Errata

Title & Document Type: **3403C True RMS Voltmeter Operating and Service Manual**

Manual Part Number: **03403-90005**

Revision Date: **August 1977**

About this Manual

We've added this manual to the Agilent website in an effort to help you support your product. This manual provides the best information we could find. It may be incomplete or contain dated information, and the scan quality may not be ideal. If we find a better copy in the future, we will add it to the Agilent website.

HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, life sciences, and chemical analysis businesses are now part of Agilent Technologies. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A. We have made no changes to this manual copy.

Support for Your Product

Agilent no longer sells or supports this product. You will find any other available product information on the Agilent Test & Measurement website:

www.agilent.com

Search for the model number of this product, and the resulting product page will guide you to any available information. Our service centers may be able to perform calibration if no repair parts are needed, but no other support from Agilent is available.

Agilent Technologies

MANUAL CHANGES
Model 6236B and 6237B DC Power Supplies
Manual HP P/N 5950-1782

Make all corrections in the manual according to errata below, then check the following table for your power supply serial number and enter any listed change(s) in the manual.

Model 6236B

SERIAL		MAKE CHANGES
Prefix	Number	
All	---	Errata
1705A	(Note 1)	1
1732A	00601-03150	1
1914A	03151-04900	1-2
2003A	04901-06600	1-3
2039A	06601-08500	1-4
2140A	08501-up	1-5

Model 6237B

SERIAL		MAKE CHANGES
Prefix	Number	
All	---	Errata
1706A	(Note 1)	1
1735A	00301-01930	1
2008A	01931-02250	1,3
2032A	02251-02930	1,3,4
2140A	02931-up	1,3-5

ERRATA:
The corrugated shipping carton for this model has been changed to HP Part No. 9211-2570. Two 9220-2703 floater pads are used.

CHANGE 1:
Change R34 to 470 ohms, 1/2W, HP Part No. 0686-4715. Also add three new resistors: R78,R79, both 825 ohms, 1%, 1/8 W, HP P/N 0757-0421; and R80, 750 ohms 1%, 1/8 W, HP P/N 0757-0420. R78, R79, and R80 are connected from base to emitter of Q1, Q7, and Q3, respectively, and are located on the circuit board as follows: R78-between Q2 and CR28, R79-near R55, and R80-between Q3 and C17. These changes prevent a turn-off overshoot.

ERRATA:
For all instruments delivered on or after July 1, 1978, change the HP P/N for fuseholder from 1400-0084 to fuseholder body 2100-0564 and fuseholder carrier 2100-0565. Change the HP P/N for fuseholder nut from 2950-0038 to 2110-0569. If old fuseholder must be replaced for any reason, replace complete fuseholder and nut with new fuseholder parts. Do not replace new fuseholder parts. Do not replace new parts with old parts.

CHANGE 2:
On schematic and parts list, change R69 to 92 ohm, +/-5%, 10 W, ww, HP P/N 0811-1041.

ERRATA
In paragraph 4-41, change last sentence to read: "While Q15 is off, it holds Q13 biased off and Q14 on; when Q15 conducts, it turns Q13 and Q14 off."

CHANGE 3:
In replaceable parts table 6-4, under Miscellaneous: add C.S.A. (Canadian Standards Association) identification label, HP P/N 7120-8572. The 6236A and 6237A supplies are now C.S.A. certified for laboratory equipment.

CHANGE 4:
On page 6-6, change the HP P/N of S1 to 3101-2269.

CHANGE 5:
In the replaceable parts list, page 6-6 under Miscellaneous, change "Foot, rubber" to HP P/N 0403-0002.

9-8-83

Note 1: Change 1 applies to the following instruments from earlier production runs. Model 6236B: serial 1705A-00502,-505,-507,-526,-533,-534,-536,-541, -544,-546,0547,-573,-577,-594. Model 6237B: serial 1706A-00263,-264,-269,-272, -291,-296,-298,-299.

OPERATING AND SERVICE MANUAL

MODEL 3403C
TRUE RMS VOLTMETER

Serial Number: 1452A01001 and higher

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 (Δ) or lettered delta (Δ_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 (Δ_1) which refers to the corresponding change in the Backdating section (Section VIII).

Manual Part No. 03403-90005

Microfiche Part No. 03403-90053

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

Printed: August 1977

HEWLETT hp PACKARD

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.

P.C. None

SUPERSEDES
NONE

SUPPLEMENTS: 3403C-4

-hp- MODEL 3403A/B/C TRUE RMS VOLTMETER

Serial Numbers: All

UPDATING THE 3403A AND ORIGINAL CONFIGURATIONS OF THE 3403A/B/C

The purpose of this service note is to:

a. Provide the information necessary to upgrade a 3403A to the current configuration of the 3403C.

b. Provide a listing of all configurations of the 3403, including models, options and production changes.

A. Updating the 3403A.

The 3403A and the 3403C have many identical board assemblies. Due to the shortage of some 3403A parts, it may be desirable to upgrade the 3403A to the current configuration of the 3403C. The following lists show the necessary parts for upgrading each configuration of the 3403A. Please note that the 3403C is not available with isolated remote control or isolated BCD output. These features of the 3403A will no longer be isolated if the instrument is converted.

3403A, STD

Replace: A4 with 03403-66517
A4A1 with 03403-66513
DPM with 5060-9188

The updated instrument will be standard.

3403A, Option 001

Replace: A4 with 03403-66517
A4A1 with 03403-66513
DPM with 5060-9188

The updated instrument will have autoranging.

KER/kkz/WN

09/78–09

Printed in U.S.A.

3403A, Option 002

Replace: A4 with 03403-66517
A4A1 with 03403-66513
A15 with 03403-66583
DPM with 5060-9127

The updated instrument will have digital output.

3403A, Option 003

Replace: A4 with 03403-66517
A4A1 with 03403-66513
A15 with 03403-66583
DPM with 5060-9127

The updated instrument will have autoranging, remote control, and BCD output.

3403A, Option 004

Replace: A4 with 03403-66517
A4A1 with 03403-66513
*A11 with 03403-66520 (A7)
A15 with 03403-66583
DPM with 5060-9127

The updated instrument will have digital output; however, the digital output will no longer be isolated.

3403A, Option 005

Replace: A4 with 03403-66517
A4A1 with 03403-66513
*A11 with 03403-66520 (A7)
A15 with 03403-66583
DPM with 5060-9127

The updated instrument will have autoranging, remote control, and BCD output; however, the BCD output and remove control will no longer be isolated.

3403A, Option 006

Replace: A4 with 03403-66517
A4A1 with 03403-66513
A12 with 03403-66592
DPM with 5060-9188

The updated instrument will have dB display.

*The A11 board (03403-66521) can be modified to substitute for the A7 board (03403-66520). It will be necessary to connect a shorting jumper between analog and digital grounds (J7, pins 20 and 34).

A 3403C Operating and Service Manual (-hp- Part Number 03403-90005) should be ordered for each converted instrument.

B. Original Configurations of the 3403A/B/C.

The following tables list all present and past configurations of the 3403.

Configurations not shown – except for combinations of options – are not valid and will not function properly.

Table 1. 3403A Serial Prefix 1124-.

	STD	OPT 001	OPT 002	OPT 003	OPT 004	OPT 005	OPT 006
A1	03403-60001	03403-60001	03403-60001	03403-60001	03403-60001	03403-60001	03403-60001
A2	03403-66530	03403-66530	03403-66530	03403-66530	03403-66530	03403-66530	03403-66530
A3	03403-66540	03403-66540	03403-66540	03403-66540	03403-66540	03403-66540	03403-66540
A4	03403-66510	03403-66510	03403-66510	03403-66510	03403-66510	03403-66510	03403-66510
A5	03403-66550	03403-66550	03403-66550	03403-66550	03403-66550	03403-66550	03403-66550
A6	03403-66560	03403-66560	03403-66560	03403-66560	03403-66560	03403-66560	03403-66560
A7	03403-66520	03403-66520	03403-66520	03403-66520	X	X	03403-66520
A8	03403-61901	03403-61901	03403-61901	03403-61901	03403-61901	03403-61901	03403-61901
A11	X	X	X	X	03403-66521	03403-66521	X
A12	X	X	X	X	X	X	03403-66591
A13	X	03403-66571	X	X	X	X	X
A14	X	X	X	03403-66572	X	03403-66572	X
A15	X	X	03403-66581	03403-66581	03403-66581	03403-66581	X
A21	03431-69501	03431-69501	03431-69501	03431-69501	03431-69501	03431-69501	03431-69501
A22	03431-69507	03431-69507	03431-69507	03431-69507	X	X	03431-69507
A23	X	X	X	X	03431-69502	03431-69502	X
A24	03431-89501	03431-89501	03431-89501	03431-89501	X	X	X
A25	X	X	X	X	03431-89502	03431-89502	X
A26	X	X	X	X	X	X	03431-89503

Table 2. 3403A Serial Prefix (Approx.) 1151- and Above.

	STD	OPT 001	OPT 002	OPT 003	OPT 004	OPT 005	OPT 006
A1	03403-60001	03403-60001	03403-60001	03403-60001	03403-60001	03403-60001	03403-60001
A2	03403-66530	03403-66530	03403-66530	03403-66530	03403-66530	03403-66530	03403-66530
A3	03403-66540	03403-66540	03403-66540	03403-66540	03403-66540	03403-66540	03403-66540
A4	03403-66511/513	03403-66511/513	03403-66511/513	03403-66511/513	03430-66511/513	03403-66511/513	03403-66511/513
A5	03403-66551	03403-66551	03403-66551	03403-66551	03403-66551	03403-66551	03403-66551
A6	03403-66561	03403-66561	03403-66561	03403-66561	03403-66561	03403-66561	03403-66561
A7	03403-66520	03403-66520	03403-66520	03403-66520	X	X	03403-66520
A8	03403-61901	03403-61901	03403-61901	03403-61901	03403-61901	03403-61901	03403-61901
A11	X	X	X	X	03403-66521	03403-66521	X
A12	X	X	X	X	X	X	03403-66591
A13	X	03403-66571	X	X	X	X	X
A14	X	X	X	03403-66572	X	03403-66572	X
A15	X	X	03403-66581	03403-66581	03403-66581	03403-66581	X
A21	03431-69501	03431-69501	03431-69501	03431-69501	03431-69501	03431-69501	03431-69501
A22	03431-66507	03431-66507	03431-66507	03431-66507	X	X	03431-66507
A23	X	X	X	X	03431-66502	03431-66502	X
A24	03431-60001	03431-60001	03431-60001	03431-60001	X	X	X
A25	X	X	X	X	03431-60002	03431-60002	X
A26	X	X	X	X	X	X	03431-60003

Table 3. 3403B Serial Prefix 1135-.

	STD	OPT 002	OPT 006
A1	03403-60002/3	03403-60002/3	03403-60002/3
A2	03403-66532	03403-66532	03403-66532
A3	03403-66542	03403-66542	03403-66542
A4	03403-66512	03403-66512	03403-66512
A5	03403-66550	03403-66550	03403-66550
A6	03403-66560	03403-66560	03403-66560
A7	03403-66520	03403-66520	03403-66520
A8	X	X	X
A11	X	X	X
A12	X	X	03403-66591
A13	X	X	X
A14	X	X	X
A15	X	03403-66581	X
A21	03431-66516	03431-66516	03431-66516
A22	03431-69507	03431-69507	03431-69507
A23	X	X	X
A24	03431-60001	03431-60001	X
A25	X	X	X
A26	X	X	03431-60003

Table 4. 3403C Serial Prefix 1303-.

	STD	OPT 001	OPT 002	OPT 003	OPT 006
A1	03403-60001	03403-60001	03403-60001	03403-60001	03403-60001
A2	03403-66530	03403-66530	03403-66530	03403-66530	03403-66530
A3	03403-66540	03403-66540	03403-66540	03403-66540	03403-66540
A4	03403-66516/513	03403-66516/513	03403-66516/513	03403-66516/513	03403-66516/513
A5	03403-66551	03403-66551	03403-66551	03403-66551	03403-66551
A6	03403-66561	03403-66561	03403-66561	03403-66561	03403-66561
A7	03403-66520	03403-66520	03403-66520	03403-66520	03403-66520
A8	03403-61901	03403-61901	03403-61901	03403-61901	03403-61901
A11	X	X	X	X	X
A12	X	X	X	X	03403-66592
A13	X	03403-66571	X	X	X
A14	X	X	X	03403-66572	X
A15	X	X	03403-66582	03403-66582	X
A20 (DPM)	5060-9133	5060-9133	5060-9133	5060-9133	5060-9133

Table 5. 3403C Serial Prefix 1452- and Above.

	STD	OPT 001	OPT 003	OPT 006
A1	03403-60001	03403-60001	03403-60001	03403-60001
A2	03403-66530	03403-66530	03403-66530	03403-66530
A3	03403-66540	03403-66540	03403-66540	03403-66540
A4	03403-66517/513	03403-66517/513	03403-66517/513	03403-66517/513
A5	03403-66551	03403-66551	03403-66551	03403-66551
A6	03403-66561	03403-66561	03403-66561	03403-66561
A7	03403-66520	03403-66520	03403-66520	03403-66520
A8	03403-61901	03403-61901	03403-61901	03403-61901
A11	X	X	X	X
A12	X	X	X	03403-66592
A13	X	03403-66571	X	X
A14	X	X	03403-66572	X
A15	X	X	03403-66583	X
A20	5061-0747	5060-0747	5061-0741	5060-0747
A21	5061-0740	5061-0740	5061-0740	5061-0740
A22	5061-0736	5061-0736	5061-0739	5061-0736
DPM	5060-9188	5060-9188	5060-9127	5060-9188

P-03403-69501-3
SERVICE NOTE

P.C. None

SUPERSEDES
NONE

-hp- MODEL 3403A/B/C TRUE RMS VOLTMETER

Serial Numbers: All

FINAL ADJUSTMENT OF CONVERTER ASSEMBLY

The exchange ac converter assembly for the 3403 has been carefully calibrated at the factory. For this calibration, potentiometer A7R1 was arbitrarily set at mid-range. Therefore, all adjustments are referenced to the setting of this potentiometer. It is necessary to perform the final converter balance adjustment (A7R1) in order to properly reference the exchange converter. This adjustment is outlined in the manual. For convenience, it is repeated below:

Final Converter Balance Adjustment.

An ac calibrator and digital voltmeter are required for this adjustment. Secure the front panel and replace bottom and side covers. Allow the instrument to warm up for at least 1 hour before proceding.

a. Set FUNCTION to AC VOLTS, RANGE to .1 V, RESPONSE TIME to FAST.

b. Connect digital voltmeter to rear panel VOLTS recorder output terminals.

c. Apply input of 100.000 mV at 100 Hz from ac calibrator. Note digital voltmeter reading.

d. Reduce input to 10.000 mV.

e. Remove left side cover and adjust A7R1* for voltmeter reading of 1/10 the reading noted in step c.

Please contact Customer Service at Loveland Instrument Division if you encounter calibration problems with the exchange converter.

*Note: Model 3403A voltmeters with isolated remote control will have A11 in place of A7.

KER/kkz/WN

09/78-09

Printed in U.S.A.

HEWLETT hp PACKARD

For more information, call your local HP Sales Office or East (201) 265-5000 • Midwest (312) 255-9800 • South (404) 434-4000
West (213) 877-1282. Or, write: Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California 94304. In Europe, 1217 Meyrin-Geneva

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. The Hewlett-Packard Model 3403C True RMS Voltmeter makes ac voltage measurements on six ranges of 10 mV to 1000 V full range, with overrange capability of up to 190 % of range except as limited by maximum allowable input voltage. In addition, the Model 3403C makes dc voltage and dc + ac measurements on five ranges. Options listed in Paragraph 1-5 are available to increase the usefulness of the instrument.

1-3. SPECIFICATIONS.

1-4. Specifications for the Model 3403C are shown in Table 1-1. Table 1-2 lists a number of typical operating characteristics.

1-5. OPTIONS.

1-6. The following options are available for the Model 3403C:

Option 001: Autoranging
Option 003: Autoranging + Remote + BCD Output
Option 006: dB Display
Option 910: An additional Operating and Service Manual may be ordered as Option 910, Part No. 03403-90005

1-7. ACCESSORY EQUIPMENT SUPPLIED.

1-8. A "banana plug to BNC" adapter, -hp- Part No. 5040-5847, is supplied with the Model 3403C. Use of this adapter disconnects input common from chassis ground, so that floating measurements may be made. A printed circuit extender, -hp- Part No. 5060-5984, is supplied as an aid to servicing the digital panel meter assembly. A remote connector, -hp- Part No. 1251-0293, is supplied with Option 003.

1-9. ACCESSORIES AVAILABLE.

1-10. Available accessories include a 50 Ω feed-thru termination, -hp- 11048C; a 75 Ω feed-thru termination, -hp- 11094B; and a 600 Ω feed-thru termination, -hp- 11095A. An output cable, -hp- 11184A, is available for connecting the BCD output to a digital recorder such as the -hp- Model 5055A or 5050B. Accessories required for rack mounting the Model 3403C include the -hp- 5060-8762 adapter frame, the -hp- 5060-8540 half-width filler panel, and if only one instrument is to be mounted, the -hp- 5060-8760 half-module filler panel. The -hp- 11096A high frequency, peak responding probe may be used to reduce the input capacitance to 2 pF and permit relative measurements up to 1 GHz.

1-11. INSTRUMENT AND MANUAL IDENTIFICATION.

1-12. Instrument identification by serial number is located on the rear panel. Hewlett-Packard uses a two-section serial number consisting of a four-digit prefix and a five-digit suffix, separated by a letter designating the country in which the instrument was manufactured, (A = U.S.A.; G = West Germany; J = Japan; U = United Kingdom.) If the four-digit prefix of the serial number of your instrument is lower than the prefix shown on the title page of this manual, backdating information located in Appendix C will define the differences between your instrument and the Model 3403C described in this manual.

1-13. SAFETY CONSIDERATIONS.

1-14. 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.

Ranges:
.01 V (ac only)
.1 V
1 V
10 V
100 V
1000 V

Functions:
AC: Responds to true RMS value of ac coupled input signal.
DC: Responds to dc component of input signal.
DC + AC: Responds to true RMS value of dc and ac signal; Reading is:

$$\sqrt{(dc)^2 + (ac\ RMS)^2}$$

Effective Common-Mode Rejection (1 kΩ unbalance in either lead):
AC Function: > 60 dB at 60 Hz.
DC Function: > 120 dB at 60 Hz.

Normal-Mode Rejection:
DC Function: > 60 dB at 60 Hz.

Voltage Measurement Accuracy: (25° C ± 5° C; < 95 % relative humidity).
AC or DC + AC voltage measurement accuracy is not specified below the point on any range where the RNG ↓ indicators light.
DC function accuracy is specified over the entire range.

Voltage Reading Accuracy = ± (% of Range + % of Reading)**

Range	Function DC	Function DC + AC	Function AC	Frequency in Hz DC	2	25	100 k	1 M	10 M	20 M	50 M	100 M
1000 V	0.3	0.3	0.3	0.2	0.4*	0.2						
100 V	0.2	0.2	0.2	0.2	0.4*	0.2	1.0					
10 V	0.2	0.2	0.2	0.2	0.4*	0.2	0.5	1.0				
1 V	0.2	0.2	0.2	0.2	0.4*	0.2	0.5	1.0	2.0	5.0	10.0	
.1 V	0.6	0.6	.04 V $\frac{0.2}{0.4}$	0.2	0.4*	0.2	0.5	2.0	2.0	5.0	10.0	
.01 V			.004 V $\frac{0.2}{0.4}$			0.3	1.2	3.0	2 M			

* DC + AC Function and Slow Response Time only.
** % of Reading Specification is representative of typical flatness.
Frequencies and Ranges in shaded areas may result in invalid readings without ranging information.

dB Measurement Accuracy (Option 006): (25° C ± 5° C; < 95 % relative humidity).
dB measurement accuracy is not specified below the point on any range where the RNG ↓ indicators light.

dB Reading Accuracy = ± dB + dB**

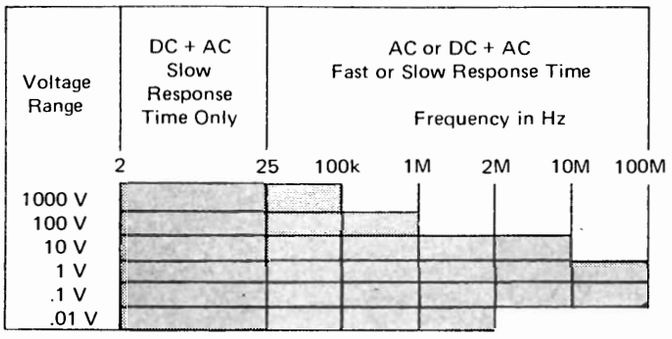
Range	Function AC	Function DC + AC	Frequency in Hz DC	2	25	100 k	1 M	10 M	20 M	50 M	100 M
1000 V	0.15	0.15	0.02	0.04*	0.02						
100 V	0.15	0.15	0.02	0.04*	0.02	0.1					
10 V	0.15	0.15	0.02	0.04*	0.02	0.05	0.1				
1 V	0.15	0.15	0.02	0.04*	0.02	0.05	0.1	0.2	0.5	1.0	
.1 V	0.15	0.15	0.02	0.04*	0.02	0.05	0.2	0.2	0.5	1.0	
.01 V	0.15					0.1	0.3	2 M			

*DC + AC Function and Slow Response Time only.
**Specification is representative of typical flatness.
Frequencies and Ranges in sladed areas may result in invalid readings without ranging information.

Temperature Coefficient (0° C to 20° C and 30° C to 50° C): TC = 0.1 x Reading accuracy (from charts)/° C.

Table 1-2. Typical Operating Characteristics.

Frequency Range.



Response Time:
Fast: 1 second
Slow: 10 seconds.

Instrument reads final reading ± 0.1 % of input voltage change in stated response time.

⚠ **Reading Rate:**
Fast response time: 4 per second
Slow response time: 2 per second

Maximum Input Voltage:
High to Low:
1000 V rms, 1500 V peak or 10^8 V Hz on any range.
Maximum dc in ac function: ± 500 V dc.

Low to Chassis:
± 500 V peak, when floated with special banana jack-to-BNC adapter.

Input Impedance:
Below 10 MHz
1 V to 1000 V ranges: 10 MΩ ± 10% in parallel with 24 pF ± 10%.

.01 V and .1 V ranges: 20 MΩ ± 10% in parallel with 20 pF ± 10%.

1 MHz to 100 MHz: The following table gives maximum loading error due to input shunt impedance across a terminated source.

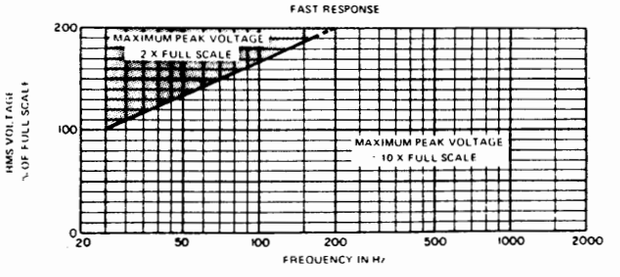
System Impedance (Source and Load)	Frequency 10 MHz	100 MHz
50 Ω	1 %	10 %
75 Ω	2 %	20 %

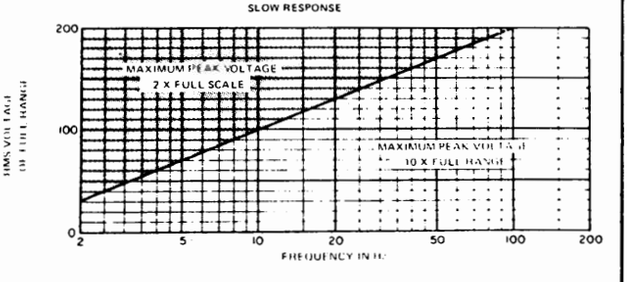
Autoranging (Options 001 and 003):
Upranging occurs at approximately 190 % of range, downranging at approximately 17 % of range.

Autorange operating frequency range: Input signals above the frequencies indicated by the Frequency Range chart in this table may result in erroneous readings and improper autorange operation.

Autorange time per range change:
Fast response time: 1 second
Slow response time: 10 seconds

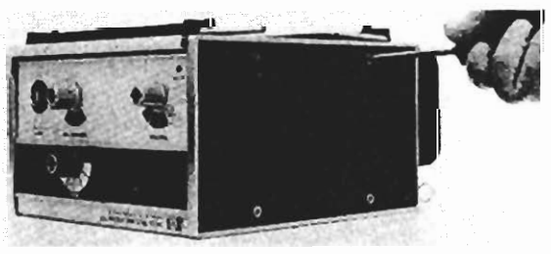
Crest Factor: Peak Voltage Limits:





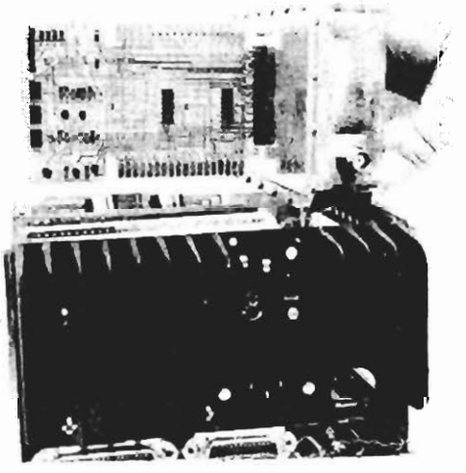
The Crest Factor capabilities of the Model 3403C are limited by two things: the dynamic range of the Input Amplifier and the Overload Protection circuitry which protects the thermopile. The dynamic range of the Input Amplifier is sufficient to handle peaks of at least 10 times full range. The Overload Protection circuit, which limits the peak temperature of the thermopile, is dependent on both the voltage level and frequency. The following figures show the ranges of frequency and level at which the RMS Converter will accept signals with peaks of 10 times full range without being limited by the Overload Protection circuit. As the frequency is reduced (or the RMS value is increased) beyond the limits shown, the maximum peak voltage allowable makes a fairly abrupt transition from 10 times to 2 times full range.

Step A



Turn 3403C upside down and remove all four screws in each side to remove side and bottom covers.

Step B



Remove AC Converter and Connector Assembly. Remove hole plug from rear panel.

Turn AC Converter and Connector Assembly over and insert with input connector toward rear of instrument.

Replace bottom and side covers. Place hole plug in front panel.

Figure 2-1. Changing Input from Front to Rear.

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary for installing the Model 3403C True RMS Voltmeter and for installing certain options within the instrument. Included are initial inspection procedures, power and grounding requirements, installation and interface 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 mars 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 procedure outlined in Section V of this manual. If there is damage or deficiency, see the warranty in the front of this manual.

2-5. POWER REQUIREMENTS.

2-6. The Model 3403C can be operated from any source of 115 or 230 volts at 48 to 440 Hz. Power dissipation is a maximum of 50 VA, depending upon options installed.

2-7. POWER CORDS AND RECEPTACLES.

2-8. Figure 2-2 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 below each receptacle drawing is the part number for a 3403C 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.

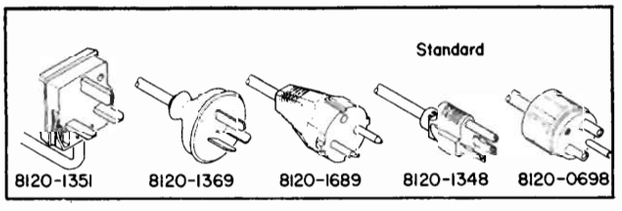


Figure 2-2. Power Cord Receptacles.

2-9. GROUNDING REQUIREMENTS.

2-10. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. The Model 3403C is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable is the ground wire. To preserve the protection feature when operating the instrument from a two-contact output, use a three-contact to two-contact adapter and connect the green wire on the adapter to power line (earth) ground.

2-11. INSTALLATION.

2-12. The Model 3403C is fully transistorized and no special cooling equipment is required. However, the instrument should not be mounted in a manner that would obstruct the free flow of air around the instrument, particularly around the rear panel cooling fins. It should not be operated where the ambient temperature exceeds 50° C (122° F) or the relative humidity exceeds 95 %. Power dissipation is 50 VA maximum.

2-13. Bench Mounting.

2-14. The Model 3403C is shipped with plastic feet and tilt stands in place, ready for use as a bench instrument.

2-15. Rack Mounting.

2-16. The 3403C may be rack mounted by using an adapter frame, -hp- Part No. 5060-8762. This adapter frame accepts a combination of submodular units for rack mounting only. An -hp- 5060-8540 half-width filler is needed above the 3403C. If only one instrument is to be rack mounted the half-module filler panel, -hp- 5060-8760 is also required.

2-17. REAR PANEL INPUT.

2-18. The design of the 3403C permits the input connector to be located either at the front panel or rear panel. Instructions for changing the input from the usual front panel location to the rear panel are given in Figure 2-1.

2-19. ADDITION OF OPTIONS.

2-20. The options available for addition to the 3403C (Options 001, 003 and 006), are available only as factory installed options. No options are available as field installable options. An additional Operating and Service Manual may be ordered as Option 910 (Part No. 03403-90005).

2-21. REPACKAGING FOR SHIPMENT.

2-22. The following paragraphs contain a general guide for repackaging the instrument for shipment. Refer to Paragraph 2-23 if the original container is to be used, 2-24 if it is not. If you have any questions, contact your nearest -hp- Sales and Service Office (see Appendix B).

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.

2-23. 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.

2-24. If original container is not be 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 and seal with strong tape or metal bands.

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

2-25. INTERFACE CONNECTIONS.

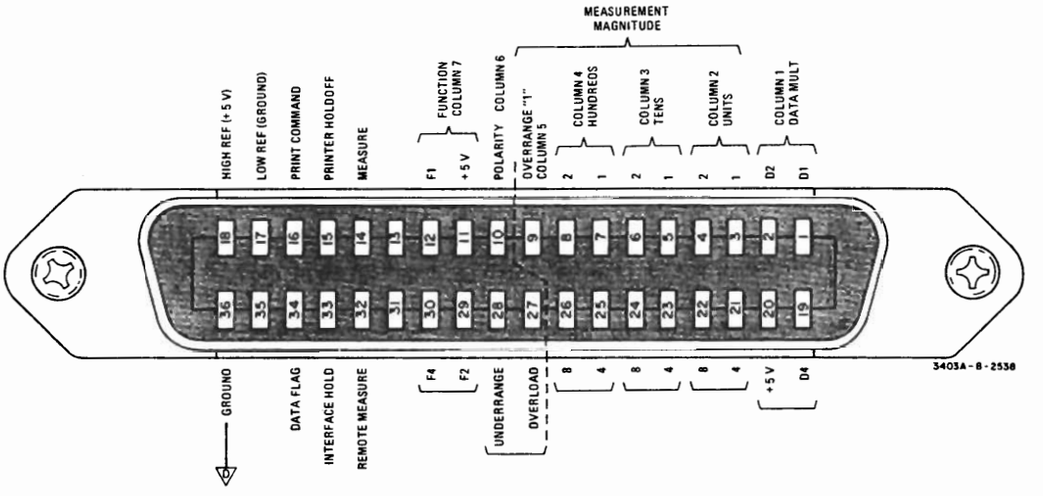
2-26. Digital Output.

2-27. If the Model 3403C is equipped with a Digital Output option, 7 columns of 1-2-4-8 coded BCD information are provided, LOW state true. In addition to 4 columns of measurement magnitude information (the 1-2-4-8 coded BCD information), range, function, polarity, and out-of-range information are provided. A true state is the condition meaning yes, assertion or enable. LOW state true means a LOW on a 1-2-4-8 BCD line is the true state for the line. For instance, the logic levels on the 1-2-4-8 BCD lines for a binary BCD presentation of the decimal number 3 is LOW, LOW, HI, HI (True, True, False, False) respectively. For the decimal number 7, the 1-2-4-8 logic levels are LOW, LOW, LOW, HI (True, True, True, False) respectively. Positive reference is + 5 V and negative reference is 0 V (ground), available at the rear panel connector. In addition to the coded information, connections are provided for several input and output signals. Figure 2-3 shows the BCD Output Connector J2 and gives required interface information. The mating connector for J2 is -hp- Part No. 1251-0084 (Amphenol No. 57-30360-375). A cable, -hp- 11184A, is available for connection to -hp- digital recorders.

2-28. Remote Control.

2-29. Option 003 permits programming of function, range, autorange and response time. Lines are also provided for remote control of sampling. Figure 2-4 shows the Remote Program Connector J3 and gives required interface information. The mating connector for J3 is -hp- Part No. 1251-0293 (Amphenol No. 57-30240).

BCD OUTPUT CONNECTOR J2



OUTPUT SIGNAL LEVELS

LOW = < + 0.5 V, 12 mA max sink current
HIGH = + 5 V, 6 kΩ source resistance
Data output signals are LOW true.
Printer columns are numbered right to left.

OUTPUT SIGNALS

Column 1: Readout Magnitude Multiplier is Decimal position in negative power of 10 beginning at a point between columns 1 and 2 (0000.0×10^{-n}). Multiplier is 1 for all dB measurements.

Print	Voltage Range
0	1000. V
1	100.0 V
2	10.00 V
3	1.000 V
4	.1000 V
5	.01000 V

Columns 2 through 5: Readout Magnitude.

Column 6: Polarity, Overload, and Underrange.

Print	Conditions
0	-
1	+
2	-, Overload
3	+, Overload
4	-, Underrange
5	+, Underrange
6	-, Underrange, Overload
7	+, Underrange, Overload

Column 7: Function.

Print	Function
0	DC + AC Volts
1	DC Volts
2	AC Volts

Column 7: Function. (cont'd)

Print	Function
3	Not used
4	DC + AC dB
5	Not used
6	AC dB
7	Not used

Print Command:
Positive- or negative-going pulse between 0 V and - 10 V. Polarity is selected by connection on Input/Output Assembly. First Transition acknowledges receipt of Remote Measure signal when in Remote mode of operation. Second transition indicates valid data available.

Data Flag:
Positive- or negative-going pulse between 0 V and + 5 V. Polarity is selected by connection on Input/Output Assembly. First transition acknowledges receipt of Remote Measure signal when in Remote mode of operation. Second transition indicates valid data available.

Print Command and Data Flag are identical except for voltage.

INPUT SIGNALS:

Interface Hold:
LOW level disables automatic sampling.

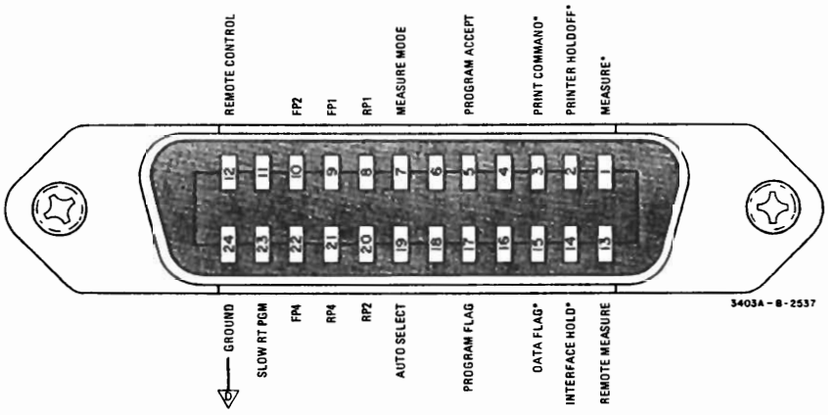
Printer Holdoff:
Level $\geq$ + 2.0 V and $\leq$ + 20 V disables automatic sampling.

Measure:
LOW > 2 microseconds initiates measurement.

Remote Measure:
LOW > 50 microseconds initiates measurement when in Remote operating mode.

Figure 2-3. BCD Output Connector J2.

REMOTE PROGRAM CONNECTOR J3



*These signals available with or without Remote option installed.

INPUT SIGNAL LEVELS

LOW = + 0.5 V, 12 mA max sink current, or contact closure to ground through < 600 Ω.
HIGH = + 5 V, 6 kΩ source resistance, or open circuit.

INPUT SIGNALS

Remote Control:
LOW level enables remote programming and disables front panel Function, Range, and Response Time Controls. Disables automatic sampling.

Remote Measure:
LOW > 50 microseconds initiates measurement when in Remote operating mode.

Interface Hold*:
LOW level disables automatic sampling.

Printer Holdoff*:
Level ⩾ + 2 V and ⩽ + 20 V disables automatic sampling.

Measure*:
LOW > 2 microseconds initiates measurement.

Program Accept:
LOW > 50 microseconds accepts remote program word.

Function Program:

Function	FP1	FP2	FP4	
D C + AC Volts	H	H	H	
DC Volts	L	H	H	
AC Volts	H	L	H	
Not used	L	L	H	
DC + AC dB	H	H	L	If dB Option not installed these states not used.
Not used	L	H	L	
AC dB	H	L	L	
Not used	L	L	L	

Range Program:

Range	RP1	RP2	RP4
1000 V	H	H	H
100 V	L	H	H
10 V	H	L	H
1 V	L	L	H
.1 V	H	H	L
.01 V	L	H	L

Auto Select:
LOW level selects autoranging when in Remote mode.

Response Time Program:
LOW = Slow; HIGH = Fast

Measure Mode Program:
LOW = Non-delayed; HIGH = Delayed

OUTPUT SIGNALS:

Program Flag:
Positive - or negative - going pulse between 0 V and + 5 V. Polarity selected by connection on Remote Assembly. First transition acknowledges receipt of Program Accept. Second transition indicated program stored.

Print Command*:
Positive - or negative - going pulse between 0 V and - 10 V. Polarity selected by connection on Input/Output Assembly. First transition acknowledges receipt of Remote Measure command when in Remote mode of operation. Second transition indicates valid data available.

Data Flag:
Positive - or negative - going pulse between 0 V and + 5 V. Polarity selected by connection on Input/Output Assembly. First transition acknowledges receipt of Remote Measure command when in Remote mode. Second transition indicates valid data available.

Figure 2-4. Remote Program Connector J3.

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. The -hp- Model 3403C True RMS voltmeter makes ac voltage measurements on six ranges from 10 mV to 1000 V full range. The Model 3403C also makes dc and dc + ac true rms measurements on five ranges from 100 mV to 1000 V full range. The dc + ac true rms measurement is equal to $\sqrt{(dc)^2 + (ac\ rms)^2}$. Overrange readings of greater than 190 % of range are possible on all except the 1000 V range. *The accuracy of readings in AC and DC + AC Functions is not specified below the point on any range where downrange indication occurs.*

3-3. In addition to voltage measurements, the dB Option 006 permits measurements of ac and dc + ac to be read directly in dB. Other options, listed in Paragraph 1-5, provide autoranging, remote programming, and digital output.

3-4. FRONT AND REAR PANEL DESCRIPTION.

3-5. Figure 3-1 shows the front and rear panel controls and connectors and gives a brief description of each. Some of the features shown are available only with certain options.

3-6. MAXIMUM INPUT VOLTAGES.

⚠ CAUTION

DO NOT EXCEED THE FOLLOWING MAXIMUM INPUT VOLTAGES OR DAMAGE TO THE INSTRUMENT MAY RESULT.

BETWEEN INPUT HIGH AND LOW:
- *AC FUNCTION: 1500 VAC PEAK, 500 VDC*
- *DC FUNCTION: ± 1000 V*
- *DC + AC FUNCTION: 1000 VRMS, 1500 V PEAK DC + AC*

BETWEEN INPUT LOW AND CHASSIS (FLOATING MEASUREMENTS): ± 500 V PEAK.

3-7. GENERAL OPERATING CHARACTERISTICS.

3-8. Turn-on and Warm-up.

3-9. Make sure the rear panel 115/230 slide switch is set to the proper line voltage before connecting the Model 3403C. To obtain readings within the specified measurement accuracy, turn the instrument on and allow to warm up for at least 15 minutes.

3-10. DC Zero.

3-11. For maximum accuracy when making dc measurements with the Model 3403C, short the input and adjust the front panel DC ZERO control for zero display.

3-12. Floating Measurements.

⚠ CAUTION

TO MAKE FLOATING OR POWER LINE VOLTAGE MEASUREMENTS WITH THE 3403C, THE BANANA JACK TO BNC ADAPTER (-hp- PART NO. 5040-5847) SUPPLIED WITH THE INSTRUMENT MUST BE USED TO DISCONNECT INPUT LOW FROM CHASSIS.

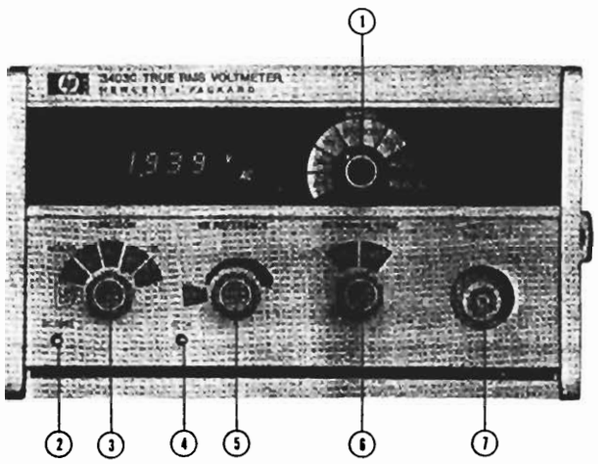
3-13. Normally, the 3403C input Low is connected to chassis (power line) ground. The banana jack to BNC adapter breaks this ground connection. *Be sure the adapter is inserted correctly and turned fully clockwise on the BNC bayonet connector.* Floating measurements may then be made of inputs up to ± 500 V peak above chassis ground, provided that any input or output equipment connected to the 3403C is also floating. If the 3403C is equipped with the Digital Output, refer to Paragraph 3-46.

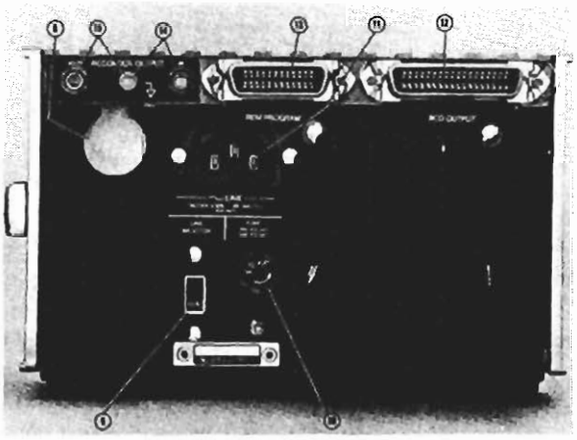
3-14. High Frequency Measurements.

3-15. At frequencies below approximately 10 MHz, input impedance is 10 MΩ ± 10 % shunted by 19 pF ± 10 % on the 1 V through 1000 V ranges, and 20 MΩ ± 10 % shunted by 16 pF ± 10 % on the .01 V and .1 V ranges. At frequencies of approximately 10 MHz and higher the input impedance is not accurately represented by the above description. When measuring signals above approximately 10 MHz, a termination should be used at the 3403C input equal to the characteristic impedance of the signal source, as shown in Figure 3-2. The impedance of the cable used should also match the source impedance. This is necessary to minimize the loading effect of mismatched impedances and standing waves. Maximum loading error due to input shunt impedance across a terminated source is shown in Table 3-1. Feed-thru terminations of 50 Ω (-hp- 11048C), 75 Ω (-hp- 11094B) and 600 Ω (-hp- 11095A) are available.

Table 3-1. Maximum Input Loading Error.

System Impedance (Source and Load)	Frequency	
	10 MHz	100 MHz
50 Ω	1 %	10 %
75 Ω	2 %	20 %





1. Range Switch. Also selects optional Autorange and Remote Control.
2. DC Zero. Corrects dc offset.
3. Function Switch and Power Line Switch.
4. dB Cal. Calibrates optional dB function to dBV or dBM 600 Ω.
5. dB Reference. Shifts dB reference level downward at least 10 dB.
6. Response Time Control. Slow selects 10 second response time and 2/s sample rate. Fast selects 1 second response time and 4/s sample rate.
7. BNC input connector. May be changed to rear panel input.
8. Location of rear panel input. See Paragraph 2-17.
9. Line voltage selector.
10. Line fuse.
11. Power input connector.
12. Digital output connector (optional).
13. Remote Control connector(optional).
14. dB Analog Recorder output terminals (optional).
15. Volts Analog Recorder output terminals.

Figure 3-1. Front and Rear Panels.

3-16. Response Time.

3-17. The Model 3403C reaches final reading ± 0.1 % of an input voltage change within the stated response time. The 3403C provides a choice of two response times. SLOW response time is approximately 10 seconds, and must be used with DC + AC Function for input frequencies below 25 Hz. FAST response time is approximately 1 second and may be used for frequencies higher than 25 Hz.

3-18. Automatic Sampling Rate.

3-19. The RESPONSE TIME control of the 3403C selects the automatic sampling rate. In the SLOW position, the reading rate is 2 per second, and 4 per second in FAST position. In both cases, the reading rate is faster than the response, resulting in one or more erroneous readings when a large step input voltage is applied. However, the faster reading rates provided are desirable when small voltage changes are being observed.

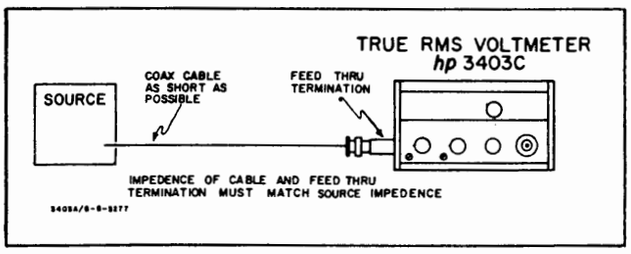


Figure 3-2. High Frequency Measurements.

3-20. Measure Command Input.

3-21. This input connection is available in the 3403C equipped with a Digital Output option. When the Interface Hold line is grounded (continuous LOW), a LOW connection at the Measure input for $>2\ \mu s$ initiates a measure-

ment. Figure 3-3 shows the measurement sequence along the external measure command input. This MEASURE COMMAND is externally applied and not the MEASURE command described in Paragraph 3-25 and Figure 3-4.

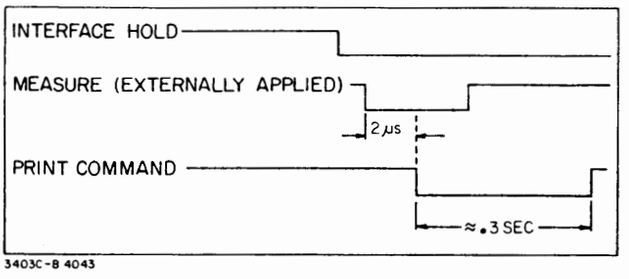


Figure 3-3. Measure Sequence (Non-Remote).

3-22. Remote Measure Command Input.

3-23. This input connection is available only in the 3403C equipped with a Remote Control option.

3-24. Non-Delayed Measure Mode. The non-delayed mode must be programmed by a LOW signal at the Measure Mode connection, J3 pin 7. See Figure 2-4 and Paragraph 3-51. In this mode of operation, a Remote Measure command (LOW $>50\ \mu s$ at the Remote Measure input of either J2 or J3) initiates a measurement within a few microseconds.

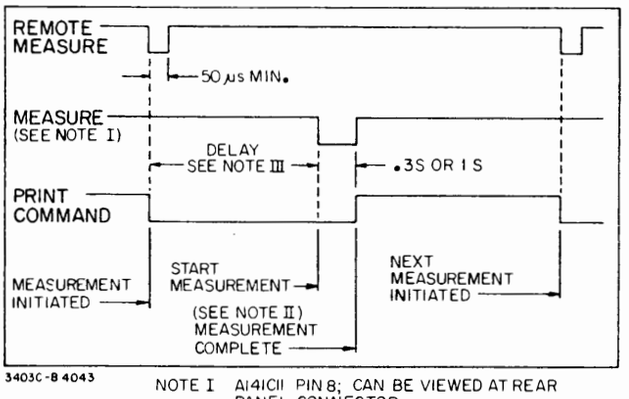


Figure 3-4. Remote Measure Sequence (Delayed).

3-25. Delayed Measure Mode. A HIGH signal (or open circuit) at the Measure Mode connection, J3 Pin 7, selects the delayed measure mode of operation. In this mode, the internal Measure command (A14IC11 pin 8) is delayed for a length of time determined by the 3403C response time programmed. See Figure 2-4 and Paragraph 3-51. If Fast response time is selected, the delay is a minimum of 1 second, and 10 seconds minimum for Slow response time. The reading rate, then, is determined by the response time selected. A Remote Measure command may be applied following the second transition of the Print Command or Data Flag signal, which indicates that the previous measurement has been completed. A Remote Measure command applied between the first and second transition of these signals will have no effect. The measurement sequence is illustrated in Figure 3-4.

3-26. Overrange Measurements.

3-27. The Model 3403C is capable of readings greater than 190 % of full range on all except the 1000 V range. The fourth digit "1" lights for all measurements of 1000 or higher.

3-28. Out-of-Range Indication.

3-29. If any or all of the ↑ , RNG, or ↓ annunciators are lit, the reading is not valid. In voltage measurements, this out-of-range indication occurs for readings below approximately 17% of range or above approximately 190% of range. If a measurement is out of range, the RNG annunciator will light up and the least significant digits will be blank except when the measurement is below 17% of range in the DC VOLTS mode. In the DC VOLTS mode, the RNG annunciator does not light and blanking does not occur in the under-range condition. In the over-range condition for all voltage measurements, the first significant digit lights up, along with the RNG and ↑ annunciators. If the digits are lit, the numbers displayed are not accurate. In dB measurements, the out-of-range limits on the two lower ranges are approximately 34% and 380% of range. On the four higher ranges, the limits are 17% and 190%. The 10 mV range for either dc or dc + ac is out of range of the specifications; on that range, all digits will blank, and the ↑, ↓, and RNG annunciators will come on.

NOTE

When used in the dc or dc + ac function in autorange, an input to the 100 mV range of approximately 17 mV causes the 3403C to downrange to the 10 mV range. The 10 mV range on the dc or dc + ac ranges cause the display to blank. The 3403C must uprange to the 100 mV range for a display to reappear. This requires an input 190% of the 10 mV range or 19 mV. As a result, in autorange the display blanks at approximately 17 mV and does not return until the input is increased to approximately 19 mV.

3-30. Autoranging.

3-31. When autoranging operation (Option 001 or 003) is selected, autoranging occurs at the points where the uprange and downrange indications occur. Autoranging

time per range change is 1 second minimum when fast response time is selected, and 10 seconds minimum for slow response time. If a step input voltage greater than approximately 220% of range is applied, the instrument will go to the 1000 V range and then downrange to the proper range. Due to the frequency response design of the attenuator, autoranging may not operate properly above certain frequencies on some ranges. These limits are shown in Table 3-2.

Table 3-2. Autorange/Frequency Limits.

Range	Maximum Frequency
.01 V	2 MHz
.1 V	100 MHz
1 V	100 MHz
10 V	10 MHz
100 V	1 MHz
1000 V	100 kHz

3-32. Analog Recorder Output.

3-33. Volts. The Volts Recorder Output at the rear panel of the Model 3403C is + 1 V for a full-range input on any range in the AC function. A full-range DC + AC input also gives + 1 V output. In the DC function, the output is ± 1 V for a full-range + or - dc input. The tolerance of the Volts Recorder Output in the AC, DC + AC or DC function is equal to that of the voltage measurement accuracy specification. The Volts Recorder Output resistance is 1 kΩ ± 10%.

3-34. dB. If the instrument incorporates the dB option, a dB Analog Output is provided in addition to the voltage output. Figure 3-5 shows the relationship between the dB Recorder Output, the display, and the range selected. The tolerance of the dB Recorder Output in the AC or DC + AC function is equal to that of the dB measurement accuracy specification. Output resistance is 1000 Ω ± 500 Ω.

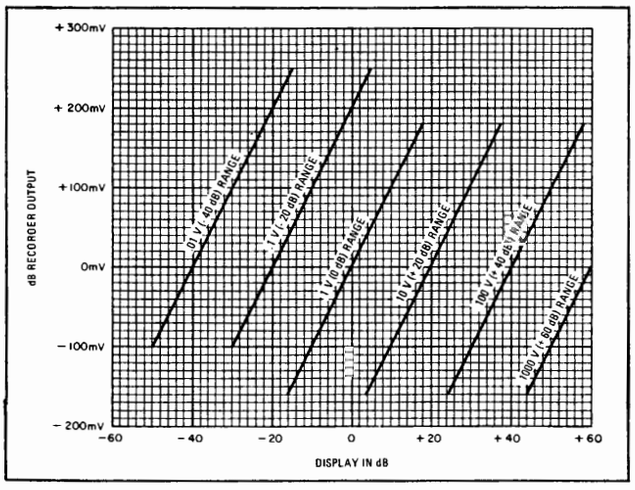


Figure 3-5. dB Analog Recorder Output.

3-35. Non-Sinusoidal Input Signals.

3-36. The Model 3403C makes true rms measurements of non-sinusoidal input signals as shown in the Crest Factor information in Table 1-2. When the frequency and rms value of the signal fall within the shaded portion of the Crest Factor graphs (Table 1-2), a peak voltage greater than 2 times full range will cause the ↑ indicator and the 3 least significant digits to flash, indicating that the peak voltage is beyond the limit of the instrument. When operating in the autorange mode, this condition will cause the instrument to go to the 1000 V range and then range downward to the proper range.

3-37. DIGITAL OUTPUT.

3-38. Output Signals and Levels.

3-39. Coded Data. The Model 3403C equipped with a Digital Output option provides 7 columns of 1-2-4-8 coded BCD information, LOW state true. LOW = < + 0.5 V, 12 mA maximum sink current; HIGH = + 5 V, 6 kΩ source resistance. In addition to measurement magnitude, coded output information includes range, function, polarity, and out-of-range conditions. Figure 2-4 shows the print codes for a standard -hp- 5050B print wheel, -1248.

3-40. Print Command and Data Flag. These two pulse outputs occur simultaneously, and are both either positive-going or negative-going. Pulse polarity is selected by a connection on the Input/Output Assembly A15. If the jumper, W1, is in position A (see Figure 7-12), the pulses are negative-going, and are positive-going if W1 is in position B. The Print Command signal goes between 0 V and - 10 V, and Data Flag between 0 V and + 5 V. The first transition of either pulse acknowledges receipt of a Remote Measure command when operating in the Remote mode, and the second transition indicates that valid data is available.

3-41. Input Signals and Levels.

3-42. Interface Hold. A continuous LOW level disables automatic sampling. LOW = + 0.5 V, 12 mA maximum sink current; or contact closure to ground through < 600 Ω. HIGH = + 5 V, 6 kΩ source resistance; or open circuit.

3-43. Printer Holdoff. A voltage level between + 2 V and + 20 V disables automatic sampling. A LOW level (< 0.5 V) or an open circuit permits automatic sampling.

3-44. Measure. A LOW > 2 microseconds initiates a measurement when the Interface Hold input is LOW. This input may be used whether the instrument has the Remote option or not. LOW = < + 0.5 V, 12 mA maximum sink current; or contact closure to ground through < 600 Ω. HIGH = + 5 V, 6 kΩ source resistance; or open circuit.

3-45. Remote Measure. A LOW input > 50 microseconds initiates a measurement when operating in the Remote mode. The measurement may be delayed or non-delayed

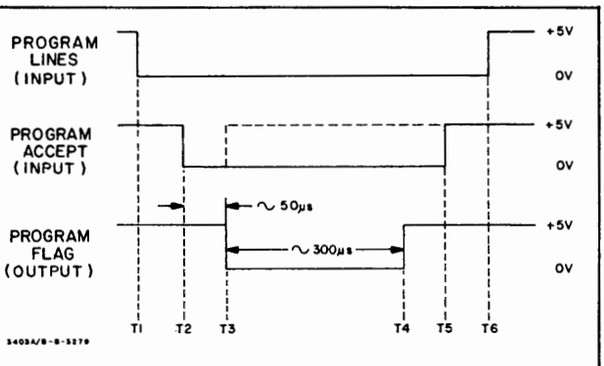
(see Paragraphs 3-22 and 3-51). LOW = < + 0.5 V, 12 mA maximum sink current; or contact closure to ground through < 600 Ω. HIGH = + 5 V, 6 kΩ source resistance; or open circuit.

3-46. Digital Output Characteristics (Option 003).

3-47. Output data and input control lines are referenced to chassis (power line) ground. The banana jack to BNC adapter (-hp- Part No. 5040-5847) supplied with the 3403C must be used at the input to disconnect input Low from chassis ground in order to make floating measurement. *Make sure the adapter is inserted correctly and turned fully clockwise on the BNC bayonet connector.* The instrument will maintain all normal- and common-mode rejection characteristics under these conditions.

3-48. REMOTE CONTROL.

3-49. Option 003 permits remote programming of function, range, autorange and response time. Lines are also provided for remote control of sampling. Characteristics for Remote Control are the same as those given for Digital Output in Paragraph 3-48. Figure 2-5 shows the Remote Program Connector J3 and gives required interface information. For all input signals, LOW = < + 0.5 V, 12 mA maximum sink current; or connect closure to ground through < 600 Ω. HIGH = + 5 V, 6 kΩ source resistance; or open circuit.



T1 - Selection of desired range, function, response time, and measure mode lines.

T2 - Program accept command. T1 and T2 may occur simultaneously.

T3 - First transition of Program Flag acknowledges receipt of Program Accept command. Program accept line may be returned HIGH. Must go HIGH before next program information is to be stored. (Program Flag signal may be inverted by changing connection of W1 on Remote Assembly A14.)

T4 - Second transition of Program Flag indicates program has been stored. If the Delayed Measure Mode is selected, a Remote Measure command may be applied. Refer to Paragraph 3-23.

T5 - Program Accept must go HIGH before next program information is to be stored.

T6 - Program selection lines may be returned HIGH. A line need not be returned HIGH unless a subsequent program change is desired. T5 and T6 may occur simultaneously.

Figure 3-6. Remote Programming Sequence.

3-50. Remote Programming.

3-51. The remote mode of operation may be selected either by the front panel switch or by a continuous LOW connection at the rear panel connector, J3. Either method enables remote programming and disables the front panel function range, and response time controls. Programming of Range, Function, Response Time, and Measure Mode must be entered and stored in the instrument by application of a Program Accept command. The remote programming sequence is shown in Figure 3-6. Autorange and Non-Delayed Measure Mode must not be programmed at the same time, or the instrument will not autorange.

3-52. Remote Measurement Control.

3-53. The remote measurement rate is affected by the programmed response time and measurement mode, and is discussed in Paragraph 3-22.

3-54. Output Signals.

3-55. Program Flag. This signal is a positive- or negative-going pulse between 0 V and + 5 V. The pulse polarity is selected by a connection, W1, on the Remote Assembly, A14. The first transition acknowledges receipt of a Program Accept command, and the second transition indicates that the program is stored.

3-56. Print Command and Data Flag. These signals are described in Paragraph 3-40.

3-57. dB DISPLAY.

3-58. Option 006 provides a choice of either a voltage or dB display. The dB display is normally calibrated in dBV (1 V = 0 dB). However, the front panel dB CAL screwdriver adjustment allows calibration in dBm 600 Ω (.7746 V = 0 dB). To accomplish dBm 600 Ω calibration, set the 3403C FUNCTION to AC dB, RANGE to 1 V, and apply an accurate .7746 V at 100 Hz from an ac calibrator (-hp- 745A). Adjust the dB CAL control for a display of 00.0 dB. A variable dB REFERENCE control is provided with which the reference level may be shifted downward at least 10 dB for comparison measurements. This range of reference levels includes dBm 75 Ω and dBm 50 Ω.

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. A block diagram of the Model 3403C is shown in Figure 7-2. The following paragraphs give a brief description of circuit operation.

4-3. AC CONVERTER ASSEMBLY.

4-4. Attenuator.

4-5. In addition to input signal attenuation, the Attenuator provides frequency compensation on all ranges. When a dc function is selected, the input blocking capacitor is by-passed by a reed relay. Attenuation ratio is also selected by reed relays. These relays are driven by signals which are initiated by the front panel switches or by optional autorange or remote program circuits. Table 4-1 shows attenuator and amplifier gains for each range.

4-6. Input Amplifier.

4-7. The Input Amplifier circuit is contained in one integrated circuit package, except for a feedback amplifier circuit which is used on all ac functions. This feedback amplifier is connected into the circuit by Field Effect Transistor (FET) switches. On the .01 V range, the Input Amplifier gain is 50 and an additional feedback capacitor is switched into the circuit. On all other ranges the gain is 5. There are two signal outputs from the Input Amplifier; one goes to the rms Converter Amplifier, and the other by-passes the Converter and is used when the "dc only" function is selected.

4-8. Converter Amplifier.

4-9. A specially designed dual thermocouple called a thermopile is used in the Converter Amplifier. Each half of the thermopile consists of 30 thermocouples in series, resulting in high sensitivity. The low thermal mass of the thin-film construction permits rapid response to input signal changes. One half of the dual thermocouple converts the ac to dc, and the other half is used in the dc feedback loop of the Converter Amplifier. Since a thermocouple is a non-linear device (output proportional to power input), the feedback offsets the non-linearity of the input to the amplifier, resulting in a linear dc output. Using the dual unit in this manner also minimizes the effect of ambient temperature drift. An integrating ac feedback loop is employed to filter out the ripple in the converter thermocouple output. A square-law amplifier in this loop offsets the non-linearity of the thermocouple output to provide a linear integrating action. Integrating capacitance is increased when Slow Response Time is selected, to permit measurement of signals down in 2 Hz.

4-10. Thermopile Protection.

4-11. The Converter Thermopile is extremely sensitive to overload voltages and is easily destroyed. Consequently, a means of protection has been devised which cuts off the input to the thermopile when overload conditions exist. This is accomplished by removing the supply voltages to the output stage of the Input Amplifier. A comparator amplifier senses the voltage drop across a resistor in the Converter Amplifier integrating feedback loop. If this voltage drop indicates an excessive input, the comparator activates the protection circuit. The protection circuit is also employed when switching to Slow Response Time, since additional capacitance added to the integrating circuit may result in an overload to the thermopile. The protection circuit also prevents a surge through the thermopile at instrument turn-on.

4-12. DC Amplifier.

4-13. The DC Amplifier has a gain of 4 on the .01 V and .1 V ranges, and a gain of 2 on all other ranges. However, this circuit is designed primarily as a filter amplifier. The DC Amplifier output is ± 1 V for a full-range input in the "dc only" function, and + 1 V for full range input on all

Table 4-1. Attenuator and Amplifier Gain.

RANGE	APPROXIMATE GAIN				TOTAL GAIN OUT/RMS IN
	ATTEN-UATOR	INPUT AMP	CONVERTER AMP	DC AMP	
.01 V	.5	50	1	4	100
.1 V	.5	5	1	4	10
1 V	.1	5	1	2	1
10 V	.01	5	1	2	.1
100 V	.001	5	1	2	.01
1000V	.0001	5	1	2	.001

ranges when an ac function is selected. Final gain adjustments for all ranges are made in the feedback circuit of this amplifier.

4-14. Converter Logic.

4-15. The Converter Logic circuits translate the Range, Function and Response Time selection signals into voltages which drive the proper reed relays and FET switches.

4-16. CONNECTOR ASSEMBLY.

4-17. The Connector Assembly carries signals and supply voltages between the AC Converter Assembly and the Master Board Assembly. In addition, comparator amplifiers on this assembly determine when the input signal is above or below the proper level for the range selected, and activate uprange or downrange indicators through logic circuits located on the Master Board. These signals are also used to initiate autoranging if the instrument incorporates this option. Buffer amplifiers are used in the range and function control lines.

4-18. Digital Panel Meter, Simplified Theory.

4-19. The Digital Panel Meter is an analog-to-digital converter. It is a self-contained dc digital voltmeter which measures between 0 V and 1.999 V for a full-scale panel meter display. Analog input voltages greater than 1.999 V cause the display to blink, indicating overrange.

4-20. The Digital Panel Meter is divided into five major sections shown in Figure 4-1. The five sections are the Analog section, the Control Logic, the Counter, the Data Multiplexer and the Display.

4-21. An analog voltage is transmitted from the instrument to the Analog section. This analog voltage corresponds to the input voltage at the instrument front panel, (e.g., instrument RANGE = 100 V, input = 50 V dc, analog voltage = 0.5 V dc, DISPLAY indicates 50.0). The Counter and Control Logic provide the necessary logic to the Analog section during each measurement cycle for the Analog section to process the analog voltage. The measurement cycle consists of 6144 pulses or sampling intervals of which 2048 comprise an auto-zero interval and 4096 comprise a measure interval. The measure and auto-zero modes are controlled by the Counter.

4-22. Each measurement cycle begins with an auto-zero interval. The INPUT to the Analog section is switched to ground. The Analog section, in conjunction with the Control Logic, establishes an equilibrium voltage which is stored. This equilibrium voltage is the offset introduced by drift in the analog section. The stored equilibrium voltage is then used to offset the drift during the measure interval.

4-23. During the measure interval, the input of the Analog section is switched to the analog voltage supplied by the instrument. This voltage is a result of the front panel input voltage. The analog voltage drives the Analog section away from the equilibrium voltage. This is sensed by the Control Logic over the analog output line. The Control Logic analyzes the analog output and responds with the necessary control logic to reestablish the Analog equilibrium. The period required to reestablish equilibrium is accumulated in the Counter via the count input line. At the end of the measure interval, the Counter section contains a count corresponding to the analog input. The greater the input voltage to the front panel, the greater the analog input voltage to the panel meter. A larger analog input voltage requires a longer period of time for the Control Logic to reestablish the analog equilibrium voltage. This results in a larger count accumulated in the Counter.

4-24. At the end of the measure interval, the count accumulated is transmitted to the Data Multiplexer over the count output line. The Data Multiplexer converts the count to 8-4-2-1 BCD information. The BCD output is synchronized with the digit and polarity strobe and applied to the display. Polarity information is also transmitted via the BCD output. When the measure interval is complete and the digits displayed, a new measurement cycle begins. The

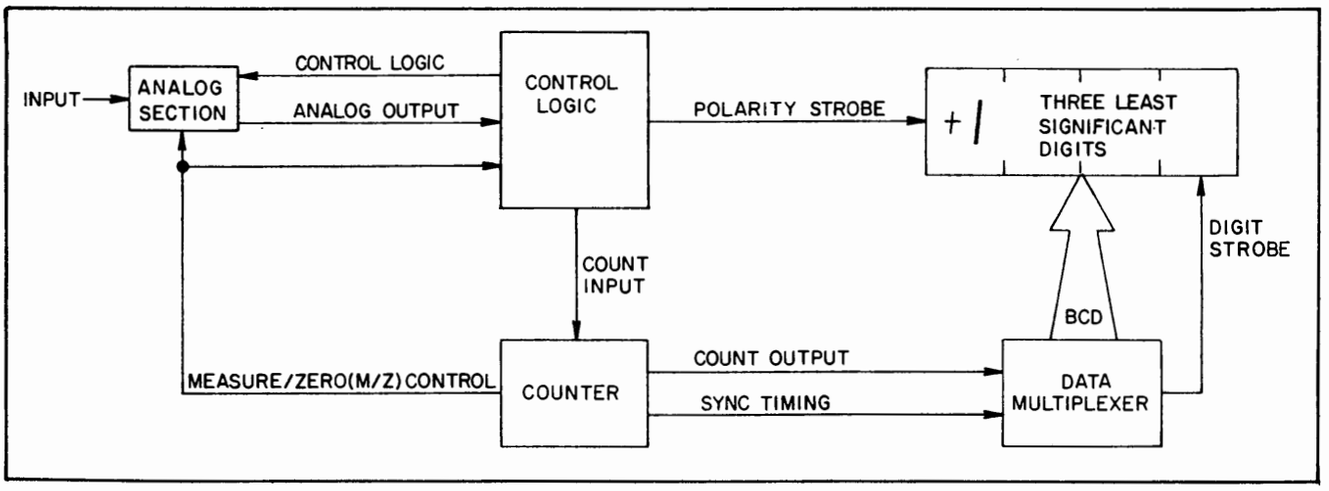


Figure 4-1. Panel Meter Block Diagram.

Analog section, during the auto-zero interval, establishes another equilibrium for the following measure interval. In this way, the drift of the Analog section is continually followed by the reestablishment of the analog equilibrium voltage which nullifies the drift each measure interval.

4-25. Digital Panel Meter, Detailed Theory.

4-26. Refer to Figure 7-13 for this discussion. The Digital Panel Meter is built around a 3½ digit analog to digital converter, set A22U1 and A22U2. Figure 4-2 is a functional diagram of these IC's. A22U1 is an analog processor which contains a bipolar comparator, a bipolar integrating amplifier, two MOS-FET input unity gain amplifiers, several P-channel enhancement mode analog switches and the necessary level shifting drivers to allow the analog and digital processors to be directly interfaced. A22U2 is a synchronous digital processor that combines the counting, storage and data multiplexing functions with the random logic necessary to control the functions of the analog processor. The digital processor contains seventeen static latches for storing the 3½ digits of BCD data, overrange, underrange and polarity information. Nine push-pull output buffers provide the sign, digit strobe and multiplexed BCD data outputs. The Digital Panel Meter provides a full scale display for an analog input voltage of 1.999 V. This full scale of the Panel Meter is not to be confused with instrument front panel full scale indications.

4-27. The following discussion of the Digital Panel Meter operation is described in the free running mode. If the External Trigger feature is present, a description of operation in this mode is provided in Paragraph 4-41.

4-28. Measurement Cycle. The 3½ digit analog-to-digital converter set, A22U1 and A22U2, converts the analog input voltage to a corresponding 8-4-2-1 BCD output once each measurement cycle. Polarity, overrange and underrange information is also determined once each measurement cycle. The measurement cycle is controlled by the time base counter located in A22U2. The time base counter divides the clock frequency generated by A20U3 into sampling intervals of 6144 pulses which constitute one measurement cycle. Each measurement cycle consists of two-intervals–an auto-zero interval and a measure interval. Of the 6144 pulse measurement cycle, 2048 pulses comprise the auto-zero interval and 4096 pulses comprise the measure interval.

4-29. Auto-Zero Interval. The purpose of the auto-zero interval is to establish an equilibrium voltage which represents the offset introduced by the drift of the analog section. Refer to Figure 4-3 and 4-4 for this discussion.

4-30. The auto-zero and measure intervals are controlled by the Measure/Zero logic (M/Z) originating from the time base counter in A22U2. A low logic level on the M/Z line switches the input of the buffer amplifier to ground. When the M/Z logic, the Up/Down logic (U/D) and the comparator output are all low, the Override section provides a high output. This turns off A22Q2 and applies - 12 V to the gate of A22Q1. A closed-loop system of integrator and auto-zero amplifier is formed by the operation of A22Q1. The delay interval, or override period, in initiating the closed-loop system, allows the integrator output to return to the equilibrium voltage of the previous measurement cycle.

4-31. The input to the auto-zero closed loop system is the summing node at the negative port of the integrator in A22U1. Three currents are summed at this node. The buffer amplifier in conjunction with A22R7 forms a voltage-to-current converter which supplies current to the integrator input summing node. Voltage-to-current conversion is also performed by the auto-zero amplifier in conjunction with A22R6 and the reference voltage in conjunction with A22R4 and A22R5. These are the other two currents summed at the summing node. Since the buffer amplifier input is grounded, the current supplied to the integrator summing node is minor. The auto-zero amplifier current and the reference current are the major currents flowing into the integrator summing node. The reference current is pulsed at a 50% duty cycle (4 clock cycles on and 4 clock cycles off) by the U/D logic generated in the control logic portion of A22U2. The output of the integrator in the closed-loop system seeks to attain an equilibrium voltage. Equilibrium occurs when the sum of the average currents at the integrator summing node equals zero. At equilibrium, the current through A22R6 will be constant and equal to half the reference current. These two currents oppose each other at the integrator summing node for a net result of zero.

4-32. The equilibrium voltage is stored on capacitor A22C3. This voltage is the dc offset introduced by the analog section. During the following measure interval, the equilibrium voltage stored on A22C3 is applied to the integrator summing node where it nullifies the offset.

4-33. Measure Interval. Refer to Figures 4-3 and 4-5 for this discussion. Following the 2048 pulse auto-zero interval, the M/Z logic goes high to begin the measure interval. The M/Z logic switches the buffer amplifier input from ground to the analog voltage supplied to the panel meter. It also opens the closed-loop system of integrator and auto-zero amplifier. The voltage-to-current converter comprised of the buffer amplifier and A22R7 supplies a current to the integrator summing node generated by the analog input voltage. This additional current flowing into the integrator summing node disrupts the balance achieved during the preceding auto-zero interval. The result is the integrator output is driven away from the equilibrium voltage maintained as a reference on A22C3. The greater the analog input voltage, the greater the integrator output deviates from the equilibrium voltage. A22CR1 in parallel with the integrator capacitor A22C2 protects the integrator against large positive analog input voltages.

4-34. The comparator of A22U1 is a differential amplifier which compares the integrator output to the equilibrium voltage stored on A22C3. The comparator transmits by

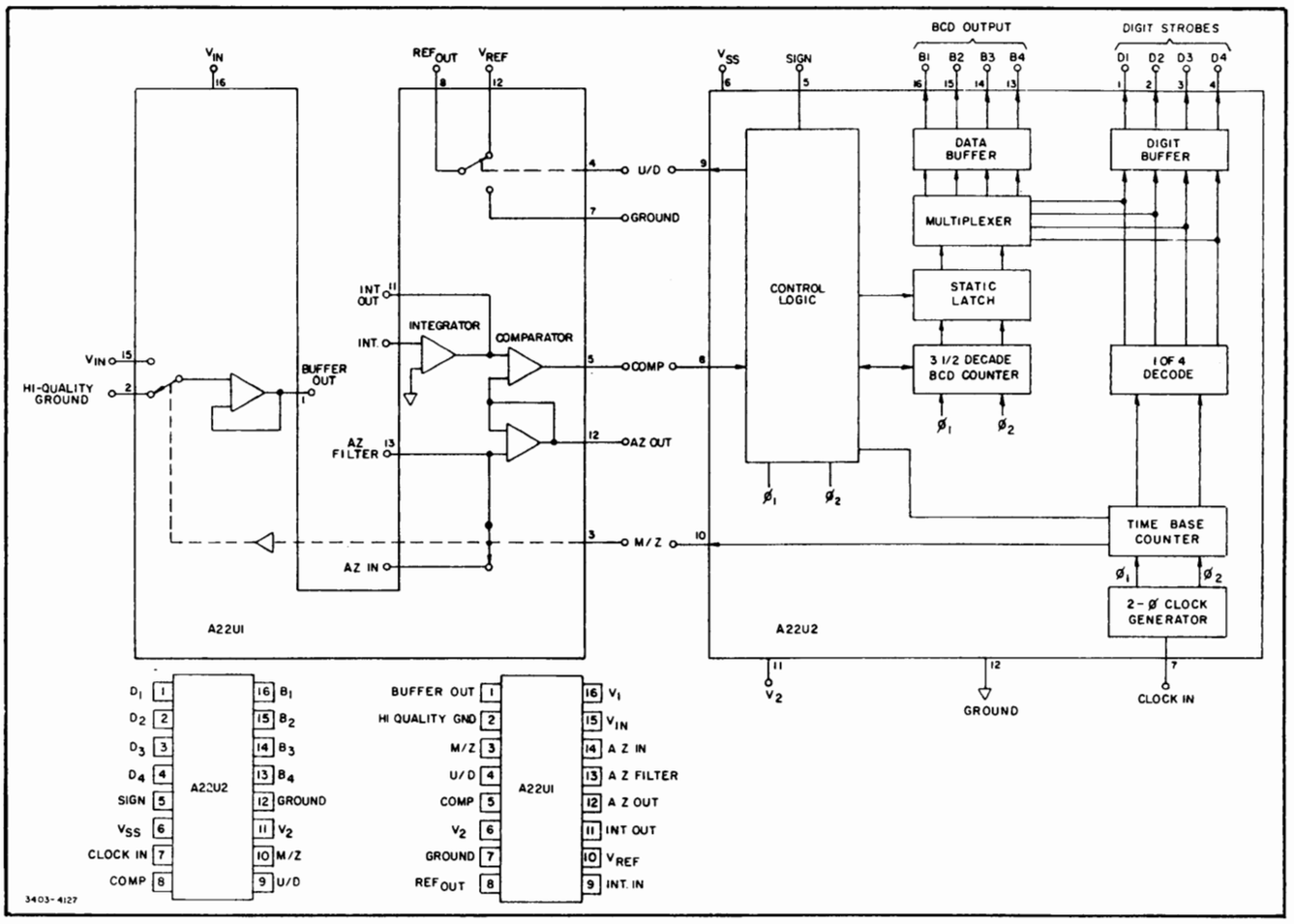


Figure 4-2. Functional Diagram of A22U1 and A22U2.

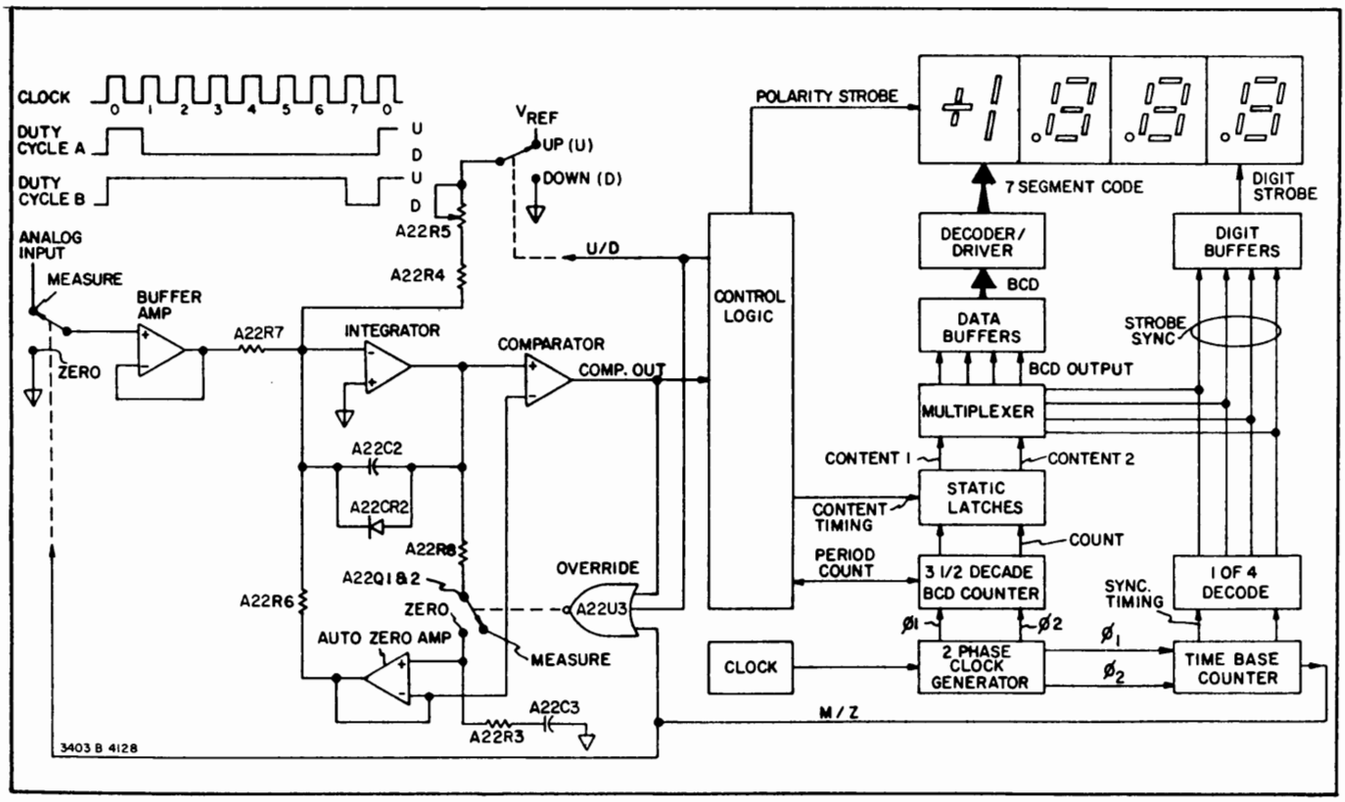


Figure 4-3. Digital Panel Meter Functional Block Diagram.

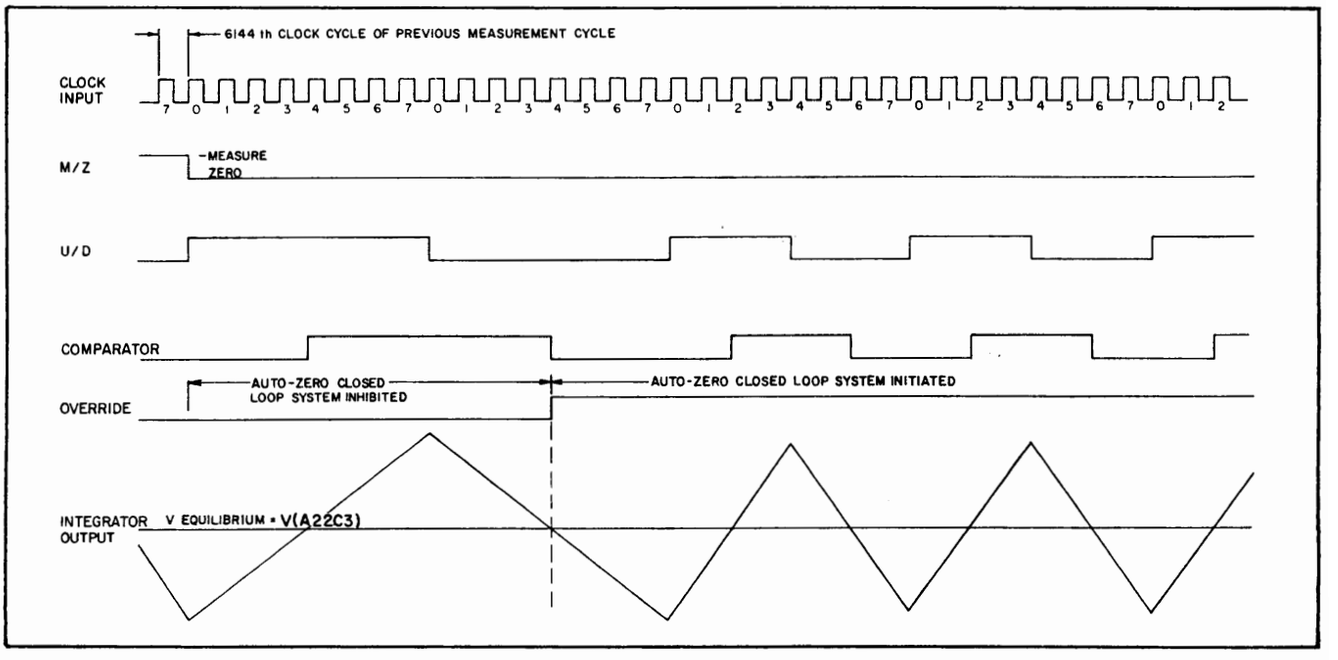


Figure 4-4. Auto-Zero Analog and Digital Timing.

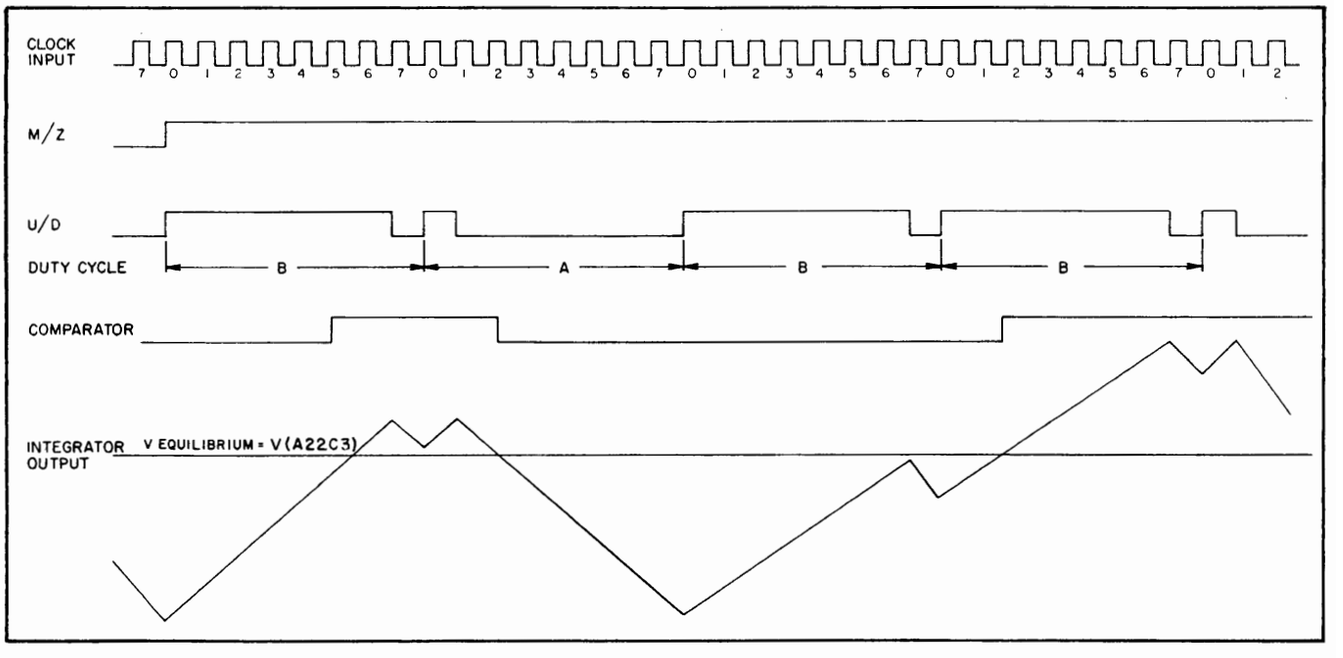


Figure 4-5. Measure Analog and Digital Timing.

logic levels to the control logic of A22U2, the state of the integrator output with respect to the equilibrium voltage. A high logic level indicates an integrator output greater than equilibrium; a low logic level indicates an integrator output less than equilibrium. The control logic attempts to reestablish the system equilibrium by using one of two U/D logic duty cycles during the measure interval. The duty cycle used depends on the comparator output in the clock cycle preceding each duty cycle. Figure 4-5 shows the timing of these duty cycles and their effect on the integrator output.

4-35. Each duty cycle is comprised of eight clock cycles. Duty cycle A shown in Figure 4-5 consists of the U/D logic high one clock cycle and the low seven clock cycles. As indicated in Figure 4-5, the U/D logic high drives the integrator output up and when low, it drives the integrator output down. Duty cycle A is used to drive the integrator

output in a negative direction. Duty cycle B consists of seven clock cycles high and one clock cycle low. This duty cycle is used to drive the integrator output in a positive direction. The Control Logic of A22U2 samples the comparator output in the clock cycle preceding each duty cycle. A high comparator output indicates the integrator output is more positive than the equilibrium voltage. This indication dictates the use of duty cycle A which will drive the integrator output more negative in an attempt to reestablish the system equilibrium. A low comparator output dictates the use of duty cycle B to drive the integrator output more positive towards equilibrium.

4-36. Throughout the measure interval, the Control logic utilizes U/D logic duty cycle A or B to reestablish the integrator output at equilibrium. The synchronous Up/Down 3½ Decade BCD Counter in A22U2 increments each clock cycle for a high state of the U/D logic or decrements each clock cycle when the U/D logic is low. The net result on the count stored in the BCD Counter is a decrease of six counts for a duty cycle A or an increase of six counts for a duty cycle B. Becuase of the number of clock cycles in the measure interval, the counter can accumulate a maximum of 3072 counts. A count of 2000 corresponds to a full scale analog input voltage. Therefore, the Digital Panel Meter can display accurately an analog input voltage 150% of full-scale. This full-scale is not to be confused with the instrument front panel full-scale. The number of counts accumulated by the counter is proportional to the input voltage. The larger the input voltage, the greater the count accumulated in the counter during the measure interval. For input voltages that are not overrange, the system equilibrium is reestablished before the end of the measure interval. The remainder of the measure interval is characterized by the counter increasing by six counts one duty cycle and decreasing by six counts the following duty cycle. This net count of zero occurs as the integrator output is maintained at equilibrium, that is, the average output equals the equilibrium voltage. At the end of the measure interval, the counter continues to count for a number of clock cycles in the auto-zero interval. This period is governed by the state of the M/Z, U/D and comparator output logic. When all three states are low, the counting stops. At this point the integrator output equals the equilibrium voltage. Therefore, this override period compensates for the voltage difference between the integrator output and the equilibrium voltage and its corresponding count at the end of the measure interval.

4-37. When the override is complete, the BCD counter of A22U2 is put on "hold". The contents of the counter are loaded into the static latches of A22U2 along with underrange information decoded from the counter contents. Underrange is 5% of full scale and corresponds to a count of 100 counts. Once the counter contents have been loaded into the static latches, the counter is cleared. The contents of the static latches are transmitted to the multiplexer where they are multiplexed to the push-pull Data Buffers in BCD format. This operation is synchronized by the 1 of 4 Decode with the Digit Buffers which provide a digit strobe. The Digit Buffers strobe the digits in a 1, 3, 2 and 4 sequence where digit 4 is the most significant digit. The digit strobe is performed by the Digit Buffers applying a high output to the terminal of A21U6 associated with the digit of interest. A21U6 provides inverters at each of the inputs and transmits a low through a base resistor, A21R8 thru R11. This low appears on the base of the transistor switch associated with the strobed digit. A low on the base of A21Q1 thru Q4 forward biases the transistor and applies the + 5 V on the emitter to the associated digit in the display. This application of + 5 V activates this digit of the display. Simultaneous with the activation of the digit, the BCD output from the Data Buffers is transmitted to the Decoder/Driver, A21U1, which converts the BCD information to a seven-segment code. This seven-segment code, being synchronized with the strobed digit, is displayed. If an analog input voltage is greater than a full-scale input of 1.999 V, the 3½ digit display will blink during the zero cycle of the counter. This blinking rate is equal to the sample rate. Although the display blinks for an analog input greater than full-scale of 1.999 V, an analog input voltage that is 150% of full-scale, or 2.999 V, is accurately displayed in the overrange blinking mode.

4-38. The polarity of the analog input voltage is determined by the state of the U/D logic when the BCD Counter is reset to zero. This information is loaded into the static latch once each measurement cycle. The control logic strobes the polarity sign by applying a high to the sign strobe terminal on A21U6. The sign strobe is performed once each measure interval. The polarity information located in the static latches is transmitted to the sign display.

4-39. Polarity Sign Blanking. Transistors A21Q5 and Q6 in conjunction with A21R12 and R13 provide a polarity sign blanking capability. When the instrument is operated in the DCA or DCV mode, a ground is supplied to the base of A21Q5. This ground forward biases A21Q5 and Q6 which supplies + 5 V to the anodes of the polarity sign segments (A21U5 pin 1). If the instrument is in the OHMS or ACV mode, + 5 V is applied to A21Q5. A21Q5 turns off and in turn reverse biases A21Q6. Whtn A21Q6 is not conducting, + 5 V is removed from the anodes of the polarity sign segments (A21U5 pin 1) blanking the polarity sign.

4-40. Reference Supply. The reference voltage is obtained by reducing the instrument's + 12 V supply to a reference voltage of + 6.2 V. Dropping resistor A20R7 reduces the supply voltage which is filtered by A20C3. A zener diode, A20CR2, is in parallel with C3 and clamps the reference voltage to + 6.2 V. The reference voltage is supplied to A20U1 and is the source of the reference current supplied to the integrator summing mode.

4-41. External Trigger Operation.

4-42. A Digital Panel Meter equipped with the external trigger section has the capability of taking a single sample of the analog voltage and holding the resulting display. The

display is held until another trigger signal initiates another sample. The external trigger section consists of A20Q1, U1 and U2. A 28 pin digital processor, A22U2, is used in place of the standard 16 pin IC. The 28 pin IC, in conjunction with A22C6 and R12, provides a means for holding the display.

4-43. A NAND gate and an inverter in series with the M/Z line from the digital processor, enable the external trigger section to allow one measurement cycle (one auto-zero interval and one measure interval) to occur for every externally applied trigger signal. Control of the M/Z line by the AND gate and inverter is accomplished by transmitting a high logic level from A20U2 to one input of the AND gate (A20U1 pin 1) when the HOLD line is high or open. The output of the AND gate is the inverse of the second input line (A20U1 pin 2). This is the M/Z logic from the digital processor. The inverter inverts the NAND gate output which results in the original M/Z logic signal. This is the free running mode of operation.

4-44. When the external trigger feature is desired, a ground is applied to the INTERFACE HOLD or REMOTE PROGRAM terminals of the rear panel Remote Connector, J3. This causes the panel meter HOLD line (J4, pin 50) to go low. The result of the HOLD line low is a low logic level transmitted to the NAND gate (A20U1, pin 1) by A20U2. The NAND gate and inverter do not follow the M/Z logic in this condition. The output of the inverter remains low which maintains the panel meter in the auto-zero mode. Information from the static latches in the digital processor is inhibited from being transferred to the multiplexer and results in the display holding the digits from the previous measurement cycle. The static latches are inhibited by application of - 12 V to pin 27 of the digital processor, A22U2.

4-45. To initiate a sample, a ground pulse $> 2\,\mu$seconds is applied to the MEASURE terminal of the rear panel Remote or BCD Output Connector, J3 or J2. This pulses the panel meter TRIGGER input (J4, pin 2) low. The trigger causes the NAND gate input from A20U2 to go high and allows the NAND gate and inverter in the M/Z line to follow the M/Z logic. The input to the AND gate from A20U2 is high for only one measurement cycle (approximately 130 mseconds). This allows the NAND gate and inverter to follow the M/Z logic for only one measurement cycle. Therefore, one sample is taken and this display is held until the next trigger is applied.

4-46. LOCAL CONTROL.

4-47. Local selection of function, range, or response time is made by switch contact to ground. This contact to ground is made through the output stage of integrated circuit inverters. If remote program operation has been selected, the output transistors of these inverters are turned off, disabling the front panel switches.

4-48. REMOTE PROGRAMMING OPTION.

4-49. Range, function, and response time may be selected remotely if the instrument has the Remote Control option. Programming of range and function is accomplished by contact to ground of coded program lines. Decoding is done on the Remote Assembly A14. A "Program Accept" signal is required to initiate or change a program. Range, function and response time programming is stored until a succeeding Program Accept command is applied. When the range switch is set to Remote, the Automatic sampling circuit is disabled, and an external trigger signal must be applied.

4-50. DISPLAY LOGIC.

4-51. +/- Blanking.

4-52. When AC or DC + AC Volts function is selected, the +/- Blank signal is HIGH, disabling the polarity display. However, if either dB function is selected, the +/- Blank signal is LOW, enabling the polarity symbol to indicate whether the measurement is above or below 0 dB.

4-53. Decimal Location.

4-54. The range selection signals are gated in such a manner that the correct decimal is lit for each voltage range. No decimal point is used for the 1000 V range. If a dB function is selected, the third, or right hand decimal is forced to remain on.

4-55. Up/Down Range Indication.

4-56. The Out of Range Detectors on the Connector Assembly are adjusted so that the Uprange line goes LOW if the input is greater than approximately 190 % of range, and the Downrange line goes low if the input is less than approximately 17 % of range. If either condition exists, the RNG annunciator will light, along with the up or down arrow to indicate the need to select a higher or lower range. If the peak value of a non-symmetrical input signal is greater than the rms value to the extent that the peaks are too high for the range in use, a detection circuit in the Converter Amplifier produces a Crest Factor signal. This signal input to the range indication logic may cause the three least significant digits to blank and the Uprange arrow to light. If the range and function switches are set to .01 V DC, the RNG annunciator and both arrows will light.

4-57. dB Display.

4-58. The dB Adder Control logic provides control signals to the dB Adder circuit on the Log Converter Assembly if the instrument has the dB Option 006. This adds or subtracts 20, 40 or 60 dB, according to the range selected.

4-59. AUTORANGE OPTION.

4-60. When Autorange is selected, an Autorange Clock provides pulses to Uprange and Downrange gates. If either of these gates is enabled by an autorange (Uprange or Downrange) signal, the clock pulse is allowed to pass through to an Up-Down Counter. Outputs from the counter are applied to a Decoder, which selects the correct range. The Counter Preset Gate "clears" the counter to the 1000 V range when a Crest Factor signal is received. The minimum Autorange Clock period is 1 second when Fast Response Time is selected, and 10 seconds for Slow Response Time.

NOTE

Crest Factor is used for dc autoranging and Up-Down Counter is used for ac autoranging.

4-61. If the instrument is equipped with Option 003, autorange may be selected remotely. In this case, since automatic sampling is disabled during remote operation, the autorange clock pulse is also applied to a gate which initiates a measurement after the correct range has been reached. Remote programming of range is accomplished by forcing the Up-Down Counter into the correct state.

4-62. DIGITAL OUTPUT OPTION.

4-63. When the Digital Panel Meter begins the auto-zero interval, the TRANSFER line goes low to indicate valid data is available. The information on the Digital Panel Meter 1-2-4-8 BCD lines and strobe lines being transmitted to the display board is also transmitted to the I/O data counting circuit. Information from the data counting circuit is transmitted to the BCD Output Connector, J2. This information is 1-2-4-8 BCD, Low true. BCD range, function and polarity information is also provided.

4-64. The output of the Log Converter Output Amplifier is 0 V for a full-range input on any range. The Add/Subtract and 20/40 Amplifier circuits add either a positive or negative voltage to this output to provide the correct display. This voltage is ± 200 mV per range for each range above or below the 1 V range. Signals from the A4 dB Adder Control logic determine whether the added voltage is positive or negative, and also determine the magnitude of this voltage.

4-65. dB OPTION.

4-66. The output of the AC Converter is a dc voltage which is directly proportional to the rms value of the input signal. When a dB function is selected, the Log Converter output is a dc voltage having a logarithmic relationship to the input, enabling the Digital Panel Meter to display the measurement in decibels. Normally, the amplifier is adjusted so that 1 V input = 0 dB. However, the front panel dB CAL control may be adjusted for a dBm (0 dBm = 0.775 V) indication.

4-67. POWER SUPPLIES.

4-68. Analog Circuit Supplies.

4-69. The AC Converter, Log Converter, and the analog circuits in the Digital Panel Meter are powered by regulated + and - 12 V supplies. Sensing terminals for these regulators are located in the AC Converter Assembly. The + and - 12 V supplies are referenced to analog ground, and are voltage regulated and current limited.

4-70. Digital Circuit Supplies.

4-71. Regulated voltages of + 12 V, - 12 V, + 5 V, and - 10 V are supplied to the digital circuits. In addition, a supply of approximately + 4 V is provided for the light emitting diodes in the display. The + 4 V supply is taken from the emitter of the series pass transistor of the + 5 V supply, and is not current limited. The - 10 V, + 12 V, - 12 V, and + 5 V supplies are voltage regulated and current limited. An over-voltage protection circuit is added to the + 5 V supply for the protection of the integrated circuits in the instrument. The digital circuit supplies are referenced to digital ground.

4-72. GROUND CIRCUITS.

4-73. Standard Instrument Ground.

4-74. In the standard 3403C, the analog and digital ground circuits are connected together. The connection is made on the Standard Connector Assembly A7, as shown in Figure 4-6. Also, analog ground is normally connected to chassis ground through S6 on the AC Converter Assembly.

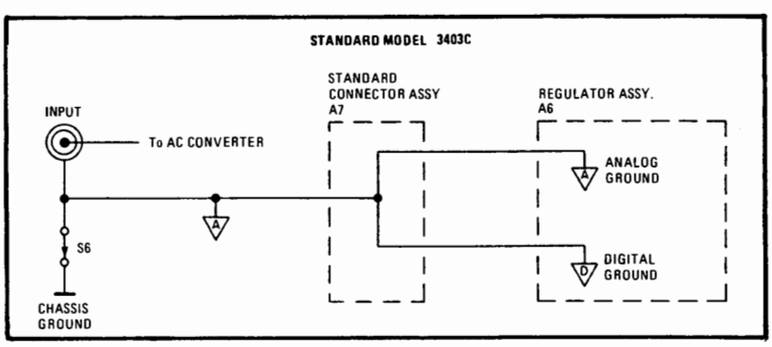


Figure 4-6. 3403C Ground Circuit.

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains information necessary to maintain the Model 3403C True RMS Voltmeter. The following paragraphs describe the Performance Checks, Adjustment Procedures, Servicing and Troubleshooting. Schematic diagrams are in Section VII.

5-3. TEST EQUIPMENT REQUIRED.

5-4. Recommended test equipment for maintaining and checking the performance of the 3403C is listed in Table 5-1. Test instruments other than those listed may be used if their specifications equal or exceed the required characteristics.

5-5. PERFORMANCE CHECK PROCEDURE.

5-6. Use the following procedures to verify proper operation of the Model 3403C True RMS Voltmeter. The 3403C and test equipment should be operated at a line voltage of 115 Vac (or 230 Vac) and ambient temperature of 20° C to 30° C unless otherwise stated. It is recommended that the performance of the 3403C be checked upon receipt and at regular intervals thereafter. A Performance Check Card is provided at the rear of this section for recording the performance of the 3403C . This card may be removed from the manual and used as a permanent record of the incoming inspection or of a routine performance check. If the 3403C is found to be out of specifications at any point, refer to the Adjustment Procedures or to the Troubleshooting Information. Allow sufficient warm-up for the 3403C and test equipment before proceeding with the Performance Checks.

5-7. AC VOLTAGE ACCURACY CHECKS.

5-8. Mid-Band Frequency Measurements.

5-9. The ac voltage measurement accuracy of the 3403C at frequencies between 10 Hz and 100 kHz may be checked using an ac calibrator (-hp- 745A) and a high voltage amplifier (-hp- 746A) as the signal source. Use the input voltages shown in Table 5-2 to verify the ac voltage accuracy at the frequencies listed. The display should be within the limits given for each measurement.

5-10. 100 kHz to 10 MHz Measurements.

5-11. AC voltage accuracy at frequencies between 100 kHz and about 10 MHz may be checked using the test set-up shown in Figure 5-1 and the test equipment recommended in Table 5-3. Recommended test equipment models are: -hp- Model 8601A Generator/Sweeper; Optimation Model PA-25 Power Amplifier; -hp- 11051A 0.45 V Thermal Converter; -hp- 11050A 1 V Thermal Converter; -hp- 11049A 3 V Thermal Converter; Englehard Model 36850 or Holt Model 6A, 11 10 V and 100 V Thermal Converters;

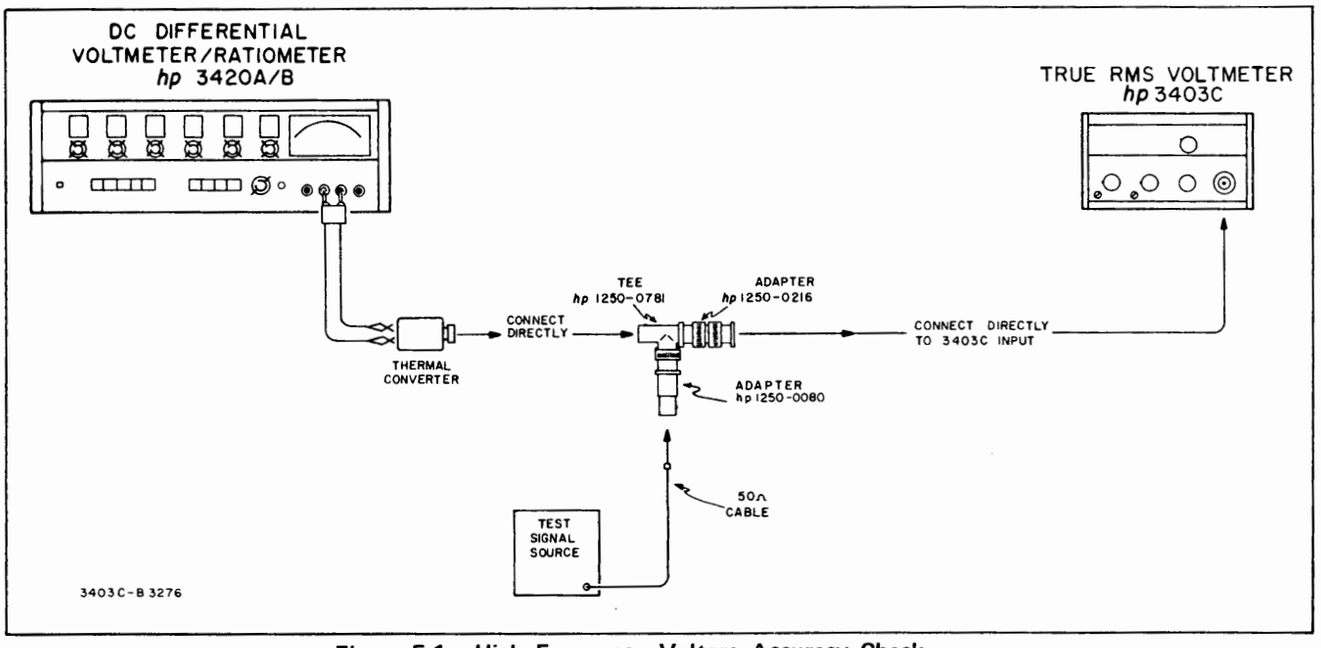


Figure 5-1. High Frequency Voltage Accuracy Check.

Table 5-1. Required Test Equipment.

Instrument Type	Required Characteristics	Use	Recommended Model
DC Voltage Standard	Voltage: 1 mV to 1000 V	Performance Checks Adjustments Troubleshooting	-hp- Model 740B DC Standard/ Differential Voltmeter
AC Calibrator/High Voltage Amplifier	Frequency: 10 Hz to 100 kHz Output Level: 1 mV to 1000 V Accuracy (mid-band): ± 0.1 % Voltage Stability: ± 0.02 % for six months	Performance Checks Adjustments Troubleshooting	-hp- Model 745A AC Calibrator/ -hp- Model 746A High Voltage Amplifier
Function Generator	Frequency: 5 Hz minimum Output Level: 10 V rms sine wave	Performance Checks	-hp- Model 3310A Function Generator
Test Oscillator	Frequency: 1 MHz to 10 MHz Output Level: 3 V rms Amplitude Flatness: ± 0.25 % (1 V and 3 V output)	Performance Checks	-hp- Model 652A Test Oscillator
AC Amplifier	Output Voltage: 10 V to 100 V Frequency: 100 kHz to 1 MHz Voltage Gain: 20 Output Power: 25 VA	Performance Checks	Optimation Inc. Model PA-25 Power Amplifier
Signal Generator	Frequency: 100 kHz - 100 MHz Output Level: 2 V rms	Performance Checks Adjustments	-hp- Model 8601A Generator/ Sweeper
DC Differential Voltmeter	Range: 1 V Resolution: 1 μV	Performance Checks Adjustments	-hp- Model 3420A/B DC Differential Voltmeter
Thermal Converters or Thermal Transfer Standards	Accuracy: Correction Factor Chart to 100 MHz Voltages: 450 mV 1 V 3 V 10 V 100 V	Performance Checks Adjustments	 -hp- Model 11051A -hp- Model 11050A -hp- Model 11049A Holt Model 6A, 11; or Englehard Model 36850
DC Digital Voltmeter	Voltage Range: 10 mV to 10 V Resolution: 0.01 mV	Adjustments Troubleshooting	-hp- Model 3480C/D/3484A Digital Voltmeter/DC Range Unit
Oscilloscope	Bandwidth: dc to 10 MHz Sweep: 0.2 μs to 5 s/div Sensitivity: 1 mV/div	Troubleshooting	-hp- Model 140A/1402A/1423A Oscilloscope
Capacitor	Capacitance: 1.0 μF Voltage: 20 vdcw	Performance Checks	-hp- Part No. 0160-2611
Resistors	Resistances: 1 kΩ ± 10 % 1/4 W 100 Ω ± 10 % 1/2 W 39 Ω ± 10% 1 W	Performance Checks Troubleshooting	-hp- Part Nos. 0684-1021 0687-1011 0698-5083
Printed Circuit Extender Board	20-pin (2 x 10)	Adjustments (Option 006)	-hp- Part No. 5060-0091
Digital Recorder	Code and Standard Print Wheel: -1248	Performance Checks	-hp- Model 5055A Digital Recorder
Printer Cable	36-pin to 50-pin	Performance Checks	-hp- 11184A Printer Cable
BNC Connectors and Adapters	 Tee Adapter, male to male Adapter, female to female	Performance Checks Adjustments	 -hp- 1250-0781 -hp- 1250-0216 -hp- 1250-0080

Table 5-2. Mid-Band AC Voltage Checks.

Function	Range	Test Signal		Maximum Display Error	Test Signal Source
		Voltage	Frequency		
AC	.01 V	10 mV	100 Hz	±5 counts	AC Calibrator
AC	.01 V	10 mV	100 kHz	±5 counts	
AC	.1 V	20 mV	100 kHz	±4 counts	
AC	.1 V	100 mV	1 kHz	±4 counts	
AC	1 V	0.5 V	200 Hz	±3 counts	
AC	1 V	1 V	20 kHz	±4 counts	
AC	10 V	10 V	100 kHz	±4 counts	
AC	10 V	15 V	100 Hz	±5 counts	
AC	100 V	20 V	50 Hz	±2 counts	
AC	100 V	100 V	50 kHz	±4 counts	
*DC + AC	100 V	100 V	20 Hz	±6 counts	
*DC + AC	1 V	1 V	10 Hz	±6 counts	
*DC + AC	.1 V	100 mV	20 Hz	±10 counts	
AC	1000 V	1000 V	100 Hz	±5 counts	AC Calibrator and High Voltage Amplifier
AC	1000 V	1000 V	10 kHz	±5 counts	

* Slow response time

-hp- Model 3420A/B DC Voltmeter/Ratiometer. Use the following procedure for each measurement in Table 5-3. The measurement uncertainty of the thermal converter must be taken into account in each measurement.

a. Set FUNCTION to AC. Select proper range. Set RESPONSE TIME to FAST.

b. Set signal generator frequency to 100 kHz and adjust output level to obtain correct 3403C display according to voltage measurement to be checked.

c. Adjust dc differential voltmeter for null indication.

d. Change signal generator to frequency to be checked.

e. Adjust signal generator output level to return dc differential voltmeter to null indication.

f. 3403C display should be within limits shown for each check.

5-12. 10 MHz to 100 MHz Measurements.

5-13. Making voltage measurements in the upper frequency range of the 3403C involves significant problems that are not present at the frequencies covered by other general purpose ac voltmeters. At high frequencies, any measurement involves transmission line problems of impedance mismatch, standing waves, etc. Even minor variations in the hardware connections can cause significant differences. For these reasons, even the National Bureau of Standards

Table 5-3. 100 kHz to 10 MHz Checks.

Range	Test Signal		Maximum Display Error	Test Signal Source	Other Equipment Required
	Voltage	Frequency			
.1 V	100 mV	1 MHz	± 22 counts	Signal Generator	0.45 V Thermal Converter, DC Differential Voltmeter
.1 V	100 mV	10 MHz	± 22 counts		
1 V	1 V	2 MHz	± 12 counts	Signal Generator	1 V Thermal Converter, DC Differential Volmteter
1 V	1 V	8 MHz	± 12 counts		
10 V	3 V	500 kHz	± 4 counts	Signal Generator	3 V Thermal Converter, DC Differential Voltmeter
10 V	3 V	5 MHz	± 5 counts		
10 V	10 V	1 MHz	± 12 counts	Signal Generator, Power Amplifier	10 V Thermal Converter, DC Differential Voltmeter
100 V	100 V	500 kHz	± 12 counts	Signal Generator, Power Amplifier	100 V Thermal Converter, DC Differential Voltmeter
100 V	100 V	1 MHz	± 12 counts		

calibration of the thermal converters used as references for the 3403C accuracy checks includes an uncertainty of up to ± 1.5 % when measured in a specific hardware configuration.

5-14. For optimum accuracy, high frequency measurements should be made using matched source, load, and cable impedances. Since the 3403C input is unterminated, the most satisfactory configuration is shown in Figure 5-1, where the reference thermal converter is electrically as close as possible to the 3403C input. This is the method used at the factory for calibration and test of the instrument. Because of the difficulties described in Paragraph 5-13, the accuracy specifications at frequencies above about 10 MHz are defined using the input hardware connections shown. Measurement in any other configuration can be expected to give different results.

5-15. The .1 V and 1 V ranges should be checked at the frequencies shown in Table 5-4, using the test set-up and hardware configuration shown in Figure 5-1. The recommended signal generator is -hp- Model 8601A Generator/Sweeper, and the other equipment is the same as listed in Paragraph 5-11. Use the procedure in Paragraph 5-11 for each check.

5-16. Low Frequency Measurements.

5-17. The accuracy of the Model 3403C may be checked on the .1 V, 1 V, and 10 V ranges at frequencies down to 5 Hz using a function generator (-hp- Model 3310A) as a signal source. The thermal converter cannot be used at frequencies below 5 Hz. Connect the equipment as shown in Figure 5-1 and use the following procedure, which checks the 1 V range as an example.

a. Set 3403C FUNCTION to AC VOLTS, RESPONSE TIME to SLOW, RANGE to 1 V.

b. Set function generator frequency to 100 Hz and adjust output level to obtain 3403C display of 1.000 V.

c. Adjust dc differential voltmeter for null indication.

d. Change frequency to 5 Hz and adjust function generator output level for null indication on differential voltmeter.

e. Display should be 1.000 V ± 6 counts.

f. The .1 V and 10 V ranges may be checked in the same manner.

5-18. dB ACCURACY CHECK (Option 006).

5-19. The input to the Log Converter is the dc output of the AC Converter, and is + 1 V for a full-range input on any range. Since the accuracy and flatness of the AC Converter have been verified by the preceding checks, the dB measurement accuracy may be verified by checking the analog recorder output. An ac calibrator and a high voltage amplifier are required for this check.

a. Set FUNCTION to AC dB, RANGE to 1 V, dB REFERENCE control fully counterclockwise to CAL position, RESPONSE TIME TO FAST.

b. Connect ac calibrator to 3403C input and set calibrator output to 1.0000 V and 100 Hz. 3403C display should be - 00.2 dB to + 00.2 dB. If not, adjust front panel dB CAL screwdriver adjustment for display of 00.0 dB, with polarity symbol alternating between + and -.

c. Select ranges and input voltages listed in Table 5-5, leaving ac calibrator frequency set at 100 Hz. 3403C display should be within limits shown in each case.

d. Reduce ac calibrator output and disconnect.

5-20. DC VOLTAGE ACCURACY CHECK.

5-21. A dc standard (-hp- 740B) is required for this check.

a. Set 3403C FUNCTION to DC VOLTS, RANGE to .1 V, RESPONSE TIME to FAST. Short input and adjust front panel DC ZERO control.

b. Connect dc standard to 3403C input and adjust standard output voltage to + .100000 V. 3403C display should be + 99.2 mV to + 100.8 mV.

Table 5-4. 10 MHz to 100 MHz Checks.

Range	Test Signal		Maximum Display Error	Test Signal Source	Other Equipment Required
	Voltage	Frequency			
.1 V	100 mV	20 MHz	± 22 counts	Signal Generator	0.45 V Thermal Converter, DC Differential Voltmeter
.1 V	100 mV	40 MHz	± 52 counts		
.1 V	100 mV	100 MHz	± 102 counts		
1 V	1 V	20 MHz	± 22 counts	Signal Generator	1 V Thermal Converter, DC Differential Voltmeter
1 V	1 V	40 MHz	± 52 counts		
1 V	1 V	100 MHz	± 102 counts		

Table 5-5. dB Accuracy Check.

3403C Range	Input Voltage	Display Limits
1 V	0.31620 V	- 09.8 dB to - 10.2 dB
.1 V	0.10000 V	- 19.8 dB to - 20.2 dB
.01 V	0.01000 V	- 39.8 dB to - 40.2 dB
10 V	10.0000 V	+ 19.8 dB to + 20.2 dB
10 V	15.0000 V	+ 23.3 dB to + 23.7 dB
100 V	100.000 V	+ 39.8 dB to + 40.2 dB
1000 V	100.000 V	Display Blanks*
1000 V	200.000 V	+ 45.8 dB to + 46.2 dB
1000 V	1000.000 V	+ 59.8 dB to + 60.2 dB

*See Paragraph 3-29, Out-of-Range Indication

c. Set RANGE to 10 V, short input, and adjust DC ZERO.

d. Select ranges and positive and negative input voltages shown in Table 5-6. Display should be within limits indicated in each case.

Table 5-6. DC Voltage Accuracy Check.

3403C Range	Input Voltage	Display Limits
.1 V	± .100000 V	± 99.2 mV to 100.8 mV
.1 V	± .070000 V	± 69.2 mV to 70.8 mV
.1 V	± .040000 V	± 39.3 mV to 40.7 mV
.1 V	± 010000 V	± 09.3 mV to 10.7 mV
1 V	± 0.10000 V	± .097 V to .103 V
1 V	± 0.50000 V	± .496 V to .504 V
1 V	± 1.00000 V	± .996 V to 1.004 V
10 V	± 1.00000 V	± 0.97 V to 1.03 V
10 V	± 5.00000 V	± 4.96 V to 5.04 V
10 V	± 10.0000 V	± 9.96 V to 10.04 V
100 V	± 10.0000 V	± 09.7 V to 10.3 V
100 V	± 50.0000 V	± 49.6 V to 50.4 V
100 V	± 100.000 V	± 99.6 V to 100.4 V
1000 V	± 100.000 V	± 096 V to 104 V
1000 V	± 500.000 V	± 495 V to 505 V
1000 V	+ 1000.00 V*	+ 995 V to 1005 V

* If -hp- Model 740B is used as dc standard, do not apply negative voltage greater than - 500 V.

5-22. AC NORMAL-MODE REJECTION CHECK.

5-23. This check indicates the ability of the 3403C to reject ac signals of 60 Hz and greater in the DC function. An ac calibrator (-hp- 745A) is required for this check.

a. Set FUNCTION to DC VOLTS, RANGE to 10 V, RESPONSE TIME to FAST.

b. Short 3403C input and adjust front panel DC ZERO until display is at least 50 counts (positive or negative). Note reading.

c. Disconnect input short and connect ac calibrator to 3403C input. Set calibrator output to 14.14 V at 60 Hz (20 V peak).

d. 3403C display should not vary more than ± 0.02 V from reading noted in step b, indicating normal-mode rejection of 60 dB, where:

$$\text{NMR} = 20 \log \frac{\text{peak normal-mode voltage}}{\text{effects on reading (peak volts)}}$$

e. Disconnect ac calibrator, short 3403C input and readjust DC ZERO for zero display.

5-24. AC COMMON-MODE REJECTION CHECK.

5-25. Effective common-mode rejection is the ratio of the common-mode voltage to the resultant error in reading with 1 kΩ unbalance in either lead. An ac calibrator, a 1 kΩ resistor, and an input adapter (-hp- Part No. 5040-5847) are required. (See Figure 5-2).

5-26. AC Volts Function.

a. Attach input adapter (supplied with 3403C) to 3403C input. This adapter is necessary to make floating measurements.

b. Connect 1 kΩ resistor and ac calibrator to 3403C as shown in Figure 5-2.

c. Set 3403C FUNCTION to AC VOLTS, RANGE to .1 V, RESPONSE TIME to FAST.

d. Adjust ac calibrator output to 70.7107 V at 60 Hz. 3403C display should be less than 100.0 mV, verifying effective common-mode rejection greater than 60 dB, where:

$$\text{ECMR} = 20 \log \frac{\text{peak common-mode voltage}}{\text{effect on reading (peak volts)}}$$

5-27. DC Volts Function.

5-28. Effective common-mode rejection in the DC VOLTS function is the sum of the common-mode rejection in the AC VOLTS function and the ac normal-mode rejection.

5-29. DIGITAL OUTPUT CHECK.

5-30. The digital output of the 3403C Options 002 or 003 may be checked by the following procedure. An ac calibrator (-hp- 745A), a dc standard (-hp- 740B), a digital recorder (-hp- 5055A), and a printer cable (-hp- 11184A) are required for this check.

a. Connect ac calibrator to 3403C input, digital recorder to BCD output. Recorder must accept -8421 input.

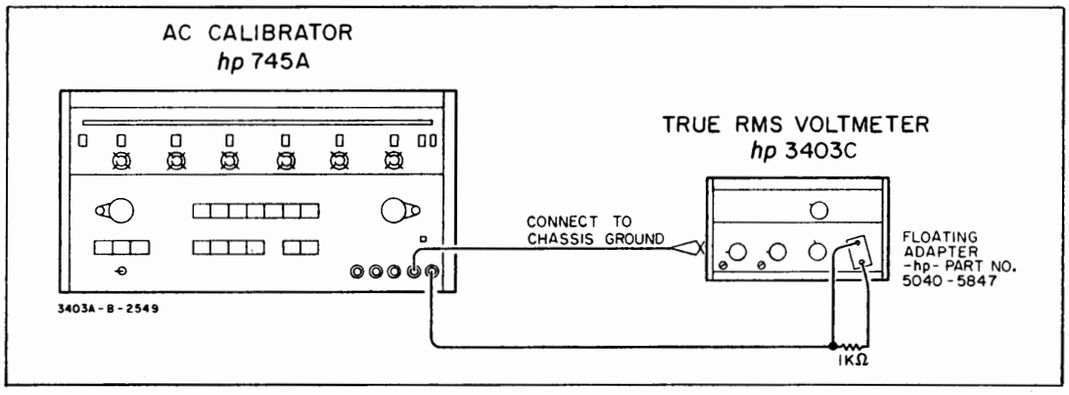


Figure 5-2. AC Common-Mode Voltage Check.

b. Set FUNCTION to AC VOLTS, RANGE to .01 V, RESPONSE TIME to FAST.

c. Adjust ac calibrator output for 3403C display of 10.00 mV.

d. Allow recorder to print at least one reading. Printout should be as indicated in first line of Table 5-7.

e. Adjust ac calibrator output for 3403C display of 17.77 mV. Printout should be as shown in line 2 of Table 5-7.

f. Select function, range and input as shown in the remainder of Table 5-7, within the capabilities of your instrument, and compare printout in each case. "x" in printout column of Table 5-7 indicates that the number printed is immaterial to this test.

5-31. REMOTE CONTROL CHECK.

5-32. The following procedure checks remote operation of the 3403C Option 003. Remote program signal requirements are shown in Figure 2-4. The mating connector for the Remote Program Connector J3 is -hp- Part No. 1251-0293 (Amphenol No. 57-30240). No input signal is required except for steps d and g.

a. Program Remote Control. Observe that REM annunciator is on. Continue to program Remote Control throughout the remaining checks.

b. Program each function and verify proper operation by observing AC, DC and dB annunciators.

NOTE

A Program Accept command is required to initiate or change a remote program.

c. Disconnect function programming and program each range. Verify proper range selection by observing decimals and V/mV annunciators.

d. Program Delayed Measure Mode, Fast Response Time, and 10 V Range. Function program lines may be left open, thus programming DC + AC Volts. Initiate Program Accept. Input 2.00 V dc from a 740B. Initiate Remote Measure and observe a 2.00 V indication on display in approximately 1 (one) second.

Table 5-7. Digital Output Check.

Function	Range	Input	Printer Column 7	6	5	4	3	2	1
AC Volts	.01 V	10.000 mV	2	1	1	0	0	0	5
AC Volts	.01 V	17.770 mV	2	1	1	7	7	7	5
AC Volts	.01 V	20.000 mV	2	3	1	x	x	x	5
AC Volts	.01 V	1.000 mV	2	5	0	x	x	x	5
AC Volts	.1 V	none	2	5	0	x	x	x	4
AC Volts	1 V	none	2	5	0	x	x	x	3
AC Volts	10 V	none	2	5	0	x	x	x	2
AC Volts	100 V	none	2	5	0	x	x	x	1
AC Volts	1000 V	none	2	5	0	x	x	x	0
AC dB	1 V	none	6	4	x	x	x	x	1
DC + AC dB	1 V	none	4	4	x	x	x	x	1
DC + AC Volts	1 V	none	0	5	x	x	x	x	3
DC Volts	1 V	+ 1.0000 V	1	1	x	x	x	x	3
DC Volts	1 V	- 1.0000 V	1	0	x	x	x	x	3
DC Volts	1 V	- 2.0000 V	1	2	x	x	x	x	3
DC Volts	1 V	+ 2.0000 V	1	3	x	x	x	x	3
DC Volts	1 V	+ .1000 V	1	1	x	x	x	x	3
DC Volts	1 V	- .1000 V	1	0	x	x	x	x	3

e. Program Response Time to Slow. Initiate Program Accept. Change the 740B output to 3.00 V. Initiate Remote Measure and observe a 3.00 V indication on the display in approximately 10 (ten) seconds.

f. Program Non-Delayed Measure Mode and Fast Response Time. Initiate Program Accept. Change the 740B output to 2.00 V. Initiate Remote Measure and observe a 2.00 V indication on the display in approximately 1 (one) second.

g. Apply input of 1 V at 100 Hz. Program AC Volts, 1000 V range, Delayed Measure Mode, Fast Response Time, and Autorange. Initiate a measurement and verify that the instrument ranges to the 1 V range and reads correctly. After instrument has completed autoranging, disconnect input and verify that instrument remains on the 1 V range (do not initiate a measurement).

5-33. ADJUSTMENT SEQUENCE.

5-34. The following procedures should be performed only after it has been determined from the performance checks that the Model 3403C is out of specifications. If any adjustment in this procedure cannot be made correctly, refer to the Troubleshooting Procedures. Cover removal and access to adjustments are shown in Figure 5-3, and the location of adjustments is given in Figure 5-4.

5-35. If the Performance Checks indicate an error only below approximately 30 % of range, and only in AC functions, it may be possible to correct this error by adjusting the RMS Converter Balance. Refer to Paragraph 5-62, Final Converter Balance Adjustment.

5-36. If an error is present that is consistent from range to range and on all functions, it may be possible to correct the error by adjustment of the Digital Panel Meter. To determine if the error is in the AC Converter or the Digital Panel Meter, perform the following check. An ac calibrator and a dc digital voltmeter are required.

a. Set FUNCTION to AC VOLTS, RANGE to 1 V, RESPONSE TIME to FAST.

b. Connect ac calibrator to 3403C input and adjust calibrator output to 1.0000 V at 100 Hz.

c. Measure voltage at rear panel VOLTS recorder output terminals with a digital voltmeter.

d. If the digital voltmeter reading is + 1.0000 V ± 0.0040, proceed to the Digital Panel Meter Adjustments, Paragraph 5-50. If the error is greater than ± 0.0040 V, perform the complete adjustment procedures.

5-37. With the exception of the above conditions, the Adjustment procedures must be performed in the order given unless otherwise stated within the procedure.

5-38. AC CONVERTER ADJUSTMENT PRECAUTIONS.

5-39. The AC CONVERTER ASSEMBLY is on the blue stripe exchange program. Extensive and somewhat specialized test equipment is required for the alignment of this assembly. It is important that all the "Required Characteristics" listed in Table 5-1, Required Test Equipment, be met before adjustments are made. If this test equipment is not available, alignment SHOULD NOT BE ATTEMPTED. The converter assembly should be returned for exchange.

5-40. If troubleshooting is performed inside the AC CONVERTER ASSEMBLY, the assembly *must be* realigned. Therefore, anyone not having alignment capability should not attempt troubleshooting.

5-41. It is relatively easy to damage the thermopile or destroy IC1 when troubleshooting the converter assembly. Troubleshooting of the AC Converter should be performed only by personnel familiar with this assembly. Exercise *extreme* care when troubleshooting. Before troubleshooting of the AC Converter begins, note that a rebuilt converter assembly can be obtained on the blue stripe exchange program through your local Sales and Service Office for considerably less than the cost of a new thermopile or IC1.

5-42. ACCESS TO ADJUSTMENTS.

5-43. Open the 3403C and the AC Converter Assembly as shown in Figure 5-3. Turn the instrument on and allow to warm up for at least 1 hour.

CAUTION

THE COMPONENTS AND PRINTED CIRCUIT BOARDS WITHIN THE AC CONVERTER ASSEMBLY MUST BE KEPT CLEAN AND FREE FROM FINGERPRINTS OR OTHER CONTAMINATION, OR PERFORMANCE MAY BE DEGRADED. IF COMPONENTS OR WIRES IN THE ATTENUATOR AREA ARE MOVED, CALIBRATION AT HIGH FREQUENCIES MAY BE ALTERED.

5-44. POWER SUPPLY ADJUSTMENTS.

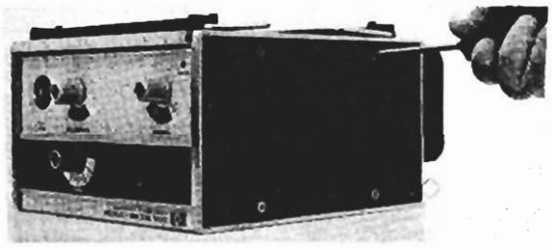
5-45. A digital voltmeter having 5-digit resolution (for 12 V measurement) is required for these adjustments. Test points and adjustments are on the Regulator Assembly, A6.

a. Connect digital voltmeter between + 5 test point and digital ground ▽ . Adjust A6R22 for voltmeter reading of + 5.000 V ± 0.050 V.

b. Connect digital voltmeter between - 10 test point and digital ground. Adjust A6R14 for digital voltmeter reading of - 10.000 V ± 0.010 V.

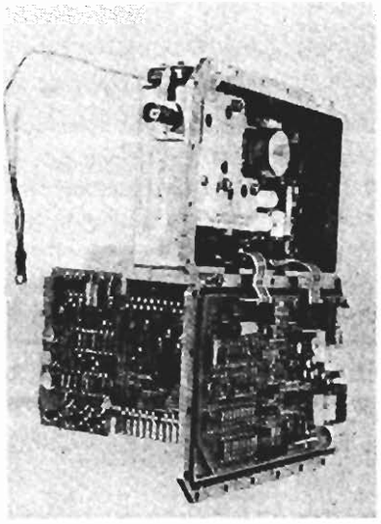
c. Measure voltage at - 5 test point (to digital ground). Voltage should be - 5.00 V ± 0.40 V. If not, troubleshoot - 5 V regulator circuit (A6Q5).

Step A



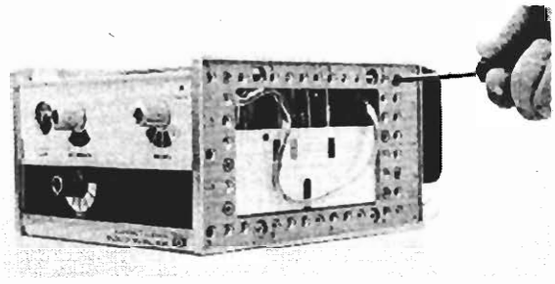
Turn instrument upside down and remove all four screws in each side to remove side and bottom covers.

Step C



Remove AC Converter from instrument. Remove screws around casting and carefully open lid. Attach the two parts in the manner shown, using two or three screws.

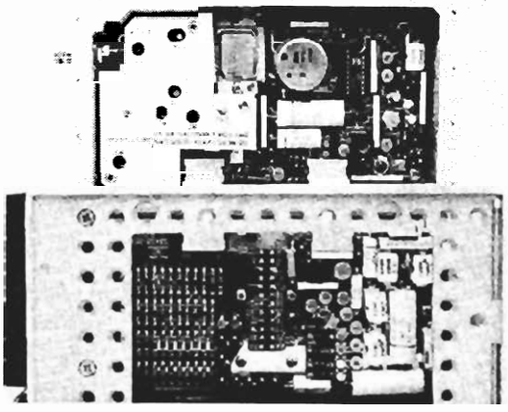
Step B



Remove one screw from each side frame to release front panel.

Step D

Before replacing AC Converter, insulate the screws on the A5 board holding Q4. Cover screws with an insulating material such as tape to prevent these screws from shorting to the AC Converter box.



Replace AC Converter and Connector Assembly in instrument in position shown.

Figure 5-3. Access to Adjustments.

d. Connect digital voltmeter between + 12 test point and analog ground ⏚ . Adjust A6R4 for voltmeter reading of + 12.000 V ± 0.010 V.

e. Connect digital voltmeter between - 12 test point and analog ground. Adjust A6R9 for voltmeter reading of - 12.000 V ± 0.010 V.

5-46. OVERLOAD PROTECTION CIRCUIT CHECK.

5-47. An oscilloscope is required for this check.

a. Turn instrument off. Set response to FAST. Attach oscilloscope probe to the base of A2Q6.

b. Turn instrument on. Waveform should step to + 12 V for about 1 sec and drop to + 10.2 V.

c. Switch response to SLOW. Waveform in "b" should be observed.

d. Set FUNCTION to DC, RANGE to 1 V and response to FAST.

e. Apply + 2.5 V DC input. Waveform should resemble a half-wave rectifier sine wave on a + 10.2 V DC offset.

f. Apply - 2.5 V DC input. Waveform should be as in "e."

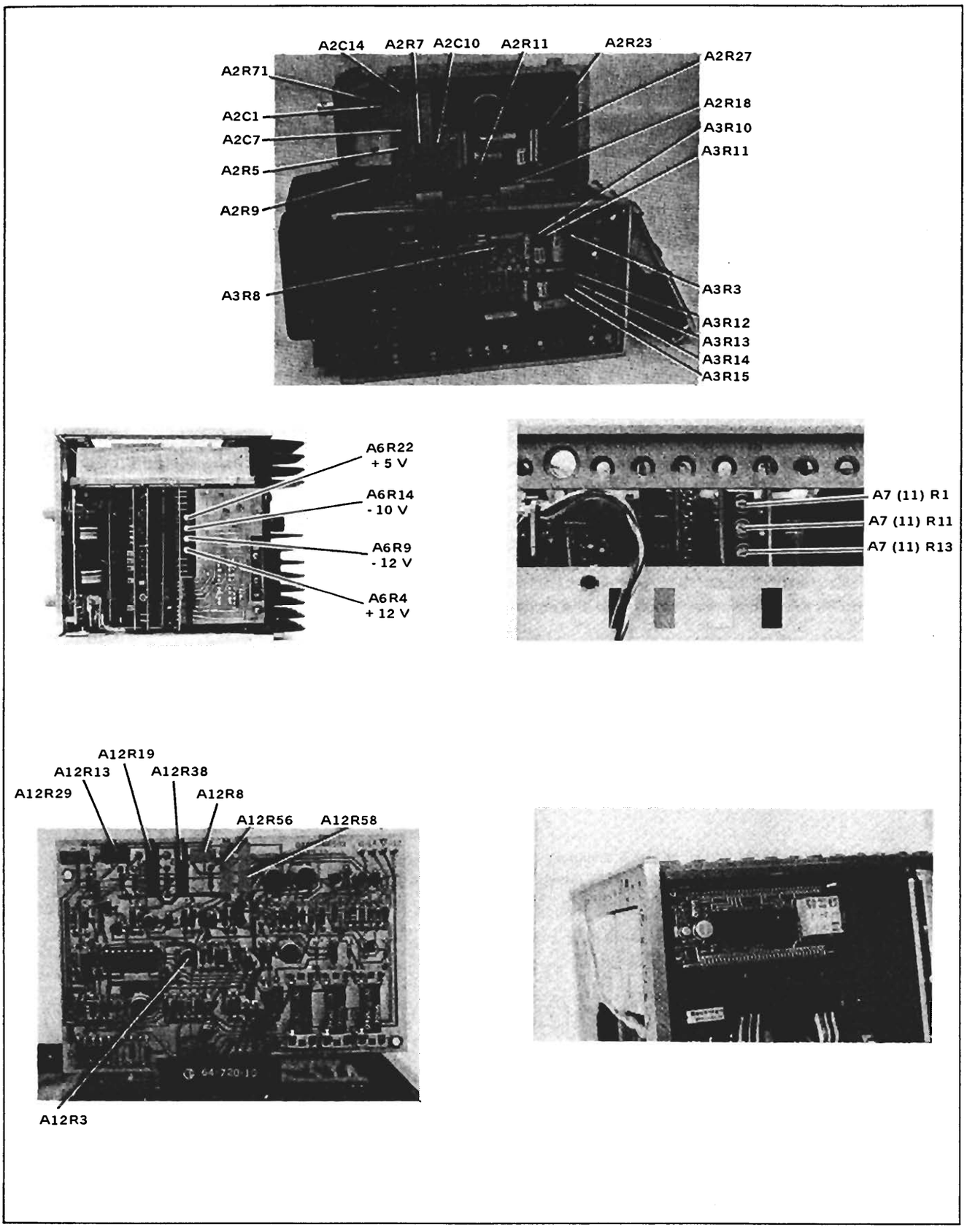


Figure 5-4. Location of Adjustments.

g. Set response to SLOW. Repeat steps e and f. Waveforms should agree with steps e and f except ac portion of waveform will be attenuated. Input voltage may be increased to a maximum of ± 3 V for ease of observation.

h. Apply + 2.5 V DC and set RANGE to .01 V. Waveform should resemble a large pulse train on a + 10.2 V reference and clipped at + 12 V.

i. Switch response to FAST. Waveform similar to that in h should be observed.

j. Note that when an overload is being sensed, the voltage on A2IC3 pin 2 should be more negative than pin 3.

5-48. ZERO ADJUSTMENTS.

5-49. A digital voltmeter having 0.01 mV resolution is required for these adjustments. All adjustments must be made in the order given.

a. Set 3403C FUNCITON to DC, RANGE to 10 V, RESPONSE TIME to FAST, INPUT open.

b. Connect digital voltmeter between test point H (A2) and analog ground. The AC Converter box is analog ground.

c. Connect short circuit between pins 7 and 8 of J10, which is the printed circuit connector at the center of A3, providing connections to and from the converter assembly.

d. Adjust A2R11 for digital voltmeter reading of 0 ± 1.0 mV. Remove short circuit.

e. Adjust front panel DC ZERO for digital voltmeter reading of 0 ± 0.05 mV.

f. Set FUNCTION to AC VOLTS. Adjust A2R18 for digital voltmeter reading of 0 ± 0.1 mV.

g. Set FUNCTION to DC VOLTS. Connect digital voltmeter to test point D (A3). Short test point H (A2) to analog ground.

h. Adjust A3R8 for digital voltmeter reading of 0 ± 0.1 mV. Remove short from test point H.

i. Adjust front panel DC ZERO for digital voltmeter reading of 0 ± 0.05 mV.

5-50. CONVERTER AMPLIFIER ADJUSTMENTS.

5-51. A digital voltmeter having 0.1 mV resolution, a dc standard, and an ac calibrator are required for these adjustments of the Converter Amplifier balance and gain. The adjustments in the preceding paragraphs must be completed before performing the following procedure.

a. Set FUNCTION to AC VOLTS, RANGE to 10 V, RESPONSE TIME to FAST. Connect digital voltmeter between test point D (on A3) and analog ground.

b. Connect ac calibrator to input and set to 10.000 V at 100 Hz.

c. Adjust A7 (A11) R1 RMS BAL to mechanical center. Note digital voltmeter reading.

d. Adjust A3R13 for digital voltmeter reading of 1 V ± .002 V.

e. Reduce input to 1.000 V and adjust A2R27 for digital voltmeter reading of 1/10 the reading noted in step d, ± 1.0 mV. Readjust according to steps d and e until the stated accuracy is obtained. If adjustment can be made correctly, proceed to step f. If the adjustment range of A2R27 is insufficient, use the following procedure to balance the amplifier.

1) Apply input of 10.000 V at 100 Hz from ac calibrator and note digital voltmeter reading (at test point D).

2) Reduce input to 1.0000 V.

3) Insert wire jumpers in positions 1, 3, 4 and 5 (near A2R27).

4) Turn A2R27 fully clockwise. If digital voltmeter reading is greater than 1/10 the reading noted in step 1, turn power off and move jumper from position 1 to position 2.

5) Bring A2R27 within the proper range by removing jumpers 3, 4 and/or 5 until the digital voltmeter reading is near 1/10 the reading of step 1 without exceeding this value. For example, remove jumper 3. If the reading does not exceed the desired value, also remove jumper 4. If removing jumper 3 causes the reading to be too high, replace jumper 3 and remove jumper 4, etc.

6) Adjust A2R27 for digital voltmeter reading of 1/10 the reading noted in step 1.

f. Disconnect ac calibrator from input. Connect digital voltmeter to test point S (on A2).

g. Adjust A2R32 for digital voltmeter reading of 0 ± 20 mV.

h. Set FUNCTION to DC. Connect digital voltmeter to test point D.

i. Connect dc standard to input and set to + 15.000 V. Note digital voltmeter reading.

j. Change FUNCTION to DC + AC and adjust A3R3 for same digital voltmeter reading noted in step i, + 0.1 mV. If this adjustment procedure is being performed after replacement of the thermopile and A3R3 has insufficient range, turn power off and rotate thermopile 180°. Turn power on and repeat steps i and j. Disconnect dc standard.

k. Set FUNCTION to AC and apply input of 10.000 V at 100 Hz. Note reading.

l. Reduce input to 1.000 V and adjust A2R27 for digital voltmeter reading 1/10 that noted in step k, ± 0.3 mV. Disconnect ac calibrator.

m. Set FUNCTION to DC and apply + 15.000 V input from dc standard. Note reading.

n. Change FUNCTION to DC + AC and adjust A3R3 for digital voltmeter reading noted in step m, ± 0.1 mV.

5-52. GAIN ADJUSTMENTS.

5-53. A digital voltmeter having 0.1 mV resolution, an ac calibrator, and a high voltage amplifier are required for these adjustments. All adjustments in the preceding paragraphs must be made before performing the following procedures. All the gain adjustments are in the AC Converter Assembly, some on A2 and some on A3.

a. Set FUNCTION to AC VOLTS, RANGE to 1000 V, RESPONSE TIME to FAST. Connect digital voltmeter between test point D and analog ground.

b. Apply input of 800.00 V at 100 Hz from ac calibrator and high voltage amplifier.

c. Adjust A3R15 for digital voltmeter reading of 0.8000 V ± 0.0002 V.

WARNING

EXERCISE EXTREME CAUTION WHEN MAKING ADJUSTMENTS WITH A HIGH VOLTAGE INPUT.

d. Change input frequency to 30 kHz. Adjust A2C1 (*with plastic tool*) for digital voltmeter reading of 0.8010 V ± 0.0002 V. Reduce input voltage and disconnect high voltage amplifier.

e. Set 3403C RANGE to .1 V and apply input of 0.1000 V at 100 Hz from ac calibrator.

f. Adjust A3R11 for digital voltmeter reading of 1.0000 V ± 0.0002 V.

g. Change input frequency to 30 kHz. Adjust A2C14 for digital voltmeter reading of 1.0000 V ± 0.0002 V.

h. Decrease input to 0.01000 V. Set 3403C RANGE to .01 V.

i. Adjust A3R10 for digital voltmeter reading of 1.0000 V ± 0.0002 V.

j. Change frequency to 100 kHz. Digital voltmeter should read 1.000 V ± .004 V. If reading is not obtained, replace K3 and K4 relays and return to Paragraph 5-48.

k. Set 3403C RANGE to 1 V. Change input to 1.0000 V at 100 Hz.

l. Adjust A3R12 for digital voltmeter reading of 1.0000 V ± 0.0002 V.

m. Change input frequency to 30 kHz. Adjust A2C7 for digital voltmeter reading of 1.0000 V ± 0.0002 V.

n. Set 3403C RANGE to 10 V. Change input to 10.000 V at 100 Hz.

o. Adjust A3R13 for digital voltmeter reading of 1.0000 V ± 0.0002 V.

p. Change input frequency to 30 kHz. Adjust A2C10 for digital voltmeter reading of 1.0000 V ± 0.0002 V. If A2C10 can be adjusted correctly, proceed to step q. If A2C10 has insufficient range of adjustment, move C4 and R3C away from each other and perform steps l through o again. If range of adjustment remains insufficient, the following procedure should be used to select the proper value of A2C9.

1) Remove A2C9.

2) With input of 10.000 V at 30 kHz (as in step o), adjust A2C10 for minimum reading on the digital voltmeter.

3) If digital voltmeter reading is less than 0.981, adjust A2C10 for reading of 1.0000 V ± 0.0002 V and proceed to step q.

4) If digital voltmeter reading is greater than 0.981, replace A2C9 with the value indicated in Table 5-8.

Table 5-8. Selection of A2C9.

Reading	A2C9 Value
0.981 to 1.011	12 pF
1.012 to 1.024	24 pF
1.025 to 1.036	33 pF
1.037 to 1.048	43 pF
1.049 or greater	51 pF

q. Set 3403C RANGE to 100 V. Adjust input to 160 V at 30 kHz.

r. Adjust A3R14 for digital voltmeter reading of 1.6000 V ± 0.0003 V.

s. Change input frequency to 100 Hz. Adjust A2R9 for digital voltmeter reading of 1.6000 V ± 0.0003 V.

5-54. HIGH FREQUENCY ADJUSTMENTS.

5-55. All the previous adjustments must be correct before beginning this procedure. The attenuator shield must be left

in place while these adjustments are made. A high frequency signal generator (-hp- 8601A), an ac calibrator (-hp- 745A), a digital voltmeter (-hp- 3480C/D/3484A), and two thermal converters with correction sheets indicating correction factors for each frequency tested, .45 V (-hp- 11051A), and 3 V (-hp- 11049A) are required for these adjustments.

CAUTION

IF COMPONENTS OR WIRES IN THE ATTENUATOR AREA ARE MOVED, CALIBRATION AT HIGH FREQUENCIES MAY BE ALTERED.

a. Set FUNCTION to AC VOLTS, RANGE to 0.1 V, RESPONSE TIME to FAST.

b. Connect digital voltmeter between A3 test point D and analog ground (converter box).

c. Adjust ac calibrator output to 0.1 V at 100 kHz and connect the calibrator to the 3403C. Note the digital voltmeter reading and record for reference in step f.

d. Set the high frequency signal generator RANGE to 0.3 V.

CAUTION

DO NOT EXCEED 0.45 V WITH AC CALIBRATOR OR SIGNAL GENERATOR WHEN -hp- 11051A THERMAL CONVERTER IS USED OR DAMAGE TO THE THERMAL CONVERTER WILL RESULT.

e. Disconnect ac calibrator and replace with high frequency signal generator. Connect 0.45 V thermal converter as shown in Figure 5-1. (Leave thermal converter output open and digital voltmeter connected to A3 test point D.) This is the configuration used at the factory for testing and calibrating the 3403C. Any other configuration can be expected to give different results. The -hp- Model 3480C/D/3484A is used in place of the 3420A/B in Figure 5-1 for these adjustments.

NOTE

The thermal converter output is used to assure the input voltage used is the same for each frequency when making high frequency adjustments. The output of the 3403C is monitored at A3 test point D during these adjustments. Therefore, the voltage at test point D must take into consideration the measurement error of the thermal converter at the test frequency.

f. Set signal generator frequency to 100 kHz and adjust output amplitude so that digital voltmeter reading is the same as noted in step c.

g. Disconnect digital voltmeter from AC Converter and connect to thermal converter output. Note and record reading for reference in succeeding steps.

h. Change signal generator frequency to 90 MHz and adjust output amplitude for digital voltmeter reading noted in step g.

i. Disconnect digital voltmeter from thermal converter output and connect between A3 test point D and analog ground. Adjust A2R71 for digital voltmeter reading of 1.000 V + thermal converter error + 2.0% for heat. Example: If thermal converter error is + 3% at 90 MHz, adjust A2R71 for 1.000 V + 0.03 V (thermal converter error) + 0.02 V (heat error) = 1.05 V. DO NOT readjust A2R71 in the following steps.

j. Disconnect digital voltmeter from A3 test point D and connect to thermal converter output.

NOTE

Since the thermal converter output changes with ambient temperature changes, it will be necessary to verify that the reference voltage of step g has not changed if readings of steps k through n and w through y are not within specification.

k. Change signal generator frequency to 100 MHz and adjust output for digital voltmeter reading noted in step g.

l. Disconnect digital voltmeter from thermal converter output and connect between A3 test point D and analog ground. Digital voltmeter should read 1.000 V + (thermal converter error at test frequency) ± (instrument spec tolerance at test frequency). Example: If thermal converter error is + 3.1% at 100 MHz, digital voltmeter reading should be 1.000 V + 0.031 V (thermal converter error) = 1.031 V ± 10.2%.

m. Record the calculated minimum and maximum value for each test frequency of step k and n for reference in step x. If 3403C does not meet the calculated reading, repeat steps a through g to verify that the thermal converter has not been affected by a change in ambient temperature. If the thermal converter output has changed from the previous reading of step g, repeat steps j, k and l using the new thermal converter output obtained for the test frequency failed and all succeeding test frequencies. If the 3403C fails to meet the calculated reading following this procedure, replace IC1 and return to the beginning of the adjustment sequence.

n. Repeat steps j, k and l (step m if required) for signal generator frequencies of 70 MHz, 50 MHz, 30 MHz and 10 MHz. Change the thermal converter error and instrument spec in step l to agree with the test frequency to determine digital voltmeter reading range. The following table indicates the instrument spec tolerance for each test frequency.

Test Frequency	Instrument Specification Tolerance
100 MHz	± 10.2%
70 MHz	± 10.2%
50 MHz	± 5.2%
30 MHz	± 5.2%
10 MHz	± 2.2%

o. Disconnect signal generator and thermal converter from 3403C.

p. Set 3403C RANGE to 1 V. Adjust ac calibrator output to 0.4 V at 100 kHz and connect calibrator to 3403C. Note digital voltmeter reading at A3 test point D and record for reference in step r.

q. Change signal generator to 1 V range and insure the output DOES NOT exceed 0.45 V. Replace ac calibrator with signal generator. Connect 0.45 V thermal converter to test setup.

r. Set signal generator frequency to 100 kHz and adjust output amplitude for digital voltmeter reading noted in step p.

s. Disconnect digital voltmeter from AC Converter and connect to thermal converter output. Note reading and record for reference in following steps.

t. Change signal generator frequency to 90 MHz and adjust output amplitude for digital voltmeter reading noted in step s.

u. Disconnect digital voltmeter from thermal converter output and connect between A3 test point D and analog ground. Adjust A2R5 for digital voltmeter reading of 0.400 V + thermal converter error + 2.0% for heat. Example: If thermal converter error is + 3% at 90 MHz, adjust A2R5 for 0.400 V + 3% of 0.4 V (thermal converter error) + 2% of 0.4 V (heat error) = 0.400 V + 0.012 V + 0.008 V = 0.420 V.

v. Disconnect digital voltmeter from test point D and connect to thermal converter output.

w. Change signal generator frequency to 100 MHz and adjust output amplitude for digital voltmeter reading noted in step s.

x. Disconnect digital voltmeter from thermal converter output and connect between A3 test point D and analog ground. Digital voltmeter should read 0.400 V + thermal converter error at test frequency ± instrument spec tolerance at test frequency. Digital voltmeter range can be obtained by taking 40% of the minimum and maximum values recorded in step m for each test frequency except 10 MHz. Minimum and maximum readings must be recalculated for 10 MHz using instrument spec tolerance of 1.2%. If the 3403C does not meet the calculated reading, repeat steps p through s to verify that the thermal converter has not been affected by a change in ambient temperature. If the thermal converter output has changed from the previous reading of step s, repeat steps v, w and x using the new thermal converter output obtained for the test frequency failed and all succeeding test frequencies. If the 3403C fails to meet the calculated reading following this procedure, replace IC1 and return to the beginning of the adjustment sequence.

y. Repeat steps v, w and x for signal generator frequencies of 70 MHz, 50 MHz, 30 MHz and 10 MHz.

z. Disconnect 0.45 V thermal converter from signal generator. Replace signal generator with ac calibrator.

aa. Set 3403C RANGE to 10 V. Adjust ac calibrator output to 2.000 V at 100 kHz. Note digital voltmeter reading at A3 test point D and record for reference in step ac.

DO NOT EXCEED 3.0 V WITH SIGNAL GENERATOR WHEN -hp- 11049A IS USED OR DAMAGE TO THE THERMAL CONVERTER WILL RESULT.

ab. Change signal generator to the 3 V range. Replace ac calibrator with signal generator. Connect 3 V thermal converter to test setup.

ac. Set signal generator frequency to 100 kHz and adjust output amplitude for digital voltmeter reading noted in step aa.

ad. Disconnect digital voltmeter from AC Converter and connect to thermal converter output. Note reading and record for reference in step ae.

ae. Change signal generator frequency to 9 MHz and adjust output amplitude for digital voltmeter reading noted in step ad.

af. Disconnect digital voltmeter from thermal converter output and connect between A3 test point D and analog ground. Adjust A2R7 for digital voltmeter reading of 0.2000 V ± 0.0004 V.

ag. Disconnect test setup. Turn 3403C off. Close AC Converter box, making sure seal is in place, and replace all screws. Replace AC Converter in instrument and turn on.

5-56. DIGITAL PANEL METER ADJUSTMENTS.

5-57. All preceding adjustments (with the exception of the High Frequency Adjustments if required test equipment is not available) must be completed before performing the Digital Panel Meter Adjustments, unless these adjustments are being performed as a result of the check given in Paragraph 5-36. A dc standard (-hp- 740B) and a dc differential voltmeter (-hp- 3420A/B) are required for these adjustments.

a. Set 3403C FUNCTION to DC, RANGE to 1 V, RESPONSE TIME to FAST.

b. Connect dc differential voltmeter to rear panel VOLTS analog output terminals.

c. Connect a short across the 3403C input and adjust the front panel DC ZERO adjustment for a dc differential voltmeter reading of 0 V.

d. Adjust A22C4 (right adjustment in Panel Meter face) for a panel meter display of .000. Last digit may alternate between 0 and 1.

e. Remove 3403C input short and connect dc standard to the input. Adjust dc standard for a dc differential voltmeter reading of + 1.5005 V.

f. Adjust A22R5 (left adjustment in Panel Meter face) for a panel meter display of + 1.500. Display can alternate between + 1.500 and + 1.501.

g. Reverse the input leads from the dc standard and adjust dc standard for a dc differential voltmeter reading of - 1.5005 V.

h. Adjust A22R5, if necessary, for a panel meter display of - 1.500. Display can alternate between - 1.499 and - 1.500.

i. Reverse dc standard leads and adjust for dc differential voltmeter reading of + 1.5005 V. Recheck the adjustment of Step f. Readjust R5 if necessary.

j. Reverse dc standard leads and adjust for dc differential voltmeter reading of - 1.5005 V. Recheck the adjustment of Step h. Readjust R5 if necessary.

k. Perform Steps i and j alternately until adjustments specified in Steps f and h are met.

l. Remove dc standard and ac differential voltmeter.

5-58. OUT-OF-RANGE ADJUSTMENTS.

5-59. An ac calibrator is required for these adjustments which set the points at which uprange and downrange blanking occurs. Both adjustments are on the Connector Assembly. This assembly may be either A7 or A11, depending on the options included. The A7 designation used in this procedure applies to all instruments, since the adjustments are identical. An ac calibrator (-hp- 745A) is required for these adjustments.

a. Set FUNCTION to AC VOLTS, RANGE to 10 V, RESPONSE TIME to FAST.

b. Apply input of 19.500 V at 100 Hz from ac calibrator.

c. Adjust A7R11 to the point where the 3-digit display goes from on to off. (The overrange "1" should remain on.)

d. Reduce input voltage to 1.650 V and adjust A7R13 to the point where the display goes from on to off.

5-60. LOG CONVERTER ADJUSTMENTS.

5-61. The Log Converter (Option 006) may be adjusted at any time after the Gain Adjustments, Paragraph 5-46, have been completed. An ac calibrator and high voltage amplifier (-hp- 745A/746A), a digital voltmeter able to resolve 0.01 mV, and a 20-pin (2 x 10) printed circuit extender board (-hp- Part No. 5060-0091) are required for this procedure.

a. Set FUNCTION to AC VOLTS, RANGE to 1 V, RESPONSE TIME to FAST, dB REFERENCE fully counterclockwise to CAL position.

b. Short test point Z to test point G. Connect digital voltmeter between test point ET and analog ground.

c. Apply input of 1.0000 V at 100 Hz ac calibrator. Digital voltmeter reading should be either positive or negative approximately 0.7 V. If the reading is negative, then adjust A12R8 clockwise until reading changes to positive, then adjust counterclockwise slowly until reading goes negative. (Because of the high gain of the amplifier, reading cannot be adjusted to zero.) If the first reading is positive, rotate A12R8 counterclockwise until reading is negative, then proceed as instructed above. Then remove short from test point Z.

d. Adjust front panel dB CAL multi-turn screwdrive adjustment fully clockwise. A faint click can be heard when wiper is at limit of travel.

e. Adjust A12R13 for digital voltmeter reading (at test point ET) of - 488.3 mV ± 0.2 mV.

f. Connect digital voltmeter between test points ET and ED (ET to High terminal, ED to Low). Voltmeter reading should be - 7 to - 10 mV. (If not, see Paragraph 5-87). Adjust front panel dB CAL for digital voltmeter reading of 0 ± 0.05 mV.

g. Connect digital voltmeter between rear panel dB recorder output terminal and ground terminal. Adjust A12R29 for voltmeter reading of 0 ± 0.05 mV.

h. Set FUNCTION to AC dB. Connect digital voltmeter between Log Converter output at J6 pin 7 and ground.

i. Reduce ac calibrator output to 0.10000 V (3403C on 1 V range). Adjust A12R19 for digital voltmeter reading of - 0.2000 V ± 0.0001 V.

j. Reduce ac calibrator output to 0.01000 V. Set 3403C RANGE to .01 V. Adjust A12R56 for digital voltmeter reading of - 0.4000 V ± 0.0001 V.

k. Set 3403C RANGE to 1000 V. Connect high voltage amplifier (-hp- 746A) to 3403C input and to ac calibrator. Set voltage to 1000 V. Adjust A12R58 for digital voltmeter reading of + 0.6000 V ± 0.0001 V. Reduce voltage and disconnect high voltage amplifier.

l. Set RANGE to .1 V. Connect ac calibrator to 3403C input and adjust voltage to 0.4000 V.

m. Digital voltmeter reading should be - 0.0774 V ± 0.0003 V. If not, adjust A12R3 to obtain this reading.

n. If necessary to adjust A12R3 in step m, repeat steps i, l and m (omit steps j and k) until readings are correct without further adjustment.

o. Set RANGE to 1 V, ac calibrator output to 0.1000 V. Note and record digital voltmeter reading (at J6 pin 7).

p. Connect digital voltmeter between rear panel dB recorder output terminal and ground terminal. Adjust A12R38 for digital voltmeter reading noted in step o ± 0.0001 V.

q. The preceding steps adjust the Log Converter for dBV readings (1 V in = 0 dB). If it is preferred to have the instrument display dBm 600 Ω readings, set RANGE to 1 V and apply an input of 0.7746 V. Adjust front panel dB CAL screwdriver adjustment for digital voltmeter reading (at dB recorder output) of 0 ± 0.001 V.

5-62. FINAL CONVERTER BALANCE ADJUSTMENT.

5-63. An ac calibrator and digital voltmeter are required for this adjustment. Secure the front panel and replace bottom and side covers. Allow the instrument to warm up for at least 1 hour before proceding.

a. Set FUNCTION to AC VOLTS, RANGE to .1 V, RESPONSE TIME to FAST.

b. Connect digital voltmeter to rear panel VOLTS recorder output terminals.

c. Apply input of 100.000 mV at 100 Hz from ac calibrator. Note digital voltmeter reading.

d. Reduce input to 10.000 mV.

e. Remove left side cover and adjust A7R1 for voltmeter reading of 1/10 the reading noted in step c.

TROUBLESHOOTING PROCEDURES

5-64. PRELIMINARY TROUBLESHOOTING.

5-65. If the Model 3403C operates incorrectly and the trouble cannot be corrected by the Adjustment Procedures, the following troubleshooting information should be used. Check for loose wires or other obvious sources of trouble, such as burned or loose components. Make sure printed circuit boards are seated firmly in connectors, and integrated circuit packages are firmly seated in sockets.

5-66. ACCESS FOR SERVICING.

5-67. Figure 5-5 illustrates the procedure for removing covers and releasing front and rear panels to gain access to the various assemblies and circuits.

5-68. TROUBLESHOOTING TREES.

5-69. The Basic Troubleshooting Tree, Figure 5-6, should be used to locate the area of difficulty. Additional troubleshooting information for the various circuits is given in the following paragraphs, in the Digital Panel Meter Troubleshooting Tree, Figure 5-7, and in the Autorange Troubleshooting Tree, Figure 5-8.

5-70. AC CONVERTER SERVICE.

5-71. AC Converter Exchange.

5-72. If the AC Converter Assembly is defective, replacement may be more practical than repair (see Paragraph 5-38). The replacement assembly is -hp- Part No. 03403-69501. This assembly is available on an exchange basis. Contact your nearest -hp- Sales and Service Office for details.

5-73. AC Converter Input/Output Checks.

5-74. The AC Converter Assembly contains the Input Attenuator and Amplifier, The Converter Amplifier and Thermopile, and the DC Amplifier, as well as the logic circuits which drive the range and function selection relays. Signals to and from the AC Converter Assembly may be checked at printed circuit board connector J10 on the side of the converter box. Figure 5-5 shows the method of access to this connector. If the instrument is equipped with Autorange or dB Options, these printed circuit boards must be removed to provide access to J10. When the Log Converter Assembly is removed, the small slide switch beside the connector on the Master Board must be switched toward the rear of the instrument to provide an output connection from the AC Converter to the Digital Panel Meter. If a signal is not correct at J10, check the proper pin at the top edge of the Connector Assembly. Connections to the pins at the top and bottom of this printed circuit board are identical.

5-75. AC Converter Service Precautions.

5-76. The AC Converter may be opened and operated for servicing as illustrated in Figure 5-3. Certain components are easily damaged by excessive voltage; consequently, extreme care must be exercised when using a voltmeter or oscilloscope probe within the assembly. In addition, calibration may be altered by movement of components or wires in the attenuator area.

CAUTION

THE COMPONENTS AND PRINTED CIRCUIT BOARDS WITHIN THE AC CONVERTER ASSEMBLY MUST BE KEPT CLEAN AND FREE FROM FINGERPRINTS OR OTHER CONTAMINATION, OR PERFORMANCE MAY BE DEGRADED.

5-77. Mother Board (A4) Replacement (Flexible Traces).

5-78. The following procedure for replacing the Mother Board (A4) is recommended to prevent damage to the board.

CAUTION

THE MOTHER BOARD (A4) CAN BE EASILY DAMAGED IF THE PROPER REPLACEMENT PROCEDURE IS NOT FOLLOWED WHEN REPLACMENT IS REQUIRED. WHEN HANDLING THE MOTHER BOARD, INSURE THE TWO HALVES OF THE BOARD ARE KEPT AT A RIGHT ANGLE.

a. Insert two teflon washers between the Mother Board and the instrument top. Insert the two screws through the board and into the top to retain teflon washers. DO NOT tighten these screws until the panel meter connector screws have been tightened.

b. Insert and tighten the screws on the panel meter connector.

c. Tighten the two screws holding the Mother Board to instrument top.

This replacement procedure prevents undue stress to the flexible traces on the Mother Board. Failure to follow this procedure can cause these traces to break.

5-79. POWER SUPPLY CHECKS.

5-80. Remove the rear panel and power supply from the instrument as indicated in Figure 5-5, and operate power supply outside the instrument.

WARNING

KEEP HANDS AND TOOLS AWAY FROM THE AC POWER INPUT CONNECTOR, THE FUSEHOLDER, AND THE 115/230 SWITCH WHILE POWER SUPPLY IS CONNECTED TO POWER LINE.

5-81. Measure power supply voltages. If a supply voltage is very low, or zero, first check the bridge rectifier output for that supply. The voltage should be approximately as shown on the schematic diagram, Figure 7-13 or 7-14. If the rectifier output is correct, the problem is usually either the series pass transistor or the regulator IC. The trouble can usually be isolated by removing the series pass transistor and shorting the base and emitter connections on the printed circuit board. If the power supply output is then nearly correct, the regulator IC is good and the series pass transistor is defective. However, if the output voltage is still incorrect with the above check, the regulator is probably defective.

5-82. CONNECTOR ASSEMBLY CHECKS.

5-83. Voltage levels of signals to and from the Master Board (at J7) may be checked at the printed circuit connector strip at the exposed edge of the A7 (or A11) assembly, since connections at both edges of the board are identical. Logic levels for the function and range selection inputs to A7 (or A11) are approximately 0 V = select, + 5 V = not select. Output levels to the AC Converter assembly are approximately 0 V = select, + 12 V = not select.

5-84. AUTORANGE CHECKS.

5-85. The Autorange Troubleshooting Tree, Figure 5-8, checks the operation of the Autorange Assembly, A13, used in 3403C Option 001. The operation of the autorange circuits of the Remote and Autorange Assembly A14, used in 3403C Option 003, is essentially the same, with the addition of the remote programming logic. When the 3403C is used in the DC mode on autorange, uprange signaling is transmitted by the Crest Factor line. In the DC mode, an overload provides a converter output of approximately 1.8 V. Since a converter output of 1.9 V is required to initiate an uprange signal from A7Q4, this signal does not occur. A7Q6 does turn on when the 3403 is overloaded in the DC mode and applies a Crest Factor signal to the Crest Factor Gate, A13IC2. This triggers the AUTORANGE SECTION and upranging occurs.

5-86. LOG CONVERTER ZERO ERROR.

5-87. If A12CR2 or A12IC2 has been replaced, it may be necessary to reselect the proper jumpers across A12R11, 12 and 14. If the digital voltmeter reading in Paragraph 5-61, step f, is not - 7 to - 10 mV, perform the following selection procedure.

a. Connect a clip lead across all three jumper positions at the lower left corner of A12. Note digital voltmeter reading between test points ET and ED. (Digital voltmeter HIGH connected to ET, LOW to ED.) Reading should be between + 7.1 mV and - 10 mV.

b. Determine voltage change necessary to bring reading to between - 7 and - 10 mV.

c. Use Table 5-9 to determine which jumper positions should be open.

d. Proceed with adjustment procedures in Paragraph 5-61.

Table 5-9. Log Converter Zero.

Voltage Change Required	Jumper Positions * Open	Shorted
2.0 mV or less	1	2, 3
2.0 mV to 4.0 mV	2	1, 3
4.0 mV to 5.9 mV	1, 2	3
5.9 mV to 7.7 mV	3	1, 2
7.7 mV to 9.4 mV	1, 3	2
9.4 mV to 11.1 mV	2, 3	1
11.1 mV to 14.1 mV	1, 2, 3	---

* Due to component tolerance it may be necessary to select one position higher or lower than indicated.

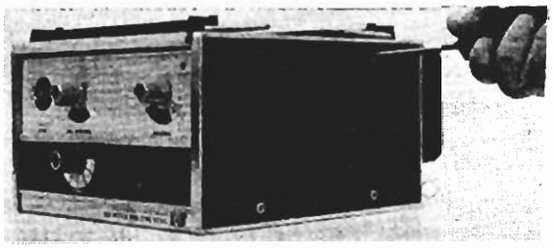
5-88. FACTORY SELECTED COMPONENTS.

5-89. The values of certain components are selected at the factory for optimum performance. These components are designated on the schematic diagram and the replaceable parts list by an asterisk (*) and the average value is shown. Actual circuit values can vary from the average value. If replacement of these parts is necessary, determine the actual component value. If the value differs from the average value, order replacement part as described in Paragraph 6-6 indicating the actual circuit value. The following paragraphs describe other critical replacement situations.

5-90. REPLACEMENT OF A2CR1, A2R4 AND A2IC1 (A2C26, 30 kHz 100 mV ADJ).

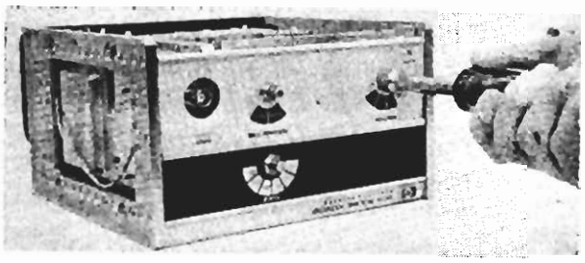
5-91. A2CR1 and A2R4 are matched for temperature coefficient and matched to the Input Amplifier A2IC1. If it is necessary to replace A2IC1, the diode and resistor are supplied with the IC and must be replaced at the same time. If A2CR1 or A2R4 require replacement, the entire matched set of IC, diode and resistor must be replaced.

Step A



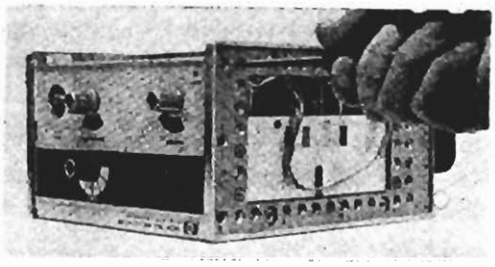
Remove four screws in each side to remove side and bottom covers. AC Converter and Connector assemblies may be removed from instrument.

Step D



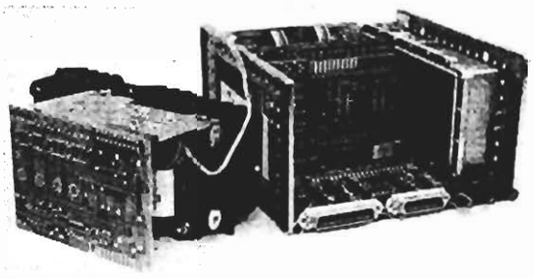
Remove control knobs and mounting nuts to remove front panel from master board assembly.

Step B



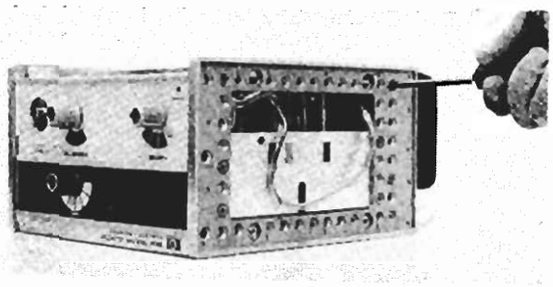
Remove one screw in each side frame to release front panel. Provides access to switching logic circuits and digital panel meter.

Step E



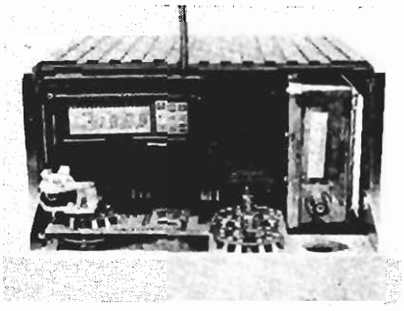
Power supply may be removed from instrument (with rear panel) and operated separately outside the instrument for power supply troubleshooting.

Step C



Remove two screws in each side frame to release rear panel and power supply assembly.

Step F & G



Remove digital panel meter by removing two screws. Remove meter assembly from printed circuit connector behind meter. Slide meter PC assembly out rear of case. Make sure insulator is in place at top of case when replacing PC assembly in case.

Figure 5-5. Access For Servicing.

5-92. DIGITAL PANEL METER.

5-93. Access to test points within the panel meter can be gained by removing panel meter from case and placing the meter on an extender board, -hp- Part No. 5060-5984. Test points and connections to the Digital Panel Meter are shown in Figure 5-7, Panel Meter Troubleshooting Tree.

5-94. Override Section.

5-95. When the Digital Panel Meter Override Section is not functioning, the display racks and does not follow the input. Monitor the output of A22U3 at R9. The output should toggle between 0 V and + 5 V. The + 5 V output corresponds to the auto-zero interval, 0 V corresponds to the measure interval. The gate of A22Q1 should toggle between + 5 V and - 12 V at the rate of the U3 output.

5-96. Numeric Display.

5-97. The seven-segment numeric displays can be tested for bag segments by applying a low to pin 3 of the decoder/driver, A21U1. This illuminates all segments. If all segments are unlit, verify + 5 V is supplied to displays by transistors A21Q1 through Q4 and A21U6. A 175 microsecond + 5 V pulse should occur every 0.7 milliseconds. If display supply is good, proceed to last waveform block of troubleshooting tree and monitor BCD outputs. If problem is not resolved at conclusion of troubleshooting tree, remove connection between A21U1 pin 3 and COM and continue from display test of troubleshooting tree.

VOLTS, RE-
LECT EACH
ITCH AND
INT AND V,
CATE COR-

ARE RANGE INDICATIONS CORRECT?

YES

NO

TROUBLESHOOT MANUAL RANGE AND FUNCTION AND/OR DECIMAL CONTROL CIRCUITS ON A4, AND DIGITAL PANEL METER

SHORT INPUT. SET RESPONSE TIME TO SLOW. SET RANGE SWITCH TO 1000 V, THEN TO AUTO AND OBSERVE RANGE INDICATIONS (DECIMAL POINT AND V, mV ANNUNCIATORS). SHOULD DOWNRANGE THROUGH ALL RANGES TO 10 mV (.01 V) RANGE. EACH RANGE CHANGE SHOULD REQUIRE ABOUT 10 SECONDS.

ARE DOWNRANGE INDICATIONS CORRECT?

YES

NO

DOES MORE THAN ONE DECIMAL LIGHT ON ANY ONE RANGE?

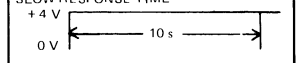
YES

REPLACE A13IC5.

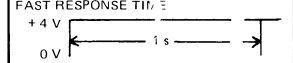
NO

MONITOR WAVEFORM AT CLK TEST POINT ON A13. CORRECT WAVEFORMS:

SLOW RESPONSE TIME



FAST RESPONSE TIME



ARE BOTH WAVEFORMS CORRECT?

YES

NO

MEASURE COUNTER OUTPUTS AT DECODER INPUTS (A13IC5). A (PIN 15), B (PIN 14), C (PIN 13). VOLTAGE LEVELS SHOULD CORRESPOND TO RANGE INDICATED IN DISPLAY. SEE TRUTH TABLE IN FIGURE 7-18. (D INPUT, PIN 12, SHOULD BE LOW.)

DO LOGIC LEVELS AGREE WITH DISPLAY RANGE?

YES

NO

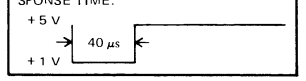
REPLACE A13IC5.

IS EITHER WAVEFORM CORRECT?

YES

Ⓐ

TROUBLESHOOT A13Q1 - 3. Q1 AND Q2 SHOULD BOTH BE ON FOR FAST RESPONSE TIME, OFF FOR SLOW. WAVEFORM AT Q3 COLLECTOR SHOULD BE APPROXIMATELY AS FOLLOWS FOR EACH CYCLE OF THE AUTORANGE CLOCK IN EITHER FAST OF SLOW RESPONSE TIME:



NO

SET RANGE SWITCH TO 1000 V. MONITOR WAVEFORM AT CLK TEST POINT WHILE MOMENTARILY GROUNDING PIN 3 OF A13IC1 CLK SHOULD GO HIGH FOR 1 SEC. IN FAST RESPONSE TIME, 10 SEC. IN SLOW, EACH TIME PIN 3 IS GROUNDED.

ARE WAVEFORMS CORRECT?

YES

A13IC3 OR A13IC4 IS DEFECTIVE.

NO

REPLACE A13IC1

NOTES

1. ACCESS FOR SERVICING MAY BE GAINED AS SHOWN IN FIGURE 5-5.

2. A DC STANDARD, A DC VOLTMETER, AND AN OSCILLOSCOPE ARE REQUIRED FOR THESE CHECKS.

3403A-B-3207

SET FUNCTION TO DC VOLTS. (IF PREVIOUS CHECK WAS CORRECT, 3403A SHOULD BE ON 10 mV RANGE, .3 DIGITS BLANK, OVERRANGE "1" MAY BE ON.) REMOVE INPUT SHORT, CONNECT DC STANDARD TO INPUT AND APPLY 10 mV. THEN INCREASE INPUT TO 20 mV. 3403A SHOULD UPRANGE TO 100 mV RANGE

IS UPRANGING CORRECT?

YES

NO

SET INPUT TO 100 mV, THEN 200 mV. 3403A SHOULD UPRANGE TO 1 V RANGE. IF SO, SET INPUT TO 1 V AND 2 V, 10 V AND 20 V, 100 V AND 200 V. 3403A SHOULD UPRANGE ONE RANGE FOR EACH STEP. IF RANGE CHANGE OCCURS IN 1 SECOND INSTEAD OF ABOUT 10 SECONDS, GO TO POINT Ⓐ BELOW.

DOES DISPLAY INDICATE 1000 V RANGE?

YES

MEASURE VOLTAGE AT PIN 14 OF A13IC6. SHOULD BE < +0.5 V.

IS VOLTAGE CORRECT?

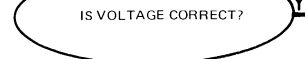
YES

NO

TROUBLESHOOT CREST FACTOR GATE CIRCUIT. INPUTS, PINS 3, 4 AND 5, SHOULD ALL BE > +2.4 V.

NO

SET RESPONSE TIME TO FAST MONITOR WAVEFORM AT PIN 4 OF A13IC6. SHOULD BE:



IS WAVEFORM CORRECT?

YES

REPLACE A13IC6.

NO

MEASURE VOLTAGE AT PIN 10 OF A13IC2. SHOULD BE > +2.4 V.

IS VOLTAGE CORRECT?

YES

REPLACE A13IC2.

NO

MEASURE VOLTAGE AT PIN 13 OF A13IC3. SHOULD BE < +0.5 V.

IS VOLTAGE CORRECT?

YES

REPLACE A13IC3.

NO

TROUBLESHOOT DOWNRANGE COMPARATOR CIRCUIT (OUT-OF-RANGE DETECTOR) ON CONNECTOR ASSEMBLY A7 (A11).

IS UPRANGING CORRECT?

YES

CHECK OUT-OF-RANGE ADJUSTMENTS. SEE PARAGRAPH 5-62

NO

DOES MORE THAN ONE DECIMAL LIGHT ON ANY ONE RANGE?

YES

REPLACE A13IC5.

NO

SET RESPONSE TIME TO FAST. MONITOR WAVEFORM AT PIN 5 OF A13IC6. SHOULD BE:

IS WAVEFORM CORRECT?

YES

REPLACE A13IC6.

NO

MEASURE VOLTAGE AT PIN 13 OF A13IC2. SHOULD BE > +2.4 V.

IS VOLTAGE CORRECT?

YES

REPLACE A13IC2.

NO

MEASURE VOLTAGE AT PIN 3 OF A13IC3. SHOULD BE < +0.5 V.

IS VOLTAGE CORRECT?

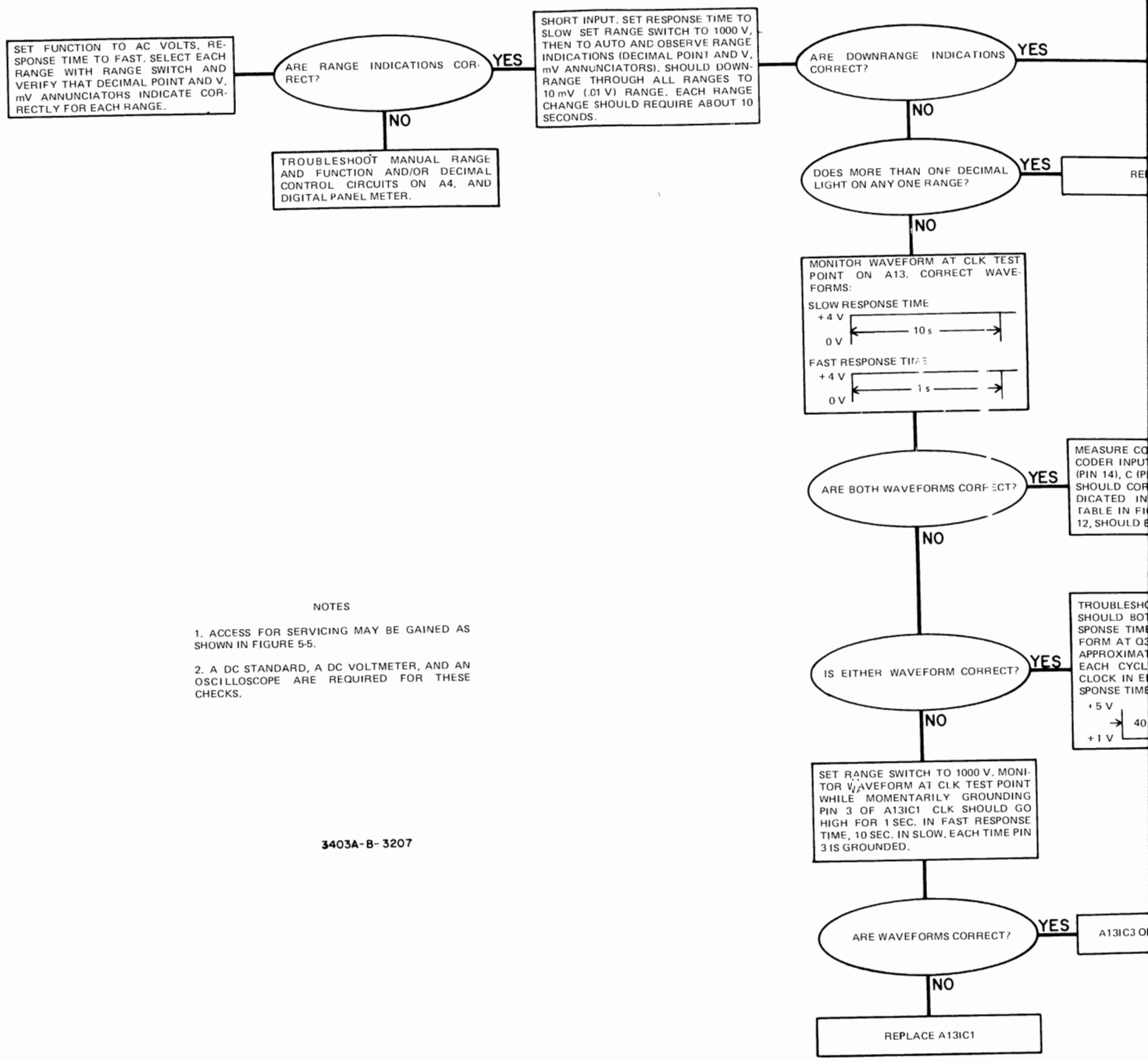
YES

REPLACE A13IC3.

NO

TROUBLESHOOT UPRANGE COMPARATOR CIRCUIT (OUT-OF-RANGE DETECTOR) ON CONNECTOR ASSEMBLY A7 (A11).

Figure 5-8. Autorange (A13) Troubleshooting Tree.
Rev. A 5-25/5-26



NOTES

1. ACCESS FOR SERVICING MAY BE GAINED AS SHOWN IN FIGURE 5-5.

2. A DC STANDARD, A DC VOLTMETER, AND AN OSCILLOSCOPE ARE REQUIRED FOR THESE CHECKS.

3403A-B-3207

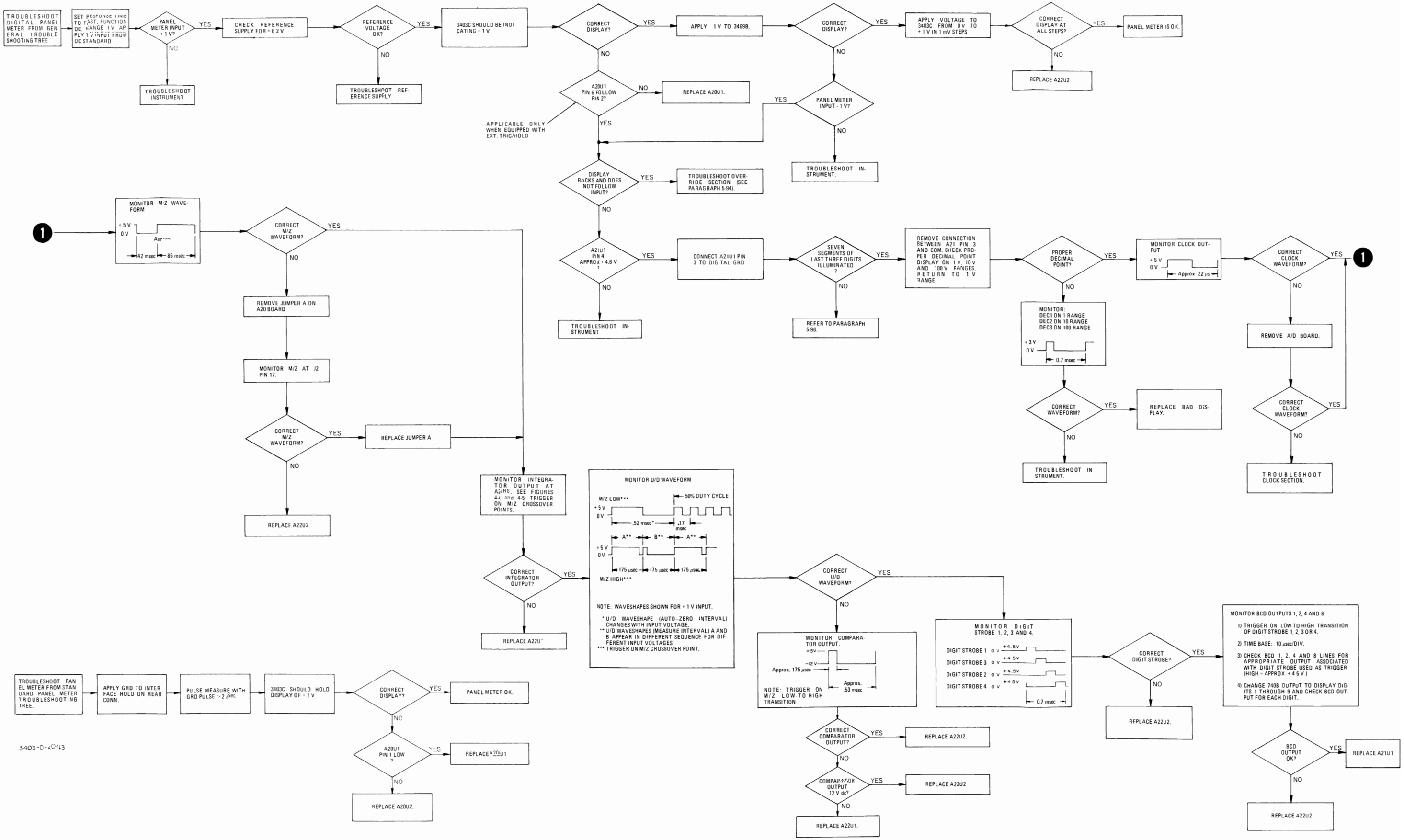
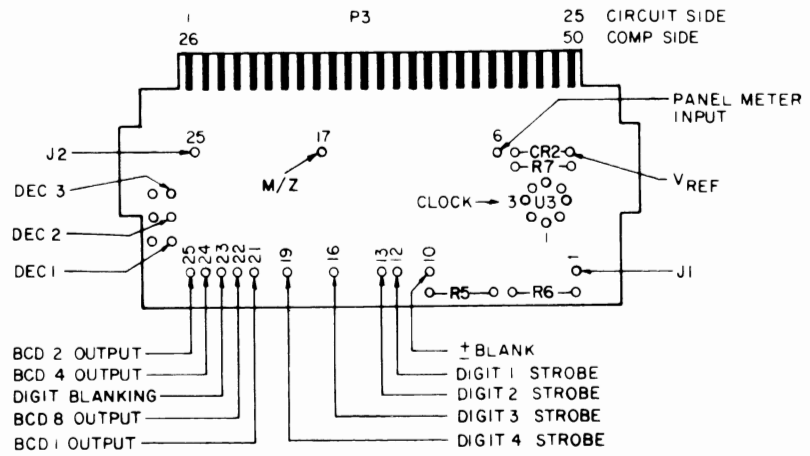


Figure 5-7. Panel Meter Troubleshooting Tree.
Rev. C 5-23/5-24

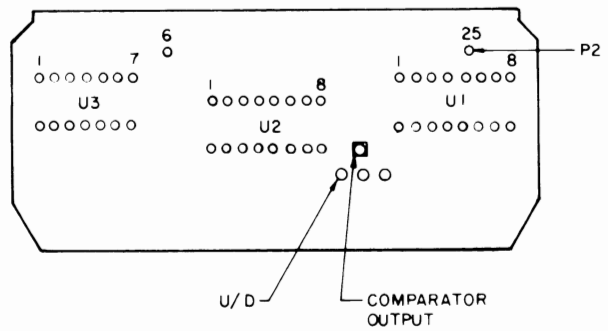
A20 CIRCUIT SIDE

(NOT ALL PADS ARE SHOWN)



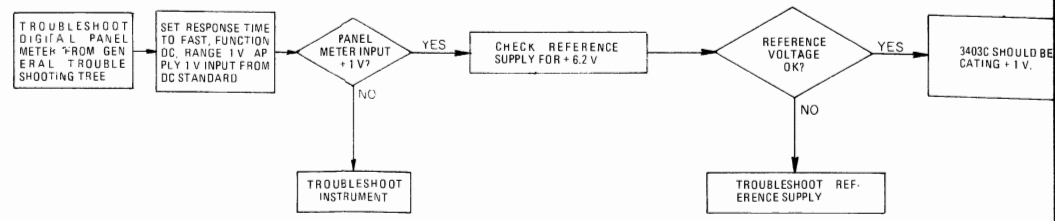
A22 CIRCUIT SIDE

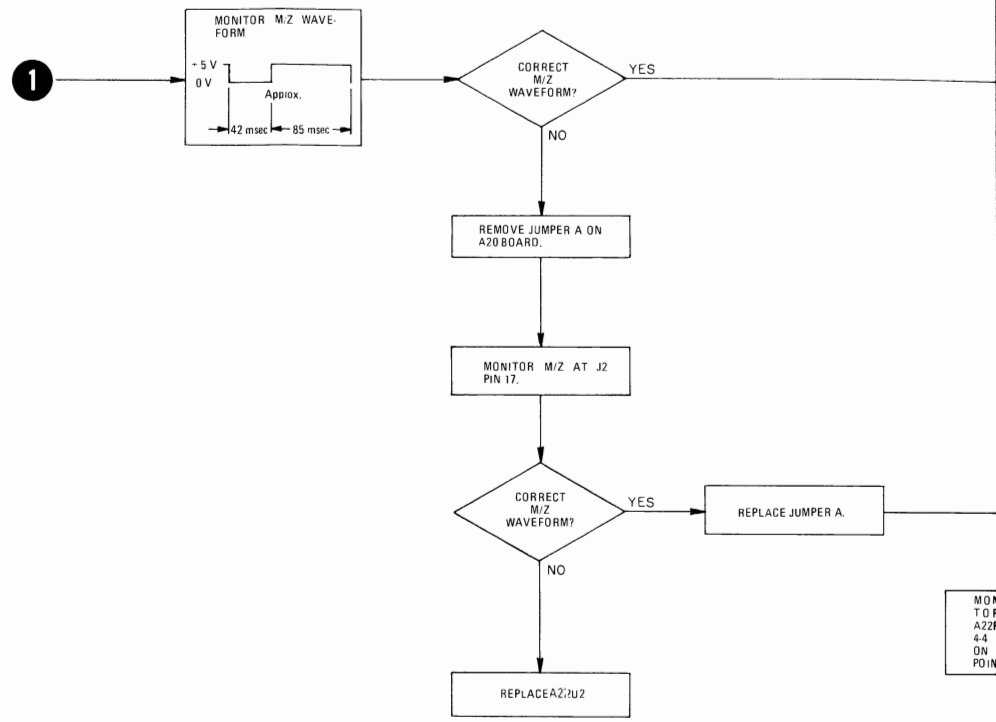
(NOT ALL PADS ARE SHOWN)

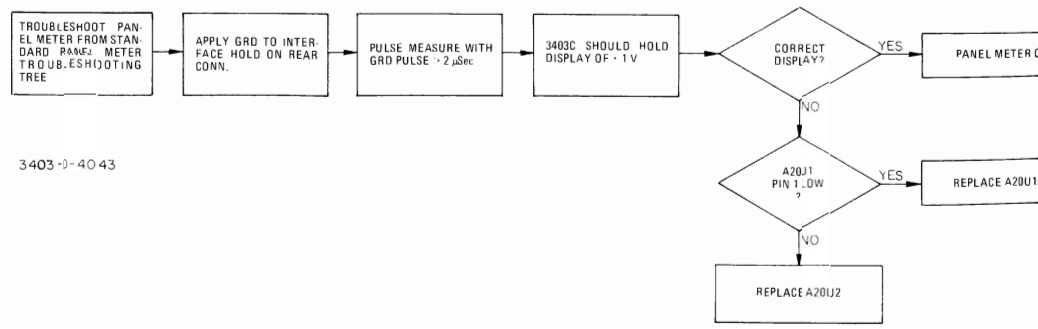


NOTE: INSERT POSTS IN COMPARATOR OUTPUT AND U/D TEST POINT TO PROVIDE A MEANS OF ATTACHING A PROBE

3403 B 4049







3403-D-4043

AND AUTO-
RESENT. SET
ON MASTER
OF INSTRU-

CHECK ALL POWER SUPPLY VOLTAGES (± 12 V, ± 5 V, - 10 V). ALLOW TOLERANGE OF ± 10 %.

ARE ALL VOLTAGES CORRECT?

YES

NO

TROUBLESHOOT POWER SUPPLIES. SEE FIGURE 5-13 OR 5-14 AND PARAGRAPH 5-81

MONITOR REAR PANEL VOLTS RECORDER OUTPUT AND APPLY FULL-RANGE AC (100 Hz) INPUT ON EACH AC VOLTS RANGE. REPEAT CHECK WITH DC INPUT ON DC FUNCTION FOR 3403A. OUTPUT SHOULD BE 1 V ± 5 % ON EACH RANGE.

ARE OUTPUT VOLTAGES CORRECT?

YES

NO

MEASURE LOGIC LEVELS OF RANGE AND FUNCTION SELECT SIGNALS TO AC CONVERTER ASSEMBLY FOR DEFECTIVE RANGE AND/OR FUNCTION. < + 0.5 V = SELECT; ≈ + 12 V = NOT SELECT SEE A7 (OR A11) SCHEMATIC AND PARAGRAPH 5-77

DO LOGIC LEVELS AGREE WITH SWITCH SETTINGS?

YES

REPLACE OR REPAIR AC CONVERTER ASSEMBLY. SEE PARAGRAPH 5-74.

NO

MEASURE LOGIC LEVELS OF RANGE AND FUNCTION SELECT SIGNALS TO CONNECTOR ASSEMBLY FOR DEFECTIVE RANGE AND/OR FUNCTION. < + 0.5 V = SELECT > + 2.4 V = NOT SELECT

DO LOGIC LEVELS AGREE WITH SWITCH SETTINGS?

YES

TROUBLESHOOT CONNECTOR ASSEMBLY CIRCUITS.

NO

TROUBLESHOOT FRONT PANEL SWITCHES AND MASTER BOARD CIRCUITS.

APPLY INPUTS OF FULL-RANGE, < 1/10 RANGE, AND 2 X FULL RANGE ON ALL RANGES AND OBSERVE UP AND DOWN RANGE INDICATORS.

ARE ↑ RNG AND RNG ↓ INDICATIONS CORRECT?

YES

NO

TROUBLESHOOT OUT-OF-RANGE DETECTORS ON CONNECTOR ASSEMBLY A7 (A11) AND UP/DOWN RANGE INDICATOR LOGIC ON MASTER BOARD A4.

TROUBLESHOOT DIGITAL PANEL METER. SEE TROUBLESHOOTING TREE, FIGURE 5-7.

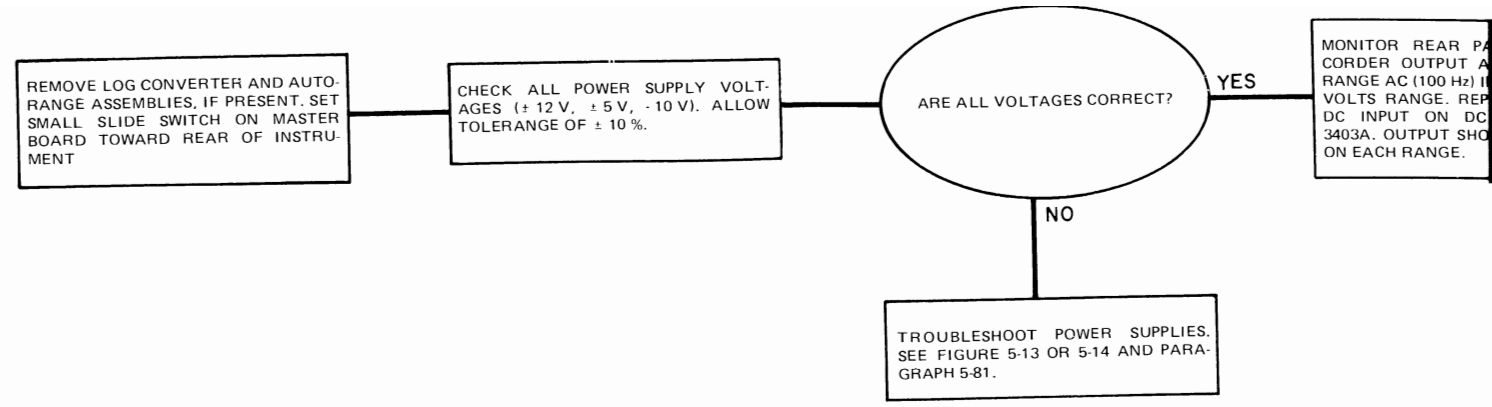
NOTES

CCESS FOR SERVICING MAY BE GAINED AS
WN IN FIGURE 5-5

DC DIGITAL VOLTMETER AND AN AC CALI-
TOR ARE REQUIRED FOR THESE CHECKS.

403A-D-3203

Figure 5-6. Basic Troubleshooting Tree.
Rev. A 5-21/5-22



NOTES

1 ACCESS FOR SERVICING MAY BE GAINED AS SHOWN IN FIGURE 5-5.

2. A DC DIGITAL VOLTMETER AND AN AC CALI-BRATOR ARE REQUIRED FOR THESE CHECKS.

3403A-D-3203

PERFORMANCE CHECK CARD

Hewlett-Packard Model 3403C
True RMS Voltmeter
Serial Number _____

Tests Performed by _____

Date _____

Paragraph	Description			Reading	Test Limits	
5-8	Mid-Band Frequencies					
	Range	Input	Frequency		Min.	Max.
	.01 V	10 mV	100 Hz	_____	9.95	10.05
	.01 V	10 mV	100 kHz	_____	9.95	10.05
	.1 V	20 mV	100 kHz	_____	19.6	20.4
	.1 V	100 mV	1 kHz	_____	99.6	100.4
	1 V	0.5 V	200 Hz	_____	.497	.503
	1 V	1 V	20 kHz	_____	.996	1.004
	10 V	10 V	100 kHz	_____	9.96	10.04
	10 V	15 V	100 Hz	_____	14.95	15.05
	100 V	20 V	50 Hz	_____	19.8	20.2
	100 V	100 V	50 kHz	_____	99.6	100.4
	100 V	100 V	*20 Hz	_____	99.4	100.6
	1 V	1 V	*10 Hz	_____	.994	1.006
	.1 V	100 mV	*20 Hz	_____	99.0	101.0
	1000 V	1000 V	100 Hz	_____	995	1005
	1000 V	1000 V	10 kHz	_____	995	1005

* Slow response time.

PERFORMANCE CHECK CARD (Cont'd)

Paragraph	Description			Reading	Test Limits	
5-10	100 kHz to 10 MHz					
	Range	Input	Frequency		Min.	Max.
	.1 V	100 mV	1 MHz	_____	97.8	102.2
	.1 V	100 mV	10 MHz	_____	97.8	102.2
	1 V	1 V	2 MHz	_____	.988	1.012
	1 V	1 V	8 MHz	_____	.988	1.012
	10 V	3 V	500 kHz	_____	2.96	3.04
	10 V	3 V	5 MHz	_____	2.95	3.05
	10 V	10 V	1 MHz	_____	9.88	10.12
	10 V	10 V	5 MHz	_____	9.88	10.12
	100 V	100 V	500 kHz	_____	98.8	101.2
	100 V	100 V	1 MHz	_____	98.8	101.2
5-12	10 MHz to 100 MHz					
	.1 V	100 mV	20 MHz	_____	97.8	102.2
	.1 V	100 mV	40 MHz	_____	94.8	105.2
	.1 V	100 mV	100 MHz	_____	89.8	110.2
	1 V	1 V	20 MHz	_____	.978	1.022
	1 V	1 V	40 MHz	_____	.948	1.052
	1 V	1 V	100 MHz	_____	.898	1.102
5-16	Low Frequency					
	1 V	1 V	5 Hz	_____	.994	1.006
5-18	dB Accuracy (Optional)					
	Range	Input		Reading	Min.	Max.
	1 V	0.31620 V		_____	- 09.8	- 10.2
	.1 V	0.10000 V		_____	- 19.8	- 20.2
	.01 V	0.01000 V		_____	- 39.8	- 40.2
	10 V	10.0000 V		_____	+ 19.8	+ 20.2
	10 V	15.0000 V		_____	+ 23.3	+ 23.7
	100 V	100.000 V		_____	+ 39.8	+ 40.2
	1000 V	1000.00 V		_____	+ 59.8	+ 60.2

PERFORMANCE CHECK CARD (Cont'd)

Paragraph	Description		Reading		Test Limits	
5-20	DC Voltage Accuracy					
	Range	Input	Pos.	Neg.	Min.	Max.
	.1 V	± .100000 V	_____	_____	99.2	100.8
	.1 V	± .070000 V	_____	_____	69.2	70.8
	.1 V	± .040000 V	_____	_____	39.3	40.7
	.1 V	± .010000 V	_____	_____	09.3	10.7
	1 V	± 0.10000 V	_____	_____	.097	.103
	1 V	± 0.50000 V	_____	_____	.496	.504
	1 V	± 1.00000 V	_____	_____	.996	1.004
	10 V	± 1.00000 V	_____	_____	0.97	1.03
	10 V	± 5.00000 V	_____	_____	4.96	5.04
	10 V	± 10.0000 V	_____	_____	9.96	10.04
	100 V	± 10.0000 V	_____	_____	09.7	10.3
	100 V	± 50.0000 V	_____	_____	49.6	50.4
	100 V	± 100.000 V	_____	_____	99.6	100.4
	1000 V	± 100.000 V	_____	_____	096	104
	1000 V	± 500.000 V	_____	_____	495	505
	1000 V	+ 1000.00 V	_____	_____	995	1005
5-22	AC Normal-Mode Rejection		_____		± 0.02 V	
5-24	AC Common-Mode Rejection		_____		100.0 mV	
5-29	Digital Output Check (Optional)					
	Column 1, Data Multiplier			_____		
	Columns 2 - 5, Data			_____		
	Column 6, Polarity, OL, Underrange			_____		
	Column 7, Function			_____		
5-31	Remote Control Check (Optional)					
	Range			_____		
	Function			_____		
	Response Time			_____		
	Delayed Mode			_____		
	Non-delayed Mode			_____		
	Autorange			_____		

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alphameric order of their reference designators and indicates the description, -hp- Part Number of each part, together with any applicable notes, and provides the following:

a. Total quantity used in the instrument (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 below.)

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

d. Manufacturers part number.

6-3. Miscellaneous parts are listed at the end of Table 6-1.

6-4. ORDERING INFORMATION.

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

6-6. NON-LISTED PARTS.

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

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

6-8. PROPRIETARY PARTS.

6-9. Items marked by a dagger (†) in the reference designator column are available only for repair and service of Hewlett-Packard instruments.

ABBREVIATIONS

Ag . . . . . silver
Al . . . . . aluminum
A . . . . . ampere(s)
Au . . . . . gold

C . . . . . capacitor
cer . . . . . ceramic
coef . . . . . coefficient
com . . . . . common
comp . . . . . composition
conn . . . . . connection

dep . . . . . deposited
DPDT . . . . . double-pole double-throw
DPST . . . . . double-pole single-throw

elect . . . . . electrolytic
encap . . . . . encapsulated

F . . . . . farad(s)
FET . . . . . field effect transistor
fxd . . . . . fixed

GaAs . . . . . gallium arsenide
GHz . . . . . gigahertz = 10^{+9} hertz
gd . . . . . guard(ed)
Ge . . . . . germanium
gnd . . . . . ground(ed)

H . . . . . henry(ies)
Hg . . . . . mercury

Hz . . . . . hertz (cycle(s) per second)

ID . . . . . inside diameter
impg . . . . . impregnated
incd . . . . . incandescent
ins . . . . . insulation(ed)

kΩ . . . . . kilohm(s) = 10^{+3} ohms
kHz . . . . . kilohertz = 10^{+3} hertz

L . . . . . inductor
lin . . . . . linear taper
log . . . . . logarithmic taper

mA . . . . . milliampere(s) = 10^{-3} amperes
MHz . . . . . megahertz = 10^{+6} hertz
MΩ . . . . . megohm(s) - 10^{+6} ohms
met flm . . . . . metal film
mfr . . . . . manufacturer
ms . . . . . millisecond
mtg . . . . . mounting
mV . . . . . millivolt(s) = 10^{-3} volts
μF . . . . . microfarad(s)
μs . . . . . microsecond(s)
μV . . . . . microvolt(s) = 10^{-6} volts
my . . . . . Mylar(R)

nA . . . . . nanoampere(s) = 10^{-9} amperes
NC . . . . . normally closed
Ne . . . . . neon
NO . . . . . normally open

NPO . . . . . negative positive zero (zero temperature coefficient)
ns . . . . . nanosecond(s) = 10^{-9} seconds
nsr . . . . . not separately replaceable

Ω . . . . . ohm(s)
obd . . . . . order by description
OD . . . . . outside diameter

p . . . . . peak
pA . . . . . picoampere(s)
pc . . . . . printed circuit
pF . . . . . picofarad(s) 10^{-12} farads
piv . . . . . peak inverse voltage
p/o . . . . . part of
pos . . . . . position(s)
poly . . . . . polystyrene
pot . . . . . potentiometer
p-p . . . . . peak-to-peak
ppm . . . . . parts per million
prec . . . . . precision (temperature coeffient, long term stability and/or tolerance)

R . . . . . resistor
Rh . . . . . rhodium
rms . . . . . root-mean-square
rot . . . . . rotary

Se . . . . . selenium
sect . . . . . section(s)
Si . . . . . silicon
sl . . . . . slide
SPDT . . . . . single-pole double-throw
SPST . . . . . single-pole single-throw

Ta . . . . . tantalum
TC . . . . . temperature coefficient
TiO_2 . . . . . titanium dioxide
tog . . . . . toggle
tol . . . . . tolerance
trim . . . . . trimmer
TSTR . . . . . transistor

V . . . . . volt(s)
vacw . . . . . alternating current working voltage
var . . . . . variable
vdcw . . . . . direct current working voltage

W . . . . . watt(s)
w/ . . . . . with
wiv . . . . . working inverse voltage
w/o . . . . . without
ww . . . . . wirewound

* . . . . . optimum value selected at factory, average value shown (part may be omitted)
** . . . . . no standard type number assigned selected or special type

(R) Dupont de Nemours

DECIMAL MULTIPLIERS

Prefix	Symbols	Multiplier	Prefix	Symbols	Multiplier
tera	T	10^{12}	centi	c	10^{-2}
giga	G	10^{9}	milli	m	10^{-3}
mega	M or Meg	10^{6}	micro	μ	10^{-6}
kilo	K or k	10^{3}	nano	n	10^{-9}
hecto	h	10^{2}	pico	p	10^{-12}
deka	da	10	femto	f	10^{-15}
deci	d	10^{-1}	atto	a	10^{-18}

STD-B-2734

DESIGNATORS

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

Table 6-1. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
†A1	03403-60001	1	AC CONVERTER ASSY	28480	03403-60001
†A1	03403-69501	1	REBUILT AC CONVERTER(Includes A2&A3 PC Assemblies)	28480	03403-69501
A1J1	1250-0047	1	CONNECTOR:RF BULKHEAD JACK	95712	12682-1
A1MP1	03403-22004	1	BOX:CONVERTER	28480	03403-22004
A1MP2	03403-22003	1	LID:CONVERTER BOX	28480	03403-22003
A1MP3	03403-00603	1	SHIELD:ATTENUATOR	28480	03403-00603
A1MP4	03403-09101	1	SPRING:LEAF	28480	03403-09101
A1MP5	0340-0740	1	INSULATOR	13103	OBD#
A1MP6	0905-0429	1	SEAL:"O" RING 0.364" ID	83259	2-012N219-7
A1MP7	0905-0435	1	SEAL:"O" RING 1.487" ID	83259	2-128N219-7
A1MP8	0905-0431	1	SEAL:"O" RING 5.987" ID	83259	2-163N219-7
A1S6	3102-0006	1	SWITCH: SENSITIVE SPDT PIN PLUNGER	91929	22SM261
		2			
†A2	03403-66530		ASSY:AMPLIFIER	28480	03403-66530
A2C1	0121-0168	2	C:VAR TEFLON 0.25-1.50 PF 600VDCW	28480	0121-0168
A2C2	0160-3841	1	C:FXD PORC 3.9+/-0.25 PF 1000WVAC	95275	VY13C3R9C
A2C3	0160-3842	1	C:FXD PORC 3.3+/-0.25 PF 1000WVAC	95275	VY10CA3R3CA
A2C4	0160-3662	1	C:FXD POLY 0.056 UF 10% 600VDCW	28480	0160-3662
A2C5	0160-3846	1	C:FXD MICA 39+/-0.5 PF 100VDCW	00853	RDM10E390DIS
A2C6	0160-3845	1	C:FXD MICA 22+/-0.5 PF 100VDCW	00853	RDM10E220DIS
A2C7	0121-0451	1	C:VAR TRIMMER 1.7-11.0 PF 250VDC	74970	187-0160-005
A2C8	0160-3844	1	C:FXD MICA 170 PF 1% 100VDCW	00853	RDM15E171FIS
A2C9*	0160-0196		C:FXD MICA 24 PF 300 V	28480	0160-0196
A2C10	0121-0114	1	C:VAR CER 7-25 PF	28480	0121-0114
A2C11	0160-3843	1	C:FXD MICA 560 PF 1% 100VDCW	00853	RDM15E561FIS
A2C12	0160-3840	1	C:FXD MICA 7800 PF 1% 100VDCW	00853	RDM19E782FIS
A2C13	0160-3851	1	C:FXD POLY 0.085 UF 1.0% 50VDCW	28480	0160-3851
A2C14	0121-0168		C:VAR TEFLON 0.25-1.50 PF 600VDCW	28480	0121-0168
A2C15	0160-3501	1	C:FXD POLY 4 UF 10% 50VDCW	84411	HEW 138
A2C16	0160-3686	1	C:FXD POLY 0.27 UF 10% 50VDCW	28480	0160-3686
A2C17	0180-1835	2	C:FXD TA 68 UF 20% 15VDCW	56289	150D686X0015R2-DYS
A2C18	0180-1835		C:FXD TA 68 UF 20% 15VDCW	56289	150D686X0015R2-DYS
A2C19	0160-3830	1	C:FXD POLY 5.0 UF 10% 50VDCW	28480	0160-3830
A2C20	0160-3829	2	C:FXD POLY 0.47 UF 10% 50VDCW	28480	0160-3829
A2C21	0160-3787	1	C:FXD POLY 1.0 UF 10% 50VDCW	28480	0160-3787
A2C22	0160-0300	1	C:FXD MY 0.0027 UF 200VDCW	56289	192P27292-PTS
A2C23	0140-0198	1	C:FXD MICA 200 PF 5%	72136	RDM15F201J3C
A2C24	0150-0084	1	C:FXD CER 0.1 UF +80-20% 100VDCW	72982	8131-100-651-104Z
A2C25	0150-0050	6	C:FXD CER 1000 PF +80-20% 1000VDCW	56289	C0678102E102ZS26-CDH
A2C26*	0150-0046	1	C:FXD TI DIOX 0.68 PF 5% 500VDCW	78488	TYPE GA
Δ A2CR1	0960-0173		MATCHED TO A2IC1 AND A2R4	28480	0960-0173
A2CR2	1902-3002	1	DIODE BREAKDOWN:2.37V 5%	28480	1902-3002
A2CR3	1901-0053	14	DIODE:SILICON 30VDCW	07263	FD3444
A2CR4	1901-0053		DIODE:SILICON 30VDCW	07263	FD3444
A2CR5	1901-0053		DIODE:SILICON 30VDCW	07263	FD3444
A2CR6	1902-3226	1	DIODE BREAKDOWN:18.2V 2%	28480	1902-3226
A2CR7	1901-0053		DIODE:SILICON 30VDCW	07263	FD3444
Δ† A2IC1	0960-0173	1	IC: HYBRID AMPLIFIER(Includes A2CR1 & A2R4)	28480	0960-0173
A2IC2	1820-0203	2	IC:OPERATIONAL AMPLIFIER	07263	SL8940
A2IC3	1820-0203		IC:OPERATIONAL AMPLIFIER	07263	SL8940
† A2IC4	1826-0052	1	IC:LINEAR HYBRID AMP	28480	1826-0052
A2K1	0490-0969	1	RELAY:REED	28480	0490-0969
A2K3	0490-0978	2	RELAY:REED	28480	0490-0978
A2K4	0490-0978		RELAY:REED	28480	0490-0978
A2K5	0490-0968	5	RELAY:REED	28480	0490-0968
A2K6	0490-0968		RELAY:REED	28480	0490-0968
A2K7	0490-0968		RELAY:REED	28480	0490-0968
A2MP1	0340-0060	2	FEEDTHRU:INSULATED MOUNTING	28480	0340-0060
A2MP2	0340-0128	1	TERMINAL: STANDOFF	28480	0340-0128
A2MP3	1200-0423	1	SOCKET:IC BLK 16 CONTACT	23880	CSA2900-168
A2MP4	1200-0508		SOCKET:IC BLK 14 CONTACT	02194	KN-143-53H
A2MP5	1200-0432	14	SOCKET-CONTACT-DIP	27264	1938-4
A2Q1	1855-0368	12	TSTR:FET SI NPN N-CHANNEL	28480	1855-0368
A2Q2	1855-0082	1	TSTR:SI FET P-CHANNEL	28480	1855-0082
A2Q3	1855-0368		TSTR:FET SI NPN N-CHANNEL	28480	1855-0368
A2Q4	1854-0071	15	TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A2Q5	1853-0020	21	TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A2Q6	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A2Q7	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A2R1	0757-0280	6	R:FXD MET FLM 1K OHM 1% 1/8W	28480	0757-0280
A2R2	0757-0280		R:FXD MET FLM 1K OHM 1% 1/8W	28480	0757-0280
A2R3	0698-7950	1	RESISTOR SET	28480	0698-7950
Δ A2R4	0960-0173		MATCHED TO A2IC1 AND A2CR1	28480	0960-0173
A2R5	2100-1984	1	R:VAR FLM 100 OHM 10% LIN 1/2W	28480	2100-1984

See introduction to this section for ordering information

Table 6-1. Replaceable Parts(Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A2R6	0698-7521	1	R:FXD FLM 5.11 OHM 5% 1/4W	28480	0698-7521
A2R7	2100-1985	1	R:VAR CERMET 20 OHM 20% LIN 1/2W	28480	2100-1985
A2R8	0698-7985	1	R:FXD FLM 2 OHM 5% 1/4W	28480	0698-7985
A2R9	2100-1986	1	R:VAR CERMET 1000 OHM 10% LIN 1/2W	28480	2100-1986
A2R10	1810-0056	1	R:NETWORK 6 (4)=50K(2)= 5K OHM	28480	1810-0056
A2R11	2100-2497	3	R:VAR FLM 2000 OHM 10% LIN 1/2W	28480	2100-2497
A2R12	0684-1001	7	R:FXD COMP 10 OHM 10% 1/4W	01121	CB 1001
A2R13	1810-0060	1	R:NETWORK 4(2)=1K(1)=5K(1)=620 OHM	28480	1810-0060
A2R14	0684-1001		R:FXD COMP 10 OHM 10% 1/4W	01121	CB 1001
A2R15	0684-1031	47	R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A2R16	0684-2241	1	R:FXD COMP 220K OHM 10% 1/4W	01121	CB 2241
A2R17	1810-0057	1	R:NETWORK 4(2)=2.6(1)=26(1)=24K OHM	28480	1810-0057
A2R18	2100-1738	6	R:VAR FLM 10K OHM 10% LIN 1/2W	28480	2100-1738
A2R19	1810-0053	1	R:PACK 5=36/30/47/130/200K OHM 5%	28480	1810-0053
A2R20	0698-3572	1	R:FXD FLM 60.4K OHM 1% 1/8W	28480	0698-3572
A2R21	0757-0466	1	R:FXD MET FLM 110K OHM 1% 1/8W	28480	0757-0466
A2R22	0811-2960	2	R:FXD WW 650K OHM 1.0% 1/5W	28480	0811-2960
A2R23	0811-2960		R:FXD WW 650K OHM 1.0% 1/5W	28480	0811-2960
A2R24	0698-7653	1	R:FXD FLM 25.5K OHM 1.0% 1/8W	28480	0698-7653
A2R25	0757-0446	1	R:FXD MET FLM 15.0K OHM 1% 1/8W	28480	0757-0446
A2R26	0698-4202	1	R:FXD FLM 8.87K OHM 1% 1/8W	28480	0698-4202
A2R27	2100-1738		R:VAR FLM 10K OHM 10% LIN 1/2W	28480	2100-1738
A2R28	1810-0059	1	R:NETWORK 4=2K/500/1K/4K OHM	28480	1810-0059
A2R29	0757-0346	3	R:FXD MET FLM 10 OHM 1% 1/8W	28480	0757-0346
A2R30	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A2R31	0757-0442	6	R:FXD MET FLM 10.0K OHM 1% 1/8W	28480	0757-0442
A2R32	2100-1738		R:VAR FLM 10K OHM 10% LIN 1/2W	28480	2100-1738
A2R33	0757-0346		R:FXD MET FLM 10 OHM 1% 1/8W	28480	0757-0346
A2R34	0698-3433	1	R:FXD MET FLM 28.7 OHM 1% 1/8W	28480	0698-3433
A2R41	0757-0420	1	R:FXD MET FLM 750 OHM 1% 1/8W	28480	0757-0420
A2R42	0684-1041	2	R:FXD COMP 100K OHM 10% 1/4W	01121	CB 1041
A2R71	2100-1788	1	R:VAR FLM 500 OHM 10% LIN 1/2W	04568	62-205-1
†A2TC1	0853-0014	1	THERMOCOUPLE	28480	0853-0014
A3	03403-66540	1	ASSY:FILTER	28480	03403-66540
A3C1	0180-0116	1	C:FXD ELECT 6.8 UF 10% 35VDCW	56289	150D685X9035B2-DYS
A3C2	0180-1794	1	C:FXD ELECT 22 UF 10% 35VDCW	56289	150D226X9035R2-DYS
A3C3	0160-3563	2	C:FXD POLY 10 UF 5% 500VDCW	84411	HEW 138
A3C4	0160-3402	2	C:FXD POLY 1.0 UF 5% 50VDCW	84411	HEW 138
A3C5	0150-0093	1	C:FXD CER 0.01 UF +80-20% 100VDCW	72982	801-K800011
A3C6	0160-3563		C:FXD POLY 10 UF 5% 500VDCW	84411	HEW 138
A3C7	0160-3402		C:FXD POLY 1.0 UF 5% 50VDCW	84411	HEW 138
A3CR1	1901-0040	41	DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR2	1901-0045	1	DIODE:SILICON 0.75A 100PIV	04713	SR1358-7
A3CR3	1901-0053		DIODE:SILICON 30VDCW	07263	FD3444
A3CR4	1901-0053		DIODE:SILICON 30VDCW	07263	FD3444
A3CR5	1901-0053		DIODE:SILICON 30VDCW	07263	FD3444
A3CR6	1901-0053		DIODE:SILICON 30VDCW	07263	FD3444
A3CR7	1901-0053		DIODE:SILICON 30VDCW	07263	FD3444
A3CR8	1901-0053		DIODE:SILICON 30VDCW	07263	FD3444
A3CR9	1901-0053		DIODE:SILICON 30VDCW	07263	FD3444
A3CR10	1901-0053		DIODE:SILICON 30VDCW	07263	FD3444
A3CR11	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR12	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR13	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR14	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR15	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR16	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR17	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR18	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR19	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR20	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR21	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR22	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR23	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR24	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR25	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR26	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR27	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR28	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR29	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3CR30	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A3IC1	1826-0018	1	IC:LINEAR OPERATIONAL AMPLIFIER	28480	1826-0018
A3J10	1251-1626	1	CONNECTOR:PC (2 X 12) 24 CONTACT	71785	252-12-30-300

See introduction to this section for ordering information

Table 6-1. Replaceable Parts(Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A3K8	0490-0968		RELAY:REED	28480	0490-0968
A3K9	0490-0968		RELAY:REED	28480	0490-0968
A3Q1	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A3Q2	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A3Q3	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A3Q4	1855-0368		TSTR:FET SI NPN N-CHANNEL	28480	1855-0368
A3Q5	1855-0368		TSTR:FET SI NPN N-CHANNEL	28480	1855-0368
A3Q6	1855-0368		TSTR:FET SI NPN N-CHANNEL	28480	1855-0368
A3Q7	1855-0368		TSTR:FET SI NPN N-CHANNEL	28480	1855-0368
A3Q8	1855-0368		TSTR:FET SI NPN N-CHANNEL	28480	1855-0368
A3Q9	1855-0368		TSTR:FET SI NPN N-CHANNEL	28480	1855-0368
A3Q10	1855-0368		TSTR:FET SI NPN N-CHANNEL	28480	1855-0368
A3Q11	1855-0368		TSTR:FET SI NPN N-CHANNEL	28480	1855-0368
A3Q12	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A3Q13	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A3Q14	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A3Q15	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A3Q16	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A3Q17	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A3Q18	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A3Q19	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A3Q20	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A3R1	1810-0054	1	R:PACK 4= 5/10/10/10K OHM 10%	28480	1810-0054
A3R2	0698-4195	1	R:FXD MET FLM 1.02K OHM 1% 1/8W	28480	0698-4195
A3R3	2100-3154	3	R:VAR CERMET 1000 OHM 10% TYPE P 3/4W	28480	2100-3154
A3R4	1810-0058	1	R:NETWORK 5 (2)=15(2)=47(1)=4.7K OHM	28480	1810-0058
A3R5	1810-0079	1	R:NETWORK	28480	1810-0079
A3R6	0684-1011	2	R:FXD COMP 100 OHM 10% 1/4W	01121	CB 1011
A3R7	0684-1011		R:FXD COMP 100 OHM 10% 1/4W	01121	CB 1011
A3R8	2100-1738		R:VAR FLM 10K OHM 10% LIN 1/2W	28480	2100-1738
A3R9	0757-0442		R:FXD MET FLM 10.0K OHM 1% 1/8W	28480	0757-0442
A3R10	2100-3056	6	R:VAR CERMET 5K OHM 10% TYPE P 3/4W	28480	2100-3056
A3R11	2100-3056		R:VAR CERMET 5K OHM 10% TYPE P 3/4W	28480	2100-3056
A3R12	2100-3056		R:VAR CERMET 5K OHM 10% TYPE P 3/4W	28480	2100-3056
A3R13	2100-3056		R:VAR CERMET 5K OHM 10% TYPE P 3/4W	28480	2100-3056
A3R14	2100-3056		R:VAR CERMET 5K OHM 10% TYPE P 3/4W	28480	2100-3056
A3R15	2100-3056		R:VAR CERMET 5K OHM 10% TYPE P 3/4W	28480	2100-3056
A3R16	1810-0062	1	R:NETWORK 4=355/342/159/671 OHM 1.0%	28480	1810-0062
A3R17	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R18	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R19	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R20	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R21	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R22	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R23	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R24	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R25	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R26	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R27	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R28	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R29	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R30	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R31	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R32	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R33	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R34	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A3R35	0684-2231	8	R:FXD COMP 22K OHM 10% 1/4W	01121	CB 2231
A3R36	0684-2231		R:FXD COMP 22K OHM 10% 1/4W	01121	CB 2231
A3R37	0684-2231		R:FXD COMP 22K OHM 10% 1/4W	01121	CB 2231
A3R38	0684-2231		R:FXD COMP 22K OHM 10% 1/4W	01121	CB 2231
A3R39	0684-2231		R:FXD COMP 22K OHM 10% 1/4W	01121	CB 2231
A3R40	0684-2231		R:FXD COMP 22K OHM 10% 1/4W	01121	CB 2231
A3R41	0684-2231		R:FXD COMP 22K OHM 10% 1/4W	01121	CB 2231
A3R42	0684-4731	6	R:FXD COMP 47K OHM 10% 1/4W	01121	CB 4731
A3R43	0757-0384	1	R:FXD FLM 20 OHM 1% 1/8W	28480	0757-0384
A3W1	8120-2490	4	CABLE ASSY	28480	8120-2490
A3W2	8120-2490		CABLE ASSY	28480	8120-2490
A4	03403-66517	1	ASSY:MASTER	28480	03403-66517
A4IC1	1820-0307	10	IC:DTL HEX INVERTER	04713	MC836P
A4IC2	1820-0511	3	IC:DGTL GATE	01295	SN7408N
A4IC3	1820-0307		IC:DTL HEX INVERTER	04713	MC836P
A4IC4	1820-0094	10	IC:DTL QUAD 2-INPUT GATE	04713	SC6903PK

See introduction to this section for ordering information

Table 6-1. Replaceable Parts(Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A4IC5	1820-0086	2	IC:DTL DUAL 4-INPUT GATE (EXPANDABLE)	04713	SC6900PK
A4IC6	1820-0310	5	IC:DTL TRIPLE 3-INPUT NAND GATE	04713	SC6910PK
A4IC7	1820-0511		IC:DTL GATE	01295	SN7408N
A4IC8	1820-0094		IC:DTL QUAD 2-INPUT GATE	04713	SC6903PK
A4IC9	1820-0307		IC:DTL HEX INVERTER	04713	MC836P
A4IC10	1820-0668	1	IC: TTL HEX BUFFER/DRIVER	28480	1820-0668
A4J4	1251-2825	1	CONNECTOR:50 PIN	28480	1251-2825
A4J5	1251-2026	2	CONNECTOR:PC 36 CONTACT	71785	252-18-30-300
A4J6	1251-2034	3	CONNECTOR:PC EDGE (2 X 10) 20 CONTACT	71785	252-10-30-300
A4J7	1251-2026		CONNECTOR:PC 36 CONTACT	71785	252-18-30-300
A4J8	1251-2034		CONNECTOR:PC EDGE (2 X 10) 20 CONTACT	71785	252-10-30-300
A4MP1	1200-0474	11	SOCKET:IC 14-PIN	28480	1200-0474
MJA	1200-0424		SOCKET:IC BLK 14 CONTACT	23880	CSA2900-14B
MJB	1200-0424		SOCKET:IC BLK 14 CONTACT	23880	CSA2900-14B
A4Q1 THRU 5	1853-0086	5	TSTR: SI PNP 2N5087	28480	1853-0086
A4R1	0684-1001		R:FXD COMP 10 OHM 10% 1/4W	01121	CB 1001
A4R2	0684-1001		R:FXD COMP 10 OHM 10% 1/4W	01121	CB 1001
A4R3	1810-0162	1	R:FXD PACKAGE 4.7 K OHM 2%	28480	1810-0162
A4R17	0683-1215	5	R:FXD 120OHM 5%	01607	CB1215
A4R18	0698-4412	4	R:FXD 143OHM 1%	03292	C4-1/8-T0-143R-F
A4R19-22	0683-1215		R:FXD 120OHM 5%	01607	CB1215
A4R23-25	0698-4412		R:FXD 143OHM 1%	03292	C4-1/8-T0-143R-F
A4S1	3101-0982	1	SWITCH:SLIDE SPST 0.5A 125V	79727	GF 124-0007
A4A1	03403-66513	1	ASSY:SWITCH	28480	03403-66513
A4A1MP1	3130-0392	3	SHAFT AND INDEX ASSY:30 DEGREE INDEX	28480	3130-0392
A4A1MP2	03403-04310	1	SWITCH PLATE:MOUNTING	28480	03403-04310
A4A1MP3	0380-0990	6	SPACER:0.375" LG	00000	OBD
A4A1MP4	0380-0991	6	SPACER:0.125" LG	00000	OBD
A4A1R3	2100-3282	1	R:VAR 25K OHM	28480	2100-3282
A4A1S1	3130-0395	1	SWITCH:WAFER	28480	3130-0395
A4A1S2	3130-0394	1	SWITCH:WAFER	28480	3130-0394
A4A1S3	3130-0393	1	SWITCH:WAFER	28480	3130-0393
A4A1W1	8120-1718		CABLE ASSY	28480	8120-1718
A4A1W2	8120-1718		CABLE ASSY	28480	8120-1718
A4A1R2	2100-3083		R:VAR 500 OHM	28480	2100-3083
	3130-1327	3	MOVABLE STOP	28480	3130-1327
A5	03403-66551	1	ASSY:RECTIFIER	28480	03403-66551
A5C9	0180-2428	1	C:FXD AL ELECT 250 UF +75-10% 25VDCW	56289	500D257G025EF7
A5C13	0180-2187	1	C:FXD ELECT 2500 UF +75-10% 15VDCW	56289	39D258G015GP4-DSB
A5CR1	1901-0638	1	DIODE ASSY:SI FULL WAVE BRIDGE	28480	1901-0638
A5CR2	1901-0363	3	DIODE ASSY:SI 100 PIV PER CELL	28480	1901-0363
A5CR3	1901-0363		DIODE ASSY:SI 100 PIV PER CELL	28480	1901-0363
A5CR4	1901-0363		DIODE ASSY:SI 100 PIV PER CELL	28480	1901-0363
A5MP1	1460-1269	1	SPRING:COMPRESSION, GROUND	00000	OBD
A5MP2	1600-0365	2	HEAT SINK	28480	1600-0365
A5Q1	1854-0402	2	TSTR:SI NPN	28480	1854-0402
A5Q2	1854-0402		TSTR:SI NPN	28480	1854-0402
A5Q4	1854-0072	1	TSTR:SI NPN 2N3054	28480	1854-0072
A6	03403-66561	1	ASSY:REGULATOR	28480	03403-66561
A6C1	0180-2506	2	C:FXD AL ELECT 470 UF +50-10% 40VDCW	73445	ET471X025A01
A6C2	0180-0049	4	C:FXD ELECT 20 UF +75-10% 50VDCW	56289	30D206G050CC2-DSM
A6C3	0160-0990	2	C:FXD MICA 100 PF 2% 300VDCW	00853	RDM15F101G3S
A6C5	0180-2506		C:FXD AL ELECT 470 UF +50-10% 40VDCW	73445	ET471X025A01
A6C6	0180-0049		C:FXD ELECT 20 UF +75-10% 50VDCW	56289	30D206G050CC2-DSM
A6C7	0160-0990		C:FXD MICA 100 PF 2% 300VDCW	00853	RDM15F101G3S
A6C10	0180-0049		C:FXD ELECT 20 UF +75-10% 50VDCW	56289	30D206G050CC2-DSM
A6C11	0160-0362	2	C:FXD MICA 510PF 5%	28480	0160-0362
A6C12	0180-0228	5	C:FXD ELECT 22 UF 10% 15VDCW	56289	150D226X9015B2-DYS
A6C14	0180-0049		C:FXD ELECT 20 UF +75-10% 50VDCW	56289	30D206G050CC2-DSM
A6C15	0160-0362		C:FXD MICA 510PF 5%	28480	0160-0362
A6C17	0180-0229	1	C:FXD ELECT 33 UF 10% 10VDCW	28480	0180-0229
A6CR1	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A6CR2	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A6CR3	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088

Table 6-1. Replaceable Parts(Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A6CR4	1901-0040		DIODE:SILICON 30WV	07263	FDG1088
A6CR7	1902-3074	1	DIODE BREAKDOWN:4.32V 2%	28480	1902-3074
A6CR8	1901-0522	1	DIODE:SI 100V PIV	28480	1901-0522
A6IC1	1820-0196	4	IC:LINEAR VOLTAGE REGULATOR(INPUT)	28480	1820-0196
A6IC2	1820-0196		IC:LINEAR VOLTAGE REGULATOR(INPUT)	28480	1820-0196
A6IC3	1820-0196		IC:LINEAR VOLTAGE REGULATOR(INPUT)	28480	1820-0196
A6IC4	1820-0196		IC:LINEAR VOLTAGE REGULATOR(INPUT)	28480	1820-0196
A6J12	1251-2034		CONNECTOR:PC EDGE (2 X 10) 20 CONTACT	71785	252-10-30-300
A6MP1	1205-0011	1	HEAT DISSIPATOR:FOR TO-5 AND TO-9 CASES	98978	TXBF-032-0258
A6Q3	1854-0039	1	TSTR:SI NPN	80131	2N3053
A6Q5	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A6R1	0813-0029	2	R:FXD WW 1 OHM 3% 3W	28480	0813-0029
A6R2	0757-0431	2	R:FXD MET FLM 2.43K OHM 1% 1/8W	28480	0757-0431
A6R3	0698-3496	2	R:FXD FLM 3.57K OHM 1% 1/8W	28480	0698-3496
A6R4	2100-2633	4	R:VAR CERMET 1K OHM 10% LIN 1/2W	28480	2100-2633
A6R5	0698-3382	2	R:FXD MET FLM 5.49K OHM 1% 1/8W	28480	0698-3382
A6R6	0813-0029		R:FXD WW 1 OHM 3% 3W	28480	0813-0029
A6R7	0757-0431		R:FXD MET FLM 2.43K OHM 1% 1/8W	28480	0757-0431
A6R8	0698-3496		R:FXD FLM 3.57K OHM 1% 1/8W	28480	0698-3496
A6R9	2100-2633		R:VAR CERMET 1K OHM 10% LIN 1/2W	28480	2100-2633
A6R10	0698-3382		R:FXD MET FLM 5.49K OHM 1% 1/8W	28480	0698-3382
A6R11	0683-0335	1	R:FXD COMP 3.3 OHM 5% 1/4W	01121	CB 0335
A6R12	0757-0283	3	R:FXD MET FLM 2.00K OHM 1% 1/8W	28480	0757-0283
A6R13	0698-4434	1	R:FXD FLM 2.32K OHM 1% 1/8W	28480	0698-4434
A6R14	2100-2633		R:VAR CERMET 1K OHM 10% LIN 1/2W	28480	2100-2633
A6R15	0698-3484	1	R:FXD FLM 6650 OHM 1% 1/8W	28480	0698-3484
A6R16	0698-5101	1	R:FXD COMP 33 OHM 10% 1/4W	01121	CB 3301
A6R17	0684-3311	1	R:FXD COMP 330 OHM 10% 1/4W	01121	CB 3311
A6R18	0684-1021	3	R:FXD COMP 1000 OHM 10% 1/4W	01121	CB 1021
A6R19	0812-0017	1	R:FXD WW 0.25 OHM 5% 3W	28480	0812-0017
A6R20	0698-4432	1	R:FXD FLM 2.1K OHM 1% 1/8W	28480	0698-4432
A6R21	0698-4435	1	R:FXD FLM 2.49K OHM 1% 1/8W	28480	0698-4435
A6R22	2100-2633		R:VAR CERMET 1K OHM 10% LIN 1/2W	28480	2100-2633
A6R23	0698-3226	1	R:FXD MET FLM 6.49K OHM 1% 1/8W	28480	0698-3226
A6R24	0684-4701	3	R:FXD COMP 47 OHM 10% 1/4W	01121	CB 4701
A6R25	0684-1001		R:FXD COMP 10 OHM 10% 1/4W	01121	CB 1001
A6R26	0684-1001		R:FXD COMP 10 OHM 10% 1/4W	01121	CB 1001
A6R27	0684-1001		R:FXD COMP 10 OHM 10% 1/4W	01121	CB 1001
A6R28	0812-0039	1	R:FXD WW 2.2 OHM 3% 3W	28480	0812-0039
A7	03403-66520	1	ASSY:CONNECTOR, STANDARD	28480	03403-66520
A7C1	0180-0228		C:FXD ELECT 22 UF 10% 15VDCW	56289	150D226X9015B2-DYS
A7C2	0180-0228		C:FXD ELECT 22 UF 10% 15VDCW	56289	150D226X9015B2-DYS
A7CR1	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A7CR2	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A7CR3	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A7CR4	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A7CR5	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A7CR6	1901-0376	2	DIODE:SILICON 35V	28480	1901-0376
A7CR7	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A7IC1	1826-0043	8	IC:LINEAR OPERATIONAL AMPLIFIER	28480	1826-0043
A7IC2	1826-0043		IC:LINEAR OPERATIONAL AMPLIFIER	28480	1826-0043
A7IC3	1826-0043		IC:LINEAR OPERATIONAL AMPLIFIER	28480	1826-0043
A7IC4	1820-0668	4	IC:TTL HEX DRIVER W/OPEN COLL(30V)	01295	SN7407N
A7IC5	1820-0668		IC:TTL HEX DRIVER W/OPEN COLL(30V)	01295	SN7407N
A7Q1	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A7Q2	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A7Q3	1855-0378	4	TSTR:FET SI N-CHANNEL	28480	1855-0378
A7Q4	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A7Q5	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A7Q6	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A7R1	2100-2522	6	R:VAR CERMET 10K OHM 10% LIN 1/2W	28480	2100-2522
A7R2	0757-0442		R:FXD MET FLM 10.0K OHM 1% 1/8W	28480	0757-0442
A7R3	0684-1831	4	R:FXD COMP 18K OHM 10% 1/4W	01121	CB 1831
A7R4	0684-4731		R:FXD COMP 47K OHM 10% 1/4W	01121	CB 4731
A7R5	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A7R6	0684-1831		R:FXD COMP 18K OHM 10% 1/4W	01121	CB 1831
A7R7	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A7R8	0757-0435	2	R:FXD FLM 3920 OHM 1% 1/8W	28480	0757-0435
A7R9	0698-4445	2	R:FXD FLM 5.76K OHM 1% 1/8W	28480	0698-4445
A7R10	0757-0282	2	R:FXD MET FLM 221 OHM 1% 1/8W	28480	0757-0282
A7R11	2100-2413	2	R:VAR FLM 200 OHM 10% LIN 1/2W	28480	2100-2413
A7R12	0757-0428	2	R:FXD MET FLM 1.62K OHM 1% 1/8W	28480	0757-0428
A7R13	2100-2520	2	R:VAR CERMET 50 OHM 20% TYPE V 1/2W	28480	2100-2520

See introduction to this section for ordering information

Table 6-1. Replaceable Parts(Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A7R14	0698-4411	2	R:FXD FLM 140 OHM 1% 1/8W	28480	0698-4411
A7R15	0684-4731		R:FXD COMP 47K OHM 10% 1/4W	01121	CB 4731
A7R16	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A7R17	0698-7394	4	R:FXD FLM 698 OHM 0.1% 1/8W	28480	0698-7394
A7R18	0698-7394		R:FXD FLM 698 OHM 0.1% 1/8W	28480	0698-7394
A7R19	0684-4731		R:FXD COMP 47K OHM 10% 1/4W	01121	CB 4731
A7R20	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A7R21	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A7R22	0684-1021		R:FXD COMP 1000 OHM 10% 1/4W	01121	CB 1021
A8	03403-61901	1	LINE SWITCH ASSY	28480	03403-61901
A8MP1	03403-04112	1	PLATE:SHIELD	28480	03403-04112
A8MP2	0340-0737	2	PLATE:INSULATOR	13103	08D0
A8MP3	1600-0226	1	PLATE:RETAINER	28480	1600-0226
A8MP4	1400-0830	1	CLAMP:CABLE 0.375" W 0.625" LG	79963	8139 MODIFIED
A8MP5	5040-5846	1	CAM:POWER SWITCH	28480	5040-5846
A8S7	3101-1304	1	SWITCH:SENSITIVE SPDT 5 AMP	91929	111 SMI-T
A12	03403-66592	1	LOG CONVERTER BOARD ASSY	28480	03403-66592
A12C1	0150-0093	3	C:FXD CER 0.01 UF +80-20% 100VDCW	72982	801-K800011
A12C2	0150-0093		C:FXD CER 0.01 UF +80-20% 100VDCW	72982	801-K800011
A12C3	0180-0374	2	C:FXD TANT. 10 UF 10% 20VDCW	56289	1500106X9020B2-DYS
A12C4	0180-0374		C:FXD TANT. 10 UF 10% 20VDCW	56289	1500106X9020B2-DYS
A12C5	0160-0181	1	C:FXD MICA 30PF 5% 300VDCW	14655	RDM15E300J3S
A12CR1	1901-0040	9	DIODE:SILICON 50 MA 30 WV	07263	FDG1088
A12CR2	1902-0777	1	DIODE:BREAKDOWN 6.2V 5%	04713	1N825
A12CR3	1901-0053	2	DIODE:SILICON 30VDCW	07263	FD3444
A12CR4	1901-0053		DIODE:SILICON 30VDCW	07263	FD3444
A12CR5	1901-0053		DIODE:SILICON 30 WV	07263	FD3444
A12CR6	1901-0053		DIODE:SILICON 30 WV	07263	FD3444
A12CR7	1901-0376	4	DIODE:SILICON 35V	28480	1901-0376
A12CR8	1901-0376		DIODE:SILICON 35V	28480	1901-0376
A12CR9	1901-0376		DIODE:SILICON 35V	28480	1901-0376
A12CR10	1901-0376		DIODE:SILICON 35V	28480	1901-0376
A12CR11	1902-3149	2	DIODE BREAKDOWN:9.09V 5%	28480	1902-3149
A12CR12	1901-0040		DIODE:SILICON 50 MA 30 WV	07263	FDG1088
A12CR13	1901-0040		DIODE:SILICON 50 MA 30 WV	07263	FDG1088
A12CR14	1901-0040		DIODE:SILICON 50 MA 30 WV	07263	FDG1088
A12IC1	1826-0111	4	IC	04713	MC1458C
A12IC2	1826-0054	1	IC:LINEAR	28480	1826-0054
A12IC3	1826-0111		IC	04713	MC1458C
A12IC4	1826-0111		IC	04713	MC1458C
A12IC5	1826-0066	1	IC:LIN. OP AMPL. 25K OHM	07263	U587777312
A12K1 THRU K3	0490-0778	3	RELAY, REED	28480	0490-0778
	1400-0760	18	CLIPS,RELAY (SETS OF 3 EACH)	28480	1400-0760
	0490-1033		RELAY/COIL, REED	28480	0490-1033
A12MP1	1200-0473	1	SOCKET:IC 16-PIN	28480	1200-0473
A12Q1	1853-0086	3	TSTR:SI PNP	80131	2N5087
A12Q2	1854-0071	14	TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A12Q3	1855-0368	5	TSTR:FET SI NPN N-CHANNEL	28480	1855-0368
A12Q4	1855-0368		TSTR:FET SI NPN N-CHANNEL	28480	1855-0368
A12Q5	1855-0368		TSTR:FET SI NPN N-CHANNEL	28480	1855-0368
A12Q6	1855-0368		TSTR:FET SI NPN N-CHANNEL	28480	1855-0368
A12Q7	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A12Q8	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A12Q11	1853-0086		TSTR:SI PNP	80131	2N5087
A12Q12	1855-0082	1	TSTR:SI FET P-CHANNEL	28480	1855-0082
A12Q13	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A12Q14	1855-0368		TSTR:FET SI NPN N-CHANNEL	28480	1855-0368
A12R1	0757-0280	1	R:FXD MET FLM 1K OHM 1% 1/8W	28480	0757-0280
A12R2	0698-3279	2	R:FXD MET FLM 4990 OHM 1% 1/8W	28480	0698-3279
A12R3	2100-2010	1	R:VAR FLM 10 OHM 20% LIN 1/2W	28480	2100-2010
A12R4	0757-0442	2	R:FXD MET FLM 10.0K OHM 1% 1/8W	28480	0757-0442
A12R5	0757-0274	1	R:FXD MET FLM 1.21K OHM 1% 1/8W	28480	0757-0274
A12R6	0757-0346	1	R:FXD MET FLM 10 OHM 1% 1/8W	28480	0757-0346
A12R7	0698-3279		R:FXD MET FLM 4990 OHM 1% 1/8W	28480	0698-3279
A12R8	2100-3274	2	R:VAR CER 10K OHM 10% LIN 1/2W	28480	2100-3274
A12R9	0757-0465	1	R:FXD MET FLM 100K OHM 1% 1/8W	28480	0757-0465
A12R10	0757-0417	2	R:FXD MET FLM 562 OHM 1% 1/8W	28480	0757-0417
A12R11	0698-4443	1	R:FXD FLM 4.53K OHM 1% 1/8W	28480	0698-4443
A12R12	0698-4433	1	R:FXD FLM 2260 OHM 1% 1/8W	28480	0698-4433

Table 6-1. Replaceable Parts(Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A12R13	2100-3354	1	R:VAR CERMET 50K OHM 10%	28480	2100-3354
A12R14	0698-4468	1	R:FXD FLM 1.13K OHM 1% 1/8W	28480	0698-4468
A12R15	0757-0448	1	R:FXD MET FLM 18.2K OHM 1% 1/8W	28480	0757-0448
A12R16	0698-8180	2	R:FXD FLM 4.22K OHM 0.1% 1/8W	28480	0698-8180
A12R17	0698-8180		R:FXD FLM 4.22K OHM 0.1% 1/8W	28480	0698-8180
A12R18	0757-0283	1	R:FXD MET FLM 2.00K OHM 1% 1/8W	28480	0757-0283
A12R19	2100-3154	2	R:VAR CERMET 1000 OHM 10% TYPE P 3/4W	28480	2100-3154
A12R20	0698-7934	2	R:FXD MET FLM 12.1K OHM 0.1% 1/8W	28480	0698-7934
A12R21	0757-0442		R:FXD MET FLM 10.0K OHM 1% 1/8W	28480	0757-0442
A12R22	0698-7934		R:FXD MET FLM 12.1K OHM 0.1% 1/8W	28480	0698-7934
A12R23	0757-0388	1	R:FXD FLM 30.1 OHM 1% 1/8W	28480	0757-0388
A12R24	0698-4442	2	R:FXD MET FLM 4.42K OHM 1% 1/8W	28480	0698-4442
A12R25	0698-4442		R:FXD MET FLM 4.42K OHM 1% 1/8W	28480	0698-4442
A12R26	0684-4711	2	R:FXD COMP 470 OHM 10% 1/4W	01121	CB 4711
A12R27	0684-1031	15	R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A12R28	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A12R29	2100-3274		R:VAR CER 10K OHM 10% LIN 1/2W	28480	2100-3274
A12R30	0684-2231	4	R:FXD COMP 22K OHM 10% 1/4W	01121	CB 2231
A12R31	0684-1041	1	R:FXD COMP 100K OHM 10% 1/4W	01121	CB 1041
A12R32	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A12R33	0684-4731	5	R:FXD COMP 47K OHM 10% 1/4W	01121	CB 4731
A12R34	0698-8060	3	R:FXD FLM 8.64K OHM 0.25% 1/8W	28480	0698-3193
A12R35	0698-8316	8	R:FXD FLM 49.9K OHM 1% 1/8W	28480	0698-8316
A12R36	0698-8316		R:FXD FLM 49.9K OHM 1% 1/8W	28480	0698-8316
A12R37	0698-8316		R:FXD FLM 49.9K OHM 1% 1/8W	28480	0698-8316
A12R38	2100-3154		R:VAR CERMET 1000 OHM 10% TYPE P 3/4W	28480	2100-3154
A12R39	0684-4731		R:FXD COMP 47K OHM 10% 1/4W	01121	CB 4731
A12R40	0684-4731		R:FXD COMP 47K OHM 10% 1/4W	01121	CB 4731
A12R41	0684-4731		R:FXD COMP 47K OHM 10% 1/4W	01121	CB 4731
A12R42	0684-4731		R:FXD COMP 47K OHM 10% 1/4W	01121	CB 4731
A12R43	0698-8421	1	R:FXD FLM 149.625K OHM .05%	28480	0698-8421
A12R44	0698-8422	1	R:FXD FLM 299.25K OHM .05%	28480	0698-8422
A12R45	0684-4721	5	R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A12R46	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A12R47	0684-1541	1	R:FXD COMP 150K OHM 10% 1/4W	01121	CB 1541
A12R48	0698-8316		R:FXD FLM 49.9K OHM 1% 1/8W	28480	0698-8316
A12R49	0698-4486	2	R:FXD MET FLM 24.9K OHM 1% 1/8W	28480	0698-4486
A12R50	0698-4481	1	R:FXD FLM 16.5 K OHM 1% 1/8W	28480	0698-4481
A12R51	0698-8316		R:FXD FLM 49.9K OHM 1% 1/8W	28480	0698-8316
A12R52	0698-3519	1	R:FXD FLM 12.4K OHM 1% 1/8W	28480	0698-3519
A12R53	0698-3122	1	R:FXD MET FLM 412 OHM .1% 1/8W	28480	0698-3122
A12R54	0684-4711		R:FXD COMP 470 OHM 10% 1/4W	01121	CB 4711
A12R55	0698-3193		R:FXD FLM 10K OHM 0.25% 1/8W	28480	0698-3193
A12R56	2100-3056	2	R:VAR CERMET 5K OHM 10% TYPE P 3/4W	28480	2100-3056
A12R57	0698-3193		R:FXD FLM 10K OHM 0.25% 1/8W	28480	0698-3193
A12R58	2100-3056		R:VAR CERMET 5K OHM 10% TYPE P 3/4W	28480	2100-3056
A12R59	0698-8316		R:FXD FLM 49.9K OHM 1% 1/8W	28480	0698-8316
A13	03403-66571	1	ASSY:AUTORANGE	28480	03403-66571
A13C1	0180-0309		C:FXD ELECT 4.7 UF 20% 10VDCW	56289	150D475X0010A2-DYS
A13C2	0160-2605	12	C:FXD CER 0.02 MFD +80-20% 25VDCW	72982	5835000-Y5U 203Z
A13C3	0160-2605		C:FXD CER 0.02 MFD +80-20% 25VDCW	72982	5835000-Y5U 203Z
A13C4	0180-1715	2	C:FXD TA-ELECT 150 UF 10% 6VDCW	56289	150D157X9006R2-DYS
A13C5	0150-0073	4	C:FXD CER 100 PF 10% 1000VDCW	56289	C0288102E101KS27-COH
A13CR1	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A13IC1	1820-0207	2	IC:TTL MONOSTABLE MULTIVIBRATOR	28480	1820-0207
A13IC2	1820-0310		IC:DTL TRIPLE 3-INPUT NAND GATE	04713	SC6910PK
A13IC3	1820-0307		IC:DTL HEX INVERTER	04713	MC836P
A13IC4	1820-0094		IC:DTL QUAD 2-INPUT GATE	04713	SC6903PK
A13IC5	1820-0491	2	IC:TTL BCD/DEC. DECODER/DRIVER	01295	SN74145N
A13IC6	1820-0546	2	IC:DIGITAL TTL SYNC 4-BIT BCD	28480	1820-0546
A13Q1	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A13Q2	1855-0378		TSTR:FET SI N-CHANNEL	28480	1855-0378
A13Q3	1854-0392	2	TSTR:SI NPN	80131	2N5088
A13R1	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A13R2	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A13R3	0698-4529	2	R:FXD FLM 226K OHM 1% 1/8W	28480	0698-4529
A13R4	0698-4486	2	R:FXD MET FLM 24.9K OHM 1% 1/8W	28480	0698-4486
A13R5	0684-2731	2	R:FXD COMP 27K OHM 10% 1/4W	01121	CB 2731
A13R6	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031

FOR A14, SEE THE END OF THIS SECTION.

Table 6-1. Replaceable Parts(Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A14	03403-66572	1	ASSY:REMOTE AND AUTORANGE	28480	03403-66572
A14C1	0180-0309		C:FXD ELECT 4.7 UF 20% 10VDCW	56289	1500475X0010A2-DYS
A14C2	0160-2605		C:FXD CER 0.02 MFD +80-20% 25VDCW	72982	5835000-Y5U 203Z
A14C3	0160-2605		C:FXD CER 0.02 MFD +80-20% 25VDCW	72982	5835000-Y5U 203Z
A14C4	0160-2605		C:FXD CER 0.02 MFD +80-20% 25VDCW	72982	5835000-Y5U 203Z
A14C5	0160-2605		C:FXD CER 0.02 MFD +80-20% 25VDCW	72982	5835000-Y5U 203Z
A14C6	0150-0073		C:FXD CER 100 PF 10% 1000VDCW	56289	C0288102E101KS27-CDH
A14C7	0150-0050		C:FXD CER 1000 PF +80-20% 1000VDCW	56289	C067B102E102ZS26-CDH
A14C8	0160-2605		C:FXD CER 0.02 MFD +80-20% 25VDCW	72982	5835000-Y5U 203Z
A14C9	0180-0195	2	C:FXD ELECT 0.33 UF 20% 35VDCW	56289	1500334X0035A2-DYS
A14C10	0160-3486	1	C:FXD CER 0.47UF -20+80% 50VDCW	72982	8131-050-651-474Z
A14C11	0150-0050		C:FXD CER 1000 PF +80-20% 1000VDCW	56289	C067B102E102ZS26-CDH
A14C12	0160-2605		C:FXD CER 0.02 MFD +80-20% 25VDCW	72982	5835000-Y5U 203Z
A14C13	0180-1715		C:FXD TA-ELECT 150 UF 10% 6VDCW	56289	1500157X9006R2-DYS
A14C14	0160-2964		C:FXD CER .01 MFD +80-20% 25VDCW	72982	5835000-Y5U 203Z
A14C15	0150-0073		C:FXD CER 100 PF 10% 1000VDCW	56289	C0288102E101KS27-CDH
A14C16	0150-0050		C:FXD CER 1000 PF +80-20% 1000VDCW	56289	C067B102E102ZS26-CDH
A14CR1	1901-0040		DIODE:SILICON .05A 30WV	07263	FDG1088
A14CR2	1910-0016	4	DIODE:GERMANIUM 100MA/0.85V 60PIV	93332	D2361
A14IC1	1820-0307		IC:DTL HEX INVERTER	04713	MC836P
A14IC2	1820-0310		IC:DTL TRIPLE 3-INPUT NAND GATE	04713	SC6910PK
A14IC3	1820-0094		IC:DTL QUAD 2-INPUT GATE	04713	SC6903PK
A14IC4	1820-0207		IC:TTL MONOSTABLE MULTIVIBRATOR	28480	1820-0207
A14IC5	1820-0310		IC:DTL TRIPLE 3-INPUT NAND GATE	04713	SC6910PK
A14IC6	1820-0307		IC:DTL HEX INVERTER	04713	MC836P
A14IC7	1820-0307		IC:DTL HEX INVERTER	04713	MC836P
A14IC8	1820-0094		IC:DTL QUAD 2-INPUT GATE	04713	SC6903PK
A14IC9	1820-0094		IC:DTL QUAD 2-INPUT GATE	04713	SC6903PK
A14IC10	1820-0094		IC:DTL QUAD 2-INPUT GATE	04713	SC6903PK
A14IC11	1820-0086		IC:DTL DUAL 4-INPUT GATE (EXPANDABLE)	04713	SC6900PK
A14IC12	1820-0491		IC:TTL BCD/DEC. DECODER/DRIVER	01295	SN74145N
A14IC13	1820-0546		IC:DIGITAL TTL SYNC 4-BIT BCD	28480	1820-0546
A14IC14	1820-0094		IC:DTL QUAD 2-INPUT GATE	04713	SC6903PK
A14IC15	1820-0307		IC:DTL HEX INVERTER	04713	MC836P
A14IC16	1820-0301	2	IC:TTL QUAD BI-STABLE D-LATCH	01295	SN7475N
A14IC17	1820-0301		IC:TTL QUAD BI-STABLE D-LATCH	01295	SN7475N
A14Q1	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A14Q2	1855-0378		TSTR:FET SI N-CHANNEL	28480	1855-0378
A14Q3	1854-0392		TSTR:SI NPN	80131	2N5088
A14R1	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A14R2	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A14R3	0684-5621	8	R:FXD COMP 5.6K OHM 10% 1/4W	01121	CB 5621
A14R4	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A14R5	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A14R6	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A14R7	0684-4701		R:FXD COMP 47 OHM 10% 1/4W	01121	CB 4701
A14R8	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A14R9	0684-5621		R:FXD COMP 5.6K OHM 10% 1/4W	01121	CB 5621
A14R10	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A14R11	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A14R12	0698-4529		R:FXD FLM 226K OHM 1% 1/8W	28480	0698-4529
A14R13	0698-4486		R:FXD MET FLM 24.9K OHM 1% 1/8W	28480	0698-4486
A14R14	0684-2731		R:FXD COMP 27K OHM 10% 1/4W	01121	CB 2731
A14R15	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A14R16	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A14R17	0684-5621		R:FXD COMP 5.6K OHM 10% 1/4W	01121	CB 5621
A14R18	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A14R19	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A14R20	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A14R21	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A14R22	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A14R23	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721
A14R24	0684-4721		R:FXD COMP 4700 OHM 10% 1/4W	01121	CB 4721

Table 6-1. Replaceable Parts(Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A15	03403-66583	1	INPUT/OUTPUT BOARD ASSY	28480	03403-66583
A15C1	0180-0210	1	C:FXD ELECT 3.3 UF 20% 15VDCW	56289	150D335X0015A2-DYS
A15C3	0160-3457	3	C:FXD CER 2000 PF +80-20% 250VDCW	56289	C067B102E102ZS26-CDH
A15C4	0180-0195	1	C:FXD ELECT 0.33 UF 20% 35VDCW	56289	150D334X0035A2-DYS
A15C5	0160-3457		C:FXD CER 2000 PF +80-20% 250VDCW	56289	C067B102E102ZS26-CDH
A15C6	0150-0073	1	C:FXD CER 100 PF 10% 1000VDCW	56289	C028B102E101KS27-CDH
A15C7	0180-0309	1	C:FXD ELECT 4.7 UF 20% 10VDCW	56289	150D475X0010A2-DYS
A15C8	0160-2605		C:FXD .02 UF 25V	28480	0160-2605
A15C9-C13	0160-2605		C:FXD .02 UF 25V	28480	0150-0093
A15IC1	1820-0094		IC:DTL QUAD 2-INPUT GATE	04713	SC6903PK
A15IC2	1820-0273	2	IC:DTL QUAD	01295	SN7408N
A15IC3	1820-0174	1	IC:DTL	01295	SN7404N
A15IC4	1820-1199	2	IC:TTL INVERTER	01295	SN74LS04N
A15IC5, C6	1820-1195	2	IC:DTL	01295	SN7475N
A15IC7	1820-0310	1	IC:DTL TRIPLE 3-INPUT NAND GATE	04713	SC6910PK
A15IC8	1820-1195		IC:DTL	01295	SN7475N
A15IC9	1820-0307	1	IC:DTL HEX INVERTER	04713	MC836P
A15IC10	1820-1411	1	IC:DTL	04713	MC1814P
A15IC11	1820-0174		IC:DTL INVERTER	01295	SN7472N
A15IC12	**1820-0207**	**2**	**IC:TTL MONOSTABLE MULTIVIBRATOR**	**28480**	**1820-0207**
A15J2	**1251-0085**	**1**	**CONNECTOR:FEMALE 36-PIN MINAT**	**28480**	**1251-0085**
A15J3	**1251-0292**	**1**	**CONNECTOR:FEMALE 24 PIN**	**28480**	**1251-0292**
A15J9	**1251-2875**	**1**	**CONNECTOR:PC (2 X 22) 44 CONTACT**	**71785**	**251-22-30-380**
A15Q1	1854-0071		TSTR:SI NPN (SELECTED FROM 2N3704)	**28480**	**1854-0071**
A15Q2	1853-0020		TSTR:SI PNP (SELECTED FROM 2N3702)	**28480**	**1853-0020**
A15Q3	1854-0092	6	TSTR: NPN	28480	1854-0092
A15R1	**0684-4721**		**R:FXD COMP 4700 OHM 10% 1/4W**	**01121**	**CB 4721**
A15R2	**0684-5621**	**5**	**R:FXD COMP 5.6K OHM 10% 1/4W**	**01121**	**CB 5621**
A15R3	**0684-1031**		**R:FXD COMP 10K OHM 10% 1/4W**	**01121**	**CB 1031**
A15R4	**0684-1031**		**R:FXD COMP 10K OHM 10% 1/4W**	**01121**	**CB 1031**
A15R5	**0684-1031**		**R:FXD COMP 10K OHM 10% 1/4W**	**01121**	**CB 1031**
A15R6	**0684-4721**		**R:FXD COMP 4700 OHM 10% 1/4W**	**01121**	**CB 4721**
A15R7	**0684-4701**	**1**	**R:FXD COMP 47 OHM 10% 1/4W**	**01121**	**CB 4701**
A15R8	**0684-4721**		**R:FXD COMP 4700 OHM 10% 1/4W**	**01121**	**CB 4721**
A15R9	**0684-5621**		**R:FXD COMP 5.6K OHM 10% 1/4W**	**01121**	**CB 5621**
A15R10	**0684-1031**		**R:FXD COMP 10K OHM 10% 1/4W**	**01121**	**CB 1031**
A15R11	**0684-2221**	**3**	**R:FXD COMP 2200 OHM 10% 1/4W**	**01121**	**CB 2221**
A15R12	**0684-2221**		**R:FXD COMP 2200 OHM 10% 1/4W**	**01121**	**CB 2221**
A15R13	**0684-1031**		**R:FXD COMP 10K OHM 10% 1/4W**	**01121**	**CB 1031**
A15R14	**0684-1031**		**R:FXD COMP 10K OHM 10% 1/4W**	**01121**	**CB 1031**
A15R15	**0684-5621**		**R:FXD COMP 5.6K OHM 10% 1/4W**	**01121**	**CB 5621**
A15R16	**0684-5621**		**R:FXD COMP 5.6K OHM 10% 1/4W**	**01121**	**CB 5621**
A15R17	**0684-5621**		**R:FXD COMP 5.6K OHM 10% 1/4W**	**01121**	**CB 5621**
A15R18,	0684-1031	1	R:FXD COMP 10K OHM 10% 1/4W	01607	CB1025
A15R19	0683-1025	1	R:FXD 1K 5%	28480	0757-0451
A15R20	0757-0451		R:FXD MET FLM 24.3K OHM 1% 1/8W	01121	CB2415
A15R21-R24	0683-2415	4	R:FXD 240 OHM .05	01121	CB5115
A15R25	0683-5115	1	R:FXD 510 OHM .05		
A20, 21, 22	5060-9188 OR 5060-9127		ASSY:PANEL METER (3403C STD, OPTIONS 001 OR 006) ASSY:PANEL METER (3403C OPTION 003)	28480 28480	5060-9188 OR 5060-9127
A20	5061-0747 OR 5061-0741	1 1	PANEL METER MOTHER BD ASSY (PART OF 5060-9188) PANEL METER MOTHER BD W/EXT. TRIGGER ASSY (PART OF 5060-9127)	28480 28480	5061-0747 5061-0741
A20C1, C2 ■	0160-2094	2	C:FXD 200 PF	28480	0160-2094
A20C3	0180-0116	1	C:FXD 6.8 UF 10% 35VDC	56289	150D685X903582
A20C4, C5	0140-0234	2	C:FXD 500 PF 1% 300WVDC	72136	DM15F501F0300WV1C
A20C6	0160-4040	1	C:FXD 1000 PF	28480	0160-4040
A20C7 ■	0180-1701		C:FXD 6.8 UF 6V	28480	0180-1701
A20CR1 ■	1901-0518	1	DIODE:SCHOTTKEY	28480	1901-0518
A20CR2	1902-0686	1	DIODE:BKDN 6.2V	04713	1N825
A20Q1 ■	1854-0071	1	TSTR:NPN SI	28480	1854-0071
A20R1, R2■	0683-5125	2	R:FXD 5.1K	01121	CB5125
A20R3■	0683-1025	1	R:FXD 1K	01121	CB1025
A20R4■	0683-1035	1	R:FXD 10K	01121	CB1035
A20R5	0698-3515	1	R:FXD 5.9K 1% 1/8W	16299	C4-1/8-TO-5901-F
A20R6	0698-4488	1	R:FXD 26.7K 1% 1/8W	24546	C4-1/8-TO-2672-F
A20R7	0698-4462	1	R:FXD 768 OHM 1% 1/8W	24546	C4-1/8-TO-768A-F
A20R8 - 10	0683-7505	3	R:FXD 75 OHM 5% 1/4W	01121	CB7505
A20U1■	1820-0583	1	IC:DIGITAL	27014	DM74L00N
A20U2■	1820-0595	1	IC:DIGITAL	27014	DM74L73N
A20U3	1826-0119	1	IC:ANALOG	18324	NE555T
	1200-0462	20	SOCKET:IC	24995	3-116141-2

■Components designated by ■ are only contained on 5061-0741 Mother Board Assy.

Table 6-1. Replaceable Parts(Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A21	5061–0740	1	PANEL METER DISPLAY BD ASSY	28480	5061–0740
A21DS2–DS10	1990–0517	9	DIO:LIGHT EMITTING	28480	1990–0517
A21Q1–Q6	1853–0016	6	TSTR:SI PNP	28480	1853–0016
A21R1–R7	0683–1515	7	R:FXD 150 OHM 5% 1/4W	01607	CB1515
A21R8–R11	0683–5115	5	R:FXD 510 OHM 5% 1/4W	01121	CB5115
A21R12	0683–1025	1	R:FXD 1K 5% 1/4W	01121	CB1025
A21R13	0683–5115		R:FXD 510 OHM 5% 1/4W	01121	CB5115
A21R14	0683–1515	1	R:FXD 150 OHM 5% 1/4W	01121	CB1015
A21R15	0683–3915	1	R:FXD 300 OHM 5% 1/4W	01607	CB3915
A21R16	0683–4305	1	R:FXD 43 OHM 5% 1/4W	01607	CB4305
A21U1	1820–1233	1	IC:DIGITAL DECODER 74L47N	01698	SN74L47N
A21U2–U4	1990–0531	3	DISPLAY:NUMERIC (7 SEG)	28480	1990–0531
A21U5	1990–0532	1	DISPLAY:POLARITY/OVERRANGE	28480	1990–0532
A21U6	1820–0471	1	IC:HEX INVERTERS BUFFERS/DRIVERS	01295	SN7406N
A22	5061–0736	1	PANEL METER A/D BD ASSY (PART OF 5060–9188)	28480	5061–0736
	OR				OR
	5061–0739	1	PANEL METER A/D BD ASSY (PART OF 5060–9127)	28480	5061–0739
A22C1 *	0160–0170	1	C:FXD .22 UF 25WVDC	28480	0160–0170
A22C2 *	0160–4243	1	C:FXD .022 UF 10% 50V	84411	HEW249
A22C3	0160–4244	1	C:FXD .1 UF 10% 50WVDC	84411	HEW249
A22C4	0121–0178	1	C:VAR .5 – 60 PF	28480	0121–0178
A22C5*	0140–999P	1	SEE PAD VALUE	28480	0140–999P
A22C6 •	0160–0127	1	C:FXD 1 UF 25V	28480	0160–0127
A22CR1	1902–3149	1	DIODE:ZENER 9.09V	04713	SZ10939–170
A22CR2	1901–0040	1	DIODE:SI	28480	1901–0040
A22Q1	1855–0309	1	TSTR:MOSFET P–CHAN E–MODE SI	04713	2N4352
A22Q2	1853–0036	1	TSTR:PNP SI	28480	1853–0036
A22R1	0698–8312	1	R:FXD 499K 0.5% 1/8W	30983	MF4C1/8–T2–4993–D
A22R2	0698–6914	2	R:FXD 55.6K 0.5% 1/8W	19701	MF4C1/8–T2–5562–D
A22R3	0698–4486	1	R:FXD 24.9K 1% 1/8W	24546	C4–1/8–TO–2492–F
A22R4	0698–6388	1	R:FXD 70K 1% 1/8W	19701	MD4C1/8–T9–7002–F
A22R5	2100–1738	1	R:VAR 10K 5%	19701	ET50W103
A22R6	0698–7082	1	R:FXD 100K 1% 1/8W	19701	MF4C1/8–T9–1003–F
A22R7	0698–6360	1	R:FXD 10K 0.1% 1/8W	19701	MF4C1/8–T9–1002–B
A22R8	0698–6914		R:FXD 55.6K 0.5% 1/8W	19701	MF4C1/8–T2–5562–D
A22R9, R10	0683–5125	2	R:FXD 5.1K 5% 1/4W	01121	CB5125
A22R11	0683–1235	1	R:FXD 12K 5% 1/4W	01121	CB1235
A22R12 •	0683–2435	1	R:FXD 24K 5% 1/4W	01121	CB2435
A22U1	1826–0195	1	IC:ANALOG PROCESSOR	28480	1826–0195
A22U2	1820–1252	1	IC:DIGITAL PROCESSOR (16 PIN) (PART OF 5061–0736)	28480	1820–1252
	OR				OR
	1820–1474	1	IC:DIGITAL PROCESSOR (28 PIN) (PART OF 5061–0739)	28480	1820–1474
A22U3	1820–0944	1	IC:DIGITAL, TRIPLE 3–INPUT NOR GATE	28480	1820–0944
	03431–01201	2	BRKT:MTG		

*Contained on the 5061-0736 assembly only.
•Contained on the 5061-0739 assembly only.
▪Components designated by ▪are only contained on 5061-0741 Mother Board Assy.

Table 6-1. Replaceable Parts(Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
			CHASSIS PARTS AND MISCELLANEOUS		
†A1	03403-60001		AC CONVERTER ASSY	28480	03403-60001
†A1	03403-69501		REBUILT AC CONVERTER ASSY	28480	03403-69501
†A2	03403-66530		ASSY:AMPLIFIER	28480	03403-66530
A3	03403-66517		ASSY:FILTER	28480	03403-66517
A4	03403-66513		ASSY:MASTER	28480	03403-66513
A4A1	03403-66551		ASSY: SWITCH	28480	03403-66551
A5	03403-66551		ASSY:RECTIFIER	28480	03403-66551
A6	03403-66561		ASSY:REGULATOR	28480	03403-66561
A7	03403-66520		ASSY:CONNECTOR, STANDARD	28480	03403-66520
A8	03403-61901		LINE SWITCH ASSY	28480	03403-61901
A11	03403-66521		ASSY:CONNECTOR, ISOLATED	28480	03403-66521
A12	03403-66591		ASSY:CONVERTER, LOG	28480	03403-66591
A13	03403-66571		ASSY:AUTORANGE	28480	03403-66571
A14	03403-66572		ASSY:REMOTE AND AUTORANGE	28480	03403-66572
A15	03403-66583		ASSY:INPUT/OUTPUT	28480	03403-66583
A20, 21, 22	5060-9188	1	PANEL METER ASSEMBLY (3403C STD, OPTIONS 001 OR 006)	28480	5060-9188
	OR				OR
	5060-9127	1	PANEL METER ASSEMBLY (3403C OPTION 003)	28480	5060-9127
				28480	03431-60002
				28480	03431-60003
F1	2110-0340	1	FUSE:0.4A AT	71400	MDL 4/10
F2	2110-0235	1	FUSE:0.2A 250V SLOW-BLOW	71400	MDL 2/10
J13	1251-2357	1	SOCKET:3-PIN MALE POWER RECEPTACLE	82389	EAC-301
J14	1510-0528	2	BINDING POST ASSY:RED INSULATOR	28480	1510-0528
J15	1510-0058	1	BINDING POST ASSY:BLK INSULATOR	28480	1510-0058
J16	1510-0528		BINDING POST ASSY:RED INSULATOR	28480	1510-0528
MP1	03403-60203	1	FRONT PANEL ASSY	28480	03403-60203
MP3	03403-04103	1	COVER:SIDE	28480	03403-04103
MP4	03403-01203	1	BRACKET:PC GUIDE	28480	03403-01203
MP5	5000-9591	1	CASE:EXTRUSION	28480	
MP7	03403-22002	1	PANEL:TOP	28480	03403-22002
MP9	6960-0060	1	PLUG-BUTTON:STL	90763	51050
MP10	03403-22005	1	PANEL:REAR	28480	03403-22005
MP11	03403-60301	1	COVER ASSY:SIDE	28480	03403-60301
MP12	1490-0032	2	STAND:TILT HALF-MODULE	28480	1490-0032
MP13	03403-27901	2	FOOT ASSY	28480	03403-27901
MP14	5040-5848	1	HOLDER:AC CONVERTER	28480	5040-5848
MP17	03403-60302	1	COVER ASSY:BOTTOM	28480	03403-60302
MP19	7120-2769	1	WINDOW(STANDARD)	28480	7120-2769
MP20	7120-2771	1	WINDOW(AUTORANGE)	28480	7120-2771
MP21	7120-2770	1	WINDOW(REMOTE & AUTORANGE)	28480	7120-2770
MP22	7120-2767	1	PANEL:INSERT, STD	28480	7120-2767
MP23	7120-2768		PANEL:INSERT DB	28480	7120-2768
MP24	0370-1103	2	KNOB:RANGE	28480	0370-1103
MP25	0370-1099	2	KNOB:JADE GREY	28480	0370-1099
MP26	0370-1097	1	KNOB:POINTER 0.50", JADE GRAY	28480	0370-1097
MP27	9320-1605	1	CARD: SPEC	28480	9320-1605
MP28	0340-0738	1	INSULATOR: OUTPUT	28480	0340-0738
MP29	03403-04104	1	FILLER PLATE:REAR PANEL	28480	03403-04104
MP31	5040-5847	1	ADAPTER:BNC TO GR	28480	5040-5847
MP32	5060-5984	1	PC EXTENDER:2 X 25	28480	5060-5984
MP33	03403-90005	1	MANUAL	28480	03403-90005
MP34	03403-20203	1	FRAME:LEFT SIDE	28480	03403-20203
MP35	03403-20204	1	FRAME:RIGHT SIDE	28480	03403-20204
MP36	0340-0424	1	INSULATOR:BINDING POST, BLACK	28480	0340-0424
MP37	0340-0749	1	INSULATOR:BINDING POST, RED	28480	0340-0749
MP38	0340-0602	2	INSULATOR: SERIES PASS TSTR (RUBBER)	28480	0340-0602
MP39	0460-1056	1	TAPE-PLASTIC	28480	0460-1056
MP40	5020-6892	1	INSULATOR: PANEL METER CASE	28480	5020-6892
MP41	5060-5940	1	PC EXTENDER	28480	5060-5940
P2	1251-0084	1	PLUG:36-CONTACT MALE W/HOOD & CLAMP	28480	1251-0084
P3	1251-0293	1	CONNECTOR:24 CONTACT	28480	1251-0293
R1	2100-3269	1	R:BAR 75 K OHM 20% 1/2W LIN	28480	2100-3269
S5	3101-1234	1	SWITCH:SLIDE DPDT	82389	11A-1242
T1	9100-3233	1	TRANSFORMER	28480	9100-3233
W1	8120-1348	1	CABLE ASSY:POWER CORD 7.5 FT.	28480	8120-1348
XF1	1400-0084	1	FUSEHOLDER:EXTRACTOR POST TYPE	75915	342014

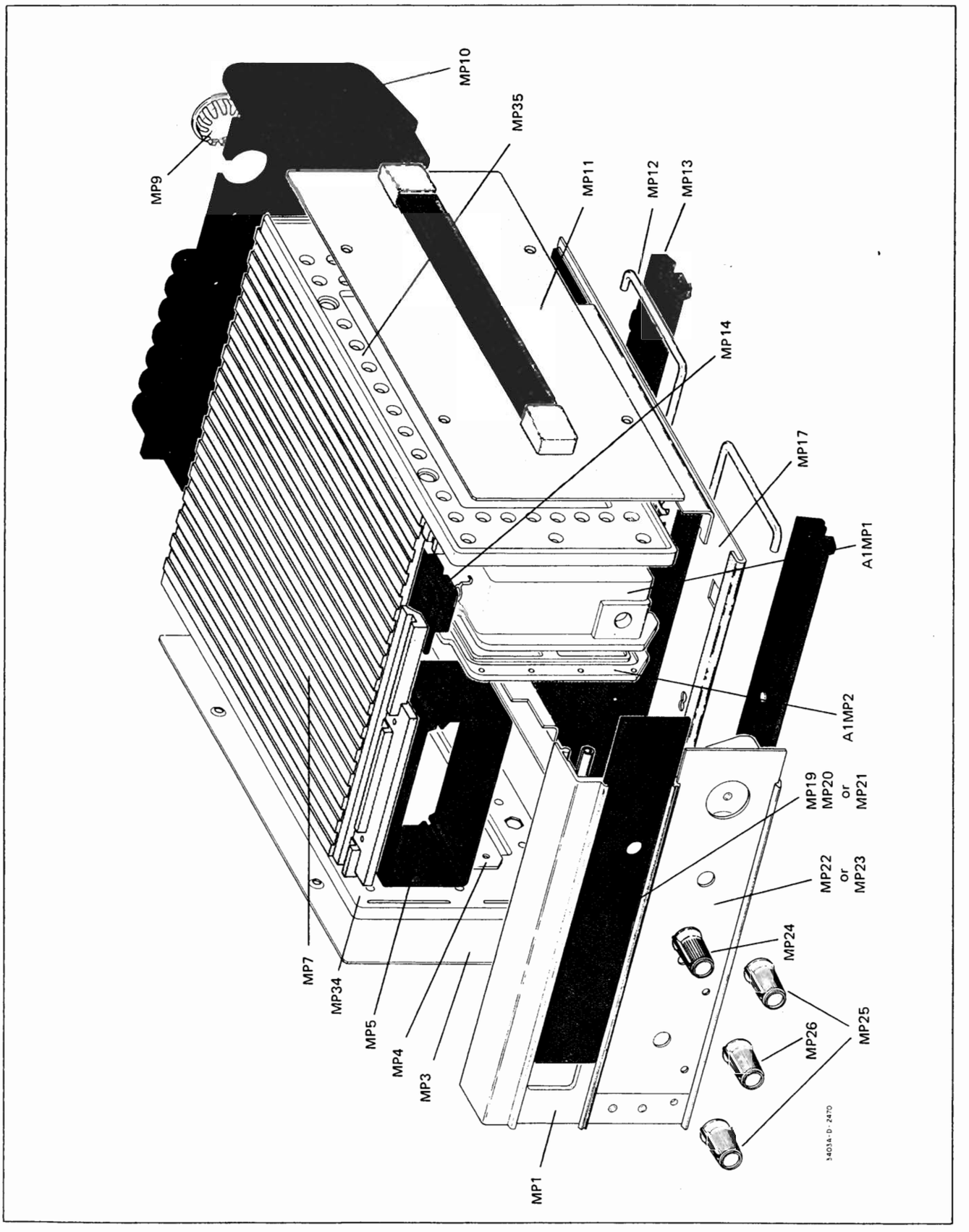


Figure 6-1. Location of Miscellaneous Parts.

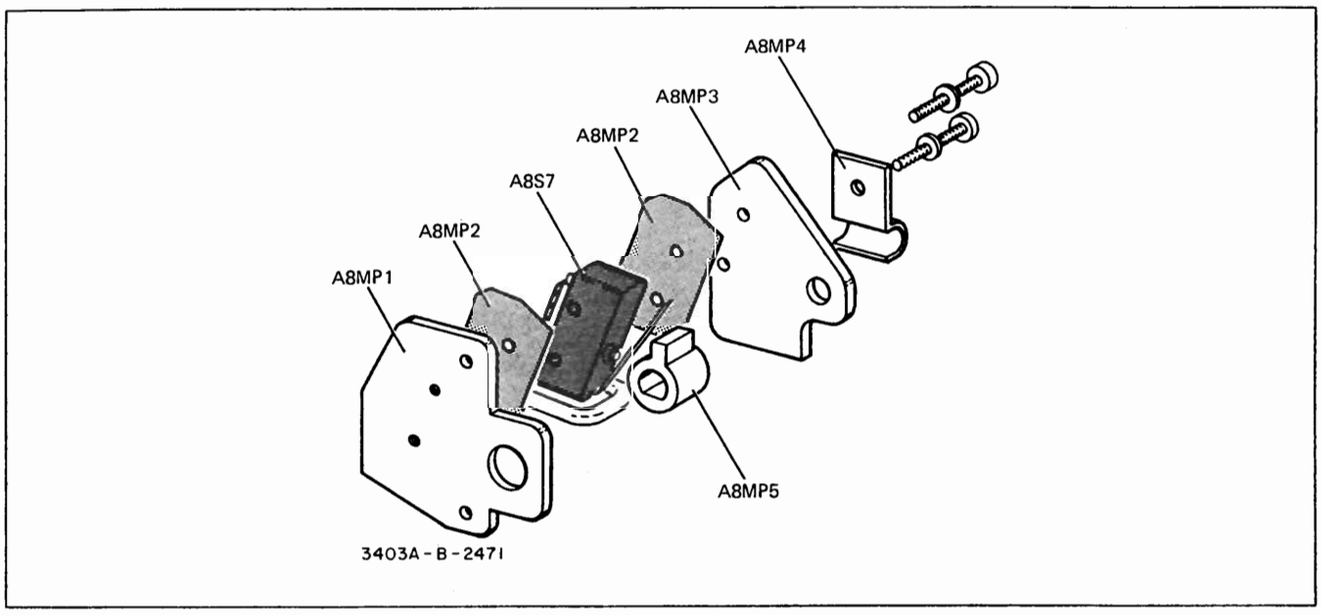


Figure 6-2. Line Switch Assembly A8.

SECTION VII
CIRCUIT DIAGRAMS

7-1. INTRODUCTION.

7-2. This section contains the diagrams necessary to maintain the Model 3403C. Both schematic diagrams and pictorial views of the circuit boards are included. Figure 7-1 shows the location of the various assemblies, and schematic diagrams are in order by assembly number. Figure 7-2 is a block diagram. The following assemblies, including options, are used in the 3403C:

A1 AC Converter Assembly (includes A2 and A3)
A2 Amplifier Assembly
A3 Filter Assembly
A4 Master Board Assembly
A5 Rectifier Assembly

A6 Regulator Assembly
A7 Standard Connector Assembly
A8 Line Switch Assembly
A12 Log Converter Assembly
A13 Autorange Assembly
A14 Remote and Autorange Assembly
A15 Input/Output Assembly
A20 Digital Panel Meter
A21
A22

7-3. NOTES.

7-4. The following notes apply in general to all schematic diagrams:

a. Partial reference designators are shown within assembly outlines. Prefix with assembly number for complete designator.

b. Component values are shown as follows unless otherwise noted:

Capacitance in microfarads
Resistance in ohms
Inductance in microhenries

c. * Average value shown. Optimum value selected at factory.

d. —— — — —— Denotes assembly.

e. ———————— Denotes main signal path.

f. — — — — — — Denotes feedback path.

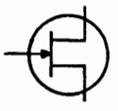
g.  Denotes screwdriver adjustment.

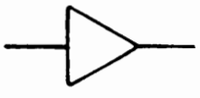
h. All relays shown de-energized.

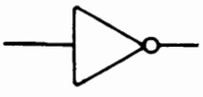
i. Rotary switches shown in extreme counterclockwise position.

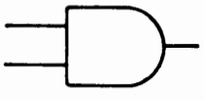
j. \924/ denotes wire color: color code same as resistor color code. First number identifies base color, second number identifies wider strip, third number identifies narrower strip, (e.g. \924/ = white, red, yellow).

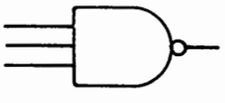
7-5. SYMBOLS.

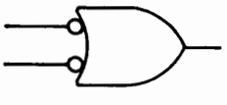
FET, N CHANNEL 

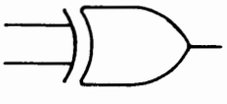
OPERATIONAL AMPLIFIER 

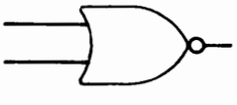
INVERTING OP. AMP. 

"AND" GATE 

MULTIPLE INPUT "NAND" GATE 

"OR" GATE WITH INVERTING INPUTS 

EXCLUSIVE "OR" GATE 

"NOR" GATE 

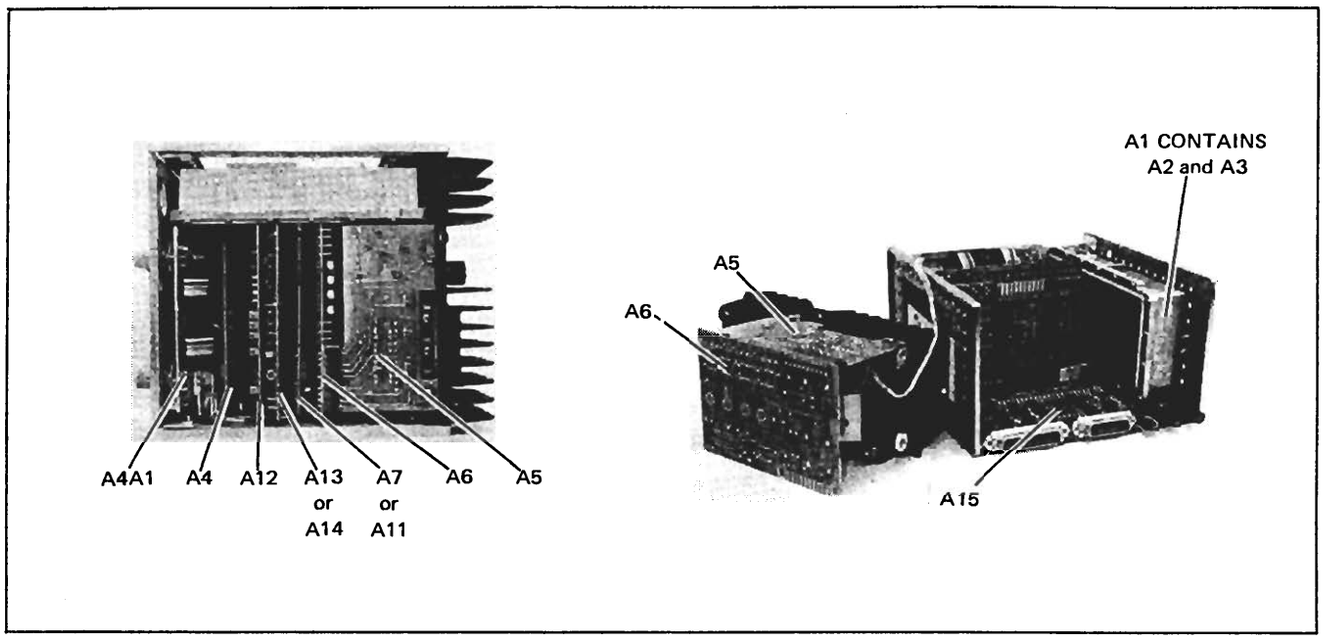
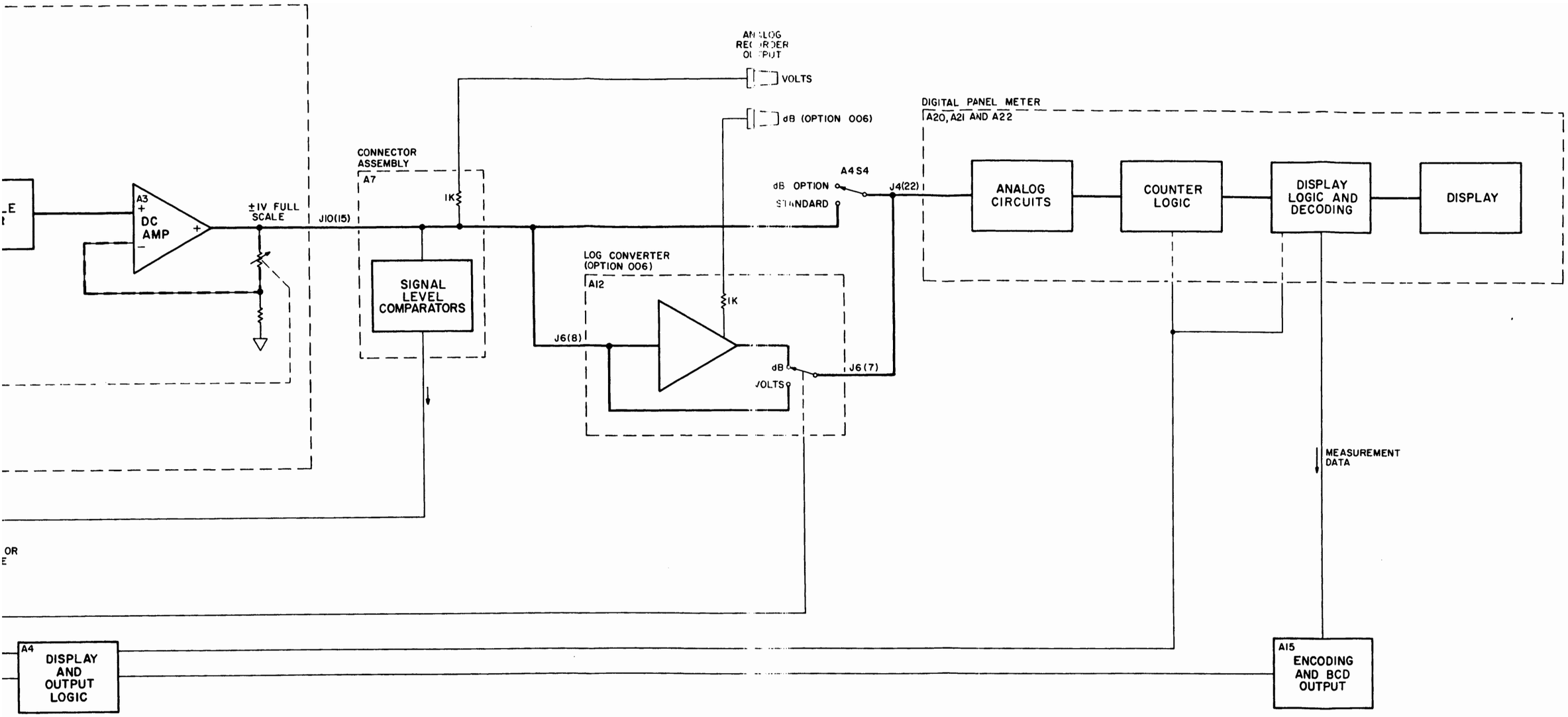


Figure 7-1. Assembly Locations.

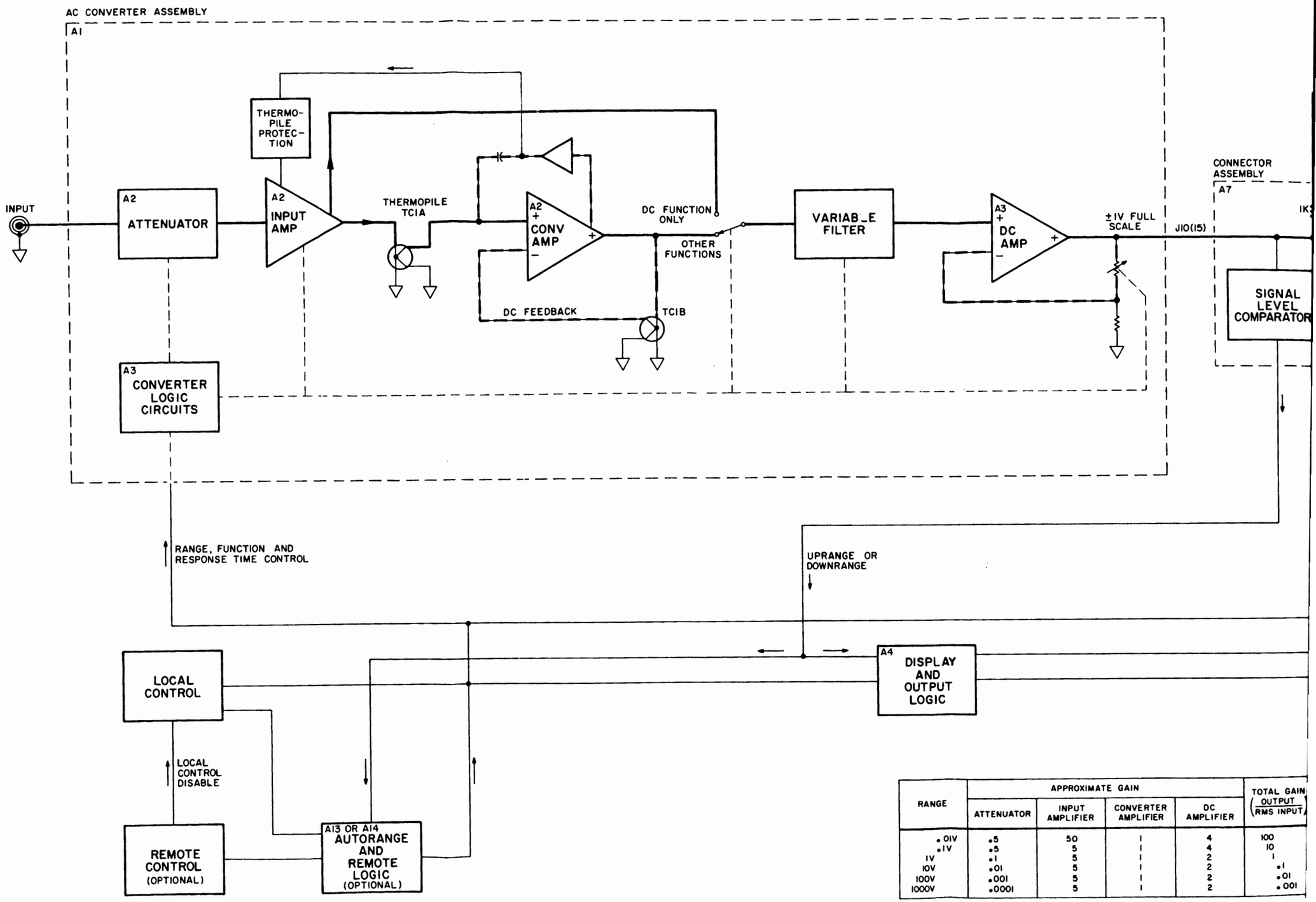
Figure 7-1. Assembly Locations.



RANGE	APPROXIMATE GAIN				TOTAL GAIN $\left(\frac{\text{OUTPUT}}{\text{RMS INPUT}}\right)$
	ATTENUATOR	INPUT AMPLIFIER	CONVERTER AMPLIFIER	DC AMPLIFIER	
.01V	.5	50	1	4	100
.1V	.5	5	1	4	10
1V	.1	5	1	2	1
10V	.01	5	1	2	.1
100V	.001	5	1	2	.01
1000V	.0001	5	1	2	.001

TOTAL GAIN = PRODUCT OF ALL OTHER GAINS

Figure 7-2. Block Diagram.



RANGE	APPROXIMATE GAIN				TOTAL GAIN (OUTPUT / RMS INPUT)
	ATTENUATOR	INPUT AMPLIFIER	CONVERTER AMPLIFIER	DC AMPLIFIER	
.01V	.5	50	1	4	100
.1V	.5	5	1	4	10
1V	.1	5	1	2	1
10V	.01	5	1	2	.1
100V	.001	5	1	2	.01
1000V	.0001	5	1	2	.001

TOTAL GAIN = PRODUCT OF ALL OTHER GAINS

3403A-E-2435

ELAYS LOSED	APPROXIMATE GAIN				TOTAL GAIN (OUTPUT / RMS INPUT)
	ATTEN-UATOR	INPUT AMP	CONV AMP	DC AMP	
NONE	•5	50	1	4	100
NONE	•5	5	1	4	10
3	•1	5	1	2	1
3, K4	•01	5	1	2	•1
4, K5	•001	5	1	2	•01
4, K6	•0001	5	1	2	•001

N = PRODUCT OF ALL OTHER GAINS

ATTENUATOR

INPUT AMPLIFIER

THERMOPILE PROTECTION

CONVERTER AMPLIFIER

P/O A3

AC FEEDBACK

DC FEEDBACK

SLOW RT SEL

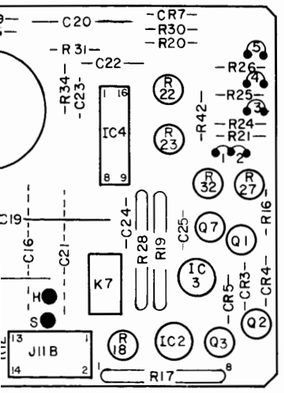
SIGNAL PATH FOR DC FUNCTION ONLY

TO A3 PIN 9

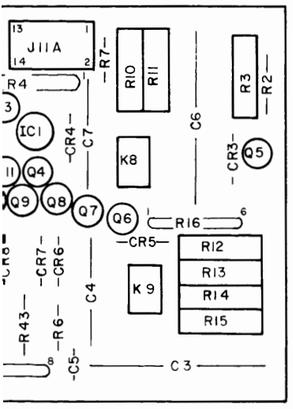
TO A3 PIN 1

CREST FACTOR

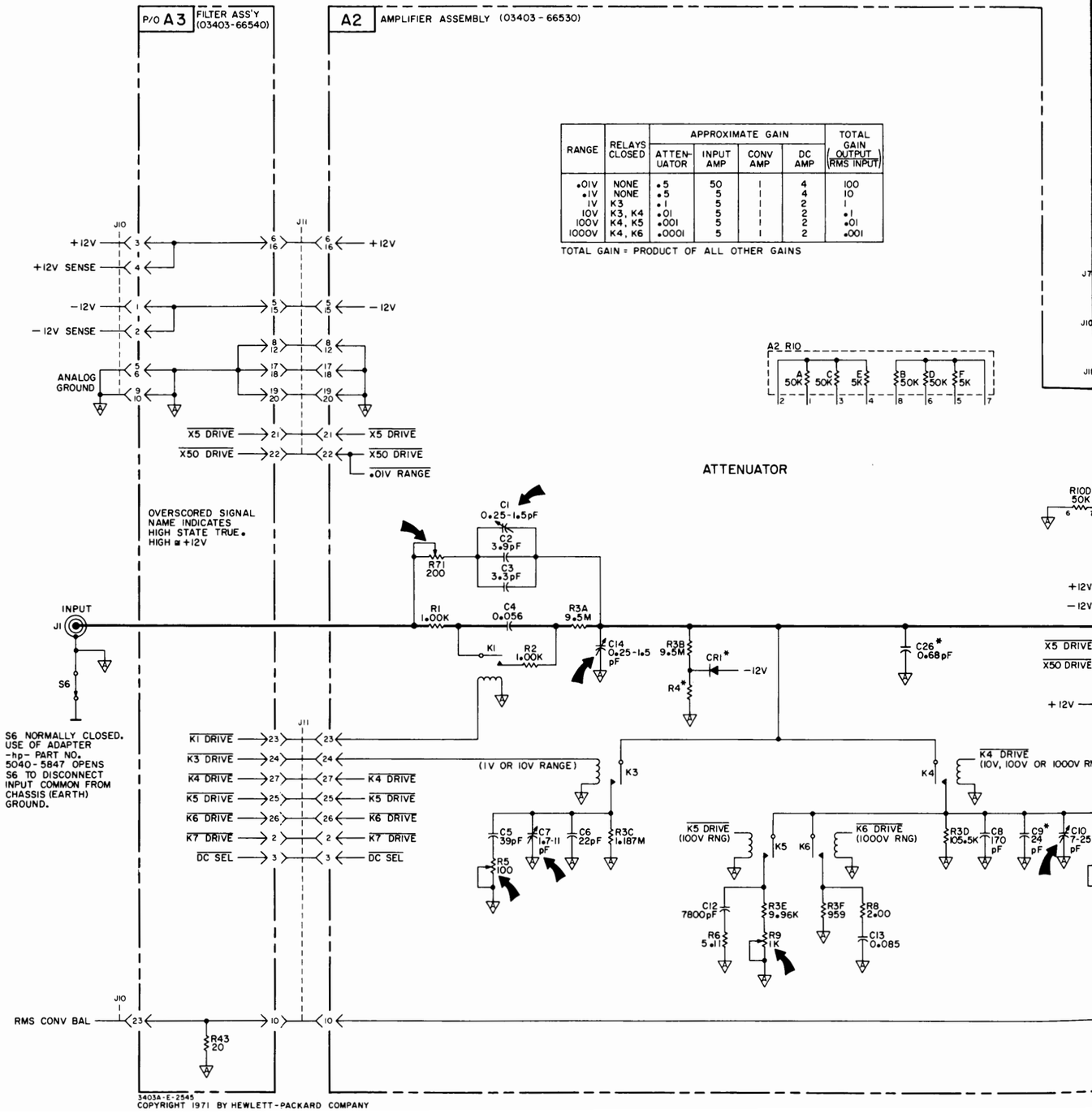
Figure 7-3. Schematic Diagram, AC Converter Amplifier Circuits, A2.
Rev. A 7-5/7-6

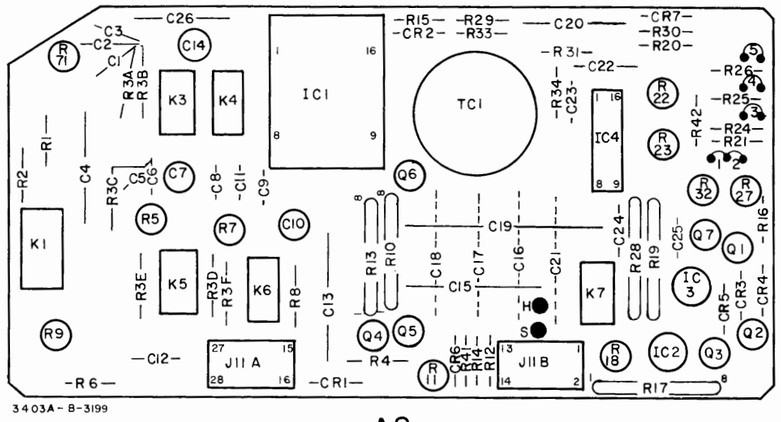

C20
CR7
R30
R20
R31
C22
R26
R25
R24
R21
R34
C23
R42
IC4
R22
R23
R32
R27
C19
C24
C25
R16
Q7
Q1
C16
C21
R28
R19
IC3
K7
CR5
CR3
CR4
Q2
J11B
R18
IC2
Q3
R17

6530


J11A
R7
R10
R11
R3
R2
R4
IC1
CR4
C7
C6
K8
CR3
Q5
Q4
Q9
Q8
Q7
Q6
R16
CR5
R12
R13
R14
R15
CR7
CR6
K9
R43
R6
C4
C5
C3

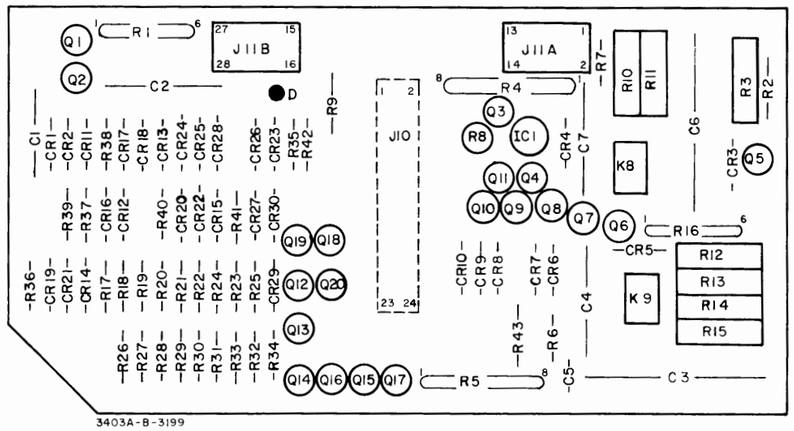
6540


P/O A3 FILTER ASS'Y (03403-66540)
A2 AMPLIFIER ASSEMBLY (03403-66530)
RANGE
RELAYS CLOSED
APPROXIMATE GAIN
ATTEN-UATOR
INPUT AMP
CONV AMP
DC AMP
TOTAL GAIN (OUTPUT / RMS INPUT)
•01V NONE •5 50 1 4 100
•1V NONE •5 5 1 4 10
1V K3 •1 5 1 2 1
10V K3, K4 •01 5 1 2 •1
100V K4, K5 •001 5 1 2 •01
1000V K4, K6 •0001 5 1 2 •001
TOTAL GAIN = PRODUCT OF ALL OTHER GAINS
J10
J11
+12V
+12V SENSE
-12V
-12V SENSE
ANALOG GROUND
X5 DRIVE
X50 DRIVE
•01V RANGE
OVERSCORED SIGNAL NAME INDICATES HIGH STATE TRUE. HIGH ≅ +12V
A2 R10
A 50K
C 50K
E 5K
B 50K
D 50K
F 5K
ATTENUATOR
C1 0.25-1.5pF
C2 3.9pF
C3 3.3pF
R71 200
INPUT J1
S6
R1 1.00K
C4 0.056
R3A 9.5M
K1
R2 1.00K
C14 0.25-1.5 pF
R3B 9.5M
CR1*
R4*
-12V
C26* 0.68pF
S6 NORMALLY CLOSED. USE OF ADAPTER -hp- PART NO. 5040-5847 OPENS S6 TO DISCONNECT INPUT COMMON FROM CHASSIS (EARTH) GROUND.
K1 DRIVE
K3 DRIVE
K4 DRIVE
K5 DRIVE
K6 DRIVE
K7 DRIVE
DC SEL
(1V OR 10V RANGE)
K3
K4
K4 DRIVE (10V, 100V OR 1000V RN
C5 39pF
C7 1.7-11 pF
C6 22pF
R3C 1.187M
R5 100
K5 DRIVE (100V RNG)
K5
K6
K6 DRIVE (1000V RNG)
R3D 105.5K
C8 170 pF
C9* 24 pF
C10 7-25 pF
C12 7800pF
R3E 9.96K
R3F 959
R8 2.00
R6 5.11
R9 1K
C13 0.085
RMS CONV BAL
R43 20
R10D 50K
+12V
-12V
+12V
X5 DRIVE
X50 DRIVE
3403A-E-2545
COPYRIGHT 1971 BY HEWLETT-PACKARD COMPANY



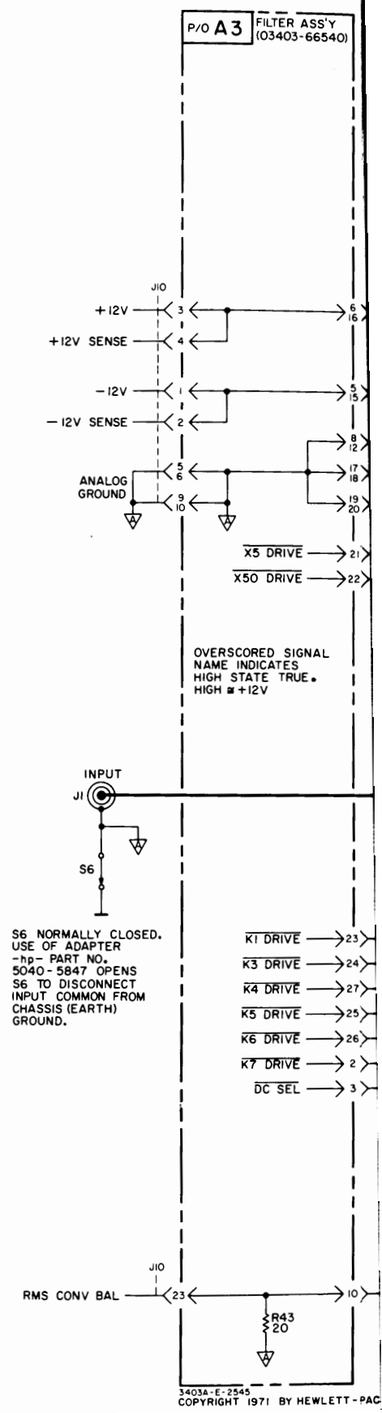
A2

hp Part No. 03403-66530



A3

hp Part No. 03403-66540



P/O A3 FILTER ASSEMBLY (03403-66540)

J10

+12V
-12V
.01V SELECT
.1V SELECT
1V SELECT
10V SELECT
100V SELECT
1000V SELECT
AC SELECT
DC SELECT
SLOW RT SELECT

R17 10K
R18 10K
R19 10K
R20 10K
R21 10K
R22 10K
R23 10K
R24 10K
R25 10K

R26 10K
R27 10K
R28 10K
R29 10K
R30 10K
R31 10K
R32 10K
R33 100
R34 10K

Q12
Q13
Q14
Q15
Q16
Q17
Q18
Q19
Q20

R35 22K
R36 22K
R37 22K
R38 22K
R39 22K
R40 22K
R41 22K

.01V RANGE
.1V RANGE
1V RANGE
10V RANGE
100V RANGE
1000V RANGE
AC SEL
DC SEL
SLOW RT SEL

CR11
CR12
CR13
CR14
CR15
CR16
CR17
CR18
CR19
CR20
CR21
CR22
CR23
CR24
CR25
CR26
CR27
CR28
CR29
CR30

R42 47K

J11

X50 DRIVE
X5 DRIVE
K3 DRIVE
K4 DRIVE
K5 DRIVE
K6 DRIVE
K1 DRIVE
DC SEL
K7 DRIVE

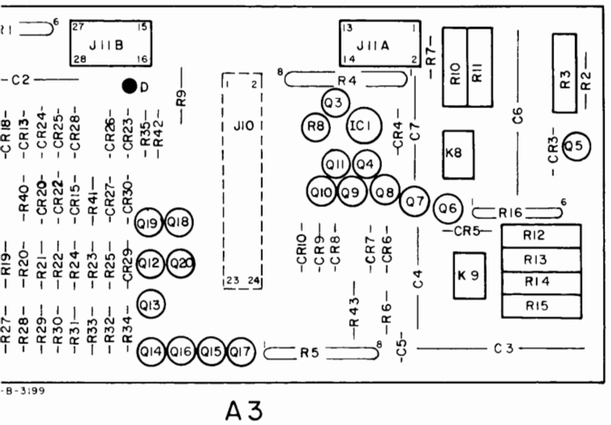
TO AMPLIFIER ASSEMBLY A2

3403A-D-2533

R16A 355
R16B 342
R16C 519
R16D 159
R16E 671
R15 5K
R11 5K
Q9
Q11

R9 10.0K
R8 10K
IC1
D
±1V FULL RANGE
AC CONVERTER OUTPUT

Figure 7-4. Schematic Diagram, AC Converter DC Amp. and Logic Circuits, A3.



A3

hp Part No. 03403-66540

P/O A3 FILTER ASSEMBLY (03403-66540)

DC AMPLIFIER

R4
A 15K
B 15K
C 47K
D 4.7K
E 47K

R5
A 83.5K
B 83.5K
C 162K
D 338K
E 55K

R16
A 335
B 342
C 519
D 159
E 671

R12 5K
R13 5K
R14 5K
R15 5K
R16A 355
R16B 342
R16C 519
R16D 159
R16E 671

IV RNG
10V RNG
100V RNG
1000V RNG
.01V RNG
.1V RNG
CR5
CR6
CR7
CR8
CR9
CR10
Q6
Q7
Q8
Q9
Q10
Q11

R10 5K
R11 5K

FROM A2 PIN 9
FROM A2 PIN 1
J11

R2 1.02K
R3 1K
R4A 15K
R4B 15K

+12V
R4E 47K
CR3
CR4
Q5
Q4
R4C 47K
R4D 4.7K
AC SEL
Q3
-12V

DC FUNCTION ONLY

SLOW RT SEL
K9
R6 100
R5C 162K
R5D 338K
R5E 55.0K
R5A 83.5K
R5B 83.5K
C3 10
C4 1
C6 10
C7 1
K8
R7 100

C5 0.01
R9 10.0K
R8 10K
IC1

AC SEL TO J5 (18) J7 (8), J9 (34)

+5V R3 4.7K

R18 100

AC SEL TO J4 (15)

DC SEL TO J4 (16)

DC SEL TO J5 (17), J7 (12), J9 (33)

R19 100

+/- BLANKING CONTROL

UP / DOWN RANGE INDICATION

CREST FACTOR

UPRANGE

DOWNRANGE

FUNCTION ANNUNCIATOR DRIVE

R25 100

R24 100

R23 100

DISPLAY BLANKING CONTROL

DECIMAL POSITION CONTROL

•01V SEL

•1V SEL

dB SEL

R22 100

R21 100

R20 100

A12 LOG CONVERTER (OPTIONAL) SEE FIG 7-10

dB ADDER CONTROL

TO IC6 (4)

TO IC6 (5)

±A LOW=ADD, HIGH=SUBTRACT

A=20

A=40

1V SEL

10V SEL

100V SEL

1000V SEL

AUTO SEL

REMOTE ENABLE

NC

J4

26 +/- BLANK (HIGH=BLANK)

15 AC

16 DC

17 ↑

45 RNG

47 ↓

18 V

19 mV

46 dB

ANNUNCIATOR (LOW STATE LIGHTS TURNS LIGHTS ON)

NOTE: IF A BRIGHTER ANNUNCIATOR DISPLAY IS DESIRED, REPLACE A4R17 THROUGH A4R25 WITH A 75Ω RESISTOR. THIS CHANGE WILL REDUCE LIFE OF THE ANNUNCIATOR LED'S.

29 L DIGIT BLANK (LOW STATE BLANKS 3 DIGIT DISPLAY)

35 DECIMAL 1

36 DECIMAL 2

38 DECIMAL 3

LOW STATE LIGHTS DECIMAL

J7

8 AC SEL

12 DC SEL

TO AC CONVERTER ASSEMBLY THRU J7

J6

17 ±A

9 A=20

10 A=40

(USED IN OPTION 006)

J4

49 SR2 {LOW=2/sec HIGH=4/sec

J5

2 SLOW RT SEL TO AUTORANGE OR REMOTE ASSEMBLY

J7

6 SLOW RT SEL TO AC CONVERTER ASSEMBLY

J4

50 HOLD TO DPM

S1 FUNCTION

S2 RESPONSE TIME

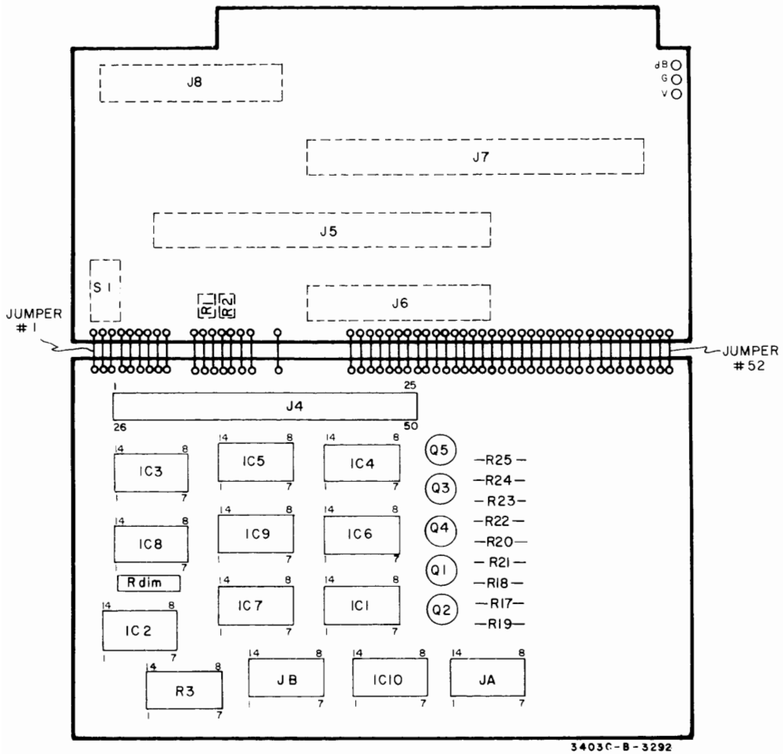
S3 RANGE

ALL SWITCHES VIEWED FROM REAR

IC1-IC10 TOP VIEW

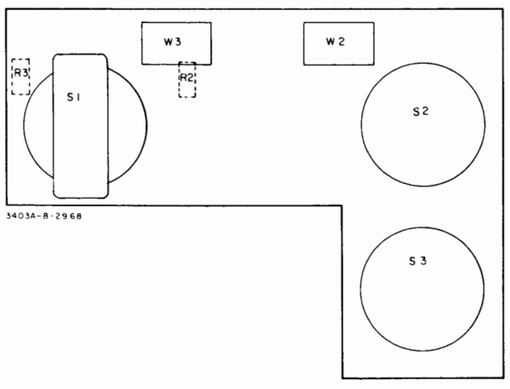
5V

Figure 7-5. Schematic Diagram, Manual Range and Function Logic, A4.
Rev. A 7-9/7-10



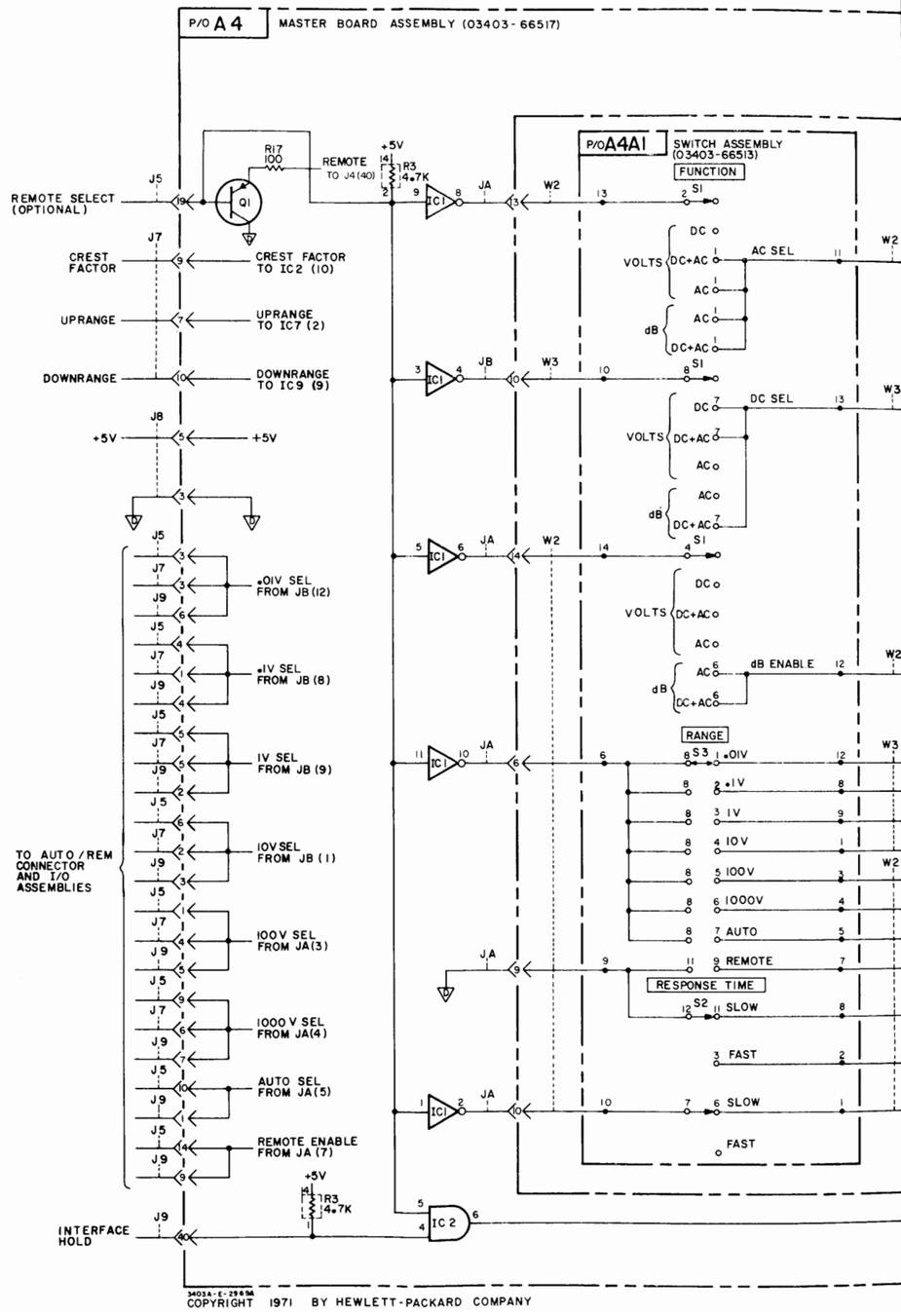
A4

-hp- PART NO. 03403-66517



A4A1

hp Part No. 03403-66513



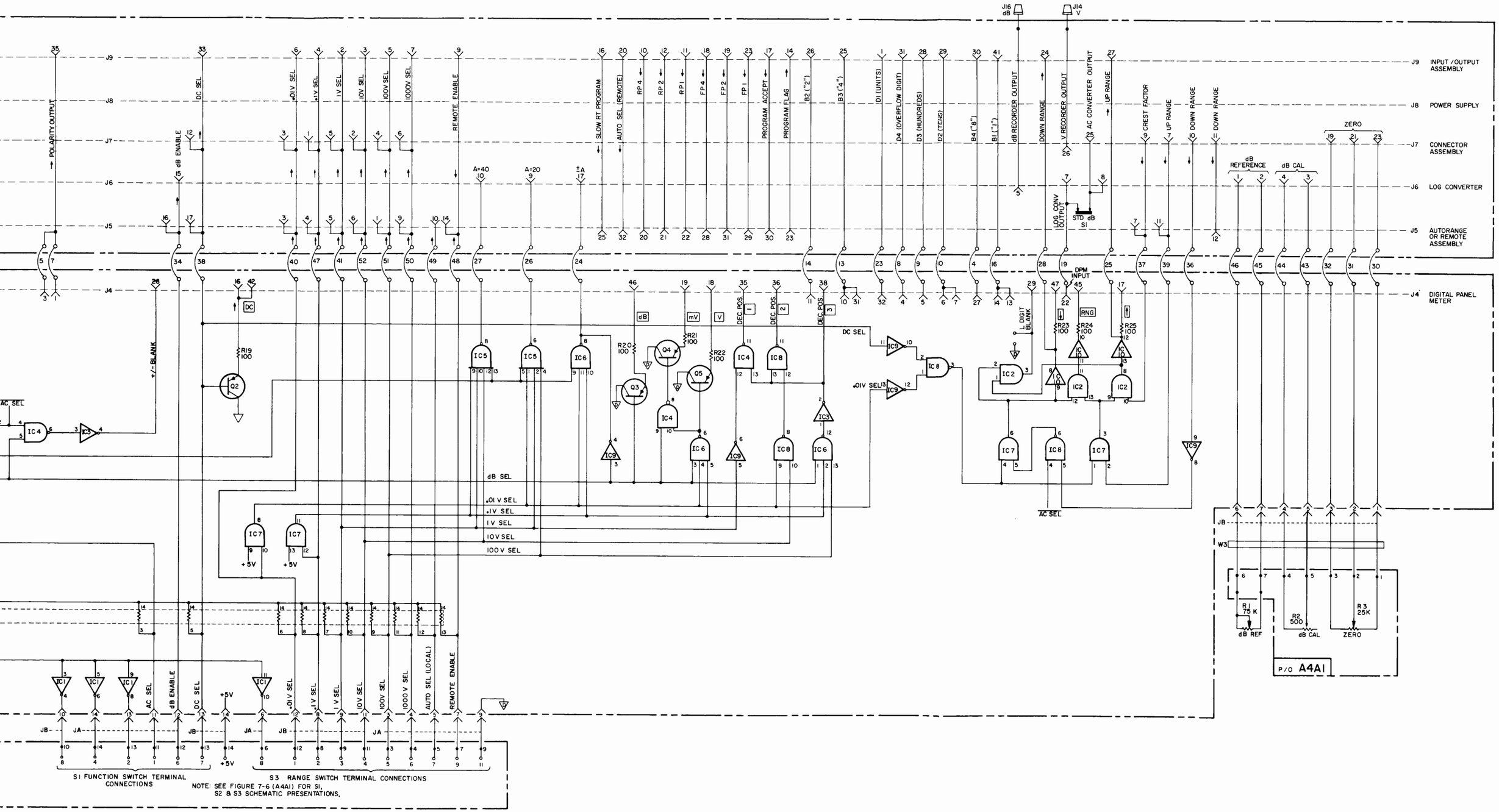


Figure 7-6. Master Board Wiring Diagram, A4.
Rev. A 7-11/7-12

P/O A4 MASTER BOARD ASSEMBLY (03403-66517)

INPUT / OUTPUT ASSEMBLY J9 · POWER SUPPLY J8 · CONNECTOR ASSEMBLY J7 · LOG CONVERTER J6 · AUTORANGE OR REMOTE ASSEMBLY J5

P/O A4 DIGITAL PANEL METER J4

+5V 22 · -10V 37 · DIGITAL GND 44 · GND J15

+12V 15 · +5V 6 · -12V 16 · DIGITAL GND 3 · DIGITAL GND 8

RECORDER GROUND 35 · 36 · HIGH CURRENT GROUND 34 · HIGH CURRENT GROUND 27 · +12V HEATER 7 · HEATER GROUND 18

R1 10 · R2 10

LOW CURRENT GROUND 18

MEASURE 35 · MEASUREMENT COMPLETE 42 · TRANSFER 43 · MEASURE REQUEST 13 · HOLD 40 · MEASURE MODE PROGRAM 8 · +12V SENSE 12 · SENSE GROUND 11 · -12V SENSE 14 · SLOW RT SEL 16 · dB SEL 23 · dB SEL 36 · AC SEL 34 · POLARITY OUTPUT 35 · DC SEL 33 · dB ENABLE 12 · .01V SEL 6 · .1V SEL 4 · 1V SEL 2 · 10V SEL 3 · 100V SEL 5 · 1000V SEL 7 · REMOTE ENABLE 9 · A=40 10 · A=20 9 · ±A 7 · SLOW RT PROGRAM 16 · AUTO SEL (REMOTE) 20 · RP4 10 · RP 2 12

+12V 22 · +5V 11 · +5V 12 · -12V 21 · DIGITAL GND 15 · DIGITAL GND 33 · 18 · 20 · TRIGGER 6 · TRANSFER 17 · HOLD 2 · REM 29 · SR 1 42 · SR 2 48 · 49 · AC 3 · 35 · POLARITY OUTPUT 5 · 7 · +/- BLANK 28 · DC 34 · 38 · .01V SEL 40 · .1V SEL 47 · 1V SEL 41 · 10V SEL 52 · 100V SEL 51 · 1000V SEL 50 · REMOTE ENABLE 49 · 48 · A=40 27 · A=20 26 · ±A 24 · dB 46

ICI THRU IC10 TOP VIEW · +5V

INDICATES CONNECTION TO FRONT PANEL DISPLAY

LOW= < +0.5V
HIGH = > +2.4V OR OPEN CIRCUIT
OVERSCORE INDICATES HIGH STATE TRUE

TRIGGER · TRANSFER · HOLD · REM · SR 1 · SR 2 · AC · DC · dB

R16 100 · R17 100 · R19 100 · R20 100

Q1 · Q2 · Q3

IC1 · IC2 · IC3 · IC4 · IC5 · IC6 · IC7 · IC9

AC SEL · +5V

dB SEL · .01V SEL · .1V SEL · 1V SEL · 10V SEL · 100V SEL

R3 4.7K

SLOW RT SEL · SR 2 · NC · AC SEL · dB ENABLE · DC SEL · +5V · .01V SEL · .1V SEL · 1V SEL · 10V SEL · 100V SEL · 1000 V SEL · AUTO SEL (LOCAL) · REMOTE ENABLE

JA · JB

S2 RESPONSE TIME SWITCH TERMINAL CONNECTIONS

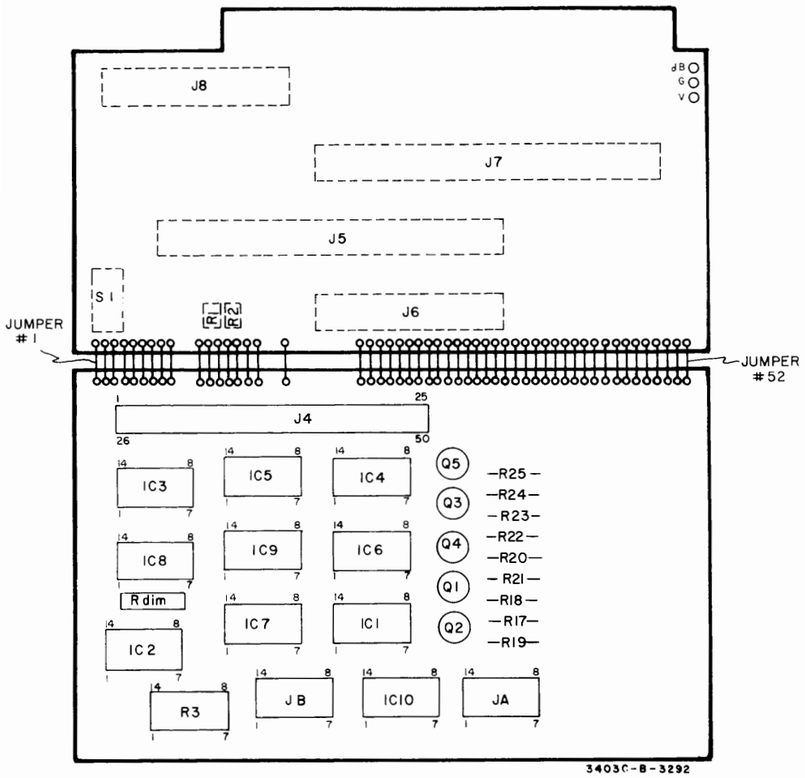
S1 FUNCTION SWITCH TERMINAL CONNECTIONS

S3 RANGE SWITCH TERMINAL CONNECTIONS

NOTE: SEE FIGURE 7-6 (A4A1) FOR S1, S2 & S3 SCHEMATIC PRESENTATIONS.

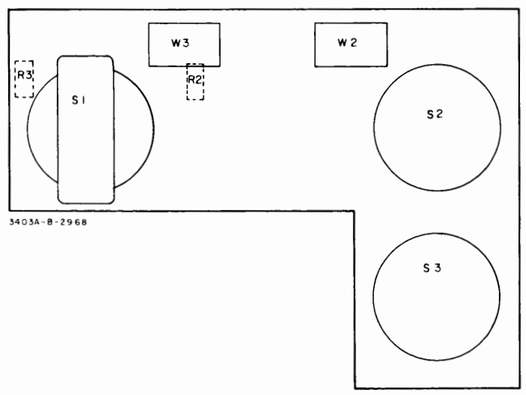
P/O A4A1 SWITCH ASSEMBLY 03403-66513

3403A-E-4126



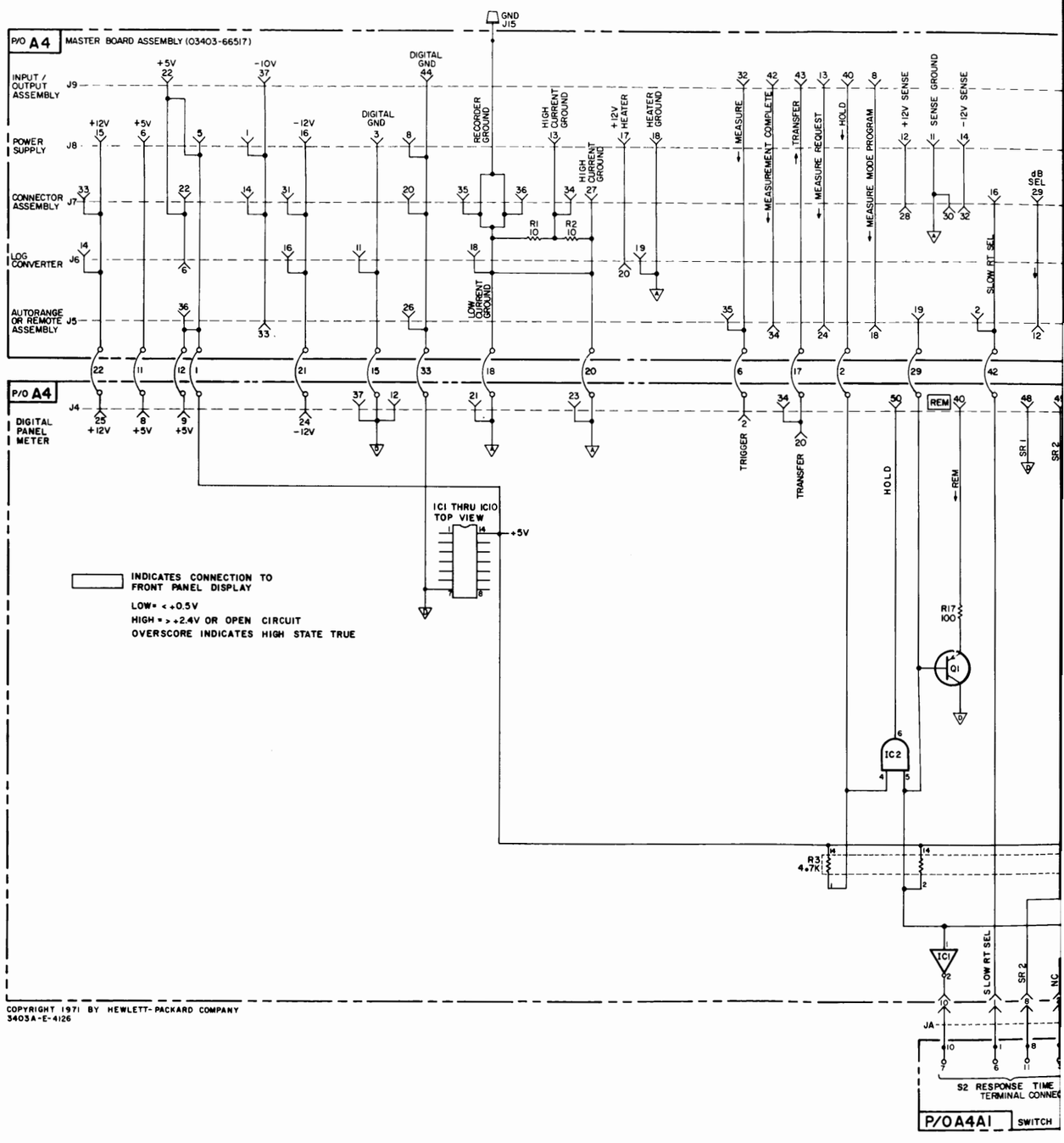
A4

-hp- PART NO. 03403-66517



A4A1

hp Part No. 03403-66513



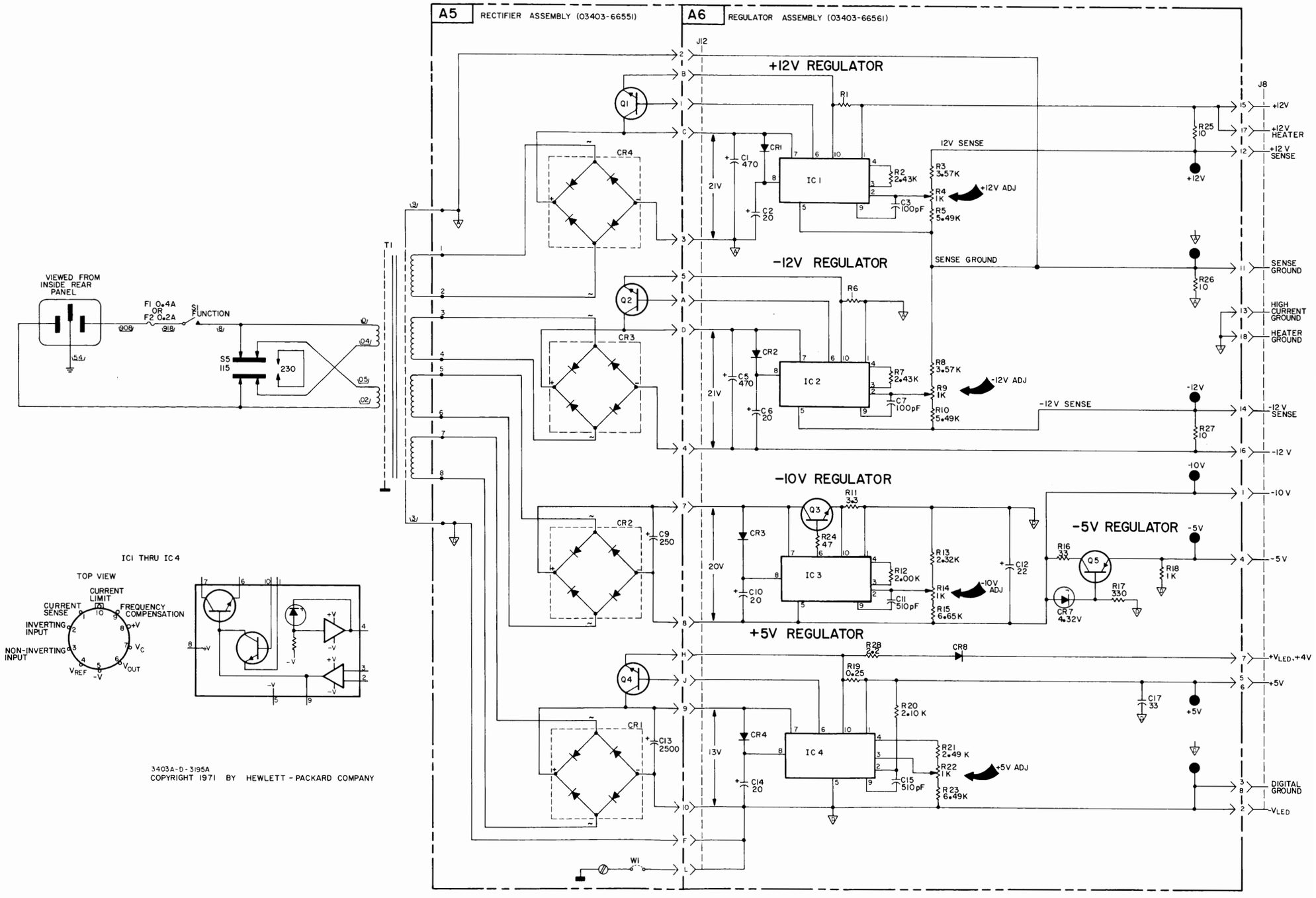
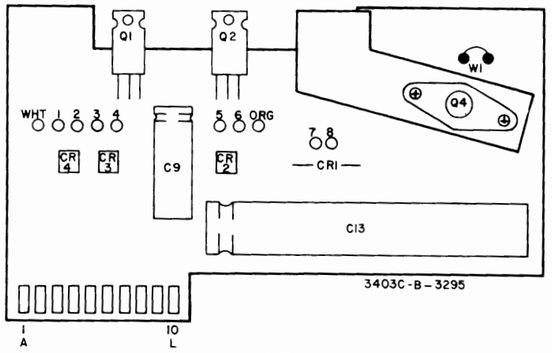
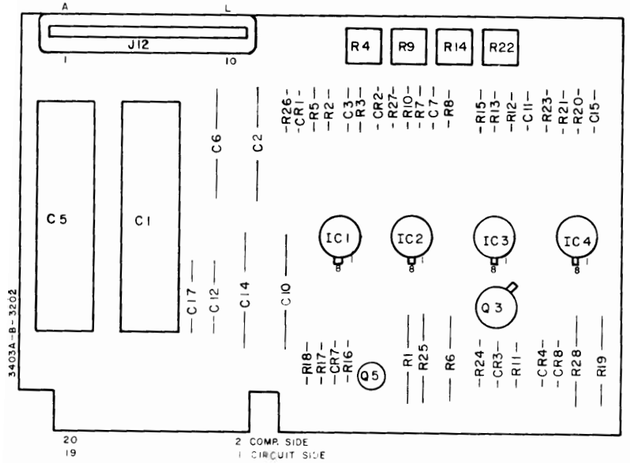


Figure 7-7. Schematic Diagram, Power Supplies, A5, A6.
Rev. A 7-13/7-14



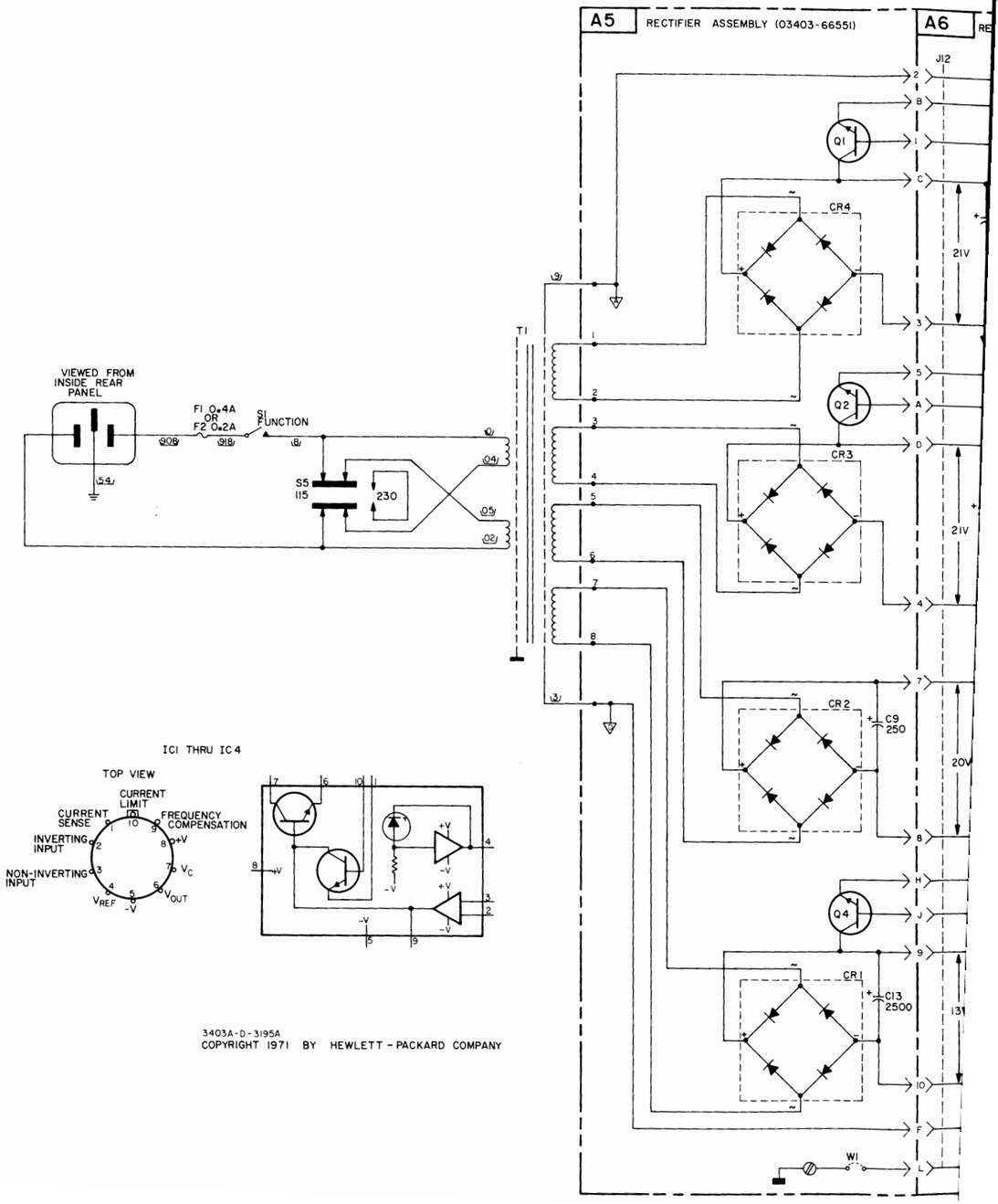
A5

hp Part No. 03403-6655I

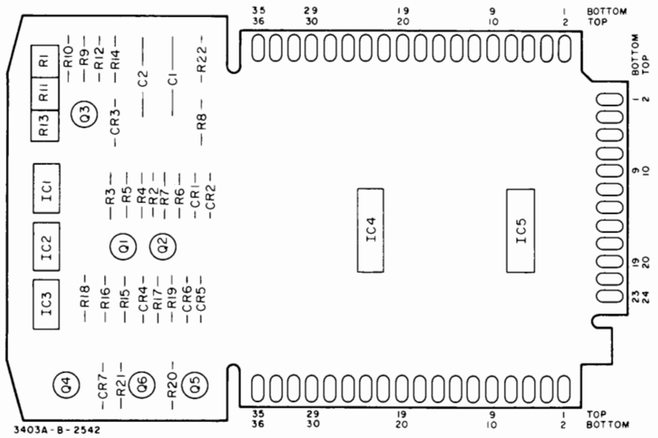


A6

03403-66561



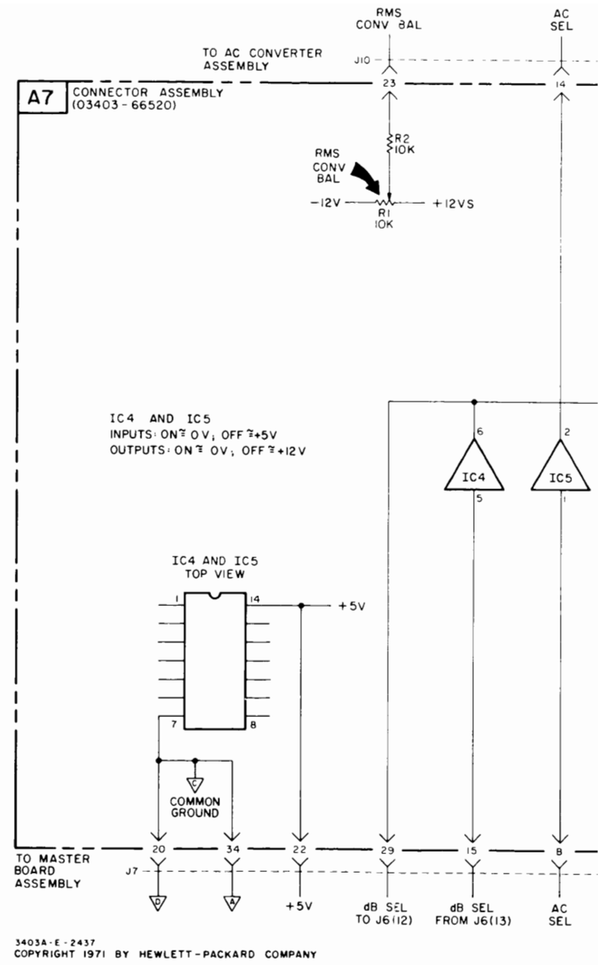
3403A-D-3195A



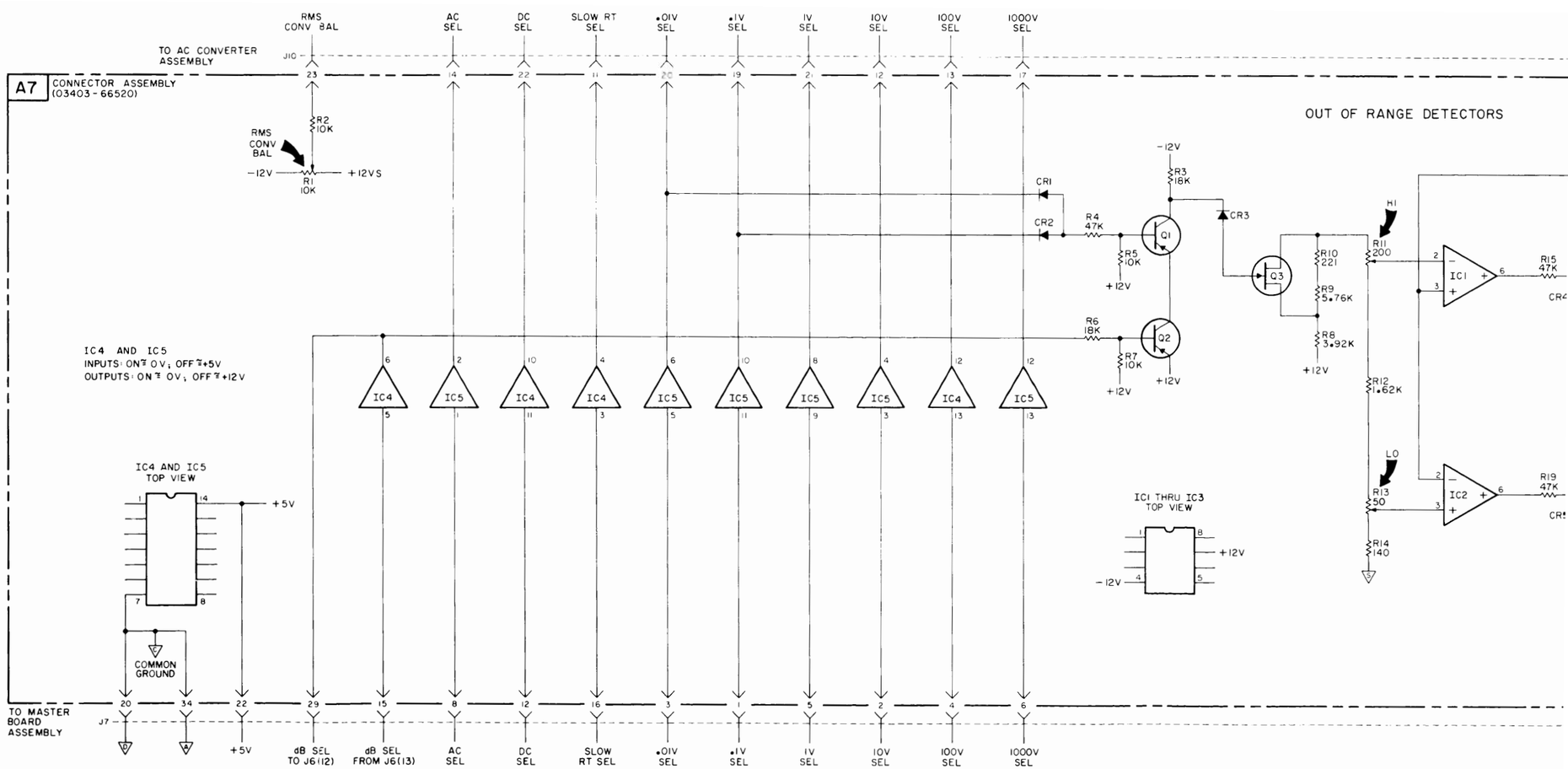
A7

hp Part No. 03403-66520

Rev. C



3403A-E-2437



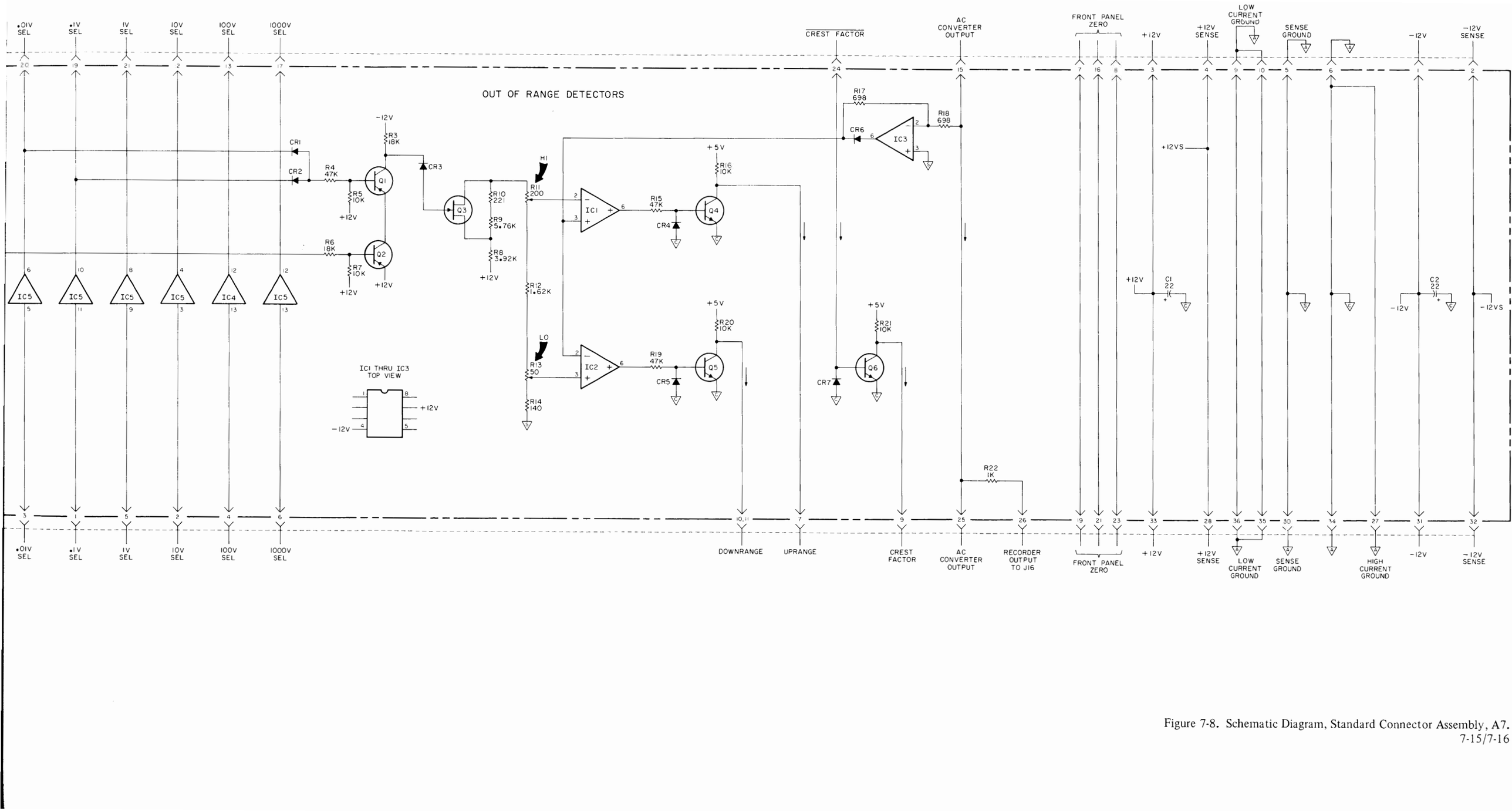


Figure 7-8. Schematic Diagram, Standard Connector Assembly, A7.

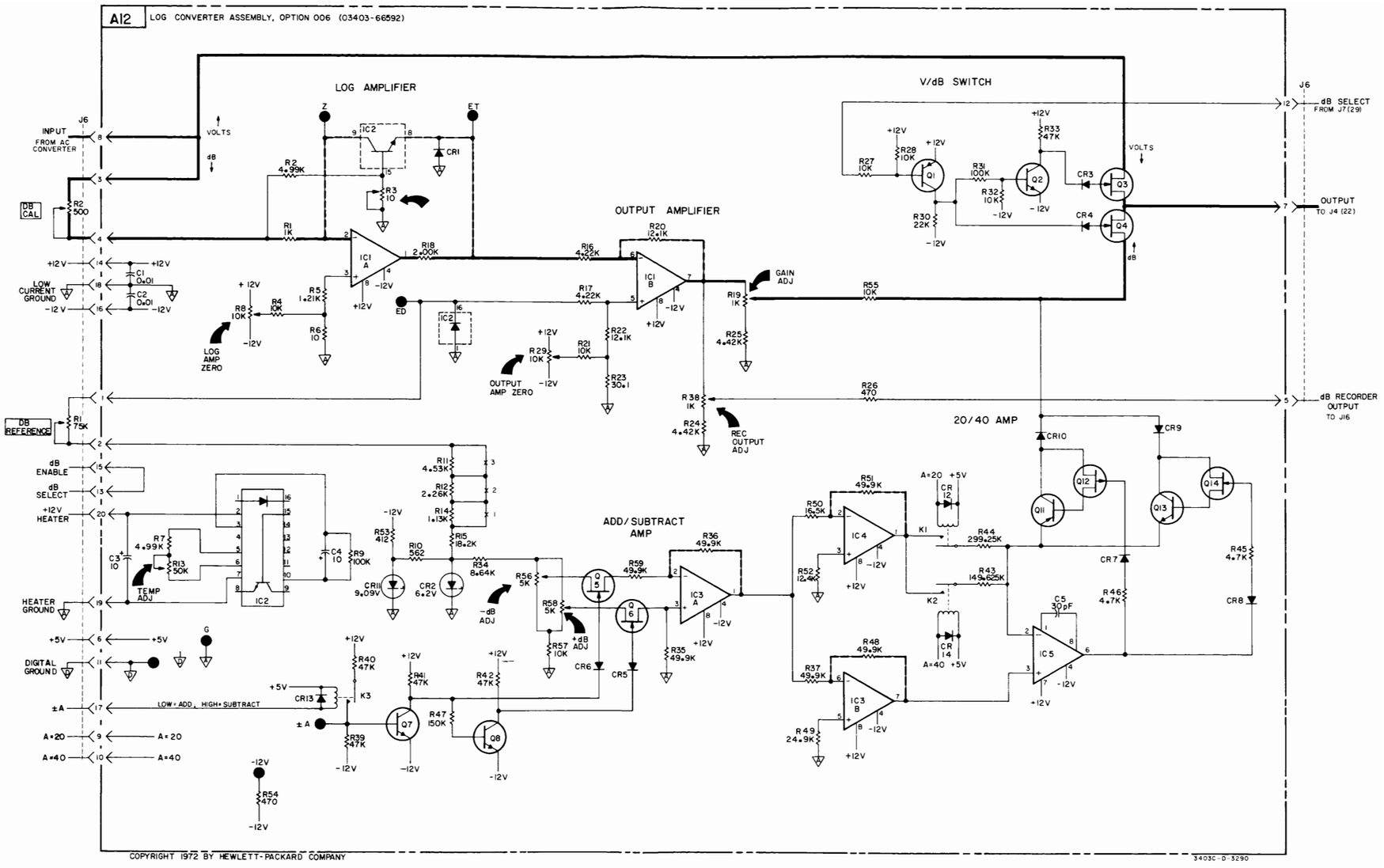
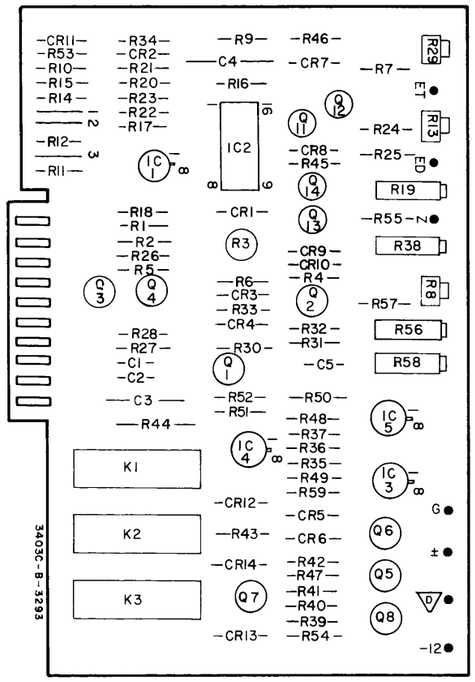
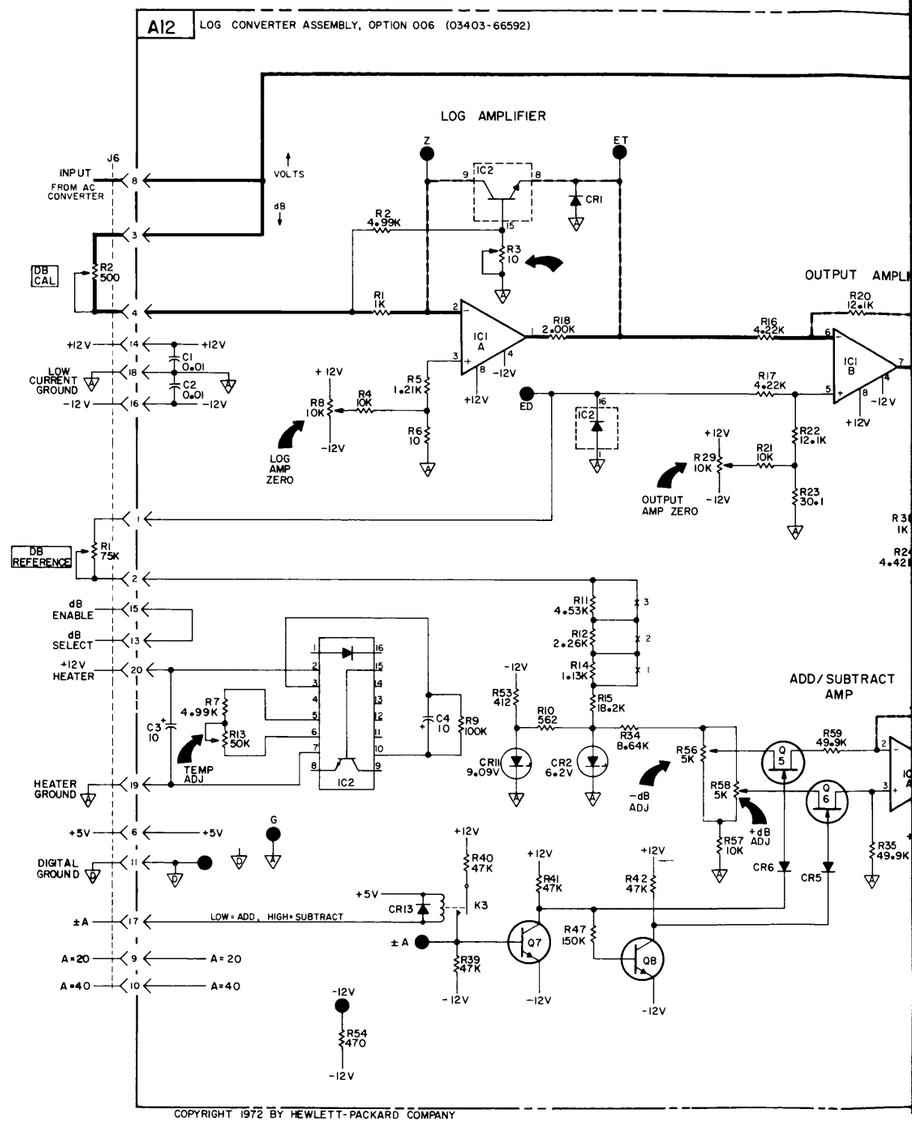
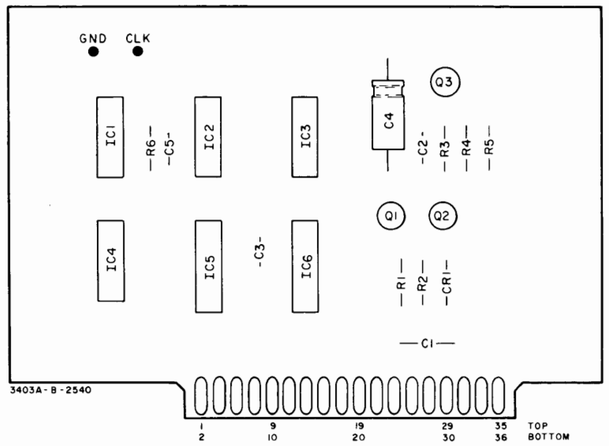


Figure 7-9. Schematic Diagram, Log Converter, A12.
Rev. A 7-17/7-18

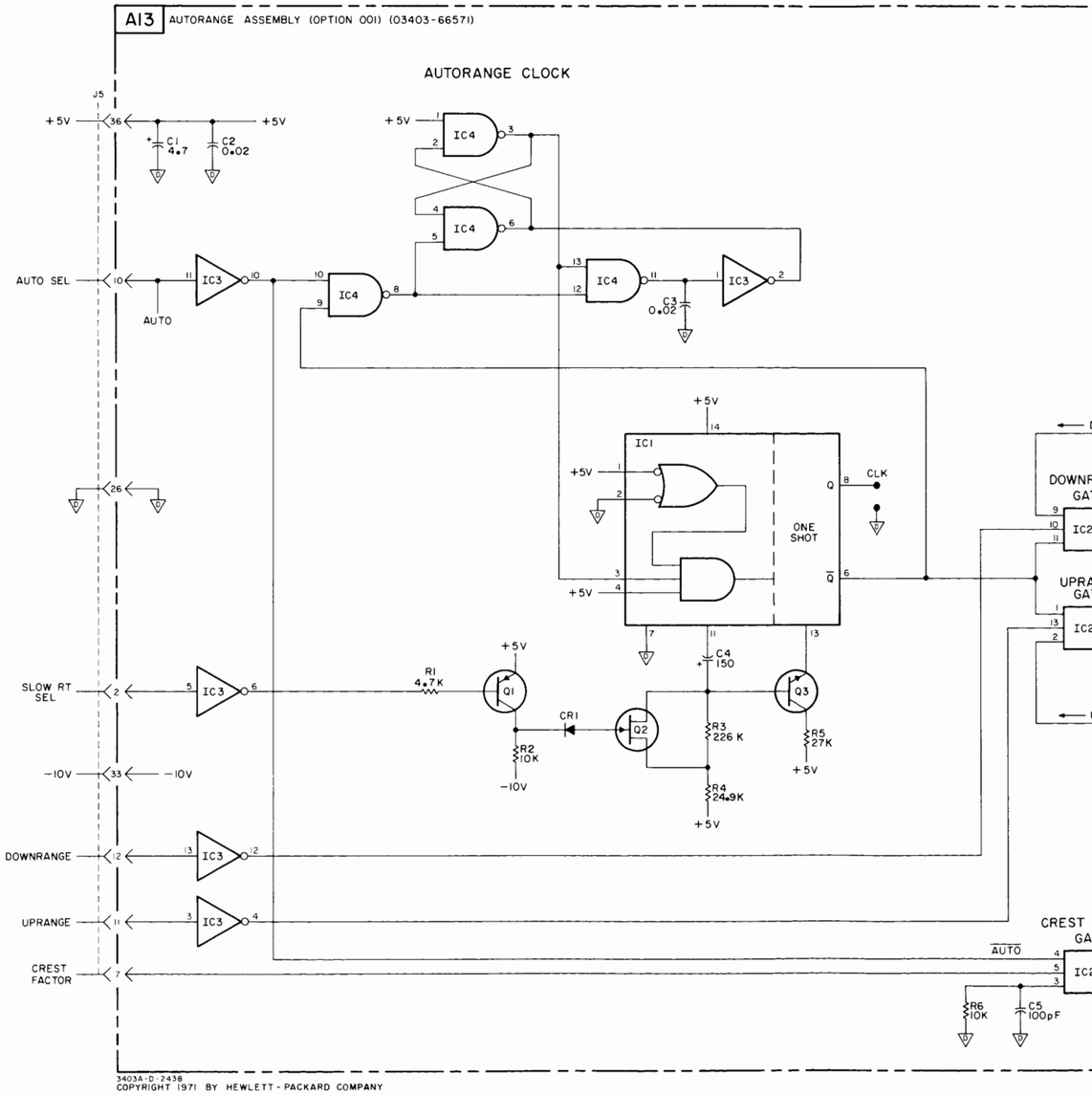

A12
hp Part No. 03403-66592
Rev A

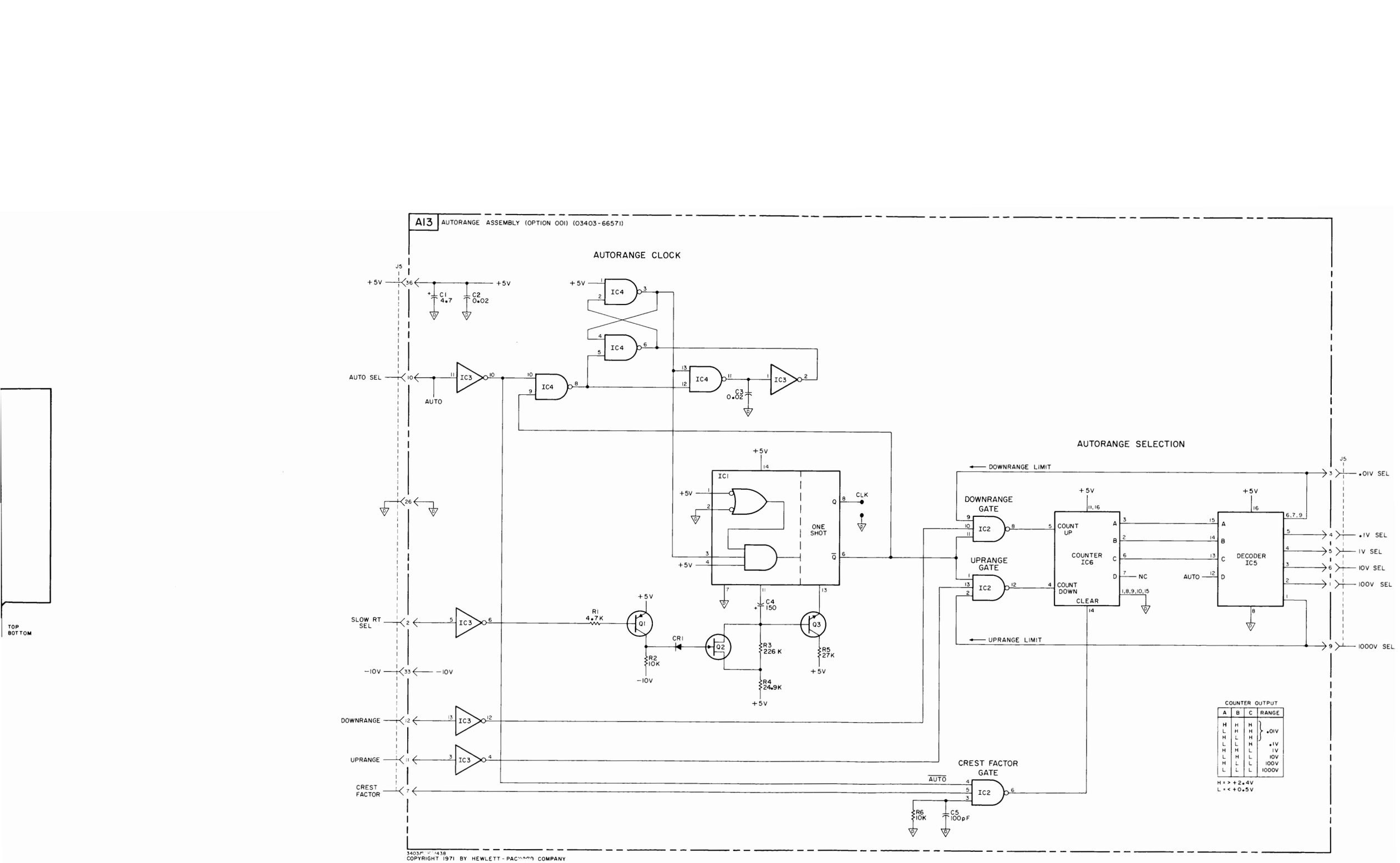

A12
LOG CONVERTER ASSEMBLY, OPTION 006 (03403-66592)
LOG AMPLIFIER
OUTPUT AMPL
ADD/SUBTRACT AMP
INPUT FROM AC CONVERTER
VOLTS
dB
DB CAL
LOW CURRENT GROUND
LOG AMP ZERO
OUTPUT AMP ZERO
DB REFERENCE
dB ENABLE
dB SELECT
+12V HEATER
HEATER GROUND
DIGITAL GROUND
TEMP ADJ
-dB ADJ
+dB ADJ
LOW=ADD, HIGH=SUBTRACT
A=20
A=40
COPYRIGHT 1972 BY HEWLETT-PACKARD COMPANY



A13

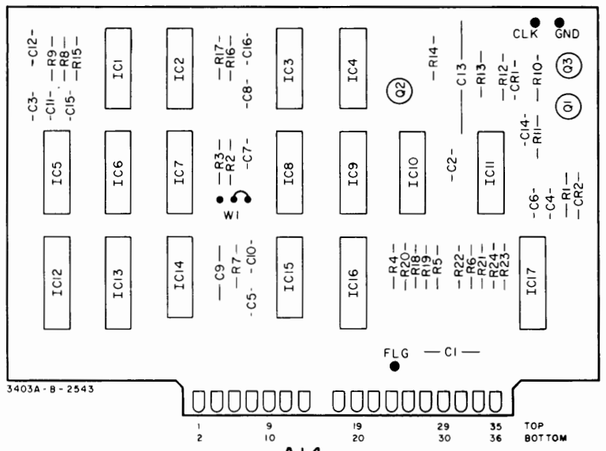
hp Part No. 03403-66571





TOP
BOTTOM

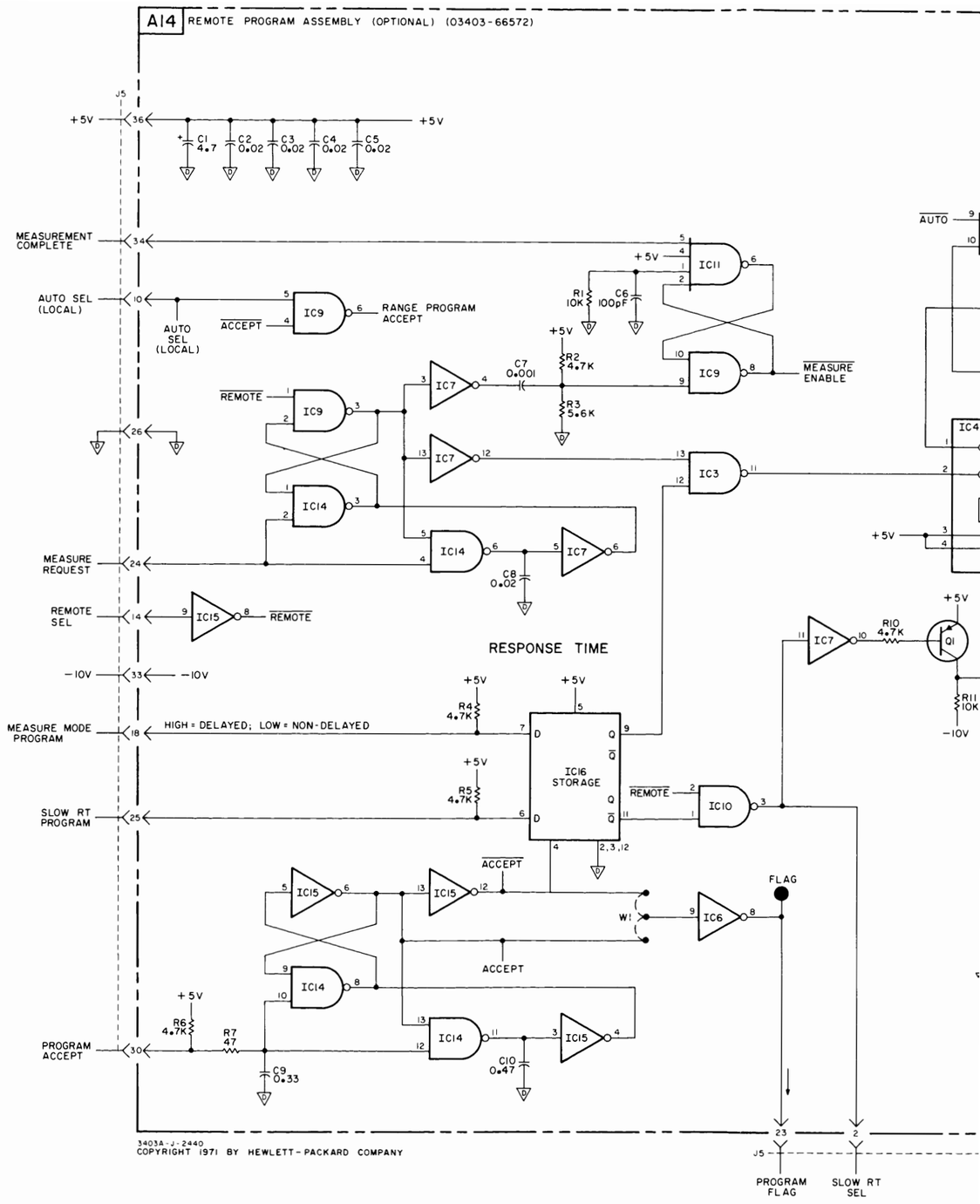
Figure 7-10. Schematic Diagram, Autorange Assembly, A13.



A14

hp Part No. 03403-66572

Rev. B



A14 REMOTE PROGRAM ASSEMBLY (OPTIONAL) (03403-66572)

AUTORANGE CLOCK

DOWNRANGE GATE

UPRANGE GATE

RESPONSE TIME

IC1-11,14,15 TOP VIEW

IC12,13,16,17 TOP VIEW

AUTORANGE CLOCK

DOWNRANGE GATE

UPRANGE GATE

REMOTE AND AUTO RANGE SELECTION

COUNTER OUTPUT

A	B	C	RANGE
H	H	H	.01V
L	H	H	
H	L	H	
L	L	H	.1V
H	H	L	1V
L	H	L	10V
H	L	L	100V
L	L	L	1000V

H = > +2.4V
L = < +0.5V

COUNTER PRESET

REMOTE FUNCTION SELECTION

ONE SHOT

IC12,13,16,17 TOP VIEW

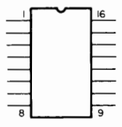
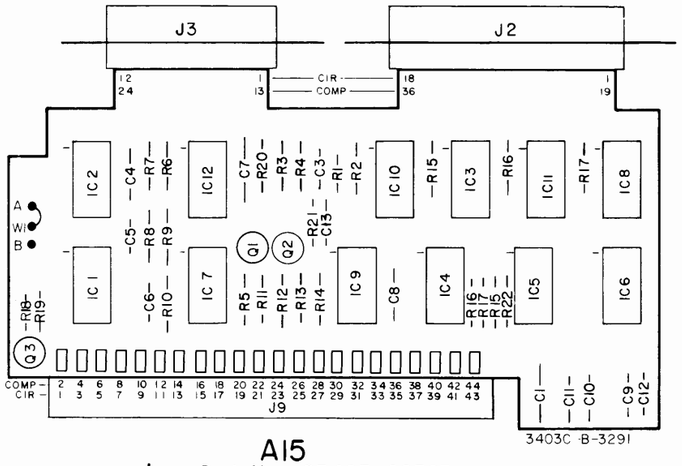


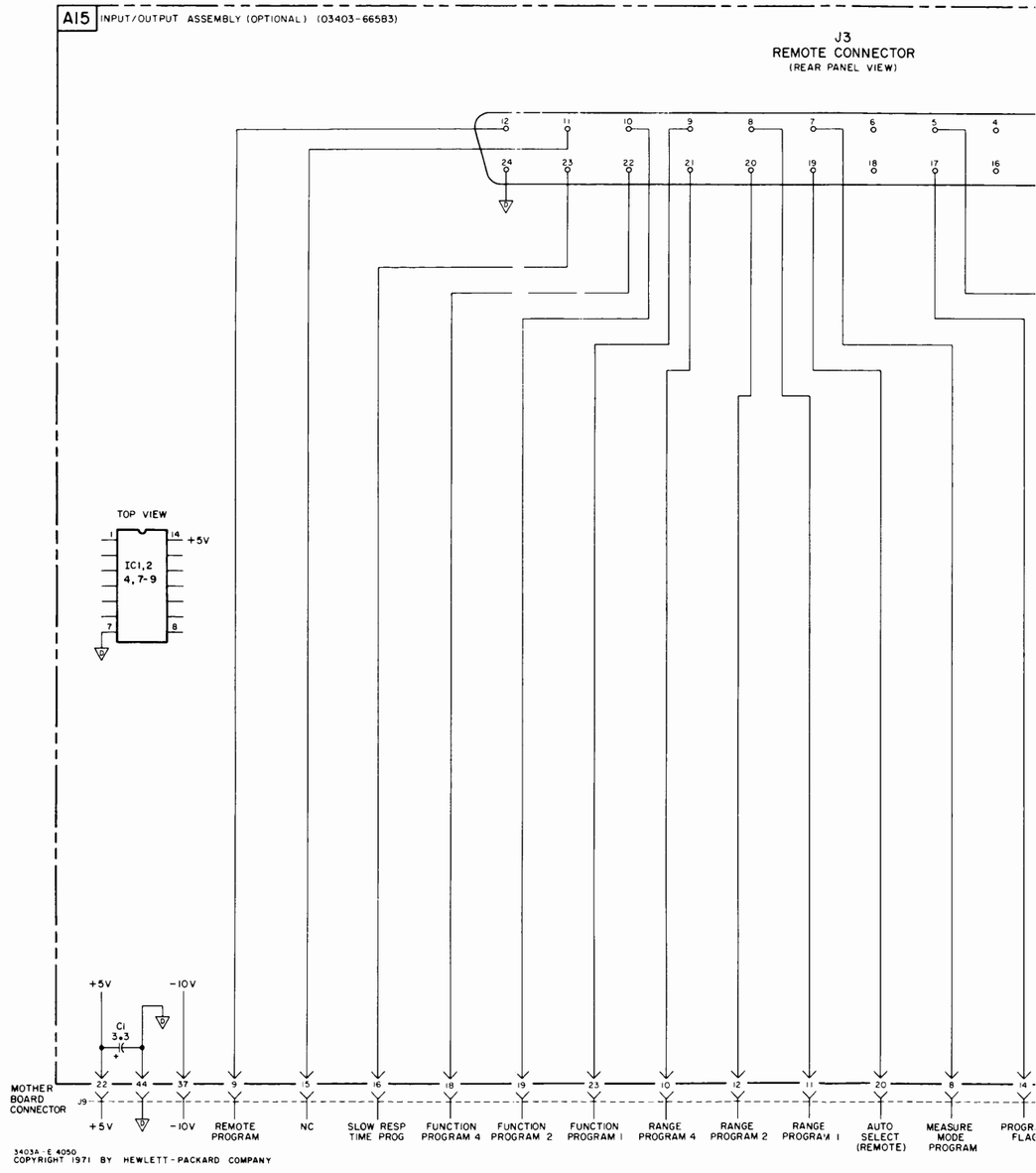
Figure 7-11. Schematic Diagram, Remote and Autorange Assembly, A14.
Rev. A 7-21/7-22

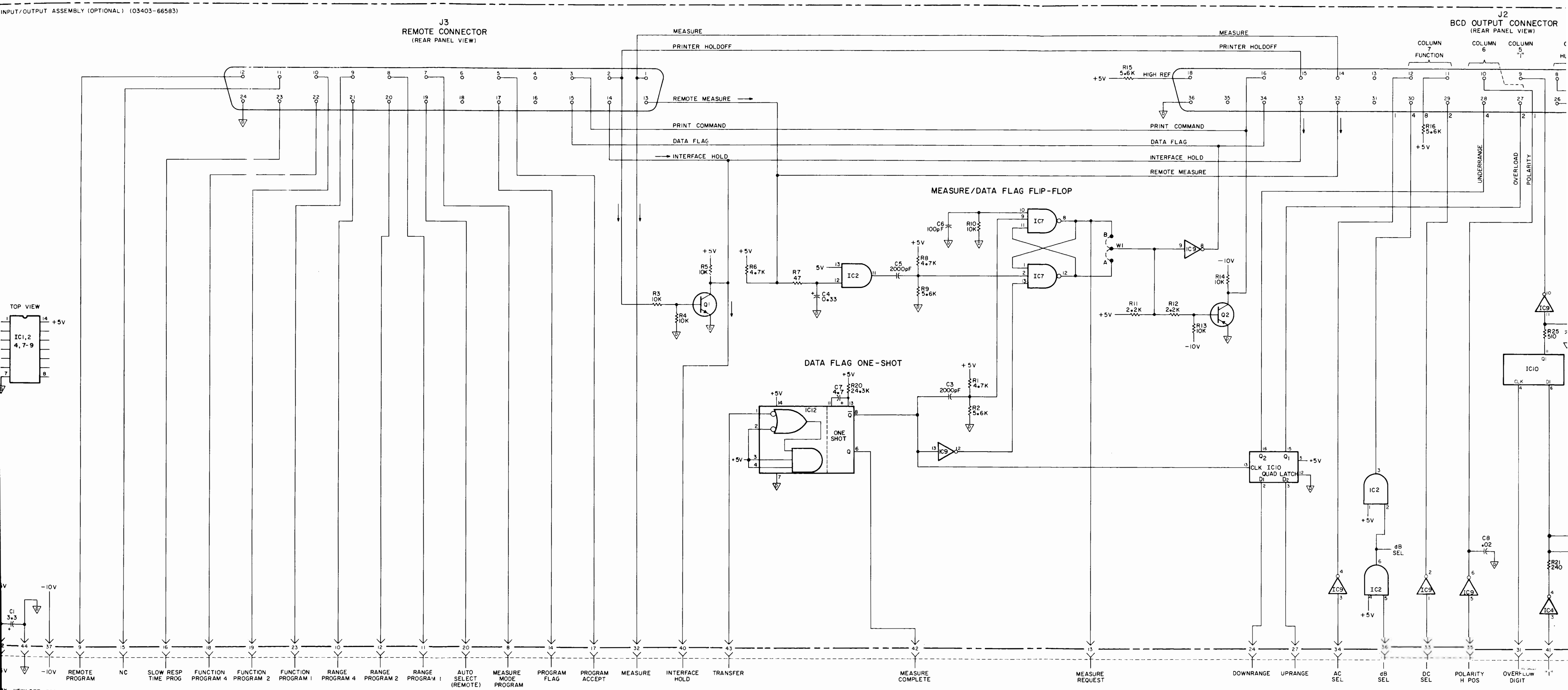


A15

hp Part No. 03403-66583

Rev. B




INPUT/OUTPUT ASSEMBLY (OPTIONAL) (03403-66583)
J3
REMOTE CONNECTOR
(REAR PANEL VIEW)
J2
BCD OUTPUT CONNECTOR
(REAR PANEL VIEW)
MEASURE
PRINTER HOLDOFF
REMOTE MEASURE
PRINT COMMAND
DATA FLAG
INTERFACE HOLD
MEASURE/DATA FLAG FLIP-FLOP
DATA FLAG ONE-SHOT
ONE SHOT
TOP VIEW
IC1,2 4,7-9
QUAD LATCH
HIGH REF
COLUMN 7 FUNCTION
COLUMN 6
COLUMN 5
UNDERRANGE
OVERLOAD
POLARITY
REMOTE PROGRAM
NC
SLOW RESP TIME PROG
FUNCTION PROGRAM 4
FUNCTION PROGRAM 2
FUNCTION PROGRAM 1
RANGE PROGRAM 4
RANGE PROGRAM 2
RANGE PROGRAM 1
AUTO SELECT (REMOTE)
MEASURE MODE PROGRAM
PROGRAM FLAG
PROGRAM ACCEPT
MEASURE
INTERFACE HOLD
TRANSFER
MEASURE COMPLETE
MEASURE REQUEST
DOWNRANGE
UPRANGE
AC SEL
dB SEL
DC SEL
POLARITY H POS
OVERFLOW DIGIT
"1"
HEWLETT-PACKARD COMPANY

J2
BCD OUTPUT CONNECTOR
(REAR PANEL VIEW)

MEASURE
PRINTER HOLDOFF
PRINT COMMAND
DATA FLAG
INTERFACE HOLD
REMOTE MEASURE

COLUMN 7 FUNCTION
COLUMN 6
COLUMN 5 "1"
COLUMN 4 HUNDREDS
COLUMN 3 TENS
COLUMN 2 UNITS
COLUMN 1 DATA MULTIPLIER

R15 5.6K HIGH REF +5V
R16 5.6K +5V
R17 5.6K +5V

UNDERRANGE
OVERLOAD
POLARITY

MEASURE/DATA FLAG FLIP-FLOP

DATA FLAG ONE-SHOT

ONE SHOT

IC10 QUAD LATCH

RANGE ENCODING

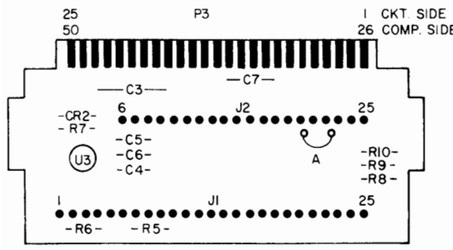
dB SEL

NC

MEASURE COMPLETE
MEASURE REQUEST
DOWNRANGE
UPRANGE
AC SEL
dB SEL
DC SEL
POLARITY H POS
OVERFLOW DIGIT
"1"
HUNDREDS
"2"
TENS
"4"
UNITS
"8"
•01V SEL
•1V SEL
1V SEL
10V SEL
100V SEL
1000V SEL

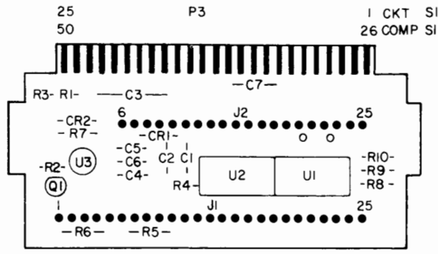
Figure 7-12. Schematic Diagram, Input/Output Assembly, A15.
Rev. B 7-23/7-24

STANDARD

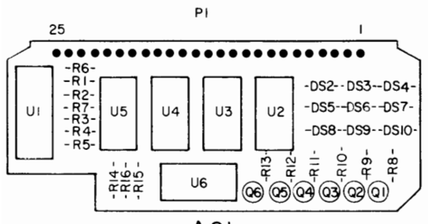


A20
hp Part No. 5061-0747

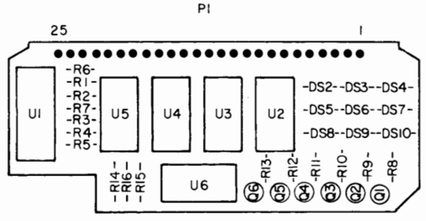
WITH EXTERNAL TRIGGER



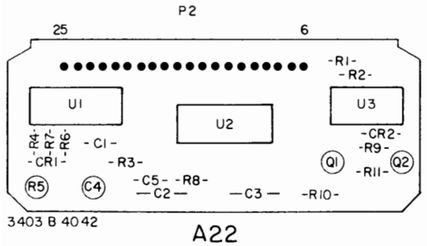
A20
hp Part No. 5061-0741



A21
hp Part No. 5061-0740

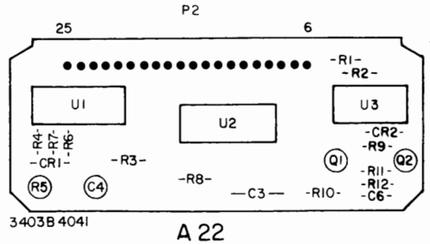


A21
hp Part No. 5061-0740



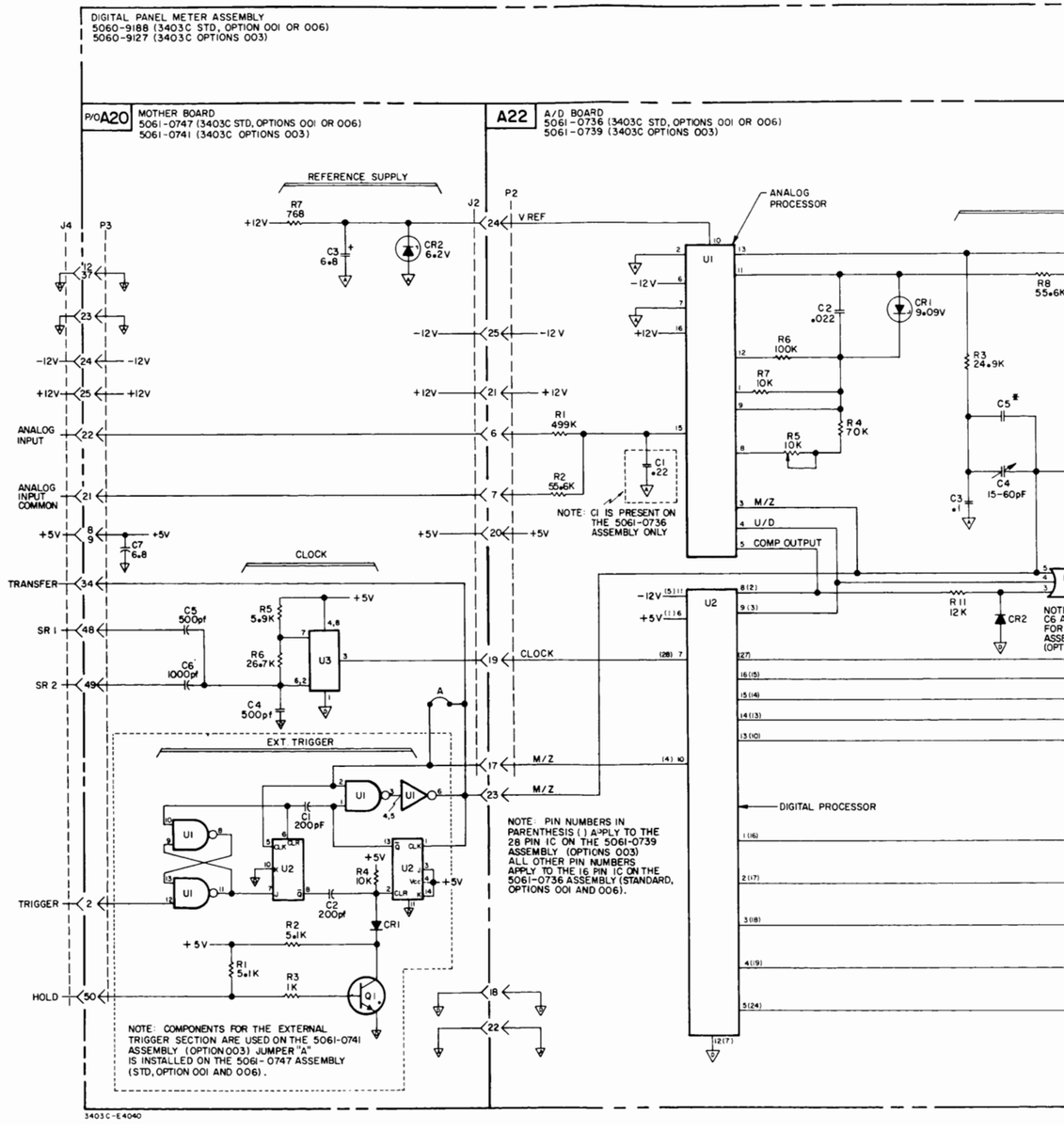
3403 B 4042

A22
hp Part No. 5061-0736



3403B 4041

A 22
hp Part No. 5061-0739



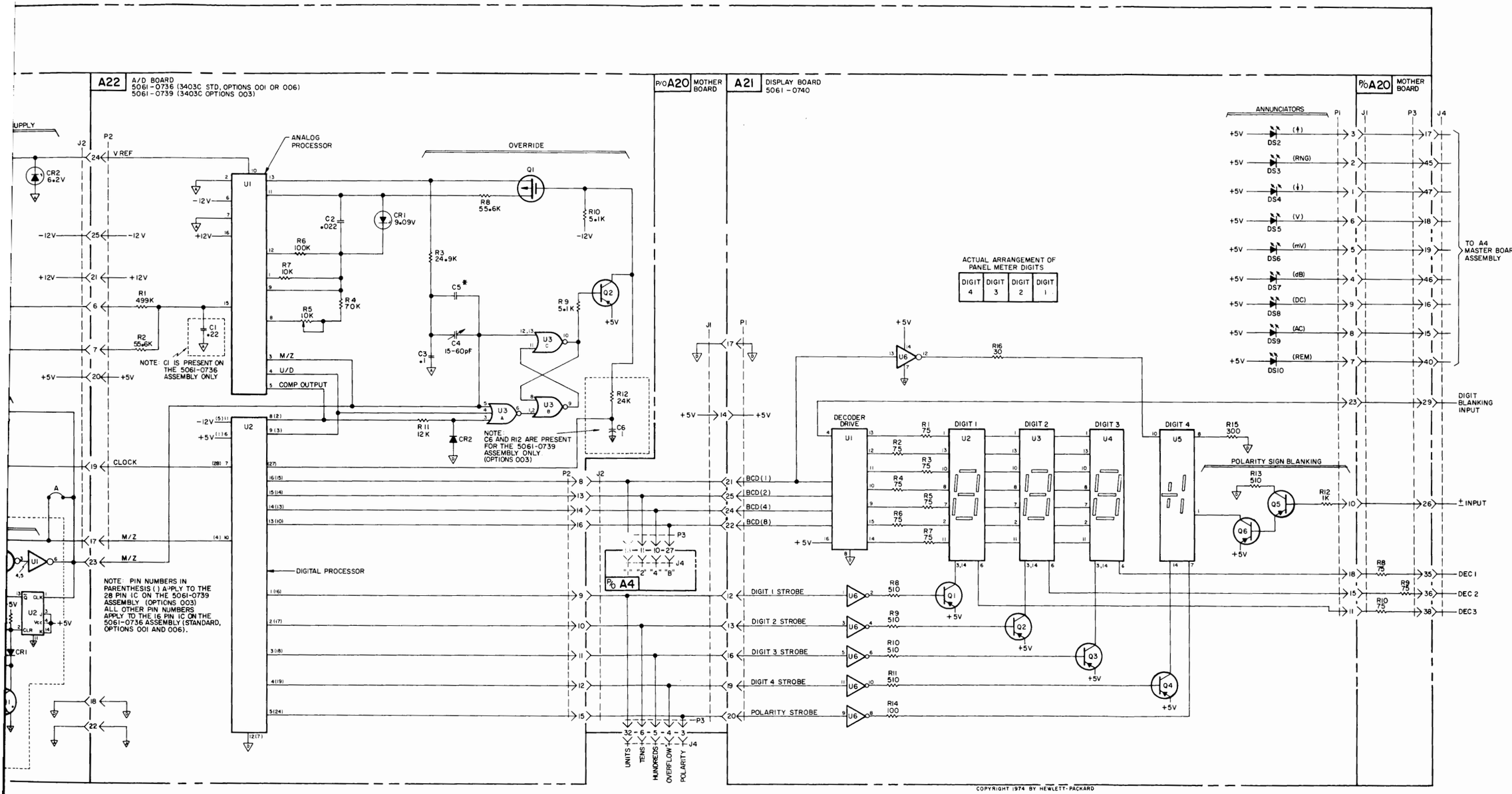


Figure 7-13. Schematic Diagram, Digital Panel Meter, A20, A21, A22.
Rev. A 7-25/7-26

the integrator. Switch Q112 is also closed, allowing the integrating capacitor to charge. The charge period lasts for approximately 33 ms, or 1000 cycles of the panel meter clock. The zero detect amplifier operates in a very high-gain configuration during the charge and discharge periods; consequently, a very small input voltage causes its output to be saturated. This amplifier is also non-inverting.

4-25. Discharge Period. At the end of the charge period, Q107 opens and a reference voltage, opposite in polarity to the input voltage, is applied to the integrator through Q108 or Q109. The integrating capacitor then discharges at a linear rate. When the voltage across the capacitor reaches zero, the output of the zero detect amplifier saturates in the opposite direction, initiating a transfer pulse which causes the count at this point to be transferred to the display. The discharge period continues for a total of 2000 clock cycles.

4-26. Auto Zero Period. Following the discharge period, switches Q110, Q111 and Q113 close, placing both amplifiers in a unity-gain configuration and grounding the input to the integrator. This discharges the integrating capacitor. Any offset present in the output of the integrating amplifier is stored on the auto zero capacitor; then, during the following measurement, this voltage is applied to the inverting input to the integrator and effectively cancels the amplifier offset.

4-27. Clock and Counters.

4-28. A free-running multivibrator provides a 30 kHz clock signal to a series of three decade counters, which count on the negative-going edge of the clock pulse. The clock operates continuously, and the signal to the counters is interrupted only during a transfer pulse. This prevents a count uncertainty that would arise if the transfer pulse occurred at the same time as the negative-going edge of the clock pulse. Counting is also continuous (unless interrupted by the 1 μs transfer pulse) and the D output pulse from the third, or hundreds, counter is used to clock the timing logic. This pulse occurs at the 1000th count. The next clock pulse sets all three counters to zero. The discharge period begins at one of these points, and the count accumulated between that point and zero detect is transferred to the display.

4-29. Display.

4-30. Three dot-matrix light-emitting diode (LED) units make up the three-digit display, and the overrange "1" is in

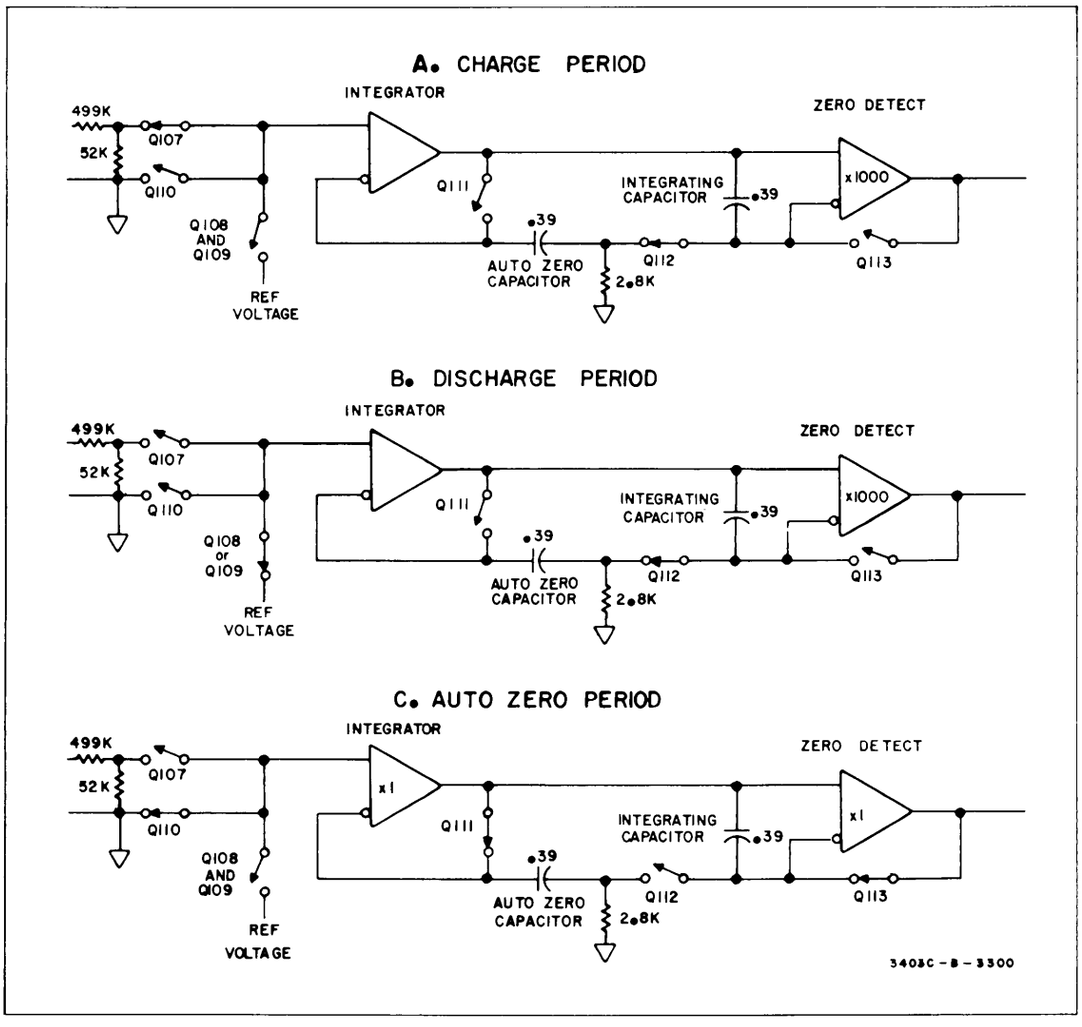


Figure 4-3. Panel Meter Analog Circuits.

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 that applies to the serial number in question.

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 Figure VI. These parts are identified by the symbol Δ.

CHANGE NO. 1:

Applies to Instrument Serial Numbers 1303A01000 and below.

Section IV. Replace Paragraphs 4-18 through 4-45 and Figures 4-1 through 4-5 with the following Paragraphs 4-18 through 4-38 and Figures 4-1 through 4-4:

4-18. DIGITAL PANEL METER.

4-19. Figure 4-2 is a block diagram of the Digital Panel Meter. The following paragraphs describe operation of the various circuits shown.

4-20. Measurement Technique.

4-21. The Digital Panel Meter uses the dual-slope integration method of analog-to-digital conversion. The integrator charges toward a voltage proportional to the input voltage for a fixed time as shown in Figure 4-1. Consequently, the charging rate and resulting charge are proportional to the input voltage. The integrator is then discharged at a fixed rate toward a known reference voltage. Since the discharge rate is constant, the time required to discharge to zero is proportional to the amplitude of the charge (and the input voltage). The counters accumulate the number of clock pulses received between the start of discharge and zero detect, and this number is displayed as the measurement amplitude.

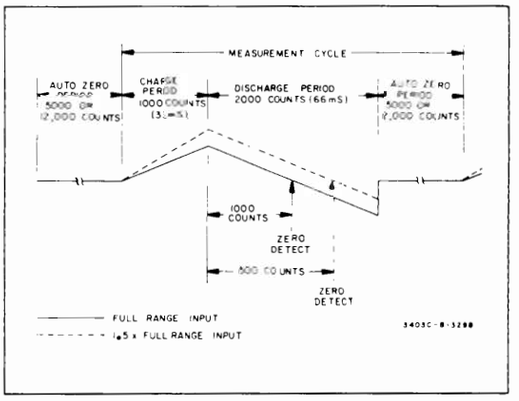


Figure 4-1. Panel Meter Measurement Cycle.

4-22. Analog Circuits.

4-23. The analog circuits consist of an integrating amplifier and a zero detect comparator amplifier, together with the FET switches needed to control operation of these amplifiers. Simplified diagrams of the analog circuits in the three states required for measurement are shown in Figure 4-3.

4-24. Charge Period. Prior to the beginning of the charge period, the integrating capacitor is discharged and the inputs to both amplifiers are at zero. At the start of the charge period, the panel meter input (divided by 10) is applied through switch Q107 to the non-inverting input of

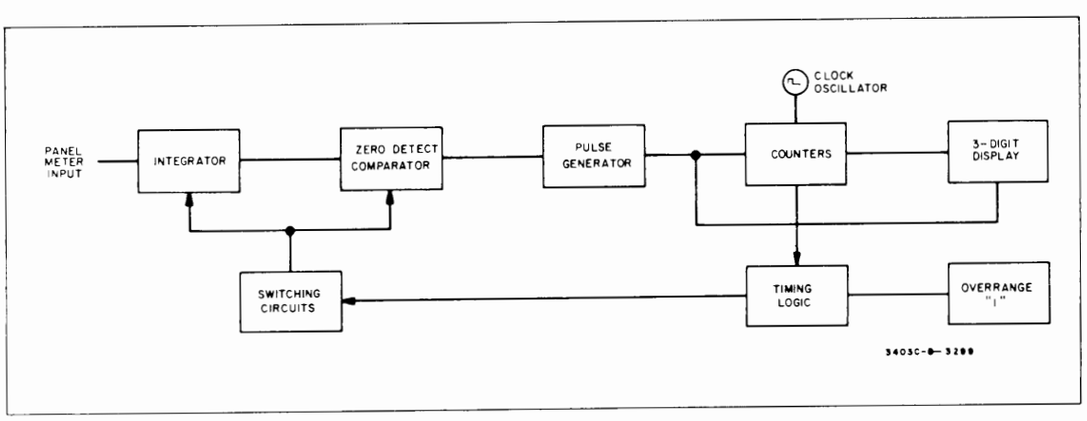


Figure 4-2. Panel Meter Block Diagram.

a fourth unit which also contains the polarity symbol. The three units decode the BCD count information to light the proper LED dots in the matrix. The transfer pulse produced at the time of zero detect enables the information to be transferred to the matrix. If zero detect occurs after the first 1000 counts in the discharge period, a signal from the timing logic causes the overrange "1" to light. If the 3403C input is above 190% of range or below 17% of range, a signal from the A4 logic circuits causes the three-digit to blank.

4-31. Polarity Display.

4-32. If AC or DC + AC volts function is selected, a signal from the A4 logic circuits blanks the polarity display. When the DC function is selected, the horizontal bar of the polarity symbol is lit continuously. If the polarity of the zero detect amplifier during the charge period is positive, the vertical bar also lights. The zero detect amplifier output is inverted by a clipper circuit and applied to the polarity flip-flop. This is a D flip-flop which is clocked at the end of the charge period, allowing the polarity display to change only at this time.

4-33. Logic Timing.

4-34. Timing Circuits. Timing of the measurement cycle is controlled by the timing counter and a BCD-to-decimal decoder. The timing counter is a synchronous 4-bit counter which triggers on the positive-going edge of the clock pulse. A clock pulse received while the Clear input is LOW resets all four outputs to LOW. A LOW level at the Preset input also disables the counter, and a clock pulse during this time presets the four outputs to agree with the data inputs. A number of gates are also associated with the counter and decoder.

4-35. Internal Trigger Operation. Figure 4-4 shows the significant timing counter and decoder signals during a complete measurement period when the Response Time control is set to Fast. The D output of the hundreds decade counter is inverted and applied to the clock input of the timing counter, clocking this counter at the end of every 1000th count received by the decade counters. At the end of the auto zero period, all four counter outputs are set to zero (LOW). This results in a LOW Charge output from the decoder which switches the integrator to the charge state. The timing counter then counts the next two clock pulses and the decoder outputs switch the integrator to the discharge state for these two counts. During the last half of the discharge period, the L Discharge 2 signal causes the counter Preset input to be LOW, through AND gate U208B (see Figure 7-13). The next clock pulse presets the counter, which then counts in a binary manner during the auto zero period. When the D output goes HIGH, this output (through NAND gate U509A) clears the counter to zero at the next clock pulse, beginning another charge period. If the Response Time control is set to Slow, NAND gates U509A, B, and C are disabled and the counter does not receive a Clear signal. In this case, the timing counter continues counting through 1111 to 0000 to begin another charge period. This lengthens the auto zero period, making the total measurement cycle 1/2 second.

4-36. External Trigger Operation. When the remote control Interface Hold line is held LOW, the Panel Meter waits in the auto zero state until a Measure command is received. A Measure command causes the Clear input to the timing counter to be LOW. A Measure command also resets the three decade counters to the "9" state so that the next clock oscillator pulse becomes the 1000th count, providing a clock pulse to the timing counter. This clears the timing counter to zero, beginning a charge period. At the end of the discharge period, the L Discharge 2 signal causes a LOW Preset input to the counter. L Hold again goes LOW, continuing the LOW Preset input. The instrument is again in the auto zero state, waiting for another Measure command.

4-37. FET Switch Drive.

4-38. Gated signals from the timing logic and the polarity flip-flop provide drive signals to the FET switches in the integrator and zero detect circuits. The drive signals turn on the FET switches at the proper times during the measurement cycle (see Paragraph 4-22).

Section V. Replace Paragraphs 5-56 and 5-57 with the following:

5-56. DIGITAL PANEL METER ADJUSTMENTS.

5-57. All preceding adjustments (with the exception of the High Frequency Adjustments if required test equipment is not available) must be completed before performing the Digital Panel Meter Adjustments, unless these adjustments are being performed as a result of the check given in Paragraph 5-36. A dc standard (-hp- 740B) and a dc differential voltmeter (-hp- 3420A/B) are required for these adjustments.

a. Set 3403C FUNCTION to DC, RANGE to 1 V, RESPONSE TIME to FAST.

b. Connect dc differential voltmeter to rear panel VOLTS analog output terminals.

c. Connect dc standard to 3403C input. Adjust standard output for differential voltmeter reading of + 1.5005 V.

d. Adjust A20 R212 (+ Cal) so that 3403C display alternates equally between + 1.500 and + 1.501.

e. Reverse polarity of dc standard output and adjust for differential voltmeter reading of - 1.5005 V.

f. Adjust A20 R211 (- Cal) so that 3403C display alternates equally between - 1.500 and - 1.501. Disconnect differential voltmeter and dc standard.

Section V. Replace Paragraphs 5-92 through 5-97 with the following Paragraphs 5-92 and 5-93:

5-92. REPLACEMENT OF DS2 THROUGH DS10.

5-93. It is unlikely that the annunciator light emitting diodes DS2 through DS10 will fail. However, if any needs to be replaced, -hp- Part Number 1990-0419 should be used. This LED is smaller in diameter than the older part, -hp- 1990-0410. If a LED fails in an annunciator containing any of the older diodes, these should be replaced with the newer part. The following procedure should be used when re-installing the annunciator housing:

a. A piece of plastic tubing 3/16 inch long, with inside diameter of .15 inch and outside diameter of .19 inch, must be provided. This may be obtained by ordering -hp- Part Number 5000-9540, or it may be cut from a piece of tubing available as -hp- Part Number 0890-0023.

b. Determine voltage change necessary to bring reading to between - 7 and - 10 mV.

c. Use Table 5-9 to determine which jumper positions should be open.

d. Proceed with adjustment procedures in Paragraph 5-55.

Section V. Foldouts. Replace Figure 5-7, Panel Meter Troubleshooting Tree, with backdated Figure 5-7.

Section VI, Table 6-1, Replaceable Parts. Delete A15C9, C10, C11 and C12. Change the following IC Part No's. as follows:

Desig	Part No.	Description
IC3	1820-0304	IC:TTL J-K M/X F/F w/clocked & inputs
IC4, 8	1820-0174	IC:DGTL INVERTER
IC5, 6, 11	1820-0055	IC:TTL DECADE COUNTER 10 MHz MIN.
IC10	1820-0665	IC:DTL 4-bit latch

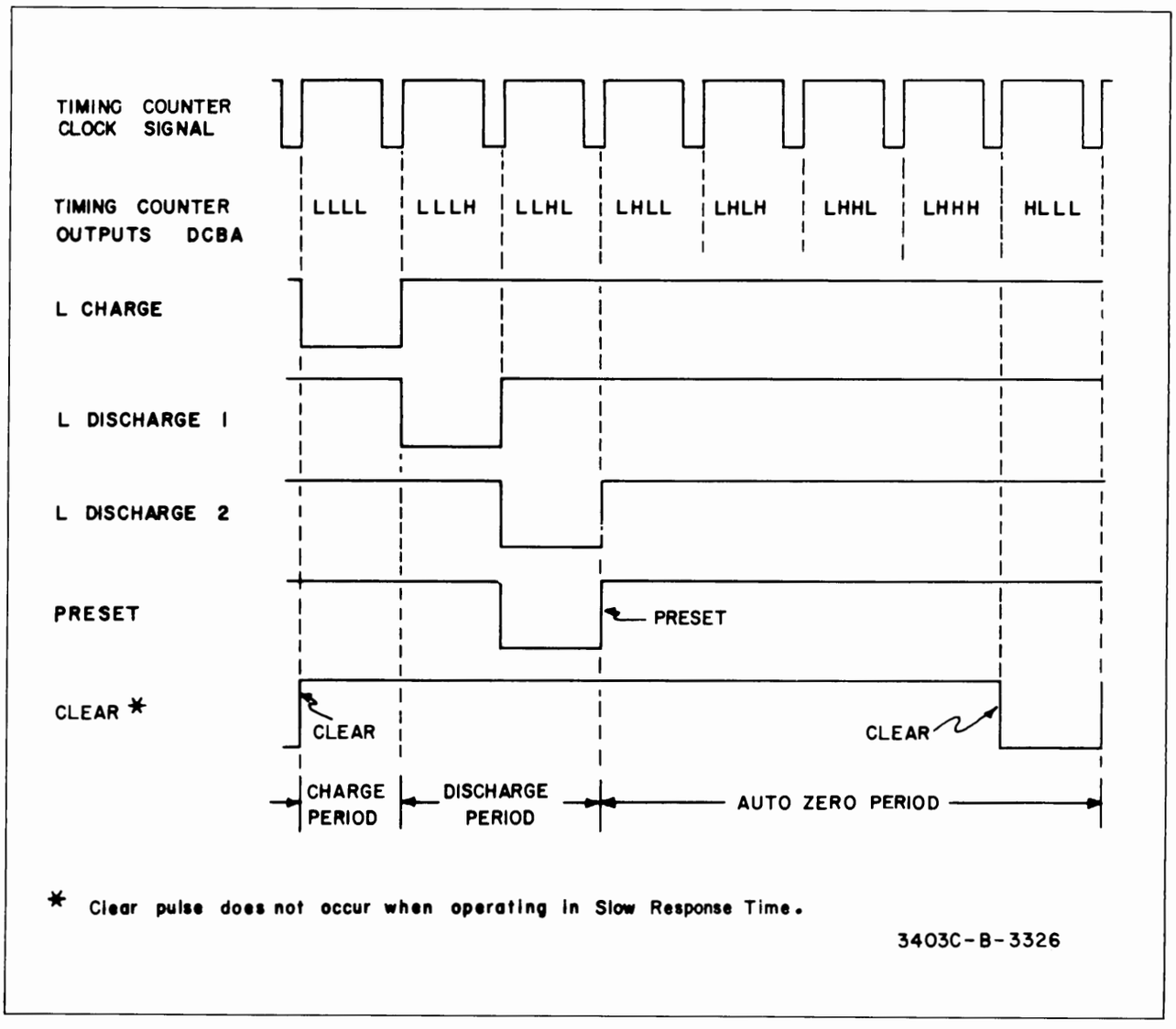


Figure 4-4. Timing Counter and Decoder Signals.

Section VI, Table 6-1, Replaceable Parts. Add MP42, 5020-6896, Insulator:Panel Meter Assembly. Replace parts list and assemblies for A20 (Mother Bd), A21 (Display Bd) and A22 (A/D Bd) with the following A20, 5060-9133, Panel Meter Assembly and associated parts list:

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A20	5060-9133	1	PANEL METER ASSEMBLY (DOES NOT INCLUDE CASE OR DISPLAY UNITS U414, U415, U416 OR U417)	28480	5060-9133
A20C103, 4	0160-3826	2	C:FXD POLY 0.39 UF 10% 50VDCW	28480	0160-3826
A20C105*	0150-0011		C:FXD 1.5 PF 500V	95121	TYPE QC
A20C104	0160-3826		C:FXD POLY 0.39 UF 10% 50VDCW	28480	0160-3826
A20C201	0150-0093		C:FXD CER 0.01 UF +80-20% 100VDCW	72982	8C1-K8C0011
A20C401	0160-0569	1	C:FXD 3000 PF	28480	0160-0569
A20C501	0160-3847	2	C:FXD CER 0.01 UF +100-10% 25VDCW	72982	8005-Q1ACB-W5R-1C3P
A20C502	0160-3847		C:FXD CER 0.01 UF +100-10% 25VDCW	72982	8005-Q1ACB-W5R-1C3P
A20C503	0150-0071	1	C:FXD CER 400 PF 5% 1000VDCW	56289	C016B102E401JS27-COH
A20CR101	1902-0072	1	DIODE:BREAKDOWN 2% 7.87V 400MW	28480	1902-0072
A20CR102	1910-0016	1	DIODE:GE 60 MIV	28480	1910-0016
A20CR103	1901-0040		DIODE:SILICON 50 MA 30 MV	07263	FDG1088
A20CR104	1902-0048	1	DIODE:BREAKDOWN 6.81V 5%	04713	SZ1C939-134
A20CR105	1901-0040		DIODE:SILICON 50 MA 30 MV	07263	FDG1088
A20CR107	1902-3149		DIODE BREAKDOWN:9.09V 5%	28480	1902-3149
A20CR108	1902-0686	1	DIODE BREAKDOWN:6.2V 2%	04713	1N825
A20CR201	1901-0040		DIODE:SILICON 50 MA 30 MV	07263	FDG1088
A20CR202	1901-0518	1	DIODE:HOT CARRIER	28480	1901-0518
A20CR203	1902-3002	1	DIODE BREAKDOWN:2.37V 5%	28480	1902-3002
A20DS2	1990-0419	9	DIODE:VISIBLE LIGHT EMITTER	28480	1990-0419
A20DS3	1990-0419		DIODE:VISIBLE LIGHT EMITTER	28480	1990-0419
A20DS4	1990-0419		DIODE:VISIBLE LIGHT EMITTER	28480	1990-0419
A20DS5	1990-0419		DIODE:VISIBLE LIGHT EMITTER	28480	1990-0419
A20DS6	1990-0419		DIODE:VISIBLE LIGHT EMITTER	28480	1990-0419
A20DS7	1990-0419		DIODE:VISIBLE LIGHT EMITTER	28480	1990-0419
A20DS8	1990-0419		DIODE:VISIBLE LIGHT EMITTER	28480	1990-0419
A20DS9	1990-0419		DIODE:VISIBLE LIGHT EMITTER	28480	1990-0419
A20DS10	1990-0419		DIODE:VISIBLE LIGHT EMITTER	28480	1990-0419
A20MP1	1200-0462	32	SOCKET:IC CONTACT	00779	3-116141-2
A20MP2	5020-6897	1	HEAT SINK	28480	5020-6897
A20MP3	1460-1366	1	SPRING:COMPRESSION, HEAT SINK	00000	OHD
A20Q101	1855-0388	2	TSTR:SI NPN DUAL	28480	1855-0388
A20Q102	1855-0388		TSTR:SI NPN DUAL	28480	1855-0388
A20Q103	1853-0086		TSTR:SI PNP	80131	2N5087
A20Q104	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A20Q106	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A20Q107	1855-0081	2	TSTR:SI FET	80131	2N5245
A20Q108	1855-0386	4	TSTR:FET N-CHANNEL	80131	2N4392
A20Q109	1855-0386		TSTR:FET N-CHANNEL	80131	2N4392
A20Q110	1855-0081		TSTR:SI FET	80131	2N5245
A20Q111	1855-0412	1	TSTR:FET	28480	1855-0412
A20Q112	1855-0386		TSTR:FET N-CHANNEL	80131	2N4392
A20Q113	1855-0386		TSTR:FET N-CHANNEL	80131	2N4392
A20Q201	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A20Q202	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A20Q203	1853-0086		TSTR:SI PNP	80131	2N5087
A20Q204	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A20Q205	1853-0086		TSTR:SI PNP	80131	2N5087
A20Q206	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A20Q207	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A20Q208	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A20Q209	1853-0020		TSTR:SI PNP(SELECTED FROM 2N3702)	28480	1853-0020
A20Q210	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A20Q211	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A20Q402	1853-0093	1	TSTR:SI PNP	28480	1853-0093
A20Q502	1854-0071		TSTR:SI NPN(SELECTED FROM 2N3704)	28480	1854-0071
A20R101	0698-8312	1	R:FXD FLM 499K OHM 1% 1/8W	28480	0698-8312
A20R102	0698-8313	1	R:FXD FLM 52.3K OHM 1% 1/8W	28480	0698-8313
A20R103	0698-3572	2	R:FXD FLM 60.4K OHM 1% 1/8W	28480	0698-3572
A20R104	0698-3572		R:FXD FLM 60.4K OHM 1% 1/8W	28480	0698-3572
A20R105	0698-4436	1	R:FXD FLM 2.80K OHM 1% 1/8W	28480	0698-4436
A20R106	0698-3558	2	R:FXD MET FLM 4.02K OHM 1% 1/8W	28480	0698-3558
A20R107	0698-3558		R:FXD MET FLM 4.02K OHM 1% 1/8W	28480	0698-3558
A20R108	0757-0290	1	R:FXD MET FLM 6.19K OHM 1% 1/8W	28480	0757-0290
A20R109	0698-3498	1	R:FXD MET FLM 8.66K OHM 1% 1/8W	28480	0698-3498
A20R110	0684-2221		R:FXD COMP 2200 OHM 10% 1/4W	01121	CB 2221
A20R111	0684-1231	1	R:FXD COMP 12K OHM 10% 1/4W	01121	CB 1231
A20R113	0698-3122	1	R:FXD MET FLM 412 OHM 1% 1/8W	28480	0698-3122
A20R114	0757-0417		R:FXD MET FLM 562 OHM 1% 1/8W	28480	0757-0417
A20R115	0698-4486		R:FXD MET FLM 24.9K OHM 1% 1/8W	28480	0698-4486
A20R116	0698-8316		R:FXD FLM 49.9K OHM 1% 1/8W	28480	0698-8316
A20R117	0698-8316		R:FXD FLM 49.9K OHM 1% 1/8W	28480	0698-8316
A20R118	0698-8314	2	R:FXD FLM 215K OHM 1% 1/8W	28480	0698-8314

Table 6-1. Replaceable Parts(Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A20R120	0698-8315	2	R:FXD FLM 3.24K OHM 1% 1/8W	28480	0698-8315
A20R121	0698-8314		R:FXD FLM 215K OHM 1% 1/8W	28480	0698-8314
A20R122	0698-8315		R:FXD FLM 3.24K OHM 1% 1/8W	28480	0698-8315
A20R124	0698-4445	1	R:FXD FLM 5.76K OHM 1% 1/8W	28480	0698-4445
A20R203	1810-0155	2	RESISTIVE NETWORK 5 X 4K OHM 10% 1/4W	56289	200C
A20R204	1810-0155	1	RESISTIVE NETWORK 5 X 4K OHM 10% 1/4W	56289	200C
A20R205	0684-1031.		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A20R206	0683-1535.		R:FXD COMP 15K OHM 5% 1/4W	01121	CB 1535
A20R207	0683-1535.		R:FXD COMP 15K OHM 5% 1/4W	01121	CB 1535
A20R208	0684-1031.		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A20R209	0684-1031		R:FXD COMP 10K OHM 10% 1/4W	01121	CB 1031
A20R210	0684-1021	1	R:FXD COMP 1000 OHM 10% 1/4W	01121	CB 1021
A20R211	2100-2061	2	R:VAR FLM 200 OHM 10% LIN 1/2W	28480	2100-2061
A20R212	2100-2061		R:VAR FLM 200 OHM 10% LIN 1/2W	28480	2100-2061
A20R401	0698-3160	1	R:FXD MET FLM 31.6K OHM 1% 1/8W	28480	0698-3160
A20R402	0757-0468	1	R:FXD FLM 13.3K OHM 1% 1/8W	28480	0757-0468
A20R403	0684-1011	1	R:FXD COMP 100 OHM 10% 1/4W	01121	CB 1011
A20R404	0684-5611	1	R:FXD COMP 560 OHM 10% 1/4W	01121	CB 5611
A20R501	0698-8378	5	R:FXD FLM 150 OHM 5%	28480	0698-8378
A20R502	0698-8378		R:FXD FLM 150 OHM 5%	28480	0698-8378
A20R503	0698-8378		R:FXD FLM 150 OHM 5%	28480	0698-8378
A20R504	0698-8378		R:FXD FLM 150 OHM 5%	28480	0698-8378
A20R505	0698-8378		R:FXD FLM 150 OHM 5%	28480	0698-8378
A20R506	0698-8379	1	R:FXD FLM 3.9K OHM 5% 1/10W	28480	0698-8379
A20U201	1826-0311		IC	04713	MC1458P
A20U208	1920-0511	1	IC:DTL QUAD 2-INPT AND GATE	28480	1920-0511
A20U212	1820-0077	2	IC:TTL SP DUAL EDGE TRIG, D F/F	01295	SN7474N
A20U213	1820-0596		IC:TTL LP DUAL EDGE TRIG, D F/F	12040	DM74L74N
A20U302	1820-0600	3	IC:TTL LP DECADE COUNTER	12040	DM85L90N
A20U303	1820-0600		IC:TTL LP DECADE COUNTER	12040	DM85L90N
A20U304	1820-0600		IC:TTL LP DECADE COUNTER	12040	DM85L90N
A20U401	1820-0207		IC:TTL MONOSTABLE MULTIVIBRATOR	28480	1820-0207
A20U414	1990-0396	1	INDICATOR PCB	28480	1990-0396
A20U415-417+	1990 0496	3	LED DISPLAYS BRIGHTNESS CATEGORY A	28480	1990 0496
	1990 0498		B	28480	1990 0498
	1990 0500		C	28480	1990 0500
	1990-0503		D	28480	1990 0503
	1990-0505		E	28480	1990 0505
	1990 0507		F	28480	1990 0507
	1990 0509		G	28480	1990 0509
A20U505	1820-0713	1	IC:TTL 4-BIT BINARY COUNTER	01295	SN7416N
A20U506	1820-0714	1	IC:TTL BCD TO DEC. DECODER	01295	SN7442N
A20U507	1820-0418	1	IC:DIGITAL DTL QUAD EXCLUSIVE OR GATE	28480	1820-0418
A20U509	1820-0694		IC:DTL QUAD 2-INPUT GATE	04713	SC6503PK
A20U510	1820-0708	1	IC:TTL TRIPLE 3-INPUT POS NAND GATE	12040	SN741CN
A20U511	1820-0584	1	IC:TTL LP QUAD 2-INPT NOR GATE	12040	DM74L02N
	5040-5839	1	HOUSING: ANNUNCIATOR	28480	5040-5839
	03403-24301	1	MASK: ANNUNCIATOR	28480	03403-24301
	5000-9540	1	SLEEVE LED	28480	5000 9540
	5000-9520		INSULATOR	28480	5000-9520
	5020-6871		CASE-EXTRU	28480	5020 6871

+ Numeric displays have one of 7 brightness categories. The brightness category is stamped on back of each display. When replacing displays, identify brightness category and replace with corresponding part number.

Section VII, Paragraph 7-2 and Figure 7-2. Delete Digital Panel Meter assembly numbers A21 and A22.

Section VII, Figure 7-5. Change the following J4 terminal numbers as follows:

Terminal Number	26	15	16	17	45	47	18	19	46	29
Change Number To	2	29	31	33	40	44	35	37	42	8
Terminal Number	35	36	38	49	40					
Change Number To	20	22	26	48	30					

Section VII, Figure 7-6. Replace with Backdated Figure 7-6.

Section VII, Figure 7-9. Change J4 pin number at OUTPUT from 22 to 43.

Section VII, Figure 7-13. Replace Digital Panel Meter schematic with backdated Figure 7-13.

Section VII, Figure 7-12.

Replace Figure 7-12 with backdated schematic.

TROUBLESHOOT DIGITAL PANEL METER (FROM GENERAL TROUBLESHOOTING TREE).

CHECK REFERENCE SUPPLIES.

DOES DISPLAY LIGHT ?
YES
NO

GROUND PIN 12 OF U510.

DOES DISPLAY LIGHT ?
YES
NO

REPLACE Q402.

SET RESPONSE TIME TO FAST. SET 3403C FUNCTION TO DC, RANGE TO 1 V. APPLY +1 V INPUT FROM DC STANDARD. MAINTAIN +1 V INPUT THROUGHOUT REST OF THESE TESTS.

IS DISPLAY CORRECT ?
YES
NO

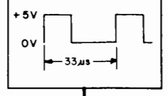
REMOVE U510 PIN 12 GROUND.

CORRECT DISPLAY LIT ?
YES
NO

PANEL METER O.K.

CHECK BLANKING CIRCUITRY AROUND U213 PIN 8.

MONITOR TP C5 WITH SCOPE (INT. SYNC, + SLOPE). WAVEFORM SHOULD BE:



IS WAVEFORM CORRECT ?
YES
NO

REPLACE U401.

CONNECT ≈100 µF IN PARALLEL WITH C401; CONNECT TP C5 TO TP C7. THE LAST DIGIT SHOULD COUNT FROM 0 TO 9 AND CARRY ONE.
CHECKS:
1. DISPLAY.
2. DECADE COUNTER.

COUNT AND CARRY ?
YES
NO

CHECK U302.

CONNECT ≈10 µF AND CHECK CENTER DIGIT AS BEFORE.

COUNT AND CARRY ?
YES
NO

CHECK U303.

CONNECT ≈1 µF AND CHECK FIRST DIGIT FOR A COUNT OF 0 TO 9.

COUNTS 0 - 9 ?
YES
NO

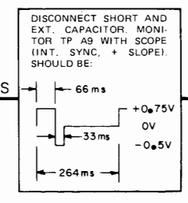
CHECK U304.

CONNECT ≈2 µF AS BEFORE. THE "1" SHOULD LIGHT EVERY 8th CYCLE OF THE FIRST DECADE.

ONE WORKS PROPERLY ?
YES
NO

CHECK U505 AND U506.

DISCONNECT SHORT AND EXT. CAPACITOR. MONITOR TP A9 WITH SCOPE (INT. SYNC, + SLOPE). SHOULD BE:



IF THE NUMBER OF COUNTS SEEMS CORRECT BUT THE DIGIT INVOLVED DOESN'T LIGHT PROPERLY, CHECK THE APPROPRIATE DISPLAY BY SUBSTITUTING ONE OF THE OTHERS.

3403C-D-3297

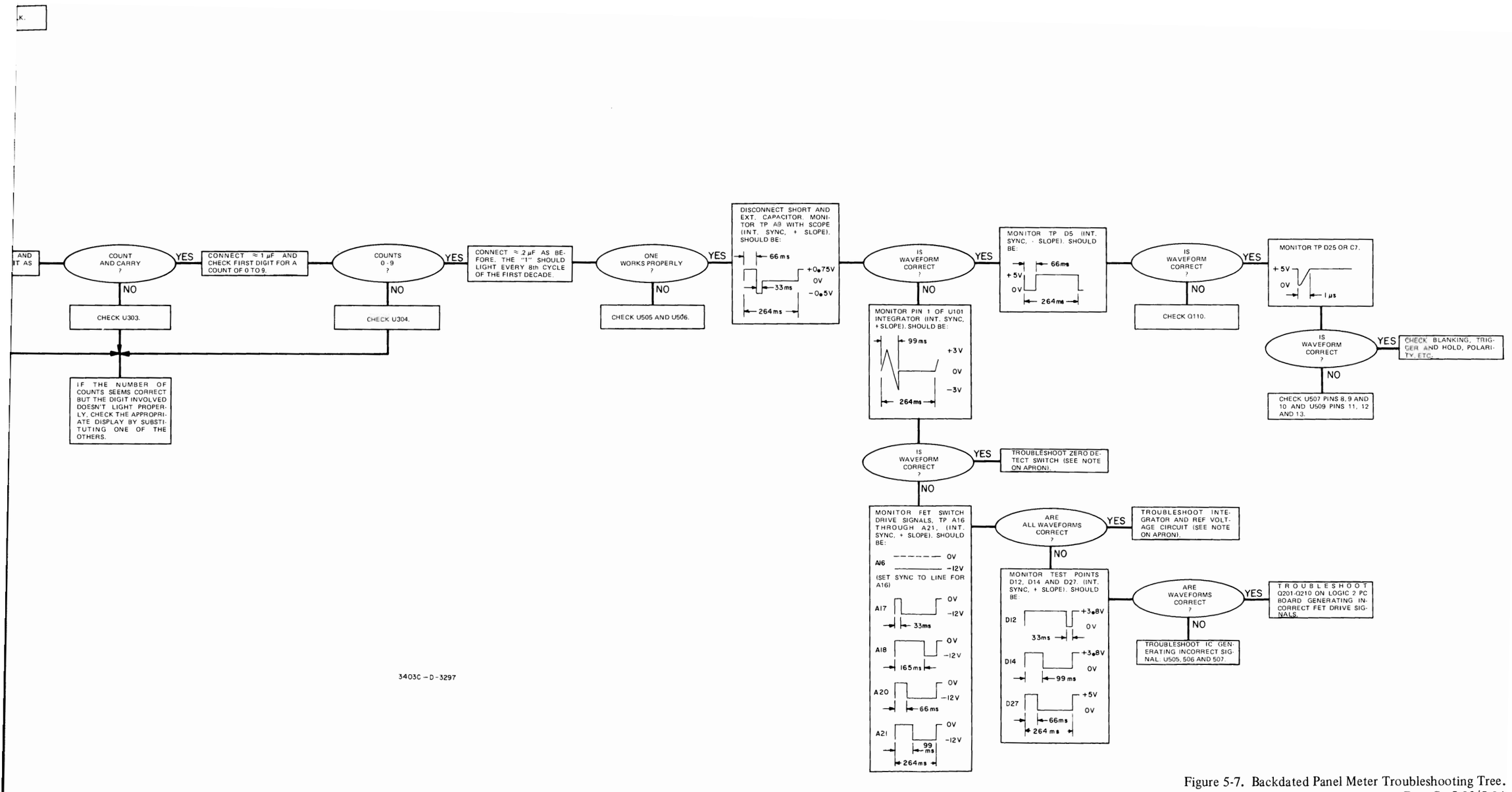
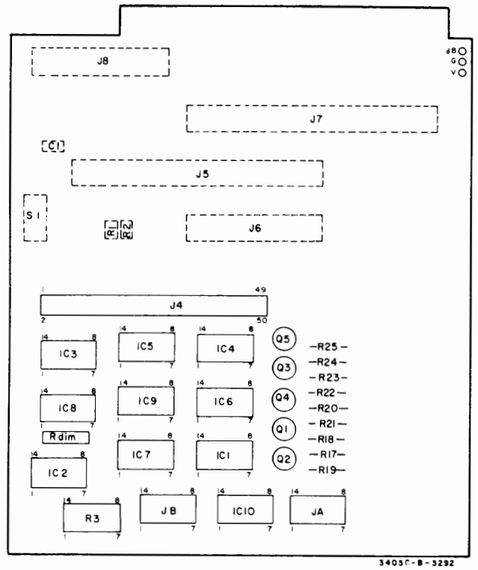
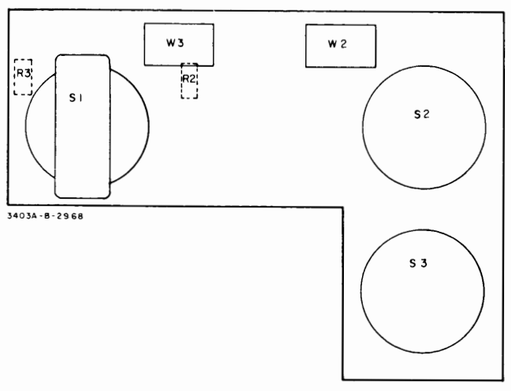


Figure 5-7. Backdated Panel Meter Troubleshooting Tree.
Rev. C 5-23/5-24



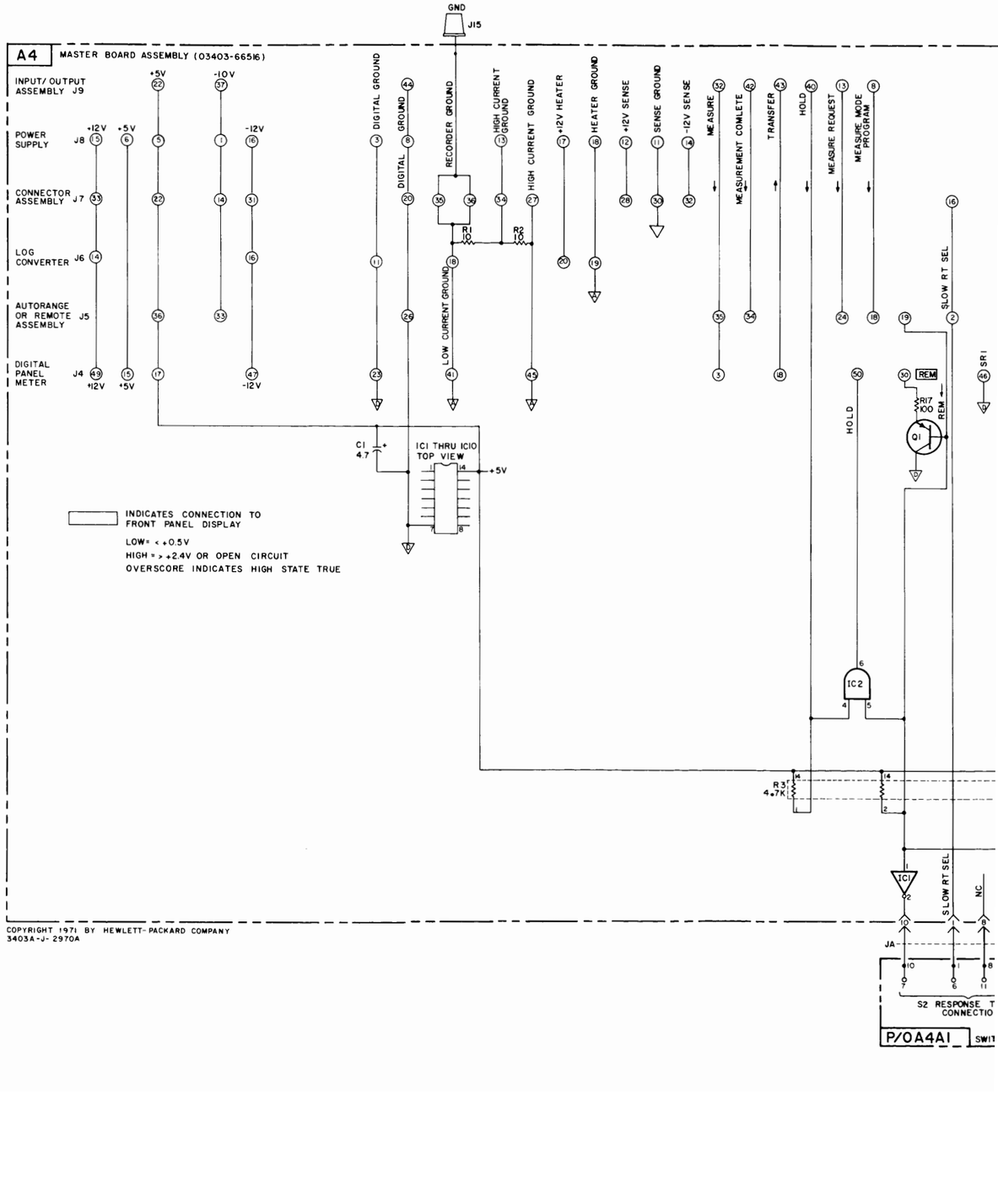
A4

hp Part No. 03403-66516



A4A1

hp Part No. 03403-66513



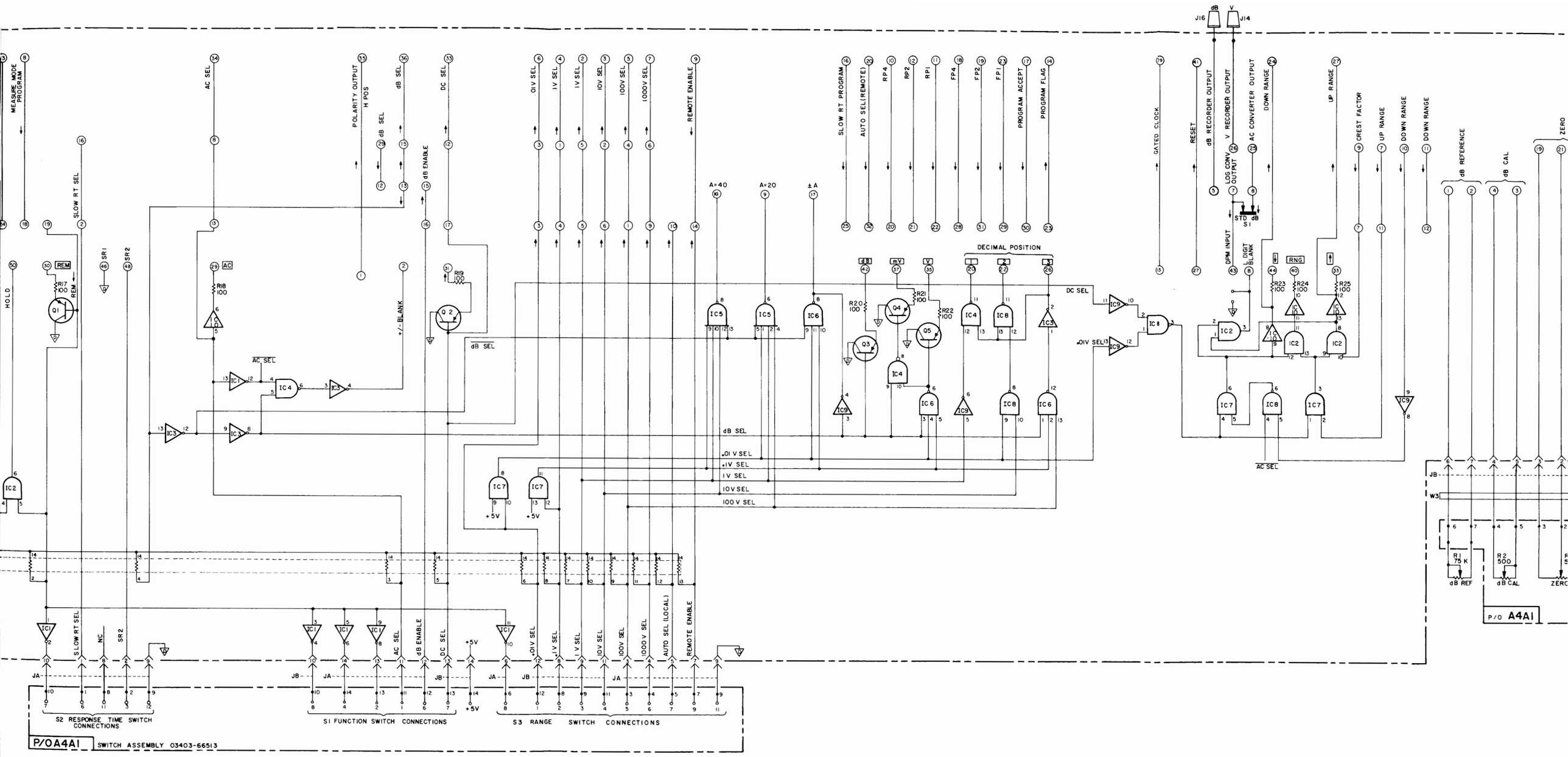


Figure 7-6. Backdated Master Bo

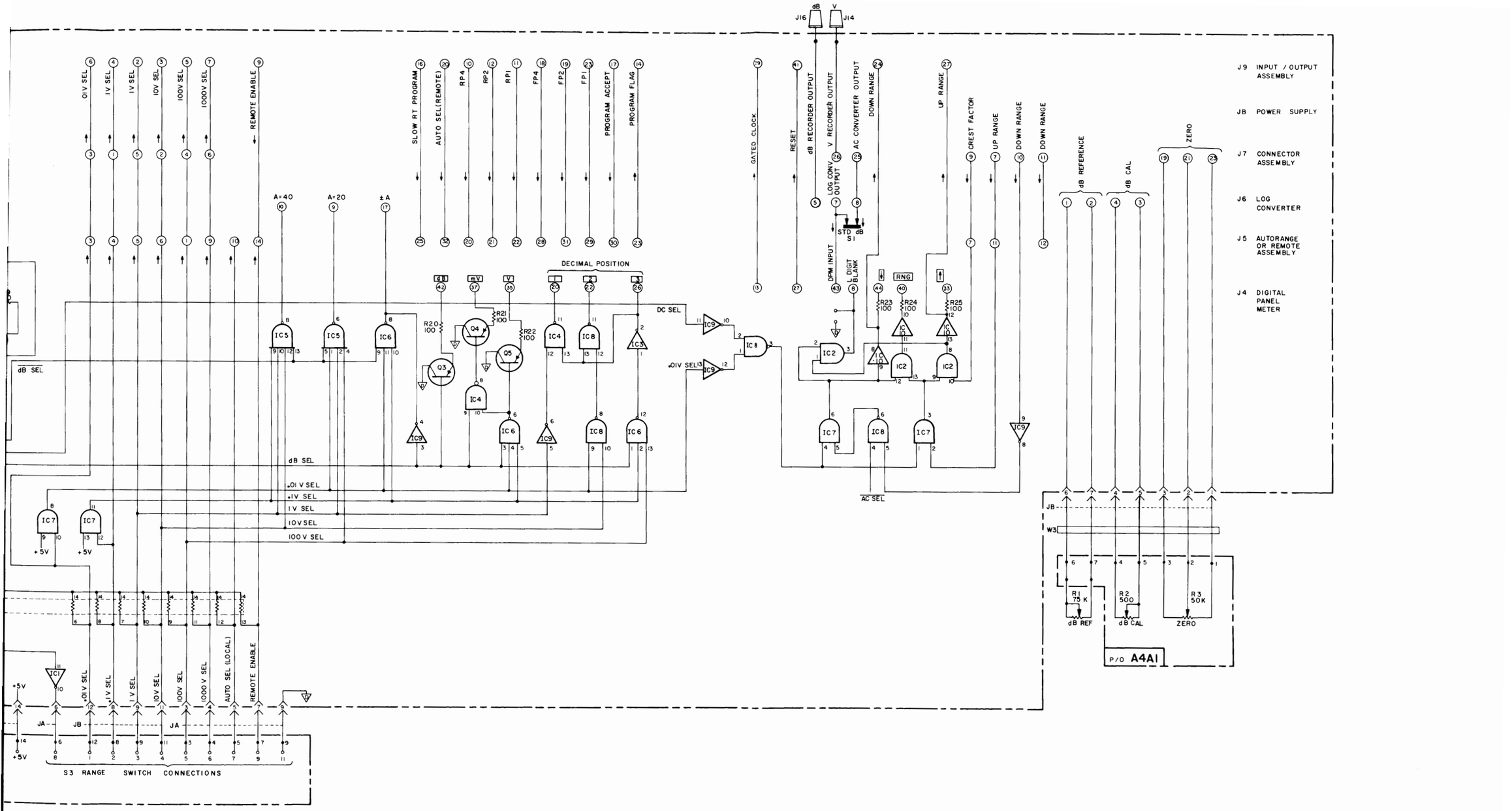
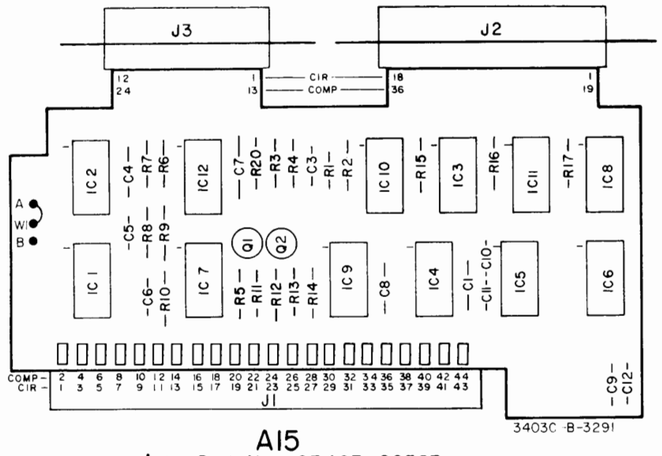
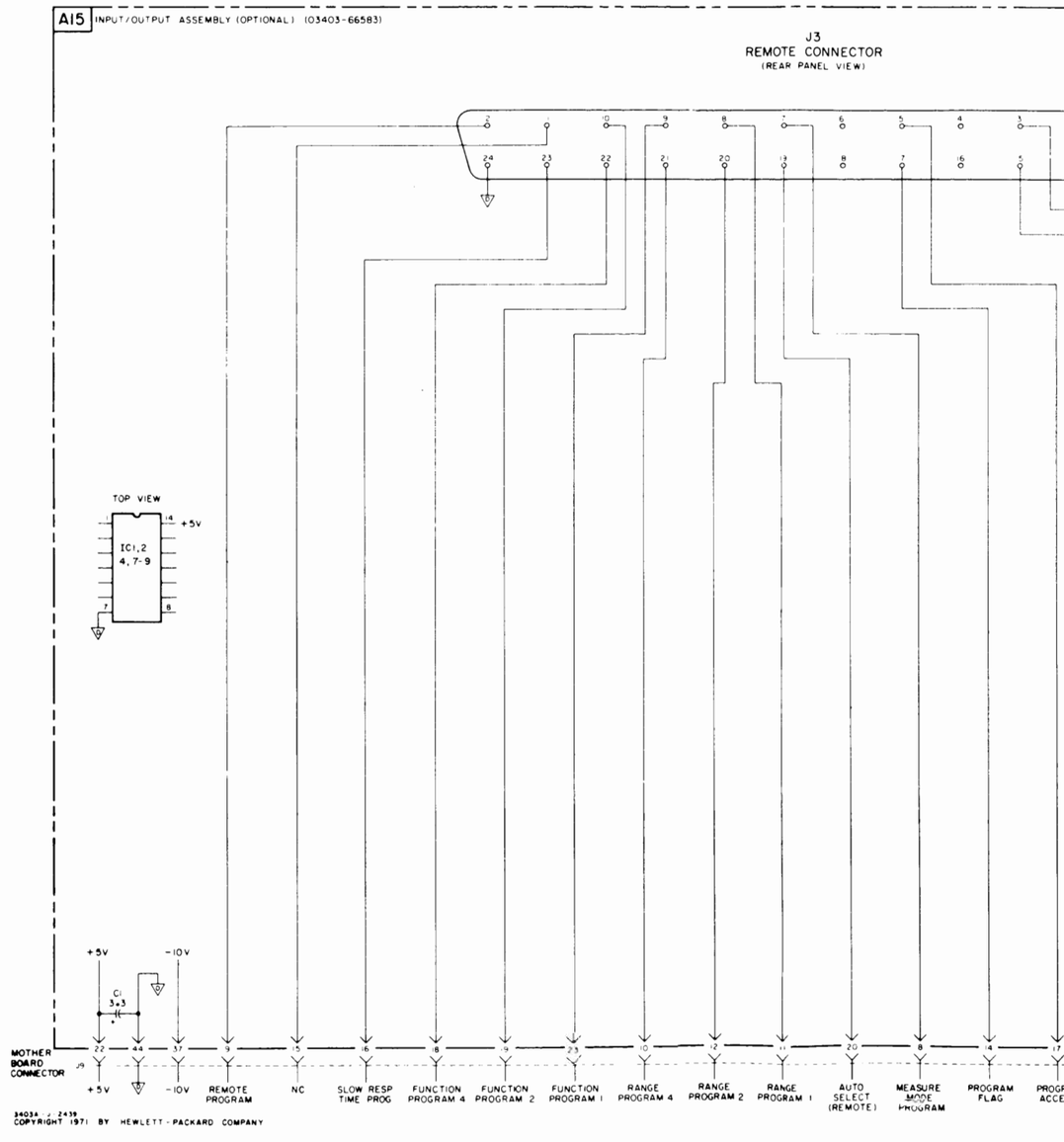


Figure 7-6. Backdated Master Board Wiring Diagram, A4.
Rev. B 7-11/7-12



A15

hp Part No. 03403-66583



J3
REMOTE CONNECTOR
(REAR PANEL VIEW)

J2
BCD OUTPUT CONNECTOR
(REAR PANEL VIEW)

MEASURE
PRINTER HOLDOFF
REMOTE MEASURE
PRINT COMMAND
DATA FLAG
INTERFACE HOLD
HIGH REF
COLUMN 7 FUNCTION
COLUMN 6
COLUMN 5
COLUMN 4 HUNDREDS
COLUMN 3 TENS
COLUMN 2 UNITS
COLUMN 1 DATA MULTIPLIER
UNDERRANGE
OVERLOAD
POLARITY

MEASURE/DATA FLAG FLIP-FLOP

DATA FLAG ONE-SHOT

DATA COUNTERS

RANGE PROGRAM 2
RANGE PROGRAM 1
AUTO SELECT (REMOTE)
MEASURE MODE PROGRAM
PROGRAM FLAG
PROGRAM ACCEPT
MEASURE
INTERFACE HOLD
TRANSFER
MEASURE COMPLETE
MEASURE REQUEST
DOWNRANGE
UPRANGE
AC SEL
dB SEL
DC SEL
POLARITY H POS
RESET FROM DPM J4 (27)
GATED CLOCK FROM DPM J4 (31)

Figure 7-12. Backdated

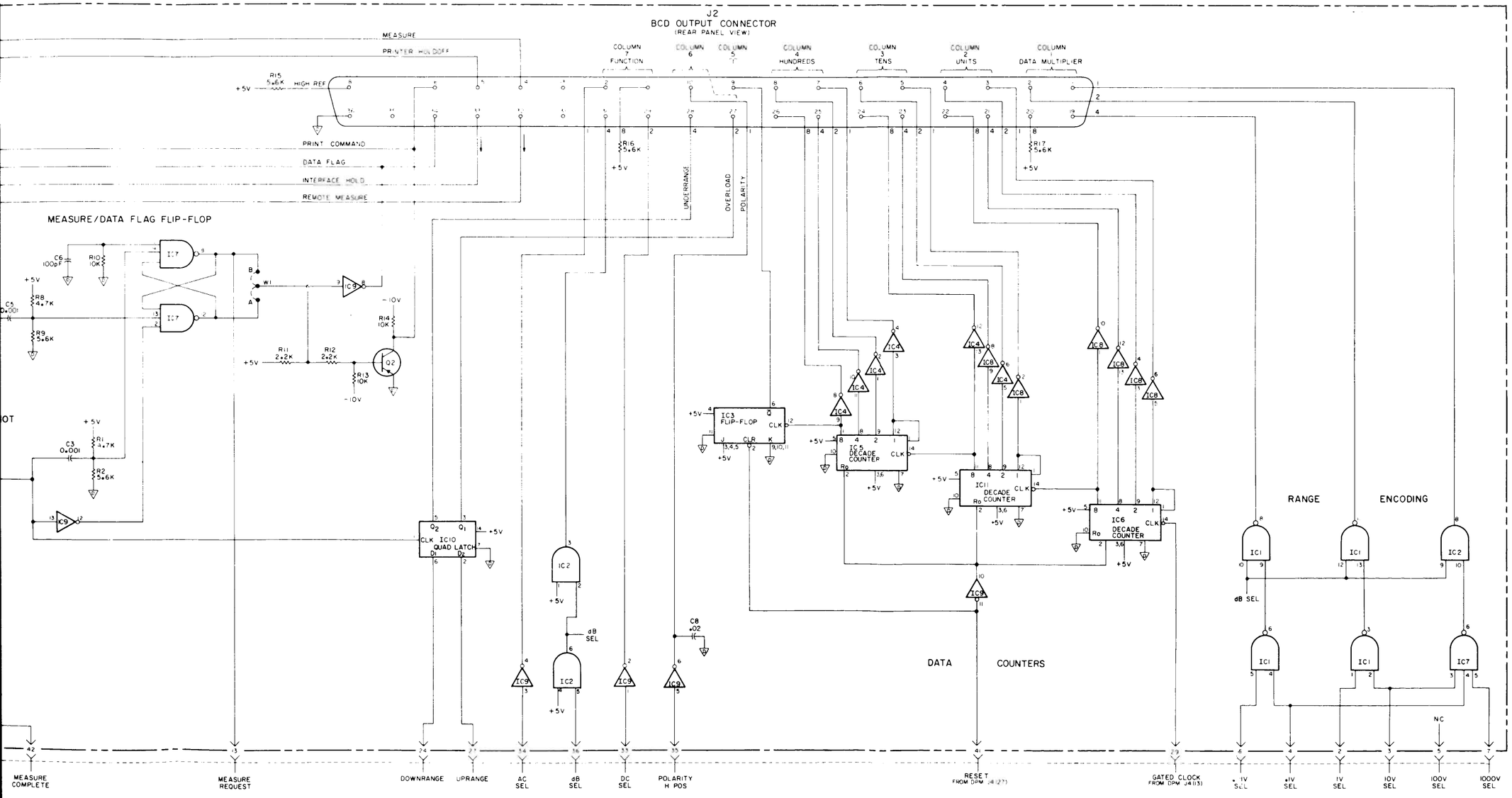


Figure 7-12. Backdated Schematic Diagram, Input/Output Assembly, A15.
Rev. A 7-23/7-24

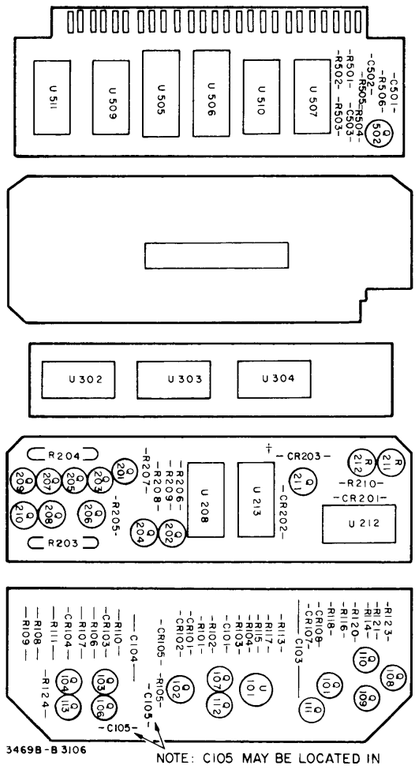
REPAIR NOTES

Do not bend the wires (that connect the various parts of the digital panel meter) more than is necessary nor more often than is necessary. The digital panel meter was so designed that most of the test points are available at the front panel (prefixed "C" and "D") to minimize any necessity to flex the wires during troubleshooting.

The digital panel meter can be more easily accessed when mounted on a board extender (-hp- Part No. 5060-5984) for maintenance.

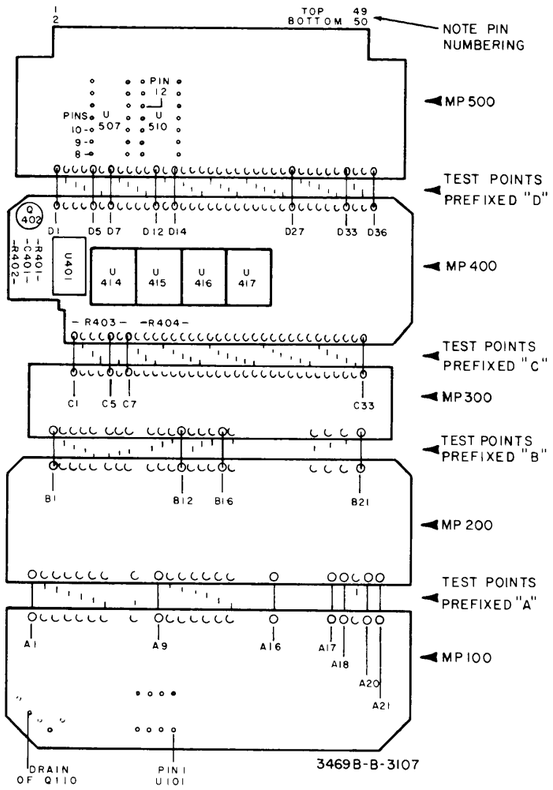
After repair and calibration has been completed, **gently and slowly** refold the digital panel meter as shown until it fits into its case.

†Earliest instruments had CR203 below Q211.

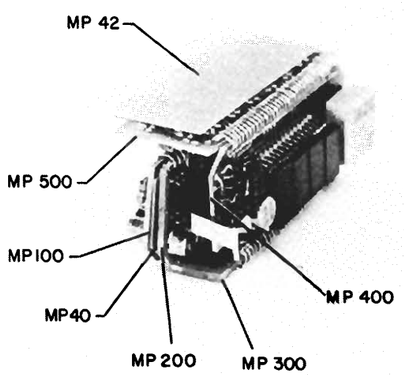


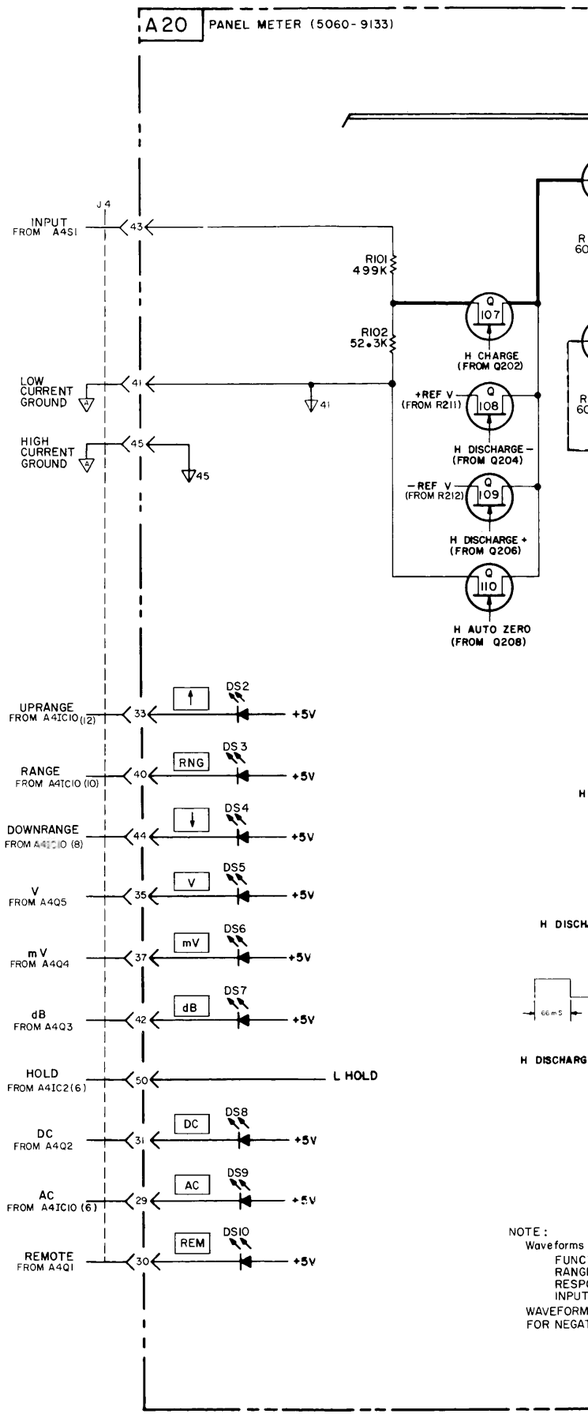
NOTE: C105 MAY BE LOCATED IN ONE OF TWO PLACES.

hp Part No. 5060-9133



hp Part No. 5060-9133





METER (5060-9133)

INTEGRATOR

ZERO DETECT COMPARATOR

CLIPPER

PULSE GENERATOR

OSCILLATOR

REFERENCE SUPPLIES

FET SWITCH DRIVE

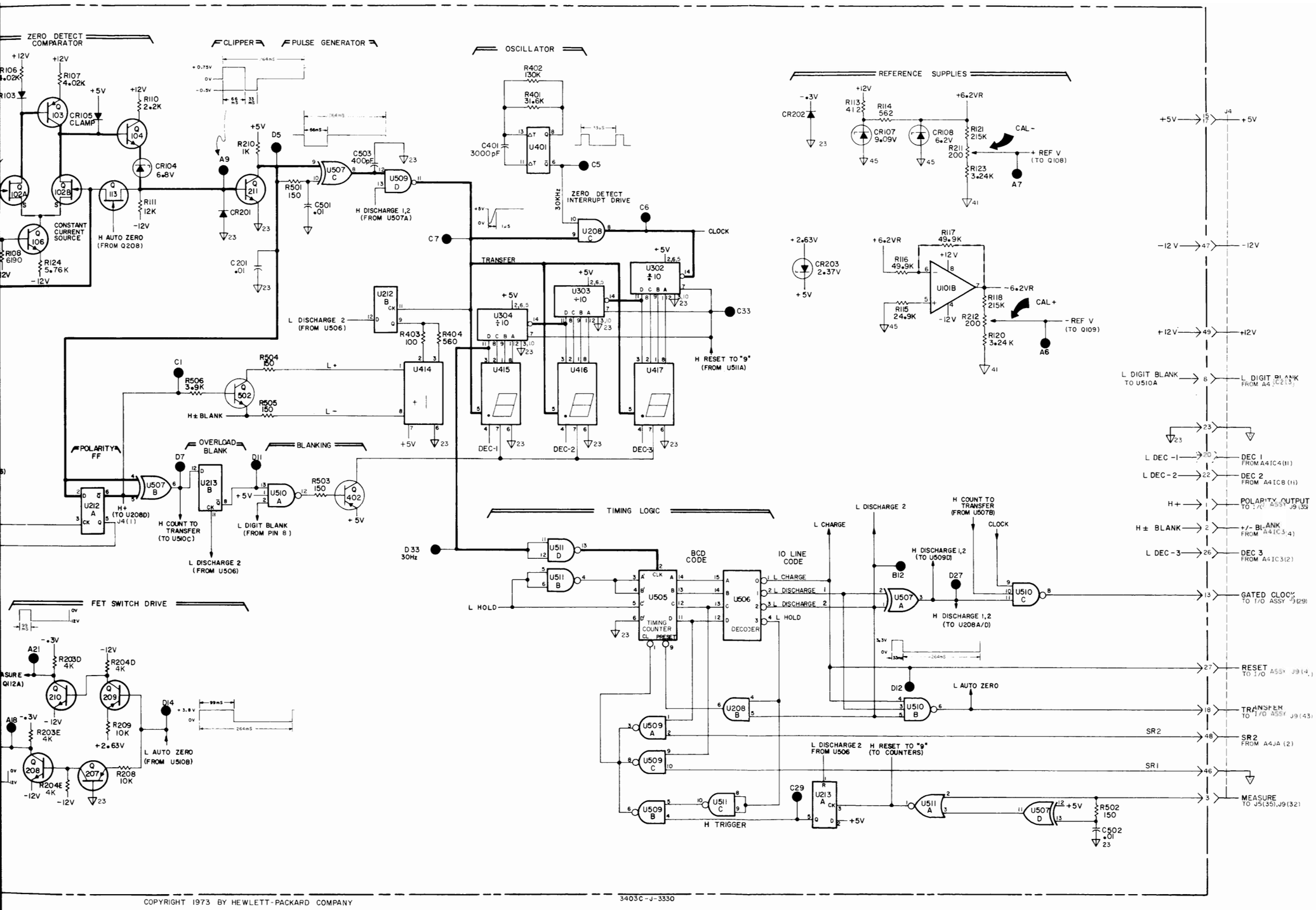
OVERLOAD BLANK

BLANKING

TIMING LOGIC

NOTE:
Waveforms observed under the following conditions:
FUNCTION: DC VOLTS
RANGE: 1V
RESPONSE TIME: FAST
INPUT: +1V
WAVEFORMS ON A16 AND A20 ARE INTERCHANGED FOR NEGATIVE INPUTS.

Figure 7-13. Backda
(Stand



3403C-J-3330

Figure 7-13. Backdated Schematic Diagram, Digital Panel Meter (Standard), A20. Rev. C 7-25/7-26

CHANGE NO. 2:

Applies to Instrument Serial Numbers 1452A01486 and below.

Section VI. Change the part number and description of A22C4 to 0121-0046, 9 – 35 pF and A22C6 to 0160-0170, .22 microfarad.

Section VII. Change the value of A22C4 to 9 – 35 pF and A22C6 to .22 microfarad.

CHANGE NO. 3:

Applies to Instrument Serial Numbers 1452A01566 and below.

Section VI. Delete A20C7.

Section VII. Delete A20C7.

CHANGE NO. 4:

Applies to Instrument Serial Numbers 1452A01685 and below.

Section VI. Change the part number and description as shown in Table 8-1.

Table 8-1. Parts List Changes.

Ref Desig	-hp- Part No.	Description
A15C9 – C12	0150-0093	.01 μF
A15U4	1820-0174	IC–SN7404N
A15U5, U6, U8, U10	1820-0876	IC–SN7475N

Delete A15C13; A15R18, R19; A15R21–R25 and A15Q3.

Section VII. Change the A15 schematic as shown in Figure 8-1.

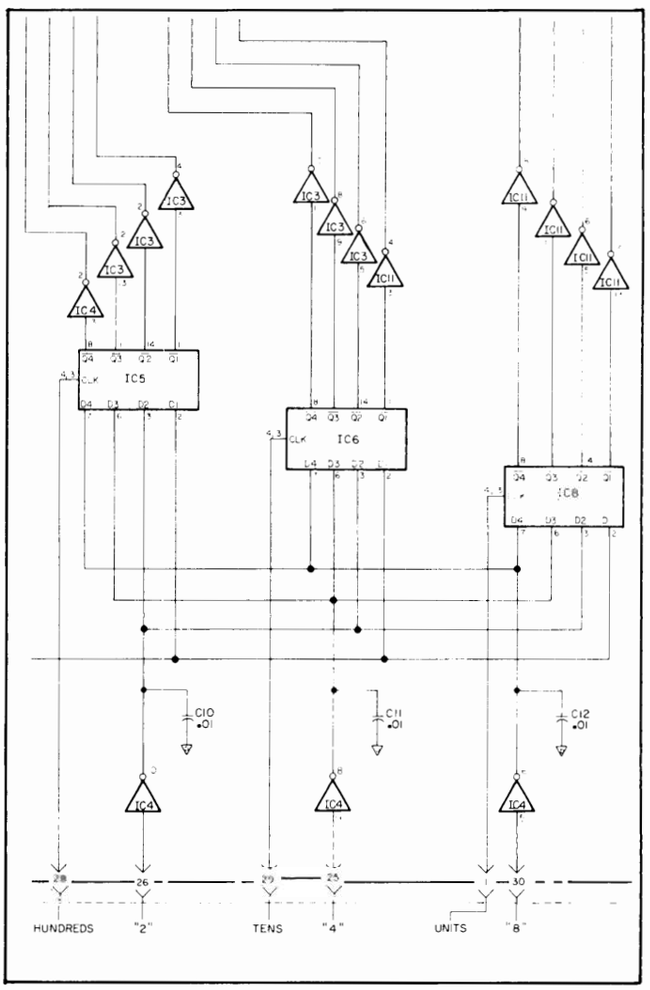


Figure 8-1. p/o A15 Schematic.

CHANGE NO. 5:

Applies to Instrument Serial Numbers 1452A01975 and below.

Section VI. Change the part number and description of A14C14 to 0160-2605, .01 microfarad. Change the part number and description of A15C3, C5 to 0150-0050, 1000 pF.

Section VII. Change A14C14 to .01 microfarad. Change A15C3, C5 to 1000 pF.

CODE LIST OF MANUFACTURERS

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

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

CODE LIST OF MANUFACTURERS

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

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

CODE LIST OF MANUFACTURERS (Continued)

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

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
94870	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A.B. Boyd Co.	San Francisco, Cal.
85474	R.M. Bracamonte & Co.	San Francisco, Cal.
85660	Koiled Kords, Inc.	Hamden, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86174	Fafnir Bearing Co.	Los Angeles, Calif.
86197	Clifton Precision Products Co., Inc.	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, Electronic Comp. & Devices Division	Harrison, N.J.
86928	Seastrom Mfg. Co.	Glendale, Cal.
87034	Marco Industries	Anaheim, Cal.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Cal.
87664	Van Waters & Rogers Inc.	San Francisco, Cal.
87930	Tower Mfg. Corp.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Cal.
89473	G.E. Distributing Corp.	Schenectady, N.Y.
89479	Security Co.	Detroit, Mich.
89665	United Transformer Co.	Chicago, Ill.
90030	United Shoe Machinery Corp.	Beverly, Mass.
90179	U.S. Rubber Co., Consumer Ind. & Plastics Prod. Div.	Passaic, N.J.
90365	Belleville Speciality Tool Mfg., Inc.	Belleville, Ill.
90763	United Carr Fastener Corp.	Chicago, Ill.
90970	Bearing Engineering Co.	San Francisco, Cal.
91146	ITT Cannon Elect. Inc., Salem Div.	Salem, Mass.
91260	Connor Spring Mfg. Co.	San Francisco, Cal.
91345	Miller Dial & Nameplate Co.	El Monte, Cal.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Willow Grove, Pa.
91673	Epiphone Inc.	New York, N.Y.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Cal.
91886	Malco Mfg., Inc.	Chicago, Ill.
91929	Honeywell Inc., Micro Switch Division	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Cal.
92180	Tru-Connector Corp.	Peabody, Mass.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tensolite Insulated Wire Co., Inc.	Tarrytown, N.Y.
92702	IMC Magnetics Corp.	Westbury, L.I., N.Y.
92966	Hudson Lamp Co.	Kearney, N.J.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins & Myers Inc.	Pallisades Park, N.J.
93410	Stemco Controls, Div. of Essex Wire Corp.	Mansfield, Ohio
93632	Waters Mfg. Co.	Culver City, Cal.
93929	G.V. Controls	Livingston, N.J.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.
94148	Scientific Electronics Products, Inc.	Loveland, Colo.
94154	Wagner Elect. Corp., Tung-Sol Div.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Patterson, N.J.
94222	South Chester Corp.	Chester, Pa.
94330	Wire Cloth Products, Inc.	Bellwood, Ill.
94375	Automatic Metal Products Co.	Brooklyn, N.Y.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
94696	Magnecraft Electric Co.	Chicago, Ill.
95023	George A. Philbrick Researchers, Inc.	Boston, Mass.
95146	Alco Elect. Mfg. Co.	Lawrence, Mass.
95236	Allies Products Corp.	Diania, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	Long Island, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Rolling Meadows, Ill.
95566	Arnold Engineering Co.	Marengo, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95984	Siemon Mfg. Co.	Wayne, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Microwave Assoc., West, Inc.	Sunnyvale, Cal.
96095	Hi-Q Div. of Aerovox Corp.	Olean, N.Y.
96256	Thordarson-Meissner Inc.	Mt. Carmel, Ill.
96296	Solar Mfg. Co.	Los Angeles, Cal.
96396	Microswitch, Div. of Minn.-Honeywell	Freeport, Ill.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Cal.
96508	Xcelite, Inc.	Orchard Park, N.Y.
96733	San Fernando Elec. Mfg. Co.	San Fernando, Cal.
96881	Thomson Ind. Inc.	Long Island, N.Y.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic & Precision Mfg.	Englewood, N.J.
97979	Reon Resistor Corp.	Yonkers, N.Y.
97983	Litton System Inc., Adler-Westrex Commun. Div.	New Rochelle, N.Y.
98141	R-Tronics, Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Cal.
98220	Hewlett-Packard Co., Medical Elec. Div.	Pasadena, Cal.
98278	Microdot, Inc.	So. Pasadena, Cal.
98291	Sealectro Corp.	Mamaronech, N.Y.
98376	Zero Mfg. Co.	Burbank, Cal.
98410	Etc Inc.	Cleveland, Ohio
98731	General Mills Inc., Electronics Div.	Minneapolis, Minn.
98734	Paeco Division of Hewlett-Packard Co.	Palo Alto, Cal.
98821	North Hills Electronics, Inc.	Glen Cove, N.Y.
98978	International Electronic Research Corp.	Burbank, Cal.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Cal.
99378	Atlee Corp.	Winchester, Mass.
99515	Marshall Ind., Capacitor Div.	Monrovia, Cal.
99707	Control Switch Division, Controls Co. of America	El Segundo, Cal.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99928	Branson Corp.	Whippany, N.J.
99934	Rembrandt, Inc.	Boston, Mass.
99942	Hoffman Electronics Corp., Semiconductor Division	El Monte, Cal.
99957	Technology-Instrument Corp. of California	Newbury Park, Cal.

The following HP Vendors have no number assigned in the latest supplement to the Federal Supply Code for Manufacturers Handbook.

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

SUPPLEMENTAL CODE LIST OF MANUFACTURERS

Code No.	Manufacturer	Address
23880	Stanford Applied Engineering	Santa Clara, California
27264	Molex Products Co.	Downes Grove, Illinois

HEWLETT hp PACKARD

SALES & SERVICE OFFICES

UNITED STATES

ALABAMA
8290 Whitesburg Dr., S.E.
P.O. Box 4207
Huntsville 35802
Tel: (205) 881-4591
TWX: 810-726-2204

Medical Only
228 W. Valley Ave.,
Room 220
Birmingham 35209
Tel: (205) 942-2081

ARIZONA
2336 E. Magnolia St.
Phoenix 85034
Tel: (602) 244-1361

2424 East Aragon Rd.
Tucson 85706
Tel: (602) 294-3148

***ARKANSAS**
Medical Service Only
P.O. Box 5646
Brady Station
Little Rock 72205
Tel: (501) 664-8773

CALIFORNIA
1430 East Orangethorpe Ave.
Fullerton 92631
Tel: (714) 870-1000

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

***Ridgecrest**
Tel: (714) 446-6165

2220 Watt Ave.
Sacramento 95825
Tel: (916) 482-1463

9606 Aero Drive
P.O. Box 23333
San Diego 92123
Tel: (714) 279-3200

COLORADO
5600 South Ulster Parkway
Englewood 80110
Tel: (303) 771-3455

CONNECTICUT
12 Lunar Drive
New Haven 06525
Tel: (203) 389-6551
TWX: 710-465-2029

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 Ellenor Dr.
Orlando 32809
Tel: (305) 859-2900
TWX: 810-850-0311

P.O. Box 12826
Pensacola 32575
Tel: (904) 434-3081

GEORGIA
P.O. Box 105005
Atlanta 30348
Tel: (404) 434-4000
TWX: 810-766-4890

Medical Service Only
***Augusta** 30903
Tel: (404) 736-0592

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: 810-260-1796

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

***KANSAS**
Derby
Tel: (316) 267-3655

KENTUCKY
Medical/Calculator Only
Atkinson Square
3901 Atkinson Dr.,
Suite 207
Louisville 40218
Tel: (502) 456-1573

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

MARYLAND
6707 Whitestone Road
Baltimore 21207
Tel: (301) 944-5400
TWX: 710-862-9157

2 Choke Cherry Road
Rockville 20850
Tel: (301) 948-6370
TWX: 710-828-9684

MASSACHUSETTS
32 Hartwell Ave.
Lexington 02173
Tel: (617) 861-8960
TWX: 710-326-6904

MICHIGAN
23855 Research Drive
Farmington Hills 48024
Tel: (313) 476-6400
TWX: 810-242-2900

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

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

NEBRASKA
Medical Only
7171 Mercy Road
Suite 110
Omaha 68106
Tel: (402) 392-0948

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

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

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

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

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

39 Saginaw Drive
Rochester 14623
Tel: (716) 473-9500
TWX: 510-253-5981

5858 East Molloy Road
Syracuse 13211
Tel: (315) 455-2486
TWX: 710-541-0482

1 Crossways Park West
Woodbury 11797
Tel: (516) 921-0300
TWX: 710-990-4951

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

OHIO
16500 Sprague Road
Cleveland 44130
Tel: (216) 243-7300
TWX: 810-423-9431

330 Progress Rd.
Dayton 45449
Tel: (513) 859-8202
TWX: 810-474-2818

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

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

OREGON
17890 SW Lower Boones
Ferry Road
Tualatin 97062
Tel: (503) 620-3350

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

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

SOUTH CAROLINA
6941-0 N. Trenholm Road
Columbia 29260
Tel: (803) 782-6493

TENNESSEE
***Memphis**
Medical Service only
Tel: (901) 274-7472

***Nashville**
Medical Service only
Tel: (615) 244-5448

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

P.O. Box 27409
6300 Westpark Drive
Suite 100
Houston 77027
Tel: (713) 781-6000
TWX: 910-881-2645

205 Billy Mitchell Road
San Antonio 78226
Tel: (512) 434-8241
TWX: 910-871-1170

UTAH
2160 South 3270 West Street
Salt Lake City 84119
Tel: (801) 487-0715

VIRGINIA
Medical Only
P.O. Box 12778
No. 7 Koger Exec. Center
Suite 212
Norfolk 23502
Tel: (804) 497-1026/7

P.O. Box 9854
2914 Hungary Springs Road
Richmond 23228
Tel: (804) 285-3431
TWX: 710-956-0157

WASHINGTON
Bellefield Office Pk.
1203-114th Ave. S.E.
Bellevue 98004
Tel: (206) 454-3971
TWX: 910-443-2446

***WEST VIRGINIA**
Medical/Analytical Only
Charleston
Tel: (304) 345-1640

WISCONSIN
9004 West Lincoln Ave.
West Allis 53227
Tel: (414) 541-0550

FOR U.S. AREAS NOT LISTED:
Contact the regional office nearest you: Atlanta, Georgia; North Hollywood, California; Rockville, Maryland; Skokie, Illinois. Their complete addresses are listed above.

***Service Only**

CANADA

ALBERTA
Hewlett-Packard (Canada) Ltd.
11748 Kingsway Ave.
Edmonton T5G 0X5
Tel: (403) 452-3670
TWX: 610-831-2431 EOTH

Hewlett-Packard (Canada) Ltd.
915-42 Avenue S.E. Suite 102
Calgary T2G 1Z1
Tel: (403) 287-1672
TWX: 610-821-6141

BRITISH COLUMBIA
Hewlett-Packard (Canada) Ltd.
837 E. Cordova Street
Vancouver V6A 3R2
Tel: (604) 254-0531
TWX: 610-922-5059 VCR

MANITOBA
Hewlett-Packard (Canada) Ltd.
513 Century St.
St. James
Winnipeg R3H 0L8
Tel: (204) 786-7581
TWX: 610-671-3531

NOVA SCOTIA
Hewlett-Packard (Canada) Ltd.
800 Windmill Road
P.O. Box 931
Dartmouth B2Y 3Z6
Tel: (902) 469-7820
TWX: 610-271-4482 HFX

ONTARIO
Hewlett-Packard (Canada) Ltd.
1785 Woodward Dr.
Ottawa K2C 0P9
Tel: (613) 225-6530
TWX: 610-562-8968

Hewlett-Packard (Canada) Ltd.
6877 Goreway Drive
Mississauga L4V 1L9
Tel: (416) 678-9430
TWX: 610-492-4246

QUEBEC
Hewlett-Packard (Canada) Ltd.
275 Hymus Blvd.
Pointe Claire H9R 1G7
Tel: (514) 697-4232
TWX: 610-422-3022
TLX: 05-821521 HPCL

Hewlett-Packard (Canada) Ltd.
2376 Galvani Street
Ste-Foy G1N 4G4
Tel: (418) 688-8710
TWX: 610-571-5525

FOR CANADIAN AREAS NOT LISTED:
Contact Hewlett-Packard (Canada) Ltd. in Mississauga.

CENTRAL AND SOUTH AMERICA

ARGENTINA
Hewlett-Packard Argentina
S.A.C.e.I.
Lavalle 1171-3° Piso
Buenos Aires
Tel: 35-0436, 35-0627, 35-0341
Telex: Public Booth No. 9
Cable: HEWPACK ARG

BOLIVIA
Stambuk & Mark (Bolivia) Ltda.
Av. Mariscal Santa Cruz 1342
La Paz
Tel: 40626, 53163, 52421
Telex: 3560014
Cable: BUKMAR

BRAZIL
Hewlett-Packard Do Brasil
I.E.C. Ltda.
Rua Frei Caneca, 1140/52 Bela Vista
01307-**São Paulo**-SP
Tel: 288-71-11, 287-81-20, 287-61-93
Telex: 391-1132-3602 HPBR-BR
Cable: HEWPACK São Paulo

Hewlett-Packard Do Brasil
I.E.C. Ltda.
Praca Dom Feliciano, 78-8° andar (Sala 806/8)
90000-**Pôrto Alegre**-RS
Tel: 25-84-70-DDD (0512)
Cable: HEWPACK Pôrto Alegre

Hewlett-Packard Do Brasil
I.E.C. Ltda.
Rua Siqueira Campos, 53, 4° andar-Copacabana
20000-**Rio de Janeiro**-GB
Tel: 257-80-94-DDD (021)
Telex: 391-212-1905 HEWP-BR
Cable: HEWPACK
Rio de Janeiro

CHILE
Calcagni y Metcalfe Ltda.
Alameda 580-Of. 807
Casilla 2118
Santiago, 1
Tel: 39813
Telex: 350001 CALMET
Cable: CALMET Santiago

Medical Only
General Machinery Co., Ltda.
Paraguay 494
Casilla 13910
Santiago
Tel: 31123, 31124
Cable: GEMCO Santiago

COLOMBIA
Instrumentación
Henrik A. Langebaek & Kier S.A.
Carrera 7 No. 48-75
Apartado Aereo 6287
Bogotá, D.E.
Tel: 69-88-77
Cable: AARIS Bogotá
Telex: 044-400

COSTA RICA
Científica Costarricense S.A.
Calle Central, Avenidas 1 y 3
Apartado 10159
San José
Tel: 21-86-13
Cable: GALGUR San José

ECUADOR
Medical Only
A.F. Viscaino Compañía Ltda.
Av. Rio Amazonas No. 239
P.O. Box 2925
Quito
Tel: 527-088, 527-804
Cable: ASTOR Quito

Calculators Only
Computadoras y Equipos Electrónicos
P.O. Box 2695
Avda. 12 De Octubre No. 2207
Quito
Tel: 233869, 236783
Telex: 02-2113 Sagita Ed
Cable: Sagitra-Quito

EL SALVADOR
IPESA
Bulevar de los Heroes II-48
San Salvador
Tel: 252787

GUATEMALA
IPESA
Avenida La Reforma 3-48, Zona 9
Guatemala City
Tel: 63627, 64786
Telex: 4192 Teletro Gu

MEXICO
Hewlett-Packard Mexicana, S.A. de C.V.
Torres Adalid No. 21, 11° Piso
Col. del Valle
Mexico 12, D.F.
Tel: (905) 543-42-32
Telex: 017-74-507

Hewlett-Packard Mexicana, S.A. de C.V.
Ave. Constitución No. 2184
Monterrey, N.L.
Tel: 48-71-32, 48-71-84
Telex: 038-843

NICARAGUA
Roberto Terán G.
Apartado Postal 689
Edificio Terán
Managua
Tel: 25114, 23412, 23454
Cable: ROTERAN Managua

PANAMA
Electrónico Balboa, S.A.
P.O. Box 4929
Calle Samuel Lewis
Cuidad de Panama
Tel: 64-2700
Telex: 3431103 Curunda, Canal Zone
Cable: ELECTRON Panama

PARAGUAY
C.A. Melamed S.R.L.
División Aparatos y Equipos Médicos
División Aparatos y Equipos Científicos y de Investigación
P.O. Box 676
Chile-482, Edificio Victoria
Asuncion
Tel: 4-5069, 4-6272
Cable: RAMEL

FERU
Compañía Electro Médica S.A.
Los Flamencos 145
San Isidro Casilla 1030
Lima 1
Tel: 413485
Cable: ELMED Lima

PUERTO RICO
Hewlett-Packard Inter-Americas
Puerto Rico Branch Office
P.O. Box 2908I
65th Inf. Station
San Juan 00929
Calle 272, Urb. Country Club
Carolina 00630
Tel: (809) 762-7255, 7455, 7655
Telex: 3450-314

URUGUAY
Pablo Ferrando S.A.
Comercial e Industrial
Avenida Italia 2877
Casilla de Correo 370
Montevideo
Tel: 40-3102
Cable: RADIUM Montevideo

VENEZUELA
Hewlett-Packard de Venezuela C.A.
Apartado 50933, Caracas 105
Edificio Edgre
Tercera Transversal
Los Ruices Norte
Caracas 107
Tel: 35-00-07, 35-00-84, 35-00-65, 35-00-31
Telex: 25146 HEWPACK
Cable: HEWPACK Caracas

FOR AREAS NOT LISTED, CONTACT:
Hewlett-Packard
Inter-Americas
3200 Hillview Ave.
Palo Alto, California 94304
Tel: (415) 493-1501
TWX: 910-373-1260
Cable: HEWPACK Palo Alto
Telex: 034-8300, 034-8493

EUROPE

AUSTRIA
Hewlett-Packard Ges m b H
Handelskai 52/3
P O Box 7
A-1205 **Vienna**
Tel (0222) 35 16 21 to 32
Cable HEWPAK Vienna
Telex 75923 hewpak a

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

DENMARK
Hewlett-Packard A/S
Datavej 52
DK-3460 **Birkerod**
Tel (02) 81 66 40
Cable HEWPACK AS
Telex 166 40 hpas

Hewlett-Packard A/S
Navervej 1
DK-8600 **Silkeborg**
Tel (06) 82 71 66
Telex 166 40 hpas
Cable HEWPACK AS

FINLAND
Hewlett-Packard OY
Nahkahousuntie 5
P O Box 6
SF-00211 **Helsinki** 21
Tel 6923031
Cable HEWPACKOY Helsinki
Telex 12-1563

FRANCE
Hewlett-Packard France
Quartier de Courtaboeuf
Boite Postale No 6
F-91401 **Orsay**
Tel (1) 907 78 25
Cable HEWPACK Orsay
Telex 600048

Hewlett-Packard France
Le Saquin
Chemin des Mouilles
Boite Postale No 12
F-69130 **Ecully**
Tel (78) 33 81 25
Cable HEWPACK Ecully
Telex 310617

Hewlett-Packard France
Agence Régionale
Péricentre de la Cépière
Chemin de la Cépière 20
F-31300 **Toulouse-Le Mirail**
Tel (61) 40 11 12
Telex 510957F

Hewlett-Packard France
Agence Régionale
Aéroport principal de
Marseille-Marignane
F-13721 **Marignane**
Tel (91) 89 12 36
Cable HEWPACK MARGN
Telex 410774F

Hewlett-Packard France
Agence Régionale
63 Avenue de Rochester
F-35000 **Rennes**
Tel (99) 36 33 21
Cable HEWPACK 74912
Telex 740912F

Hewlett-Packard France
Agence Régionale
74 Allée de la Robertsau
F-67000 **Strasbourg**
Tel (88) 35 23 20 21
Telex 890141
Cable HEWPACK STRBG

Medical/Calculator Only
Hewlett-Packard France
Agence Régionale
Centre Vauban
201 rue Colbert
Entrée A2
F-59000 **Lille**
Tel (20) 51 44 14
Telex 820744

GERMAN FEDERAL REPUBLIC
Hewlett-Packard GmbH
Vertriebszentrale Frankfurt
Bernerstrasse 117
Postfach 560 140
D-6000 **Frankfurt** 56
Tel (0611) 50 04-1
Cable HEWPACKSA Frankfurt
Telex 04 13249 hpffmd

Hewlett-Packard GmbH
Technisches Buero Böblingen
Herrenbergerstrasse 130
D-7030 **Böblingen**, Württemberg
Tel (07031) 667-1
Cable HEPAK Böblingen
Telex 07265739 bbn

Hewlett-Packard GmbH
Technisches Buero Dusseldorf
Emanuel-Leutze-Str 1 (Seestern)
D-4000 **Dusseldorf**
Tel (0211) 59711
Telex 85 86 533 hpdd d

Hewlett-Packard GmbH
Technisches Buero Hamburg
Wendenstrasse 23
D-2000 **Hamburg** 1
Tel (040) 24 13 93
Cable HEWPACKSA Hamburg
Telex 21 63 032 hphh d

Hewlett-Packard GmbH
Technisches Buero Hannover
Mellendorfer Strasse 3
D-3000 **Hannover-Kleefeld**
Tel (0511) 55 60 46
Telex 092 3259

Hewlett-Packard GmbH
Technisches Buero Nuremberg
Neumeyer Str 90
D-8500 **Nuremberg**
Tel (0911) 56 30 83/85
Telex 0623 860

Hewlett-Packard GmbH
Technisches Buero München
Unterhachinger Strasse 28
ISAR Center
D-8012 **Ottobrunn**
Tel (089) 601 30 61/7
Telex 52 49 85
Cable HEWPACKSA Munchen
Telex 0524985

(West Berlin)
Hewlett-Packard GmbH
Technisches Buero Berlin
Keith Strasse 2-4
D-1000 **Berlin** 30
Tel (030) 24 90 86
Telex 18 3405 hpbln d

GREECE
Kostas Karayannis
18 Ermou Street
GR-**Athens** 126
Tel 3237731
Cable RAKAR Athens
Telex 21 59 62 rkar gr

Analytical Only
"INTECO" G Papathanassiou & Co
Marni 17
GR-**Athens** 103
Tel 521 915
Cable INTEKNIKA
Telex 21 5329 INTE GR

Medical Only
Technomed Hellas Ltd
52 Skoufa Street
GR-**Athens** 135
Tel 626 972 663 930 674 959
Cable ETALAK Athens
Telex 21-4693 ETAL GR

ICELAND
Medical Only
Elding Trading Company Inc
Hafnarhvoli - Tryggvatotu
IS-**Reykjavik**
Tel 1 58 20
Cable ELDING Reykjavik

IRAN
Hewlett-Packard Iran Ltd
Mir Emad Avenue
14th Street No 19
IR-**Tehran**
Tel 85 10 82/86

IRELAND
Hewlett-Packard Ltd
King Street Lane
Winnersh, Wokingham
GB-**Berkshire** RG11 5AR
Tel (0734) 78 47 74
Telex 847178/848179

ITALY
Hewlett-Packard Italiana S p A
Casella postale 3645
I-20124 **Milano**
Tel (2) 6251 (10 lines)
Cable HEWPACKIT Milano
Telex 32046

Hewlett-Packard Italiana S p A
Via Pietro Maroncelli 40
(ang Via Visentin)
I-35100 **Padova**
Tel (49) 66 48 88
Telex 32046 via Milano

Medical only
Hewlett-Packard Italiana S p A
Via d Aghiardi 7
I-56100 **Pisa**
Tel (050) 2 32 04
Telex 32046 via Milano

Hewlett-Packard S p A
Via G Armellini 10
I-00143 **Roma** Eur
Tel (06) 54 69 61
Telex 61514
Cable HEWPACKIT Roma

Hewlett-Packard Italiana S p A
Via San Quintino 46
I-10121 **Torino**
Tel 53 82 64 54 84 68
Telex 32046 via Milano

Medical/Calculators Only
Hewlett-Packard Italiana S p A
Via Principe Nicola 43 G/C
I-95126 **Catania**
Tel (095) 37 05 05

Hewlett-Packard Italiana S p A
Via Amerigo Vespucci 9
I-80142 **Napoli**
Tel (81) 33 77 11

Hewlett-Packard Italiana S p A
Via E Masi 9/B
I-40137 **Bologna**
Tel (051) 30 78 87

LUXEMBURG
Hewlett-Packard Benelux
S A /N V
Avenue du Col-Vert 1
(Groenkraaglaan)
B-1170 **Brussels**
Tel (02) 672 22 40
Cable PALOBEN Brussels
Telex 23 494

NETHERLANDS
Hewlett-Packard Benelux N V
Van Heuven Goedhartlaan 121
P O Box 667
NL- **Amstelveen** 1134
Tel (020) 47 20 21
Cable PALOBEN Amsterdam
Telex 13 216 hepa nl

NORWAY
Hewlett-Packard Norge A/S
Nesveien 13
Box 149
N-1344 **Haslum**
Tel (02) 53 83 60
Telex 16621 hpnas n

POLAND
BIURO INFORMACJI TECHNICZNEJ
Hewlett-Packard
U1 Stawki 2 6P
00-950 **Warsaw**
Tel 39 67 43
Telex 81 24 53 hepa pl

PORTUGAL
Telectra-Empresa Técnica de
Equipamentos Eléctricos S a r l
Rua Rodrigo da Fonseca 103
P O Box 2531
P-**Lisbon** 1
Tel (19) 68 60 72
Cable TELECTRA Lisbon
Telex 12598

Mundinter
Intercambio Mundial de Comércio
S a r l
Av A A de Aguiar 138
P O Box 2761
P - **Lisbon**
Tel (19) 53 21 31/7
Cable INTERCAMBIO Lisbon

RUMANIA
Hewlett-Packard Technical Office
BD N Balcescu 16
Bucharest
Tel 158023/138885
Telex 10440

SPAIN
Hewlett-Packard Española S A
Jerez No 3
E-**Madrid** 16
Tel (1) 458 26 00 (10 lines)
Telex 23515 hpe

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

Hewlett-Packard Española S A
Av Ramón y Cajal 1-9
(Edificio Sevilla I)
E-**Seville 5**
Tel 64 44 54/58

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
Gran Via Fernando El Católico 67
E-**Valencia**-8
Tel 326 67 28/326 85 55

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

Hewlett-Packard Sverige AB
Frotallisgatan 30
S-421 32 **Vastra Frolunda**
Tel (031) 49 09 50
Telex 10721 Via Bromma Office

SWITZERLAND
Hewlett-Packard (Schweiz) AG
Zurcherstrasse 20
P O Box 307
CH-8952 Schlieren **Zurich**
Tel (01) 98 18 21
Cable HPAG CH
Telex 53933 hpag ch

Hewlett-Packard (Schweiz) AG
9 Chemin Louis-Pictet
CH-1214 Vernier-**Geneva**
Tel (022) 41 49 50
Cable HEWPACKAG Geneva
Telex 27 333 hpag ch

TURKEY
Telekom Engineering Bureau
P O Box 437
Beyoglu
TR-**Istanbul**
Tel 49 40 40
Cable TELEMATION Istanbul

UNITED KINGDOM
Hewlett-Packard Ltd
King Street Lane
GB-**Winnersh**, Wokingham
Berks RG11 5AR
Tel (0734) 78 47 74
Cable Hewpie London
Telex 847178/9

Hewlett-Packard Ltd
"The Grattons"
Stamford New Road
GB-**Altrincham**
Cheshire WA14 IDJ
Tel (061) 928 9021
Cable Hewpie Manchester
Telex 668068

Hewlett-Packard Ltd
Lygon Court
Dudley Road
GB-**Halesowen**, Worcs
Tel (021) 550 7053
Telex (021) 550 7273

Hewlett-Packard Ltd
4th Floor
Wedge House
799 London Road
GB-**Thornton Heath** CR4 6XL
Surrey
Tel (01) 684 0103/0105
Telex 946825

Hewlett-Packard Ltd
c/o Makro
South Service Wholesale Centre
Wear Industrial Estate
Washington
GB-**New Town**, County Durham
Tel Washington 464001 ext 57/58

Hewlett-Packard Ltd 's registered
address for V A T purposes
only
70 Finsbury Pavement
GB **London** EC2A1SX
Registered No 690597

USSR
Hewlett-Packard Representative
Office USSR
Pokrovsky Boulevard 4/17, Suite 12
Moscow 101000
Tel 294 2024
Telex 7825 hewpak SU

YUGOSLAVIA
Iskra-Standard/Hewlett-Packard
Office
Miklosiceva 38/VII
61000 **Ljubljana**
Tel 315 879/321-674
Telex 31583 YU HEWPAK

AFRICA, ASIA, AUSTRALIA

AMERICAN SAMOA
Calculators Only
Oceanic Systems Inc
P O Box 777
Pago Pago Bayfront Road
Pago Pago 96799
Tel 633-5513
Cable OCEANIC Pago Pago

ANGOLA
Telectra
Empresa Técnica de
Equipamentos
Eléctricos S A R L
R Barbosa Rodrigues 42-I°DT °
Caixa Postal 6487
Luanda
Tel 35515/6
Cable TELECTRA Luanda

AUSTRALIA
Hewlett-Packard Australia
Pty Ltd
31-41 Joseph Street
Blackburn, Victoria 3130
P O Box 36
Doncaster East, Victoria 3109
Tel 89-6351
Telex 31-024
Cable HEWPARD Melbourne

Hewlett-Packard Australia
Pty Ltd
31 Bridge Street
Pymble
New South Wales 2073
Tel 449-6566
Telex 21561
Cable HEWPARD Sydney

Hewlett-Packard Australia
Pty Ltd
153 Greenhill Road
Parkside 5063 S A
Tel 27-2591
Telex 82536 ADEL
Cable HEWPARD ADELAIDE

Hewlett-Packard Australia
Pty Ltd
141 Stirling Highway
Nedlands W A 6009
Tel 86-5455
Telex 93859 PERTH
Cable HEWPARD PERTH

Hewlett-Packard Australia
Pty Ltd
121 Wollongong Street
Fyshwick A C T 2609
Tel 95 3733
Telex 62650 Canberra
Cable HEWPARD CANBERRA

Hewlett Packard Australia
Pty Ltd
5th Floor
Teachers Union Building
495-499 Boundary Street
Spring Hill 4000 Queensland
Tel 29 1544
Telex 42133 BRISBANE

CYPRUS
Kypronics
19 Gregorios & Xenopoulos Rd
P O Box 1152
CY **Nicosia**
Tel 45628/29
Cable KYPRONICS PANDEHIS

GUAM
Medical/Pocket Calculators Only
Guam Medical Supply Inc
Jay Ease Building, Room 210
P O Box 8383
Tamuning 96911
Tel 646-4513
Cable EARMED Guam

HONG KONG
Schmidt & Co (Hong Kong) Ltd
P O Box 297
Connaught Centre
39th Floor
Connaught Road, Central
Hong Kong
Tel H-255291-5
Telex 74766 SCHMC HX
Cable SCHMIDTCO Hong Kong

INDIA
Blue Star Ltd
Kasturi Buildings
Jamshedji Tata Rd
Bombay 400 020
Tel 29 50 21
Telex 2156
Cable BLUEFROST

Blue Star Ltd
Sahas
414/2 Vir Savarkar Marg
Prabhadevi
Bombay 400 025
Tel 45 78 87
Telex 4093
Cable FROSTBLUE

Blue Star Ltd
Band Box House
Prabhadevi
Bombay 400 025
Tel 45 73 01
Telex 3751
Cable BLUESTAR

Blue Star Ltd
14/40 Civil Lines
Kanpur 208 001
Tel 6 88 82
Telex 292
Cable BLUESTAR

Blue Star Ltd
7 Hare Street
P O Box 506
Calcutta 700 001
Tel 23-0131
Telex 7655
Cable BLUESTAR

Blue Star Ltd
Blue Star House
34 Mahatma Gandhi Rd
Lajpatnagar
New Delhi 110 024
Tel 62 32 76
Telex 2463
Cable BLUESTAR

Blue Star Ltd
Blue Star House
11/11A Magarath Road
Bangalore 560 025
Tel 55668
Telex 430
Cable BLUESTAR

Blue Star Ltd
Meeakshi Mandiran
xxx/1678 Mahatma Gandhi Rd
Cochin 682 016 Kerala
Tel 32069 32161 32282
Telex 046-514
Cable BLUESTAR

Blue Star Ltd
1-1-117/1
Sarojini Devi Road
Secunderabad 500 003
Tel 70126 70127
Cable BLUEFROST
Telex 459

Blue Star Ltd
23/24 Second Line Beach
Madras 600 001
Tel 23954
Telex 379
Cable BLUESTAR

Blue Star Ltd
Nathraj Mansions
2nd Floor Bistupur
Jamshedpur 831 001
Tel 7383
Cable BLUESTAR
Telex 240

INDONESIA
BERCA Indonesia P T
P O Box 496
1st Floor JL Cikini Raya 61
Jakarta
Tel 56038, 40369, 49886
Telex 42895
Cable BERCACON

BERCA Indonesia P T
63 JL Raya Gubeng
Surabaya
Tel 44309

IRAN
Hewlett-Packard Iran Ltd
Mir Emad Ave
14th Street No 19
IR-**Tehran**
Tel 851082-6
Telex 21 25 74

ISRAEL
Electronics & Engineering Div
of Motorola Israel Ltd
16 Kremenetski Street
P O Box 25016
Tel-Aviv
Tel 38973
Telex 33569
Cable BASTEL Tel-Aviv

JAPAN
Yokogawa-Hewlett-Packard Ltd
Ohashi Building
1-59-1 Yoyogi
Shibuya-ku **Tokyo**
Tel 03-370-2281/92
Telex 232-2024YHP
Cable YHPMARKET TOK 23-724

Yokogawa-Hewlett-Packard Ltd
Nissei Ibaraki Building
2-8 Kasuga 2-chome, Ibaraki-shi
Osaka 567
Tel (0726) 23-1641
Telex 5332-385 YHP OSAKA

Yokogawa-Hewlett-Packard Ltd
Nakamo Building
24 Kami Sasajima-cho
Nakamura-ku **Nagoya** 450
Tel (052) 571-5171

Yokogawa-Hewlett-Packard Ltd
Tanigawa Building
2-24-1 Tsuruya-cho
Kanagawa-ku
Yokohama 221
Tel 045-312-1252
Telex 382-3204 YHP YDK

Yokogawa-Hewlett-Packard Ltd
Mito Mitsui Building
105 1-chrome, San-no-maru
Mito Ibaragi 310
Tel 0292-25-7470

Yokogawa-Hewlett-Packard Ltd
Inoue Building
1348-3 Asahi-cho 1-chome
Atsugi Kanagawa 243
Tel 0462-24-0452

KENYA
Technical Engineering
Services(E A)Ltd
P O Box 18311
Nairobi
Tel 557726/556762
Cable PROTON

Medical Only
International Aeradio(E A)Ltd
P O Box 19012
Nairobi Airport
Nairobi
Tel 336055/56
Telex 22201/22301
Cable INTAERIO Nairobi

KOREA
American Trading Company
Korea
C P O Box 1103
Dae Kyung Bldg 8th Floor
107 Sejong-Ro
Chongro-Ku **Seoul**
Tel (4 lines) 73-8924-7
Telex K 28338
Cable AMTRACO Seoul

LEBANON
Constantin E Macridis
Clemenceau Street 34
P O Box 7213
RL **Beirut**
Tel 36 63 97/8
Telex 21114 Leb
Cable ELECTRONUCLEAR Beirut

MALAYSIA
Teknik Mutu Sdn Bhd
2 Lorong 13/6A
Section 13
Petaling Jaya **Selangor**
Tel 7734505 (3 lines)

MOZAMBIQUE
A N Goncalves Lta
162 1° Apt 14 Av D Luis
Caixa Postal 107
Lourenco Marques
Tel 27091 27114
Telex 6 203 Negon Mo
Cable NEGON

NEW ZEALAND
Hewlett-Packard (N Z) Ltd
4-12 Cruickshank Street
Kilbirnie Wellington 3
Mailing Address Hewlett-Packard
(N Z) Ltd
P O Box 9443
Courtney Place
Wellington
Tel 877-199
Telex NZ 3839
Cable HEWPACK Wellington

Hewlett-Packard (N Z) Ltd
Pakuranga Professional Centre
267 Pakuranga Highway
Box 51092
Pakuranga
Tel 569-651
Telex NZ 3839
Cable HEWPACK Auckland

Analytical/Medical Only
Medical Supplies N Z Ltd
Scientific Division
79 Carlton Gore Rd , Newmarket
P O Box 1234
Auckland
Tel 75-289
Telex 2958 MEDISUP
Cable DENTAL Auckland

Analytical/Medical Only
Medical Supplies N Z Ltd
P O Box 1994
147-161 Tory St
Wellington
Tel 850-799
Telex 3858
Cable DENTAL, Wellington

Analytical/Medical Only
Medical Supplies N Z Ltd
P O Box 309
239 Stanmore Road
Christchurch
Tel 892-019
Cable DENTAL, Christchurch

Analytical/Medical Only
Medical Supplies N Z Ltd
303 Great King Street
P O Box 233
Dunedin
Tel 88-817
Cable DENTAL, Dunedin

NIGERIA
The Electronics
Instrumentations Ltd
N6B/770 Oyo Road
Oluseun House
P M B 5402
Ibadan
Tel 61577
Telex 31231 TEIL Nigeria
Cable THETEIL Ibadan

The Electronics Instrumentations Ltd
144 Agege Motor Road Mushin
P O Box 6645
Lagos
Cable THETEIL Lagos

PAKISTAN
Mushko & Company, Ltd
Oosman Chambers
Abdullah Haroon Road
Karachi-3
Tel 511027, 512927
Telex KR894
Cable COOPERATOR Karachi

Mushko & Company, Ltd
38B Satellite Town
Rawalpindi
Tel 41924
Cable FEMUS Rawalpindi

PHILIPPINES
The Online Advanced Systems
Corporation
6th Floor, Yujuico Building
560 Quintin Paredes Street
Binondo, **Manila**
Tel 40-05-41, 40-05-31
Telex 3327 GENBANK

RHODESIA
Field Technical Sales
45 Kelvin Road North
P O Box 3458
Salisbury
Tel 705231 (5 lines)
Telex RH 4122

SINGAPORE
Hewlett-Packard Singapore
(Pte) Ltd
Blk 2, 6th Floor, Jalan
Bukit Merah
Redhill Industrial Estate
Alexandra P O Box 58,
Singapore 3
Tel 633022
Telex HPSG RS 21486
Cable HEWPACK, Singapore

SOUTH AFRICA
Hewlett-Packard South Africa
(Pty) Ltd
Private Bag Wendywood
Sandton, Transvaal 2144
Hewlett-Packard House
Daphne Street, Wendywood,
Sandton, Transvaal 2144
Tel 802-104016
Telex SA43-4782JH
Cable HEWPACK JOHANNESBURG

Hewlett-Packard South Africa
(Pty), Ltd
P O Box 120
Howard Place, Cape Province
7450
Pine Park Center, Forest Drive,
Pinelands, Cape Province, 7405
Tel 53-7955 thru 9
Telex 57-0006

Hewlett-Packard South Africa
(Pty) Ltd
P O Box 37099
Overport, Durban 4067
641 Ridge Road, Durban
Durban 4001
Tel 88-7478 / 1080 88-2520
Telex 6-7954
Cable HEWPACK

TAIWAN
Hewlett-Packard Far East Ltd ,
Taiwan Branch
39 Chung Shiao West Road
Sec 1, 7th Floor
Taipei
Tel 389160,1,2,3
Telex 21824 HEWPACK
Cable HEWPACK TAIPEI

Hewlett-Packard Taiwan
38, Po-Ai Lane, San Min Chu,
Kaohsiung
Tel (07) 242318

Analytical Only
San Kwang Instruments Co , Ltd ,
No 20, yung Sui Road
Taipei, 100
Tel 3713171-4
Telex 22894 SANKWANG
Cable SANKWANG TAIPEI

TANZANIA
Medical Only
International Aeradio (E A), Ltd
P O Box 861
Daressalaam
Tel 21251 Ext 265
Telex 41030

THAILAND
UNIMESA Co Ltd
Elcom Research Building
Bangjak Sukumvit Ave
Bangkok
Tel 932387, 930338
Cable UNIMESA Bangkok

UGANDA
Medical Only
International Aeradio(E A), Ltd ,
P O Box 2577
Kampala
Tel 54388
Cable INTAERIO Kampala

ZAMBIA
R J Tilbury (Zambia) Ltd
P O Box 2792
Lusaka
Tel 73793
Cable ARJAYTEE Lusaka

MEDITERRANEAN AND MIDDLE EAST COUNTRIES NOT SHOWN PLEASE CONTACT:
Hewlett-Packard S A
Mediterranean and Middle
East Operations
35 Kolokotroni Street
Platia Kefallariou
GR-Kifissia-**Athens**
Telex 21-6588
Cable HEWPACKSA Athens

OTHER AREAS NOT LISTED, CONTACT:
Hewlett-Packard Intercontinental
3200 Hillview Ave
Palo Alto, California 94304
Tel (415) 493-1501
TWX 910-373-1267
Cable HEWPACK Palo Alto
Telex 034-8300 034-8493