

# OPERATING AND SERVICE MANUAL

## MULTIMETER

3465A



HEWLETT  PACKARD



## OPERATING AND SERVICE MANUAL

### MODEL 3465A

### MULTIMETER

Serial Numbers: 1546A01501 and greater

#### IMPORTANT NOTICE

This loose leaf manual does not normally require a change sheet. All major change information has been integrated into the manual by page revision. In cases where only minor changes are required, a change sheet may be supplied.

If the Serial Number of your instrument is lower than the one on this title page, the manual contains revisions that do not apply to your instrument. Backdating information given in the manual adapts it to earlier instruments.

Where practical, backdating information is integrated into the text, parts list and schematic diagrams. Backdating changes are denoted by a delta sign. An open delta ( $\Delta$ ) or lettered delta ( $\Delta_A$ ) on a given page, refers to the corresponding backdating note on that page. Backdating changes not integrated into the manual are denoted by a numbered delta ( $\Delta_1$ ) which refers to the corresponding change in the Backdating section (Section VIII).

 This symbol is an international symbol meaning "refer to the Operating and Service Manual." The symbol flags important operating instructions in Figure 3-1 and Paragraphs 3-13, 3-16, 3-21 and 3-27.

#### WARNING

*To prevent potential fire or shock hazard, do not expose equipment to rain or moisture.*

-hp- Part No. 03465-90004  
(complete Manual including binder)

-hp- Part No. 03465-90001  
(Includes Binder, Cover Inserts — no Pages)

-hp- Part No. 03465-90003  
(Loose-Leaf Pages Only)

Microfiche Part No. 03465-90051

Copyright Hewlett-Packard Company 1975  
P.O. Box 301, Loveland, Colorado 80537 U.S.A.



### **CERTIFICATION**

*Hewlett-Packard Company certifies that this instrument met its published specifications at the time of shipment from the factory. Hewlett-Packard Company 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 AND ASSISTANCE**

This Hewlett-Packard product is warranted against defects in materials and workmanship for a period of one year from the date of shipment, except that in the case of certain components, if any, listed in Section I of this operating manual, the warranty shall be for the specified period. Hewlett-Packard will, at its option, repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard, and provided the proper preventive maintenance procedures as listed in this manual are followed. Repairs necessitated by misuse of the product are not covered by this warranty. **NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. HEWLETT-PACKARD IS NOT LIABLE FOR CONSEQUENTIAL DAMAGES.**

If this product is sold as part of a Hewlett-Packard integrated instrument system, the above warranty shall not be applicable, and this product shall be covered only by the system warranty.

Service contracts or 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.

## TABLE OF CONTENTS

| Section                                                  | Page | Section                                          | Page      |
|----------------------------------------------------------|------|--------------------------------------------------|-----------|
| I. GENERAL INFORMATION                                   | 1-1  | 4-35. Display                                    | 4-4       |
| 1-1. Introduction                                        | 1-1  | 4-37. Power Supply                               | 4-5       |
| 1-3. Description                                         | 1-1  | 4-39. Detailed Theory                            | 4-5       |
| 1-5. Specifications                                      | 1-1  | 4-41. Precision Resistor Pack (R75)              | 4-5       |
| 1-7. Instrument and Manual Identification                | 1-1  | 4-43. Ohms Converter                             | 4-5       |
| 1-9. Options                                             | 1-1  | 4-50. AC-to-DC Converter                         | 4-6       |
| 1-11. Option 001                                         | 1-1  | 4-56. A-D Conversion Using a Monopolar Reference | 4-6       |
| 1-13. Option 002                                         | 1-1  | 4-64. Data Accumulator                           | 4-8       |
| 1-15. Accessories                                        | 1-1  | 4-69. Display                                    | 4-8       |
| 1-17. Safety Considerations                              | 1-1  | 4-72. Power Supply                               | 4-10      |
| II. INSTALLATION                                         | 2-1  | 4-78. + 10 V Series Voltage Regulation           | 4-11/4-12 |
| 2-1. Introduction                                        | 2-1  | 4-80. - 12 V Supply                              | 4-11/4-12 |
| 2-3. Initial Inspection                                  | 2-1  | 4-82. Battery Low-Voltage Detection              | 4-11/4-12 |
| 2-5. Power Requirements                                  | 2-1  |                                                  |           |
| 2-7. Grounding Requirements                              | 2-1  |                                                  |           |
| 2-10. Environmental Requirements                         | 2-1  |                                                  |           |
| 2-12. Repackaging for Shipment                           | 2-1  |                                                  |           |
| 2-16. Power Cords and Receptacles                        | 2-2  |                                                  |           |
| III. OPERATING INSTRUCTIONS                              | 3-1  | V. MAINTENANCE                                   | 5-1       |
| 3-1. Introduction                                        | 3-1  | 5-1. Introduction                                | 5-1       |
| 3-3. Front and Rear Panel Features                       | 3-1  | 5-3. Test Equipment Required                     | 5-1       |
| 3-5. Turn-on and Warm-up                                 | 3-1  | 5-5. Performance Tests                           | 5-1       |
| 3-7. Internal Battery Voltage Measurement and Recharging | 3-1  | 5-6. DC Voltmeter Accuracy Test                  | 5-1       |
| 3-9. Low Battery Voltage Detection                       | 3-1  | 5-8. DC Ammeter Accuracy Test                    | 5-1       |
| 3-11. Overload Indication                                | 3-1  | 5-10. Ohms Accuracy Test                         | 5-2       |
| 3-13. AC Voltage Measurements                            | 3-1  | 5-12. AC Voltage Accuracy Test                   | 5-2       |
| 3-14. AC Voltage Ranges                                  | 3-1  | 5-14. AC Ammeter Accuracy Test                   | 5-2       |
| 3-16. DC Voltage Measurements                            | 3-3  | 5-16. AC Normal-Mode Rejection Test              | 5-5       |
| 3-17. 10 mV Range Zero Adjust                            | 3-3  | 5-18. AC Effective Common-Mode Rejection Test    | 5-5       |
| 3-19. DC Voltage Ranges                                  | 3-3  | 5-20. DC Voltmeter Input Resistance Test         | 5-5       |
| 3-21. Current Measurements                               | 3-3  | 5-22. AC Voltmeter Input Impedance Test          | 5-6       |
| 3-23. AC Current Ranges                                  | 3-3  | 5-24. Adjustment Procedures                      | 5-7       |
| 3-25. DC Current Ranges                                  | 3-3  | 5-26. Power Supply Adjustment                    | 5-8       |
| 3-27. Ohms Measurements                                  | 3-4  | 5-30. Input Amplifier Adjustments                | 5-8       |
| 3-28. Ohmmeter Ranges                                    | 3-4  | 5-33. Ohms Converter Adjustments (R58 and R69)   | 5-9       |
| 3-30. Ohmmeter Reference Current                         | 3-4  | 5-35. AC - DC Converter Adjustments              | 5-9       |
| IV. THEORY OF OPERATION                                  | 4-1  |                                                  |           |
| 4-1. Introduction                                        | 4-1  | PERFORMANCE TEST CARDS                           |           |
| 4-3. Description                                         | 4-1  | VI. REPLACEABLE PARTS                            | 6-1       |
| 4-6. Simplified Theory                                   | 4-2  | 6-1. Introduction                                | 6-1       |
| 4-8. Signal Conditioning                                 | 4-2  | 6-4. Ordering Information                        | 6-1       |
| 4-18. Analog-to-Digital (A-D) Converter                  | 4-3  | 6-6. Non-Listed Parts                            | 6-1       |
| 4-26. Logic Section                                      | 4-4  | 6-8. Parts Changes                               | 6-1       |
|                                                          |      | 6-10. Proprietary Parts                          | 6-1       |

## TABLE OF CONTENTS (cont'd)

| Section                                                                       | Page | Section                                                       | Page |
|-------------------------------------------------------------------------------|------|---------------------------------------------------------------|------|
| VII. TROUBLESHOOTING AND<br>CIRCUIT DIAGRAMS . . . . .                        | 7-1  | 7-17. Data Accumulator Input/Output<br>Verification . . . . . | 7-2  |
| 7-1. Introduction . . . . .                                                   | 7-1  | 7-19. Display and Display Driver<br>Verification . . . . .    | 7-3  |
| 7-3. Schematic Diagrams . . . . .                                             | 7-1  | Section                                                       | Page |
| 7-5. Preliminary Troubleshooting . . . . .                                    | 7-1  | VIII. BACKDATING . . . . .                                    | 8-1  |
| 7-7. Analog Troubleshooting . . . . .                                         | 7-1  | 8-1. Introduction . . . . .                                   | 8-1  |
| 7-10. Digital Troubleshooting . . . . .                                       | 7-1  | 8-3. Change Sequence . . . . .                                | 8-1  |
| 7-13. Polarity, Zero Detect and Clock<br>Circuit Verification . . . . .       | 7-2  | 8-5. Parts not Included in Backdating . . . . .               | 8-1  |
| 7-15. Analog Switch Lines and Control<br>State Counter Verification . . . . . | 7-2  | Appendix A. Electronic Sales and Service Offices              |      |

## LIST OF TABLES

| Table                                           | Page | Table                                                                     | Page |
|-------------------------------------------------|------|---------------------------------------------------------------------------|------|
| 1-1. Specifications . . . . .                   | 1-2  | 5-6. AC Ammeter Accuracy Test, 100 $\mu$ A thru<br>10 mA Ranges . . . . . | 5-4  |
| 1-2. General Information . . . . .              | 1-3  | 5-7. AC Ammeter Accuracy Test, 100 mA and<br>1000 mA Ranges. . . . .      | 5-5  |
| 3-1. Ohmmeter Current Through Unknown . . . . . | 3-4  | 5-8. Power Supply Jumpers . . . . .                                       | 5-8  |
| 4-1. Display Interface Connections . . . . .    | 4-9  | 6-1. Standard Abbreviations . . . . .                                     | 6-1  |
| 5-1. Test Equipment Required . . . . .          | 5-0  | 6-2. Code List of Manufacturers . . . . .                                 | 6-2  |
| 5-2. DC Voltmeter Accuracy Test . . . . .       | 5-1  | 6-3. Replaceable Parts List . . . . .                                     | 6-3  |
| 5-3. DC Ammeter Accuracy Test . . . . .         | 5-2  | 8-1. Manual Backdating Changes. . . . .                                   | 8-1  |
| 5-4. Ohms Accuracy Test . . . . .               | 5-2  |                                                                           |      |
| 5-5. AC Voltage Accuracy Test . . . . .         | 5-3  |                                                                           |      |

## LIST OF ILLUSTRATIONS

| Figure                                                        | Page | Figure                                                                  | Page      |
|---------------------------------------------------------------|------|-------------------------------------------------------------------------|-----------|
| 2-1. Power Receptacles. . . . .                               | 2-2  | 5-2. Ohms Accuracy Test . . . . .                                       | 5-2       |
| 3-1. Front and Rear Panel Features. . . . .                   | 3-2  | 5-3. AC Ammeter Accuracy Test 100 $\mu$ A thru<br>10 mA Range . . . . . | 5-3       |
| 4-1. Basic Block Diagram and Measurement<br>Sequence. . . . . | 4-1  | 5-4. AC Normal-Mode Rejection Test . . . . .                            | 5-5       |
| 4-2. Simplified Diagram, Ohms Converter. . . . .              | 4-2  | 5-5. AC Effective Common-Mode<br>Rejection Test . . . . .               | 5-6       |
| 4-3. Block Diagram, AC-to-DC Converter . . . . .              | 4-3  | 5-6. DC Voltmeter Input Resistance Test. . . . .                        | 5-6       |
| 4-4. Block Diagram, Power Supply . . . . .                    | 4-5  | 5-7. AC Voltmeter Input Impedance Test. . . . .                         | 5-6       |
| 4-5. Over-Voltage Protection Circuit . . . . .                | 4-5  | 5-8. Multimeter Adjustment Location . . . . .                           | 5-7       |
| 4-6. Basic Diagram, AC Converter Amplifier . . . . .          | 4-6  | 7-1. Functional Block Diagram. . . . .                                  | 7-5/7-6   |
| 4-7. Functional Diagram, A-D Converter. . . . .               | 4-7  | 7-2. Signal Conditioning . . . . .                                      | 7-7/7-8   |
| 4-8. Data Accumulator . . . . .                               | 4-9  | 7-3. Analog-to-Digital Converter . . . . .                              | 7-9/7-10  |
| 4-9. Basic Diagram, DC-to-DC Converter . . . . .              | 4-10 | 7-4. Logic and Display . . . . .                                        | 7-11/7-12 |
| 4-10. Simplified Diagram, DC-to-DC Converter . . . . .        | 4-10 | 7-5. Power Supply . . . . .                                             | 7-13/7-14 |
| 5-1. DC Ammeter Accuracy Test . . . . .                       | 5-1  |                                                                         |           |

## SECTION I

### GENERAL INFORMATION

#### 1-1. INTRODUCTION.

1-2. This section contains general information concerning the -hp- Model 3465A Multimeter. Included is an instrument description, specifications, information about instrument and manual identification, option and accessory information and safety considerations.

#### 1-3. DESCRIPTION.

1-4. The -hp- Model 3465A Multimeter is a 4-1/2 digit, five function digital multimeter. The five functions are dc volts, ac volts, dc current, ac current and ohms. Measurements can be made to four significant digits with a sample rate of 2-1/2 readings per second. Throughout this manual, the 3465A Multimeter will be referred to as Multimeter.

#### 1-5. SPECIFICATIONS.

1-6. Instrument specifications are listed in Table 1-1. These specifications are the performance standards or limits against which the instrument is tested. Any change in the specifications due to manufacturing, design or traceability to the U.S. National Bureau of Standards will be covered by revised pages to this manual. Additional information describing the operating characteristics are not specifications but are supplemental information for the user.

#### 1-7. INSTRUMENT AND MANUAL IDENTIFICATION.

1-8. Hewlett-Packard uses a two-section serial number. The first section (prefix) identifies a series of instruments. The last section (suffix) identifies a particular instrument within the series. If a letter is included with the serial number, it identifies the country where the instrument was manufactured. This manual is kept up-to-date with the instrument at all times by revision. If the serial prefix of your instrument differs from the one on the title page of this manual, refer to Section VIII for backdating information that will adapt this manual to your instrument. All correspondence with Hewlett-Packard should include the complete serial number.

#### 1-9. OPTIONS.

1-10. Multimeter options are available to provide alternate methods of powering the instrument. The standard instrument is powered by rechargeable NiCad batteries or can be powered from an ac source of 86 to 127 V or 172 to 254V, 48 to 66 Hz.

#### 1-11. Option 001.

1-12. Option 001 allows ac line operation only. Power is

derived from an ac source of 86 to 127 V or 172 to 254 V, 48 to 66 Hz. Two NiCad Battery Packs can be installed at any time to allow portable operation of the Multimeter.

#### 1-13. Option 002.

1-14. Option 002 is powered by four "D" type dry cell batteries (U2 in Europe). Alternate power can be derived from most Hewlett-Packard hand-held calculator battery chargers such as the Model 82002A Battery Charger/AC Adapter through a special rear panel input connector.

#### 1-15. ACCESSORIES.

1-16. The following accessories are available to extend the usefulness of your Multimeter:

1. Model 11096A RF Probe, 100 kHz to 500 MHz (down 3 dB at 10 kHz and 700 MHz), for use on the 10 V and 100 V ranges in the DCV function only.
2. Model 11002A Test leads, dual banana to dual alligator.
3. Model 11003A test leads, dual banana to probe and alligator.
4. Submodule front handle, -hp- Part No. 5061-2001.
5. Handle Kit (Rack), -hp- Part No. 5061-0088.
6. Rack adapter kit (includes 1/2 module filler), -hp- Part No. 5061-0054.
7. Nickel Cadmium Battery Pack (2 required) -hp- Part No. 00035-60024.
8. Model 82002A Battery Charger/AC Adapter, alternate power (battery elimination) for the Option 002 Multimeter.
9. 11129A Binding Post Kit.

#### 1-17. SAFETY CONSIDERATIONS.

1-18. This operating and service manual contains cautions and warnings alerting the user to hazardous operating and maintenance conditions. This information is flagged by a caution or warning heading and/or the symbol . The  symbol appears on the front panel and is an international symbol meaning "refer to the Operating and Service Manual". This symbol flags important operating instructions located in Section III. To ensure the safety of the operating and maintenance personnel and retain the operating condition of the instrument, these instructions must be adhered to.

Table 1-1. Specifications.

| <p><b>DC VOLTMETER</b></p> <p><b>Ranges:</b> 10 mV, 100 mV, 1 V, 10 V, 100 V, 1000 V</p> <p><b>Overrange:</b> 100% on all ranges except 1000 V max. on the 1000 V range.</p> <p><b>Accuracy:</b> (90 days, + 23°C ± 5°C):</p> <table border="1"> <thead> <tr> <th>RANGE</th><th>SPECIFICATION<br/>± (% Reading + % Range)</th></tr> </thead> <tbody> <tr> <td>10 mV</td><td>± (0.03 % + 0.02%)</td></tr> <tr> <td>100 mV through 100 V</td><td>± (0.02 % + 0.01%)</td></tr> <tr> <td>1000 V</td><td>± (0.025% + 0.01%)</td></tr> </tbody> </table> <p><b>Temperature Coefficient</b> (0°C to 50°C): ± 0.003% of Reading/°C</p> <p><b>Effective Common-Mode Rejection</b> (with 1 kΩ imbalance in either lead):</p> <p>AC: &gt; 120 dB at 50/60 Hz ± 0.1%</p> <p><b>AC Normal-Mode Rejection:</b></p> <p>&gt; 60 dB at 50/60 Hz ± 0.1%</p> <p><b>Input Resistance:</b></p> <p>10 mV through 1 V ranges: (80% R.H.) ≥ 10<sup>10</sup> Ω</p> <p>10 V through 1000 V ranges: 10 MΩ ± 1%</p> <p><b>AC VOLTMETER</b></p> <p><b>Ranges:</b> 100 mV, 1 V, 10 V, 100 V, 1000 V (500 V Max)</p> <p><b>Overrange:</b> 100% on all ranges to 10 kHz decreasing linearly to 0% at 20 kHz. Maximum input voltage on the 1000 V range is 500 V rms.</p> <p><b>Accuracy:</b> (90 days, + 23°C ± 5°C) ± (% Reading + % Range)</p> <p><b>Temperature Coefficient</b> (0°C to 50°C): ± (0.005% of Reading + 0.002% of Range)/°C</p> <p><b>Input Impedance:</b> 1 M ± 1% shunted by &lt; 100 pF</p> <p><b>DC AMMETER</b></p> <p><b>Ranges:</b> 100 μA, 1 mA, 10 mA, 100 mA, 1000 mA</p> <p><b>Overrange:</b> 100% on all ranges</p> | RANGE                                          | SPECIFICATION<br>± (% Reading + % Range) | 10 mV | ± (0.03 % + 0.02%) | 100 mV through 100 V | ± (0.02 % + 0.01%) | 1000 V | ± (0.025% + 0.01%) | <p><b>Accuracy:</b> (90 days, + 23°C ± 5°C)</p> <table border="1"> <thead> <tr> <th>RANGE</th><th>SPECIFICATION<br/>± (% of Reading + % of Range)</th></tr> </thead> <tbody> <tr> <td>100 μA, 1 mA</td><td>± (0.07% + 0.01%)</td></tr> <tr> <td>10 mA</td><td>± (0.11% + 0.01%)</td></tr> <tr> <td>100 mA, 1000 mA</td><td>± (0.6 % + 0.01%)</td></tr> </tbody> </table> <p><b>Temperature Coefficient</b> (0°C to 50°C):</p> <table border="1"> <thead> <tr> <th>RANGE</th><th>SPECIFICATION<br/>± (% of Reading)/°C</th></tr> </thead> <tbody> <tr> <td>100 μA</td><td>± 0.006%</td></tr> <tr> <td>1 mA, 10 mA</td><td>± 0.004 %</td></tr> <tr> <td>100 mA, 1000 mA</td><td>± 0.01 %</td></tr> </tbody> </table> <p><b>AC AMMETER</b></p> <p><b>Ranges:</b> 100 μA, 1 mA, 10 mA, 100 mA, 1000 mA</p> <p><b>Overrange:</b> 100% on all ranges to 10 kHz decreasing linearly to 0% at 20 kHz.</p> <p><b>Accuracy:</b> (90 days, + 23°C ± 5°C)</p> <p>± (% of Reading + % of Range)</p> <p><b>Temperature Coefficient</b> (0°C to 50°C): ± 0.01% of Reading/°C</p> <p><b>OHMMETER</b></p> <p><b>Ranges:</b> 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ, 1000 kΩ, 10 MΩ</p> <p><b>Overrange:</b> 100% on all ranges</p> <p><b>Accuracy:</b>(90 days, + 23°C ± 5°C)</p> <table border="1"> <thead> <tr> <th>RANGE</th><th>SPECIFICATION<br/>± (% of Reading + % of Range)</th></tr> </thead> <tbody> <tr> <td>100 Ω</td><td>± (0.02% + 0.02%)</td></tr> <tr> <td>1 kΩ through 1 MΩ</td><td>± (0.02% + 0.01%)</td></tr> <tr> <td>10 MΩ</td><td>± (.1% + .01%)</td></tr> </tbody> </table> <p><b>Temperature Coefficient</b> (0°C to 50°C):</p> <table border="1"> <thead> <tr> <th>RANGE</th><th>SPECIFICATION<br/>± (% of Reading)/°C</th></tr> </thead> <tbody> <tr> <td>100 Ω through 1 MΩ</td><td>± 0.0015%</td></tr> <tr> <td>10 MΩ</td><td>± 0.004 %</td></tr> </tbody> </table> | RANGE | SPECIFICATION<br>± (% of Reading + % of Range) | 100 μA, 1 mA | ± (0.07% + 0.01%) | 10 mA | ± (0.11% + 0.01%) | 100 mA, 1000 mA | ± (0.6 % + 0.01%) | RANGE | SPECIFICATION<br>± (% of Reading)/°C | 100 μA | ± 0.006% | 1 mA, 10 mA | ± 0.004 % | 100 mA, 1000 mA | ± 0.01 % | RANGE | SPECIFICATION<br>± (% of Reading + % of Range) | 100 Ω | ± (0.02% + 0.02%) | 1 kΩ through 1 MΩ | ± (0.02% + 0.01%) | 10 MΩ | ± (.1% + .01%) | RANGE | SPECIFICATION<br>± (% of Reading)/°C | 100 Ω through 1 MΩ | ± 0.0015% | 10 MΩ | ± 0.004 % |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|------------------------------------------|-------|--------------------|----------------------|--------------------|--------|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------------------------------------------------|--------------|-------------------|-------|-------------------|-----------------|-------------------|-------|--------------------------------------|--------|----------|-------------|-----------|-----------------|----------|-------|------------------------------------------------|-------|-------------------|-------------------|-------------------|-------|----------------|-------|--------------------------------------|--------------------|-----------|-------|-----------|
| RANGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | SPECIFICATION<br>± (% Reading + % Range)       |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| 10 mV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | ± (0.03 % + 0.02%)                             |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| 100 mV through 100 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | ± (0.02 % + 0.01%)                             |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| 1000 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | ± (0.025% + 0.01%)                             |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| RANGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | SPECIFICATION<br>± (% of Reading + % of Range) |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| 100 μA, 1 mA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | ± (0.07% + 0.01%)                              |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| 10 mA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | ± (0.11% + 0.01%)                              |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| 100 mA, 1000 mA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | ± (0.6 % + 0.01%)                              |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| RANGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | SPECIFICATION<br>± (% of Reading)/°C           |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| 100 μA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | ± 0.006%                                       |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| 1 mA, 10 mA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | ± 0.004 %                                      |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| 100 mA, 1000 mA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | ± 0.01 %                                       |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| RANGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | SPECIFICATION<br>± (% of Reading + % of Range) |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| 100 Ω                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | ± (0.02% + 0.02%)                              |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| 1 kΩ through 1 MΩ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ± (0.02% + 0.01%)                              |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| 10 MΩ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | ± (.1% + .01%)                                 |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| RANGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | SPECIFICATION<br>± (% of Reading)/°C           |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| 100 Ω through 1 MΩ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | ± 0.0015%                                      |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |
| 10 MΩ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | ± 0.004 %                                      |                                          |       |                    |                      |                    |        |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                |              |                   |       |                   |                 |                   |       |                                      |        |          |             |           |                 |          |       |                                                |       |                   |                   |                   |       |                |       |                                      |                    |           |       |           |

Table 1-2. General Information.

| Maximum Input Voltages:                                                                                                      |                                          | Nominal current through unknown resistance:                                                         |                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|-----------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Between Input HIGH (V, $\Omega$ ) and COM:                                                                                   |                                          | RANGE                                                                                               | CURRENT                                                                                                                                                                              |
| FUNCTION                                                                                                                     | MAX VOLTAGE                              | 100 $\Omega$                                                                                        | 1 mA                                                                                                                                                                                 |
| DC Volts                                                                                                                     | 1000 V (dc + peak ac)                    | 1 K $\Omega$                                                                                        | 1 mA                                                                                                                                                                                 |
| AC Volts                                                                                                                     | 600 V dc; 500 V ac rms;<br>800 V peak ac | 10 K $\Omega$                                                                                       | 10 $\mu$ A                                                                                                                                                                           |
| Ohms                                                                                                                         | 350 V (dc + peak ac)                     | 100 K $\Omega$                                                                                      | 10 $\mu$ A                                                                                                                                                                           |
|                                                                                                                              |                                          | 1000 K $\Omega$                                                                                     | 1 $\mu$ A                                                                                                                                                                            |
|                                                                                                                              |                                          | 10 M $\Omega$                                                                                       | 0.1 $\mu$ A                                                                                                                                                                          |
| Between AMPS (A), HIGH (V, $\Omega$ ) and COM terminals and ground:                                                          |                                          | Power Requirements:                                                                                 |                                                                                                                                                                                      |
| $\pm$ 500 V (dc + peak ac)                                                                                                   |                                          | Standard                                                                                            | ac source: 86 to 127 V; 48 to 66 Hz<br>172 to 254 V; 48 to 66 Hz<br>batteries: 2 rechargeable NiCad battery packs                                                                    |
| ACA and DCA Voltage Burden (nominal at full-scale):<br>1000 m range: < 250 mV<br>All other ranges: < 125 mV                  |                                          | Option 001                                                                                          | ac source: 86 to 127 V; 48 to 66 Hz<br>172 to 254 V; 48 to 66 Hz                                                                                                                     |
| Reading Rate: 2.5 samples per second                                                                                         |                                          | Option 002                                                                                          | batteries: 4 "D" type dry cells (U-2 cells in Europe)<br>battery elimination: Most Hewlett-Packard hand-held calculator chargers such as the Model 82002A Battery Charger/AC Adapter |
| Overload Indication: Display Blanks except for overrange "1" and decimal point (also polarity sign on DCV or DCA FUNCTIONS). |                                          | Environmental Considerations:                                                                       |                                                                                                                                                                                      |
| Ohms Terminal Characteristics:                                                                                               |                                          | Operating temperature: 0 $^{\circ}$ C to 55 $^{\circ}$ C (32 $^{\circ}$ F to 131 $^{\circ}$ F)      |                                                                                                                                                                                      |
| Configuration: 2 wire                                                                                                        |                                          | Humidity range: 95% at 40 $^{\circ}$ C                                                              |                                                                                                                                                                                      |
| Open-circuit voltage: < 5 V max.                                                                                             |                                          | Storage temperature: - 40 $^{\circ}$ C to + 75 $^{\circ}$ C (- 40 $^{\circ}$ F to 167 $^{\circ}$ F) |                                                                                                                                                                                      |
| Overload protection: 350 V (dc + peak ac)                                                                                    |                                          |                                                                                                     |                                                                                                                                                                                      |

## SECTION II

### INSTALLATION

#### 2-1. INTRODUCTION.

2-2. This section contains information and instructions for the installation and shipping of the Multimeter. Included are initial inspection procedures, power and grounding requirements, environmental information and instructions for repackaging for shipment.

#### 2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be free of marks or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit, and the electrical performance should be tested using the performance tests outlined in Section V. If there is damage or deficiency, see the warranty inside the front of this manual.

#### 2-5. POWER REQUIREMENTS.

2-6. The Standard and Option 002 Multimeters have an internal battery source. In addition, either Standard or Option 002 instruments can be operated from any ac source of 86 V to 127 V or 172 V to 254 V at 48 Hz to 66 Hz. The Option 002 instrument requires the use of a Hewlett-Packard hand-held calculator Battery Charger/AC Adapter Model 82002A for instrument operation from the ac source.

#### CAUTION

*Verify that the 110 V/220 V Line Voltage Selection switch, located on the rear panel of the Standard, Option 001 Multimeter or the Model 82002A Battery Charger/AC Adapter, is set to the ac source voltage to be used before inserting the power cord and turning the instrument on.*

#### 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 Standard and Option 001 Multimeters are equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable is the ground wire.

2-9. To preserve the protection feature when operating from a two-contact outlet, use a three-prong to two-prong

adapter and connect the green pigtail on the adapter to power line ground.

#### 2-10. ENVIRONMENTAL REQUIREMENTS.

2-11. The Multimeter should not be operated where the ambient temperature exceeds 0°C to 55°C (32°F to 131°F) or stored where the ambient temperature exceeds -40°C to +75°C (-40°F to 167°F).

#### WARNING

*To prevent potential electrical or fire hazard, do not expose equipment to rain or moisture.*

#### 2-12. REPACKAGING FOR SHIPMENT.

2-13. The following paragraphs contain a general guide for repackaging the instrument for shipment. Refer to Paragraph 2-14 if the original container is to be used; 2-15 if it is not. If you have any questions, contact your nearest -hp- Sales and Service Office (see back of Manual for office locations).

#### NOTE

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

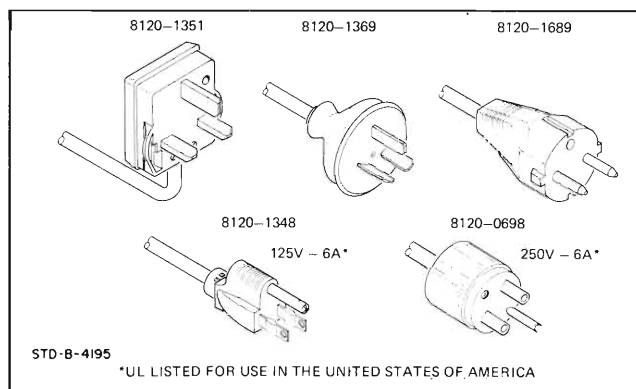
2-14. Place instrument in original container with appropriate packing material and seal well with strong tape or metal bands. If original container is not available, one can be purchased from your nearest -hp- Sales and Service Office.

2-15. 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.

**2-16. POWER CORDS AND RECEPTACLES.**

2-17. Figure 2-1 illustrates the standard power receptacle (wall outlet) configurations that are used throughout the United States and in other countries. The -hp- part number shown directly above each receptacle drawing is the part number for a Standard or Option 001 Multimeter power cord equipped with the appropriate mating plug for that receptacle. If the appropriate power cord is not included with the instrument, notify the nearest -hp- Sales and Service Office and a replacement cord will be provided. The Multimeter power cord, power input receptacle and mating connectors meet the safety standards set forth by the International Electrotechnical Commission (IEC).

**Figure 2-1. Power Receptacles.**

## SECTION III

### OPERATING INSTRUCTIONS

#### 3-1. INTRODUCTION.

3-2. This section contains instructions for using the Multimeter for making dc voltage, ac voltage, dc current, ac current and ohms measurements. The section also contains a description of the front and rear panel features.

#### WARNING

*To prevent potential electrical or fire hazard, do not expose the Multimeter or its accessories to rain or moisture.*

#### 3-3. Front and Rear Panel Features.

3-4. An illustration and description of the front and rear panels is provided in Figure 3-1. All controls and connectors are identified and briefly described. Some rear panel features are available with certain options only and are identified in the description.

#### 3-5. Turn-on and Warm-up.

3-6. For specified measurement accuracy, allow the instrument to warm-up for at least 10 minutes.

#### CAUTION

*Before operating from an ac source, verify that the 110/220 V line voltage selection switch, located on the rear panel of the Standard and Option 001 Multimeter or the Model 82002A Battery Charger/AC Adapter, is set to the ac source voltage to be used.*

#### 3-7. Internal Battery Voltage Measurement and Recharging.

3-8. The Multimeter contains a feature allowing the user to check battery strength to determine the need for battery replacement or recharging. The procedure is to place the Multimeter in the DCV function and depress the 10 megohms range switch. Batteries with full charge will produce a front panel display of approximately .370. If the front panel display is .300 or less, replace Option 002 dry-cell batteries or recharge the Standard Multimeter NiCad batteries. Recharging of the NiCad batteries is performed by operating the Multimeter on an ac source (verify line voltage selection switch is in correct position for source voltage used). Measurements can be made with the Multimeter operated from the ac source during the recharging period.

#### NOTE

*After 14 hours, a completely discharged battery*

*will be fully charged. Shorter charge periods will allow reduced battery operating time. There is no danger of overcharge. For convenience, overnight charging is recommended.*

#### 3-9. Low Battery Voltage Detection.

3-10. The Standard and Option 002 Multimeters contain an internal battery source (Standard contains rechargeable NiCads; Option 002 contains "D" cell or "U2" batteries). A battery source safety feature of the Multimeter is a low battery voltage detection circuit which turns the instrument off when battery voltage reaches a low level. This protects against cell reversal of the NiCad batteries. If during operation the display disappears or immediately after turn-on the display appears and disappears after several seconds, low battery voltage is indicated. To verify low battery voltage, the procedure described in the preceding paragraph can be used or verify by placing the OFF/ON switch to OFF and to ON again. The display will appear and again disappear. Operation from an ac line source and recharging of the NiCad batteries is required in a Standard instrument. Replacement of "D" cell or "U2" batteries is required in an Option 002 instrument.

#### 3-11 Overload Indication.

3-12. The Multimeter is capable of displaying up to 100% of range (19999) for all functions and ranges except the 1000 V range in ac or dc volts (see ac and dc voltage measurement paragraphs). In an overload condition where the input exceeds 19999, the last four digits blank and the overrange "1" and decimal point will be displayed. The polarity sign is also displayed in the dc volts and dc current functions in the overload condition.

#### 3-13. AC VOLTAGE MEASUREMENTS.



#### CAUTION

*Maximum input voltage in the ACV FUNCTION is 500 V rms, 800 V peak and 600 V dc. Do not exceed these voltages or damage to the instrument will occur.*

#### 3-14. AC VOLTAGE Ranges.

3-15. The ACV FUNCTION has five ranges from 100 mV to 1000 V. Each range (except the 1000 V range) has a 100% overrange capability up to 10 kHz decreasing linearly to 0% at 20 kHz. Maximum input voltage on the 1000 V range is indicated in the AC VOLTAGE MEASUREMENTS caution in Paragraph 3-13.

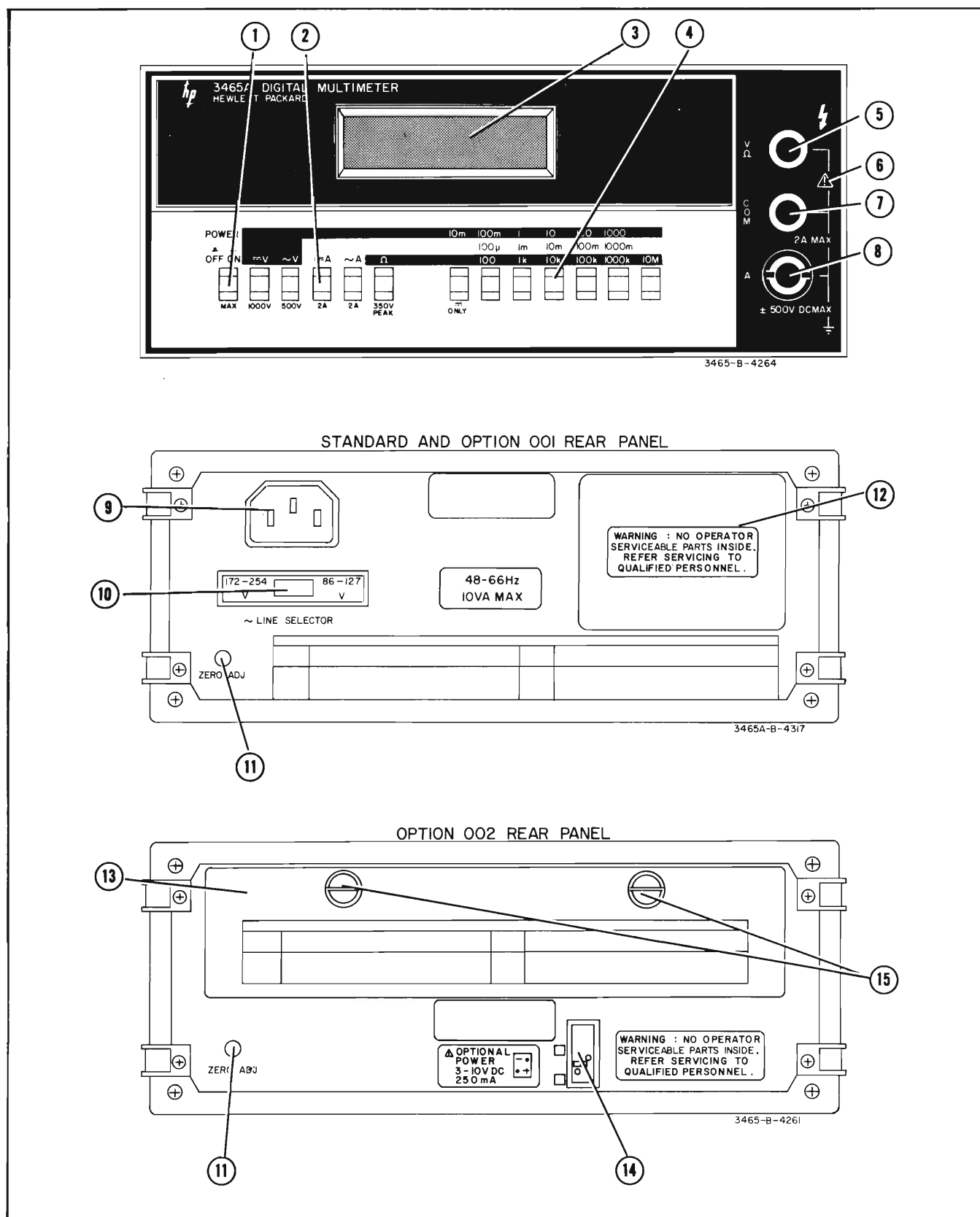


Figure 3-1. Front and Rear Panel Features.

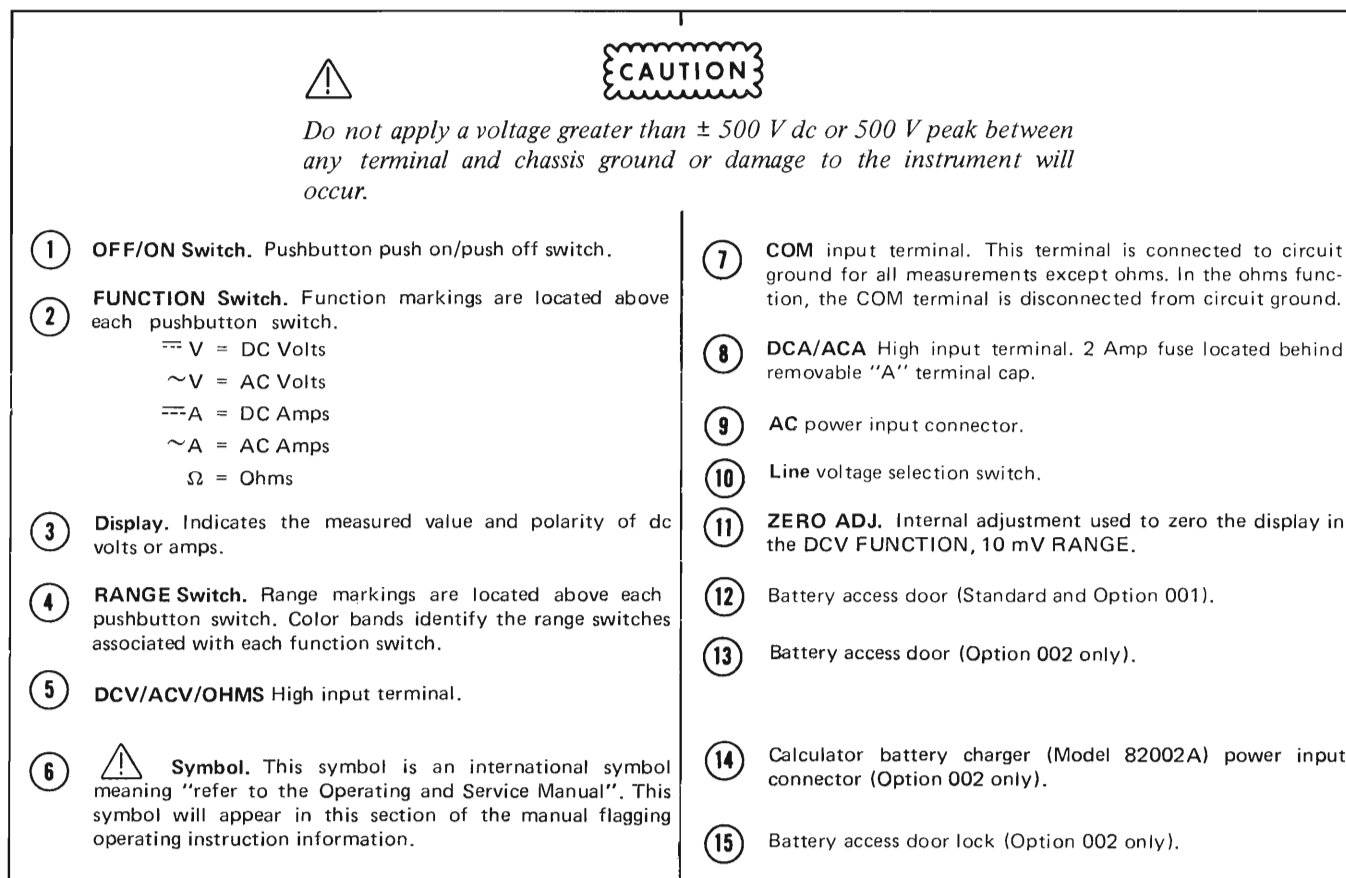


Figure 3-1. Front and Rear Panel Features (cont'd).

**3-16. DC VOLTAGE MEASUREMENTS.**

Do not exceed a maximum input voltage of 1000 V dc and peak ac on the 1000 V range or damage to the instrument will occur. There is no overrange capability on the 1000 V range.

**3-17. 10 mV Range Zero Adjust.**

3-18. When using the Multimeter on the 10 mV range in DC volts, short the input terminals and zero the Multimeter display with the rear panel ZERO ADJ control (see Figure 3-1). The display should indicate 0.000 before proceeding with measurements.

**3-19. DC Voltage Ranges.**

3-20. DC Voltage measurements can be made from 10 mV to 1000 V full-range. Each range has 100% overrange capability except the 1000 V range which has a maximum input of 1000 V dc and peak ac (see DC Voltage measurements caution in Paragraph 3-16).

**3-21. CURRENT MEASUREMENTS.**

Do not exceed a maximum dc or ac rms input

current of 2 A or the amps fuse, located directly behind the "A" terminal, will open. See the following paragraph for replacement instructions.

3-22. The Multimeter is protected from the application of excessive current by a 2 A fuse located directly behind the front panel "A" terminal. If it is necessary to replace this fuse, use the side slots on the "A" terminal to rotate the terminal. The terminal and fuse will protrude from the front panel. Remove the terminal and fuse, replace fuse with a 2 A rated fuse as listed in Table 6-3 Miscellaneous Parts General, and designated F1.

**3-23. AC Current Ranges.**

3-24. AC current measurements can be made over a frequency of 40 Hz to 20 kHz. There are five current ranges from 100  $\mu A$  to 1000 mA with 100% overrange up to 10 kHz decreasing linearly to 0% at 20 kHz. (See current measurements Caution in Paragraph 3-21.)

**3-25. DC Current Ranges.**

3-26. DC Current measurements can be made on five current ranges from 100  $\mu A$  to 1000 mA. Each range has a 100% overrange capability (see current measurements caution in Paragraph 3-21).

**3-27. OHMS MEASUREMENTS.**

*Do not apply voltage greater than  $\pm 350$  V dc + Peak AC between the ohms and common input terminals in the ohms function or damage to the instrument will occur.*

**3-28. Ohmmeter Ranges.**

3-29. Resistance measurements can be made on six ranges from 100 ohms to 10 megohms each with a 100% over-range capability. Both input terminals ( $\Omega$  and COM) are floating with respect to circuit ground.

**3-30. Ohmmeter Reference Current.**

3-31. The ohmmeter reference current through the unknown resistance for each range is shown in Table 3-1.

**Table 3-1. Ohmmeter Current Through Unknown.**

| Range           | Current<br>Through Unknown |
|-----------------|----------------------------|
| 100 $\Omega$    | 1 mA                       |
| 1 K $\Omega$    | 1 mA                       |
| 10 K $\Omega$   | 10 $\mu$ A                 |
| 100 K $\Omega$  | 10 $\mu$ A                 |
| 1000 K $\Omega$ | 1 $\mu$ A                  |
| 10 M $\Omega$   | 0.1 $\mu$ A                |

Maximum open-circuit voltage at the ohms input terminals is less than 5 V.

## SECTION IV

### THEORY OF OPERATION

#### 4.1. INTRODUCTION.

4-2. This section contains the theory of operation for the Multimeter. The information is divided into two parts:

1. Simplified Theory
2. Detailed Theory

The simplified theory provides an overview of the operation of each section in the Multimeter while the detailed theory describes the circuit operation of each section.

#### 4.3. Description.

4-4. The Multimeter is a five-function, 4-1/2 digit multimeter with 100% overrange capability on all ranges except the 1000 V range. The five functions measured are dc volts,

ac volts, dc current, ac current and ohms. The dual-slope integration technique is used for measurements. This technique charges an integrator for a fixed length of time, to a voltage proportional to the input signal, then discharges the integrator at a fixed rate determined by a known reference voltage. The measurement display is determined by the discharge time of the integrator, which is proportional to the input signal.

4-5. Figure 4-1, Basic Block Diagram and Measurement Sequence, illustrates the major functional blocks of the Multimeter. The illustration of the measurement sequence shows the integrator output for each interval of a measurement cycle. This diagram is to supplement the functional block diagram for the simplified theory discussion.

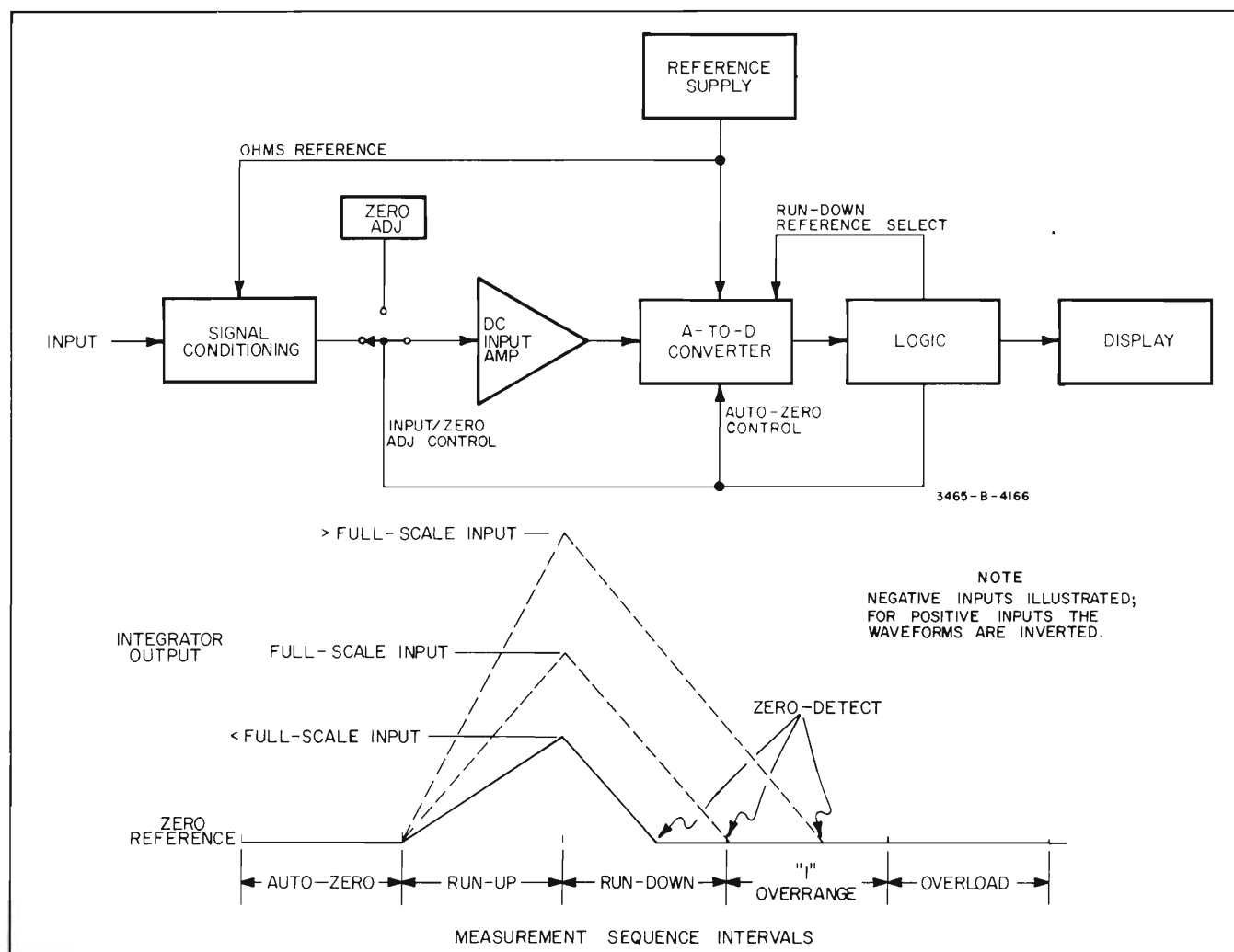


Figure 4-1. Basic Block Diagram and Measurement Sequence.

## 4-6. SIMPLIFIED THEORY.

4-7. A simplified theory of operation of the Multimeter is presented in the following paragraphs. The simplified theory describes each section of the functional block diagram, Figure 7-1. These sections are the signal conditioning section, analog-to-digital section, logic section and the display section. Also presented is a simplified description of the power supply. Refer to Figure 7-1, Functional Block Diagram, and Figure 4-1, Basic Block Diagram and Measurement Sequence, for this discussion.

## 4-8. Signal Conditioning.

4-9. Signal conditioning consists of attenuating and/or converting the input signal to a dc voltage within the working limits of the input amplifier. For full-scale inputs, this voltage can vary from 10 mV dc to 1 V dc depending on the function and range.

4-10. The signal conditioning section consists of current shunts, an input attenuator, ohms converter and an ac-to-dc converter. The output from the signal conditioning section is applied to the input amplifier during the run-up interval of the measurement sequence. The Input Amplifier Gain Table located on Figure 7-3 indicates the full-scale input level applied to the input amplifier for each function and range. This signal is the output of the signal conditioning section.

4-11. **Ohms Converter.** The ohms converter is a high gain integrating amplifier. A simplified diagram of the ohms converter is presented in Figure 4-2. The blocks of the ohms converter are the integrating amplifier, protection diodes, over-voltage protection circuit and the overload loop. An integrating amplifier is used because this type of amplifier is less susceptible to oscillations. The protection diodes clamp the HI terminal to a voltage of about +1.2 V in the positive direction or -0.7 V in the negative direction.

With the HI terminal clamped, protection against excessive voltages applied to the ohms terminals is provided by an over-voltage protection circuit located between the ohms amplifier and the LOW terminal. For excessive voltages, this circuit isolates the LOW terminal from the ohms amplifier.

4-12. Figure 4-2 shows two outputs of the ohms converter being applied to the input amplifier. The ohms output is the ohms converter measurement signal and the auto-zero output is the ohms amplifier dc offset signal which is called the auto-zero (AZ) signal. This AZ signal is applied to the input amplifier during the auto-zero interval of the measurement sequence and establishes the reference for the analog-to-digital converter. An AZ signal greater than  $\pm 1$  mV causes the instrument readings to be invalid. This condition (AZ signal  $> \pm 1$  mV) is present when the unknown resistance,  $R_x$ , is removed and an open loop is present on the ohms amplifier. To maintain the AZ signal at  $< \pm 1$  mV when an open loop is present, an overload feedback circuit is used.

4-13. The ohms output, (LO terminal of the ohms converter) is applied to the input amplifier. This output is a dc voltage, the level of which is dependent on the ratio of the unknown resistance,  $R_x$ , to the variable resistance,  $10^n$ , and the ohms reference supply. The variable resistance,  $10^n$ , is a resistor string located in the precision resistor pack R75. The value of  $10^n$  is selected by the range switches shorting those resistors in the string that are not required. The value of  $10^n$  can range from 10 k $\Omega$  to 10 M $\Omega$ . A discussion of the precision resistor pack R75 can be found in the detailed theory.

4-14. The formula for the ohms converter output voltage is:

$$\text{Ohms Output} = - \left[ \frac{R_x}{10^n} \right] \text{Reference Supply Voltage} + V_{\text{offset}}$$

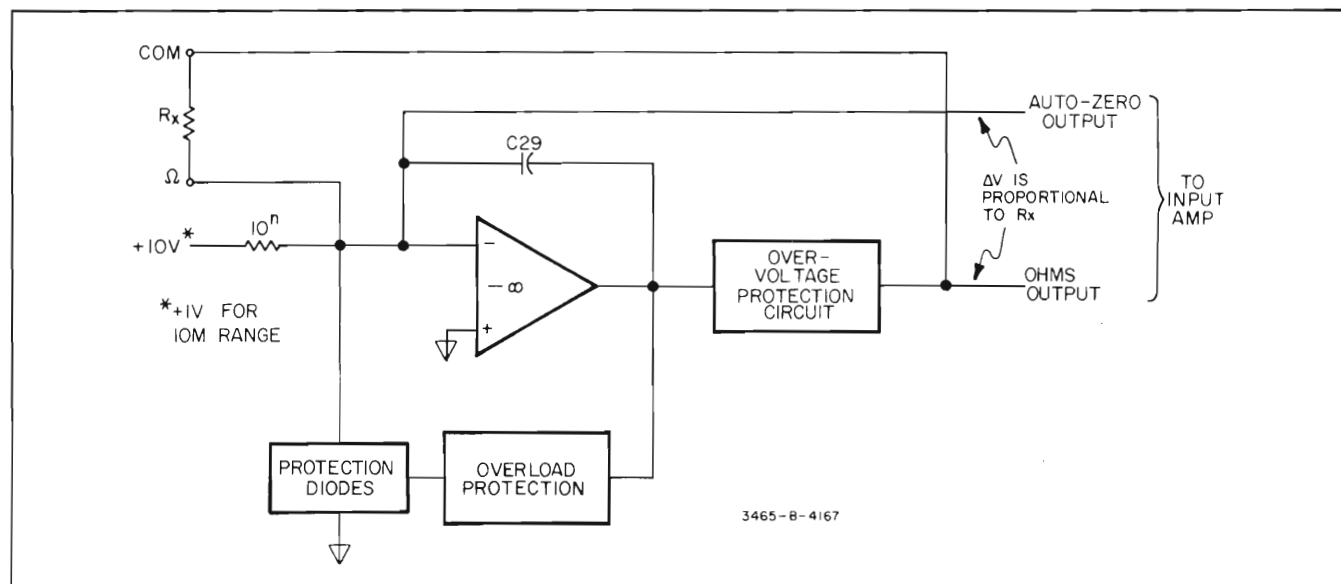


Figure 4-2. Simplified Diagram, Ohms Converter.

The reference supply is +10 V for all ranges except the 10 M range. For this range the reference supply is +1 V. The full-scale output of the ohms converter is 1 V dc. On the 10 M range with a  $R_x$  of 10 M $\Omega$  (full-scale), an output of 1 V dc is needed. From the formula for the ohms output, it can be seen that  $10^n$  would have to equal 100 M $\Omega$ . Since the range of  $10^n$  is 10 k $\Omega$  to 10 M $\Omega$ , a  $10^n$  of 10 M $\Omega$  combined with a reference supply of 1 V provides the desired 1 V dc full-scale ohms converter output.

**4-15. AC—DC Converter.** The ac—dc converter is an average responding ac converter. It measures the average value of a sine wave and multiplies this by a fixed scale factor to convert it to an rms value. The output of the converter is a dc voltage equal to the rms value of the sine wave.

4-16. Figure 4-3 is a block diagram of the ac—dc converter. The blocks consist of an impedance converter, an ac converter and a filter. The impedance converter has a high input impedance to prevent loading of the input signal. It also provides the gain necessary to drive the ac converter. An impedance converter gain of unity, 9.964 or 10 is selected by the function and range switching. The gain of 9.964 is used with the ACI function and the gain of 10 is used with the 100 mV, .1 mA, 100  $\Omega$  and 10 V, 10 mA, 10 k $\Omega$  ranges.

4-17. The ac converter amplifies the signal from the impedance converter by the scale factor. This converts the average value of the sine wave to the rms value. Half-wave rectification of the sine wave is also performed by the ac converter. This rectified signal is filtered to provide the proportional dc output which is applied to the analog—to-digital converter.

#### 4-18. Analog—to—Digital (A—D) Converter.

4-19. The A—D converter block is comprised of an input amplifier, reference supply, integrator, slope amplifier, comparator and auto-zero circuit. It makes an analog—to-digital conversion using the dual-slope integrating technique. Four control state signals from the logic section (IO, IZ, I1 and I2) regulate the measurement sequence. IO and IZ regulate the input amplifier and auto-zero switching respectively while I1 and I2 select the reference supply required during the run-down interval.

**4-20. Input Amplifier.** The first stage of the A—D converter is the input amplifier. During the run-up interval of the measurement sequence, control state signal IO switches the output of the signal conditioning block to the input amplifier. The output of the signal conditioning block is a dc voltage which varies between 10 mV and 1 V for full-scale inputs, depending on the function and range selected. The gain of the input amplifier is adjusted by the function and range switching to provide an output of 1 V dc for any full-scale input signal. See Input Amplifier Gain Table on Figure 7-3.

**4-21. Reference Supply.** The A—D converter uses a monopolar reference supply of +10 V. A reference voltage is applied to the integrator during the run-down interval to discharge the integrating capacitor. Since the discharge rate is constant, the time required for the integrator to reach a zero reference is proportional to the input signal. This time period is the run-down interval and is processed to determine the display. A positive and negative reference voltage is required since the input signal can be either polarity. A detailed discussion of the operation of the monopolar reference supply can be found in the detailed theory.

**4-22. Integrator.** The integrator output is a result of a current summation at the integrator summing junction (inverting input). A positive current summation (current flowing into the integrator input) will cause the integrator to ramp negative. A negative current summation (current flowing out of the integrator input) will cause the integrator to ramp positive. The integrator sums currents from the input amplifier, reference supply, -7 V supply and the auto-zero loop.

**4-23. Slope Amplifier.** Following the integrator is a X4000 amplifier. This amplifier is divided into two stages; the first with a gain of 40 and the second with a gain of 100. The slope amplifier amplifies the integrator output to provide a more vertical crossing of this output with the reference level. This provides greater accuracy of the voltage—to-time conversion during the run-down interval.

**4-24. Comparator.** The comparator provides two logic outputs; a high output of 0 V or a low output of -7 V. The comparator output is high when the integrator output is greater than the reference level. The comparator is low when the integrator output is less than the reference level.

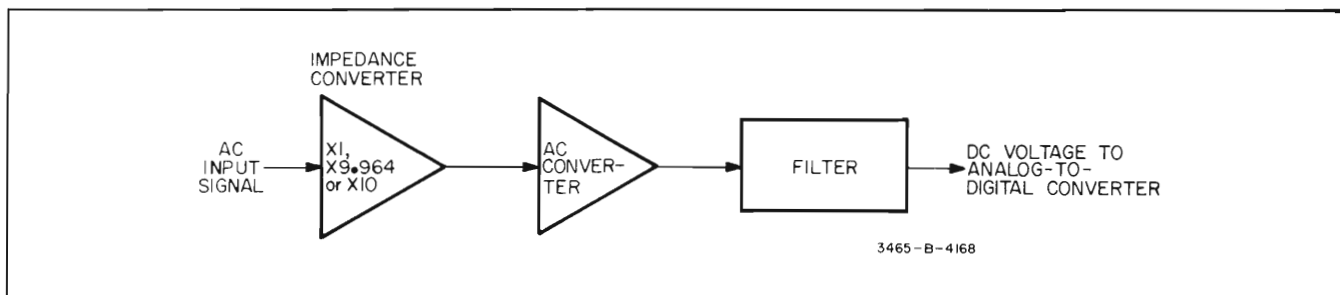


Figure 4-3. Block Diagram, AC—to—DC Converter.

This logic level is sensed by the logic section to determine polarity and zero-detect.

**4-25. Auto-Zero Circuit.** During the measurement sequence, the auto-zero loop is closed except for the run-up and run-down intervals. This loop includes the slope amplifier and the integrator but does not physically include the input amplifier although the loop does compensate for the input amplifier offset. When the auto-zero loop is closed, the input of the input amplifier is grounded. If the summation of currents at the integrator summing junction is not zero, the integrator begins to ramp up for a negative summation or ramp down for a positive summation. The integrator output is applied through the X4000 slope amplifier to the auto-zero capacitor, C4. The voltage on the auto-zero capacitor causes a current to flow at the summing junction that returns the summation to zero. This auto-zero configuration compensates for the analog offset of the input amplifier and integrator by providing a current at the summing junction that cancels the currents resulting from the offset.

#### 4-26. Logic Section.

4-27. The Logic Section is comprised of combinational and state logic. This section processes the comparator output to determine the polarity of the input signal and to make a voltage-to-time conversion of the input signal. Time accumulated during the conversion is proportional to the input signal and is stored. The display is derived from this accumulated time. A voltage-to-time conversion with the accumulated time being stored occurs once each measurement sequence.

4-28. Seven blocks make up the logic section. These blocks are:

1. Clock
2. State Clock
3. Polarity and Zero Detect
4. Data Transfer and Reset
5. Control State Counter
6. Control State Decode
7. Data Accumulator

The HIGH and LOW logic levels used in the logic section are 0 V and -7 V respectively. The following discussion describes the basic operation of the logic section.

**4-29. Clock and State Clock.** The timing of the logic section is derived from the clock circuit. The clock operates at 100 kHz and is crystal-controlled. A state clock, driven by the clock output and the count extend line from the data accumulator, drives the control state counter to initiate each measurement interval.

**4-30. Polarity and Zero Detect.** The polarity and zero-detect circuit monitors the comparator output. The state of this output at the beginning of the run-down interval determines the polarity of the input signal. Zero-detect is determined at the point the comparator output changes states during the run-down, overrange or overflow intervals.

If the integrator ramps positive (negative input signal) during run-up, the comparator output goes HIGH and returns to LOW at the zero-detect point. If the integrator ramps negative (positive input signal) during run-up, the comparator output goes low and returns to high at the zero-detect point. These comparator output logic states are stored in a D flip-flop. At the beginning of the run-down interval, this state identifies the polarity of the input signal. The outputs of the D flip-flop provide the signals needed to select the correct polarity display and the correct reference supply signal (I1, I2) during the run-down interval. An EXCLUSIVE OR and latch processes the comparator output to provide the zero-detect signal.

**4-31. Data Transfer and Reset.** The data transfer and reset circuits provide logic signals to the data accumulator required to load the storage latches and reset the decade counters. A detailed description of the data accumulator is provided in the detailed theory section. While the TXFR input of the data accumulator is low, data in the decade counters is transferred to the static storage latches. The RESET input resets the decade counters to zero when low. This must occur after the transfer to the storage latches has taken place. To ensure that reset occurs after termination of transfer, an RC delay circuit precedes the reset gates.

**4-32. Control State Counter.** The control state counter provides the timing for the measurement sequence intervals. The output from the counter establishes the timing of the analog control signals (IZ, IO, I1 and I2) which are applied to the A-D converter. The state clock and reset inputs to the control state counter determine the outputs of the counter.

**4-33. Control State Decode.** The control state decode converts the polarity, zero-detect and control state counter inputs to the correct analog control signals. These signals, applied to the A-D converter, perform the measurement sequence switching. This switching consists of the input amplifier switch, the auto-zero switch and the reference supply switches.

**4-34. Data Accumulator.** The data accumulator consists of a counter, data latches, a multiplexer, digit select decoder and output buffers. At the beginning of the Run-Down interval of the measurement sequence, the data accumulator begins to count clock pulses until zero-detect occurs. This count is proportional to the input signal and is the time conversion used to generate the display. The digit select decoder scans the display digits from the most significant digit to the least significant digit while the multiplexer provides the corresponding BCD outputs for each digit. A detailed discussion of the data accumulator is presented in the detailed theory.

#### 4-35. Display.

4-36. The multimeter display contains four full digits with an overrange "1", polarity sign and sample rate indicators. All segments and indicators are light-emitting diodes. A BCD-to-seven-segment decoder receives BCD informa-

tion from the data accumulator and applies the seven-segment code to the display drivers. The display drivers apply the seven-segment code to all digits simultaneously. Digit strobe lines activate the digit corresponding to the seven-segment code at that point in time. Scanning of the digits is from the most significant to the least significant digit. To complete the display, the proper decimal point is enabled by range switching.

#### 4-37. Power Supply.

4-38. Figure 4-4 is a block diagram of the power supply. The power supply develops four output voltages from a single dc input voltage (+VB). This dc input voltage is applied to a dc-to-dc converter which develops output voltages of +11 V dc and -7 V dc. A series regulated +10 V output is developed from the +11 V converter output. This +10 V is used as the reference voltage in the A-D converter and to develop the reference current in the ohms converter and as the reference voltage for the converter regulator. The converter regulator controls the converter and regulates the -7 V and +11 V outputs of the converter. The fourth voltage (-12 V) is derived from the -7 V converter output with a voltage doubler circuit driven by the 100 kHz clock. A discussion of the operation and regulation process of the dc-to-dc converter is presented in the detailed theory.

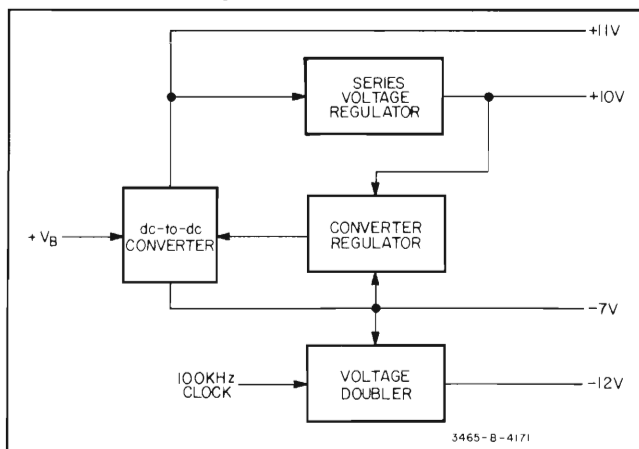


Figure 4-4. Block Diagram, Power Supply.

#### 4-39. DETAILED THEORY.

4-40. This portion of the theory of operation provides a detailed discussion of the circuits in the Multimeter. The circuits described here are the ohms converter, ac-dc converter, monopolar reference supply, data accumulator of the logic section, display and the power supply. A discussion of the precision resistor pack (R75) is also provided. The detailed discussion makes use of the schematics in Section VII.

#### 4-41. Precision Resistor Pack (R75).

4-42. The precision resistor pack, R75, is a laser trimmed substrate providing high precision resistances. A diagram of R75 is shown on Figure 7-2. The input attenuator, power supply, ohms reference supply, A-D reference supply and the input amplifier require highly accurate resistances to

maintain the accuracy of the Multimeter. These resistances are part of the resistor pack. The advantage to the resistor pack is high precision resistors and good temperature tracking. As resistance values of the resistor pack change due to temperature changes, the ratio of the resistors remains the same.

#### 4-43. Ohms Converter.

4-44. Refer to Figure 7-2 for this discussion. Both ends of the ohms converter are floating with respect to the instrument ground. The unknown resistor,  $R_x$ , becomes the feedback loop of the ohms amplifier. The ratio of  $R_x$  to  $10^n$  determines the gain of the ohms amplifier, Q25 and U15.  $10^n$  is a variable resistance between 10 k $\Omega$  and 10 M $\Omega$  selected by the range switching. The ohms converter input is the reference voltage provided by the ohms reference supply. This reference voltage times the amplifier gain is the ohms converter output supplied to the input amplifier during the run-up interval. Full-scale ohms converter gain and output values are provided in the ohms converter table located on Figure 7-2.

4-45. The HI terminal of the ohms converter is connected to the reference supply through  $10^n$  of the resistor pack R75. The HI terminal is clamped by protection diodes CR15 and CR25 to prevent the destruction of FET Q25 and R75 by the application of large voltages. These diodes clamp the HI terminal to about +1.2 V positive or -0.7 V negative.

4-46. With the HI terminal clamped, over-voltage protection must be provided to protect the ohms amplifier from excess voltage. The over-voltage protection circuit is located between the ohms amplifier and the LO terminal and is shown in Figure 4-5. During normal operation < 2 mA of current flows through Q30, R94 and Q32. If a large voltage is applied to the ohms terminals, the current through this circuit will try to exceed 2 mA. This current will cause a large enough voltage drop across R94 to turn on Q31. When Q31 is on, it removes the base drive from Q30, which turns off, disconnecting the LO terminal from the ohms converter. Since Q30 is a high voltage transistor, large voltages are not applied to the ohms converter.

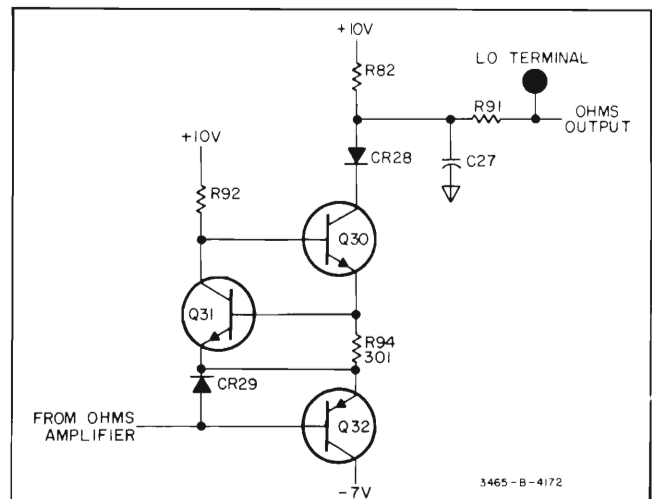


Figure 4-5. Over-Voltage Protection Circuit.

4-47. In the event of open loop ( $R_x = \infty$ ), the ohms amplifier output begins to drive negative. The input (negative port), which is the auto-zero output, could exceed  $\pm 1$  mV under an open loop condition due to the lack of negative feedback through an  $R_x$ . This auto-zero output must be maintained at  $\leq \pm 1$  mV for accurate operation of the A-D converter. To satisfy this requirement, an overload protection circuit consisting of CR23, CR24 and R86 is used. When the ohms amplifier output goes below approximately +1.5 V, the zener diode (CR23) turns off. The overload loop, CR24 and R86, is introduced by the turn-on of CR24 when CR23 is off. This loop provides the negative feedback required to maintain an auto-zero output  $< \pm 1$  mV. When an  $R_x$  is introduced, CR23 turns-on, CR24 turns-off, and the overload loop is inoperative.

4-48. A maximum output by the ohms converter of  $\leq 5$  V is guaranteed by a voltage divider composed of R93 and R95. Additional protection components of the ohms converter are: A) CR29 which prevents Q32 junction breakdown due to fast transients, B) CR28 which blocks negative transients that could come in via the LO terminal and C) R91 and C27 which prevent high voltage and high frequency transients.

4-49. Degradation of accuracy in the ohms function due to changes in the ohms reference with respect to the A-D reference is minimized since both reference voltages are derived from the same +10 V reference supply. If the reference supply voltage changes, both the ohms reference and the A-D reference are affected alike and any change is effectively cancelled.

#### 4-50. AC-to-DC Converter.

4-51. The AC-to-DC converter is an average responding ac converter. It has a bandwidth of 40 Hz to 20 kHz. The converter is composed of two stages (see Figure 7-2). The first stage, U19, is an impedance converter. The purpose of this amplifier is to provide a high impedance to the input so loading of the input signal does not occur. It also provides high drive capability for the ac converter stage, U18. The input of the impedance converter is protected against large voltage swings by diodes CR35 and CR37. Voltages in excess of +10 V or -7 V peak ac will turn these diodes, returning excess current to the power supply.

4-52. The impedance converter, U19, has a selection of three gains; the 100 mV, .1 mA, 100  $\Omega$  and 10 V, 10 mA, 10 k $\Omega$  ranges select a gain of 10. The ACI function selects a gain of 9.964, while the remainder of the ranges and functions select a gain of unity (see U19 Gain Table, Figure 7-2).

4-53. The second stage of the AC-to-DC converter is the ac converter, U18. A basic diagram of this stage is shown in Figure 4-6. The amplifier has three feedback loops. These loops are the ac negative feedback loop, the dc negative feedback loop, and the positive feedback loop. The ac negative feedback loop is divided into two branches; one branch for the positive cycle and the second branch for the negative cycle. Diodes CR33 and CR34 switch between the

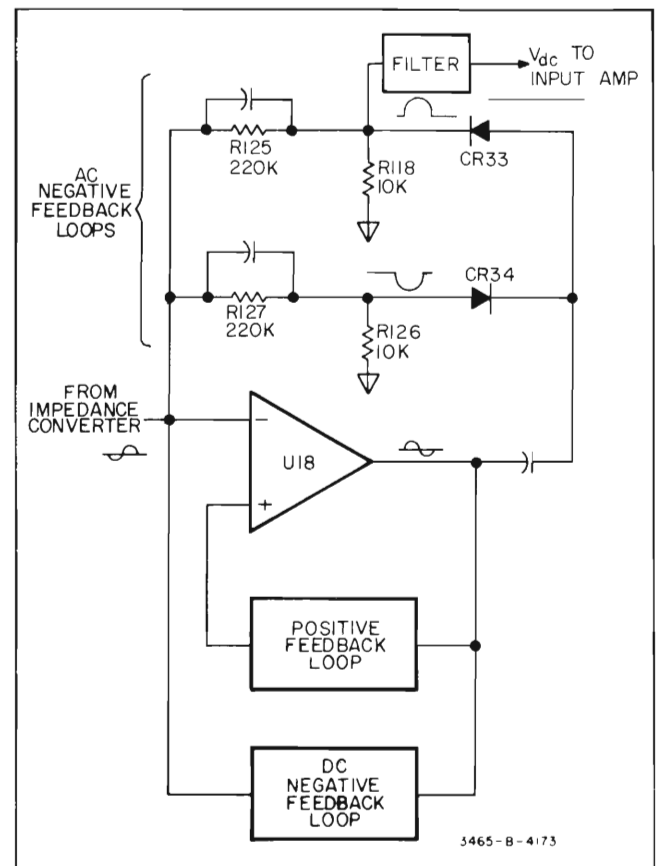


Figure 4-6. Basic Diagram, AC Converter Amplifier.

positive and negative half-cycles to introduce the correct loop for its respective half-cycle.

4-54. During switching of the diodes, little negative feedback is present. During the switching transition, the positive feedback loop (C45, R120 and R123) boosts the amplifier gain. This boost in gain speeds the switching transition of the diodes which gives a good frequency response at low signal levels. Once the switching transition has occurred, negative feedback is again present. The negative feedback overrides the effects of the positive feedback loop at all times other than the diode switching transition period.

4-55. The output of the AC-to-DC converter is derived from the positive half-cycle, negative feedback loop. The positive half-cycle developed across the load resistor R118 is the half-wave rectified signal of the ac converter amplifier output. This rectified signal is filtered to provide the dc output that is applied to the input amplifier during the run-up interval of the measurement sequence. For full-scale inputs, the AC-to-DC converter output is 0.8 V dc. This output is kept relatively free of the dc offset present on the negative port of U18 (pin 2) by the voltage divider R125 and R118. The portion of the offset appearing across the load resistor R118 is attenuated by a factor of 23.

#### 4-56. A-D Conversion Using a Monopolar Reference.

4-57. Before preceeding with this discussion, review the

A-D converter description of the integrator, slope amplifier and auto-zero circuit in the simplified theory. Figure 4-7, Functional Diagram, A-D Converter, illustrates these circuits in relation to the monopolar reference supply, the

input amplifier and the comparator. It also illustrates the integrator output and the four control state signals, IZ, IO, I1 and I2, with respect to the measurement sequence intervals.

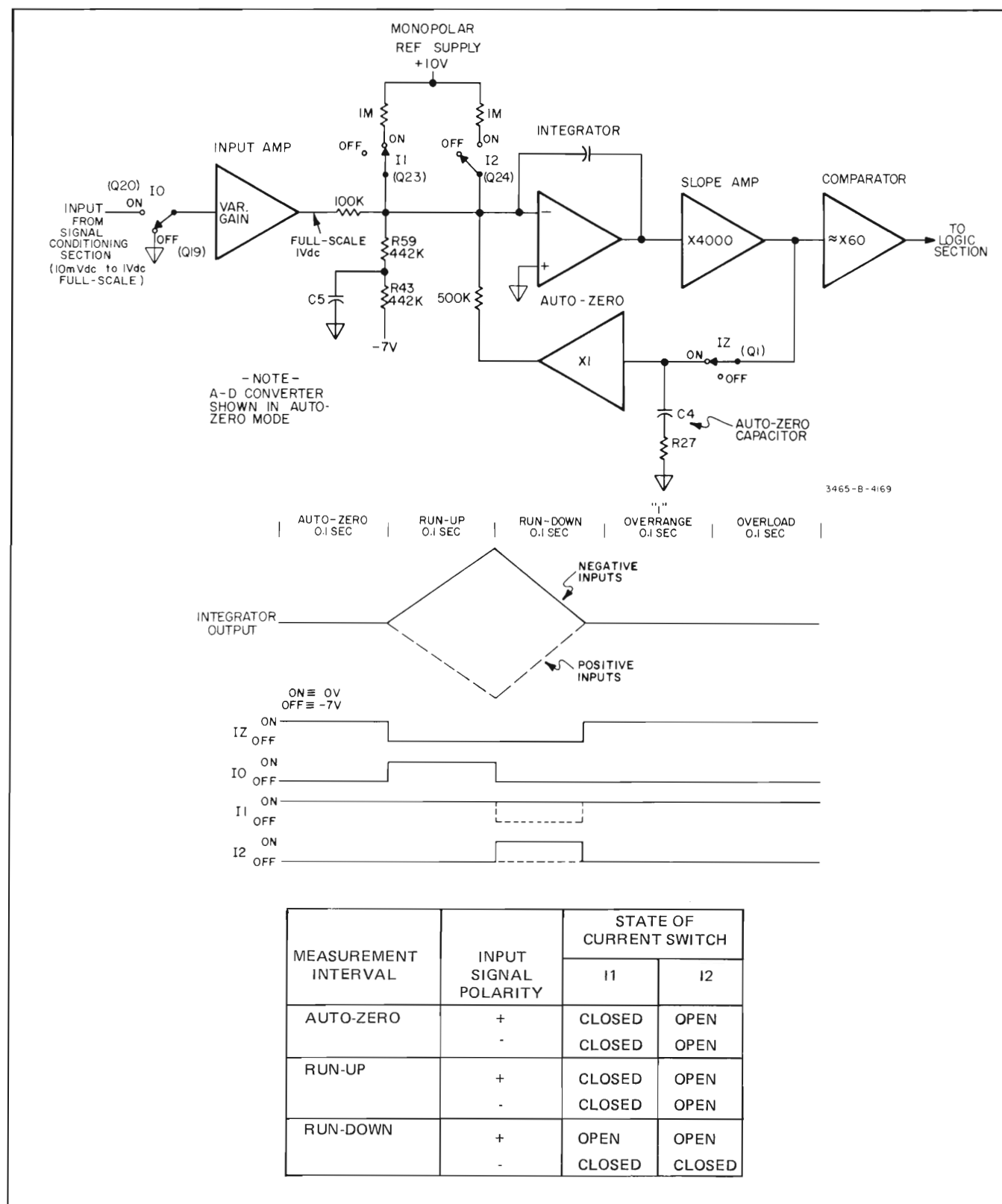


Figure 4-7. Functional Diagram, A-D Converter.

4-58. The A-D converter of Figure 4-7 is shown in the auto-zero mode. The input amplifier is grounded at the input, control state switch I1 is closed, I2 is open and the auto-zero loop is closed. Note that the auto-zero loop does not include the input amplifier but is connected to the integrator summing junction (integrator inverting input). Also connected to the summing junction are the input amplifier output, two current paths from the monopolar reference supply and the -7 V supply through R59 and R43.

4-59. The auto-zero loop uses a current balancing technique at the integrator summing junction to establish the reference. The basic principle is that the algebraic sum of currents at the integrator summing junction must be equal to zero. When the sum is zero, the output of the integrator will not change. If the sum is not zero, the integrator will ramp up for a negative current or ramp down for a positive current because of the inverting input.

4-60. When the auto-zero loop is closed, the currents summed at the integrator summing junction come from four sources; 1) the output of the input amplifier with its input grounded, 2) one current path of the monopolar reference supply (switch I1 closed), 3) the -7 V supply through R43 and R59 and 4) the auto-zero loop. The input amplifier output is the analog offset of this amplifier. The current due to the -7 V supply is roughly the negative of the current from the monopolar reference supply. The auto-zero loop then stores a voltage on the auto-zero capacitor that produces a current through R28 and R42 of the correct magnitude to force the summation of currents at the integrator summing junction to zero. Forcing the summation of currents to zero compensates for the analog offset of the input amplifier and integrator.

4-61. During the run-up interval, the auto-zero loop is opened by control state switch IZ. The voltage stored on the auto-zero capacitor is still applied to the integrator summing junction and the summation of currents remains zero. At the time the auto-zero loop is opened, the output of the signal conditioning section is switched to the input amplifier by control state signal IO. The output of the input amplifier causes the algebraic summation of currents at the integrator summing junction to deviate from zero. This causes the integrator to run-up.

4-62. At the end of the run-up interval, the input amplifier is switched back to ground by control state signal IO. The summation of currents at the integrator summing junction is again zero and if no other action were taken, the integrator output would not change. The integrator output is positive at the end of run-up for negative inputs and negative for positive inputs. At the end of the run-up interval, the polarity of the integrator output is determined by the logic section. This also identifies the polarity of the input signal.

4-63. At the beginning of the run-down interval, the logic section selects the appropriate reference to return the

integrator output to zero. Run-down uses the summation of currents principle at the summing junction of the integrator. The two current paths (I1 and I2) of the monopolar reference supply provide the means of changing the summation of the currents. The summation of currents at the summing junction can be made negative by opening switch I1 and removing this current flow to the junction. The summation can be made positive by closing switch I2 in addition to I1, and providing twice the current from the monopolar reference supply. Opening switch I1 with I2 open, runs the integrator up which is required for positive inputs (see Figure 4-7). Closing I1 and I2 runs the integrator down which is required for negative inputs. The time required for the integrator to reach zero-detect during the run-down interval is proportional to the input voltage which caused run-up and determines the display.

#### 4-64. Data Accumulator.

4-65. Refer to Figure 4-8, Data Accumulator Diagram, for this discussion. The data accumulator processes the logic signals from the logic section and provides the BCD output and the scan signals that determine the display. The data accumulator consists of a counter, data latches, a multiplexer, digit select decoder and output buffers. At the beginning of the measurement, the reset signal ( $\overline{\text{RESET}}$ ) goes to a logic 0 to initialize the counter and digit select decoder. At the beginning of the run-down interval of the measurement sequence, the counter begins to accumulate a count proportional to the run-down time.

4-66. The counter consists of four divide by 10 circuits. The output of each circuit is a BCD number representing one digit of the input signal. At the end of the run-down interval, the transfer signal ( $\overline{\text{TXFR}}$ ) is set to a logic 0. This stores the counter outputs in the data latches.

4-67. The scan signal will gate each BCD signal from the latches, beginning with the most significant digit first, through the multiplexer to the output. At the same time that the scan gates the digits through the multiplexer, the gating signal is output to the display as a digit activation pulse.

4-68. The BCD output of the multiplexer is applied to the display section (see Figure 7-4). The  $\overline{\text{BCD}}$  is applied to quad NAND gates in the display section where the  $\overline{\text{BCD}}$  logic is converted to BCD logic. The BCD is applied to the seven segment decoder where it is transformed to a seven bit binary number and applied to each numeral in the display. As the digit activation pulse from the data accumulator sequentially activates each numeral from most significant to least significant, the seven bit binary data will be displayed.

#### 4-69. Display.

4-70. Refer to Figure 7-4 for this discussion. The display segments are powered by a +3 V supply. This voltage is

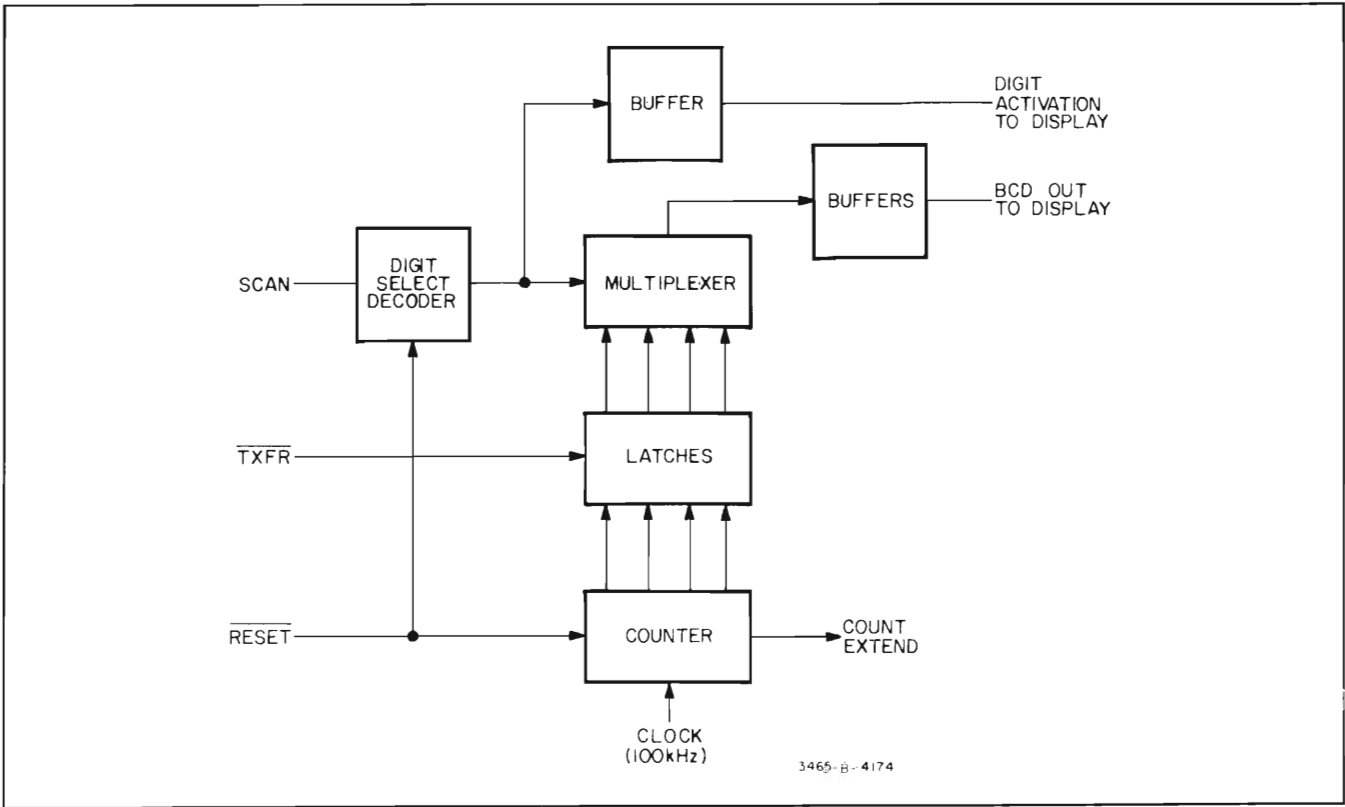


Figure 4-8. Data Accumulator.

derived from VB and the +11 V output of the power supply. A series voltage regulator, Q21, Q22 and Q23 maintains the +3 V output constant. This provides constant display intensity for changes in the magnitude of VB due to battery life and results in low power consumption

for a high VB (new or recharged batteries).

4-71. Twenty-five connections interface the display and the main assembly. Table 4-1 indicates each terminal and the source of the signal from the main assembly.

Table 4-1. Display Interface Connections.

| CONNECTION DESIGNATION                                   | SOURCE OF SIGNAL            |                  |
|----------------------------------------------------------|-----------------------------|------------------|
| DIGIT STROBES: MSD, 2MSD, 3MSD, LSD<br>BCD: 1, 2, 4, 8   | DATA ACCUMULATOR<br>(A1U11) |                  |
| DECIMAL POINT: A, B, C, D                                | RANGE SWITCHES              |                  |
| POLARITY ENABLE: $\overline{PE}$                         | FUNCTION SWITCHES           |                  |
| POLARITY: PL<br>SAMPLE RATE: SR                          | A1U4                        | LOGIC<br>SECTION |
| OVERRANGE: OR<br>OVERLOAD: OL                            | A1U5                        |                  |
| TRANSFER: $\overline{TR}$                                | A1U6                        |                  |
| + VB, + 11 V, GND, - 7 V, - 7 V <sub>F</sub> and - 12 V. | POWER SUPPLY                |                  |
| PIN 25                                                   | NO CONNECTION               |                  |

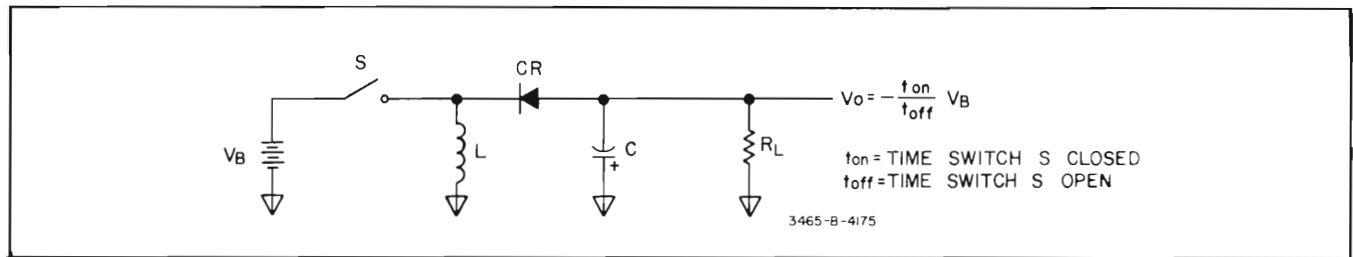


Figure 4-9. Basic Diagram, DC-to-DC Converter.

**4-72. Power Supply.**

4-73. This paragraph is a description of a simple dc-to-dc converter. Figure 4-9 is a diagram of this converter. When switch S is closed ( $t_{on}$ ), battery voltage  $V_B$  is applied to the inductor L. Since the battery voltage is constant, the inductor current increases linearly with time. The inductor current establishes a magnetic field which stores energy transferred from the battery. During  $t_{on}$ , C supplies current to the load,  $R_L$ . When switch S is opened ( $t_{off}$ ), the voltage across the inductor inverts and forward biases diode CR. For a constant  $V_O$ , the inductor current decreases linearly with time and transfers energy to the capacitor and load resistor, C and  $R_L$ . The energy transferred from the battery to the load is controlled by switch S. By controlling switch S the output voltage can be made greater than, equal to or less than the battery voltage  $V_B$  and can be regulated for changes in the battery voltage ( $V_B$ ) and in the load ( $R_L$ ). For a steady state condition, the duty-cycle of switch S is

$$\frac{t_{on}}{T} = \frac{|V_O|}{|V_O| + V_B} \quad \begin{array}{l} t_{on} = \text{time switch S closed.} \\ T = \text{period of one cycle.} \end{array}$$

The duty-cycle depends only on the output voltage ( $V_O$ ) and the battery voltage ( $V_B$ ).

4-74. A simplified diagram of the dc-to-dc converter is shown in Figure 4-10. Refer to this diagram and the converter of Figure 7-5 for this discussion. A negative output is derived from a portion of the energy stored in the primary winding inductance or magnetizing inductance of T1 while the switch, Q33 is on. This output is obtained by the same process described previously for the simple switch-type dc-to-dc converter. A positive output is developed by transformer-coupling a portion of the energy stored in the primary winding inductance through the secondary winding of T1. This output is equal to the turns-ratio times the voltage developed by the primary of T1 across C34 when switch Q33 is off.

4-75. The following paragraphs describe the circuit operation of the dc-to-dc converter. When the battery voltage  $V_B$  is applied to the circuit, Q33 saturates. A constant voltage is applied across the primary of T1. The collector current determined by the constant battery voltage ( $V_B$ ) and the primary winding inductance, increases linearly with time until Q33 comes out of saturation ( $h_{FE}I$ ). As this occurs, the collector of Q33 begins a negative transition. This transition at pin 1 of transformer T1 causes pin 3 of T1 to begin a positive transition. The positive transition is applied to the base of Q33 by the feedback circuit R81 and C25 and turns Q33 off. As Q33 turns off, the voltage across

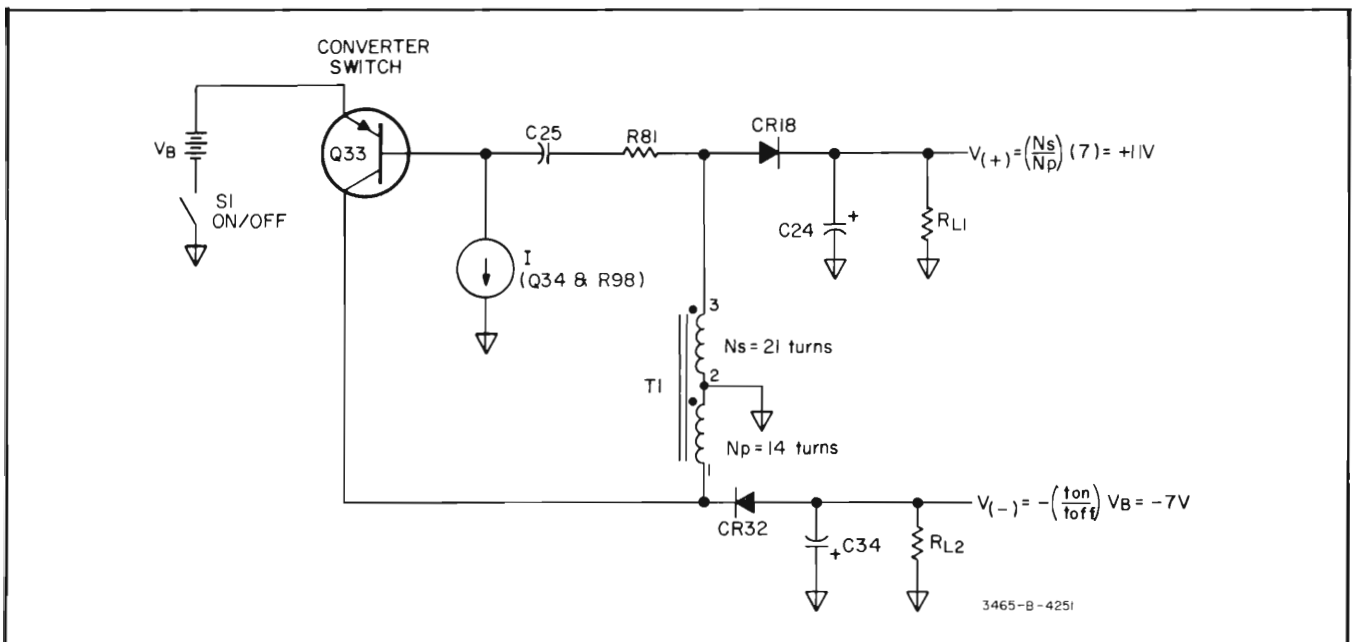


Figure 4-10. Simplified Diagram, DC-to-DC Converter.

the primary and secondary windings of T1 inverts and forward biases CR18 and CR32. The energy stored in the primary winding inductance of T1 is transferred to the output capacitors, C24 and C34, and their loads.

4-76. The cycle ends as Q33 turns on. This results when either the voltage at the base of Q33 decreases to the point that Q33 begins to turn on or the energy stored in transformer T1 goes to zero. Both events cause the collector of Q33 to begin a positive transition. Pin 3 of transformer T1 begins a negative transition at the same time and is applied to the base of Q33 through the feedback circuit of R81 and C25. This action causes Q33 to saturate and the cycle begins again.

**4-77. Converter Regulation.** Regulation of the dc-to-dc converter is accomplished by controlling the energy transfer to the load. The energy transfer to the load is controlled by the switch, Q33 and the current source I. The magnitude of I is determined by Q34, R98 and the voltage at the base of Q34. The base of Q34 is driven by U17. The inverting input of U17 is connected to ground through R116. A 10-to-7 voltage divider (R117 and R114) is connected to the non-inverting input of U17. One end of the divider (R117) senses the constant voltage of the +10 V series voltage regulator. The other end of the divider (R114) senses the -7 V output of the dc-to-dc converter. A change in voltage at the -7 V output results in an error voltage at the non-inverting input of U17 and is amplified by U17. The output voltage of U17 drives the base of Q34 and regulation of the -7 V output is achieved. Since the +11 V output is the transformer turns-ratio times the -7 V output, this output is also regulated.

#### **4-78. +10 V Series Voltage Regulation.**

4-79. The temperature compensated zener diode CR17 is the voltage reference from which the +10 V reference is derived. The zener voltage is applied to the non-inverting input of U16. A resistor divider in the precision resistor

pack (R75) senses the voltage at the output. A portion of the voltage is fed to the inverting input of U16. This error voltage is amplified by U16 to drive Q26. The collector current of Q26 then provides base drive for the series pass transistor Q27. To ensure turn-on of the dc-to-dc converter, the collector, as opposed to the emitter of the series pass transistor Q27, is connected to the output. The low collector-to-emitter saturation voltage aids in the turn-on process of the converter. This ensures start-up for battery voltages as low as 2 to 3 volts. One advantage to this configuration is that the +11 V supply can decrease to within the collector-to-emitter saturation voltage of the +10 V regulated output and regulation is still maintained.

#### **4-80. -12 V Supply.**

4-81. Refer to Figure 7-5. The -12 V output is developed from the -7 V supply by use of a voltage doubler circuit driven by the 100 kHz clock generated in the logic section. Transistors Q21 and Q22 prevent loading of the clock.

#### **4-82. Battery Low-Voltage Detection.**

4-83. Refer to the power supply schematic, Figure 7-5. The battery low-voltage detection circuit is comprised of a differential amplifier, Q36 and Q37. The voltage at the base of Q36 is set at about +2.9 V by the voltage divider R139 and R141. If the battery voltage (+VB) is greater than +2.9 V, Q36 conducts and Q37 is off. When the battery voltage drops below +2.9 V, Q37 turns on providing base drive for Q38. When Q38 is on, the base of Q34 is pulled to -7 V and Q34 turns off. This action turns the ac-to-dc converter of the power supply off removing all power supply outputs. This removes the front panel display indication. To reinstate the display, the OFF/ON switch must be turned OFF and again ON. The display indication will reappear while capacitor C51 charges to +2.9 V. When the voltage on C51 (which is the base voltage of Q36) exceeds the battery voltage (+VB), the circuit deactivates the power supply as previously described and the display indication disappears again.

## **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.*

Table 5-1. Test Equipment Required.

| INSTRUMENT TYPE                       | REQUIRED CHARACTERISTICS                                                                                                                                                                                                                                                                                                                                                                        | RECOMMENDED MODEL                                                                                                                                                                                   |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Digital Volt/Ohmmeter                 | DC Volts: 1 V, 10 V and 100 V range<br>Accuracy: $\pm 0.04\%$<br>Input Resistance: 10 M $\Omega$<br>Ohms: 200 k $\Omega$<br>Accuracy: $\pm 0.07\%$                                                                                                                                                                                                                                              | -hp- 3470 System;<br>-hp- 34702A Multimeter                                                                                                                                                         |
| Digital Voltmeter                     | DC Volts: 5 digit resolution to 1 $\mu$ V on 100 mV dc range.<br>Accuracy: $\pm 0.007\%$<br><br>AC Volts: 1 V and 10 V range<br>Frequency: 40 Hz to 20 kHz<br>Accuracy: 0.25%                                                                                                                                                                                                                   | -hp- 3450B                                                                                                                                                                                          |
| AC Calibrator/ High Voltage Amplifier | Frequency: 20 Hz to 100 kHz<br>Output: 1 mV to 1000 V<br>Accuracy (mid band): $\pm 0.1\%$                                                                                                                                                                                                                                                                                                       | -hp- 745A/746A                                                                                                                                                                                      |
| DC Standard                           | Output: 1 mV to 1000 V<br>Accuracy: $\pm 0.02\%$                                                                                                                                                                                                                                                                                                                                                | -hp- 740B                                                                                                                                                                                           |
| Meter Calibrator                      | Output: 1 A<br>Accuracy: $\pm 0.1\%$                                                                                                                                                                                                                                                                                                                                                            | -hp- 6920B                                                                                                                                                                                          |
| Electronic Counter                    | Frequency: 50 and 60 Hz<br>Accuracy: $\pm 0.01\%$                                                                                                                                                                                                                                                                                                                                               | -hp- 5300A/5302A                                                                                                                                                                                    |
| Power Supply                          | Output: 20 V, 1 A                                                                                                                                                                                                                                                                                                                                                                               | -hp- 6294A                                                                                                                                                                                          |
| Resistor Decade Box                   | 10 $\Omega$ , 100 $\Omega$ , 1 k $\Omega$ , 10 k $\Omega$ , 100 k $\Omega$ and 1 M $\Omega$ steps<br>Accuracy: $\pm 0.005\%$                                                                                                                                                                                                                                                                    | General Radio<br>Mdl GR 1433-Z                                                                                                                                                                      |
| Capacitor                             | 1 $\mu$ F $\pm 10\%$                                                                                                                                                                                                                                                                                                                                                                            | 0160-3407                                                                                                                                                                                           |
| Resistors                             | 1 $\Omega \pm 0.1\%$<br>10 $\Omega \pm 0.1\%$<br>1 k $\Omega \pm 0.1\%$<br>2 k $\Omega \pm 0.1\%$<br>10 k $\Omega \pm 0.1\%$<br>20 k $\Omega \pm 0.1\%$<br>100 k $\Omega \pm 0.1\%$<br>1 M $\Omega \pm 0.1\%$<br>10 M $\Omega \pm 0.1\%$<br><br>30 $\Omega \pm 1\%$<br>100 $\Omega \pm 1\%$<br>1 k $\Omega \pm 1\%$<br>22 k $\Omega \pm 1\%$<br>66.5 k $\Omega \pm 1\%$<br>1 M $\Omega \pm 1\%$ | 0811-0615<br>0698-5452<br>0698-3491<br>0698-6612<br>0698-4157<br>0698-6943<br>0698-4158<br>0698-6369<br>0698-8194<br><br>0757-0388<br>0698-7320<br>0727-0751<br>0757-1087<br>0698-4503<br>0698-5049 |

## SECTION V

### MAINTENANCE

#### 5-1. INTRODUCTION.

5-2. This section of the manual contains Performance Tests and Adjustment Procedures. The Performance Tests are designed to verify the critical specifications listed in Table 1-1. A Performance Test Card is at the end of this section for recording the results of the performance tests.

#### 5-3. Test Equipment Required.

5-4. Equipment required for the performance tests and adjustment procedures is listed in Table 5-1, Recommended Test Equipment. Equipment that satisfies the critical specifications given in the table may be substituted for a recommended model.

#### NOTE

*Throughout the Performance Tests and Adjustment Procedures, the -hp- Model 3465A is referred to as Multimeter.*

#### 5-5. PERFORMANCE TESTS.

#### 5-6. DC Voltmeter Accuracy Test.

5-7. A DC Standard is required for this test.

a. Set the Multimeter function to DCV ( $\overline{=}$  V) and range to 10 m. Short the V $\Omega$  and COM terminals together and adjust the display for 0.000, using the ZERO ADJ on the rear panel.

b. Disconnect the short and connect the DC Standard between the V $\Omega$  and COM terminals.

c. Check all the dc ranges listed in Table 5-2 for the tolerances indicated.



*Do not apply more than 1000 V, otherwise damage to the instrument may result.*

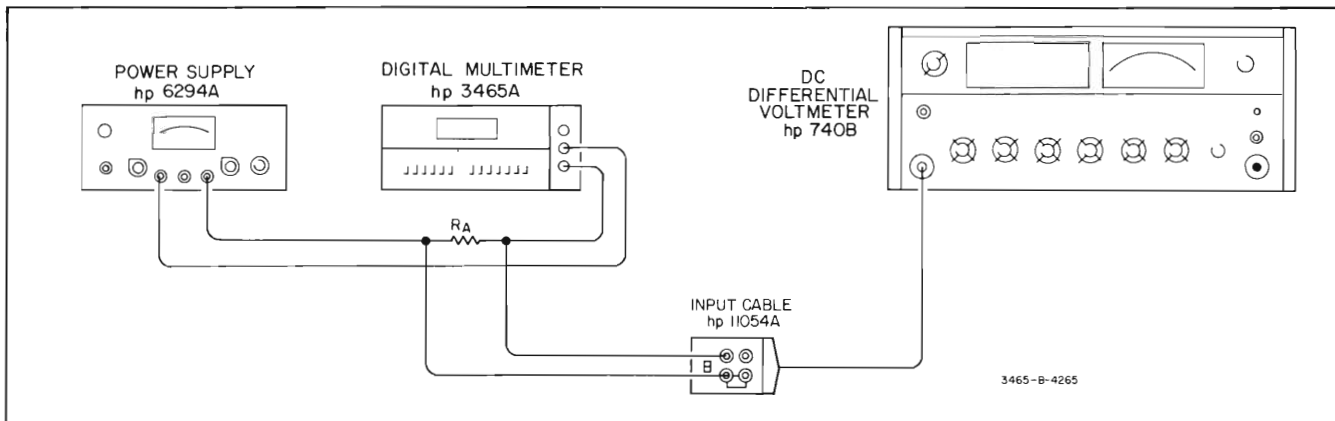
**Table 5-2. DC Voltmeter Accuracy Test.**

| DC Range | DC Standard Output                                    | Multimeter Display Limits                                |
|----------|-------------------------------------------------------|----------------------------------------------------------|
| 10 mV    | $\pm 0.00100$ V<br>$\pm 0.00500$ V<br>$\pm 0.01000$ V | .998 – 1.002 mV<br>4.996 – 5.004 mV<br>9.995 – 10.005 mV |
| 100 mV   | $\pm 0.01000$ V<br>$\pm 0.05000$ V<br>$\pm 0.10000$ V | 9.99 – 10.01 mV<br>49.98 – 50.02 mV<br>99.97 – 100.03 mV |
| 1 V      | $\pm 0.10000$ V<br>$\pm 0.50000$ V<br>$\pm 1.00000$ V | .9999 – 1.0001 V<br>.4998 – .5002 V<br>.9997 – 1.0003 V  |
| 10 V     | $\pm 1.00000$ V<br>$\pm 5.00000$ V<br>$\pm 10.0000$ V | .999 – 1.001 V<br>4.998 – 5.002 V<br>9.997 – 10.003 V    |
| 100 V    | $\pm 10.0000$ V<br>$\pm 50.0000$ V<br>$\pm 100.000$ V | 9.99 – 10.01 V<br>49.98 – 50.02 V<br>99.97 – 100.03 V    |
| 1000 V   | $\pm 100.000$ V<br>$\pm 500.000$ V<br>$\pm 1000.00$ V | 99.8 – 100.2 V<br>499.7 – 500.3 V<br>999.6 – 1000.4 V    |

#### 5-8. DC Ammeter Accuracy Test.

5-9. This test requires the use of a power supply, a DC Differential Voltmeter and a precision resistor listed in Table 5-3 (part numbers are given in Table 5-1) or a resistor decade box.

a. Connect the Multimeter and test equipment as shown in Figure 5-1.



**Figure 5-1. DC Ammeter Accuracy Test.**

Table 5-3. DC Ammeter Accuracy Test.

| Multimeter Range | Current Level                           | $R_A$                     | Differential VM Reading          | Multimeter Display Limits                                               |
|------------------|-----------------------------------------|---------------------------|----------------------------------|-------------------------------------------------------------------------|
| 100 $\mu$ A      | 10 $\mu$ A<br>50 $\mu$ A<br>100 $\mu$ A | 100 k $\Omega$ $\pm$ 0.1% | 1.0000 V<br>5.0000 V<br>10.000 V | 9.98 – 10.02 $\mu$ A<br>49.95 – 50.05 $\mu$ A<br>99.92 – 100.08 $\mu$ A |
| 1 mA             | .1 mA<br>.5 mA<br>1 mA                  | 1 k $\Omega$ $\pm$ 0.1%   | .10000 V<br>.50000 V<br>1.0000 V | .0998 – .1002 mA<br>.4995 – .5005 mA<br>.9992 – 1.0008 mA               |
| 10 mA            | 1 mA<br>5 mA<br>10 mA                   | 1 k $\Omega$ $\pm$ 0.1%   | 1.0000 V<br>5.0000 V<br>10.000 V | .998 – 1.002 mA<br>4.993 – 5.007 mA<br>9.988 – 10.012 mA                |
| 100 mA           | 10 mA<br>50 mA<br>100 mA                | 10 $\Omega$ 0.1%          | .10000 V<br>.5000 V<br>1.0000 V  | 9.93 – 10.07 mA<br>49.69 – 50.31 mA<br>99.39 – 100.61 mA                |
| 1000 mA          | 100 mA<br>500 mA<br>1000 mA             | 1 $\Omega$ 0.1%           | .10000 V<br>.50000 V<br>1.0000 V | 99.3 – 100.7 mA<br>496.9 – 503.1 mA<br>993.9 – 1006.1 mA                |

b. Connect the 100 kilohm  $\pm$  0.1% resistor in the  $R_A$  position as shown.

c. Set the Multimeter function to DCA (  $\overline{\text{---}}$  A) and range to 100  $\mu$ A. Adjust the power supply output for a differential voltmeter reading of 1.000 V. The Multimeter should indicate 99.98 to 100.02  $\mu$ A.

d. Check all the Multimeter ranges, using the values of  $R_A$  and differential voltmeter readings shown in Table 5-3. The Multimeter display should indicate within the limits provided.

### 5-10. Ohms Accuracy Test.

5-11. A precision resistive decade box will be required for this test. It should be calibrated and have a known accuracy of .005%.

a. Connect the equipment as shown in Figure 5-2.

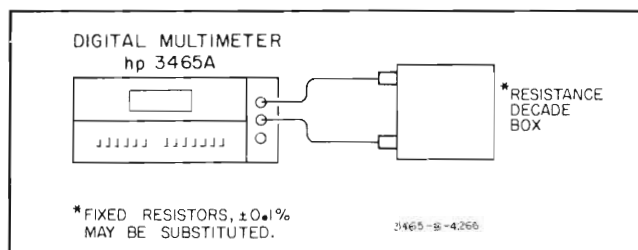


Figure 5-2. Ohms Accuracy Test.

b. Set the Multimeter function to OHMS ( $\Omega$ ) and check all the ranges in Table 5-4 using the decade box to supply the indicated resistances. The Multimeter display should indicate within the limits provided.

### 5-12. AC Voltage Accuracy Test.

5-13. An AC Calibrator and High Voltage Amplifier will be required for the following tests.

Table 5-4. Ohms Accuracy Test.

| Multimeter Range | Resistive Decade Setting                            | Multimeter Display Limits                                                         |
|------------------|-----------------------------------------------------|-----------------------------------------------------------------------------------|
| 100 $\Omega$     | 10 $\Omega$<br>50 $\Omega$<br>100 $\Omega$          | 9.98 – 10.02 $\Omega$<br>49.97 – 50.03 $\Omega$<br>99.96 – 100.04 $\Omega$        |
| 1 k $\Omega$     | 100 $\Omega$<br>500 $\Omega$<br>1 k $\Omega$        | .0999 – .1001 k $\Omega$<br>.4998 – .5002 k $\Omega$<br>.9997 – 1.0003 k $\Omega$ |
| 10 k $\Omega$    | 1 k $\Omega$<br>5 k $\Omega$<br>10 k $\Omega$       | .999 – 1.001 k $\Omega$<br>4.998 – 5.002 k $\Omega$<br>9.997 – 10.003 k $\Omega$  |
| 100 k $\Omega$   | 10 k $\Omega$<br>50 k $\Omega$<br>100 k $\Omega$    | 9.99 – 10.01 k $\Omega$<br>49.98 – 50.02 k $\Omega$<br>99.97 – 100.03 k $\Omega$  |
| 1000 k $\Omega$  | 100 k $\Omega$<br>500 k $\Omega$<br>1000 k $\Omega$ | 99.9 – 100.1 k $\Omega$<br>499.8 – 500.2 k $\Omega$<br>999.7 – 1000.3 k $\Omega$  |
| 10 M             | 1 M $\Omega$<br>5 M $\Omega$<br>10 M $\Omega$       | .998 – 1.002 M $\Omega$<br>4.994 – 5.006 M $\Omega$<br>9.989 – 10.011 M $\Omega$  |

a. Set the Multimeter function to ACV ( $\sim$ V). Connect the AC Calibrator between the V $\Omega$  terminal and COM terminal. Be sure to connect the Calibrator sense leads.

b. Check the voltage ranges listed in Table 5-5 at each frequency listed. The Multimeter should indicate within the limits provided.

### 5-14. AC Ammeter Accuracy Test

5-15. An AC Calibrator, a 3450B Digital Voltmeter and discrete resistors ( $R_A$ ) indicated in Table 5-6 are required for this test.

a. Set the Multimeter function to ACA ( $\sim$  A) and range to 100  $\mu$ A. Connect the equipment as shown in Figure 5-3 using a discrete resistor for  $R_A$ . (To select  $R_A$ , note the

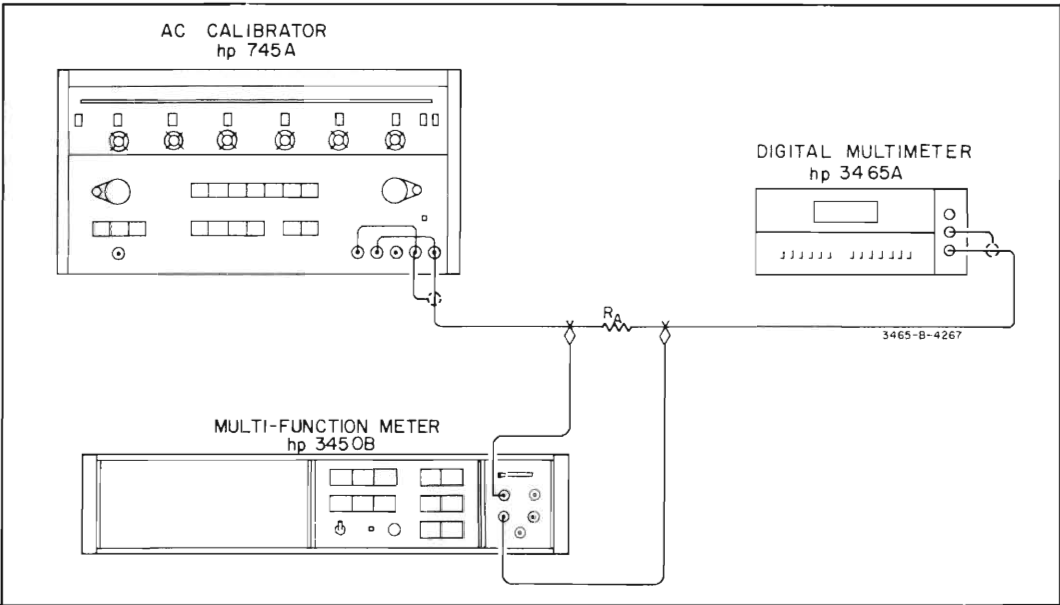


Figure 5-3. AC Ammeter Accuracy Test 100  $\mu$ A thru 10 mA Range.

Table 5-5. AC Voltage Accuracy Test.

| Multimeter Range | AC Standard Output | Test Frequency         | Multimeter Display Limits |
|------------------|--------------------|------------------------|---------------------------|
| 100 mV           | 10 mV              | 40 Hz, 400 Hz, 10 kHz  | 9.93 – 10.07 mV           |
|                  | 50 mV              | 40 Hz, 1 kHz, 10 kHz   | 49.87 – 50.13 mV          |
|                  | 100 mV             | 40 Hz, 5 kHz, 10 kHz   | 99.80 – 100.20 mV         |
|                  | 10 mV              | 11 kHz, 15 kHz, 20 kHz | 9.80 – 10.20 mV           |
|                  | 50 mV              | 11 kHz, 15 kHz, 20 kHz | 49.60 – 50.40 mV          |
|                  | 100 mV             | 11 kHz, 15 kHz, 20 kHz | 99.35 – 100.65 mV         |
| 1 V              | 100 mV             | 40 Hz, 400 Hz, 10 kHz  | .0993 – .1007 V           |
|                  | 500 mV             | 40 Hz, 1 kHz, 10 kHz   | .4987 – .5013 V           |
|                  | 1 V                | 40 Hz, 5 kHz, 10 kHz   | .9980 – 1.0020 V          |
|                  | 100 mV             | 11 kHz, 15 kHz, 20 kHz | .0980 – .1020 V           |
|                  | 500 mV             | 11 kHz, 15 kHz, 20 kHz | .4960 – .5040 V           |
|                  | 1 V                | 11 kHz, 15 kHz, 20 kHz | .9960 – 1.0065 V          |
| 10 V             | 1 V                | 40 Hz, 400 Hz, 10 kHz  | .993 – 1.007 V            |
|                  | 5 V                | 40 Hz, 1 kHz, 10 kHz   | 4.987 – 5.013 V           |
|                  | 10 V               | 40 Hz, 5 kHz, 10 kHz   | 9.980 – 10.020 V          |
|                  | 1 V                | 11 kHz, 15 kHz, 20 kHz | .980 – 1.020 V            |
|                  | 5 V                | 11 kHz, 15 kHz, 20 kHz | 4.960 – 5.040 V           |
|                  | 10 V               | 11 kHz, 15 kHz, 20 kHz | 9.935 – 10.065 V          |
| 100 V            | 10 V               | 40 Hz, 400 Hz, 10 kHz  | 9.99 – 10.07 V            |
|                  | 50 V               | 40 Hz, 1 kHz, 10 kHz   | 49.87 – 50.13 V           |
|                  | 100 V              | 40 Hz, 5 kHz, 10 kHz   | 99.80 – 100.20 V          |
|                  | 10 V               | 11 kHz, 15 kHz, 20 kHz | 9.80 – 10.20 V            |
|                  | 50 V               | 11 kHz, 15 kHz, 20 kHz | 49.60 – 50.40 V           |
|                  | 100 V              | 11 kHz, 15 kHz, 20 kHz | 99.35 – 100.65 V          |
| 1000 V           | 100 V              | 40 Hz, 400 Hz, 1 kHz   | 99.3 – 100.7 V            |
|                  | 500 V              | 40 Hz, 400 Hz, 1 kHz   | 498.7 – 501.3 V           |
|                  | 100 V              | 1.5 kHz, 2 kHz         | 99.0 – 101.0 V            |
|                  | 500 V              | 1.5 kHz, 2 kHz         | 497.0 – 503.0 V           |

value of  $R_A$  as directed in Table 5-6 and install the part number indicated in Table 5-1. A resistor decade box *WILL NOT* provide the accuracy required of  $R_A$  because of the introduction of wire-wound resistor inductance by the decade box).

b. Set the AC Calibrator frequency to the desired test frequency indicated in Table 5-6.

c. Adjust the AC Calibrator amplitude for a 3450B Digital Voltmeter display as indicated in Table 5-6 for the range and current level being tested.

d. *REMOVE* the 3450B Digital Voltmeter from the test setup.

e. Verify the Multimeter Display Limits as indicated in the last column of Table 5-6.

f. Reconnect the 3450B Digital Voltmeter as shown in Figure 5-3.

g. Repeat Steps b through f for each frequency of each range and current level listed in Table 5-6. Change  $R_A$  as indicated for each current level.

h. To check the 100 mA and 1 A ranges, it is necessary to use an ac current source capable of these current outputs such as the 6920B Meter Calibrator. Set the 6920B OUTPUT SWITCH to OFF and replace the AC Calibrator with the 6920B.

i. Set the 6920B FUNCTION switch to AC and RANGE switch to 100 milliamperes. Adjust the digital potentiometer readout control to provide a 10 mA output.

j. Set the OUTPUT SWITCH to ON HOLD. Verify Multimeter Display Limits shown in Table 5-7.

k. Return the 6920B OUTPUT SWITCH to OFF before changing ranges. Adjust the 6920B for the 100 mA range outputs listed in Table 5-7 and verify the Multimeter Display Limits.

l. Change Multimeter range to 1000 mA and verify Multimeter Display Limit for the 100 mA input.

m. With the 6920B OUTPUT switch at OFF, change the 6920B range to 1A. Check the Multimeter Display Limits for the 500 mA and 1000 mA inputs indicated in Table 5-7.

Table 5-6. AC Ammeter Accuracy Test, 100  $\mu$ A thru 10 mA Ranges.

| Multimeter Range | 3450B Digital Voltmeter Display Indication | AC Calibrator Frequency                                       | $R_A$ Value              | Current Level | Multimeter Display Limits                                                  |
|------------------|--------------------------------------------|---------------------------------------------------------------|--------------------------|---------------|----------------------------------------------------------------------------|
| 100 $\mu$ A      | .99985 to 1.00015                          | 40 Hz and 400 Hz<br>1 kHz, 5 kHz, 10 kHz<br>15 kHz and 20 kHz | 100 k $\Omega$ $\pm$ .1% | 10 $\mu$ A    | 9.91 – 10.09 $\mu$ A<br>9.92 – 10.08 $\mu$ A<br>9.79 – 10.21 $\mu$ A       |
|                  |                                            | 40 Hz and 400 Hz<br>1 kHz, 5 kHz, 10 kHz<br>15 kHz and 20 kHz | 20 k $\Omega$ $\pm$ .1%  | 50 $\mu$ A    | 49.75 – 50.25 $\mu$ A<br>49.82 – 50.18 $\mu$ A<br>49.55 – 50.75 $\mu$ A    |
|                  |                                            | 40 Hz and 400 Hz<br>1 kHz, 5 kHz, 10 kHz<br>15 kHz and 20 kHz | 10 k $\Omega$ $\pm$ .1%  | 100 $\mu$ A   | 99.55 – 100.45 $\mu$ A<br>99.70 – 100.30 $\mu$ A<br>99.25 – 100.75 $\mu$ A |
| 1 mA             | 9.9985 to 10.0015                          | 40 Hz and 400 Hz<br>1 kHz, 5 kHz, 10 kHz<br>15 kHz and 20 kHz | 100 k $\Omega$ $\pm$ .1% | .1 mA         | .0991 – .1009 mA<br>.0992 – .1008 mA<br>.0979 – .1021 mA                   |
|                  |                                            | 40 Hz and 400 Hz<br>1 kHz, 5 kHz, 10 kHz<br>15 kHz and 20 kHz | 20 k $\Omega$ $\pm$ .1%  | .5 mA         | .4975 – .5025 mA<br>.4982 – .5018 mA<br>.4955 – .5045 mA                   |
|                  |                                            | 40 Hz and 400 Hz<br>1 kHz, 5 kHz, 10 kHz<br>15 kHz and 20 kHz | 10 k $\Omega$ $\pm$ .1%  | 1 mA          | .9955 – 1.0045 mA<br>.9970 – 1.0030 mA<br>.9925 – 1.0075 mA                |
| 10 mA            | 9.9985 to 10.0015                          | 40 Hz and 400 Hz<br>1 kHz, 5 kHz, 10 kHz<br>15 kHz and 20 kHz | 10 k $\Omega$ $\pm$ 0.1% | 1 mA          | .991 – 1.009 mA<br>.992 – 1.008 mA<br>.979 – 1.021 mA                      |
|                  |                                            | 40 Hz and 400 Hz<br>1 kHz, 5 kHz, 10 kHz<br>15 kHz and 20 kHz | 2 k $\Omega$ $\pm$ .1%   | 5 mA          | 4.975 – 5.025 mA<br>4.982 – 5.018 mA<br>4.955 – 5.045 mA                   |
|                  |                                            | 40 Hz and 400 Hz<br>1 kHz, 5 kHz, 10 kHz<br>15 kHz and 20 kHz | 1 k $\Omega$ $\pm$ .1%   | 10 mA         | 9.955 – 10.045 mA<br>9.970 – 10.030 mA<br>9.925 – 10.075 mA                |

**Table 5-7. AC Ammeter Accuracy Test,  
100 mA and 1000 mA Ranges.**

| Multimeter Range | Output Meter Calibration | Multimeter Display Limits |
|------------------|--------------------------|---------------------------|
| 100 mA           | 10 mA                    | 9.87 – 10.13 mA           |
|                  | 50 mA                    | 49.55 – 50.45 mA          |
|                  | 100 mA                   | 99.15 – 100.85 mA         |
| 1000 mA          | 100 mA                   | 98.7 – 101.3 mA           |
|                  | 500 mA                   | 495.5 – 504.5 mA          |
|                  | 1000 mA                  | 991.5 – 1008.5 mA         |

### 5-16. AC Normal-Mode Rejection Test.

5-17. AC normal-mode rejection is the ratio of the peak normal-mode voltage to the resultant error in reading.

$$\text{NMR}_{(\text{db})} = 20 \log_{10} \frac{\text{Peak ac superimposed voltage}}{\text{Effect on reading (peak volts)}}$$

An AC Calibrator, an Electronic Counter, a 1  $\mu\text{F}$  capacitor (-hp- Part No. 0160-3407) and a 22  $\text{k}\Omega$  resistor (-hp- Part No. 0757-1087) are required for this test.

a. Connect the test equipment as shown in Figure 5-4. Do not connect the Multimeter at this time.

b. Using the Electronic Counter as a monitor, adjust the AC Calibrator frequency to 60 Hz  $\pm$  0.1%.

c. Set the Multimeter function to DCV (--- V) and range to 10 V. Short the Multimeter input and note the indication.

d. Disconnect the short and connect the AC Calibrator to the Multimeter input. Adjust the Calibrator output to 7.07 V rms (10 V peak).

e. The Multimeter indication should not vary more than .007 V from the indication noted in Step C. This verifies a normal-mode rejection of greater than 60 dB.

f. Repeat Steps c, d and e for an AC Calibrator output frequency of 50 Hz  $\pm$  0.1% as monitored by the Electronic Counter.

### 5-18. AC Effective Common-Mode Rejection Test.

5-19. An AC Calibrator, an Electronic Counter and a 1  $\text{k}\Omega$   $\pm$  1% resistor are required for this test.

a. Connect a 1  $\text{k}\Omega$  resistor between the V $\Omega$  and COM terminals.

b. Set the Multimeter function to DCV (--- V) and range to 1 V. Note the Multimeter indication.

c. Connect the AC Calibrator to the Multimeter as shown in Figure 5-5.

d. Using the Electronic Counter as a monitor, set the AC Calibrator frequency to 60 Hz  $\pm$  0.1% (50 Hz  $\pm$  0.1% if operating Multimeter from a 50 Hz source).

e. Adjust the Calibrator output to 7.07 V rms (10 V peak).

f. Note the Multimeter indication. The reading should not vary more than .00001 V from reading noted in Step b verifying an ac common-mode rejection of greater than 120 dB.

### 5-20. DC Voltmeter Input Resistance Test.

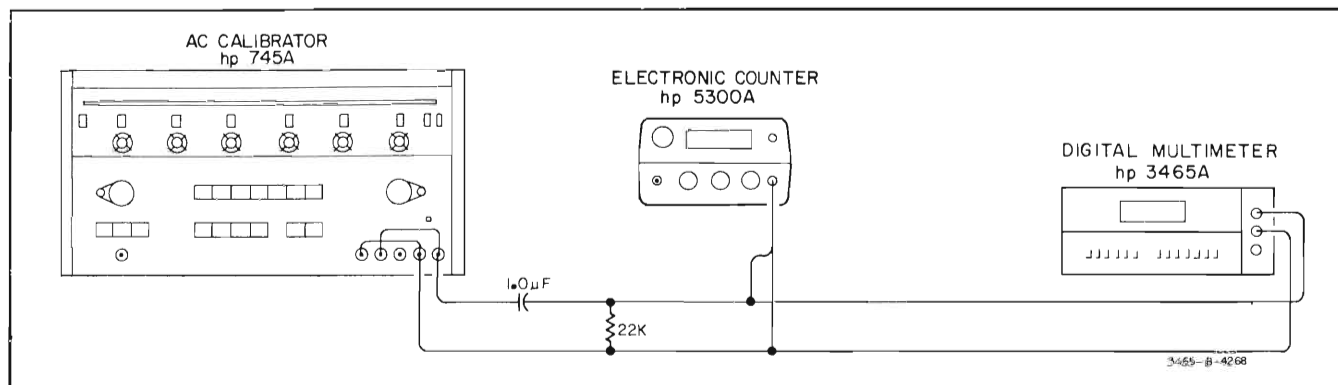
5-21. A DC Standard and a 10  $\text{M}\Omega$   $\pm$  0.1% resistor (-hp- Part No. 0698-8194) are required for this test.

a. Connect the Multimeter, DC Standard and resistor as shown in Figure 5-6.

b. Set the Multimeter function to DCV (--- V) and range to 10 V.

c. Connect a jumper across the 10  $\text{M}\Omega$  resistor and adjust the DC Standard to provide a Multimeter display of +10.000.

d. Remove the jumper from the 10  $\text{M}\Omega$  resistor. The Multimeter display should indicate 4.950 to 5.027 verifying an input resistance of 10  $\text{M}\Omega$   $\pm$  1% on the 10 V through 1000 V ranges.



**Figure 5-4. AC Normal-Mode Rejection Test.**

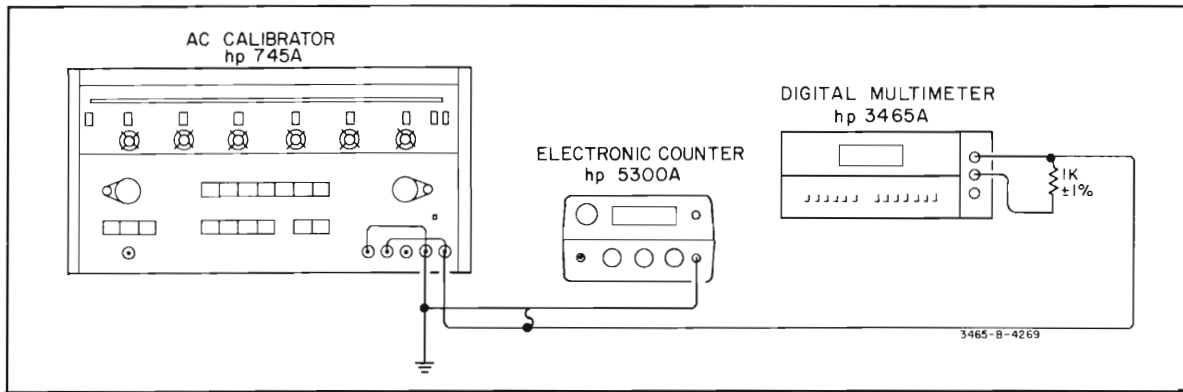


Figure 5-5. AC Effective Common-Mode Rejection Test.

e. Change the DC Standard output to 0 V and change the Multimeter range to 1 V.

f. Connect a jumper across the 10 M $\Omega$  resistor and adjust the DC Standard to provide a Multimeter display of +1.0000.

g. Remove the jumper from the 10 M $\Omega$  resistor. The Multimeter display should indicate .9990 or greater verifying an input resistance of  $\geq 10^{10}$  on the 10 mV through 1 V ranges.

## 5-22. AC Voltmeter Input Impedance Test.

5-23. An AC Calibrator and a 1 M $\Omega \pm 0.1\%$  resistor (-hp-Part No. 0698-6369) are required for this test.

a. Connect the AC Calibrator and a 1 M $\Omega$  resistor as shown in Figure 5-7. Connect a jumper across the resistor.

b. Set the Multimeter function to ACV ( $\sim$  V) and range to 1 V.

c. Set the AC Calibrator frequency to 40 Hz and adjust the output amplitude for a Multimeter display of 1.0000.

d. Remove the jumper from the 1 M $\Omega$  resistor. The Multimeter display should indicate .4950 to .5027 verifying an input impedance resistive component of 1 M $\Omega \pm 1\%$ .

e. Maintain the AC Calibrator at 40 Hz and adjust the output amplitude for a Multimeter display of 1.0000.

f. Change the AC Calibrator frequency to 3183 Hz. The Multimeter display should indicate .7071 to 1.0000 verifying a shunt capacitance less than 100 pF.

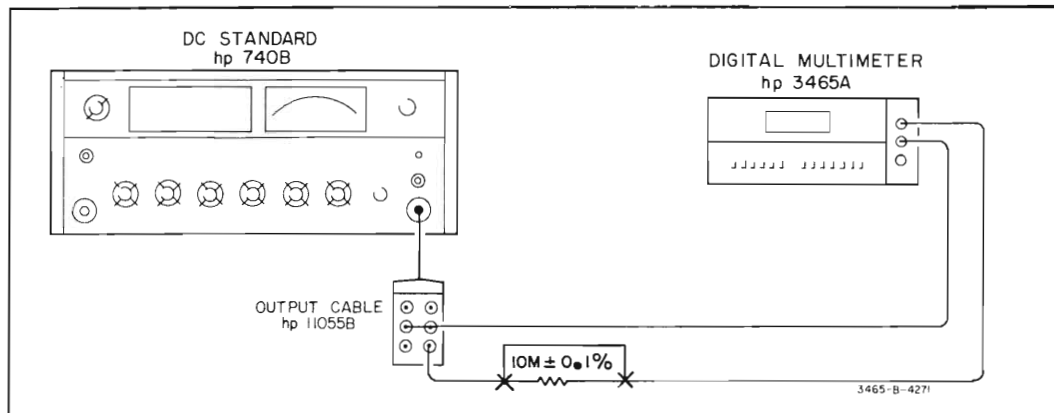


Figure 5-6. DC Voltmeter Input Resistance Test.

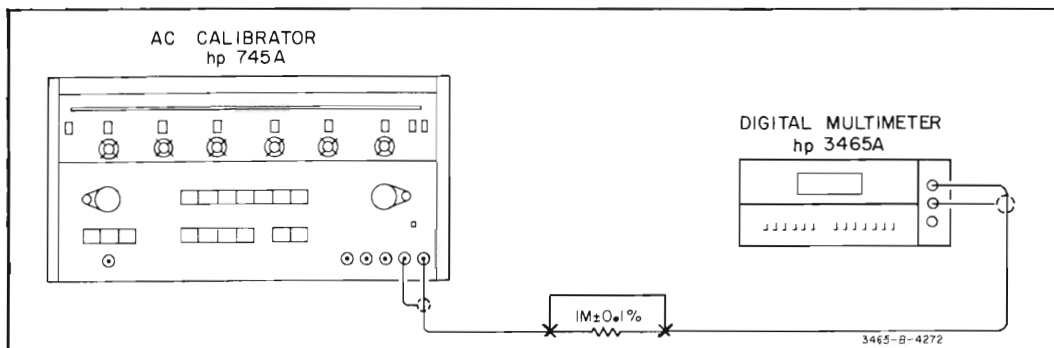


Figure 5-7. AC Voltmeter Input Impedance Test.

## ADJUSTMENT PROCEDURES

## 5-24. ADJUSTMENT PROCEDURES.

**WARNING**

*Adjustment Procedures of Section V are intended for qualified service personnel only. To reduce the possibility of electrical shock, only qualified personnel are to perform maintenance duties.*

5-25. The following procedures should be performed only.

after it has been determined from Performance Tests that the Multimeter does not meet specifications. If any adjustment in these procedures cannot be made, refer to the troubleshooting procedures of Section VII. Location of the Multimeter adjustments is shown in Figure 5-8.

**NOTE**

*After use of a soldering iron, flux remover or freon on the A1 Assembly, allow 10 to 15 minutes for the instrument to thermally stabilize before an adjustment is performed.*

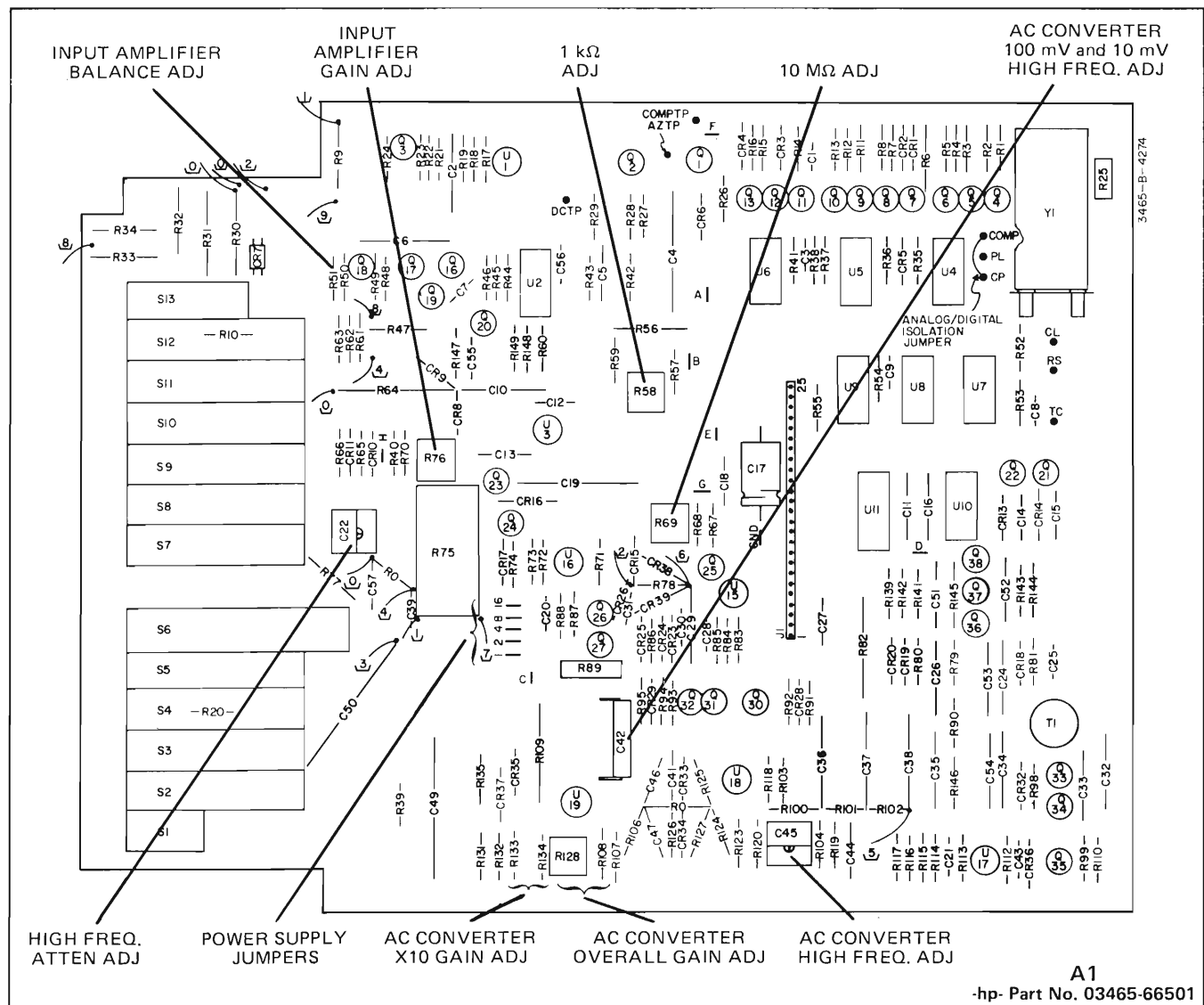


Figure 5-8. Multimeter Adjustment Location.

### 5-26. Power Supply Adjustment.

#### 5-27. Power Supply + 10 V Reference Voltage Adjustment.

Coarse adjustment of the + 10 V reference voltage is made by selecting the proper combination of power supply jumpers designated 1, 2, 4, 8 and 16. Coarse adjustment is necessary whenever the + 10 V reference cannot be adjusted with A1R89 (+ 10 V ADJ - fine adjustment) to obtain a display of 1.0000 for a 1 V dc input. This can occur after replacement of A1CR17, A1R75 or A1U16 or because of the long-term drift of the A1CR17 zener voltage.

5-28. Power supply jumpers 1, 2, 4, 8 and 16 parallel resistors in A1R75 which are used as a regulator feedback network. Removing a jumper decreases the + 10 V reference voltage and results in an increase in the Multimeter display for a given input. Clockwise rotation of the + 10 V ADJ, A1R89 (fine adjustment), also results in an increase in the Multimeter display for a given input.

5-29. A DC Standard is required for this adjustment.

a. Set Multimeter function to DCV (  $\overline{\text{---}}$  V) and range to 1 V.

b. Connect A1R75 pin 22 to ground.

c. Apply +1 V dc from the DC Standard between the V $\Omega$  and COM terminals.

d. Note and record the Multimeter display.

e. Refer to Table 5-8, Power Supply Jumpers. Locate the line with LO and HI reading limits that bound the Multimeter display recorded and note the jumper combination. (If reading is out of range of table, check A1CR17 for  $6.95 \text{ V} \pm 0.25 \text{ V}$ , A1R75 and A1U16).

f. A "0" means to remove jumper; a "1" means leave jumper in place. Introduce the jumper combination noted in Step e.

g. Remove the connection from R75 pin 22 to ground.

h. Adjust A1R89 (+10 V ADJ) for a Multimeter display of  $+1.0000 \pm 2$  counts.

#### NOTE

*If a display of + 1.0000 cannot be attained with A1R89 after installing the proper jumper combination, a new jumper combination must be selected. If the + 1.0000 display is low, install the jumper combination from the line in Table 5-8 preceeding the jumper combination installed. If the + 1.0000 display is high, install the jumper combination from the line in Table 5-8 succeeding the jumper combination installed.*

Table 5-8. Power Supply Jumpers.

| READING |        | POWER SUPPLY JUMPER |   |   |   |   |
|---------|--------|---------------------|---|---|---|---|
| LO      | HI     | 16                  | 8 | 4 | 2 | 1 |
| NOTE 1  | .8961  | 0                   | 0 | 0 | 0 | 0 |
| .8962   | .8984  | 0                   | 0 | 0 | 0 | 1 |
| .8985   | .9008  | 0                   | 0 | 0 | 1 | 0 |
| .9009   | .9032  | 0                   | 0 | 0 | 1 | 1 |
| .9033   | .9057  | 0                   | 0 | 1 | 0 | 0 |
| .9058   | .9082  | 0                   | 0 | 1 | 0 | 1 |
| .9083   | .9108  | 0                   | 0 | 1 | 1 | 0 |
| .9109   | .9134  | 0                   | 0 | 1 | 1 | 1 |
| .9135   | .9161  | 0                   | 1 | 0 | 0 | 0 |
| .9162   | .9189  | 0                   | 1 | 0 | 0 | 1 |
| .9190   | .9217  | 0                   | 1 | 0 | 1 | 0 |
| .9218   | .9245  | 0                   | 1 | 0 | 1 | 1 |
| .9246   | .9274  | 0                   | 1 | 1 | 0 | 0 |
| .9275   | .9304  | 0                   | 1 | 1 | 0 | 1 |
| .9305   | .9335  | 0                   | 1 | 1 | 1 | 0 |
| .9336   | .9366  | 0                   | 1 | 1 | 1 | 1 |
| .9367   | .9397  | 1                   | 0 | 0 | 0 | 0 |
| .9398   | .9430  | 1                   | 0 | 0 | 0 | 1 |
| .9431   | .9463  | 1                   | 0 | 0 | 1 | 0 |
| .9464   | .9497  | 1                   | 0 | 0 | 1 | 1 |
| .9498   | .9532  | 1                   | 0 | 1 | 0 | 0 |
| .9533   | .9568  | 1                   | 0 | 1 | 0 | 1 |
| .9569   | .9604  | 1                   | 0 | 1 | 1 | 0 |
| .9605   | .9641  | 1                   | 0 | 1 | 1 | 1 |
| .9642   | .9680  | 1                   | 1 | 0 | 0 | 0 |
| .9681   | .9719  | 1                   | 1 | 0 | 0 | 1 |
| .9720   | .9759  | 1                   | 1 | 0 | 1 | 0 |
| .9760   | .9800  | 1                   | 1 | 0 | 1 | 1 |
| .9801   | .9843  | 1                   | 1 | 1 | 0 | 0 |
| .9844   | .9886  | 1                   | 1 | 1 | 0 | 1 |
| .9887   | .9930  | 1                   | 1 | 1 | 1 | 0 |
| .9931   | NOTE 2 | 1                   | 1 | 1 | 1 | 1 |

"0" = Remove Jumper

"1" = Leave Jumper In Place

NOTE 1. For Readings less than .8922, adjustment cannot be made. Check A1CR17 zener voltage for  $6.95 \text{ V} \pm 0.25 \text{ V}$ .

NOTE 2. Adjustment cannot be made for readings greater than 1.0000. Check A1CR17 zener voltage for  $6.95 \text{ V} \pm 0.25 \text{ V}$ .

### 5-30. Input Amplifier Adjustments.

5-31. Input Amplifier Gain Adjustment (R76). A DC Standard is required for this adjustment.

a. Set the Multimeter function to DCV (  $\overline{\text{---}}$  V) and range to 10 m.

b. Connect a short across the input terminals (V $\Omega$  and COM) and adjust the Multimeter display for 0.000 with R25 (rear panel ZERO ADJ).

c. Remove the short from the input terminals and apply + 10 mV to the input terminals from the DC Standard.

d. Adjust R76 (INPUT AMP GAIN ADJ) for a Multimeter display of  $+10.000 \pm 3$  counts.

5-32. Input Amplifier Balance Adjustment (R50/R51 potentiometer). The input amplifier balance adjustment must be performed if A1Q16, A1U1 or A1R75 are replaced. A Digital Voltmeter is required for this adjustment.

- a. Set Multimeter function to DCV (  $\overline{\text{---}}$  V) and range to 1 V.
- b. Connect ground to the gate of A1Q16 at the junction of A1C7.
- c. Connect the Digital Voltmeter to DCTP.
- d. Adjust R50/R51 for a Digital Voltmeter reading at DCTP of less than 1 mV.

### 5-33. Ohms Converter Adjustments (R58 and R69).

5-34. A Digital Voltmeter, a  $1\text{ k}\Omega \pm 1\%$  resistor -hp- Part No. 0727-0751 and a  $10\text{ M}\Omega \pm 1\%$  resistor, -hp- Part No. 0698-5049 are required for this adjustment.

- a. Set Multimeter function to OHMS ( $\Omega$ ) and range to 1K.
- b. Short the Multimeter input terminals (V $\Omega$  and COM).
- c. Connect Digital Voltmeter to junction of A1R78 and A1Q25 gate.
- d. Adjust A1R69 ( $10\text{ M}\Omega$  ADJ) for a Digital Voltmeter reading of  $< 0.5\text{ mV}$ .
- e. Remove the input short and the Digital Voltmeter.
- f. Put a  $1\text{ k}\Omega \pm 1\%$  resistor across the input terminals and adjust A1R58 ( $1\text{ k}\Omega$  ADJ) for Multimeter display of  $1.0000 \pm 2$  counts. If R58 does not have enough range to achieve this display, cut jumper B to introduce A1R57 and readjust A1R58 for the  $1.0000 \pm 2$  count display.
- g. Change Multimeter range to 10 M.
- h. Remove the  $1\text{ k}\Omega$  resistor at the input terminals and apply a  $10\text{ M}\Omega \pm 1\%$  resistor across the input terminals. Adjust A1R69 for a display of  $10.000 \pm 3$  counts.
- i. Remove the  $10\text{ M}\Omega$  resistor at the input and change range to 1K.
- j. Repeat Steps f, g, h and i ( $1\text{ k}\Omega$  ADJ and  $10\text{ M}\Omega$  ADJ) until both adjustment specifications of Steps f and h are met.

#### NOTE

*If the A1 Assembly switch shield (component side) has been removed, the ac-to-dc converter must be recalibrated by readjusting C45, C42 and C22 with the shield replaced.*

### 5-35. AC – DC Converter Adjustments.

### 5-36. AC Overall Gain Adjustment (R107\*, R108\* and R128).

#### NOTE

*The selection of a new resistance value of R107\* and R108\* should be performed **ONLY** if the AC Converter amplifier, A1U18, is replaced. If A1U18 has not been replaced, the AC Overall Gain Adjustment can be made by performing Steps a, k, l and m which adjust A1R128 only.*

A digital Voltmeter with 5 digit resolution, an Ohmmeter and an AC Standard are required for this adjustment.

- a. Set Multimeter function ACV ( $\sim$  V) and range to 1 V.
- b. Remove one end of A1R107 from the pc board and connect A1U2 pin 8 to ground.
- c. Apply a 1 V, 200 Hz signal from the AC Standard at the junction of A1R106 and A1R107\*.
- d. Measure and record the dc voltage at DCTP. Designate this reading  $V_1$ .
- e. Decrease the AC Standard output to 0.1 V, 200 Hz.
- f. Measure and record the dc voltage at DCTP. Designate this reading  $V_2$ .
- g. Calculate the AC Converter constant (CONST):

$$\text{CONST} = \frac{V_1 - V_2}{0.9}$$

- h. Disconnect the AC Standard and disconnect one end of R106 from the pc board. Measure and record the actual resistance value of R106.

- i. Calculate and record the R107\*, R108\* resistance total:

$$(R107^* + R108^*) = R106 (0.9995 \times \text{CONST} - 1) - 500$$

- j. Select a resistance combination for R107\* and R108\* nearest the  $(R107^* + R108^*)$  calculated value from the R107\*, R108\*, R133\* and R134\* Padding List located in the miscellaneous parts list of Section VI. Install the selected resistors.

- k. Apply a 1 V, 200 Hz signal from the AC Standard to the Multimeter input terminals.

- l. Adjust A1R128 (AC GAIN ADJ) for a Multimeter display of  $1.0000 \pm 12$  counts.

- m. Remove the AC Standard.

### 5-37. AC–DC Converter X10 Gain Adjustment (R133 and R134). An AC Standard is required for this adjustment.

a. Set the Multimeter function to ACV ( $\sim$  V) and range to 100 m.

b. Apply a 100 mV, 200 Hz signal from the AC Standard to the Multimeter input terminals (V $\Omega$  and COM).

c. Adjust the R133/R134 potentiometer for a Multimeter display of  $100.00 \pm 12$  counts.

**5-38. AC Converter High Frequency Adjustment (C45).** An AC Standard is required for this adjustment.

a. Set Multimeter function to ACV ( $\sim$  V) and range to 1 V.

b. Apply a 0.1 V, 20 kHz signal with the AC Standard to the input terminals.

c. Adjust A1C45 (CONVERTER HIGH FREQ ADJ) for a Multimeter display of  $.1000 \pm 100$  counts.

d. Maintain the AC Standard for the following adjustment.

**5-39. AC Converter 100 mV and 10 V High Frequency Adjustment (C42).** An AC Standard is required for this adjustment.

a. Set Multimeter function to ACV ( $\sim$  V) and range to 100 m.

b. Apply a 0.1 V, 20 kHz signal with the AC Standard to the input terminals.

c. Adjust A1C42 (100 mV and 10 V HIGH FREQ ADJ) for a Multimeter display of  $100.00 \pm 100$  counts.

d. Maintain the AC Standard for the following adjustment.

**5-40. High Frequency Attenuator Adjustment (C22).** An AC Standard is required for this adjustment.

a. Set Multimeter function to ACV ( $\sim$  V) and range to 10 V.

b. Apply a 10 V, 20 kHz signal with the AC Standard to the input terminals.

c. Adjust A1C22 (HIGH FREQ ATTEN ADJ) for a Multimeter display of  $10.000 \pm 100$  counts.

d. Remove AC Standard from input terminals.

# PERFORMANCE TEST CARD

Hewlett-Packard Model 3465A  
Multimeter  
Serial No. \_\_\_\_\_

Tests Performed By \_\_\_\_\_  
Date \_\_\_\_\_

| PARAGRAPH<br>NUMBER | TEST                               | TEST LIMIT             | TEST<br>RESULT |
|---------------------|------------------------------------|------------------------|----------------|
| 5-6                 | DC Voltmeter Accuracy              |                        |                |
|                     | <u>10 mV Range</u>                 |                        |                |
|                     | 1 mV                               | .998 – 1.002 mV        | _____          |
|                     | 5 mV                               | 4.996 – 5.004 mV       | _____          |
|                     | 10 mV                              | 9.995 – 10.005 mV      | _____          |
|                     | <u>100 mV Range</u>                |                        |                |
|                     | 10 mV                              | 9.99 – 10.01 mV        | _____          |
|                     | 50 mV                              | 49.98 – 50.02 mV       | _____          |
|                     | 100 mV                             | 99.97 – 100.03 mV      | _____          |
|                     | <u>1 V Range</u>                   |                        |                |
|                     | 0.1 V                              | .0999 – .1001 V        | _____          |
|                     | 0.5 V                              | .4998 – .5002 V        | _____          |
|                     | 1.0 V                              | .9997 – 1.0003 V       | _____          |
|                     | <u>10 V Range</u>                  |                        |                |
|                     | 1 V                                | .999 – 1.001 V         | _____          |
|                     | 5 V                                | 4.998 – 5.002 V        | _____          |
|                     | 10 V                               | 9.997 – 10.003 V       | _____          |
|                     | <u>100 V Range</u>                 |                        |                |
|                     | 10 V                               | 9.99 – 10.01 V         | _____          |
|                     | 50 V                               | 49.98 – 50.02 V        | _____          |
|                     | 100 V                              | 99.97 – 100.03 V       | _____          |
|                     | <u>1000 V Range</u>                |                        |                |
|                     | 100 V                              | 99.8 – 100.2 V         | _____          |
|                     | 500 V                              | 499.7 – 500.3 V        | _____          |
|                     | 1000 V                             | 999.6 – 1000.4 V       | _____          |
| 5-8                 | DC Ammeter Accuracy                |                        |                |
|                     | <u>100 <math>\mu</math>A Range</u> |                        |                |
|                     | 10 $\mu$ A                         | 9.98 – 10.02 $\mu$ A   | _____          |
|                     | 50 $\mu$ A                         | 49.95 – 50.05 $\mu$ A  | _____          |
|                     | 100 $\mu$ A                        | 99.92 – 100.08 $\mu$ A | _____          |
|                     | <u>1 mA Range</u>                  |                        |                |
|                     | 0.1 mA                             | .0998 – .1002 $\mu$ A  | _____          |
|                     | 0.5 mA                             | .4995 – .5005 $\mu$ A  | _____          |
|                     | 1.0 mA                             | .9992 – 1.0008 $\mu$ A | _____          |
|                     | <u>10 mA Range</u>                 |                        |                |
|                     | 1 mA                               | 0.998 – 1.002 mA       | _____          |
|                     | 5 mA                               | 4.993 – 5.007 mA       | _____          |
|                     | 10 mA                              | 9.988 – 10.012 mA      | _____          |

# PERFORMANCE TEST CARD (cont'd)

| PARAGRAPH<br>NUMBER | TEST                 | TEST LIMIT        | TEST<br>RESULT |
|---------------------|----------------------|-------------------|----------------|
| 5-8<br>(cont'd)     | <u>100 mA Range</u>  |                   |                |
|                     | 10 mA                | 09.93 – 10.07 mA  | _____          |
|                     | 50 mA                | 49.69 – 50.31 mA  | _____          |
|                     | 100 mA               | 99.39 – 100.61 mA | _____          |
|                     | <u>1000 mA Range</u> |                   |                |
|                     | 100 mA               | 099.3 – 100.7 mA  | _____          |
|                     | 500 mA               | 496.9 – 503.1 mA  | _____          |
|                     | 1000 mA              | 993.9 – 1006.1 mA | _____          |
| 5-10                | Ohms Accuracy        |                   |                |
|                     | <u>100 Ω Range</u>   |                   |                |
|                     | 10 Ω                 | 09.98 – 010.02 Ω  | _____          |
|                     | 50 Ω                 | 49.97 – 50.03 Ω   | _____          |
|                     | 100 Ω                | 99.96 – 100.04 Ω  | _____          |
|                     | <u>1 kΩ Range</u>    |                   |                |
|                     | 0.1 kΩ               | .0999 – .1001 kΩ  | _____          |
|                     | 0.5 kΩ               | .4998 – .5002 kΩ  | _____          |
|                     | 1 kΩ                 | .9997 – 1.0003 kΩ | _____          |
|                     | <u>10 kΩ Range</u>   |                   |                |
|                     | 1 kΩ                 | .999 – 1.001 kΩ   | _____          |
|                     | 5 kΩ                 | 4.998 – 5.002 kΩ  | _____          |
|                     | 10 kΩ                | 9.997 – 10.003 kΩ | _____          |
|                     | <u>100 kΩ Range</u>  |                   |                |
|                     | 10 kΩ                | 9.99 – 10.01 kΩ   | _____          |
|                     | 50 kΩ                | 49.98 – 50.02 kΩ  | _____          |
|                     | 100 kΩ               | 99.97 – 100.03 kΩ | _____          |
|                     | <u>1000 kΩ Range</u> |                   |                |
|                     | 100 kΩ               | 99.9 – 100.1 kΩ   | _____          |
|                     | 500 kΩ               | 499.8 – 500.2 kΩ  | _____          |
|                     | 1000 kΩ              | 999.7 – 1000.3 kΩ | _____          |
|                     | <u>10 MΩ Range</u>   |                   |                |
|                     | 1 MΩ                 | 0.998 – 1.002 MΩ  | _____          |
|                     | 5 MΩ                 | 4.994 – 5.006 MΩ  | _____          |
|                     | 10 MΩ                | 9.989 – 10.011 MΩ | _____          |

# PERFORMANCE TEST CARD (cont'd)

| PARAGRAPH<br>NUMBER | TEST                | TEST LIMIT        | TEST<br>RESULT |
|---------------------|---------------------|-------------------|----------------|
| 5-12                | AC Voltage Accuracy |                   |                |
|                     | <u>100 mV Range</u> |                   |                |
|                     | 40 Hz to 10 kHz     |                   |                |
|                     | 10 mV               | 9.93 — 10.07 mV   | _____          |
|                     | 50 mV               | 49.87 — 50.13 mV  | _____          |
|                     | 100 mV              | 99.80 — 100.20 mV | _____          |
|                     | 10 kHz — 20 kHz     |                   |                |
|                     | 10 mV               | 9.80 — 10.20 mV   | _____          |
|                     | 50 mV               | 49.60 — 50.40 mV  | _____          |
|                     | 100 mV              | 99.35 — 100.65 mV | _____          |
|                     | <u>1 V Range</u>    |                   |                |
|                     | 40 Hz — 10 kHz      |                   |                |
|                     | 0.1 V               | .0993 — .1007 V   | _____          |
|                     | 0.5 V               | .4987 — .5013 V   | _____          |
|                     | 1.0 V               | .9980 — 1.0020 V  | _____          |
|                     | 10 kHz — 20 kHz     |                   |                |
|                     | 0.1 V               | .0980 — .1020 V   | _____          |
|                     | 0.5 V               | .4960 — .5040 V   | _____          |
|                     | 1.0 V               | .9935 — 1.0065 V  | _____          |
|                     | <u>10 V Range</u>   |                   |                |
|                     | 40 Hz — 10 kHz      |                   |                |
|                     | 1 V                 | .993 — 1.007 V    | _____          |
|                     | 5 V                 | 4.987 — 5.013 V   | _____          |
|                     | 10 V                | 9.980 — 10.020 V  | _____          |
|                     | 10 kHz — 20 kHz     |                   |                |
|                     | 1 V                 | .980 — 1.020 V    | _____          |
|                     | 5 V                 | 4.960 — 5.040 V   | _____          |
|                     | 10 V                | 9.935 — 10.065 V  | _____          |
|                     | <u>100 V Range</u>  |                   |                |
|                     | 40 Hz — 10 kHz      |                   |                |
|                     | 10 V                | 9.93 — 10.07 V    | _____          |
|                     | 50 V                | 49.87 — 50.13 V   | _____          |
|                     | 100 V               | 99.80 — 100.20 V  | _____          |
|                     | 10 kHz — 20 kHz     |                   |                |
|                     | 10 V                | 9.80 — 10.20 V    | _____          |
|                     | 50 V                | 49.60 — 50.40 V   | _____          |
|                     | 100 V               | 99.35 — 100.65 V  | _____          |
|                     | <u>1000 V Range</u> |                   |                |
|                     | 40 Hz — 1 kHz       |                   |                |
|                     | 100 V               | 99.3 — 100.7 V    | _____          |
|                     | 500 V               | 498.7 — 501.3 V   | _____          |
|                     | 1 kHz — 2 kHz       |                   |                |
|                     | 100 V               | 99.0 — 101.0 V    | _____          |
|                     | 500 V               | 497.0 — 503.0 V   | _____          |

# PERFORMANCE TEST CARD (cont'd)

| PARAGRAPH<br>NUMBER | TEST                               | TEST LIMIT             | TEST<br>RESULT |
|---------------------|------------------------------------|------------------------|----------------|
| 5-14                | AC Ammeter Accuracy                |                        |                |
|                     | <u>100 <math>\mu</math>A Range</u> |                        |                |
|                     | 10 $\mu$ A                         |                        |                |
|                     | 40 Hz – 1 kHz                      | 9.91 – 10.09 $\mu$ A   | _____          |
|                     | 1 kHz – 10 kHz                     | 9.92 – 10.08 $\mu$ A   | _____          |
|                     | 10 kHz – 20 kHz                    | 9.79 – 10.21 $\mu$ A   | _____          |
|                     | 50 $\mu$ A                         |                        |                |
|                     | 40 Hz – 1 kHz                      | 49.75 – 50.25 $\mu$ A  | _____          |
|                     | 1 kHz – 10 kHz                     | 49.82 – 50.18 $\mu$ A  | _____          |
|                     | 10 kHz – 20 kHz                    | 49.55 – 50.45 $\mu$ A  | _____          |
|                     | 100 $\mu$ A                        |                        |                |
|                     | 40 Hz – 1 kHz                      | 99.55 – 100.45 $\mu$ A | _____          |
|                     | 1 kHz – 10 kHz                     | 99.70 – 100.30 $\mu$ A | _____          |
|                     | 10 kHz – 20 kHz                    | 99.25 – 100.75 $\mu$ A | _____          |
|                     | <u>1 mA Range</u>                  |                        |                |
|                     | 0.1 mA                             |                        |                |
|                     | 40 Hz – 1 kHz                      | .0991 – .1009 mA       | _____          |
|                     | 1 kHz – 10 kHz                     | .0992 – .1008 mA       | _____          |
|                     | 10 kHz – 20 kHz                    | .0979 – .1021 mA       | _____          |
|                     | 0.5 mA                             |                        |                |
|                     | 40 Hz – 1 kHz                      | .4975 – .5025 mA       | _____          |
|                     | 1 kHz – 10 kHz                     | .4982 – .5018 mA       | _____          |
|                     | 10 kHz – 20 kHz                    | .4955 – .5045 mA       | _____          |
|                     | 1.0 mA                             |                        |                |
|                     | 40 Hz – 1 kHz                      | .9955 – 1.0045 mA      | _____          |
|                     | 1 kHz – 10 kHz                     | .9970 – 1.0030 mA      | _____          |
|                     | 10 kHz – 20 kHz                    | .9925 – 1.0075 mA      | _____          |
|                     | <u>10 mA Range</u>                 |                        |                |
|                     | 1 mA                               |                        |                |
|                     | 40 Hz – 1 kHz                      | .991 – 1.009 mA        | _____          |
|                     | 1 kHz – 10 kHz                     | .992 – 1.008 mA        | _____          |
|                     | 10 kHz – 20 kHz                    | .979 – 1.021 mA        | _____          |
|                     | 5 mA                               |                        |                |
|                     | 40 Hz – 1 kHz                      | 4.975 – 5.025 mA       | _____          |
|                     | 1 kHz – 10 kHz                     | 4.982 – 5.018 mA       | _____          |
|                     | 10 kHz – 20 kHz                    | 4.955 – 5.045 mA       | _____          |
|                     | 10 mA                              |                        |                |
|                     | 40 Hz – 1 kHz                      | 9.955 – 10.045 mA      | _____          |
|                     | 1 kHz – 10 kHz                     | 9.970 – 10.030 mA      | _____          |
|                     | 10 kHz – 20 kHz                    | 9.925 – 10.075 mA      | _____          |
|                     | <u>100 mA Range</u>                |                        |                |
|                     | 10 mA                              | 9.87 – 10.13 mA        | _____          |

**PERFORMANCE TEST CARD (cont'd)**

| PARAGRAPH<br>NUMBER | TEST                  | TEST LIMIT                      | TEST<br>RESULT |
|---------------------|-----------------------|---------------------------------|----------------|
| 5-14<br>(cont'd)    | 50 mA                 | 49.55 – 50.45 mA                | _____          |
|                     | 100 mA                | 99.15 – 100.85 mA               | _____          |
|                     | <u>1000 mA Range</u>  |                                 |                |
|                     | 100 mA                | 98.7 – 101.3 mA                 | _____          |
|                     | 500 mA                | 495.5 – 504.5 mA                | _____          |
|                     | 1000 mA               | 991.5 – 1008.5 mA               | _____          |
| 5-15                | Normal Mode Rejection | < .007 V (60 dB)                | _____          |
| 5-17                | Common Mode Rejection | < .00001 V (120 dB)             | _____          |
| 5-20                | DC Input Resistance   |                                 |                |
|                     | 10 V – 1000 V Range   | 4.950 – 5.027 (10 M)            | _____          |
|                     | 10 mV – 1 V Range     | ≥ .9990 (10 <sup>10</sup> ohms) | _____          |
| 5-22                | Input Impedance       |                                 |                |
|                     | Resistive component   | .4950 – .5027                   | _____          |
|                     | Shunt capacitance     | .7071 – 1.0000                  | _____          |

## SECTION VI

### REPLACEABLE PARTS

## 6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-3 lists parts in alphameric order of their reference designators and indicates the description, -hp Part Number of each part, together with any applicable notes, and provides the following:

- a. Total quantity used in the instrument (Qty column). The total quantity of a part is given the first time the part number appears.
- b. Description of the part. (See list of abbreviations in Table 6-1.)
- c. Typical manufacturer of the part is a five-digit code. (See Table 6-2 for list of manufacturers.)
- d. Manufacturer's part number.

6-3. Miscellaneous parts are listed in Table 6-3 following their respective assemblies. General miscellaneous parts are listed at the conclusion of Table 6-3.

#### 6-4. ORDERING INFORMATION.

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

## 6-6. NON-LISTED PARTS.

6-7. To obtain a part that is not listed, include:

- Instrument model number.
- Instrument serial number.
- Description of the part.
- Function and location of the part.

### 6-8. PARTS CHANGES.

6-9. Components which have been changed are so marked by one of three symbols; i.e.,  $\Delta$ ,  $\Delta$  with a letter subscript, e.g.,  $\Delta_a$ , or  $\Delta$  with a number subscript, e.g.,  $\Delta_{10}$ . A  $\Delta$  with no subscript indicates the component listed is the preferred replacement for an earlier component. A  $\Delta$  with a letter subscript indicates a change which is explained in a note at the bottom of the page. A  $\Delta$  with a number subscript indicates the related change is discussed in backdating (Section VIII). The number of the subscript indicates the number of the change in backdating which should be referred to.

## 6-10. PROPRIETARY PARTS.

6-11. Items marked by a dagger (†) in the reference designator column are available only for repair and service of Hewlett-Packard instruments.

### Table 6-1. Standard Abbreviations.

| ABBREVIATIONS                                    |                                                        |                                                                                             |                                                                                             |
|--------------------------------------------------|--------------------------------------------------------|---------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| Ag . . . . . silver                              | Hz . . . . . hertz (cycle(s) per second)               | NPO . . . . . negative positive zero<br>(zero temperature coefficient)                      | sl . . . . . slide                                                                          |
| Al . . . . . aluminum                            | ID . . . . . inside diameter                           | ns . . . . . nanosecond(s) = 10 <sup>-9</sup> seconds                                       | SPDT . . . . . single-pole double-throw                                                     |
| A . . . . . ampere(s)                            | impq . . . . . impregnated                             | nsr . . . . . not separately replaceable                                                    | SPST . . . . . single pole single-throw                                                     |
| Au . . . . . gold                                | incd . . . . . incandescent                            |                                                                                             |                                                                                             |
| C . . . . . capacitor                            | ins . . . . . insulation(ed)                           | Ω . . . . . ohm(s)                                                                          | Ta . . . . . tantalum                                                                       |
| cer . . . . . ceramic                            | kΩ . . . . . kilohm(s) = 10 <sup>+3</sup> ohms         | obd . . . . . order by description                                                          | TC . . . . . temperature coefficient                                                        |
| coef . . . . . coefficient                       | kHz . . . . . kilohertz = 10 <sup>+3</sup> hertz       | OD . . . . . outside diameter                                                               | TiO <sub>2</sub> . . . . . titanium dioxide                                                 |
| com . . . . . common                             |                                                        |                                                                                             | tog . . . . . toggle                                                                        |
| comp . . . . . composition                       | L . . . . . inductor                                   | p . . . . . peak                                                                            | tol . . . . . tolerance                                                                     |
| conn . . . . . connection                        | lin . . . . . linear taper                             | pA . . . . . picoampere(s)                                                                  | trim . . . . . trimmer                                                                      |
|                                                  | log . . . . . logarithmic taper                        | pc . . . . . printed circuit                                                                | TSTR . . . . . transistor                                                                   |
| dep . . . . . deposited                          | mA . . . . . milliampere(s) = 10 <sup>-3</sup> amperes | pF . . . . . picofarad(s) 10 <sup>-12</sup> farads                                          |                                                                                             |
| DPDT . . . . . double-pole double-throw          | MHz . . . . . megahertz = 10 <sup>+6</sup> hertz       | piv . . . . . peak inverse voltage                                                          | V . . . . . volt(s)                                                                         |
| DPST . . . . . double-pole single-throw          | MΩ . . . . . megohm(s) · 10 <sup>+6</sup> ohms         | p/o . . . . . part of                                                                       | vacw . . . . . alternating current working voltage                                          |
|                                                  | met flm . . . . . metal film                           | pos . . . . . position(s)                                                                   | var . . . . . variable                                                                      |
| elect . . . . . electrolytic                     | mfr . . . . . manufacturer                             | poly . . . . . polystyrene                                                                  | vwcv . . . . . direct current working voltage                                               |
| encap . . . . . encapsulated                     | ms . . . . . millisecond                               | pot . . . . . potentiometer                                                                 |                                                                                             |
|                                                  | mtg . . . . . mounting                                 | p-p . . . . . peak-to-peak                                                                  | W . . . . . watt(s)                                                                         |
| F . . . . . farad(s)                             | mV . . . . . millivolt(s) = 10 <sup>-3</sup> volts     | ppm . . . . . parts per million                                                             | w/ . . . . . with                                                                           |
| FET . . . . . field effect transistor            | μF . . . . . microfarad(s)                             | prec . . . . . precision (temperature coefficient,<br>long term stability and/or tolerance) | wiv . . . . . working inverse voltage                                                       |
| fxd . . . . . fixed                              | μs . . . . . microsecond(s)                            |                                                                                             | w/o . . . . . without                                                                       |
|                                                  | μV . . . . . microvolt(s) = 10 <sup>-6</sup> volts     | R . . . . . resistor                                                                        | ww . . . . . wirewound                                                                      |
| GaAs . . . . . gallium arsenide                  | my . . . . . Mylar®                                    | Rh . . . . . rhodium                                                                        |                                                                                             |
| GHz . . . . . gigahertz = 10 <sup>+9</sup> hertz | nA . . . . . nanoampere(s) = 10 <sup>-9</sup> amperes  | rms . . . . . root-mean-square                                                              | * . . . . . optimum value selected at factory,<br>average value shown (part may be omitted) |
| gd . . . . . guard(ed)                           | NC . . . . . normally closed                           | rot . . . . . rotary                                                                        | ** . . . . . no standard type number assigned<br>selected or special type                   |
| Ge . . . . . germanium                           | Ne . . . . . neon                                      | Se . . . . . selenium                                                                       |                                                                                             |
| gnd . . . . . ground(ed)                         | NO . . . . . normally open                             | sect . . . . . section(s)                                                                   |                                                                                             |
|                                                  |                                                        | Si . . . . . silicon                                                                        |                                                                                             |
| H . . . . . henry (ies)                          |                                                        |                                                                                             |                                                                                             |
| Hg . . . . . mercury                             |                                                        |                                                                                             |                                                                                             |
|                                                  |                                                        |                                                                                             |                                                                                             |
| A . . . . . assembly                             | FL . . . . . filter                                    | Q . . . . . transistor                                                                      | TS . . . . . terminal strip                                                                 |
| B . . . . . motor                                | HR . . . . . heater                                    | QCR . . . . . transistor-diode                                                              | U . . . . . microcircuit                                                                    |
| BT . . . . . battery                             | IC . . . . . integrated circuit                        | R . . . . . resistor                                                                        | V . . . . . vacuum tube, neon bulb, photocell, etc.                                         |
| C . . . . . capacitor                            | J . . . . . jack                                       | RT . . . . . thermistor                                                                     | W . . . . . cable                                                                           |
| CR . . . . . diode                               | 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 6-2. Code List of Manufacturers.

| MFR NO. | MANUFACTURER'S CODE LIST                       | ADDRESS                 |
|---------|------------------------------------------------|-------------------------|
| 00000   | U.S.A. COMMON                                  | ANY SUPPLIER OF USA     |
| 00160   | OHARA METAL PRODUCTS                           | SAN FRANCISCO CAL 94107 |
| 01121   | ALLEN BRADLEY CO.                              | MILWAUKEE WI 53212      |
| 01295   | TEXAS INSTRUMENT INC. SEMICONDUCTOR CMPNT DIV. | DALLAS TX 75231         |
| 01686   | RCL ELECTRONICS INC.                           | MANCHESTER NH 03102     |
| 02735   | RCA CORP. SOLID STATE DIV.                     | SOMMERVILLE NJ 08876    |
| 03888   | PYROFILM CORP.                                 | WHIPPANY NJ 07981       |
| 04713   | MOTOROLA SEMICONDUCTOR PRODUCTS                | PHOENIX AZ 85008        |
| 12954   | DICKSON ELECTRONICS CORP.                      | SCOTTSDALE AZ 85252     |
| 14140   | EDISON ELEK DIV MCGRAW-EDISON                  | MANCHESTER NH 03130     |
| 16299   | CORNING GLASS WORKS ELEC CMPNT DIV.            | RALEIGH NC 27604        |
| 17856   | SILICONIX INC.                                 | SANTA CLARA CA 95050    |
| 19701   | MEPCO/ELECTRA CORP.                            | MINERAL WELLS TX 76067  |
| 24546   | CORNING GLASS WORKS (BRADFORD)                 | BRADFORD PA 16701       |
| 27014   | NATIONAL SEMICONDUCTOR CORP.                   | SANTA CLARA CA 95051    |
| 28480   | HEWLETT-PACKARD CO. CORPORATE HQ               | PALO ALTO CA 94304      |
| 32997   | BOURNS INC TRIMPOT PROD DIV.                   | RIVERSIDE CA 92707      |
| 56289   | SPRAGUE ELECTRIC CO.                           | NORTH ADAMS MA 01247    |
| 71400   | BUSSMAN MFG DIV OF MCGRAW-EDISON CO.           | ST LOUIS MO 63017       |
| 72136   | ELECTRO MOTIVE MFG CO., INC.                   | WILLIMANTIC CT 06226    |
| 73138   | BECKMAN INSTRUMENTS INC HELIPOT DIV.           | FULLERTON CA 92634      |
| 74970   | JOHNSON E. F. CO.                              | WASECA MN 56093         |
| 84411   | TRW CAPACITOR DIV                              | OGALLALA NE 69153       |
| 91506   | AUGAT INC                                      | ATTLEBORO MA 02703      |
| 95121   | QUALITY COMPONENTS INC                         | ST MARYS PA 15857       |
| 98291   | SEAELECTRO CORP.                               | MAMARONECK NY 10544     |

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | Qty | Description                               | Mfr Code | Mfr Part Number    |
|-----------------------|----------------|-----|-------------------------------------------|----------|--------------------|
| A1                    | 03465-66501    | 1   | P.C. ASSEMBLY, MAIN                       | 28480    | 03465-66501        |
| A1C1                  | 0140-0149      | 1   | CAPACITOR-FXD 470PF +-5% 300WVDC MICA     | 72136    | DM15F471J0300WV1CR |
| A1C2                  | 0180-0374      | 1   | CAPACITOR-FXD; 10UF+-10% 20VDC TA-SOLID   | 56289    | 150D105X902052     |
| A1C3                  | 0150-0071      | 3   | CAPACITOR-FXD 400PF +-5% 1000WVDC CER     | 28480    | 0150-0071          |
| A1C4                  | 0160-0320      | 1   | CAPACITOR-FXD .33UF +-10% 100WVDC POLYE   | 84411    | 6630W33491W        |
| A1C5                  | 0180-1743      | 1   | CAPACITOR-FXD; .1UF+-10% 35VDC TA-SOLID   | 56289    | 150D104X9035A2     |
| A1C6                  | 0160-0165      | 1   | CAPACITOR-FXD .056UF +-10% 200WVDC POLYE  | 56289    | 292P56392          |
| A1C7                  | 0160-2207      | 1   | CAPACITOR-FXD 300PF +-5% 300WVDC MICA     | 28480    | 0160-2207          |
| A1C8                  | 0150-0071      | 1   | CAPACITOR-FXD 400PF +-5% 1000WVDC CER     | 28480    | 0150-0071          |
| A1C9                  | 0150-0071      | 1   | CAPACITOR-FXD 400PF +-5% 1000WVDC CER     | 28480    | 0150-0071          |
| A1C10                 | 0170-0055      | 1   | CAPACITOR-FXD .1UF +-20% 200WVDC POLYE    | 56289    | 292P10407          |
| A1C11                 | 0170-0024      | 1   | CAPACITOR-FXD .022UF +-20% 200WVDC POLYE  | 56289    | 292P22302          |
| A1C12                 | 0160-2204      | 1   | CAPACITOR-FXD 100PF +-5% 300WVDC MICA     | 28480    | 0160-2204          |
| A1C13                 | 0160-0763      | 1   | CAPACITOR-FXD 5PF +-10% 500WVDC MICA      | 28480    | 0160-0763          |
| A1C14                 | 0150-0121      | 2   | CAPACITOR-FXD .1UF +-80-20% 50WVDC CER    | 28480    | 0150-0121          |
| A1C15                 | 0150-0121      | 2   | CAPACITOR-FXD .1UF +-80-20% 50WVDC CER    | 28480    | 0150-0121          |
| A1C16                 | 0160-0161      | 1   | CAPACITOR-FXD .01UF +-10% 200WVDC POLYE   | 56289    | 292P10392          |
| A1C17                 | 0180-0061      | 1   | CAPACITOR-FXD; 100UF+-75-10% 16VDC AL     | 56289    | 30T107G0160C2      |
| A1C18                 | 0180-0210      | 1   | CAPACITOR-FXD; 3.3UF+-20% 15VDC TA        | 56289    | 150D335X0015A2     |
| A1C19                 | 0160-4347      | 1   | CAPACITOR-FXD 0.44 UF 0.10%               | 28480    | 0160-4347          |
| A1C20                 | 0160-2205      | 2   | CAPACITOR-FXD 120PF +-5% 300WVDC MICA     | 28480    | 0160-2205          |
| A1C21                 | 0160-0362      | 1   | CAPACITOR-FXD 510PF +-5% 300WVDC MICA     | 28480    | 0160-0362          |
| A1C22                 | 0212-0128      | 1   | CAPACITOR; VAR; TRMR; AIR; 1.4/9.2PF      | 74970    | 189-0503-005       |
| A1C24                 | 0180-0228      | 2   | CAPACITOR-FXD; 22UF+-10% 15VDC TA-SOLID   | 56289    | 150D226X9015B2     |
| A1C25                 | 0140-0207      | 2   | CAPACITOR-FXD 330PF +-5% 500WVDC MICA     | 72136    | DM15F331J0500WV1CR |
| A1C26                 | 0180-0228      | 1   | CAPACITOR-FXD; 22UF+-10% 15VDC TA-SOLID   | 56289    | 150D226X9015B2     |
| A1C27                 | 0150-0052      | 1   | CAPACITOR-FXD .05UF +-20% 400WVDC CER     | 28480    | 0150-0052          |
| A1C28                 | 0160-2605      | 1   | CAPACITOR-FXD .02UF +-80-20% 25WVDC CER   | 28480    | 0160-2605          |
| A1C29                 | 0160-0157      | 1   | CAPACITOR-FXD 4700PF +-10% 200WVDC POLYE  | 56289    | 292P47292          |
| A1C30, C31            | 0160-0207      | 2   | CAPACITOR-FXD .01UF +-5% 200WVDC          | 56289    | 292P10352          |
| A1C32                 | 0180-0566      | 3   | CAPACITOR-FXD; 33UF+-10% 10VDC TA-SOLID   | 28480    | 0180-0566          |
| A1C33                 | 0160-0153      | 1   | CAPACITOR-FXD 1000PF +-10% 200WVDC POLYE  | 56239    | 292P10292          |
| A1C34, C35            | 0180-0566      | 1   | CAPACITOR-FXD; 33UF+-10% 10VDC TA-SOLID   | 28480    | 0180-0566          |
| A1C36                 | 0160-0168      | 3   | CAPACITOR-FXD .1UF +-10% 200WVDC POLYE    | 56289    | 292P10492          |
| A1C37                 | 0160-0168      | 1   | CAPACITOR-FXD .1UF +-10% 200WVDC POLYE    | 56289    | 292P10492          |
| A1C38                 | 0160-0168      | 1   | CAPACITOR-FXD .1UF +-10% 200WVDC POLYE    | 56289    | 292P10492          |
| A1C39                 | 0160-2046      | 1   | CAPACITOR-FXD 2PF +-5PF 500WVDC MICA      | 28480    | 0160-2046          |
| A1C41                 | 0180-0291      | 2   | CAPACITOR-FXD; 1UF+-10% 35VDC TA-SOLID    | 56289    | 150D105X9035A2     |
| A1C42                 | 0121-0427      | 1   | CAPACITOR, VAR, TRMR, MICA, 170/780PF     | 72136    | T52917-6           |
| A1C43                 | 0160-2205      | 1   | CAPACITOR-FXD 120PF +-5% 300WVDC MICA     | 28480    | 0160-2205          |
| A1C44                 | 0180-0291      | 1   | CAPACITOR-FXD; 1UF+-10% 35VDC TA-SOLID    | 56289    | 150D105X9035A2     |
| A1C45                 | 0121-0147      | 1   | CAPACITOR; VAR; TRMR; AIR; 2/19.3PF       | 74970    | 189-507-5          |
| A1C46                 | 0150-0015      | 2   | CAPACITOR-FXD 2.2PF +-10% 500WVDC TI      | 95121    | TYPE OC            |
| A1C47                 | 0150-0015      | 2   | CAPACITOR-FXD 2.2PF +-10% 500WVDC TI      | 95121    | TYPE OC            |
| A1C48                 | 0140-0207      | 1   | CAPACITOR-FXD 330PF +-5% 500WVDC MICA     | 72136    | DM15F331J0500WV1CR |
| A1C49                 | 0160-2115      | 1   | CAPACITOR-FXD 1.3UF +-10% 50WVDC POLYE    | 56289    | 149P345            |
| A1C50                 | 0160-3581      | 1   | CAPACITOR-FXD .1UF +-20% 1000WVDC MET     | 28480    | 0160-3581          |
| A1C51, C52            | 0180-0228      | 1   | CAPACITOR-FXD; 22UF+-10% 15VDC TA-SOLID   | 56289    | 150D226X9015B2     |
| A1C53, C54            | 0180-0566      | 1   | CAPACITOR-FXD; 33UF+-10% 10VDC TA-SOLID   | 28480    | 0180-0566          |
| A1C55 *               |                |     | SEE PADDING LIST UNDER A1 ASSY MISC PARTS |          |                    |
| A1C56                 | 0150-0093      | 1   | CAPACITOR-FXD .01UF +-80-20% 100WVDC CER  | 28480    | 0150-0093          |
| A1C57                 | 0140-0201      | 1   | CAPACITOR-FXD 12PF +/-5% 500WVDC MICA     | 72136    | DM15C120J0500WV1CR |
| A1CR7                 | 1901-0040      | 1   | DIODE-SWITCHING 2NS 30V 50MA              | 28480    | 1901-0040          |
| A1CR8                 | 1906-0023      | 1   | DIODE-MULT FULL WAVE BRIDGE RECTIFIER     | 04713    | MNA922-4           |
| A1CR9                 | 1901-0586      | 2   | DIODE-GEN PRP 30V 25MA                    | 28480    | 1901-0586          |
| A1CR10                | 1901-0586      | 2   | DIODE-GEN PRP 30V 25MA                    | 28480    | 1901-0586          |
| A1CR11                | 1902-3062      | 2   | DIODE-ZNR 3.92V 5% D0-7 PD=.4W TC=-.049%  | 04713    | SZ 10939-65        |
| A1CR12                | 1902-3062      | 2   | DIODE-ZNR 3.92V 5% D0-7 PD=.4W TC=-.049%  | 04713    | SZ 10939-65        |
| A1CR13                | 1901-0040      | 1   | DIODE-SWITCHING 2NS 30V 50MA              | 28480    | 1901-0040          |
| A1CR14                | 1901-0040      | 1   | DIODE-SWITCHING 2NS 30V 50MA              | 28480    | 1901-0040          |
| A1CR15                | 1901-0376      | 3   | DIODE-GEN PRP 35V 50MA                    | 28480    | 1901-0376          |
| A1CR16                | 1901-0376      | 3   | DIODE-GEN PRP 35V 50MA                    | 28480    | 1901-0376          |
| A1CR17                | 1902-1818      | 1   | DIODE-ZNR                                 | 28480    | 1902-1818          |
| A1CR18                | 1910-0034      | 2   | DIODE-SWITCHING 8NS 30V 80MA              | 28480    | 1910-0034          |
| A1CR19                | 1902-3136      | 1   | DIODE-ZNR 8.06V 5% D0-7 PD=.4W TC=+.052%  | 04713    | SZ 10939-155       |
| A1CR20                | 1902-3182      | 3   | DIODE-ZNR 12.1V 5% D0-7 PD=.4W TC=+.064%  | 04713    | SZ 10939-206       |
| A1CR23                | 1902-0057      | 1   | DIODE-ZNR 6.49V 5% D0-7 PD=.4W TC=+.029%  | 04713    | SZ 10939-128       |
| A1CR24                | 1901-0040      | 1   | DIODE-SWITCHING 2NS 30V 50MA              | 28480    | 1901-0040          |
| A1CR25                | 1901-0040      | 1   | DIODE-SWITCHING 2NS 30V 50MA              | 28480    | 1901-0040          |
| A1CR26                | 1901-0376      | 1   | DIODE-GEN PRP 35V 50MA                    | 28480    | 1901-0376          |
| A1CR27 Δ4             |                |     | NOT ASSIGNED                              |          |                    |
| A1CR28                | 1901-0029      | 1   | DIODE-PWR RECT 500V 750MA                 | 28480    | 1901-0029          |

See introduction to this section for ordering information

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | Qty | Description                             | Mfr Code | Mfr Part Number   |
|-----------------------|----------------|-----|-----------------------------------------|----------|-------------------|
| A1CR29                | 1901-0040      |     | DIODE-SWITCHING 2NS 30V 50MA            | 28480    | 1901-0040         |
| A1CR32                | 1910-0034      |     | DIODE-SWITCHING 8VS 30V 80MA            | 28480    | 1910-0034         |
| A1CR33                | 1901-0513      |     | DIODE-SCHOTTKY                          | 28480    | 1901-0513         |
| A1CR34                | 1901-0513      |     | DIODE-SCHOTTKY                          | 28480    | 1901-0513         |
| A1CR35                | 1901-0040      |     | DIODE-SWITCHING 2NS 30V 50MA            | 28480    | 1901-0040         |
| A1CR36                | 1901-0040      |     | DIODE-SWITCHING 2NS 30V 50MA            | 28480    | 1901-0040         |
| A1CR37                | 1901-0040      |     | DIODE-SWITCHING 2NS 30V 50MA            | 28480    | 1901-0040         |
| A1CR38, CR39          | 1901-0376      |     | DIODE-GEN PRP 35V 50MA                  | 28480    | 1901-0376         |
| A1J1                  | 1251-4109      | 1   | CONNECTOR STRIP-25-PIN                  | 28480    | 1251-4109         |
| A1L1                  | 9170-0894      |     | CORE-SHIELDING BEAD                     | 02114    | 56-590-65/4A6     |
| A1Q1                  | 1855-0208      | 3   | TRANSISTOR J-FET 2N4117 N-CHAN D-MODE   | 17856    | 2N4117            |
| A1Q2                  | 1855-0308      | 2   | TRANSISTOR-JFET DUAL N-CHAN D-MODE SI   | 28480    | 1855-0308         |
| A1Q3                  | 1854-0071      | 25  | TRANSISTOR NPN SI PD=300MW FT=200MHZ    | 28480    | 1854-0071         |
| A1Q4                  | 1853-0086      | 8   | TRANSISTOR PNP SI PD=310MW FT=40MHZ     | 28480    | 1853-0086         |
| A1Q5                  | 1853-0086      |     | TRANSISTOR PNP SI PD=310MW FT=40MHZ     | 28480    | 1853-0086         |
| A1Q6                  | 1854-0071      |     | TRANSISTOR NPN SI PD=300MW FT=200MHZ    | 28480    | 1854-0071         |
| A1Q7                  | 1853-0086      |     | TRANSISTOR PNP SI PD=310MW FT=40MHZ     | 28480    | 1853-0086         |
| A1Q8                  | 1854-0071      |     | TRANSISTOR NPN SI PD=300MW FT=200MHZ    | 28480    | 1854-0071         |
| A1Q9                  | 1854-0071      |     | TRANSISTOR NPN SI PD=300MW FT=200MHZ    | 28480    | 1854-0071         |
| A1Q10                 | 1853-0086      |     | TRANSISTOR PNP SI PD=310MW FT=40MHZ     | 28480    | 1853-0086         |
| A1Q11                 | 1853-0086      |     | TRANSISTOR PNP SI PD=310MW FT=40MHZ     | 28480    | 1853-0086         |
| A1Q12                 | 1854-0071      |     | TRANSISTOR NPN SI PD=300MW FT=200MHZ    | 28480    | 1854-0071         |
| A1Q13                 | 1853-0086      |     | TRANSISTOR PNP SI PD=310MW FT=40MHZ     | 28480    | 1853-0086         |
| A1Q16                 | 1855-0222      | 1   | TRANSISTOR-JFET DUAL D-MODE SI PD=500MW | 28480    | 1855-0222         |
| A1Q17                 | 1854-0071      |     | TRANSISTOR NPN SI PD=300MW FT=200MHZ    | 28480    | 1854-0071         |
| A1Q18                 | 1853-0086      |     | TRANSISTOR PNP SI PD=310MW FT=40MHZ     | 28480    | 1853-0086         |
| A1Q19                 | 1855-0208      |     | TRANSISTOR J-FET 2N4117 N-CHAN D-MODE   | 17856    | 2N4117            |
| A1Q20                 | 1855-0208      |     | TRANSISTOR J-FET 2N4117 N-CHAN D-MODE   | 17856    | 2N4117            |
| A1Q21                 | 1854-0071      |     | TRANSISTOR NPN SI PD=300MW FT=200MHZ    | 28480    | 1854-0071         |
| A1Q22                 | 1853-0020      | 2   | TRANSISTOR PNP SI PD=300MW FT=150MHZ    | 28480    | 1853-0020         |
| A1Q23                 | 1855-0093      | 2   | TRANSISTOR J-FET N-CHAN D-MODE TO-18 SI | 28480    | 1855-0093         |
| A1Q24                 | 1855-0093      |     | TRANSISTOR J-FET N-CHAN D-MODE TO-18 SI | 28480    | 1855-0093         |
| A1Q25                 | 1855-0308      |     | TRANSISTOR-JFET DUAL N-CHAN D-MODE SI   | 28480    | 1855-0308         |
| A1Q26                 | 1854-0071      |     | TRANSISTOR NPN SI PD=300MW FT=200MHZ    | 28480    | 1854-0071         |
| A1Q27                 | 1853-0020      |     | TRANSISTOR PNP SI PD=300MW FT=150MHZ    | 28480    | 1853-0020         |
| A1Q30                 | 1854-0079      | 1   | TRANSISTOR NPN 2N3439 SI TO-5 PD=1W     | 02735    | 2N3439            |
| A1Q31                 | 1854-0071      |     | TRANSISTOR NPN SI PD=300MW FT=200MHZ    | 28480    | 1854-0071         |
| A1Q32                 | 1853-0086      |     | TRANSISTOR PNP SI PD=310MW FT=40MHZ     | 28480    | 1853-0086         |
| A1Q33                 | 1853-0318      | 1   | TRANSISTOR PNP SI PD=500MW FT=60MHZ     | 04713    | MP56562           |
| A1Q34, Q35            | 1854-0071      |     | TRANSISTOR NPN SI PD=300MW FT=200MHZ    | 28480    | 1854-0071         |
| A1Q36, Q37            | 1853-0020      |     | TRANSISTOR PNP SI PD=300MW FT=150MHZ    | 28480    | 1853-0020         |
| A1Q38                 | 1854-0071      |     | TRANSISTOR NPN SI PD=300MW FT=200MHZ    | 28480    | 1854-0071         |
| A1R0                  | 8150-3375      | 2   | JUMPER WIRE 22AWG                       | 28480    | 8150-3375         |
| A1R1                  | 0698-3572      | 5   | RESISTOR 60.4K 1% .125W F TC=0+-100     | 16299    | C4-1/8-T0-6042-F  |
| A1R2                  | 0683-3335      | 1   | RESISTOR 33K 5% .25W FC TC=-400/+800    | 01121    | C83335            |
| A1R3                  | 0757-0442      | 1   | RESISTOR 10K 1% .125W F TC=0+-100       | 24546    | C4-1/8-T0-1002-F  |
| A1R4                  | 0683-2225      | 1   | RESISTOR 2.2K 5% .25W FC TC=-400/+700   | 01121    | C82225            |
| A1R5                  | 0683-5635      | 5   | RESISTOR 56K 5% .25W FC TC=-400/+800    | 01121    | C85635            |
| A1R6                  | 0757-0344      | 1   | RESISTOR 1M 1% .25W F TC=0+-100         | 24546    | C5-1/4-T0-1004-F  |
| A1R7                  | 0757-0288      |     | RESISTOR 9.09K 1% .125W F TC=0+-100     | 19701    | MF4C1/8-T0-9091-F |
| A1R8                  | 0683-1045      | 10  | RESISTOR 100K 5% .25W FC TC=-400/+800   | 01121    | C81045            |
| A1R9                  | 0689-3025      | 1   | RESISTOR-FXD 3K OHM 5% 1W               | 28480    | 0689-3025         |
| A1R11                 | 0683-2235      | 1   | RESISTOR 22K 5% .25W FC TC=-400/+800    | 01121    | C82235            |
| A1R12                 | 0683-4725      | 3   | RESISTOR 4.7K 5% .25W FC TC=-400/+700   | 01121    | C84725            |
| A1R13                 | 0757-0449      | 1   | RESISTOR 20K 1% .125W F TC=0+-100       | 24546    | C4-1/8-T0-2002-F  |
| A1R14                 | 0698-4123      |     | RESISTOR 499 1% .125W F TC=0+-100       | 16299    | C4-1/8-T0-4992-F  |
| A1R15                 | 0683-4735      | 3   | RESISTOR 47K 5% .25W FC TC=-400/+800    | 01121    | C84735            |
| A1R16                 | 0683-4725      |     | RESISTOR 4.7K 5% .25W FC TC=-400/+700   | 01121    | C84725            |
| A1R17                 | 0683-3025      | 1   | RESISTOR 3K 5% .25W FC TC=-400/+700     | 01121    | C83025            |
| A1R18                 | 0698-3572      |     | RESISTOR 60.4K 1% .125W F TC=0+-100     | 16299    | C4-1/8-T0-6042-F  |
| A1R19                 | 0698-3572      |     | RESISTOR 60.4K 1% .125W F TC=0+-100     | 16299    | C4-1/8-T0-6042-F  |
| A1R21                 | 0698-3215      | 1   | RESISTOR 499K 1% .125W F TC=0+-100      | 03888    | PME555            |
| A1R22                 | 0757-0472      | 3   | RESISTOR 200K 1% .125W F TC=0+-100      | 24546    | C4-1/8-T0-2003-F  |
| A1R23                 | 0698-4496      | 1   | RESISTOR 45.3K 1% .125W F TC=0+-100     | 24546    | C4-1/8-T0-4532-F  |
| A1R24                 | 0683-6845      | 3   | RESISTOR 680K 5% .25W FC TC=-800/+900   | 01121    | C86845            |
| A1R25                 | 2100-3358      | 1   | RESISTOR-VAR TRMR 1MOHM 20% C SIDE ADJ  | 73138    | 72XR1M            |
| A1R26                 | 0683-1055      | 4   | RESISTOR 1M 5% .25W FC TC=-800/+900     | 01121    | C81055            |
| A1R27                 | 0683-1545      | 4   | RESISTOR 150K 5% .25W FC TC=-800/+900   | 01121    | C81545            |
| A1R28                 | 0757-0465      | 2   | RESISTOR 100K 1% .125W F TC=0+-100      | 24546    | C4-1/8-T0-1003-F  |
| A1R29                 | 0757-0465      |     | RESISTOR 100K 1% .125W F TC=0+-100      | 24546    | C4-1/8-T0-1003-F  |
| A1R30                 | 0811-3428      | 1   | RESISTOR .1 .5% 4W PW TC=0+-90          | 28480    | 0811-3428         |
| A1R31                 | 0811-3427      | 1   | RESISTOR .9 .5% 4W PW TC=0+-90          | 28480    | 0811-3427         |
| A1R32                 | 0811-3391      | 1   | RESISTOR 9 .1% .062W PW TC=0+-10        | 14140    | 1274              |

See introduction to this section for ordering information

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | Qty | Description                                                                              | Mfr Code | Mfr Part Number    |
|-----------------------|----------------|-----|------------------------------------------------------------------------------------------|----------|--------------------|
| A1R33                 | 0811-3390      | 1   | RESISTOR 90 .05% .031W PWM TC=0+/-10                                                     | 14140    | 1274               |
| A1R34                 | 0811-3392      | 1   | RESISTOR 900 .05% .031W PWM TC=0+/-10                                                    | 14140    | 1274               |
| A1R35                 | 0683-3355      | 3   | RESISTOR 3.3M 5% .25W FC TC=-900/+1100                                                   | 01121    | CR3355             |
| A1R36                 | 0683-3355      | 1   | RESISTOR 3.3M 5% .25W FC TC=-900/+1100                                                   | 01121    | CR3355             |
| A1R37                 | 0683-3355      | 1   | RESISTOR 3.3M 5% .25W FC TC=-900/+1100                                                   | 01121    | CR3355             |
| A1R38                 | 0683-1035      | 6   | RESISTOR 10K 5% .25W FC TC=-400/+700                                                     | 01121    | CB1035             |
| A1R39                 | 0698-7332      | 1   | RESISTOR 1M 1% .125W F TC=0+/-100                                                        | 19701    | MF5C1/8-T0-1004-F  |
| A1R40                 | 0757-0449      | 1   | RESISTOR FXD 20K 1%                                                                      | 24546    | C4-1/8-T0-2002-F   |
| A1R41                 | 0683-1045      | 1   | RESISTOR 100K 5% .25W FC TC=-400/+800                                                    | 01121    | CB1045             |
| A1R42                 | 0698-4539      | 1   | RESISTOR 402K 1% .125W F TC=0+/-100                                                      | 03888    | PME555             |
| A1R43                 | 0698-4541      | 2   | RESISTOR 442K 1% .125W F TC=0+/-100                                                      | 03888    | PME555             |
| A1R44                 | 0683-2745      | 2   | RESISTOR 270K 5% .25W FC TC=-800/+900                                                    | 01121    | CR2745             |
| A1R45                 | 0683-1045      | 1   | RESISTOR 100K 5% .25W FC TC=-400/+800                                                    | 01121    | CB1045             |
| A1R46                 | 0683-1035      | 1   | RESISTOR 10K 5% .25W FC TC=-400/+700                                                     | 01121    | CB1035             |
| A1R47                 | 0683-1035      | 1   | RESISTOR 10K 5% .25W FC TC=-400/+700                                                     | 01121    | CB1035             |
| A1R48                 | 0683-1055      | 1   | RESISTOR 1M 5% .25W FC TC=-800/+900                                                      | 01121    | CB1055             |
| A1R49                 | 0683-5135      | 1   | RESISTOR 51K 5% .25W FC TC=-400/+800                                                     | 01121    | CB5135             |
| A1R50 $\Delta_1$      | 2100-3211      | 1   | RESISTOR-VAR TRMR 1KOHM 10% C TOP ADJ                                                    | 73138    | 72PR1K             |
| A1R51 $\Delta_1$      | 0683-5635      | 1   | (THIS ONE POTENTIOMETER INCORPORATE S R50 & R51)<br>RESISTOR 56K 5% .25W FC TC=-400/+800 | 01121    | CB5635             |
| A1R52                 | 0683-1245      | 1   | RESISTOR 120K 5% .25W FC TC=-800/+900                                                    | 01121    | CB1245             |
| A1R53                 | 0683-1035      | 1   | RESISTOR 10K 5% .25W FC TC=-400/+700                                                     | 01121    | CB1035             |
| A1R54                 | 0683-1815      | 1   | RESISTOR 180 5% .25W FC TC=-400/+600                                                     | 01121    | CB1815             |
| A1R55                 | 0811-2764      | 1   | RESISTOR 99.5K .1% .125W PWM TC=0+/-10                                                   | 14140    | 1250-1/8-D-9952-R  |
| A1R56                 | 0698-3446      | 1   | RESISTOR 383 1% .125W F TC=0+/-100                                                       | 16299    | C4-1/8-T0-383R-F   |
| A1R57                 | 2100-0554      | 2   | RESISTOR-VAR TRMR 500 OHM 10% C TOP ADJ                                                  | 73138    | 72PR500            |
| A1R58                 | 0698-4541      | 1   | RESISTOR 442K 1% .125W F TC=0+/-100                                                      | 03888    | PME555             |
| A1R59                 | 0683-1045      | 1   | RESISTOR 100K 5% .25W FC TC=-400/+800                                                    | 01121    | CB1045             |
| A1R60                 | 0683-2405      | 1   | RESISTOR 24 5% .25W FC TC=-400/+500                                                      | 01121    | CB2405             |
| A1R61                 | 0683-1065      | 1   | RESISTOR 10M 5% .25W FC TC=-900/+1100                                                    | 01121    | CB1065             |
| A1R62                 | 0683-1215      | 9   | RESISTOR 120 5% .25W FC TC=-400/+600                                                     | 01121    | CB1215             |
| A1R63                 | 0693-1041      | 2   | RESISTOR 100K 10% 2W CC TC=0+882                                                         | 01121    | H81041             |
| A1R64                 | 0683-1545      | 1   | RESISTOR 150K 5% .25W FC TC=-800/+900                                                    | 01121    | CB1545             |
| A1R65                 | 0683-9135      | 1   | RESISTOR 91K 5% .25W FC TC=-400/+800                                                     | 01121    | CB9135             |
| A1R66                 | 0683-6845      | 1   | RESISTOR 680K 5% .25W FC TC=-800/+900                                                    | 01121    | CB6845             |
| A1R67                 | 0757-0462      | 1   | RESISTOR 75K 1% .125W F TC=0+/-100                                                       | 24546    | C4-1/8-T0-7502-F   |
| A1R68                 | 2100-0554      | 1   | RESISTOR-VAR TRMR 500 OHM 10% C TOP ADJ                                                  | 73138    | 72PR500            |
| A1R69                 | 0698-8345      | 1   | SEE PADDING LIST UNDER A1 ASSY MISC PARTS<br>RESISTOR 634K 1% .125W F TC=0+/-100         | 19701    | MF5C1/8-T0-6343-F  |
| A1R70                 | 0757-0472      | 1   | RESISTOR 200K 1% .125W F TC=0+/-100                                                      | 24546    | C4-1/8-T0-2003-F   |
| A1R71                 | 0698-4470      | 1   | RESISTOR 6.98K 1% .125W F TC=0+/-100                                                     | 24546    | C4-1/8-T0-4991-F   |
| A1R72                 | 0698-3279      | 1   | RESISTOR 4.99K 1% .125W F TC=0+/-100                                                     | 16299    | C4-1/8-T0-4991-F   |
| A1R73                 | T88044         | 1   | FINE LINE ASSEMBLY                                                                       | 28480    | T88044             |
| A1R74                 | 2100-0558      | 1   | RESISTOR-VAR TRMR 20 KOHM 10% C TOP ADJ                                                  | 73138    | 72PR20K            |
| A1R75                 | 0686-1035      | 1   | RESISTOR 10K 5% .5W CC TC=0+765                                                          | 01121    | E81035             |
| A1R76                 | 0683-4735      | 1   | RESISTOR 47K 5% .25W FC TC=-400/+800                                                     | 01121    | CB4735             |
| A1R77                 | 0683-2005      | 1   | RESISTOR 20 5% .25W FC TC=-400/+500                                                      | 01121    | CB2005             |
| A1R78                 | 0683-2225      | 6   | RESISTOR 2.2K 5% .25W FC TC=-400/+700                                                    | 01121    | CB2225             |
| A1R79                 | 0683-3015      | 4   | RESISTOR 300 5% .25W FC TC=-400/+600                                                     | 01121    | CB3015             |
| A1R80                 | 0693-1041      | 1   | RESISTOR 100K 10% 2W CC TC=0+882                                                         | 01121    | H81041             |
| A1R81                 | 0683-1025      | 1   | RESISTOR 1K 5% .25W FC TC=-400/+600                                                      | 01121    | CB1025             |
| A1R82                 | 0698-3572      | 1   | RESISTOR 60.4K 1% .125W F TC=0+/-100                                                     | 16299    | C4-1/8-T0-6042-F   |
| A1R83                 | 0698-3572      | 1   | RESISTOR 60.4K 1% .125W F TC=0+/-100                                                     | 16299    | C4-1/8-T0-6042-F   |
| A1R84                 | 0683-4725      | 1   | RESISTOR 4.7K 5% .25W FC TC=-400/+700                                                    | 01121    | CB4725             |
| A1R85                 | 0683-1035      | 2   | RESISTOR 10K 5% .25W FC TC=-400/+700                                                     | 01121    | CB1035             |
| A1R86                 | 0683-5125      | 1   | RESISTOR 5.1K 5% .25W FC TC=-400/+700                                                    | 01121    | CB5125             |
| A1R87                 | 2100-3123      | 1   | RESISTOR-VAR TRMR 500 OHM 10% C SIDE ADJ                                                 | 32997    | 3006P-1-501        |
| A1R88                 | 0683-2025      | 1   | RESISTOR 2K 5% .25W FC TC=400/+700                                                       | 01121    | CB2025             |
| A1R89                 | 0683-4705      | 1   | RESISTOR 47 5% .25W FC TC=-400/+500                                                      | 01121    | CB4705             |
| A1R90                 | 0683-1545      | 1   | RESISTOR 150K 5% .25W FC TC=-800/+900                                                    | 01121    | CB1545             |
| A1R91                 | 0683-2745      | 1   | RESISTOR 270K 5% .25W FC TC=-800/+900                                                    | 01121    | CB2745             |
| A1R92                 | 0757-0410      | 1   | RESISTOR 301 1% .125W F TC=0+/-100                                                       | 24546    | C4-1/8-T0-301R-F   |
| A1R93                 | 0683-1045      | 1   | RESISTOR 100K 5% .25W FC TC=-400/+800                                                    | 01121    | CB1045             |
| A1R94                 | 0683-3015      | 1   | RESISTOR 300 5% .25W FC TC=-400/+600                                                     | 01121    | CB3015             |
| A1R95                 | 0683-1505      | 1   | RESISTOR 15 5% .25W FC TC=-400/+500                                                      | 01121    | CB1505             |
| A1R96                 | 0698-3456      | 3   | RESISTOR 287K 1% .125W F TC=0+/-100                                                      | 16299    | C4-1/8-T0-2873-F   |
| A1R97                 | 0698-3456      | 1   | RESISTOR 287K 1% .125W F TC=0+/-100                                                      | 16299    | C4-1/8-T0-2873-F   |
| A1R98                 | 0683-2445      | 1   | RESISTOR 240K 5% .25W FC TC=-800/+900                                                    | 01121    | CB2445             |
| A1R99                 | 0683-2245      | 1   | RESISTOR 220K 5% .25W FC TC=-800/+900                                                    | 01121    | CB2245             |
| A1R100                | 0698-8203      | 1   | RESISTOR 120K 1% .125W F TC=0+/-15                                                       | 19701    | MF4C1/8-T10-1203-F |
| A1R101                | 0698-4735      | 1   | SEE PADDING LIST UNDER A1 ASSY MISC PARTS<br>SEE PADDING LIST UNDER A1 ASSY MISC PARTS   | 01121    | HP4735             |
| A1R102                | 0692-4735      | 1   | RESISTOR 47K 5% 2W CC TC=0+765                                                           | 01121    | HP4735             |
| A1R103                |                |     |                                                                                          |          |                    |
| A1R104                |                |     |                                                                                          |          |                    |
| A1R105                |                |     |                                                                                          |          |                    |
| A1R106                |                |     |                                                                                          |          |                    |
| A1R107*               |                |     |                                                                                          |          |                    |
| A1R108*               |                |     |                                                                                          |          |                    |
| A1R109                |                |     |                                                                                          |          |                    |

See introduction to this section for ordering information

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | Qty | Description                                       | Mfr Code | Mfr Part Number     |
|-----------------------|----------------|-----|---------------------------------------------------|----------|---------------------|
| A1R110                | 0683-2425      | 1   | RESISTOR 2.4K 5% .25W FC TC=-400/+700             | 01121    | CB2425              |
| A1R112                | 0683-5125      | 1   | RESISTOR 5.1K 5% .25W FC TC=-400/+700             | 01121    | CB5125              |
| A1R113                | 0683-4755      | 1   | RESISTOR 4.7K 5% .25W FC TC=-900/+1100            | 01121    | CB4755              |
| A1R114                | 0698-3149      | 1   | RESISTOR 255K 1% .125W F TC=0+-100                | 16299    | C4-1/8-T0-2553-F    |
| A1R115                | 0683-6845      | 1   | RESISTOR 680K 5% .25W FC TC=-800/+900             | 01121    | CB6845              |
| A1R116                | 0683-1545      | 1   | RESISTOR 150K 5% .25W FC TC=-800/+900             | 01121    | CB1545              |
| A1R117                | 0757-0478      | 1   | RESISTOR 365K 1% .125W F TC=0+-100                | 19701    | MF4C1/8-T0-3653-F   |
| A1R118                | 0698-6871      | 2   | RESISTOR 10K .5% .125W F TC=0+-50                 | 03888    | PME555              |
| A1R119                | 0683-1055      | 1   | RESISTOR 1M 5% .25W FC TC=-800/+900               | 01121    | CB1055              |
| A1R120                | 0683-4735      | 1   | RESISTOR 47K 5% .25W FC TC=-400/+800              | 01121    | CB4735              |
| A1R123                | 0683-1035      | 2   | RESISTOR 10K 5% .25W FC TC=-400/+700              | 01121    | CB1035              |
| A1R124                | 0683-1055      | 1   | RESISTOR 1M 5% .25W FC TC=-800/+900               | 01121    | CB1055              |
| A1R125                | 0698-6385      | 1   | RESISTOR 220K 1% .125W F TC=0+-25                 | 03888    | PME555              |
| A1R126                | 0698-6871      | 1   | RESISTOR 10K .5% .125W F TC=0+-50                 | 03888    | PME555              |
| A1R127                | 0698-6385      | 1   | RESISTOR 220K 1% .125W F TC=0+-25                 | 03888    | PME555              |
| A1R128                | 2100-3211      | 1   | RESISTOR-VAR TRMR 1K OHM 10% C TOP ADJ            | 73138    | 72PR1K              |
| A1R131                | 0698-6362      | 1   | RESISTOR 1K .1% .125W F TC=0+-25                  | 24546    | NE55                |
| A1R132                | 0698-8613      | 1   | RESISTOR, FXD 8.97K OHM 0.1% .125W F              | 29480    | Q698-8613           |
| A1R133* $\Delta_1$    | 2100-3383      | 1   | RESISTOR-VAR TRMR 50 OHM 10% C TOP ADJ            | 73138    |                     |
| A1R134* $\Delta_1$    |                |     | (THIS ONE POTENTIOMETER INCORPORATES R133 & R134) |          |                     |
| A1R135                | 0683-4745      | 1   | RESISTOR 470K 5% .25W FC TC=-800/+900             | 01121    | CB4745              |
| A1R139                | 0698-4504      | 1   | RESISTOR 69.8K 1% .125W F TC=0+-100               | 24546    | C4-1/8-T0-6982-F    |
| A1R140                |                |     | NOT ASSIGNED                                      |          |                     |
| A1R141                | 0757-0978      | 1   | RESISTOR 95.3K 1% .125W F TC=0+-100               | 24546    | C4-1/8-T0-9532-F    |
| A1R142, 43            | 0683-3335      | 1   | RESISTOR 33K 5% .25W FC TC=-400/+800              | 01121    | CB3335              |
| A1R144                | 0683-1035      | 1   | RESISTOR 10K 5% .25W FC TC=-400/+700              | 01121    | CB1035              |
| A1R145, 46            | 0683-4735      | 1   | RESISTOR 47K 5% .25W FC TC=-400/+800              | 01121    | CB4735              |
| A1R147                | 0683-1035      | 1   | RESISTOR 10K 5% .25W FC TC=-400/+700              | 01121    | CB1035              |
| A1R148                | 0683-1055      | 1   | RESISTOR 1M 5% .25W FC TC=-800/+900               | 01121    | CB1055              |
| A1R149                | 0683-1045      | 1   | RESISTOR 100K 5% .25W FC TC=-400/+800             | 01121    | CB1045              |
| A1T1                  | 9100-0657      | 1   | TRANSFORMER, POWER CONVERTER                      | 28480    | 9100-0657           |
| A1U1                  | 1826-0310      | 6   | IC, LIN MC3476G AMPL                              | 04713    | MC3476G             |
| A1U2                  | 1820-0946      | 2   | IC CD4001AE                                       | 02735    | CD4001AE            |
| A1U3                  | 1820-0223      | 1   | IC LM301AH                                        | 27014    | LM301AH             |
| A1U4, U5              | 1820-0939      | 3   | IC CD4013AE                                       | 02735    | CD4013AE            |
| A1U6                  | 1820-0949      | 4   | IC CD4011AE                                       | 02735    | CD4011AE            |
| A1U7                  | 1820-0947      | 2   | IC CD4030AE                                       | 02735    | CD4030AE            |
| A1U8                  | 1820-0946      | 1   | IC CD4025AE                                       | 02735    | CD4025AE            |
| A1U9                  | 1820-0946      | 1   | IC CD4001AE                                       | 02735    | CD4001AE            |
| A1U10                 | 1820-0947      | 1   | IC CD4030AE                                       | 02735    | CD4030AE            |
| A1U11                 | 1820-1239      | 1   | IC MKK 5007P                                      | 28480    | 1820-1239           |
| A1U15-U19             | 1826-0310      | 1   | IC, LIN MC3476G AMPL                              | 04713    | MC3476G             |
|                       | 03465-61602    | 1   | CABLE ASSY, 25-PIN(INCLUDES P2, P3)               | 28480    | 03465-61602         |
| A1Y1                  | 0410-0595      | 1   | CRYSTAL, QUARTZ 100KHZ 0.1%                       | 28480    | 0410-0595           |
| A1A1                  | 03465-61901    | 1   | SWITCH ASSEMBLY                                   | 28480    | 03465-61901         |
| A1A1R10               | 0757-0273      | 1   | RESISTOR 3.01K 1% .125W F TC=0+-100               | 24546    | C4-1/8-T0-3011-F    |
| A1A1R20               | 0757-0472      | 1   | RESISTOR 200K 1% .125W F TC=0+-100                | 24546    | C4-1/8-T0-2003-F    |
| A1A1S1-S13            | 3101-1949      | 1   | SWITCH, PUSHBUTTON 14-STATION                     | 28480    | 3101-1949           |
| A1A1W1                | 03465-61601    | 1   | CABLE, SWITCH                                     | 28480    | 03465-61601         |
| C55*                  | 1200-0770      | 1   | A1 ASSEMBLY MISCELLANEOUS PARTS                   | 28480    | 1200-0770           |
|                       | 1460-1425      | 1   | SOCKET-XTAL 2-CONT HC-6/U-PKG                     | 28480    | 1460-1425           |
|                       |                |     | SPRING, FUSE                                      |          |                     |
|                       | 0160-0763      | 1   | PADDING LIST FOR C55*                             | 28480    | 0160-0763           |
|                       | 0160-0205      | 1   | CAPACITOR:FXD 5PF +/-10% 500WVDC MICA             | 28480    | 0160-0205           |
| R70*                  |                |     | CAPACITOR:FXD 10PF +/-5% 500WVDC MICA             |          |                     |
|                       | 0698-4491      | 1   | PADDING LIST FOR R70*                             | 24546    | C4-1/8-T0-3092-F    |
|                       | 0698-4504      | 1   | RESISTOR:FXD 30.9K .125W                          | 24546    | C4-1/8-T0-6982-F    |
|                       |                |     | RESISTOR:FXD 69.8K .125W                          |          |                     |
| R107* AND R108*       |                |     | PADDING LIST FOR R107* AND R108*                  |          |                     |
|                       | 0683-0515      | 1   | RESISTOR 5.1 5% .25W FC TC=-400/+500              | 01121    | CB51G5              |
|                       | 0757-0346      | 1   | RESISTOR 10 1% .125W F TC=0+-100                  | 24546    | C4-1/8-T0-10R0-F    |
|                       | 0757-0378      | 1   | RESISTOR 11 1% .125W F TC=0+-100                  | 19701    | MF4C1/8-T0-11R0-F   |
|                       | 0757-0379      | 1   | RESISTOR 12.1 1% .125W F TC=0+-100                | 19701    | MF4C1/8-T0-12R1-F   |
|                       | 0757-0380      | 1   | RESISTOR 13 1% .125W F TC=0+-100                  | 19701    | MF4C1/8-T0-13R0-F   |
|                       | 0698-4358      | 1   | RESISTOR 14 1% .125W F TC=0+-100                  | 03888    | PME55-1/8-T0-14R0-F |
|                       | 0757-0381      | 1   | RESISTOR 15 1% .125W F TC=0+-100                  | 19701    | MF4C1/8-T0-15R0-F   |
|                       | 0698-0334      | 1   | RESISTOR 20 1% .125W F TC=0+-100                  | 28480    | Q698-0334           |
|                       | 0757-0291      | 1   | RESISTOR 24.9 1% .125W F TC=0+-100                | 19701    | MF4C1/8-T0-24R2-F   |
|                       | 0757-0398      | 1   | RESISTOR 30.1 1% .125W F TC=0+-100                | 24546    | C4-1/8-T0-30R1-F    |
|                       | 0698-4126      | 1   | RESISTOR 33.7 1% .125W F TC=0+-100                | 16299    | C4-1/8-T0-33R7-F    |
|                       | 0698-4123      | 2   | RESISTOR 499 1% .125W F TC=0+-100                 | 16299    | C4-1/8-T0-499R-F    |
|                       | 0757-0280      | 2   | RESISTOR 1K 1% .125W F TC=0+-100                  | 24546    | C4-1/8-T0-1001-F    |
|                       | 0757-0427      | 1   | RESISTOR 1.5K 1% .125W F TC=0+-100                | 24546    | C4-1/8-T0-1501-F    |

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number                                                | Qty                   | Description                                                                                                                                                                                      | Mfr Code                                  | Mfr Part Number                                                                                   |
|-----------------------|---------------------------------------------------------------|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|---------------------------------------------------------------------------------------------------|
|                       | 0757-0283<br>0698-4442<br>0757-0439<br>0757-0288<br>0698-3262 | 1<br>1<br>1<br>2<br>1 | RESISTOR 2K 1% .125W F TC=0+/-100<br>RESISTOR 4.42K 1% .125W F TC=0+/-100<br>RESISTOR 6.81K 1% .125W F TC=0+/-100<br>RESISTOR 9.09K 1% .125W F TC=0+/-100<br>RESISTOR 40.2 1% .125W F TC=0+/-100 | 24546<br>16299<br>24546<br>19701<br>16299 | C4-1/8-T0-2001-F<br>C4-1/8-T0-4421-F<br>C4-1/8-T0-6811-F<br>MF4C1/8-T0-9091-F<br>C4-1/8-T0-4022-F |
|                       | 0757-0277<br>0698-4387<br>0698-4391<br>0698-4396<br>0757-0400 | 1<br>1<br>1<br>1<br>1 | RESISTOR 49.9 1% .125W F TC=0+/-100<br>RESISTOR 60.4 1% .125W F TC=0+/-100<br>RESISTOR 69.8 1% .125W F TC=0+/-100<br>RESISTOR 80.6 1% .125W F TC=0+/-100<br>RESISTOR 90.9 1% .125W F TC=0+/-100  | 24546<br>16299<br>16299<br>16299<br>24546 | C4-1/8-T0-4992-F<br>C4-1/8-T0-6044-F<br>C4-1/8-T0-6988-F<br>C4-1/8-T0-8068-F<br>C4-1/8-T0-9099-F  |
|                       | 0757-0401<br>0757-0407<br>0757-0410<br>0698-3445<br>0698-4453 | 1<br>1<br>2<br>1<br>1 | RESISTOR 100 1% .125W F TC=0+/-100<br>RESISTOR 200 1% .125W F TC=0+/-100<br>RESISTOR 301 1% .125W F TC=0+/-100<br>RESISTOR 348 1% .125W F TC=0+/-100<br>RESISTOR 402 1% .125W F TC=0+/-100       | 24546<br>24546<br>24546<br>16299<br>24546 | C4-1/8-T0-101-F<br>C4-1/8-T0-201-F<br>C4-1/8-T0-301-F<br>C4-1/8-T0-348-F<br>C4-1/8-T0-402-F       |
|                       | 0698-3510                                                     | 1                     | RESISTOR 453 1% .125W F TC=0+/-100                                                                                                                                                               | 16299                                     | C4-1/8-T0-453-F                                                                                   |
| A2                    | 03465-66502                                                   | 1                     | P.C. ASSEMBLY, DISPLAY INTERFACE                                                                                                                                                                 | 28480                                     | 03465-66502                                                                                       |
| A2C1                  | 0180-0106                                                     | 1                     | CAPACITOR-FXD: 60UF+-20% 6VDC TA-SOLID                                                                                                                                                           | 56289                                     | 150D606X000692                                                                                    |
| A2C2                  | 0150-0096                                                     | 1                     | CAPACITOR-FXD .05UF +80-20% 100WVDC CER                                                                                                                                                          | 28480                                     | 0150-0096                                                                                         |
| A2J2                  | 1251-4112                                                     | 2                     | CONNECTOR STRIP, 25-PIN                                                                                                                                                                          | 28480                                     | 1251-4112                                                                                         |
| A2P1                  | 1251-4166                                                     | 1                     | P.C. BD. CONNECTOR, RECTANGULAR                                                                                                                                                                  | 28480                                     | 1251-4166                                                                                         |
| A2Q1                  | 1854-0071                                                     | 4                     | TRANSISTOR NPN SI PD=300MW FT=200MHZ                                                                                                                                                             | 28480                                     | 1854-0071                                                                                         |
| A2Q2                  | 1854-0071                                                     |                       | TRANSISTOR NPN SI PD=300MW FT=200MHZ                                                                                                                                                             | 28480                                     | 1854-0071                                                                                         |
| A2Q3                  | 1854-0071                                                     |                       | TRANSISTOR NPN SI PD=300MW FT=200MHZ                                                                                                                                                             | 28480                                     | 1854-0071                                                                                         |
| A2Q4                  | 1853-0016                                                     |                       | TRANSISTOR PNP SI TO-92 PD=300MW                                                                                                                                                                 | 28480                                     | 1853-0016                                                                                         |
| A2Q5                  | 1855-0081                                                     | 4                     | TRANSISTOR J-FET 2N5245 N-CHAN D-MODE SI                                                                                                                                                         | 01295                                     | 2N5245                                                                                            |
| A2Q6                  | 1853-0016                                                     | 4                     | TRANSISTOR PNP SI TO-92 PD=300MW                                                                                                                                                                 | 28480                                     | 1853-0016                                                                                         |
| A2Q7                  | 1855-0081                                                     |                       | TRANSISTOR J-FET 2N5245 N-CHAN D-MODE SI                                                                                                                                                         | 01295                                     | 2N5245                                                                                            |
| A2Q8                  | 1853-0016                                                     |                       | TRANSISTOR PNP SI TO-92 PD=300MW                                                                                                                                                                 | 28480                                     | 1853-0016                                                                                         |
| A2Q9                  | 1855-0081                                                     |                       | TRANSISTOR J-FET 2N5245 N-CHAN D-MODE SI                                                                                                                                                         | 01295                                     | 2N5245                                                                                            |
| A2Q10                 | 1853-0016                                                     | 4                     | TRANSISTOR PNP SI TO-92 PD=300MW                                                                                                                                                                 | 28480                                     | 1853-0016                                                                                         |
| A2Q11                 | 1855-0081                                                     | 4                     | TRANSISTOR J-FET 2N5245 N-CHAN D-MODE SI                                                                                                                                                         | 01295                                     | 2N5245                                                                                            |
| A2Q12                 | 1854-0071                                                     |                       | TRANSISTOR NPN SI PD=300MW FT=200MHZ                                                                                                                                                             | 28480                                     | 1854-0071                                                                                         |
| A2Q13                 | 1854-0071                                                     |                       | TRANSISTOR NPN SI PD=300MW FT=200MHZ                                                                                                                                                             | 28480                                     | 1854-0071                                                                                         |
| A2Q14                 | 1854-0071                                                     |                       | TRANSISTOR NPN SI PD=300MW FT=200MHZ                                                                                                                                                             | 28480                                     | 1854-0071                                                                                         |
| A2Q15                 | 1854-0071                                                     | 4                     | TRANSISTOR NPN SI PD=300MW FT=200MHZ                                                                                                                                                             | 28480                                     | 1854-0071                                                                                         |
| A2Q16                 | 1854-0071                                                     | 4                     | TRANSISTOR NPN SI PD=300MW FT=200MHZ                                                                                                                                                             | 28480                                     | 1854-0071                                                                                         |
| A2Q17                 | 1854-0071                                                     |                       | TRANSISTOR NPN SI PD=300MW FT=200MHZ                                                                                                                                                             | 28480                                     | 1854-0071                                                                                         |
| A2Q18                 | 1854-0071                                                     |                       | TRANSISTOR NPN SI PD=300MW FT=200MHZ                                                                                                                                                             | 28480                                     | 1854-0071                                                                                         |
| A2Q19                 | 1854-0071                                                     |                       | TRANSISTOR NPN SI PD=300MW FT=200MHZ                                                                                                                                                             | 28480                                     | 1854-0071                                                                                         |
| A2Q20                 | 1854-0071                                                     | 4                     | TRANSISTOR NPN SI PD=300MW FT=200MHZ                                                                                                                                                             | 28480                                     | 1854-0071                                                                                         |
| A2Q21                 | 1854-0071                                                     | 1                     | TRANSISTOR NPN SI PD=300MW FT=200MHZ                                                                                                                                                             | 28480                                     | 1854-0071                                                                                         |
| A2Q22                 | 1854-0547                                                     |                       | TRANSISTOR NPN 2N3725 SI TO-9 PD=800MW                                                                                                                                                           | 01295                                     | 2N3725                                                                                            |
| A2Q23                 | 1854-0071                                                     |                       | TRANSISTOR NPN SI PD=300MW FT=200MHZ                                                                                                                                                             | 28480                                     | 1854-0071                                                                                         |
| A2R1                  | 0683-1025                                                     | 2                     | RESISTOR 1K 5% .25W FC TC=-400/+700                                                                                                                                                              | 01121                                     | CB1025                                                                                            |
| A2R2                  | 0683-5635                                                     |                       | RESISTOR 56K 5% .25W FC TC=-400/+800                                                                                                                                                             | 01121                                     | CB5635                                                                                            |
| A2R3                  | 0683-6835                                                     |                       | RESISTOR 68K 5% .25W FC TC=-400/+800                                                                                                                                                             | 01121                                     | CB6835                                                                                            |
| A2R4                  | 0683-1025                                                     |                       | RESISTOR 1K 5% .25W FC TC=-400/+700                                                                                                                                                              | 01121                                     | CB1025                                                                                            |
| A2R5                  | 0683-5635                                                     | 3                     | RESISTOR 56K 5% .25W FC TC=-400/+800                                                                                                                                                             | 01121                                     | CB5635                                                                                            |
| A2R6                  | 0683-6835                                                     |                       | RESISTOR 68K 5% .25W FC TC=-400/+800                                                                                                                                                             | 01121                                     | CB6835                                                                                            |
| A2R7                  | 0683-1625                                                     |                       | RESISTOR 1.6K 5% .25W FC TC=-400/+700                                                                                                                                                            | 01121                                     | CB1625                                                                                            |
| A2R8                  | 0683-5635                                                     |                       | RESISTOR 56K 5% .25W FC TC=-400/+800                                                                                                                                                             | 01121                                     | CB5635                                                                                            |
| A2R9                  | 0683-6835                                                     | 3                     | RESISTOR 68K 5% .25W FC TC=-400/+800                                                                                                                                                             | 01121                                     | CB6835                                                                                            |
| A2R10                 | 0683-1045                                                     |                       | RESISTOR 100K 5% .25W FC TC=-400/+800                                                                                                                                                            | 01121                                     | CB1045                                                                                            |
| A2R11                 | 0683-1045                                                     |                       | RESISTOR 100K 5% .25W FC TC=-400/+800                                                                                                                                                            | 01121                                     | CB1045                                                                                            |
| A2R12                 | 0683-1045                                                     |                       | RESISTOR 100K 5% .25W FC TC=-400/+800                                                                                                                                                            | 01121                                     | CB1045                                                                                            |
| A2R13                 | 0683-1045                                                     | 3                     | RESISTOR 100K 5% .25W FC TC=-400/+800                                                                                                                                                            | 01121                                     | CB1045                                                                                            |
| A2R14                 | 0683-1045                                                     |                       | RESISTOR 100K 5% .25W FC TC=-400/+800                                                                                                                                                            | 01121                                     | CB1045                                                                                            |
| A2R15                 | 0683-2025                                                     |                       | RESISTOR 2K 5% .25W FC TC=-400/+700                                                                                                                                                              | 01121                                     | CB2025                                                                                            |
| A2R16                 | 0683-2025                                                     | 9                     | RESISTOR 2K 5% .25W FC TC=-400/+700                                                                                                                                                              | 01121                                     | CB2025                                                                                            |
| A2R17                 | 0683-2025                                                     |                       | RESISTOR 2K 5% .25W FC TC=-400/+700                                                                                                                                                              | 01121                                     | CB2025                                                                                            |
| A2R18                 | 0683-2025                                                     |                       | RESISTOR 2K 5% .25W FC TC=-400/+700                                                                                                                                                              | 01121                                     | CB2025                                                                                            |
| A2R19                 | 0683-2015                                                     |                       | RESISTOR 200 5% .25W FC TC=-400/+600                                                                                                                                                             | 01121                                     | CB2015                                                                                            |
| A2R20                 | 0683-3035                                                     | 10                    | RESISTOR 30K 5% .25W FC TC=-400/+800                                                                                                                                                             | 01121                                     | CB3035                                                                                            |
| A2R21                 | 0683-2035                                                     |                       | RESISTOR 20K 5% .25W FC TC=-400/+800                                                                                                                                                             | 01121                                     | CB2035                                                                                            |
| A2R22                 | 0683-1215                                                     |                       | RESISTOR 120 5% .25W FC TC=-400/+600                                                                                                                                                             | 01121                                     | CB1215                                                                                            |
| A2R23                 | 0683-3035                                                     |                       | RESISTOR 30K 5% .25W FC TC=-400/+800                                                                                                                                                             | 01121                                     | CB3035                                                                                            |
| A2R24                 | 0683-2035                                                     | 10                    | RESISTOR 20K 5% .25W FC TC=-400/+800                                                                                                                                                             | 01121                                     | CB2035                                                                                            |
| A2R25                 | 0683-1215                                                     |                       | RESISTOR 120 5% .25W FC TC=-400/+600                                                                                                                                                             | 01121                                     | CB1215                                                                                            |
| A2R26                 | 0683-3035                                                     |                       | RESISTOR 30K 5% .25W FC TC=-400/+800                                                                                                                                                             | 01121                                     | CB3035                                                                                            |
| A2R27                 | 0683-2035                                                     |                       | RESISTOR 20K 5% .25W FC TC=-400/+800                                                                                                                                                             | 01121                                     | CB2035                                                                                            |
| A2R28                 | 0683-1215                                                     |                       | RESISTOR 120 5% .25W FC TC=-400/+600                                                                                                                                                             | 01121                                     | CB1215                                                                                            |
| A2R29                 | 0683-3035                                                     |                       | RESISTOR 30K 5% .25W FC TC=-400/+800                                                                                                                                                             | 01121                                     | CB3035                                                                                            |
| A2R30                 | 0683-2035                                                     |                       | RESISTOR 20K 5% .25W FC TC=-400/+800                                                                                                                                                             | 01121                                     | CB2035                                                                                            |

Table 6-3. Replaceable Parts

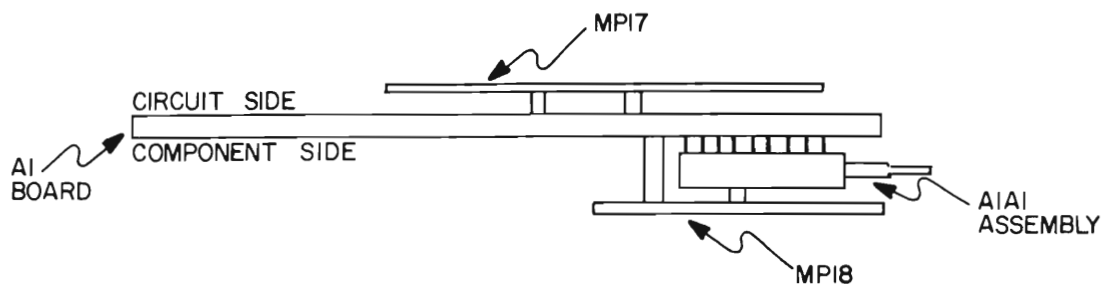
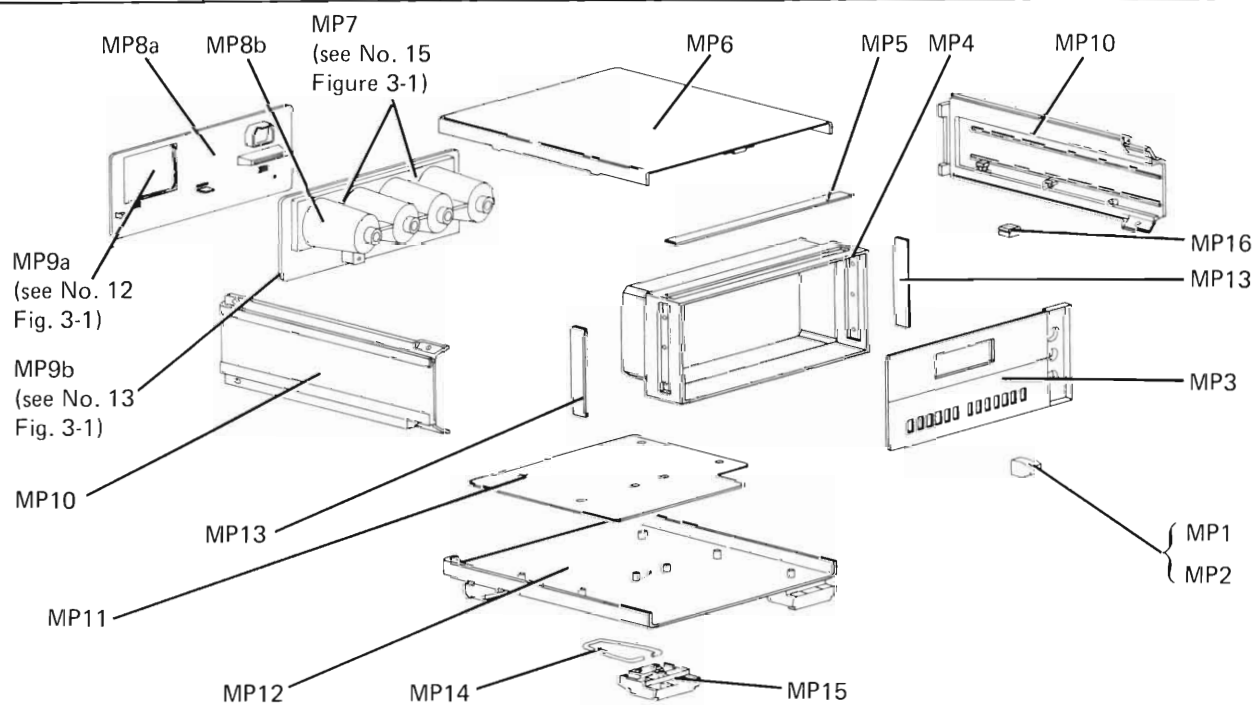
| Reference Designation | HP Part Number | Qty | Description                                       | Mfr Code | Mfr Part Number     |
|-----------------------|----------------|-----|---------------------------------------------------|----------|---------------------|
| A2R31                 | 0683-1215      |     | RESISTOR 120 5% .25W FC TC=-400/+600              | 01121    | CB1215              |
| A2R32                 | 0683-3035      |     | RESISTOR 30K 5% .25W FC TC=-400/+800              | 01121    | CB3035              |
| A2R33                 | 0683-2035      |     | RESISTOR 20K 5% .25W FC TC=-400/+800              | 01121    | CB2035              |
| A2R34                 | 0683-1215      |     | RESISTOR 120 5% .25W FC TC=-400/+600              | 01121    | CB1215              |
| A2R35                 | 0683-3035      |     | RESISTOR 30K 5% .25W FC TC=-400/+800              | 01121    | CB3035              |
| A2R36                 | 0683-2035      |     | RESISTOR 20K 5% .25W FC TC=-400/+800              | 01121    | CB2035              |
| A2R37                 | 0683-1215      |     | RESISTOR 120 5% .25W FC TC=-400/+600              | 01121    | CB1215              |
| A2R38                 | 0683-3035      |     | RESISTOR 30K 5% .25W FC TC=-400/+800              | 01121    | CB3035              |
| A2R39                 | 0683-2035      |     | RESISTOR 20K 5% .25W FC TC=-400/+800              | 01121    | CB2035              |
| A2R40                 | 0683-1215      |     | RESISTOR 120 5% .25W FC TC=-400/+600              | 01121    | CB1215              |
| A2R41                 | 0683-3025      |     | RESISTOR 30K 5% .25W FC TC=-400/+800              | 01121    | CB3025              |
| A2R42                 | 0683-2035      |     | RESISTOR 20K 5% .25W FC TC=-400/+800              | 01121    | CB2035              |
| A2R43                 | 0683-1215      |     | RESISTOR 120 5% .25W FC TC=-400/+600              | 01121    | CB1215              |
| A2R44                 | 0683-3035      |     | RESISTOR 30K 5% .25W FC TC=-400/+800              | 01121    | CB3035              |
| A2R45                 | 0683-2035      |     | RESISTOR 20K 5% .25W FC TC=-400/+800              | 01121    | CB2035              |
| A2R46                 | 0683-2035      |     | RESISTOR 20K 5% .25W FC TC=-400/+800              | 01121    | CB2035              |
| A2R47                 | 0698-4475      |     | RESISTOR 9.76K 1% .125W F TC=0+-100               | 03888    | PME55-1/8-TO-9761-F |
| A2R48                 | 0757-0273      |     | RESISTOR 3.01K 1% .125W F TC=0+-100               | 24546    | C4-1/8-TO-3011-F    |
| A2R49                 | 0683-0335      |     | RESISTOR 3.3 5% .25W FC TC=-400/+500              | 01121    | CB0335              |
| A2R50-R55             | 0683-2035      |     | RESISTOR 20K 5% .25W FC TC=-400/+800              | 01121    | CB2035              |
| A2U1                  | 1820-0949      | 1   | IC CD4011AE                                       | 02735    | CD4011AE            |
| A2U2                  | 1820-0950      |     | IC CD4012AE                                       | 02735    | CD4012AE            |
| A2U3                  | 1820-0949      |     | IC CD4011AE                                       | 02735    | CD4011AE            |
| A2U4                  | 1820-0939      | 1   | IC CD4013AE                                       | 02735    | CD4013AE            |
| A2U5                  | 1820-1413      |     | IC MC14511CP                                      | 04713    | MC14511CP           |
| A2U6                  | 1820-0949      |     | IC CD4011AE                                       | 02735    | CD4011AE            |
| A5                    | 03465-66505    | 1   | LED DISPLAY ASSEMBLY                              | 28480    | 03465-66505         |
| A5CR1                 | 1990-0450      | 1   | LED-VISIBLE (SAMPLE RATE)                         | 28480    | 1990-0450           |
| A5DS1                 | 1990-0532      | 1   | LED DISPLAY 0.3" (POLARITY/OVERRANGE)             | 28480    | 1990-0532           |
| A5DS2                 | 1990-0531      | 4   | SEG DISPLAY, 0.3" X 7" (7 SEGMENT)                | 28480    | 1990-0531           |
| A5DS3                 | 1990-0531      |     | SEG DISPLAY, 0.3" X 7"                            | 28480    | 1990-0531           |
| A5DS4                 | 1990-0531      |     | SEG DISPLAY, 0.3" X 7"                            | 28480    | 1990-0531           |
| A5DS5                 | 1990-0531      |     | SEG DISPLAY, 0.3" X 7"                            | 28480    | 1990-0531           |
| A5J3                  | 1251-4112      |     | CONNECTOR STRIP- 25PIN                            | 28480    | 1251-4112           |
| A10                   | 03465-80000    | 1   | STANDARD OR OPTION 001<br>NI CAD BATTERY ASSEMBLY | 28480    | 03465-80000         |
| A10B1                 | 00035-60024    | 2   | BATTERY PACK ASSEMBLY(STD ONLY)                   | 28480    | 00035-60024         |
| A10B2                 | 00035-60024    |     | BATTERY PACK ASSEMBLY(STD ONLY)                   | 28480    | 00035-60024         |
| A10A6                 | 03465-66506    | 1   | PC ASSEMBLY, AC LINE & NI-CAD POWER               | 28480    | 03465-66506         |
| A10A6C1               | 0180-2552      | 1   | CAPACITOR-FXD; 400UF+75-10% 15VDC AL              | 56289    | 5020125             |
| A10A6C2               | 0150-0024      |     | C:FXD .02UF +80-20 600VWVDC                       | 71590    | DD203-25U+-80-20    |
| A10A6CR1              | 1902-3097      | 1   | DIODE-ZNR 5.23V 2% 00-7 PD=.4W TC=-.003%          | 12954    | DZ730712C           |
| A10A6CR2-CR5          | 1901-0753      | 4   | DIODE-PWR RECT 400V 750MA                         | 28480    | 1901-0753           |
| A10A6F1               | 2110-0311      | 1   | FUSE .062A 250V SLO BLO                           | 75915    | 313.062S            |
| A10A6Q1               | 1854-0701      | 1   | TRANSISTOR, NPN MJE2100                           | 28480    | 1854-0701           |
| A10A6Q2               | 1853-0374      | 1   | TRANSISTOR PNP TO-18 PD=500MW                     | 28480    | 1853-0374           |
| A10A6Q3               | 1853-0394      | 1   | TRANSISTOR, NPN MJE2370                           | 28480    | 1853-0394           |
| A10A6R1               | 0684-4711      | 1   | RESISTOR 470 10% .25W FC TC=-400/+600             | 01121    | CB4711              |
| A10A6R2               | 0684-4721      | 1   | RESISTOR 4.7K 10% .25W FC TC=-400/+700            | 01121    | CB4721              |
| A10A6R3               | 0683-1005      | 1   | RESISTOR 10 5% .25W                               | 01121    | CB1005              |
| A10A6R4               | 0686-5105      | 2   | RESISTOR 51 5% .5W CC TC=0+412                    | 01121    | CB5105              |
| A10A6R5               | 0686-5105      |     | RESISTOR 51 5% .5W CC TC=0+412                    | 01121    | CB5105              |
| A10A6S1               | 3101-2027      | 2   | SWITCH-PB 1A 300VAC PC                            | 28480    | 3101-2027           |
| A10A6S2               | 00035-40026    | 1   | LINE SELECTOR SLIDE SWITCH                        | 28480    | 00035-40026         |
| A10A6T1               | 9100-3490      | 1   | TRANSFORMER                                       | 28480    | 9100-3490           |
| W2                    | 1460-1426      | 2   | A10 ASSEMBLY MISCELLANEOUS PARTS                  | 28480    | 1460-1426           |
|                       | 0363-0084      | 2   | SPRING-CONTACT                                    | 00160    | 080                 |
|                       | 2110-0269      | 2   | CONTACT, SINGLE PIECE SWITCH                      | 91506    | 6008-32CN           |
|                       | 5000-5086      | 1   | FUSEHOLDER, CLIP TYPE .25 FUSE                    | 28480    | 5000-5086           |
|                       | 5000-5087      | 2   | CONTACT, MALE (AC POWER CONNECTOR PINS)           | 28480    | 5000-5087           |
|                       | 5040-7854      | 1   | CONTACT, MALE (AC POWER CONNECTOR PIN-GRD)        | 28480    | 5040-7854           |
|                       | 8120-1348      | 1   | CAM-LINE PLUG                                     | 28480    | 8120-1348           |
|                       |                | 1   | CABLE-AC POWER                                    | 28480    |                     |
|                       |                |     |                                                   |          |                     |
|                       |                |     |                                                   |          |                     |

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | Qty | Description                              | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|------------------------------------------|----------|-----------------|
| A20                   | 03465-80002    | 1   | OPTION 002 ONLY<br>PRI BATTERY ASSEMBLY  | 28480    | 03465-80002     |
| A20B1-B4              | 1420-0224      | 4   | BATTERY CELL "D" 1.5V ("U2 IN EUROPE)    | 00000    | OBD             |
| A20A7                 | 03465-66507    | 1   | PC ASSEMBLY, DRY CELL POWER              | 28480    | 03465-66507     |
| A20A7CR1              | 1902-3182      |     | DIODE-ZNR 12.1V 5% DO-7 PD=.4W TC=+.064% | 04713    | SZ 10939-206    |
| A20A7CR2              | 1902-3182      |     | DIODE-ZNR 12.1V 5% DO-7 PD=.4W TC=+.064% | 04713    | SZ 10939-206    |
| A20A7R1-A20A7R4       | 0683-2265      | 4   | RESISTOR 22M 5% .25W FC TC=-900/+1200    | 01121    | CB2265          |
| A20A7S1               | 3101-2027      |     | SWITCH, PUSHBUTTON                       | 28480    | 3101-2027       |
|                       |                |     | A20 ASSEMBLY MISCELLANEOUS PARTS         |          |                 |
|                       | 7185-0086      | 1   | ROD-BRASS                                | 28480    | 7185-0086       |
|                       | 1460-1428      | 1   | BATTERY CONTACT SPRING                   | 28480    | 1460-1428       |
|                       | 0363-0108      |     | PIN-CHARGER                              | 00160    | OBD             |
|                       | 1460-1426      | 2   | SPRING, CONTACT                          | 28480    | 1460-1426       |
|                       |                |     | MISCELLANEOUS PARTS GENERAL              |          |                 |
| J4, J5                | 03465-26001    | 2   | INSERT-TERM (V, OHM & COM)               | 28480    | 03465-26001     |
|                       | 5040-7843      | 1   | DETENT TERM                              | 28480    | 5040-7843       |
|                       | 5040-7861      | 2   | PC GUIDE (A2)                            | 28480    | 5040-7861       |
|                       | 7120-4675      | 1   | DECAL-FRONT PANEL                        | 28480    | 7120-4675       |
|                       | 03465-26002    | 1   | INSERT-TERMINAL BATTERY                  | 28480    | 03465-26002     |
|                       | 5040-7928      | 1   | TERMINAL-FUSED CAP (A)                   | 28480    | 5040-7928       |
| J6                    | 5040-7928      | 1   | TERMINAL-FUSED CAP (A)                   | 28480    | 03465-26003     |
|                       | 5040-7922      | 1   | LENS, FRONT, RED                         | 28480    | 5040-7922       |
|                       | 03465-00601    | 1   | SWITCH, SHIELD                           | 28480    | 03465-00601     |
| W1                    | 03465-61602    |     | CABLE ASSY, 25-PIN(INCLUDES P2, P3)      | 28480    | 03465-61602     |
| P2, P3                | 1251-4113      |     | PC BOARD CONNECTOR-25-PIN                | 28480    | 1251-4113       |
| F1                    | 2110-0002      | 1   | FUSE 2A 250V 1.25X.25                    | 71400    | AGC-2           |
|                       |                |     | IEC (AMPS PROTECTION)                    |          |                 |
|                       | 2360-0372      | 4   | SCREW-MACH PLASTIC                       | 28480    | 2360-0372       |

Table 6-3. Replaceable Parts.

| REFERENCE DESIGNATOR | -hp- PART NO. | TQ | DESCRIPTION                             | MFR.  | MFR. PART NO. |
|----------------------|---------------|----|-----------------------------------------|-------|---------------|
| MP1                  | 0370-2625     | 1  | MECHANICAL PARTS LIST                   | 28480 | 0370-2625     |
| MP2                  | 0370-2486     | 12 | KEY, CAP (WHITE) (OFF/ON)               | 28480 | 0370-2486     |
| MP3                  | 5040-7824     | 1  | PUSHBUTTON (SOLID GREY)(FUNC. & RANGE)  | 28480 | 5040-7824     |
| MP4                  | 5020-8813     | 1  | FRONT PANEL                             | 28480 | 5020-8813     |
| MP5                  | 5040-7203     | 1  | FRONT FRAME                             | 28480 | 5040-7203     |
| MP6                  | 5040-7208     | 1  | TRIM-TOP                                | 28480 | 5040-7208     |
| MP7                  | 5040-7208     | 1  | TOP COVER                               | 28480 | 5040-7208     |
| MP8a                 | 5040-7852     | 2  | BATTERY ACCESS DOOR LOCK (OPT. 002)     | 28480 | 5040-7852     |
| MP8b                 | T46994        | 1  | REAR PANEL (STD OR OPTION 001)          | 28480 | T46994        |
| MP9a                 | 5040-7850     | 1  | REAR PANEL (OPTION 002 ONLY)            | 28480 | 5040-7850     |
| MP9b                 | 5040-7971     | 1  | BATTERY ACCESS DOOR (STD OR OPTION 001) | 28480 | 5040-7971     |
| MP10                 | 5040-7851     | 1  | BATTERY ACCESS DOOR (OPTION 002 ONLY)   | 28480 | 5040-7851     |
| MP11                 | 5040-7212     | 2  | SIDE COVER                              | 28480 | 5040-7212     |
| MP12                 | 03465-00602   | 1  | BOTTOM SHIELD                           | 28480 | 03465-00602   |
| MP13                 | 5040-7209     | 1  | BOTTOM COVER                            | 28480 | 5040-7209     |
| MP14                 | 5001-0438     | 2  | TRIM STRIP                              | 28480 | 5001-0438     |
| MP15                 | 1460-1345     | 2  | WIREFORM TILT STAND                     | 28480 | 1460-1345     |
| MP16                 | 5040-7201     | 4  | FOOT                                    | 28480 | 5040-7201     |
| MP17                 | 5040-7970     | 6  | PC BOARD GUIDES                         | 28480 | 5040-7970     |
| MP18                 | 03465-00603   | 1  | TOP SHIELD                              | 28480 | 03465-00603   |
| MP19                 | 03465-00601   | 1  | SWITCH SHIELD                           | 28480 | 03465-00601   |



3465-B-440I

## SECTION VII

### TROUBLESHOOTING AND CIRCUIT DIAGRAMS

#### 7-1. INTRODUCTION.

7-2. This section of the manual contains troubleshooting information, the functional block diagram and circuit diagrams for the Multimeter. The troubleshooting paragraphs are divided into three parts:

1. Preliminary troubleshooting
2. Analog troubleshooting
3. Digital troubleshooting

Additional troubleshooting information is located on the block diagram and individual circuit diagrams in the form of dc voltage levels and notes.

#### 7-3. SCHEMATIC DIAGRAMS.

7-4. The schematic diagrams (Figure 7-2 through Figure 7-5) contained in this section illustrate the circuits of the Multimeter. Components marked with an asterisk are those that are critical in value. Some of these "starred" components are part of an adjustment procedure. A method for selecting the correct value is outlined in the adjustment procedures of Section V, if service in these circuit areas is required.

#### WARNING

*Maintenance procedures of Sections V and VII are intended for qualified service personnel only. To reduce the possibility of electrical shock, only qualified personnel are to perform maintenance duties.*

#### 7-5. PRELIMINARY TROUBLESHOOTING.

7-6. Preliminary troubleshooting consists of verifying the + 11 V, + 10 V reference, - 7 V and - 12 V power supply voltages. These voltages must be established prior to analog or digital troubleshooting. If power supply voltages are not present on a battery operated Multimeter, low battery voltage can be responsible. Verify low battery voltage by the procedure of Section III under the paragraph concerning low battery voltage detection. After all power supply voltages have been established, the problem must be isolated to the analog or digital and display section. This is accomplished by moving the ANALOG/DIGITAL ISOLATION JUMPER (located near crystal Y1). Disconnect test point CP from test point COMP and connect CP to test point PL. This action isolates the digital and display section from the analog circuits and provides a simulated zero cross-over pulse to the digital circuits for digital troubleshooting.

#### 7-7. ANALOG TROUBLESHOOTING.

7-8. After the power supply voltages are established, analog troubleshooting should proceed using schematics 1 and 2. Failure symptoms should indicate whether the failure is in the signal conditioning circuits (input attenuator, current shunts, ohms converter and ac-to-dc converter) of schematic 1 or the input amplifier and A-D converter of schematic 2. A total failure (all functions inoperative) indicates the input amplifier or A-D converter of schematic 2 is defective.

7-9. A normal input signal may be applied through the front panel terminals of the instrument and half-splitting techniques applied to the analog circuitry when troubleshooting.

#### NOTE

*If the ACA and DCA functions alone are inoperative, check the 2 A fuse located in the front panel AMPS terminal.*

Refer to schematic notes and voltages for additional information when troubleshooting a particular circuit area.

#### 7-10. DIGITAL TROUBLESHOOTING.

#### CAUTION

*This instrument contains CMOS digital IC's and, therefore, is highly susceptible to failure due to static discharge. Extra handling precautions should be used when servicing circuit areas containing these devices.*

7-11. The need for digital troubleshooting is indicated by the failure of one or more of the following verification steps. The verification steps are divided into four areas:

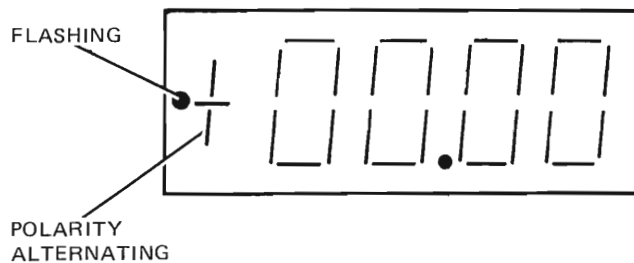
1. Polarity, zero detect and clock circuit verification.
2. Analog switch lines/control state counter verification.
3. Data accumulator input/output verification.
4. Display and display driver verification.

The procedure for checking the verification steps is

initiated by establishment of all power supply voltages and placement of the ANALOG/DIGITAL ISOLATION JUMPER from test point CP to test point PL. Place the front panel controls in the following positions:

POWER ..... ON  
 FUNCTION ..... DC Volts  
 RANGE ..... 100 m

7-12. The first indication that the digital and display section is functioning properly will be a front panel display of



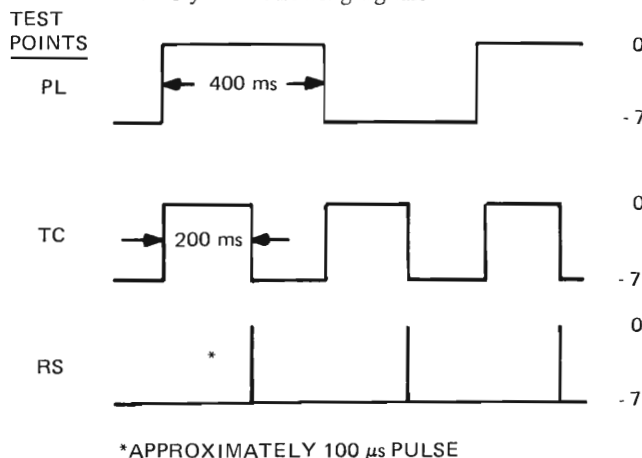
with the sample rate indicator flashing and the plus/minus indicator alternating at a 1.25 Hz rate. In the event that this verification or any of the following verifications fail, normal digital troubleshooting techniques in conjunction with schematic 3 should be used to isolate and correct the failure.

### 7-13. Polarity, Zero Detect and Clock Circuit Verification.

7-14. Maintain the ANALOG/DIGITAL ISOLATION JUMPER connection between test points CP and PL with FUNCTION and RANGE settings at DCV and 100 m respectively.

A. Verify the 100 kHz clock at test point CL.

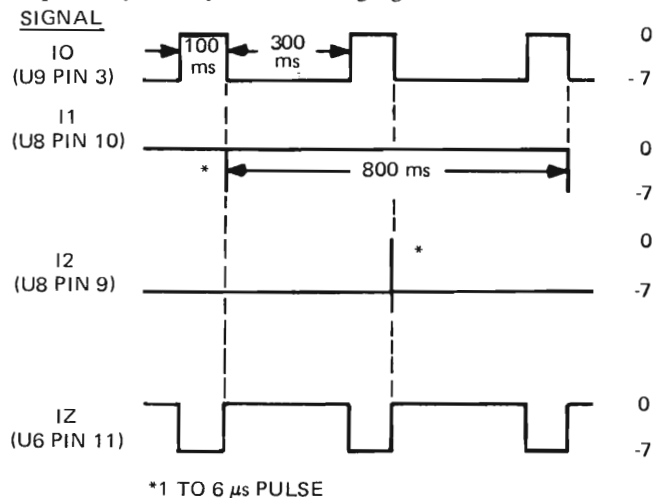
B. Verify the following signals:



If the PL, TC and RS signals are present, the polarity, zero detect and clock circuits are verified.

### 7-15. Analog Switch Lines and Control State Counter Verification.

7-16. Maintain the ANALOG/DIGITAL ISOLATION JUMPER connection between test points CP and PL with FUNCTION and RANGE settings at DCV and 100 m respectively. Verify the following signals:

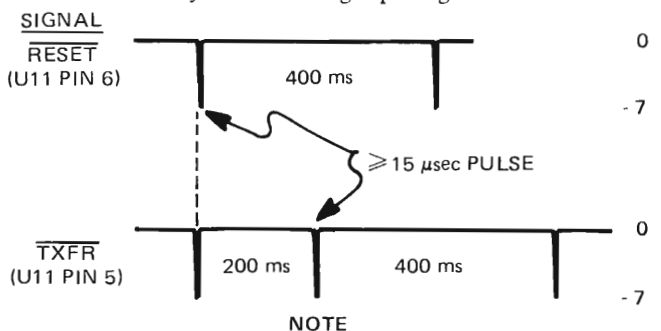


If verification of the IO, I1, I2, and IZ signals is made, the analog switch lines and control state counter are functioning.

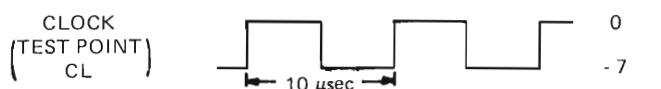
### 7-17. Data Accumulator Input/Output Verification.

7-18. Maintain the ANALOG/DIGITAL ISOLATION JUMPER connection between test points CP and PL with FUNCTION and RANGE settings at DCV and 100 m respectively. Perform the following steps:

A. Verify the following input signals:



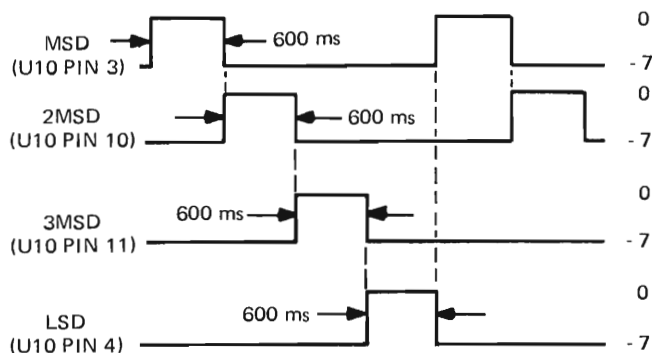
*It is essential the clock frequency be verified. An incorrect clock frequency can make U11 appear defective.*



B. Verify the following output signals:

1. Connect test point RS to -7 V and verify COUNT EXTEND output for a 10 microsecond pulse going LOW (-7 V) at A1U6 pin 10 every 0.1 seconds.

2. Remove jumper between test point RS and -7 V. Verify MSD, 2MSD, 3MSD and LSD drive lines from A1U10 as follows:



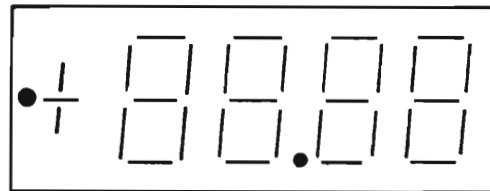
### 7-19. Display and Display Driver Verification.

7-20. There are two display driver and display verification tests that can be performed. One can be implemented from the A1 board as a quick check and the other can be used for troubleshooting and is accessed from the A2 display interface board. For both tests, maintain the ANALOG/DIGITAL ISOLATION JUMPER connection between test points CP and PL with FUNCTION and RANGE settings at DCV and 100 m respectively.

7-21. **Display and Display Driver Quick Test.** This verification test is a quick method to test the display and display driver and is implemented from the A1 board.

- A. Apply -7 V to the test point pad DT on the A1 board.

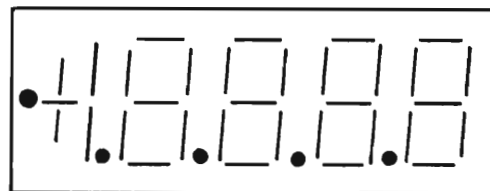
- B. Verify the display indication as illustrated below with sample rate indicator flashing and plus/minus indicator alternating.



**7-22. Display and Display Driver Verification and Troubleshooting Test.** This test should be performed in addition to the quick test to check the display and display driver. The test is also used for troubleshooting between the display driver and display LED inputs.

Implement the test as follows:

- A. Connect test point -7 and test point  $\overline{LT}$  located on the A2 display interface board.  
B. Verify display. If all drivers and LED's are functioning properly, the display will appear as follows:

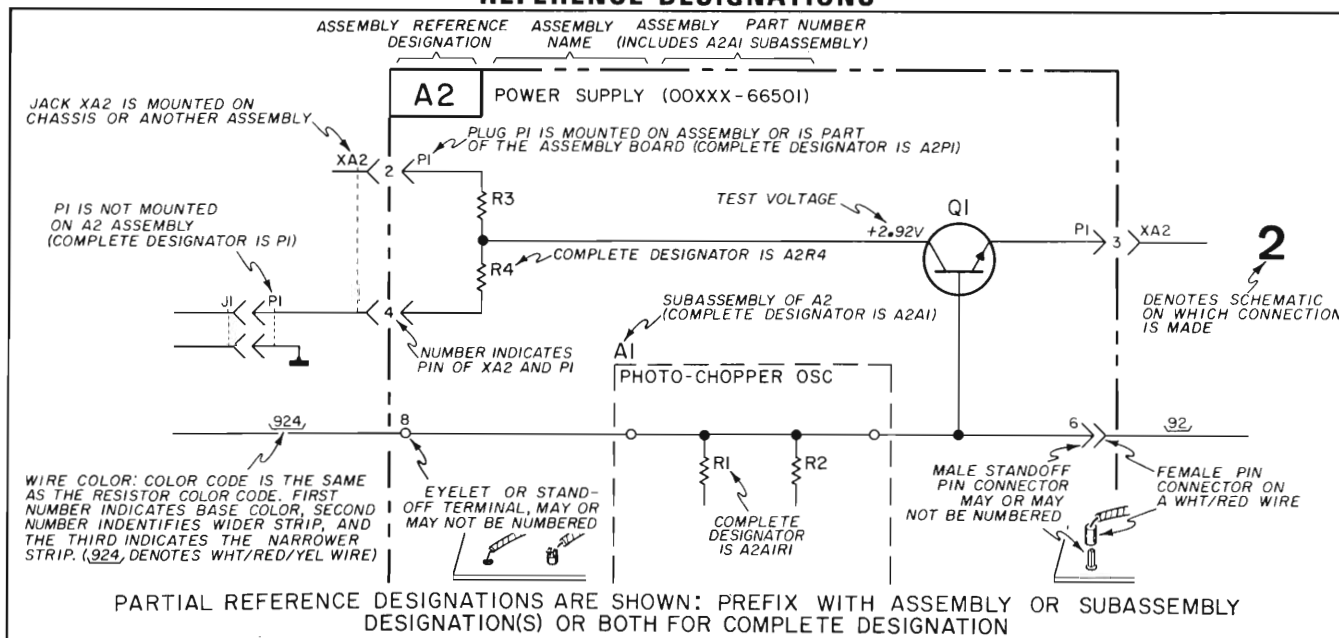


If this display is not realized, the failure can be determined by symptoms and the use of schematic 3.

### NOTE

When digital troubleshooting is completed, return the ANALOG/DIGITAL ISOLATION JUMPER to its original position (connect test point COMP to CP).

### REFERENCE DESIGNATIONS



## GENERAL SCHEMATIC NOTES

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

2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED.

RESISTANCE IN OHMS  
CAPACITANCE IN MICROFARADS  
INDUCTANCE IN MILLIHENRYS

3.  DENOTES FRAME OR SHIELD GROUND. USED FOR TERMINALS WHICH ARE PERMANENTLY CONNECTED WITHIN APPROXIMATELY 0.1 OHM OF EARTH GROUND.

 DENOTES GROUND ON PRINTED CIRCUIT ASSEMBLY.

5.  DENOTES ASSEMBLY.

6.  DENOTES FRONT PANEL MARKING.

7.  DENOTES REAR PANEL MARKING.

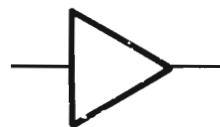
8.  DENOTES SCREWDRIVER ADJUST.

9. \* AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY. THE VALUE OF THESE COMPONENTS MAY VARY FROM ONE INSTRUMENT TO ANOTHER.

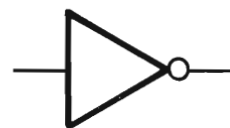
10.  DENOTES SECOND APPEARANCE OF A CONNECTOR PIN.

11. 924 DENOTES WIRE COLOR: COLOR CODE SAME AS RESISTOR COLOR CODE. FIRST NUMBER IDENTIFIES BASE COLOR, SECOND NUMBER IDENTIFIES WIDER STRIP, THIRD NUMBER IDENTIFIES NARROWER STRIP. (e.g., 924 = WHITE, RED, YELLOW.)

12. DC VOLTAGE LEVELS WERE MEASURED WITH RESPECT TO CIRCUIT GROUND USING A DVM WITH 10 MEGOHM INPUT IMPEDANCE. THE VOLTAGE LEVELS SHOWN ARE NOMINAL AND MAY VARY FROM ONE INSTRUMENT TO ANOTHER DUE TO CHANGE IN TRANSISTOR CHARACTERISTICS. A VARIATION OF  $\pm 10\%$  SHOULD BE ALLOWED.



DENOTES BUFFER

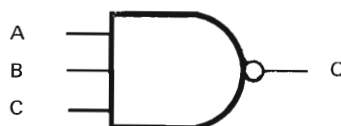


DENOTES INVERTER



DENOTES AND GATE

| A | B | C | Q |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 1 |



DENOTES NAND GATE

| A | B | C | Q |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 0 |



DENOTES NOR GATE

| A | B | C | Q |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 0 |



DENOTES EXCLUSIVE OR GATE

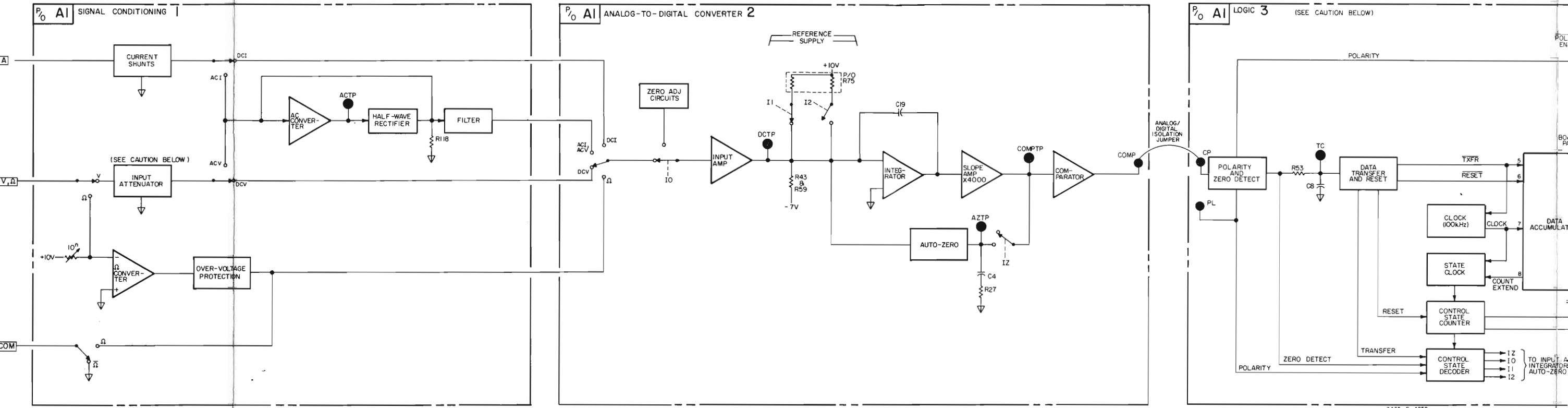
| A | B | Q |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

#### FUNCTIONAL BLOCK DIAGRAM NOTES

1. FUNCTIONAL BLOCK DIAGRAM SHOWN IN DCV FUNCTION DURING RUN-UP INTERVAL OF MEASUREMENT SEQUENCE.

2. ASSEMBLY DESIGNATION                      SCHEMATIC TITLE                      DETAILED SCHEMATIC NUMBER

|        |                     |   |
|--------|---------------------|---|
| p/o A1 | SIGNAL CONDITIONING | 1 |
|--------|---------------------|---|

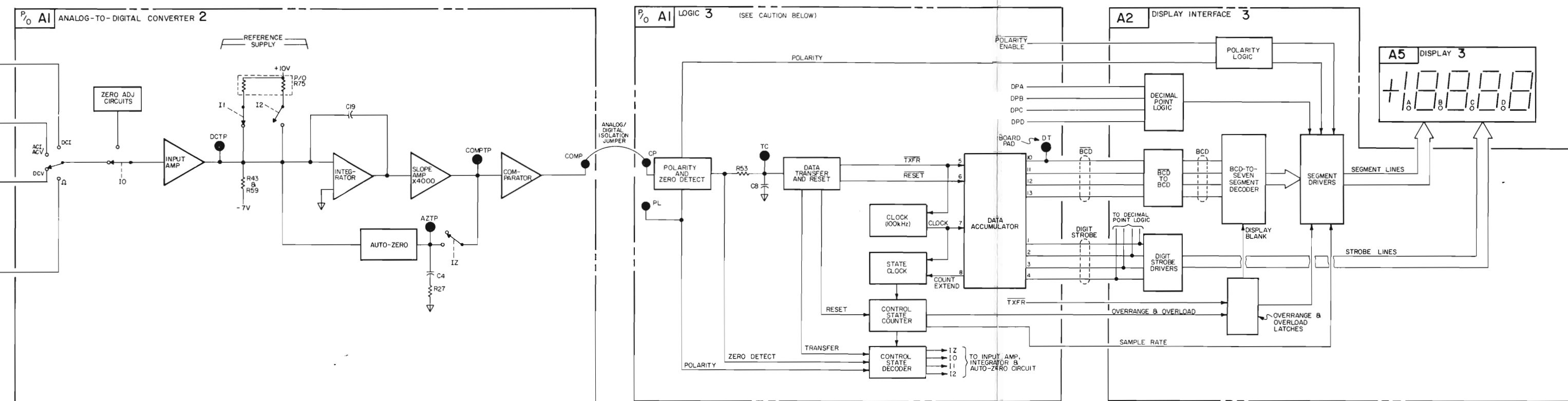


**CAUTION**

INPUT ATTENUATOR, 28 PIN CERAMIC PRECISION RESISTOR PACK (R75), MUST BE KEPT FREE OF DIRT, GREASE OR SOLDER FLUX. THESE CONTAMINANTS CAN BE ABSORBED INTO THE CERAMIC PACKAGE RESULTING IN A DEGRADATION OF THE MULTIMETER'S ENVIRONMENTAL SPECIFICATION. USE CLEAN HANDLING PROCEDURES IF THIS COMPONENT REQUIRES SERVICING (DO NOT TOUCH CERAMIC CASE WITH BARE HANDS).

**CAUTION**

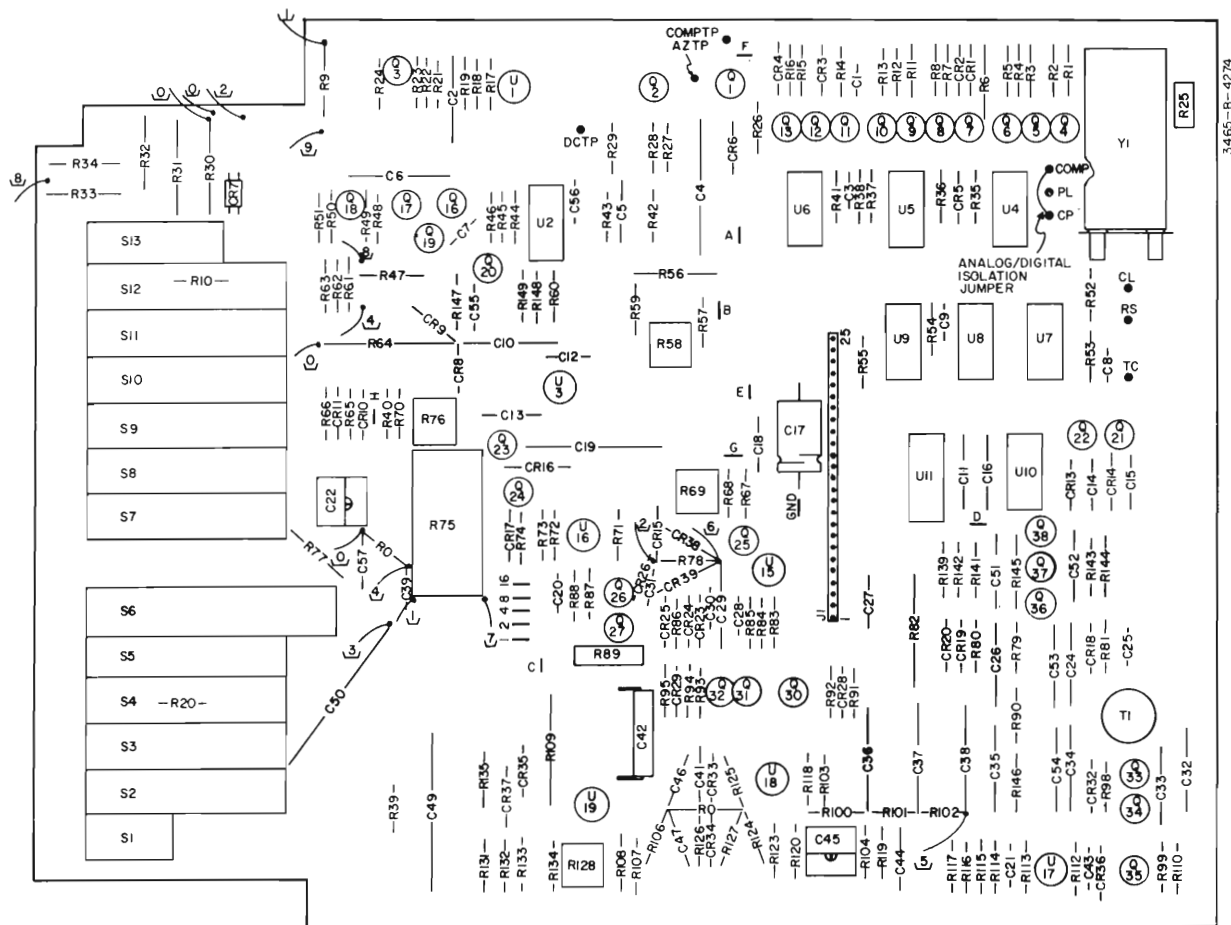
THIS INSTRUMENT CONTAINS CMOS DIGITAL IC'S AND THEREFORE IS HIGHLY SUSCEPTABLE TO FAILURE DUE TO STATIC DISCHARGE. EXTRA HANDLING PRECAUTIONS SHOULD BE USED WHEN HANDLING OR SERVICING CIRCUIT AREAS CONTAINING THESE DEVICES.



**CAUTION**

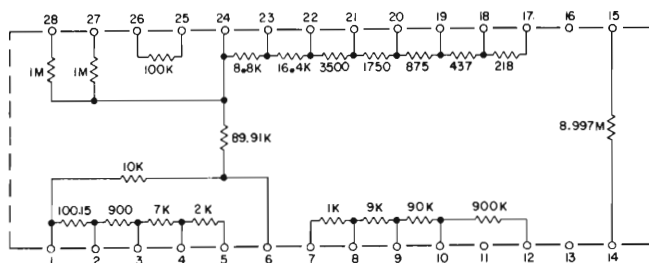
THIS INSTRUMENT CONTAINS CMOS DIGITAL IC'S AND THEREFORE IS HIGHLY SUSCEPTABLE TO FAILURE DUE TO STATIC DISCHARGE. EXTRA HANDLING PRECAUTIONS SHOULD BE USED WHEN HANDLING OR SERVICING CIRCUIT AREAS CONTAINING THESE DEVICES.

Figure 7-1. Functional Block Diagram.  
7-5/7-6



A1

hp- Part No. 03465-66501



R75  
PRECISION RESISTOR PACK  
(TOP VIEW)

3465-B-4260

## NOTES

1. SCHEMATIC NO. 1 IS SHOWN IN THE DCV FUNCTION, 1 V RANGE. AN OPERATED SWITCH ON THE A1 ASSEMBLY IS INDICATED ON ALL SCHEMATICS BY THE TERMINAL SLIDE CONNECTING THE RIGHT HALF OF THE TERMINAL SET. THE SWITCH BELOW IS SHOWN OPERATED.

| SWITCH<br>NO. | SWITCH<br>DESIG. |
|---------------|------------------|
| 1             | 1                |
| 2             | 2                |
| 3             | 3                |
| 4             | 4                |
| 5             | 5                |
| 6             | 6                |
| 7             | 7                |
| 8             | 8                |
| 9             | 9                |
| 10            | 10               |
| 11            | 11               |
| 12            | 12               |
| 13            | 13               |
| 14            | 14               |
| 15            | 15               |
| 16            | 16               |
| 17            | 17               |
| 18            | 18               |
| 19            | 19               |
| 20            | 20               |
| 21            | 21               |
| 22            | 22               |
| 23            | 23               |
| 24            | 24               |
| 25            | 25               |
| 26            | 26               |
| 27            | 27               |
| 28            | 28               |
| 29            | 29               |
| 30            | 30               |
| 31            | 31               |
| 32            | 32               |
| 33            | 33               |
| 34            | 34               |
| 35            | 35               |
| 36            | 36               |
| 37            | 37               |
| 38            | 38               |
| 39            | 39               |
| 40            | 40               |
| 41            | 41               |
| 42            | 42               |
| 43            | 43               |
| 44            | 44               |
| 45            | 45               |
| 46            | 46               |
| 47            | 47               |
| 48            | 48               |
| 49            | 49               |
| 50            | 50               |
| 51            | 51               |
| 52            | 52               |
| 53            | 53               |
| 54            | 54               |
| 55            | 55               |
| 56            | 56               |
| 57            | 57               |
| 58            | 58               |
| 59            | 59               |
| 60            | 60               |
| 61            | 61               |
| 62            | 62               |
| 63            | 63               |
| 64            | 64               |
| 65            | 65               |
| 66            | 66               |
| 67            | 67               |
| 68            | 68               |
| 69            | 69               |
| 70            | 70               |
| 71            | 71               |
| 72            | 72               |
| 73            | 73               |
| 74            | 74               |
| 75            | 75               |
| 76            | 76               |
| 77            | 77               |
| 78            | 78               |
| 79            | 79               |
| 80            | 80               |
| 81            | 81               |
| 82            | 82               |
| 83            | 83               |
| 84            | 84               |
| 85            | 85               |
| 86            | 86               |
| 87            | 87               |
| 88            | 88               |
| 89            | 89               |
| 90            | 90               |
| 91            | 91               |
| 92            | 92               |
| 93            | 93               |
| 94            | 94               |
| 95            | 95               |
| 96            | 96               |
| 97            | 97               |
| 98            | 98               |
| 99            | 99               |
| 100           | 100              |

## TERMINAL NUMBERS



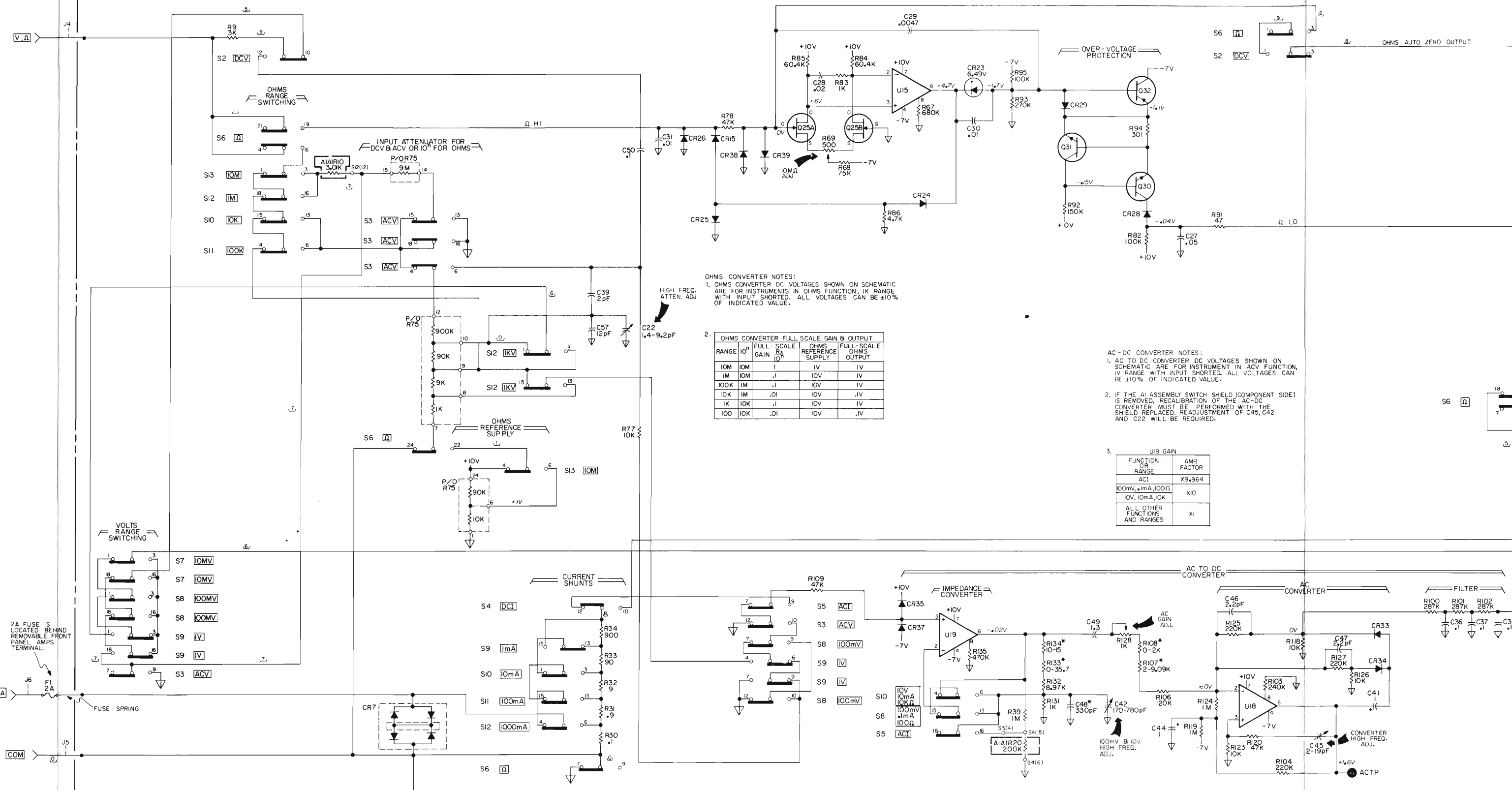
FOR EACH SET OF SWITCH TERMINALS, THE SWITCH NO. AND DESIGNATION WILL APPEAR ONCE BUT CAN APPEAR ON EITHER SIDE OF THE TERMINALS.

(SWITCH CONVENTION FOR THE A10A6 AND A20A7 ASSEMBLIES IS INDICATED BY A NOTE LOCATED ON THE RESPECTIVE SCHEMATICS.)

2. SWITCH TERMINALS ARE NUMBERED IN A COUNTER-CLOCKWISE DIRECTION WHEN VIEWING THE SWITCH BANK FROM THE COMPONENT SIDE (SEE BELOW).

[illegible]

3. COMPONENTS DESIGNATED R0 ON THE A1 COMPONENT LOCATOR ARE JUMPER WIRES IDENTIFIABLE BY ONE BLACK BAND. JUMPERS TO BE USED AS AN AID TO TROUBLESHOOTING ARE DESIGNATED BY LETTERS (A THROUGH G, ALSO J) AND THEIR LOCATION IS SHOWN ON THE A1 COMPONENT LOCATOR.



OHMS CONVERTER NOTES:  
1. OHMS CONVERTER DC VOLTAGES SHOWN ON SCHEMATIC ARE FOR INSTRUMENTS IN OHMS FUNCTION. 1K RANGE WITH INPUT SHORTED. ALL VOLTAGES CAN BE  $\pm 10\%$  OF INDICATED VALUE.

2. OHMS CONVERTER FULL SCALE GAIN & OUTPUT

| RANGE | 10 <sup>n</sup> | FULL-SCALE GAIN | OHMS REFERENCE SUPPLY | FULL-SCALE OHMS OUTPUT |
|-------|-----------------|-----------------|-----------------------|------------------------|
| 10M   | 10M             | 1               | 1V                    | 1V                     |
| 1M    | 1M              | .1              | 10V                   | 1V                     |
| 100K  | 1M              | .1              | 10V                   | 1V                     |
| 10K   | 1M              | .01             | 10V                   | .1V                    |
| 1K    | 10K             | .1              | 10V                   | 1V                     |
| 100   | 10K             | .01             | 10V                   | .1V                    |

AC-DC CONVERTER NOTES:  
1. AC-DC CONVERTER DC VOLTAGES SHOWN ON SCHEMATIC ARE FOR INSTRUMENT IN ACV FUNCTION. 1V RANGE WITH INPUT SHORTED. ALL VOLTAGES CAN BE  $\pm 10\%$  OF INDICATED VALUE.

2. IF THE AI ASSEMBLY SWITCH SHIELD (COMPONENT SIDE) IS REMOVED, RECALIBRATION OF THE AC-DC CONVERTER MUST BE PERFORMED WITH THE SHIELD REPLACED. READJUSTMENT OF C45, C42 AND C22 WILL BE REQUIRED.

3. U19 GAIN

| FUNCTION OR RANGE              | AMP FACTOR |
|--------------------------------|------------|
| ACV                            | X9.964     |
| 100mV, 1mA, 100K               | X10        |
| 10V, 10mA, 10K                 | X10        |
| ALL OTHER FUNCTIONS AND RANGES | X1         |

2A FUSE IS LOCATED BEHIND REMOVABLE FRONT PANEL AMPS TERMINAL.

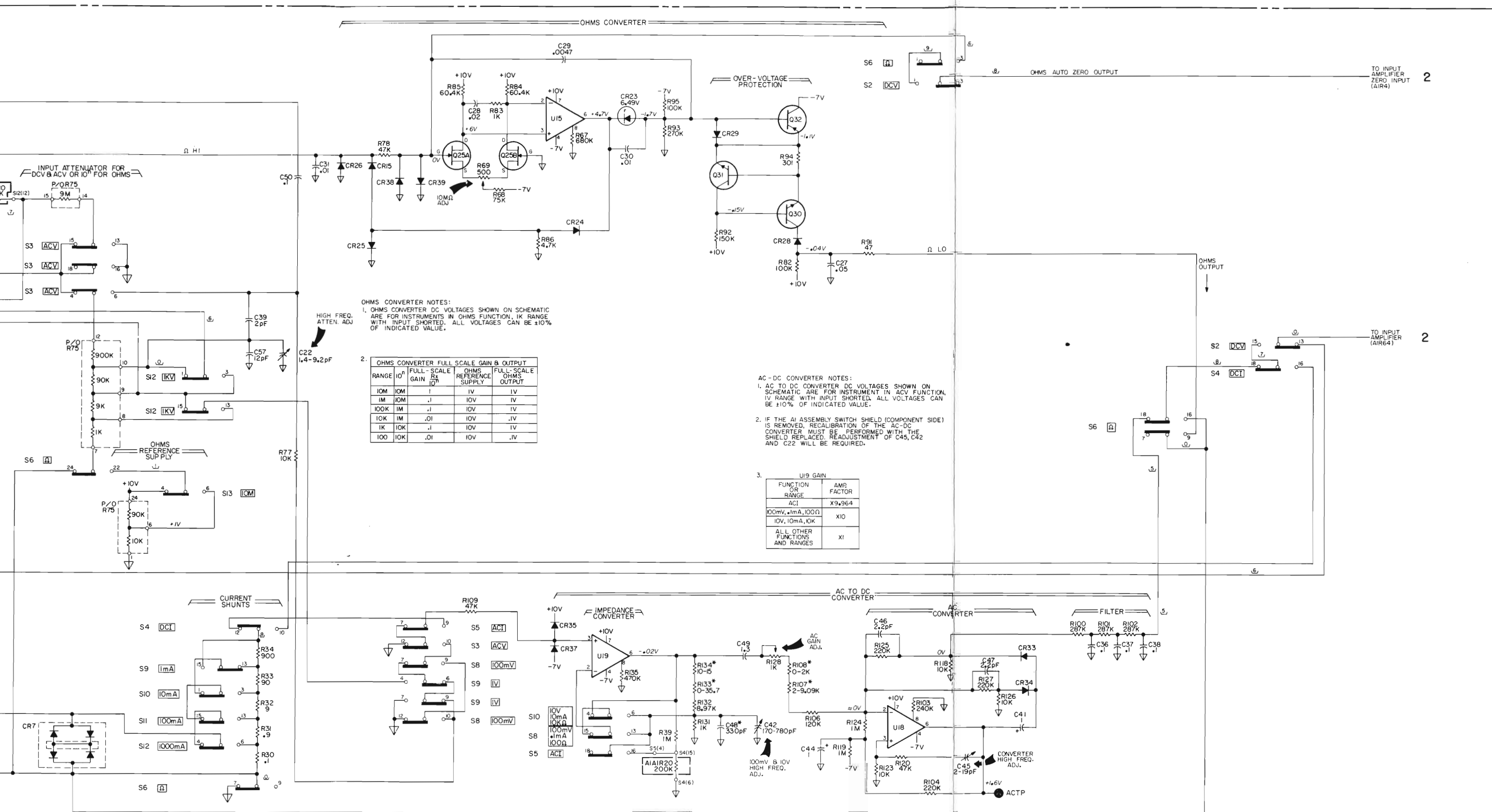
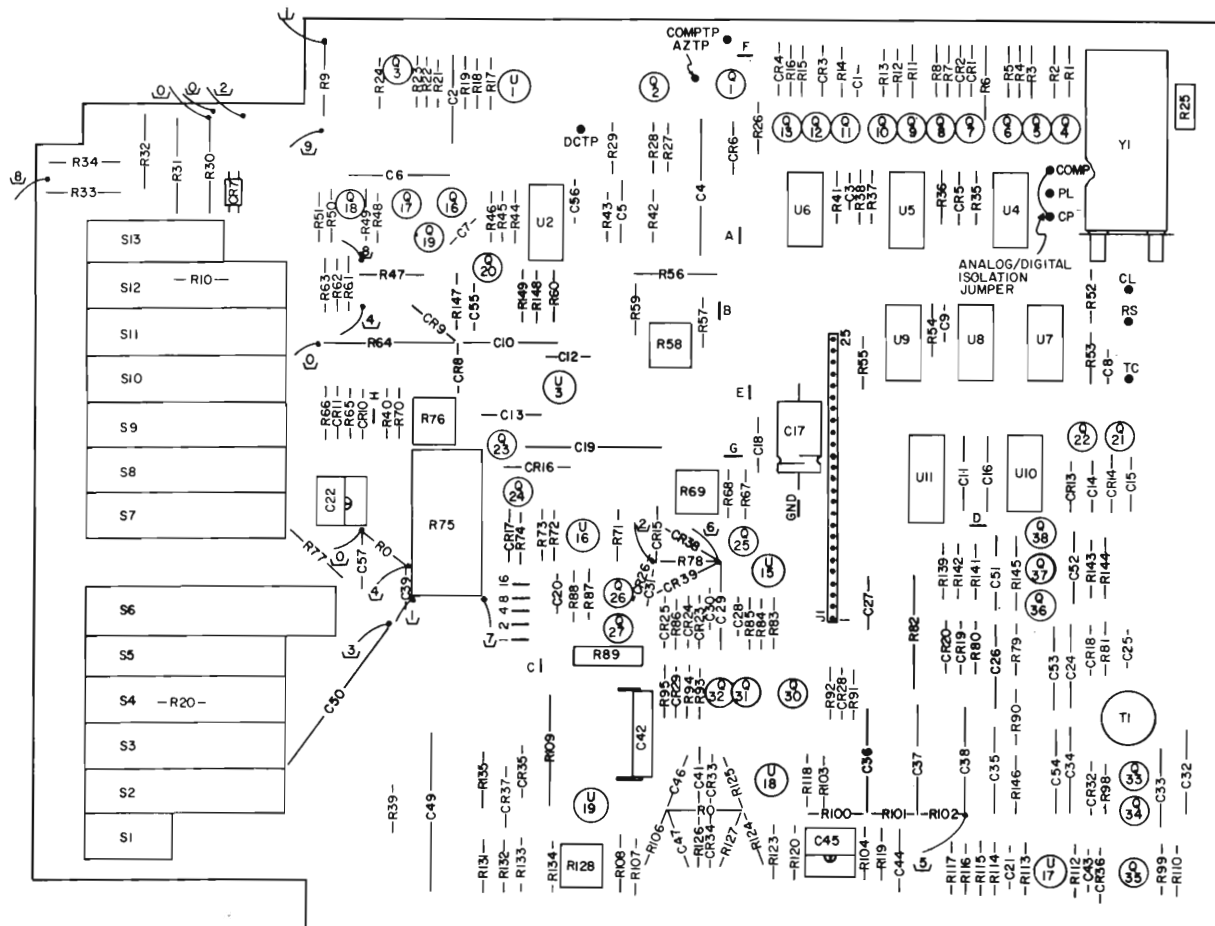
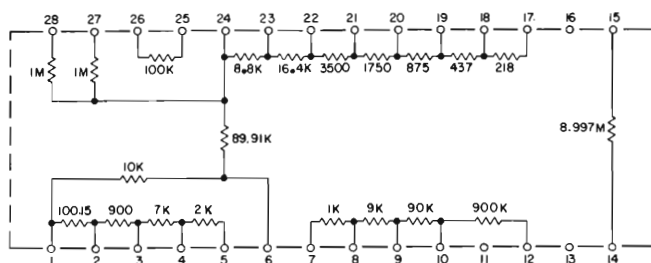


Figure 7-2. Signal Conditioning.  
7-7/7-8

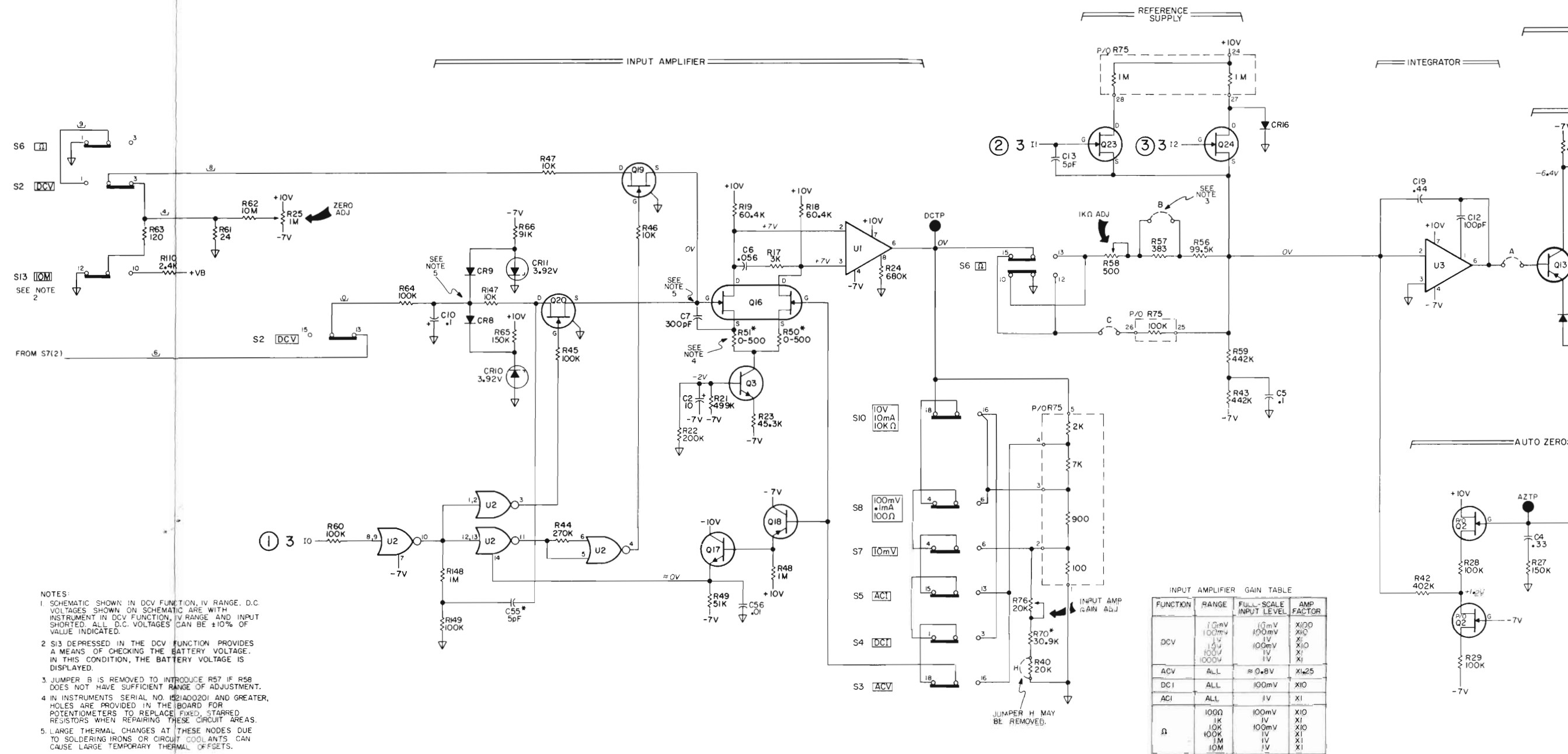


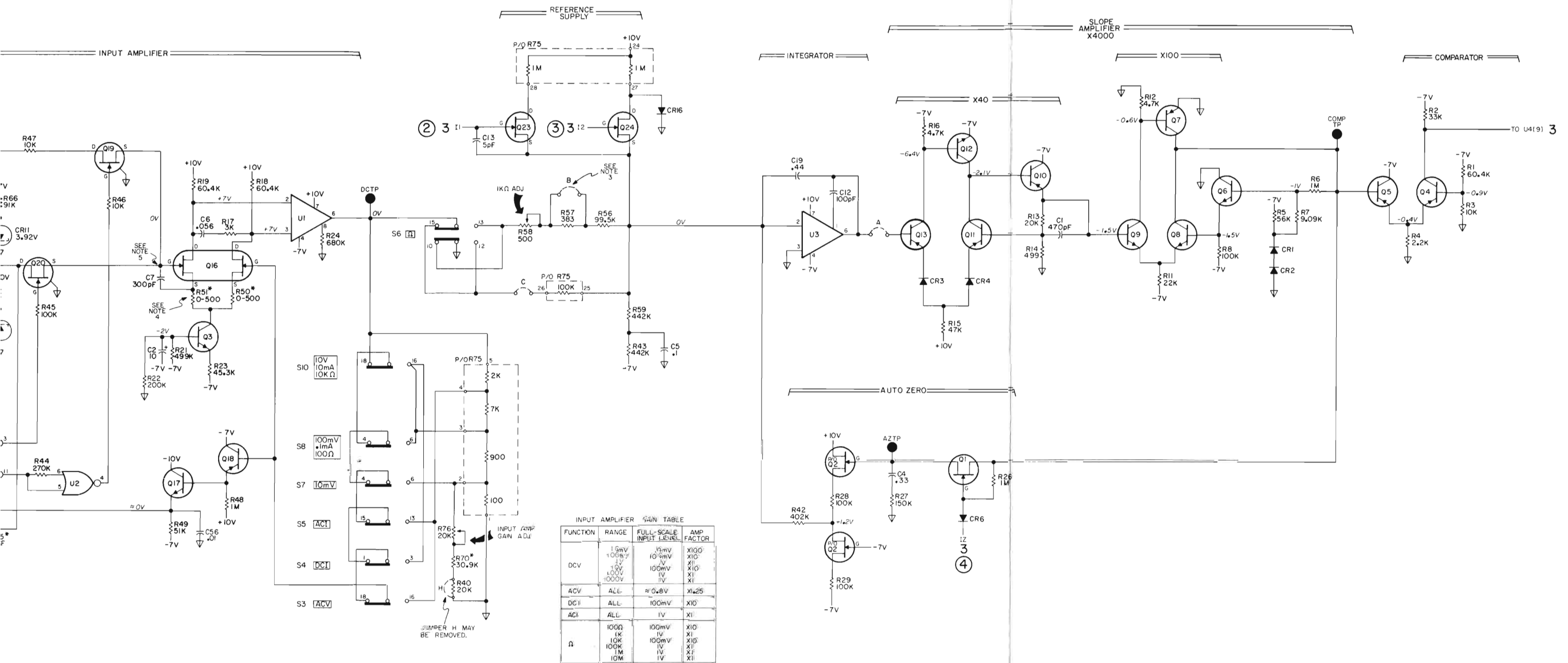
A1

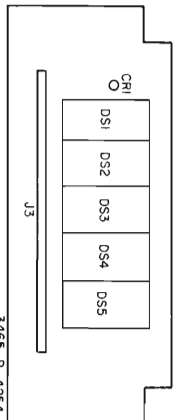
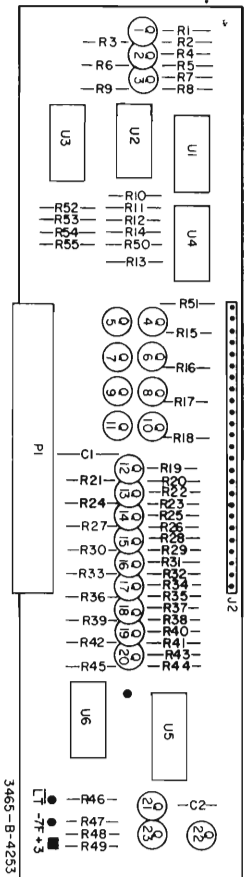
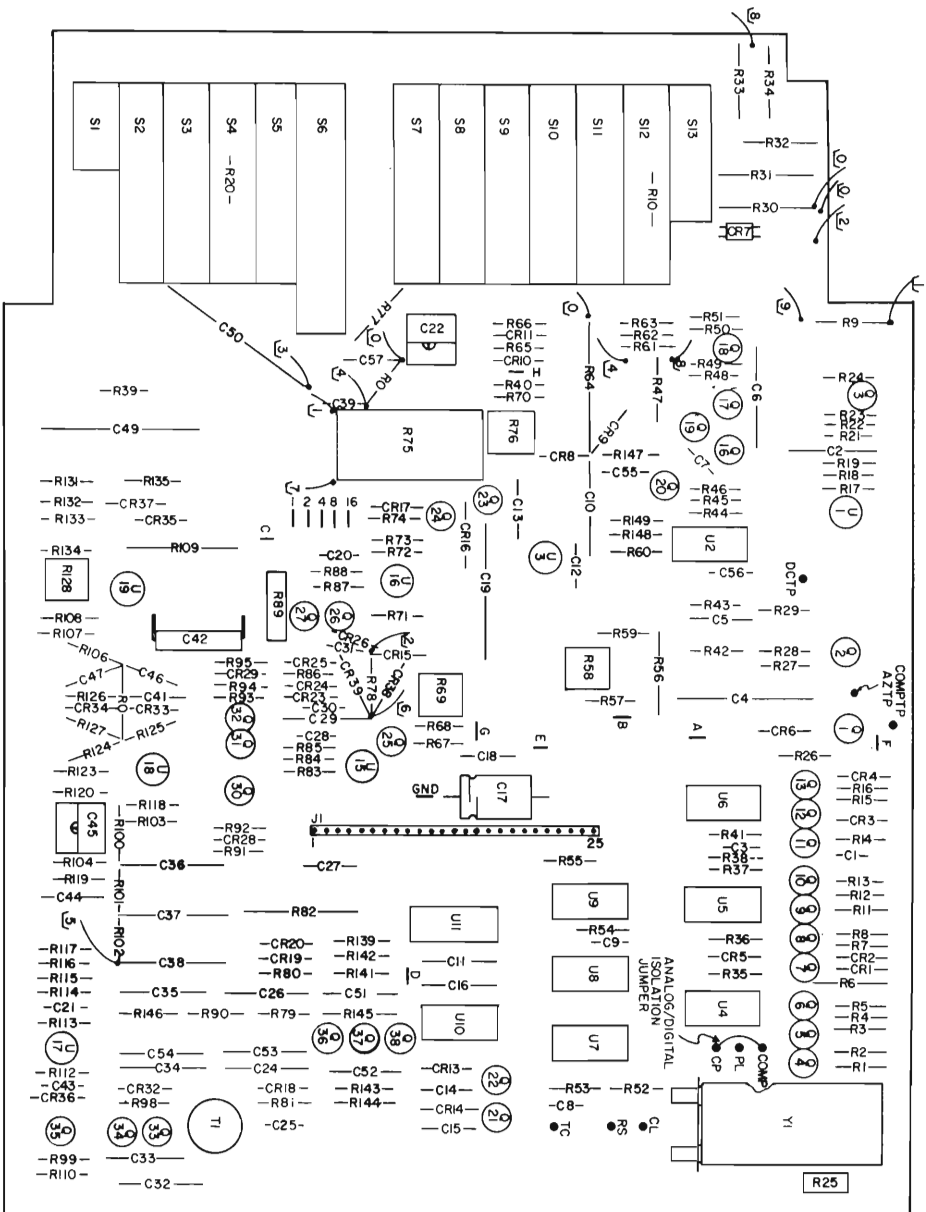
hp- Part No. 03465-66501

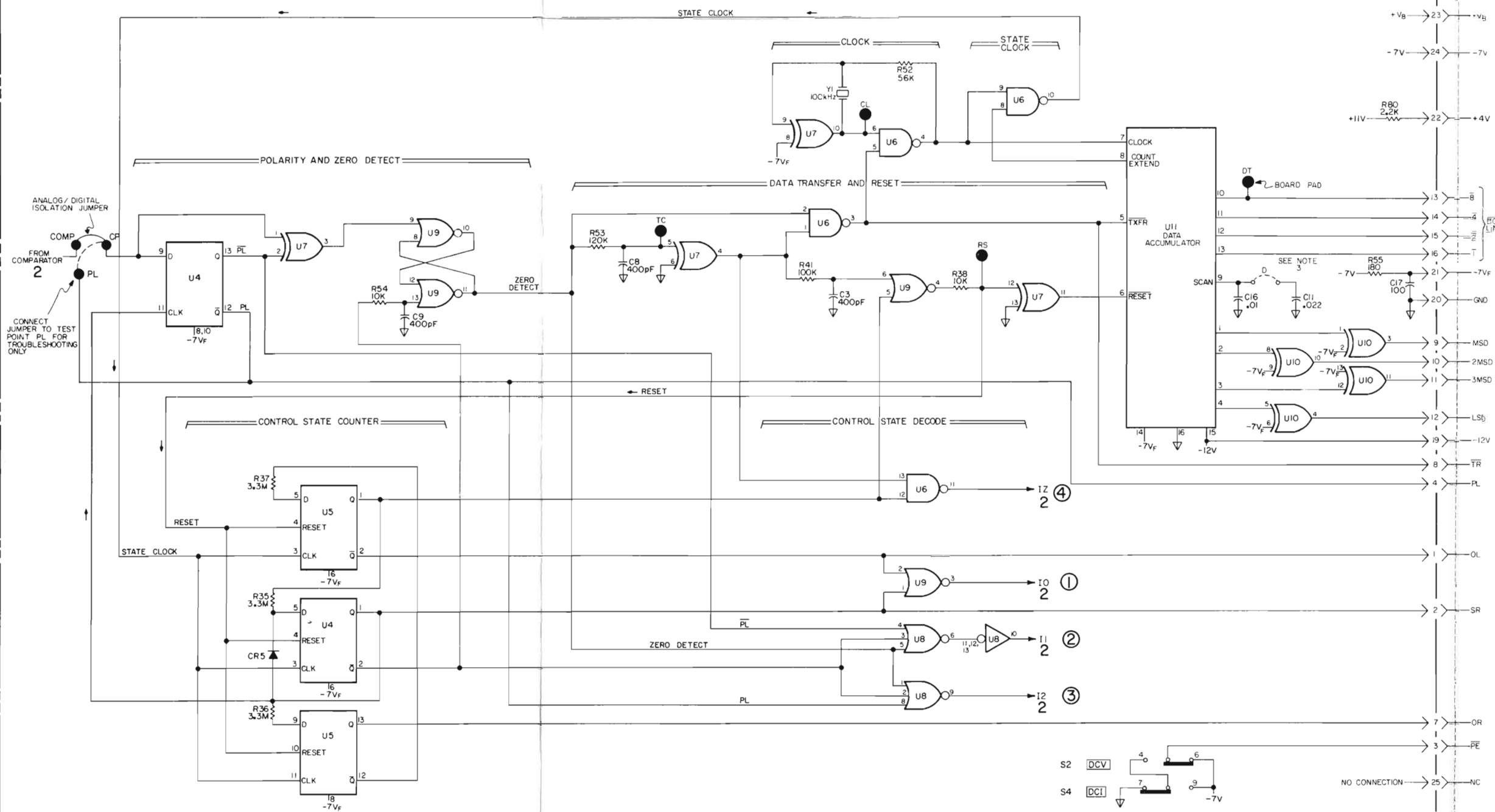


R75  
PRECISION RESISTOR PACK  
(TOP VIEW)





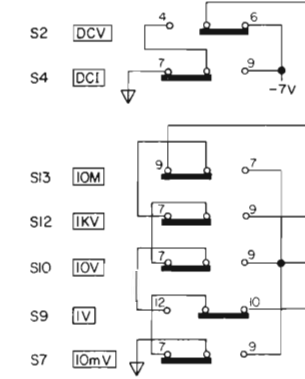




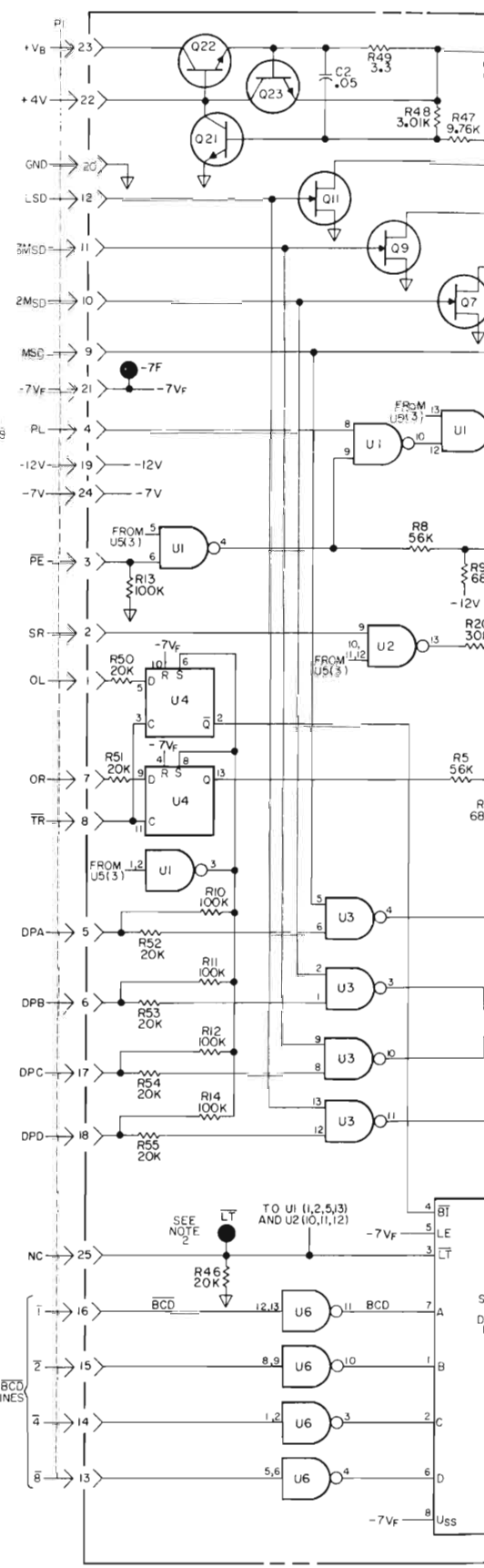
- NOTES:
- 1. SCHEMATIC SHOWN IN DCV FUNCTION, IV RANGE.
  - 2. ALL GATE PACKAGES  
PIN 7 = -7V<sub>F</sub>  
PIN 14 = GND
  - 3. JUMPER D IS REMOVED FOR LED DISPLAY.
  - 4. SEE DIGITAL TROUBLESHOOTING FOR ANALYSIS OF THIS CIRCUITRY.
  - 5.

**CAUTION**

THIS INSTRUMENT CONTAINS CMOS DIGITAL IC'S AND THEREFORE IS HIGHLY SUSCEPTIBLE TO FAILURE DUE TO STATIC DISCHARGE. EXTRA HANDLING PRECAUTIONS SHOULD BE USED WHEN HANDLING OR SERVICING CIRCUIT AREAS CONTAINING THESE DEVICES.

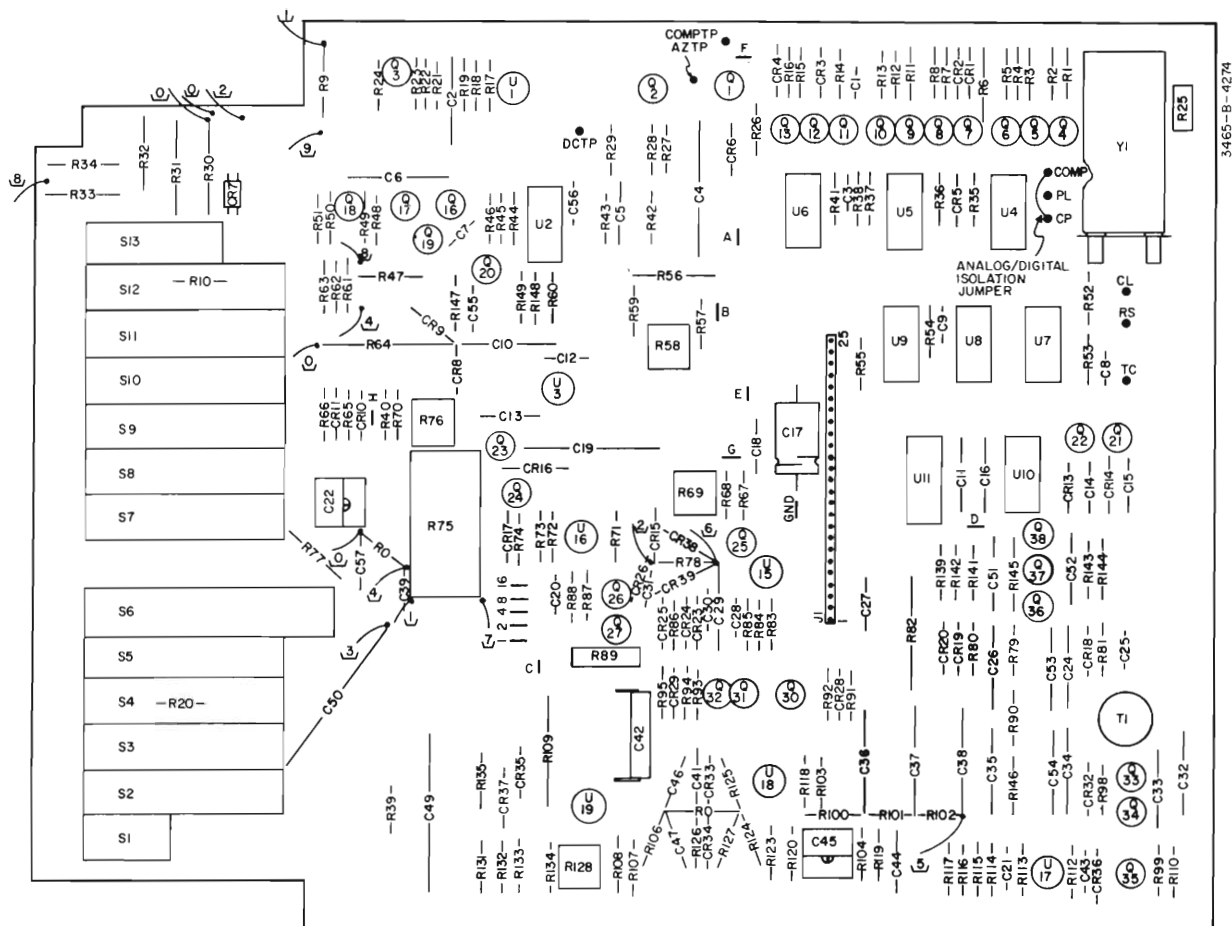


NO CONNECTION

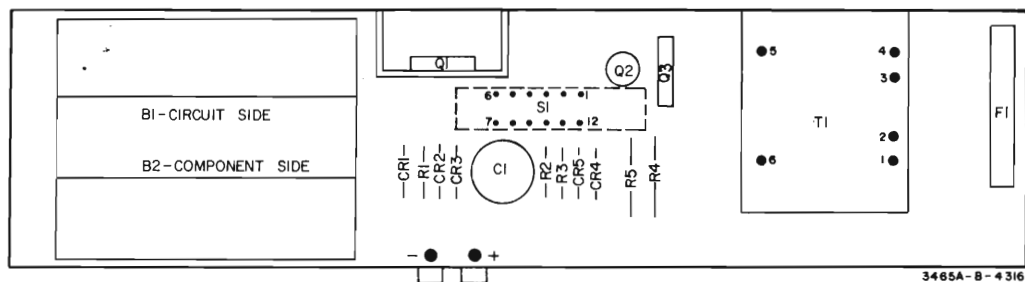




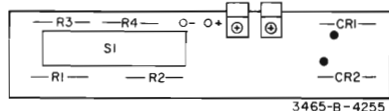
7-11/7-12



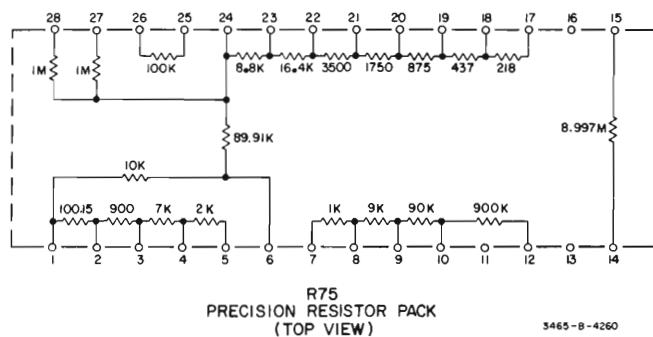
**A1**  
**-hp- Part No. 03465-66501**



**A10A6**  
-hp- Part No. 03465-66506



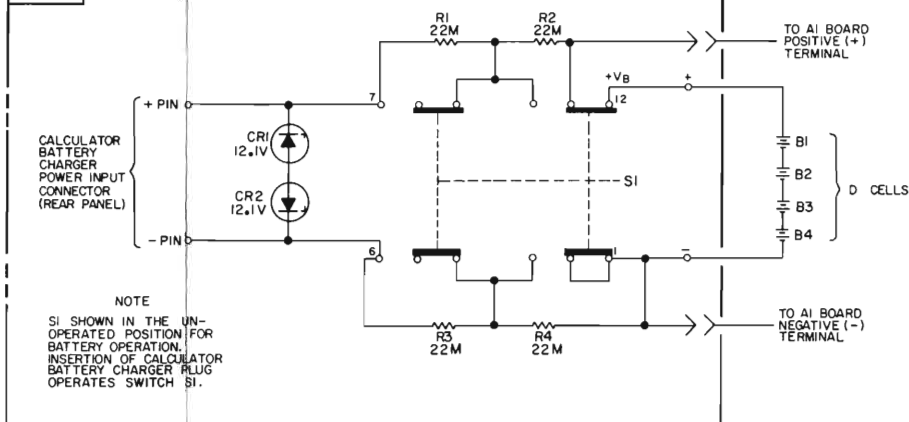
**A20A7**  
-hp- Part No. 03465-66507



A20A7

## BATTERY ELIMINATOR &amp; DRY CELL POWER SUPPLY (OPTION 002)

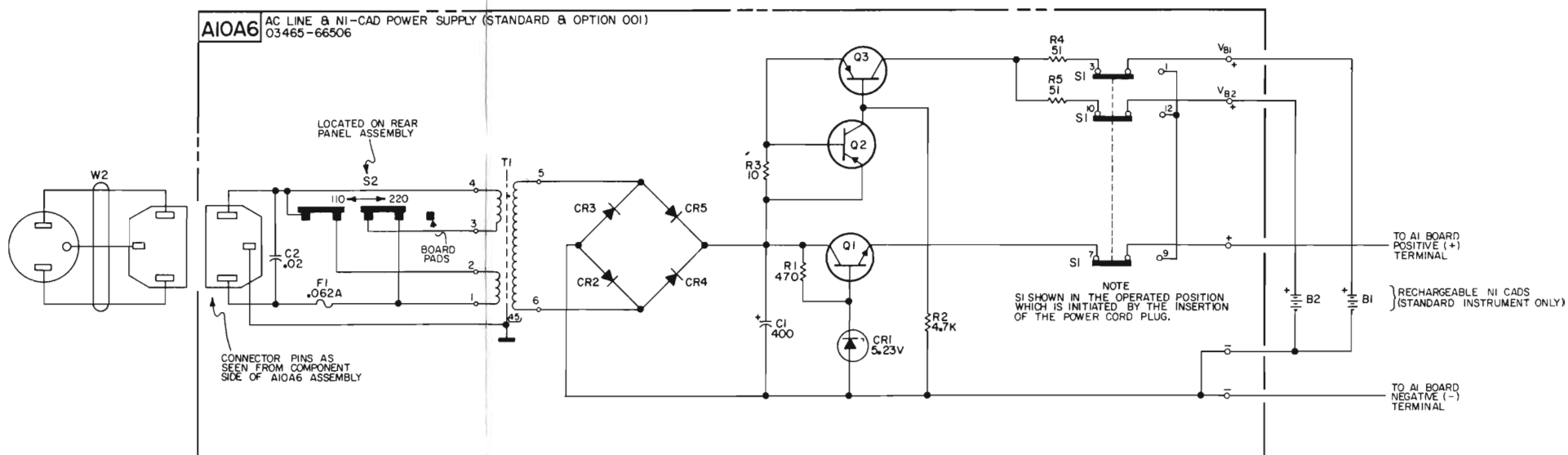
03465-66507

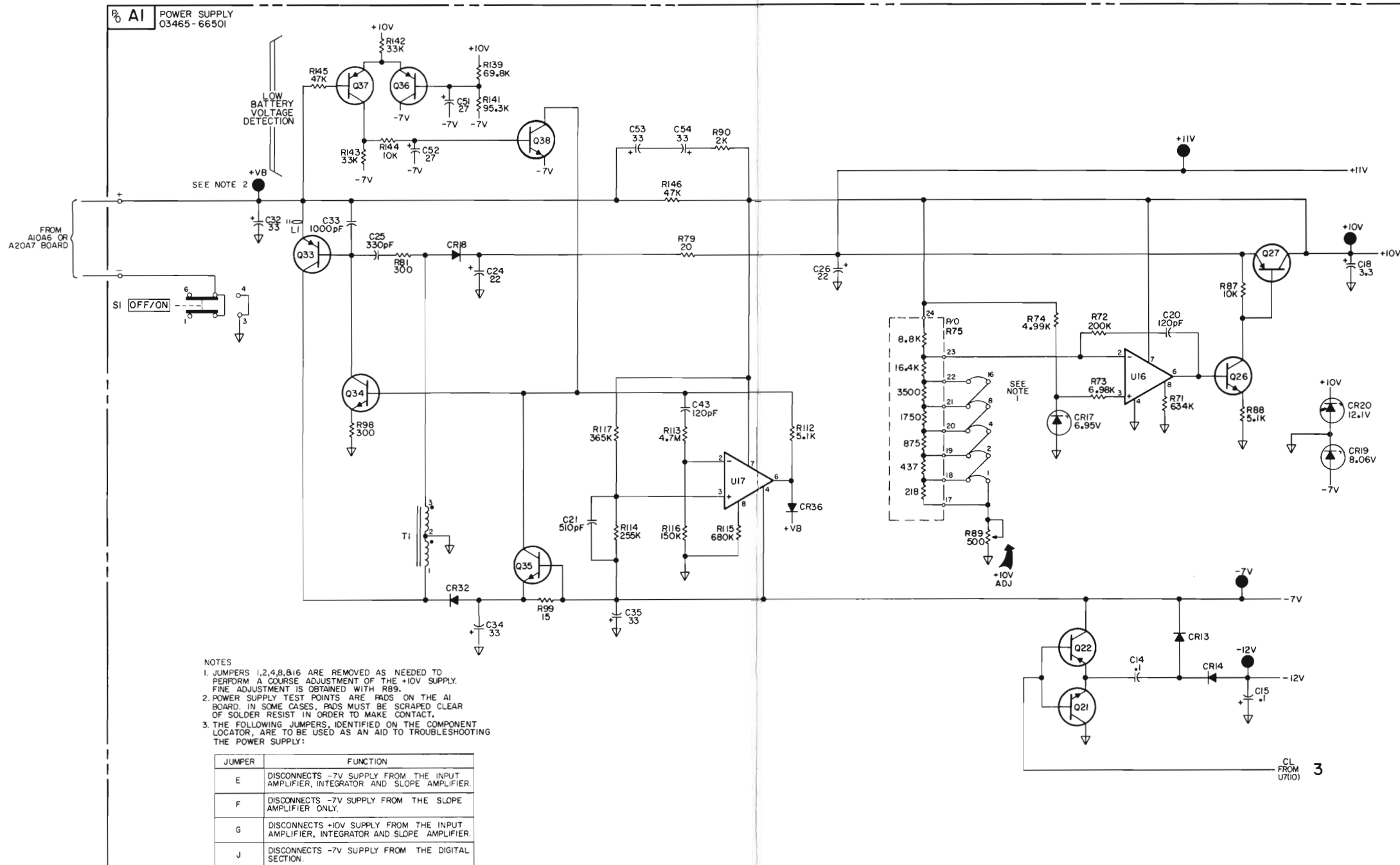


A10A6

## AC LINE &amp; NI-CAD POWER SUPPLY (STANDARD &amp; OPTION 001)

03465-66506





## SECTION VIII

### BACKDATING

#### 8-1. INTRODUCTION.

8-2. This section contains backdating information which adapts this manual to instruments with serial numbers lower than that shown on the title page.

#### 8-3. CHANGE SEQUENCE.

8-4. Changes are listed in the serial number order that they occurred in the manufacture of the instrument. However, in adapting this manual to an instrument with a particular serial number, apply the changes in reverse order. That is, begin with the latest change and progress to the earliest change applying to that serial number. Table 8-1 lists the serial numbers to which each change applies.

#### 8-5. PARTS NOT INCLUDED IN BACKDATING.

8-6. When replacing a part whose value or part number differs from the schematic diagram or parts list in this manual, yet is not listed in the following changes, use the replacement part number shown in the replaceable parts list of Section VI.

**Table 8-1. Manual Backdating Changes.**

| Instrument Serial Number                                                                                                             | Make Manual Changes |
|--------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| 1521A00101 thru<br>1521A00200                                                                                                        | 1 thru 4            |
| 1521A00255 and below<br>except suffix:<br>-00211, -00212, -00215,<br>-00220, -00227, -00230,<br>-00237, -00240, -00244<br>and -00245 | 2 thru 4            |
| 1521A00201 thru<br>1521A00400                                                                                                        | 3, 4                |
| 1521A01500 and below                                                                                                                 | 4                   |

#### CHANGE 1:

Section V. Replace Paragraphs 5-33, 5-34 and 5-39 with the following paragraphs. These paragraphs provide procedures for adjustments using fixed value resistors as opposed to potentiometers listed in Section VI.

##### 5-33. Input Amplifier Gain Adjustment (R76\*).

This adjustment is required if A1R75, Q16 or U1 is replaced. A DC Standard and a  $66.5 \text{ k}\Omega \pm 1\%$  resistor (-hp- Part No. 0698-4503) are required for this adjustment.

a. Install a  $66.5 \text{ k}\Omega \pm 1\%$  resistor in place of R76\*.

b. Set the Multimeter function to DCV (  $\text{--- V}$  ) and range to 10 m.

c. Connect a short across the input terminals (V $\Omega$  and COM) and adjust the Multimeter display for 0.000 with R25 (rear panel ZERO ADJ).

d. Remove short from input terminals and apply +10 mV to the input terminals from the DC Standard.

e. Record the Multimeter maximum display reading for use in next step.

f. Locate the maximum display reading in Table 5-9 and note the corresponding value of R-parallel (R76\*).

g. Replace the R76\*  $66.5 \text{ k}\Omega$  test resistor with R-parallel (R76\*) -hp- part number obtained from Table 5-9.

**Table 5-9. R76\* Selection.**

| Multimeter maximum display reading | R-Parallel (R76*) | -hp- Part Number |
|------------------------------------|-------------------|------------------|
| 9.993                              | 44.2 k $\Omega$   | 0698-4207        |
| 9.994                              | 46.4 k $\Omega$   | 0698-3162        |
| 9.995                              | 48.7 k $\Omega$   | 0698-4497        |
| 9.996                              | 52.3 k $\Omega$   | 0757-0272        |
| 9.997                              | 54.9 k $\Omega$   | 0698-4499        |
| 9.998                              | 57.6 k $\Omega$   | 0698-4500        |
| 9.999                              | 60.4 k $\Omega$   | 0698-3572        |
| 10.000                             | 66.5 k $\Omega$   | 0698-4503        |
| 10.001                             | 69.8 k $\Omega$   | 0698-4504        |
| 10.002                             | 75 k $\Omega$     | 0757-0462        |
| 10.003                             | 82.5 k $\Omega$   | 0757-0463        |
| 10.004                             | 90.9 k $\Omega$   | 0757-0464        |
| 10.005                             | 100 k $\Omega$    | 0757-0465        |
| 10.006                             | 110 k $\Omega$    | 0757-0466        |
| 10.007                             | 121 k $\Omega$    | 0757-0467        |

##### 5-34. Input Amplifier Balance Adjustment (R50\* and R51\*).

#### NOTE

*This adjustment does not need to be performed unless A1Q16, A1U1 or A1R75 have been replaced.*

A Digital Voltmeter, a decade resistor box and a  $100\ \Omega \pm 1\%$  resistor (-hp- Part No. 0698-7320) are required for this adjustment.

a. Install the  $100\ \Omega \pm 1\%$  resistor in the R51\* position.

b. Connect the decade resistor box in the R50\* position minimizing interconnection lead length.

c. Set Multimeter function to DCV (--- V) and range to 1 V.

d. Connect ground to the gate of A1Q16 at the junction of A1C7.

e. Connect the Digital Voltmeter to DCTP.

f. Adjust the decade resistor box for a Digital Voltmeter reading at DCTP of 0.5 mV.

g. Change Multimeter range to 100 m.

h. Verify a Digital Voltmeter reading of less than 10 mV at DCTP. If this reading is verified, go to Step j. If this reading is not realized, adjust the decade box to achieve less than 10 mV at DCTP and go to Step i.

i. Change Multimeter range to 1 V. Perform Steps f, g and h until Digital Voltmeter readings specified in these steps are attained.

j. Note the decade resistor box value required to obtain the preceding adjustment sequence.

k. Select the resistor and -hp- Part No. of the value nearest the decade resistor box value from the "R107\* and R108\* Padding List" located in the A1 Assembly Miscellaneous Parts of Table 6-3.

l. Remove the decade resistor box and the Digital Voltmeter. Install the selected padding list resistor in the R50\* position.

**5-39. AC-DC Converter X10 Gain Adjustment (R133\* and R134\*).** A Digital Voltmeter with 5-digit resolution, a DC Standard and a  $30\ \Omega \pm 1\%$  resistor, -hp- Part No. 0757-0388 are required for this adjustment.

a. Install the  $30\ \Omega \pm 1\%$  test resistor in place of R133\* and R134\*.

b. Set Multimeter function to ACV ( $\sim$  V) and range to 100 m.

c. Short the input terminals (V $\Omega$  and COM).

d. Measure and record the dc voltage at U19 pin 6. Designate this voltage  $V_1$ .

e. Apply +0.5 V dc to the input terminals with the DC Standard.

f. Measure and record the dc voltage at U19 pin 6. Designate this voltage  $V_2$ .

g. Calculate and record the gain constant (GAIN CONST.):

$$\text{GAIN CONST.} = \frac{V_2 - V_1}{0.5}$$

h. Calculate and record the R133\*, R134\* resistance total:

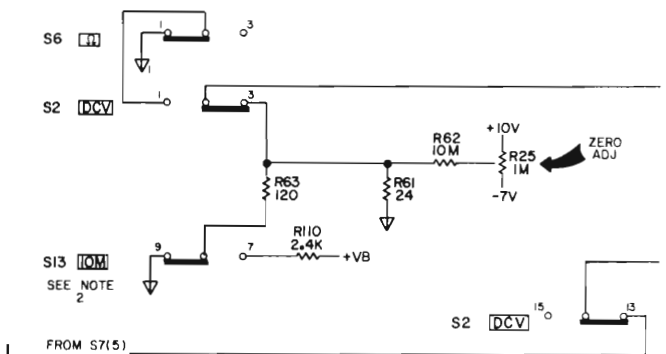
$$(R133^* + R134^*) = (30) \left( \frac{10}{\text{GAIN CONST.}} - 1 \right) (10^4)$$

i. Select a resistance combination for R133\* and R134\* nearest the  $(R133^* + R134^*)$  calculated value from the R107\*, R108\*, R133\* and R134\* Padding List located in the miscellaneous parts list of Section VI. Install the selected values.

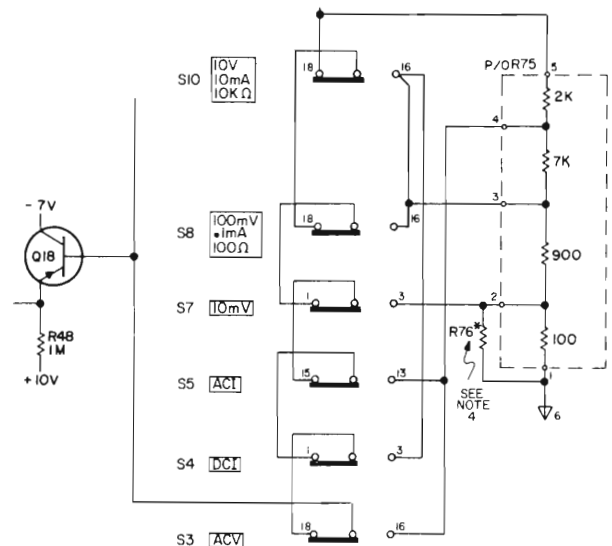
Replace Figure 7-2 (Schematic 1) with backdated Figure 8-1 (Schematic 1).

Table 6-3, Replaceable Parts. Delete A1C30 and A1R70\*. Change A1R76\* to Part No. 2100-3214, R-Var, 100kilohm. Delete the R70\* Padding List under A1 Assembly Miscellaneous Parts.

Page 7-9/7-10, Figure 7-3, Schematic No. 2. Make the following switch terminal changes:



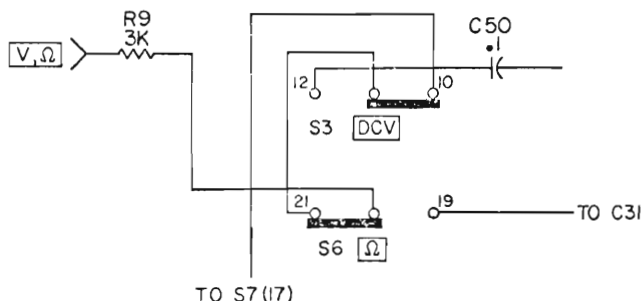
Make the following switch terminal changes, delete R70\* and change R76 to a starred value of 66.5 K:



3065-9-1270

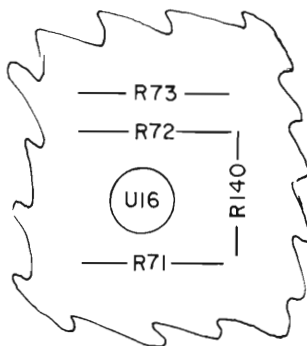
**CHANGE 2:**

Page 7-7/7-8, Figure 7-2, Schematic No. 1. The portion of input switching involving A1R9 is assembled as shown in the following diagram. This switching should be changed to agree with the corresponding portion as shown in Schematic No. 1 of Section VII.

**CHANGE 3:**

Section VI, Table 6-3, Replaceable Parts. Add R140 -hp- Part No. 0698-4530, R: fxd 232 K  $\pm$  1%. Change Part No. of A1R75, Fine Line Assy, to 1810-0228.

Section VII, Figure 7-5. Add resistor R140 (232 K) connected between R75 pins 23 and 24 in the + 10 V regulator circuit of the power supply. Location of R140 on the A1 Assembly Component Locator is as follows:



Part of A1  
Component Locator

**CHANGE 4:**

Section III, Page 3-1. Delete paragraph heading 3-9 and paragraph text 3-10.

Section IV, Page 4-11. Delete Paragraph heading 4-82 and paragraph text 4-83.

Page 5-7, Add Power Supply Zener Reference Current Adjustment (R74\*) preceding the Power Supply + 10 V Reference Voltage Adjustment.

**5-28. Power Supply Zener Reference Current Adjustment (R74\*).****NOTE**

*The Power Supply Zener Current Adjustment (R74\*) should be performed only if A1CR17 has been replaced.*

If A1CR17 is changed, R74\* should be selected and installed prior to adjusting the + 10 V reference voltage. A Digital Voltmeter is required for this adjustment.

a. Maintain existing R74\* in circuit (+ 10 V regulator adjustment jumpers 1, 2, 4, 8 and 16 are not to be changed from previous adjustment).

b. Apply power to the Multimeter.

c. Verify the power supply is operating correctly by checking the following voltages:

$$1. -7 \text{ V Supply Voltage} = -\frac{7}{10} \times +10 \text{ V Supply Voltage}$$

$$2. +11 \text{ V Supply Voltage} \cong -1.5 \times -7 \text{ V Supply Voltage}$$

$$3. (+11 \text{ V Supply Voltage}) - (+10 \text{ V Supply Voltage}) \cong 0.8 \text{ V}$$

d. Measure and record the voltage across A1CR17.

e. Calculate and record the value of R74\*:

$$R74^* = \frac{10 - V_{CR17}}{500 \mu A}$$

f. Select the resistor and part number of the value nearest to that calculated in the previous step from the R74\* Padding List located in the A1 Assembly Miscellaneous Parts List of Section VI. Replace R74\* if required.

Page 5-8, Paragraph 5-29 Step e. Change A1CR17 zener voltage to 6.4 V  $\pm$  5%.

Page 5-9, Table 5-8. Replace table and Notes 1 and 2 with the following:

**Table 5-8. Power Supply Jumpers.**

| READING |        | POWER SUPPLY JUMPER |   |   |   |   |
|---------|--------|---------------------|---|---|---|---|
| LO      | HI     | 16                  | 8 | 4 | 2 | 1 |
| NOTE 1  | .8839  | 0                   | 0 | 0 | 0 | 0 |
| .8840   | .8866  | 0                   | 0 | 0 | 0 | 1 |
| .8867   | .8893  | 0                   | 0 | 0 | 1 | 0 |
| .8894   | .8920  | 0                   | 0 | 0 | 1 | 1 |
| .8921   | .8948  | 0                   | 0 | 1 | 0 | 0 |
| .8949   | .8977  | 0                   | 0 | 1 | 0 | 1 |
| .8978   | .9006  | 0                   | 0 | 1 | 1 | 0 |
| .9007   | .9036  | 0                   | 0 | 1 | 1 | 1 |
| .9037   | .9066  | 0                   | 1 | 0 | 0 | 0 |
| .9067   | .9097  | 0                   | 1 | 0 | 0 | 1 |
| .9098   | .9128  | 0                   | 1 | 0 | 1 | 0 |
| .9129   | .9160  | 0                   | 1 | 0 | 1 | 1 |
| .9161   | .9193  | 0                   | 1 | 1 | 0 | 0 |
| .9194   | .9227  | 0                   | 1 | 1 | 0 | 1 |
| .9228   | .9261  | 0                   | 1 | 1 | 1 | 0 |
| .9262   | .9296  | 0                   | 1 | 1 | 1 | 1 |
| .9297   | .9331  | 1                   | 0 | 0 | 0 | 0 |
| .9332   | .9368  | 1                   | 0 | 0 | 0 | 1 |
| .9369   | .9405  | 1                   | 0 | 0 | 1 | 0 |
| .9406   | .9443  | 1                   | 0 | 0 | 1 | 1 |
| .9444   | .9482  | 1                   | 0 | 1 | 0 | 0 |
| .9483   | .9521  | 1                   | 0 | 1 | 0 | 1 |
| .9522   | .9562  | 1                   | 0 | 1 | 1 | 0 |
| .9563   | .9604  | 1                   | 0 | 1 | 1 | 1 |
| .9605   | .9646  | 1                   | 1 | 0 | 0 | 0 |
| .9647   | .9690  | 1                   | 1 | 0 | 0 | 1 |
| .9691   | .9734  | 1                   | 1 | 0 | 1 | 0 |
| .9735   | .9780  | 1                   | 1 | 0 | 1 | 1 |
| .9781   | .9827  | 1                   | 1 | 1 | 0 | 0 |
| .9828   | .9874  | 1                   | 1 | 1 | 0 | 1 |
| .9875   | .9924  | 1                   | 1 | 1 | 1 | 0 |
| .9925   | NOTE 2 | 1                   | 1 | 1 | 1 | 1 |

"0" = Remove Jumper

"1" = Leave Jumper In Place

NOTE 1. For Readings less than .8788, adjustment cannot be made. Check A1CR17 zener voltage for 6.4 V  $\pm$  5%, A1R75 and A1U16.

NOTE 2. Adjustment cannot be made for readings greater than 1.0000. Check A1CR17 for 6.4 V  $\pm$  5%, A1R75 and A1U16.

Section VI, Table 6-3. Change A1CR17 to Part No. 1902-0649, Diode-Znr 1N4567 6.4 V 5%. Change A1R72 to Part No. 0698-4531, Res 267 K 1% .125W. Change A1R73 to Part No. 0698-3498, Res 8.66 K 1% .125W. Change A1R74 to a starred value (A1R74\*) with the following padding list:

**R74\*, PADDING LIST FOR R74\***

0698-3226, R:Fxd Met Flm 6.49 K Ohm 1% 1/8W, 28480, 0698-3226  
 0698-3484, R:Fxd Met Flm 6.65 K Ohm 1% 1/8W, 28480, 0698-3484  
 0757-0439, R:Fxd Met Flm 6.81 K Ohm 1% 1/8W, 28480, 0757-0439  
 0698-4470, R:Fxd Met Flm 6.98 K Ohm 1% 1/8W, 28480, 0698-4470  
 0698-4471, R:Fxd Met Flm 7.15 K Ohm 1% 1/8W, 28480, 0698-4471  
 0698-3518, R:Fxd Met Flm 7.32 K Ohm 1% 1/8W, 28480, 0698-3518  
 0757-0440, R:Fxd Met Flm 7.50 K Ohm 1% 1/8W, 28480, 0757-0440  
 0698-4472, R:Fxd Met Flm 7.68 K Ohm 1% 1/8W, 28480, 0698-4472  
 0698-3259, R:Fxd Met Flm 7.87 K Ohm 1% 1/8W, 28480, 0698-3259

Change A1R75 to Part No. 1810-0239.

Section VI, Table 6-3. Add A1CR27, Part No. 1901-0040, Diode-Switching 2NS 30 V 50 mA. Change A1R90 to 0683-3015, Res 300 5% .25W. Delete A1C51 through A1C56, A1CR38, A1CR39, A1Q36, A1Q37, A1Q38, A1R139, A1R141 through A1R149, A2C2 and A2R50 through A2R55.

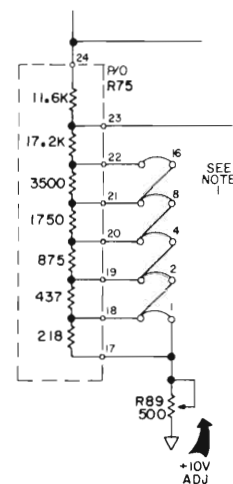
Section VII, Page 7-1. Delete from Paragraph 7-6 the following sentences: "If power supply voltages are not present on a battery operated Multimeter, low battery voltage can be responsible. Verify low battery voltage by the procedure of Section III under the paragraph concerning low battery voltage detection."

Page 7-7/7-8, Figure 7-2. Delete A1CR38 and CR39 from the ohms converter.

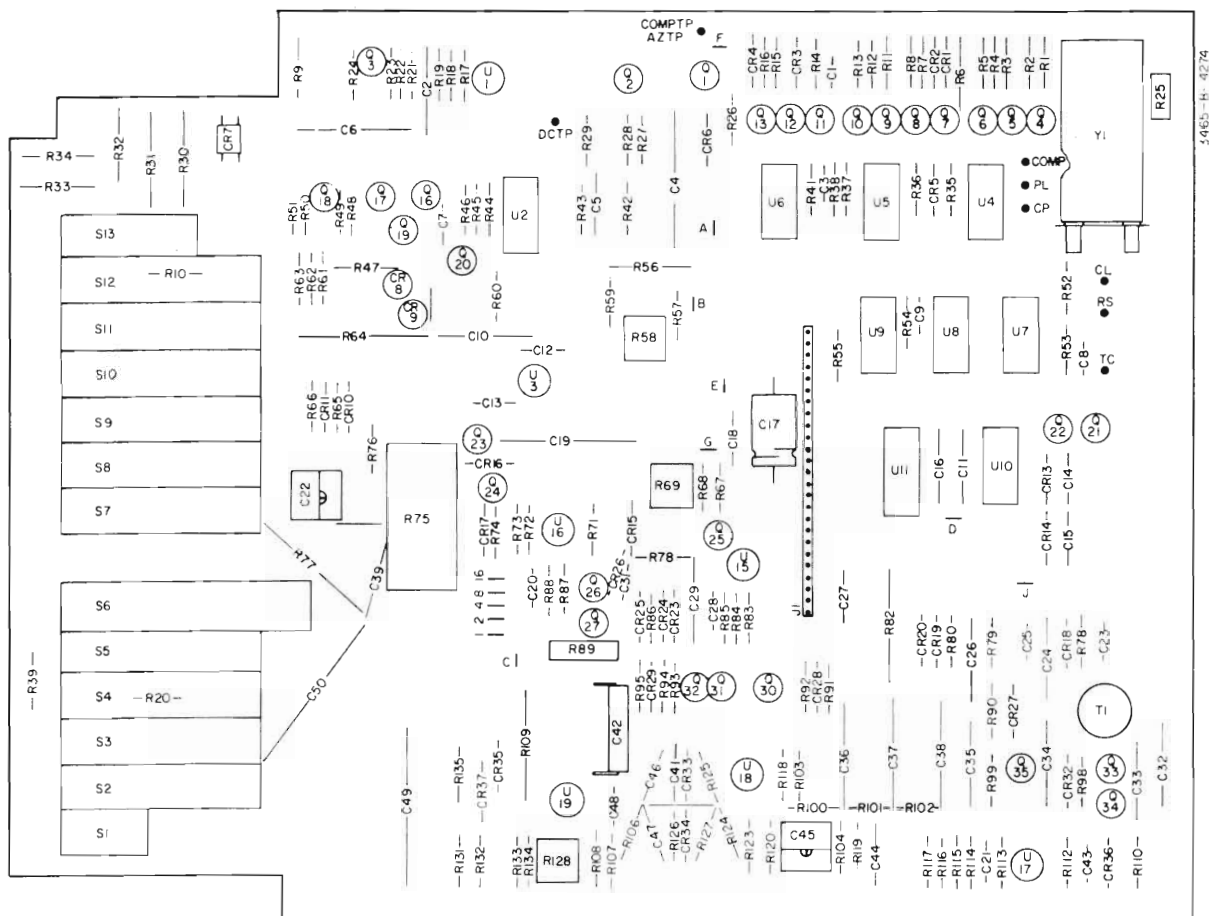
Page 7-9/7-10, Figure 7-3. Replace A1R147 with a short. Delete A1C55, A1C56, A1R148 and A1R149.

Page 7-11/7-12, Figure 7-4. Delete A2R50 through A2R55 and make direct connections.

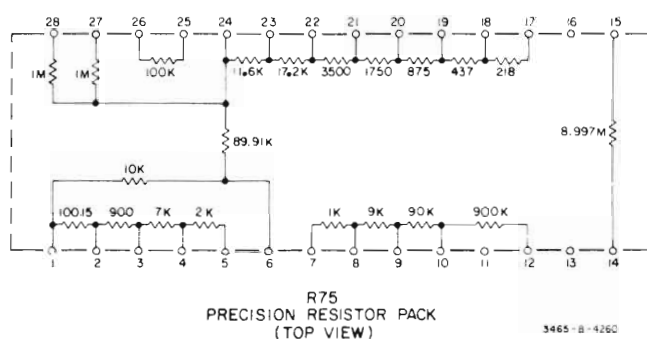
Page 7-13/7-14, Figure 7-5. Change value of A1R90 to 300 ohms. Replace the combination of A1C53 and C54 with A1CR27, anode to + VB, cathode to A1R90. Delete A1C51, C52, A1Q36, Q37 and Q38, A1R139, A1R141 through R146 and A2C2. Change CR17 voltage to 6.4 V. Change R72 to 267 K, R73 to 8.68 K, and R74 to a starred value (R74\*). Change Part No. of R75 to 1810-0239 and change values of p/o R75 as shown below:



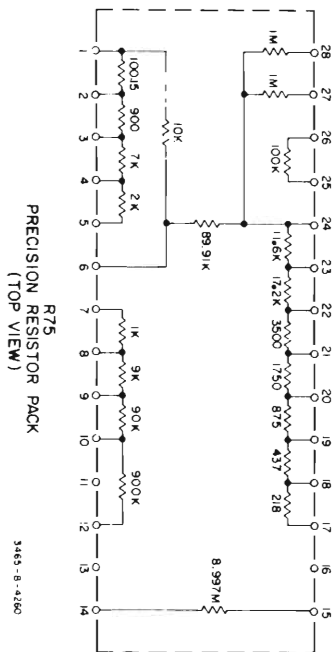
Pages 7-9 through 7-14. Replace the A1 component locator and top view of R75, Precision Resistor Pack, with the following diagrams.



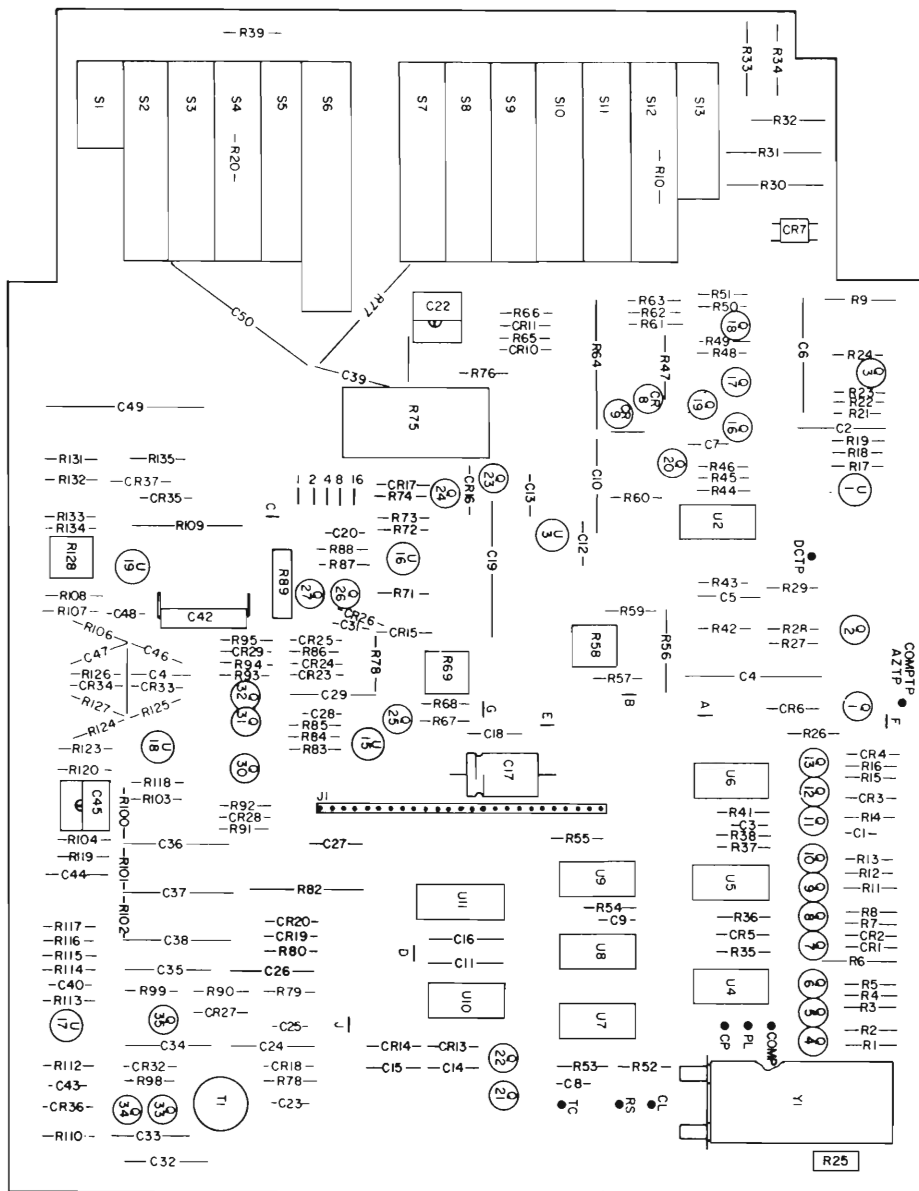
**A1**  
-hp- Part No. 03465-66501  
For Serial Numbers 1521A00201 thru 1521A01500



-hp- Part No. 1810-0239



A1  
-hp Part No. 03465-66501



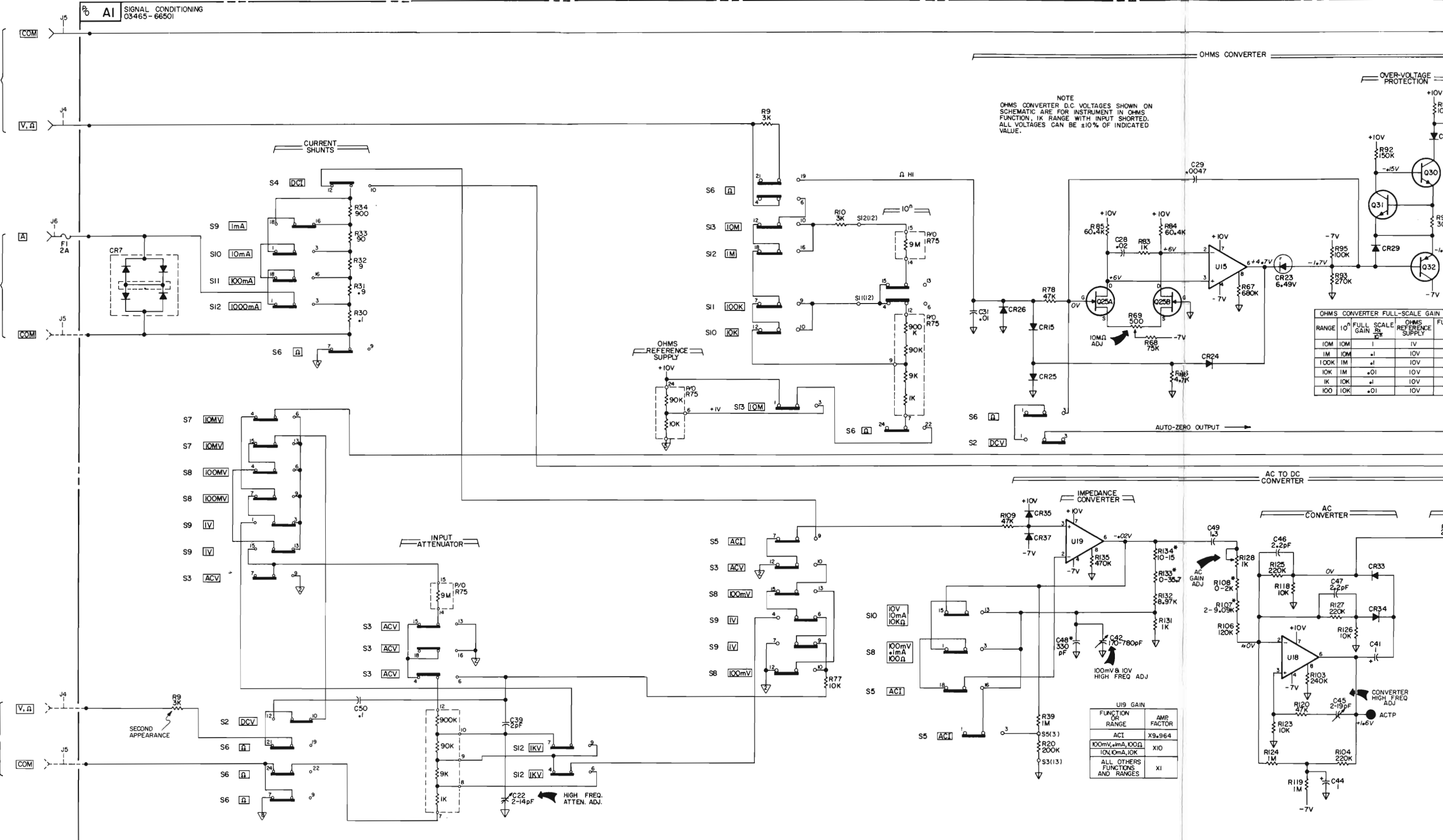
|     |                        | 12 | 0 | 0 | 0 | 0 | 7 |   |   |    |    |
|-----|------------------------|----|---|---|---|---|---|---|---|----|----|
| S13 | IOM                    | 0  | 0 | 0 | 0 | 0 | 0 | 6 |   |    |    |
|     |                        | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |    |
| S12 | 1KV<br>1000mA<br>1MΩ   | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9  |    |
|     |                        | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9  |    |
| S11 | 100V<br>100mA<br>100KΩ | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |    |
|     |                        | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9  |    |
| S10 | 10V<br>10mA<br>10KΩ    | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |    |
|     |                        | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9  |    |
| S9  | 1V<br>1mA<br>1K        | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |    |
|     |                        | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9  |    |
| S8  | 1mV<br>1mA<br>100Ω     | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |    |
|     |                        | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9  |    |
| S7  | 10mV                   | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |    |
|     |                        | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9  |    |
| S6  | Ω                      | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0  | 13 |
|     |                        | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0  | 12 |
| S5  | ACI                    | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |    |
|     |                        | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9  |    |
| S4  | DCI                    | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |    |
|     |                        | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9  |    |
| S3  | ACV                    | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |    |
|     |                        | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9  |    |
| S2  | DCV                    | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |    |
|     |                        | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9  |    |
| S1  | OFF/ON                 | 6  | 0 | 4 |   |   |   |   |   |    |    |
|     |                        | 0  | 0 | 3 |   |   |   |   |   |    |    |

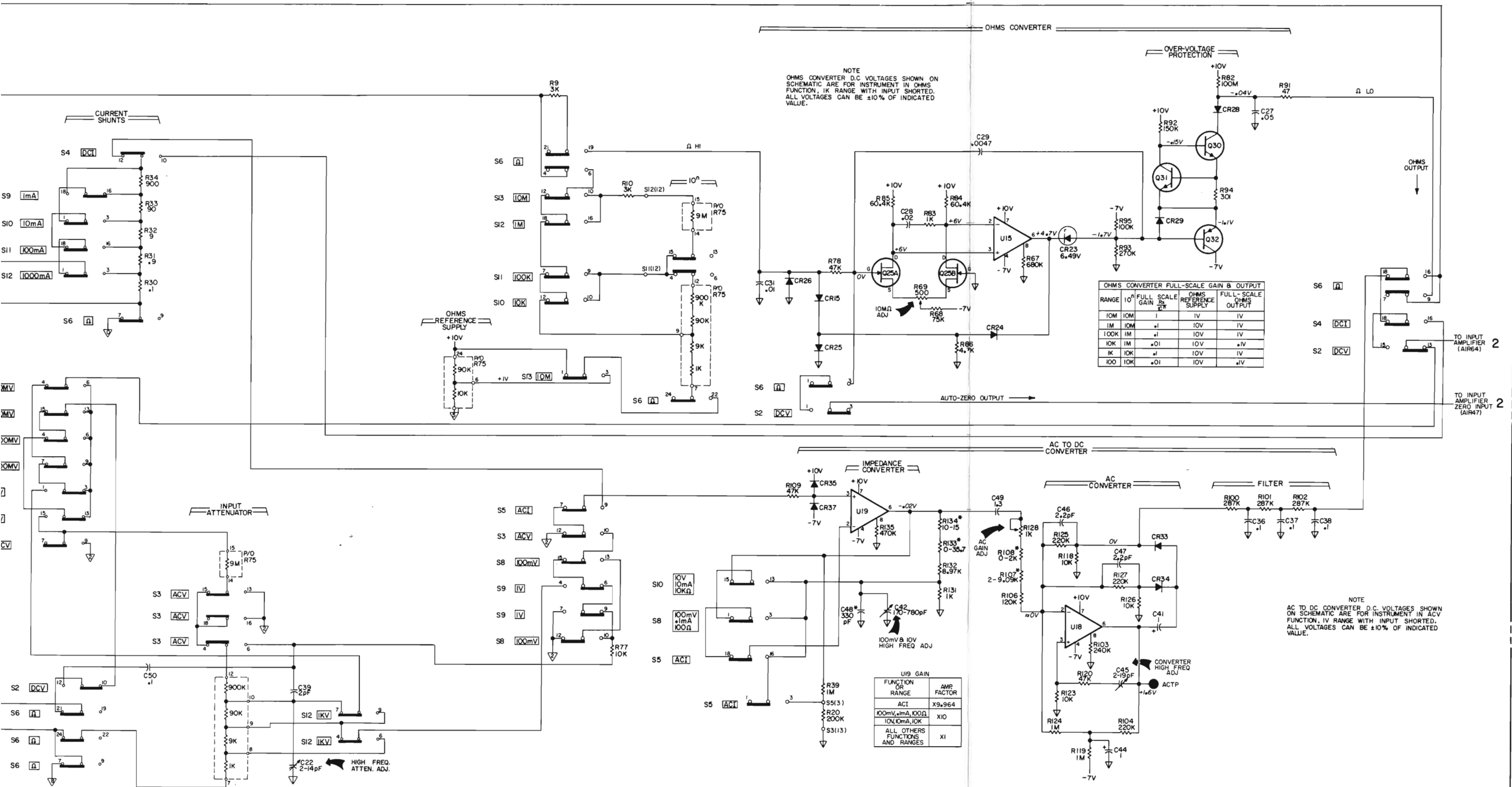
SWITCH BANK PIN NUMBERING  
(COMPONENT SIDE)

OHMS MEASUREMENTS

AC AND DC CURRENT MEASUREMENTS

AC AND DC VOLTAGE MEASUREMENTS





## SALES & SERVICE OFFICES

### UNITED STATES

#### ALABAMA

8290 Whitesburg Dr. S.E.  
P.O. Box 4207  
Huntsville 35802  
Tel: (205) 881-4591  
TWX 810-726-2294  
Medical Only  
228 W. Valley Ave.  
Room 302  
Birmingham 35209  
Tel: (205) 879-2081

#### ARIZONA

2336 E. Magnolia St.  
Phoenix 85034  
Tel: (602) 244-1361  
TWX 910-951-1331  
2424 East Aragon Rd.  
Tucson 85706  
Tel: (602) 889-4661

#### ARKANSAS

Medical Service Only  
Little Rock 72205  
Tel: (501) 664-8773

#### CALIFORNIA

1430 East Orangethorpe Ave.  
Fullerton 92631  
Tel: (714) 870-1000  
TWX 910-592-1288  
3939 Lankershim Boulevard  
North Hollywood 91604  
Tel: (213) 877-1282  
TWX 910-499-2170  
6305 Arizona Place  
Los Angeles 90045  
Tel: (213) 649-2511  
TWX 910-328-6147  
Los Angeles  
Tel: (213) 776-7500  
3003 Scott Boulevard  
Santa Clara 95050  
Tel: (408) 249-7000  
TWX 910-338-0518  
Ridgeway  
Tel: (415) 446-6165  
2220 Watt Ave.  
Sacramento 95825  
Tel: (916) 482-1463  
TWX 910-367-2092

#### COLORADO

5606 South Ulster Parkway  
Englewood 80110  
Tel: (303) 771-3455  
TWX 910-935-0705  
12 Lunar Drive  
New Haven 06525  
Tel: (203) 389-6551  
TWX 710-465-2029

#### CONNECTICUT

21 East Wright St.  
Suite 1  
Pensacola 32501  
Tel: (904) 434-3081

#### FLORIDA

P.O. Box 24210  
2806 W. Oakland Park Blvd.  
Ft. Lauderdale 33307  
Tel: (305) 731-2020  
TWX 510-955-4099  
Jacksonville  
Medical Service Only  
Tel: (904) 725-6333  
P.O. Box 13910  
6177 Lake Eleanor Dr.  
Orlando 32809  
Tel: (305) 859-2900  
TWX 810-850-0113  
21 East Wright St.  
Suite 1  
Pensacola 32501  
Tel: (904) 434-3081

#### GEORGIA

P.O. Box 28234  
450 Interstate North  
Atlanta 30328  
Tel: (404) 434-4000  
TWX 810-766-4890

#### HAWAII

2875 So. King Street  
Honolulu 96814  
Tel: (808) 955-4455

#### ILLINOIS

5500 Howard Street  
Skokie 60076  
Tel: (312) 677-0400  
TWX 910-223-3613  
St. Joseph  
Tel: (217) 469-2133

#### INDIANA

7301 North Shadeland Ave.  
Indianapolis 46250  
Tel: (317) 842-1000  
TWX 810-290-1796

#### IOWA

1902 Broadway  
Iowa City 52240  
Tel: (319) 338-9466  
Night: (319) 338-9467

#### KANSAS

Derby  
Tel: (316) 267-3655

#### LOUISIANA

P.O. Box 840  
3239 Williams Boulevard  
Kenner 70062  
Tel: (504) 721-6201  
TWX 810-955-5524

#### KENTUCKY

Medical Calculator Only  
8003 Trounwood Court  
Louisville 40291  
Tel: (502) 426-4341

#### MARYLAND

6707 Whitestone Road  
Baltimore 21207  
Tel: (301) 944-5400  
TWX 710-862-9157  
4 Choke Cherry Road  
Rockville 20850  
Tel: (301) 948-6370  
TWX 710-828-9685  
710-828-0487  
P.O. Box 1648  
2 Choke Cherry Road  
Rockville 20850  
Tel: (301) 948-6370  
TWX 710-828-9684

#### MASSACHUSETTS

156 Wyatt Drive  
Las Cruces 88001  
Tel: (505) 526-2485  
TWX 910-983-0550

#### MINNESOTA

2400 N. Prior Ave.  
Roseville 55113  
Tel: (612) 636-0700  
TWX 910-563-3734

#### MISSISSIPPI

Jackson  
Medical Service Only  
Tel: (601) 982-9363

#### MISSOURI

11131 Colorado Ave.  
Kansas City 64137  
Tel: (816) 763-8000  
TWX 910-771-2087

#### NEBRASKA

Medical Only  
11902 Elm Street  
Suite 4C  
Omaha 68144  
Tel: (402) 333-6017

#### NEW JERSEY

W. 120 Century Rd.  
Paramus 07652  
Tel: (201) 265-5000  
TWX 710-990-4951

#### NEW MEXICO

P.O. Box 11634  
Station E  
11300 Lomas Blvd. N.E.  
Albuquerque 87123  
Tel: (505) 292-1330  
TWX 910-989-1185

#### NEW YORK

6 Automation Lane  
Computer Park  
Albany 12205  
Tel: (518) 458-1550  
TWX 710-441-8270

#### NEW YORK

1251 Avenue of the Americas  
Floor 32 - Suite 3296  
New York City 10020  
Tel: (212) 265-5575

#### NEW YORK

Manhattan, Bronx  
Contact Paramus, NY Office  
Tel: (201) 265-5000  
Brooklyn, Queens, Richmond  
Contact Woodbury, NY Office  
Tel: (516) 921-0300

#### NEW YORK

201 South Avenue  
Poughkeepsie 12601  
Tel: (914) 454-7330  
TWX 510-248-0012

#### NEW YORK

148 Weldon Parkway  
Maryland Heights 63043  
Tel: (314) 567-1455  
TWX 910-764-0830

#### NEW YORK

5858 East Molloy Road  
Rochester 14623  
Tel: (716) 473-9500  
TWX 510-253-5981

#### NEW YORK

1 Crossways Park West  
Woodbury 11797  
Tel: (516) 921-0300  
TWX 510-221-2168

#### NEW YORK

P.O. Box 5188  
1923 North Main Street  
High Point 27262  
Tel: (919) 885-8101  
TWX 510-926-1516

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

330 Progress Rd.  
Dayton 45449  
Tel: (513) 859-8202  
TWX 810-459-1925

#### NEW YORK

1041 Kingsmill Parkway  
Columbus 43229  
Tel: (614) 436-1041

#### NEW YORK

P.O. Box 32008  
Oklahoma City 73132  
Tel: (405) 721-0200  
TWX 910-830-6862

#### NEW YORK

17890 SW Boones Ferry Road  
Tualatin 97062  
Tel: (503) 620-3350  
TWX 910-467-8714

#### NEW YORK

111 Zeta Drive  
Pittsburgh 15238  
Tel: (412) 782-0400  
Night: 782-0401  
TWX 710-795-3124

#### NEW YORK

1021 8th Avenue  
King of Prussia Industrial Park  
King of Prussia 19406  
Tel: (215) 265-7000  
TWX 510-660-2670

#### NEW YORK

6941-N N. Trenholm Road  
Columbia 29260  
Tel: (803) 782-6493

#### NEW YORK

Memphis  
Medical Service Only  
Tel: (901) 274-7472

#### NEW YORK

Nashville  
Medical Service Only  
Tel: (615) 244-5448

#### NEW YORK

P.O. Box 1270  
201 E. Arapaho Rd.  
Richardson 75080  
Tel: (214) 231-6101  
TWX 910-867-4723

#### NEW YORK

TEXAS  
P.O. Box 1270  
201 E. Arapaho Rd.  
Richardson 75080  
Tel: (214) 231-6101  
TWX 910-867-4723

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

#### NEW YORK

16500 Sprague Road  
Cleveland 44130  
Tel: (216) 243-7300  
Night: 243-7305  
TWX 910-423-9431

## EUROPE

**AUSTRIA**  
Hewlett-Packard Ges m b H  
Handelsk 52.3  
P.O. Box 7  
A-1205 Vienna  
Tel: (0222) 35 16 20 to 29  
Cable: HEWPAK Vienna  
Telex: 59233 hewpak a

**BELGIUM**  
Hewlett-Packard Benelux  
S.A. N.V.  
Avenue de Col-Vert 1  
(Grootkruislaan)  
B-1170 Brussels  
Tel: (02) 672 22 40  
Cable: PALOBEN Brussels  
Telex: 23 494 paloben bru

**DENMARK**  
Hewlett-Packard A/S  
Dattvejs 52  
DK-3460 Birkerød  
Tel: (02) 81 66 40  
Cable: HEWPAK AS  
Telex: 166 40 hpas  
Hewlett-Packard A/S  
Navevej 1  
DK-8600 Silkeborg  
Tel: (06) 82 71 66  
Telex: 165 40 hp as  
Cable: HEWPAK AS

**FINLAND**  
Hewlett-Packard Oy  
Nankkousentie 5  
P.O. Box 6  
SF-00211 Helsinki 21  
Tel: 6523031  
Cable: HEWPAK OY Helsinki  
Telex: 12-15363

**FRANCE**  
Hewlett-Packard France  
Quartier de Courtabouff  
Boite Postale No. 6  
F-91401 Orsay  
Tel: (1) 907 78 25  
Cable: HEWPAK Orsay  
Telex: 60048  
Hewlett-Packard France  
Agence Regionale  
Chemin des Mouilles  
Boite Postale No. 12  
F-69130 Ecullay  
Tel: (78) 33 81 25  
Cable: HEWPAK Ecullay  
Telex: 31 617  
Hewlett-Packard France  
Agence Regionale  
Zone Aeronautique  
Avenue Clement Ader  
F-31770 Colomiers  
Tel: (61) 78 11 55  
Telex: 51957

Hewlett-Packard France  
Agence Regionale  
Centre d'aviation generale  
F-13721 Aéroport de  
Marseille  
Tel: (91) 89 12 36  
Telex: 41770 F

Hewlett-Packard France  
Agence Regionale  
63 Avenue de Rochester  
F-35000 Rennes  
Tel: 74912 F  
Telex: 74 912 F

Hewlett-Packard France  
Agence Regionale  
74 Allée de la Robertsau  
F-67000 Strasbourg  
Tel: (88) 35 23 20 21  
Telex: 89141  
Cable: HEWPAK STRBG

Hewlett-Packard GmbH  
Technisches Büro München  
Unterhachinger Strasse 28  
ISAR Center  
D-80124 Ottobrunn  
Tel: (089) 601 30 51/7  
Telex: 52 49 85  
Cable: HEWPAKSA München  
(West Berlin)  
Hewlett-Packard GmbH  
Technisches Büro Berlin  
Keith Strasse 2-4  
D-1000 Berlin 30  
Tel: (030) 24 90 86  
Telex: 18 34 05 hpbm d

**GERMAN FEDERAL REPUBLIC**  
Hewlett-Packard GmbH  
Vertriebszentrale Frankfurt  
Bernhardstrasse 117  
Postfach 560 140  
D-6000 Frankfurt 55  
Tel: (0611) 50 04-1  
Cable: HEWPAKSA Frankfurt  
Telex: 41 32 49 fra

Hewlett-Packard GmbH  
Technisches Büro Böblingen  
Herrenbergstrasse 130  
D-7030 Böblingen, Württemberg  
Tel: (07031) 66 71  
Cable: HEWPAK Böblingen  
Telex: 0765739 bbn  
Hewlett-Packard GmbH  
Technisches Büro Düsseldorf  
Vogelsanger Weg 38  
D-4000 Düsseldorf  
Tel: (0211) 63 80 31/5  
Telex: 85 86 533 hpbm d

Hewlett-Packard GmbH  
Technisches Büro Hamburg  
Wendenstrasse 23  
D-2000 Hamburg 1  
Tel: (040) 24 13 93  
Cable: HEWPAKSA Hamburg  
Telex: 21 63 032 hpbm d

Hewlett-Packard GmbH  
Technisches Büro Hannover  
Meinendorfer Strasse 3  
D-3000 Hannover-Kleefeld  
Tel: (0511) 55 60 48  
Telex: 092 3259  
Hewlett-Packard GmbH  
Technisches Büro Nürnberg  
Neumeyer Str. 90  
D-8500 Nürnberg  
Tel: (0911) 56 30 83/5  
Telex: 0623 860

Hewlett-Packard GmbH  
Technisches Büro München  
Unterhachinger Strasse 28  
ISAR Center  
D-80124 Ottobrunn  
Tel: (089) 601 30 51/7  
Telex: 52 49 85  
Cable: HEWPAKSA München

Hewlett-Packard GmbH  
Technisches Büro München  
Unterhachinger Strasse 28  
ISAR Center  
D-80124 Ottobrunn  
Tel: (089) 601 30 51/7  
Telex: 52 49 85  
Cable: HEWPAKSA München

Hewlett-Packard GmbH  
Technisches Büro München  
Unterhachinger Strasse 28  
ISAR Center  
D-80124 Ottobrunn  
Tel: (089) 601 30 51/7  
Telex: 52 49 85  
Cable: HEWPAKSA München

**IRELAND**  
Hewlett-Packard Ltd  
King Street Lane  
Meitendortel Strasse 3  
D-3000 Hannover-Kleefeld  
Tel: (0511) 55 60 48  
Telex: 092 3259

Hewlett-Packard Ltd  
King Street Lane  
Meitendortel Strasse 3  
D-3000 Hannover-Kleefeld  
Tel: (0511) 55 60 48  
Telex: 092 3259

Hewlett-Packard Ltd  
King Street Lane  
Meitendortel Strasse 3  
D-3000 Hannover-Kleefeld  
Tel: (0511) 55 60 48  
Telex: 092 3259

Hewlett-Packard Ltd  
King Street Lane  
Meitendortel Strasse 3  
D-3000 Hannover-Kleefeld  
Tel: (0511) 55 60 48  
Telex: 092 3259

Hewlett-Packard Ltd  
King Street Lane  
Meitendortel Strasse 3  
D-3000 Hannover-Kleefeld  
Tel: (0511) 55 60 48  
Telex: 092 3259

**IRELAND**  
Hewlett-Packard Ltd  
King Street Lane  
Meitendortel Strasse 3  
D-3000 Hannover-Kleefeld  
Tel: (0511) 55 60 48  
Telex: 092 3259

Hewlett-Packard Ltd  
King Street Lane  
Meitendortel Strasse 3  
D-3000 Hannover-Kleefeld  
Tel: (0511) 55 60 48  
Telex: 092 3259

Hewlett-Packard Ltd  
King Street Lane  
Meitendortel Strasse 3  
D-3000 Hannover-Kleefeld  
Tel: (0511) 55 60 48  
Telex: 092 3259

Hewlett-Packard Ltd  
King Street Lane  
Meitendortel Strasse 3  
D-3000 Hannover-Kleefeld  
Tel: (0511) 55 60 48  
Telex: 092 3259

**ITALY**  
Hewlett-Packard Italiana S.p.A.  
Via Amerigo Vesputo 2  
I-20124 Milan  
Tel: (2) 6251 (10 lines)  
Cable: HEWPAK/IT Milan  
Telex: 32046

Hewlett-Packard Italiana S.p.A.  
Via Pietro Maroncelli 40  
(ang. Via Ventimila)  
I-35100 Padova  
Tel: 56 48 85  
Telex: 32046 via Milan  
Medical Only  
Hewlett-Packard Italiana S.p.A.  
Via Medaglie d'Oro 2  
I-56100 Pisa  
Tel: (050) 2 32 04  
Telex: 32046 via Milan

Hewlett-Packard S.p.A.  
Via G. D'Adda 10  
I-00143 Rome-Eur  
Tel: (6) 5912544-5  
Cable: HEWPAK/IT Rome  
Hewlett-Packard Italiana S.p.A.  
Via San Quintino 46  
I-10121 Turin  
Tel: 53 82 64-54 84 68  
Telex: 32046 via Milan

Hewlett-Packard Italiana S.p.A.  
Via San Quintino 46  
I-10121 Turin  
Tel: 53 82 64-54 84 68  
Telex: 32046 via Milan

Hewlett-Packard Italiana S.p.A.  
Via San Quintino 46  
I-10121 Turin  
Tel: 53 82 64-54 84 68  
Telex: 32046 via Milan

**NETHERLANDS**  
Hewlett-Packard Benelux N.V.  
Van Heuven Goedhartlaan 121  
P.O. Box 66  
NL-1134 Amsterdam  
Tel: (020) 47 20 21  
Cable: PALOBEN Amsterdam  
Telex: 13 216 hpa ni

**NORWAY**  
Hewlett-Packard Norge A/S  
Nesveien 13  
N-1344 Haslum  
Tel: 25 38 360  
Telex: 16621 hpnas n

**POLAND**  
Hewlett-Packard Medical Only  
Warsaw Technical Office  
UL. Saplana 1  
00-120 Warsaw  
Tel: 268031 ext. 30  
Telex: 812453

**PORTUGAL**  
Teletra-Empresa Técnica de  
Equipamentos Eléctricos S. A. r l  
Rua Rodrigo da Fonseca 103  
P.O. Box 2531  
P-Lisbon 1  
Tel: (01) 98 18 21  
Cable: HPAG CH  
Telex: 53933 hpag

**SPAIN**  
Hewlett-Packard Española S.A.  
Jerez No. 3  
E-Madrid 16  
Tel: (1) 48 26 00 (10 lines)  
Telex: 23515 hps  
Hewlett-Packard Española S.A.  
Milanesado 21-23  
E-Barcelona 17  
Tel: (3) 203 6200 (5 lines)  
Telex: 52603 hps e

Hewlett-Packard Española S.A.  
Milanesado 21-23  
E-Barcelona 17  
Tel: (3) 203 6200 (5 lines)  
Telex: 52603 hps e

Hewlett-Packard Española S.A.  
Milanesado 21-23  
E-Barcelona 17  
Tel: (3) 203 6200 (5 lines)  
Telex: 52603 hps e

Hewlett-Packard Española S.A.  
Milanesado 21-23  
E-Barcelona 17  
Tel: (3) 203 6200 (5 lines)  
Telex: 52603 hps e

Hewlett-Packard Española S.A.  
Milanesado 21-23  
E-Barcelona 17  
Tel: (3) 203 6200 (5 lines)  
Telex: 52603 hps e

Hewlett-Packard Española S.A.  
Edificio Albia II 7 B  
E-Bilbao  
Tel: 23 83 06 23 82 06  
Calculators Only  
Hewlett-Packard Española S.A.  
Alvaro Bazan 12  
(Edificio Luz)  
E-Vallencia - 10  
Tel: 60 42 00

**SWEDEN**  
Hewlett-Packard Sverige AB  
Engnätstegen 1-3  
Fax  
S-161 20 Bromma 20  
Tel: (08) 730 05 50  
Cable: MEASUREMENTS  
Stockholm  
Telex: 10721

Hewlett-Packard Sverige AB  
Hagaparksgatan 96  
S-431 41 Molndal  
Tel: (031) 27 68 00/1  
Telex: 13 216 hpa ni

**SWITZERLAND**  
Hewlett-Packard (Schweiz) AG  
Zürcherstrasse 20  
P.O. Box 64  
CH-8952 Schlieren Zurich  
Tel: (01) 98 18 21  
Cable: HPAG CH  
Telex: 53933 hpag

Hewlett-Packard (Schweiz) AG  
Zürcherstrasse 20  
P.O. Box 64  
CH-8952 Schlieren Zurich  
Tel: (01) 98 18 21  
Cable: HPAG CH  
Telex: 53933 hpag

Hewlett-Packard (Schweiz) AG  
Zürcherstrasse 20  
P.O. Box 64  
CH-8952 Schlieren Zurich  
Tel: (01) 98 18 21  
Cable: HPAG CH  
Telex: 53933 hpag

Hewlett-Packard (Schweiz) AG  
Zürcherstrasse 20  
P.O. Box 64  
CH-8952 Schlieren Zurich  
Tel: (01) 98 18 21  
Cable: HPAG CH  
Telex: 53933 hpag

Hewlett-Packard (Schweiz) AG  
Zürcherstrasse 20  
P.O. Box 64  
CH-8952 Schlieren Zurich  
Tel: (01) 98 18 21  
Cable: HPAG CH  
Telex: 53933 hpag

Hewlett-Packard (Schweiz) AG  
Zürcherstrasse 20  
P.O. Box 64  
CH-8952 Schlieren Zurich  
Tel: (01) 98 18 21  
Cable: HPAG CH  
Telex: 53933 hpag

Hewlett-Packard Ltd  
c/o Makro  
South Service Wholesale Centre  
Amber Way  
Halesowen Industrial Estate  
GB-Halesowen Worcs  
Tel: Birmingham 7860  
Hewlett-Packard Ltd  
4th Floor  
Wedge House  
799 London Road  
GB-Thornthorpe Heath CR4 6XL  
Surrey  
Tel: (01) 684 0105  
Telex: 946825

Hewlett-Packard Ltd  
c/o Makro  
South Service Wholesale Centre  
Washington  
GB-New Town, County Durham  
Tel: Washington 464001 ext. 57 58  
Hewlett-Packard Ltd registered  
address for V.A.T. purposes  
only.  
70, Finsbury Pavement  
London EC2A1SX  
Registered No. 690597

**USSR**  
Hewlett-Packard USSR  
c/o Commercial Office  
American Embassy (Box M)  
A-1091 Vienna Austria  
Tel: 221-79-71  
Telex: 7825 hewpak SU

**YUGOSLAVIA**  
Iskra-Standard Hewlett-Packard  
Office  
Miklosiceva 38/VII  
61000 Ljubljana  
Tel: 221-79-71  
Telex: 31265

**UNITED KINGDOM**  
Hewlett-Packard Ltd  
King Street Lane  
Winnesh, Wokingham  
GB-Berkshire RG11 5AR  
Tel: Wokingham 384774  
Telex: 847778 hpa b79  
Hewlett-Packard Ltd.  
The Graftons  
Stamford New Road  
GB-Atricham, Cheshire  
Tel: (061) 928-9021  
Telex: 668068

**UNITED KINGDOM**  
Hewlett-Packard Ltd  
King Street Lane  
Winnesh, Wokingham  
GB-Berkshire RG11 5AR  
Tel: Wokingham 384774  
Telex: 847778 hpa b79  
Hewlett-Packard Ltd.  
The Graftons  
Stamford New Road  
GB-Atricham, Cheshire  
Tel: (061) 928-9021  
Telex: 668068

**UNITED KINGDOM**  
Hewlett-Packard Ltd  
King Street Lane  
Winnesh, Wokingham  
GB-Berkshire RG11 5AR  
Tel: Wokingham 384774  
Telex: 847778 hpa b79  
Hewlett-Packard Ltd.  
The Graftons  
Stamford New Road  
GB-Atricham, Cheshire  
Tel: (061) 928-9021  
Telex: 668068

**UNITED KINGDOM**  
Hewlett-Packard Ltd  
King Street Lane  
Winnesh, Wokingham  
GB-Berkshire RG11 5AR  
Tel: Wokingham 384774  
Telex: 847778 hpa b79  
Hewlett-Packard Ltd.  
The Graftons  
Stamford New Road  
GB-Atricham, Cheshire  
Tel: (061) 928-9021  
Telex: 668068

**UNITED KINGDOM**  
Hewlett-Packard Ltd  
King Street Lane  
Winnesh, Wokingham  
GB-Berkshire RG11 5AR  
Tel: Wokingham 384774  
Telex: 847778 hpa b79  
Hewlett-Packard Ltd.  
The Graftons  
Stamford New Road  
GB-Atricham, Cheshire  
Tel: (061) 928-9021  
Telex: 668068

**SOCIALIST COUNTRIES**  
PLEASE CONTACT:  
Hewlett-Packard S.A.  
7, rue du Bois-du-Lan  
P.O. Box 349  
CH-1217 Meyrin 1 Geneva  
Switzerland  
Tel: (022) 41 54 00  
Cable: HEWPAKSA Geneva  
Telex: 2 24 86

**SOCIALIST COUNTRIES**  
PLEASE CONTACT:  
Hewlett-Packard S.A.  
7, rue du Bois-du-Lan  
P.O. Box 349  
CH-1217 Meyrin 1 Geneva  
Switzerland  
Tel: (022) 41 54 00  
Cable: HEWPAKSA Geneva  
Telex: 2 24 86

**SOCIALIST COUNTRIES**  
PLEASE CONTACT:  
Hewlett-Packard S.A.  
7, rue du Bois-du-Lan  
P.O. Box 349  
CH-1217 Meyrin 1 Geneva  
Switzerland  
Tel: (022) 41 54 00  
Cable: HEWPAKSA Geneva  
Telex: 2 24 86

**SOCIALIST COUNTRIES**  
PLEASE CONTACT:  
Hewlett-Packard S.A.  
7, rue du Bois-du-Lan  
P.O. Box 349  
CH-1217 Meyrin 1 Geneva  
Switzerland  
Tel: (022) 41 54 00  
Cable: HEWPAKSA Geneva  
Telex: 2 24 86

**SOCIALIST COUNTRIES**  
PLEASE CONTACT:  
Hewlett-Packard S.A.  
7, rue du Bois-du-Lan  
P.O. Box 349  
CH-1217 Meyrin 1 Geneva  
Switzerland  
Tel: (022) 41 54 00  
Cable: HEWPAKSA Geneva  
Telex: 2 24 86

## AFRICA, ASIA, AUSTRALIA

**ANGOLA**  
Teletra  
Empresa Técnica de  
Equipamentos de  
Eléctricos, S.A.R.L.  
R. Barbosa Rodrigues, 42-1° D-1  
Casa Postal, 6487-Luanda  
Tel: 35515-6  
Cable: ELECTRA Luanda

**AUSTRALIA**  
Hewlett-Packard Australia  
Pty. Ltd.  
31-41 Joseph Street  
Blackburn Victoria 3130  
Tel: 89-6351, 89-6306  
Telex: 31-024  
Cable: HEWPAK Melbourne  
Hewlett-Packard Australia  
Pty. Ltd.  
31 Bridge Street  
Pymble  
New South Wales 2073  
Tel: 445-6566  
Telex: 21561  
Cable: HEWPAK Sydney  
Hewlett-Packard Australia  
Pty. Ltd.  
87 Churchill Road  
Prospect 5082  
South Australia  
Tel: 44 8151  
Cable: HEWPAK Adelaide  
Hewlett-Packard Australia  
Pty. Ltd.  
141 Stirling Highway  
Claremont W.A. 6010  
Tel: 86-5455  
Telex: 93859  
Cable: HEWPAK  
Hewlett-Packard Australia  
Pty. Ltd.  
121 Wollongong Street  
Fyshwick A.C.T. 2609  
Tel: 95 3733

**INDONESIA**  
Hewlett-Packard Indonesia P.T.  
P.O. Box 496  
Tel: 41 45 8 87  
Telex: 4093  
Cable: FROSTBLUE  
Blue Star Ltd  
Sahaja  
414-2 Vir Savarkar Marg  
Prabhadew  
Bombay 400 025  
Tel: 45 73 01  
Telex: 3751  
Cable: BLUESTAR  
Blue Star Ltd  
14-40 Civil Lines  
Karnpur 208 001  
Tel: 6 8 8 82  
Cable: BLUESTAR  
Blue Star Ltd  
7 Nare Street  
P.O. Box 506  
Calcutta 700 001  
Tel: 25 4343  
Telex: 655  
Cable: BLUESTAR  
Blue Star Ltd  
11 Nare Street  
P.O. Box 506  
Calcutta 700 001  
Tel: 25 4343  
Telex: 655  
Cable: BLUESTAR

**INDONESIA**  
Hewlett-Packard Indonesia P.T.  
P.O. Box 496  
Tel: 41 45 8 87  
Telex: 4093  
Cable: FROSTBLUE  
Blue Star Ltd  
Sahaja  
414-2 Vir Savarkar Marg  
Prabhadew  
Bombay 400 025  
Tel: 45 73 01  
Telex: 3751  
Cable: BLUESTAR  
Blue Star Ltd  
14-40 Civil Lines  
Karnpur 208 001  
Tel: 6 8 8 82  
Cable: BLUESTAR  
Blue Star Ltd  
7 Nare Street  
P.O. Box 506  
Calcutta 700 001  
Tel: 25 4343  
Telex: 655  
Cable: BLUESTAR

**INDONESIA**  
Hewlett-Packard Indonesia P.T.  
P.O. Box 496  
Tel: 41 45 8 87  
Telex: 4093  
Cable: FROSTBLUE  
Blue Star Ltd  
Sahaja  
414-2 Vir Savarkar Marg  
Prabhadew  
Bombay 400 025  
Tel: 45 73 01  
Telex: 3751  
Cable: BLUESTAR  
Blue Star Ltd  
14-40 Civil Lines  
Karnpur 208 001  
Tel: 6 8 8 82  
Cable: BLUESTAR  
Blue Star Ltd  
7 Nare Street  
P.O. Box 506  
Calcutta 700 001  
Tel: 25 4343  
Telex: 655  
Cable: BLUESTAR

**INDONESIA**  
Hewlett-Packard Indonesia P.T.  
P.O. Box 496  
Tel: 41 45 8 87  
Telex: 4093  
Cable: FROSTBLUE  
Blue Star Ltd  
Sahaja  
414-2 Vir Savarkar Marg  
Prabhadew  
Bombay 400 025  
Tel: 45 73 01  
Telex: 3751  
Cable: BLUESTAR  
Blue Star Ltd  
14-40 Civil Lines  
Karnpur 208 001  
Tel: 6 8 8 82  
Cable: BLUESTAR  
Blue Star Ltd  
7 Nare Street  
P.O. Box 506  
Calcutta 700 001  
Tel: 25 4343  
Telex: 655  
Cable: BLUESTAR

**INDONESIA**  
Hewlett-Packard Indonesia P.T.  
P.O. Box 496  
Tel: 41 45 8 87  
Telex: 4093  
Cable: FROSTBLUE  
Blue Star Ltd  
Sahaja  
414-2 Vir Savarkar Marg  
Prabhadew  
Bombay 400 025  
Tel: 45 73 01  
Telex: 3751  
Cable: BLUESTAR  
Blue Star Ltd  
14-40 Civil Lines  
Karnpur 208 001  
Tel: 6 8 8 82  
Cable: BLUESTAR  
Blue Star Ltd  
7 Nare Street  
P.O. Box 506  
Calcutta 700 001  
Tel: 25 4343  
Telex: 655  
Cable: BLUESTAR

**INDONESIA**  
Hewlett-Packard Indonesia P.T.  
P.O. Box 496  
Tel: 41 45 8 87  
Telex: 4093  
Cable: FROSTBLUE  
Blue Star Ltd  
Sahaja  
414-2 Vir Savarkar Marg  
Prabhadew  
Bombay 400 025  
Tel: 45 73 01  
Telex: 3751  
Cable: BLUESTAR  
Blue Star Ltd  
14-40 Civil Lines  
Karnpur 208 001  
Tel: 6 8 8 82  
Cable: BLUESTAR  
Blue Star Ltd  
7 Nare Street  
P.O. Box 506  
Calcutta 700 001  
Tel: 25 4343  
Telex: 655  
Cable: BLUESTAR

**INDONESIA**  
Hewlett-Packard Indonesia P.T.  
P.O. Box 496  
Tel: 41 45 8 87  
Telex: 4093  
Cable: FROSTBLUE  
Blue Star Ltd  
Sahaja  
414-2 Vir Savarkar Marg  
Prabhadew  
Bombay 400 025  
Tel: 45 73 01  
Telex: 3751  
Cable: BLUESTAR  
Blue Star Ltd  
14-40 Civil Lines  
Karnpur 208 001  
Tel: 6 8 8 82  
Cable: BLUESTAR  
Blue Star Ltd  
7 Nare Street  
P.O. Box 506  
Calcutta 700 001  
Tel: 25 4343  
Telex: 655  
Cable: BLUESTAR

**INDONESIA**  
Hewlett-Packard Indonesia P.T.  
P.O. Box 496  
Tel: 41 45 8 87  
Telex: 4093  
Cable: FROSTBLUE  
Blue Star Ltd  
Sahaja  
414-2 Vir Savarkar Marg  
Prabhadew  
Bombay 400 025  
Tel: 45 73 01  
Telex: 3751  
Cable: BLUESTAR  
Blue Star Ltd  
14-40 Civil Lines  
Karnpur 208 001  
Tel: 6 8 8 82  
Cable: BLUESTAR  
Blue Star Ltd  
7 Nare Street  
P.O. Box 506  
Calcutta 700 001  
Tel: 25 4343  
Telex: 655  
Cable: BLUESTAR

**HONG KONG**  
Schmidt & Co. (Hong Kong) Ltd  
P.O. Box 297  
Consignment Centre  
39th Floor  
Connaught Road, Central  
Hong Kong  
Tel: 747655CHMCHX  
Cable: SCHMIDTCO Hong Kong

**INDIA**  
Blue Star Ltd  
Kastur Buildings  
Jamshedji Tata Rd  
Bombay 400 020  
Tel: 25 50 21  
Cable: BLUESTAR  
Blue Star Ltd  
25 50 21  
Cable: BLUESTAR

**INDIA**  
Blue Star Ltd  
Kastur Buildings  
Jamshedji Tata Rd  
Bombay 400 020  
Tel: 25 50 21  
Cable: BLUESTAR  
Blue Star Ltd  
25 50 21  
Cable: BLUESTAR

**INDIA**  
Blue Star Ltd  
Kastur Buildings  
Jamshedji Tata Rd  
Bombay 400 020  
Tel: 25 50 21  
Cable: BLUESTAR  
Blue Star Ltd  
25 50 21  
Cable: BLUESTAR

**INDIA**  
Blue Star Ltd  
Kastur Buildings  
Jamshedji Tata Rd  
Bombay 400 020  
Tel: 25 50 21  
Cable: BLUESTAR  
Blue Star Ltd  
25 50 21  
Cable: BLUESTAR

**INDIA**  
Blue Star Ltd  
Kastur Buildings  
Jamshedji Tata Rd  
Bombay 400 020  
Tel: 25 50 21  
Cable: BLUESTAR  
Blue Star Ltd  
25 50 21  
Cable: BLUESTAR

**INDIA**  
Blue Star Ltd  
Kastur Buildings  
Jamshedji Tata Rd  
Bombay 400 020  
Tel: 25 50 21  
Cable: BLUESTAR  
Blue Star Ltd  
25 50 21  
Cable: BLUESTAR

**INDIA**  
Blue Star Ltd  
Kastur Buildings  
Jamshedji Tata Rd  
Bombay 400 020  
Tel: 25 50 21  
Cable: BLUESTAR  
Blue Star Ltd  
25 50 21  
Cable: BLUESTAR

**INDIA**  
Blue Star Ltd  
Kastur Buildings  
Jamshedji Tata Rd  
Bombay 400 020  
Tel: 25 50 21  
Cable: BLUESTAR  
Blue Star Ltd  
25 50 21  
Cable: BLUESTAR

**INDIA**  
Blue Star Ltd  
Kastur Buildings  
Jamshedji Tata Rd  
Bombay 400 020  
Tel: 25 50 21  
Cable: BLUESTAR  
Blue Star Ltd  
25 50 21  
Cable: BLUESTAR

**IRAN**  
Multi Corp International Ltd  
Avenue Soraya 130  
P.O. Box 1212  
IR-Teheran  
Tel: 83 10 35-39  
Cable: MULTICORP Tehran  
Telex: 2693 mci tn

**IRAN**  
Multi Corp International Ltd  
Avenue Soraya 130  
P.O. Box 1212  
IR-Teheran  
Tel: 83 10 35-39  
Cable: MULTICORP Tehran  
Telex: 2693 mci tn

# MANUAL CHANGES

MODEL 3465A

MULTIMETER

Manual Part No. 03465-90004

■ New or Revised Item

## ERRATA

Page 1-1, Paragraph 1-16. Change item 5 to "Model 11173A Handle Kit (Rack).

Page 5-0, Table 5-1. Change value in required characteristics column for resistor part no. 0698-5049 (last resistor in the table) to 10 M,  $\pm 1\%$ .

Page 5-9, Paragraph 5-36, Step i. Within parenthesis in formula for  $(R107 * + R108 *)$ , replace the number 0.9995 with 0.9966.

Page 6-3, Table 6-3. Add diodes A1CR1 through A1CR6 to the parts list as follows:

A1CR1, CR2, 1901-0040, 13, Diode-Switching, 28480, 1901-0040  
A1CR3, CR4, 1901-0518, 4, Diode-Schottky, 28480, 1901-0518  
A1CR5, CR6, 1901-0040, Diode-Switching, 28480, 1901-0040

Page 6-4, Table 6-3. Add designations A1L2, A1L3 and A1L4 to the parts list. These components are the same as A1L1, part no. 9170-0894, Core-Shielding Bead.

Page 6-5, Table 6-3. Change part no. of the fine line assembly, A1R75, to 1810-0253.

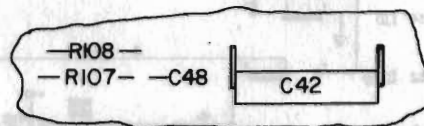
Page 6-7, Table 6-3. Add designation A2L1, part no. 9170-0894, Core-Shielding Bead.

Page 6-8, Table 6-3. Add A10A6C3, part no. 0150-0093, C:fxd .01  $\mu$ F, 100 V. Change part no. of Transformer, A10A6T1 to 9100-3851. Under A10 Assembly Miscellaneous Parts, add "Battery Clamp" to description of part no. 1460-1426.

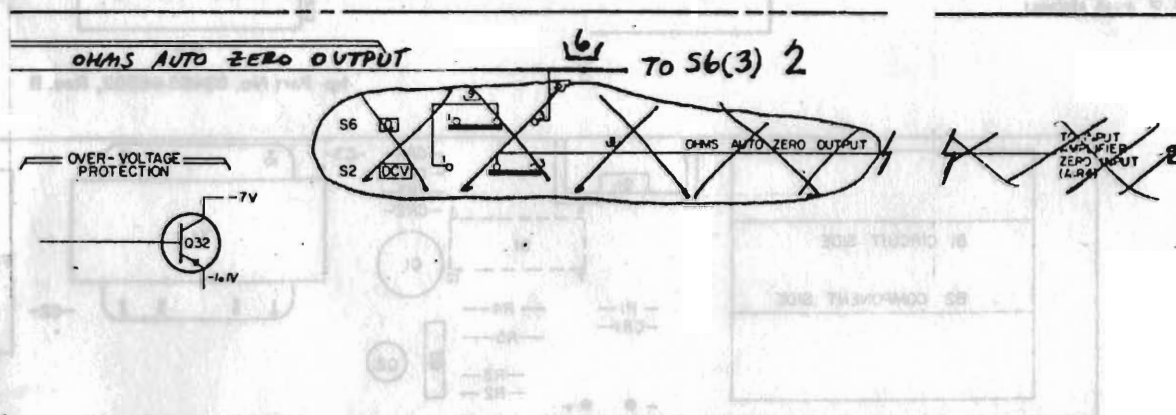
Page 6-10, Table 6-3, Mechanical Parts List. Change part no. of MP8a (Rear Panel-Std or Option 001) to 5040-8026. Change part no. of MP18 (Switch Shield) to 03465-60604. This is now a "SWITCH SHIELD ASSEMBLY".

Section VII, Schematic No. 1. Make the following change to the OHMS AUTO ZERO OUTPUT SWITCHING:

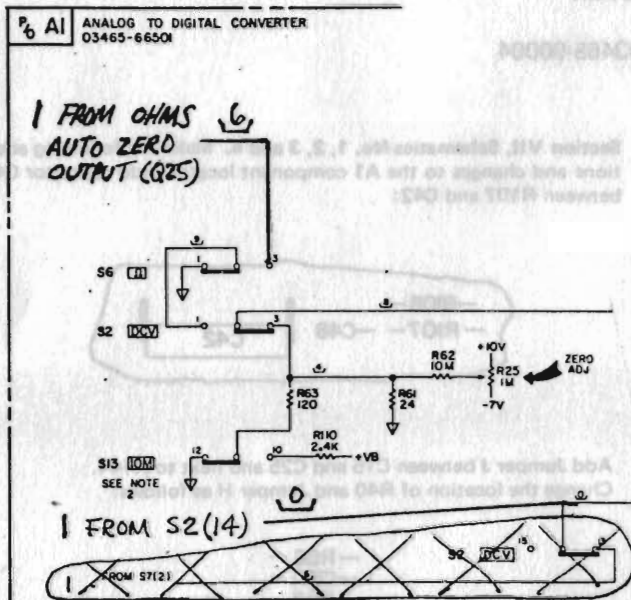
Section VII, Schematics No. 1, 2, 3 and 4. Make the following additions and changes to the A1 component locator. Add capacitor C48 between R107 and C42:



Add Jumper J between C15 and C25 and next to R144. Change the location of R40 and Jumper H as follows:



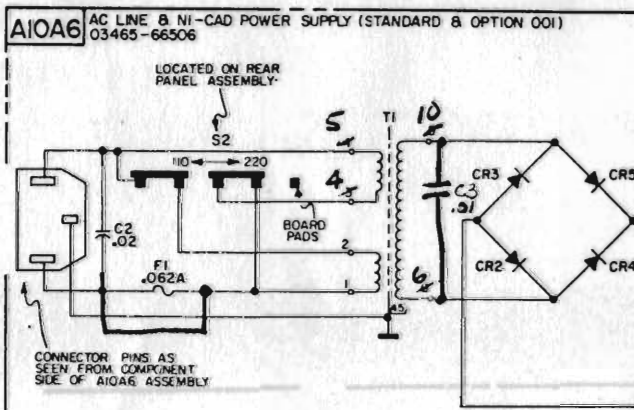
Section VII, Schematic No. 2. Make the following changes to the input amplifier switching:



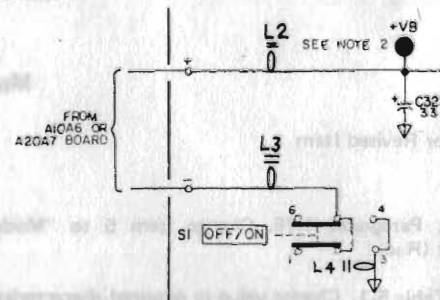
Section VII, Schematic 3. Add shielding bead A2L1 to the emitter of A2Q22 on the Display Interface board.

Section VII, Schematic 4. Replace the A10A6 component locator and modify the A10A6 schematic to:

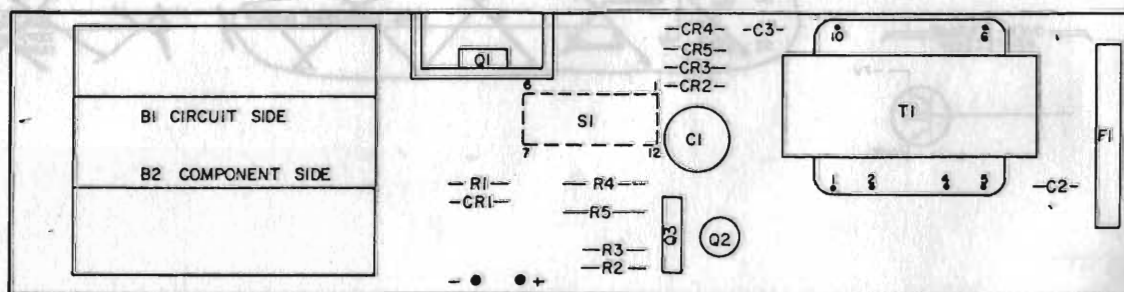
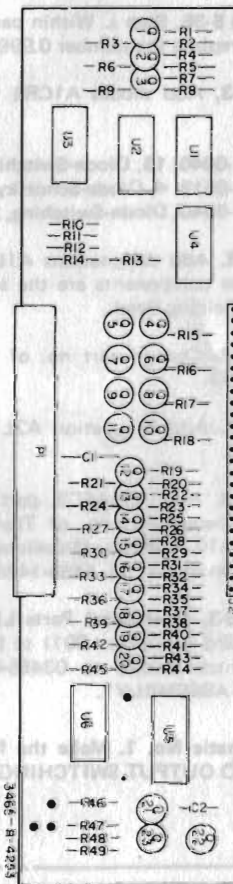
1. Change connection of C2 to other side of Fuse F1.
2. Change pin numbers of transformer T1.
3. Add C3 (see following).



Section VII, Schematic 4. Add shielding beads, A1L2, A1L3 and A1L4 as follows:



Section VIII, Backdating CHANGE 4. Add the following: "Schematic No. 3, Replace the A2 component locator with the following:



A10A6  
hp- Part No. 03465-66506

## ERRATA

Page 3-1, Add to Paragraph 3-10.

## NOTE

*In protecting batteries and circuitry the low battery voltage detection circuit may shut down the instrument if*

1. *the power switch is momentarily turned off then back on, or*
2. *if a live line power cord is attached to the instrument, while it is operating in the battery mode.*

*To restore normal operation the instrument must be turned off for a minimum of 10 seconds.*

Page 5-9, Paragraph 5-36(i). Change  $(0.9995 \times \text{CONST-1})$  to  $(0.9966 \times \text{CONST-1})$ .

Page 5-10, Paragraphs 5-39(c) and 5-40(c). Change  $\pm 100$  counts to  $\pm 10$  counts.

Page 6-8, Table 6-3. Reference Designation A10A6Q3, -hp- Part No. 1853-0394, Description. Change NPN to PNP.

## ERRATA

Page 7-13/7-14, Figure 7-5, Assembly A20A7 Schematic. Add wire connections from pin 4 to 5, and from pin 8 to 9 of S1.

CHANGE NO. 1 applies to S/N 1521A01501 and greater.

Page 7-11/7-12, Figure 7-4, Control Logic Assembly, A1, Schematic. Add capacitor C23, 100 pF from the junction of Y1, R52 and pin 9 of U7 to PC assembly ground.

Page 6-3. Add in sequence Ref. Desig., P/N, Qty and Desc., A1C23, 0150-0073, 1, Capacitor - FXD 100 pF 1000 V.

CHANGE NO. 2 applies to S/N 1546A01701 and greater.

Page 7-11/7-12, Figure 7-4, Control Logic Assembly, A1, Schematic. Delete C11, jumper D and Note 3. Renumber Notes 4 and 5 to 3 and 4 respectively.

Page 7-11, Figure 7-4, Display Interface, A2, Schematic. Delete C2.

Page 6-3. Delete A1C11 and all relevant nomenclature.

Page 6-7. Delete A2C2 and all relevant nomenclature.

CHANGE NO. 3 applies to S/N 1546A02151 and greater.

Page 6-9. Delete Part No. 0363-0108 and all relevant nomenclature. Add Part No. and Description 0380-0578, Standoff.

CHANGE NO. 4 applies to S/N 1546A04401 and greater.

Page 6-7. Delete A2Q12, A2R19, A2R20, A2R21 and all relevant nomenclature.

Page 6-8. Delete A5CR1 and all relevant nomenclature.

Page 7-11/7-12, Figure 7-4. Delete R19, R20, R21 and Q12 of the Display Interface, A2, Schematic and CR1 of the Display, A5, Schematic.

CHANGE NO. 5 applies to S/N 1546A01700 and greater.

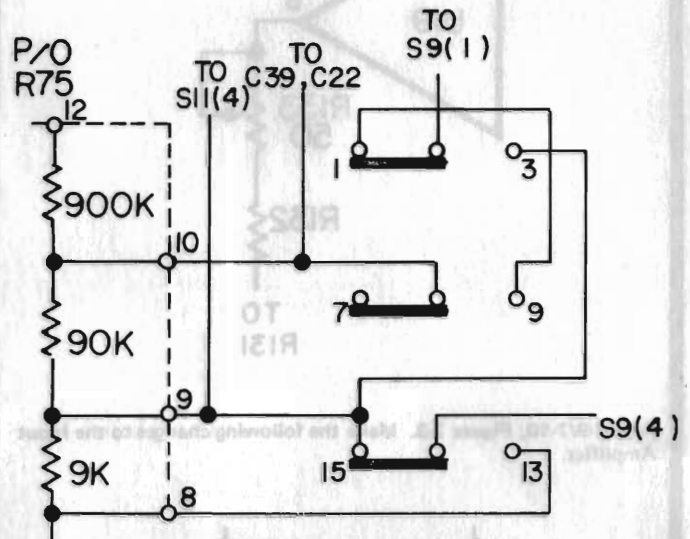
Page 6-5. Change the Part Number and value of A1R103 from 0683-2445, 240 K to 0683-1245, 120 K.

Page 7-7/7-8, Figure 7-2. Change the value of R103 from 240 K to 120 K.

CHANGE NO. 6 applies to S/N 1546A01701 and greater.

Page 6-3. Change the Part Number and value of A1C39 from 0160-2046, 2 pF  $\pm .5$  pF to 0160-999P PAD VALUE. Star the Reference Designations A1C39 and A1C57.

Page 7-7/7-8, Figure 7-2. Change the switch wiring by adding a contact between R75 pin 10 and S12 as shown.



CHANGE NO. 7 applies to all Serial Numbers.

Page 6-8. Change the quantity from 2 to 1 on Part Number 5000-5087.

Change the quantity from 1 to 2 on Part Number 5000-5086.

CHANGE NO. 8 applies to Serial Number 1546A02151 and greater.

Page 6-3. Change the Part Number and value of C42 from 0121-0427, 170/780 pf to 0121-0426, 50/380 pf.

Page 6-6. Change the Part Number and value of R135 from 0683-4745 470K .05 to R135\* - See padding list under A1 Assy Misc. Parts.

|       |           |                       |
|-------|-----------|-----------------------|
| R135* | 0683-2445 | Resistor 240K 5% .25W |
|       |           | FC TC = - 800/+ 900   |
|       | 0683-4745 | Resistor 470K 5% .25W |
|       |           | FC TC = - 800/+ 900   |

CHANGE NO. 9 applies to Serial Number 1546A04201 and greater.

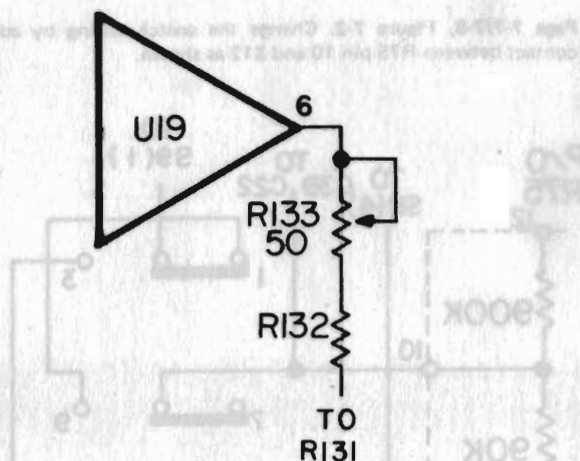
Page 6-3. Change the Part Number of C13, \*55, \*57 to 0140-0209.

Page 6-8. Change the Part Number of A10A6C3 to 0160-2055.

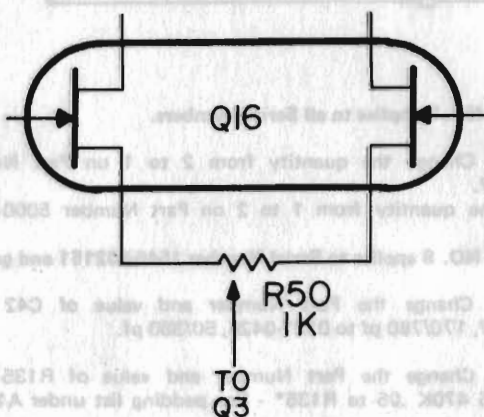
CHANGE NO. 10 applies to Serial Number 1546A02601 and greater.

Page 6-6. Delete \* on A1R133\*.

Page 7-7/7-8, Figure 7-2. Make the following changes to the output of the Impedance Converter.



Page 7-9/7-10, Figure 7-3. Make the following changes to the Input Amplifier.



#### ERRATA:

Page 6-6. Change the Part Number of A1U8 to 1820-0944.

Page 5-0, Table 5-1. Revise Resistor Section to read as follows:

|                           |                     |
|---------------------------|---------------------|
| 1.0 $\Omega \pm 0.02\%$   | Gen. Rad. 1440-9601 |
| 10 $\Omega \pm 0.01\%$    | Gen. Rad. 1440-9611 |
| 1 k $\Omega \pm 0.01\%$   | Gen. Rad. 1440-9631 |
| 10 k $\Omega \pm 0.01\%$  | Gen. Rad. 1440-9641 |
| 100 k $\Omega \pm 0.01\%$ | Gen. Rad. 1440-9651 |
| 1 M $\Omega \pm 0.01\%$   | Gen. Rad. 1440-9661 |
| 10 M $\Omega \pm 0.1\%$   | -hp-0698-8194       |
| 1 k $\Omega \pm 1\%$      | -hp-0727-0751       |
| 22 k $\Omega \pm 1\%$     | -hp-0757-1087       |
| 10 M $\Omega \pm 1\%$     | -hp-0698-5049       |

Page 5-2, Table 5-3. Change tolerance of the 1  $\Omega$  value of  $R_A$  from 0.1% to 0.02%.

Change the tolerance of the remaining values of  $R_A$  from 0.1% to 0.01%.

Page 5-4, Table 5-6. Delete all mid-range (50  $\mu$ A, 0.5 mA and 5 mA) tests.