.6, 0.5, 0.3, 0.2 and 0.1 volt signals. In each case the reading should be within two minor divisions of the known input signal.

g. Set the Model 427A to the 3 volt range and apply 2.5, 2, 1.5, 1, and 0.5 volt signals. In each case the reading should be within 1-1/2 minor divisions of the known input signal.

5-11. Frequency Response

5-12. The frequency range of the -hp- Model 652A is 10 Hz to 10 MHz. The set level indication mentioned in the following steps is used to reestablish the proper amplitude each time the frequency is changed.

a. Set S1 in Figure 5-1 to position B. Set the Model 427A RANGE to 0.01.

b. Set the test oscillator to 400 Hz and adjust the output for a 0.95 indication on the 427A 0-1 scale.

c. Set test oscillator to expand, and adjust the set level control (REF SET) for convenient meter indication.

d. Record set level indication for use as a reference in steps e and f.

e. Change the oscillator frequency to 10 Hz and reset the oscillator amplitude to the set level indication established in step c. DO NOT readjust the set level control on the oscillator. The 427A indication should not vary by more than ± 2 minor scale division (± 2%).

f. Repeat step e for 100 Hz, 1 kHz, 10 kHz, 100 kHz, 500 kHz and 1 MHz. In each case the 427A indication should not vary by more than ± 2 minor scale divisions (± 2%).

5-13. Repeat Paragraph 5-11 with the 427A RANGE set to 3 volts, and test oscillator output set to give 3 V reading on 427A in step b. The 427A reading should not vary by more than ± 2% (±1-1/2 small scale divisions).

5-14. RESISTANCE ACCURACY

5-15. To check the resistance accuracy, precision resistances are needed. Figure 5-2 shows the resistance accuracy check using a General Radio Model 1432Z Decade Resistor. The resistance used should be accurate to within ± 0.5% and should have a range of 10 ohms to 10 M ohms.

a. With the input open, set the Model 427A FUNCTION to OHMS and the RANGE to X10. Adjust the DC ZERO/Ω∞ adjustment for a meter indication of ∞.

b. Connect the decade resistor and the Model 427A as shown in Figure 5-2, and set the decade for 10 Ω.

c. The 427A meter should read within ± 5% of the known resistance (– one small scale division, + one-half small division).

d. Repeat steps a through c using the RANGE and decade resistor settings listed in Table 5-2.

NOTE

The DC ZERO/Ω∞ adjustment must be made on all ranges.

Table 5-2. Resistance Accuracy

Range	Decade
X100	100 Ω
X1K	1000 Ω
X10K	10 KΩ
X100K	100 KΩ
X1M	1 MΩ
X10M	10 MΩ

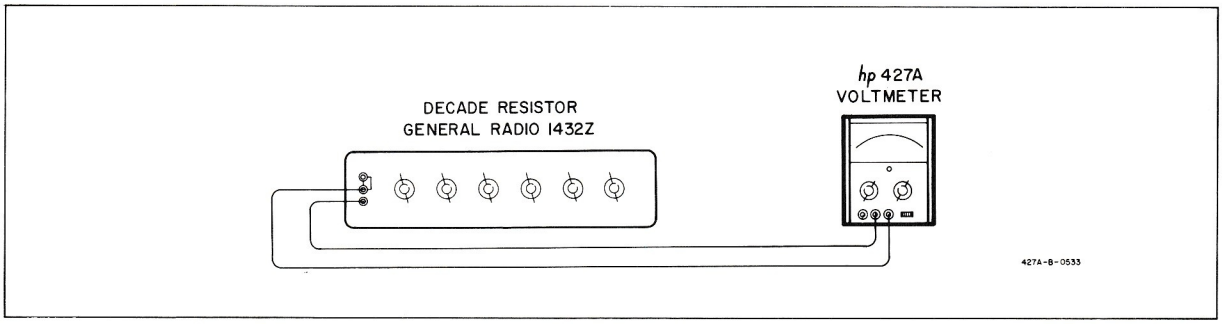


Figure 5-2. Resistance Accuracy

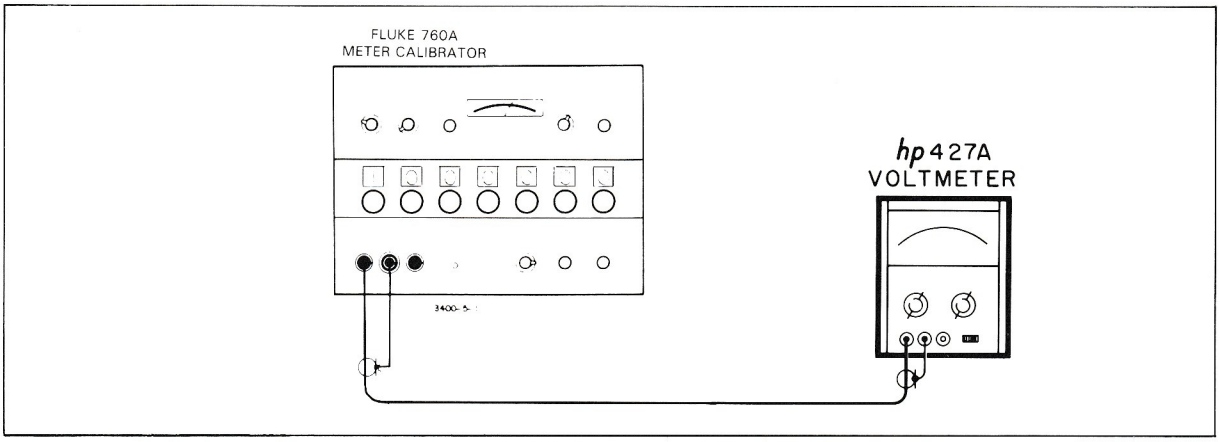


Figure 5.3. DC Accuracy and Linearity

5-16. DC ACCURACY

5-17. The DC Accuracy requires a dc voltage standard that is accurate to within ± 0.2% of its indicated output from 0.1 volt to 300 volts. Figure 5-3 shows the test setup for the DC Accuracy.

a. Set the Model 421A FUNCTION to + DCV and the RANGE to 0.1.

b. Adjust the DC ZERO/Ω∞ for zero. This adjustment need only be made on the 0.1 volt range.

c. Connect the meter calibrator and the Model 427A as shown in Figure 5-3.

d. Set the meter calibrator output to 0.1 volts dc. The Model 427A should read 0.1 volt ± 2%.

e. Repeat steps a through e for each RANGE selection to 300 V by setting the meter calibrator output to the full scale value for each range. The Model 427A indication should not vary from the known input by more than ± 2% on any range. 2% corresponds to 2 minor divisions on the 0-1 scale and 1-1/2 minor division on the 0-3 scale.

f. Set the dc RANGE to 1000 V and the meter calibrator to 300 V. The Model 427A should read 300 V ± 2% of full scale on the 1000 volt range.

g. Set the Model 427A to the 1 volt range and apply 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, and 0.1 volt dc signals from the meter calibrator. In each case the reading should be within two minor divisions of the known input voltage.

h. Set the Model 427A to the 3 volt range and apply 1.5, 1, and 0.5 volt dc signals. In each case the reading should be within 1-1/2 minor divisions on the 0-3 scale.

i. Repeat steps a through f with the FUNCTION set to − DCV and the meter calibrator set for a negative output. The test results should be the same.

WARNING

THE VARIABLE LINE TRANSFORMER, USED IN PARAGRAPH 5-19, PROVIDES A DANGEROUS VOLTAGE. INSURE THAT THE CASE OF THE 427A IS GROUNDED AND THAT THE TRANSFORMER IS PROPERLY WIRED AND FUSED BEFORE PERFORMING THE AC REJECTION TEST.

5-18. AC REJECTION

5-19. A peak ac superimposed noise signal 100 times the full scale input should affect the Model 427A reading less than 1%. Figure 5-4 shows the test setup using a variable line transformer as a noise generator. A 7.07 volt rms output from the variable line transformer corresponds to a 10 volt peak noise signal. The 10 volt noise signal will be applied to the 0.1 volt dc range.

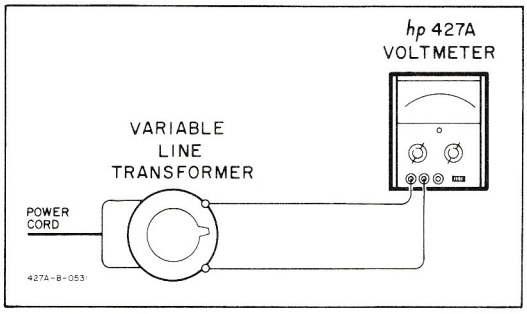


Figure 5-4. AC Rejection

a. Set the 427A FUNCTION to + DCV and short the input. Set the RANGE to 0.1 and adjust the DC ZERO/Ω∞ for 0 meter indication.

b. Switch the FUNCTION to ACV and the RANGE to 10. Connect the variable line transformer and the Model 427A as shown in Figure 5-4.

c. Adjust the transformer output for a reading of 7.07 volts rms on the 427A.

d. Switch the 427A FUNCTION to + DCV and the RANGE to 0.1.

e. The meter reading should be less than 1 minor division above 0. This verifies an AC Normal Mode rejection of > 80 dB.

NOTE

The meter may move upscale momentarily and then return to zero. This indicates the charging of the DC Filter capacitors and is normal.

f. Repeat steps a through e using the 1 volt dc range and 70.7 volt rms signal from the transformer.

5-20. INPUT IMPEDANCE

5-21. Input Resistance

5-22. Figure 5-5 shows the setup for the input resistance. A 1 MΩ resistor is connected in series with the input, and the voltage drop across the input resistance will be:

$$E_R = E_{applied} \frac{R_{in}}{R_{series} + R_{in}}$$

With 1 volt applied, E_R will be 0.91 volt if the input resistance is 10 MΩ. E_R varies directly with changes in R_{in}.

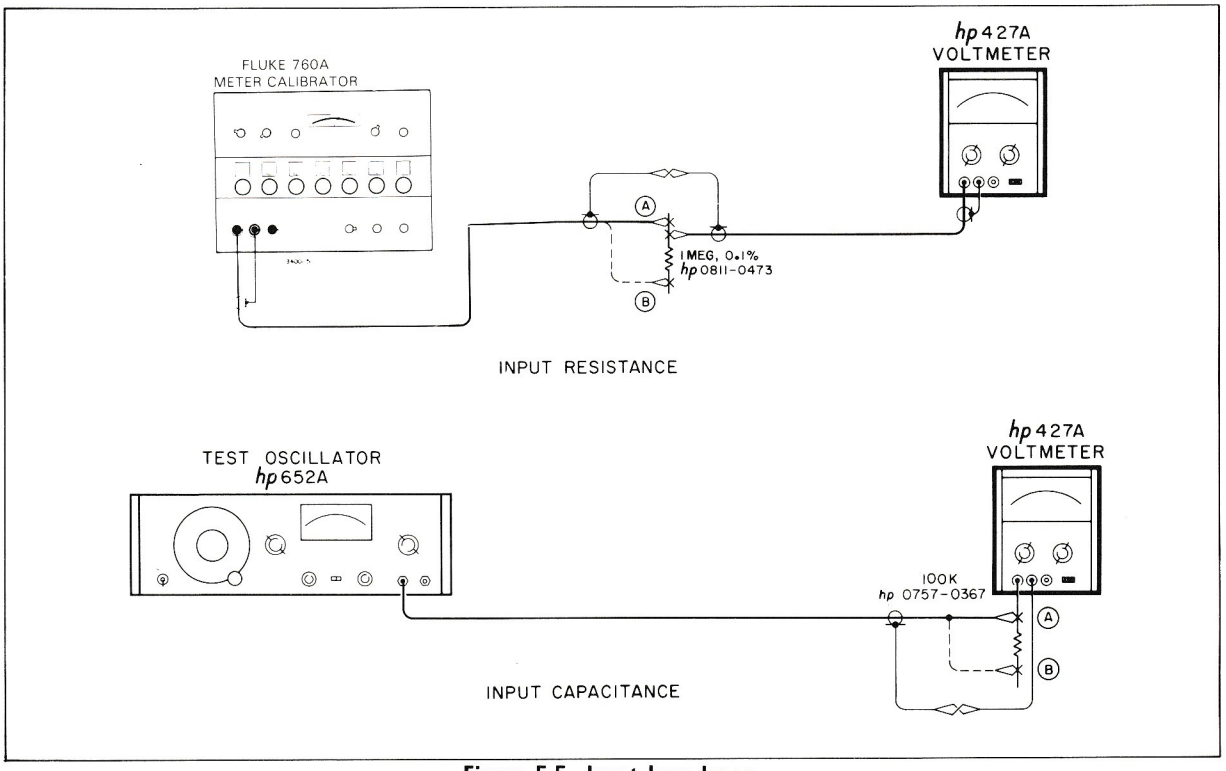


Figure 5-5. Input Impedance

a. Connect the Model 427A and the meter calibrator to position A illustrated in Figure 5-5. Set the Model 427A FUNCTION to + DCV and RANGE to 1 V.

b. Set the meter calibrator for + 1 V output.

c. Connect the meter calibrator to position B shown in Figure 5-5.

d. The voltmeter reading should drop to 0.91, indicating an input resistance of 10 MΩ. The input resistance may vary slightly, and a tolerance of ± 2% should be allowed.

5-23. Input Capacitance

5-24. The 10 MΩ input resistance is shunted with 40 pF on the 0.01 through 1 volt ac ranges and with 20 pF on the 3 through 300 volt ac ranges. For this input capacitance check a 100 kΩ resistor is placed in series with the meter input. At a known frequency, the reactance of the shunt capacitance will be equal to 100 kΩ. At this point the voltage across the input resistance and shunt capacitance will be equal to 0.707 times the input voltage. The input capacitance may be checked by finding the frequency at which the displayed voltage drops to 0.707 times the input. As input capacitance decreases, the roll off frequency increases, and vice versa.

a. Connect oscillator and Model 427A to position A of the input capacitance check (Figure 5-5), and set the Model 427A FUNCTION to ACV and RANGE to 1V.

b. Set the oscillator frequency to 100 Hz and adjust the amplitude for a full scale display on the Model 427A.

c. Connect the oscillator to position B and increase the frequency until the meter display drops to 0.707. The frequency at this point should be about 40 kHz. The input capacitance is nominally specified at 40 pF and may vary from instrument to instrument. A frequency variation of ± 10% is acceptable.

d. Repeat steps a through c using the 3 volt range of the 427A. Increase the frequency in step c until the reading drops to 2.1 volts. This should occur at about 80 kHz. This verifies input capacitance of 20 pF on 3 volt range and above.

5-25. ADJUSTMENT AND CALIBRATION PROCEDURES

5-26. The following adjustment and calibration procedures should be used only if it has been determined through the performance tests in Paragraphs 5-5 through 5-24 that the Model 427A is not performing within its specifications. The location of the internal adjustments is shown in Figures 5-6 and 6-2.

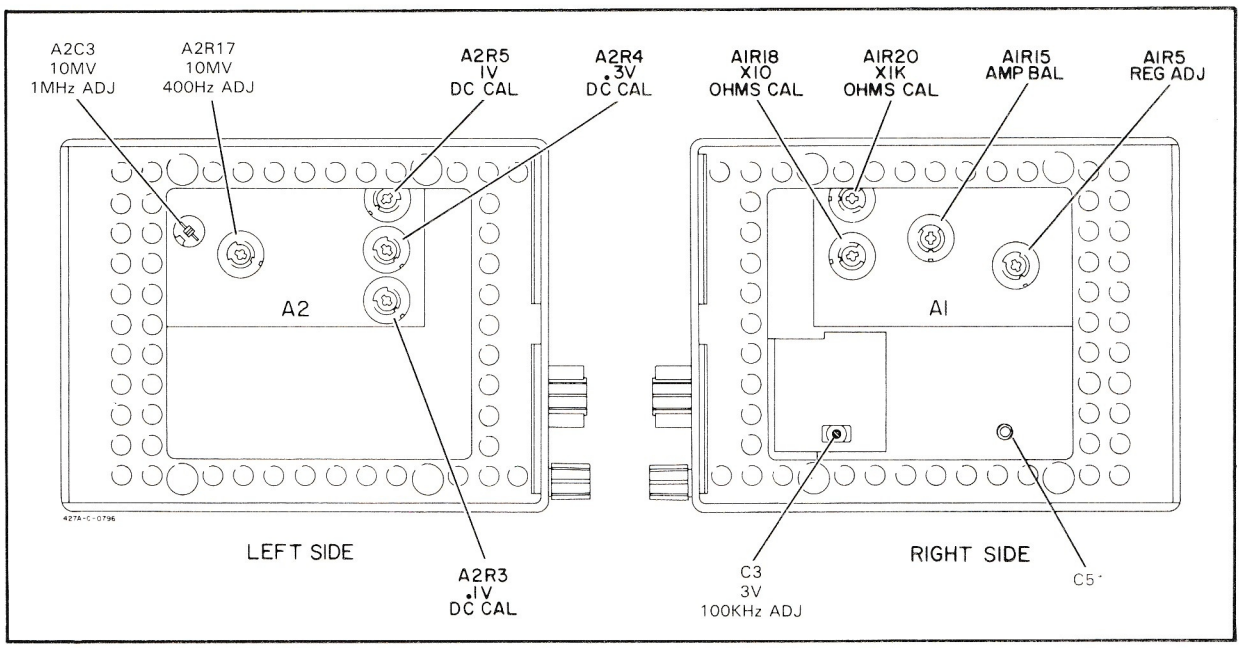


Figure 5-6. Location of Internal Adjustments

5-27. Cover Removal

5-28. To remove the top or bottom covers, remove the Phillips screws securing the cover, slide the cover about 1 inch to the rear, and lift it off. To replace the cover, reverse the removal procedure.

5-29. To remove a side cover, remove the four Phillips screws and lift it off.

NOTE

Before beginning the calibration, be sure to adjust the mechanical meter zero according to the steps in Paragraph 3-6.

5-30. Amplifier Balance Adjustment

a. Set the RANGE switch to .1.

b. Set the FUNCTION switch to + DCV and rotate the DC ZERO/Ω∞ control fully to the right.

c. Set the FUNCTION switch to − DCV and rotate the DC ZERO/Ω∞ control fully to the left. Note meter readings.

d. Repeat Steps b and c and adjust A1R15 AMP BAL until the meter indicator is the same in both steps.

5-31. Regulator Adjust

a. Complete Amplifier Balance adjustment (Paragraph 5-30).

b. Short VOLTS to COM and OHMS to COM. Set FUNCTION to + DCV. Meter should be zeroed within 2 minor divisions upscale.

c. Switch FUNCTION to OHMS. If meter deflects adjust A1R5 REG ADJ for zero deflection. This may affect + DCV zero setting, so rotate FUNCTION back and forth between OHMS and + DCV, and adjust A1R5 until meter reading is the same in both positions.

5-32. AC Calibration

5-33. Four adjustments are required to calibrate the 427A's ac circuits. First, A2R17 adjusts the absolute amplitude calibration with a 10mV 400 Hz input. Then A2C3 is adjusted with a 10mV 1 MHz input to calibrate the high frequency response. Next the frequency response of the AC Post Attenuator is set by adjusting C6 with a 1V 1 MHz signal. Finally the frequency response of the AC Range Attenuator is set by adjusting C3 with a 3V 100 kHz signal.

5-34. Low Frequency Calibration

a. Set the meter calibrator for a 400 Hz 0.01 volt output.

b. Connect the 427A as shown in Figure 5-1 and set switch S1 to position A. If switch S1 is not used, connect the 427A directly to the meter calibrator.

c. Set the 427A RANGE Switch to .001 and the FUNCTION Switch to ACV.

d. Adjust A2R17 (10mV 400 Hz ADJ; see Figure 5-6) on the 427A for a 0.01 volt reading on the 427A's meter. If the adjustment range is insufficient, go to paragraph 5-81.

5-35. High Frequency Calibration

a. Make sure the Low Frequency Calibration procedure (see previous paragraph) has been performed before doing the following steps.

b. Connect the 427A as shown in Figure 5-1 and set switch S1 to position B. If switch S1 is not used, connect the 427A directly to the oscillator.

c. Make sure the 427A RANGE Switch is set to 0.01 and the FUNCTION Switch to ACV.

d. Set the oscillator for a 400 Hz output. Then adjust the oscillator output for a 0.01 volt reading shown on the 427A's meter.

e. Adjust the oscillator set level control (REF SET) for a center indication on the oscillator's meter. Note and record that meter setting.

f. Set the oscillator frequency to 1 MHz and adjust the amplitude vernier until the oscillator's meter indication is the same as noted in step e. DO NOT readjust the set level control (i.e., REF SET).

g. Adjust A2C3 (10mV 1 MHz ADJ) on the 427A for a 0.01 volt reading on the 427A's meter. If the adjustment range is insufficient, go to paragraph 5-76.

h. Set the 427A's RANGE Switch to 1 and set switch S1 to position A (or connect the meter calibrator to the 427A). Set the meter calibrator for a 400 Hz 1 volt output. Note and record the reading on the 427A.

i. Set switch S1 to position B (or connect the oscillator directly to the 427A) and set the oscillator for a 400 Hz output. Then adjust the oscillator output until the reading on the 427A is the same as noted in step h.

j. Adjust the oscillator set level control (REF SET) for a center indication on the oscillator's meter. Note and record the meter setting.

k. Set the oscillator frequency to 100 kHz and adjust the amplitude vernier until the oscillator meter indication is the same as noted in step j. DO NOT readjust the set level control (i.e., REF SET).

l. Make sure the reading on the 427A is within its specified limits (±2%). If the 427A is out of the specified limits, go to paragraph 5-82.

m. Set the 427A's RANGE Switch to 3 and set switch S1 to position A (or connect the meter calibrator to the 427A). Set the meter calibrator for a 400 Hz 3 volt output. Note and record the reading on the 427A.

n. Set switch S1 to position B (or connect the oscilllator directly to the 427A) and set the oscillator for a 400 Hz output. Then adjust the oscillator output until the reading on the 427A is the same as noted in step m.

o. Adjust the oscillator set level control (REF SET) for a center indication on the oscillator's meter. Note and record the meter setting.

p. Set the oscillator frequency to 100 kHz and adjust the amplitude vernier until the oscillator meter indication is the same as noted in step o. DO NOT readjust the set level control (i.e., REF SET).

q. Adjust C3 (3V 100 kHz ADJ) on the 427A for a 3 volt reading on the 427A's meter.

5-36. Resistance Infinity Adjustment

5-37. The resistance calibration is affected by the amplifier balance and regulator adjustments. Perform the steps in Paragraph 5-30 and 5-31 before making the resistance infinity adjustment.

a. Set FUNCTION to OHMS and RANGE to X10.

b. Short OHMS to COM and adjust the DC ZERO/Ω∞ for zero indication. Open the input and adjust A1R18 X10 OHMS CAL for an ∞ indication. The indicator should rest on the mark just to the left of ∞.

c. Change RANGE to X1K, short OHMS to COM and adjust DC ZERO/Ω∞ for zero indication. Open the input and adjust A1R20 X1K OHMS CAL for an ∞ indication.

5-38. DC Calibration

5-39. Use the recommended meter calibrator to calibrate the 427A's dc ranges. Adjust A2R3, A2R4, and A2R5 for full scale inputs on the 0.1, 0.3, and 1 volt ranges, respectively. No calibration is required on the 3 volt through 1000 volt ranges since these are calibrated by A2R5. Use the test setup in Figure 5-3 and do the following:

a. Set FUNCTION to + DCV and RANGE to 0.1. Set the meter calibrator output to + 0.1 volt.

b. Adjust A2R3 0.1 V DC CAL for full scale on the 0-1 scale.

PERFORMANCE TEST CARD

Hewlett-Packard Model 427A
Voltmeter
Serial No. _____

Tests performed by_____
Date_____

Description	
1. AC ACCURACY:	.01 V _____ .03 V _____ .1 V _____ .3 V _____ 1 V _____ 3 V _____ 10 V _____ 30 V _____ 100 V _____ 300 V _____
2. FREQUENCY RESPONSE:	±2% 10 Hz to 1 MHz 10 Hz _____ 100 Hz _____ 1 kHz _____ 10 kHz _____ 100 kHz _____ 500 kHz _____ 1 MHz _____
3. RESISTANCE ACCURACY:	±5% of reading at midscale **Range** **Reading** X10 _____ X100 _____ X1K _____ X10K _____ X100K _____ X1M _____ X10M _____
4. DC ACCURACY:	.1 V _____ .3 V _____ 1 V _____ 3 V _____ 10 V _____ 30 V _____ 100 V _____ 300 V _____ 1000 V _____
5. AC REJECTION:	100 times full scale input, <1% change _____
6. INPUT RESISTANCE:	10 MΩ all ranges _____
7. INPUT CAPACITANCE:	40 pF .01 - 1 volt Range _____ 20 pF 3 - 200 volt Range _____

c. Rotate RANGE to 0.3, and change the calibrator output to + 0.3 volt.

d. Adjust A2R4 0.3 V DC CAL for 3 on the 0-3 scale.

e. Rotate RANGE to 1 and change the calibrator output to 1 volt.

f. Adjust A2R5 1 V DC CAL for full scale on the 0-1 scale.

5-40. ALTERNATE PERFORMANCE TESTS AND CALIBRATION PROCEDURES

5-41. The following alternate procedures should be used only if the equipment in Table 5-1 is not available. In each alternate procedure use an instrument of the specified accuracy. If a less accurate instrument is used, the calibration or test may not be within the Model 427A specifications. To guarantee a specific accuracy, use a standard at least four times more accurate than the Model 427A.

5-42. AC Circuits

5-43. Any test oscillator with low distortion (<2%) may be used as an ac voltage standard. If the distortion level is too high, the calibration may be wrong, as the 427A is an average responding rms calibrated meter. (The effects of harmonic distortion are discussed in more detail in Section III, Paragraphs 3-14 and 3-15.)

5-44. Monitor the oscillator output with a recently calibrated rms voltmeter known to be four times as accurate as the Model 427A over the same band of frequencies. The rms voltmeter serves as a reference. Each time the oscillator frequency is changed, readjust the output for the reference. The Model 427A ac calibration is based on a 400 Hz absolute reference, so always start the ac calibration or performance checks at 400 Hz.

5-45. Resistance Circuits

5-46. If a decade resistor is not available, a selection of precision resistors may be used. The resistors should be at least 1% resistors and the values selected should correspond to the RANGE settings. The -hp- part numbers for 1% resistors for each range are given in Table 5-3.

Table 5-3. 1% Resistors

Resistor (±1%)	-hp- Part No.
10 Ω	0757-0984
100 Ω	0757-0198
1 kΩ	0757-0159
10 kΩ	0757-0839
100 kΩ	0757-0367
1 MΩ	0698-3583
10 MΩ	0698-3592

5-47. DC Circuits

5-48. A precision dc voltage source is required for dc calibration and performance checks. Since the 427A is only calibrated on the 1 volt, 0.3 volt and 0.1 volt ranges, only three different voltages are needed.

5-49. A mercury battery has good short term stability. Connect a series voltage divider with a variable output across the battery and monitor the output with a recently calibrated dc voltmeter known to be four times as accurate as the Model 427A. Use this output to calibrate the 0.1, 0.3, and 1 volt ranges.

5-50. AC Rejection

5-51. To check AC Rejection on 0.1 volt range an oscillator with output of 10 volt peak-to-peak into 10 M ohms may be used. If the -hp- Model 738BR Voltmeter Calibrator is available a 400 Hz 10 volt peak-to-peak output may also be used to check the AC Rejection of Model 427A.

5-52. Input Impedance

5-53. Measure the resistance between the VOLTS and COM terminals using the recommended multimeter with the 427A set to the + DCV or − DCV function. If the recommended multimeter is not available, another multimeter with ohms capability (10 M ohms or above) can be used. If an L-C meter is available, use the meter to check the input capacitance between the VOLTS and COM terminals. The 427A has to be in the ACV function to measure the capacitance.

5-54. BATTERY REPLACEMENT

5-55. Figure 5-7 shows the battery holder and the battery connections. Turn the twist-lock fastener 1/4 turn counterclockwise, tilt the battery and holder toward the rear of the instrument, and lift out. Replace the battery with an Eveready 763 or RCA VS102, 22-1/2 volt dry cell.

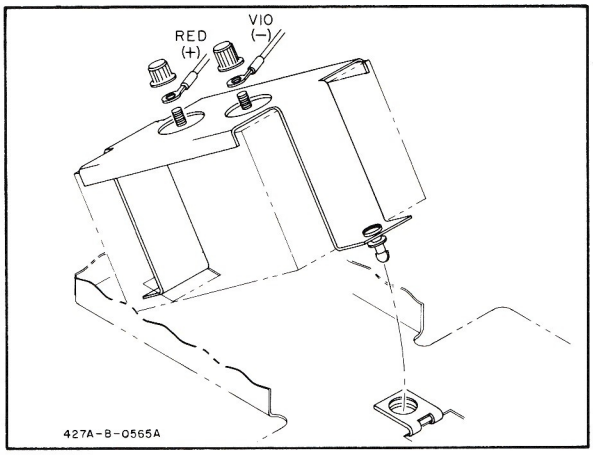


Figure 5-7. Battery Replacement

5-56. TROUBLESHOOTING

5-57. When the Model 427A operates improperly, first adjust and calibrate it according to the procedures in Paragraph 5-25. If calibration is impossible, then proceed with the troubleshooting steps.

5-58. Check the instrument for obvious evidence of trouble, such as loose or broken wires or broken connectors. Check the printed circuit boards for cracks and separations, and ensure that all connectors and pins are clean and tight.

5-59. Isolate the trouble to a particular circuit using the troubleshooting table (Table 5-4) and the Theory of Operation (Section VI). Then refer to the Troubleshooting steps for that circuit in the following paragraphs.

Table 5-4. Troubleshooting

Symptom	Probable Trouble Area
Battery good, no response to input.	Power Supply. (See Paragraph 5-60.)
All + DCV ranges pegged with no input. ACV and OHMS good.	DC offset circuit. Check A2CR1. Then check A1Q6.
Nonlinear tracking on voltage ranges.	DC Amplifier. Check A1Q8 and associated circuit. Check value of range resistors. Check A1R14 and A1Q9.
Constant upscale deflection on lower – DCV ranges; voltage at TP1 low.	DC Amplifier. (See Paragraph 5-63.)
Meter pegs on + DCV and OHMS ranges.	DC Amplifier; check A1Q6, A1Q8, and A1Q9. (See Paragraph 5-65.)
OHMS range always reads near zero, DCV and ACV good.	Range resistor (R_a in Figure 4-3) open. Check R19 through R25 on S1. Range resistors (R_b in Figure 4-3) shorted. Check R12 through R18 on S1. Check Power Supply.
OHMS always reads ∞. DCV and ACV good.	Either one of R19 through R25 (R_a) shorted or one of R12 through R18 open.
Intermittent operation.	Power supply, check A1Q4 (See Paragraph 5-60.)
Zero-offset in ACV FUNCTION greater than 2%.	AC Metering Circuit (See Paragraph 5-67.)
Meter pegs full scale on any AC range.	AC Metering Circuit, check A2CR3 and A2CR4 (See Paragraph 5-67.)

5-60. Power Supply

5-61. Check at A1 pin 7 for +6.4 to + 7 volts and A1 pin 9 for −6.4 to −7 volts. If there is no output, check A1Q4 first. If the power supply has been overloaded, A1Q4 may be bad. Minimum battery voltage is 15.5 volts.

5-62. Measure the dc voltages at the check points given in Table 5-5. All measurements are made with reference to circuit ground.

Table 5-5. Power Supply Voltages

NOTE

The voltages listed in this table are nominal. Allow a tolerance of ±10%, except for the minimum voltages noted.

Check Point	Voltage
Emitter A1Q1	+16V (+8V min)
Collector A1Q1	+7.3V
Base A1Q1	+15.3V (+7.3V min)
Emitter A1Q2	+6.7V (+6.4V min)
Collector A1Q2	+17V (+8.6V min)
Emitter A1Q3	−0.6V
Collector A1Q3	−0.2V
Collector A1Q4	−6.7V (−6.4V min)
Base A1Q5	+0.6V
Across A1CR2	+6.19V

5-63. DC Amplifier

5-64. To make an operational check of the DC Amplifier, set the RANGE switch to 1 and the FUNCTION switch to + DCV. Connect a 1 volt source to the VOLTS and COM terminals and monitor the voltage at A1 pin 8. Since the DC Amplifier is a unity gain amplifier, the voltage should be +1.07 ±0.07 volts dc. If this reading is correct, the DC Amplifier is operating properly. If it is incorrect, proceed with the following troubleshooting procedures.

5-65. Check at the collector of A1Q9 for +3.5 Vdc, and check for +3.0 Vdc at A1TP1. If the voltage at the collector of A1Q9 is quite high (6 or 7 volts) and the voltage at A1TP1 is +3.0 Vdc, A1Q9 is probably open. If the collector voltage is low and the test point voltage is correct, A1Q8 is probably shorted. If both voltages are incorrect, A1Q7 or A1Q8 is probably bad.

5-66. If the collector voltage on A1Q9 is correct and the voltage at A1TP1 is slightly higher than normal, A1Q6 is probably bad.

NOTE

If A1Q6 is replaced and the meter remains pegged or indicates upscale and cannot be adjusted, check the value of factory selected component A1R19. See Paragraph 5-71 and 5-73.*

5-67. AC Metering Circuit

5-68. To check the AC Metering Circuit, set the RANGE to 0.01 and the FUNCTION to ACV. Connect a 10 mV rms source to the VOLTS and COM terminals and monitor the signal at A2 pin 0. The signal at A2 pin 0 should be 10.7 mV rms ±0.7 mV. If the measured signal is incorrect, the trouble is in either the DC Amplifier or the AC Post Attenuator.

5-69. Monitor the signal at the collector of A2Q3. The signal should be 0.28V rms ±0.04 V. If the measured signal is correct, the AC Metering Circuit is functioning properly. If not, proceed with the following trouble-shooting procedures.

5-70. Check for dc voltage levels listed in Table 5-6. If a given reading is wrong, the trouble is probably in that component or its associated circuit. If A2CR3 or A2CR4 are replaced and the zero offset in ACV FUNCTION is greater than 2%, check the value of factory selected component A2R14*. See Paragraph 5-72 and 5-77.

Table 5-6. AC Metering Circuit Voltages

NOTE *The voltages listed in this table are nominal. A tolerance of ±10% should be allowed.*	
Check Point	**Voltage**
A2TP1	+2.8 V
A2Q1 Collector	+2.8 V
A2Q2 Emitter	+2.2 V
A2Q3 Collector	−0.5 V

5-71. ADJUSTMENT OF FACTOR SELECTED COMPONENTS

5-72. Certain components within the Model 427A are individually selected in order to compensate for slightly varying circuit parameters. These components are denoted by an asterisk (*) on the schematic, and the optimum or average value is shown. The following paragraphs describe the function of each factory selected component and give instructions for their selection. Normally these components do not need to be changed unless another associated component is changed. For example, replacement of a transistor may require the changing of an associated factory selected component.

5-73. A1R19*

5-74. A1R19* adjust the range of the AMP BAL resistor A2R15. If the AMP BAL A1R15 cannot be adjusted properly after replacing transistor A1Q6, A1R19* may need to be changed. Use the following steps to select A1R19*.

a. Set RANGE to 0.3.

b. Set DC ZERO/Ω∞ adjustment to center and A1R15 to its center.

c. Select the FUNCTION (+ DCV or − DCV) which will produce an upscale deflection.

d. If the − DCV FUNCTION is selected, increase the value of A1R19. If the + DCV FUNCTION is selected, decrease the value of A1R19. The A1R19 values range from 0 ohm to 1650 ohms and are listed as follows:

A1R19*	-hp- Part Number
243 ohms 1/8W 1%	0757-0408
453 ohms 1/8W 1%	0698-3510
649 ohms 1/8W 1%	0698-4460
845 ohms 1/8W 1%	0698-4463
1050 ohms 1/8W 1%	0698-4467
1240 ohms 1/8W 1%	0698-3223
1470 ohms 1/8W 1%	0757-1094
1650 ohms 1/8W 1%	0698-4427

5-75. A2C2*, A1C11*

5-76. A2C2* adjusts the range of the frequency calibration capacitor A2C3 (1 MHz ADJ) and A1C11* adjust the high frequency response of the DC Amplifier. If during the high frequency calibration (Paragraph 5-35) A2C3 cannot be adjusted for the proper reading, first change the value of A2C2*. If the reading is consistently high, change the value of A2C2* to 47 pF (-hp- Part No. 0160-0182) or if the reading is low, remove A2C2*. A1C11* should only be changed if any active component (Q6, Q7, etc.) in the DC Amplifier is replaced and only if unable to adjust the frequency range by A2C2*. If the reading is high, lower the value of A1C11* or if the reading is low, increase the value of A1C11*. The values of A1C11 are as follows:

A1C11* Value	-hp- Part Number
22pF 300V	0140-0145
36pF 300V	0160-2308
51pF 300V	0160-2201
75pF 300V	0160-2202

5-77. A2R14*

5-78. A2R14* is factory selected to improve upscale meter tracking and correct any non-linearity of diodes A2CR3 and A2CR4. If diode A2CR3 or A2CR4 are replaced, A2R14* may need to be changed. Use the procedure outlined in the following paragraph to select A2R14*.

5-79. If a zero-offset greater than 2% (two minor divisions on the 0-1 scale) exists in ACV FUNCTION replace A2R14* with a smaller value of resistance. The correct value for A2R14* is the largest value of resistance that adjusts the zero-offset to less than 2%. Tracking error could result if the zero-offset indication is reduced below 1%. The nominal value for A2R14* is 91 ohms (-hp- Part

No. 0683-9105). The recommended replacement value for A2R14* is either a 47 ohm (-hp- Part No. 0683-4705) or 68 ohm (-hp- Part No. 0683-6805) 1/4 W, 5% resistor.

5-80. A1C7*

5-81. A1C7* suppresses parasitic oscillations in the dc amplifier. It has a nominal value of 10 pF (-hp- Part Number 0160-0205), but can be as small as 5 pF (Part Number 0160-0763) or as large as 15 pF (Part Number 0140-0202). Use the smallest value necessary to suppress oscillations.

5-82. S1C5*,S1C6*

5-83. S1C5* and S1C6* are used to bring the 1V range into the specified limits at a frequency of 100KHz. Try adjusting C5* first (see Figure 5-6 for location), if the 427A is so equipped, and then select C6*. If C5* is not installed, install one with the same value and part number given in the parts list, schematic, and following this paragraph. Then try changing or deleting C6*. The values for C5* and C6* are as follows:

S1C5*	-hp- Part Number
5.5pF to 18pF	0121-0036

S1C6* Value	-hp- Part Number
110pF 300V	0140-0194
200pF 300V	0140-0198
300pF 300V	0160-2207
360pF 300V	0160-2209

5-84. ETCHED CIRCUIT BOARD REPAIR

5-85. The Model 427A uses plated-through doublesided etch circuit boards. To prevent damage to the circuit board and components, observe the following rules when soldering:

a. Wear clean, lint free cotton or rubber gloves when handling the circuit boards. Avoid touching the board or components with bare fingers as skin oils can cause leakage paths.

b. Use a low-heat (25 to 50 watts) small-tip soldering iron, and a small diameter rosin core solder.

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

CAUTION

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

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

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

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

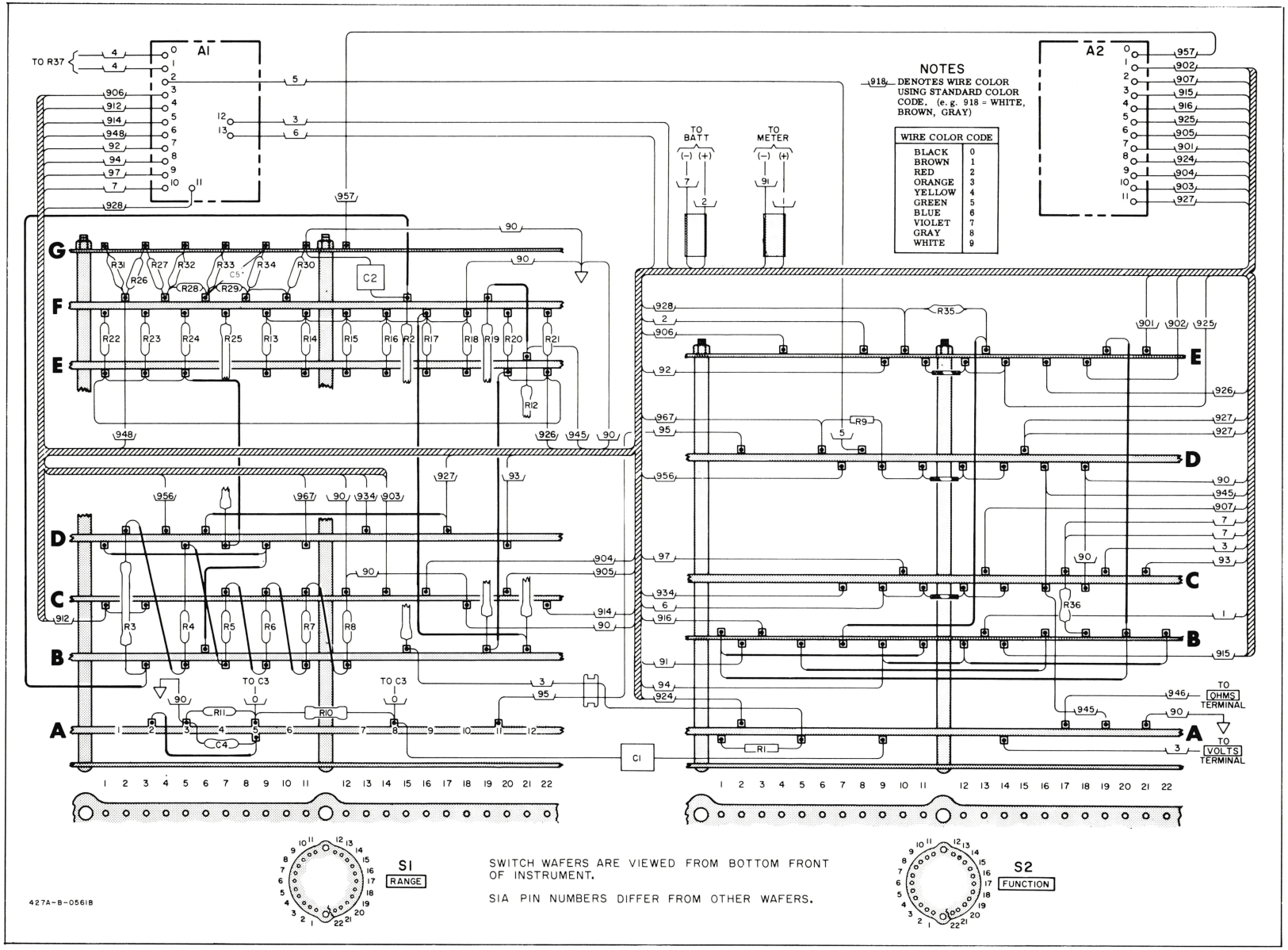


Figure 6-1. Location of Switch Components

SECTION VI
CIRCUIT DIAGRAMS

6-1. INTRODUCTION

6-2. This section contains the schematic diagram of the Model 427A and the circuit diagrams. Figure 6-1 shows the layout of both the FUNCTION and RANGE switches. The switches are viewed from the bottom with the switches flattened out. The front of the instrument is at the bottom of the page.

6-3. Figure 6-2 shows the layout of the two circuit boards and the bottom view of the instrument. Figure 6-3 is the schematic diagram of the Model 427.

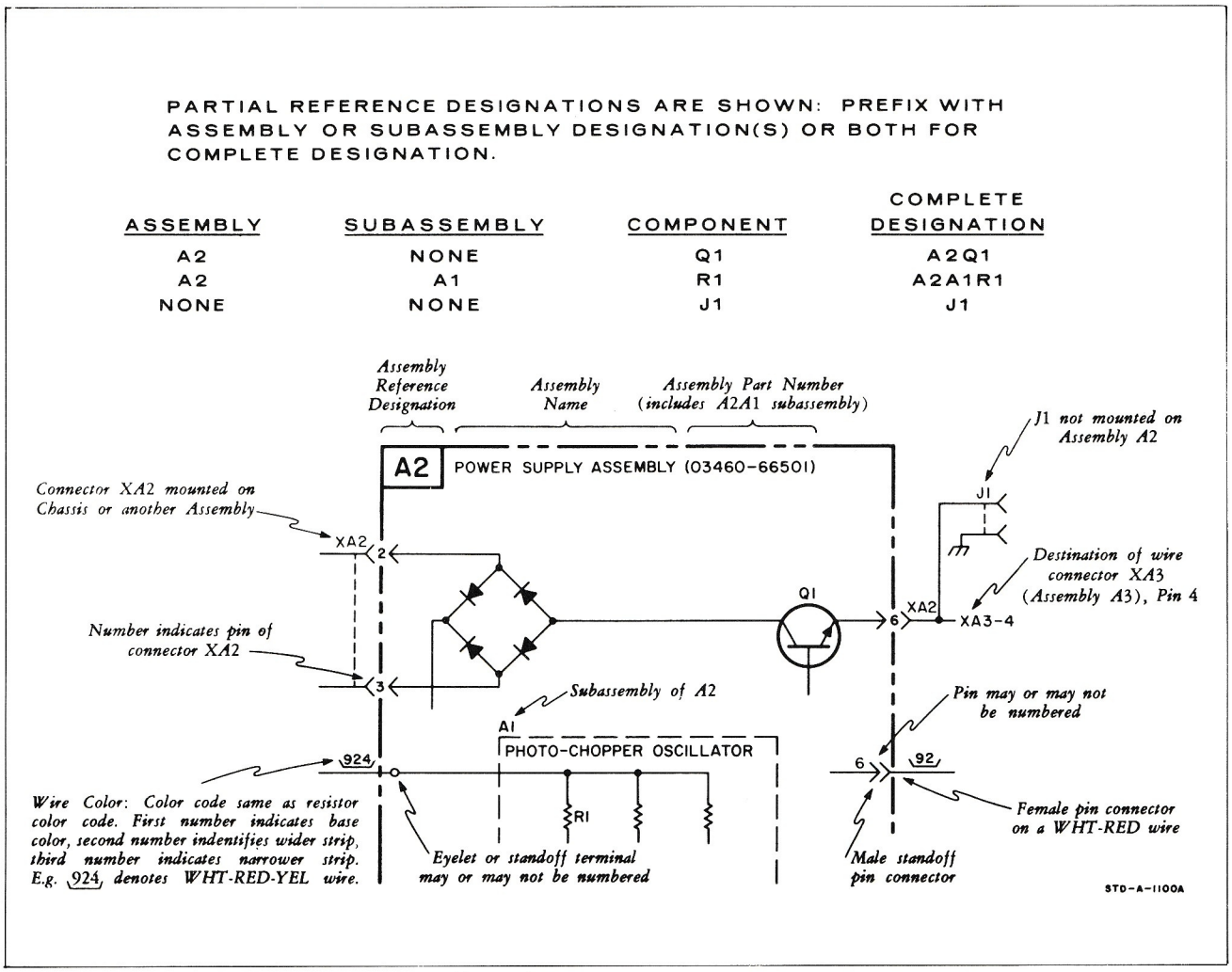
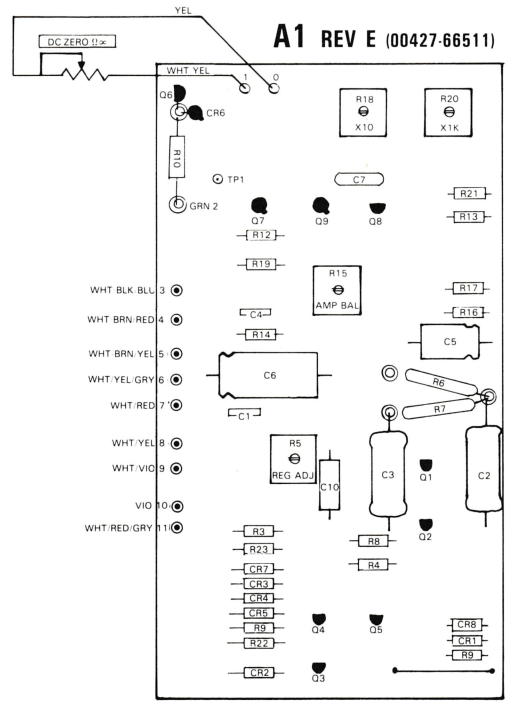
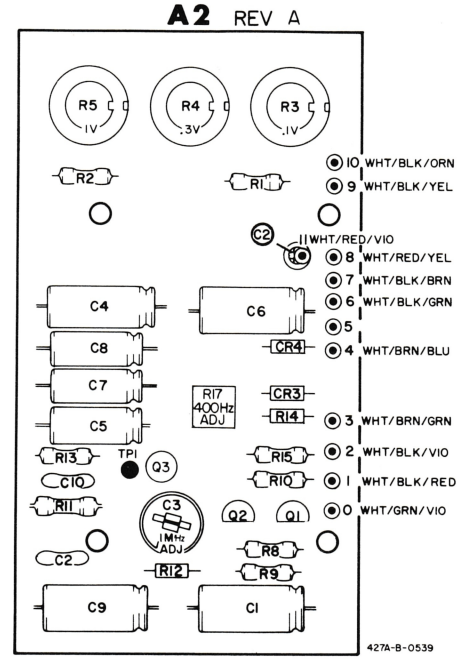
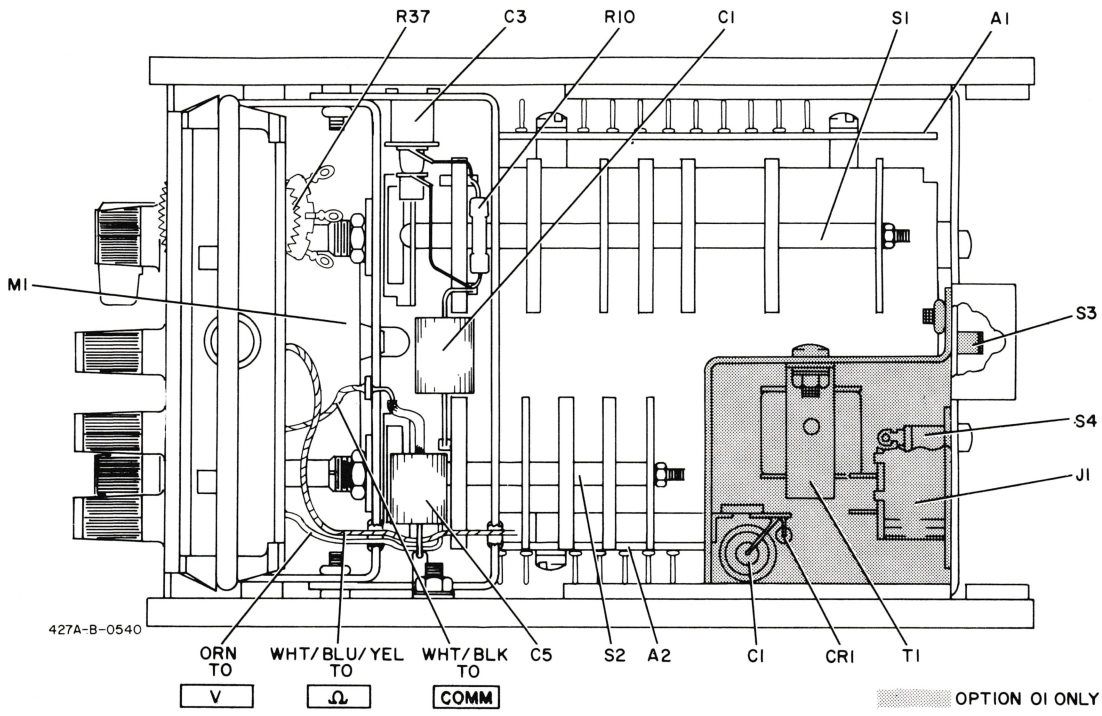


Figure 6-2. Component Location





ANY PC PLUG ON BOARDS ARE FOR FACTORY TEST ONLY. NUMBERS BY STAND-OFF PINS APPEAR ON SCHEMATICS.



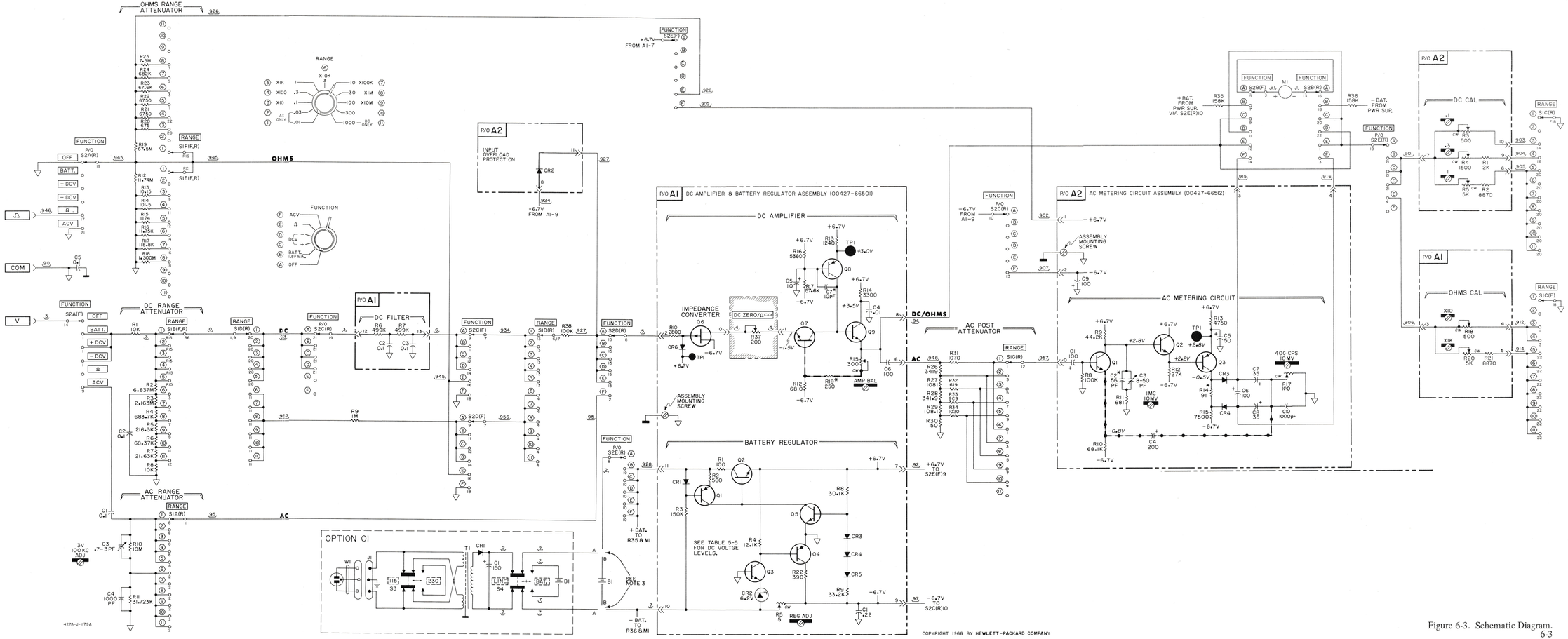


Figure 6-3. Schematic Diagram.

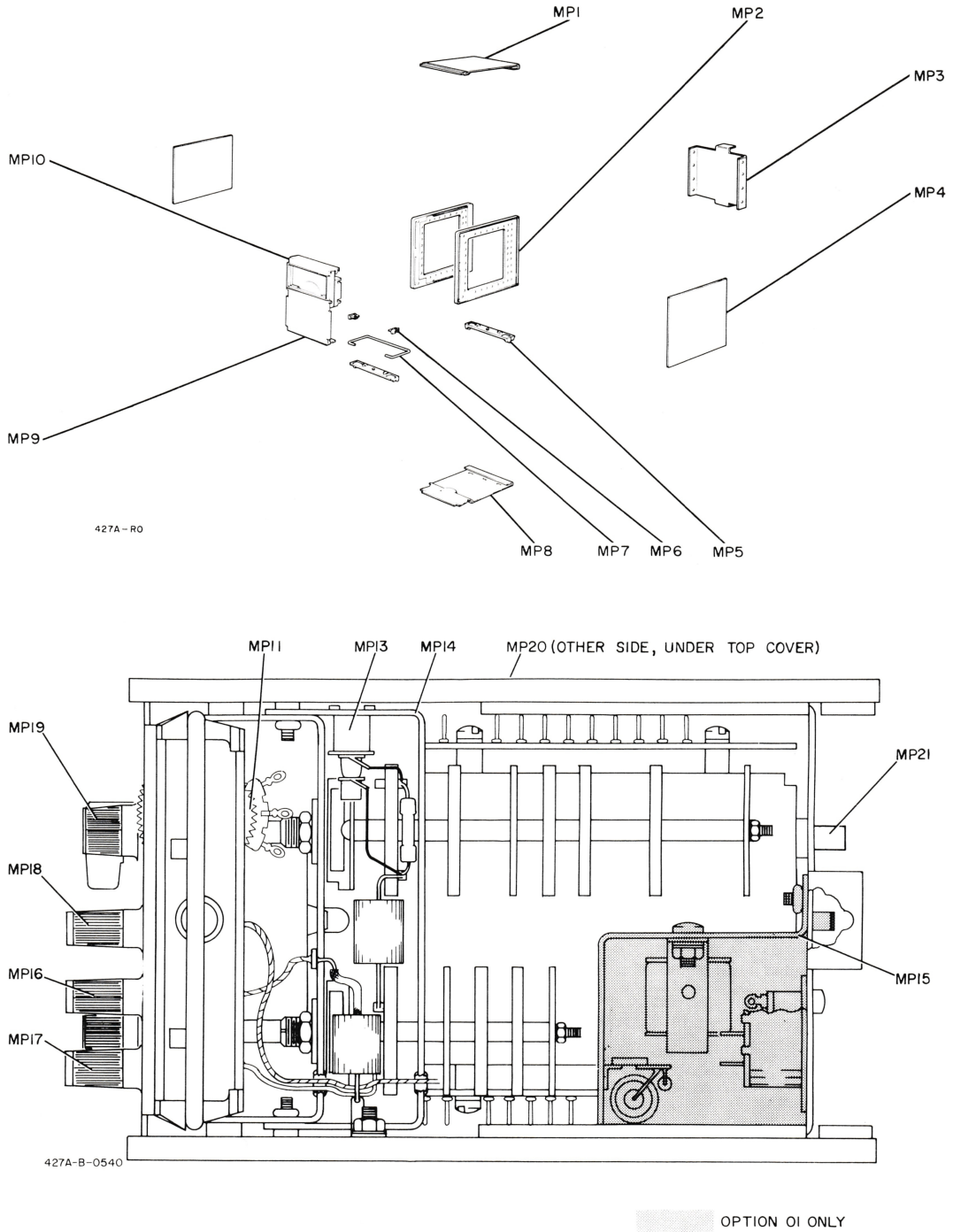


Figure 7-1. Location of Mechanical Parts

SECTION VII
REPLACEABLE PARTS

7-1. INTRODUCTION

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

a. Total quantity used in the instrument (TQ) column.

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

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

d. Manufacturer's part number.

7-3. Miscellaneous parts are listed at the end of Table 7-1. Each factory selected component is keyed to paragraph describing the selection of the component value.

7-4. ORDERING INFORMATION

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

7-6. NON-LISTED PARTS

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

a. Instrument model number.
b. Instrument serial number.
c. Description of the part.
d. Function and location of the part.

ABBREVIATIONS

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

DESIGNATORS

A	assembly	FL	filter	Q	transistor	TS	terminal strip
B	motor	HR	heater	QCR	transistor-diode	U	microcircuit
BT	battery	IC	integrated circuit	R(p)	resistor(pack)	V	vacuum tube, neon bulb, photocell, etc.
C	capacitor	J	jack	RT	thermistor	W	cable
CR	diode or thyristor	K	relay	S	switch	X	socket
DL	delay line	L	inductor	T	transformer	XDS	lampholder
DS	lamp	M	meter	TB	terminal board	XF	fuseholder
E	misc electronic part	MP	mechanical part	TC	thermocouple	Y	crystal
F	fuse	P	plug	TP	test point	Z	network

Table 7-1. Replaceable Parts

Reference Designation	HP Part Number	CD	Qty	Description	Mfr Code	Mfr Part Number
A1	00427-66511	7	1	ASSEMBLY: BOARD DC AMPLIFIER	28480	00427-66511
A1C1	0160-0170	5	1	C: FXD CER 0.22UF +80% -20% 25 VDCW	56289	5C9A OBD
A1C2, A1C3	0160-0168	1	2	C: FXD 0.1 UF +-10% 200 VDCW	56289	192P10492
A1C4	0150-0093	0	1	C: FXD 0.01 UF +80% -20% 100 VDCW	91418	TA OBD
A1C5	0180-0224	2	1	C: FXD A1 ELECT 10 UF +75% -10% 15 VDCW	56289	30D106G015BA4
A1C6	0180-1800	2	1	C: FXD A1 ELECT 100 UF +100% -10% 6VDCW	56289	NON-POLAR 30D TYPE OBD
A1C7*	0160-0205	7	1	C: FXD 10 PF +-5% 500 VDCW	28480	0160-0205
A1C10	0160-0156	7	1	C: FXD MY 0.0039UF +-10% 200 VDCW	56289	192P39292-PTS
A1C11*	0140-0145	2	1	C: FXD MICA 22PF 5% 500 VDCW	72136	RDM15E220J5C
A1CR1	1901-0040	1	6	DIODE: GEN 50MA 30V	28480	1901-0040
A1CR2	1902-3114	8	1	DIODE: BREAKDOWN 6.19V	28480	1902-3114
A1CR3 THRU A1CR5	1901-0040	1		DIODE: GEN 50MA 30V	28480	1901-0040
A1CR6	1901-0586	0	1	DIODE: GEN PRP 30V 25MA	28480	1901-0586
A1CR7,CR8	1901-0040	1		DIODE: GEN 50 MA 30V	28480	1901-0040
A1Q1	1853-0086	2	2	TSTR: SI PNP SPS3322	28480	1853-0086
A1Q2,Q3	1854-0071	7	3	TSTR: SI NPN SPS5103	28480	1854-0071
A1Q4	1853-0086	2		TSTR: SI PNP SPS3322	28480	1853-0086
A1Q5	1854-0071	7		TSTR: SI NPN SPS5103	28480	1854-0071
A1Q6	1855-0227	7	1	TSTR: SI J-FET P-CHAN D-MODE	28480	1855-0227
A1Q7	1854-0009	1	2	TSTR: SI NPN 2N709	28480	1854-0009
A1Q8	1853-0036	2	2	TSTR: SI PNP 2N3906	28480	1853-0036
A1Q9	1854-0009	1		TSTR: SI NPN 2N709	28480	1854-0009
A1R2	0684-5611	9	1	R: FXD COMP 560 OHMS +-10% 1/4W	01121	CB5611
A1R3	0684-1541	6	1	R: FXD COMP 150K +-10% 1/4W	01121	CB1541
A1R4	0698-4477	2	1	R: FXD PREC MET FLM 10.5K +-1% 1/8W	28480	0698-4477
A1R5	2100-3345	8	1	R: VAR 10 SGL TURN TOP	28480	2100-3345
A1R6, A1R7	0698-4972	2	2	R: FXD PREC MET FLM 499K +-1% 1/2W	75042	CEC T-O OBD
A1R8	0757-0453	2	1	R: FXD PREC MET FLM 30.1K +-1% 1/8W	75042	CEC T-O OBD
A1R9	0757-0452	1	1	R: FXD PREC MET FLM 27.4K +-1% 1/8W	28480	0757-0452
A1R10	0698-4199	5	1	R: FXD PREC MET FLM 2800 OHMS +-1% 1/4W	19701	MF6C T-0 OBD
A1R11				NOT ASSIGNED		
A1R12	0757-0439	4	1	R: FXD PREC MET FLM 6810 OHMS +-1% 1/8W	75042	CEA T-O OBD
A1R13	0757-0440	7	1	R: FXD PREC MET FLM 7.5K +-1% 1/8W	28480	0757-0440
A1R14	0683-3325	6	1	R: FXD COMP 3300 OHMS +-5% 1/4W	01121	CB3325
A1R15	2100-0554	5	2	R: VAR 500 SGL TURN TOP	28480	2100-0554
A1R16	0698-4205	4	1	R: FXD PREC MET FLM 21K +-1% 1/8W	28480	0698-4205
A1R17	0698-4207	6	1	R: FXD PREC MET FLM 44.2K +-1% 1/8W	28480	0698-4207
A1R18	2100-0554	5		R: VAR 500 SGL TURN TOP	28480	2100-0554
A1R19*	0757-0408	7	1	R: FXD PREC MET FLM 250 OHMS +-1% 1/8W (SEE PARAGRAPH 5-73)	75042	CEA T-O OBD
A1R20	2100-3252	6	1	R: VAR 5K SGL TURN TOP	28480	2100-3252
A1R21	0698-4202	1	1	R: FXD PREC MET FLM 8870 OHMS +-1% 1/8W	75042	CEA T-O OBD
A1R22	0684-3911	8	1	R: FXD COMP 390 OHMS +-10% 1/4W	01121	CB3911
A1R23	0757-0465	6	1	R: FXD PREC MET FLM 100K +-1% 1/8W	28480	0757-0465
A2	00427-66512	8	1	ASSEMBLY: BOARD AC METERING CIRCUIT INCLUDES C1 THRU 69 Q1 THRU Q3 CR1 THRU CR4 R1 THRU R17	28480	00427-66512
A2C1	0180-0039	7	3	C: FXD ELECT 100 UF 12 VDCW	56289	30D107G012DC4M1
A1C2*	0140-0191	8	1	C: FXD MICA 56 PF +-5% 300 VDCW (SEE PARAGRAPH 7-75)	28480	0140-0191
A2C3	0130-0017	6	1	C: VAR CER 8-50 PF	72982	557-019-U2P0-34R
A2C4	0180-0060	4	1	C: FXD ELECT 200 UF +100% -10% 3 VDCW	56289	30D207G003DC4
A2C5	0180-0033	1	1	C: FXD ELECT 50 UF +100% -10% 6 VDCW	56289	30D506G006CB4M1
A2C6	0180-0039	7		C: FXD ELECT 100 UF 12 VDCW	56289	30D107G012DC4M1
A2C7, A2C8	0180-0064	8	2	C: FXD ELECT 35 UF +100% -10% 6 VDCW	56289	30D356G006BB4
A2C9	0180-0039	7		C: FXD ELECT 100 UF 12 VDCW	56289	30D107G012DC4M1
A2C10	0160-0195	4	1	C: FXD CER 100 PF +-20% 250 VDCW	56289	5628919C251A1-DCH
A2CR2	1901-0586	0	1	DIODE: GEN PRP 30V 25MA	28480	1901-0586
A2CR3, A2CR4	1910-0022	8		DIODE: GE HD1872	03877	OBD
A2Q1, A2Q2	1854-0215	1		TSTR: SI 2N3904	24446	2N3904
A2Q3	1853-0089	5		TSTR: SI NPN 2N4917 PNP	01295	OBD
A2R1	0757-0283	6	1	R: FXD PREC MET FLM 2000 OHMS +-1% 1/8W	75042	CEA T-O OBD
A2R2	0698-4202	1	1	R: FXD PREC MET FLM 8870 OHMS +-1% 1/8W	75042	CEA T-O OBD
A2R3	2100-0328	1		R: VAR WW 500 OHMS +-10% 1-1/2W	71450	110 OBD
A2R4	2100-0291	7	1	R: VAR WW 1500 OHMS +-20% 1-1/2W	71450	110 OBD
A2R5	2100-0205	3		R: VAR PREC WW 5000 OHMS +-10% 1-1/2W	28480	2100-0205

See introduction to this section for ordering information
*Indicates factory selected value

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

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A2R8	0757-0465	6	1	R: FXD PREC MET FLM 100K +-1% 1/8W	75042	CEA T-O OBD
A2R9	0698-4207	6	1	R: FXD PREC MET FLM 44.2K +-1% 1/8W	75042	CEA T-O OBD
A2R10	0757-0461	2	1	R: FXD PREC MET FLM 68.1K +-1% 1/8W	75042	CEA T-O OBD
A2R11	0757-0419	0	1	R: FXD PREC MET FLM 681 OHMS +-1% 1/8W	75042	CEA T-O OBD
A2R12	0684-2731	8	1	R: FXD COMP 27K +-10% 1/4W	01121	CB2731
A2R13	0757-0437	2	1	R: FXD PREC MET FLM 4750 OHMS +-1% 1/8W	75042	CEA T-O OBD
A2R14*	0683-9105	2	1	R: FXD COMP 91 OHMS +-5% 1/4W (SEE PARAGRAPH 5-77)	01121	CB9105
A2R15	0757-0440	7		R: FXD PREC MET FLM 7500 OHMS +-1% 1/8W	75042	CEA T-O OBD
A2R17	2100-0568	1	1	R: VAR 100 OHMS +-10%	28480	2100-0568
BT1	1420-0030	9	1	BATTERY: 22-1/2 V DRY CELL	83740	NO. 763 OBD
C5	0160-4316	9		C: FXD .09 UF +-10% 600 VDCE	28480	0160-4316
J1				SEE OPTION 01		
J2				SEE MP16 AND MP18		
M1	1120-0903	9	1	METER: 100 UA	28480	1120-0903
R35, R36	0757-0471	4	2	R: FXD PREC MET FLM 182K +-1% 1/8W	28480	0757-0471
R37	2100-1990	5	1	R: VAR WW 200 OHMS +-20% DC ZERO/OHMS∞	71450	TYPE 118 OBD
R38	0757-0465			R: 100K 1% .125W	24546	C4-1/8-TO-1003-F
S1	00427-61902	0	1	SWITCH: RANGE	28480	00427-61902
S1C1, C2	0170-0022	7	3	C: FXD MY 0.1 UF +-20% 600 VDCW	84411	HEW-27 OBD
S1C3	0132-0003	4	1	C: VAR TRIMMER 0.7 TO 3 PF	72982	535-016-4R
S1C4	0140-0152	1	1	C: FXD MICA 1000 PF +-5% 300 VDCW	04062	DM16F102J
S1C5*	0121-0036	0	1	C: VAR CER 5.5-18PF	72982	538-006 COPO 92R
S1C6*	0160-2207		1	C: FXD 300PF	28480	0160-2207
S1R1	0684-1031	9	1	R: FXD COMP 10K +-10% 1/4W	01121	CB1031
S1R2	0698-4217	8	1	R: FXD PREC CARBON FLM 6.837 MEG +-1% 2W	91637	DC2 OBD
S1R3	0730-0113	5	1	R: FXD PREC CARBON FLM 2.163 MEG +-1% 1W	91637	DC1 OBD
S1R4	0698-4214	5	1	R: FXD PREC MET FLM 683.7K +-0.5% 1/4W	75042	CEB T-O OBD
S1R5	0698-4212	3	1	R: FXD PREC MET FLM 216.3K +-0.5% 1/4W	75042	CEB T-O OBD
S1R6	0698-4209	8	1	R: FXD PREC MET FLM 68.37K +-0.5% 1/4W	75042	CEB T-O OBD
S1R7	0698-4206	5	1	R: FXD PREC MET FLM 21.63K +-0.5% 1/4W	75042	CEB T-O OBD
S1R8	0698-4203	2	1	R: FXD PREC MET FLM 10K +-0.5% 1/4W	75042	CEB T-O OBD
S1R9	0684-1051	3	1	R: FXD COMP 1 MEG +-10% 1/4W	01121	CB1051
S1R10	0698-4128	0	1	R: FXD PREC MET FLM 10 MEG +-0.25% 1/2W	03888	PME 70 OBD
S1R11	0698-4129	1	1	R: FXD PREC MET FLM 31.723K +-0.1% 1/4W	75042	CEB T-3 OBD
S1R12	0698-4219	0	1	R: FXD PREC CARBON FLM 11.74 MEG +-1% 1W	91637	DC1 OBD
S1R13	0698-4189	3	1	R: FXD PREC MET FLM 10.15 OHMS +-1% 1/4W	19701	MF6C T-O OBD
S1R14	0698-4191	7	1	R: FXD PREC MET FLM 101.5 OHMS +-1% 1/4W	19701	MF5C T-O OBD
S1R15	0698-4198	4	1	R: FXD PREC MET FLM 1174 OHMS +-1% 1/4W	19701	MF6C T-0 OBD
S1R16	0698-4204	3	1	R: FXD PREC MET FLM 11.75K +-1% 1/4W	19701	MF6C T-O OBD
S1R17	0698-4210	1	1	R: FXD PREC MET FLM 118.8K +-1% 1/4W	19701	MF6C T-O OBD
S1R18	0757-0872	9	1	R: FXD PREC MET FLM 1.30 MEG +-1% 1/2W	01738	MFF-1/2-10, T-1
S1R19	0698-4220	3	1	R: FXD PREC CARBON FLM 67.5 MEG +-1% 2W	91637	DC2 OBD
S1R20	0698-4194	0	1	R: FXD PREC MET FLM 675 OHMS +-5% 1/4W	75042	CEB T-0 OBD
S1R21,S1R22	0698-4201	0	2	R: FXD PREC MET FLM 6750 OHMS +-0.5% 1/4W	75042	CEB T-O OBD
S1R23	0698-4208	7	1	R: FXD PREC MET FLM 67.6K +-0.5% 1/4W	75042	CEB T-O OBD
S1R24	0698-4213	4	1	R: FXD PREC MET FLM 682K +-0.5% 1/4W	75042	CEB T-O OBD
S1R25	0730-0131	7	1	R: FXD PREC CARBON FLM 7.5 MEG +-1% 1W	91637	DC-1 OBD
S1R26	0698-4200	9	1	R: FXD PREC MET FLM 3419 OHMS +-0.25% 1/8W	75042	CEA T-O OBD
S1R27	0698-4197	3	1	R: FXD PREC MET FLM 1081 OHMS +-0.25% 1/8W	75042	CEA T-O OBD
S1R28	0698-4193	9	1	R: FXD PREC MET FLM 341.9 OHMS +-0.25% 1/8W	75042	CEA T-O OBD
S1R29	0698-4192	8	1	R: FXD PREC MET FLM 108.1 OHMS +-0.25% 1/8W	75042	CEA T-O OBD
S1R30	0698-4190	6	1	R: FXD PREC MET FLM 50 OHMS +-0.25% 1/8W	75042	CEA T-O OBD
S1R31	0698-4196	2	1	R: FXD PREC MET FLM 1070 OHMS +-1% 1/8W	75042	CEA T-O OBD
S1R32	0757-0418	9	1	R: FXD PREC MET FLM 619 OHMS +-1% 1/8W	75042	CEA T-O OBD
S1R33	0757-0422	5	1	R: FXD PREC MET FLM 909 OHMS +-1% 1/8W	75042	CEA T-O OBD
S1R34	0698-4195	1	1	R: FXD PREC MET FLM 1020 OHMS +-1% 1/8W	75042	CEA T-O OBD
S2	00427-61901	9	1	SWITCH: FUNCTION	28480	00427-61901
	00427-69501			CONVERSION KIT (TO OPTION 01)	18480	00427-69501

See introduction to this section for ordering information
*Indicates factory selected value

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

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
				OPTION 01		
C1	0180-1802	4	1	C: FXD A1 ELECT 150UF +100% -10% 40 VDCW	56289	OBD
CR1	1901-0025	2	1	DIODE: SI 100 MA AT +1V 100 PIV 12PF	28480	1901-0025
J1	1251-2357	8	1	CONNECTOR: AC POWER CORD RECEPTACLE	82389	AC-3 OBD
S3*	3101-1234	3	1	SWITCH: SLIDE DPDT 115/230	42190	4633 OBD
S4*	3101-1235	4	1	SWITCH: SLIDE DPDT 1.5A 125 VAC	82389	11A-1240A
T1*	9100-1328	0	1	TRANSFORMER: AC POWER	28480	9100-1328
W1	8120-1348	5	1	POWER CORD	70903	KH-7041
	00427-05501	7	1	SHIELD, CAN ASS'Y	28480	00427-05501
				*THESE PARTS ARE INCLUDED WITH MP3, PART NUMBER 00427-60201. (OPT. 01 ONLY)		
				MECHANICAL PARTS		
				SEE FIGURE 7-1		
MP1	5060-5972	8	1	COVER: TOP (WITH HANDLE)	28480	5060-5972
MP2	5060-0702	2	2	ASSEMBLY: FRAME6 X 8 SM	28480	5060-0702
MP3	00427-60201	0	1	PANEL: REAR (OPTION 01 ONLY)	28480	00427-60201
MP3	00427-00202	5	1	PANEL: REAR (STD)	28480	00427-00202
MP4	5000-8563	3	2	COVER: SIDE 6 X 8 SM	28480	5000-8563
MP5	5060-0727	1	2	ASSEMBLY: FOOT THIRD MODULE	28480	5060-0727
MP6	5040-0700	8	2	HINGE	28480	5040-0700
MP7	1490-0031	7	1	STAND: TILT THIRD MODULE STAINLESS STEEL ROD	91260	OBD
MP8	5000-8569	9	1	COVER: BOTTOM 5 X 8 SM	28480	5000-8569
MP9	00427-00206	9	1	PANEL: FRONT	28480	00427-00206
MP10	5020-6852	1	1	METER TRIM: THIRD MODULE	28480	5020-6852
MP11	0370-0311	1	1	THUMBWHEEL: DC ZERO/OHMS∞	28480	0370-0311
MP12				NOT ASSIGNED		
MP13	1750A-64A	8	1	HOLDER: TRIMMER CAPACITOR (USED WITH C3)	28480	1750A-64A
MP14	00427-00601	8	1	SHIELD: SWITCH	28480	00427-00601
MP15	00427-05501	7	1	SHIELD: CAN (OPTION 01 ONLY)	28480	00427-05501
MP16	1510-0091	3	2	BINDING POST: SLG 3/8-32 JGK/RED SGL TU	28480	1510-0091
MP17	1510-0091	3		BINDING POST: SGL 3/8-32 JGK/RED SGL TU	28480	1510-0091
MP18	1510-0090	2	1	BINDING POST: SGL 3/8-32 JGK SGL TU	28480	1510-0090
MP19	0370-2994	0	2	KNOB, BASE. PTR AND BAR-CAP	28480	0370-2994
MP20	00427-06401	8	1	HOLDER: BATTERY	28480	00427-06401
MP21	1510-0038	8	1	BINDING POST: SGL 1/4-32 THD STUD	28480	1510-0038
				MISCELLANEOUS		
	00427-00101	3	1	DECK: MAIN	28480	00427-00101
	1390-0047	3		FASTERNER: BATTERY HOLDER	94222	2-0-180
	00427-61601	6	1	CABLE: MAIN	28480	00427-61601
	7120-4609	6	1	LABEL: WARNING	28480	7120-4609
	7122-0058	5	1	PLATE: SERIAL	28480	7122-0058

See introduction to this section for ordering information
*Indicates factory selected value

APPENDIX A
MANUAL BACKDATING CHANGES

MODEL 427A

VOLTMETER

Prefix 550-,621-,731-,0947A

This following backdating information adapts this manual to instruments with lower serial numbers and lower serial number prefixes than listed on the title page of this manual. If the component values in the instrument are different than the ones shown on the schematic and parts list and are NOT listed in this appendix, replace with the component values presently shown on the schematic and in the parts list.

Instrument Serial Prefix/Number	Make Manual Changes
All	Change 5
Prefix 550 and below	Change 2,4
Prefix 621 and below	Change 3,4
Prefix 731 and below	Change 1 thru 4
Below 0947A11451	Change 4
Below 0947A13651	Change 6
Below 0947A14651	Change 6,7
Below 0947A15451	Change 6 thru 8
Below 0947A16001	Change 6 thru 9
Below 0947A16251	Change 6 thru 10
Below 0947A17931	Change 11
0947A16251 to 0947A19660	Change 13
0947A17931 to 0947A19360	Change 12
0947A17931 to 0947A22150	Change 14
Below 0947A22261	Change 15

CHANGE 1

Page 7-4: Replaceable Parts OPTION 01:

Change J1 to -hp- Part No. 1251-0148.
Change S3 to -hp- Part No. 3101-0033.
Change W1 to -hp- Part No. 8120-0078.
Change MP3 to -hp- Part No. 00427-00203

CHANGE 2

Table 7-1, Replaceable Parts:

Change MP9, front panel, to -hp- 00427-00201.*
Add MP12, bracket, DC ZERO/Ω∞ adjust, -hp- Part No. 00427-01201

*When ordering new front panels use -hp- Part Number 00427-00204.

CHANGE 3

Schematic Diagram and Repleaceable Parts:

Remove resistor A1R22 (390 Ω) from collector of A1Q4.

NOTE

A Printed Circuit Board 00427-66501 with Revision C or beyond has A1R22 added in collector circuit of A1Q4. Resistor A1R22 was added to reduce power dissipation in A1Q4 during overload.

CHANGE 4

Change A2R17 to 2100-2069, R: var ww 1000 ohms ± 20% 1-1/2 W.

CHANGE 5

The cover panels and trim listed on Page 7-4 are for instruments with mint gray[1] front panels and olive gray[2] covers.
Parts for instruments with light gray panels[3] and blue/gray[4] covers are:

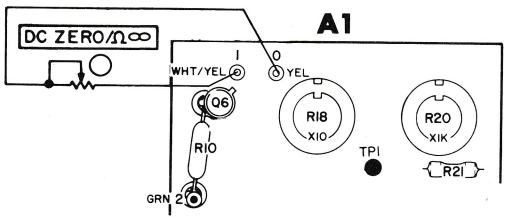
1. -hp- color no. 6009-0019
2. -hp- color no. 6009-0016
3. -hp- color no. 6009-0004
4. -hp- color no. 6009-0006

MP1	Cover: top	5060-5918
MP4	Cover: side	5000-0702
MP8	Cover: bottom	5000-0710
MP9	Panel: front	00427-00204
MP10	Meter trim	5020-5388

CHANGE 6

Schematic Diagram and Replaceable Parts:

Remove capacitor A1C7 (5 pF) from base to collector of A1Q8.
Change A1 component locator as shown:



CHANGE 7

Schematic Diagram (Page 6-3) and Repleaceable Parts (Page 7-3):

Make the following changes on the A2 assembly:

Delete:

C2*	C: fxd, 47 pF (0160-0182)
C10	C: fxd, 100 pF (0160-0195)
Q3	XSTR: 2N4917 (1853-0089)
Q1,Q2	XSTR: 2N3904 (1854-0215)
R17	R: Var, 100 Ω (2100-3270)

Add:

C2*	C: fxd, 18 pF (0160-0356)
R16	R: fxd, 84.5 Ω (0698-4397)[1]
Q3	XSTR: Si (P/N 1853-0023)
Q1,Q2	XSTR: 2N3855A (1854-0057)
R17	R: Var, 200 Ω (2100-3212)[2]

1. Connected in same position as C10.
2. In some earlier instruments R17 was 250 Ω (Part Number 2100-3212), or 1 kΩ (Part Number 2100-2069). Much earlier versions of the instrument used a 2 kΩ potentiometer. However, the 1 kΩpotentiometer is recommended for replacement of the 2 kΩ potentiometer.

CHANGE 8

Schematic Diagram and Replaceable Parts.

Pages 6-3 and 7-3:

Change C5 from C: fxd, .09 μF to C: fxd, .1 μF (0170-0022).

Page 7-5:

Make the following changes:

Delete:

MP16, Binding Post (1510-0091)
MP18, Binding Post (1510-0091)
MP19, Binding Post (1510-0090)
M20, Knob: Pointer (0370-2473)
Label, warning (7120-4609)
Binding Post, grounding (1510-0038)

Add:

MP16, Binding Post (5060-0635)
MP18, Binding Post (5060-0634)
MP19, Binding Post (5080-5170)
MP20, Knob: Skirted (0370-0077

CHANGE 9

Repleaceable Parts:

Page 7-4:

Change the Part Number of S4 to 3101-0011

CHANGE 10

Schematic Diagram and Replaceable Parts:

Pages 7-2 and 7-3:

Change the Part Number of the A2 Assembly to 00427-66502. Also make the following changes to the A2 Assembly:

Delete:

CR2, Diode: Si (9101-0376)

Add:

R6, R: fxd, 20 kΩ (0757-0449)
R7, R: Var, 50 kΩ (2100-0094)
CR1, Diode: Bkdn, 6.6 V (1902-0571

Change the A1 Assembly as follows:

Delete:

R12, R: fxd, 1240 Ω (0698-3223)
R16, R: fxd, 5360 Ω (0698-3258)
R17, R: fxd, 57.6 kΩ (0698-4500)
Q6, XSTR: Fet. P Chan (1855-0227)
CR6, Diode: Si (1901-0376)

Add:

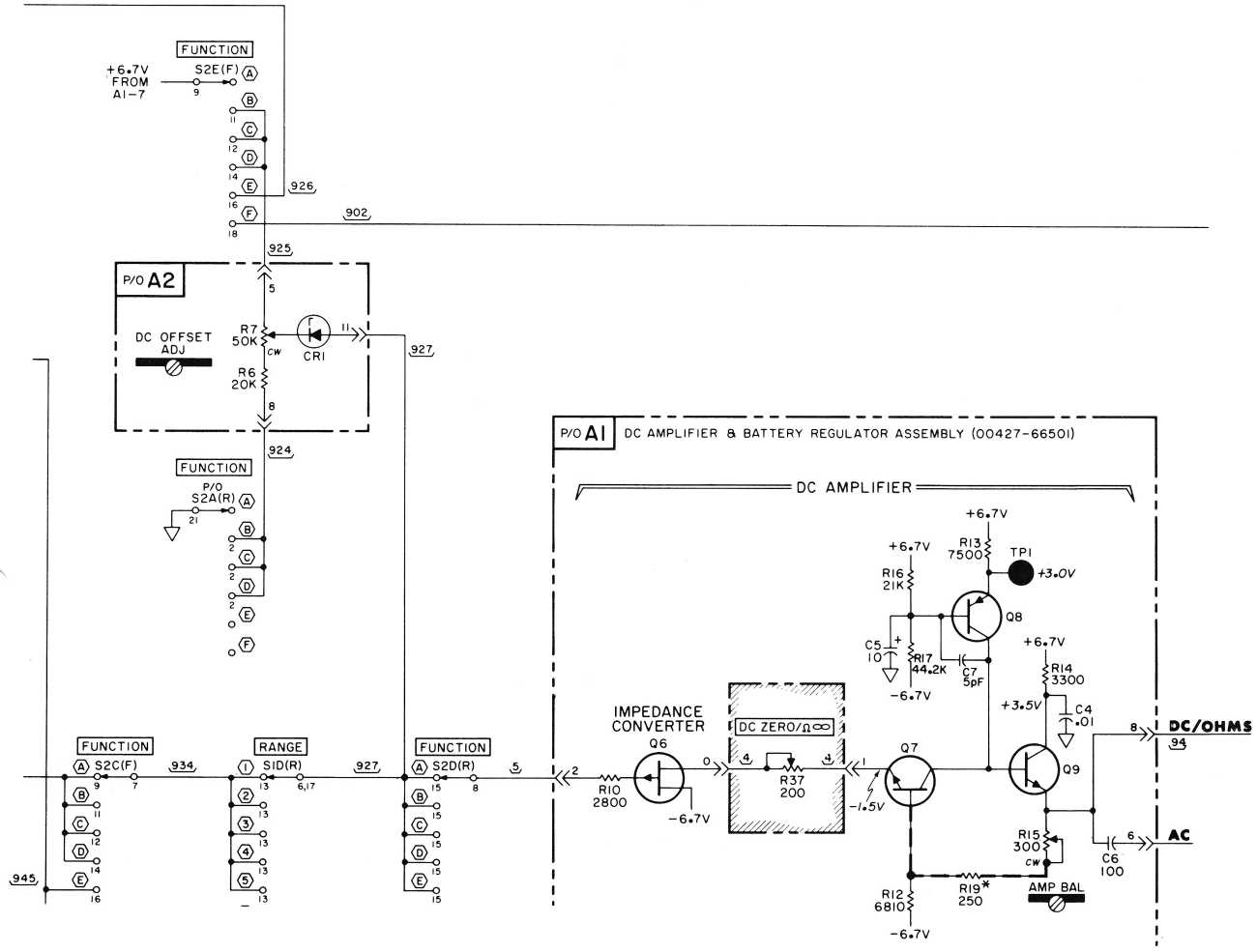
R13, R: fxd, 7500 Ω (0757-0440)
R16, R: fxd, 21 kΩ (0698-4205)
R17, R: fxd, 44.2 kΩ (0698-4207)
Q6, XSTR: Fet. P Chan (1855-0023)

Page 7-4:

Delete R38, R: fxd, 100 kΩ (0757-0465)

Figure 6-3, Page 6-3:

Change the Schematic Diagram as shown below:



CHANGE 11

Schematic Diagrams and Replaceable Parts:

Page 7-2, Table 7-1:

Change the part number of the A1 Assembly to 00427-66501. If any part on the 00427-66501 board is no longer available, replace the assembly with the one presently listed in the parts list (No. 00427-66511).

Change the following parts in the table:

A1CR1	Diode: Si (1901-0025)
A1CR2	Diode: breakdown 6.2V (1902-0568)
A1CR3 thru A1CR5	Diode: Ge HD 1872 (1910-0022)
A1Q1	TSTR: Ge PNP 2N404A (1850-0111)
A1Q2	TSTR: Si NPN 2N3417 (1854-0087)
A1Q3	TSTR: Si NPN 2N3391 (1854-0033)
A1Q4	TSTR: Ge PNP 2N404A (1850-0111)
A1Q5	TSTR: Si NPN 2N3391 (1854-0033)
A1R1	R: fxd 100 ohm (0757-0198)
A1R4	R: fxd 12.1K ohm (0757-0444)
A1R9	R: fxd 33.2K ohm (0757-0454)

Delete A1CR7, A1CR8, and A1R23.

Page 7-4, Table 7-1:

Change R35 and R36 on the Function Switch Assembly (00427-61901) to the following:

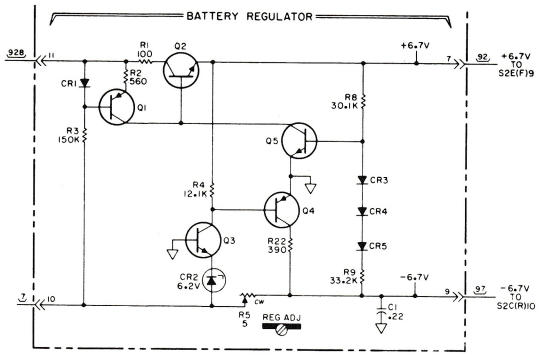
R: fxd 158K ohm (0697-4211).

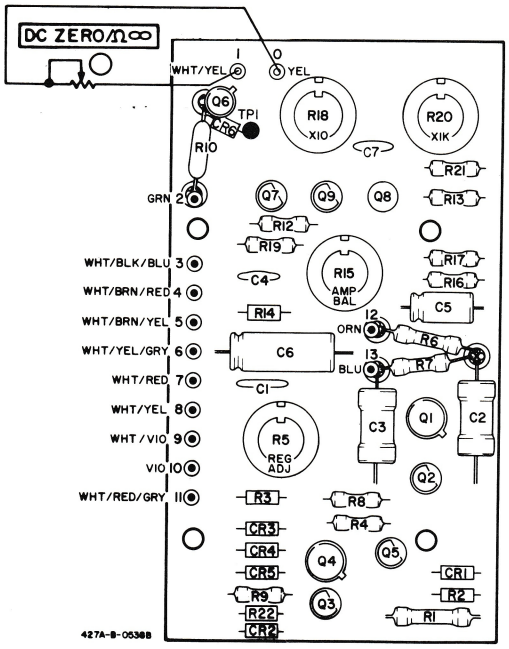
NOTE

These resistors should be changed to the value listed in the parts list (182K ohm, Part No. 0757-0471), if the A1 Assembly is changed to Part No. 00427-66511.

Figure 6-3, Page 6-3:

Change the Schematic Diagram and Component Locators to the ones shown as follows:





CHANGE 12

Schematic Diagrams and Replaceable Parts:

Figure 6-3, Page 6-3:

Change the Schematic Diagram for the A1 Assembly (00427-66511) as follows:

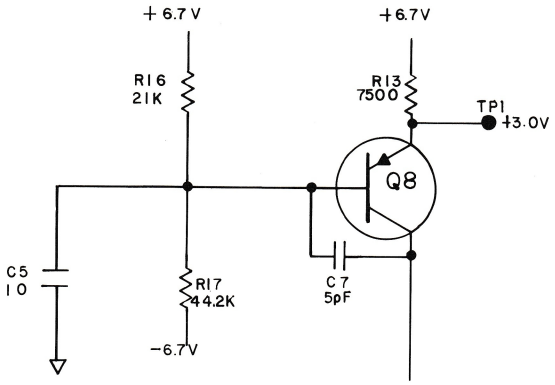


Figure 6-3, Page 6-3:

On the A1 Assembly, replace jumper connected between collector of Q2 and R2 with R1 (292.4 ohms; -hp- Part Number: 0727-0063).

CHANGE 13

Schematic Diagrams and Replaceable Parts:

Figure 6-3, Page 6-3:

Change the following resistor values on the A1 Assembly.

A1R13	R: fxd 1.24K 1% (0698-3223)
A1R16	R: fxd 5.36K 1% (0698-3258)
A1R17	R: fxd 57.6K 1% (0698-4500)

CHANGE 14

Schematic Diagrams and Replaceable Parts:

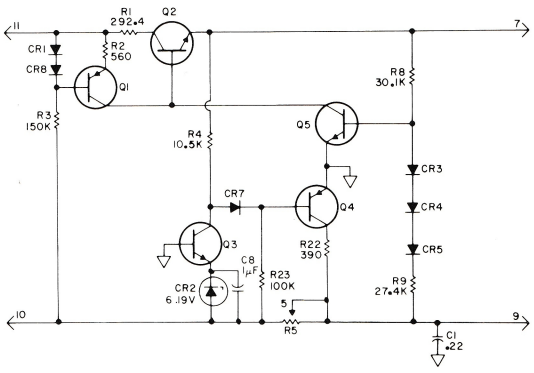
Page 7-2, Table 7-1:

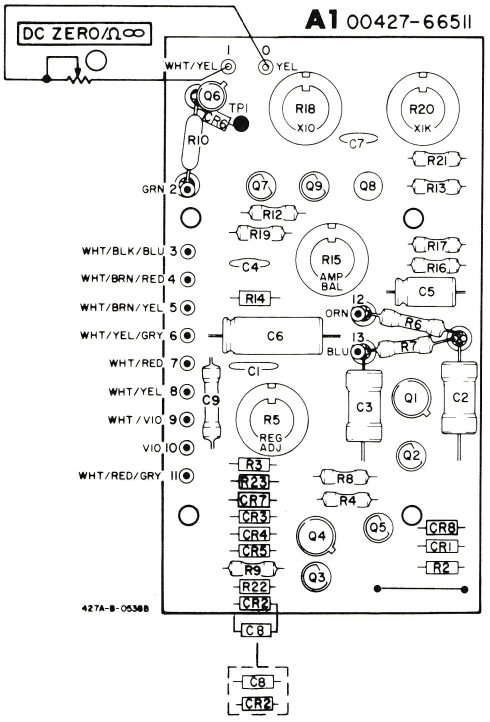
Add the following capacitors to the table:

A1C8	C: fxd 1μF 25V (0160-0127)
A1C9	C: fxd 0.1μF 200 V (0160-0168)

Figure 6-3, Page 6-3:

Change the Schematic Diagram and Component Locator for the A1 Assembly (00427-66511) as follows:





CHANGE 15

Schematic Diagram and Replaceable Parts:

Page 7-3, Table 7-1:

Delete the following capacitors from the table:

S1C5*	C: var 5.5 to 18pF (0120-0036)
S1C6*	C: fxd 300pF 300V (0160-2207)

Figure 6-3, Page 6-3:

Delete C5* and C6* from switch S1

CODE LIST OF MANUFACTURERS

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

Code No.	Manufacturer	Address
00000	U. S. A Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00287	Cemco, Inc.	Danielson, Conn.
00334	Humidial	Colton, Calif.
00348	Mictron, Co., Inc.	Valley Stream, N.Y.
00373	Garlock Inc.	Cherry Hill, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp. Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00809	Croven, Ltd.	Whitby, Ontario, Canada
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Co., Pickens Div.	Pickens, S.C.
00866	Goe Engineering Co.	City of Industry, Cal.
00891	Carl E. Holmes Corp.	Los Angeles, Cal.
00929	Microlab Inc.	Livingston, N.J.
01002	General Electric Co., Capacitor Dept.	Hudson Falls, N.Y.
01009	Alden Products Co.	Brockton, Mass.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Cal.
01281	TRW Semiconductors, Inc.	Lawndale, Cal.
01295	Texas Instruments, Inc., Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co	Alliance, Ohio
01538	Small Parts Inc.	Los Angeles, Cal.
01589	Pacific Relays, Inc.	Van Nuys, Cal.
01670	Gudebrod Bros. Silk Co.	New York, N.Y.
01930	Amerock Corp.	Rockford, Ill.
01960	Pulse Engineering Co	Santa Clara, Cal.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02116	Wheelock Signals, Inc.	Long Branch, N.J.
02286	Cole Rubber and Plastics Inc	Sunnyvale, Cal.
02660	Amphenol-Borg Electronics Corp.	Broadview, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Division	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins EngineeringCo.	San Fernando, Cal.
02875	Hudson Tool & Die	Newark, N.J.
03296	Nylon Molding Corp.	Springfield, N.J.
03508	G. E. Semiconductor Prod. Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	Compton, Calif.
03818	Parker Seal Co.	Los Angeles, Cal.
03877	Transitron Electric Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N.J.
03954	Singer Co., Diehl Div., Finderne Plant	Sumerville, N.J.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taruus Corp.	Lambertville, N.J.
04062	Arco Electronic Inc.	Great Neck, N.Y.
04217	Essex Wire	Los Angeles, Cal.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04354	Precision Paper Tube Co.	Wheeling, Ill.
04404	Palo Alto Division of Hewlett-Packard Co.	Palo Alto, Cal.
04651	Sylvania Electric Products, Microwave Device Div.	Mountain View, Cal.
04673	Dakota Engr. Inc.	Culver City, Cal.
04713	Motorola Inc. Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Div.	Culver City, Cal.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire Co.	Redwood City, Cal.
04811	Precision Coil Spring Co.	El Monte, Cal.
04870	P. M. Motor Company	Westchester, Ill.
04919	Component Mfg. Service Co.	W. Bridgewater, Mass.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Cal.
05277	Westinghouse Electric Corp. Semiconductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Cal.
05397	Union Carbine Corp., Elect. Div.	New York, N.Y.
05574	Viking Ind. Inc.	Canoga Park, Cal.
05593	Icore Electro-Plastics Inc.	Sunnyvale, Cal.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metro-Tel Corp.	Westbury, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Cal.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	Bassick Co., Div. of Stewart Warner Corp.	Bridgeport, Conn.
06090	Raychem Corp.	Redwood City, Cal.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E. T. A. Products Co. of America	Chicago, Ill.
06540	Amatom Electronic Hardware Co., Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Components Inc., Ariz. Div	Phoenix, Arizona
06812	Torrington Mfg. Co., West Div.	Van Nuys, Cal.
06980	Varian Assoc. Etmac Div.	San Carlos, Cal.
07088	Kelvin Electric Co.	Van Nuys, Cal.
07126	Digitran Co.	Pasadena, Cal.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp., Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Cal.
07256	Silicon Transistor Corp.	Carle Place, N.Y.
07261	Avnet Corp.	Culver City, Cal.
07263	Fairchild Camera & Inst. Corp., Semiconductor Div.	Mountain View, Cal.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	Birtcher Corp, The	Monterey Park, Cal.
07397	Sylvania Elect. Prod. Inc., Mt. View Operations	Mountain View, Cal.
07700	Technical Wire Products Inc.	Cranford, N.J.
07829	Bodine Elect. Co.	Chicago, Ill.
07910	Continental Device Corp.	Hawthorne, Cal.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Cal.
07980	Hewlett-Packard Co., New Jersey Division	Rockaway, N.J.
08145	U. S. Engineering Co.	Los Angeles, Cal.
08289	Blinn, Delbert Co.	Pomona, Cal.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08524	Deutsch Fastener Corp.	Los Angeles, Cal.
08664	Bristol Co., The	Waterbury, Conn.
08717	Sloan Company	Sun Valley, Cal.
08718	ITT Cannon Electric Inc., Phoenix Div.	Phoenix, Arizona
08727	National Radio Lab. Inc.	Paramus, N.J.
08792	CBS Electronics Semiconductor Operations, Div. of CBS Inc	Lowell, Mass.
08806	General Electric Co., Miniature Lamp Dept.	Cleveland, Ohio
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays Div.	Costa Mesa, Cal.
09097	Electronic Enclosures Inc.	Los Angeles, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Tech. Ind. Inc. Atohm Elect.	Burbank, Cal.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09353	C & K Components Inc.	Newton, Mass.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09795	Pennsylvania Florocarbon Clifton Heights, Penn.	
09922	Burndy Corp	Norwalk, Conn.
10214	General Transistor Western Corp.	Los Angeles, Cal.
10411	Ti-Tal, Inc.	Berkeley, Cal.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Cal.
11242	Bay State Electronics Corp.	Waltham, Mass.
11312	Teledyne Inc., Microwave Div.	Palo Alto, Cal.
11314	National Seal	Downey, Cal.
11453	Precision Connector Corp.	Jamaica, N.Y.
11534	Duncan Electronics Inc.	Costa Mesa, Cal.
11711	General Instrument Corp., Semiconductor Division Products Group	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Cal.
11870	Melabs, Inc.	Palo Alto, Cal.
12136	Philadelphia Handle Co.	Camden, N.J.
12361	Grove Mfg. Co., Inc.	Shady Grove, Pa.
12574	Gulton Ind. Inc., Data System Div.	Albuquerque, N.M.
12697	Clarostat Mfg. Co.	Dover, N.H.
12728	Elmar Filter Corp	W. Haven, Conn.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12881	Metex Electronics Corp.	Clark, N.J.
12930	Delta Semiconductor Inc.	Newport Beach, Cal.
12954	Dickson Electronics Corp.	Scottsdale, Arizona
13019	Airco Supply Co., Inc.	Witchita, Kansas
13061	Wilco Products	Detroit, Mich.
13103	Thermolloy	Dallas, Texas
13327	Solitron Devices Inc.	Tappan, N.Y.
13396	Telefunken (GmbH)	Hanover, Germany
13835	Midland-Wright Div. of Pacific Industries, Inc.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Cal.
14193	Calif. Resistor Corp	Santa Monica, Cal.
14298	American Components, Inc.	Conshohocken, Pa.
14433	ITT Semiconductor, a Div. of Int. Telephone and Telegraph Corporation	West Palm Beach, Fla.
14493	Hewlett-Packard Company	Loveland, Colo.
14655	Cornell Dublier Electric Corp	Newark, N.J.
14674	Corning Glass Works	Corning, N.Y.
14752	Electro Cube Inc.	San Gabriel, Cal.
14960	Williams Mfg. Co.	San Jose, Cal.
15106	The Sphere Co., Inc.	Little Falls, N.J.
15203	Webster Electronics Co.	New York, N.Y.
15287	Scionics Corp.	Northridge, Cal.
15291	Adjustable Bushing Co.	N. Hollywood, Cal.
15558	Micron Electronics.	Garden City, Long Island, N.Y.
15566	Amprobe Inst. Corp.	Lynbrook, N.Y.
15631	Cabletronics	Costa Mesa, Cal.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Cal.
15801	Fenwal Elect. Inc.	Framingham, Mass.
15818	Amelco Inc.	Mountain View, Cal.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16179	Omni-Spectra Inc.	Detroit, Ill.
16352	Computer Diode Corp.	Lodi, N.J.
16554	Electroid Co.	Union, N.J.
16585	Boots Aircraft Nut Corp.	Pasadena, Cal.
16688	Ideal Prec. Meter Co., Inc., De Jur Meter Div.	Brooklyn, N.Y.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
17109	Thermonetics Inc.	Canoga Park, Cal.
17474	Tranex Company	Mountain View, Cal.
17675	Hamlin Metal Products Corp.	Akron, Ohio
17745	Angstrohm Prec. Inc.	No. Hollywood, Cal.
17856	Siliconix Inc.	Sunnyvale, Cal.
17870	McGraw-Edison Co.	Manchester, N.H.
18042	Power Design Pacific Inc.	Palo Alto, Cal.
18083	Clevite Corp. Semiconductor Div.	Palo Alto, Cal.
18324	Signetics Corp.	Sunnyvale, Cal.
18476	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
18486	TRW Elect. Comp. Div.	Des Plaines, Ill.
18565	Chomerics	Plainville, Mass.
18583	Curtis Instrument, Inc.	Mt. Kisco, N.Y.
18612	Vishay Instruments Inc.	Malvern, Pa.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
18911	Durant Mfg. Co.	Milwaukee, Wis.
19315	The Bendix Corp., Navigation & Control Div.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison	West Orange, N.J.
19589	Concoa	Baldwin Park, Cal.

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
19644	LRC Electronics	Horseheads, N.Y.
19701	Electra Mfg. Co.	Independence, Kansas
20183	General Atronics Corp.	Philadelphia, Pa.
21226	Executone, Inc.	Long Island City, N.Y.
21355	Fafnir Bearing Co., The	New Britian, Conn.
21520	Fansteel Metallurgical Corp.	N. Chicago, Ill.
23020	General Reed Co.	Metuchen, N.J.
23042	Texscan Corp.	Indianapolis, Ind.
23783	British Radio Electronics Ltd.	Washington, D.C.
24455	G.E. Lamp Division, Nela Park,	Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
24681	Memcor Inc., Comp. Div.	Huntington, Ind.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobert File Co. of America, Inc.	Carlstadt, N.J.
26851	Compac Hollister Co.	Hollister, Cal.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Cal.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
30817	Instrument Specialties Co., Inc.	Little Falls, N.J.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Coil Products, Ltd.	Hawkesbury, Ontario, Canada
36287	Cunningham, W.H. & Hill, Ltd.	Toronto, Ontario, Canada
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
40931	Honeywell Inc.	Minneapolis, Minn.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
46384	Penn Eng. & Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer & Inst. Co.	Southampton, Pa.
49956	Microwave & Power Tube Div.	Waltham, Mass.
52090	Rowan Controller Co.	Westminster, Md.
52983	HP Co., Med. Elec. Div.	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Raytheon Co. Commercial Apparatus & System Div.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Elect. Co.	Bristol, Conn.
59446	Telex Corp.	Tulsa, Okla.
59730	Thomas & Betts Co.	Elizabeth, N.J.
60741	Triplett Electrical Inst. Co.	Bluffton, Ohio
61775	Union Switch and Signal Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Inc. Weston-Newark	Newark, N.J.
66295	Wittek Mfg. Co.	Chicago, Ill.
66346	Minnesota Mining & Mfg. Co. Revere Mincom Div.	St. Paul, Minn.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control	New York, N.Y.
70318	Allmetal Screw Product Co., Inc.	Garden City, N.Y.
70417	Amplex, Div. of Chrysler Corp.	Detroit, Mich.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	Union City, N.J.
70674	ADC Products Inc.	Minneapolis, Minn.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electric Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71034	Bliley Electric Co., Inc.	Erie, Pa.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincey, Mass.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionics Corp.	Cambridge, Mass.
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Cardwell Condenser Corp.	Lindenhurst, L.I., N.Y.
71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71447	Calif. Spring Co., Inc.	Pico-Rivera, Cal.
71450	CTS Corp.	Elkhart, Ind.
71468	ITT Cannon Electric Inc.	Los Angeles, Cal.
71471	Cinema, Div. Aerovox Corp.	Burbank, Cal.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	Cornish Wire Co., The	New York, N.Y.
71707	Coto Coil Co., Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	Indiana General Corp., Electronics Div.	Keasby, N.J.
72699	General Instrument Corp., Cap Division	Newark, N.J.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72962	Elastic Stop Nut Corp.	Union, N.J.
72964	Robert M. Hadley Co.	Los Angeles, Cal.
72982	Erie Technological Products, Inc.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Inst., Inc.	Fullerton, Cal.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Cal.
73445	Amperex Elect. Co.	Hicksville, L.I., N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73586	Circle F Mfg. Co.	Trenton, N.J.
73682	George K. Garrett Co., Div. MSL Industries, Inc.	Philadelphia, Pa.
73734	Federal Screw Products, Inc.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	General Industries Co., The	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Corp.	San Jose, Cal.
73957	Groove-Pin Corp.	Ridgefield, N.J.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronic Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75263	Keystone Carbon Co., Inc.	St. Marys, Pa.
75378	CTS Knights, Inc.	Sandwich, Ill.
75382	Kulka Electric Corp.	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Cal.
76433	General Instrument Corp., Micamold Division	Newark, N.J.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Cal.
76530	Cinch-Monadnock, Div. of United Carr Fastener Corp.	San Leandro, Cal.
76545	Mueller Electric Co.	Cleveland, Ohio
76703	National Union	Newark, N.J.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	The Bendix Corp., Electrodynamics Div.	N. Hollywood, Cal.
77075	Pacific Metals Co.	San Francisco, Cal.
77221	Phaostran Instrument and Electronic Co.	So. Pasadena, Cal.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine & Foundry Co. Potter & Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77638	General Instrument Corp., Rectifier Division	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Cal.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78277	Sigma	So. Braintree, Mass.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Cal.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	San Gabriel, Cal.
78947	Ucinite Co.	Newtonville, Mass.
79136	Waldes Kohinoor Inc.	Long Island City, N.Y.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80033	Prestole Corp.	Toledo, Ohio
80120	Schnitzer Alloy Products Co.	Elizabeth, N.J.
80131	Electronic Industries Association. Standard tube or semi-conductor device, any manufacturer.	
80207	Unimax Switch, Div. Maxon Electronics Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Inc.	Riverside, Cal.
80411	Arco Div. of Robertshaw Controls Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Label Co.	Monrovia, Cal.
80583	Hammarlund Co., Inc.	Mars Hill, N.C.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
80813	Dimco Gray Co.	Dayton, Ohio
81030	International Inst. Inc.	Orange, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Cal.
81312	Winchester Elec. Div. Litton Ind., Inc.	Oakville, Conn.
81349	Military Specification	
81483	International Rectifier Corp.	El Segundo, Cal.
81541	Airpax Electronics, Inc.	Cambridge, Maryland
81860	Barry Controls, Div. Barry Wright Corp.	Watertown, Mass.
82042	Carter Precision Electric Co.	Skokie, Ill.
82047	Sperti Faraday Inc., Copper Hewitt Electric Div.	Hoboken, N.J.
82116	Electric Regulator Corp.	Norwalk, Conn.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Fairchild Camera & Inst. Corp., Space & Defense Systems Div.	Paramus, N.J.
82209	Magurie Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod., Inc. Electronic Tube Division	Emporium, Pa.
82376	Astron Corp.	East Newark, Harrison, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals & Controls Inc., Spencer Products	Attleboro, Mass.
82768	Phillips-Advance Control Co.	Joliet, Ill.
82866	Research Products Corp.	Madison, Wis.
82877	Rolton Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Cal.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	General Instrument Corp., Capacitor Div.	Darlington, S.C.
83148	ITT Wire and Cable Div.	Los Angeles, Cal.
83186	Victory Eng. Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83324	Rosan Inc.	Newport Beach, Cal.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83332	Tech Labs	Palisades Park, N.J.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Union Carbide Corp., Consumer Prod. Div.	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
83942	Aeronautical Inst. & Radio Co.	Lodi, N.J.
84171	Arco Electronics Inc.	Great Neck, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Cal.
84411	TRW Capacitor Div.	Ogallala, Neb.

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
94870	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A. B. Boyd Co.	San Francisco, Cal.
85474	R. M. Bracamonte & Co.	San Francisco, Cal.
85660	Koiled Kords, Inc.	Hamden, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86174	Fafnir Bearing Co.	Los Angeles, Calif.
86197	Clifton Precision Products Co., Inc.	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, Electronic Comp. & Devices Division	Harrison, N.J.
86928	Seastrom Mfg. Co.	Glendale, Cal.
87034	Marco Industries	Anaheim, Cal.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Cal.
87664	Van Waters & Rogers Inc.	San Francisco, Cal.
87930	Tower Mfg. Corp.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Cal.
89473	G.E. Distributing Corp.	Schenectady, N.Y.
89479	Security Co.	Detroit, Mich.
89665	United Transformer Co.	Chicago, Ill.
90030	United Shoe Machinery Corp.	Beverly, Mass.
90179	U.S. Rubber Co., Consumer Ind. & Plastics Prod. Div.	Passaic, N.J.
90365	Belleville Speciality Tool Mfg., Inc.	Belleville, Ill.
90763	United Carr Fastener Corp.	Chicago, Ill.
90970	Bearing Engineering Co.	San Francisco, Cal.
91146	ITT Cannon Elect. Inc., Salem Div.	Salem, Mass.
91260	Connor Spring Mfg. Co.	San Francisco, Cal.
91345	Miller Dial & Nameplate Co.	El Monte, Cal.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Willow Grove, Pa.
91673	Epiphone Inc.	New York, N.Y.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Cal.
91886	Malco Mfg., Inc.	Chicago, Ill.
91929	Honeywell Inc., Micro Switch Division	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Cal.
92180	Tru-Connector Corp.	Peabody, Mass.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tensolite Insulated Wire Co., Inc.	Tarrytown, N.Y.
92702	IMC Magnetics Corp.	Westbury, L.I., N.Y.
92966	Hudson Lamp Co.	Kearney, N.J.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins & Myers Inc.	Pallisades Park, N.J.
93410	Stemco Controls, Div. of Essex Wire Corp.	Mansfield, Ohio
93632	Waters Mfg. Co.	Culver City, Cal.
93929	G.V. Controls	Livingston, N.J.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.
94148	Scientific Electronics Products, Inc.	Loveland, Colo.
94154	Wagner Elect. Corp., Tung-Sol Div.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Patterson, N.J.
94222	South Chester Corp.	Chester, Pa.
94330	Wire Cloth Products, Inc.	Bellwood, Ill.
94375	Automatic Metal Products Co.	Brooklyn, N.Y.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
94696	Magnecraft Electric Co.	Chicago, Ill.
95023	George A. Philbrick Researchers, Inc.	Boston, Mass.
95146	Alco Elect. Mfg. Co.	Lawrence, Mass.
95236	Allies Products Corp.	Diania, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	Long Island, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Rolling Meadows, Ill.
95566	Arnold Engineering Co.	Marengo, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95984	Siemon Mfg. Co.	Wayne, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Microwave Assoc., West, Inc.	Sunnyvale, Cal.
96095	Hi-Q Div. of Aerovox Corp.	Olean, N.Y.
96256	Thordarson-Meissner Inc.	Mt. Carmel, Ill.
96296	Solar Mfg. Co.	Los Angeles, Cal.
96396	Microswitch, Div. of Minn.-Honeywell	Freeport, Ill.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Cal.
96508	Xcelite, Inc.	Orchard Park, N.Y.
96733	San Fernando Elec. Mfg. Co.	San Fernando, Cal.
96881	Thomson Ind. Inc.	Long Island, N.Y.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic & Precision Mfg.	Englewood, N.J.
97979	Reon Resistor Corp.	Yonkers, N.Y.
97983	Litton System Inc., Adler-Westrex Commun. Div.	New Rochelle, N.Y.
98141	R-Tronics, Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Cal.
98220	Hewlett-Packard Co., Medical Elec. Div.	Pasadena, Cal.
98278	Microdot, Inc.	So. Pasadena, Cal.
98291	Sealectro Corp.	Mamaronech, N.Y.
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99707	Control Switch Division, Controls Co. of America	El Segundo, Cal.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
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99934	Rembrandt, Inc.	Boston, Mass.
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99957	Technology-Instrument Corp. of California	Newbury Park, Cal.

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0000Z	Willow Leather Products Corp.	Newark, N.J.
000AB	ETA	England
000BB	Precision Instrument Comp. Co.	Van Nuys, Cal.
000CS	Hewlett-Packard Co., Colorado Springs Div.	Colorado Springs, Colorado
000MM	Rubber Eng. & Development	Hayward, Cal.
000NN	A "N" D Mfg. Co.	San Jose, Cal.
000QQ	Cooltron	Oakland, Cal.
000WW	California Eastern Lab	Burlington, Cal.
000YY	S.K. Smith Co.	Los Angeles, Cal.

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Product Line Sales/Support Key

Key	Product Line
A	Analytical
CM	Components
C	Computer Systems Sales only
CH	Computer Systems Hardware Sales and Services
CS	Computer Systems Software Sales and Services
E	Electronic Instruments & Measurement Systems
M	Medical Products
MP	Medical Products Primary SRO
MS	Medical Products Secondary SRO
P	Personal Computation Products
*	Sales only for specific product line
**	Support only for specific product line

IMPORTANT: These symbols designate general product line capability. They do not insure sales or support availability for all products within a line, at all locations. Contact your local sales office for information regarding locations where HP support is available for specific products.

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P.O. Box 895
IS-REYKJAVIK
Tel: 1-58-20, 1-63-03
M

INDIA

Computer products are sold through Blue Star Ltd. All computer repairs and maintenance service is done through Computer Maintenance Corp.

Blue Star Ltd.
Sabri Complex II Floor
24 Residency Rd.
***BANGALORE** 560 025*
Tel: 55660
Telex: 0845-430
Cable: BLUESTAR
A,CH,CM,CS*,E*

Blue Star Ltd.
Band Box House
Prabhadevi
***BOMBAY** 400 025*
Tel: 422-3101
Telex: 011-3751
Cable: BLUESTAR
A,M

Blue Star Ltd.
Sahas
414/2 Vir Savarkar Marg
Prabhadevi
***BOMBAY** 400 025*
Tel: 422-6155
Telex: 011-4093
Cable: FROSTBLUE
A,CH,CM,CS*,E,M*

Blue Star Ltd.
Kalyan, 19 Vishwas Colony
*Alkapuri, **BORODA**, 390 005*
Tel: 65235
Cable: BLUE STAR
A

Blue Star Ltd.
7 Hare Street
***CALCUTTA** 700 001*
Tel: 12-01-31
Telex: 021-7655
Cable: BLUESTAR
A,M

Blue Star Ltd.
133 Kodambakkam High Road
***MADRAS** 600 034*
Tel: 82057
Telex: 041-379
Cable: BLUESTAR
A,M

Blue Star Ltd.
Bhandari House, 7th/8th Floors
91 Nehru Place
***NEW DELHI** 110 024*
Tel: 682547
Telex: 031-2463
Cable: BLUESTAR
A,CH,CM,CS*,E,M*

Blue Star Ltd.
15/16:C Wellesley Rd.
***PUNE** 411 011*
Tel: 22775
Cable: BLUE STAR
A

Blue Star Ltd.
2-2-47/1108 Bolarum Rd.
***SECUNDERABAD** 500 003*
Tel: 72057
Telex: 0155-459
Cable: BLUEFROST
A,E

Blue Star Ltd.
T.C. 7/603 Poornima
Maruthankuzhi
***TRIVANDRUM** 695 013*
Tel: 65799
Telex: 0884-259
Cable: BLUESTAR
E

Computer Maintenance Corporation Ltd.
115, Sarojini Devi Road
***SECUNDERABAD** 500 003*
Tel: 310-184, 345-774
Telex: 031-2960
*CH***

INDONESIA

BERCA Indonesia P.T.
P.O.Box 496/JKT.
Jl. Abdul Muis 62
JAKARTA
Tel: 373009
Telex: 46748 BERSAL IA
Cable: BERSAL JAKARTA
P

BERCA Indonesia P.T.
P.O.Box 2497/Jkt Antara Bldg.,
17th Floor
Jl. Medan Merdeka Selatan 17
JAKARTA-PUSAT
Tel: 21-344-181
Telex: BERSAL IA
A,CS,E,M

BERCA Indonesia P.T.
P.O. Box 174/SBY.
Jl. Kutei No. 11
SURABAYA
Tel: 68172
Telex: 31146 BERSAL SB
Cable: BERSAL-SURABAYA
A,E,M,P*

IRAQ

Hewlett-Packard Trading S.A.
Service Operation
Al Mansoor City 9B/3/7
BAGHDAD
Tel: 551-49-73
Telex: 212-455 HEPAIRAQ IK
CH,CS

SALES & SUPPORT OFFICES
Arranged alphabetically by country

IRELAND
Hewlett-Packard Ireland Ltd.
82/83 Lower Leeson Street
DUBLIN 2
Tel: (1) 60 88 00
Telex: 30439
A,CH,CM,CS,E,M,P

Cardiac Services Ltd.
Kilmore Road
Artane
DUBLIN 5
Tel: (01) 351820
Telex: 30439
M

ISRAEL
Eldan Electronic Instrument Ltd.
P.O.Box 1270
***JERUSALEM** 91000*
16, Ohaliav St.
***JERUSALEM** 94467*
Tel: 533 221, 553 242
Telex: 25231 AB/PAKRD IL
A

Electronics Engineering Division
Motorola Israel Ltd.
16 Kremenetski Street
P.O. Box 25016
TEL-AVIV 67899
Tel: 3-338973
Telex: 33569 Motil IL
Cable: BASTEL Tel-Aviv
CH,CM,CS,E,M,P

ITALY
Hewlett-Packard Italiana S.p.A
Traversa 99C
Via Giulio Petroni, 19
I-70124 **BARI**
Tel: (080) 41-07-44
M

Hewlett-Packard Italiana S.p.A.
Via Martin Luther King, 38/111
I-40132 **BOLOGNA**
Tel: (051) 402394
Telex: 511630
CH,E,MS

Hewlett-Packard Italiana S.p.A.
Via Principe Nicola 43G/C
I-95126 **CATANIA**
Tel: (095) 37-10-87
Telex: 970291
C,P

Hewlett-Packard Italiana S.p.A.
Via G. Di Vittorio 9
I-20063 **CERNUSCO SUL NAVIGLIO**
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Telex: 334632
A,CH,CM,CS,E,MP,P

Hewlett-Packard Italiana S.p.A.
Via Nuova San Rocco a
Capodimonte, 62/A
I-80131 **NAPLES**
Tel: (081) 7413544
Telex: 710698
A,CH,E

Hewlett-Packard Italiana S.p.A.
Viale G. Modugno 33
I-16156 **GENOVA PEGLI**
Tel: (010) 68-37-07
Telex: 215238
E,C

Hewlett-Packard Italiana S.p.A.
Via Turazza 14
I-35100 **PADOVA**
Tel: (049) 664888
Telex: 430315
A,CH,E,MS

Hewlett-Packard Italiana S.p.A.
Viale C. Pavese 340
I-00144 **ROMA**
Tel: (06) 54831
Telex: 610514
A,CH,CM,CS,E,MS,P*

Hewlett-Packard Italiana S.p.A.
Corso Svizzera, 184
I-10149 **TORINO**
Tel: (011) 74 4044
Telex: 221079
CH,E

JAPAN
Yokogawa-Hewlett-Packard Ltd.
152-1, Onna
000 **ATSUGI**, Kanagawa, 243
Tel: (0462) 28-0451
CM,C*,E

Yokogawa-Hewlett-Packard Ltd.
Towa Building
2-3, Kaigan-dori, 2 Chome Chuo-ku
KOBE, 650
Tel: (078) 392-4791
C,E

Yokogawa-Hewlett-Packard Ltd.
Kumagaya Asahi 82 Bldg
3-4 Tsukuba
KUMAGAYA, Saitama 360
Tel: (0485) 24-6563
CH,CM,E

Yokogawa-Hewlett-Packard Ltd.
Asahi Shinbun Daiichi Seimei Bldg.
4-7, Hanabata-cho
KUMAMOTO,860
Tel: (0963) 54-7311
CH,E

Yokogawa-Hewlett-Packard Ltd.
Shin-Kyoto Center Bldg.
614, Higashi-Shiokoji-cho
Karasuma-Nishiiru
Shiokoji-dori, Shimogyo-ku
KYOTO, 600
Tel: 075-343-0921
CH,E

Yokogawa-Hewlett-Packard Ltd.
Mito Mitsui Bldg
4-73, Sannomaru, 1 Chome
MITO, Ibaragi 310
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CH,CM,E

Yokogawa-Hewlett-Packard Ltd.
Sumitomo Seimei 14-9 Bldg.
Meieki-Minami, 2 Chome
Nakamura-ku
NAGOYA, 450
Tel: (052) 571-5171
CH,CM,CS,E,MS

Yokogawa-Hewlett-Packard Ltd.
Chuo Bldg.,
4-20 Nishinakajima, 5 Chome
Yodogawa-ku
OSAKA, 532
Tel: (06) 304-6021
Telex: YHPOSA 523-3624
A,CH,CM,CS,E,MP,P*

Yokogawa-Hewlett-Packard Ltd.
27-15, Yabe, 1 Chome
SAGAMIHARA Kanagawa, 229
Tel: 0427 59-1311

Yokogawa-Hewlett-Packard Ltd.
Daiichi Seimei Bldg.
7-1, Nishi Shinjuku, 2 Chome
Shinjuku-ku,**TOKYO** 160
Tel: 03-348-4611-5
CH,E

Yokogawa-Hewlett-Packard Ltd.
29-21 Takaido-Higashi, 3 Chome
Suginami-ku **TOKYO** 168
Tel: (03) 331-6111
Telex: 232-2024 YHPTOK
A,CH,CM,CS,E,MP,P*

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UTSUNOMIYA, Tochigi 320
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Yokogawa-Hewlett-Packard Ltd.
Yasuda Seimei Nishiguchi Bldg.
30-4 Tsuruya-cho, 3 Chome
YOKOHAMA221
Tel: (045) 312-1252
CH,CM,E

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Mouasher Cousins Company
P.O. Box 1387
AMMAN
Tel: 24907, 39907
Telex: 21456 SABCO JO
CH,E,M,P

KENYA
ADCOM Ltd., Inc., Kenya
P.O.Box 30070
NAIROBI
Tel: 331955
Telex: 22639
E,M

KOREA
Samsung Electronics Computer Division
76-561 Yeoksam-Dong
Kwangnam-Ku
C.P.O. Box 2775
SEOUL
Tel: 555-7555, 555-5447
Telex: K27364 SAMSAN
A,CH,CM,CS,E,M,P

KUWAIT
Al-Khaldiya Trading & Contracting
P.O. Box 830 Safat
KUWAIT
Tel: 42-4910, 41-1726
Telex: 22481 Areeg kt
CH,E,M

Photo & Cine Equipment
P.O. Box 270 Safat
KUWAIT
Tel: 42-2846, 42-3801
Telex: 22247 Matin kt
P

LEBANON
G.M. Dolmadjian
Achrafieh
P.O. Box 165.167
BEIRUT
Tel: 290293
MP*

LUXEMBOURG
Hewlett-Packard Belgium S.A./N.V.
Blvd de la Woluwe, 100
Woluwedal
B-1200 **BRUSSELS**
Tel: (02) 762-32-00
Telex: 23-494 paloben bru
A,CH,CM,CS,E,MP,P

MALAYSIA
Hewlett-Packard Sales (Malaysia) Sdn. Bhd.
1st Floor, Bangunan British American
Jalan Semantan, Damansara Heights
KUALA LUMPUR 23-03
Tel: 943022
Telex: MA31011
A,CH,E,M,P*

Protel Engineering
P.O.Box 1917
Lot 6624, Section 64
23/4 Pending Road
*Kuching, **SARAWAK***
Tel: 36299
Telex: MA 70904 PROTEL
Cable: PROTELENG
A,E,M

MALTA
Philip Toledo Ltd.
Notabile Rd.
MRIEHEL
Tel: 447 47, 455 66
Telex: Media MW 649
P

MEXICO
Hewlett-Packard Mexicana, S.A. de C.V.
Av. Periferico Sur No. 6501
Tepepan, Xochimilco
MEXICO D.F. 16020
Tel: 676-4600
Telex: 17-74-507 HEWPACK MEX
A,CH,CS,E,MS,P

Hewlett-Packard Mexicana, S.A. de C.V.
Ave. Colonia del Valle #409
Col. del Valle
Municipio de Garza Garcia
MONTERREY, N.L.
Tel: 78 42 41
Telex: 038 410
CH

ECISA
José Vasconcelos No. 218
Col. Condesa Deleg. Cuauhtémoc
***MEXICO** D.F. 06140*
Tel: 553-1206
Telex: 17-72755 ECE ME
M

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Dolbeau
81 rue Karatchi
CASABLANCA
Tel: 3041-82, 3068-38
Telex: 23051, 22822
E

Gerep
2 rue d'Agadir
Boite Postale 156
CASABLANCA
Tel: 272093, 272095
Telex: 23 739
P

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Hewlett-Packard Nederland B.V.
Van Heuven Goedhartlaan 121
NL 1181KK **AMSTELVEEN**
P.O. Box 667
NL1180 AR **AMSTELVEEN**
Tel: (020) 47-20-21
Telex: 13 216 HEPA NL
A,CH,CM,CS,E,MP,P

Hewlett-Packard Nederland B.V.
Bongerd 2
NL 2906VK **CAPELLE, A/D IJSSEL**
P.O. Box 41
NL 2900AA **CAPELLE, A/D IJSSEL**
Tel: (10) 51-64-44
Telex: 21261 HEPAC NL
A,CH,CS,E

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Hewlett-Packard (N.Z.) Ltd.
169 Manukau Road
P.O. Box 26-189
Epsom, **AUCKLAND**
Tel: 687-159
Cable: HEWPACK Auckland
CH,CM,E,P*

Hewlett-Packard (N.Z.) Ltd.
4-12 Cruickshank Street
Kilbirnie, **WELLINGTON 3**
P.O. Box 9443
Courtenay Place, **WELLINGTON 3**
Tel: 877-199
Cable: HEWPACK Wellington
CH,CM,E,P

Northrop Instruments & Systems Ltd.
369 Khyber Pass Road
P.O. Box 8602
AUCKLAND
Tel: 794-091
Telex: 60605
A,M

Northrop Instruments & Systems Ltd.
110 Mandeville St.
P.O. Box 8388
CHRISTCHURCH
Tel: 486-928
Telex: 4203
A,M

Northrop Instruments & Systems Ltd.
Sturdee House
85-87 Ghuznee Street
P.O. Box 2406
WELLINGTON
Tel: 850-091
Telex: NZ 3380
A,M

NORTHERN IRELAND
See United Kingdom

NORWAY
Hewlett-Packard Norge A/S
Folke Bernadottes vei 50
P.O. Box 3558
N-5033 **FYLLINGSDALEN** (Bergen)
Tel: (05) 16-55-40
Telex: 16621 hpnas n
CH,CS,E,MS

Hewlett-Packard Norge A/S
Österndalen 18
P.O. Box 34
N-1345 **ÖSTERÅS**
Tel: (02) 17-11-80
Telex: 16621 hpnas n
A,CH,CM,CS,E,M,P

OMAN
Khimjil Ramdas
P.O. Box 19
MUSCAT
Tel: 722225, 745601
Telex: 3289 BROKER MB MUSCAT
P

Suhail & Saud Bahwan
P.O.Box 169
MUSCAT
Tel: 734 201-3
Telex: 3274 BAHWAN MB

PAKISTAN
Mushko & Company Ltd.
1-B, Street 43
Sector F-8/1
ISLAMABAD
Tel: 26875
Cable: FEMUS Rawalpindi
A,E,M

Mushko & Company Ltd.
Oosman Chambers
Abdullah Haroon Road
***KARACHI** 0302*
Tel: 524131, 524132
Telex: 2894 MUSKO PK
Cable: COOPERATOR Karachi
A,E,M,P*

PANAMA
Electrónico Balboa, S.A.
Calle Samuel Lewis, Ed. Alfa
Apartado 4929
PANAMA 5
Tel: 64-2700
Telex: 3483 ELECTRON PG
A,CM,E,M,P

SALES & SUPPORT OFFICES

Arranged alphabetically by country

PERU
Cía Electro Médica S.A.
Los Flamencos 145, San Isidro
Casilla 1030
***LIMA** 1*
Tel: 41-4325, 41-3703
Telex: Pub. Booth 25306
CM,E,M,P

PHILIPPINES
The Online Advanced Systems Corporation
Rico House, Amorsolo Cor. Herrera Street
Legaspi Village, Makati
P.O. Box 1510
*Metro **MANILA***
Tel: 85-35-81, 85-34-91, 85-32-21
Telex: 3274 ONLINE
A,CH,CS,E,M

Electronic Specialists and Proponents Inc.
690-B Epifanio de los Santos Avenue
*Cubao, **QUEZON CITY***
P.O. Box 2649 Manila
Tel: 98-96-81, 98-96-82, 98-96-83
Telex: 40018, 42000 ITT GLOBE MACKAY BOOTH
P

PORTUGAL
Mundinter
Intercambio Mundial de Comércio S.A.R.L.
P.O. Box 2761
Avenida Antonio Augusto de Aguiar 138
P-LISBON
Tel: (19) 53-21-31, 53-21-37
Telex: 16691 munter p
M

Soquimica
Av. da Liberdade, 220-2
*1298 **LISBOA** Codex*
Tel: 56 21 81/2/3
Telex: 13316 SABASA
P

Telectra-Empresa Técnica de Equipmentos Eléctricos S.A.R.L.
Rua Rodrigo da Fonseca 103
P.O. Box 2531
***P-LISBON** 1*
Tel: (19) 68-60-72
Telex: 12598
CH,CS,E,P

PUERTO RICO
Hewlett-Packard Puerto Rico
P.O. Box 4407
CAROLINA, Puerto Rico 00628
Calle 272 Edificio 203
Urb. Country Club
RIO PIEDRAS, Puerto Rico
Tel: (809) 762-7255
A,CH,CS

QATAR
Computearbia
P.O. Box 2750
DOHA
Tel: 883555
Telex: 4806 CHPARB
P

Eastern Technical Services
P.O.Box 4747
DOHA
Tel: 329 993
Telex: 4156 EASTEC DH

Nasser Trading & Contracting
P.O.Box 1563
DOHA
Tel: 22170, 23539
Telex: 4439 NASSER DH
M

SAUDI ARABIA
Modern Electronic Establishment
Hewlett-Packard Division
P.O. Box 281
Thuobah
AL-KHOBAR
Tel: 864-46 78
Telex: 671 106 HPMEEK SJ
Cable: ELECTA AL-KHOBAR
CH,CS,E,M,P

Modern Electronic Establishment
Hewlett-Packard Division
P.O. Box 1228
Redec Plaza, 6th Floor
JEDDAH
Tel: 644 38 48
Telex: 4027 12 FARNAS SJ
Cable: ELECTA JEDDAH
CH,CS,E,M,P

Modern Electronic Establishment
Hewlett-Packard Division
P.O.Box 2728
RIYADH
Tel: 491-97 15, 491-63 87
Telex: 202049 MEERYD SJ
CH,CS,E,M,P

SCOTLAND
See United Kingdom

SINGAPORE
Hewlett-Packard Singapore (Sales) Pte. Ltd.
P.O. Box 58 Alexandra Post Office
SINGAPORE, 9115
6th Floor, Inchcape House
450-452 Alexandra Road
SINGAPORE 0511
Tel: 631788
Telex: HPSGSO RS 34209
Cable: HEWPACK, Singapore
A,CH,CS,E,MS,P

Dynamar International Ltd.
Unit 05-11 Block 6
Kolam Ayer Industrial Estate
***SINGAPORE** 1334*
Tel: 747-6188
Telex: RS 26283
CM

SOUTH AFRICA
Hewlett-Packard So Africa (Pty.) Ltd.
P.O. Box 120
Howard Place **CAPE PROVINCE** 7450
Pine Park Center, Forest Drive, Pinelands
CAPE PROVINCE 7405
Tel: 53-7954
Telex: 57-20006
A,CH,CM,E,MS,P

Hewlett-Packard So Africa (Pty.) Ltd.
P.O. Box 37099
92 Overport Drive
DURBAN 4067
Tel: 28-4178, 28-4179, 28-4110
Telex: 6-22954
CH,CM

Hewlett-Packard So Africa (Pty.) Ltd.
6 Linton Arcade
511 Cape Road
Linton Grange
PORT ELIZABETH 6001
Tel: 041-302148
CH

Hewlett-Packard So Africa (Pty.) Ltd. P.O.Box 33345
Glenstantia 0010 **TRANSVAAL**
1st Floor East
Constantia Park Ridge Shopping Centre
Constantia Park
PRETORIA
Tel: 982043
Telex: 32163
CH,E

Hewlett-Packard So Africa (Pty.) Ltd.
Private Bag Wendywood
SANDTON 2144
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Telex: 4-20877
Cable: HEWPACK Johannesburg
A,CH,CM,CS,E,MS,P

SPAIN
Hewlett-Packard Española S.A.
Calle Entenza, 321
E-BARCELONA 29
Tel: 322.24.51, 321.73.54
Telex: 52603 hpbee
A,CH,CS,E,MS,P

Hewlett-Packard Española S.A.
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Edificio Albia II
E-BILBAO 1
Tel: 423.83.06
A,CH,E,MS

Hewlett-Packard Española S.A.
Crta. de la Coruña, Km. 16, 400
Las Rozas
E-MADRID
Tel: (1) 637.00.11

CH,CS,M

Hewlett-Packard Española S.A.
Avda. S. Francisco Javier, S/no
Planta 10. Edificio Sevilla 2,
E-SEVILLA 5
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Telex: 72933
A,CS,MS,P

Hewlett-Packard Española S.A.
Calle Ramon Gordillo, 1 (Entlo.3)
E-VALENCIA 10
Tel: 361-1354
CH,P

SWEDEN
Hewlett-Packard Sverige AB
Sunnanvagen 14K
S-22226 **LUND**
Tel: (046) 13-69-79
Telex: (854) 17886 (via Spånga office)
CH

Hewlett-Packard Sverige AB
Vastra Vintergatan 9
S-70344 **OREBRO**
Tel: (19) 10-48-80
Telex: (854) 17886 (via Spånga office)
CH

Hewlett-Packard Sverige AB
Skalholtsgatan 9, Kista
Box 19
S-16393 **SPÅNGA**
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Telex: (854) 17886
A,CH,CM,CS,E,MS,P

Hewlett-Packard Sverige AB
Frötallisgatan 30
S-42132 **VÄSTRA-FRÖLUNDA**
Tel: (031) 49-09-50
Telex: (854) 17886 (via Spånga office)
CH,E,P

SWITZERLAND
Hewlett-Packard (Schweiz) AG
Clarastrasse 12
CH-4058 **BASLE**
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A

Hewlett-Packard (Schweiz) AG
7, rue du Bois-du-Lan
Case Postale 365
CH-1217 **MEYRIN** 1
Tel: (0041) 22-83-11-11
Telex:27333 HPAG CH
CH,CM,CS

Hewlett-Packard (Schweiz) AG
Allmend 2
CH-8967 **WIDEN**
Tel: (0041) 57 31 21 11
Telex: 53933 hpag ch
Cable: HPAG CH
A,CH,CM,CS,E,MS,P

SYRIA
General Electronic Inc.
Nuri Basha P.O. Box 5781
DAMASCUS
Tel: 33-24-87
Telex: 11216 ITIKAL SY
Cable: ELECTROBOR DAMASCUS
E

Middle East Electronics
Place Azmé
P.O.Box 2308
DAMASCUS
Tel: 334592
Telex: 11304 SATACO SY
M,P

TAIWAN
Hewlett-Packard Far East Ltd.
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KAOHSIUNG
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CH,CS,E

Hewlett-Packard Far East Ltd.
Taiwan Branch
5th Floor
205 Tun Hwa North Road
TAIPEI
Tel: (02) 712-0404
Cable:HEWPACK Taipei
A,CH,CM,CS,E,M,P

Ing Lih Trading Co.
3rd Floor, 7 Jen-Ai Road, Sec. 2
TAIPEI 100
Tel: (02) 3948191
Cable: INGLIH TAIPEI
A

THAILAND
Unimesa
30 Patpong Ave., Suriwong
***BANGKOK** 5*
Tel: 235-5727
Telex: 84439 Simonco TH
Cable: UNIMESA Bangkok
A,CH,CS,E,M

Bangkok Business Equipment Ltd.
5/5-6 Dejo Road
BANGKOK
Tel: 234-8670, 234-8671
Telex: 87669-BEQUIPT TH
Cable: BUSIQUIPT Bangkok
P

TRINIDAD & TOBAGO
Caribbean Telecoms Ltd.
50/A Jerningham Avenue
P.O. Box 732
PORT-OF-SPAIN
Tel: 62-44213, 62-44214
Telex: 235,272 HUGCO WG
CM,E,M,P

TUNISIA
Tunisie Electronique
31 Avenue de la Liberte
TUNIS
Tel: 280-144
E,P

Corema
1 ter. Av. de Carthage
TUNIS
Tel: 253-821
Telex: 12319 CABAM TN
M

TURKEY
Teknim Company Ltd.
Iran Caddesi No. 7
*Kavaklidere, **ANKARA***
Tel: 275800
Telex: 42155 TKNM TR
E

E.M.A.
Medina Eldem Sokak No.41/6
Yuksel Caddesi
ANKARA
Tel: 175 622
M

UNITED ARAB EMIRATES
Emitac Ltd.
P.O. Box 1641
SHARJAH
Tel: 354121, 354123
Telex: 68136 Emitac Sh
CH,CS,E,M,P

UNITED KINGDOM

GREAT BRITAIN
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A,CH,CS,E,M

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GREAT BRITAIN (Cont'd)

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March 1983 5952-6900

HP distributors are printed in italics.

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00427-90008

Printed in U.S.A.