Errata

Title & Document Type: **3450B Multi-Function Meter Operating and Service Manual**

Manual Part Number: **03450-90007**

Revision Date: **January 1976**

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HP References in this Manual

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HP 3450B

OPERATING AND SERVICE MANUAL

MULTI-FUNCTION METER

3450B

HEWLETT PACKARD

HP 3450B

OPERATING AND SERVICE MANUAL

-hp- Part No. 03450-90007

MODEL 3450B
MULTI-FUNCTION METER

Serials Prefixed: 1229A

WARNING

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

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

Printed: January 1976

HEWLETT hp PACKARD

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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.

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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.

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SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. The Hewlett-Packard Model 3450B Multi-Function Meter is a five digit integrating digital voltmeter/ohmmeter with Ratio measurement capability. A dual-slope integrating technique and fully guarded measurement circuitry provide excellent immunity from noise and common-mode voltages. DC measurement is basic to the instrument, with AC and Ohms functions added by optional plug-in assemblies. True four-terminal Ratio measurements are possible on DC, AC and Ohms functions. Ranging may be automatic over all non-Ratio and Ratio ranges.

1-3. Five DC ranges from 100 mV to 1000 V full scale provide 15 measurements per second, with 20% overranging on all ranges. A 1 μV resolution is achieved on the 100 mV range. An input resistance of greater than 10^{10} ohms is achieved on the 100 mV thru 10 V ranges, and 10 megohms on the 100 V and 1000 V ranges. Four Ratio ranges X1, X10, X100 and X1000 accommodate Reference Voltages from ± 100 mV to ± 120 V.*

1-4. AC Option provides four ranges from 1 V to 1000 V with true rms response for frequencies from 45 Hz to 1 MHz. Sine waves or nonsinusoidal waves having a crest factor up to 7 may be measured. There are four AC Ratio ranges.

1-5. Ohms Option has a six range capability of 100 Ω to 10 MΩ full scale, with 20% overranging on all ranges. A 1 mΩ sensitivity is offered on the 100 Ω range which has the maximum 1 mA signal current. A four-terminal technique allows measurements without lead resistance errors on non-Ratio, and complete isolation between the two resistors on Ratio. The Ohms Measurement may be in error if the component under test contains inductive or capacitive components, due to the pulsating nature of the ohms current source.

1-6. Other Options that may be added to the Standard instrument are Limit Test, Digital Output, Remote Control and Rear Input. Limit Test is a digital comparison against two programmed limits to give a "HI", "GO" and "LO" display. In no way does Limit Test affect or interfere with the normal measurement or readout. Digital output provides a digital output of the measurement data, function, range, polarity, limit-test decisions and some timing signals. Remote Control allows complete control of the instrument with coded voltages or switch closures to ground. Rear Input supplements the front panel terminals.

* Ratio ranges are limited by the Reference Voltage. See Paragraph 3-17.

1-7. SPECIFICATIONS.

1-8. Each 3450B is adjusted at the factory to operate according to the specifications on the following pages. Procedures are given in Section V to check the accuracy and other specifications and to readjust the instrument at the calibration intervals. The 30- and 90-day accuracy specifications apply for a 20°C to 30°C temperature range. For temperatures outside this range, a temperature coefficient factor times the number of degrees below 20°C or above 30°C must be added on. Accuracy increases with the percent of scale on each range, including not only the Ratio and non-Ratio ranges, but Y reference range too on Ratio. AC accuracy is specified for a sine wave, but may be applied to a nonsinusoidal waveform by considering the sine components of the wave without regard to phase.

1-9. PROGRAMMING AND OUTPUT LEVELS.

1-10. Alternate logic voltage levels at the Remote Control, Digital Output and Limit Test jacks may be selected by repositioning internal jumper wires on A3, A6, A24 and A25 assemblies. See Section V.

PROGRAMMING LEVELS

"0" = -0.5 V to + 2.5 V, or ground
"1" = + 5.5 V to + 12 V, or open

Alternate Levels

"0" = - 0.5 V to + 1 V, or ground
"1" = + 2.5 V to + 5 V, or open

OUTPUT LEVELS

"0" = + 0.5 V ± 0.5 V, 12 mA max sink current
"1" = + 11.5 V ± 0.5 V, 12 kΩ source resistance

Alternate Levels

"0" = + 0.5 V ± 0.5 V, 20 mA max sink current
"1" = + 4.5 V ± 0.3 V, 12 kΩ source resistance

1-11. OPTIONS.

Six options may be added to the Standard DC instrument.

OPTION	FACTORY INSTALLED	FIELD INSTALLED
AC Converter	Option 001	11078A
Ohms Converter	Option 002	11077A
Limit-Test	Option 003	11079A
Digital Output	Option 004	11080A
Remote Control	Option 005	11099A
Rear Input	Option 006	–

Table 1-1. Specifications.

DC

RANGES.

Full Scale Range Display.

± 100.000 mV
± 1.00000 V
± 10.0000 V
± 100.000 V
± 1000 00 V

Overranging.

20% on all ranges.

Range Selection.

Automatic, manual or remote (optional).

PERFORMANCE.

Accuracy.

24 hours (23°C ± 1°C, < 50% RH. Accuracy referenced to calibrating source.)

Range	Specification
1 V thru 1000 V	± (0.003% of reading + 0.001% of range)
100 mV	± (0.003% of reading + 0.004% of range)

30 days (25°C ± 5°C).

Range	Specification
1 V thru 1000 V	± (0.008% of reading + 0.002% of range)
100 mV	± (0.008% of reading + 0.01% of range)

90 days (25°C ± 5°C).

Add 0.002% of range to 30-day specification.

Temperature Coefficient (0°C to 50°C).

± (0.0004% of reading + 0.0003% of range) per °C.

Measuring Speed.

Integration Period	Reading Period (no autoranging)	Autorange Time (per range)
1/10 s	380 ms	380 ms
1/60 s	65 ms	65 ms

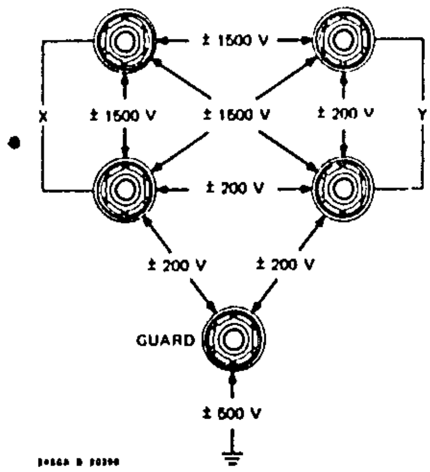
Each reading is within specified accuracy with a step input voltage change between reading periods.

INPUT CHARACTERISTICS.

Input Resistance.

Range	Specification
100 mV, 1 V 10 V	$>10^{10}\,\Omega$ (10 MΩ ± 0.1% selectable by external switch closure to ground)
100 V, 1000 V	10 MΩ ± 0.1%

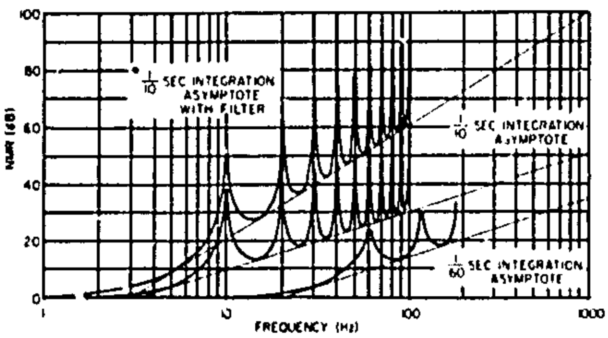
Maximum Peak Input Voltage.



(Note: Y terminals are used only on Ratio.)

Normal-Mode Rejection.

NMR is the ratio of the peak normal-mode signal to the peak error in reading. Sum of the dc input and peak normal-mode signal must not exceed 140% of range. Applies to DC and Ohms functions.



**Filter is available in H01-3450B (60 Hz) or H13-3450B (50 Hz).*

Effective Common-Mode Rejection.

ECMR is the ratio of the peak common-mode voltage to the resultant error in reading with 1 kΩ unbalance in either lead. Applies to DC and Ohms functions.

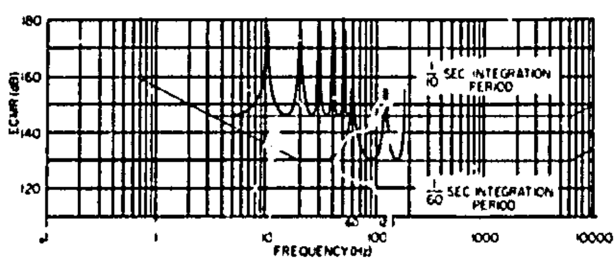


Table 1-1. Specifications (Cont'd).

DC RATIO

RANGES.

Full Scale Ratio Range Display.

± 1.00000
± 10.0000
± 100.000
± 1000.00

Y Denominator Ranges.

± 1 V
± 10 V
± 100 V

X Numerator Ranges.

± 1 V
± 10 V
± 100 V
± 1000 V

Note: X range equals Y range times Ratio range.

Overranging.

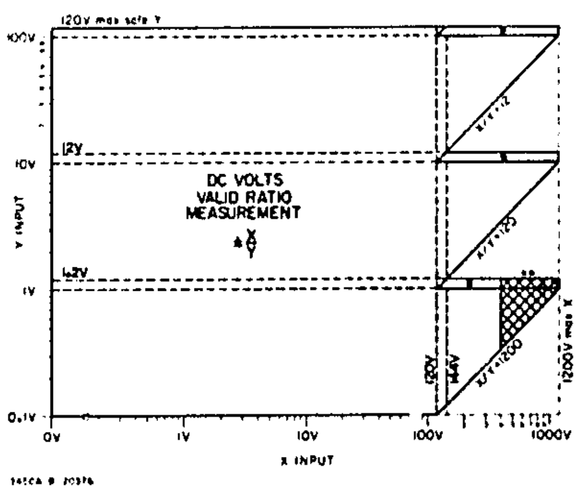
20% on all ranges.

Range Selection.

Automatic, manual or remote (optional) for Ratio range

Automatic for Y range.

Ratio Capability.



*Y must be on lower of two possible ranges

**Not specified in the crosshatch area.

PERFORMANCE.

Accuracy.

30 days (25°C ± 5°C).

± (0.01% of reading * + 0.002% of Ratio range + $\frac{\text{Y range}}{\text{Y voltage}}$ x 0.002% of Ratio range).

90 days (25°C ± 5°C).

± (0.01% of reading * + 0.002% of Ratio range + $\frac{\text{Y range}}{\text{Y voltage}}$ x 0.003% of Ratio range).

*Add 0.005% of reading for X >100 V.

Temperature Coefficient (0°C to 50°C).

± (0.0006% of reading + 0.0003% of Ratio range) per °C.

Measuring Speed.

Integration Period	Reading Period (no autoranging)	Autorange Time (per range)	
		Y input	X input
1/10 s	840 ms	380 ms	840 ms
1/60 s	210 ms	65 ms	210 ms

Each reading is within specified accuracy with a step input voltage ratio change between reading periods.

INPUT CHARACTERISTICS.

Input Configuration.

Isolated 4-terminal, guarded. No common ground necessary between X and Y voltages.

Input Resistance.

Same as DC function for both X and Y inputs.

Normal-Mode Rejection.

Same as DC function for X input.

Effective Common-Mode Rejection (ECMR).

Same as DC function for X input.

Maximum Peak Input Voltage.

Same as DC function.

Table 1-1. Specifications (Cont'd).

AC

RANGES (RMS responding, 45 Hz to 1 MHz).

Full Scale Range Display.

1.00000 V
10.0000 V
100.000 V
1000.00 V

Overranging.

20% on 1 V thru 100 V ranges.

1500 V peak on 1000 V range.

(Note: 1500 V peak = 1060 V rms for sine wave.)

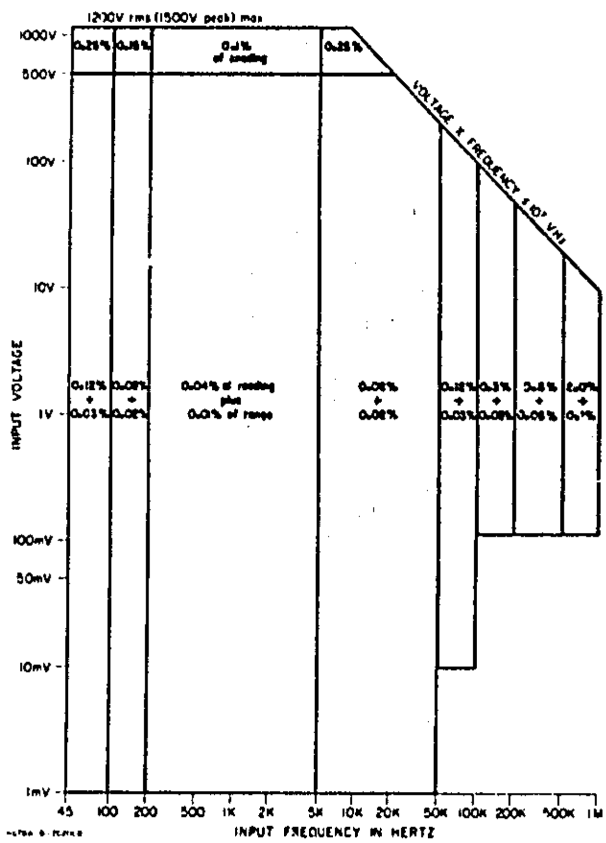
Range Selection.

Automatic, manual or remote (optional).

PERFORMANCE.

Accuracy (± %)

90 days (25°C ± 5°C).



(Note: This is also the accuracy of the X and Y inputs on Ratio.)

Stability.

24 hours (23°C ± 1°C, 10 mV to 500 V).

Frequency Range	Specification
45 Hz to 200 Hz	± (0.03% of reading + 0.003% of range)
200 Hz to 5 kHz	± (0.01% of reading + 0.002% of range)
5 kHz to 100 kHz	± (0.03% of reading + 0.003% of range)

Temperature Coefficient (0°C to 50°C).

Frequency Range	Coefficient ± (% of reading +% of range) per °C	
45 Hz to 100 Hz	0.003%	0.001 %
100 hz to 200 Hz	0.002%	0.0005%
200 Hz to 5 kHz	0.001%	0.0004%
5 kHz to 50 kHz	0.002%	0.0005%
50 kHz to 200 kHz	0.003%	0.001 %
200 kHz to 500 kHz	0.01 %	0.001 %
500 kHz to 1 MHz	0.02 %	0.002 %

Measuring Speed.

Integration Period	Reading Period (no autoranging)	Autorange Time (per range)
1/10 s	2.9 s	2.9 s

Each reading is within 0.1% of final value with a step input voltage change of 10%-to-100% of range between reading periods.

Crest Factor.

7:1 for frequencies > 1 kHz; 1 MHz bandwidth.

4:1 for < 1 kHz.

(Maximum peak voltage 1500 V.)

INPUT CHARACTERISTICS.

Input Impedance.

Front terminals: 2 MΩ shunted by 90 pF ± 10 pF in series with 0.1 μF.

Rear terminals: 2 MΩ shunted by 135 pF ± 15 pF in series with 0.1 μF.

Maximum Peak Input Voltage.

Same as DC function except that the maximum dc offset on the X terminals is ± 1000 V.

Table 1-1. Specifications (Cont'd).

AC RATIO

RANGES (RMS responding, 45 Hz to 1 MHz).

Full Scale Ratio Range Display.

1.00000
10.0000
100.000
1000.00

Y Denominator Ranges.

1 V
10 V
100 V

X Numerator Ranges.

1 V
10 V
100 V
1000 V

Note: X range equals Y range times Ratio range.

Overranging.

20% on X and Y 1 V thru 100 V ranges.

1500 V peak on 1000 V X range.

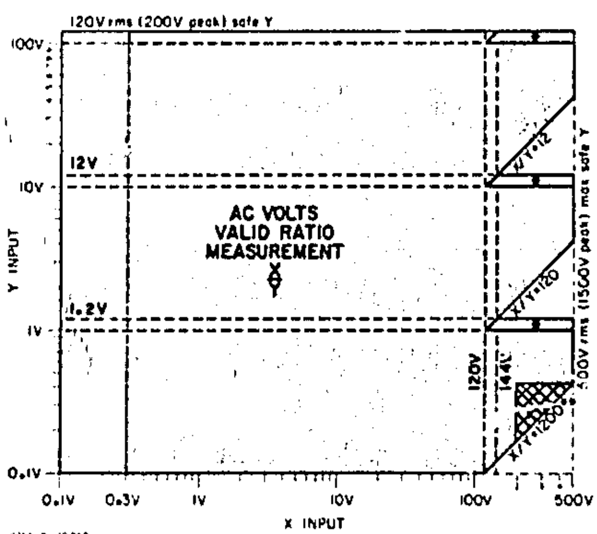
20% on Ratio ranges if Y ≤ 100% of scale.

Range Selection.

Automatic, manual or remote (optional) for Ratio range.

Automatic for Y range.

Ratio Capability.



*Y must be on lower of two possible ranges.

**In the crosshatch area, X terminal volts-hertz product must not exceed 2.5 x 10^6 VHz.

PERFORMANCE.

Accuracy.

90 days (25°C ± 5°C).

± (0.02% of reading + 0.01% of Ratio range + sum of accuracies of X and Y inputs determined from AC function accuracy graph.)

Temperature Coefficient (0°C to 50°C, 200 Hz to 5 kHz).

± (0.002% of reading + 0.001% of Ratio range) per °C.

Measuring Speed.

Integration Period	Reading Period (no autoranging)	Autorange Time (per range)	
		Y Input	X Input
1/10 s	8.7 s	2.9 s	8.7 s

Each reading is within 0.1% of final value with a step input voltage ratio change of 10%-to-100% of range between reading periods.

Crest Factor.

7:1 for frequencies > 1 kHz; 1 MHz bandwidth.

4:1 for < 1 kHz.

(Maximum peak voltage 1500 V.)

INPUT CHARACTERISTICS.

Input Configuration.

Isolated 4-terminal, guarded. No common ground necessary between X and Y voltages.

Input Impedance.

Same as AC function for both X and Y inputs.

Inter-terminal capacitance between X and Y terminals: < 10 pF.

Maximum Peak Input Voltage.

Same as DC function except that the maximum dc offset on the X terminals is ± 1000 V.

Table 1-1. Specifications (Cont'd).

OHMS

RANGES.

Full Scale Range Display.

100.000 Ω
1.00000 kΩ
10.0000 kΩ
100.000 kΩ
1000.00 kΩ
10000.0 kΩ

Overranging.

20% on all ranges.

Range Selection.

Automatic, manual or remote (optional).

PERFORMANCE.

Accuracy.

30 days (25°C ± 5°C).

Range	Specification
100 Ω	± (0.01% of reading + 0.01% of range)
1 kΩ 10 kΩ 100 kΩ	± (0.01% of reading + 0.002% of range)
1000 kΩ	± (0.02% of reading + 0.002% of range)
10000 kΩ	± (0.1% of reading + 0.002% of range)

90 days (25°C ± 5°C).

Add 0.002% of range to 30-day specification.

Stability.

24 hours (23°C ± 1°C).

Range	Specification
100 Ω	± (0.004% of reading + 0.004% of range)
1 kΩ through 10000 kΩ	± (0.004% of reading + 0.001% of range)

Temperature Coefficient. (0°C to 50°C).

± (0.0006% of reading + 0.0003% of range) per °C.

Measuring Speed.

Integration Period	Reading Period (no autoranging)	Autorange Time (per range)
1/10 s	380 ms	380 ms
1/60 s	65 ms (165 ms on 10 MΩ range*)	65 ms (165 ms on 10 MΩ range*)

*Integration Delay must be programmed on 10 MΩ range on 1/60 s Integration Period.

Each reading is within specified accuracy with a step input resistance change between reading periods.

INPUT CHARACTERISTICS.

Input Configuration.

4 terminal, guarded.

Current Through Resistance (See Paragraph 1-5).

Range	Signal Current
100 Ω 1 kΩ 10 kΩ	1 mA
100 kΩ 1000 kΩ	10 μA
10000 kΩ	1 μA

Normal Mode Rejection.

Same as DC function.

Effective Common-Mode Rejection.

Same as DC function.

Overload Protection.

± 200 V peak for X and Y inputs.

Table 1-1. Specifications (Cont'd).

OHMS RATIO

RANGES.

Full Scale Ratio Range Display.

1.00000
10.0000
100.000
1000.00

Y Denominator Ranges.

1 kΩ
10 kΩ
100 kΩ
1 MΩ
10 MΩ

X Numerator Ranges.

1 kΩ
10 kΩ
100 kΩ
1 MΩ
10 MΩ

Note: X range equals Y range times Ratio range.

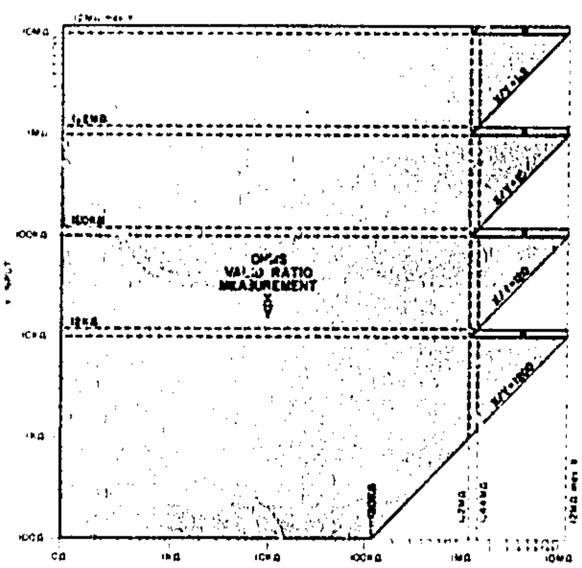
Overranging.

20% on all ranges.

Range Selection.

Automatic, manual or remote (optional) for Ratio range.
Automatic for Y range.

Ratio Capability.



*Y must be on lower of two possible ranges.

PERFORMANCE.

Accuracy (at terminals).

30 days (25°C ± 5°C).

± (% of Ratio reading error + % of Ratio range error), where

% of Ratio reading error is the greater percentage given below for the X and Y resistances.

0 – 100	100 – 1 K	1 K – 2 K	2 K – 9 K	9 K – 500 K	500 K – 5 M	5 M – 12 MΩ
5%	0.55%	0.1%	0.05%	0.02%*	0.05%	0.2%

*0.01% for ratios between 0.95 and 1.05 if X and Y are between 10 kΩ and 500 kΩ.

% of Ratio range error = (0.004% + $\frac{\text{Y range}}{\text{Y resistance}}$ x 0.002%).

90 days (25°C ± 5°C).

Same as 30-day specification except % of Ratio range error = (0.004% + $\frac{\text{Y range}}{\text{Y resistance}}$ x 0.003%).

Temperature Coefficient (0°C to 50°C).

± (0.0009% % of reading + 0.0003% of Ratio range) per °C.

Measuring Speed.

Integration Period	Reading Period (no autoranging)	Autorange time (per range) Y Input	Autorange time (per range) X Input
1/10 s	840 ms	380 ms	840 ms
1/60 s	210 ms	65 ms	210 ms

Each reading is within specified accuracy with a step input resistance ratio change between reading periods.

INPUT CHARACTERISTICS.

Input Configuration.

Isolated 4-terminal, guarded. Two terminals per resistor.

Current Through X and Y Resistances.

Same as Ohms function.

Normal-Mode Rejection.

Same as DC function for X input.

Common-Mode Rejection.

Same as DC function for X input.

Overload Protection.

± 200 V peak for X and Y input

Table 1-1. Specifications (Cont'd).

LIMIT TEST

Capability.

Limit Test may be used on DC, DC Ratio, Ohms, Ohms Ratio, AC, and AC Ratio functions. There is no degradation in performance on any function.

Limit Selection.

Two 4-digit limits (with 20% overrange) and polarity are programmed in BCD form by external switch closure to ground (< 3 kΩ, 2.8 mA max) or application of the "0" voltage defined below:

State	12 V Level	5 V Level*
"0"	- 0.5 V to + 2.5 V	- 0.5 V to + 1.0 V
"1"	+ 5.5 V to + 12 V	+ 2.5 V to + 5.0 V

(*The 5 V level is selected by moving a jumper wire on A24 assembly.)

The limits must be on the same range and polarity.

Limit Display.

HI, GO and LO illuminate on the front panel as follows:

HI ≥ high limit
GO < high limit and ≥ low limit
LO < low limit

Digital Output.

HI, GO and LO decisions are available in coded form with the Digital Output Option 004.

REMOTE CONTROL

Control.

All remote control is done by external switch closure to ground (< 3 kΩ, 2.8 mA max) or application of the "0" voltage defined below:

State	12 V Level	5 V Level
"0"	- 0.5 V to + 2.5 V	- 0.5 V to + 1.0 V
"1"	+ 5.5 V to + 12 V	+ 2.5 V to + 5.0 V

Programs

Remote Control Program. Programs Remote Control mode remotely. There must be a > 200 µsec delay between the time Remote Control information is output and external trigger is executed.

Man/External. Programs front-panel manual/rear-panel external triggering mode.

Manual Inhibit. Inhibits manual triggering.

External Trigger*. "0" state for > 50 µs preceded by "1" state for > 20 ms triggers instrument for new measurement.

1/60 Sec Gate*. Decreases integration interval of Input Voltage from 1/10 s to 1/60 s and timing intervals proportionally to increase reading rate.

Integration Delay*. Increases delay before measurement of Input Voltage after Trigger by 100 ms to allow for source settling time.

10 MΩ DC Input*. Changes input resistance from > 10^{10} Ω to 10^7 Ω on 100 mV, 1 V and 10 V DC ranges.

Function. 4-line code selects DC, AC, Ohms, Ratio, and Limit Test functions.

Non-Ratio Range. 4-line code selects non-Ratio ranges.

Ratio Range. 3-line code selects Ratio ranges.

Decimal Point. 4-line code selects display decimal point position independent of the actual range.

*These capabilities are included in the Standard instrument.

DIGITAL OUTPUT

Outputs.

4-line binary codes ("1" state positive) are supplied for
the polarity, limit test decision, and overload combined;
each of the N1 thru N6 data digits;
the non-Ratio and Ratio range; and
the function.

The output and reference levels are defined below:

State	12 V Level	5 V Level*
"0"	+ 0.5 V ± 0.5 V 12 mA max sink current	+ 0.5 V ± 0.5 V 20 mA max sink current
"1"	+ 11.5 V ± 0.5 V 12 kΩ source resistance	+ 4.5 V ± 0.3 V 12 kΩ source resistance

Ref Level	12 V Level	5 V Level	Source Resistance
Negative	+ 1 V	+ 0.4 V	3 kΩ
Positive	+ 6 V	+ 3 V	10 kΩ

(*The 5 V level is selected by moving a jumper wire on A25 assembly and changing two components.)

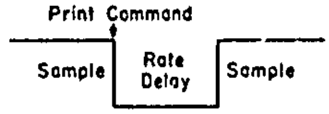
The output signal levels of a reading are held until Print Command of the next reading.

Print Command.

Print Command is a high-to-low transition (dc coupled) at the end of each non-Ratio and Ratio measurement period. The digital output signals of the measurement are encoded at this time. Switches on the Digital Output Assy may be set to prohibit Print Command signal on HI, GO and/or LO decisions on Limit Test function.

Print level: 0 V, 12 mA max current.

No-print level: 12 V or 5 V determined by the logic level selected.



Print or Trigger Holdoff.

Print Command signal or INT Trigger* may be heldoff until a printer is ready. (*A jumper is moved on A7 assembly to give holdoff of INT Trigger.)

Holdoff level: - 0.5 V to + 2.5 V, or ground, 9 mA max current.

GENERAL

Operating Temperature.

0°C to 50°C, unless otherwise specified.

Storage Temperature.

- 40°C to + 75°C.

Power (115 V or 230 V ± 10%, 50 Hz to 400 Hz).

< 75 watts with all Options.

Dimensions.

21 3/8", 16 3/4", 3 15/32"

Weight.

Basic instrument. Net 31 lb (14, 1 kg)
Including all Options. Net 36 lb (16, 3 kg)
Shipping. 59 lb (22, 7 kg)

1-12. EQUIPMENT AVAILABLE.

RACK MOUNT KIT - Includes mounting brackets, two 15 pin assembly extenders 5060-6033, and a 36 pin connector 1251-0084 for the Remote Control Jack. (Supplied with Standard instrument.)	03450-84401
LAMP REPLACEMENT KIT - Includes five lamps 1450-0356, and tool 4040-0427. (Supplied with standard instrument.)	03450 84402
3450B OPERATING AND SERVICE MANUAL - (Supplied with standard instrument.)	03450-90007
POWER CORD - (Supplied with standard instrument) 8120-1348.	8120-1348
ASSEMBLY EXTENDER KIT - Includes one 6 pin extender 5060-5914, and one 12 pin extender 5060-5915. (Supplied with AC Option 001 and 11078A.)	11078-84401
CONNECTOR - 50 pin (Supplied with Limit Test Option 003 and 11079A.)	1251-2303
LIMIT SELECTOR - Used with Limit-Test Option 003 to select A and B limits, and polarity.	11112A
CONNECTOR - 50 pin (Supplied with Digital Output Option 004 and 11080A.)	1251-0086
DIGITAL PRINTER - Used with Digital Output Option 004.	Model 5050A
REAR INPUT CABLE - (Supplied with Rear Input Option 006 -hp- Part No. 1251-1233 4-connector plug.)	11133A

1-13. INSTRUMENT/MANUAL IDENTIFICATION.

1-14. Hewlett-Packard uses a two-section serial number separated by a letter. If the first four digits (serial prefix) on your instrument does not agree with that on the title page of this manual, then a Manual Changes supplement will describe any difference between your instrument and the Model 3450B of this manual.

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This Section explains how to prepare the Model 3450B Multi-Function Meter for use. Included are initial inspection procedures, power and grounding requirements, environmental information, mounting instructions and instructions for repackaging for shipment. Field installation of Options is also included in this section.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. If the shipping container is damaged it should be kept until the contents of the shipment have been checked mechanically and electrically. If the instrument does not pass a mechanical inspection or the electrical performance tests given in Section V, notify the carrier and refer to the warranty on the front cover of this manual.

2-5. POWER REQUIREMENTS.

2-6. The Model 3450B can be operated from any source of 115 V or 230 V ac +5% - 10% of 48 to 440 Hz frequency. The instrument can be easily adapted to the available line voltage by changing the position of the slide switches of the rear panel.

2-7. Figure 2-1 illustrates the standard power plug configurations that are used throughout the United States and in other countries. The -hp- part number shown directly below each plug drawing is the part number for a power cord equipped with the proper plug. If the appropriate power cord is not included with the instrument, notify the nearest Hewlett-Packard office and a replacement cord will be provided.

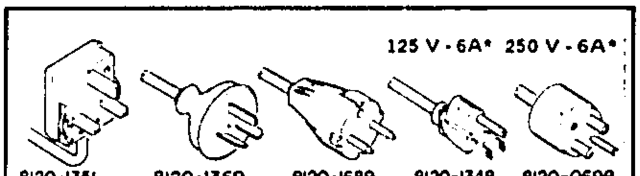


Figure 2-1. Power Plugs.

2-8. GROUNDING REQUIREMENTS.

2-9. For the safety of operating personnel, the instrument must be grounded. Th offset pin of the power plug grounds the instrument when plugged into the proper receptacle.

2-10. INSTRUMENT MOUNTING.

2-11. The 3450B is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument. The plastic feet are shaped so that the 3450B can be mounted on top of another -hp- instrument. If desired, the 3450B can be rack mounted using the rack mounting kit supplied with the instrument. Installation instructions are included with the kit.

2-12. LAMP REPLACEMENT.

2-13. A package containing five replacement bulbs and a bulb extractor tool is provided with the 3450B. The Service Note, P-4040-0427, contains instructions for removing and replacing the bulbs and switches.

2-14. FIELD INSTALLATION OF OPTIONS.

2-15. OHMS CONVERTER 11077A.

CAUTION

USE CLEAN HANDLING TECHNIQUES WHILE INSTALLING OPTIONS IN THE 3450B.

a. Remove the 3450B top cover, plastic insulator cover and internal guard cover.

b. Connect the five wires on the Ohms Converter to the matching color pins on the Relay Channel wall.

c. Plug the A58 and A59 (with A72) Ohms Converter Assemblies into the 3450B (see Figure 7-1).

d. Remove the A4 assembly and cut off the two OHM jumper wires (see Figure 7-10). Solder C2 into the right OHM jumper position. Replace A4.

e. Replace the function display tube on A13 with -hp- Part Number 1970-0038. Replace the three covers removed in Step a.

f. Using a narrow bladed screwdriver or Extractor Tool No. 4040-0427, pop out the lens labeled NO OHMS by pressing up at the front of the slot on the bottom of the button. Replace the NO OHMS label with the OHMS label.

g. Check the Ohms performance as described in Section V.

2-16. AC CONVERTER 11078A.

CAUTION

USE CLEAN HANDLING TECHNIQUES WHILE INSTALLING OPTIONS IN THE 3450B.

a. Remove the 3450B top cover, plastic insulator cover, and internal guard cover.

b. Remove the flat head screw on the right side and the two nylon screws on the left side of the 11078A top cover. Do not remove any other nylon screws. Remove the top cover by pulling straight up until the metal shields are clear of the guides.

c. Remove the rear assembly A85 from the 11078A.

d. Place the 11078A into the 3450B while carefully aligning the input pin on the front left corner of the 11078A with the pin jack on the 3450B (see Page 7-2).

e. Replace A85 into the 11078A, and replace the 11078A top cover, the 3450B internal guard cover, and the plastic insulator cover.

f. Remove A4 assembly and cut off the two AC jumper wires (see Page 7-19). Solder C1 into the right AC jumper position. Replace A4.

g. Replace the function display tube on A13 with Part No. 1970-0038 if not already installed with the Ohms Converter, and replace the 3450B top cover.

h. Replace the NO AC label on the front panel pushbutton with the AC label (see Paragraph 4-15f).

i. Check the AC performance as described in Section V.

2-17. LIMIT TEST 11079A.

a. Remove the cover plate on the top right corner of the 3450B rear panel.

b. Remove the 3450B top cover.

c. If the Digital Output Option is not installed, then it is necessary to install a Strapping Board to which the Limit Test and Digital Output assemblies connect. The Strapping Board plugs onto the back of the Outguard Mother Board holding A2 thru A9 assemblies.

(1) On instruments 953-01301 and above, a red/green/white wire for Ext Trig signal and a green Clock wire are clamped next to the position of the Strapping Board to be installed. Unclamp the wires and remove the insulators from the ends. Install the Strapping Board, using the plastic cable clamp as an insulator against the board on the mounting screw nearer the middle of the instrument. Use a lock washer and flat washer on each mounting screw. (No Teflon washers are needed.) Solder the two wires to the appropriate points on the top of the Strapping Board.

(2) On most instruments below 953-01301, two wires must be installed from the Ext Trig and Clock points on the Strapping Board to pins 19 and 31 respectively of the Remote Control Jack. (There is one other wire on pin 19.) Use 26 gage stranded wire. Use a plastic cable clamp 1400-0053 as an insulator on the mounting screw nearer the center of the instrument on the Strapping Board.

d. Install the Limit Test Assembly A24 into the rear panel of the 3450B with the component side up. See Page 3-3.

e. Remove A4 assembly and cut off the L.T. jumper wire. See Page 7-19. Replace A4.

f. Replace the 3450B top cover.

g. Replace the NO LIMIT TEST label on the front panel pushbutton with the LIMIT TEST label (see Paragraph 2-15f).

2-18. DIGITAL OUTPUT 11080A.

a. Remove the cover plate on the bottom right corner of the 3450B rear panel.

b. Remove the 3450B top cover.

c. If the Limit Test Option is not installed, then it is necessary to install a Strapping Board to which the Digital Output and Limit Test assemblies connect (see Paragraph 2-17c).

d. Position switches S1 thru S3 on the Digital Output assembly to program the Print Command signal to occur only on the desired HI, GO, and/or LO Limit-Test decisions. Print Command occurs with the switches in the HI, GO, and LO positions.

e. Install the Digital Output Assembly A25 into the rear panel of the 3450B with the component side up. See Page 3-3.

f. Replace the 3450B top cover.

2-19. REMOTE CONTROL 11099A.

a. Remove the 3450B top cover.

b. Plug the Remote Control Assembly A3 into the 3450B (see Page 7-2).

c. Remove A4 assembly. Cut off the two REM jumper wires. Replace A4.

d. Replace the 3450B top cover.

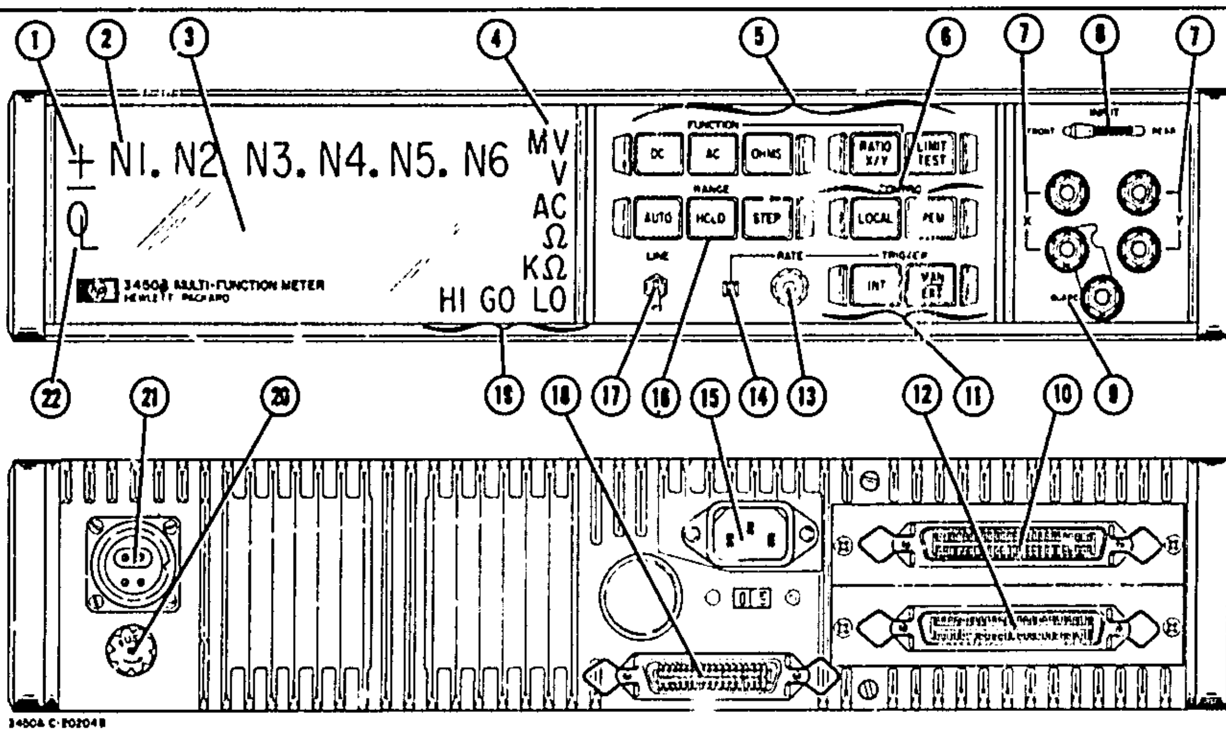
e. Replace the NO REM label on front panel pushbutton with the REM label (see Paragraph 2-15f)

2-20. REPACKAGING FOR SHIPMENT.

2-21. If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument describing the work to be accomplished and identifying the owner and instrument. Identify the instrument by serial number, model number, and name in any correspondence. If you have any questions, contact your local Hewlett-Packard Sales and Service Office. See Appendix B for office locations.

2-22. If the original shipping container is to be used, place the instrument in the container with appropriate packing material and seal the container well with strong tape or metal bands. A new container may be purchased from your nearest -hp- Sales and Service Office.

2-23. If an -hp- container is not to be used, then use a heavy carton or wooden box with an inner container. Wrap the instrument with heavy paper or plastic and place cardboard strips across the face for protection before placing the instrument in the inner container. Use packing material around all sides of the inner container, and seal the outer container well with strong tape or metal bands. Mark the container with "DELICATE INSTRUMENT," or "FRAGILE".



(1)	Polarity: On Ratio is (+) for (+/+), and (-) for (+/-) or (-/+).	(11)	TRIGGER: Select INT triggering or MAN/EXT triggering mode. Manually triggers at the MAN/EXT button or externally triggers at the rear panel Remote Control jack.
(2)	N1 digit blanks for < 100% of scale on a given range; N1 thru N6 blank and Overload indicates for ≥ 120% of range.	(12)	Digital Output: Use plug 1251-0086 to monitor data, function, range, polarity, overload and limit test decisions.
(3)	Display: Indicates polarity, overload, six data digits, range, function and limit test decisions.	(13)	RATE: adjusts triggering rate on INT mode.
(4)	Function Indicators: Blank on Ratio.	(14)	Rate Lamp flashes at the beginning of each measurement period and at each autorange change of X and Y inputs.
(5)	Function: Selects DC, AC OHMS basic measurement function. RATIO and LIMIT TEST are selected in conjunction with any basic function. RATIO and LIMIT TEST are push on/push off buttons.	(15)	AC power: 115 V or 230 V may be applied to this connector. LINE VOLTAGE SWITCH MUST BE IN CORRECT POSITION BEFORE POWER IS APPLIED.
(6)	Control: Select LOCAL or REMOTE mode. Remote mode may also be selected at rear panel Remote Control Jack.	(16)	Range: Select AUTO or HOLD ranging mode.
(7)	X Y Terminals: Use X terminals for DC and AC non-Ratio measurements. Use X and Y in parallel on Ohms non-Ratio. Use X for numerator and Y for denominator on DC, AC and Ohms Ratio.	(17)	LINE switch: Applies line voltage to the instrument when in the up position.
(8)	Input: Select FRONT panel X and Y input terminals or REAR panel Input Jack.	(18)	Remote Control. Use plug 1251-0084 to program Remote Control mode, Internal or Manual/External triggering modes, function, range, integration delay, 10 MΩ DC Input and 1/60 sec Gate. Apply voltage or ground pulses for external triggering.
(9)	**CAUTION** TO AVOID INSTRUMENT DAMAGE, DO NOT LEAVE THE GUARD TERMINAL FLOATING. CONNECT GUARD TO X LOW ON NON-RATIO, OR X OR Y LOW ON RATIO; THEN CONNECT LOW X AND Y TO THE SOURCE; AND LAST CONNECT HIGH X AND Y TO THE SOURCE. DISCONNECT IN THE REVERSE ORDER. SEE PARAGRAPHS 3-26, 3-29 AND 3-36. DO NOT SELECT OHMS FUNCTION WITH > ±200 V PEAK ON THE INPUT TERMINALS.	(19)	HI: Data ≥ high limit GO: Data < high limit and ≥ low limit. LO: Data < low limit.
		(20)	Fuse: Use fuse 2110-0312 for 115 V line; 2110-0202 for 230 V line.
		(21)	Input: Use Rear Input Cable 11133A for X and Y inputs and use GUARD as per Paragraph 3-36.
(10)	Limit Test: Use plug 1251-2303 to program HI and LO limits of Limit Test Function.	(22)	Overload: Indicates and Y is measured if Y < 100 mV or 100 Ω on Ratio.

Figure 3-1. Controls, Indicators, Connectors.

SECTION III
OPERATING INSTRUCTIONS

3-1. CONTROL MODES.

3-2. The 3450B has two control modes, Local (front-panel) and Remote (rear-panel). However, external triggering, HI-LO limit programming and some miscellaneous control programming are permitted at the rear-panel on Local Control. Front-panel triggering is allowed on REM with the MAN/EXT button.

3-3. Local Control is selected by pressing the LOCAL button. Remote Control is selected by pressing the REM button or by momentarily grounding the Remote Control Program line. The line may be held low to prevent the regaining of Local Control at the front panel. Manual-Inhibit Program also locks out Local Control (see Paragraph 3-45.

3-4. LOCAL CONTROL.

3-5. All front panel control may be accomplished between measurement Sample Periods and also during the prior Sample Period. This control includes a change between DC, AC, OHMS, RATIO, and LIMIT TEST functions a change between AUTO and HOLD ranging modes; a STEP range change on HOLD a change between LOCAL and REM control modes a change between INT and MAN/EXT TRIGGERING modes. A change of triggering RATE on INT. MAN trigger is active only after the end of a Sample Period.

3-6. TRIGGERING.

3-7. Sample rate is adjusted with the RATE control when INT mode is selected; manual triggering is accomplished with the MAN/EXT button, and external triggering is done with voltage pulses at the rear-panel Remote Control Jack after the MAN/EXT button is pressed to disable internal triggering. (If it is pressed between Sample Periods, both the MAN/EXT mode is selected and a trigger is initiated at the same time. It is recommended that MAN/EXT mode be selected if the instrument is on standby.)

3-8. The front panel RATE lamp illuminates during the interval of the Sample Period which is from trigger at t_0 until the Input Voltage has charged the Integrator at t_3. Auto-ranging causes a reset to t_0 from t_7 or t_{14}; so the Rate Lamp illuminates not only for each separate measurement readout (each Clock output pulse) but also for each auto-range change of X and Y.

3-9. FUNCTION SELECTION.

3-10. The three elementary functions – DC, AC, and Ohms – in conjunction with Limit-Test and/or Ratio on each of the three, lead to twelve function possibilities:

DC	AC	Ohms
HI>DC>LO	HI>AC>LO	HI>Ohms>LO
DC/DC	AC/AC	Ohms/Ohms
HI>DC/DC>LO	HI>AC/AC>LO	HI>Ohms/Ohms>LO

3-11. The DC, AC, and OHMS buttons are push-on type; LIMIT-TEST and RATIO are push-on/push-off.

3-12. If AC function is selected when the instrument is on the 100 mV DC range, a recycle to the 1000 V AC range will occur and then auto-downranging if on AUTO mode. So three range changes may take place upon going to AC.

3-13. If the input terminals are open on AUTO range mode on DC or Ohms, an auto-ranging "lockup" may happen whereby continuous auto-ranging occurs, giving no control over the RATE or selection of function.

3-14. If AC, Ohms, or Limit Test Option is not installed in the instrument, but the particular function is selected, the data display will blank-out, and the polarity display position indicate overload (Ω).

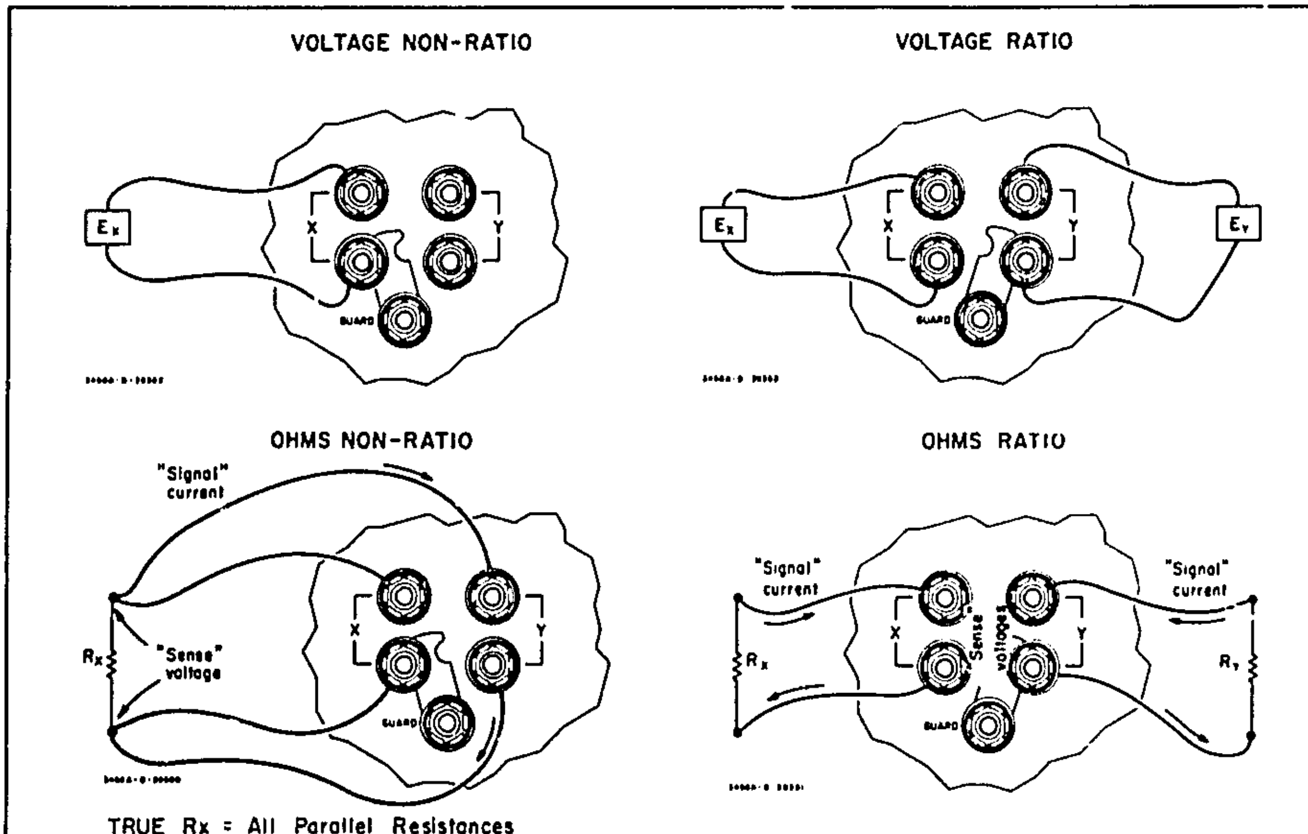
3-15. RANGING.

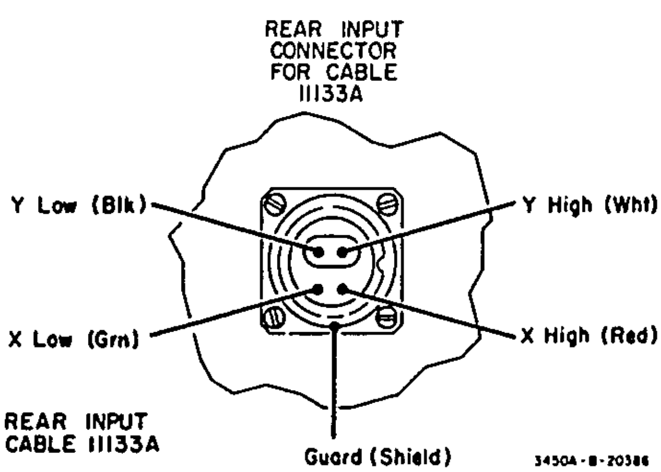
3-16. Two modes of ranging are possible, automatic (AUTO) and manual (STEP). Auto-downranging is at 10% of scale, and auto-upranging at 120% of scale on all functions. For manual ranging, press HOLD to disable auto-ranging, and then press STEP for each range change desired. STEP downranges on non-Ratio (recycling to top range), and upranges on Ratio (recycling to bottom range).

3-17. The non-Ratio and Ratio ranges are interrelated; the non-Ratio X range becomes the Y denominator range on Ratio, and the Y range multiplied by the Ratio range gives the X numerator range. Since the maximum absolute range of the 3450B is 1000 V or 10 MΩ, a Ratio range may not be selected such that the product of the Y range in volts or kilohms times the Ratio range (X1, X10, X100, X1000) exceeds 1000 V or 10 MΩ; i.e., all four Ratio ranges may be selected with Y on the 1 V range, but only the X1 Ratio range is permitted with Y on the 1000 V range.

3-18. Y range is always selected automatically on Ratio regardless of the ranging mode AUTO or HOLD; Y upranges at 120% of scale and downranges at 10% of scale. As a result of the hystersis between the ranging points, values of Y in the overrange region from 100% to 120% of scale on one range may also exist in the 10%-to-12% region of the next higher range. For best accuracy, Y should be on the lower of the two possible ranges. This can be done by bringing Y voltage up to its measured value from the low side; by disconnecting the Y terminals on DC or AC, or shorting them on Ohms for one Sample Period; or by going to non-Ratio and selecting the Y range.

3-19. When on a Ratio mode, the X and Y ranges autorange internally, depending on the Ratio Range selected and the magnitude of the Y input. The relationship is X Range=Y Range multiplied by Ratio-Range. The maximum X Range must not be exceeded by the given product or the Ratio Range will recycle to "x1" despite the fact that another range is programmed. The 3450B will then give a valid reading for the x1 Range or go into overload if the ratio is greater than 1:2. Example: If Ratio Range x100 is programmed on AC-Ratio then 10 volts (RMS) or more is put across the Y input terminals; Y autoranges to the 100 V Range, causing X to want to range to the 10,000 V Range, a prohibited condition since the maximum Y Range is 1000 V. Therefore, the Ratio Range recycles to x1 while X and Y are measured on the 100 V Ranges. If Y is lowered to an acceptable value and the x100 Ratio Range is still programmed, two triggers are required to return the instrument to the x100 Range.



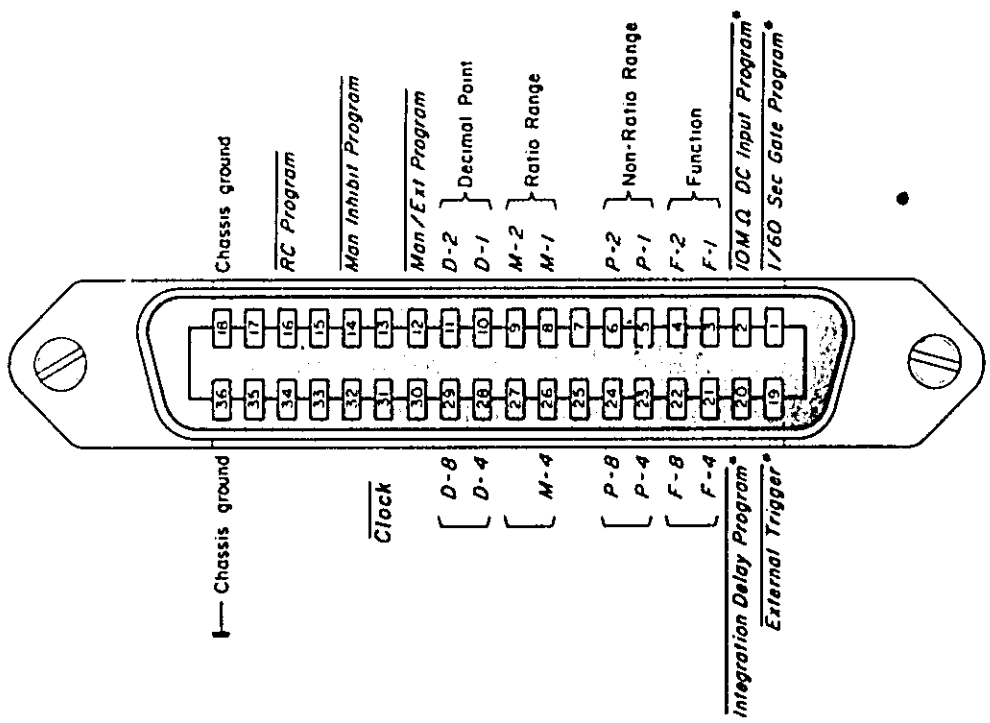


CAUTION

TO AVOID INSTRUMENT DAMAGE, DO NOT LEAVE THE GUARD TERMINAL FLOATING. CONNECT GUARD TO X LOW ON NON-RATIO, OR X OR Y LOW ON RATIO; THEN CONNECT LOW X AND Y TO THE SOURCE; AND LAST CONNECT HIGH X AND Y TO THE SOURCE. DISCONNECT IN THE REVERSE ORDER. SEE PARAGRAPHS 3-26, 3-29, and 3-36. DO NOT SELECT OHMS FUNCTION WITH >± 200 V PEAK ON THE INPUT TERMINALS.

Figure 3-2. Input Volts and Ohms Hookup.

REMOTE CONTROL JACK (Option 005)



Line above signal name means "0" true; otherwise "1" true.

"0" = -0.5 V to + 2.5 V, or ground
"1" = + 5.5 V to + 12 V, or open

*These programs and external triggering are possible on Local Control without Remote Control Option installed. These four lines go to A6 assy; all others to A3.

CODE 1	2	4	8	FUNCTION
0	0	0	0	DC
1	0	0	0	AC
0	1	0	0	Ω
1	1	0	0	DC
0	0	1	0	DC-Ratio
1	0	1	0	AC-Ratio
0	1	1	0	Ω-Ratio
1	1	1	0	DC-Ratio
0	0	0	1	DC-LT
1	0	0	1	AC-LT
0	1	0	1	Ω-LT
1	1	0	1	DC-LT
0	0	1	1	DC-Ratio-LT
1	0	1	1	AC-Ratio-LT
0	1	1	1	Ω-Ratio-LT
1	1	1	1	DC-Ratio-LT

CODE 1	2	4	8	NON-RATIO RANGE	
1	0	0	0	10 MΩ	
0	1	0	0	1 MΩ	1 kV
1	1	0	0	100 kΩ	100 V
0	0	1	0	10 kΩ	10 V
1	0	1	0	1kΩ	1 V
0	1	1	0	100 Ω	100 mV
-	-	-	1	Auto	Auto

CODE 1	2	4	RATIO RANGE
0	0	0	X1
1	0	0	X10
0	1	0	X100
1	1	0	X1000
-	-	1	Auto

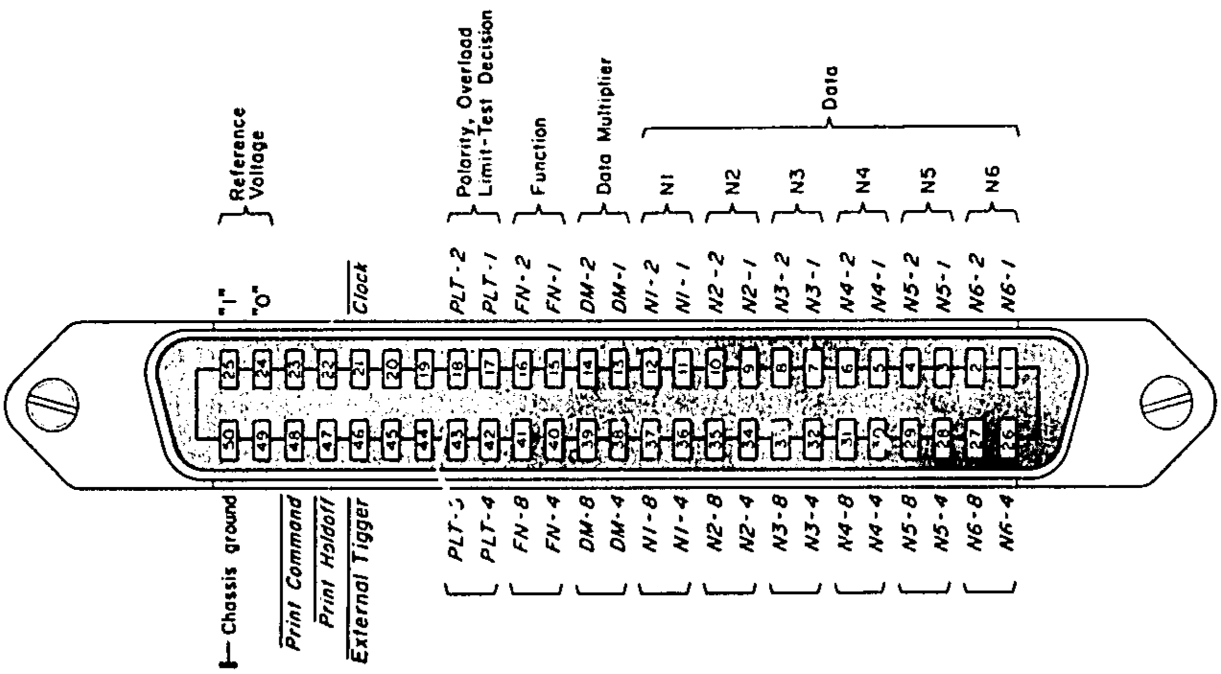
CODE 1	2	4	8	DECIMAL POINT
1	0	0	0	E
0	1	0	0	D
1	1	0	0	C
0	0	1	0	B
1	0	1	0	A
-	-	-	1	Auto

DATA DISPLAY

N1 . N2 . N3 . N4 . N5 . N6
A B C D E
DECIMAL POINT

Figure 3-3. Remote Control Jack.

DIGITAL OUTPUT JACK (Option 004)



Line above signal name means "0" true; otherwise "1" true.

"0" = + 0.5 V ± 0.5 V, 12 mA max sink current for all except Print Holdoff.
"1" = + 11.5 V ± 0.5 V, 12 kΩ source resistance.

Print Holdoff:
"0" = - 0.5 V to + 2.5 V, or ground
"1" = + 5.5 V to + 12 V, or open

POL, OL LT	PRINT*	CODE 1	2	4	8
+	0	0	0	0	0
-	1	1	0	0	0
+ OL	2	0	1	0	0
- OL	3	1	1	0	0
+ LO	4	0	0	1	0
- LO	5	1	0	1	0
+ LO, OL	6	0	1	1	0
- LO, OL	7	1	1	1	0
+ GO	8	0	0	0	1
- GO	9	1	0	0	1
+ GO, OL	+	0	1	0	1
- GO, OL	-	1	1	0	1
+ HI	V	0	0	1	1
- HI	A	1	0	1	1
+ HI, OL	Ω	0	1	1	1
- HI, OL	*	1	1	1	1

FUNCTION	PRINT*	CODE 1	2	4	8
DC	0	0	0	0	0
AC	1	1	0	0	0
Ohms	2	0	1	0	0
—	3	1	1	0	0
DC Ratio	4	0	0	1	0
AC Ratio	5	1	0	1	0
Ohms Ratio	6	0	1	1	0

*Using standard print wheel on -hp- Model 5050B Digital Recorder.

DATA MULT	PRINT*	CODE 1	2	4	8
—	0	0	0	0	0
10^{-1}	1	1	0	0	0
10^{-2}	2	0	1	0	0
10^{-3}	3	1	1	0	0
10^{-4}	4	0	0	1	0
10^{-5}	5	1	0	1	0
10^{-6}	6	0	1	1	0

DATA

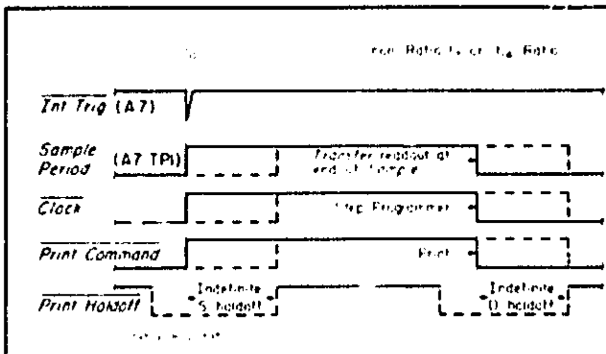
.N1	.N2	.N3	.N4	.N5	.N6
10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}

DATA MULTIPLIER

NOTE: AC prints (+) polarity; Ohms (-) polarity; Ohms Ratio (+) polarity.

Data x Data Mult = volts or kΩ on non-Ratio; dimensionless number on Ratio.

Figure 3-4. Digital Output Jack.



Clock signal goes low to step a programmer.

Print Command goes low to enable a printer.

Print Holdoff voltage is applied to holdoff either the beginning or the end of the Sample Period according to jumper position on A7 assy.

Figure 3-4 (Cont'd). Digital Output Jack.

3-20. When the Ratio Range upranges or downranges three times on AC Ratio the total time required is 32.4 sec. Three range changes require 24.3 sec plus 8.1 sec for the measurement.

3-21. LIMIT-TEST PROGRAMMING (Option 003).

3-22. Selection of the HI and LO limits on Limit-Test function is done in either Local or Remote control mode but is accomplished by rear-panel programming and is described in Paragraph 3-50.

3-23. MISC PROGRAMS.

3-24. The 1/60 Sec Gate, 10 MΩ DC Input, and Integration Delay are capabilities of the standard instrument (Remote Control Option 005 is not needed) and may be utilized on either Local or Remote Control. See Paragraph 3-59 for more detail.

3-25. INPUT CONSIDERATIONS.

3-26. X AND Y INPUTS.

3-27. X terminals are the non-Ratio input, or the numerator input on Ratio; Y terminals are the denominator input on Ratio. Y terminals also serve on non-Ratio Ohms as a "signal" output for classical four-terminal ohms measurements; with X serving as the "sense" input.

3-28. A four-terminal "sense-signal" ohms measurement (non-Ratio only) has the advantage of rejecting lead resistance from the measurement. This hookup involves the use of the four leads each connected directly to the measured resistance. The high X and Y leads (from red terminals) are connected to one end of the resistance, and the low (black) leads to the other end. The Y leads supply a constant "signal" current through the resistance, and the X leads measure ("sense") the voltage across the resistance. On Ratio, each pair of X and Y terminals supply a "signal" current and at the same time "sense" the voltage; and lead resistance is included in the measurement.

CAUTION

THE INSTRUMENT MAY BE DAMAGED IF SUBJECTED TO VOLTAGES EXCEEDING THE FOLLOWING LIMITS:

± 1500 V PEAK (1060 V RMS) BETWEEN ANY TWO OF THE FOUR X AND Y INPUT TERMINALS.

± 200 V PEAK BETWEEN THE TWO Y INPUT TERMINALS.

± 200 V PEAK BETWEEN ANY TWO OF THE THREE GUARD AND LOW TERMINALS.

± 500 V PEAK BETWEEN CHASSIS AND GUARD TERMINAL.

CONNECT GUARD TO ITS DRIVE VOLTAGE FIRST, THEN LOW X AND Y TO THEIR VOLTAGES, AND FINALLY HIGH X AND Y; AND DISCONNECT IN REVERSE ORDER.

3-29. DC POLARITY.

3-30. In general, the polarity on DC measurement hookups should be disregarded and the red X and Y terminals connected to the higher absolute potentials from ground in respect to the black terminals. Positive or negative polarity is then displayed accordingly.

3-31. COMPLEX WAVEFORMS.

3-32. Input voltages having complex or irregular waveforms may cause improper synchronization on AC measurements, resulting in some measurement error. In general, the AC Converter will synchronize to an input waveform that crosses zero going in a negative direction only once during each cycle of the fundamental frequency (45 Hz or higher). This error due to improper synchronization decreases as the frequency of the input signal increases.

3-33. INPUT CONSTRAINTS.

3-34. Overload (Ω) indicates and the data display blanks out for 120% of scale or greater on any non-Ratio or Ratio range. Also, if Y input falls below 100 mV on DC or AC, or 100 ohms on Ohms, on any Ratio range, then overload indicates; and uniquely, Y input itself is measured on the 1 V range and displayed as a non-Ratio measurement (although the decimal point may not be correct). The reading rate increases to the non-Ratio rate to indicate this latter measurement mode, and the maximum readout for Y is 009999.

3-35. There are also certain narrow ratio regions where overload indicates even though the given Ratio range is not overloaded if Y input is on the wrong range. Y may be between 10% and 12% of scale rather than properly in the overrange region from 100% to 120% of scale on the next lower range. This ambiguity of ranges is due to hysteresis between the auto-ranging points at 10% and 120% of scale. So to select the proper lower range of Y, the operator must *increase* Y to the measured value, as from 9 V to 11 V, rather than from 13 V to 11 V. The ratio 500 V/11 V is an example of when this must be done to get a readout. See the Ratio Capability graphs of Section I.

3-36. GUARD HOOKUP.

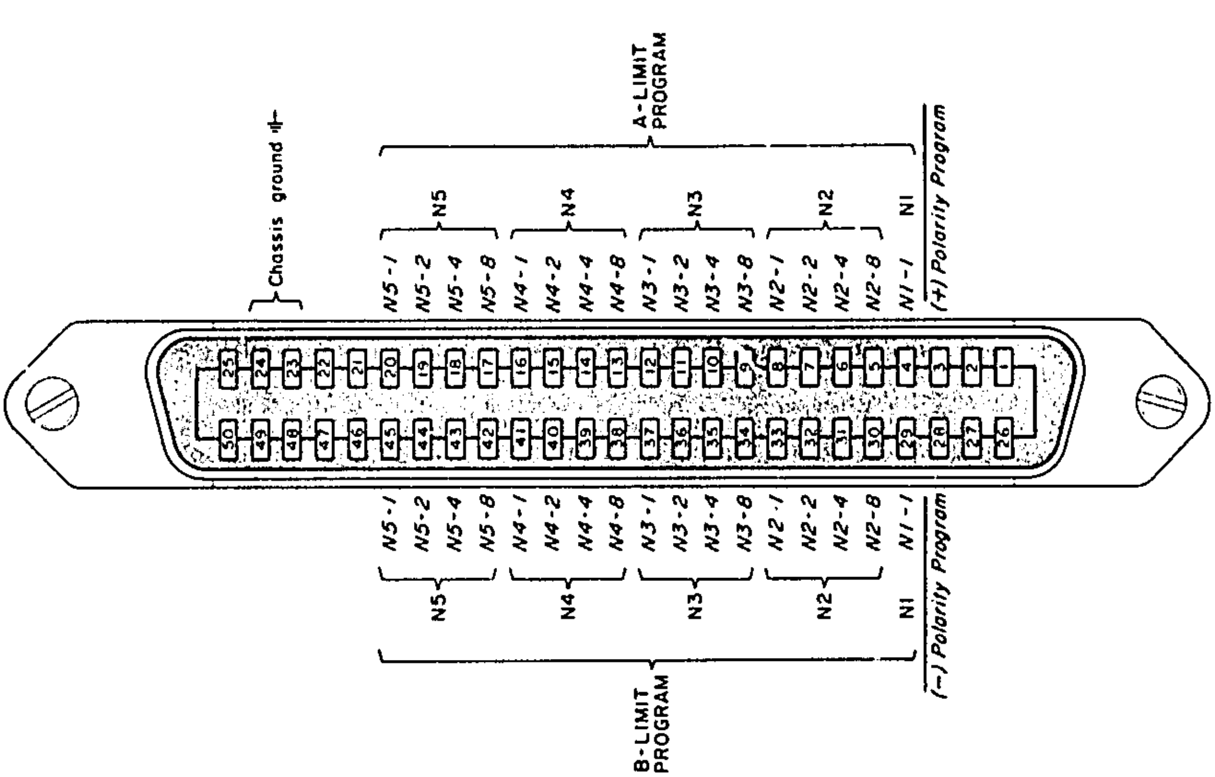
3-37. Proper use of the guard terminal provides high rejection of AC and DC common-mode voltages from the measurement. Common-mode voltages are those existing in the source circuitry between low measurement point and power-line ground, and between the power-line ground point of the source and that of the 3450B.(Common mode voltages tend to drive currents in the *same* direction through both the high and low input terminals.) The following two rules are given for optimum guard hookup:

a. Guard is connected to a DC potential above ground equal to that of the low input terminal, but in a manner such that

b. The guard current does not flow through any source circuit impedance affecting the measured voltage.

3-38. In Figure 3-6, guard potential is held equal to Low ($E_{Z_1} = 0$) so that I_L is not driven through R_1, R_2, and R_3

LIMIT-TEST PROGRAMMING JACK (Option 003)



N1 is most significant digit.

Line above signal name means "0" true; otherwise "1" true.

"0" = - 0.5 V to + 2.5 V, or ground
"1" = + 5.5 V to 12 V, or open

Figure 3-5. Limit Test Jack.

via Z_1 to affect the accuracy of the measurement. R_4 and R_5 are added to the source to hold guard potential equal to low. (A separate voltage supply may be used instead to drive guard, or a proper point may already exist within the source circuitry.) Note that guard current does not flow through R_1, R_2 and R_3. E_{CM1} due to E_1 is the DC common-mode voltage; E_{CM1}, due to E_2, E_{CM2} and E_{CM3}, are the AC common-mode voltages. Z_1 and Z_2 are leakage impedances between the low and guard terminals to chassis (power line) ground.

3-39. In measurements where common-mode voltages are not expected to be a problem, guard may be connected directly to the low terminal using the strap provided. (The strap is removable for other guard hookups.) In any case, the GUARD SHOULD NEVER BE LEFT FLOATING because a voltage at the high or low terminal may be divided by internal impedances to exceed the 200 V limitation between low and guard. See Page 3-4.

3-40. On Ratio measurements, guard should generally be used for the Y input, as noise rejection is less on this input, unless the common-mode or superimposed noise problem is definitely on the X input.

3-41. REMOTE CONTROL.

3-42. PROGRAMMING LEVELS.

3-43. Two types of programming are involved in Remote Control: single-line and coded-line. Single-line programs function individually and are true at the "low" level. Coded-lines function as "high-true" 1-2-4-8 binary codes.

REMOTE PROGRAM LEVELS

"low" or "0" = - 0.5 V to + 2.5 V, or grounded circuit
"high" or "1" = + 5 5 V to + 12 V, or open circuit

Alternate Levels*

"low" or "0" = - 0.5 V to + 1 V, or grounded circuit
"high" or "1" = + 2.5 V to + 5 V, or open circuit

* Alternate levels are selected by moving jumper wires on A3, A6, and A24 assemblies.

3-44. MISC PROGRAMS (Standard Instrument).

3-45. Three programs, 1/60 Sec Gate, 10 Megohm DC Input, and Integration Delay, although all acting through the Remote Control Jack are permitted on either Remote or Local control. 1/60 Sec Gate Program shortens the integration gate period from 1/10 sec to 1/60 sec, and the remainder of the Sample Period in the same proportion to increase the reading rate (but reduce noise rejection). 10 MΩ DC Input Program reduces the input resistance on the .1 V thru 10 V DC ranges from $>10^{10}$ ohms to 10^7 ohms.

3-46. Integration Delay inserts a 100 ms delay interval into the Sample Period prior to the integration of each Input Voltage (once per Sample Period on non-Ratio and three times on Ratio). It is required that Integration Delay be programmed when 1/60 Sec Gate is programmed on the 10 Megohm range. AC function automatically adds an Integration Delay of 2.4 sec. (3 x 2.4 sec = 7.2 sec total delay per Sample Period on AC Ratio.)

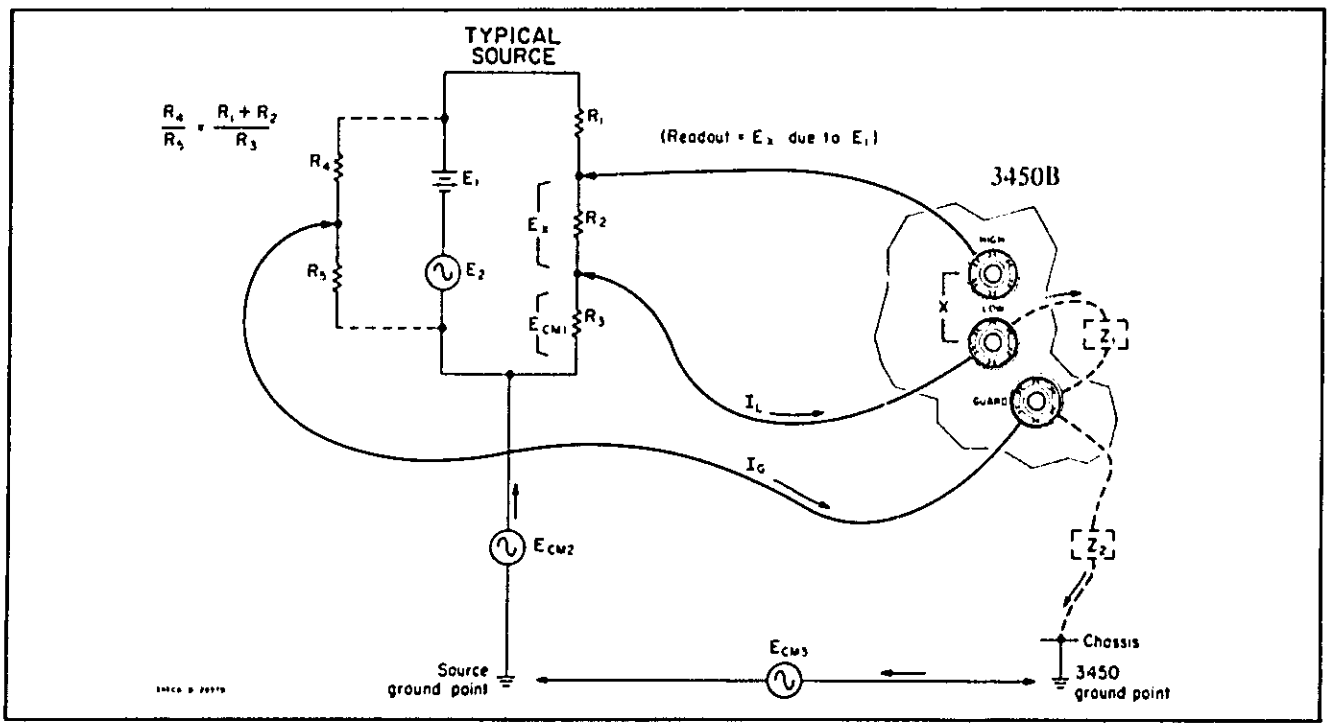


Figure 3-6. Typical Guard Hookup.

3-47. LIMIT-TEST PROGRAMMING (Option 003).

3-48. Limit Test programming is done at the rear panel on either Local or Remote control modes. (However, Limit-Test mode itself may be programmed from the rear panel only if Option 005 is installed.) Only the five most significant digits may be programmed; and both limits must be of the same polarity if they are unequal, or both equal if they are of opposite polarity. A and B limits are programmed by absolute digital value only, without regard to range and polarity; and the polarity is programmed separately (except on AC and Ohms).

3-49. For instance if A Limit were programmed "10200," and B Limit programmed "10300," then B Limit would be the upper limit above which a HI readout would result. LO would readout below "10200," and GO between "10200" and "10300." (HI ≥ high limit; GO < high limit and ≥ low limit; LO < low limit.)

3-50. These absolute values are valid for each range; i.e., "10300" = 103.00 mV, 1.0300 V, 10.300 V, 103.00 V, and 1030.0 V. Also "10300" may be of either polarity or both as desired. If negative polarity is programmed, and the 10 V range is selected, then the HI limit is - 10.300 V, and the LO limit - 10.200 V for the examples used.

3-51. High-true 1-2-4-8 binary programming is used for the A and B limits, and low-true single line programming for the polarity. To program "10300" as the A limit; pins 4, 11, and 12 would be left open or high, and the remainder grounded. Positive polarity is programmed by grounding pin 3; negative polarity by grounding pin 28; and both polarities by grounding both pins. A continuous LO readout results with both polarity program pins open.

3-52. A special programming technique may be used to achieve a GO region between limits of opposite polarity, but the limits must be equal. A (or B) is programmed zero, "00000," and B (or A) programmed for the deisred limits of opposite polarity. Both polarities are also programmed, however, a LO readout is not possible in this situation; HI will indicate for voltages above either polarity, and GO between + V and - V.

3-53. DIGITAL OUTPUT (Option 004).*

3-54. The Digital Output Option provides a binary coded output of the six data digits (N1 thru N6), decimal point position (Data Multiplier), instrument function, polarity, overload, and limit-test decisions. Also, Clock, Print Command, and Scanner Sync signals are given. Clock waveform is identical to the Sample Period signal and so may be used to step a programmer or other equipment at the reading rate when the signal goes low. Print Command is also identical to Sample Period on non-Limit-Test; but on Limit-Test, switches on the Digital Output Assy A25 may be closed to enable the signal to go low at the end of the sample period only on the desired HI, GO, or LO decision. A Print Holdoff signal (low level) may be applied to the Digital Output Jack to holdoff the end of the Sample Period and readout transfer until a printer is ready.

* See Section V, Paragraph 5-240 for change of logic voltage levels on A25.

3-55. The Scanner Sync circuit is included only on instruments below Serial No. 950-01176 with A25 11080-66501 assembly. Scanner Sync pulse occurs at t_4 on non-Ratio, and t_{14} on Ratio. This point is the earliest time during the Sample Period that a scanner may switch the 3450B X and Y Input Voltages for the next Sample Period.

NOTE

No auto-ranging of X or Y is allowed because Scanner Sync will occur at the wrong time or more than once on that Sample Period. Y must be kept between 10% and 120% of its range to avoid auto-ranging on either Auto or Hold mode. X auto-ranges only on Auto mode.

3-56. FUNCTION SELECTION (Option 005).

3-57. DC, AC, or Ohms, and Limit-Test and/or Ratio are selected by the appropriate "high-low" code at the four function lines of the Remote Control Jack. Note from the function code table, Figure 3-3, that DC-Ratio-LT is programmed if all four lines are left open ("1"). So just going to Remote Control gives Ratio and Limit Test functions unless programmed differently at the Remote Control Jack.

3-58. RANGING (Option 005).

3-59. Remote ranging is accomplished by four coded lines on non-Ratio, or three separate lines on Ratio. Both the auto-ranging mode and individual ranges may be programmed. Auto-ranging is programmed if all lines are left open. See Paragraph 3-18 concerning auto-ranging of the Y input.

3-60. TRIGGERING (Option 005).

3-61. In Remote Control mode, triggering is internal and adjustable from the front-panel RATE control. When Man/Ext mode is programmed (grounded) at the RC Jack, external triggers may be applied at the RC Jack, or manual triggering may be accomplished at the front-panel Man/Ext button. A further program, Man Inhibit, may then be used to prevent manual triggering, leaving only external triggering possible. This latter program also functions as Remote Control Program does when held true, to lockout Local Control at the front panel (see Paragraph 3-3).

3-62. INDEPENDENT DECIMAL POINT PROGRAMMING (Option 005).

3-63. Remote Control offers the ability not available at the front panel to position and hold the display decimal point totally independent of the actual range. This is accomplished by programming the proper code at the four decimal control lines. All four lines high give the normal automatic positioning of the decimal point according to range.

SECTION IV
THEORY OF OPERATION

4-1. BASIC MEASUREMENT TECHNIQUE.

4-2. A dual-slope integrating measurement technique is employed by the 3450B. An Integrator is charged by the Input Voltage for a fixed precise 1/10 sec timing interval, and then discharged to zero by a fixed Reference Voltage. Since the charge slope is proportional to the Input Voltage, and the discharge slope fixed, the time taken for discharge is proportional to the Input Voltage. Thus a voltage-to-time conversion is achieved. A readout of the voltage is then obtained by counting pulses from a Crystal Oscillator during the discharge time (100,000 counts = full scale). On Ratio, the X numerator voltage is used for Integrator charge-up, and the Reference Voltage replaced by the Y denominator voltage for discharge. The ratio of X to Y is then measured because the discharge slope is proportional to Y rather than fixed, and the charge slope proportional to X as before, yielding a discharge time directly proportional to X and inversely proportional to Y.

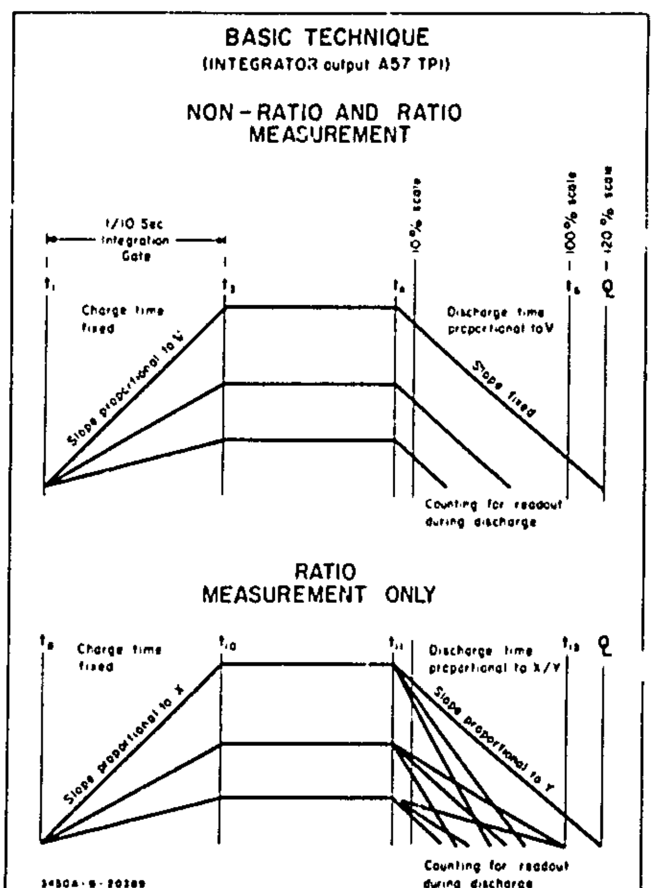


Figure 4-1. Basic Measurement Technique.

4-3. NON-RATIO MEASUREMENT.

4-4. A Trigger pulse begins the measurement at t_0, and the Data Counter begins counting pulses from the 1 MHz Crystal Oscillator. (An Integration Delay interval occurs at t_0 on AC function or, if programmed, on DC and Ohms.) At the 100,000 and 200,000 count points respectively, the 2nd counter digit goes from 9 to 0 and triggers the Master Timing Binaries on A6 to generate timing points t_1 and t_3. It is during the precise 1/10 sec or 1/60 sec interval from t_1 to t_3 ($_1T_3$) that the input voltage is allowed to charge the Integrator.

4-5. At t_3 the polarity of the Input Voltage is determined so that the Reference Voltage may be routed around or through the Polarity Amp as necessary to discharge the Integrator. Discharging begins at t_4, at which time the Data Counter again begins counting pulses from the Crystal Oscillator, but now for readout. The counter stops when the Integrator is discharged to zero between t_4 and Overload point.

4-6. Transfer of the data count to the readout occurs at t_7 to end the measurement unless auto-ranging occurs. Auto-ranging resets the Sample Period to t_0 to make another measurement on the new range.

4-7. RATIO MEASUREMENT.

4-8. In Ratio, the Y denominator input is first measured alone using the Reference Voltage to discharge the Integrator. If ranging of Y is needed, then it is done automatically at t_7, and the Sample Period is reset to t_0 to begin over again with a new measurement of Y. Ranging of Y, in Ratio, is always done automatically. If ranging is not needed at t_7 then the Sample Period continues on with a second integration cycle for the actual ratio measurement of X to Y. The timing of the Integrator charging intervals, $_1T_3$ and $_8T_{10}$, and the generation of the data readout is accomplished by the Crystal Oscillator and Data Counter as on non-Ratio. The polarity is decided by the polarities of Y at t_3, and X at t_{10}. A flip-flop is toggled to the (-) Pol state at t_3 or t_{10} for a negative ratio; or toggled to (-) Pol and then back to (+) Pol, or not toggled at all, for a positive ratio.

4-9. CONTROL.

4-10. The instrument control mode, Local or Remote, is defined by the Control flip-flop on A4. At the end of a Sample Period or any time between Sample Periods, this flip-flop assumes the state of the A12 Control flip-flop. The A12 flip-flop may be controlled by the front panel Local or

Remote switches on A11, or it may be alternated to the Remote state and held there by the RC Program signal from the Remote Control Assy A3.

4-11. TRIGGERING.

4-12. The instrument triggering mode, Internal or Manual/External, is defined by the Trigger flip-flop on A12. The state of the flip-flop is determined by the Internal and Manual/External switches on A11 or by the Remote Control Assy according to the control mode selected. Internal mode allows the Rate Delay one-shot on A7 to trigger the Sample Period flip-flop to begin a new Sample Period after a delay interval initiated by the end of the previous Sample Period. The front panel Rate control adjusts the delay interval. Manual/External mode allows manual triggering at the MAN/EXT button, or external triggering at the rear panel RC Jack. The External Trigger is conditioned by a driver on A6 and the Manual Trigger is enabled by a gate on A12 to trigger the Sample Period flip-flop on A7 via the Trigger flip-flop on A4. Gating on A7 allows a Trigger to be active only after the end of a Sample Period. The A4 flip-flop provides storage to avoid multiple triggering due to switch bounce. It is "reset" to the false state by the Transfer signal at the end of a Sample Period so that a Trigger incurred during a Sample Period will not be stored past the end of the Sample Period to become active.

NOTE

If Ratio Range is x100 of AC Ratio when 10 V (RMS) or more is put across the Y input terminals, Y autoranges to the 100 V range, causing X to want to range to the 10,000 V range, a disallowed state. Therefore, the Ratio Range recycles to x1 while X and Y are measured on the 100 V ranges. If Y is lowered to an acceptable value, two triggers are required to return the instrument to the x100 range.

4-13. TIMING (1/10 sec Gate).

4-14. Each Sample Period is divided into seven intervals on non-Ratio, and fourteen (plus a Transfer Delay interval) on Ratio as defined by the Master Timing Binaries on A6. The Sample Period begins at t_0 when the Sample Period flip-flop on A7 is internally, manually, or externally triggered to generate Timing Reset and Counter Reset pulses. Timing points t_1 and t_3 (t_8 and t_{10} on Ratio) are developed by the Crystal Oscillator and Data Counter on A5 and A10 to accurately determine the 1/10 sec Integrator charging intervals $_1T_3$ and $_8T_{10}$. The 1 MHz oscillator pulses are applied to the counter at t_0 by the A5 Count Gate; and the 8-bit of the 2nd digit is monitored for the points at which it goes to "0" at 100,000 and 200,000 counts respectively. These two points advance the Master Timing Binaries to t_1 and t_3 (t_8 and t_{10} on Ratio).

4-15. All other cardinal timing points, including t_2 and t_9, are determined by an astable Clock circuit on A5. Non-cardinal timing points t_0' and t_7' (so called because they are not defined by the A6 Master Timing Binaries) are the 80,000 count points between t_0 and t_1, and t_7 and t_8, and are used to open the Integrator shorting relay, K29, prior to charging of the Integrator.

4-16. The end of the measurement on Ratio at t_{14} is delayed by 80 msec after t_{14} by the A7 Transfer Delay one-shot to allow time for zeroing of the Input Amp before the next Sample Period.

4-17. If the non-Ratio X input or the Ratio Y input auto-ranges at t_7, or the Ratio X input auto-ranges at t_{14}', then the Sample Period does not end as usual, but resets to t_0 to begin again on the new range. So a Sample Period is extended by a multiple of the $_0T_7$ or $_0T_{14}$ intervals according to the number of auto range changes accomplished. (Three auto-range changes on AC Ratio require 24.3 sec plus 8.1 sec for the measurement.

4-18. Delay periods of 100 msec to allow for settling of the Input Voltage may be programmed into the Sample Period at t_0, and at t_7 and t_{10} on Ratio, prior to the input integration periods $_1T_3$, $_3T_{10}$ and $_{11}T_{ZD}$. A 2.4 sec delay is automatically inserted at these points on AC function to allow for AC Converter response.

4-19. Normally, the timing intervals $_0T_1$, $_1T_3$, $_7T_8$, and $_8T_{10}$ are 100 msec, and the intervals from t_3 to t_7, and t_{10} to t_{14} are 45 msec; but 1/60 Sec Gate may be programmed at the rear panel Remote Control Jack to shorten all of the intervals to one-sixth of their normal duration to increase the reading rate. 6 MHz pulses rather than 1 MHz are then counted to determine t_1, t_3, t_8, and t_{10}; and the Clock is speeded up to determine the other timing points. This shortens the Y and X integration invervals $_1T_3$ and $_8T_{10}$ to 1/60 sec, and the Y integration interval from t_{11} to Zero Detect proportionately.

4-20. FUNCTION.

4-21. The instrument functions DC, AC, Ohms, Ratio, and Limit-Test are defined by flip-flops on A4 Assy. All except Limit-Test are controlled by front-panel-storage flip-flops on A12; Limit-Test has its front-panel-storage flip-flop with it on A4. Notice that the measurement signal is gated into these flip-flops on A4 so that the instrument function may change only between measurements (although the front panel changes immediately).

4-22. RANGE.

4-23. Two assemblies, A8 and A9, are involved in range definition. On either Ratio or non-Ratio, the actual instrument input range on all functions is determined by the Input Range circuitry on A8. The Primary Range on A8 and the Ratio (Multiplier) Range on A9 are gated together by the Input Range Encoding circuit so as to satisfy the range requirements of both the numerator and denominator inputs. The input range on non-Ratio is simply equal to the Primary Range. On Ratio, the Y denominator Input Range equals the Primary Range, and the X numerator Input

Range equals the Primary Range *times* the Ratio Multiplier Range. Y range is used for the 1st cycle non-ratio measurement of Y and for the Y discharge of the 2nd cycle ratio measurement; X Input Range is used only for the X charge-up of the Ratio Cycle. So the Input Range changes from denominator range to numerator range and back to denominator range during the course of a Ratio Sample Period, but remains equal to the Primary Range full time on non-Ratio. The decimal point is positioned according to the Primary Range on non-Ratio, and the Multiplier Range on Ratio. The Input Attenuator and Input Amp determine the Input Range on DC; the Ohms Converter and Input Amp on Ohms; and the AC Converter alone on AC.

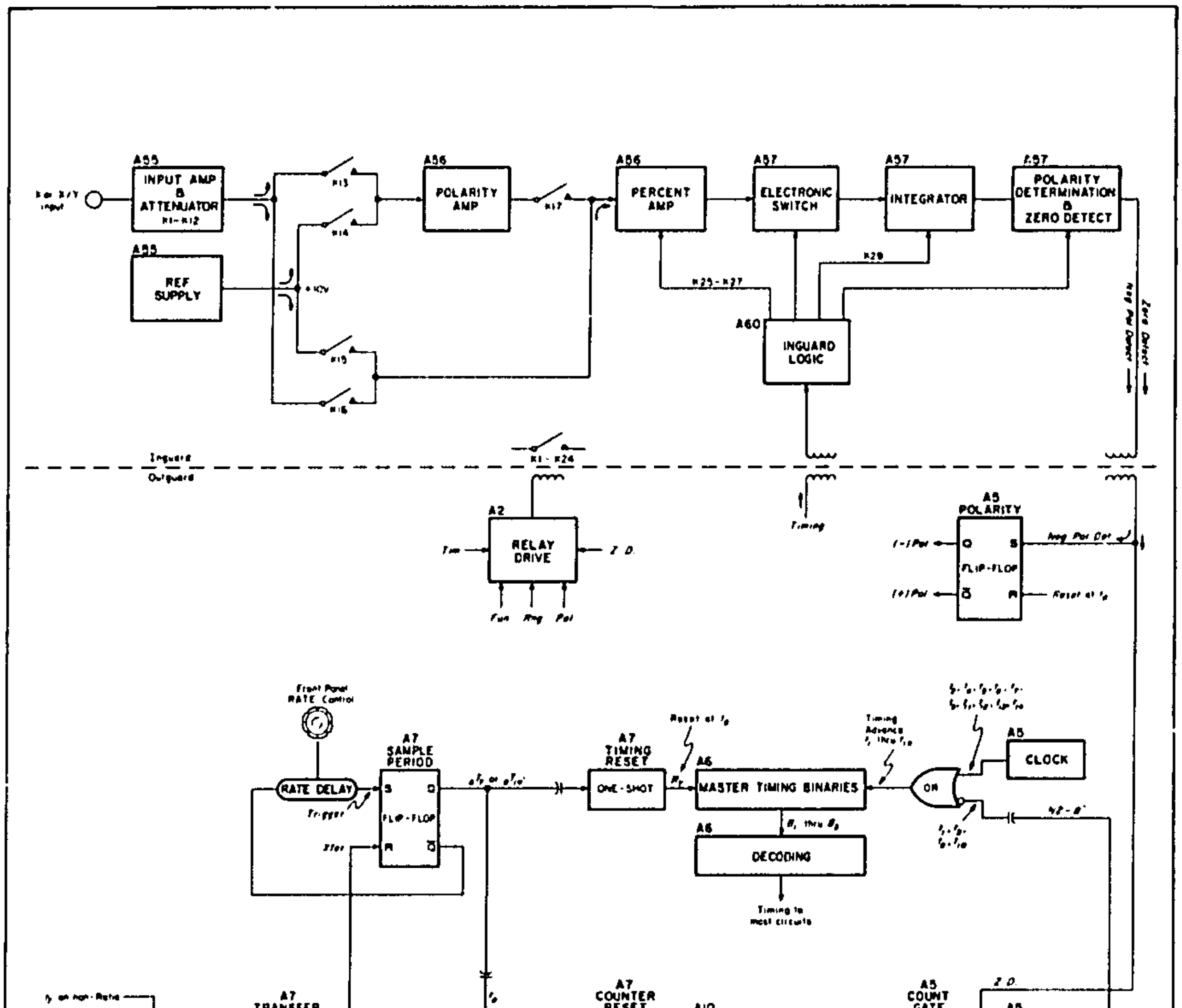


Figure 4-2. 3450B Simplified Block Diagram.

NON-RATIO RANGE

X Input Range on A8 (determines decimal point) = Primary Range on A8 (full time).

RATIO RANGES

Y denominator Input Range on A8 = Primary Range on A8 (during $_{10}T_7$).

X numerator Input Range on A8 = Primary Range on A8 times Ratio (Multiplier) Range on A9 (during $_7T_{10}$). See table at right.

Ratio Range (determines decimal point) = Ratio (Multiplier) Range on A9 (full time).

RATIO X NUMERATOR INPUT RANGE DURING $_7T_{10}$

PRIMARY RNG CODE			MULT RNG CODE		INPUT RNG CODE			PRIMARY RANGE (Y)	RATIO RANGE	X INPUT RANGE	DECIMAL POINT
P_1	P_2	P_4	M_1	M_2	E_1	E_2	E_4				
1	0	0	0	0	1	0	0	10MΩ	X1	10MΩ	A
0	1	0	0	0	0	1	0	1KV/1MΩ	X1	1KV/1MΩ	A
1	1	0	0	0	1	1	0	100V/100KΩ	X1	100V/100KΩ	A
0	0	1	0	0	0	0	1	10V/10KΩ	X1	10V/10KΩ	A
1	0	1	0	0	1	0	1	1V/1KΩ	X1	1V/1KΩ	A
0	1	0	1	0	1	0	0	1MΩ	X10	10MΩ	B
1	1	0	1	0	0	1	0	100V/100KΩ	X10	1KV/1MΩ	B
0	0	1	1	0	1	1	0	10V/10KΩ	X10	100V/100KΩ	B
1	0	1	1	0	0	0	1	1V/1KΩ	X10	10V/10KΩ	B
1	1	0	0	1	1	0	0	100KΩ	X100	10MΩ	C
0	0	1	0	1	0	1	0	10V/10KΩ	X100	1KV/1MΩ	C
1	0	1	0	1	1	1	0	1V/1KΩ	X100	100V/100KΩ	C
0	0	1	1	1	1	0	0	10KΩ	X1000	10MΩ	D
1	0	1	1	1	0	1	0	1V/1KΩ	X1000	1KV/1MΩ	D

3450A B 2024?

N1 . N2 . N3 . N4 . N5 . N6 DISPLAY

A B C D E DECIMAL POINT

Figure 4-3. X Range.

4-24. RANGING.

4-25. Ranging of the A8 and A9 Primary and Multiplier Range Binaries is handled on the same assemblies. Three decisions must be reached: 1) which input X or Y is to be ranged, 2) which direction of ranging is needed, and 3) whether to execute the range change. The Primary Binaries are ranged for X input on non-Ratio or Y on Ratio, and the Multiplier Binaries ranged for X on Ratio. Upranging is chosen for an input greater than 120% of scale, or when Stepping on Hold on Ratio; downranging is for less than 10% of scale or when Stepping on Hold on non-Ratio. Ranging of Y on Ratio is always automatic; but ranging of X on either Ratio or non-Ratio is automatic only on Auto mode.

4-26. POLARITY.

4-27. Polarity determination is an easy task on non-Ratio; but on Ratio, four input polarity combinations must be considered. The polarity of the non-Ratio X input or the Y denominator input is determined at t_3. A pulse is generated by the Polarity Determination circuit on A57 to toggle the A5 Polarity flip-flop to the (-) Pol state if the input is negative. A positive input does not generate a pulse and the flip-flop remains in the (+) Pol state as "reset" at t_0.

4-28. At t_{10} the polarity of the X/Y ratio is determined. Here the A5 flip-flop is toggled back to the (+) Pol state if both X and Y are negative. It is toggled only once at t_3 or at t_{10} for a negative ratio; and never toggled out of the (+) Pol state if both X and Y are positive. The Ohms Converter has a negative output, so the Polarity flip-flop is toggled at both t_3 and t_{10}. The AC Converter has a positive output and so the flip-flop is never toggled on AC function.

4-29. ZERO DETECT.

4-30. Zero Detect is the point at which the Integrator charge reaches zero and the Data Counter stops at a count proportional to the Input Voltage. The Zero Detect regions are from t_4 to the Overload point for the X measurement on non-Ratio, or the Y measurement on Ratio; and from t_{11} to the Overload point for the X/Y ratio measurement.

4-31. A pulse is generated at IC4 on A57 and passed through Q1 or Q2 of A17 according to the input polarity to "set" the Zero Detect flip-flop on A6. The flip-flop is "reset" to the false state at t_0, and at t_7 on Ratio.

4-32. PERCENT-AMP SCALING (RATIO).

4-33. A variable gain Percent Amp is installed between the Input Amp and Integrator to increase the precision of the Zero Detect on the Ratio Cycle for Y inputs of less than full scale. The amplifier gain is increased for the Ratio Cycle over that of the Primary Cycle in inverse proportion to the percent of scale of Y in an attempt to hold the Y discharge slope fixed irrespective of Y. A precise Zero Detect would be difficult if the Y discharge slope were allowed to decrease with decreasing Y. No error in the X/Y ratio is developed by this gain change because the gain is increased prior to the numerator charge-up to amplify both numerator and denominator by the same factor.

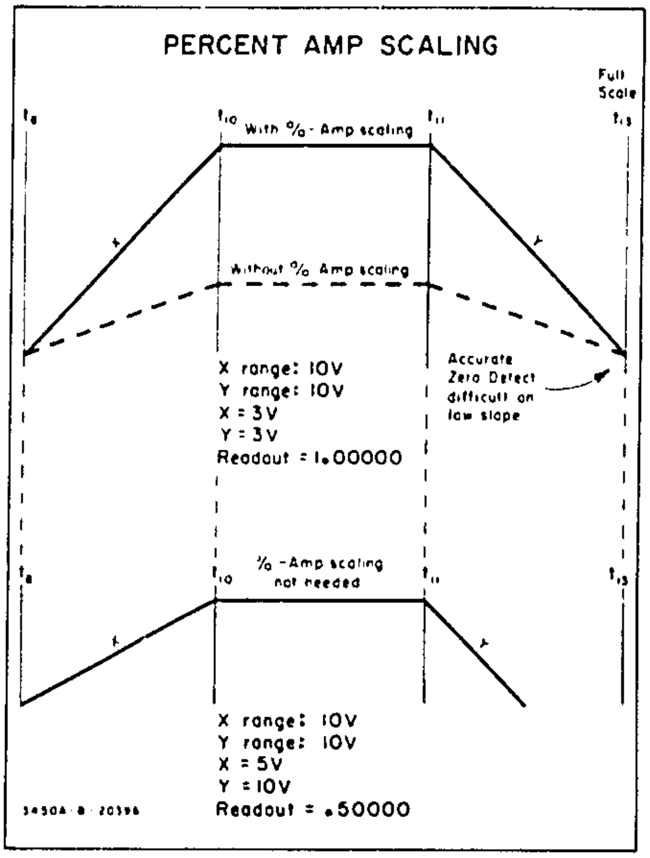


Figure 4-4. Percent Amp Scaling.

4-34. A binary code developed on A60 by counting the number of times that the 3rd digit of the Data Counter reaches 8 as the Reference Voltage is discharging the Integrator on the Primary Cycle controls the gain of the Percent Amp on the Ratio Cycle. The 1-bit of the code, representing 10% of scale, is ignored, resulting in a gain change every 20% of scale at 18, 38, 58, 78, and 98%. With six discrete gain settings rather than a continuously variable gain, the Y discharge slope may vary by a maximum of 2 as Y decreases from one gain-change point to the next.

4-35. READOUT.

4-36. The Data Readout is developed by counting pulses from the A5 Crystal Oscillator during the discharging of the Integrator (on the 2nd integration cycle on Ratio). The A5 Count Gate applies the pulses to the A10 Data Counter. (The Crystal Oscillator, Count Gate, and Data Counter are also used to time the Integrator charge-up intervals. See Paragraph 4-4.)

4-37. Storage IC's at the output of the Data Counter on A13 transfer the data count (000000 to 119999) to the readout at the end of the Sample Period at t_7 or t_{14}. Further storage on A13 transfers the function and polarity to the readout. Storage of the decimal point position is provided on A9 Assy. The Limit-Test Assy A24 has storage for the HI/GO/LO decision; and the Digital Output Assy A25 has storage for the function, data multiplier (decimal point), and polarity.

4-38. A55 INPUT AMP ASSY.

4-39. Three different gain settings of the Input Amplifier and two of the Input Attenuator in combination provide the five DC ranges. Relays K10A, K11, and K12 choose between X1, X10, and X100 gain factors of the Input Amp; K4 and K5 select between the input attenuation factors of X1 and X0.01. K3 of the Input Attenuator opens to provide an input resistance of greater than 10^{10} ohms whenever K4 is closed.

4-40. An automatic zeroing of the amplifier is achieved with K7, K8 and K9. These relays provide a zero input (or a low voltage from the Auto Zero Adj) to the amplifier, and a charge path for the Auto Zero Capacitor during the dwell time of the amplifier. The capacitor charges to whatever output drift voltage of either polarity that may have developed up to this time. It then acts as a battery at the inverting input of the amplifier to shift the output back to effectively zero drift when the amplifier is used again on the next Sample Period. Zeroing of the amplifier takes place from t_3 to the beginning of the next Sample Period on non-Ratio; and from t_3 to t_7, and 2nd Zero Detect to the next Sample Period on Ratio.

4-41. An Input Overload circuit with zener diodes CR10 and CR11 protect the amplifier from saturation above the 15 V level when K10B is closed for X1 amplifier gain on the 10 V and 1000 V ranges. With K10 open for higher gain on the other ranges the Input Voltage is held to a lower value by Q10, Q11 and associated diodes.

4-42. A +10 V Reference Supply on A55 discharges the Integrator on the Primary Cycle. Its reference diode is placed within the Cooler Assy A71 to be maintained at a constant temperature.

4-43. A56 POLARITY AMP ASSY.

4-44. In order to provide correct polarity for charging and discharging the Integrator, a unity gain polarity inverting amplifier is situated between the Input Amp and Integrator. It is used for Integrator charge-up on both cycles on DC, AC, and Ohms; for discharge on Ohms and (-) inputs on the Primary Cycle; and for discharge on (-) ratio inputs on the Ratio Cycle.

4-45. The Ratio Percent Amp is included for the purpose of amplifying the discharge slope of the Ratio Cycle in order to achieve an accurate Zero Detect.* K25, K26, and K27 control the gain according to the percent of scale of the Y input measured during the Primary Cycle. They close in coded formation at Zero Detect on the Primary Cycle to increase the amplifier gain on the Ratio Cycle as Y decreases by increments of 20% of full scale.

4-46. K28 at the output of the Percent Amp increases the Integrator charge current when 1/60 Sec Gate is programmed at the RC Jack.

* See Paragraph 4-32.

4-47. A57 INTEGRATOR ASSY.

4-48. Charging and discharging of the Integrator is controlled by the Electronic Switch. Q3 cuts off and Q4 turns on for the charging intervals $_1T_3$ and $_8T_{10}$, and the discharging intervals from t_4 and t_{11} to Zero Detect. K29 assures a zero charge on the Integrator Capacitor prior to charge-up. It closes from Zero Detect to t_0' of the next Sample Period on non Ratio; and from Zero Detect to t_7', and Zero Detect to t_0' of the next Sample Period on Ratio.

4-49. For polarity determination, IC4 is held saturated to a positive output prior to t_3 (and t_{10} on Ratio) by a false (negative) Polarity Strobe. At t_3 (and t_{10} on Ratio) Polarity Strobe goes positive allowing IC4 to switch to negative output polarity and generate a Negative Polarity Detect if IC3 has a positive output. IC3 has a positive output on (-) input or Ohms. Ohms is treated as a negative polarity due to the negative output of the Ohms Converter.

4-50. Zero Detect is actually not at zero voltage, but rather at a slight voltage of the opposite polarity to the Integrator charge as determined by the Level Amp. The 18 V from the Percent Amp times the 0.01 gain of the Level Amp results in a Zero Detect level of 180 mV at TP2 or 1.8 mV at TP1 on the Primary Integration Cycle on non-Ratio or Ratio. IC4 switches output polarities to generate a Zero Detect pulse when the Integrator discharges through zero to this positive or negative millivolt level. Polarity Strobe has been high since t_3 or t_{10} to allow this action.

4-51. Since Zero Detect is not at zero voltage, it is necessary to compensate for this by subtracting counts from the A10 Data Counter during the discharging of the Integrator. A Zero Detect level of 1.8 mV is one part in 10^4 of the 18 V full scale Integrator charge, which is equivalent to 10 counts of the 100000 full scale readout. A circuit on A10 subtracts the 10 counts.

4-52. During the discharging of the Ratio Integration cycle, the Percent Amp output voltage is proportional to the Y input voltage, not fixed at 18 V as on the Primary Cycle. This varies the Zero Detect level to compensate for different discharge slopes with different possible Y inputs for a given X/Y ratio.

4-53. GENERAL LOGIC.

4-54. SIGNAL LEVELS.

4-55. The logic circuitry uses two discrete information levels called "1" and "0", or "high" and "low". Normal signals are true at the "high" level ("pos-true"), and inverted signals true at the "low" level ("neg-true").

"1" or "high" = relatively high (more positive) voltage, or open circuit.

"0" or "low" = relatively low (less positive) voltage, or grounded circuit.

4-56. Inverted signals are recognized by bars above the names, indicating that they are low-true. The bar is often read as "not," emphasizing that the signals are false when high; i.e., "$\overline{\text{Overload}}$" is read "not overload," meaning that the instrument is not overloaded when the line is high. The lettering of all logic signal names is slanted on the schematics of Section VII for easy recognition.

$\overline{Overload}$	*Overload*
Line is low if instrument is overloaded.	Line is high if instrument is overloaded.

Figure 4-5. Signal Levels

4-57. GATES.

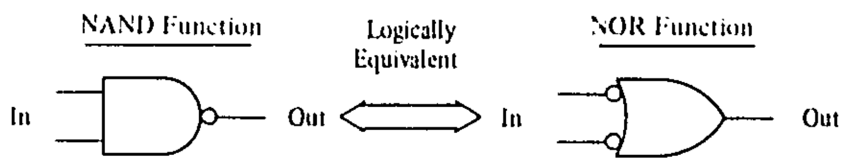
4-58. There are two gate functions, AND and OR. A gate circuit may consist of discrete components, an integrated circuit, or simply a circuit junction; and each individual gate may serve either logic function depending on which of the output levels is considered active by following circuitry. (If a gate serves both functions then an arbitrary choice of symbols is made.) The low active level is indicated by small circles commonly called level indicators or inverters at the inputs and outputs of logic symbols. All of the integrated-circuit gates are symbolized as in Figure 4-6 depending on their use

4-59. Logic equations may be written for gates in terms of the input and output signals by letting a dot represent the AND function, and a plus sign OR. Two logic gating situations are illustrated in Figure 4-7, one with a neg-true input signal, and the other with a neg-true output signal. The choice between the AND and OR symbols would be according to whether C or F needs to be true or false for some following circuit operation. Note that the low-signal bar and inverter symbols cancel logically.

4-60. In several instances the inputs to a gate are connected together or only one input used, and the device serves only to electrically condition and logically invert. It is then referred to as a "driver". See Figure 4-8.

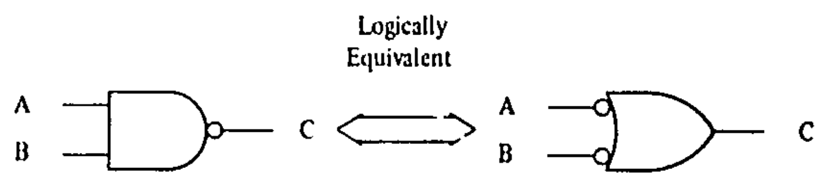
4-61. Six different integrated circuit gates are used in the 3450B. The 1820-0094, 1820-0349 and 1820-0107 IC packages are logically identical with 4 gates each and two inputs per gate, but differ in that the power supply voltages at pins 7 and 8 may be selected to give a voltage level change between the input and output logic levels. This is done on A3, A6, A24, and A25 assemblies for instrument interface signals. The -0086 and -0096 are also logically identical, but the -0096 has a greater source and sink current capability. One of the five inputs to these gates may be expanded into several inputs by the use of diodes. The -0310 is electrically identical to -0303 but different in the logic makeup.

4-62. A capacitor is sometimes used alone at a gate input terminal to delay the change of output levels. The capacitor charges or discharges through the gate input resistance when all input signals go high or one goes low respectively. The technique is used considerably on A2 Assy.



NAND: all inputs-high yields low output
NOR: any input-low yields high output

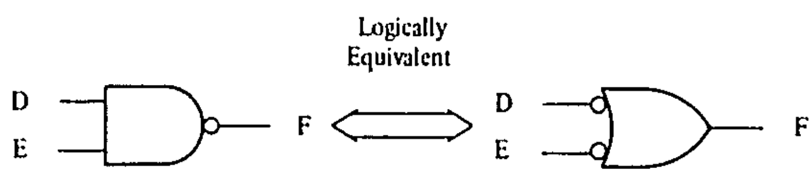
Figure 4-6. Integrated Circuit Gates



$A \bullet B = \overline{C}$
A and -B = not-C
A-high and B-high = C-low
A-high and B-low = C high

$\overline{A} + \overline{B} = C$
not-A or B = C
A-low or $\overline{B}$-low = C-high
A-false or B-true = C-true

(Event C occurs when either A is false or B is true.)

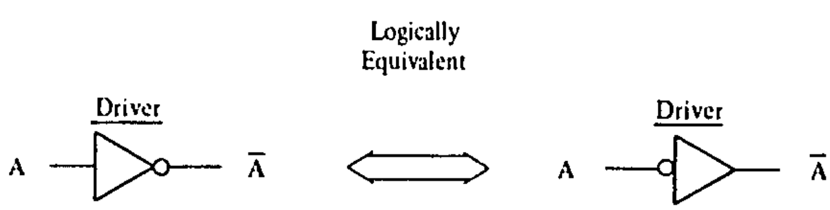


$D \bullet E = \overline{F}$
D and E = $\overline{F}$
D-high and E-high = F-low
D-true and E-true = F-true

$\overline{D} + \overline{E} = F$
not-D or not-E = not-F
D-low or E-low = $\overline{F}$-high
D-false or E-false = F-false

(Event F occurs only when both D and E are true.)

Figure 4-7. Logic Equations.



Low output (A-true) considered active.

High output (A-false) considered active.

Figure 4-8. Drivers

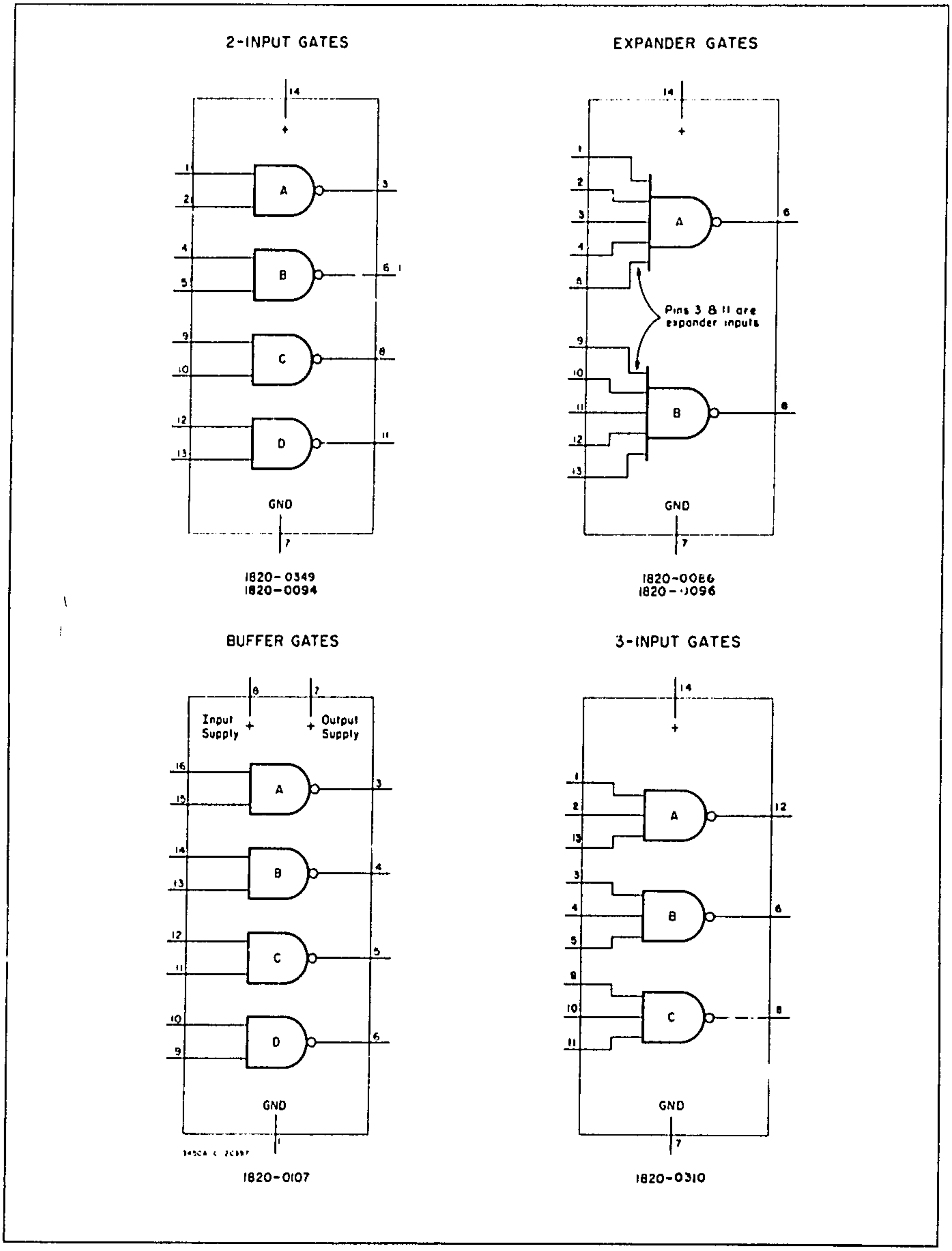


Figure 4-9. Integrated Circuits.

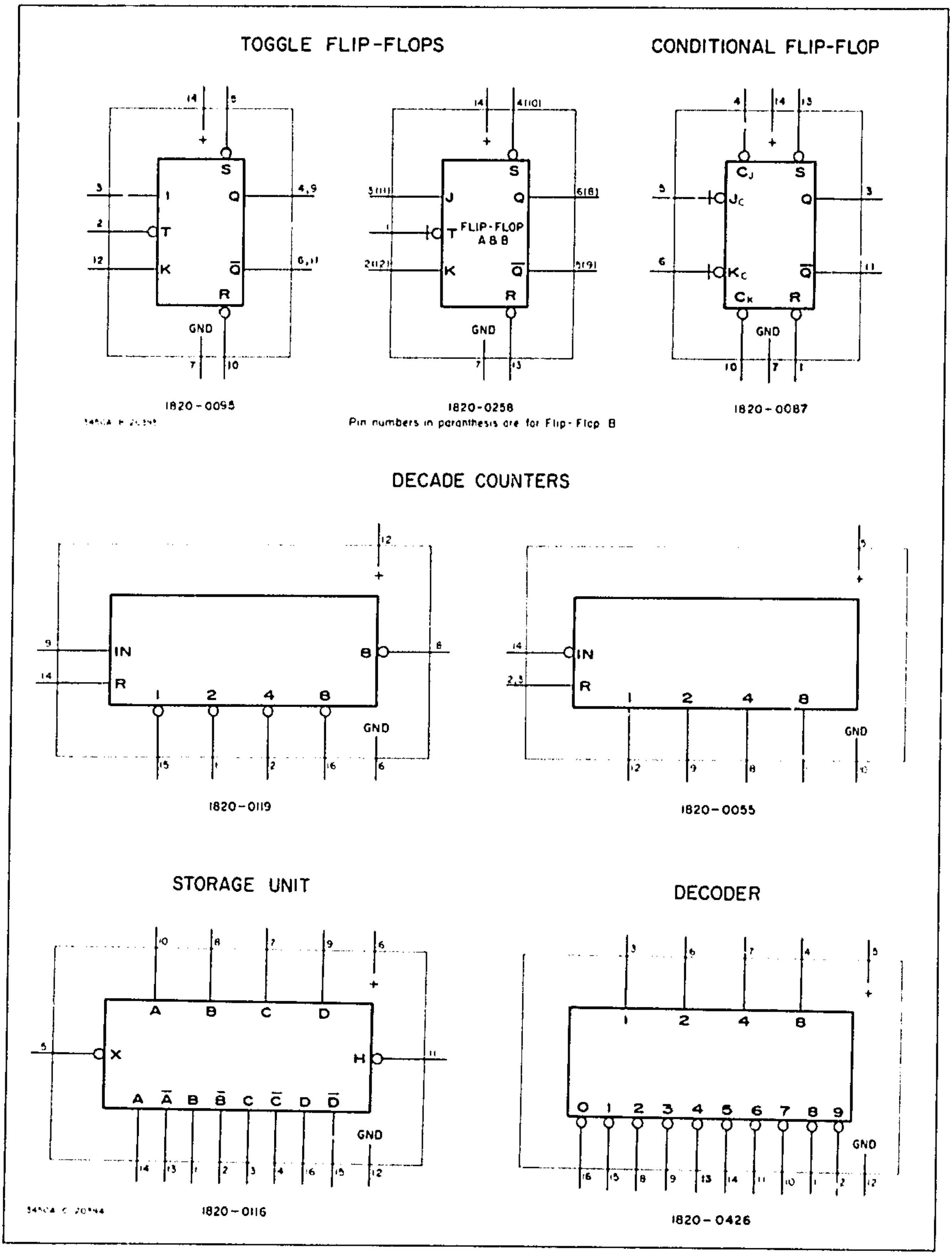


Figure 4-9 (Cont'd). Integrated Circuits.

4-63. FLIP-FLOPS.

4-64. Flip-Flops are binary storage elements with two stable output states: $Q \cdot \overline{Q} = 1 \cdot 0$ (true or set) state, and $Q \cdot \overline{Q} = 0 \cdot 1$ (false or reset) state. The two output lines are always held at opposite logic levels (under normal operating conditions). Various input operations are used to alternate between the two output states. Three different IC flip-flops and IC gates connected as flip-flops are used in the 3450B.

4-65. TOGGLE FLIP–FLOPS

4-66. The toggle flip-flops have two input operations, S-R and T, as described in Figures 4-10 and 4-11. The S-R inputs must go to opposite levels to alternate the flip-flop. A low pulse (high-to-low alternation) is required at the T input. IC 1820-0258 has two flip-flops per package. A one-shot operation is obtained by a delayed external feedback around the toggle flip-flop on A7 Assy. A low pulse at T initiates the unstable state $Q \cdot \overline{Q} = 1 \cdot 0$ that is held for the delay interval.

INPUT S-R

CONDITIONS	S	R	Q	$\overline{Q}$
Used for T operation →	L	L	Either state	
J low →	H	L	H	L
K low →	L	H	L	H

INPUT	CONDITIONS	OPERATION
T	J high; R low	Low pulse at T alternates $Q \cdot \overline{Q}$ to 1 - 0 (true) state.
	K high; S low	Low pulse at T alternates $Q \cdot \overline{Q}$ to 0 - 1 (false) state.

Figure 4-10. Toggle Flip-Flop 1820-0078

INPUT S-R

CONDITIONS	S	R	Q	$\overline{Q}$
	H	L	L	H
	L	H	H	L
Used for T operation →	H	H	Either state	

INPUT	CONDITIONS	OPERATION
T	J high; S and R high	Low pulse at T alternates $Q \cdot \overline{Q}$ to 1 - 0 (true) state.
	K high; S and R high	Low pulse at T alternates $Q \cdot \overline{Q}$ to 0 - 1 (false) state.

Figure 4-11. Toggle Flip-Flop 1820-0258

INPUT	CONDITIONS	OPERATION
S-R	Not used →	see table
	Used for J_c - K_c operation →	see table
J_c - K_c	C_J low; S and R high	Low pulse at J_c alternates Q - $\overline{Q}$ to 1 - 0 (true) state.
	C_K low; S and R high	Low pulse at K_c alternates Q - $\overline{Q}$ to 0 - 1 (false) state.

S	R	Q	$\overline{Q}$
L	L	H	H
H	L	L	H
L	H	H	L
H	H	Either state	

Figure 4-12. Conditional Flip-Flop

4-67. CONDITIONAL FLIP-FLOP.

4-68. The conditional flip-flop has two input operations, S-R and J_c-K_c. If either of the S and R inputs are held low, the flip-flop is not affected by the J_c-K_c inputs. A low pulse is required at the J_c-K_c inputs.

4-69. GATE FLIP-FLOP.

4-70. In many instances, two IC gates are interconnected so as to perform the S-R operation of the conditional flip-flop. Low signals at the unused inputs of the two gates alternate the flip-flop.

4-71. DECADE COUNTER.

4-72. Two different IC decade counters are used on the A5, A10 and A60 Assemblies. The 1820-0119 counts high pulses and gives a low true 1-2-4-8 binary coded decimal output, with the 8-bit on two different lines. The - 0055 counts low pulses and gives a high-true output. Reset-to-zero is accomplished at both units with a high level at the R input.

4-73. STORAGE UNIT.

4-74. The storage IC acts as four flip-flops with gated inputs, such that the flip-flops are affected by the input signals only when a low is received at the Xfer input. Each of the four input signals sets or resets a flip-flop according to whether the signal is high or low respectively. Storage of the input signals as they exist at the time of transfer is thus achieved. Another control input at pin 11, when held low, holds the four "not" outputs high. This feature is used on A9 Assembly.

4-75. DECODER.

4-76. The 1820-0426 is a BCD-to-decimal decoder. A high true 1-2-4-8 binary coded decimal input is converted into a single line low-true decimal output. One of ten high-voltage transistors within the IC turns-on and the others off to give a particular 0 thru 9 digit output.

4-77. CHANNEL RELAY DRIVE ASSY A2.

4-78. Channel Relay Drive Assy operates relays K1 thru K24 located on the top and bottom lids of the channel through the center of the instrument These relays along with pulse transformers on A50 assembly provide a means of controlling the analog signal handling section without having holes in the guard. The relay coils are outside the guard, and the reeds inside.

4-79. The opening and closing points as well as the conditions for closure are shown on the Relay Timing Diagram in Section VII. An example is K14 which is closed from t_3 to Zero Detect on a negative input on non-Ratio or a negative denominator on Ratio.

4-80. REMOTE CONTROL ASSY A3.

4-81. Remote Control Assy selects the range, function, decimal point position, ranging mode and triggering mode when on Remote Control Mode. It also *selects* the Remote Control Mode and locks-out front panel control if Remote Control Mode is programmed at pin 16 of the RC Jack. The Primary or Ratio Range binaries on A8 and A9 are directly set and reset to give the non-Ratio or Ratio range programmed. Flip-flops on A4 and A12 are controlled for the programmed function and ranging and triggering modes. The decimal point is directly controlled on A13, or is allowed to move automatically according to the dictates of A9 assembly.

4-82. FUNCTION ASSY A4.

4-83. The instrument measurement function, ranging mode, local or remote control mode, and some miscellaneous remote controlled timing parameters are stored on A4 assembly. Also some control over the front panel manual triggering and range stepping is accomplished here

4-84. A change among the DC, AC, Ohms, Ratio and Limit Test functions may occur only between Sample Periods when the Samp line is high to enable the AND gates at the storage flip-flops. However, the actual *selection* among these functions at the front-panel may be accomplished during the Sample Period and stored on A30 assembly until the Samp line goes high. The ranging mode and control mode are likewise affected by the Sample signal.

4-85. In the Ranging circuit, a low pulse is coupled through C8 to set flip-flop IC14 and enable IC1B with a high level at pin 13 when the front panel STEP button is released. When Samp goes high, Step Initiate goes low and steps the A8 or A9 range binaries. At the same time, the low pulse also resets flip-flop IC13, making pin 12 low and pin 11 high to allow IC14 to be set. But as Step Initiate goes low, IC13 flip-flop is immediately alternated back to the set state to hold IC13 pin 12 high. Then when Samp goes low at the beginning of the next Sample Period, Step Initiate goes high to reset flip-flop IC14 to allow the process to be repeated.

4-86. The Trigger flip-flop is alternated by a front panel Manual Trigger or rear panel External Trigger pulse to begin a Sample Period on A7 assy. Xfer signal goes low at the end of a Sample Period to reset the flip-flop false should a trigger have arrived during a Sample Period. So a trigger must be generated between Sample Periods to be effective.

4-87. The 1/60 Sec Gate Enable circuit gives shorter timing intervals for faster sampling. Integration Delay Enable provides a delay before integration to allow for settling of the Input Voltage. 10 MΩ DC Input Enable provides a continuous 10 MΩ input resistance on the 100 mV, 1 V and 10 V ranges on DC function.

4-88. Overprogram gate blanks the front panel Data display if AC, Ohms or Limit-Test function, or Remote Control mode is selected when these Options are not installed.

4-89. CRYSTAL OSCILLATOR ASSY A5.

4-90. Crystal Oscillator Assembly generates pulses to advance the timing and develop the Data readout; and stores the input polarity. 1 MHz pulses from the Count Gate are counted by the A10 Data Counter to develop timing points t_1 and t_3, and t_8 and t_{10} on Ratio, at 100,000 and 200,000 counts respectively. Pulses from the Clock Timing Advance circuit advance the timing at t_2, t_4, t_5, t_6 and t_7, and t_9, t_{11}, t_{12}, t_{13}, and t_{14}. At t_4 and t_{11} the Count Gate opens to supply pulses to the Data Counter for generation of the Data readout while the Clock is advancing the timing.

4-91. The timing advance process begins when $\overline{_0T_3}$ signal goes low at IC10A in the Gate Control circuit to open the Count Gate with a high level at IC3 pin 2. $\overline{_0T_3}$ remains low until the Data Counter generates t_1 and t_3 and the Clock t_2.

4-92. The Clock then takes over to generate t_4 thru t_7. The Clock is basically a free-running circuit and would continue to advance the timing if not for disable signals from the A6 Master Timing assembly. $_0T_1$ and $_2T_3$ signals disable the Clock so that the Data Counter may generate t_1 and t_3; and $_7T_0$ disables the Clock between non-Ratio Sample Periods.

4-93. On Ratio, the Sample Period continues on past t_7 when the $\overline{_7T_{10}}$ signal goes low in the Gate Control to allow the Data Counter to generate t_8 and t_{10}. $_7T_8$ and $_9T_{10}$ disable the Clock for these two points; and $_{14}T_0$ disables the Clock between the Ratio Sample Periods.

4-94. At t_2 and t_9, which is midway during the chargeup of the Integrator by the Input Voltage, the Count Gate is closed for a number of counts, 0 thru 5 as programmed, to increase the charge time and thus the discharge time to compensate for dielectric absorption in the A57 Integrator Capacitor. (A capacitor will not relinquish quite as much charge as it will absorb.) $\overline{_2T_3}$ or $\overline{_9T_{10}}$ line goes low in the Add Counts circuit to make IC2 pins 11 and 13 high and Count Gate pin 7 low to close the Count Gate. The binary lines from the IC1 counter are low to hold IC2 pins 5 and 12 high at this time.

4-95. When IC2 pin 8 goes high, IC1 begins counting the 1 MHz or 6 MHz pulses through IC2A. At the programmed number of counts, the necessary "1", "2" and/or "4" binary coded lines go high to drive IC2 pin 6 low and pin 11 high to open the Count Gate again. The low level from pin 6 stops the counting by holding IC2 pin 2 low via CR2. The binary counter lines are reset to low level at t_4 and t_{11}.

4-96. $\overline{\text{Integration Delay}}$ from A7 closes the Count Gate at t_0, t_7 and t_{10} for 100 msec or 2.4 sec to lengthen the intervals $_0T_1$, $_7T_8$ and $_{10}T_{11}$ to allow for settling of the Input Voltage and response of the AC Converter before the Integrator charges and discharges on the X and Y voltages.

4-97. To generate the data readout, the $\overline{_4T_5}$ and $\overline{_{11}T_{12}}$ signals go low at t_4 and t_{11} to "set" the Gate Control flip-flop and hold IC10 pin 2 low and pin 3 high to open the Count Gate. Zero Detect closes the Count Gate to stop the Data Counter when the A57 Integrator discharges to zero. A delay is provided in the opening of the gate to compensate for the delay in the arrival of the Zero Detect signal from the inguard section of the instrument through the A50 pulse transformers.

4-98. The Polarity Storage flip-flop is reset to the (+) Pol state at the beginning of the Sample Period at t_0. It is then toggled to the (-) Pol state at t_3 or t_{10} for a negative non-Ratio input or a negative denominator or numerator on Ratio. It is toggled back to (+) Pol at t_{10} on a (/) ratio.

4-99. MASTER TIMING ASSY A6.

4-100.The Master Timing Binaries on A6 define the timing points and intervals when all of the analog and logic events occur throughout the non-Ratio and Ratio Sample Periods (except the points t_0', t_7' and t_{14}'). They are advanced to their different coded states by the N2-8' pulses through the Counter Timing Advance gates at TP1, and the Clock Timing Advance pulses at A5TP2. B_5 Binary distinguishes between the non-Ratio and Ratio measurement cycles of the Sample Period; and B_1 thru B_4 divide these two separate measurements into seven intervals each.

4-101.The five bit code B_1 thru B_5 is not used directly, but decoded by gates on A6 to define distinct timing intervals on individual lines. Some lines carry two separate intervals, the second one appearing only on Ratio Sample Periods. For instance, $_3T_4$ and $_{10}T_{11}$ are on the same line which goes high from t_3 to t_4 on every Sample Period, and high from t_{10} to t_{11} on Ratio.

4-102.Another function of A6 is to generate pulses at t_1, t_3, t_4, t_8, t_{10} and t_{11}, and at both Zero Detects to advance the inguard G Timing Binaries on A60 and operate the A57 Electronic Switch to control the Integrator.

4-103.Also, A6 stores the Zero Detect signal. The storage flip-flop is gated so as to trigger at Overload point when N1-N2 data digits reach 12 if Zero Detect does not occur. This is needed for inguard timing on A60.

4-104.A minor job performed on A6 is the buffering of some programming lines from the Remote Control Jack. Neg Polarity Detect signal is inverted and sent to A5 to be stored.

4-105.SAMPLE PERIOD ASSY A7.

4-106.The basic function of the Sample Period Assy is to define the total interval $_0T_7$ or $_0T_{14}'$ during which the entire timing sequence of one measurement takes place. It is fixed at about 380 msec on non-Ratio and about 840 msec on Ratio, except as programmed to 65 msec and 210 msec by 1.60 Sec Gate Program.

4-107.TP1 goes high to begin the Sample Period when IC5 flip-flop is triggered by the Rate Delay one-shot or a Man/Ext Trigger from A4 assembly. Rate Delay generates an Int Trig pulse at the end of a delay interval initiated by the end of the previous Sample Period on Internal Trigger mode of operation.

4-108.When the Sample Period goes true at the Trigger it generates $Reset_C$ and $Reset_T$ pulses to reset the Data Counter, Master Timing Binaries and other circuits. $Reset_C$ also occurs at t_7 if on Ratio and not overloaded or on non-Ratio or Ratio and auto-ranging, and at t_{14}' if auto-ranging on Ratio. $Reset_T$ occurs at t_7 and t_{14}' if auto-ranging.

4-109.A Transfer pulse is generated at t_7 on non-Ratio or t_{14}' on Ratio to end the Sample Period and transfer the measured Data to the readout if no auto-ranging takes place. If Y < 100 mV on Ratio, then $\overline{\text{Ratio}}$ Inhb line goes low to give a Transfer at t_7 to delete the ratio measurement and display the Y measurement.

4-110.Print Holdoff line may be held low at the rear panel Digital Output Jack to holdoff Transfer and the end of the Sample Period with the "D" jumper, or the beginning of the Sample Period with the "S" jumper.

4-111.The Integration Delay circuit develops a low level of 2.4 sec on AC or 100 msec on DC or Ohms functions to disable the Count Gate and Clock Timing Advance on A5 to provide time for settling of the AC Converter and Input Voltage. It occurs at t_0 on non-Ratio; and at t_0, t_7 and t_{10} on Ratio. It must be programmed to occur on DC and Ohms.

4-112.Non-Cardinal Timing refers to timing points not defined by the A6 Master Timing Binaries. Points t_0' and t_7' open relay K29 after it has shorted the A57 Integrator Capacitor. $\overline{\text{N2-8}}'$ from the Data Counter goes low at 80,000 counts while generating t_1 and t_8 to give pulses that are coupled through a pulse transformer on A50 to trigger the H Timing Binaries on the Inguard Timing Assy A60.

4-113.Scale-Y pulses are generated by $\overline{\text{N3-8}}'$ while the Reference Voltage is discharging the Integrator on the Primary Y measurement cycle on Ratio to set the gain of the Percent Amp on the Ratio measurement cycle. The lower the percent of scale of Y, the fewer the pulses generated, and the higher the gain of the Percent Amp.

4-114.PRIMARY RANGE ASSY A8.

4-115.On A8 are the Primary Range Binaries which store the X range on non-Ratio and the Y range on Ratio. They may be auto-ranged at t_7 on Auto Range Mode on non-Ratio; or at t_7 on Ratio, Auto Range Mode or not. They may be step ranged only on non-Ratio. The direction of both auto and step ranging is according to the Up and Down Range Enable signals from A9.

4-116.The binaries are recycled to the highest range at a Step pulse on the lowest range or an overloaded range, or if ever they should get into a disallowed state. The Primary Range code is used directly by some circuits, but is decoded into distinct range lines for others.

4-117.Separate ranges are needed for the X and Y inputs on Ratio. The Input Range circuitry on A8 supplies the Primary Range directly to A2 to become the X input range on non-Ratio or the Y input range on Ratio; and multiplies the Primary Range times the Ratio Range for the X range on Ratio. So, during the course of a Ratio Sample Period, the Input Range may assume two different values: first the Y range from t_0 to t_7, then the X range from t_7 to t_{10}, followed by the Y range again on out to t_7 of the next Sample Period.

4-118. RATIO RANGE ASSY A9.

4-119. The Ratio Range is stored in binaries on A9 and fed back to A8 to develop the X input range on Ratio by multiplying the Primary Range by 1, 10, 100 or 1000. The binaries may be auto-ranged at t_{14}', or Step ranged at any time from t_{14}' to the next Sample Period. A recycle to the lowest range occurs with a Step on the highest range, or at any time the A8 Primary and A9 Ratio Binaries might fall into a disallowed combination.

4-120. The direction of ranging of both the Primary and Multiplier Ranges is controlled by circuits on A9. Down-ranging is chosen if X or X/Y is less than 10% of scale, or if on Hold or non-Ratio; but only on the condition that the range is not already the lowest one possible. Upranging is chosen if a range is overloaded, or if on Hold on Ratio but not if already on the highest range. $\overline{\text{Up Range Enable}}$ and $\overline{\text{Down Range Enable}}$ lines go high due to $Reset_C$ at t_0, and t_7 on Ratio, but go back low in 2 ms to become true. They remain high if false. $\overline{\text{Auto Range Reset Enable}}$ line generates $Reset_C$ and $Reset_T$ pulses on A7 and inhibits the Xfer pulse to reset the Sample Period to t_0 at t_7 or t_{14}' if X or Y auto-ranges.

4-121. An overloaded range is determined by N1-1' and N2-2' bits, representing 120% of scale from the A10 Data Counter. Overload signal is also generated via CR7 if Y < 10% of scale on the 1V range. This holds Down Range Enable false to prevent Y from going to the 100 mV range on Ratio.

4-122. Minimum Y circuit drives Ratio Inhibit to end the Sample Period at t_7 on Ratio if Y < 100 mV. It also makes Overload signal true to prevent downranging to the 100 mV range; and at the same time disables a gate on A10 so that the front panel readout will not blank-out due to the Overload signal. The 10% Scale flip-flop that drives Minimum Y and Down Range Enable is set to a high output at $Reset_C$, and then reset false when N2 digit reaches 1 at 10% of scale.

4-123. The readout Decimal Point is determined on A9 from the Primary Range on non-Ratio, and the Ratio (Multiplier) Range on Ratio.

4-124. DATA COUNTER & DISPLAY ASSYS A10/A13.

4-125. These two assemblies contain the Data Counter, readout storage, and front panel display tubes. The Data Counter has five binary decade counters for the N6 thru N2 digits; and a flip-flop for N1, the most significant digit. N6 counter has high-true binary output lines; and N5 thru N2 low-true, with the "8" bit on two separate lines. The counters are arranged so that when a given counter reaches a count of 10 and the "8" bit goes false, it advances the next higher decade once to achieve the required 10:1 ratio among the decades.

4-126. A flip-flop on A10 subtracts the first 10 counts at the beginning of the data generation at t_4 and t_{11} so that the Zero Detect point for the discharging of the A57 Integrator may be set at a slight voltage level above zero (but of the opposite polarity to the charge voltage). $_2T_3$ and $_9T_{10}$ signals go low at t_3 and t_{10} to set IC4 pin 3 high and pin 8 low to disable the input to N5 counter IC3. Then when N6-8' goes low at the 10th count, it cannot trigger N5 because IC4 pin 6 is held high; but it does reset the flip-flop to make IC4 pin 4 high so that N2-8' may trigger N5 at each 10 counts thereafter. All decades are reset to zero at t_0 and t_7 on Ratio, by $Reset_C$; and at t_3, and t_{10} on Ratio, by timing signals from A5 assembly.

4-127. Storage of the Function, Data and Polarity Display is provided by A13IC6 thru IC11 and A10IC8. This information is supplied to the readout tubes and may be changed only at the end of a Sample Period when Xfer occurs.

4-128. Overload signal blanks the Data and Polarity Display and illuminates Φ by making A10IC5 pin 12 high, A13IC11 pins 6, 9 and 1 low and 2 and 15 high. $\overline{Y < 100\text{ mV}}$ signal on Ratio also gives the Φ indication, but it prohibits the Data from blanking-out by holding A10IC5 pin 13 low and 11 high.

4-129. LIMIT TEST ASSY A24.

4-130. A24 assembly monitors the Data Counter during the discharging of the Integrator from t_4 or t_{11} to Zero Detect. Two limits are programmed as comparison points for the Data Count. When the count reaches the lower limit, one of the flip-flops is set to indicate GO; when the count reaches the upper limit, the other flip-flop is set to indicate HI in combination with the other flip-flop. LO is indicated if the count does not reach the lower limit so that neither flip-flop is set.

4-131. A flip-flop is set when all of the inputs to IC6A or B go high; and this requires that all of the outputs of OR gates IC1 thru IC5, or IC8 thru IC12 are high. The OR gates of the limit program section have high outputs if the program pins are grounded *or* the Data Counter bits go low. This provides for the method of programming the limits. The appropriate program pins are left open to designate the particular binary bits that are to be the limit, and the others grounded. Then the Data Counter bits corresponding to those of the limit must go low (true) to drive high the outputs of the OR gates having the open limit program pins.

4-132. Polarity programming is done similarly, except that the program pins are *grounded* for the desired polarity. If the (+) Pol Prog pin 3 is grounded, then IC1 pin 4 and IC8 pin 5 are held high as needed, and the (-) Pol signal at CR42 and CR44 must go low (false) on positive input polarity to hold IC1 pin 6 and IC8 pin 3 high to allow a GO or HI readout. On Ohms or AC function, CR37, CR39, CR41 and CR43 are held low so that polarity does not have to be programmed.

4-133. DIGITAL OUTPUT ASSY A25.

4-134. Signals substituting for the front panel display are supplied by the Digital Output Assembly. See Section III for the signal formats.

4-135. The N1 thru N6 Data digits are supplied in BCD (binary coded decimal) form with driver IC's connected to the A13 Storage circuit. A four-line binary code, called the Data Multiplier, indicates the non-Ratio range using the P code from A8 assembly; and indicates the Ratio range using the M code from A9.

4-136. The Print Command signal is identical to the Samp signal at TP1 on A7 assembly on non-Limit Test when CR1 and IC2 pin 9 are held low and IC8 pin 15 high. On Limit Test, CR1 is held high; and a low level must be received through S1, S2 or S3 to drive IC8 pin 15 high so that Print Command may be indicated. If the switches are open, or the proper limit test decision is not reached, the Print Command line will remain high.

4-137. FRONT PANEL ASSY A30.

4-138. The Front Panel Assembly is comprised of two sub-assemblies, one, A11, having the switches with lamps, the other, A12, with flip-flops that store the front panel Function, Ranging Mode, Control Mode and Trigger Mode. The flip-flops are controlled by the switches when the Local signal from A4 is high, or they are controlled by the Remote Control Assembly A3 when Local is low.

4-139. The front panel signals do not represent the actual operation modes of the instrument; they just store the operator's choice of modes until the flip-flops on A4 assembly may change states between Sample Periods.

4-140. INGUARD TIMING ASSY A60.

4-141. The Inguard Timing Assembly interrogates the A57 Integrator Assembly for the polarity of the Input Voltage with the Polarity Strobe signal; drives the Electronic Switch on A57, operates K29 relay on A57, supplies timing signals to the AC and Ohms Converters, and controls the gain of the Percent Amp on A56. To perform these duties the G and H Timing Binaries are advanced through several combinations of states to define the timing intervals needed. Pulses from A6 advance the G Binaries at t_1, t_3, t_4, ZDNo 1, t_8, t_{10}, t_{11} and ZDNo. 2. The H Binaries advance at $Reset_T$ (t_0), t_0 and t_7 with pulses from A7; and at t_3 and t_{10} with changes in the G Binaries.

4-142. On Ratio, Scale-Y pulses are generated while the Reference Voltage is discharging the Integrator on the Y measurement cycle. The pulses are counted on A60 to determine the gain used for the Percent Amp on the Ratio Measurement Cycle. The longer the discharging takes, the greater the number of pulses generated, and the *lower* the gain of the Percent Amp. Relay K26 is held open and K25 and K27 closed full time on non-Ratio to give a fixed gain.

4-143. OHMS CONVERTER A59.

4-144. The purpose of the Ohms Converter is to develop a voltage across the R_X resistance that can be measured by the basic dc measuring technique of the 3450B (see Figure 4-13). A current, determined by the Ohms Reference Voltage and the Feedback Resistance, is driven through the R_X to be measured, and is independent of R_X. The high-gain differential amplifier assumes whatever output voltage is needed to drive the required current through R_f to hold its own differential input voltage, $E_{ref} - E_{rf}$, at nearly zero.

4-145. Relays K32 thru K34 vary R_f to give the three ranges of the Ohms Converter which are used with three ranges of the 3450B Input Amp to provide the six Ohms ranges. K30 and K31 supply the current to R_X and R_Y. On Ratio, they alternate to first measure Y using the Ohms Reference Voltage to discharge the Integrator and then charge the Integrator with X and discharge it with X to measure X/Y. On non-Ratio, K30 remains open and K31 closed.

4-146. A four terminal technique is utilized on non-Ratio, whereby separate pairs of terminals supply the current (Y) and measure the voltage (X). This permits lead resistance to be ignored in the measurement if all four leads are connected directly to R_X. On Ratio, this technique is not possible, and each pair of terminals supplies the current and measures the voltage across R_X or R_Y.

NOTE

The 3450B is primarily designed for measuring pure resistances in OHMS. Measurements of resistances containing capacitive or inductive components are invalid due to the pulsing nature of the signal current.

4-147. K35 closes during the discharging of the Integrator by the Ohms Reference Voltage on the X measurement on non-Ratio and the Y measurement on Ratio. K35A supplies the Ohms Reference Voltage to the 3450B ; K35B provides a current path to keep the Ohms Amp from saturating when the Polarity Amp input resistance is in parallel to R_f on the 10 MΩ range; and K35C provides a more direct path to the 3450B ground.

4-148. AC CONVERTER.

4-149. The Model 11078A AC Converter substitutes for the DC Input Amp of the Standard instrument to generate a dc voltage proportional to the rms value of the AC Input Voltage that is measured by the basic dc measurement technique of the 3450B. The dc output is + 10 V at full scale on all ranges, with range attenuation being accomplished entirely within the 11078A.

4-150. A thermocouple makes a power comparison between the AC Input Signal and the dc output of the Converter to generate an Error Signal which corrects the dc output.

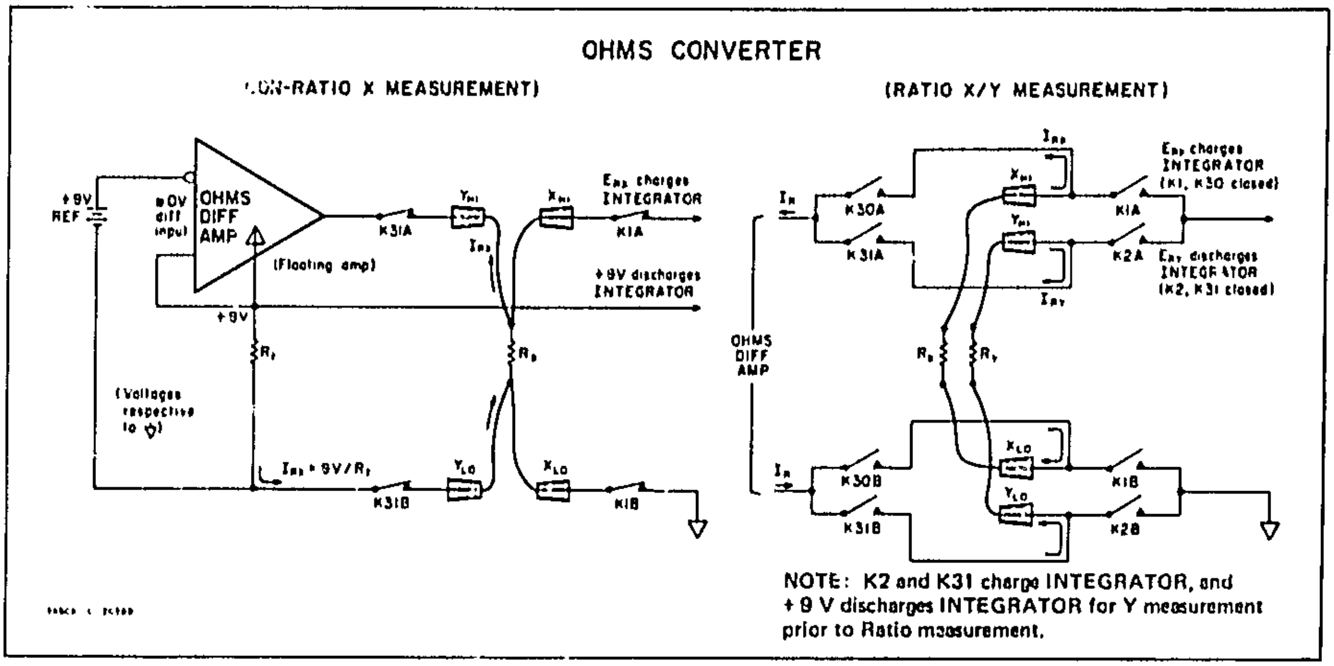


Figure 4-13. Ohms Converter.

4-151. AC INPUT AMP.

4-152.The broadband AC Input Amp is responsible for the range capability of the AC Converter. Its gain equals the feedback impedance divided by the input impedance, and is varied between 0.3, 0.03 and 0.003 for the 1 V thru 100 V ranges by the feedback resistance. The 1000 V range is derived by dividing the amplifier output by 10.

4-153.The AC Attenuator output is applied to the Modulator to be alternately sampled in equal times with a Reference square wave developed from the Integrator output.

4-154.An output from the amplifier before the Attenuator is used by the 5 Hz Sync Generator to synchronize the Modulator and Demodulator.

4-155.To minimize input capacitance, the A86 Feedback Assembly and input lines are placed within a shield that is driven by a voltage approximately equal to the Input Voltage.

4-156. DC-TO-SQUARE WAVE CONVERTER.

4-157.A 2 kHz astable multivibrator drives two FET switches at a 1 kHz rate via a 2:1 Divider. As Q13 and Q14 alternately turn off and on, they generate a square wave between ground and a dc voltage proportional to the Integrator output. This Reference Signal is alternated with the Input Signal at a 5 Hz rate by the Modulator and applied to the Sampling Amp.

4-158. MODULATOR.

4-159.FET switches in the Modulator alternately apply the Input Signal and the 1 kHz Reference square wave to the Sampling Amp at a 5 Hz rate.

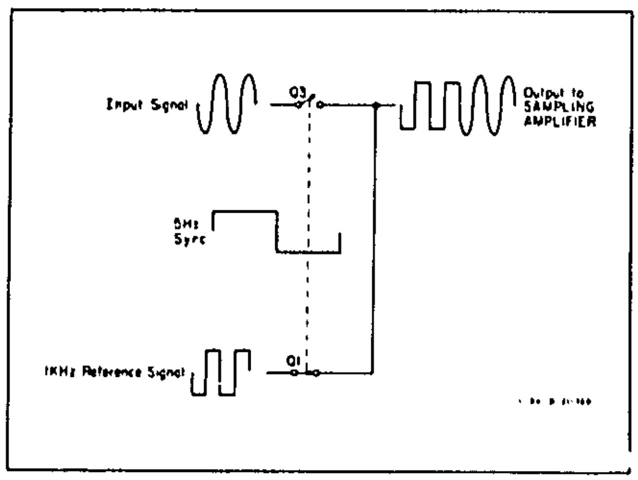


Figure 4-14. Modulator.

4-160. SAMPLING AMP.

4-161.The purpose of the unity-gain broadband Sampling Amp is to provide a low resistance signal identical in waveshape to the Input Signal to bias the Modulator and drive the Thermocouple Preamp. The gate-to-source junction of the Modulator FET's during their turn-on period is held at a fixed low dc voltage irrespective of the Input Signal to provide a consistent low turn-on resistance for the FET's.

4-162. THERMOCOUPLE AMPS.

4-163. The variable gain Thermocouple Preamp and Driver function to amplify the Modulator output and supply a nearly constant current to the Thermocouple regardless of the Input Signal amplitude. A voltage derived from the Thermocouple output controls the gain of the amplifiers by varying the feedback resistance with a photoresistor. The gain of the Integrator is changed in the reverse direction to hold the overall gain constant for loop stability.

4-164. THERMOCOUPLE.

4-165. The Thermocouple generates a dc voltage proportional to the square of its rms input voltage. As the Modulator samples first the Input Signal and then the chopped Integrator output, the Thermocouple output voltage varies slightly at a 5 Hz rate if there is any rms difference between the Input Signal (from the Input Amp) and the Integrator output. This 5 Hz Error Signal is rectified by the Demodulator to produce a negative or positive voltage to drive the Integrator output voltage in the direction to reduce the Error Signal.

4-166. 5 Hz SYNC GENERATOR.

4-167. The 5 Hz Sync Generator drives the Modulator and Demodulator in synchronization so that the Demodulator can determine which way to correct the Integrator voltage. A free running multivibrator is slaved to the negative-going zero crossing points of the Input Signal to supply an integral number of cycles of the Input Signal to the Sampling Amp.

4-168. LOW LEVEL & ERROR AMPS.

4-169. The Low Level and Error amplifiers supply high gain 180° phased signals to the Modulator, and a voltage to the AGC Amp to control the gain of the Thermocouple amplifiers.

4-170. AGC AMP.

4-171. The AGC Amplifier monitors the Thermocouple output voltage through the Low Level Amp to control the gain of the Thermocouple amplifiers and Integrator with photoresistors. If the Thermocouple output voltage increases, the AGC Amp increases the brightness of the lamp illuminating the photoresistors, decreasing the gain of the amplifiers and increasing the gain of the Integrator; the reverse happens if the Thermocouple voltage decreases. Thus a constant current is maintained through the Thermocouple and the overall gain of the system remains constant too. The photoresistors vary in resistance from about 200 Ω at maximum illumination at full scale to about 2 kΩ at 1/10 scale.

4-172. DEMODULATOR.

4-173. The Demodulator acts as a full wave rectifier of the Error Signal to supply a negative or positive ripple voltage to drive the Integrator output voltage up or down to match the rms value of the Input Signal. It is synchronized with the Modulator to provide a negative voltage if the Input Signal is the greater; and positive if the Integrator output is the greater.

4-174. INTEGRATOR.

4-175. The Integrator is an active filter of 5×10^4 gain that supplies the + 10 V full scale output to the basic DC measurement system of the 3450B. Its dc output voltage is controlled by the Error Signal and stabilizes at a level equal to the rms of the Input Signal. A photoresistor varies the gain of the Integrator in the reverse direction to that of the Thermocouple amplifiers to hold the overall gain constant.

WARNING

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

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains information necessary for maintenance of the 3450B. Included are performance checks for incoming inspection, and calibration adjustment procedures for the **30- or 90-day** calibration interval or post repair. Table 5-1 lists the test equipment required.

5-3. The instrument may be modified for alternate logic voltage levels at the Remote Control, Digital Output, and Limit Test Jacks; and it may be modified for optimum performance at 50 Hz line frequency as described in this section.

CAUTION

DO NOT USE AN AC CALIBRATOR FOR PERFORMANCE CHECKS OR CALIBRATION THAT DEVELOPS TRANSIENT VOLTAGES GREATER THAN 1500 V PEAK DURING SWITCHING, OR SEVERE DAMAGE TO THE 3450B MAY RESULT. IT IS KNOWN THAT SOME AC CALIBRATORS DEVELOP TRANSIENTS OF 3 KV.

Table 5-1 Test Equipment

USE	EQUIPMENT	RECOMMENDED MODEL
DC Accuracy Check & Adjustment	DC Standard Acc: ± (0.002% of setting + 0.0004% of range) Zero control 10:1 Voltage Divider Acc: ± 0.001% Variable line transformer	-hp- 740B Julie Research L 's Model VDR106
Ohms Accuracy Check & Adjustment	100Ω, 1 kΩ, 10 kΩ, 1 MΩ, 10 MΩ Standard Resistors Acc: NBS calibrated Variable line transformer	
AC Accuracy Check & Adjustment	AC Calibrator Ranges: 1 mV to 100 V Acc: 50 Hz to 20 kHz ± 0.022%; 45 Hz to 50 Hz, and 20 kHz to 100 kHz ± 0.065% Test Oscillator Freq: 100 kHz to 1 MHz Acc: ± 0.25% Pulse Generator Pulse width: 35μs to 45μs Pulse rep. rate: 500 Hz Voltage: 1 V Variable line transformer 50Ω feed thru connector BNC-to-Banana plug Oscilloscope Vert. sens: 10 mV/cm to 10 V/cm Sweep time: 0.1μs/cm to 0.5 s/cm Freq: DC to 20 MHz	-hp- 745A -hp- 652A -hp- 8004A -hp- 11048A/B -hp- 10111A -hp- 140B/1406A/1423A
Digital Output Check	Digital Recorder	-hp- 5050B
Normal-Mode Rejection Check	Oscillator Freq: 60 Hz Voltage: 500 mV Oscilloscope Line, int, ext trigger AC Voltmeter Acc: ± 2% Battery operated	-hp- 204C/D -hp- 140B -hp- 403B
Troubleshooting	Digital Voltmeter or Multimeter External Trigger DC Null Volt-Ammeter	-hp- 3450B -hp- 3480C/D -hp- 3460B -hp- 3490A -hp- 419A

Table 5-1 Test Equipment (Cont'd)

USE	EQUIPMENT	RECOMMENDED MODEL
Common Mode Rejection Check	500 V dc source 1 kΩ resistor	-hp- 740B
Input Resistance Check	DC Standard 1 MΩ resistor Acc ± 0.01%	hp 740B

5-4. Troubleshooting procedures are given to isolate faulty circuits in the event of malfunction, and also procedures to adjust some circuits after repair.

5-5. PERFORMANCE CHECKS.

5-6. A Performance Test Card is included so that the readings to the 3450B may be recorded as the performance checks are accomplished. It may be removed from the end of Section V without loss of continuity.

5-7. Confusion may arise as to why the specification is ± 950 counts and the performance test card and Paragraph 5-20 only allow ± 122 counts. The specification is a 90 day accuracy while the ± 122 is a 24 hour specification, i.e., on receipt or after calibration is performed (see Paragraph 5-2).

5-8. PRELIMINARY.

5-9. At turn-on, the 3450B should assume the following modes of operation:

DC function, AUTO range, LOCAL control, INT trigger.

5-10. Turn the RATE control fully clockwise and short the X input terminals. After warm-up, the display should be within 10 counts of zero on the 100 mV range, with the N1 digit blank.

5-11. Select HOLD range mode and STEP through all the ranges. The display should be 00000 ± 2 counts on the 1 V thru 1000 V ranges. Remove the short and select AUTO range mode.

5-12. DC ACCURACY

5-13. DC accuracy is checked with a 704B DC Standard and a 10:1 Voltage Divider. Zero the 740B on each of its ranges. Connect the 3450B Guard strap to X low terminal on the non-Ratio checks and to Y low on Ratio.

a. Connect the 740B to the 3450B X terminals using copper wire, and connect the 3450B GUARD strap to the X low terminal.

b. Select zero output voltage on the 740B 1 V range, and adjust the ZERO control for a zero readout on the 3450B 100 mV range. Some noise can be expected here.

c. Select the output voltages listed in Table 5-2, and check the 3450B readout. Remember to zero the 740B on each of its ranges, and make sure that the 3450B is on the range desired. The 3450B may be STEP ranged on HOLD if needed.

Table 5-2 DC Accuracy

740B OUTPUT	3450B	
	RANGE	READING
1 V	1 V	1.00000 V ± 10 counts**
Zero 740B on 10 V range		
1.1 V*	10 V	1.1000 V ± 3 counts
2 V	10 V	2.0000 V ± 4 counts
3 V	10 V	3.0000 V ± 4 counts
4 V	10 V	4.0000 V ± 5 counts
5 V	10 V	5.0000 V ± 6 counts
6 V	10 V	6.0000 V ± 7 counts
7 V	10 V	7.0000 V ± 8 counts
8 V	10 V	8.0000 V ± 8 counts
9 V	10 V	9.0000 V ± 9 counts
10 V	10 V	10.0000 V ± 10 counts
Zero 740B on 100 V range		
100 V	100 V	100.000 V ± 10 counts
Zero 740B on 1000 V range		
1000 V	1000 V	1000.00 V ± 10 counts

* Switch 740B to 1.3 V and then back to 1.1 V to cause 3450B to autorange to 10 V range.

** 100,000 "counts" = full scale readout.

d. Select a low output voltage on the 740B and reverse the connections to the 3450B to give a negative polarity. Repeat Steps b and c.

e. Select 1 V output on the 740B 1 V range and connect the 10:1 Divider between the 740B and the 3450B X terminals. The 3450B should read 100.000 mV ± 18 counts.

f. Leave the 10:1 Divider connected, and add connections from the 740B directly to the 3450B Y terminals. Select 15 V output on the 740B and RATIO on the 3450B. The 3450B should read .10000 ± 16 counts.

g. Remove the 10:1 Divider and connect the 740B directly to the X and Y terminals in parallel. Select the voltages listed in Table 5-3 and check the 3450B readout on the X1 Ratio range.

h. Select 1 V output on the 740B and HOLD on the 3450B. STEP thru the X1, X10, X100, and X1000 ranges; and check the 3450B readout for the following: 1.00000 ± 15 counts, 1.0000 ± 5 counts, 01.000 ± 4 counts, and 001.00 ± 4 counts.

i. Select AUTO range after STEPping to the X1000 range, and watch for auto-downranging to the X1 or X10 range.

j. Switch the connections to the X or Y terminals to give a negative ratio, and select the voltages in Table 5-3 again. Disconnect the 740B.

Table 5-3. DC Ratio Accuracy.

740B OUTPUT	3450B RATIO READING
1.7 V	1.00000 ± 24 counts*
1.9 V	1.00000 ± 23 counts
3.7 V	1.00000 ± 17 counts
3.9 V	1.00000 ± 17 counts
5.7 V	1.00000 ± 16 counts
5.9 V	1.00000 ± 15 counts
7.7 V	1.00000 ± 15 counts
7.9 V	1.00000 ± 15 counts
9.7 V	1.00000 ± 14 counts
10 V	1.00000 ± 14 counts

* 100,000 "counts" = full scale readout

5-14. OHMS ACCURACY (Option 002).

5-15. Ohms accuracy is checked with NBS calibrated Standard Resistors, and is to be done in conjunction with the DC Accuracy Check. A reasonable confidence of proper operation on all Ohms ranges is possible by using only a 10 kilohm Standard Resistor. Table 5-4 lists the accuracy required of all ranges if all six Standard Resistors are available.

a. Select non-Ratio and short all four X and Y terminals with copper wire. STEP through all the ranges to check the zero. No more than 2 counts should be displayed on the 1 kΩ thru 10 MΩ ranges, and 10 counts on the 100 Ω range.

b. Connect the Standard Resistors in turn to the 3450B and check the readout on both non-Ratio and Ratio. The resistors are connected with one terminal to both the X and Y High terminals, and the other terminal to the X and Y Low terminals. This gives an absolute measurement on non-Ratio, and a unity measurement on Ratio. It may be necessary to shield the standard resistors; connect the shield to the GUARD terminal. Connect the GUARD strap to the Y low terminal. STEP to the X1 range on Ratio.

5-16. AC ACCURACY (Option 001).

5-17. AC accuracy is checked with a 745A AC Calibrator, a 652A Test Oscillator and a 8004A Pulse Generator.

5-18. LINEARITY.

a. Select AC function and HOLD range and short the X terminals with a copper wire. STEP to the 10 V range, the readout should be within 2 counts of zero. Remove the short and STEP to the 100 V range.

b. Connect the 745A to the 3450B X terminals and select 100 V, 500 Hz on the 745A. The 3450B should read 100.000 ± 50 counts.

c. Select the output voltages listed in Table 5-5 and STEP the 3450B thru the ranges to check the readout. Record the 10 V readout on the 100 V range.

Table 5-5. AC Accuracy.

745A OUTPUT	3450B RANGE	3450B READING
100 V	100 V	100.000 ± 50 counts
10 V	100 V	* 10.000 ± 14 counts
10 V	10 V	10.0000 ± 50 counts
1 V	10 V	1.0000 ± 14 counts
1 V	1 V	1.00000 ± 50 counts
100 mV	1 V	.10000 ± 14 counts
10 mV	1 V	.01000 ± 10 counts
1 mV	1 V	.00100 ± 10 counts

*Record this reading

d. STEP to the 1000 V range and select 100 V output on the 745A. The 3450B should have the same readout ± 2 counts as that recorded in Step c.

5-19. FREQUENCY RESPONSE.

a. Set the 745A to 50 Hz at 100 V, and then to the settings listed in Table 5-6 to check the frequency response. STEP downrange the 3450B as required.

Table 5-4. Ohms Accuracy.

STANDARD RESISTOR	3450B RANGE	3450B READING NON-RATIO	3450B READING RATIO
10 MΩ	10,000 kΩ	10000.0 kΩ ± 102 counts	1.00000 ± 206 counts
1 MΩ	1000 kΩ	1000.00 kΩ ± 22 counts	1.00000 ± 56 counts
100 k Ω	100 kΩ	100.000 kΩ ± 12 counts	1.00000 ± 26 counts
* 10 k Ω	100 kΩ	10.000 kΩ ± 3 counts	1.00000 ± 25 counts
* 10 k Ω	10 kΩ	10.0000 kΩ ± 12 counts	1.00000 ± 16 counts
1 k Ω	1 kΩ	1.00000 kΩ ± 12 counts	1.00000 ± 106 counts
100 Ω	100 Ω	100.000 Ω ± 20 counts	** 1.00000 ± 556 counts

* These checks in addition to the zero check on all ranges is the minimum recommended accuracy check on Ohms.
** Y input is measured and Ω indicated on Ratio if the readout on non-Ratio is < 100.000 Ω.

Table 5-6. Frequency Response.

745A		3450B	
VOLTAGE	FREQUENCY	RANGE	READING
100 V	50 Hz	1000 V	100.00 ± 52 counts
100 V	100 kHz	1000 V	100.00 ± 52 counts
100 V	100 kHz	100 V	100.000 ± 150 counts
100 V	50 kHz	100 V	100.000 ± 100 counts
100 V	500 Hz	100 V	100.000 ± 60 counts
100 V	50 Hz	100 V	100.000 ± 150 counts
10 V	50 Hz	10 V	10.0000 ± 150 counts
10 V	500 Hz	10 V	10.0000 ± 50 counts
10 V	50 kHz	10 V	10.0000 ± 100 counts
10 V	100 kHz	10 V	10.0000 ± 150 counts
1 V	100 kHz	1 V	1.00000 ± 150 counts
1 V	10 kHz	1 V	1.00000 ± 100 counts
1 V	50 kHz	1 V	1.00000 ± 100 counts
1 V	500 Hz	1 V	1.00000 ± 50 counts
1 V	45 Hz	1 V	1.00000 ± 150 counts

5-20. RATIO.

a. Leave the 745A connected to the X terminals and add connections from the 745A to the Y terminals. With the 745A on a low voltage, move the 3450B GUARD strap to the Y low terminal.

b. Set the 745A to 9 V, 500 Hz; and select RATIO and AUTO range on the 3450B. The 3450B should read 1.00000 ± 122 counts on the X1 range.

c. STEP to the X10 range the 3450B should read 1.0000 ± 72 counts. STEP to the X100 range; the 3450B should read 01.000 ± 62 counts. Disconnect the 745A.

5-21. HIGH FREQUENCY.

a. Press the RATIO button to select non-Ratio, and STEP to the 1 V range on the 3450B. Move the GUARD strap to the X low terminal.

b. Connect the 652A Test Oscillator to the 3450B X terminals using a 11048B 50 Ω Feed Thru Connector.

c. Set the 652A to 1 kHz on the 1 V range and adjust the OUTPUT AMPLITUDE for a reading of 1.00000 V ± 10 counts on the 3450B.

d. Switch the OUTPUT MONITOR to EXPAND and adjust the REF SET to the 0% point as a reference level on the 652A Meter.

e. Change the 652A frequency to 500 kHz and adjust the OUTPUT AMPLITUDE to give the same reference point as in Step d. The 3450B readout should be 1.00000V ± 850 counts.

f. Change the 652A frequency to 1 MHz and readjust the AMPLITUDE. The 3450B should read 1.00000 V ± 2100 counts. Disconnect the 652A.

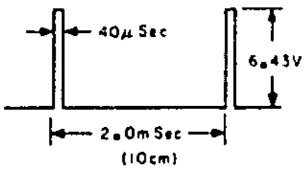
5-22. DYNAMIC RANGE.

a. Connect the 8004A Pulse Generator to the 3450B X terminals using the 50 Ω Feed Thru connector, and connect the 140A Oscilloscope to the X terminals using a 10:1 probe.

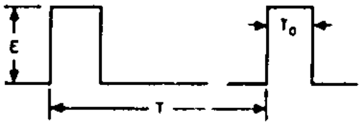
b. Set the Oscillosope as follows:

Vertical sensitivity . . . 0.1 V/cm
Coupling . . . . DC
Sweep time . . . . 0.2 ms/cm
Sync . . . . Internal +

c. Set the Pulse Generator repetition rate, pulse width, and amplitude as accurately as possible to obtain the following waveform:



d. Change the Oscilloscope sweep time to 5 μs/cm and adjust the 8004A pulse width as accurately as possible to 40 μs (8 cm). The 3450B should read .90000 V ± 1800 counts for a crest factor of 7.



$$\text{Crest factor} = \sqrt{\frac{T - T_0}{T_0}}$$

$$E_{rms} = E\sqrt{\frac{T_0\,(T - T_0)}{T^2}} = E \times \frac{T_0}{T} \times CF$$

e. Now adjust the 8004A amplitude to give a readout as near as possible to .90000 V to establish a reference point.

f. Adjust the pulse width to 45 μs (9 cm) for a crest factor of 6.59. The 3450B should read .95300 V ± 2000 counts.

g. Adjust the pulse width to 35 μs (7 cm) for a crest factor of 7.49. The 3450B should read .84250 V ± 1700 counts.

h. Change the pulse polarity to negative and repeat Steps f and g. Disconnect the Pulse Generator and Oscilloscope.

5-23. NORMAL MODE REJECTION.

5-24. A 200CD Oscillator is used for a noise source, and a 140A Oscilloscope to set the Oscillator to 60 Hz for the normal-mode rejection check. A 403B AC Voltmeter measures the oscillator output.

a. Select DC function, HOLD range, and STEP to the 10 V range.

b. Connect the Oscillator to both the 3450B X input and the Oscilloscope. Connect the GUARD strap to the X low terminal.

c. Set the Oscilloscope to LINE trigger, and adjust the Oscillator frequency for a *fixed* 60 Hz display on the Oscilloscope. (The noise frequency must be 60 Hz ± 0.1%.)

d. Adjust the Oscillator voltage to 424 mV rms (600 mV peak) as measured with the AC Voltmeter (The 3450B readout should be less than 6 counts from zero to verify a normal-mode rejection of >60 dB at 60 Hz.

$$NMR_{dB} = 20 \times \log_{10}\left(\frac{\text{Peak normal-mode voltage}}{\text{Readout}}\right)$$

5-25. EFFECTIVE COMMON-MODE REJECTION.

5-26. A 500 V dc source and a 1 kΩ 0.1% resistor are used for a common-mode rejection check

a. On DC, HOLD: STEP to the 100 mV range.

b. Remove the GUARD strap, and connect the GUARD terminal to the X high terminal, and the 1 kΩ resistor across the X high and low terminals. Note the readout if not exactly zero.

c. Connect the 500 V dc source from the X high terminal to the chassis side frame. No change in readout should be observed for an effective common-mode rejection of 160 dB at dc with 1 kΩ source unbalance.

CAUTION

Disconnect the 500 V Source before proceeding further.

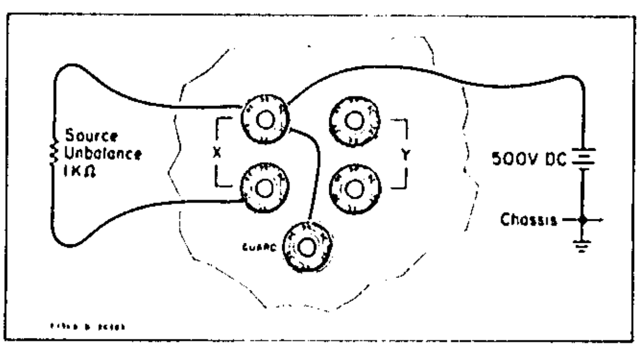


Figure 5-1. Common Mode Rejection.

$$ECMR_{dB} = 20 \times \log_{10}\left(\frac{\text{Common mode voltage}}{\text{Readout}}\right)$$

5-27. INPUT RESISTANCE.

a. Select HOLD range on INT trigger mode, and STEP to the 100 V range on DC.

b. Connect the 740B DC Standard in series with a 1 MΩ ± 0.01% resistor (-hp- Part No. 0811-0202) to the 3450B X terminals. Short out the resistor with a jumper lead.

c. Adjust the 740B to give a readout of 99.000 V on the 3450B.

d. Remove the jumper. The 3450B readout should go to 90.000 V ± 90 counts to verify an input resistance of 10 MΩ ± 0.1%.

$$R_{in} = \frac{E_{read} \times R_{series}}{E_{in} - E_{read}},$$

where E_{in} = 99.000 V and E_{read} = 90.000 V.

e. Short out the resistor again and STEP to the 10 V range.

f. Adjust the 740B for a 10.0000 V readout on the 3450B, and then remove the resistor short. The 3450B readout should change less than 10 counts to verify an input resistance of $> 10^{10}$ Ω.

5-28. REMOTE CONTROL (Option 005).

5-29. Remote Control is checked by grounding various lines at the rear panel jack and applying trigger pulses.

a. Select Remote Control mode by momentarily grounding pin 16 of the Remote Control Jack. The REM button should illuminate.

b. Select 1/60 Sec Gate by grounding pin 1. The triggering rate should speed up considerably on INT mode. (RATE knob fully clockwise.)

c. Ground pin 20 to select Integration Delay. The triggering rate should decrease but remain greater then when pin 1 was not grounded. Unground pin 20.

d. Ground pin 12 to select Man/Ext mode of triggering. The triggering should stop. Try manual triggering at the MAN/EXT button. Ground pin 14 to see that this will inhibit both manual triggering and the return to Local control at the front panel.

e. Apply external trigger pulses from the -hp- Model 8004A Pulse Generator to pin 19. Set the pulse repetition, rate to 15/sec. A triggering rate of 15/sec can be checked at the Print Command pin 48 of the Digital Output Jack with an oscilloscope. It should go high for 65 ms at each trigger.

f. Ground various pins of the Remote Control Jack to change the range, function, and decimal point according to the tables on Page 3-5.

g. Check the 10 MΩ DC Input program by grounding pin 2 and using the procedure in Paragraph 5-27. Steps a thru d on the 10 V range.

5-30. DIGITAL OUTPUT (Option 004).

5-31. Digital Output is checked with an -hp- Model 5050B Digital Recorder. The coded information is "1" state true See Page 3-6. Check the Clock and Print Command outputs with an Oscilloscope. Ground Print Holdoff pin 47 to see that this will stop the triggering.

5-32. LIMIT TEST (Option 003).

5-33. Limit Test is checked by grounding pins at the jack to program two limits and a polarity. LO, GO and HI should illuminate on Limit Test function as the input voltage is increased through these limits. The HI, GO and LO decisions should also appear at the Digital Output Jack.

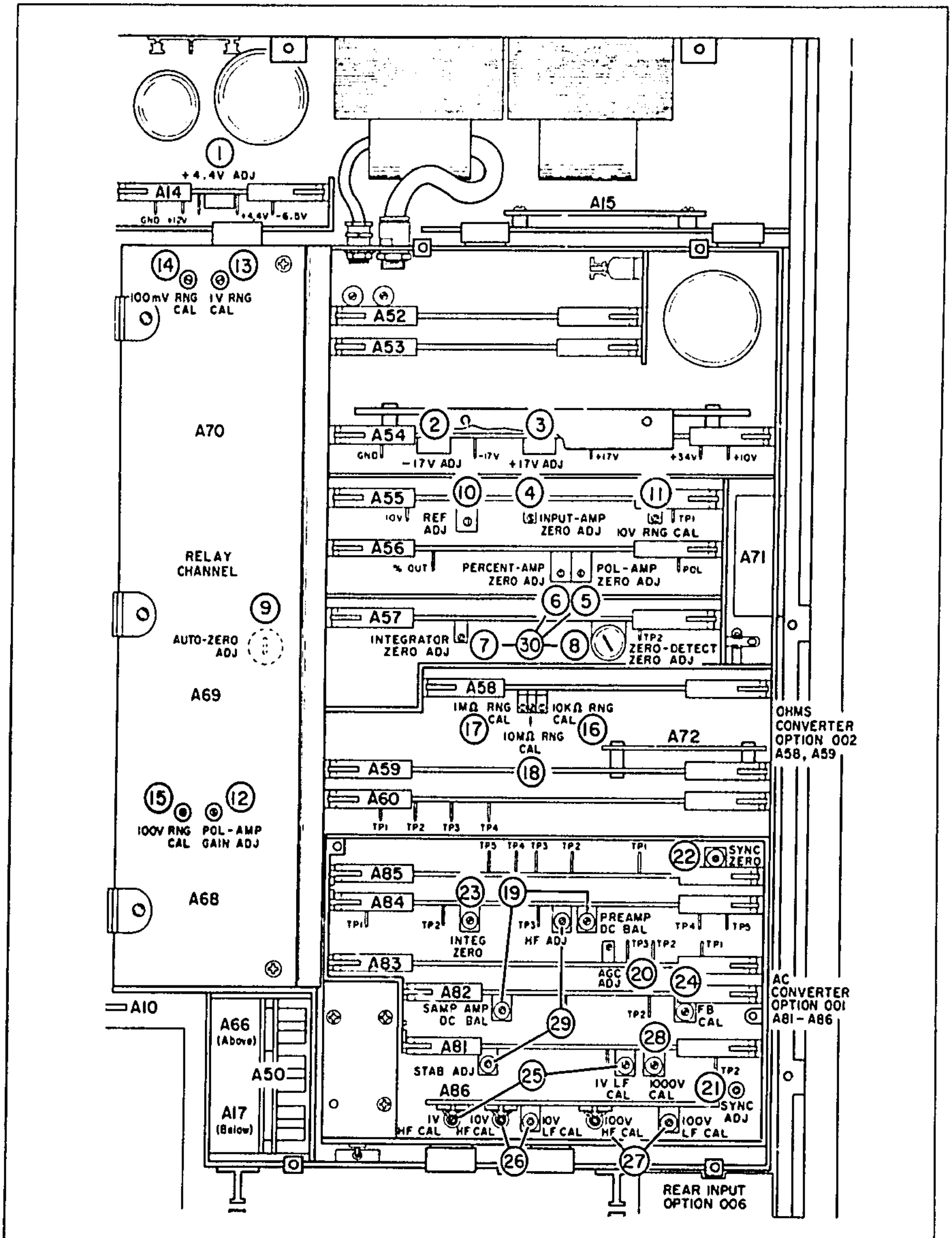


Figure 5-2. Adjustment Points.

5-34. CALIBRATION ADJUSTMENT.

CAUTION

CLEAN HANDLING TECHNIQUES ARE REQUIRED WITHIN THE 3450B AND ITS OPTION ASSEMBLIES. FINGER PRINTS, DUST, OR SOLDER ROSIN INSIDE THE RELAY CHANNEL OR ON THE INPUT SWITCH, COOLER ASSEMBLY, A55 THRU A57 ASSEMBLIES AND CONNECTORS, OHMS AND AC CONVERTER ASSEMBLIES, AND TEFLON CONNECTORS MAY DEGRADE MEASUREMENT ACCURACY.

5-35. Do not turn off the 3450B during the calibration adjustment procedure unless otherwise stated. The Ohms and AC calibrations must be done *after* the DC calibration. Follow the sequence given.

5-36. DC FUNCTION.

5-37 PRELIMINARY.

5-38. Remove the top cover, plastic insulator cover, internal guard cover, and the AC Converter top cover. A flathead screw on the right and two small nylon screws on the left hold the AC Converter cover.

5-39. Turn on the 3450B and allow a 45 minute warm-up time. At turn-on, the LOCAL, DC, AUTO, and INT buttons should illuminate. Turn the RATE control fully clockwise and connect the GUARD strap to the X low terminal.

5-40. OUTGUARD POWER SUPPLY. (1)

a. Select MAN/EXT trigger.

b. Set the 740B to 4.4 V output.

c. Connect the 740B (-) OUTPUT terminal to the 3450A chassis side frame, and the 419A between the 740B (+) OUTPUT terminal and the common line to K1 thru K12 (right-most trace) on the flexible printed circuit at the middle of the instrument.

d. Turn the +4.4 V Adj to zero the 419A (± 75 mV). Disconnect the 740B and 419A.

5-41. INGUARD POWER SUPPLY. (2)(3)

a. Set the 740B to 17 V output.

b. Connect the 740B (+) terminal to the A54 GND test point, and the 419A between the 740B (-) terminal and the - 17 V test point on A54.

c. Turn the - 17 V Adj to zero the 419A (± 20 mV).

d. Connect the 740B (-) terminal to the A54 GND test point, and the 419A between the 740B (+) terminal and the + 17 V test point on A54.

e. Turn the + 17 V Adj to zero the 419A (± 20 mV). Disconnect the 740B and 419A.

5-42. INPUT AMP ZERO. (4)

a. Connect the 419A between the right test point TP1 on A55 and the X low front panel input terminal.

b. Turn the Input Amp Zero Adj to zero the 419A (± 100 μV).

5-43. POLARITY AMP ZERO. (5)

a. Connect the 419A between the right test point on A56 and the X low terminal.

b. Turn the Polarity Amp Zero Adj to give a reading of + 20 μV (± 20 μV) on the 419A.

5-44. PERCENT AMP ZERO. (6)

a. Connect the 419A between the left test point on A56 and the X low terminal.

b. Turn the Percent Amp Zero Adj to give a reading of + 20 μV (± 120 μV) on the 419A.

5-45. INTEGRATOR ZERO. (7)

a. Connect the 419A between the left test point TP1 on A57 and the X low terminal.

b. Turn the Integrator Zero Adj to zero the 419A (± 10 μV).

5-46. ZERO-DETECT ZERO. (8)

a. Connect the 419A between the right test point TP2 on A57 and the X low terminal.

b. Turn the Zero Detect Zero Adj to zero the 419A (± 3 mV). Disconnect the 419A.

5-47. REFERENCE SUPPLY. (9)

a. Set the 740B to 0.00000 V output on the 10 V range and connect the 419A across the 740 B OUTPUT terminals.

b. Turn the 740B ZERO control to zero the 419A. Disconnect the 419A.

c. Set the 740B to 10.0000 V output. Leave the 3450B on MAN/EXT.

d. Connect the 740B (-) terminal to the X low terminal; the 419A (+) terminal to the 10 V test point on A55; and the 419A (-) terminal to the 740B (+) terminal.

e. Turn the Reference Adj to zero the 419A (within + 20 μV). Disconnect the 740B and 419A.

5-48. POLARITY AMP GAIN. (10)

a. Apply a negative voltage to the X terminals from some source other than the 740B. Select INT trigger.

b. Short together A6TP3 and A7TP2. See Figure 7-1. This stops the Sample Period in the $_5T_6$ timing interval to hold K14 closed to apply the + 10 V Reference Voltage to the Polarity Amp.

c. With the 740B on 10.0000 V output, connect the (+) terminal to the X low terminal; the 419A (-) terminal to the right test point on A56; and the 419A (+) terminal to the 740B (-) terminal.

d. Turn the Polarity Amp Gain Adj to zero the 419A (within + 20 μV). Disconnect the 740B, 419A, and the two test points.

5-49. AUTO ZERO. (11)

a. Select HOLD range, and STEP to the 1000 V range.

b. Short the X input terminals with a copper wire, and note the readout and polarity if not exactly zero.

c. Now STEP to the 100 mV range and observe the readout.

d. If the readout is not the same on the 100 mV and 1000 V ranges, then remove the two screws from the right corners of the Relay Channel lid and turn the Auto Zero Adj under the lid to give the required readout (counter-clockwise increases the positive readout). Ignore changes in the readout while the lid is up. STEP through all the ranges to see that the readout remains the same. Replace the Relay Channel lid screws and remove the short.

5-50. V RANGE. (12)

a. Select AUTO range.

b. Connect the 740B OUTPUT terminals to the 3450B X terminals to read a positive polarity.

c. Set the 740B to 0.00000 V output on the 10 V range and turn the ZERO knob to give a 00.00 mV readout on the 3450B.

d. Now set the 740B to 10.0000 V output without touching the ZERO knob.

e. Turn the 10 V Range Cal to give a 10.0000 V readout on the 3450B.

5-51. 1 V RANGE. (13)

a. Set the 740B to .000000 V output on the 1 V range and turn the ZERO knob to give a 00.000 mV readout on the 3450B.

b. Now set the 740B to 1.00000 V output.

c. Turn the 1 V Range Cal for a front panel reading of 1.00000 V. Disconnect the 740B.

5-52. 100 mV RANGE. (14)

a. Connect the 740B OUTPUT terminals to the input of the 10:1 Voltage Divider, and the Divider output to the 3450B X terminals for a positive readout.

b. Set the 740B to .000000 V output on the 1 V range and turn the ZERO knob to give a 00.000 mV readout on the 3450B. If the ZERO knob does not have enough adjustment range to zero the 3450B, then note the exact readout and polarity.

c. Now set the 740B to 1.00000 V output.

d. Turn the 100 mV Range Cal to give a readout on the 3450B of 100.000 mV plus the positive or minus the negative readout in Step b. Disconnect the 740B and Voltage Divider.

5-53. 100 V RANGE. (15)

a. Connect the 740B OUTPUT terminals to the 3450B X terminals to read a positive polarity.

b. Set the 740B to 000.000 V output on the 100 V range and turn the ZERO knob to give a 00.000 mV readout on the 3450B.

c. Now set the 740B to 100.000 V output.

d. Turn the 100 V Range Cal to give a 100.000 readout on the 3450B. Select a low voltage on the 740B and disconnect it.

5-54. At this point the AC Converter may be calibrated beginning with Paragraph 5-62 if the Ohms Converter is not to be calibrated. If neither the Ohms Converter nor the AC Converter are to be calibrated, then accomplish the Final Zero Adjustment (30) as in Paragraph 5-77.

5-55. OHMS FUNCTION.

5-56. For the Ohms calibration, a few precautions are necessary: 1) Use the four-wire technique in connecting the Standard Resistors to the 3450B. Two copper wires are connected directly from the X and Y High terminals to one end of the resistor, and two copper wires directly from the X and Y Low terminals to the other end of the resistor. 2) It may be necessary to shield the Standard Resistors, particularly the 10 MΩ; connect the shield to the GUARD terminal, and the GUARD strap to the X low terminal.

5-57. 10 kΩ RANGE. (16)

a. Select INT trigger, OHMS function, and AUTO range; and connect the 10 kΩ (± 10 ppm) Standard Resistor to the X and Y terminals using the four-wire technique.

b. Turn the 10 kΩ RNG CAL to give a readout of 10.0000 kΩ.

5-58. 1 MΩ RANGE. (17)

a. Connect the 1 MΩ (± 20 ppm) Standard Resistor to the X and Y terminals.

b. Turn the 1 MΩ RNG CAL to give a readout of 1000.00 kΩ.

5-59. 10 MΩ RANGE. (18)

a. Connect the 10 MΩ (± 40 ppm) Standard Resistor to the X and Y terminals.

b. Turn the 10 MΩ RNG CAL to give a readout of 10000.0 kΩ. Remove the Standard Resistor.

5-60. If the AC Converter is not to be calibrated, then accomplish the Final Zero Adjust (30), Paragraph 5-77.

5-61. AC FUNCTION.

5-62. Select AC, INT and AUTO; and connect the 745A AC Calibrator to the 3450B X terminals. The top cover mounting bracket on the right of the AC Converter will be the ground reference point for all of the adjustments unless otherwise stated.

5-63 PREAMP & SAMPLE AMP DC ADJ. (19)

a. Set the 745A to 1.000000 V, 500 Hz, and connect The 419A Null Meter to A84TP5

b. Turn the Preamp DC BAL A84R4 for a 419A reading of + 0.5 V ± 0.2 V, and note the exact reading.

c. Set the 745A to 1 mV and turn the Sample Amp DC BAL A82R11 to give the same 419A reading as in Step b.

d. Repeat these two adjustments until the 419A reads the same within ± 0.2 V with 1 V and 1 mV inputs. Disconnect the 419A.

5-64 AGC ADJ (20)

a. Connect the Oscilloscope to A83TP1 with a 10:1 probe. Set the vertical sensitivity to 0.01 V/cm, sweep time to 0.1 ms/cm, and sync to internal.

b. Set the 745A to 100 mV, 5 kHz.

c. Turn the AGC ADJ A83R24 for an amplitude of 720 mV peak-to-peak on the square wave portion of the signal. If your instrument does not have (21) adjustment, then go to (22).

5-65. SYNC ADJ. (21)

a. Set the 745A to 1 V, 45 Hz; and connect the Oscilloscope to A85TP1. STEP to the 1 V range on the 3450A.

b. Turn the Sync Adj A90R4 located to the right of A86 for a symmetrical waveform on the Oscilloscope. Disconnect the Oscilloscope.

5-66 SYNC ZERO (22)

a. Set the 745A to 1 mV, 500 Hz; and connect the 419A to A85TP1. Select HOLD, and STEP to the 100 V range.

b. Turn the Sync Zero A85R10 for a zero reading ± 0.5 V on the 419A.

5-67. INTEG ZERO. (23)

a. Set the 3450B to the 1 V range.

b. Set the 745A to 1 V, 500 Hz; and connect the positive side of the 419A to A84TP3, and the ground side to A84TP2.

c. Turn the Integ Zero for a reading between zero and - 500 μV on the 419A. Disconnect the 745A and 419A.

5-68 FB CAL (24)

a. Select "DC" function and AUTO range on the 3450A.

b. Set the 745A to 300 mV, 5 kHz; and connect it to A81TP2.

c. Connect a jumper from A84TP4 to the X high input terminal.

d. Adjust the FB Cal to give a full scale readout on the 10 V range. Disconnect the 745A and jumper.

5-69. If the HF ADJ or STAB ADJ of Step (29) has been adjusted without accordance with Paragraph 5-74, then it should be adjusted now according to Paragraph 5-75 or 5-76. Otherwise replace the AC Converter cover (power off).

5-70. 1 V RANGE CAL (25)

a. Set the 745A to 1 V, 50 kHz; and connect it to the X terminals. Select AC function on the 3450B.

b. Turn the 1 V HF CAL A86C6 through the hole in the cover to give a readout of 1.00000 ± 100 counts

c. Set the 745A to 500 Hz and turn the 1 V LF CAL A81R34 to give a readout of 1.00000 ± 5 counts. Now set the 745A to 100 mV and check the readout for .10000 ± 8 counts.

d. Set the 745A to 1 V, 50 kHz; and turn the 1 V HF CAL again to give a readout of 1.00000 ± 10 counts. Now set the 745A to 10 kHz and check the readout for 1.00000 ± 60 counts.

5-71. 10 V RANGE CAL (26)

a. Set the 745A to 10 V, 50 kHz; and turn the 10 V HF CAL A86C7 to give a readout of 10.0000 ± 100 counts.

b. Set the 745A to 500 Hz, and turn the 10 V LF CAL A86R5 to give a readout of 10.0000 ± 5 counts.

c. Set the 745A back to 50 kHz, and turn the 10 V HF CAL again to give a readout of 10.0000 ± 10 counts.

5-72. 100 V RANGE CAL. (27)

a. Set the 745A to 100 V, 50 kHz; and turn the 100 V HF CAL A86C8 to give a readout of 100.000 ± 100 counts.

b. Set the 745A to 500 Hz and turn the 100 V LF CAL A86R6 to give a readout of 100.000 ± 5 counts.

c. Set the 745A back to 50 kHz, and turn the 100 V HF CAL again to give a readout of 100.000 ± 10 counts. Now set the 745A to 100 kHz and check the readout for 100.000 ± 80 counts.

5-73. 1000 V RANGE CAL (28)

a. Select HOLD range on the 3450A. The range should be 100 V.

b. Set the 745A to 10 V, 500 Hz. Note the readout; it should be 10.000 ± 8 counts.

c. STEP the 3450B to the 1000 V range; and set the 745A to 100 V. Turn the 1000 V LF CAL A81R35 to give the same readout as in the preceding step. Select a low voltage on the 745A and disconnect it.

5-74. HIGH FREQUENCY CAL. (29)

a. Connect the 652A Test Oscillator to the 3450B X terminals using a 50 Ω Feed Thru connector, and select AUTO range mode on the 3450B.

b. Set the 652A to 1 kHz, 1 V OUTPUT; and adjust the AMPLITUDE to give a readout of 1.00000 ± 10 counts on the 3450B. Then switch to EXPAND and adjust the REF SET to the 0% point as a reference level.

c. Change the 652A frequency to 1 MHz and adjust the AMPLITUDE to give the reference point set in Step b. If the 3450B does not indicate 1.00000 ± 500 counts, then *very slightly* turn the HF ADJ A84R20 (clockwise increases readout) and also the STAB ADJ A81R17 if necessary (counterclockwise increases readout). If either of these two adjustments is turned more then 10°, or if the reading in Step d is not obtained; then it will be necessary to perform the HF ADJ and STAB ADJ in Paragraphs 5-75 and 5-76 and reaccomplish the procedure in this paragraph.

d. Change the 652A frequency to 500 kHz and readjust the AMPLITUDE. The 3450B should indicate 1.00000 ± 400 counts.

5-75. High Freq Adj

a. Leave the 652A connected as in 5-74a and set it to 5 kHz at 1 V.

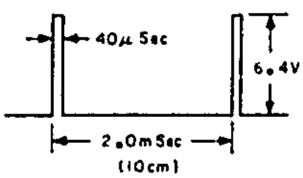
b. Connect the Oscilloscope to A83TP1 with a 10:1 probe and select 0.01 V/cm vertical sensitivity and 0.2 μs/cm sweep time. Trigger on (+) slope.

c. Turn the HF ADJ clockwise until the ringing on the square wave just stops. Disconnect the 652A and Oscilloscope.

5-76. Stab Adj

a. Connect the 222A Pulse Generator and Oscilloscope to the X terminals.

b. Adjust the 222A to give the following waveform on the Oscilloscope:



c. Now connect the Oscilloscope to A81TP1. Turn the STAB ADJ counterclockwise until the ringing on the square wave just begins. Disconnect the Oscilloscope and return to Paragraph 5-74.

5-77. FINAL ZERO. (30)

a. Replace the guard cover with two screws, set the top cover back in place, and allow a 45 minute warmup.

b. Select DC function, HOLD range and MAN trigger; and short the X terminals with a copper wire.

c. Remove the top cover and readjust the Integrator Zero (7) in Paragraph 5-45 through the center and left holes in the guard cover.

d. Remove the guard cover and *immediately* readjust the Polarity Amp Zero (5) and Percent Amp Zero (6) in Paragraphs 5-43 and 5-44, and replace the guard cover with all the screws.

e. STEP to the 1000 V range and, if necessary, turn the Zero-Detect Zero Adjust through the right hole to give a 000.00 V readout

f. STEP through all the ranges to see that the readout remains at zero.

g. Replace the plastic insulator cover (CLEAN HANDLING) and top cover

5-78. TROUBLESHOOTING.

5-79. The first step in troubleshooting is to check that all modifications have been performed. Also check the current manual change sheet. Next remove all optional boards and the strapping board (A26). If the problem disappears, troubleshoot the faulty option board. If a problem persists, then check the circuits as described in the following paragraphs.

CAUTION

Do not remove or install any assembly with the power on; but the power may be turned on with any assembly removed.

5-80. OUTGUARD POWER SUPPLIES.

5-81. With all standard boards installed, turn the power on and check the supplies, comparing the results to Table 5-7.

Table 5-7. Power Supplies.

Supply	Test Point	Limits	Adj.
+200 V	If Nixies Light, 200 V is Good		
+ 12 V	A14 "12"	+ 11.75 ± 1 V	
+ 4.4 V	A14 "4.5"	+ 4.4 ± .076 V	A14R22

5-82. Connect the 3450B power line through a Variac and reduce the line voltage to 103 volts. Connect a scope probe to the 4.4 volt supply on A14 and check for breakdown of the supply and for ripple. If breakdown occurs, change A100C3.

5-83. TURN-ON.

5-84. At turn-on the instrument should light the DC, AUTO, LOCAL and INT pushbuttons. If not, check the TURN-ON circuit of A7 at A12 pin 16. With a scope setting of 2 msec/cm, .2 V/div, dc coupled, the TURN-ON should go from Low to High in about 8 milliseconds after the instrument is turned on. If there is no transition, remove A4, A6, and A8 to unload the A7 board. Also, the Front Panel Storage Assembly A12 may have a faulty circuit.

5-85. SAMPLE RATE.

5-86. If there is no sample, check the states of the Master Timing Binaries as compared to the timing figure on Page 7-23.

a. If locked up at T_1 or T_3, check Counter Timing Advance of A10.

b. If locked up on other points, check Clock Timing Advance and transfer of A5 and the gates of A6.

c. If Ratio locks up the sample, check the states for the Ratio timing T_7 to T_{14}.

5-87. MASTER TIMING LOOP.

5-88. At turn-on A7IC5 is made true which generates $Reset_C$ and $Reset_T$. The data Count Gate (A5IC3) passes 1 MHz or 6 MHz pulses which are counted by the Data Counter. When N2-8' (A10) goes low at 100,000 counts, it advances the Master Timing Binaries on A6 to T_1. This causes $\overline{0T_1}$ to go low and activate the Clock Timing Advance on A5. After a 45 ms delay, A5IC4 is reset allowing one pulse of the 1 MHz sync to pass and advance the Master Timing Binaries on A6 to T_2. T_3 is generated when N2-8' goes low at 200,000 counts advancing the binaries. T_4 and T_7 are generated by the Clock Timing Advance on A5. When Zero Detect or Overload is received, the Count Gate is closed and the counts that have passed are stored on A13 until T_7. At T_7, Transfer is generated to display the counts stored and to end the sample.

WARNING

200 V is supplied to the A13 IC's. Use care when working around that assembly.

5-89. To test the Master timing Binaries, remove A5 and A9. Attach a clip lead to A6TP1. With the other end, scrape the side frame to give pulses. Logic levels at A6 test points 4, 5, 7 and 8 should alternate.

5-90. To check each binary, monitor a test point and apply a single ground pulse to A6TP1. Test Points 4, 7 and 8 are high for four pulses and low for three pulses. TP5 is low for four pulses and high for three pulses.

5-91. To check A6TP9 and TP10, ground A7TP1 and apply a ground pulse to A7TP3 to reset the binaries. Apply a few ground pulses to A6TP1, checking that TP9 goes low and TP10 goes high.

5-92. If the binaries do not alternate properly, the problem is a timing decoding gate loading down. The C_1 input must be low before Q output can go high and C_k must be low before Q can go low. *Remove all clip leads.*

5-93. CLOCK TIMING ADVANCE.

5-94. Remove A6 and install A5. Connect a scope to A5TP2 and check for pulses every 45 milliseconds.

5-95. COUNTER TIMING ADVANCE.

5-96. Check for 1 MHz pulses at A10TP4. If the pulses are missing, check the inputs to A5IC3. Install A9 and ground A10TP5. The following conditions result: N1 will display a one, N2 will count rapidly and the other nixes will blur. Check for 10 Hz pulses at A10IC4 pins 11, 12 or 13. If they are present, remove the ground from A10TP5.

5-97. TRANSFER.

5-98. Install A6, ground A7TP2 and press the MAN/EXT button a few times until the sample light stays on. Using the +4.4 volt supply on A14, momentarily apply 4.4 volts to A6TP5 and check for a negative going spike at A10TP5. If there is no change, check the transfer circuit of A7. Remove all leads.

5-99. DIGITAL TROUBLESHOOTING.

5-100. HALF-SPLIT THE INSTRUMENT.

5-101. Lift the A57 and the A60 boards and short A6TP2 to A6TP3 (creating a false Zero Detect). Turn the instrument on. The front panel should display ≈ +450,000 counts. Select RATIO X/Y and the display should double. If the RATE light is flashing and is controllable from the front panel rate control knob, 90% of the digital circuitry is working and the next logical step is to go to the ANALOG TROUBLESHOOTING Section. It is through the testing of the Analog Section that the problem, if it is in the Digital Section, will become apparent. If the Analog Section should prove to be operating correctly, the problem is either in the signals from A2 or through the pulse generator.

5-102. DIGITAL OVERLOAD.

5-103. If, at turn-on, the display registers overload, monitor the signal at the cathode of A9CR5 with an oscilloscope triggered from A7TP3. If the signal goes high at 250 ms, check the A9 overload circuit. If the signal stays low, check the Zero Detect Storage on A6. If, by shorting A6TP2 and TP3 together, a zero readout or a readout of about 900 counts results, check the Gate Control on A5.

5-104. DATA COUNTER AND STORAGE.

5-105. Ground A10TP5 and short A6TP2 to A6TP11. Select MAN/EXT. Connect a clip lead to A10TP4 and scrape against the side frame to create pulses. The display should count to 119,999 and blank. If pulsed one at a time, notice that the first 10 pulses are subtracted. Remove all clip leads.

5-106. TIMING CHECKS.

5-107. Remove A2, A8 and A9 boards. Check for timing at A7TP1 or TP2. DC and OHMS should be 380 ms, AC should be 2.7 seconds if installed, DC RATIO and OHMS RATIO should be 840 ms and AC RATIO should be 9 seconds if installed. If the DC timing is wrong, check the frequency of the 1 MHz line and the anode of CR6 for the $0T_1$ Period for the Clock Timing Advance. If the AC timing is wrong, check the Integration Delay on A7. If the RATIO timing is wrong, check the Transfer Delay on A7. Reinstall A2, A8 and A9.

5-108. RANGING.

5-109. NON-RATIO RANGING.

5-110. Short A7TP4 to the bottom (or right) of A8C4, select HOLD and short A6TP2 to A6TP3. Check the P Up/Down Range Command at A8IC1 (pin 6) to see that the Down Range Enable goes low and the Up Range Enable goes high for P Recycle pulses. Check also the Primary Range Decoding. Remove all jumpers.

5-111. AUTO DOWN RANGING.

5-112. Remove A57 and A60, short A6TP2 to A6TP11, ground A10TP5, select HOLD and STEP to the 1000 V range. Then select AUTO: the instrument display should downrange one range at a time. If not, check A6IC2 (pin 8) for a low at T_7, that Down Range Enable will go low and that Up/Down Range Enable will go high. Remove the A6 short.

5-113. AUTO UP RANGING.

5-114. Select HOLD and step to the 100 mV range (A10TP5 is still grounded). Select AUTO and the instrument display should uprange one range at a time. If not, check A8IC5 and the Up/Down Range Enable or the Up Range Enable on A9.

5-115. RATIO RANGING.

5-116. With A57 and A60 removed and A10TP5 grounded, short together A6TP2 and TP3. Select HOLD and step to the 1 V range. Then select RATIO and step through the ranges. Remove the ground from A10TP5 and short A6TP9 to A8C4 (bottom) for continuous ranging. If stepping or continuous ranging does not occur, check the Ratio Multiplier Range Binaries or loading of gates on A9 for M Command signal at A9IC17 (pin 6), for Up Range Enable signal, for M Recycle pulse, and the Ratio Range Decoding and Local Decimal Point circuits.

5-117. AUTO DOWN RANGING (RATIO).

5-118. Short A6TP12 to A6TP2 and TP3 with A10TP5 still grounded. Step to the 1 V range, select RATIO and step to the x1000 range. Then select AUTO; the instrument display should downrange one range at a time. If not, check A9 for Local Ratio Ranging and Down Range Enable.

5-119. AUTO UP RANGE (RATIO).

5-120. Short A6TP2 to A6TP7 and step to the 1 V range. Select RATIO then AUTO. The instrument display should uprange one range at a time. If not, check A9 for Local Ratio Ranging and Up Range Enable.

5-121. This completes the Digital Troubleshooting. If the problem persists, continue to the Analog section. Reinstall A57 and A60 and remove all clip leads.

5-122. ANALOG TROUBLESHOOTING.

5-123. The following procedure is built around the use of a 419A DC Null Voltmeter, 3450A/B Multifunction Meter, a 3460B Digital Voltmeter, a 3480C/D Voltmeter or a 3490A Multimeter. When the 3450A/B under repair is sampling, the bench meter must be on the 10 V range. For an External Trigger source to an oscilloscope, use A7TP3.

5-124. INGUARD POWER SUPPLIES (A52, A53, A54).

5-125. Resistance between guard to chassis and guard to low must be greater than 5000 MΩ. Shorted grounds will cause breakdown at high voltages, produce ground loops, make calibration impossible and also be unsafe for operation.

5-126. Isolate the supplies by taping pins 11 and M on A54. Apply + 10 V to the + 10 V test point and remove A55, A56, A57 and A60. Check that the power supply voltages are within the limits of Table 5-8.

Table 5-8. Inguard Power Supplies.

Supply	Test Point	Limits	ADJ
+ 0 V	A55 "+ 10 V"	+ 10 ± .5 V (Initial setting)	-
+ 34 V	A54 "+ 34 V"	$+34\ ^{+1.5}_{-1.0}$ V	–
+ 17 V	A54 "+ 17 V"	+ 17 ± .02 V	A54R15
- 17 V	A54 "- 17 V"	- 17 ± .02 V	A54R26
- 35 V	A53 "- 35 V"	$-35\ ^{+1.0}_{-1.5}$ V	–
+ 5 V	A53 "+ 5 V"	+ 5 ± .5 V	–
- 5 V	A53 "- 5 V"	- 5 ± .5 V	–

5-127. If either of the 17 V supplies is not within the limits, adjust the appropriate resistor (Table 5-8).

5-128. If none of the supplies is defective or appropriate repairs have been made, replace A55, A56, A57 and A60 and remove the tape from A54.

NOTE

If the + 5 V supply reads approximately 1 V, the overload protection (A53CR3) has fired. Turn the 3450 off then on again.

5-129. To test the Voltage Limiter (A53CR3), place A54 on extenders and monitor the + 5 V supply while rotating A54R26 clockwise. The + 5 V should rise to + 5.6 V ± .3 V then fall rapidly to about + 1 V (when A53CR3 fires). Readjust A54R26 to within the limits of Table 5-8.

5-130. COOLER DRIVE.

5-131. Incorrect drive causes instability and possibly a slow warmup. Connect an oscilloscope probe to the "COOLER DRIVE" test point on the inguard mother board (directly to the right and behind A60). With scope settings of 5 sec/cm, 0.1 V/cm, Polarity + and Input GND, center the trace. Then set the Input to DC, turn the 3450 off for 30 seconds then on, and observe the waveform of Figure 5-3.

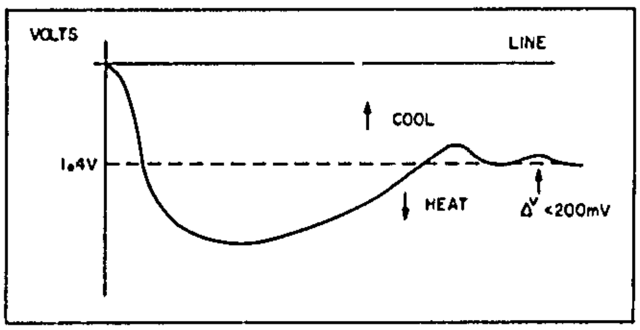


Figure 5-3. Cooler Drive.

5-132. The trace must overshoot the - 1 volt level and the second positive peak must be within 0.3 V of the final settling value. If the waveform is incorrect, check A100Q4, Q5 and Q6.

5-133. INGUARD TIMING ASSEMBLY.

5-134. Lift the A57 board and short A6TP2 to A6TP3. With oscilloscope settings of 50 ms/cm, .2 V/cm, negative polarity, NORM, and dc coupling, connect a 10:1 divider probe to the test points of A60 (ground to inguard ground lug by cooler) and verify the waveforms of Figure 5-4.

5-135. A60TP4 should be a straight line around zero volts for non-Ratio operation. Depress the Ratio pushbutton and verify waveform of Figure 5-4(c). If not, check K6 and A60 pin 5.

5-136. If the pulse of A60TP1 is less than 4 msec, check A60C7. The waveforms of A60 pins K and L should be exactly opposite of each other. If not check the G TIMING BINARIES. Reinstall A57.

5-137. DC ATTENUATOR AND AUTO-ZERO.

5-138. Connect the bench voltmeter to A55TP1. Short the X input terminals of the 3450 and step through the ranges. Check for a zero reading on the bench voltmeter. If the reading is not zero, ground the green wire (A69 to A71). If a zero reading results, check the DC ATTENUATOR. If there is noise on the 100 V, 1 V and 100 mV ranges, check for a shorted shield cable between A69 and A70.

5-139. Remove the short on the X terminals and all applied grounds. Check each range, except the 1000 V range, with a voltage applied. Check for proper relay drive in accordance with the Relay Timing Diagram of Figure 7-5, Page 7-9.

5-140. To check the reed relays remove A2 and any input voltage. Select MAN/EXT. With a 412A on the 1 Ω range, measure across the reed contacts. Energize the reed by pulsing the signal input lead of the relay coil with a clip lead from ground (being careful not to ground the + 5 V supply). The glass reeds should read less than 200 MΩ and not vary; the others should read less than 300 MΩ and not vary. If a reed fails to close, check its coil resistance. Reinstall A2.

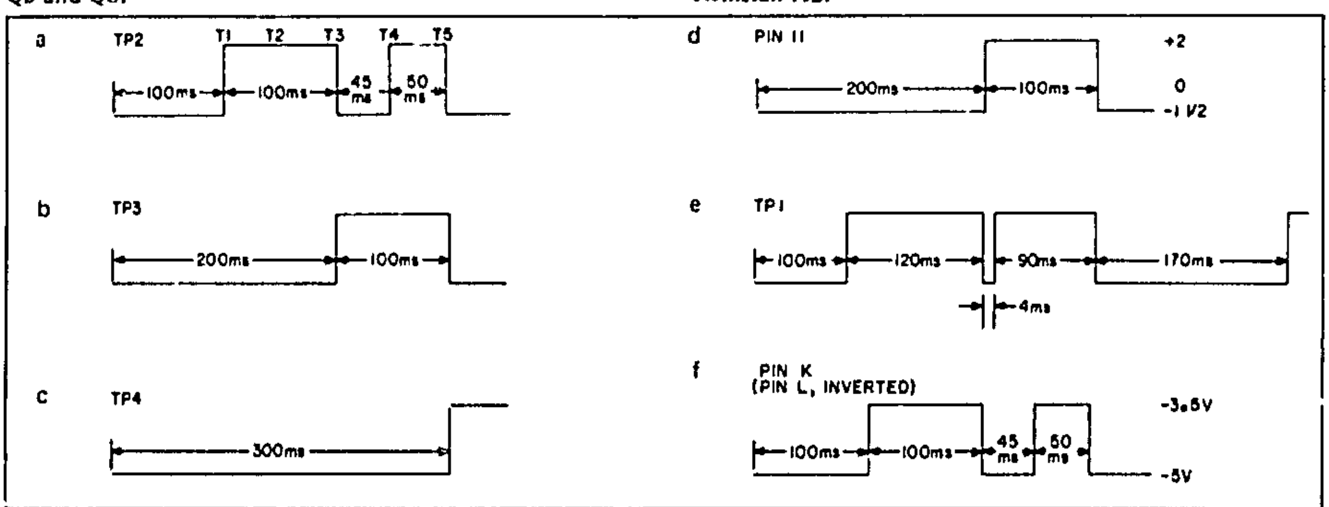


Figure 5-4. Inguard Timing Waveforms.

5-141. If the 100 mV range is noisy, but the noise decreases as the Input Amp Gain decreases, check K7, K8 and K9.

5-142. INPUT AMPLIFIER.

5-143. To test whether the DC INPUT AMP will adjust through zero, select MAN/EXT and pull the A2 Board. Ground the yellow wire to A70C1 and the green wire from A69 to A71 to chassis. Tape pins 9 and 10 of A55 and put A55 on an extender. Check for a ± 10 volt swing across A70C1 when A55R14 is adjusted. If there is no pass through zero, remove A55Q1 (or use the FET substitution board). If there is a pass through zero, then A55Q1 is faulty; if there is no pass through zero, then A71Q1 is at fault. Remove the tape from the pins.

5-144. While adjusting A55R14, check for a ± 7 V swing across the tops of A55R4 and R5; a ± 5 V swing across A55R8 and R9; a ± 3 V swing from the top of A55CR3 to ground; and a 2.8 V swing from A55TP1 to inguard ground.

5-145. Remove all the grounds and install A2. Adjust A55R14 and check that A55TP1 remains at 0 V ± 1 mV. This verifies operation of the Auto-Zero circuits. Re-zero the DC Input Amplifier to 0 V ± 200 μV (using A55TP1 and A55R14).

5-146. POLARITY AMPLIFIER.

5-147. Check that the A56 Pol Output TP will pass through zero by selecting MAN/EXT, connecting the bench voltmeter positive lead to Pol Output TP and the negative lead to guard. With A56R14 check for a ± .3 V swing.

5-148. If there is no swing, remove A2, lift the black wire on A69 which connects to A71 (Cooler Ass'y) and connect it to inguard ground, remove A56Q1 (or use a FET substitution board) and select MAN/EXT. Check for a ± .2 V swing across A56C1. If there is none, check A56C3 for leakage or A71Q2. There should also be a ± 8 V swing across C2, a ± 5 V swing across the tops of A56R8 and R9, and a + 27 V to - 13 V swing from Pol Output TP to inguard ground.

5-149. Reconnect the black wire to A69 and check that the amplifier will zero. If not, check the Gain Feedback loop.

5-150. Install A2, remove grounds and zero the Polarity Amp as per Paragraph 5-128.

5-151. PERCENT AMPLIFIER.

5-152. To check whether A56 Percent Output TP will pass through zero, select MAN/EXT, connect the positive lead from the bench voltmeter to Percent TP and the negative lead to guard. While adjusting A56R34 there should be an approximate - 5 mV to + 50 mV sweep.

5-153. If the Percent Amplifier does not pass through zero, remove A2, apply an inguard ground to A56 pin B, disconnect the orange wire to A56 and ground the half leading to A71. Select MAN/EXT; if the amplifier will now zero, check the Gain Feedback loop of the Percent Amplifier.

5-154. If the amplifier does not pass through zero, after the procedure of Paragraph 5-133, remove A56Q8 (or use a FET substitution board) and check across A56C4 for an approximate .2 V swing with MAN/EXT selected. If there is a pass through zero, A56Q8 is at fault; if there is no pass, check A56C6 for leakage or A71Q3. There should also be a ± 8 V swing across A56C5, a ± 5 V swing across the tops of A56R28 and R29, and a ± 25 V swing from Percent Output TP to inguard ground. Replace the orange wire, remove all grounds and install A2. Re-zero the Percent AMP as per Paragraph 5-132.

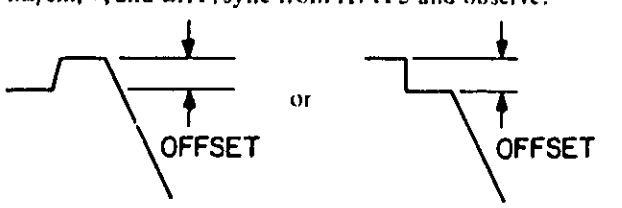
5-155. To check the switching points of the Percent Amplifier, put the 3450 in DC, RATIO, and AUTO. With copper shorting straps, connect X_H to X_L and X_L to Y_L (to measure positive ratio) and X_L to GUARD. Monitor the Percent TP of A56 with oscilloscope settings of DC, EXT, 1 V/cm, and 50 msec/cm. Sync the scope to A7TP3. With a 740B DC Standard apply an input to the 3450 of 9.7 volts. While observing the waveform on the scope, change the voltage to 9.9 V. The gain of the Percent Amp should decrease after passing the cardinal point of .8. Check to see that the front panel display of the 3450 reads the same before and after switching. Check the wave shape and display with the following voltages: 7.7 - 7.9 V, 5.7 - 5.9 V, 3.7 - 3.9 V, 1.7 - 1.9 V. Remove the shorting straps.

5-156. If there is a change of more than 2 counts, check the A56 board for thermal compensation wires, leads, and board cleanliness. Also check the inputs from A60.

5-157. INTEGRATOR.

5-158. To check that the integrator swings through zero, select HOLD, 10 V range, and MAN/EXT. Connect the bench voltmeter to A57TP1 and adjust A57R12. If A57TP1 does not zero, remove A60 and check the left ends of A57R5 and R6 for a ± .5 V swing, the left ends of A57R9 and R10 for a ± .5 V swing; the top of A57C2 to inguard ground for a ± 30 V swing; A57TP1 to ground for a ± 30 V swing; the right end of A57C8 to ground for a ± 1 V swing; and A57TP2 to ground for a + 2 V to - 1 V swing. Reinstall A60.

5-159. Apply 0.0005 V to the 3450, ground pin 1 of the Remote Control jack (for fast gate) and connect an oscilloscope probe to A57TP2. Set the scope to .005 V/cm, 5 ms/cm, +, and EXT; sync from A7TP3 and observe:



The above condition is caused when the integrator opens.

The problem may be corrected by moving the wire located alongside the coil of A57K29. This wire induces an opposing current. The physical position of the wire determines the magnitude of induced current. Move the wire until the initial offset is zero. Remove the ground on pin 1 of the Remote Control jack.

5-160. RATIO.

5-161. Apply less than 90 mV to the Y input, select RATIO and AUTO. The 3450 should read the voltage applied to the Y input, the Overload light should be lit and the function blank. If not, check the Scale - Y circuitry of A60, the gain switching of the Percent Amp and the resistance and cycling of K1 and K2.

5-162. ZERO DETECT.

5-163. Short A6TP2 to A6TP3 and apply +9 V on the 10 V range. Check the waveshapes given on Figure 7-25. Check for a 1.5 μs pulse at the left end of A57CR17 and at the yellow wire to A66. If a pulse is present, check for a fault in the pulse transformer assembly (A50) or its connections. Remove the A6 short.

5-164. NOISE.

5-165. Some of the common causes of noise are:

a. 1854-0475 dual transistors (A54Q5, 12; A56Q1, 8; A55Q1, 2; A57Q6, 7). If the transistor cases have a voltage on them, change the transistors.
b. A56R1, R2, R21 and R22.
c. A56R38 and/or R39.
d. A100C1.
e. Cooler FETS.
f. Timing of relay drives and A60.
g. Ungrounded ac power line.
h. Guard strap on front panel loose.
i. Open connection between the front panel guard terminal and the internal sheet metal.
j. Loose connection in the reed channel.
k. Reed switches.
l. Power Supply ripple.

5-166. If noise is range dependent, check the DC Attenuator or the Input Amp Gain circuitry.

5-167. OHMS CONVERTER OPTION 002.

5-168. Before troubleshooting, check that the five lead wires to A59 Ohms Reference Assembly are connected as required in Paragraph 2-15. The following procedures should be performed if the equipment failed to meet the specifications given in Paragraph 5-14 or the calibration procedures of Paragraph 5-55.

5-169. OHMS RANGE AND OHMS LOGIC (A58, A59).

5-170. In order to STEP range, if overload is indicated, use a jumper wire to short A6TP2 to A6TP3. Remove jumper wire to check readout. If range error exists, check for correct drive signal (Low) to the appropriate OHMS RANGE relay (A58K32, K33, K34) at A58 pins 11, 9, and 10. Check OHMS LOGIC circuit on A59 assembly. Check OHMS LOGIC circuit on A59 assembly. Check A2 INPUT RANGE and A60 timing inputs.

5-171. VOLTAGE OVERLOAD CIRCUIT (A72).

5-172. A readout error that increases with percent of scale is usually caused by a defective A72Q8. Connect a jumper wire from Y_{HI} terminal to the black wire at A59K35B, bypassing the VOLTAGE OVERLOAD circuit. Check for correct readout with a full-scale input resistance on each range. If correct, suspect A72Q8 or CR2.

5-173. OHMS REFERENCE CIRCUIT (A59).

5-174. Measure the Reference Voltage between A72TP2 and A59K35C (green wire). Voltage should be 9.09 ± 0.18 V dc. If incorrect, suspect A59CR1 CR5 or Q1.

5-175. OHMS POWER SUPPLY CIRCUIT (A59, A72).

5-176. Set TRIGGER to MAN. Short the Y_{IN} terminals. Check for 30 ± 2 V dc across A72C4 and C5. If Low, check for 8 V p-p square wave (slightly rounded) at the collectors of A59Q2 and Q3. Check for correct oscillator frequency of 20 kHz ± 3 kHz. Probable causes of low voltage with high frequency are: 1) trouble in OHMS AMP; 2) VOLTAGE OVERLOAD or bridge rectifier circuit; or 3) if a relay is open that should be closed. The oscillator frequency is determined by A59T1, R2 and the external load on T2. If the voltage across A72C4 is below 15 V dc, check for a shorted A72Q6. If A59Q2 and Q3 do not oscillate, check transistors and for open winding in T_1, T_2, or L_1.

5-177. To completely isolate the OHMS POWER SUPPLY for troubleshooting, unsolder primary windings of A59T2 from A59 and tack-solder two 150 ohm, 1/2 W resistors in their place. The oscillator frequency should be as specified. This test should isolate the trouble, such as shorted turn(s), to T_2.

5-178. OHMS AMPLIFIER CIRCUIT (A72).

5-179. Before troubleshooting the Ohms Amp circuit, a gain check should be performed. To check gain, STEP to the 10 kilohm RANGE (A6TP2 and TP3 may have to be jumpered) and select MAN TRIGGER. Connect a 10 kilohm resistor across the Y terminals. Measure the differential input voltage to the OHMS AMP between the gates of A72Q1A and B using the 419A (most accessible points are red wire terminating at bottom of A72 and ground end of A72C5). The differential voltage should not be greater than 15 mV (typically 5 mV). Place a short across the 10 kilohm resistor. The differential voltage change must be less than

90 microvolt to verify an amplifier gain of $X10^5$. If the gain check fails, repeat the test after connecting jumper wires between: 1) Y_{HI} terminal and A59K35B terminal (black wire); 2) Y_{LO} Terminal to A59K35B (brown wire); and 3) across contacts of A58K32A and K32B. If gain check is correct, suspect open circuit in VOLTAGE OVERLOAD or a relay.

5-180. Locate a defective amplifier stage using the following procedures. Turn off LINE power switch. Disconnect all leads to X and Y terminals and jumper wires across relays that were connected in Paragraph 5-176. Connect the 419A between A72R1 and R2 (actually across CR9). Turn on LINE power switch. Set TRIGGER to MAN. Set the 740B DC Standard to Ohms Reference Voltage and connect the 740B positive output to the ground side of A72C5. Connect the 740B negative output to A59K35C (green wire). Vary the 740B voltage slightly above and below the Ohms Reference Voltage and watch for the 419A to swing to *both* polarities. If the 419A stays at one polarity or the voltage swing is symmetrical about zero for equal positive and negative voltage changes from the 740B, suspect A72Q1 or Q2. To test the other differential stages, repeat the test with the 419A connected: 1) between A72R4 and R5 (actually across C2--R6); and 2) between A72R8 and R9. To test the A72Q5/Q6 differential amplifier, connect the 419A across A72C3. The voltage should swing from 0 to approximately - 25 V. Repeat this test with the 419A connected to A72Q7 emitter. If voltage swing is incorrect only in last test, suspect A72Q7, CR3, or CR4. CR3 or CR4 may be checked by turning off LINE switch and unsoldering blue and yellow supply voltage wires on A59.

5-181. OUTPUT RELAYS.

5-182. Check the drive voltages to A59K30, K31, and K35. Relay K30 remains open and K31 closed on Non-Ratio but are timed on Ratio according to the Relay Timing Diagram in Section VII. Relay K35 is timed on Non-Ratio and Ratio. Connect a jumper wire between A6TP2 and TP3 to generate a Zero Detect signal. Sync the oscilloscope at A7TP1 (+) slope on 50 ms/cm sweep time.

5-183. AC CONVERTER OPTION 001.

5-184. The first step in troubleshooting the AC Converter is to check all of the ranges. If overload is displayed, A6TP2 and TP3 may be jumpered to allow range STEPPING. Remove the jumper to check the readout. If correct readout is present only on some ranges, the probable cause is in A85 (AC LOGIC) or A86. The AC LOGIC would also be at fault if + 10 V were measured at A84TP4 at full scale but A85K41 or K42 (on Ratio) does not close to supply the voltage to the 3450B for measurement. The AC LOGIC operates from signals from Channel Relay Drive Assembly A2 and Inguard Timing Assembly A60. Compare the relay timing on A85 and A86 with the Relay Timing Diagram shown in Figure 7-5. Sync the oscilloscope at A7TP1 on (+) slope.

5-185. AC INPUT AMPLIFIER (A81, A86, A90).

5-186. Amplifier gain and ranging are tested as follows. Connect the oscilloscope with 10:1 probe to A81TP2. Set the vertical sensitivity to 0.02 V/cm. Table 5-9 shows the peak-to-peak output voltage with given rms inputs and range settings.

Table 5-9. Input Amp Output.

Input Voltage (rms) at 500 Hz	3450B Range	A81TP2 Volts p-p
1.0	1 V	0.84840
10.0	10 V	0.84840
100.0	100 V	0.84840
100.0	1000 V	0.08484

5-187. AC Input Amp A81 operation may be checked as follows. Remove A86. Place A81 on an extender card. Check A81Q3 emitter for - 11.5 V dc. Check the differential amplifiers' voltage swings by connecting a 1 megohm resistor to the junction of A81CR1/CR2 and alternately touching the other end of the resistor to the + 17 V dc and - 17 V dc supply voltage. Using a 419A, measure the voltages across A81C2 (+ 0.4 V/- 0.4 V) A81C3 (+ 0.3 V/ - 0.3 V). A81C8 plus side to ground (+ 0.4 V/- 0.4 V). A81C8 minus side to ground (+ 0.4 V/- 0.4 V), and A81TP1 to ground (+ 5 V/- 5 V).

5-188. SAMPLING AMP (A82).

5-189. The output of the Sampling Amp at A82TP1 should be the 1 kHz Reference Signal at A82TP2 alternating at a 5 Hz rate with the Input Signal at A81TP2. Under normal operation the Reference Signal will have a 5:7 peak voltage ratio with a sine wave Input Signal. However, with an improper output voltage from the Integrator at A84TP4, the Reference signal across A82R41 could be 0 V to 600 mV (full-scale) proportional to the Integrator output. If the output of the Sampling Amp does not settle down to the proper waveform due to a changing Integrator voltage, the following procedure may be used to substitute an external voltage for the Integrator.

5-190. Remove A82 assembly and put a piece of electrical tape around pin 12, front and back, and place the assembly on an extender board. Apply + 600 mV from the 740B to the top of R41 on A82.

5-191. If only one of the two signals appears at the Sampling Amp output (assuming that the Integrator output is not zero), the Modulator, 5 Hz Sync Generator or DC-to-Square Wave Converter is not operating. (A6TP2 and TP3 may have to be shorted to allow range STEPping to a low range.) Check the 5 Hz Sync signal at A85TP5 and the Reference Signal at A82TP2.

5-192. To check the bias of the Sampling Amp, place A82 on an extender board and ground TP1 to the top cover mounting bracket on the right side of AC Converter. Disconnect any Input voltage and remove A84. Check the bipolar voltage swing across the stages with a 419A while turning the A82 DC Bal. Check the emitter voltage of the Q7 current source. The voltage across A82C4 and C6 should swing from + 1 V to - 1 V. The voltage across C7 should swing from 0 to + 15 V.

CAUTION

Do not short C7 to the adjacent trace.

The voltage at TP1 (ungrounded) should swing from + 30 mV to - 30 mV.

5-193. THERMOCOUPLE DRIVER (A83).

5-194. Under normal operation the AGC Amp (A84) should stabilize the Thermocouple output voltage from 1.2 mV to 1.5 mV with an Input Signal from full scale down to about 3 mV on the 1 V range. Measure the voltage with the 419A positive side to A83TP3 and the negative side to TP2. Connect A85TP5 to the - 17 V test point on A54 to stop the 5 Hz Sync and hold the Modulator open to supply the Input Signal continuously to the Thermocouple. This makes the Thermocouple Loop entirely independent of the integrator output voltage.

CAUTION

Do not apply an overload input voltage with this hook-up.

Short A6TP2 and TP3 to allow STEPping to the 1 V or 10 V range. Adjust the A84TP5 voltage with the A82 and A84 DC Balances as described in the Calibration Adjustment, Paragraph 5-63. Adjust the A83 AGC Adj to give 1.3 1.3 mV across A83TP3 and TP2.

5-195. Connect the oscilloscope to A84TP1 and select a vertical sensitivity of 0.2 V , a sweep time of 0.5 sec/cm, and line sync. Change the Input voltage from 1 V to 100 mV, 10 mV, 1 mV, 10 mV, 100 mV, and back to 1 V to observe an AGC settling time of 1.5 sec (3 cm on the scope). If the settling time is greater than 1.5 sec, the gain of the Low Level Amp or AGC Amp might be low.

5-196. DC FEEDBACK LOOP (A83, A84).

5-197. If the voltage at A84TP5 cannot be adjusted correctly, remove A82. Turn DC Bal control A84R4 fully cw, then fully ccw while checking + 7 V to - 7 V swing at TP5. Other check points and voltage swings in the Thermocouple Preamp, Driver, and Feedback Amp are: 1) across A84C3 (+ 1 V/- 1 V); 2) across A84C4 (+ 0.3 V/- 0.3 V); 3) top of A84C14 to ground (- 5 V/- 15 V); 4) top of A83C3 to ground (- 2 V/+ 7 V); 5) bottom of A83C3 to ground (- 7 V/to + 2 V); 6) top of A83C7 to ground (0 V/+ 6 V); 7) bottom of A83C8 to ground (0 V/- 6 V); 8) bottom of A84C6 to ground (+ 0.3 V/- 0.3 V); 9) top of A84C5 to ground (- 1 V/+ 2 V); and 10) A84TP5 to ground (+ 6 V/ - 6 V).

5-198. AGC LOOP (A83, A84).

5-199. If the Thermocouple output voltage at A83TP3 cannot be set to 1.3 mV, or will not stabilize to this value within 1.5 sec of an Input voltage change, then suspect the Thermocouple, Low Level Amp or AGC Amp. A 1 V peak-to-peak sine wave at A83TP1 should give about 1.3 mV across TP3 and TP2. Measure the Thermocouple resistance for about 30 ohm from TP1 to ground. Turn the AGC Adj A83R24 fully cw and ccw and check for a 0 V to + 10 V swing at A84TP1. Other check points and voltage swings are: 1) A83Q5A and B between collectors (+ 0.2 V/ - 0.2 V) 2) A83Q7 base to Q8 base (+ 2 V/- 2 V); and 3) A84C10 (+ side) to ground (+ 1 V/- 1 V). If the voltage at A84TP1 did change from 0 V to + 10 V, but the Thermocouple output voltage did not change from 0.5 mV to 8 mV with a full scale input voltage present, the photocell A84V1 is defective. The voltage at A84TP1 should normally be + 7.5 V to + 9 V at full scale, and + 0.4 V to + 0.8 V at 1 mV, on the 1 V range.

5-200. DEMODULATOR (A83).

5-201. The Thermocouple generages a 5 Hz Error Signal proportional in amplitude to the difference in the square of the rms value of the Integrator output voltage and the Input Signal. The Demodulator rectifies this signal in synchronization with the Modulator responsible for the signal to give negative or positive pulses to drive the Integrator voltage up or down respectively. During proper operation, the Error Signal is never visible at A83TP3 with an oscilloscope, and only slightly visible at A84TP3, except during overload or when the input voltage is changing.

5-202. Disconnect the disable line from the 5 Hz Sync Generator to the - 17 V Supply. If an Error Signal cannot be made to appear at A84TP3 by overloading a range, there is a problem in the Error Amp or Demodulator. The continued presence of an Error Signal greater than 50 mV p-p means that the Integrator is not responding and its dc output voltage is not equal to the rms of the Input Signal.

5-203. Remove A82 assembly and put a piece of electrical tape around pin 12, front and back, and place the assembly on an extender board. Apply + 600 mV from the 740B to the top of R41 on A82, and apply 1.1 V rms, 500 Hz from the 745A to the X terminals. An Error Signal of 2 V p-p should develop at A84TP3 to verify the operation of the Error Amp and Demodulator. Use a 10:1 probe on the oscilloscope. See the schematic on Page 7-59 for the correct waveform of the Error Signal. Disconnect the 740B and remove the tape and reinstall A82.

5-204. FILTER INTEGRATOR (A84).

5-205. The dc action of the Integrator may be checked by grounding the top end of A84C13 and turning the Integ

Zero Adj fully cw and ccw. TP4 voltage should swing from 0 V to + 13 V.

5-206. PHOTOCELL A84V1.

5-207. Check the signals at A83TP1, A83TP3 and A84TP1 with the oscilloscope while changing the Input voltage back and forth from 1 V to 1 mV. If these signals do not settle down to their normal state after the Input voltage is changed, the photocell V1 is probably defective. A83TP1 should alternately display, at a 5 Hz rate, a sine wave and square wave of 7:5 amplitude ratio. A83TP3 is the Error Signal which should fall to less than 50 mV p-p. A84TP1 is the AGC voltage which should stabilize at a dc level.

5-208. An out-of-circuit check of the photocell may be performed as follows with a dc power supply and an ohmmeter.

CAUTION

Do not apply greater than 10 V (or 20 mA) to the photocell lamp, 1 V to the L-CELL, or 30 V to the H-CELL.

a. Connect the dc power supply to the lamp terminals, and adjust the voltage to give an L-CELL (V1A) resistance of 250 ohm. Then measure the H-CELL resistance.

1. Lamp voltage must be: > 6.9 V, < 9.0 V.
2. H-CELL resistance must be: > 35 kΩ, > 65 kΩ.

b. Readjust the voltage for an L-CELL resistance of 2.5 kilohm.

1. Lamp voltage must be: > 3.7 V, < 5.0 V.
2. H-CELL resistance must be: > 350 kΩ, < 650 kΩ.

c. Readjust the voltage for an L-CELL resistance of 25 kilohm.

1. Lamp voltage must be: > 2.3 V, < 3.5 V.
2. H-CELL resistance must be: > 3.5 MΩ, < 6.5 MΩ.

d. Adjust the lamp voltage to 0 V.

1. H-CELL resistance must be: > 500 kΩ, < 100 MΩ

5-209. MISCELLANEOUS CHECKS.

5-210. More subtle errors in the AC Converter output voltage may be caused by a leaky Q18 on A84, improprer rise and fall times of the 5 Hz Sync Signal and Reference Signal, a spike generated by the DC-to-Square Wave Converter, improper turn-on and turn-off of the Modulator, and noise from A81CR6, Q2 or Q1. R22 on A81 should be 12kilohm. Noise from A81 will probably cause an error on the 1 V range only. It can be determined that the problem is on A81 or A86 by using the hookup for the FB Cal adjustment in Paragraph 5-68.

5-211. The rise and fall times of the Reference Signal at A82TP2 should be less than 200 nanoseconds with a full scale Input voltage. Rise and fall times of 500 nanoseconds and 100 nanoseconds respectively should be measured at A85TP5.

5-212. To check for a feedthru spike from the DC-to-Square Wave Converter, apply 1 mV input and connect the oscilloscope to A82TP2 with a 10:1 probe. Select 0.005 V/cm vertical sensitivity and 0.2 μs/cm sweep time and sync the scope at the gates of Q13 and Q14 on (+) slope. If the pulses are greater than 50 mV, then A82C12 will need to be enlarged, or Q13 or Q14 replaced. Values that are used for C12 are 820, 1000, 1300 and 2000 pF. Do not use a larger value than necessary.

5-213. For noise on the AC Converter output, suspect CR11 or solder connections around TC1 and Q5 on A83, TC1 itself, Q5 if it is not an 1854-0369, or the Demodulator FET's. On A84, Q1, Q2 or the photocell may cause noise.

5-214. POST REPAIR ADJUSTMENTS.

5-215. Several circuits in the 3450B may need special adjustment after repair. Perform the Calibration Adjustments in Paragraph 5-34 after these repair adjustments.

5-216. A5 GATE-OPEN DELAY.

5-217. Accomplish this procedure if the A50 Pulse Transformer or A57 Integrator Assembly is replaced.

a. Apply 0.001 to the 3450B on its 1 V range.

b. Ground pin 1 of the rear panel Remote Control Jack to program 1/60 Sec Gate. The readout should not change if the Gate Open Delay is correct. If the readout changes, proceed with Step c.

c. Jumper wires and/or R9 are added or removed to adjust the delay so that the readout does not change when 1/60 Sec Gate is programmed. The bottom jumper changes the readout by 1 count, the top jumper 1 or 2 counts, and R9 4 counts.

5-218. A5 ADD-COUNTS.

5-219. Accomplish this procedure if the A57 Integrator Capacitor is replaced.

a. Select RATIO on the 3450B and apply 0.9 V to the X and Y terminals to give a negative ratio readout.

b. If the readout is not - 1.00000, then add or remove Add-Count jumpers on A5. The numbers printed under the jumpers are the counts that will be added with the jumpers in place. No more than a total of 5 counts should be needed.

c. If the revision number of the 03450-66535 assembly is "REV A", two counts can be added by bridging a jumper wire from the outside pad of the "2" PC pads to the outside pad of the "4" PC pads. Step b applies directly to all other revisions.

5-220. A7R15.

5-221. Accomplish this procedure if components in the Integration Delay circuit are replaced.

a. Select AC function and check the interval of the Integration Delay at A7 pin 4-B. Trigger the oscilloscope on (-) slope.

b. If the delay interval is not 2.4 sec, change A7R15.

5-222. A52C8, C9.

5-223. Accomplish this procedure if A52 or the power supply transformer T1 is replaced.

a. Remove the Ohms Converter and select MAN trigger. Disconnect the GUARD strap from the X low terminal.

b. Connect an oscilloscope between the GUARD and X low terminals.

c. Adjust C8 and C9 to obtain a minimum 60 Hz voltage.

5-224. A55R12.

5-225. A55R12 is removed or changed in value among 9 megohm, 12 megohm, 15.7 megohm and 16.7 megohm if the 10 V Rng Cal cannot be adjusted in Paragraph 5-50.

5-226. A55R37, R38.

5-227. Accomplish this procedure if A55 or A71 assembly is replaced.

a. Place A55 on an extender board and center R33 REF ADJ.

b. Select MAN trigger and measure the base voltage of A71QCR1 with a 3450B or 3460B at the test point between R35 and R36 on A55. Use the X low terminal as the ground point. (Resistors or jumpers must be in the R37 and R38 positions for the measurement. Use 500 Ω and 5 Ω values if the new assembly has the positions open or if the old resistors are not available.)

c. Select values for R37 and R38 from Table 5-10 by choosing the voltage nearest to that measured for QCR1. Solder the resistors in place.

d. On MAN trigger, measure the Reference Voltage at the 10 V test point on A55 using the X low terminal as the ground point. Turn the REF ADJ to see that the Reference Voltage can be adjusted to 1 mV on either side of + 10 V.

5-228. A57R21.

5-229. Accomplish this procedure if A57Q12 or Q13 is changed.

a. Measure the resistance from A57TP1 to the left end of R21.

b. Subtract the resistance reading from 2500 Ω to obtain the value for R21.

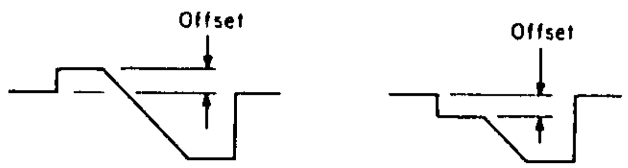
5-230. A57K29.

5-231. Accomplish this procedure if the wire next to K29 is moved.

a. Connect the oscilloscope to A57TP2, with the solder lug to the right of A57 as the ground point. Select 0.005 V/cm, 50 ms/cm, and externally sync the scope at A7TP1 on (+) slope.

b. Select HOLD and STEP to the 10 V range. Apply an input voltage of +0.0005 V.

c. Move the wire closer or farther from K29 to reduce the offset to a minimum.



5-232. A57R33.

5-233. Accomplish this procedure if the Integrator Capacitor or any component to the right of IC1 on the A57 schematic is replaced.

a. STEP to the 1000 V range of the 3450B, and select 0.990000 V on the 1 V range of the 740B DC Standard. Connect the 740B to the X terminals.

b. Increase the thousands digit of the 740B until the 3450B changes from 000.99 to 001.00; then reverse the polarity from the 740B and repeat the procedure.

c. The average of the points at which the 3450B changes from 000.99 to 001.00 on positive and negative polarity should be 0.996 or 0.997. *Decrease* R33 by 10 Ω/count to *increase* the average, and vice-versa.

5-234. A86 ASSEMBLY.

5-235. If this assembly is to be replaced, the matched sets of capacitors and resistors must be retained or else the entire sets replaced, including the numbers on the Chassis A90.

5-236. A86 JUMPERS.

5-237. Accomplish this procedure if A86 or the matched set of capacitors is replaced and the 100 V HF CAL in Paragraph 5-72 cannot be accomplished.

a. Replace jumper wires A and/or B on A86 and turn the 100 V HF CAL to 17 turns clockwise from the left extreme position. Replace A86 and its shield.

Table 5-10. Selection of A55R37, R38.

REFERENCE BASE VOLTS	R37	R38	REFERENCE BASE VOLTS	R37	R38	REFERENCE BASE VOLTS	R37	R38
6.454	0	0	6.720	300	35	6.949	600	70
6.458	0	5	6.724	300	40	6.952	600	75
6.462	0	10	6.727	300	45	6.955	600	80
6.467	0	15	6.731	300	50	6.959	600	85
6.471	0	20	6.735	300	55	6.962	600	90
6.475	0	25	6.738	300	60	6.965	600	95
6.479	0	30	6.742	300	65	6.966	700	0
6.484	0	35	6.745	300	70	6.971	700	5
6.488	0	40	6.749	300	75	6.974	700	10
6.492	0	45	6.753	300	80	6.977	700	15
6.496	0	50	6.756	300	85	6.981	700	20
6.500	0	55	6.760	300	90	6.984	700	25
6.505	0	60	6.763	300	95	6.987	700	30
6.509	0	65	6.767	400	0	6.990	700	35
6.513	0	70	6.771	400	5	6.993	700	40
6.517	0	75	6.774	400	10	6.996	700	45
6.521	0	80	6.778	400	15	6.999	700	50
6.525	0	85	6.781	400	20	7.002	700	55
6.529	0	90	6.785	400	25	7.005	700	60
6.533	0	95	6.788	400	30	7.008	700	65
6.538	100	0	6.792	400	35	7.011	700	70
6.542	100	5	6.795	400	40	7.014	700	75
6.546	100	10	6.799	400	45	7.017	700	80
6.550	100	15	6.802	400	50	7.020	700	85
6.554	100	20	6.806	400	55	7.024	700	90
6.558	100	25	6.809	400	60	7.027	700	95
6.562	100	30	6.813	400	65	7.030	800	0
566	100	35	6.816	400	70	7.033	800	5
6.570	100	40	6.820	400	75	7.036	800	10
6.574	100	45	6.823	400	80	7.039	800	15
6.578	100	50	6.827	400	85	7.042	800	20
6.582	100	55	6.830	400	90	7.045	800	25
6.586	100	60	6.834	400	95	7.048	800	30
6.590	100	65	6.837	500	0	7.050	800	35
6.594	100	70	6.840	500	5	7.053	800	40
6.598	100	75	6.844	500	10	7.056	800	45
6.602	100	80	6.847	500	15	7.059	800	50
6.606	100	85	6.851	500	20	7.062	800	55
6.610	100	90	6.854	500	25	7.065	800	60
6.614	100	95	6.857	500	.0	7.068	800	65
6.618	200	0	6.861	500	35	7.071	800	70
6.622	200	5	6.864	500	40	7.074	800	75
6.625	200	10	6.867	500	45	7.077	800	80
6.629	200	15	6.871	500	50	7.080	800	85
6.633	200	20	6.874	500	55	7.083	800	90
6.637	200	25	6.877	500	60	7.086	800	95
6.641	200	30	6.881	500	65	7.089	900	0
6.645	200	35	6.884	500	70	7.092	900	5
6.649	200	40	6.887	500	75	7.094	900	10
6.652	200	45	6.891	500	80	7.097	900	15
6.656	200	50	6.894	500	85	7.100	900	20
6.660	200	55	6.897	500	90	7.103	900	25
6.664	200	60	6.901	500	95	7.106	900	30
6.668	200	65	6.904	600	0	7.109	900	35
6.671	200	70	6.907	600	5	7.112	900	40
6.675	200	75	6.910	600	10	7.114	900	45
6.679	200	80	6.914	600	15	7.117	900	50
6.683	200	85	6.917	600	20	7.120	900	55
6.687	200	90	6.920	600	25	7.123	900	60
6.690	200	95	6.923	600	30	7.126	900	65
6.694	300	0	6.927	600	35	7.129	900	70
6.698	300	5	6.930	600	40	7.131	900	75
6.701	300	10	6.933	600	45	7.134	900	80
6.705	300	15	6.936	600	50	7.137	900	85
6.709	300	20	6.939	600	55	7.140	900	90
6.713	300	25	6.943	600	60	7.143	900	95
6.716	300	30	6.946	600	65			

b. STEP to the 100 V range on AC and apply 100 V, 50 kHz from the 745A to the X terminals.

c. Select the jumpers to be cut according to the 3450A reading. Refer to Table 5-11.

Table 5-11. A86 Jumpers.

3450A READING	CUT JUMPER
92.5 V to 95.5 V	A
95.5 V to 98.5 V	B
98.5 V to 101.5 V	None

5-238. FIELD INSTALLATION OF OPTIONS.

5-239. See Section II for this procedure.

5-240. CHANGE OF LOGIC VOLTAGE LEVELS.

5-241. The programming and digital output logic voltage levels may be changed from the 12 V to the alternate 5 V level by moving jumper wires on A3, A6, A24 and A25 assemblies. Also, R7 on A25 must be changed to 1.07 kilohm 0698-4196 and R8 to a diode 1910-0016, cathode to the base of Q_2.

5-242. H50 MODIFICATION.

5-243. 3450B-H50 is a Model 3450B Multi-Function Meter that has been modified as best suited for 50 Hz power line operation. The short integration interval given by the rear panel 1/60 Sec Gate Program has been changed to 1/50 sec to move the cusps of greatest normal-mode noise rejection to multiples of 50 Hz. This has been accomplished by changing the Data Count frequency to 5 MHz and lengthening the Clock interval to 1/50 sec on A5 Assy. Kit K50-3450B contains instructions and components making the modifications listed below:

A5 ASSEMBLY

Crystal is changed to 5 MHz order by description.
C13 is changed to C: fxd mylar .056 microfarads 2% 50 VDCW order by description.
50 Hz jumper wire is cut to right of IC10.

A56 ASSEMBLY 03450-66556

R38 is changed to R: fxd met flm 237 kilohms 1% 1/8 W -hp- Part No. 0698-3266.
R39 is changed to R: fxd met flm 60.4 kilohms 1% 1/8 W -hp- Part No. 0698-3572.

A100 CHASSIS

Fuse is changed to 2 amp slow-blow, -hp- Part No. 2100-0303.
A 50 Hz plate, -hp- Part No. 7120-4080, is also added around the fuse receptacle.

5-244. COOLER REPLACEMENT.

5-245. The most important caution to be observed in this repair is that certain areas should not be contaminated with finger prints: A55, A56, A57 assemblies, Cooler Assembly and flex cables, and assemblies inside the Relay Channel.

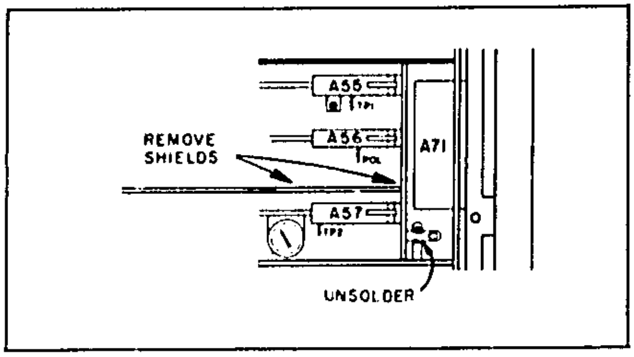


Figure 5-5. Cooler Replacement.

a. Remove A55, A56 and A57 (CLEAN HANDLING).

b. Remove the bottom cover, plastic insulator cover (CLEAN HANDLING), and bottom guard cover.

c. Remove the two shields to the left of the A71 Cooler. The shield between A56 and A57 is held by two screws on the bottom; the other shield is held by the solder lug.

d. Remove the right side vinyl cover.

e. Remove the side casting with eight screws on the side and one each on the top and bottom front corners. Do not remove the four screws in the cneter that appear to go into the Cooler. Note the gray cable that runs under the Cooler next to the side casting; it must be properly positioned during reassembly.

f. Pull loose the Peltier device (honeycomb) from the Cooler. Do not unsolder the red and black wires holding this. Do not remove the gray metal casting.

g. Remove the four screws (Part No. 2200-0169) holding the white Cooler block to the gray metal casting. Do not remove the four screws holding the Cooler together.

h. Open the upper Relay Channel lid at the center of the instrument with two screws.

i. Disconnect the yellow, green and black wires that go from the Cooler flex cable through the Relay Channel wall to pins inside (CLEAN HANDLING). Note the pin that each wire is connected to, and the way that the wires are laced into the Channel. Do not unsolder the wires from the flex cable.

j. Unplug the two flex cables to remove the Cooler (CLEAN HANDLING).

k. Reassemble the instrument with the rebuilt Cooler in the reverse order.

l. Accomplish the procedure in Paragraph 5-226 to see if A55R37 and R38 need to be changed.

PERFORMANCE CHECK TEST CARD

Hewlett-Packard Model 3450B
Multi-Function Meter

Test performed by ______________

Serial No. ______________

Date ______________

CHECK	LIMITS	READING
5-8. PRELIMINARY		
5-10. 100 mV Zero	± 10 counts	______
5-11. 1 V Zero	± 2 counts	______
10 V Zero	± 2 counts	______
100 V Zero	± 2 counts	______
1000 V Zero	± 2 counts	______
5-12. DC ACCURACY		
5-13.		
c-d. ± 1 V	± 10 counts	______
± 1.1 V (10 V rng)	± 3 counts	______
± 2 V	± 4 counts	______
± 3 V	± 4 counts	______
± 4 V	± 5 counts	______
± 5 V	± 6 counts	______
± 6 V	± 7 counts	______
± 7 V	± 8 counts	______
± 8 V	± 8 counts	______
± 9 V	± 9 counts	______
± 10 V	± 10 counts	______
± 100 V	± 10 counts	______
± 1000 V	± 10 counts	______
e. ± 100 mV	± 18 counts	______
f. .1 Scale Ratio	± 16 counts	______
g-j. ± 1.7 V Ratio	± 24 counts	______
± 1.9 V Ratio	± 23 counts	______
± 3.7 V Ratio	± 17 counts	______
± 3.9 V Ratio	± 17 counts	______
± 5.7 V Ratio	± 16 counts	______
± 5.9 V Ratio	± 15 counts	______
± 7.7 V Ratio	± 15 counts	______
± 7.9 V Ratio	± 15 counts	______
± 9.7 V Ratio	± 14 counts	______
± 10 V Ratio	± 14 counts	______
h. X1 Ratio	± 14 counts	______
X10 Ratio	± 5 counts	______
X100 Ratio	± 4 counts	______
X1000 Ratio	± 4 counts	______

PERFORMANCE CHECK TEST CARD (Cont'd)

CHECK	LIMITS	READING
5-14. OHMS ACCURACY		
5-15.		
a. 100 Ω Zero	± 10 counts	
1 kΩ Zero	± 2 counts	
10 kΩ Zero	± 2 counts	
100 kΩ Zero	± 2 counts	
1 MΩ Zero	± 2 counts	
10 MΩ Zero	± 2 counts	

b.	(Non-Ratio)		(Ratio)	
10 MΩ	± 102		± 206 counts	
1 MΩ	± 22		± 56 counts	
100 kΩ	± 12		± 26 counts	
10 kΩ(100 kΩ rng)	± 3		± 25 counts	
10 kΩ	± 12		± 16 counts	
1 kΩ	± 12		± 106 counts	
100 Ω	± 20		± 556 counts	

5-16. AC ACCURACY

CHECK	LIMITS	READING
5-18. LINEARITY		
a. Zero	± 2 counts	
b-c. 100 V	± 50 counts	
10 V (100 V rng)	± 14 counts	
10 V	± 50 counts	
1 V (10 V rng)	± 14 counts	
1 V	± 50 counts	
100 mV	± 14 counts	
10 mV	± 10 counts	
1 mV	± 10 counts	
d. 1000 V	± 2 counts	

CHECK	LIMITS	READING
5-19. FREQUENCY RESPONSE		
100 V, 50 Hz (1 kV rng)	± 52 counts	
100 V, 100 kHz (1 k V rng)	± 52 counts	
100 V, 100 kHz	± 150 counts	
100 V, 50 kHz	± 100 counts	
100 V, 500 Hz	± 50 counts	
100 V, 50 Hz	± 150 counts	
10 V, 50 Hz	± 150 counts	
10 V, 500 Hz	± 50 counts	
10 V, 50 kHz	± 100 counts	
10 V, 100 kHz	± 150 counts	
1 V, 100 kHz	± 150 counts	
1 V, 10 kHz	± 100 counts	
1 V, 50 kHz	± 100 counts	
1 V, 500 Hz	± 50 counts	
1 V, 45 Hz	± 150 counts	

PERFORMANCE CHECK TEST CARD (Cont'd)

CHECK	LIMITS	READING
5-20. RATIO		
X1	± 122 counts	
X10	± 72 counts	
X100	± 62 counts	
5-21. HIGH FREQUENCY		
e. 500 kHz	± 850 counts	
f. 1 MHz	± 2100 counts	
5-22. DYNAMIC RANGE.		
d-h. CF 7	± 1800 counts	
CF 6.59	± 2000 counts	
CF 7.49	± 1700 counts	
5-23. NORMAL MODE REJECTION	< 6 counts	
5-25. EFFECTIVE COMMON-MODE REJECTION	No readout change	
5-27. INPUT RESISTANCE		
10 MΩ ± 0.1 %	± 90 counts	
$>10^{10}\,\Omega$	< 10 counts change	
5-28. REMOTE CONTROL		
a. RC Program		
b. 1/60 Sec Gate Program		
c. Integration Delay Program		
d. Man/Ext Program		
Man Inhibit Program		
e. External Triggering		
f. Non-Ratio Range		
Ratio Range		
Function		
Decimal Point		
g. 10 MΩ DC Input Program		
5-30. DIGITAL OUTPUT		
Data		
Data Multiplier		
Function		
Polarity, LT		
Clock		
Print Command		
Print Holdoff		
5-32. LIMIT TEST		
+ HI		
+ GO		
+ LO		
- HI		
- GO		
- LO		

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 in addition to the Hewlett Packard part numbers, provides the following:

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

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

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

d. Manufacturer's part number.

6-4. ORDERING INFORMATION.

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

ABBREVIATIONS

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

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DESIGNATORS

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

Table 6-1. Replaceable Parts

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR	MFR PART NO
A2	03450 66532			**CHANNEL RELAY DRIVE ASSY**	hp	
C1	0180 0210		1	C fxd ta elect 3 3 microfarads 20 % 15 vdcw	56289	150D335X0015A2 DYS
C2	0180 1735		4	C fxd ta elect 0.22 microfarads 10 % 35 vdcw	56289	150D224X9035A2 DYS
C3	0180 0291		34	C fxd Ta elect 1 0 microfarads 10 % 35 vdcw	56289	150D105X9035A2 DYS
C4	0180 1735			C fxd ta elect 0 22 microfarads 10 % 35 vdcw	56289	150D224X9035A2 DYS
C5 thru C11	0180 0376		12	C fxd Ta elect 0.47 microfarads 10 %	56289	obd
C12, C13	0180 0291		2	C fxd Ta elect 1 0 microfarads 10 % 35 vdcw	56289	150D105X9035A2 DYS
C14	0180 0376			C fxd Ta elect 0 47 microfarads 10 % 35 vdcw	56289	150D474X9035A2 DYS
C15, C16	0180 0376			C fxd Ta elect 0.47 microfarads 10 % 35 vdcw	56289	150D474X9035A2 DYS
C17, C18	0180 2605		61	C fxd cer 0 02 microfarads + 80% - 20% 25 vdcw	72982	5835 Y5U203Z
C19	0180 0197			C fxd Ta elect 2 2 microfarads 10% 20 vdcw	56289	150D225X9020A2 DYS
CR1 thru CR7	1901-0040		160	Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR8 thru CR10	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
CR11 thru CR19	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR20	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
CR21	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR22 thru CR26	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
CR27 thru CR35	1901 0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
IC1	1820 0096		24	Integrated circuit. Expander gate	04713	SC6905PK
IC2	1820 0094		84	Integrated circuit: 2 input gate	04713	SC6903PK
IC3	1820 0310		31	Integrated circuit 3 input gate	04713	SC6910PK
IC4, IC5	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC6	1820 0310			Integrated circuit. 3 input gate	04713	SC6910PK
IC7, IC8	1820 0094			Integrated circuit. 2 input gate	04713	SC6903PK
IC9	1820 0096			Integrated circuit Expander gate	04713	SC6905PK
IC10				Not assigned		
IC11 thru IC20	1820 0096			Integrated circuit. Expander gate	04713	SC6905PK
R1	0683 1035		44	R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
A3	11099-66511			**REMOTE CONTROL ASSY**	hp	
C1, C2	0160-2605			C: fxd cer 0.02 microfarads +80% -20% 25 vdcw	72982	5335-V5U203Z
C3	0180-0197			C: fxd Ta elect 2.2 microfarads 10% 20 vdcw	56289	150D225X9020A2-DYS
CR1 thru CR4	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR5 thru CR27	1910-0016			Diode: Ge 60 piv 1 ms	14433	G718
CR28 thru CR31	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR32,	1910-0016			Diode: Ge 60 piv 1 ms	14433	G718
CR34 thru CR36	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR37 thru CR43	1910-0016			Diode: Ge 60 wiv 1 ms	14433	G718
IC1	1820-0107		26	Integrated circuit Buffer gate	-hp-	
IC2	1820-0310			Integrated circuit: 3 - input gate	04713	SC6910PK
IC3	1820 0107			Integrated circuit: Buffer gate	hp-	
IC4, IC5	1820-0094			Integrated circuit: 2-input gate	04713	SC6903PK
IC6	1820-0107			Integrated circuit: Buffer gate	hp-	
IC7	1820-0094			Integrated circuit: 2 - input gate	04713	SC6903PK
IC8	1820-0310			Integrated circuit 3 - input gate	04713	SC6910PK
IC9 thru IC11	1820 0094			Integrated circuit 2 - input gate	04713	SC6903PK
IC12	1820 0107			Integrated circuit. Buffer gate	hp-	
IC13, IC14	1820-0094			Integrated circuit 2 - input gate	04713	SP680A
IC15	1820 0107			Integrated circuit Buffer gate	hp-	
R1	0683-1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A4	03450 66534			**FUNCTION ASSY**	hp	
C1, C2	0150 0093		5	C fxd cer 0 01 microfarads +80 % 20 % 100 vdcw	91418	TA obd
C3	0160 0153		5	C fxd my 0 001 microfarads 10% 200 vdcw	56289	192P10292 PTS
C4	0160 0298		1	C fxd my 0 0015 microfarads 10 % 200 vdcw	56289	29215292 PTS
C5, C6	0180 1735		6	C fxd Ta elect 0 22 microfarads 10 % 35 vdcw	56289	150D224X9035A2 DYS
C7	0160 0301		1	C fxd my 0 012 microfarads 10% 200 vdcw	56289	192 2392 PTS
C8	0160 0154			C fxd my 0 0022 microfarads 10% 200 vdcw	56289	192P22292 PTS
C9	0150 0122			C fxd cer 2000 pF 20% 510 vdcw	15450	801 000 Y5S 202M
C10, C11	0160 0153			C fxd my 0 001 microfarads 10% 200 vdcw	56289	192P10292 PTS
C12	0180 0197			C fxd Ta elect 2 2 microfarads 10% 20 vdcw	56289	150D225X9020A2 DYS
C13	0180 1735			C fxd Ta elect 0 22 microfarads 10% 35 vdcw	56289	150D224X9035A2 DYS
C14	0180 0197			C fxd Ta elect 2 2 microfarads 10% 20 vdcw	56289	150D225X9020A2 DYS
C15	0160 0153			C fxd my 0 001 microfarads 10% 200 vdcw	56289	192P10292 PTS
CR1 thru CR19	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
IC1	1820 0086			Integrated circuit Expander gate	04713	SC6900PK
IC2 thru IC8	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC9, IC10	1820 0310			Integrated circuit 3 input gate	04713	SC6910PK
IC11 thru IC13	1820 0094			Integrated circuit 2 input gate	04713	SC6903 PK
IC14	1820 0349			Integrated circuit 2 input NAND gate	04713	SC6991PK
IC15, IC16	1820 0094			Integrated circuit Quad 2 input gate	04713	SC6903PK
Q1 thru Q14	1854 0071	75		TSTR Si NPN 2N3391	01295	SKA1124
R1, R2	0683 5625		21	R fxd comp 5600 ohms 5% 1/4 W	01121	CB5625
R3, R4	0683 4725		15	R fxd comp 4700 ohms 5% 1/4 W	01121	CB4725
R5, R6	0683 3925		6	R fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R7, R8	0683 4725			R fxd comp 4700 ohms 5% 1/4 W	01121	CB4725
R9, R10	0683 5625			R fxd comp 5600 ohms 5% 1/4 W	01121	CB5625
R11 thru R14	0683 4725			R fxd comp 4700 ohms 5% 1/4 W	01121	CB4725
R15 thru R17	0683 1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R18	0683 4725			R fxd comp 4700 ohms 5% 1/4 W	01121	CB4725
R19, R20	0683 2035		19	R fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R21	0683 1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R22	0683 4725			R fxd comp 4700 ohms 5% 1/4 W	01121	CB4725
R23, R24	0683 5625			R fxd comp 5600 ohms 5% 1/4 W	01121	CB5625
R25, R26	0683 2725		6	R fxd comp 2700 ohms 5% 1/4 W	01121	CB2725
R27	0683 1555		1	R fxd comp 1.5 megohms 5% 1/4 W	01121	CB1555
R28	0683 8225		18	R fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R29	0683 1235		21	R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R30	0683 1025		13	R fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R31, R32	0683 5625			R fxd comp 5600 ohms 5% 1/4 W	01121	CB5625
R33, R34	0683 4725			R fxd comp 4700 ohms 5% 1/4 W	01121	CB4725
R35	0683 8225			R fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R36	0683 1235			R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R37	0683 1525		4	R fxd comp 1.5 kilohm 5% 1/4 W	01121	CB1525
	0380 0474		3	Standoff teflon	hp	
	03450 07951		1	Radiator	hp	
A5	03450 66535			**CRYSTAL OSCILLATOR ASSY**	hp	
C1, C2	0160 2964		3	C fxd cer 0 01 microfarads +80% 20% 25 vdcw	15450	5835 000 Y5UC 103Z
C3	0160 2 [illegible]9		1	C fxd mica 30 pF 5% 300 vdcw	72136	RDM15E300J3C
C4	0160 2207		1	C fxd mica 300 pF 5% 300 vdcw	04062	RDM15F301J3C
C5	0160 0362		7	C fxd mica 510 pF 5% 300 vdcw	72136	RDM15F511J3C
C6	0160 0298		1	C fxd my 0.0015 microfarads 10% 200 vdcw	56289	192P15292 PTS
C7, C8	0160 2605			C fxd cer 0 02 microfarads +80% 20% 25 vdcw	72982	5835V5U203Z
C9, C10	0160 0362			C fxd mica 510 pF 5% 300 vdcw	72136	RDM15F511J3C
C11	0150 0093			C fxd cer 0.01 microfarads + 80 % 20 % 100 vdcw	91418	TA obd
C12	0160 3163		1	C fxd my 0.22 microfarads 2% 50 vdcw	13934	3X(3 224 5F)
C13	0160 3165		1	C fxd my 0 047 microfarads 2% 50 vdcw	13934	obd
C14, C15	0160 2605			C fxd cer 0.02 microfarads +80% 20% 25 vdcw	72982	5835V5U203Z
C16	0180 0197			C fxd Ta elect 2.2 microfarads 10% 20 vdcw	56289	150D225X9020A2 DYS
C17	0160-0356			C: fxd mica 18 pF 5%	72136	RDM15C180J3C
CR2, CR3	1910 0016			Diode. Ge 60 piv 1 ms	04433	G718

Model 3450B Section VI

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR PART NO.
A5 (Cont'd)						
CR4	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR5 thru CR9	1910 0016			Diode Ge 60 piv 1 ms	14433	G71P
CR10 thru CR12	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR13 thru CR16	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
IC1	1820 0055		3	Integrated circuit Decade counter	01295	SN4356
IC2	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC3	1820 0096			Integrated circuit Expander gate	04713	SC6905PK
IC4	1820-0258			Integrated circuit Toggle flip flop	04713	MC852P
IC5 thru IC7	1820 0095		18	Integrated circuit Toggle flip flop	04713	SC6904PK
IC8, IC9	1820 0094			Integrated circuit 2 - input gate	04713	SC6903PK
IC10	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC11	1820 0096			Integrated circuit Expander gate	04713	SC6905PK
L1, L2	9100 1641		2	Coil, molded choke 240 microhenries 5%	82142	15 1315 21J
Q1, Q2	1854 0345		2	TSTR Si NPN 2N5179	04713	obd
Q3	1854 0019		2	TSTR Si NPN	07263	S 6516
Q4, Q5	1854-0071			TSTR Si NPN 2N3391	01295	SKA1124
Q6	1854 0019			TSTR Si NPN	07263	S 6516
Q7 thru Q10	1854-0071			TSTR Si NPN 2N3391	01295	SKA1124
Q11	1853 0036		14	TSTR Si PNP 2N3906	04713	SPS 3612
Q12	1854-0009			TSTR Si NPN 2N709	18324	SS7376K
R1	0683 7525			R fxd comp 7.5 kilohms 5% 1/4 W	01121	CB7527
R2	0683 2725		1	R fxd comp 2.7 kilohms 5% 1/4 W	01121	CB2725
R3	0683 4715		2	R fxd comp 470 ohms 5% 1/4 W	01121	CB4715
R4	0683 2215		1	R fxd comp 220 ohms 5% 1/4 W	01121	CB2215
R5	0683 4735			R fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R6	0683 2035			R: fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R7	0757 0273			R fxd met flm 3.01 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R8	0757-0426		1	R fxd met flm 1300 ohms 1% 1/8 W	91637	MFF 1/8 T-0 obd
R9*	0698-3162		1	R fxd met flm 46.4 kilohms 1% 1/8 W	75042	CEA T-0 obd
R10, R11				Not assigned		
R12	0698-3264		1	R: fxd met flm 11.8 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R13	0698 4452		1	R: fxd met flm 374 ohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R14	0698-4308		1	R: fxd met flm 16.9 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R15	0757-0278		1	R fxd met flm 1780 ohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R16	0683 6225		1	R fxd comp 6200 ohms 5% 1/4 W	01121	CB6225
R17	0683-2025		7	R: fxd comp 2000 ohms 5% 1/4 W	01121	CB2025
R18	0683-8225			R: fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R19	0683 1015		4	R: fxd comp 100 ohms 5% 1/4 W	01121	CB1015
R20	0683 1035			R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R21	0757-0449		4	R: fxd met flm 20 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R22, R23	0684 3931		1	R: fxd comp 39 kilohms 1% 1/4 W	01121	CB 3931
R24 thru R26	0683-2035			R: fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R27	0757-0476		1	R: fxd met flm 301 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R28	0698-4991		1	R: fxd met flm 1.27 megohms 1% 1/2 W	91637	MFF 1/2 T-1 obd
R29	0683 1025			R: fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R30	0698 3558			R fxd met flm 4.02 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R31	0698-3382		1	R: fxd met flm 5490 ohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R32	0698 1195		1	R: fxd met flm 1020 ohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R33	0683-2035			R: fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R34	0683-8225			R: fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R35	0757-0280		12	R: fxd met flm 1000 ohms 1% 1/8 W	75041	CEA T-0 obd
R37	0683-1025			R: fxd 1 kilohm 5% 1/4 W	01121	CB1025
	0360 0124		38	Terminal: solder stud	-hp-	
	0410 0185			Crystal: quartz 6.0 MHz	-hp-	obd
				Crystal 5.0 MHz for H50 special instrument	-hp-	
A6	03450-66536			**MASTER TIMING ASSY**	-hp-	
C1	0150-0122			C: fxd cer 2000 pF 20% 500 vdcw	15450	801-000-Y5S-202M
C2	0150-0093			C fxd cer 0.01 microfarads + 80 % - 20 % 100 vdcw	91418	TA obd
C3	0140-0149		1	C: fxd mica 470 pF 5%	72136	RDM15F471J3S

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR	MFR PART NO.
A6 (Cont'd)						
C4	0180 0376			C fxd Ta elect 0 47 microfarads 10 % 35 vdcw	56289	150D474X9035A2 DYS
C5, C6	0150 0069		6	C fxd cer 0 001 microfarads 20% 500 vdcw	hp	
C7	0160 0297		7	C fxd my 0 0012 microfarads 10 % 200 vdcw	56289	292P12292 PTS
C8	0150 0122			C fxd cer 2000 pF 20 % 500 vdcw	15450	801 000 Y5S 202M
C9, C10	0160 0362			C fxd mica 510 pF 5 % 300 vdcw	72136	RDM15F511J3C
C11 thru C14	0160 2605			C fxd cer 0 02 microfarads +80% 20% 25 vdcw	72982	5835V5U203Z
C15	0180 0197			C fxd Ta elect 2 2 microfarads 10% 20 vdcw	56289	150D225X9020A2 DYS
C16	0160 0162			C fxd 0 022 microfarads 10 % 200 vdcw	56289	192P22392PTS
C19	0160 2605			C fxd 0 02 microfarads + 80 % 20 % 25 vdcw	72982	5835Y5U203Z
CR1 thru CR9	1910-0016			Diode. Ge 60 piv 1 ms	14433	G718
IC1	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC2	1820 0310			Integrated circuit 3 input gate	04713	SC6910PK
IC3, IC4	1820 0096			Integrated circuit Expander gate	18324	MC832P
IC5	1820 0095			Integrated circuit Toggle flip flop	04713	SC6901PK
IC6	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC7 thru IC9	1820 0095			Integrated circuit Toggle flip flop	04713	SC6903PK
IC10	1820 0087			Integrated circuit flip flop	04713	SC6904PK
IC11 thru IC15	1820 0094			Integrated circuit. 2 input gate	04713	SC6903PK
IC16	1820 0302			Integrated circuit 3 input gate	18324	SP670A
IC17, IC18	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC19	1820 0310			Integrated circuit triple 3 input NAND gate	04713	SC6910PK
IC20	1820 0094			Integrated circuit 2 input gate	04713	SC6904PK
IC21	1820 0310			Integrated circuit triple 3 input NAND gate	04713	SC6910PK
IC22	1820 0107			Integrated circuit. Buffer gate	hp	
R1	0683 8225			R fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R2	0683 1235			R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R3 thru R4	0683 1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R6	0683 8225			R fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R7	0683 1235			R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R8, R9	0683 3925			R fxd comp 3900 ohms 5 % 1/4 W	01121	CB3925
R5				Not assigned		
A7	03450 66537			**SAMPLE PERIOD ASSY**	hp	
C1	0180 0106		1	C fxd Ta elect 60 microfarads 20 % 6 vdcw	56289	150D606X0006B2 DYS
C2	0150 0069			C fxd cer 1000 pF 20 +100 % 500 vdcw	72982	801 019X5G0192Z
C3	0180 0291			C fxd ta 1 0 microfarads 10 % 35 vdcw	56289	150D105X9035A2 DYS
C4	0180 0228		1	C fxd Ta 22 microfarads 10 % 15 vdcw	56289	150D226X9015B2 DYS
C5	0180 0022		1	C fxd Ta elect 3 9 microfarads 10% 35 vdcw	56289	150D395X9035B2
C6	0160 2605			C fxd cer 0 02 microfarads + 80 % 20 % 25 vdcw	72982	5835V5U203Z
C7	0150 0093			C fxd cer 0.01 microfarads + 80 % 20 % 100 vdcw	91418	TA
C8	0180 0197			C fxd Ta elect 2 2 microfarads 10% 20 vdcw	56289	150D225X9020A2 DYS
C9	0180 0374		1	C fxd Ta elect 10 microfarads 10% 20 vdcw	56289	150D106X9020B2 DYS
C10	0180 0376			C fxd Ta elect 0 47 microfarads 10% 35 vdcw	56289	150D474X9035A2 DYS
C11	0160 2605			C fxd cer 0 02 microfarads +80% 20% 25 vdcw	72982	5835V5U203Z
C12	0180 0197			C fxd Ta elect 2 2 microfarads 10% 20 vdcw	56289	150D225X9020A2 DYS
C13	0180 2050		3	C fxd Ta elect 0 082 microfarads 10% 35 vdcw	56289	150D823X9035A2 DYS
C14	0160 2605			C fxd cer 0 02 microfarads +80% 20% 25 vdcw	72982	5835V5U203Z
C15	0150 0122			C fxd cer 2000 pF 20 % 500 vdcw	15450	801 000 Y5S 202M
C16	0180 0291			C fxd ta 1.0 microfarads 10 % 35 vdcw	56289	150D105X9035A2 DYS
C19	0160 3134			C fxd 01 microfarad 10% 100 wvdc	hp	
C17	0160 2605			C fxd cer 0.02 microfarads + 80 % 20 % 25 vdcw	72982	5835000Y5U2035
C18	0150 0122			C fxd cer 2000 pF 20% 500 vdcw	15450	801 000 Y5S 202M
C21	0150 0093			C fxd cer 0.01 microfarads 20 % + 80 % 100 vdcw	91418	TA
C20, C22, C23	0160 2605			C fxd cer 0 02 microfarads + 80 % 20 % 25 vdcw	72982	5835V5U203Z
C24	0180 0197			C fxd ta elect 2.2 microfarads 10 % 20 vdcw	56289	150D225X902A2 DYS
CR1 thru CR3	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR4, CR5	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
CR6	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR7, CR8	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
CR9	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR10 thru CR18	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
CR20, CR21	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
IC1	1820 0095			Integrated circuit Conditional flip flop	04713	SC6904PK
IC2, IC3	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC4	1820 0310			Integrated circuit 3 input gate	04713	SC6910PK
IC5	1820 0087			Integrated circuit flip flop	04713	SC6901PK
IC6	1820 0207		1	Integrated circuit one shot	07263	SL12895

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR	MFR PART NO
A7 (Cont'd)						
IC7	1820 0310			Integrated circuit 3 input gate	04713	SC6910PK
IC8 thru IC14	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
Q1	1853 0036			TSTR Si PNP 2N3906	04713	SPS 3612
Q2 thru Q4	1854 0071			TSTR Si NPN 2N3391	01295	SKA1124
Q5	1853 0036			TSTR Si PNP 2N3906	04713	SPS 3612
Q6	1854 0071			TSTR Si NPN 2N3391	01295	SKA1124
Q7	1854 0087		9	TSTR Si NPN 2N3417	24446	4JX16N2989
Q8 thru Q11	1854 0071			TSTR Si NPN 2N3391	01295	SKA1124
Q12	1854 0087			TSTR Si NPN	24446	4JX16N2989
R1	0757 0277		1	R fxd met flm 49.9 ohms 1% 1/8 W	75042	CEA T 0 bd
R2	0683 1025			R fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R3	0683 2035			R fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R4	0683 8225			R fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R5	0683 1235			R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R6	0683 8225			R fxd comp 8200 ohms 5% 1/4 W	01121	CB822[illegible]
R7	0683 1235			R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R8, R9	0683 2035			R fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R10	0683 1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R11	0683 2035			R fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R12	0683 5115		4	R fxd comp 510 ohms 5% 1/4 W	01121	CB5115
R13	0687 3035		1	R 30 kilohms 5% 1/4 W	01121	CB3035
R14	0683 1535		2	R fxd comp 15 kilohms 5% 1/4 W	01121	CB1535
R15*	0757 0468			R fxd flm 130 kilohms 1% 1/8 W	14674	C4 obd
	0698 3451			R fxd flm 133 kilohms 1% 1/8 W	14674	C4 obd
	0698 4518			R fxd flm 137 kilohms 1% 1/8 W	14674	C4 obd
	0698 4519			R fxd flm 140 kilohms 1% 1/8 W	14674	C4 obd
	0698 4520			R fxd flm 143 kilohms 1% 1/8 W	91637	CMF 1/10 31
R16	0683 2725			R fxd comp 2700 ohms 5% 1/4 W	01121	CB2725
R17	0683 2025			R fxd comp 2000 ohms 5% 1/4 W	01121	CB2025
R18, R19	0683 2035			R fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R20	0683 4725			R fxd comp 4700 ohms 5% 1/4 W	01121	CB4725
R21	0683 3925			R fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R22	0683 2035			R fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R23	0683 1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R24	0683 1025			R fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R25	0683 2035			R fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R26	0683 1025			R fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R27	0683 8225			R fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R28, R29	0683 1235			R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R30	0683 1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R31	0757 0407			R fxd comp 200 ohms 1% 1/8 W	24546	C4 1 8 TO 201 F
R32	0683 1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R33	0683 1025			R fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R34	0683 8225			R fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R35	0683 1235			R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R36	0683 1525			R fxd comp 1500 ohms 5% 1/4 W (See Q12)	01121	CB1525
R37	0683 1215			R fxd flm 120 ohms 5% 1/4 W	01121	CB1215 0 32 1 1
R38	0683 9115		4	R fxd comp 910 ohms 5% 1/4 W	01121	CB9115
A8	03450 66538			**PRIMARY RANGE ASSY**	hp	
C1, C4	0160 0154			C fxd my 0.0022 microfarads 10% 200 vdcw	56289	192P22292 PTS
C5	0160 0158			C fxd der 0.0056 microfarads 10% 200 vdcw	56289	292P56292 PTS
C6, C7	0180 2050			C fxd Ta elect 0.082 microfarads 10% 35 vdcw	56289	150D823X9035A2 DYS
C8 thru C10	0160 2605			C fxd cer 0.02 microfarads +80% 20% 25 vdcw	72982	5833V5U203Z
C11	0180 0197			C fxd Ta elect 2.2 microfarads 10% 20 vdcw	56289	150D225X9020A2 DYS
C12	0140 0190			C fxd Ta elect 39 pF 300 vdcw	72136	DM15E390J0300WV1CR
C13 thru C16	0150 0069			C fxd .001 microfarad 500 vdcw	hp	
CR1 thru CR4	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
CR5, CR6				Not assigned		
CR7 thru CR11	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
CR12	1901 0040			Diode Si .05 A 30 V	hp	
CR13	1901 0016			Diode Ge 60 piv 1 ms	14433	G718
CR14, CR15	1901 0040			Diode Si .05 A 30 V	hp	
IC1	1820 0310			Integrated circuit 3 input gate	04713	SC6910PK
IC2, IC3	1820 0087			Integrated circuit flip flop	04713	SC6901PK
IC4	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC5	1820 0087			Integrated circuit flip flop	04713	SC6901PK
IC6	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC7	1820 0310			Integrated circuit 3 input gate	04713	SC6910PK
IC8	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK

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

REFERENCE DESIGNATOR	-hp- PART NO		TQ	DESCRIPTION	MFR	MFR PART NO
A8 (Cont'd)						
IC9	1820 0310			Integrated circuit 3 input gate	04713	SC6910PK
IC10	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC11, IC12	1820 0310			Integrated circuit 3 input gate	04713	SC6910PK
IC13, IC14	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC15, IC16	1820 0310			Integrated circuit 3 input gate	04713	SC6910PK
IC17, IC18	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC19 thru IC21	1820 0310			Integrated circuit 3 input gate	04713	SC6910PK
IC22	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
R1	0683 8225			R fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R2	0683 1235			R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R3, R4				Not assigned		
R5	0683 2735			R fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R6	0683 8225			R fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R7	0683 1235			R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R8	0683 1815		1	R fxd comp 180 ohms		
R9, R10	0684 1031			R fxd comp 10 kilohms 10% 1/4 W	01121	CB1031
R11, R12	0684 2211			R fxd comp 220 ohms 10% 1/4 W	01121	CB2211
A9	03450 66539			**RATIO MULTIPLIER RANGE ASSY**	hp	
C1	0160 0162		3	C fxd my 0.022 microfarads 10% 200 vdcw	56289	292P22392 PTS
C2	0160 0154			C fxd my 0.0022 microfarads 10% 200 vdcw	56289	192P22292 PTS
C3	0180 1743		1	C fxd Ta elect 0.1 microfarads 10% 35 vdcw	56289	150D104X9035A2 DYS
C4	0160 0195			C fxd cer 1000 pF 20% 250 vdcw	56289	19C251A1 CDH
C5	0150 0093			C fxd cer 0.01 microfarads +80% -20% 100 vdcw	91418	TA obd
C6	0160 0297			C fxd my 0.0012 microfarads 10% 200 vdcw	56289	292I2292 PTS
C7	0180 1743			C fxd ta 0.1 microfarads 10% 35 vdcw	56289	150D104X9035A2 DYS
C8	0160 0297			C fxd my 0.0012 microfarads 10% 200 vdcw	56289	192P22292 PTS
C9, C10	0160 2605			C fxd cer 0.02 microfarads +80% -20% 25 vdcw	72982	5835V5U2032
C11	0180 0197			C fxd Ta elect 2.2 microfarads 10% 20 vdcw	56289	150D225X9020A2 DYS
CR1 thru CR4	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
CR5	1901 0040			Diode Si 30 piv 3 mA 2 ns 2 pF	07263	FDG1088
CR6 thru CR16	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
IC1 thru IC8	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC9	1820 0096			Integrated circuit Expander gate	04713	SC6905PK
IC10	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC11	1820 0086			Integrated circuit Expander gate	04713	SC6900PK
IC12	1820 0116		9	Integrated circuit Storage unit	hp	
IC13	1820 0086			Integrated circuit Expander gate	04713	SC6900PK
IC14	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC15	1820 0087			Integrated circuit flip flop	04713	SC6901PK
IC16	1820 0095			Integrated circuit Toggle flip flop	04713	SC6904PK
IC17	1820 0310			Integrated circuit 3 input gate	04713	SC6910PK
IC18, IC19	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC20	1820 0310			Integrated circuit 3 input gate	04713	SC6910PK
IC21, IC22	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
R1	0683 8225			R fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R2	0683 1235			R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R3	0683 1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R4	0683 4725			R fxd comp 4700 ohms 5% 1/4 W	01121	CB4725
A10	03450 66540			**DATA COUNTER ASSY**	hp	
C1	0160 2605			C fxd cer 0.02 microfarads +80% -20% 25 vdcw	72982	5835V5U2032
C2	0140 0176			C fxd mica 100 pF 2% 300 vdcw	72136	RDM15F101G3C
C3, C4	0160 2605			C fxd cer 0.02 microfarads +80% -20% 25 vdcw	72982	5835V5U2032

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR	MFR PART NO
A10 (Cont'd)						
C5				Not assigned		
C6	0180 0197			C fxd Ta elect 2 2 microfarads 10% 20 vdcw	56289	150D225X9020A2 DYS
IC1 thru IC3	1820 0119		4	Integrated circuit Decade counter	hp	
IC4 IC5	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC6	1820 0055			Integrated circuit Decade counter	01295	SN4356
IC7	1820 0094			Integrated circuit 2 input	04713	SC6903PK
IC8	1820 0116			Integrated circuit Storage unit	hp	
IC9	1820 0119			Integrated circuit Decade counter	hp	
IC10	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
R1	0683 8225			R fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R2	0683 1235			R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R3	0683 5115			R fxd comp 510 ohms 5% 1/4 W	01121	CB5115
R4	0683 2025			R fxd comp 2000 ohms 5% 1/4 W	01121	CB2025
R5	0683 1525			R fxd comp 1 5 kilohm 5% 1/4 W	01121	CB1525
	1251 2172		1	Connector P C 64 pin contacts (2 x 32)	07955	0289 64 0 2 003
A11	03450 69517			**FRONT PANEL SWITCH SUBASSY**		
DS1 thru DS12	1450 0356		12	Lamp Indicator	hp	
DS13	2140 0024			Lamp Neon RATE	hp	
Q1 thru Q12	1854 0071		12	TSTR Si NPN 2N3391	01295	SKA1124
R1	2100 2701		1	R var lin C comp 50 kilohms 10% 1/5 W	71450	U 70
R2 thru R5	0683 5625			R fxd comp 5600 ohms 5% 1/4 W	01121	CB5625
R6	0683 8225			R fxd comp 8 2 kilohms 5% 1/4 W	01121	CB8225
R7 thru R13	0683 5625			R fxd comp 5600 ohms 5% 1/4 W	01121	CB5625
R14	0683 4735			R fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
S13	3101 0849			Switch Toggle LINE	hp	
	1251 1931		2	Connector P C 15 contacts	09133	00 8129 015 603 003
	1251 2194		24	Connector Single contact lead spring socket	00779	3 331272 0
	0370 0125			Knob	hp	
	5040 0234			Lampholder	hp	
	0370 0767		12	Pushbutton	hp	
	0370 0768		12 .	Pushbutton lens	hp	
	5000 7129		12	Spring contacts	hp	
	0370 0125		12	Knob	hp	
	5040 0234		12	Lampholder	hp	
	0370 0974		12	Pushbutton	hp	
	0370 0768		5	Pushbutton lens	hp	
	5000 7129		5	Spring contacts	hp	
	0370 0975		1	Cap Left end	hp	
	0370 0976			Cap Right end	hp	
	03450 00254			Panel Switching	hp	
	03450 27304			Cable Flex	hp	
	03450 01209			Cable Support	hp	
A12	03450 69518			**FRONT PANEL STORAGE SUBASSY**	hp	
C1	0160 2605			C fxd cer 0 02 microfarads +80% 20% 25 vdcw	72982	5835V5U203Z
C2, C3	0180 1735			C fxd Ta elect 0 22 microfarads 10% 35 vdcw	56289	150D224X9035A2 DYS
C4 thru C6	0160 2605			C fxd cer 0 02 microfarads +80% 20% 25 vdcw	72982	5835V5U203Z
C7	0180 0197			C fxd Ta elect 2 2 microfarads 10% 20 vdcw	56289	5835V5U203Z
C8, C9	0160 2605			C fxd cer 0 02 microfarads +80% 20% 25 vdcw	72982	5835V5U203Z
CR1 thru CR6	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
CR7	1902 3345			Diode breakdown 51 1 V 5% 400 mW	04713	SZ10939 386
IC1, IC2	1820 0086			Integrated circuit Expander gate	04713	SC6900PK
IC3	1820 0310			Integrated circuit 3 input gate	04713	SC6910PK
IC4 thru IC6	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC7	1820 0310			Integrated circuit 3 input gate	04713	SC6910PK
IC8	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
Q1	1854 0358		19	TSTR Si NPN 2N4410	01295	SKA1124
R1 thru R3	0683 3015			R fxd comp 300 ohms 5% 1/4 W	01121	CB3015
R4	0683 1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R5, R6	0683 2235			R fxd comp 22 kilohms 5% 1/4 W	01121	CB2235
R7	0684 1221			R fxd comp 1200 ohms 10% 1/4 W	01121	CB1221
R8, R9	0683 3015			R fxd comp 300 ohms 5% 1/4 W	01121	CB3015
R10	0683 1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R11, R12	0683 3015			R fxd comp 300 ohms 5% 1/4 W	01121	CB3015
R13	0683 1515		1	R fxd comp 150 ohms 5% 1/4 W	01121	CB1515
R14	0683 2035			R fxd comp 20 kilohms 5% 1/4 W	01121	CB2035

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A12 (Cont'd)						
					hp	
					hp	
	1251 1931			Connector P C 15 contacts	09133	00 8129 015 603 003
	0360 0124			Terminal Solder stud	hp	
A13	03450 66573			**DATA DISPLAY ASSY**	hp	
C1 thru C3	0 12605			C fxd cer 0.02 microfarads +80 20 25 vdcw	72982	5835V5U2037
C4	0 0197			C fxd Ta elect 2 2 microfarads 10 20 vdcw	56289	150D225X9020A2 DYS
CR1 thru CR8	0015			Diode Ge 60 piv 1 ms	14433	G718
CR9	1902 3175		3	Diode breakdown 100 V 5 1 W	04713	SZ 11213 428
CR10 thru CR12	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
CR13	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR14, CR15	1902 3175			Diode breakdown 100 V 5 1 W	04713	SZ11213 428
CR16	1901 0025			Diode Si 100 mA at 1 V NOTE Nixie tubes not included under A13 Part No	07263	FD2387
DS1	1970 0037		1	Nixie tube (for Std instrument)	83594	B 5447
	1970 0038		1	Nixie tube AC (if Ohms and or AC is installed)	83594	B 5449
DS2 thru DS7	1970 0018		6	Tube electron	83594	B 5441
DS8	1970 0032		1	Tube special purpose	83594	B 5448
IC1 thru IC5	1820 0707		5	Integrated circuit Digital Decoder	01295	SN74141N
IC6 thru IC11	1820 0116			Integrated circuit Storage unit	hp	
IC12	1820 0095			Integrated circuit Toggle flip flop	04713	SC6904PK
IC13	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
Q1 thru Q12	1854 0358			TSTR: Si NPN 2N4410	01295	SKA1124
Q13	1854 0234			TSTR Si NPN 2N3440	86684	2N3440
Q14 thru Q19	1854 0358			TSTR Si NPN 2N4410	01295	SKA1124
R1	0683 3325		5	R fxd comp 3300 ohms 5 1 4 W	01121	CB3325
R2 thru R11	0683 1035			R fxd comp 10 kilohms 5 1 4 W	01121	CB1035
R12	0698 7604		3	R fxd comp 30 kilohms 5% 1W	14674	C32 obd
R13	0683 1035			R fxd comp 10 kilohms 5 1 4 W	01121	CB1035
R14	0683 2225		2	R fxd comp 2200 ohms 5 1 4 W	01121	CB2225
R15 thru R20	0686 2035		6	R fxd comp 20 kilohms 5 1 2 W	01121	EB2035
R21	0686 4335		1	R fxd comp 43 kilohms 5% 1 2 W	01121	EB4335
R22	0683 6825		1	R fxd comp 6800 ohms 5 1 4 W	01121	CB6825
R23	0683 1645			R fxd comp 160 kilohms 5 1 4 W	01121	CB1645
R24	0698 7604			R fxd comp 30 kilohms 5 1 W	14674	C32 obd
R25, R26	0683 1235			R fxd comp 12 kilohms 5 1 4 W	01121	CB1645
R27 thru R31	0683 1035			R fxd comp 10 kilohms 5 1 4 W	01121	CB1245
R32	0683 1245			R fxd comp 120 kΩ 5 1 4 W		
R33	0683 3935			R fxd comp 39 kΩ 5 1 4 W		
R34	0684 3921			R fxd flm comp 3 9 kilohms 10 1 4 W	01121	CB 3921
	1205 0205			Heat sink on Q13 on REV A	13103	1116A 5 obd
	1205 0033			Heat sink on Q13 on REV B	13103	obd
	1200 0766			Socket	hp	
	0380 0119			Standoff under A13	76854	2295 408
A14	03450 66514			**4.4 V OUTGUARD POWER SUPPLY ASSY**	hp	
C1	0180 0061		1	C fxd Al elect 100 microfarads +75 10 15 vdcw	56289	30D107G015DC2 DSM
C2	0180 0294		1	C fxd Ta elect 390 microfarads 20 10 vdcw	56289	109D397X0010T2
C3	0180 1942		1	C fxd Al elect 150 microfarads +75 10 15 vdcw	56289	30D157G015DD2 DSM
C4	0180 0309		3	C fxd Ta elect 4 7 microfarads 20 10 vdcw	56289	150D475X0010A2 DYS
CR1	1902 3114		1	Diode breakdown 6 19 V 2	04713	SZ10939 123
CR2	1902 3062		2	Diode breakdown 3 92 V 5 400 mW	04713	SZ10939 65
CR3, CR4	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
CR5	1902 3086		2	Diode breakdown 4 75 V		
CR6	1884 0066		1	Thyristor Si controlled	04713	SCR682
Q1 thru Q3	1854 0071			TSTR Si NPN 2N3391	01295	SKA1124
Q4 thru Q7	1853 0020		10	TSTR Si PNP	01295	SKA1123
Q8	1850 0062		1	TSTR Ge PNP	hp	6JX1K66
Q9	1854 0071			TSTR Si NPN 2N3391	01295	SKA1124

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR	MFR. PART NO	
A14 (Cont'd)							
R1	0683 2725			R fxd comp 2700 ohms 5% 1/4 W	01121	CB2725	
R2	0683 1835		1	R fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R3	0683 3915		3	R fxd comp 390 ohms 5% 1/4 W	01121	CB3915	
R4	0683 1235			R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R5, R6	0683 0365			R fxd comp 3 6 ohms 5% 1/4 W	01121	CB36G5	
R7	0683 2225			R fxd comp 2200 ohms 5% 1/4 W	01121	CB2225	
R8*	0698 3496		2	R fxd met flm 3570 ohms 1% 1/8 W	75042	CEAT 0	obd
R9	0698 3155		1	R fxd met flm 4640 ohms 1% 1/8 W	91637	MFF 1/8 T 1	obd
R10	0698 4825		1	R fxd met flm 64 9 ohms 1% 1/2 W	91637	MFF 1/2 T 1	obd
R11	0683 3915			R fxd comp 390 ohms 5% 1/4 W	01121	CB3915	
R12	0698 3445			R fxd met flm 348 ohms 1% 1/8 W	91637	MFF 1/8 T 1	obd
R13	0757-0419		1	R: 681 ohms 1% 1/8 W			
R14	0811 2616		1	R fxd prec ww 0 12 ohms 3% 3 W	91637	RS2B 95	
R15	0698 4421		1	R fxd met flm 249 ohms 1% 1/8 W	75042	CEA T 0	obd
R16*	0698 3496		2	R fxd met flm 3570 ohms 1% 1/8 W	75042	CEAT 0	
R17	0683 8225			R fxd comp 8200 ohms 5% 1/4 W	01121	CB8225	
R18	0683 1525			R fxd comp 1500 ohms 5% 1/4 W	01121	CB1525	
R19	0757 0433		5	R fxd met flm 3320 ohms 1% 1/4 W	91637	MFF 1/8 T 1	obd
R20	0757 0273		3	R fxd met flm 3010 ohms 1% 1/8 W	91637	MFF 1/8 T 1	obd
R21	0757 0429		3	R fxd met flm 1820 ohms 1% 1/8 W	91637	MFF 1/8 T 1	obd
R22	2100 1773		1	R var ww lin 1000 ohms 10% 1/2 W	75042	Type 500	
R23	0757 0273			R fxd met flm 3010 ohms 1% 1/8 W	91637	MFF 1/8 T 1	obd
R24	0683 1015			R fxd comp 100 ohms 5% 1/4 W	01121	CB1015	
A15	03450 66515			**OUTGUARD RECTIFIER ASSY**	hp		
CR1 thru CR4	1901 0045		8	Diode Si 100 piv	04713	SR1358 7	
CR5, CR6	1901 0030		2	Diode Si 800 piv	04713	SR1358 (11)	
Q1	1854 0300		1	TSTR Si NPN 2N4921	01295	SKA1124	
R1	0683 1015			R fxd comp 100 ohms 5% 1/4 W	01121	CB1015	
	03450 01259		1	Bracket diode	hp		
A17	03450 66517			**OUTGUARD PULSE TRANSFORMER DRIVE SUBASSY**	hp		
CR1, CR2	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088	
Q1 thru Q3	1854 0071			TSTR Si NPN 2N3391	01295	SKA1124	
R1	0757 0435		2	R fxd met flm 3920 ohms 1% 1/8 W	91637	MFF 1/8 T 1	obd
R2	0757 0280			R fxd met flm 1000 ohms 1% 1/8 W	75042	CEA T 0	obd
R3	0757 0435			R fxd met flm 3920 ohms 1% 1/8 W	91637	MFF 1/8 T 1	obd
R4	0757 0280			R fxd met flm 1000 ohms 1% 1/8 W	75042	CEA T 0	obd
R5	0757 0409		1	R fxd met flm 274 ohms 1% 1/8 W	75042	CEA T 0	obd
R6	0698 4123		4	R fxd met flm 499 ohms 1% 1/8 W	91637	MFF 1/8 T 1	obd
R7	0757 0407		1	R fxd met flm 200 ohms 1% 1/8 W	75042	CEA T 0	obd
R8	0698 4123			R fxd met flm 499 ohms 1% 1/8 W	91637	MFF 1/8 T 1	obd
R9	0757 0280			R fxd met flm 1000 ohms 1% 1/8 W	75042	CEA T 0	obd
	1251 2176		11	Connector test point	000LW	3394 2 03	

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

REFERENCE DESIGNATOR	-hp- PART NO		TQ	DESCRIPTION	MFR	MFR PART NO
A19	03450-66519			**HI/GO/LO DISPLAY ASSY**	hp	
DS1 thru DS3	1450-0356			Lamp: indicator	hp	
	03450-24501			Decal Plastic reflector	hp	03450-24501
A24	11079-66501			**LIMIT-TEST ASSY**	hp	
C1, C2	0160-0362			C: fxd mica 510 pF 5% 300 vdcw	72136	RDM15F511J3C
C3	0160-2605			C: fxd cer 0.02 microfarads +80 -20% 25 vdcw	72982	5835-V5U2032
C4	0180-0197			C: fxd Ta elect 2.2 microfarads 10% 20 vdcw	56289	150D225X9020A2-DYS
C5, C6	0160-2605			C: fxd cer 0.02 microfarads +80% -20% 25 vdcw	72982	5835-V5U2032
C7	0180-0197			C: fxd Ta elect 2.2 microfarads 10% 20 vdcw	56289	150D225X9020A2-DYS
CR1 thru CR48	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
IC1 thru IC5	1820-0107			Integrated circuit: Buffer gate	hp	
IC6	1820-0318			Integrated circuit: Expander gate	18324	SP616A
IC7	1820-0303			Integrated circuit: 2 input gate	18324	SP680A
IC8 thru IC12	1820-0107			Integrated circuit: Buffer gate	hp	
IC13	1820-0302			Integrated circuit: 3 input gate	18324	SP670A
IC14	1820-0116			Integrated circuit: Storage unit	hp	
J79B	1251-2302		1	Connector: rack and panel 50 contact	02660	57-40500-375
Q1 thru Q3	1854-0071			TSTR: Si NPN 2N3391	01295	SKA1124
A25	11080-66502			**DIGITAL OUTPUT ASSY**		
C1 thru C7	0160-2605			C: fxd cer 0.02 microfarads +80% -20% 25 vdcw	72982	5835-V5U2032
C8	0180-0197			C: fxd Ta elect 2.2 microfarads 10% 20 vdcw	56289	150D225X9020A2-DYS
CR1	1910-0016			Diode: Ge 60 piv 1 ms	14433	G718
CR2	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR3 thru CR7	1910-0016			Diode: Ge 60 piv 1 ms	14433	G718
IC1	1820-0094			Integrated circuit: 2 input gate	04713	SC6903PK
IC2	1820-0310			Integrated circuit: 3 input gate	04713	SC6910PK
IC3	1820-0094			Integrated circuit: 2 input gate	04713	SC6903PK
IC4	1820-0116			Integrated circuit: Storage unit	hp	
IC5, IC6	1820-0107			Integrated circuit: Buffer gate	hp	
IC7	1820-0116			Integrated circuit: Storage unit	hp	
IC8 thru IC10	1820-0107			Integrated circuit: Buffer gate	hp	
IC11	1820-0094			Integrated circuit: 2 input gate	04713	SC6903PK
IC12 thru IC14	1820-0107			Integrated circuit: Buffer gate	hp	
Q1 thru Q3	1854-0071			TSTR: Si NPN 2N3391	01295	SKA1124
R1, R2	0683-2035			R: fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R3	0683-8225			R: fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R4	0683-1235			R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R5	0683-2035			R: fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R6	0683-5625			R: fxd comp 5600 ohms 5% 1/4 W	01121	CB5625
R7	0683-3025		3	R: fxd comp 3000 ohms 5% 1/4 W	01121	CB3025
R8	0757-0273			R: fxd met flm 3010 ohms 1% 1/8 W	91637	MFF-1/8-T-1 obd
R9	0698-3496			R: fxd met flm 3570 ohms 1% 1/8 W	91637	MFF-1/8-T-1 obd
R10	0683-3015			R: fxd comp 300 ohms 5% 1/4 W	01121	CB3015
R11	0757-0449			R: fxd met flm 20 kilohms 1% 1/8 W	91637	MFF-1/8-T-1 obd
R12	0698-4481			R: fxd met flm 16.5 kilohms 1% 1/8 W	91637	MFF-1/8-T-1 obd
R13	0757-0433			R: fxd met flm 3320 ohms 1% 1/8 W	91637	MFF-1/8-T-1 obd
R14	0683-2035			R: fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R15	0683-1235			R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
S1 thru S3	3101-1341		3	Switch: slide SPDT	79727	7254
J808	1251-0087		1	Connector: rack and panel 50 contact	71785	57-40500-375

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR	MFR PART NO
A50	03450 60401			**PULSE TRANSFORMER ASSY**	hp	
A17	03450 66517			Outguard Pulse Transformer Drive Subassembly	hp	
A66	03450 66566			Inguard Pulse Transformer Drive Subassembly	hp	
T1	9100 1455			Transformer Pulse (on 03450 26518 board)	hp	
	9100 1497			Transformer Pulse (on 03450 26528 board)	hp	
T2, T3	9100 1454			Transformer Pulse	hp	
A52	03450 66552			**INGUARD RECTIFIER ASSY**	hp	
C1, C2	0160 0127		2	C fxd cer 1 0 microfarads 20% 25 vdcw	56289	obd
C3	0180 2187		1	C fxd Al elect 2500 microfarads +75% -10% 15 vdcw	56289	39D258G015GP4 DSB
C4 thru C7	0180 1819		7	C fxd Al elect 100 microfarads +75% -10% 50 vdcw	56289	30D107G050DH2 DSM
C8, C9	0121 0105			C: var 9 35 pF		
CR1, CR2	1901 0200		2	Diode. Si 100 piv	04713	obd
CR3 thru CR6	1901 0045			Diode. Si 100 piv	04713	SR1358-7
A53	03450 66553			**5 V INGUARD POWER SUPPLY ASSY**	hp	
C1	0150 0093		12	C fxd cer 0.01 microfarads +80% -20% 100 vdcw	91418	TA
C2	0180 1941		2	C fxd Al elect 130 microfarads +75% -10% 15 vdcw	56289	30D137G015DC2 DSM
C3	0180 0197			C: fxd Ta elect 2.2 microfarads 10% 20 vdcw	56289	150D225X9020A2 DYS
C4	0180 0309		1	C fxd Ta elect 4 7 microfarads 20% 10 vdcw	56289	obd
C5	0150 0093			C: fxd cer 0.01 microfarads +80% 20% 100 vdcw	91418	TA
C6	0180 1941			C fxd Al elect 130 microfarads +75% 10% 15 vdcw	56289	30D137G015DC2 DSM
C7	0180 0197			C: fxd Ta elect 2.2 microfarads 10% 20 vdcw	56289	150D225X9020A2 DYS
C8, C9	0180 0149		2	C: fxd Al elect 65 microfarads +100% -10% 60 vdcw	56289	30D36978 DSM
C10, C11	0150 0093			C fxd cer 0.01 microfarads +80% 20% 100 vdcw	91418	TA
C12	0180 0050		1	C fxd Al elect 40 microfarads +75% 10% 50 vdcw	56289	30D406G050DD2 DSM
CR1	1901 0025		1	Diode Si 100 wiv 12 pF 100 mA	93332	D3072
CR2	1902 0041			Diode breakdown 5.11 V 5% 400 mW	04713	SZ10939 98
CR3	1884 0069		1	Thyristor Si controlled	04713	SCR683
CR4 thru CR7	1901 0158		4	Diode Si 200 piv 0.75 mA	04713	obd
CR8	1902 3302		1	Diode breakdown 34 8 V 2% 400 mW	04713	SZ10939 339
CR9, CR10	1901 0040			Diode. Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR	MFR PART NO
A53 (Cont'd)						
Q1, Q2	1854 0071			TSTR Si NPN 2N3391	01295	SKA1124
Q3, Q4	1854 0087			TSTR Si NPN 2N3417	24446	4JX16N2989
Q5 thru Q8	1853 0020			TSTR Si PNP	01295	SKA1123
Q9	1853 0064		1	TSTR Si PNP 2N4918	26992	obd
Q10	1853 0036			TSTR Si PNP 2N3906	04713	SPS 3612
Q11	03450 69511		3	TSTR Si NPN (Q11 & R24 matched set)	hp	
R1	0686 3915		1	R fxd comp 390 ohms 5% 1/2 W	01121	EB3915
R2	0683 1545		5	R fxd comp 150 kilohms 5% 1/4 W	01121	CB1545
R3	0683 2235 ●			R fxd comp 22 kilohms 5% 1/4 W	01121	CB2235
R4	0683 6215		2	R fxd comp 620 ohms 5% 1/4 W	01121	CB6215
R5	0683 9125		2	R fxd comp 9100 ohms 5% 1/4 W	01121	CB9125
R6	0813 0029		2	R fxd ww 1 ohm 3% 3 W	91637	RS2B 95
R7	0683 1525			R fxd comp 1500 ohms 5% 1/4 W	01121	CB1525
R8	0698 4473		2	R fxd met flm 8060 ohms 1% 1/8 W	19701	MF5C T O obd
R9	0757 0449			R fxd met flm 20 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R10	0757 0283		8	R fxd met flm 2000 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R11	0757 0439		3	R fxd met flm 6810 ohms 1% 1/8 W	19701	MF5C T O obd
R12	0683 1015			R fxd comp 100 ohms 5% 1/4 W	01121	CB1015
R13	0683 1545			R fxd comp 150 kilohms 5% 1/4 W	01121	CB1545
R14				Not assigned		
R15	0683 6215			R fxd comp 620 ohms 5% 1/4 W	01121	CB6215
R16	0683 9125			R fxd comp 9100 ohms 5% 1/4 W	01121	CB9125
R17	0813 0029			R fxd ww 1 ohm 3% 3 W	91637	RS2B 95
R18	0683 1525			R fxd comp 1500 ohms 5% 1/4 W	01121	CB1525
R19	0698 4473			R fxd met flm 8060 ohms 1% 1/8 W	19701	MF5C T O obd
R20	0757 0442			R fxd met flm 10 kilohms 1% 1/8 W	75042	CEA T O obd
R21	0757 0283			R fxd met flm 2000 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R22	0757 0439			R fxd met flm 6810 ohms 1% 1/8 W	19701	MF5C T O obd
R23	0683 1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R24	03450 69511		1	R fxd met flm 1% 1/8 W (R24 & Q11 matched set)	hp	
	1205 0224			Heat sink	98978	PAZ 1CB
A54	03450 66554			**17 V INGUARD POWER SUPPLY ASSY**	hp	
C1	0150 0122			C fxd cer 2000 pF 20% 500 vdcw	75450	801 000 Y5S 202M
C2	0160 0938		1	C fxd mica 1000 pF 5%	72136	RDM15E102J1C
C3	0180 1819			C fxd Al elect 100 microfarads +75% -10% 50 vdcw	56289	30D107G050DH2 DSM
C4	0150 0093			C fxd cer 0.01 microfarads +80% -20% 100 vdcw	91418	TA
C5	0180 1819			C fxd Al elect 100 microfarads +75% -10% 50 vdcw	56289	30D107G050DH2 DSM
C6	0140 0176			C fxd mica 100 pF 2% 300 vdcw	56289	RDM15F101G3C
C7	0180 1819			C fxd Al elect 100 microfarads +75% -10% 50 vdcw	56289	30D107G050DH2 DSM
C8	0180 0100		1	C fxd Ta elect 4.7 microfarads 10% 35 vdcw	56289	150D475X9035B2 DYS
CR1 thru CR3	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR4	1902 0761		6	Diode T C reference 1N821	04713	obd
CR5	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
CR6	1902 0761			Diode T C reference 1N821	04713	obd
CR7	1902 3062			Diode breakdown 3.92 V 5% 400 mW	04713	SZ10939 65
CR8, CR9	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
Q1, Q2	1854-0071			TSTR: Si NPN 2N3391	01295	SKA1124
Q3	1854-0087			TSTR: Si NPN 2N3417	01002	4JX16N2989
Q4	1853-0012			TSTR: Si PNP 2N2904A	01295	2N2904A
Q5	1854 0475		13	TSTR Si NPN dual	32293	ITS 1068
Q6	1854 0071			TSTR Si NPN 2N3391	01295	SKA1124
Q7	1854 0087			TSTR Si NPN	24446	4JX16N2989
Q8 thru Q11	1853 0036			TSTR Si PNP 2N3906	04713	SPS 3612
Q12	1854 0475			TSTR Si NPN dual	32293	ITS 1068
Q13	1854 0087			TSTR Si NPN	24446	4JX16N2989
Q14	1853 0036			TSTR Si PNP 2N3906	04713	SPS 3612
Q15, Q16	1854 0090			TSTR Si NPN	04713	SM8158
R1	0757 0288		2	R fxd met flm 9090 ohms 1% 1/8 W	75042	CEA T O obd
R2, R3	0683 6205		2	R fxd comp 62 ohms 5% 1/4 W	01121	CB6205
R4	0683 1825		1	R fxd comp 1800 ohms 5% 1/4 W	01121	CB1825

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A54 (Cont'd)						
R5	0757-0442		3	R: fxd met flm 10 kilohms 1% 1/8 W	75042	CEA T-0 obd
R6	0698-4479		2	R: fxd met flm 14 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R7	0757-0288			R: fxd met flm 9090 ohms 1% 1/8 W	75042	CEA T-0 obd
R8, R9	0683-3325			R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R10	0683-1545			R: fxd comp 150 kilohms 5% 1/4 W	01121	CB1545
R11	0683-3935			R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R12	0683-5615		3	R: fxd comp 560 ohms 5% 1/4 W	01121	CB5615
R13	0683-3035			R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035
R14	0698-6254			R: fxd comp 1.8 ohms 5% 1/4 W	01121	EB6254
R15	2100-1772		2	R: var lin ww 500 ohms 10% 1/2 W	75042	Type 500
R16	0683-3025			R: fxd comp 3000 ohms 5% 1/4 W	01121	CB3025
R17	0698-4488		2	R: fxd met flm 26.7 kilohms 10% 1/8 W	91637	MFF 1/8 T-1 obd
R18	0698-3279		2	R: fxd met flm 4990 ohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R19	0698-4432			R: fxd flm 2.1 kilohms 1% 1/8 W	14674	C4 T-0 obd
R20	0698-4438			R: fxd flm 3.09 kilohms 1%	91637	CMF 1/10-32 T-1
R21	0683-1545			R: fxd comp 150 kilohms 5% 1/4 W	01121	CB1545
R22	0683-3935			R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R23	0683-5615			R: fxd comp 560 ohms 5% 1/4 W	01121	CB5615
R24	0683-3035			R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035
R25	0698-6254			R: fxd comp 1.8 ohms 5% 1/2 W	01121	ED6254
R26	2100-1772			R: var lin ww 500 ohms 10% 1/2 W	75042	Type 500
R27	0683-3025			R: fxd comp 3000 ohms 5% 1/4 W	01121	CB3025
R28	0698-4488			R: fxd met flm 26.7 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R29	0698-3279			R: fxd met flm 4990 ohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R30	0698-4432			R: fxd flm 2.1 kilohms 1% 1/8 W	14674	C4 T-0 obd
R31	0698-4433			R: fxd flm 3.09 kilohms 1%	91637	CMF 1/10-32 T-1
R32	0683-2035			R: fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R33	0698-3152			R: fxd met flm 3.48 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R34	0683-1545			R: fxd comp 150 kilohms 5% 1/4 W	01121	CB1545
R35	0683-5635		2	R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R36	0683-5615			R: fxd comp 560 ohms 5% 1/4 W	01121	CB5615
R37	0683-1235			R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R38	0683-3005		3	R: fxd comp 30 ohms 5% 1/4 W	01121	CB3005
R39	0757-0442			R: fxd met flm 10 kilohms 1% 1/8 W	75042	CEA T-0 obd
R40	0757-0437			R: fxd met flm 4750 ohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R41	0757-0123		1	R: fxd met flm 34.8 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R42	0698-4479			R: fxd met flm 14 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
	1205-0011			Heat Dissipator	98978	TXBF 032 025B
A55	03450-66555			**DC INPUT AMP ASSY**	-hp-	
C1	0170-0040			C: fxd my 0.047 microfarads 10% 200 vdcw	56289	192P47392-PTS
C2	0160-0128		1	C: fxd cer 2.2 microfarads 20% 25 vdcw	56289	5C15[illegible]
C3	0140-0198		1	C: fxd mica 200 pF 5% 300 vdcw	72136	RDM15F201J3C
C4	0150-0121			C: fxd cer 0.1 microfarads +80% -20% 50 vdcw	15450	obd
C5	0170-0040			C: fxd my 0.047 microfarads 10% 200 vdcw	56289	192P47392-PTS
C6	0180-0031		2	C: fxd Ta elect 50 microfarads +20% -15% 10 vdcw	56289	109D266-DYP
C7, C8	0140-0145		2	C: fxd mica 22 pF 5%	72136	RDM15C220J5C
CR1 thru CR4	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR5	1902-0049		1	Diode: breakdown 6.19 V 5% 400 mW	04713	SZ10939-122
CR6 thru CR9	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR10, CR11	1302-3208		2	Diode: breakdown 15.4 V 5% 400 mW	04713	SZ10939-236
CR12	1902-0761			Diode: T.C. reference 1N821	04713	obd
Q1	1854-0475			TSTR: Si NPN dual	32293	ITS 1068
Q2, Q3	1854-0215		23	TSTR: Si NPN 2N3904	04713	SPS-3611
Q4, Q5	1853-0235		3	TSTR: Si PNP	12007	obd
Q6	1854-0071			TSTR: Si NPN 2N3391	01295	SKA1124
Q7	1854-0215			TSTR: Si NPN 2N3904	04713	SPS-3611
Q8	1853-0236			TSTR: Si PNP		
Q9, Q10	1854-0087			TSTR: Si NPN 2N3417	24446	4JX16N2987
Q11	1853-0036			TSTR: Si PNP 2N3906	04713	SPS-3612
Q12	1854-0475			TSTR: Si NPN dual	32293	ITS 1068
Q13, Q14	1854-0071			TSTR: Si NPN 2N3391	01295	SKA1124

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR	MFR. PART NO
A55 (Cont'd)						
R1, R2	0757 04[illegible]2			R fxd met flm 75 kilohms 1% 1/8 W	75042	CEA T0 obd
R3	0757 0410		2	R fxd met flm 301 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R4, R5	0757 0458		5	R fxd met flm 51 1 kilohms 1% 1/8 W	75042	CEA T0 obd
R6	0757 0280			R fxd met flm 1000 ohms 1% 1/8 W	75042	CEA T0 obd
R7	0698 44[illegible]		1	R fxd met flm 35 7 kilohms 1% 1/8 W	75042	CEA T0 obd
R8, R9	0757 0465		6	R fxd met flm 100 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R10	0698 3179		1	R fxd met flm 2550 ohms 1% 1/8 W	75042	CEA T0 obd
R11	0757 0465	●		R fxd met flm 100 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R12*	0727 0299		2	R fxd C flm 4 90 megohms 1% 1/2 W	91637	OCS1/2
↓	0727 0312		2	R fxd C flm 9 megohms 1% 1/2 W	91637	MCS1/2
	0730-0146			R. fxd 15.7 megohms 1% 1W	91637	DC-1
R14	2100 2646		2	R var lin 100 ohms 20% 3/4 W	73138	78PR100
R15	0683 1535			R. fxd comp 15 kilohms 5% 1/4 W	01121	CB1535
R16	0757 0446			R fxd met flm 15 kilohms 1% 1/8 W	75042	CEA T0 obd
R17, R18	0757 0388		2	R fxd met flm 30 1 ohms 1% 1/8 W	75042	CEA T0 obd
R19	2100 2669		1	R var lin 10 ohms 20% 3/4 W	73138	78PR10
R20	0698 4438			R fxd met flm 5090 ohms 1% 1/8 W	75042	CEA T0 obd
R21	0698 4496		2	R fxd met flm 45 3 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R22 thru R24	0757 0453		3	R: fxd met flm 30 1 kilohms 1% 1/8 W	75042	CEA T0 obd
R25	0698 3457		1	R fxd met flm 316 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R26	0757 0280			R fxd met flm 1000 ohms 1% 1/8 W	75042	CEA T0 obd
R27	0811 0920		1	R fxd ww 1200 ohms 3% 3 W	91637	RS28 95
R28	0811-1335		1	R fxd prec ww 11 kilohms 3% 3 W	hp-	
R29	0698 4518		1	R. fxd met flm 137 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R30	0757 0439			R fxd met flm 6810 ohms 1% 1/8 W	19701	MF5C T0 obd
R31	0811-2607		1	R: fxd prec ww 71 8 kilohms 0.025% 1/20 W	07088	KP.10
R32	0811 2608		1	R fxd prec ww 1310 ohms 0 25% 1/10 W	07088	KP.10
R33	2100 1485			R var ww 20 kilohms 5% 3/4 W	12697	76JA3CM32591
R34	0698 4509		1	R. fxd met flm 80.6 kilohms 1% 1/8 W	75042	CEA T0 obd
R35, R36	0811 2581		1	Resistor set: matched ww 1486 ohms 0 01%, 2662 ohms 0 01%	hp-	
R37*	0811-1597		1	R fxd prec ww 100 ohms 0 25% 1/20 W	07088	KP123
│	0811-1598		1	R fxd prec ww 200 ohms 0.25% 1/20 W	54294	obd
│	0811 1599		1	R fxd prec ww 300 ohms 0.25% 1/20 W	15909	R1776
│	0811 1600		1	R fxd prec ww 400 ohms 0 25% 1/20 W	15909	R1776
│	0811 1601		1	R fxd prec ww 500 ohms 0.25% 1/20 W	15909	R1776
│	0811-1602		1	R fxd prec ww 600 ohms 0 25% 1/20 W	15909	R1776
│	0811 1603		1	R: fxd prec ww 700 ohms 0 25% 1/20 W	15909	R1776
│	0811 1604		1	R: fxd prec ww 800 ohms 0.25% 1/20 W	15909	R1776
↓	0811 1605		1	R fxd prec ww 900 ohms 0 25% 1/20 W	15909	R1776
R38*	0698-3106		1	R: fxd 5 ohms 1% 1/8 W	91637	DC 1/8
│	0757 0489		1	R: fxd met flm 10 ohms 1% 1/4 W	75042	CEA T0 obd
│	0757 0493		1	R. fxd met flm 15 ohms 1% 1/4 W	91637	MFF 1/4 T-1 obd
│	0757 0496		1	R fxd met flm 20 ohms 1% 1/4 W	91637	MFF 1/4 T-1 obd
│	0757 1025		1	R fxd met flm 25 ohms 1% 1/4 W	91637	MFF 1/4 T 1 obd
│	0757 0500		1	R fxd met flm 30.1 ohms 1% 1/4 W	91637	MFF 1/4 T 1 obd
│	0757 1026		1	R fxd met flm 35 ohms 1% 1/4 W	19701	MF6C T0 obd
│	0757-1038		1	R. fxd met flm 40 ohms 1% 1/4 W	19701	MF6C T0 obd
│	0757-1039		1	R. fxd met flm 45 ohms 1% 1/4 W	91637	MFF 1/4 T 1 obd
│	0757-1040		1	R. fxd met flm 50 ohms 1% 1/4 W	91637	MFF 1/4 T 1 obd
│	0757-1041		1	R fxd met flm 55 ohms 1% 1/4 W	91637	MFF 1/4 T-1 obd
│	0757 1042		1	R fxd met flm 60 ohms 1% 1/4 W	91637	MFF 1/4 T-1 obd
│	0757 1043		1	R fxd met flm 65 ohms 1% 1/4 W	91637	MFF 1/4 T 1 obd
│	0757-1044		1	R. fxd met flm 70 ohms 1% 1/4 W	19701	MF6C T0 obd
│	0757 0710		1	R: fxd met flm 75 ohms 1% 1/4 W	91637	MFF 1/4 T 1 obd
│	0757 1045		1	R: fxd met flm 80 ohms 1% 1/4 W	19701	MF6C T0 obd
│	0757 1046		1	R: fxd met flm 85 ohms 1% 1/4 W	19701	MF6C T0 obd
│	0757 1047		1	R: fxd met flm 90 ohms 1% 1/4 W	19701	MF6C T0 obd
↓	0757 1048		1	R: fxd met flm 95 ohms 1% 1/4 W	19701	MF6C T0 obd
A56	03450 66586			**POLARITY AMP ASSY**	hp-	
C1	0160 3183		2	C fxd my 0 47 microfarads 20% 50 vdcw	84411	HEW-101
C2	0160 0157		4	C fxd my 0 0047 microfarads 10% 200 vdcw	56289	192P47292 PTS
C3	0160 0157			C fxd my 0 0047 microfarads 10% 200 vdcw	56289	192P47292 PTS
C4	0160 3183		1	C fxd my 0 47 microfarads 20% 50 vdcw	84411	HEW-101
C5	0160 0157			C fxd my 0 0047 microfarads 10% 200 vdcw	56289	192P47292 PTS

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A56 (Cont'd)						
C6	0160-0300			C: fxd my 0.0027 microfarads 10% 200 vdcw	56289	192P27292 PTS
C7	0140-0147		1	C: fxd mica 180pF 5%	72136	RDM15F181J5S
CR1	1902-0761			Diode: T.C. reference 1N821	04713	obd
CR2 thru CR6	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR7	1902-0761			Diode: T.C. reference 1N821	04713	obd
CR8 thru CR12	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
K25 thru K28	0490-0366		5	Switch: reed magnetic	-hp-	
	0490-0776		5	Coil: reed relay	-hp-	
Q1	1854-0475			TSTR: Si NPN dual	32293	ITS 1068
Q2, Q3	1854-0215			TSTR:SI NPN 2N3904	04713	SPS 3611
Q4, Q5	1853-0235			TSTR: Si PNP	04713	SPS-3612
Q6, Q7	1854-0071			TSTR: SI NPN 2N3391	-HP-	SKA1124
U8	1854-0475			TSTR: Si NPN dual	32293	ITS 1068
Q9, Q.0	1854-0215			TSTR:SI NPN 2N3904	04713	SPS 3611
Q11, Q12	1853-0236			TSTR: Si PNP	04713	SPS-3612
Q13, Q14	1854-0071			TSTR: SI NPN 2N3391	-HP-	SPS-3611
Q15 thru Q17	1854-0071			TSTR: Si NPN 2N3391	01295	SKA1124
R1, R2	0811-2585			R: fxd set matched ww 80 kilohms .5%	07088	Type KP-110
R3	0757-0416		3	R: fxd met flm 511 ohms 1% 1/8 W	75042	CEA T-0 obd
R4, R5	0698-3228		9	R: fxd met flm 49.9 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R6	0757-0429			R: fxd met flm 1820 ohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R7	0698-3484		2	R: fxd met flm 6650 ohms 1% 1/8 W	75042	CEA T-0 obd
R8, R9	0698-3228			R: fxd met flm 49.9 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R10, R11	0683-4705		2	R: fxd comp 47ohms 5% 1/4 W	01121	CB4705
R12	0698-4126		1	R: fxd met flm 953 ohms 1% 1/8 W	75042	CEA T-0 obd
R13	0698-4511			R: fxd met flm 86.6 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R14	2100-1481		2	R: var ww 50 ohms 5% 3/4 W	12697	76JA3 CM32465
R15	0683-3325			R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R16	0698-3540		3	R: fxd met flm 15.4 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R17	0698-3228			R: fxd met flm 49.9 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R18	0698-7802		1	R: fxd met flm 523kilohms 1% 1/8 W	19701	MF5C T-0 obd
R19	0698-4531		1	R: fxd met flm 267 kilohms 1% 1/8 W	91637	CMF-1/10-32 T-1 obd
R20	0757-0468		4	R: fxd met flm 130 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R21, R22	0611-2585			R: fxd set matched ww 80 kilohms .5%	07088	Type KP-110
R23	0757-0416			R: fxd met flm 511 ohms 1% 1/8 W	75042	CEA T-0 obd
R24, R25	0698-3228			R: fxd met flm 49.9 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R26	0757-0429			R: fxd met flm 1820 ohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R27	0757-0444		1	R: fxd met flm 12.1 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R28, R29	0698-3228			R: fxd met flm 49.9 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R30, R31	0683-7505		3	R: fxd comp 75 ohms 5% 1/4 W	01121	CB7505
R32	0757-0420		1	R: fxd met flm 750 ohms 1% 1/8 W	75042	CEA T-0 obd
R33	0698-4511			R: fxd met flm 86.6 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R34	2100-1481			R: var ww 50 ohms 5% 3/4 W	12697	76JA3 CM32465
R35	0683-3325			R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R36	0698-3540			R: fxd met flm 15.4 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R37	0698-7803		1	R: FXD MET FLM 576 KILOHMS 1% 1/8W	30983	MF5C-1/8-TO-5763-F
R38	0757-0270		2	R: fxd met flm 249 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R39	0698-3228			R: fxd met flm 49.9 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
	0340-0037		6	Post: terminal-turret	00866	HP-3000M ?
	0340-0060		9	Insulator: feed-thru teflon	98291	FT-E-15
	0360-0124			Terminal: solder stud	-hp-	
	0360-0479		3	Terminal: solder stud	00779	61038-1LP
	0340-0039		1	Bushing: Terminal insulator	00866	HP-3000T-1
	03450-61612			Wires: gray & orange	-hp-	
A57	03450-66557			**INTEGRATOR ASSY**	-hp-	
C1	0160-3237			C: fxd cer 0.1 microfarad 20% 50 vdcw	15450	8523006Z5U104M
C2	0160-0157			C: fxd my 0.0047 microfarads 10% 200 vdcw	56289	192P47292-PTS

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A57 (Cont'd)						
C3, C4	0150-0093			C: fxd cer 0.01 microfarads +80% -20% 100 vdcw	91418	TA
C5	0160-4025		1	C: fxd teflon 0.33 microfarads 10% 100 VDCW	-HP-	obd
C6	0160-0932		1	C: fxd mica 1000 pF 5%	72136	obd
C7	0160-0154			C: fxd my 0.0022 microfarads 10% 200 vdcw	56289	192P22292 PTS
C8	0150-0022		2	C: fxd cer 3.3 pF 10% 500 vdcw	78488	Type GA
C9	0160-2018		2	C: fxd mica 250 pF 5% 500 vdcw	72136	RDM15F251J5S
C10	0160-0154			C: fxd my 0.0022 microfarads 10% 200 vdcw	56289	192P22292 PTS
C11	0150-0022			C: fxd cer 3.3 pF 10% 500 vdcw	78488	Type GA
C12	0180-0376			C: fxd [illegible] 0.47 microfarads 10% 35 vdcw	56289	1500474X9035A2 DYS
C13 thru C17	0150-0093			C: fxd cer 0.01 microfarads +80% -20% 100 vdcw	91418	TA
CR1	1902-0761			Diode: T.C. reference 1N821	04713	obd
CR2 thru CR4	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR5	1910-0016			Diode: Ge 60 piv 1 ms	14433	G718
CR6 thru CR19	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
IC1 thru IC4	1826-0078		4	INTEGRATED CIRCUIT: LINEAR OPERATIONAL AMPLIFIER	86684	CA3030
K29	0490-0366		3	Switch: reed magnetic	hp	
	0490-0776			Coil: reed relay	hp	
Q1, Q2	1854-0094		2	TSTR: Si NPN 2N3646	07263	obd
Q3, Q4	1855-0093		2	TSTR: field effect N Channel	83740	F1748
Q5	03450-87901		1	TSTR: dual field effect N Channel		
Q6, Q7	1854-0475			TSTR: Si NPN dual	05397	BD 1148
Q8	1854-0071			TSTR: Si NPN 2N3391	01295	SKA1124
Q9	1853-0235		2	TSTR: Si PNP	12007	obd
Q10	1854-0022		1	TSTR: Si NPN	01295	SG1294
Q11	1853-0235			TSTR: Si PNP	12007	obd
Q12, Q13	1855-0100		3	TSTR: field effect N Channel	15818	U 1867E
R1, R2	0683-5115			R: fxd comp 510 ohms 5% 1/4 W	01121	CB5115
R3, R4	0683-1025			R: fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R5, R6	0698-3451		2	R: fxd met flm 133 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R7	0683-2025			R: fxd comp 2000 ohms 5% 1/4 W	01121	CB2025
R8	0757-0283			R: fxd met flm 2000 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R9, R10	0757-0465			R: fxd met flm 100 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R11	0698-3484		1	R: fxd met flm 6650 ohms 1% 1/8 W	75042	CEA T 0 obd
R12	2100-2646			R: var lin 100 ohms 20% 3/4 W	73138	78PR100
R13	0757-0433			R: fxd met flm 3320 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R14	0698-3540			R: fxd met flm 15.4 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R15	0698-4496			R: fxd met flm 45.3 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R16	0698-3242		1	R: fxd met flm 357 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R17, R18	0683-3005			R: fxd comp 30 ohms 5% 1/4 W	01121	CB3005
R19	0757-0410			R: fxd met flm 301 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R20	0757-0416			R: fxd met flm 511 ohms 1% 1/8 W	75042	CEA T 0 obd
R21*	0698-4123		1	R: fxd met flm 499 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
	0698-4455		1	R: fxd met flm 536 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
	0698-4457		1	R: fxd met flm 576 ohms 1% 1/8 W	01295	obd
	0757-0418		1	R: fxd met flm 619 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
	0698-3511		1	R: fxd met flm 665 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
	0698-3700		1	R: fxd met flm 715 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
	0757-0420		1	R: fxd met flm 750 ohms 1% 1/8 W	01295	obd
	0698-4014		1	R: fxd met flm 787 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
	0757-0421		1	R: fxd met flm 825 ohms 1% 1/8 W	01295	obd
	0698-3495		1	R: fxd met flm 866 ohms 1% 1/8 W	75042	CEA T 0 obd
	0757-0422		1	R: fxd met flm 909 ohms 1% 1/8 W	01295	obd
	0698-4125		1	R: fxd met flm 953 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
	0698-4195		1	R: fxd met flm 1.02 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
	0698-4467		1	R: fxd met flm 1.05 kilohms 1% 1/8 W	75042	CEA T 0 obd
	0757-0424		1	R: fxd met flm 1.10 kilohms 1% 1/8 W	01295	obd
	0698-4469		1	R: fxd met flm 1.15 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
	0698-3512		1	R: fxd met flm 1.18 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R22	2100-1761		1	R: var ww lin 10 kilohms 10% 1/2 W	75042	Type 506
R23, R24	0698-3215			R: fxd met flm 499 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R25	0757-0281			R: fxd met flm 2740 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R26	0698-4486		1	R: fxd met flm 24.9 kilohms 1% 1/8 W	75042	CEA T 0 obd
R27	0757-0283			R: fxd met flm 2000 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R28	0757-0430		1	R: fxd met flm 2210 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R29	0757-0449			R: fxd met flm 20 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R30	0757-0283			R: fxd met flm 2000 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R31	0757-0465			R: fxd met flm 100 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R32	0757-0280			R: fxd met flm 1000 ohms 1% 1/8 W	75042	CEA T 0 obd
R33*						

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR	MFR PART NO
A57 (Cont'd)						
R34	0757 0283			R fxd met flm 2000 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R35	0683 2025			R fxd comp 2000 ohms 5% 1/4 W	01121	CB2025
	0340 0060			Insulator feed thru teflon	98291	FT E 15
	0360 0124			Terminal solder stud	hp	
	0360 0479			Terminal solder stud	00779	61038 1LP
	0360 1512		14	Terminal teflon stand off	98291	ST 1000SL 1L
	03450 61611			Wire gray	hp	
				OHMS CONVERTER ASSY REPLACEMENT		
A58, A59, A72	11077 60001			Ohms Converter Assy (New)	hp	
A58, A59, A72	11077 69501			Ohms Converter Assy (Rebuilt Exchange)	hp	
A58	11077 66558			**OHMS RANGE ASSY** (P/O OHMS CONV)	hp	
CR1 thru CR3	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
K32	{0490 0801			Switch reed magnetic	hp	
	{0490 0798			Coil reed relay	hp	
K33, K34	{0490 0801			Switch reed magnetic	hp	
	{0490 0776			Coil reed relay	hp	
R1	0811 2622		1	R fxd prec ww 9861 ohms 0.01% 1/4 W	hp	
R2	0757 0284		1	R fxd met flm 150 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R3	0757 0317		1	R fxd met flm 1330 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R4	2100 2775		1	R var lin 2000 ohms 20% 3/4 W	73138	78LR2K
R5	0811 2624		1	R fxd prec ww 989.5 kilohms 0.01% 1/4 W	hp	
R6	2100 2322		1	R var lin 1000 ohms 20% 3/4 W	73138	78LR1K
R7, R8	0811 2623			Resistor set matched 4.496 megohms 0.01%	hp	
R9	2100 2774			R var lin 100 kilohms 20% 3/4 W	73138	obd
	0340 0008		11	Insulator stand off teflon	98291	ST 1000 P60
	0340 0060			Insulator feed thru teflon	98291	FT E 15
	0360 1512			Terminal teflon stand off	98291	ST 1000 SL 1L
A59	11077 66502			**OHMS REFERENCE ASSY** (P/O OHMS CONV)	hp	
C1	0180 0228			C fxd Ta elect 22 microfarads 10% 15 vdcw	56289	150D226X9015B2 DYS
C2	0180 0309			C fxd Ta elect 4.7 microfarads 20% 10 vdcw	56289	150D475X0010A2 DYS
C3, C4	0180 0032		2	C fxd Al elect 10 microfarads +75% -10% 12 vdcw	56289	30D106G012BA2 DSM
C5	0180 0081			C fxd Ta elect 50 microfarads +20% -15% 10 vdcw	56289	109D266 DYP
CR1 thru CR4	1901 0025			Diode Si 100 wiv 12 pF 100 mA	93332	D3072
CR5	1902 3150		1	Diode breakdown 9.09 V 2% 400 mW	04713	SZ10939 171
CR6, CR7	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
CR8	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR9	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
IC1	1820 0096			Integrated circuit Expander gate	04713	SC6905PK
IC2	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC3, IC4	1820 0096			Integrated circuit Expander gate	04713	SC6905PK
K30, K31	{0490 0802		2	Switch reed magnetic	hp	
	{0490 0798			Coil reed relay	hp	
K35	{0490 080[illegible]			Switch reed magnetic	hp	
	{0490 0799			Coil reed relay	hp	
L1	9140 0031		1	Coil fxd RF 75 microhenries 10%	99848	1075 15 750
Q1	1855 0100			TSTR field effect N Channel	15818	U 1867E
Q2, Q3	1853 0093		2	TSTR Si PNP	hp	

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR	MFR. PART NO
A59 (Cont'd)						
R1	0683 1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R2	0683 2715			R fxd comp 270 ohms 5% 1/4 W		
R3	0683 2025			R fxd comp 2000 ohms 5% 1/4 W	01121	CB2025
T1	9100 1447		1	Transformer	hp	
T2	9100 1441		1	Transformer	hp	
V1	1970 0050			Tube Protection 230 V 15% breakdown 2 pF	95984	B1 A230
	0340 0008		4	Insulator Stand off teflon	98291	ST 1000 P60
	0380 0474			Teflon standoff	98291	227267
	11077 04101			Insulator Sheet	hp	
A60	03450 66590			**INGUARD TIMING ASSY**	hp	
C1, C2, C3	0160 2605			C fxd cer 0 02 microfarads +80% 20% 25 vdcw	72982	5835 V5U203Z
C4	0160 2605			C fxd cer 0 02 microfarads +80% 20% 25 vdcw	72982	5835 V5U203Z
C5	0180 0197			C fxd Ta elect 2 2 microfarads 10% 20 vdcw	56289	150D225X9020A2 DYS
C6	0180 0291			C fxd Ta elect 1 microfarad 10% 35 vdcw	56289	150D105X9035A2 DYS
C7	0180 0376		1	C fxd al 20 microfarads 10 + 50 % 200 vdcw	56289	34D206F200FJ4 DYS
C8	0150 0122			C fxd cer 2000 pF 20% 500 vdcw	15450	801 000 Y5S 202M
C9	0150 0073		2	C fxd cer 100 pF 10% 500 vdcw	56289	40C100A2 CDH
C10	0160 0195			C fxd cer 1000 pF 20% 250 vdcw	56289	19C251A1 CDH
C11	0150 0073			C fxd cer 100 pF 10% 500 vdcw	56289	40C200A2 CDH
C12	0160 0195			C fxd cer 1000 pF 20% 250 vdcw	56289	19C251A1 CDH
C13	0160 2605			C fxd cer 0 02 microfarads +80% 20% 25 vdcw	72982	5835 V5U203Z
C14	0160 0195			C fxd cer 1000 pF 20% 250 vdcw	56289	19C251A1 CDH
C15	0150 0093			C fxd cer 0 01 microfarads + 80% 20% 100 vdcw	91418	TA obd
C16	0180 0197			C fxd Ta elect 2 2 microfarads 10% 20 vdcw	56289	obd
CR1 thru CR5	1910 0016			Diode Ge 60 piv 1 ms	14433	G718
CR6 thru CR9	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
IC1	1820 0310			Integrated circuit 3 input gate	04713	SC6910PK
IC2 thru IC4	1820 0095			Integrated circuit clocked flip flop	04713	SC6904PK
IC5	1820 0096			Integrated circuit Expander gate	04713	SC6905PK
IC6	1820 0055			Integrated circuit Decade counter	04713	SC7515PK
IC7, IC8	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC9	1820 0095			Integrated circuit Toggle flip flop	04713	SC6904PK
IC10	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC11	1820 0096			Integrated circuit Expander gate	04713	SC6905PK
IC12	1820 0207			Integrated circuit 2 input gate	07263	9601PC
Q1, Q2	1854 0354		2	TSTR Si NPN	01295	SKA1124
Q3	1853 0020			TSTR Si PNP	01295	SKA1123
Q4, Q5	1854 0071			TSTR Si NPN 2N3391	01295	SKA1124
R1	0683 1025			R fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R2	0683 1035		1	R fxd 10 kilohm 5 % 1/4 W	01121	CB 1035
R3	0683 4725		1	R fxd 4700 ohms 5 % 1/4 W	01121	CB 4725
R5	0683 6815		2	R fxd comp 680 ohms 5% 1/4 W	01121	CB6815
R6	0683 2425		2	R fxd comp 2400 ohms 5% 1/4 W	01121	CB2425
R7	0683 5125		4	R fxd comp 5100 ohms 5% 1/4 W	01121	CB5125
R8	0683 1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R9	0683 6815			R fxd comp 680 ohms 5% 1/4 W	01121	CB6815
R10	0683 2425			R fxd comp 2400 ohms 5% 1/4 W	01121	CB2425
R11	0683 5125			R fxd comp 5100 ohms 5% 1/4 W	01121	CB5125
R12	0683 1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R13	0683 8225			R fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R14	0683 1235			R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R15	0683 8225			R fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R16	0683 1235			R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R17	0683 1035			R fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R18	0683 5635			R fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R19	0683 1025			R fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R20	0683 4725			R fxd comp 4700 ohms 5% 1/4 W	01121	CB4725
R21	0698 4487			R fxd flm 25 5 kilohm 1% 1/8 W	91637	CMF 1/10 32 T 1

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR	MFR PART NO
A66	03450 66566			**INGUARD PULSE TRANSFORMER DRIVE SUBASSY**	hp	
C1	0150 0121			C fxd cer 0 1 microfarads +80% 20% 50 vdcw	15450	obd
CR1 CR2	1901 0040			Diode Si 30 piv 30 mA 2 pF	07263	FDG1088
Q1 thru Q3	1854 0071			TSTR Si NPN 2N3391	56289	17 1083
R1 R2	0698 4123			R fxd met flm 499 ohms 1 1/8 W	91637	MFF 1/8 T 1 obd
R3	0757 0280			R fxd met flm 1000 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R4	0698 3558			R fxd met flm 4020 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R5	0757 0280			R fxd met flm 1000 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R6	0698 3558			R fxd met flm 4020 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
A68	03450 66568			**INPUT ATTENUATOR ASSY**	hp	
K36	0490 1001		1	Relay reed & coil	hp	
R1, R2	0813 0032		2	R fxd prec ww 50 kilohms 5% 5 W	91637	RS5 78
R3 thru R5	0811 2583		3	R fxd set matched ww 2 ea 4 95 megohms 1 ea 99 9 kilohms	hp	
	03050 24104		2	Plastic Insulator	28480	03050 24104
	03450 24103		1	Relay Channel Lid Insulator	28480	03450 24103
A69	03450 66569			**AUTO-ZERO ASSY**	hp	
C1, C2	0160 2430		2	C fxd poly 0 001 microfarads 5% 100 vdcw	84411	863T
CR1, CR2	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
R1	0757 0401		1	R fxd met flm 100 ohms 1% 1/8 W	75042	CEA T 0 obd
R2	2100 1776		1	R 10 kilohms		
R3	0698 3215		1	R fxd met flm 499 kilohms 1% 1/8 W	75042	CEA T 0 obd
R4	0683 5125			R fxd met flm 5100 ohms 5% 1/4 W	01121	CB5125
R5	0728 0004		1	R fxd C flm 1 ohm 1% 1/2 W	75042	CEA T 0 obd
R6	0683 5125			R fxd met flm 5100 ohms 5% 1/4 W	01121	CB5125
R7, R8	0811 2580		1	R fxd matched set ww 100 kilohms 005%	hp	
	0360 0479		26	Terminal solder stud	00779	61038 1LP
A70	03450 66570			**INPUT AMP GAIN ASSY**	hp	
C1	0160 3204		1	C fxd met my 4 microfarads 10% 200 vdcw	84411	HEW 75
C2, C3	0160 2202		2	C fxd mica 75 pF 5%	00853	RDM15E750J3C
C4	0160 2430		1	C fxd poly 0 001 microfarads 5% 100 vdcw	84411	863T
CR1 thru CR6	1901 0586		8	Diode Si 30 piv 10 pA	18356	FN910
CR7, CR8	1902 3190		2	Diode breakdown 13 V 5% 400 mW	04713	SZ10939 215
R1	0811 1335		1	R fxd prec ww 11 kilohms 3% 3 W	91637	RS2B 95
R2 thru R4	0811 2584		3	R fxd set matched 98 9 kilohms, 999 85 ohms, 10 kilohms	hp	
R5, R6	0757 0442		2	R fxd met flm 10 kilohms 1% 1/8 W	75042	CEA T 0 obd
L1 thru L7	9170 0894		7	Core magnetic (added to each end of C1)	02114	56 590 6514A6

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A71	03450-69502			COOLER ASSY	hp	
	03450-69504			Rebuilt exchange		
	03450-24702			MOUNTING BLOCK	-HP-	
				NOTE: A71 is not field repairable except for replacement of Peltier cell.		
	0360-1721			Mounting block	hp	
	0960-0041			Peltier Cell	08018	930
	3980-0059			White porcelain plate	hp	
	03450-61613			Wire: orange to A56	hp	
A72	11077-66501			OHMS AMP SUBASSY (P/O OHMS CONV)	hp	
C1, C2	0160-3237			C: fxd cer 0.1 microfarads 20% 50 vdcw	15450	8523006Z5U104M
C3	0160-0155		1	C: fxd my 0.0033 microfarads 10% 200 vdcw	56289	192P33292 PTS
C4, C5	0180-2192		2	C: fxd Ta elect 6.8 microfarads 10% 50 vdcw	56289	150D685X9050R2-DYS
C6	0140-0206			C: fxd mica 270 pF 5%	72136	RDM15F271J5C obd
CR1	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR2	1901-0036		1	Diode: Si 1000 piv 0.60 A	04713	SR1358-12
CR3, CR4	1901-0586		2	Diode: Si 30 wiv 10 pA	18356	FN910
CR5 thru CR8	1901-0025			Diode: Si 100 wiv 12 pF 100 mA	93332	D3072
CR9	1910-0016			Diode: GE 60V	hp	
CR10	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ms	07263	FDG1088
CR11, CR12	1901-0586			Diode: Si 30 piv 10 pA	18356	FN910
Q1	1855-0036		1	TSTR: Dual	05397	obd
Q2	1854-0475			TSTR: Si NPN dual		
Q3, Q4	1854-0215			TSTR: Si NPN 2N3904	04713	SPS-3611
Q5 thru Q7	1853-0080			TSTR: Si PNP 2N4888	12007	obd
Q8	1855-0304		1	TSTR: FET N-Channel PD800 mW	15818	U1882
R1, R2	0757-0458			R: fxd met flm 51.1 kilohms 1% 1/8 W	75042	CEA T-0 obd
R3	0757-0421		2	R: fxd met flm 825 ohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R4, R5	0757-0451		2	R: fxd met flm 24.3 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R6	0757-0421			R: fxd met flm 825 ohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R7	0698-4486		1	R: fxd met flm 24.9 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R8, R9	0757-0469			R: fxd met flm 150 kilohms 1% 1/8 W	75042	CEA T-0 obd
R10	0698-4435		1	R: fxd met flm 2490 ohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R11, R12	0757-0280			R: fxd met flm 1000 ohms 1% 1/8 W	75042	CEA T-0 obd
R13	0757-0466		1	R: fxd met flm 110 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R14	0698-4502		1	R: fxd met flm 64.9 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R15	0757-0452		1	R: fxd met flm 27.4 kilohms 1% 1/8 W	91637	MFF 1/8 T-1 obd
R16	0683-1035			R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R17	0683-1055			R: fxd comp 1 megohm 5% 1/4 W	01121	CB1055
R18	0683-1025			R: fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R19	0757-0458			R: fxd met flm 51.1 kΩ 1% 1/8 W	75042	CEA T-0 obd
R20	0683-1025			R: fxd comp 1 kilohm 5% 1/4 W	01121	CB1025
	0340-0092			Insulator: feed thru teflon cloverleaf	98291	FT-E-12
A81	11078-66501		3	AC INPUT AMP ASSY	hp	
C1	0180-0376		8	C: fxd Ta elect 0.47 microfarad 10% 35 vdcw	56289	150D474X9035A2
C2	0140-0232		1	C: fxd mica 460 pF 1% 300 vdcw	04062	RDM15F461F3C
C3	0140-0202		1	C: fxd mica 15 pF 5% 500 vdcw	04062	RDM15C150J6C
C4	0150-0122		3	C: fxd cer .002 microfarad 20% 1000 vdcw	56289	19C203ACDH
C5, C6	0150-0055		2	C: fxd cer 10 pF 5% 500 vdcw	78488	Type GA
C7	0180-0376			C: fxd Ta elect 0.47 microfarad 10% 35 vdcw	56289	150D474X9035A2
C8	0180-0309		2	C: fxd Ta elect 4.7 microfarad 20% 10 vdcw	56289	150D475X0010A2
C9 thru C11	0180-1735		8	C: fxd Ta elect 0.22 pF 10% 35 vdcw	56289	150D224X9035A2
C12, C13	0150-0122			C: fxd cer .002 microfarad 20% 1000 vdcw	56289	19C203ACDH
C14	0180-1735			C: fxd Ta elect 0.22 microfarad 10% 35 vdcw	56289	150D224X9035A2
C15	0160-3190		1	C: fxd my 5 microfarads 10% 50 vdcw	84411	HEW-101
CR1 thru CR4	1901-0376		4	Diode: Si 35 V 2 pF at 0 V	07910	CD8335
CR5	1902-3149		2	Diode: breakdown 9.09 V 5% 400 mW	04713	SZ10939-170
CR6	1902-0049		7	Diode: Si breakdown 6.19 V 5% 400 mW	07910	CD35646
CR7 thru CR10	1901-0047		4	Diode: Si 20 piv 1 pF 10 ns	14433	5545
CR11, CR12	1902-3073		2	Diode: breakdown 4.32 V 5% 400 mW	04713	SZ10939-77
CR13 thru CR15	1901-0040		22	Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR16, CR17	1901-0025		6	Diode: Si 100 piv 12 pF 100 mA	94144	RD1526
K37, K38	0490-0729		4	Relay: reed switch	hp	

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A81 (Cont'd)						
Q1	1855 0036		5	TSTR dual	000LD	UN577
Q2	1854 0475		4	TSTR Si NPN dual	32293	ITS 1066
Q3, Q4	1854 0215		14	TSTR Si NPN	04713	SPS3611
Q5, Q6	1853 0089		6	TSTR Si PNP 2N4917	07263	obd
Q7, Q8	1853 0036		13	TSTR Si PNP 2N3906	04713	SPS 3612
Q9	1854 0314		2	TSTR Si NPN	04713	MPS 6521 5
Q10	1854 0215			TSTR Si NPN	04713	SPS 3611
Q11	1853 0036			TSTR Si PNP 2N3906	04713	SPS 3612
R1	0683 1545		4	R fxd comp 150 kilohm 5% 1/4 W	01121	CB1545
R2	0683 3645		1	R fxd comp 360 kilohms 5% 1/4 W	01121	CB3645
R3	0683 1015		3	R fxd comp 100 ohms 5% 1/4 W	01121	CB1015
R4	0683 1025		6	R fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R5	0683 6225		3	R fxd comp 6200 ohms 5% 1/4 W	01121	CB6225
R6	0683 1545			R fxd comp 150 kilohms 5% 1/4 W	01121	CB1545
R7	0683 1635		5	R fxd comp 16 kilohms 5% 1/4 W	01121	CB1635
R8	0698 4125		1	R fxd met flm 953 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R9	0683 8225		1	R fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R10, R11	0698 4445		2	R fxd met flm 5760 ohms 1% 1/8 W	75042	CEA T 0 obd
R12, R13	0698 4408		2	R fxd met flm 124 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R14	0757 0273		3	R fxd met flm 3010 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R15, R16	0757 0403		2	R fxd met flm 121 ohms 1% 1/8 W	19701	MF5C T 0 obd
R17	2100 2632		1	R var lin 100 ohms 30% 1/2 W	73138	72PA
R18, R19	0757 0447		2	R fxd met flm 15 2 kΩ 1% 1/8 W	19701	MF4C T 0 obd
R20	0698 3150		1	R fxd met flm 2370 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R21	0698 4423		1	R fxd met flm 1370 ohms 1% 1/8 W	19701	MF5C T 0 obd
R22	0683 1235		2	R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R23, R24	0683 1025			R fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R25, R26	0683 1015			R fxd comp 100 ohms 5% 1/4 W	01121	CB1015
R27	0683 6825		1	R fxd comp 6800 ohms 5% 1/4 W	01121	CB6825
R28, R29	0683 3305		2	R fxd comp 33 ohms 5% 1/2 W	01121	CB3305
R30	0683 9115			R fxd comp 910 ohms 5% 1/4 W	01121	CB9115
R31, R32	0698 6819		1	R fxd two matched resistors 1 8 kilohms and 200 02 ohms	82142	obd
R33	0683 9115			R fxd comp 910 ohms 5% 1/4 W	01121	CB9115
R35	2110 2520			R var 50 ohms ±20%	19701	ET50X500
R34	2100 2670		2	R var lin 20 ohms + 30% 10% 1/2 W	73138	62PAR20
R36	0757 1102		1	R fxd met flm 180 ohms 1% 1/8 W	75042	CEA T 0 obd
R37	0698 3228		1	R fxd met flm 49 9 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R38	0698 5572		1	R fxd met flm 12 5 kilohms 0 5% 1/8 W	75042	CEA T 0 obd
A82	11078 66502			**SAMPLING AMP ASSY**	hp	
C1, C2	0180 1735			C fxd Ta elect 0 22 microfarad 10% 35 vdcw	56289	150D224X9035A1
C3	0150 0055		1	C fxd cer 10 pF 10% 200 vdcw	00656	ELA105A100AK
C4	0160 2203		1	C fxd mica 91 pF 5% 300 vdcw	04062	RDM15F910J3C
C5	0180 0376			C fxd Ta elect 0 47 microfarad 10% 35 vdcw	56289	150D474X9035A2
C6	0140 0201		3	C fxd mica 12 pF 5% 500 vdcw	04062	RDM15C120J5C
C7	0180 0116		4	C fxd Ta elect 6 8 microfarads 10% 35 vdcw	56289	150D685X9035B2
C8, C9	0160 0156		2	C fxd my 0 0039 microfarads 10% 200 vdcw	56289	192P39292 PTS
C10	0180 1735			C fxd Ta elect 0 22 microfarad 10% 35 vdcw	56289	150D224X9035A2
C11	0180 0309			C fxd Ta elect 4 7 microfarads 20% 10 vdcw	56289	150D475X0010A2
C12*	0160 0938			C fxd mica 1000 pF 5%	72136	RDM15E102J1C
C13	0140 0201			C fxd mica 12 pF 5% 500 vdcw	04062	RDM15C120J5C
C14	0160 2605		5	C fxd cer 0 02 microfarad + 80% 20% 25 vdcw	15450	5835V5U2032
C15	0180 1719		1	C fxd Ta elect 22 microfarads 10% 25 vdcw	56289	109D226X9025C2
C16, C17*	0160 0205		1	C fxd mica 10 pF 2% 500 wvdc	hp	obd
CR1, CR2	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR3	1902 3139		1	Diode breakdown 8 25 V 5% 400 mW	04713	SZ10939 158
CR4	1902 0049			Diode breakdown 6 19 V 5% 400 mW	07910	CE5646
CR5	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
IC1	1820 0095		1	Integrated circuit Conditional flip flop	04713	SC6904PK

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A82 (Cont'd)						
L1	9100 1422		1	Coil choke	hp	
Q1	1855 0006		3	TSTR Si P channel FET	000LD	SU414A
Q2	1854 0215			TSTR Si NPN	04713	SPS 3611
Q3	1855 0057		1	TSTR field effect N channel	04713	MPF 105 5
Q4	0853 0036		4	TSTR Si PNP 2N3906	04713	SPS 3612
Q5	1855 0036			TSTR Si P channel FET	000LD	SU414A
Q6	1854 0475			TSTR Si NPN dual	32293	ITS 1068
Q7	1854 0215			TSTR Si NPN	04713	SPS 3611
Q8, Q9	1853 0036			TSTR Si PNP 2N3906	04713	SPS 3612
Q10, Q11	1853 0089			TSTR Si PNP 2N4917	07263	obd
Q12	1854 0042		1	TSTR Si NPN	73445	obd
Q13, Q14	1855 0092		2	TSTR Si N channel FET	83740	F1762
Q15	1854 0215			TSTR Si NPN	04713	SPS 3611
Q16	1853 0036			TSTR Si PNP 2N3906	04713	SPS 3612
Q17, Q18	1854 0087		6	TSTR Si NPN	24446	40X16N2989
R1	0683 5135		2	R fxd comp 51 kilohms 5% 1/4 W	01121	CB5135
R2	0683 3335		2	R fxd comp 33 kilohms 5% 1/4 W	01121	CB3335
R3	0683 9135		2	R fxd comp 91 kilohms 5% 1/4 W	01121	CB9135
R4	0683 3335			R fxd comp 33 kilohms 5% 1/4 W	01121	CB3335
R5	0683 9135			R fxd comp 91 kilohms 5% 1/4 W	01121	CB9135
R6	0683 5135			R fxd comp 51 kilohms 5% 1/4 W	01121	CB5135
R7	0683 2235			R fxd comp 22 kilohms 5% 1/4 W	01121	CB2235
R8	0757 0281		1	R fxd met flm 2740 ohms 1% 1/8 W	91637	MFF 1 8 T 1 obd
R9, R10	0757 0452		2	R fxd met flm 27.4 kilohms 1% 1/8 W	19701	MF5C T 0 obd
R11	2100 2520		2	R var lin 50 ohms 30% 1/2 W	73138	62 91 + 0
R12	0698 3151		1	R fxd met flm 2870 ohms 1% 1/8 W	75042	CEA T 0 obd
R13, R14	0757 0405		2	R fxd met flm 162 ohms 1% 1/8 W	75042	CEA T 0 obd
R15	0757 0417		2	R fxd met flm 365 ohms 1% 1/8 W	75042	CEA T 0 obd
R16	0683 1625		2	R fxd comp 1600 ohms 5% 1/4 W	01121	CB1625
R17	0757 0273			R fxd met flm 3010 ohms 1% 1/8 W	91637	MFF 1 8 T 1 obd
R18, R19	0698 4474		2	R fxd met flm 8450 ohms 1% 1/8 W	19701	MF5C T 0 obd
R20, R21	0698 3487		2	R fxd met flm 255 ohms 1% 1/8 W	91637	MFF 1 8 T 1 obd
R22, R23	0683 1635			R fxd comp 16 kilohms 5% 1/4 W	01121	CB1635
R24	0698 3557		1	R fxd met flm 806 ohms 1% 1/8 W	75042	CEA T 0 obd
R25	0683 2015		4	R fxd comp 200 ohms 5% 1/4 W	01121	CB2015
R26	0683 1525		1	R fxd comp 1500 ohms 5% 1/4 W	01121	CB1525
R27	0683 3625		2	R fxd comp 3600 ohms 5% 1/4 W	01121	CB3625
R28	0683 1025			R fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R29	0683 1835		3	R fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R30	0683 2015			R fxd comp 200 ohms 5% 1/4 W	01121	CB2015
R31	0683 6225			R fxd comp 6200 ohms 5% 1/4 W	01121	CB6225
R32	0683 5115			R fxd comp 510 ohms 5% 1/4 W	01121	CB5115
R33	0683 5125		3	R fxd comp 5100 ohms 5% 1/4 W	01121	CB5125
R34, R35	0698 4502		2	R fxd met flm 64.9 kilohms 1% 1/8 W	75042	CEA T 0 obd
R36	0683 2025		4	R fxd comp 2000 ohms 5% 1/4 W	01121	CB2025
R39	2100 2583		1	R var lin 10 ohms 30% 1/2 W	73138	62 89 0
R40, R41	0698 6816		1	R fxd set matched 3 128 ohms and 200 ohms	82142	obd
R42	0683 2015			R fxd comp 200 ohms 5% 1/4 W	01121	CB2015
A83	11078 66503			**THERMOCOUPLE ASSY**	hp	
C1 thru C3	0180 0197		11	C fxd Ta elect 2.2 microfarads 10% 20 vdcw	56289	150D225X9010A2
C4	0150 0093		1	C fxd cer 0.01 microfarad +80% -10% 100 vdcw	91418	TA obd
C5, C6	0180 0354		2	C fxd Ta elect 40 microfarads 5% 10 vdcw	56289	150D406X5010B2
C7, C8	0180 0159		2	C fxd Ta elect 220 microfarads 20% 10 vdcw	56789	150D227X0010S2
C9	0140 0199		1	C fxd mica 240 pF 5% 300 vdcw	04062	RDM15F131J3C

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A83 (Cont'd)						
C10, C11	0180-0376			C: fxd Ta elect 0.47 microfarad 10% 35 vdcw	56289	150D474X5035A2
C12	0180-0228		2	C: fxd Ta elect 22 microfarad 10% 15 vdcw	56289	150D226X9015B2
C13	0180-2050		1	C: fxd Ta elect 0.082 microfarad 10% 35 vdcw	56289	150D823X9035A2
C14	0180-0228			C: fxd Ta elect 22 microfarads 10% 15 vdcw	56289	150D226X9015B2
C15, C16	0180-2105		2	C: fxd Ta elect 5 microfarads 20% 35 vdcw	84411	HEW 104
C17	0160-0163		1	C: fxd my 0.033 microfarad 10% 200 vdcw	56289	192P33392 PTS
C18	0140-0197			C: fxd mica 180 pF 5%	19701	RDM15F181J3C
CR1, CR2	1902-3182		4	Diode: breakdown 12.1 V 5% 400 mW	04713	SZ10939 206
CR3	1902-3104		2	Diode: breakdown 5.62 V 5% 400 mW	07910	CD35634
CR4	1902-3149			Diode: breakdown 9.09 V 5% 400 mW	04713	SZ10939 170
CR5 thru CR7	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR8, CR9	1901-0582		2	Diode: Si	24446	STD 631
CR10	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR11	1902-0761		1	Diode: breakdown 5.9 - 6.5 V 1N821	75042	obd
CR12 thru CR14	1901-0040			Diode: Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR15 thru CR18	1901-0044		5	Diode: Si 20 mA at +1 V 50 piv 2 pF 6 ns	14433	5542
Q1	1854-0314			TSTR: Si NPN	04713	MPS 6521 5
Q2	1854-0215			TSTR: Si NPN	04713	SPS 3611
Q3	1853-0036			TSTR: Si PNP 2N3906	04713	SPS 3612
Q4	1854-0215			TSTR: Si NPN	04713	SPS 3611
Q5A, Q5B	1854-0369		1	TSTR: Si NPN dual	-hp-	
Q6A, Q6B	1855-0036			TSTR: dual	000LD	DN577
Q7, Q8	1853-0036			TSTR: Si PNP 2N3906	04713	SPS 3612
Q9 thru Q11	1854-0226		3	TSTR: Si NPN 2N4384	56289	obd
Q12	1853-0036			TSTR: Si PNP 2N3906	04713	SPS 3612
Q13 thru Q15	1854-0071			TSTR: Si NPN	01295	SKA1124
Q16	1855-0040		2	TSTR: Si N channel FET 2N3819	01295	obd
Q17	1855-0006			TSTR: Si P channel FET	000LD	SU414A
Q18	1855-0040			TSTR: Si N channel FET 2N3819	01295	obd
Q19	1855-0006			TSTR: Si P channel FET	000LD	SU414A
R1	0683-4315		1	R: fxd comp 430 ohms 5% 1/4 W	01121	CB4315
R2	0683-6815		1	R: fxd comp 680 ohms 5% 1/4 W	01121	CB6815
R3	0757-0273			R: fxd met flm 3010 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R4	0683-7515		1	R: fxd comp 750 ohms 5% 1/4 W	01121	CB7515
R5	0683-1855		1	R: fxd comp 1.8 megohm 5% 1/4 W	01121	CB1855
R6	0757-0312			R: fxd met flm 366 ohms 1% 1/8 W	75042	CEA T 0 obd
R7	0683-3625			R: fxd comp 3600 ohms 5% 1/4 W	01121	CB3625
R8	0683-2005		2	R: fxd comp 20 ohms 5% 1/4 W	01121	CB2005
R9, R10	0757-0407		2	R: fxd met flm 200 ohms 1% 1/8 W	75042	CEA T-0 obd
R11, R12	0698-4613		2	R: fxd met flm 953 ohms 1% 1/4 W	91637	MFF 1/4 T 1 obd
R13	0683-2005			R: fxd comp 20 ohms 5% 1/4 W	01121	CB2005
R14	0698-4362		1	R: fxd met flm 16.5 ohms 1% 1/8 W	19701	MF5C T 0 obd
R15	0757-0346		1	R: fxd met flm 10 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R16	0698-4037		1	R: fxd met flm 46.4 ohms 1% 1/8 W	19701	MF5C T 0 obd
R17	0757-0383		1	R: fxd met flm 18.2 ohms 1% 1/8 W	75042	CEA T 0 obd
R18, R19	0757-0462		2	R: fxd met flm 75 kilohms 1% 1/8 W	75042	CEA T-0 obd
R20, R21	0757-0446		2	R: fxd met flm 15 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R22	0698-3223		1	R: fxd met flm 1240 ohms 1% 1/8 W	19701	MF5C T 0 obd
R23	0698-4495		1	R: fxd met flm 37.4 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R24	2100-2646		1	R: var lin 100 ohms 20% 3/4 W	73138	62PA
R25	0757-0444		1	R: fxd met flm 12.1 kilohms 1% 1/8 W	75042	CEA T 0 obd
R26	0698-4484		1	R: fxd met flm 19.1 kilohms 1% 1/8 W	75042	CEA T 0 obd
R27	0757-0382		1	R: fxd met flm 16.2 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R28	0757-0428		1	R: fxd met flm 1620 ohms 1% 1/8 W	19701	MF5C T 0 obd
R29, R30	0698-3496		4	R: fxd met flm 3570 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R31	0683-1235		4	R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R32	0683-1035		4	R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R33	0757-0471		1	R: fxd met flm 182 kilohms 1% 1/8 W	19701	MF5C T 0 obd
R34	0698-3158		1	R: fxd met flm 23.7 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R35	0683-6225			R: fxd comp 6200 ohms 5% 1/4 W	01121	CB6225

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A83 (Cont'd)						
R36	0698 3496			R fxd met flm 3570 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R37, R38	0757 0442		4	R fxd met flm 10 kilohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R39, R40	0757 0420		2	R fxd met flm 750 ohms 1% 1/8 W	19701	MF5C T 0 obd
R41	0683 3935		4	R fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R42	0698 3147		1	R fxd met flm 191 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R43	0698 3496			R fxd met flm 3570 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R44, R45	0683 6855		2	R fxd comp 6 8 megohms 5% 1/4 W	01121	CB6855
R46, R47	0683 1055		3	R fxd comp 1 megohms 5% 1/4 W	01121	CB1055
R48	0683 1045		1	R fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R49	0683 1025			R fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
TC1	0853 0011		1	Thermocouple assembly	hp	
A84	11078 66504			**THERMOCOUPLE PREAMP ASSY**	hp	
C1, C2	0180 0376			C fxd Ta elect 0.47 microfarads 10% 35 vdcw	56289	150D474X9035A2
C3	0140 0193			C fxd mica 82 pF 5% 300 vdcw	04062	RDM15E820J3C
C4	0140 0201			C fxd mica 12 pF 5% 500 vdcw	04062	RDM15C120J5C
C5	0180 1735			C fxd Ta elect 0 22 microfarad 10% 35 vdcw	56289	150D224X9035A2
C6	0180 0116			C fxd Ta elect 6 8 microfarads 10% 35 vdcw	56289	150D685X9035B2
C7	0150 0015		1	C fxd cer 2 2 pF 10% 500 vdcw	78488	Type GA
C8	0160 2F77		1	C fxd my .47 microfarad 10% 50 vdcw	84411	HEW 101
C9	0180 0197			C fxd Ta elect 2.2 microfarads 10% 20 vdcw	56289	150D225X9020A2
C10	0180 0291		2	C fxd Ta elect 1 microfarad 10% 35 vdcw	56289	150D105X9035A2
C11	0160 2207		1	C fxd mica 300 pF 5% 300 vdcw	04062	RDM15F301J3C
C12	0180 0197			C fxd Ta elect 2 2 microfarads 10% 20 vdcw	56289	150D225X9020A2
C13	0160-3583		1	C FXD POLY 5 MICROFARADS 10% 50 VDCW	-HP-	LP9A1A505A
C14	0180-0348			C fxd Ta elect 1.2 MICROFARAD 10% 35 VDCW	56289	150D125X9035B2
C15	0180 0376			C fxd Ta elect 0.47 microfarad 10% 35 vdcw	56289	150D474X9035A2
CR1	1902 0049			Diode Si breakdown 6.19 V 5% 400 mW	07910	CD35646
CR2	1902 0048		1	Diode breakdown 6 81 V 5% 400 mW	07910	CD35658
CR3	1902 0064		1	Diode breakdown 7 50 V 5% 400 mW	07910	CD35670
CR4	1902 3205		1	Diode breakdown 15 V 5% 400 mW	04713	SZ10939 233
CR5, CR6	1901 0025			Diode Si 100 piv 12 pF 100 mA	94144	RD1526
CR7	1902 3104			Diode breakdown 5 62 V 5% 400 mW	07910	CD35634
CR8	1902 0025			Diode breakdown 10 V 5% 400 mW	04713	SZ10939 182
CR9	1902 0049			Diode Si breakdown 6 19 V 5% 400 mW	07910	CD35646
CR10	1901 0044			Diode Si 20 mA at + 1 V 50 piv 2 pF 6 ns	14433	S542
CR11 thru CR13	1901 0043			Diode Si breakdown 6 19 V 5% 400 mW	07910	CD35646
CR14	1901 C044			Diode Si 20 mA at + 1 V 50 piv 2 pF 6 ns	14433	S542
IC1, IC2	1820 0104		2	Integrated circuit	12040	LM 201
Q1	1855 0036			TSTR dual	000LD	DN577
Q2	1854 0475			TSTR Si NPN dual	32293	ITS 1068
Q3, Q4	1854 0215			TSTR Si NPN	04713	SPS3611
Q5, Q6	1853 0036			TSTR Si PNP 2N3906	04713	SP3612
Q7, Q8	1853 0089			TSTR Si PNP 2N4917	07263	obd
Q9, Q10	1854 0071			TSTR Si NPN	01295	SKA1124
Q11	1854 0475			TSTR Si NPN dual	32293	ITS 1068
Q12	1854 0087			TSTR Si NPN	24446	4JX16N2989
Q13	1855 0036			TSTR dual	000LD	DN577
Q14	1854 0071			TSTR Si NPN	01295	SKA1124
Q15	1855 0036			TSTR dual	000LD	DN577
Q16	1854 0071			TSTR Si NPN	01295	SKA1124
Q17	1901 0586		1	TSTR Si 30 piv	17856	FN910
Q18	1854 0071			TSTR Si NPN	000LD	DN577
R1	0757 0435		1	R fxd met flm 3920 ohms 1% 1/8 W	19701	MF5C T 0 obd
R2, R3	0757 0406		2	R fxd met flm 182 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R4	2100 2520			R var lin 50 ohms 30% 1/2 W	73138	62 91 0

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

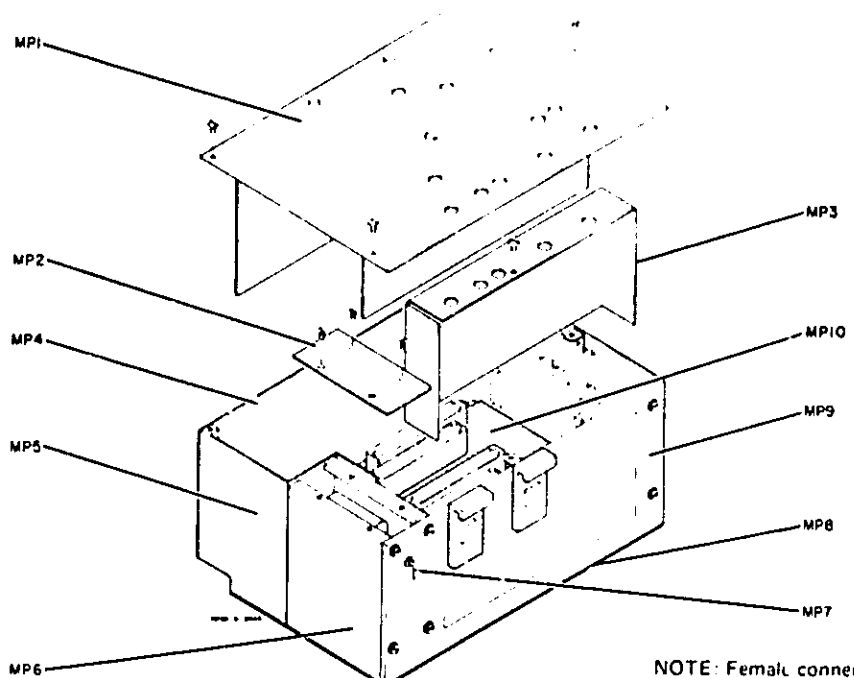
REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A84 (Cont'd)						
R5	0698 4437		1	R fxd met flm 2940 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R6, R7	0757 0289		2	R fxd met flm 13 3 kilohms 1% 1/8 W	75042	CEA T 0 obd
R8	0757 0429		1	R fxd met flm 1820 ohms 1/8 W	91637	MFF 1/8 T 1 obd
R9	0683 2035		5	R fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R10, R11	0757 0442			R fxd met flm 10 kilohms 1% 1/8 W	91637	MFF 1/8 T 0 obd
R12, R13	0683 1835			R fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R14	0698 4432		1	R fxd met flm 2100 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R15, R16	0698 4402		2	R fxd met flm 97 6 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R17	0683 2015			R fxd comp 200 ohms 5% 1/4 W	01121	CB2015
R18	0757 0427		1	R fxd met flm 1500 ohms 1% 1/8 W	91637	MFF 1/8 T 1 obd
R19	0683 3925		1	R fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R20	2100 2633		1	R var lin 1000 ohms 30% 1/2 W	73138	62PA
R21	0683 5645		1	R fxd comp 560 kilohms 5% 1/4 W	01121	CB5645
R22	0683 1025			R fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R23	0683 7535		1	R fxd comp 75 kilohms 5% 1/4 W	01121	CB7535
R24	0683 1635			R fxd comp 16 kilohms 5% 1/4 W	01121	CB1635
R25	0683 9115			R fxd comp 910 ohms 5% 1/4 W	01121	CB9115
R26	0683 2035			R fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R27	0683 1625			R fxd comp 1600 ohms 5% 1/4 W	01121	CB1625
R28	0683 1535		1	R fxd comp 15 kilohms 5% 1/4 W	01121	CB1535
R29 thru R31	0683 3935			R fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R32	0683 4735		1	R fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R33	0683 3915		1	R fxd comp 390 ohms 5% 1/4 W	01121	CB3915
R34	0698 4481		1	R fxd met flm 16 5 kilohms 1% 1/8 W	91637	MFF 1/8 T 0 obd
R35	0698 3558		1	R fxd met flm 4020 ohms 1% 1/8 W	91637	MFF 1/8 T 0 obd
R36	0698 3516		1	R fxd met flm 6340 ohms 1% 1/8 W	91637	MFF 1/8 T 0 obd
R37	0683 1055			R fxd comp 1 megohm 5% 1/4 W	01121	CB1055
R38	0757 0462		1	R fxd met flm 75 kilohms 1% 1/8 W	75042	CEA T 0 obd
R39	0683 2035			R fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R40	0698 3581		2	R fxd met flm 13 7 kilohms 1% 1/8 W	19701	MF5C T 0 obd
R41, R42	0757 0453		4	R fxd met flm 30 1 kilohms 1% 1/8 W	75042	CEA T 0 obd
R43	0698 4501		1	R fxd met flm 59 kilohms 1% 1/8 W	75042	CEA T 0 obd
R44	0683 7525		3	R fxd comp 7500 ohms 5% 1/4 W	01121	CB7525
R45	0683 2265		1	R fxd comp 22 megohms 5% 1/4 W	01121	CB2265
R46, R47	0683 7525			R fxd comp 7500 ohms 5% 1/4 W	01121	CB7525
R48	2100 2654		2	R var lin 25 kilohms 30% 1/2 W	73138	62PAR25K
R49	0757 0480		1	R fxd met flm 432 kilohms 1% 1/8 W	75042	CEA T 0 obd
R50	0757 0283		3	R fxd met flm 2000 ohms 1% 1/8 W	01121	CB2035
R51, R52	0757 0453			R fxd met flm 30.1 kilohms 1% 1/8 W	75042	CEA T 0 obd
R53	0683 2035			R fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R54	0698 3581			R fxd met flm 13 7 kilohms 1% 1/8 W	19701	MF5C T 0 obd
R55	0683 5125			R fxd comp 5100 ohms 5% 1/4 W	01121	CB5125
R56	0683 6815		2	R fxd comp 680 ohms 5% 1/4 W	01121	CB6805
R57	0683 9125		1	R fxd comp 9100 ohms 5% 1/4 W	01121	CB9125
R58	0683 1235			R fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
V1	1990 0081			Photocell dual module	hp	
A85	11078 66505			**SYNC GENERATOR ASSY**	hp	
C1, C2	0180 0116			C fxd Ta elect 6.8 microfarads 10% 35 vdcw	56289	150D685X9035B2
C3	0160 2201		1	C fxd mica 31 pF 5% 300 vdcw	04062	RDM15E510J3C
C4 thru C7	0180 0197			C fxd Ta elect 2 2 microfarads 10% 20 vdcw	56389	150D225X9020A2
C8	0140 0198		1	C fxd mica 200 pF 50% 300 vdcw	04062	RDM15F201J3C
C9	0140 0192		1	C fxd mica 68 pF 5% 300 vdcw	04062	RDM15E680J3C
C10	0140 0197		1	C fxd mica 180 pF 5% 300 vdcw	04062	RDM15F181J3C
C11	0180 0197			C fxd Ta elect 2.2 microfarads 10% 20 vdcw	56289	150D225X9020A2

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A85 (Cont'd)						
C12	0170 0021		1	C fxd my .0047 microfarad 10 400 vdcw	56289	obd
C13, C14	0180 1775		2	C fxd Ta elect 1.8 microfarads 5 35 vdcw	56289	150D185X503582
C15	0180 0197			C fxd Ta elect 2.2 microfarads 10 20 vdcw	56289	150D225X9020A2
C16 thru C19	0160 2105		4	C fxd cer .02 microfarads +80 20 25 vdcw	72982	5835Y5U2037
CR1, CR2	1902 3182			Diode breakdown 12.1 V 5 400 mW	04713	SZ10939 206
CR3 thru CR6	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR7, CR8	1910 0016		3	Diode Ge 60 piv 1 ns	03877	S3185G
CR9	1901 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
CR10	1910 0016			Diode Ge 60 piv 1 ns	03877	S3185G
CR11 thru CR14	1910 0040			Diode Si 30 piv 30 mA 2 pF 2 ns	07263	FDG1088
IC1	1826 0078		1	Integrated circuit linear operational amplifier	86684	CA3030
IC2	1820 0094			Integrated circuit 2 input gate	04713	SC6903PK
IC3 thru IC5	1820 0096			Integrated circuit expander gate	04713	SC6905PK
K41, K42	0490 0764		2	Reed relay	hp	
Q1, Q2	1854 0215			TSTR Si NPN	04713	SPS3611
Q3	1854 0087			TSTR Si NPN	24446	4JX16N2989
Q4, Q5	1854 0094		2	TSTR Si NPN 2N3646	07263	obd
Q6, Q7	1854 0087			TSTR Si NPN	24446	4JX16N2989
Q8, Q9	1854 0215			TSTR Si NPN	04713	SPS 3611
R1, R2	0683 9105		2	R fxd comp 91 ohms 5 1/4 W	01121	CB9105
R3	0683 1135		1	R fxd comp 11 kilohms 5 1/4 W	01121	CB1135
R4, R5	0683 1235			R fxd comp 12 kilohms 5 1/4 W	01121	CB1235
R6, R7	0757 0283			R fxd met flm 2000 ohms 1 1/8 W	91637	MFF 1/8 T 1 obd
R8, R9	0757 0468			R fxd met flm 130 kilohms 1 1/8 W	91637	MFF 1/8 T 1 obd
R10	2100 2654			R var fxd 25 kilohms 30 1/2 W	73138	62PAL25K
R11, R12	0683 3315		2	R fxd comp 330 ohms 5 1/4 W	01121	CB3315
R13	0683 2025			R fxd comp 2000 ohms 5 1/4 W	01121	CB2025
R14	0698 3268		1	R fxd met flm 11.5 kilohms 1 1/8 W	91637	MFF 1/8 T 1 obd
R15	0683 2035			R fxd comp 20 kilohms 5 1/4 W	01121	CB2035
R16	0698 3519		1	R fxd met flm 12.4 kilohms 1 1/8 W	19701	MF5C T 0 obd
R17	0698 3484			R fxd met flm 6650 ohms 1 1/8 W	19701	MF5C T 0 obd
R18	0698 3159		1	R fxd met flm 26.1 kilohms 1 1/8 W	75042	CEA T 0 obd
R19	0757 0288		1	R fxd met flm 9090 ohms 1 1/8 W	19701	MF5C T 0 obd
R20	0757 0450		1	R fxd met flm 22.1 kilohms 1 1/8 W	91637	MFF 1/8 T 1 obd
R21	0683 5115			R fxd comp 510 ohms 5 1/4 W	01121	CB5115
R22	0683 2025			R fxd comp 2000 ohms 5 1/4 W	01121	CB2025
R23	0757 0434		1	R fxd met flm 3650 ohms 1 1/8 W	19701	MF5C T 0 obd
R24	0683 1635			R fxd comp 16 kilohms 5 1/4 W	01121	CB1635
R25, R26	0683 1545			R fxd comp 150 kilohms 5 1/4 W	01121	CB1545
R27	0698 4895		1	R fxd met flm 2800 ohms 1 1/2 W	91637	MFF 1/2 T 1 obd
R28	0757 0468			R fxd met flm 130 kilohms 1 1/8 W	91637	MFF 1/8 T 1 obd
R29	0698 3265		1	R fxd met flm 118 kilohms 1 1/8 W	19701	MF5C T 0 obd
R30	0757 0830		1	R fxd met flm 3920 ohms 1 1/2 W	91637	MFF 1/2 T 1 obd
R31, R32	0683 3615		2	R fxd comp 360 ohms 5 1/4 W	01121	CB3615
R33 thru R35	0683 1035			R fxd comp 10 kilohms 5 1/4 W	01121	CB1035
R36	0683 6805			R fxd comp 68 ohms 5 1/4 W	01121	CB6805
A86	11076 66506			**AC INPUT AMP GAIN ASSY**	hp	
				NOTE A90 components must be replaced if A86 is replaced		
C3 thru C5	0160 3200		1	C set 15 pF, 180 pF, 2000 pF (A90C1, C2 also included in this set.)	95275	obd
C6	0121 0422		1	C var 0.8 microfarads 4.5 pF 1250 vdcw	18736	TP5G
C7	0121 0423		1	C var 0.8 microfarads 23 pF 1250 vdcw	18736	TP23G
C8	0121 0424		1	C var 1.0 pF 75 pF 1000 vdcw	18736	TP75G
C9	0160 31[illegible]		2	C fxd mica 73 pF 1 300 V	72136	RDM15E730F3S
C10*	0160 2205			C fxd mica 120 pF 5 300 V	hp	

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A86 (Cont'd)						
CR1, CR2	1901-0025			Diode: Si 100 piv 12 pF 100 mA	94144	RD1526
K39, K40	0490-0720		2	Relay reed guarded	hp	
R2 thru R4	0698-6820		1	R: fxd matched set 613.46 kilohms, 68.060 kilohms and 6.186 kilohms (A90R1 also included in this set.)	82142	obd
R5	2100-2672		1	R: var lin 100 ohms + 30% 1/2 W	73138	62PAR100
R6	2100-2671		1	R: var lin 10 ohms + 30% 1/2 W	73138	62PAR10
A90				**AC CHASSIS ASSY**		
C1, C2	0160-3200			C: matched set 13 pF (A86C3 thru C6 also included in this set.)	95275	obd
C3	0160-3192			C: fxd poly 0.1 microfarad 20% 1200 vdcw	99949	LP104-18M
J1 thru J5	1251-1626		5	Connector: printed circuit 24 contacts	76530	65-7168
J6	1251-1941		1	Connector: printed circuit 6 contacts	76530	66-710-6
R1	0690-6820			R: fxd matched set 1 megohm (A86R2 thru R4 also included in this set.)	82142	obd
R2	0683-2025			R: fxd comp 2000 ohms 5% 1/4 W	01121	CB2025
R3	0683-1045			R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R4	2100-2655			R: var 100 kilohms 10% 1/2 W	73138	62-213-0
R5	0683-7535			R: fxd comp 75 kilohms 5% 1/4 W	01121	CB7535
MP1	11078-64101			Cover: top	-hp-	
	2200-0707			Screw: nylon 4-40 1/4" long	-hp-	
	2210-0018			Screw: 100° flat head 4-40 3/16" long	-hp-	
MP2	11078-04103			Cover: attenuator top	-hp-	
	2210-0018			Screw:	-hp-	
MP3	11078-04105			Shield	-hp-	
	2200-0030			Screw:	-hp-	
MP4	11078-04101			Panel: back	-hp-	
MP5	11078-21201			Panel: side	-hp-	
MP6	11078-28501			Housing: attenuator	-hp-	
MP7	11078-27601			Connector: input	-hp-	
MP8	11078-04104			Cover: bottom	-hp-	
MP9	11078-66507			Panel: front	-hp-	
				Screw: binding head w/lock 4-40, 1/4" long	-hp-	
MP10	11078-66508			Mother Board: AC	-hp-	



NOTE: Female connector located on chassis, -hp- Part No. 1251-2151.

Figure 6-1. AC Chassis Assembly A90 Mechanical Parts Location.

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A100				**CHASSIS ASSY**		
C1	0180 2190			C: fxd Al elect 8500 microfarads +75% -10% 15 vdcw	56289	obd
C2	0180 2163			C: fxd Al elect 35 microfarads/200 microfarads	56289	obd
C3	0180 2190			C: fxd Al elect 8500 microfarads +75% -10% 15 vdcw	56289	obd
CR1, CR2	1901 1001			Diode: dual	-hp-	
F1	2110 0312			Fuse: 1.0 A 115 V line	71400	MDL 1 obd
	2110 0202			Fuse: 0.5 A 230 V line	71400	MDL 1/2 obd
	1400-0085		1	**FUSE HOLDER**	**-HP-**	
K1, K2	0490 0741		2	Relay: reed 5 V	-hp-	
K3	{ 0490 0802		1	Switch: reed magnetic	-hp-	
	{ 0490 0494			Coil: reed relay	-hp-	
K4	0490 0740			Relay: reed	-hp-	
K5	0490 0742			Relay: reed	-hp-	
K6	{ 0490 0778		15	Switch: reed magnetic	30874	SW765830
	{ 0490 0494			Coil: reed relay	-hp-	
K7, K8	0490 0742			Relay: reed	-hp-	
K9	{ 0490 0778			Switch: reed magnetic	30874	SW765830
	{ 0490 0494			Coil: reed relay	-hp-	
K10	{ 0490 0778			Switch: reed magnetic	30874	SW765830
	{ 0490-0816			Coil: reed relay	-hp-	
K11	{ 0490 0778			Switch: reed magnetic	30874	SW765830
	{ 0490 0494			Coil: reed relay	-hp-	
K12	{ 0490 0778			Switch: reed magnetic	30874	SW765830
	{ 0490 0494			Coil: reed relay	-hp-	
K13	{ 0490 0778			Switch: reed magnetic	30874	SW765830
	{ 0490 0494			Coil: reed relay	-hp-	
K14	{ 0490 0778			Switch: reed magnetic	30874	SW765830
	{ 0490 0494			Coil: reed relay	-hp-	
K15	{ 0490 0778			Switch: reed magnetic	30874	SW765830
	{ 0490 0494			Coil: reed relay	-hp-	
K16	{ 0490 0778			Switch: reed magnetic	30874	SW765830
	{ 0490 0494			Coil: reed relay	-hp-	
K17	{ 0490 0778			Switch: reed magnetic	30874	SW765830
	{ 0490 0494			Coil: reed relay	-hp-	
K18	{ 0490 0778			Switch: reed magnetic	30874	SW765830
	{ 0490 0494			Coil: reed relay	-hp-	
K19	{ 0490 0778			Switch: reed magnetic	30874	SW765830
	{ 0490 0494			Coil: reed relay	-hp-	
K21	{ 0490 0778			Switch: reed magnetic	30874	SW765830
	{ 0490 0494			Coil: reed relay	-hp-	
K22	{ 0490 0778			Switch: reed magnetic	30874	SW765830
	{ 0490 0494			Coil: reed relay	-hp-	
K23	{ 0490 0778			Switch: reed magnetic	30874	SW765830
	{ 0490 0494			Coil: reed relay	-hp-	
K24	{ 0490 0778			Switch: reed magnetic	30874	SW765830
	{ 0490 0494			Coil: reed relay	-hp-	
Q1, Q2	1854 0300		4	TSTR: Si NPN } NOTE: Insulators for Q1 thru Q7 listed below.	04713	SJE116
Q3	1853-0236		2	TSTR: Si PNP 2N5193	04713	2N5193
Q4, Q5	1854 0300			TSTR: Si NPN	04713	SJE116
Q6	1853-0236			TSTR: Si PNP 2N5193	04713	
Q7	1850 0424		1	TSTR: 2N2156	04713	obd
R1/R2	03450-01203			Resistor assembly: 50 ohms	-hp-	
R3/R4	03450-01203			Resistor assembly: 50 ohms	-hp-	
R5	0811 2733			R: fxd prec ww 4 ohms 5% 10 W	-hp-	
R6	0683 2245			R: fxd comp 220 kilohms 5% 1/4 W	01121	CB2245
R7, R8	0686-5105			R: fxd comp 51 Ω 5% 1/2 W	01121	EB5105
S1	3100-1784			Switch: lever FRONT/REAR	-hp-	
S2	3101 1234			Switch: slide DPDT 115 V/230 V	-hp-	
T1	**9100-3472**			Transformer: Inguard	-hp-	
T2	9100 1453			Transformer: Outguard	-hp-	
	03450-01261			**POWER SUPPLY BRACKET**	**-HP-**	
Serial No. 1229A01160 and below {	03450 60304		**	Panel Front Input	-hp-	
	1510 0063			Binding post: red	-hp-	
	1510 0064			Binding post: black	-hp-	
	1510 0065			Binding post: blue	-hp-	
	03461 24701			Binding post support	-hp-	
	0340 0481			Binding post insulator	-hp-	

**Binding Post Assy's are not interchangeable with Front Input Panels

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

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
Serial No 1229A01161 and above	03450-60306		**	Panel Front Input	hp	
	1510-0536		4	Binding Post Assy	hp	
	*		1	Binding Post Assy	hp	
	0340-0751		5	Front Insul Bdg Post	hp	
	0340-0752		5	Rear Insul Bdg Post	hp	
	03450-69501			Channel relay flex cable assy	hp	
	1251-2357			Connector power	hp	
	8120-0078			Cord power	hp	
	8120-1348			Cord power	hp	
	5000-0142			Cover side	hp	
	03450-04101			Cover top Guard	hp	
	03450-04102			Cover bottom Guard	hp	
	03450-04151			Cover top	hp	
	03450-04152			Cover bottom	hp	
	03450-04156			Cover top insulator	hp	
	03450-04157			Cover bottom insulator	hp	
	5060-0767			Foot assembly	hp	
	03450-24404			Frame rear	hp	
	03450-22001			Frame side	hp	
	5000-7137			Guard strap	hp	
	0340-0426			Insulator: under Q7	hp	
	03450-24102			Insulator under Q1 thru Q6	hp	
	03450-66551			Mother board inguard	hp	
	03450-66501			Mother board outguard	hp	
	03450-66526			Strapping board	hp	
	5000-0050			Trim metal: fluted front side	hp	
	5020-5327			Trim metal: upper front	hp	
	5020-5328			Trim metal: lower front	hp	
	5040-7035			Window front panel	hp	
	03450-49353			Window filter	hp	
	03450-48351		2	Support red plastic for Guard at front of instrument	hp	
	1251-0085			Remote Control Jack	hp	
	1251-1232			Rear Input Connector (Option 006)	hp	

*Part No. Not assigned - order by description

**Binding Post Assy's are not interchangeable with Front Input Panels

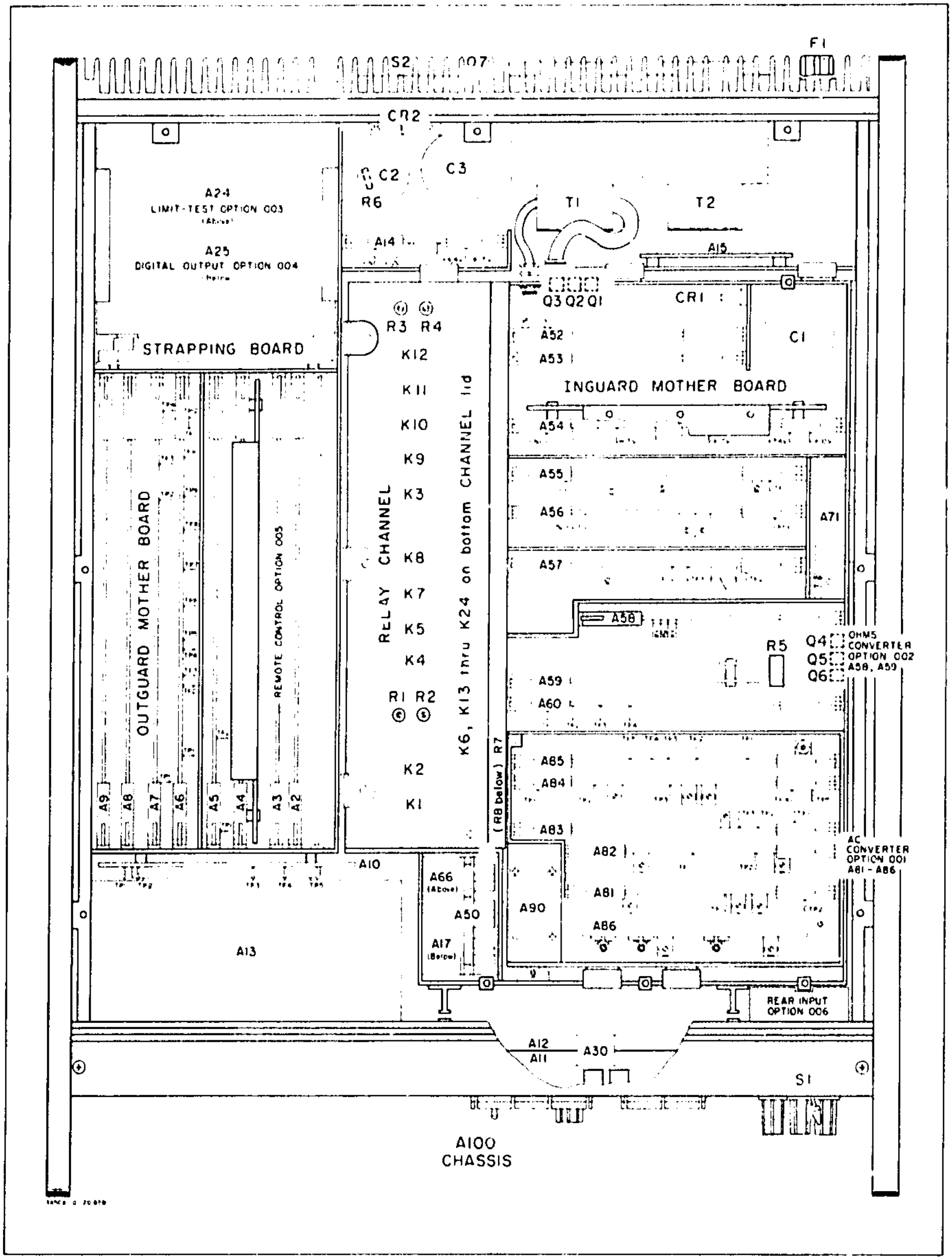


Figure 6-2. Chassis (A100) Component Location.

SECTION VII
CIRCUIT DIAGRAMS

7-1. INTRODUCTION.

7-2. This section contains five block diagrams, a relay timing diagram, and schematics of all the circuits of the 3450A and its Options. See Section IV of the Manual for explanation of the logic symbology used on the schematics.

7-3. SCHEMATIC NOTES.

a. Resistor and capacitor values are in ohms and microfarads unless otherwise noted.

b. Relays are numbered sequentially throughout the instrument, all other components according to A2 thru A100 assemblies.

c. Relays are shown in the de-energized position.

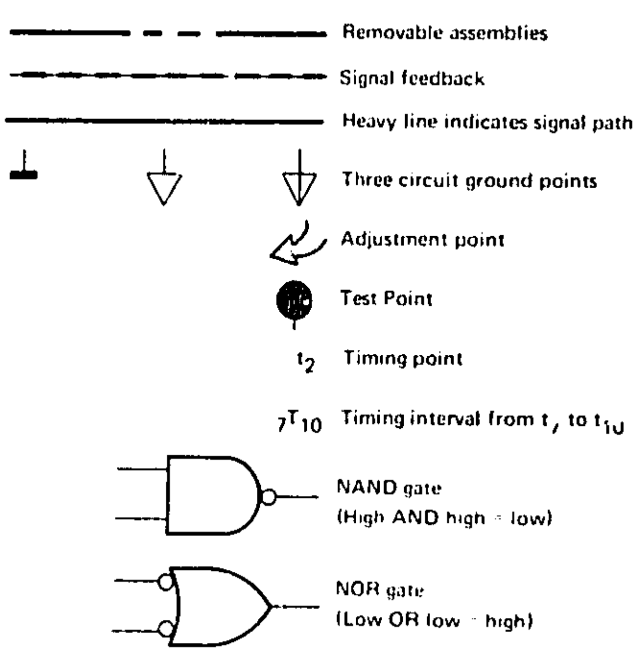
d. Arrows on schematics indicate signal flow.

e. There are three separate circuit ground points. The outguard circuitry uses chassis ground ⏊, the inguard circuitry is floating with ▽ as the ground point, and the amplifier of the Ohms Converter has a separate floating ground point ▽.

f. Arrows on assembly layout drawings indicate trouble-shooting points.

g. On assembly pin numbers, the A or - B suffix represents the right or left connector (viewed from the component side of the assembly); and the prefix digit or letter represents the front or rear contact on the connector.

7-4. SYMBOLS.



7-5. ASSEMBLIES.

A2	Channel Relay Drive Assy	03450-66532
A3	Remote Control Assy	11099-66511
A4	Function Assy	03450-66534
A5	Crystal Oscillator Assy	03450-66535
A6	Master Timing Assy	03450-66536
A7	Sample Period Assy	03450-66537
A8	Primary Range Assy	03450-66538
A9	Ratio Multiplier Range Assy	03450-66539
A10	Data Counter Assy	03450-66540
A11	Front Panel Switch Subassy	03450-66511
A12	Front Panel Storage Subassy	03450-66542
A13	Display Assy	03450-66523
A14	12 V Power Supply Assy	03450-66514
A15	Outguard Rectifier Assy	03450-66515
A17	Outguard Pulse Transformer Drive Subassy	03450-66517
A19	HI/GO/LO Display Assy	03450-66519
A24	Limit-Test Assy	11079-66501
A25	Digital Output Assy	11080-66501 or 11080-66502
A50	Pulse Transformer Assy	03450-60401
A52	Inguard Rectifier Assy	03450-66552
A53	5 V Power Supply Assy	03450-66553
A54	17 V Power Supply Assy	03450-66554
A55	Input Amp Assy	03450-66555
A56	Polarity-Amp Assy	03450-66586
A57	Integrator Assy	03450-66557
A58	Ohms Range Assy	11077-66558
A59	Ohms Reference Assy	11077-66502
A60	Inguard Timing Assy	03450-66590
A66	Inguard Pulse Transformer Drive Subassy	03450-66566
A68	Input Attenuator Assy	03450-66568
A69	Auto-Zero Assy	03450-66569
A70	Input-Amp Gain Assy	03450-66570
A71	Cooler Assy	03450-67901
A72	Ohms Amp Subassy	11077-66501
A81	AC Input Amp Assy	11078-66501
A82	Sampling Amp Assy	11078-66502
A83	Thermocouple Assy	11078-66503
A84	Thermocouple Preamp Assy	11078-66504
A85	Sync Generator Assy	11078-66505
A86	AC Input Amp Gain Assy	11078-66506
A90	AC Converter Chassis Assy	Not in manual
A100	Chassis Assy	Not in manual

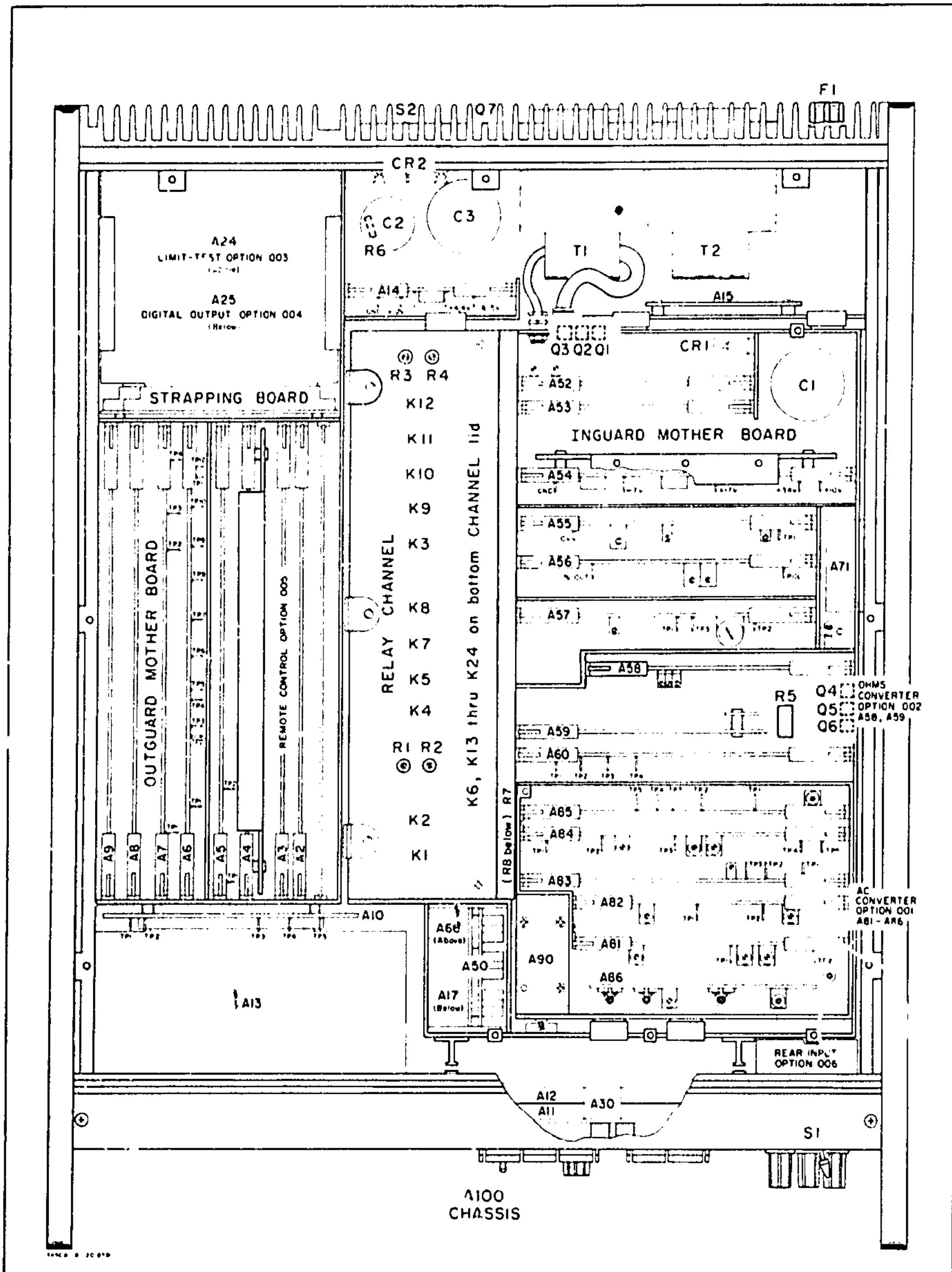


Figure 7-1. Assembly Location.

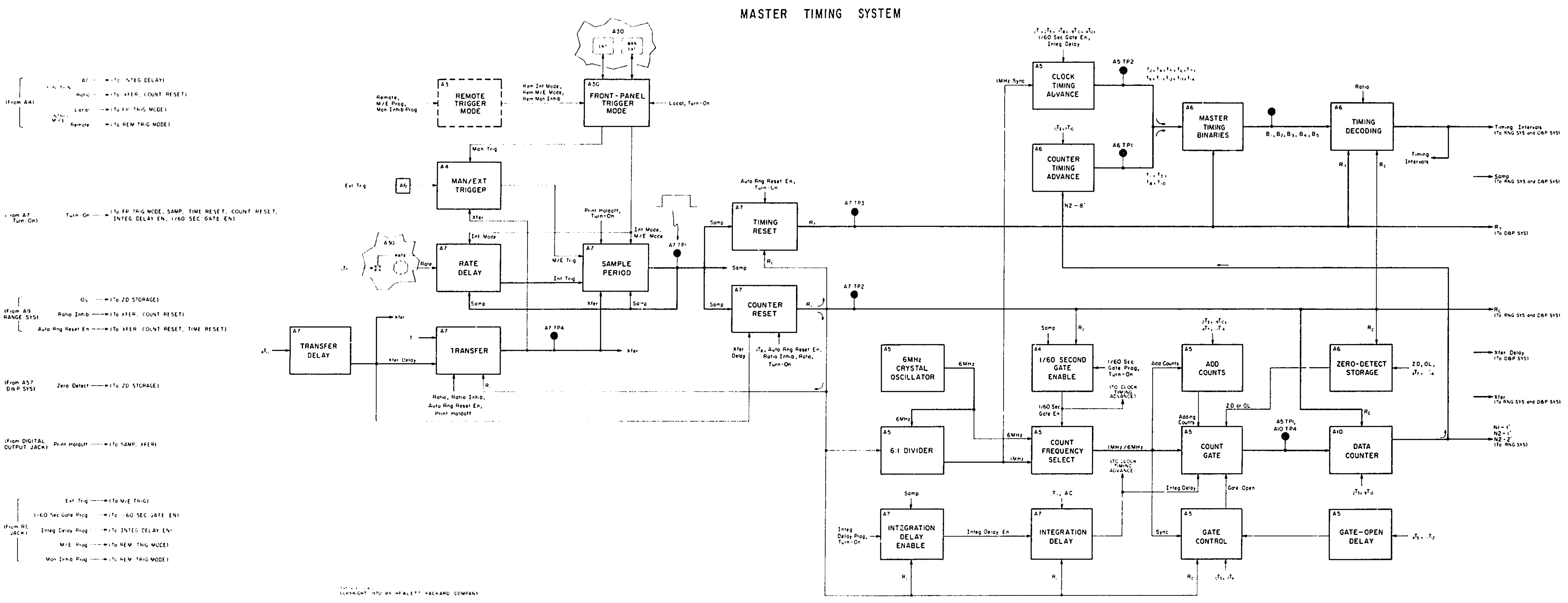


Figure 7-2. Master Timing System Diagram.

RANGE SYSTEM

Figure 7-3. Range System Diagram.

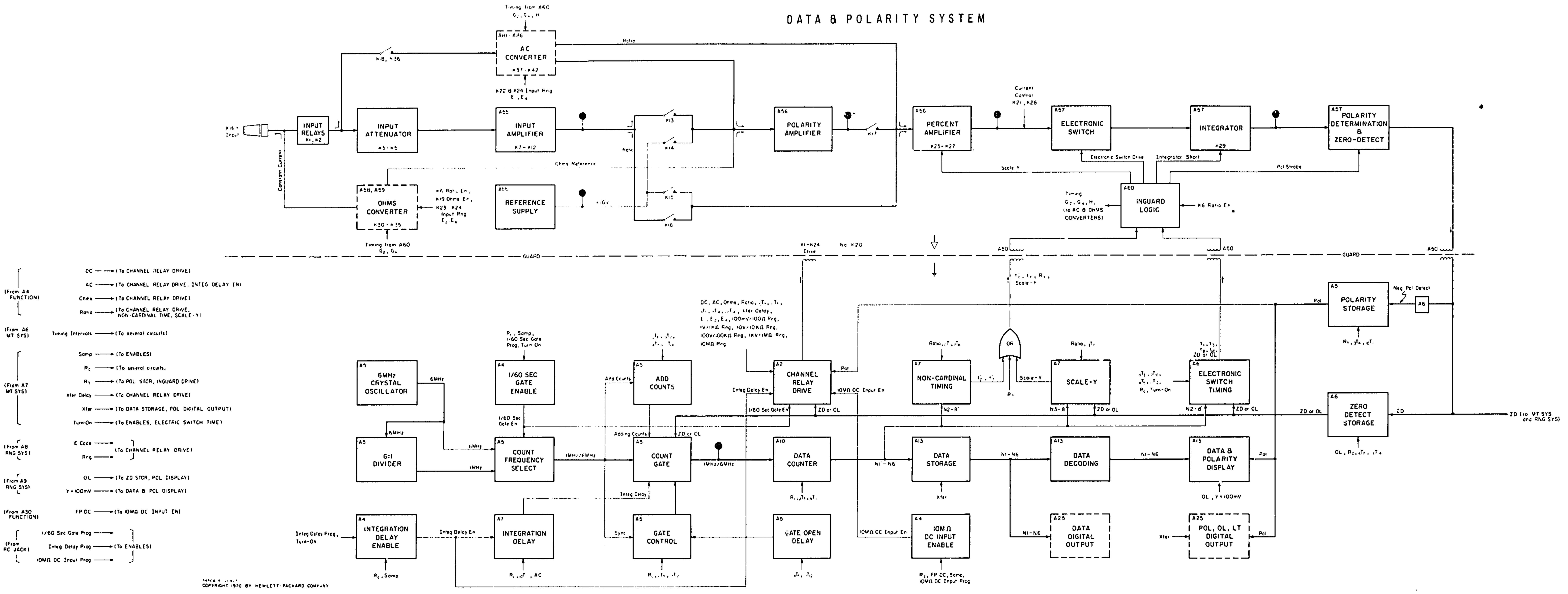


Figure 7-4. Data and Polarity System Diagram.

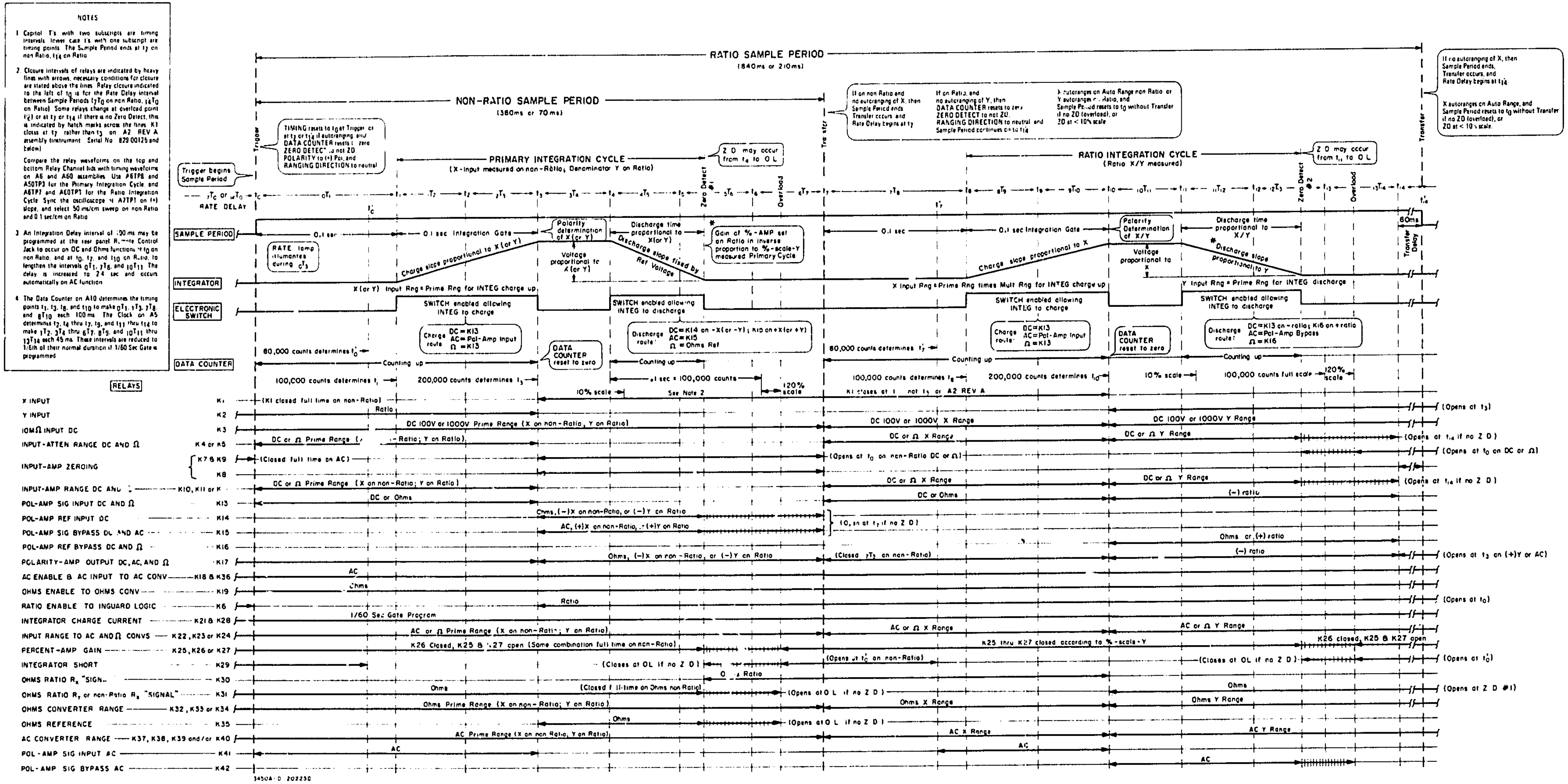


Figure 7-5. Relay Timing Diagram.

AC CONVERTER

Figure 7-6. AC Converter Diagram.

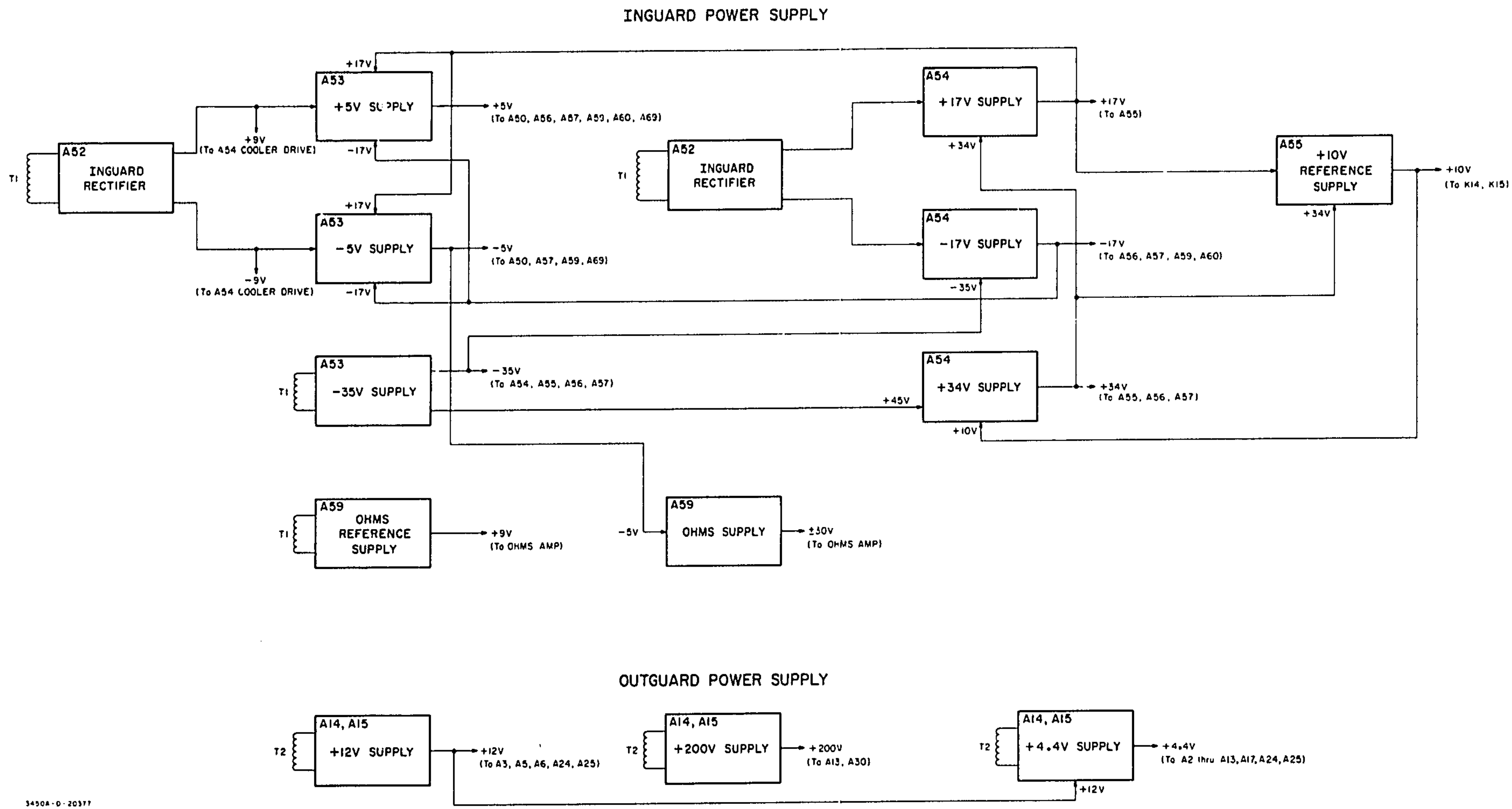
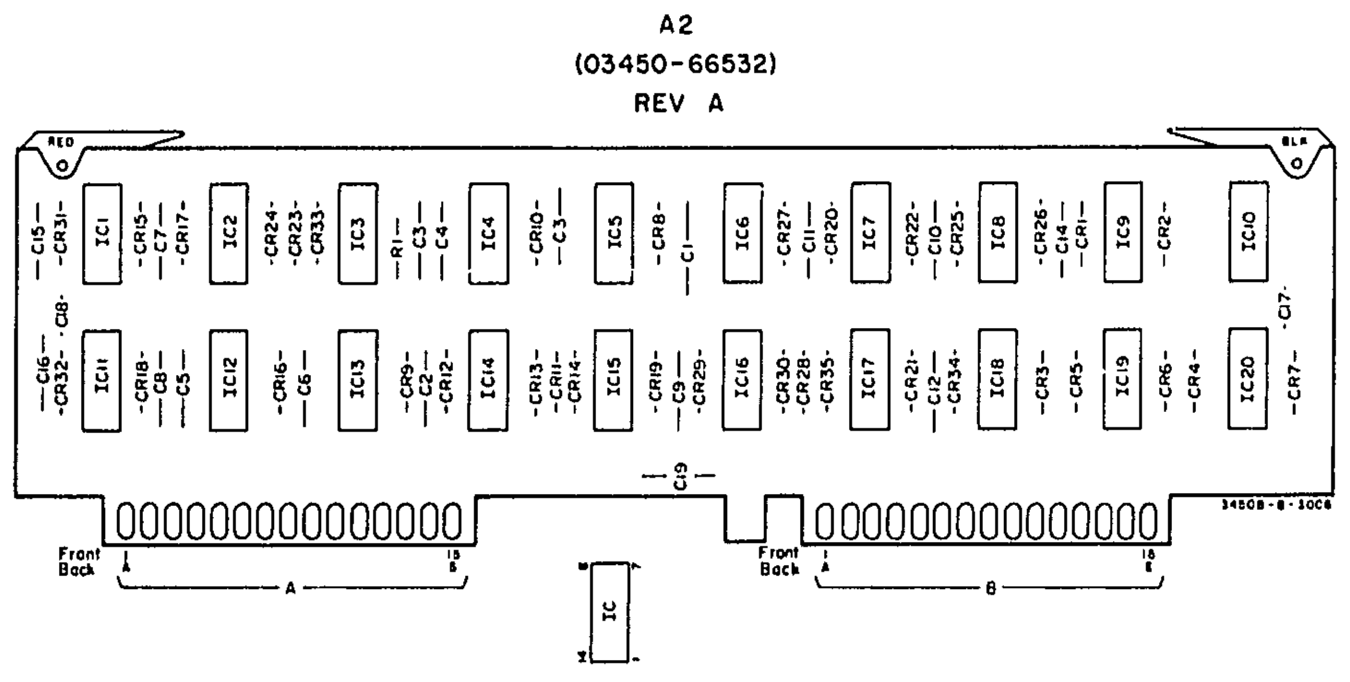


Figure 7-7. Power Supply Diagram.



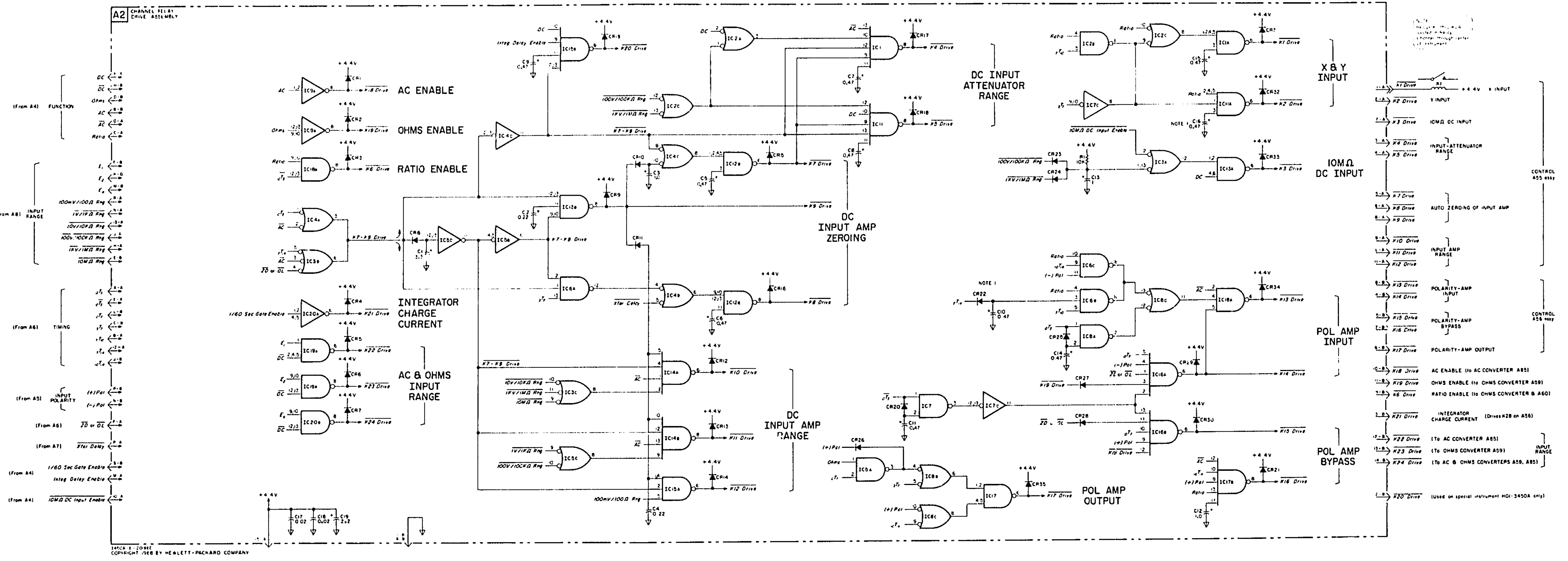
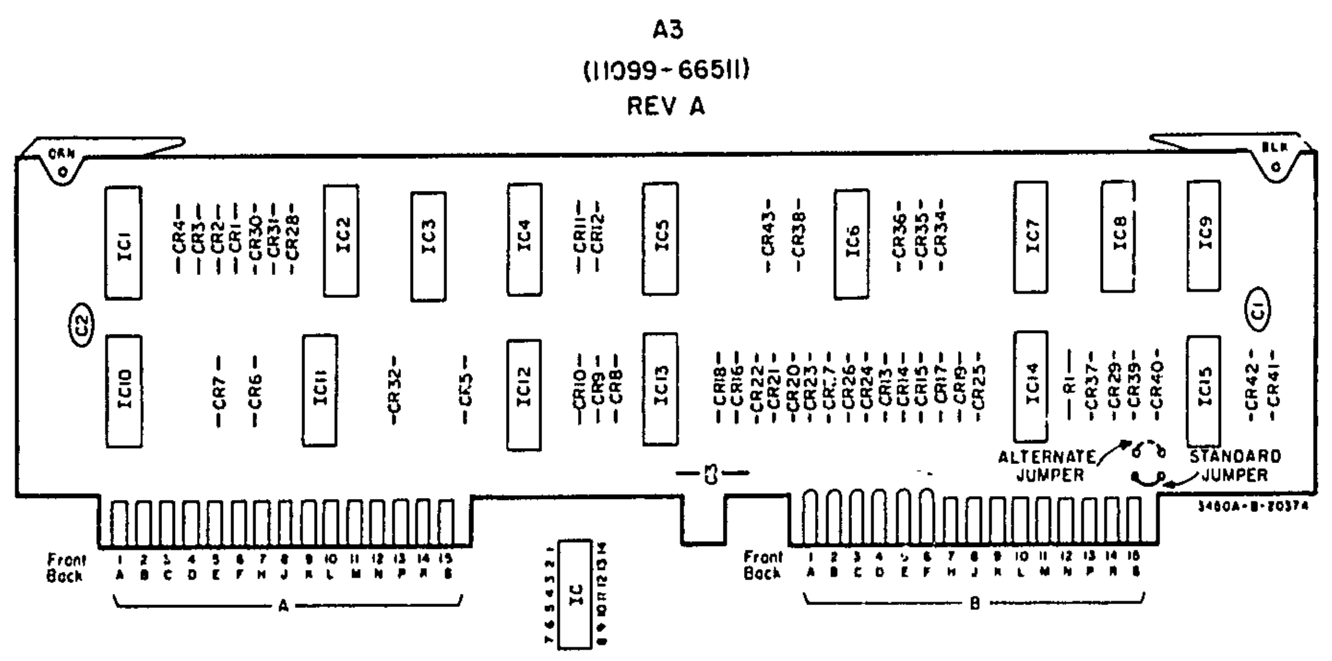


Figure 7-8. Channel Relay Drive Assembly (A2).



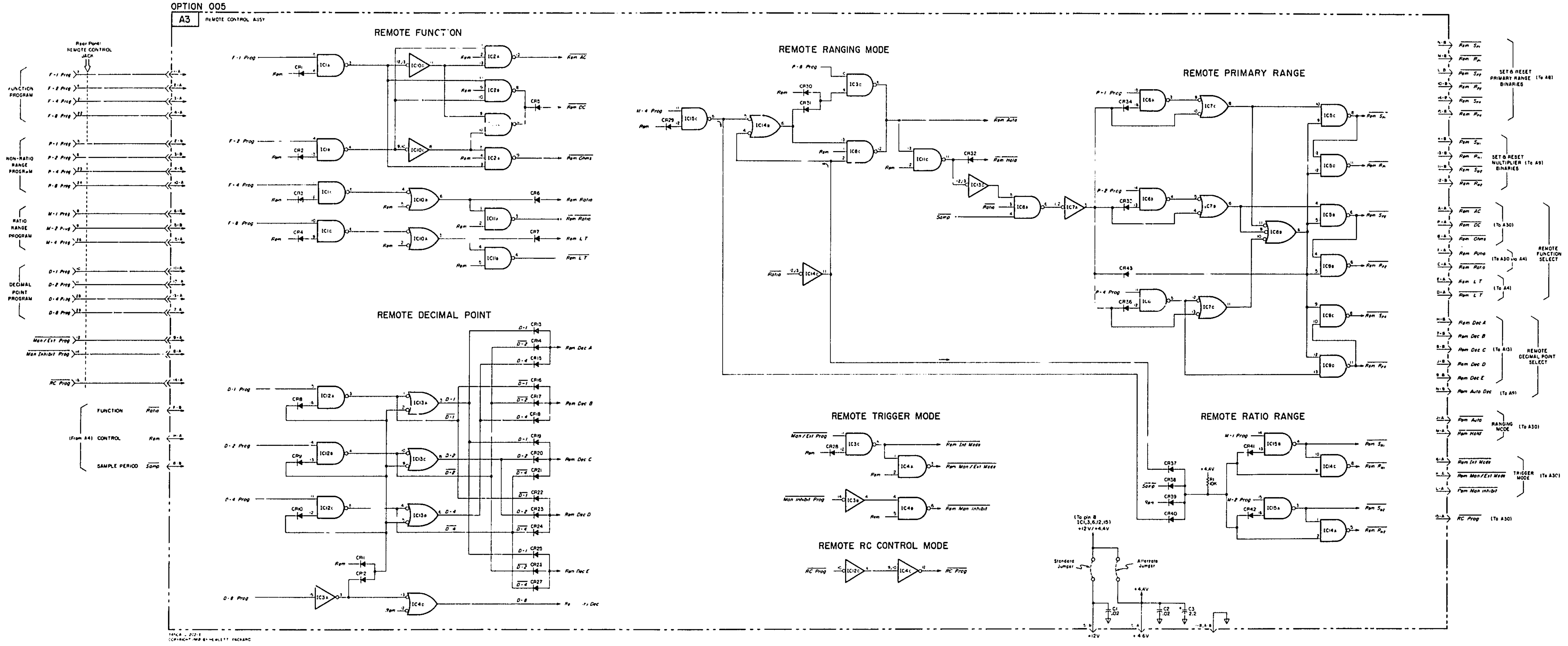


Figure 7-9. Remote Control Assembly (A3).

A4
(03450-66534)
REV A

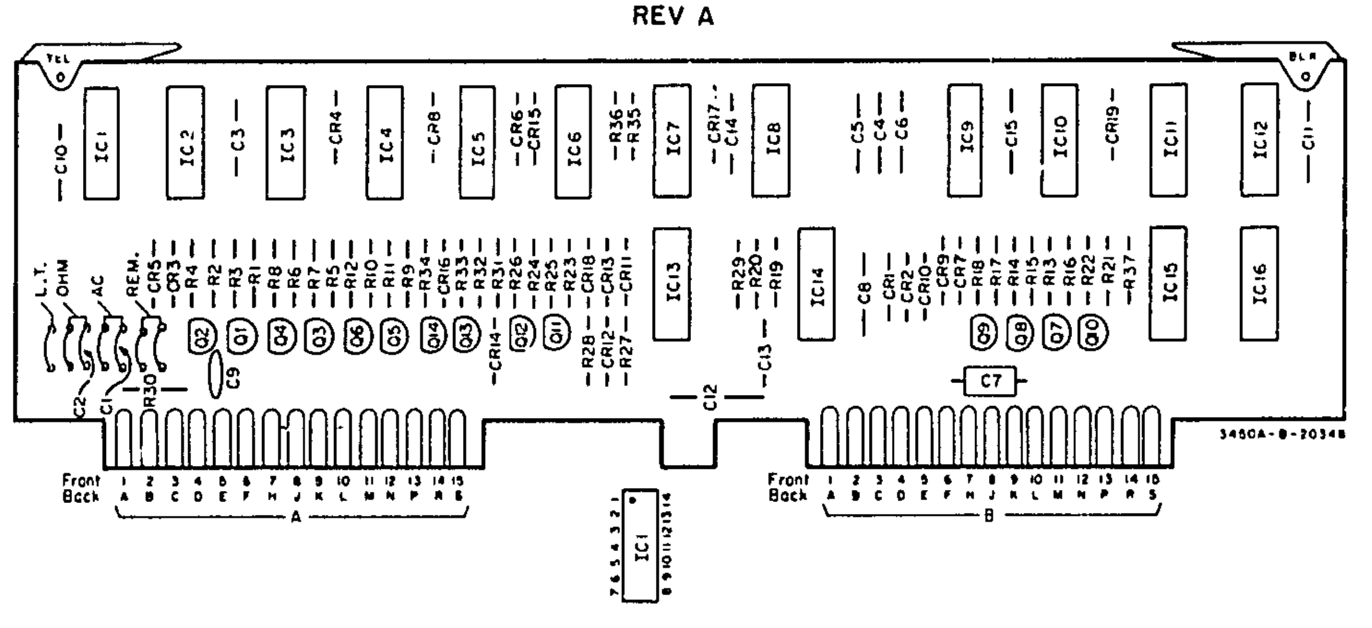
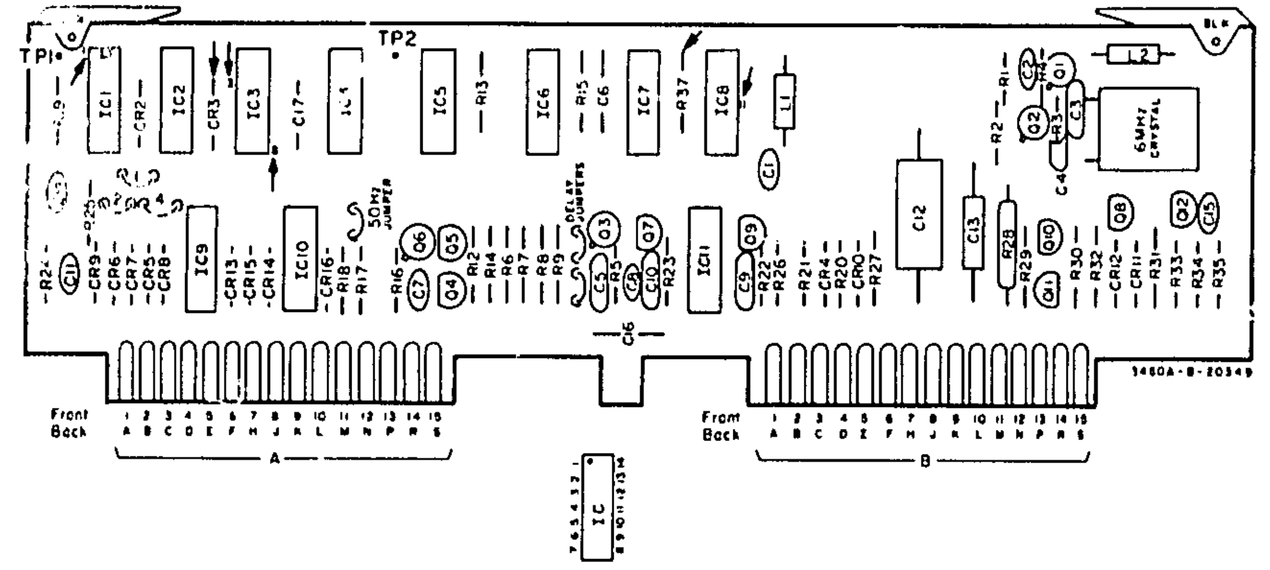
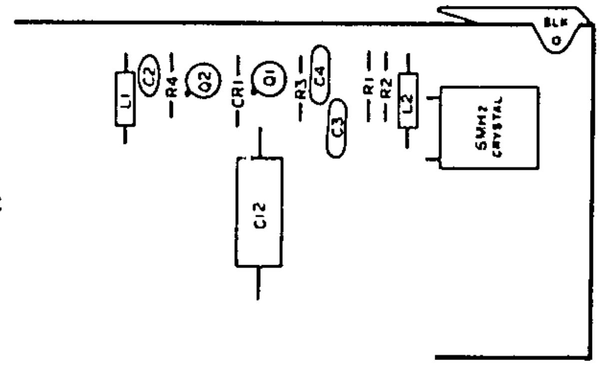


Figure 7-10. Function Assembly (A4).

A5
(03450-66535)
REV A





CR1 in series with R3 replaced by a 10Ω resistor at Serial No. 941-01001.

A5
REV C

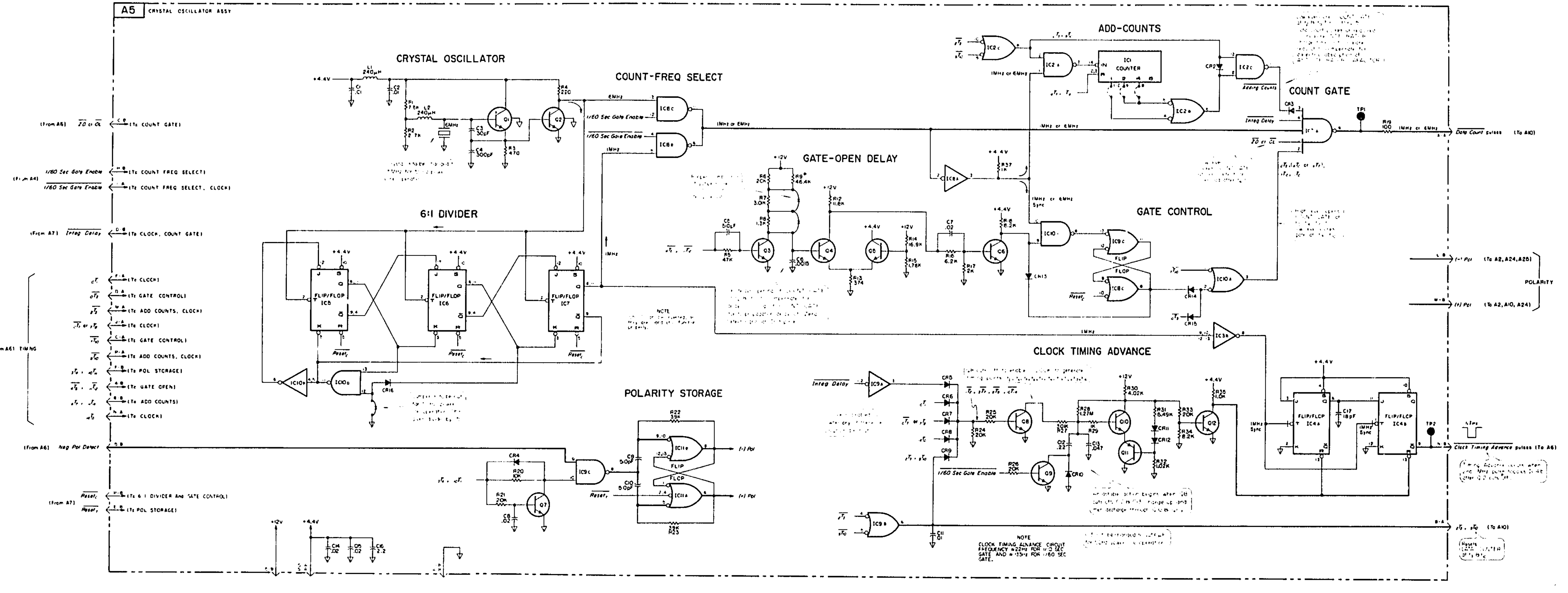
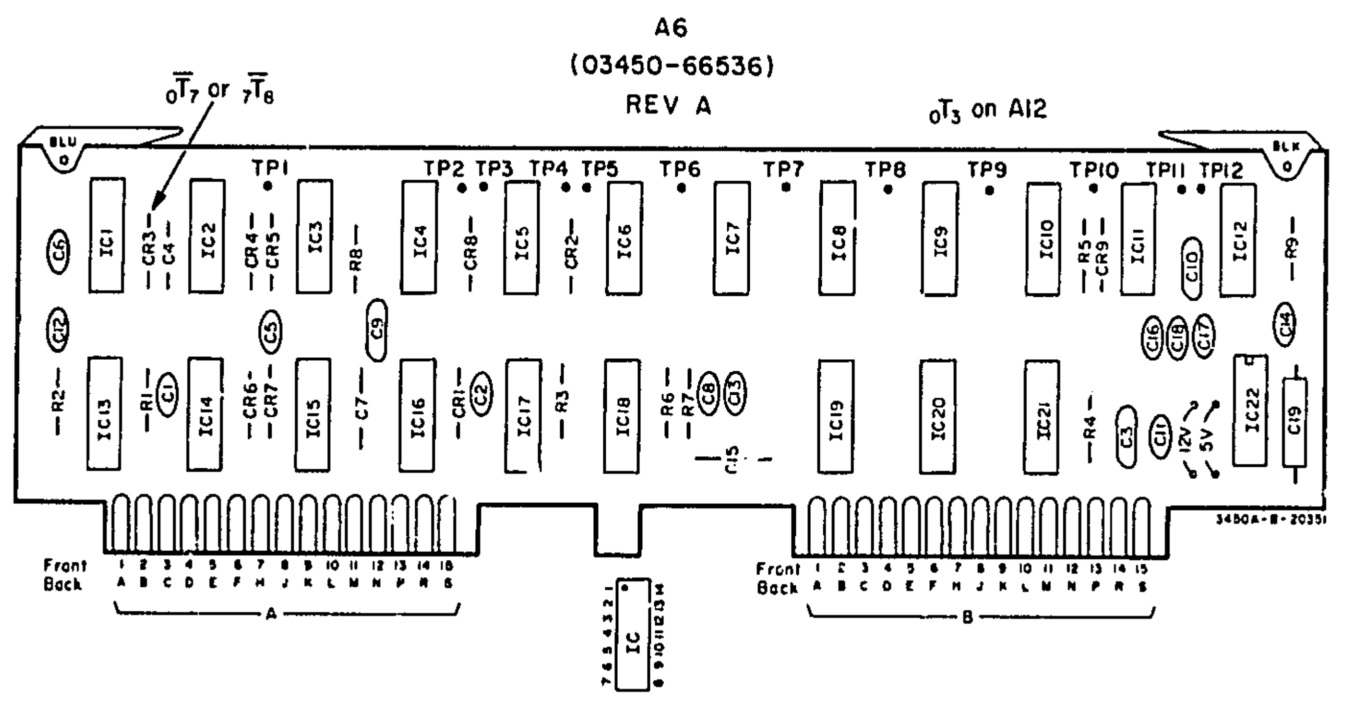


Figure 7-11. Crystal Oscillator Assembly (A5).

NOTE

All timing interval signals that begin at t_7 or later (left subscript is 7 or greater) go true only on Ratio. For example, ${}_7T_{10}$ is true [illegible]igh) only from t_7 to t_{10} on Ratio [illegible] is low from t_{10} of one Sample Period to t_7 of the next, and low full time on non-Ratio.



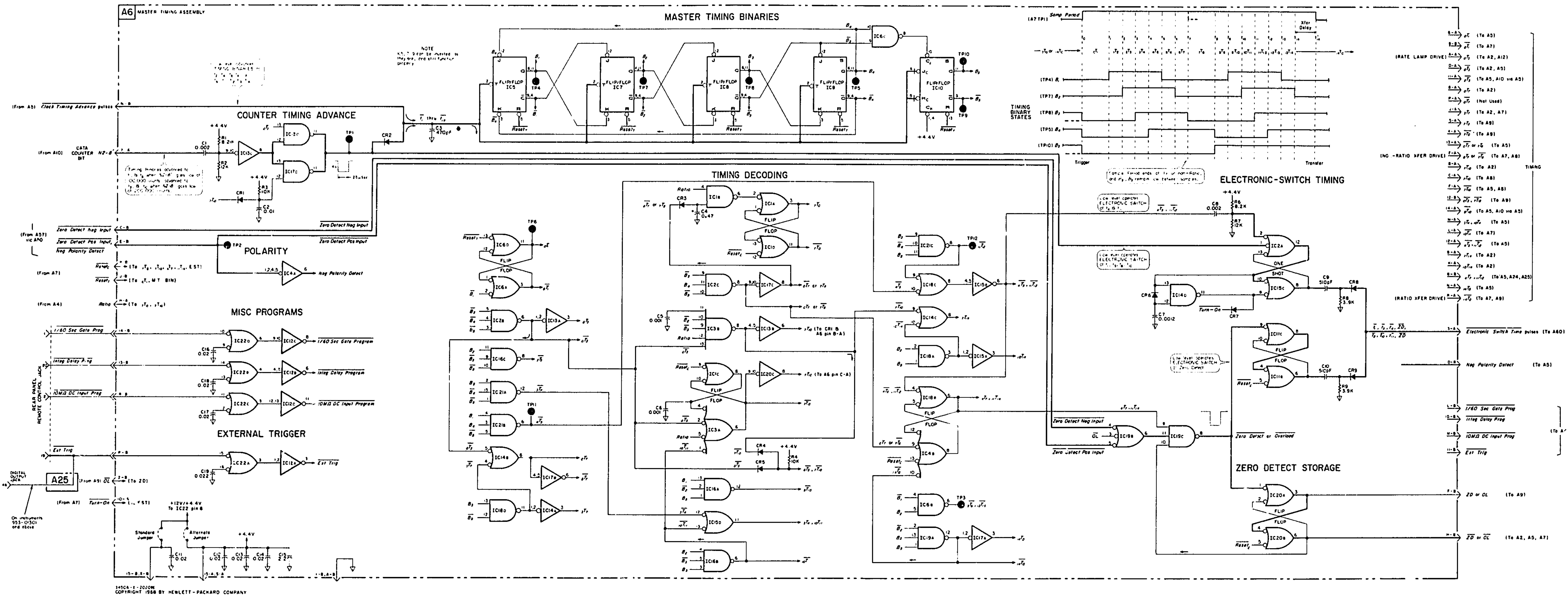
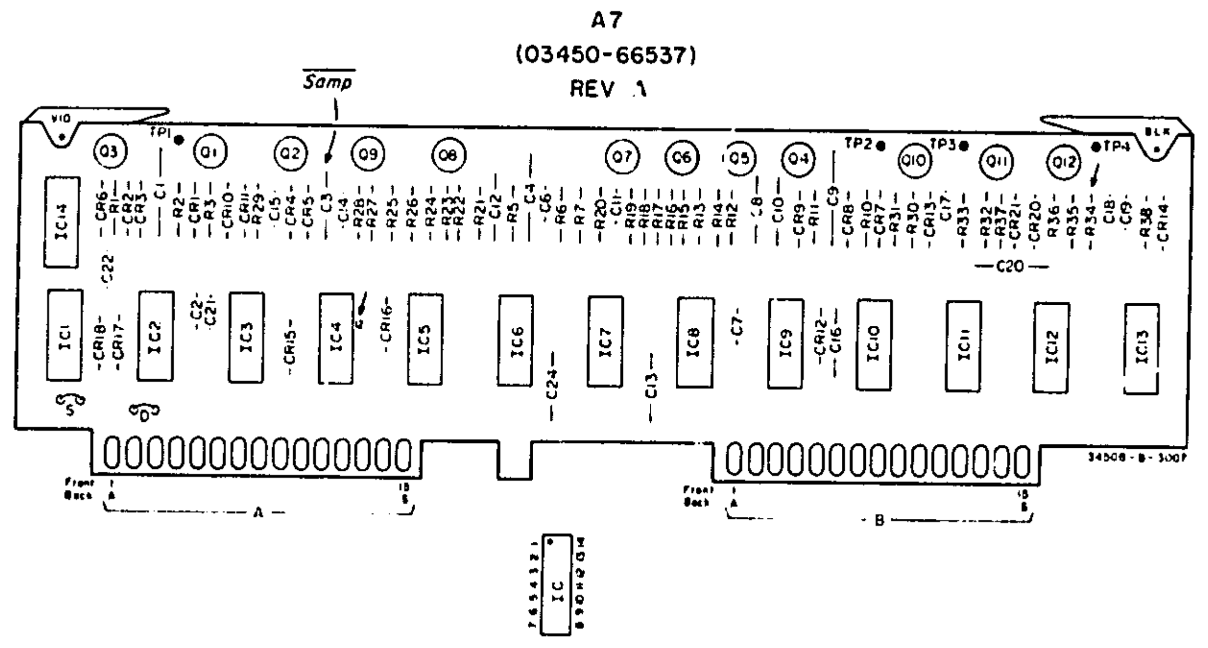


Figure 7-12. Master Timing Assembly (A6).



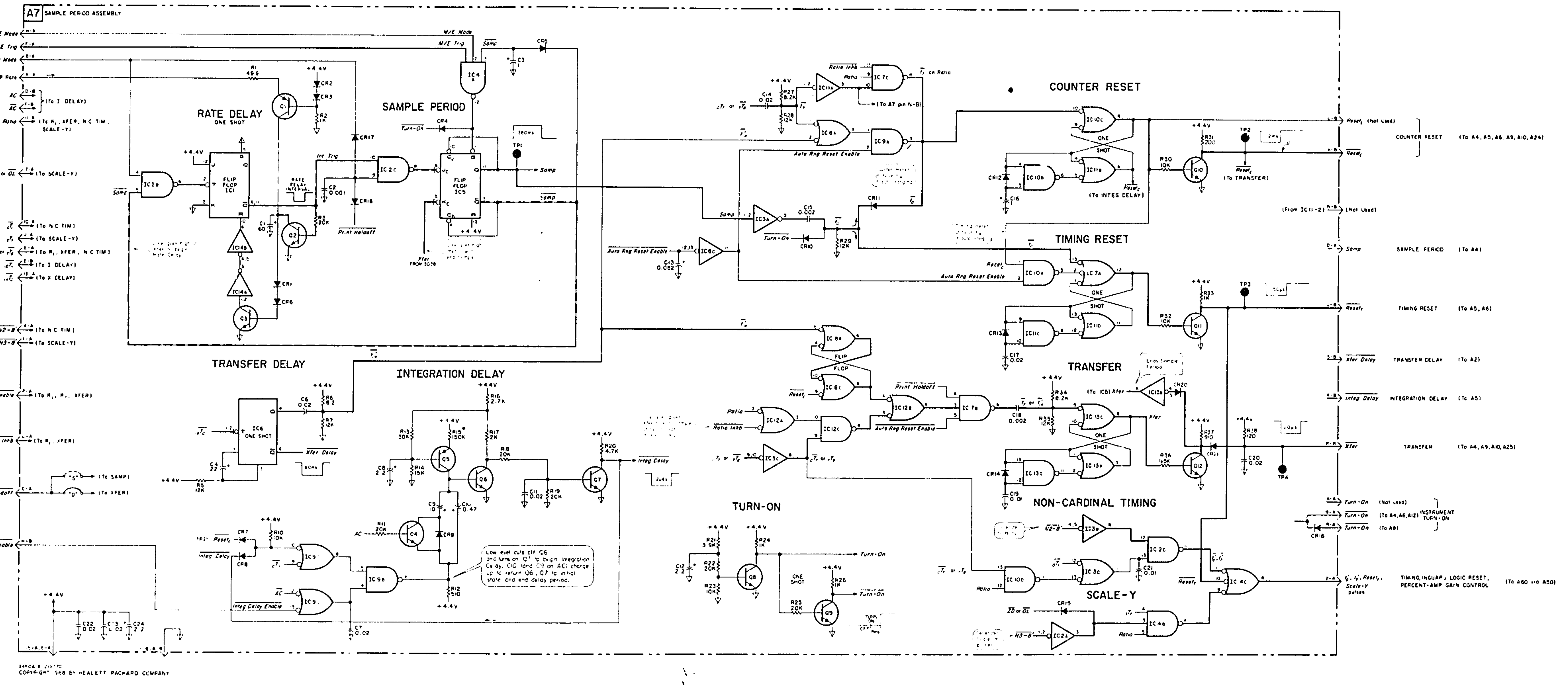


Figure 7-13. Sample Period Assembly (A7).

NON-RATIO RANGE

X Input Range on A8 (determines decimal point) = Primary Range on A8 (full time).

RATIO RANGES

Y denominator Input Range on A8 = Primary Range on A8 (during ${}_{10}T_7$).

X numerator Input Range on A8 = Primary Range on A8 times Ratio (Multiplier) Range on A9 (during ${}_{7}T_{10}$). See table at right.

Ratio Range (determines decimal point) = Ratio (Multiplier) Range on A9 (full time).

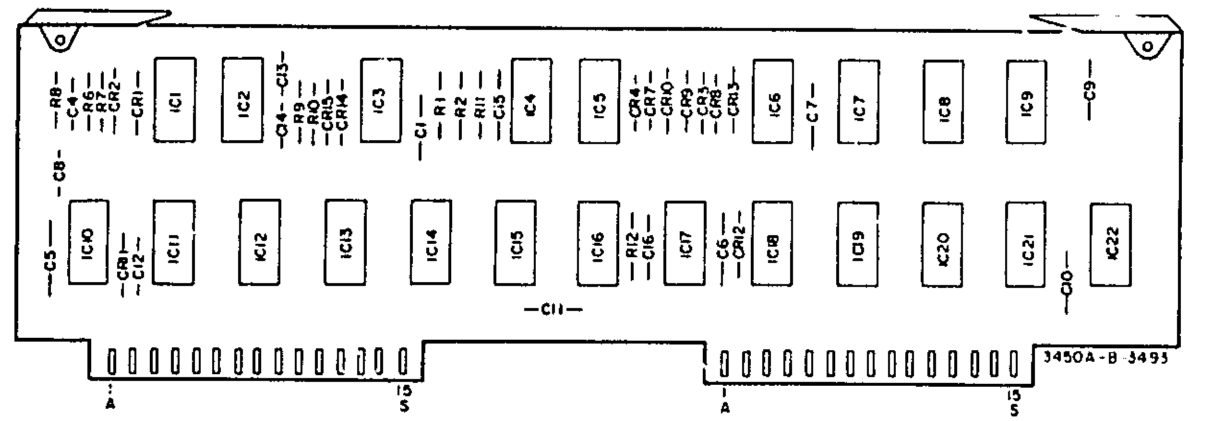
RATIO X NUMERATOR INPUT RANGE DURING ${}_{7}T_{10}$

PRIMARY RNG CODE			MULT RNG CODE		INPUT RNG CODE			PRIMARY RANGE (Y)	RATIO RANGE	X INPUT RANGE	DECIMAL POINT
P_1	P_2	P_4	M_1	M_2	E_1	E_2	E_4				
1	0	0	0	0	1	0	0	10MΩ	X1	10MΩ	A
0	1	0	0	0	0	1	0	1KV/1MΩ	X1	1KV/1MΩ	A
1	1	0	0	0	1	1	0	100V/100KΩ	X1	100V/100KΩ	A
0	0	1	0	0	0	0	1	10V/10KΩ	X1	10V/10KΩ	A
1	0	1	0	0	1	0	1	1V/1KΩ	X1	1V/1KΩ	A
0	1	0	1	0	1	0	0	1MΩ	X10	10MΩ	B
1	1	0	1	0	0	1	0	100V/100KΩ	X10	1KV/1MΩ	B
0	0	1	1	0	1	1	0	10V/10KΩ	X10	100V/100KΩ	B
1	0	1	1	0	0	0	1	1V/1KΩ	X10	10V/10KΩ	B
1	1	0	0	1	1	0	0	100KΩ	X100	10MΩ	C
0	0	1	0	1	0	1	0	10V/10KΩ	X100	1KV/1MΩ	C
1	0	1	0	1	1	1	0	1V/1KΩ	X100	100V/100KΩ	C
0	0	1	1	1	1	0	0	10KΩ	X1000	10MΩ	D
1	0	1	1	1	0	1	0	1V/1KΩ	X1000	1KV/1MΩ	D

3450A-B-20242

N1 . N2 . N3 . N4 . N5 . N6 DISPLAY

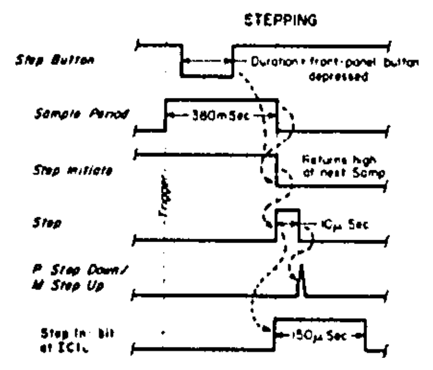
A B C D E DECIMAL POINT



A8

hp Part No. 03450-66538

Rev. B



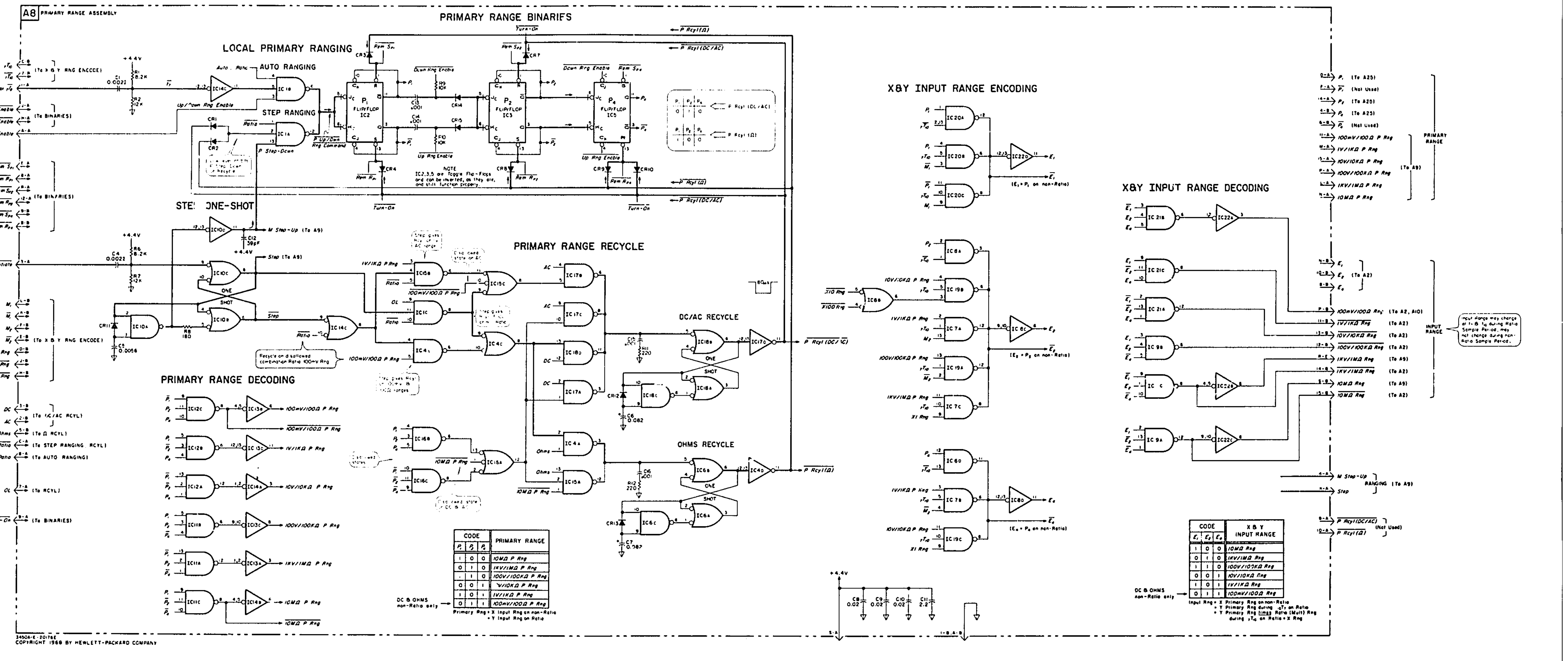
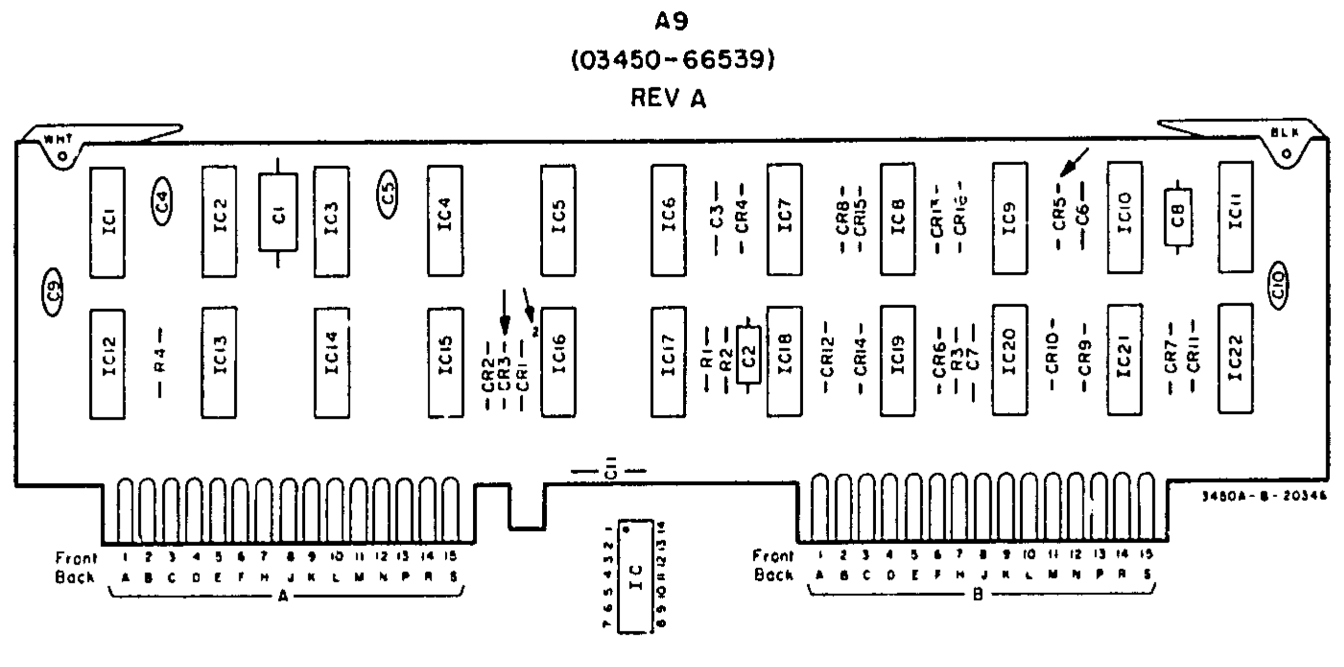


Figure 7-14. Primary Range Assembly (A8).



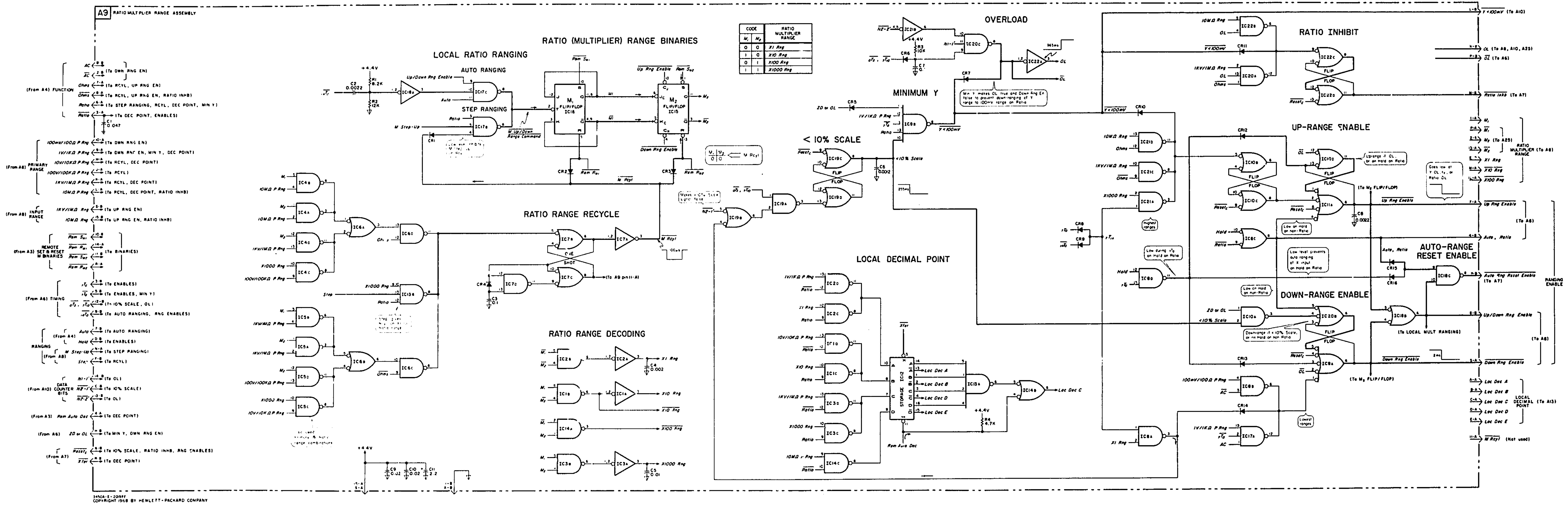
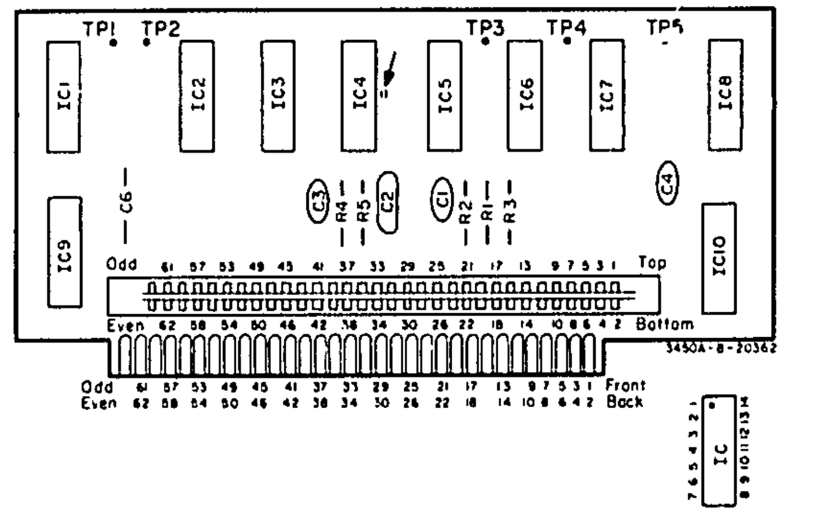
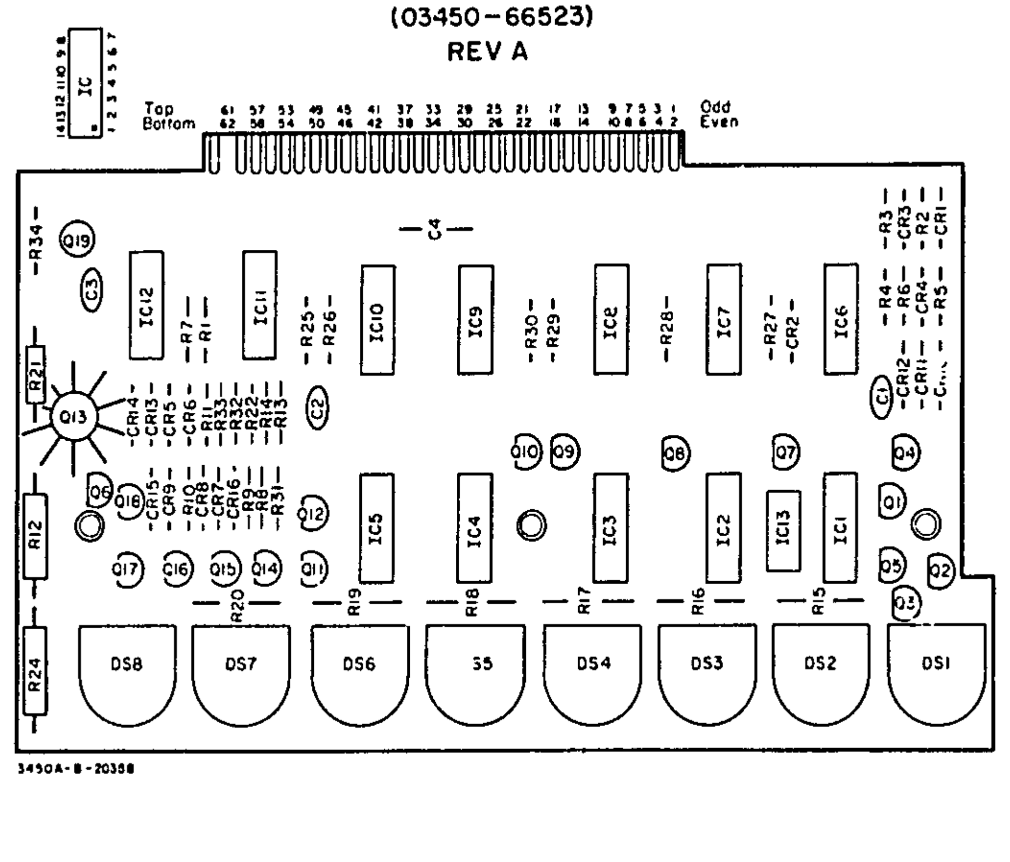


Figure 7-15. Ratio Multiplier Range Assembly (A9).

A10
(03450-66540)
REV A



A13
(03450-66523)
REV A



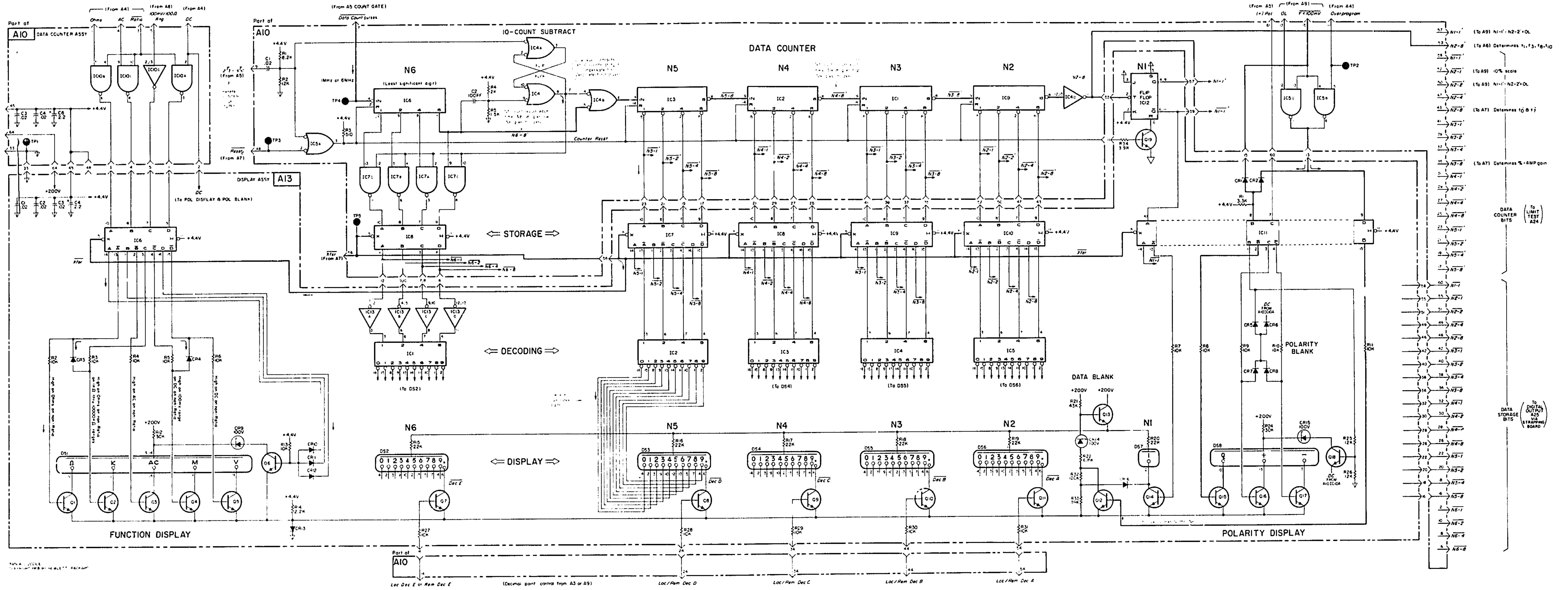
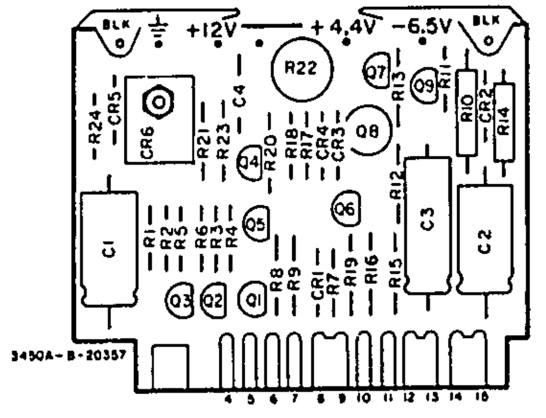
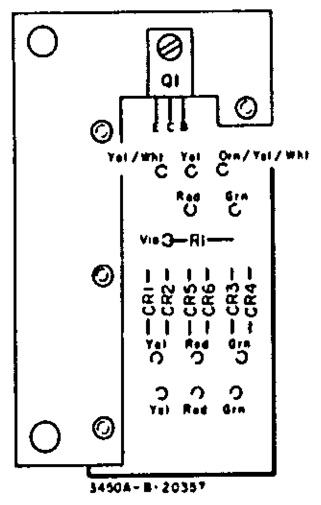


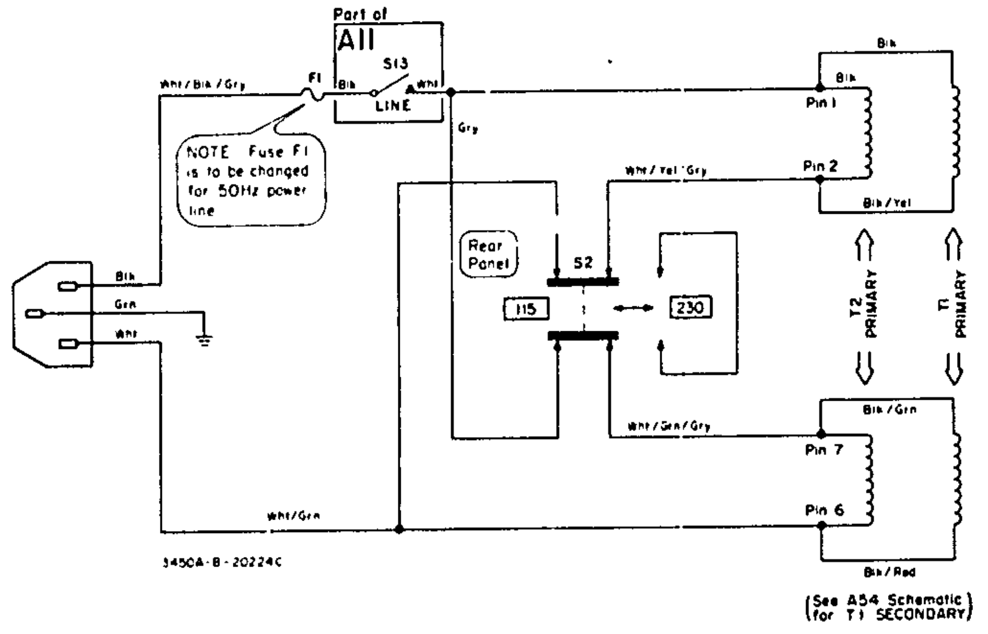
Figure 7-16. Data Counter and Display Assemblies (A10, A13).

A14
(03450-66514)
REV B



A15
(03450-66515)
REV B





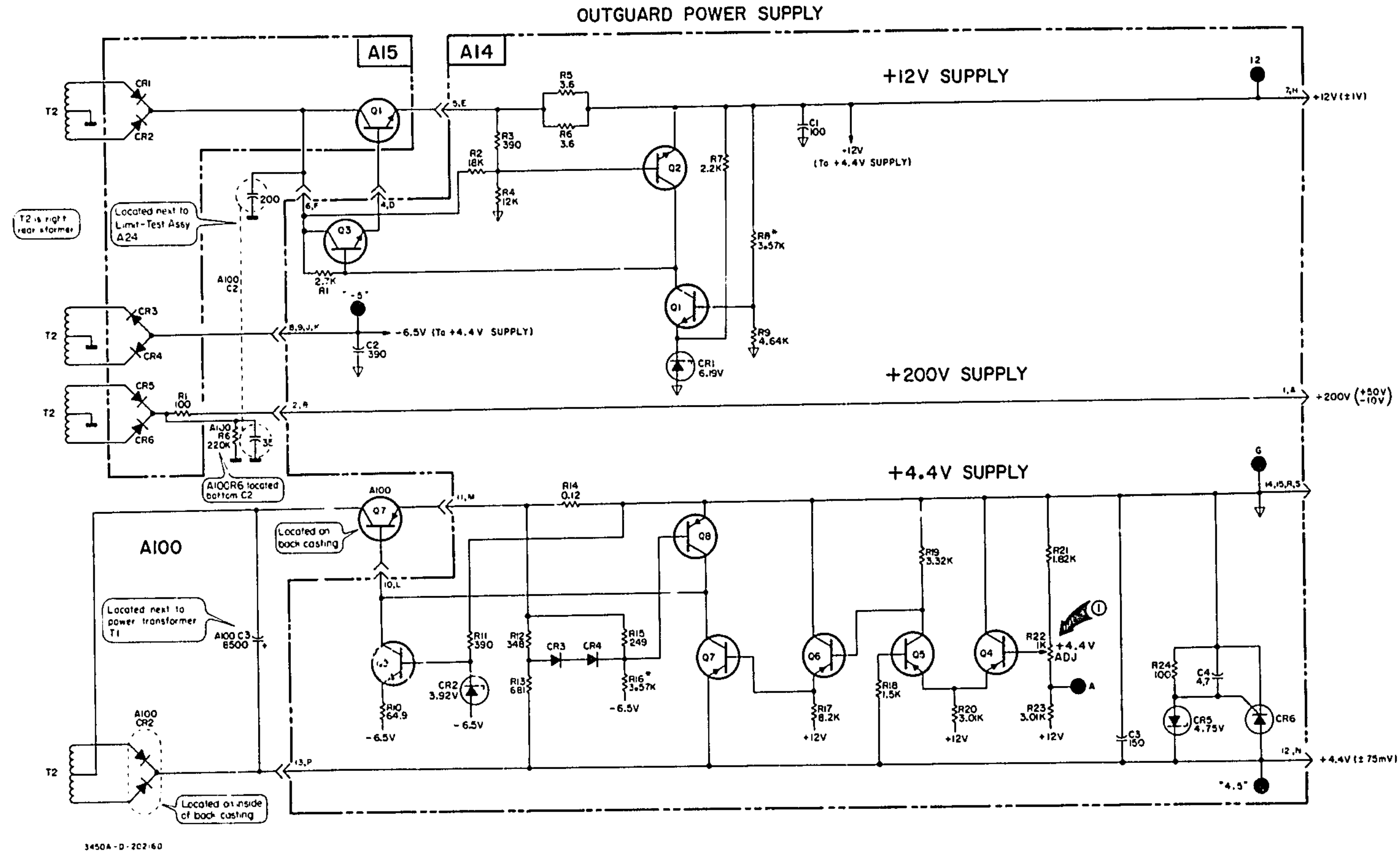
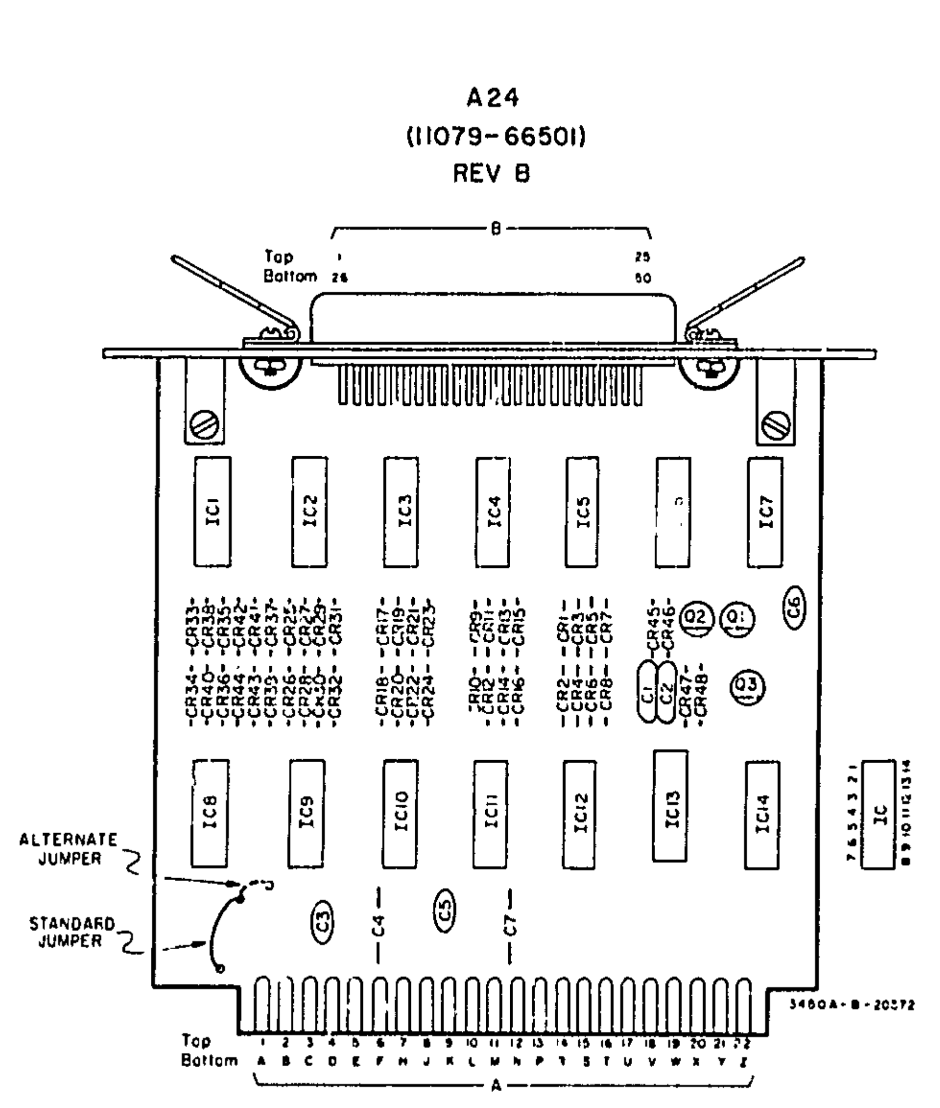


Figure 7-17. Outguard Power Supply Assemblies (A14, A15).



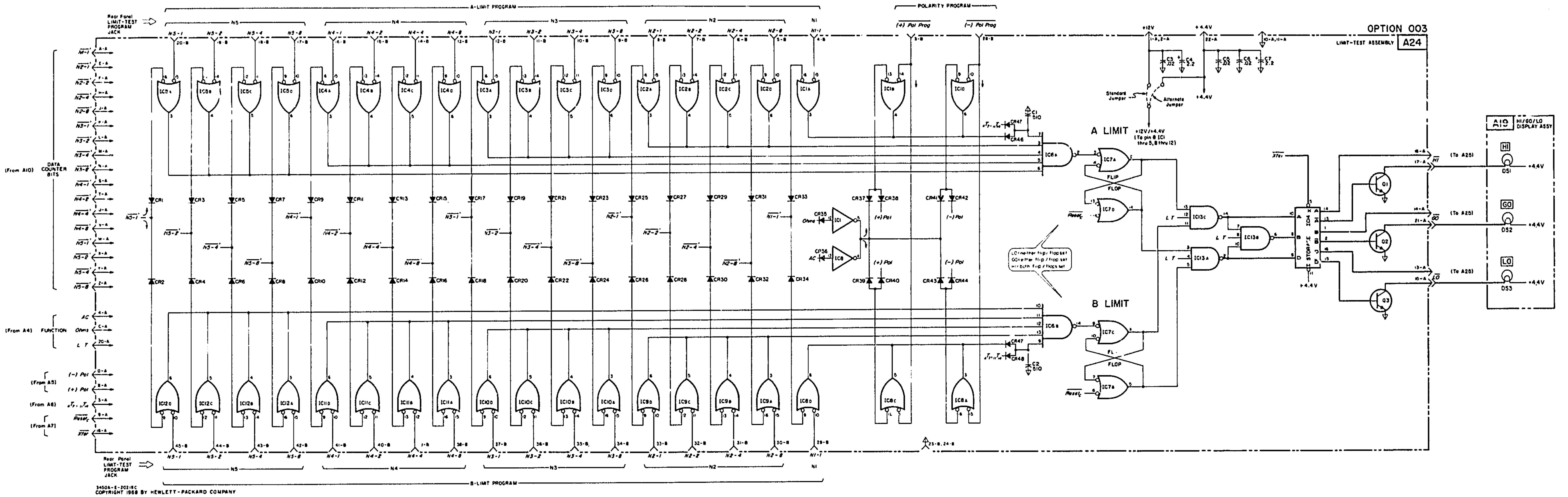
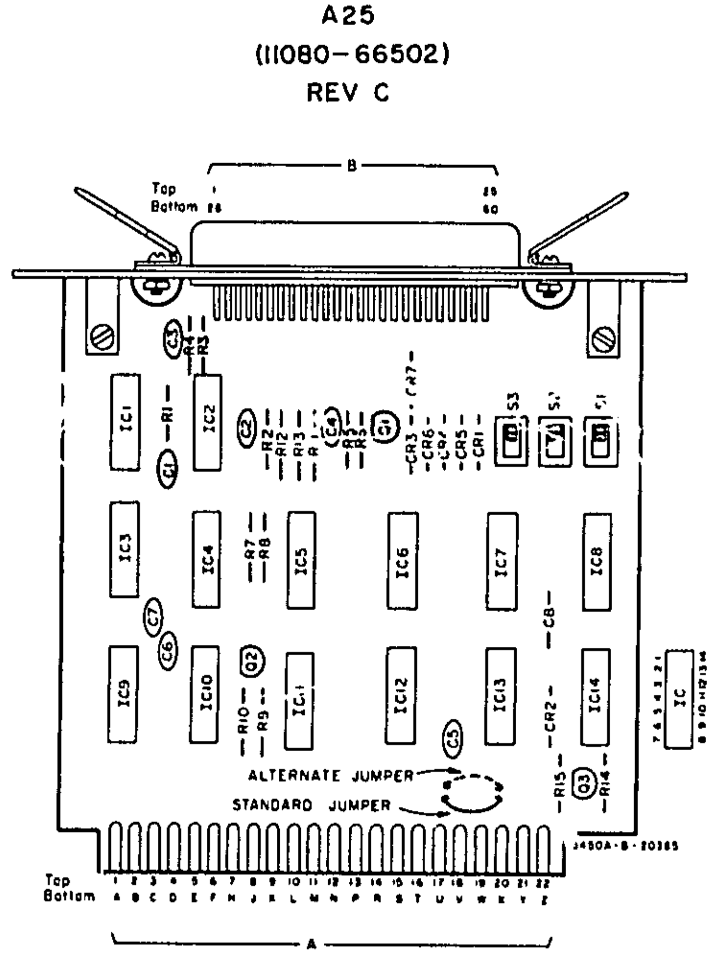
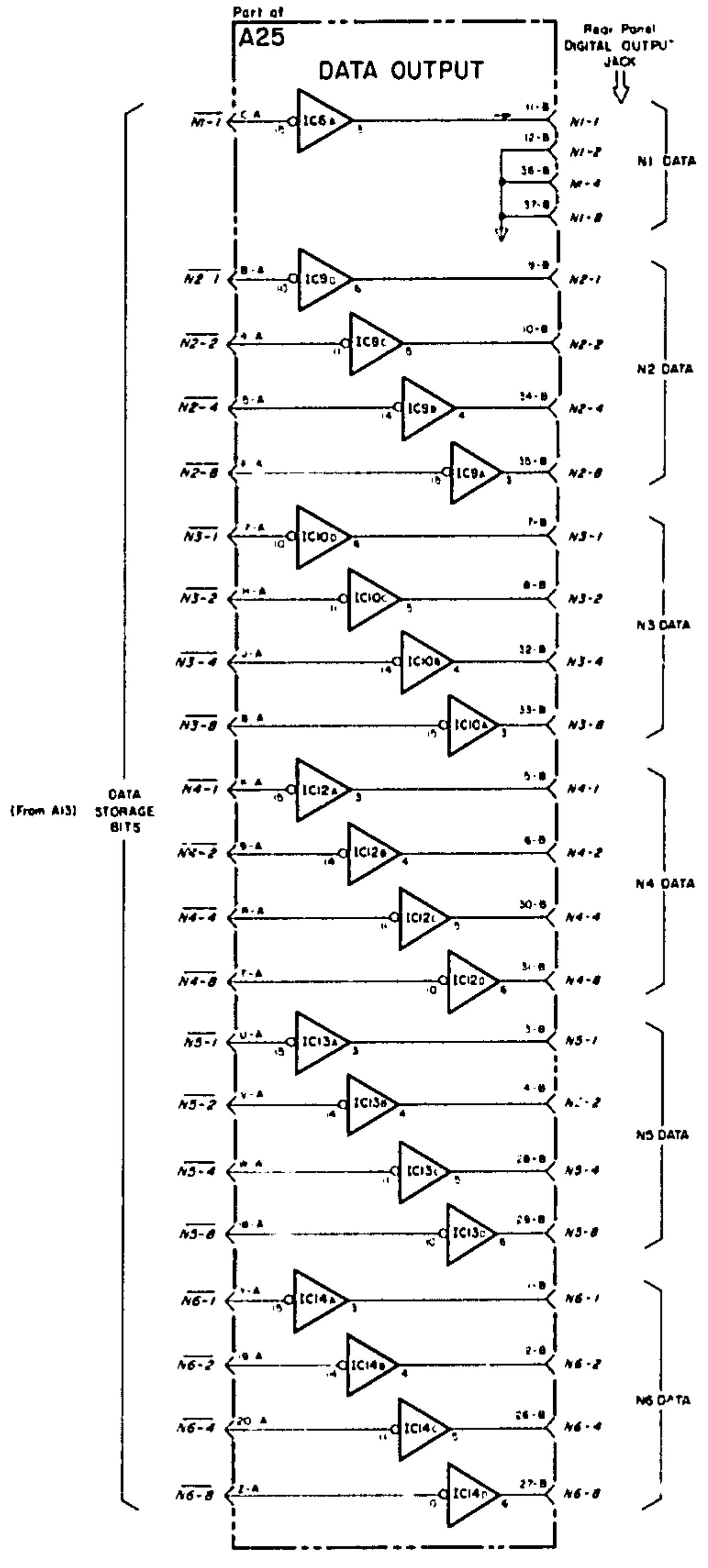


Figure 7-18. Limit Test Assemblies (A19, A24).



NOTE: Change A25R7 to 1.07 kΩ 0698-4196, and R8 to diode 1910-0016 for Alternate logic levels.



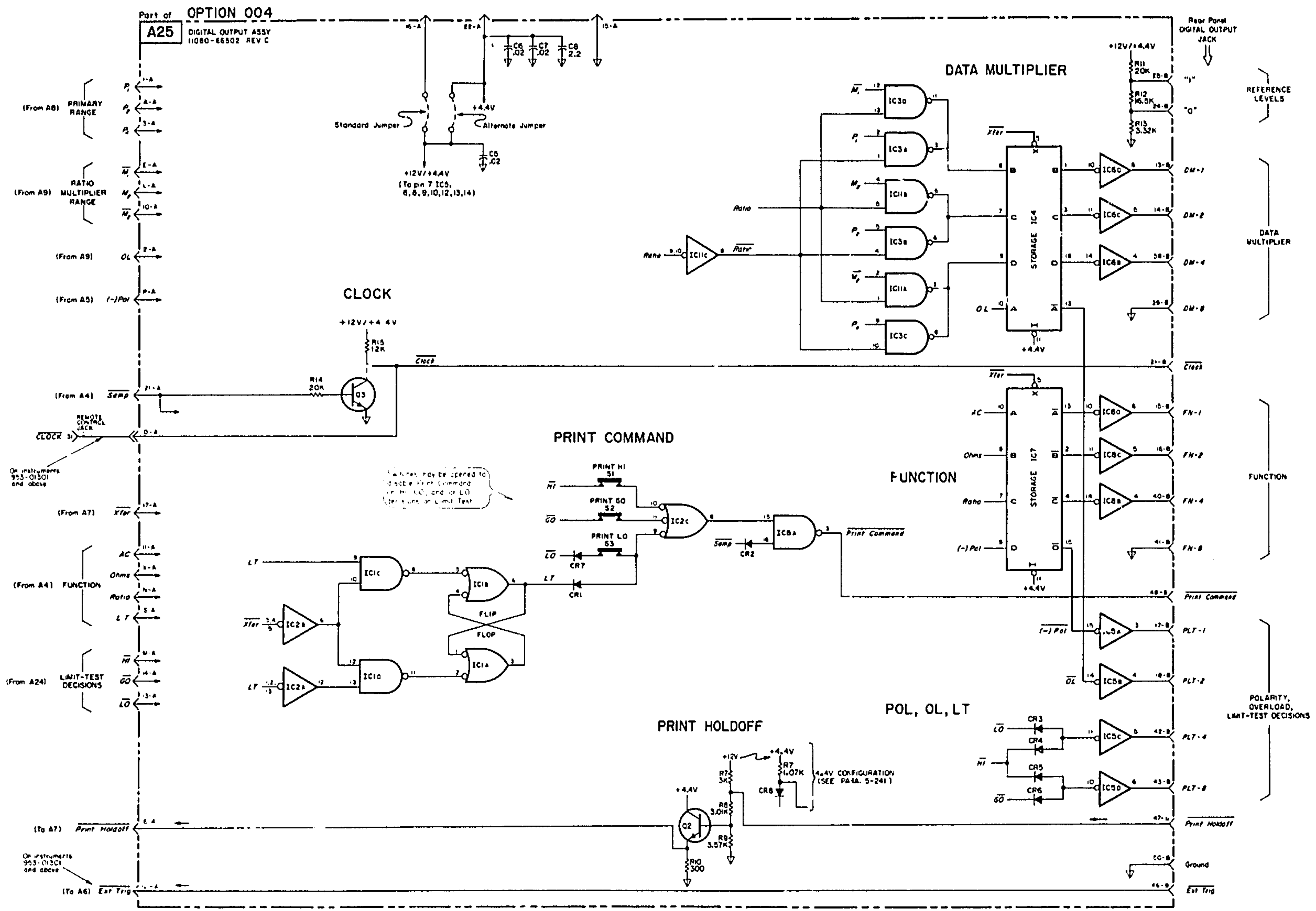
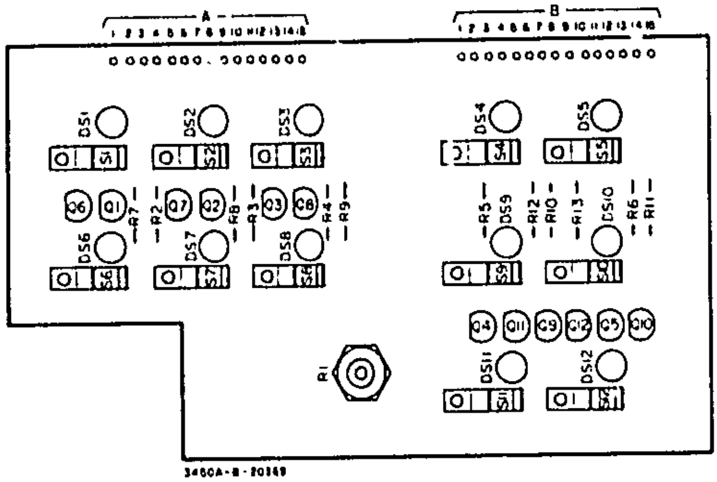
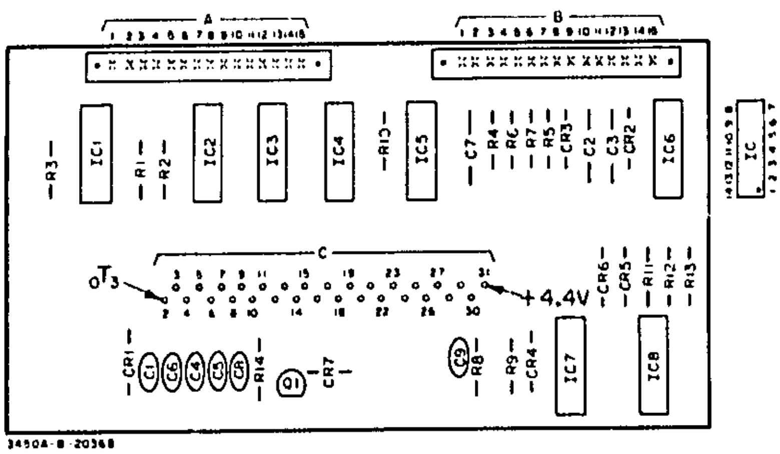


Figure 7-19. Digital Output Assembly (A25).

A11
(03450-66511)



A12
(03450-66542)



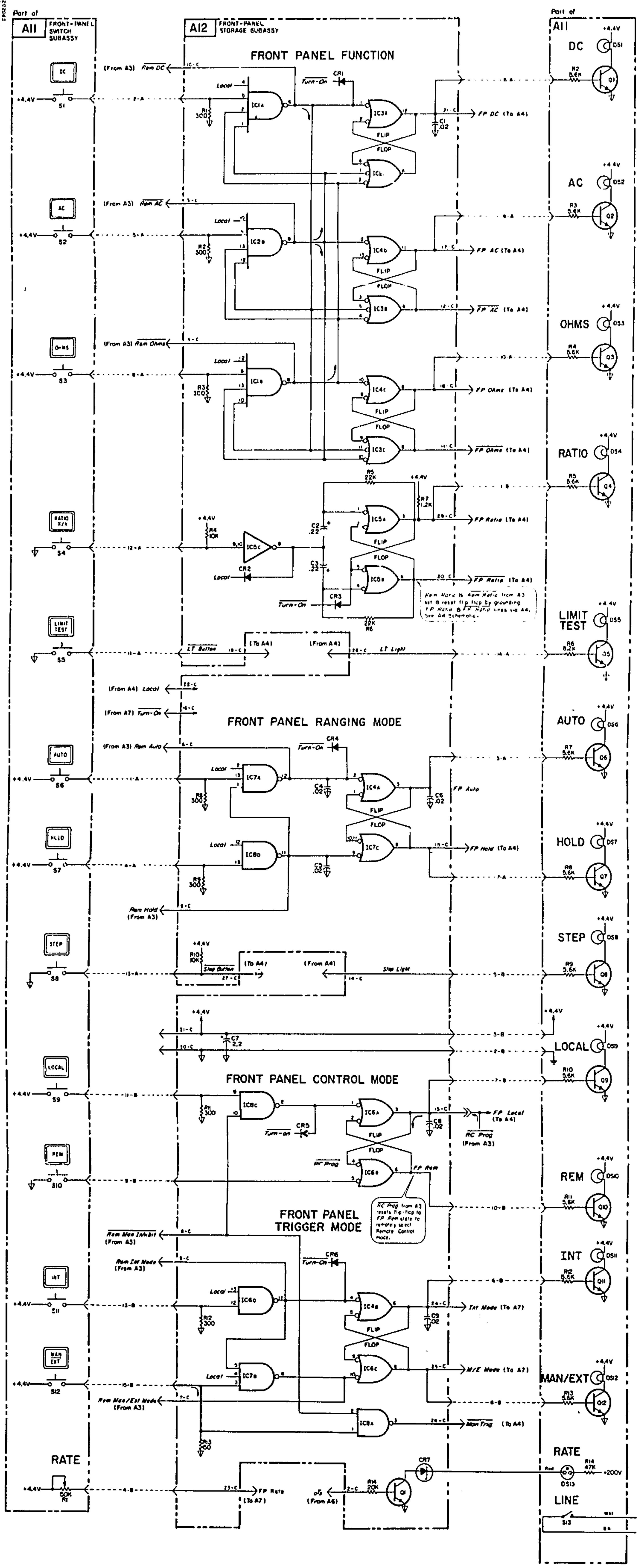
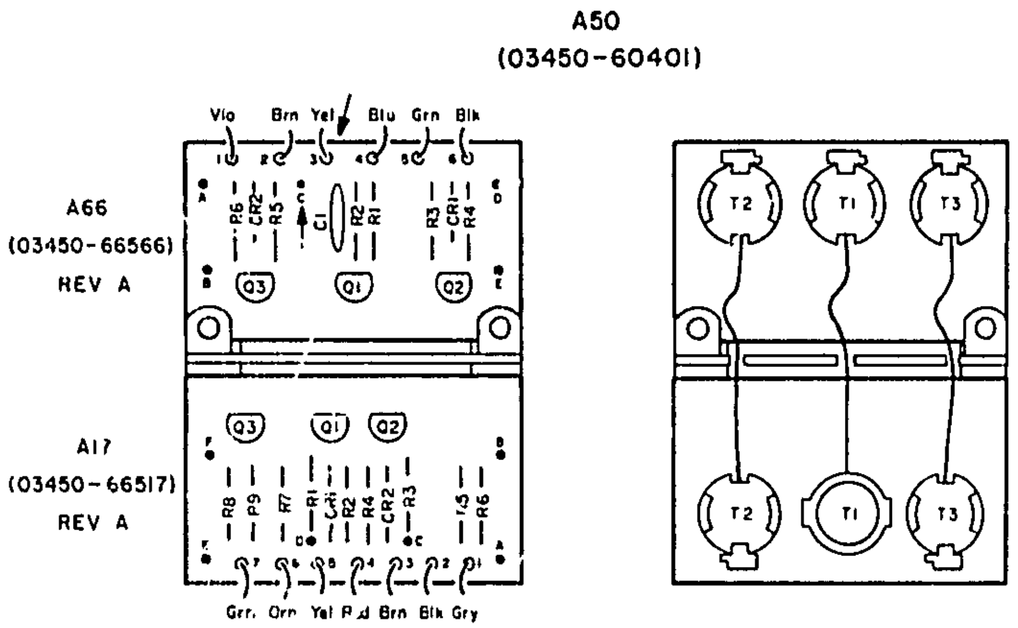


Figure 7-20. Front Panel Assemblies (A11, A12).



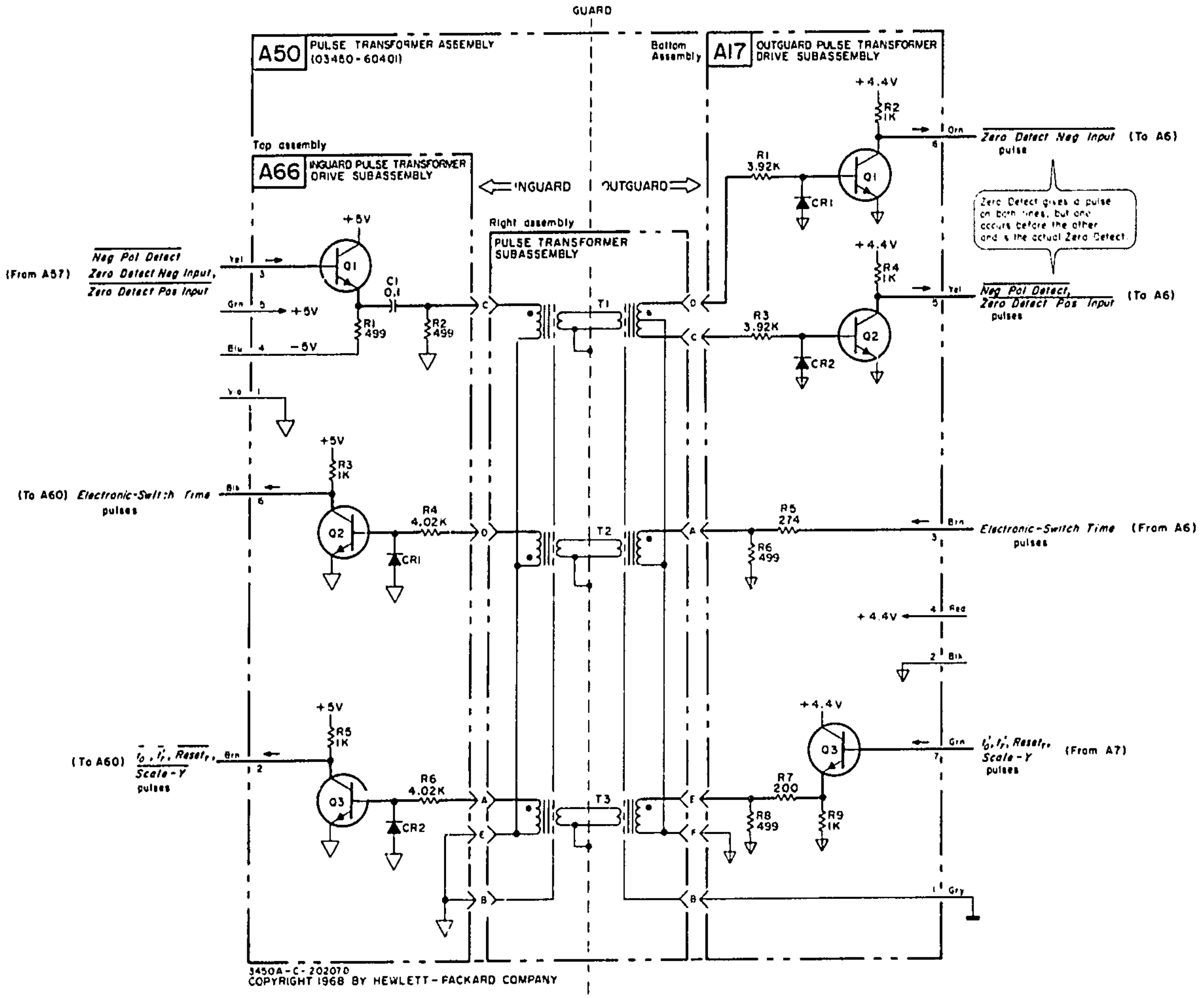
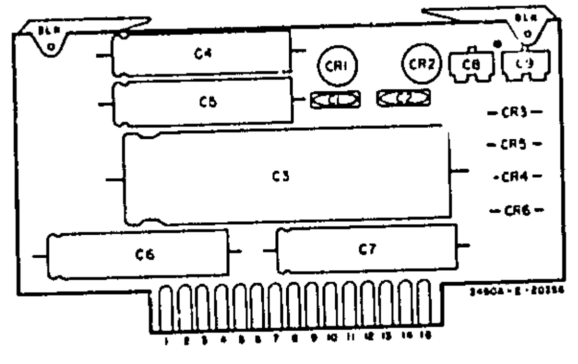
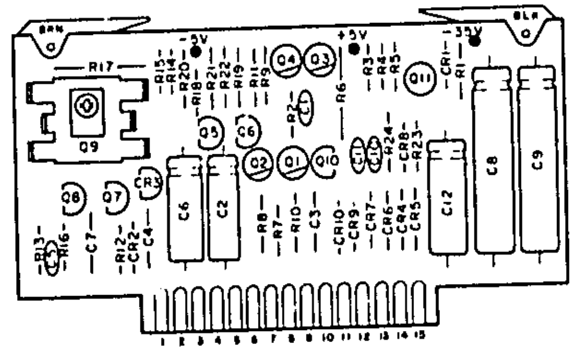


Figure 7-21. Pulse Transformer Assembly (A50)

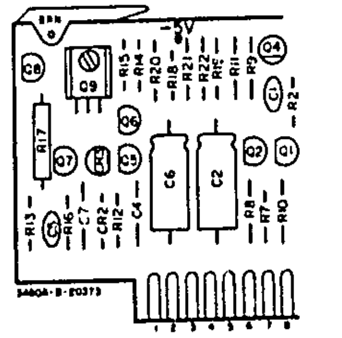
A52
(03450-66552)
REV C



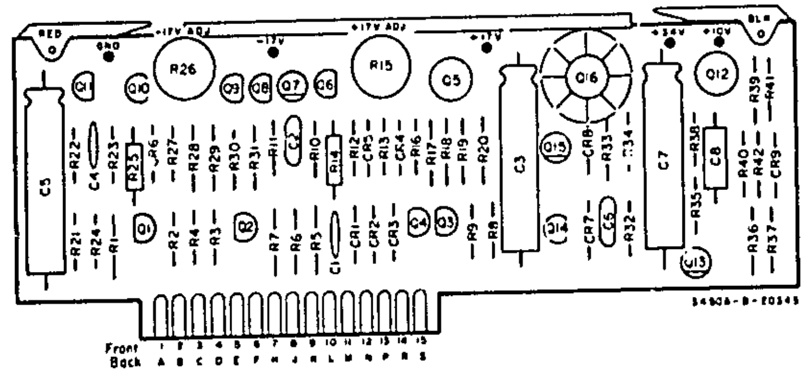
A53
(03450-66553)
REV C



A53
REV B



A54
(03450-66554)
REV A



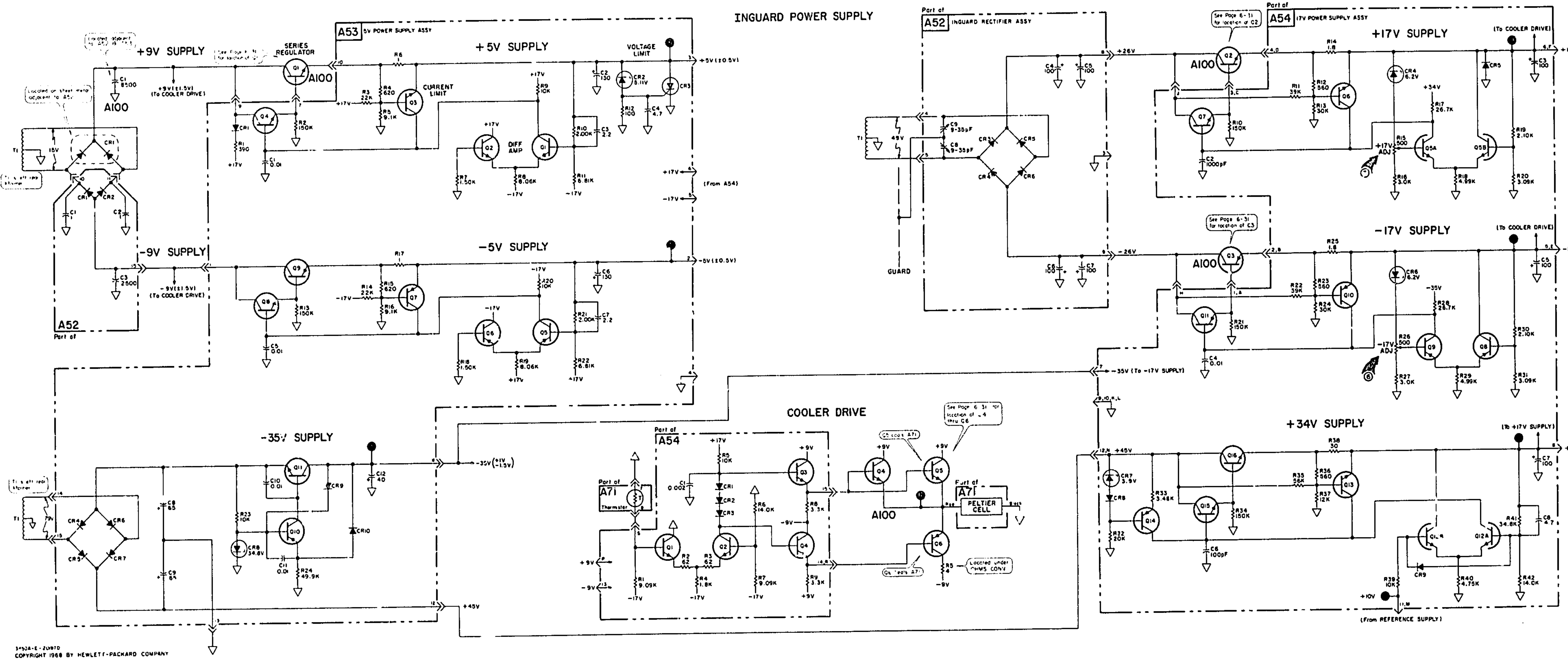
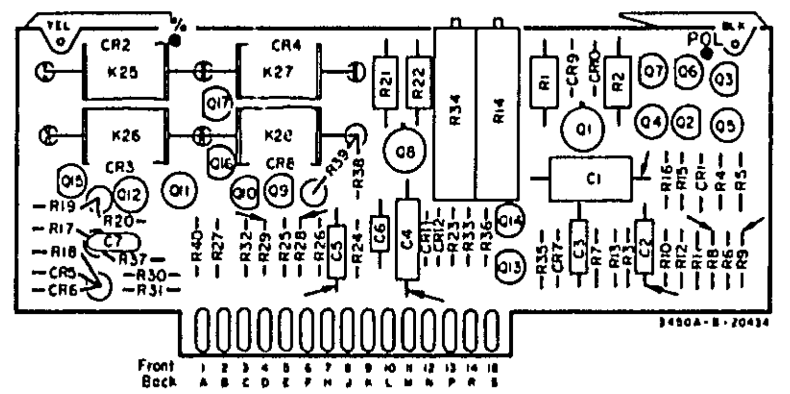
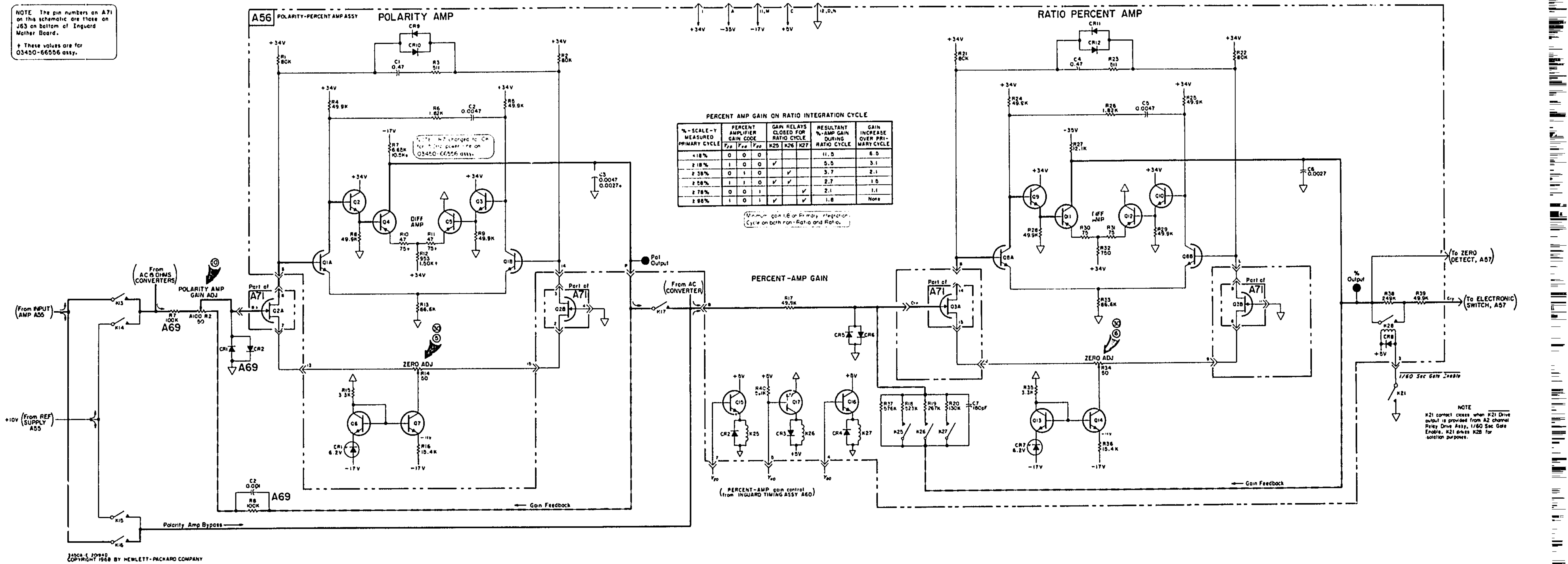


Figure 7-22. Inguard Power Supply Assemblies (A52, A53, A54).

Figure 7-23. Input Amplifier Assembly (A55).

A56
(03450-66586)
REV A

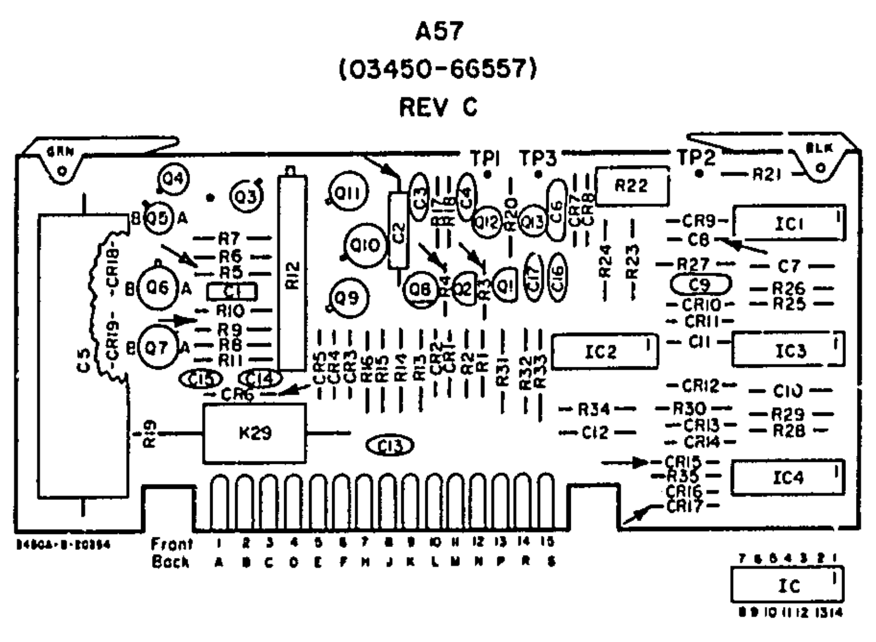




PERCENT AMP GAIN ON RATIO INTEGRATION CYCLE

%-SCALE-Y MEASURED PRIMARY CYCLE	PERCENT AMPLIFIER GAIN CODE			GAIN RELAYS CLOSED FOR RATIO CYCLE			RESULTANT %-AMP GAIN DURING RATIO CYCLE	GAIN INCREASE OVER PRIMARY CYCLE
	Y_{10}	Y_{20}	Y_{40}	K25	K26	K27		
<18%	0	0	0				11.8	6.6
≥18%	1	0	0	✓			5.6	3.1
≥38%	0	1	0		✓		3.7	2.1
≥58%	1	1	0	✓	✓		2.7	1.5
≥78%	0	0	1			✓	2.1	1.1
≥98%	1	0	1	✓		✓	1.8	None

Figure 7-24. Polarity Amp Assembly (A56).



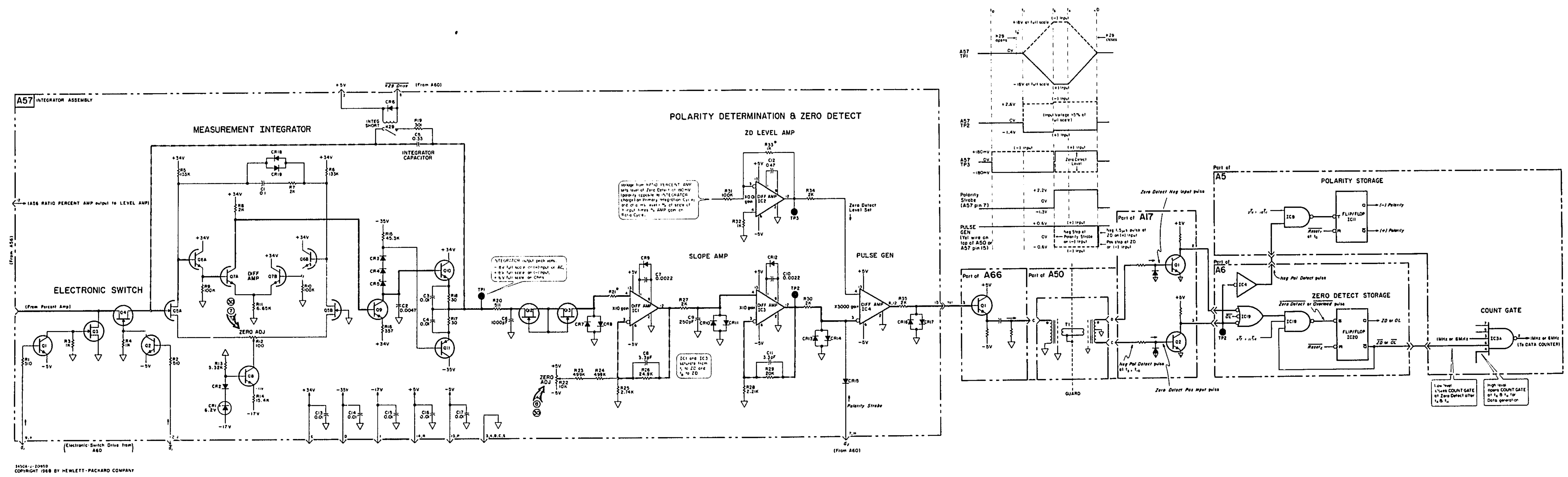
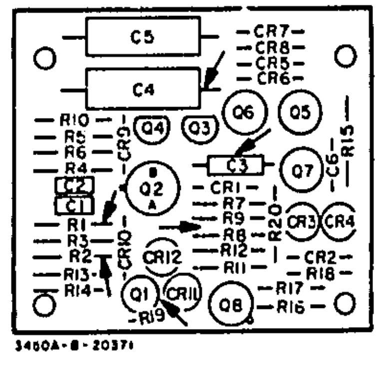
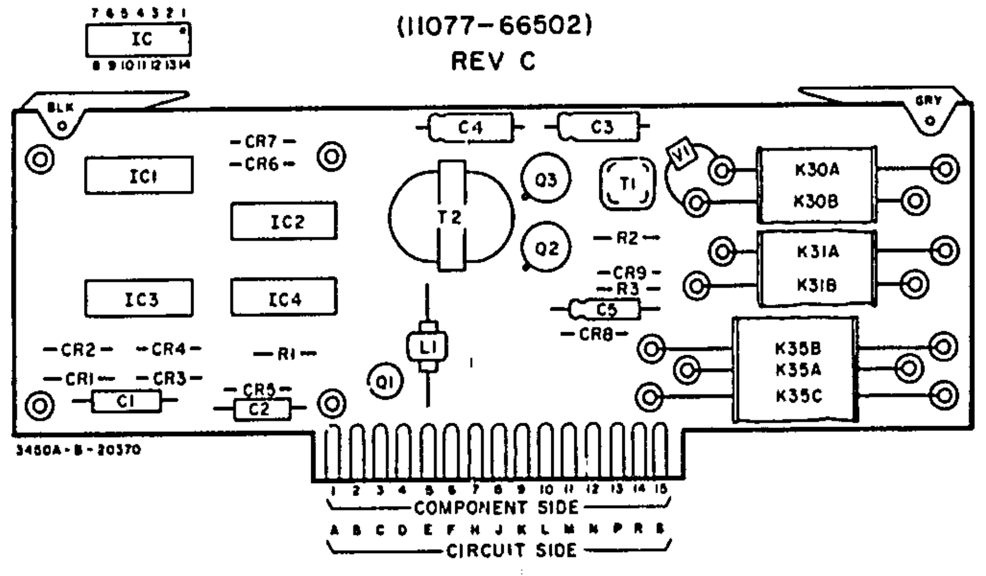


Figure 7-25. Integrator Assembly (A57).

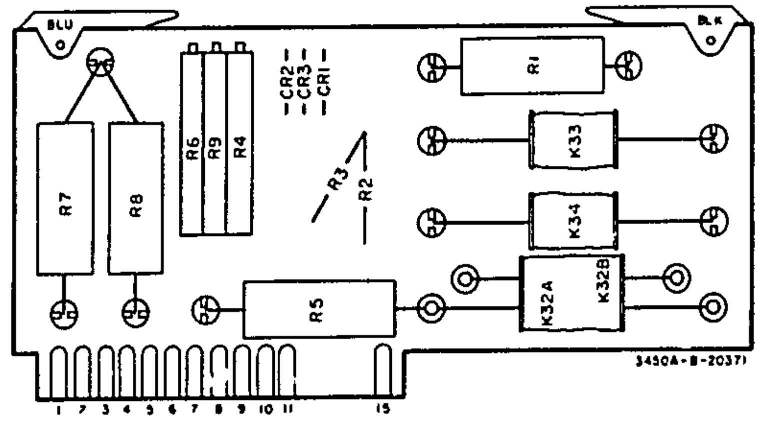
A72
(11077-66501)
REV D

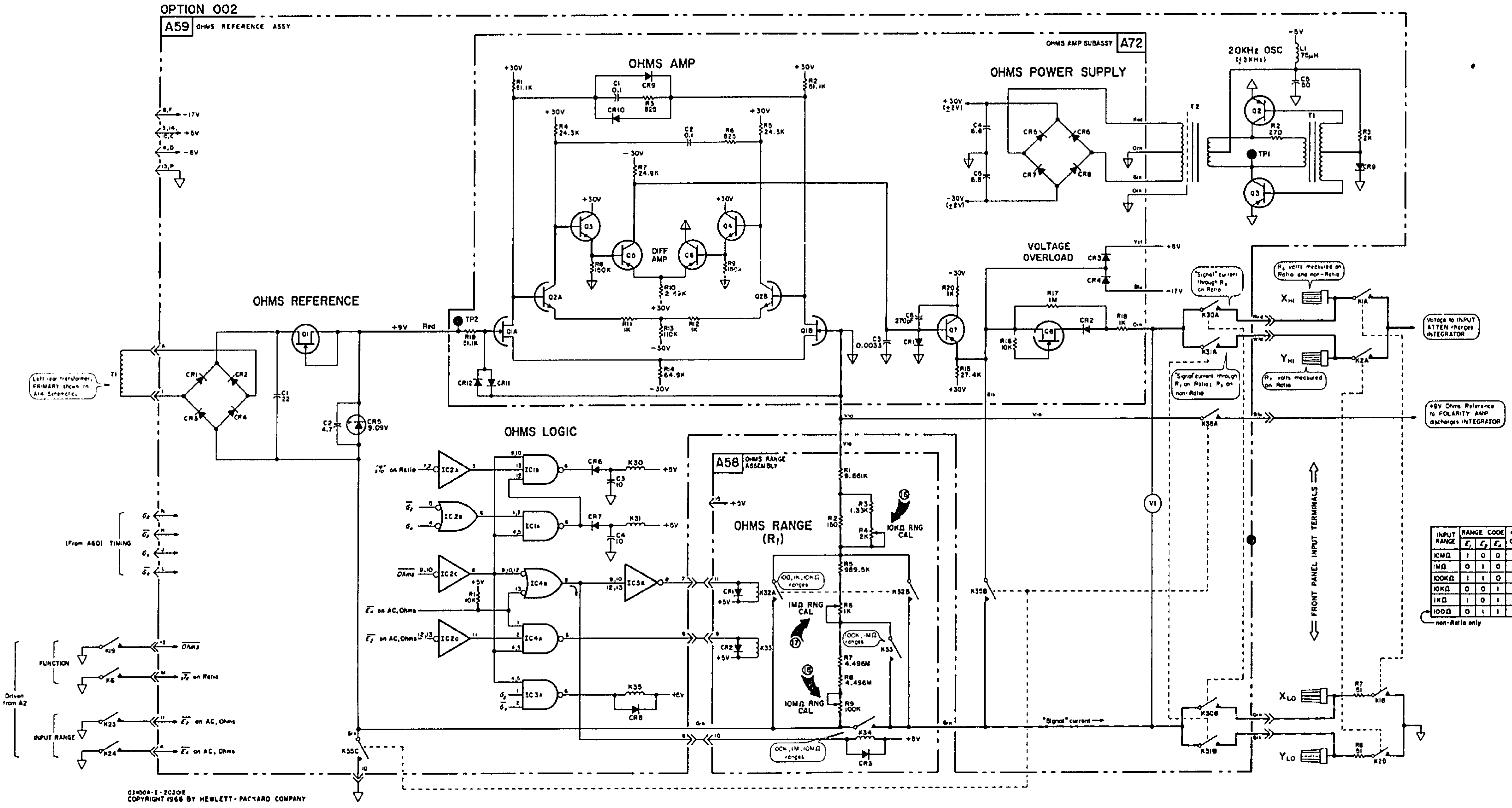


A59
(11077-66502)
REV C



A58
(11077-66558)
REV A

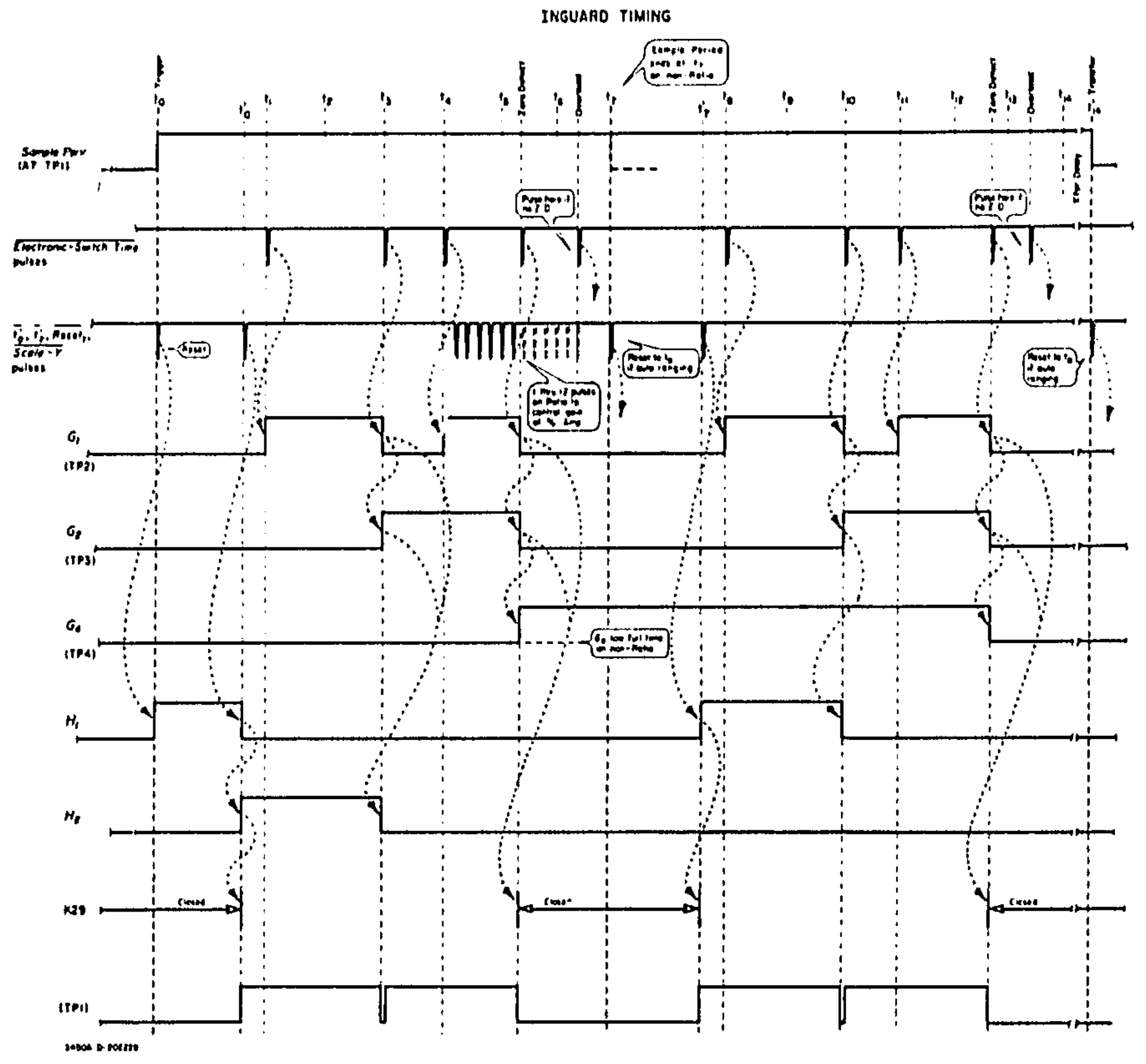




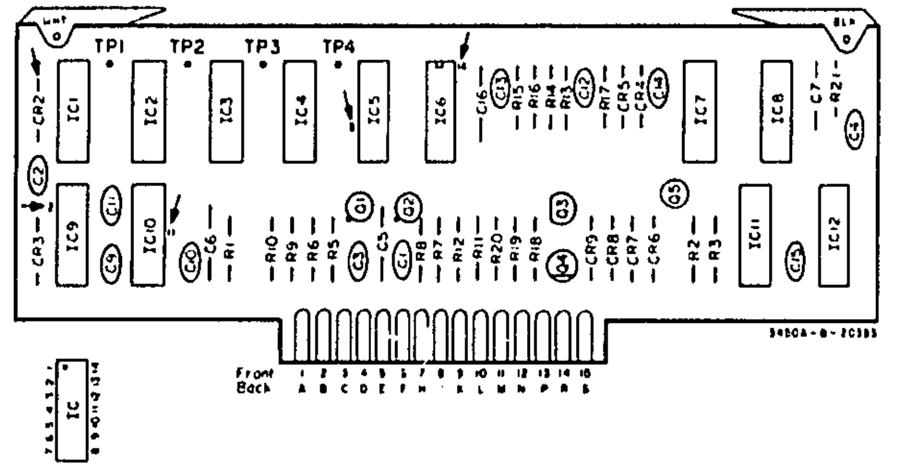
INPUT RANGE	RANGE CODE			"SIGNAL" CURRENT	Rx/n VOLTS FULL SCALE	A58 INPUT ATTEN GAIN	A56 INPUT AMP GAIN
	E_1	E_2	E_4				
10MΩ	1	0	0	0.9μA	9V	X1	X1
1MΩ	0	1	0	9μA	9V	X1	X1
100KΩ	1	1	0	9μA	0.9V	X.1	X10
10KΩ	0	0	1	900μA	9V	X1	X1
1KΩ	1	0	1	900μA	0.9V	X1	X10
100Ω	0	1	1	900μA	0.09V	X1	X100

non-Ratio only

Figure 7-26. Ohms Converter Assemblies (A58, A59).



A60
(03450-66590)
REV A



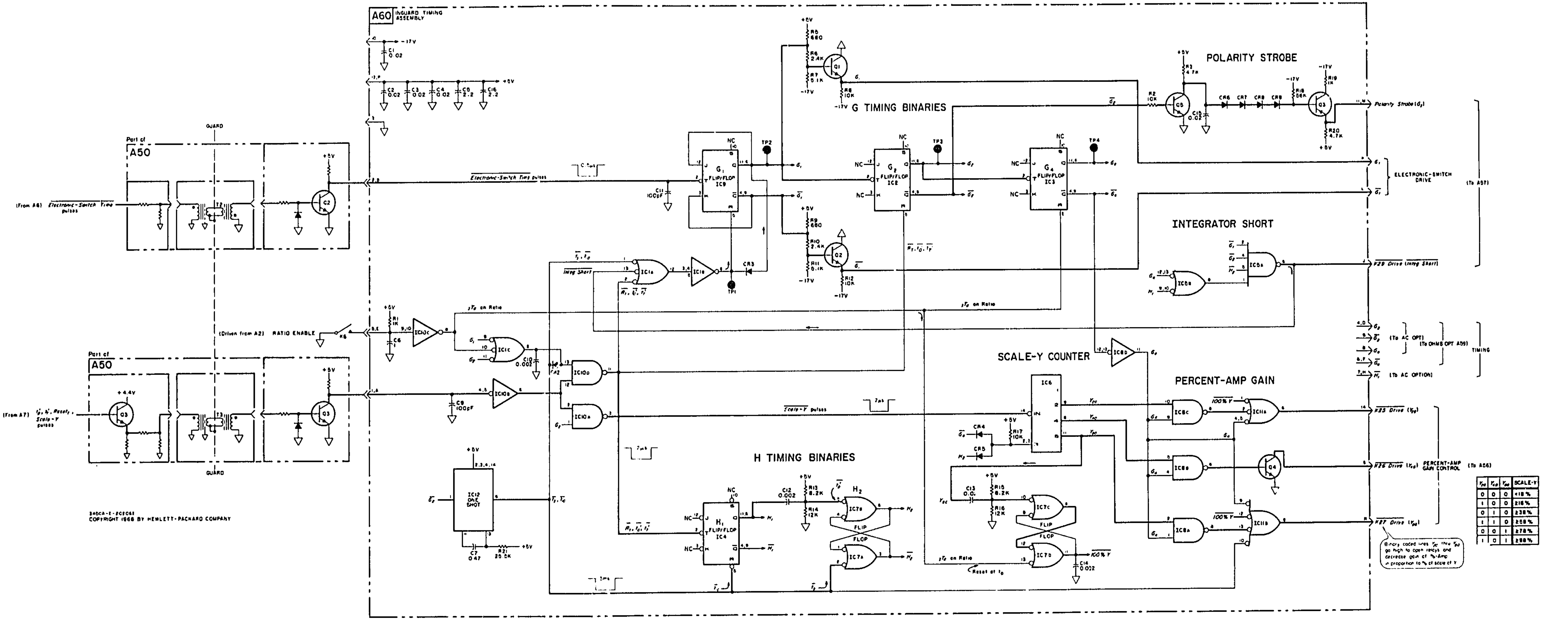
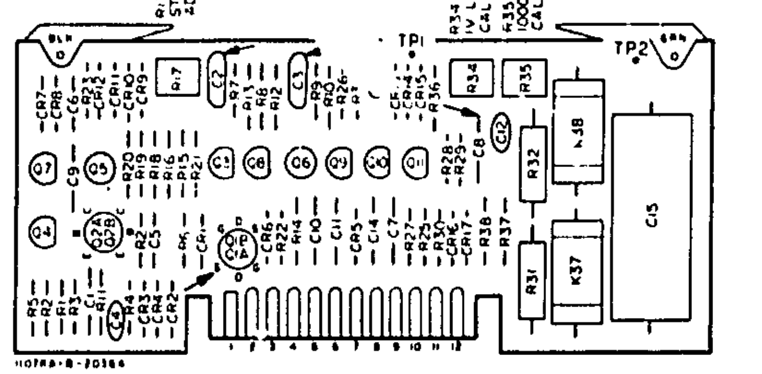
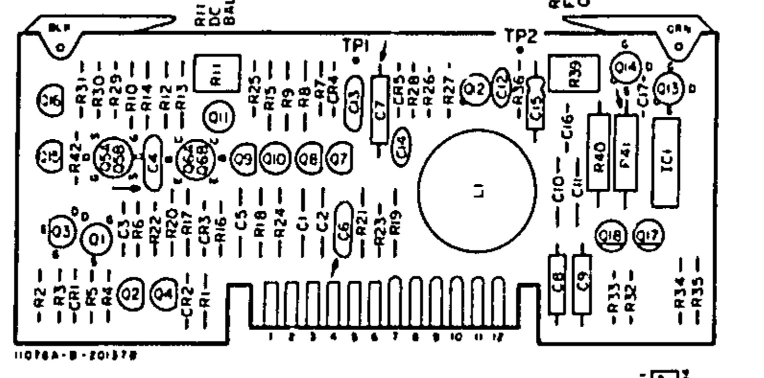


Figure 7-27. Inguard Timing Assembly (A60).

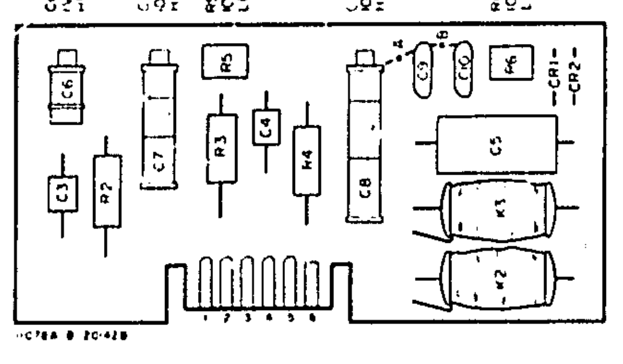
A81
(11078-66501)
REV B



A82
(11078-66502)
REV C



A86
(11078-66506)
REV A



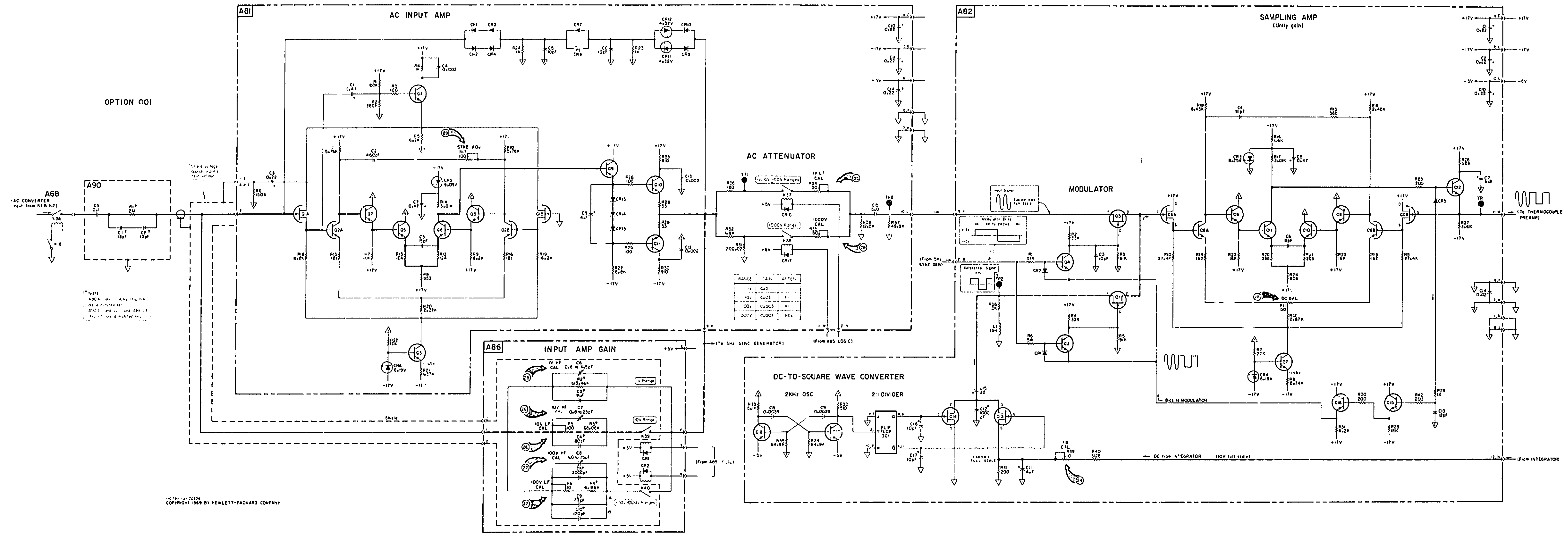
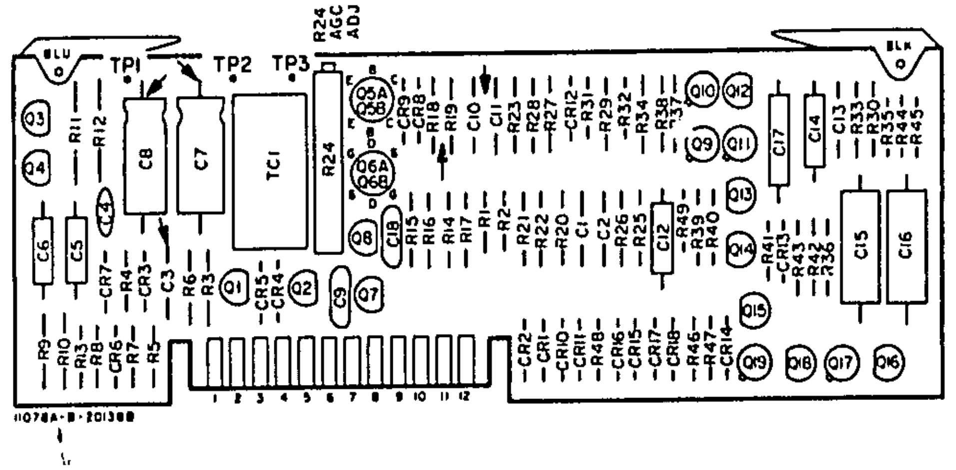


Figure 7-28. AC Converter Input Assemblies (A81, A82).

A83

(11078-66503)

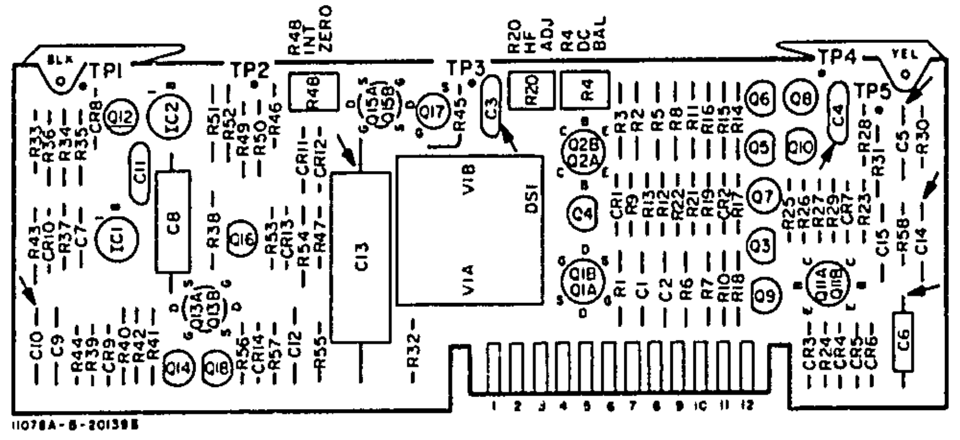
REV B



A84

(11078-66504)

REV B



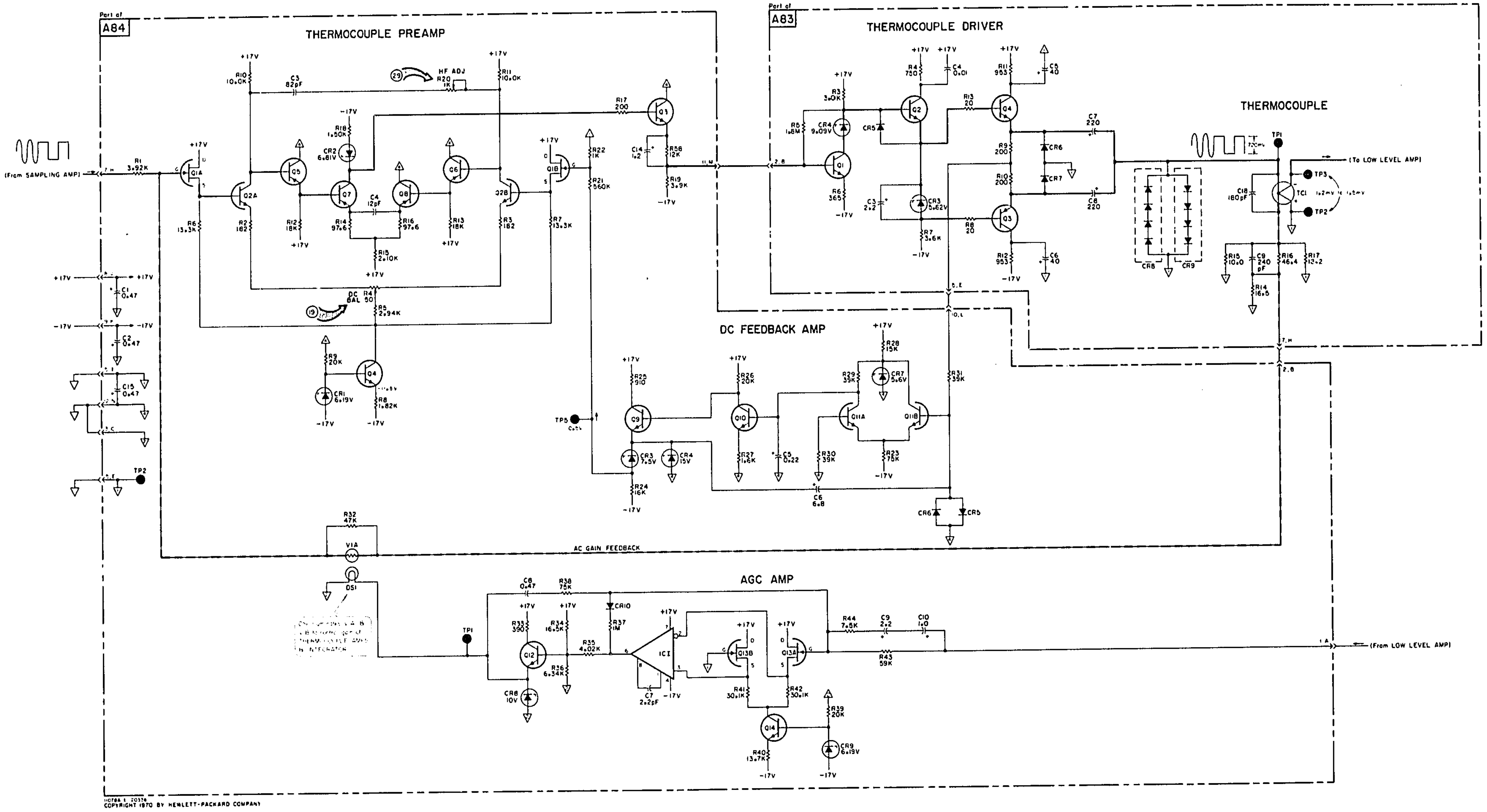
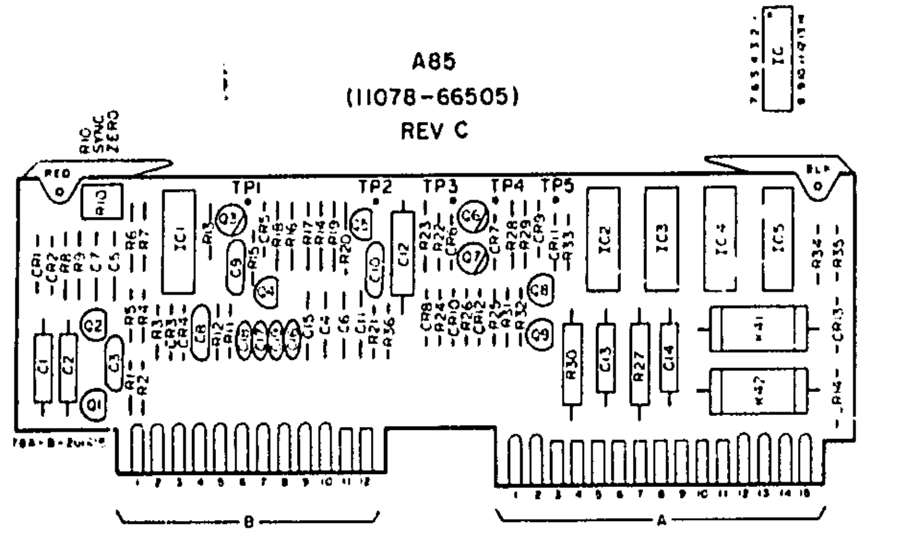


Figure 7-29. AC Converter Thermocouple Assemblies (A83, A84).



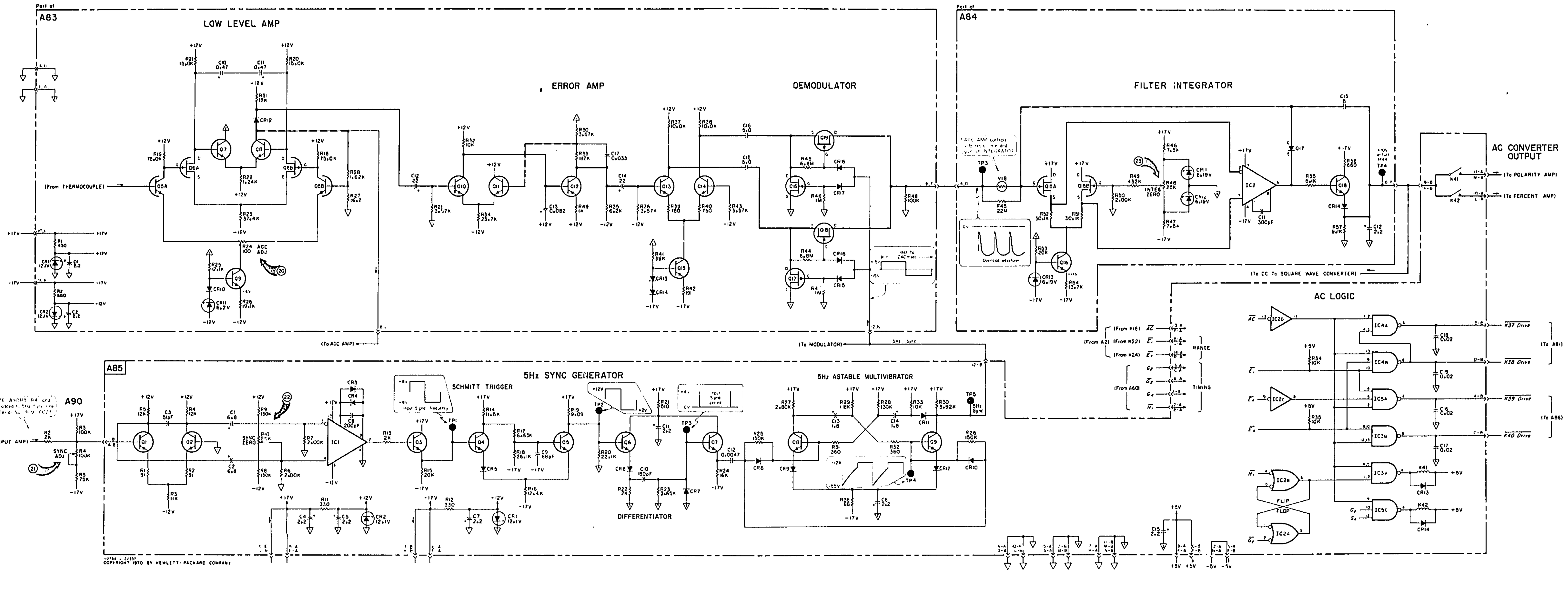


Figure 7-30. AC Converter Output Assembly (A85).

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.
01261	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.
C3296	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.
03808	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N.J.
03954	Singer Co., Diehl Div. Finderne Plant	Somerville, N.J.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn
04013	Taruus Corp	Lambertville, N J.
04C62	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 Carbide 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 Eimac 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.
11235	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 Dubilier 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

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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
3287	Cunningham, W H & Hill, Ltd	Toronto, Ontario, Canada
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
40931	Honeywell Inc.	Minneapolis, Minn.
42190	Muter Co.	Chicago, Ill.
43990	C A Norgren Co.	Englewood, Colo
44655	Ohmite Mfg. Co.	Skokie, Ill
46384	Penn Eng. & Mfg. Corp.	Doylestown, Pa
47904	Polaroid Corp.	Cambridge, Mass
48620	Precision Thermometer & Inst. Co.	Southampton, Pa.
49956	Microwave & Power Tube Div.	Waltham, Mass.
52090	Rowan Controller Co	Westminster, Md
52983	HP Co., Med. Elec. Div.	Waltham, Mass.
54294	Shallcross Mfg Co	Selma, N C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp	Elmsford, N Y
55938	Raytheon Co. Commercial Apparatus & System Div.	So. Norwalk, Conn
56137	Spaulding Fibre Co., Inc	Tonawanda, N.Y
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Elect. Co.	Bristol, Conn.
59446	Telex Corp.	Tulsa, Okla.
59730	Thomas & Betts Co.	Elizabeth, N J.
60741	Triplett Electrical Inst. Co.	Bluffton, Ohio
61775	Union Switch and Signal Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N Y
64959	Western Electric Co., Inc.	New York, N.Y
65092	Weston Inst. Inc. Weston-Newark	Newark, N.J.
66295	Wittek Mfg. Co.	Chicago, Ill.
66346	Minnesota Mining & Mfg. Co. Revere Mincom Div.	St. Paul, Minn.
70276	Allen Mfg Co	Hartford, Conn
70309	Allied Control	New York, N.Y
70318	Allmetal Screw Product Co., Inc	Garden City, N Y
70417	Amplex, Div. of Chrysler Corp	Detroit, Mich
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	Union City, N J
70674	ADC Products Inc.	Minneapolis, Minn
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electric Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y
71034	Bliley Electric Co., Inc.	Erie, Pa
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincey, Mass
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionics Corp	Cambridge, Mass
71286	Camloc Fastener Corp.	Paramus, N J
71313	Cardwell Condenser Corp.	Lindenhurst, L I, N Y
71400	Bussmann Mfg Div. of McGraw-Edison Co.	St. Louis, Mo
71436	Chicago Condenser Corp.	Chicago, Ill.
71447	Calif. Spring Co., Inc.	Pico-Rivera, Cal
71450	CTS Corp.	Elkhart, Ind.
71468	ITT Cannon Electric Inc.	Los Angeles, Cal
71471	Cinema, Div. Aerovox Corp.	Burbank, Cal
71482	C P Clare & Co	Chicago, Ill
71590	Centralab Div. of Globe Union Inc	Milwaukee, Wis
71616	Commercial Plastics Co	Chicago, Ill
71700	Cornish Wire Co., The	New York, N Y
71707	Coto Coil Co., Inc	Providence, R I
71744	Chicago Miniature Lamp Works	Chicago, Ill
71785	Cinch Mfg. Co., Howard B. Jones Div	Chicago, Ill
71984	Dow Corning Corp	Midland, Mich
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72619	Dialight Corp	Brooklyn, N Y
72656	Indiana General Corp., Electronics Div	Keasby, N J
72699	General Instrument Corp., Cap Division	Newark, N J
72765	Drake Mfg. Co	Harwood Heights, Ill
72825	Hugh H. Eby Inc	Philadelphia, Pa
72928	Gudeman Co	Chicago, Ill
72962	Elastic Stop Nut Corp.	Union, N J
72964	Robert M. Hadley Co.	Los Angeles, Cal.
72982	Erie Technological Products, Inc	Erie, Pa
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H M Harper Co.	Chicago, Ill
73138	Helipot Div. of Beckman Inst., Inc	Fullerton, Cal
73293	Hughes Products Division of Hughes Aircraft Co	Newport Beach, Cal
73445	Amperex Elect. Co.	Hicksville, L I., N Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn
73559	Carling Electric, Inc.	Hartford, Conn
73586	Circle F Mfg. Co.	Trenton, N J
73682	George K. Garrett Co., Div. MSL Industries, Inc.	Philadelphia, Pa
73734	Federal Screw Products, Inc	Chicago, Ill
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	General Industries Co., The	Elyria, Ohio
73846	Goshen Stamping & Tool Co	Goshen, Ind.
73899	JFD Electronics Corp	Brooklyn, N Y.
73905	Jennings Radio Mfg. Corp	San Jose, Cal
73957	Groove-Pin Corp	Ridgefield, N J.
74276	Signalite Inc	Neptune, N J
74455	J H Winns, and Sons	Winchester, Mass
74861	Industrial Condenser Corp.	Chicago, Ill
74868	R F Products Division of Amphenol-Borg Electronic Corp.	Danbury, Conn
74970	E. F. Johnson Co.	Waseca, Minn
75042	International Resistance Co.	Philadelphia, Pa.
75263	Keystone Carbon Co., Inc	St. Marys, Pa.
75378	CTS Knights, Inc	Sandwich, Ill.
75382	Kulka Electric Corp.	Mt. Vernon, N Y
75818	Lenz Electric Mfg. Co	Chicago, Ill.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Cal
76433	General Instrument Corp., Micamold Division	Newark, N J
76487	James Millen Mfg. Co., Inc	Malden, Mass
76493	J W Miller Co	Los Angeles, Cal.
76530	Cinch-Monadnock, Div. of United Carr Fastener Corp	San Leandro, Cal
76545	Mueller Electric Co	Cleveland, Ohio
76703	National Union	Newark, N J.
76854	Oak Manufacturing Co	Crystal Lake, Ill.
77068	The Bendix Corp., Electrodynamics Div	N Hollywood, Cal.
77075	Pacific Metals Co	San Francisco, Cal
77221	Phaostran Instrument and Electronic Co.	So Pasadena, Cal.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa
77342	American Machine & Foundry Co Potter & Brumfield Div	Princeton, Ind.
77630	TRW Electronic Components Div	Camden, N J
77638	General Instrument Corp., Rectifier Division	Brooklyn, N Y
77764	Resistance Products Co	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Cal
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78277	Sigma	So Braintree, Mass
78283	Signal Indicator Corp	New York, N Y.
78290	Struthers-Dunn Inc	Pitman, N J
78452	Thompson-Bremer & Co	Chicago, Ill
78471	Tilley Mfg. Co	San Francisco, Cal
78488	Stackpole Carbon Co	St. Marys, Pa
78493	Standard Thomson Corp	Waltham, Mass
78553	Tinnerman Products, Inc	Cleveland, Ohio
78790	Transformer Engineers	San Gabriel, Cal
78947	Ucinite Co	Newtonville, Mass
79136	Walden Kohinoor Inc	Long Island City, N Y
79142	Veeder Root, Inc	Hartford, Conn
79251	Wenco Mfg. Co	Chicago, Ill
79727	Continental-Wirt Electronics Corp	Philadelphia, Pa
79963	Zierick Mfg. Corp	New Rochelle, N Y.
80031	Mepco Division of Sessions Clock Co	Morristown, N.J.
80033	Prestole Corp	Toledo, Ohio
80120	Schnitzer Alloy Products Co	Elizabeth, N J
80131	Electronic Industries Association Standard tube or semi-conductor device, any manufacturer	
80207	Unimax Switch, Div. Maxon Electronics Corp	Wallingford, Conn
80223	United Transformer Corp	New York, N Y
80248	Oxford Electric Corp	Chicago, Ill.
80294	Bourns Inc	Riverside, Cal
80411	Acro 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	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod., Inc Electronic Tube Division	Emporium, Pa
82376	Astron Corp	East Newark, Harrison, N J.
82389	Switchcraft, Inc	Chicago, Ill
82647	Metals & Controls Inc., Spencer Products	Attleboro, Mass.
82768	Phillips-Advance Control Co	Joliet, Ill
82866	Research Products Corp	Madison, Wis.
82877	Rotron Mfg. Co., Inc	Woodstock, N. Y.
82893	Vector Electronic Co.	Glendale, Cal
83058	Carr Fastener Co	Cambridge, Mass
83086	New Hampshire Ball Bearing, Inc	Peterborough, N H
83125	General Instrument Corp., Capacitor Div	Darlington, S C
83148	ITT Wire and Cable Div	Los Angeles, Cal
83186	Victory Eng. Corp	Springfield, N J
83298	Bendix Corp., Red Bank Div.	Red Bank, N J
83315	Hubbell Corp	Mundelein, Ill
83324	Rosan Inc	Newport Beach, Cal.
83330	Smith, Herman H., Inc	Brooklyn, N. Y.
83332	Tech Labs	Palisades Park, N J
83385	Central Screw Co	Chicago, Ill
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp	Brookfield, Mass
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N J
83740	Union Carbide Corp., Consumer Prod. Div	New York, N. Y.
83777	Model Eng. and Mfg., Inc	Huntington, Ind
83821	Loyd Scruggs Co	Festus, Mo
83942	Aeronautical Inst. & Radio Co	Lodi, N J
84171	Arco Electronics Inc	Great Neck, N. Y.
84396	A. J. Glesener Co., Inc	San Francisco, Cal
84411	TRW Capacitor Div	Ogallala, Neb

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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
92160	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	Palisades 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	Mamaroneck, 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

Code No	Manufacturer	Address
0000F	Malco Tool and Die	Los Angeles, Calif.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AB	ETA	England
000BB	Precision Instrument 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

00015-49
Revised: May, 1970

From Handbook Supplements
H4-1 Dated January 1970

MANUAL CHANGES

Model 3450B

MULT–FUNCTION METER

Manual Part No. 03450-90007

▌New or Revised Item

CHANGE NO. 1 applies for serial numbers 1229A-01251 and above.

Page 6-13, Table 6-1, Replaceable Parts.
Change A54Q3 from Part No. 1854-0087 to 1854-0409.
Add Part No. A54L1, 9170-0894, Bead - Ferrite.

CHANGE NO. 2 applies to all serial numbers prefixed 1229A and above.

Page 1-1, Paragraph 1-11, Options. Change the statement following Paragraph 1-11 to:

Eight options may be added to the standard DC Instrument.

OPTION	FACTORY INSTALLED	FIELD INSTALLED
AC Converter	Option 001	11078A
Ohms Converter	Option 002	11077A
Limit Test	Option 003	11079A
Digital Output	Option 004	11080A
Remote Control	Option 005	11099A
Rear Input	Option 006	....
Rack Mount Kit	Option 908	03450-84411
Op. and Service Manual	Option 910	....

Page 1-8, Paragraph 1-12, Equipment Available. Replace Rack Mount Kit paragraph with the following.

Rack Mount Kit – Option 908, part number 5060-8739 includes mounting brackets, two 15 pin assembly extenders 5060-6033, and a 36 pin connector 1251-0084 for the Remote Control Jack. The Rack Mount Kit may also be ordered as an accessory, 03450-84411.

Page 1-9, Paragraph 1-12. Replace 3450B Operating and Service Manual paragraph as shown.

3450B Operating and Service Manual – A manual is supplied with the instrument. An additional manual is available as Option 910, part number 03450-90007.

CHANGE NO. 3 applies to serial numbers 1229A01401 and above.

Page 6-21, Table 6-1, Replaceable Parts. Change A72CR11, CR12 from part number 1901-0686, Diode:Si 30 piv to part number 1906-0086, Diode: Dual.

CHANGE NO. 4 applies to all serial numbers.

Page 6-30, Table 6-1, Replaceable Parts. Add part number 0340-0170, Insul - Bshg.

Page 1-8, Table 1-1, Specifications under General. Change power requirements from 50 Hz to 400 Hz to 48 Hz to 440 Hz.

CHANGE NO. 5 applies to serial numbers 1229A01371 and above.

Page 6-17, Table 6-1, Replaceable Parts. Change A57Q5 from part number 03450-87901, Tstr: dual field to part number 1855-0311, JFET - Dual DN196.