

FLUKE 510 A / AD



Instruction Manual

FOR REFERENCE PURPOSES ONLY

Model

510 A/AD

AC Reference Standard

(33A1-12-102P-11)

P/N 313379

NOVEMBER 1971

REV. 2 10/75

LIMITED WARRANTY

The JOHN FLUKE MFG. CO., INC., warrants each instrument it manufactures to be free from defects in material and workmanship under normal use and service for the period of one year from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargeable type batteries are warranted for 90 days), or any product or parts which have been subject to misuse, neglect, accident or abnormal conditions of operations.

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If any fault develops, the following steps should be taken:

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The John Fluke Mfg. Co., Inc. will be happy to answer all application or use questions, which will enhance your use of this instrument. Please direct your requests or correspondence to: JOHN FLUKE MFG. CO., INC., P.O. Box 43210, MOUNTLAKE TERRACE, WASHINGTON 98043, Attn: Sales Dept. For European Customers: FLUKE (Nederland) B.V., Zevenhevelenweg 53, Tilburg, The Netherlands.

* For European customers, Air Freight prepaid.

John Fluke Mfg. Co., Inc. • P.O. Box 43210 • Mountlake Terrace, Washington 98043

THIS DOCUMENT CONTROLS SPECIFICATIONS AND FABRICATION
 OF A SPECIAL INSTRUMENT MANUFACTURED BY THE JOHN FLUKE
 MANUFACTURING COMPANY, INCORPORATED.

MODEL 510A/AD

		JOHN FLUKE MFG CO., INC. P.O. BOX 7428, SEATTLE, WN.		510A/AD-130
SPECIFICATION CONTROL DRAWING SPECIAL PRODUCTS DIVISION				
PROJ. ENG. <i>R. J. Lewis</i>	DATE <i>2-3-72</i>	510A/AD-130		
MKTG. <i>A. J. ...</i>	DATE <i>2-7-72</i>			
ENG. APPD. <i>R. P. ...</i>	DATE <i>2-3-72</i>			
<i>11/1/72</i>	<i>2-3-72</i>	JF NO. 257915	NO. OF PAGES 6	REV. 2

DOCUMENT CHANGE RECORD

REV. LTR.	PAGE	DESCRIPTION OF CHANGE	
1	4	Delete: Item 10 Add: Items 13, 15, 18 & 19 Correct: Dwg. number on Items; 14 from 3001 to 3003 16 from 4001 to 4003 17 from 4002 to 4004	530 # 7141 10-9-3
2	4 5 6	Remove MFG usage for Item 1 Add Item 7 Test Procedure changed from -160 to -150	DB 12-28-3
		<p align="center">JOHN FLUKE MANUFACTURING CO., INC.</p>	
		510A/AD	REV PAGE 2 2

- 1.0 GENERAL - Similar to 510A-04 with the following exceptions:
- 1.1 Capable of being phase locked to an external 400Hz 26V RMS reference.
 - 1.2 Provides two separate transformer isolated outputs at 10V RMS into 100K ohms.
 - 1.3 Housed in 3-1/2 inch high full rack width package.
- 2.0 ELECTRICAL - All electrical specifications apply with each output loaded into 100K ohms.
- 2.1 Phase reference input: 26V RMS \pm 10%, 380 to 420Hz, 30K ohm input impedance.
 - 2.2 Outputs: Two, transformer coupled, at 10V RMS \pm .05%.
Phase relationship to phase reference input 0 \pm 1 degree.
Total harmonic distortion: < 0.15%.
Isolation between any two outputs or input to any output: 300V DC or peak AC; 1100 pf maximum capacitance.
- 3.0 MECHANICAL
- 3.1 Chassis size 3-1/2 inch high, 19 inches wide (rack mountable), 15-1/2 inch depth behind front panel.
 - 3.2 Input and output binding posts on 3/4 inch centers located on rear panel.
 - 3.3 Overload indicator on front panel.
- 4.0 PARTS LIST - See Bills of Material and Engineering Drawings listed in Section 5.2 MFG Column.
- 5.0 DOCUMENTATION
- 5.1 Standard 510A Manual with 510A/AD-130 Specification Control Drawing and Drawings listed in Section 5.2 MNLS Column.

	JOHN FLUKE MANUFACTURING CO., INC.	
	510A/AD - 130	REV PAGE 3

5.2		DOCUMENTATION INDEX				MODEL: 510A/AD			
ITEM	DRAWING NUMBER	DRAWING TITLE	SHEETS	B/MTL	USAGE				
					MFG	MNLS			
1	510A/AD-160	Acceptance Test Procedure				X			
2	510A/AD-1001	Schematic Output AC Ref Std.	1		X	X			
3									
4	510A/AD-2001	Front Panel Punch	1		X				
5	510A/AD-2002	Rear Panel Punch	1		X				
6	510A/AD-2003	Front Panel Screened	1		X				
7	510A/AD-2004	Rear Panel Screened	1		X				
8	510A/AA-2005	Inner Panel LH	1		X				
9	510A/AA-2006	Inner Panel RH	1		X				
10									
11	510A/AA-2008	Hold Down, Transformer	1		X				
12	510A/AA-2009	Pad, Transformer Mtg.	1		X				
13	510A/AA-2010	Support	1		X				
14	510A/AA-3003	Drill Detail Phase Lock PCB Assy.	2		X				
15	510A/AA-2011	Support	1		X				
16	510A/AD-4003	Phase Lock PCB Assy.	1	X	X	X			
17	510A/AN-4004	Main PCB Assy. (Modification)	1	X	X	X			
18	510A/AA-2012	Support	1		X				
19	510A/AA-2013	Support	1		X				
20									
					JOHN FLUKE MANUFACTURING CO., INC.				
					510A/AD-130				REV PAGE 2 4

5.2

DOCUMENTATION INDEX

MODEL: 510A/AD

ITEM	DRAWING NUMBER	DRAWING TITLE	SHEETS	USAGE			
				B/MTL	MFG	MNLS	
1	510A/AD-5001	Final Assy.	3	X	X		
2	510A/AA-6510	Power Transformer	1		X		
3	510A/AN-8001	8 Output Ratio Transformer	2		X		OEEO 17534 (Purch)
4							
5	510A/AD	Test & Button-up	1	X	X		
6							
7	510A/AD-150	Production Test Procedure			X		
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
Applicable Drawings			JOHN FLUKE MANUFACTURING CO., INC.				
			510A/AD-130				REV PAGE 2 5

6.0 TEST PROCEDURE - See 510A/AD-150.

JOHN FLUKE MANUFACTURING CO., INC.

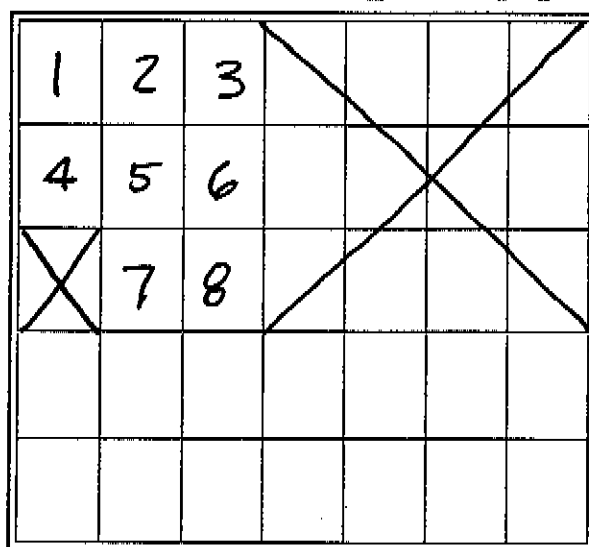
510A/AD-130

REV	PAGE
2	6

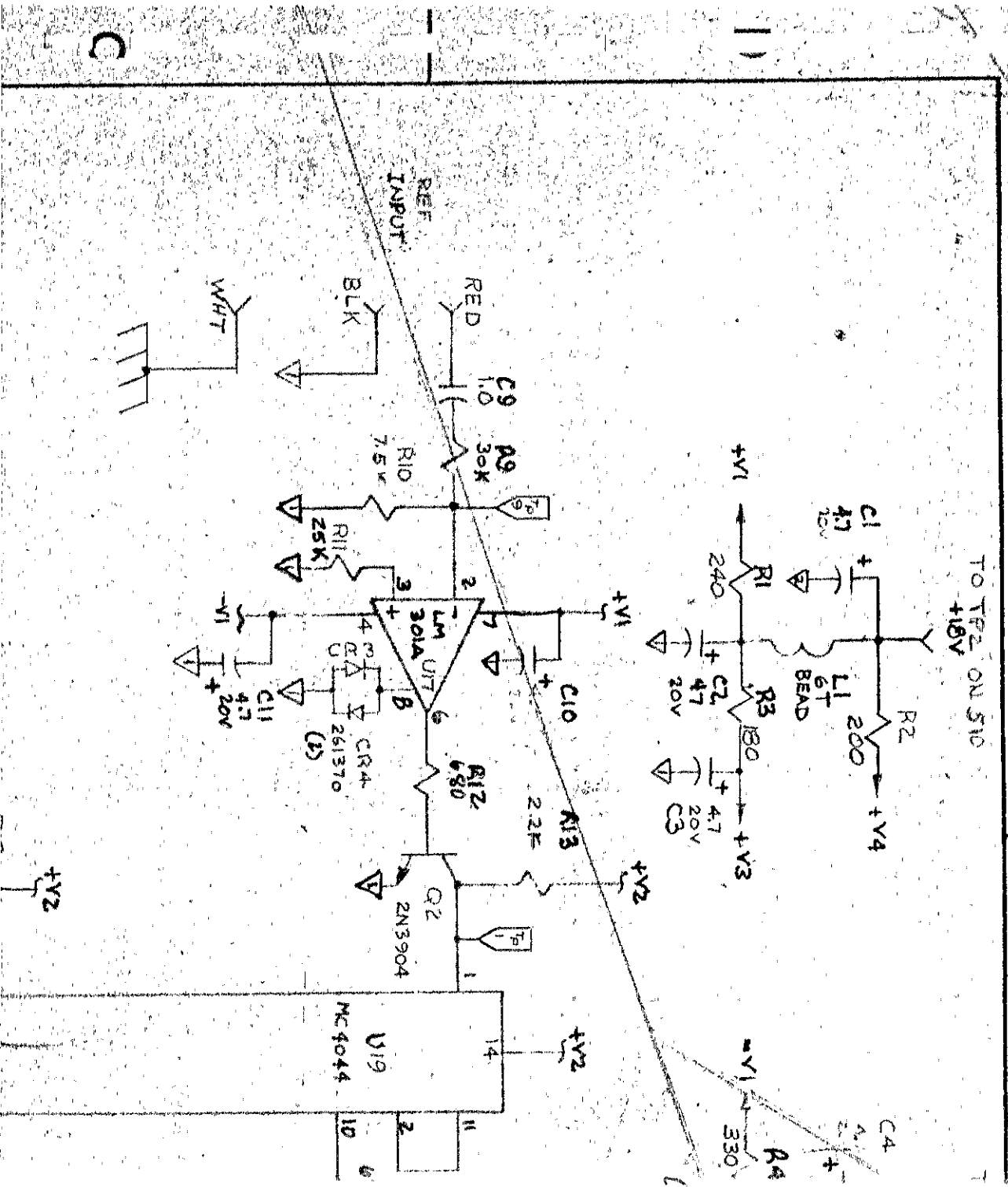
PHASE LOCK PCB ASSEMBLY

DWG. 510A/AD-1001

DIAGRAM LAYOUT



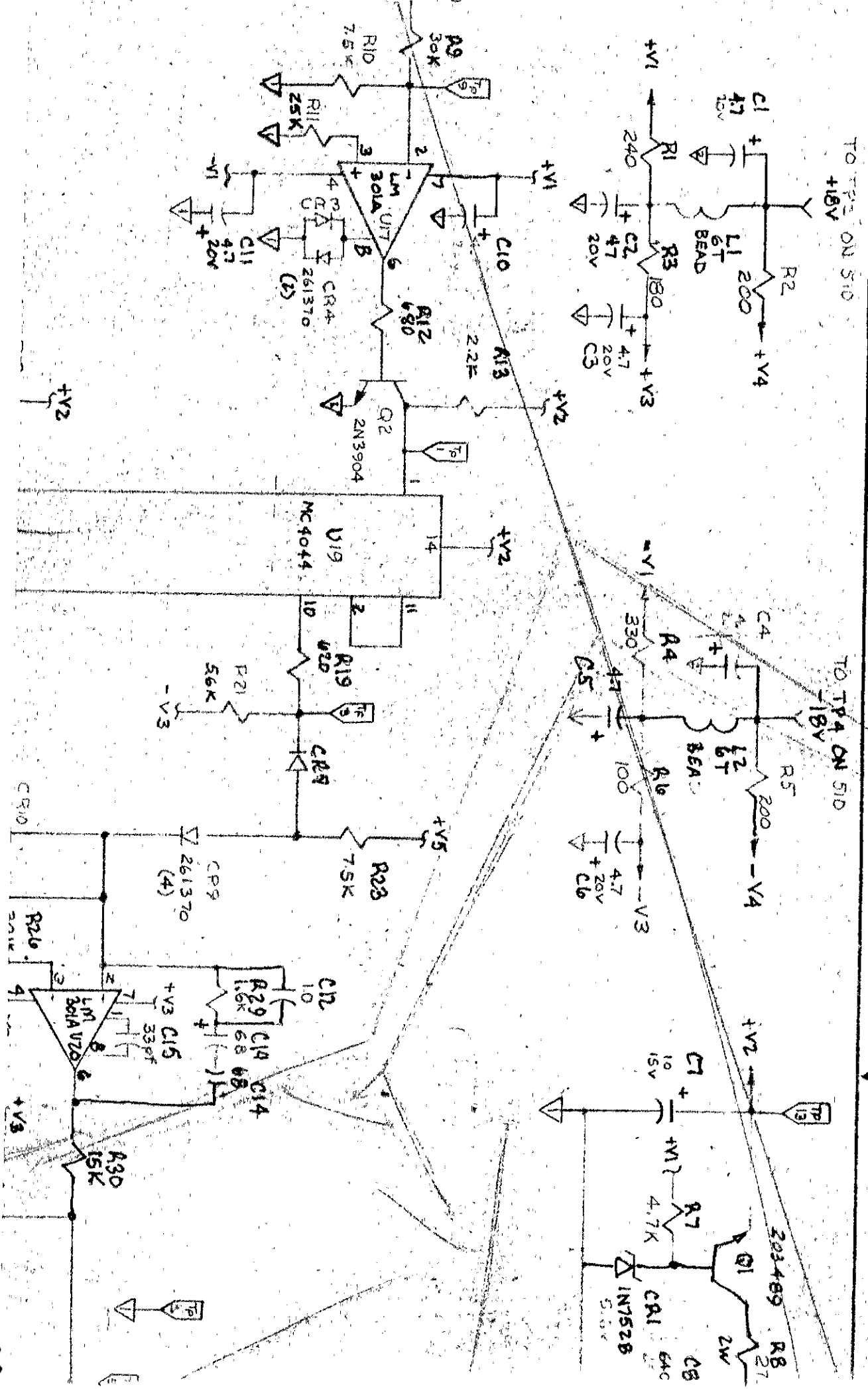
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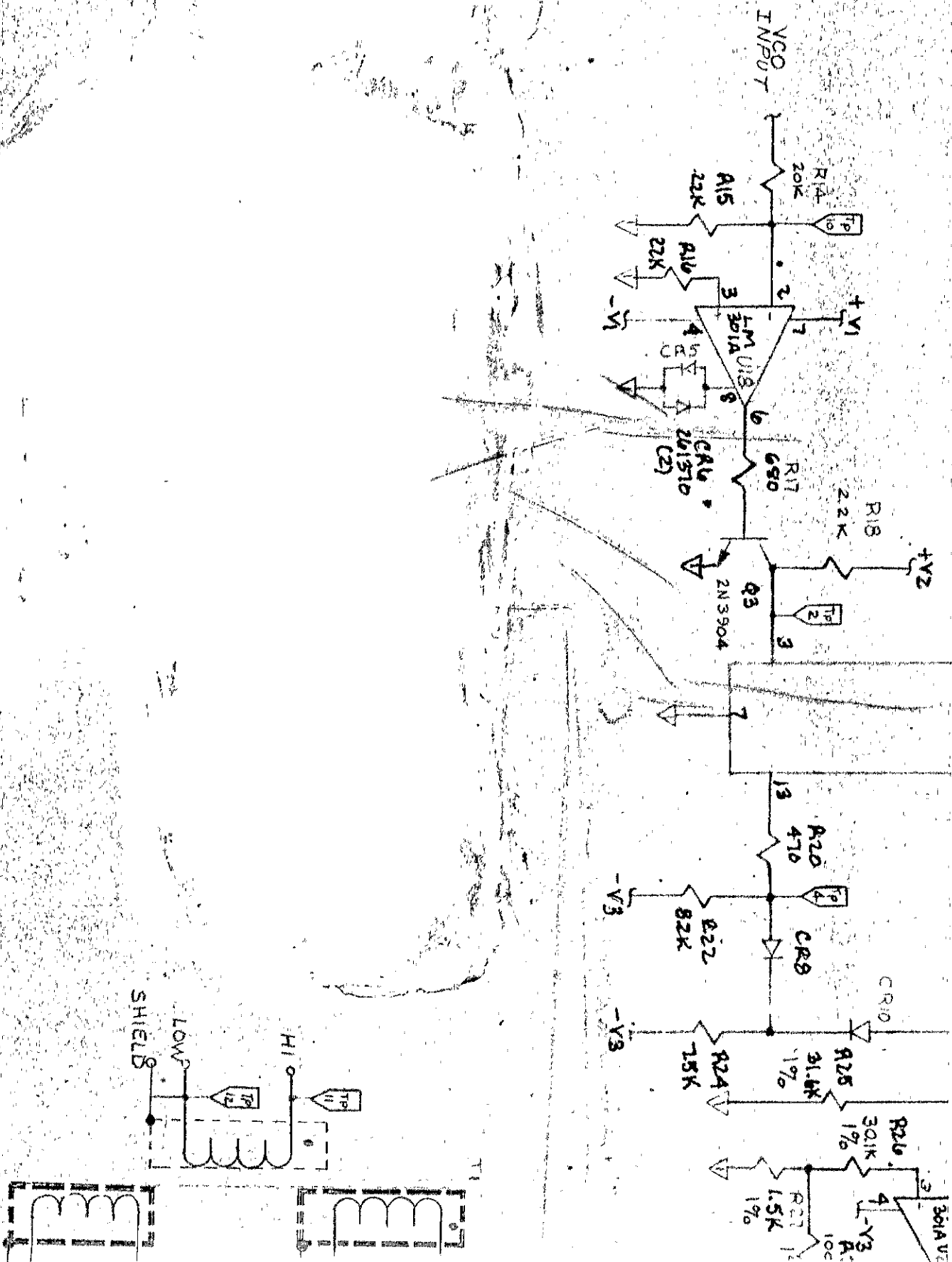


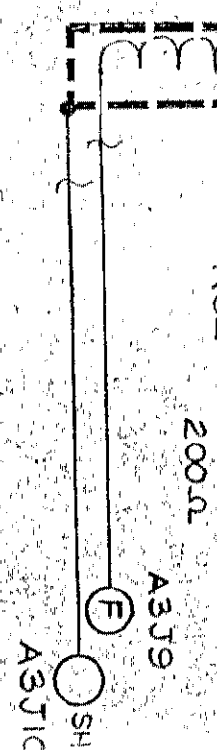
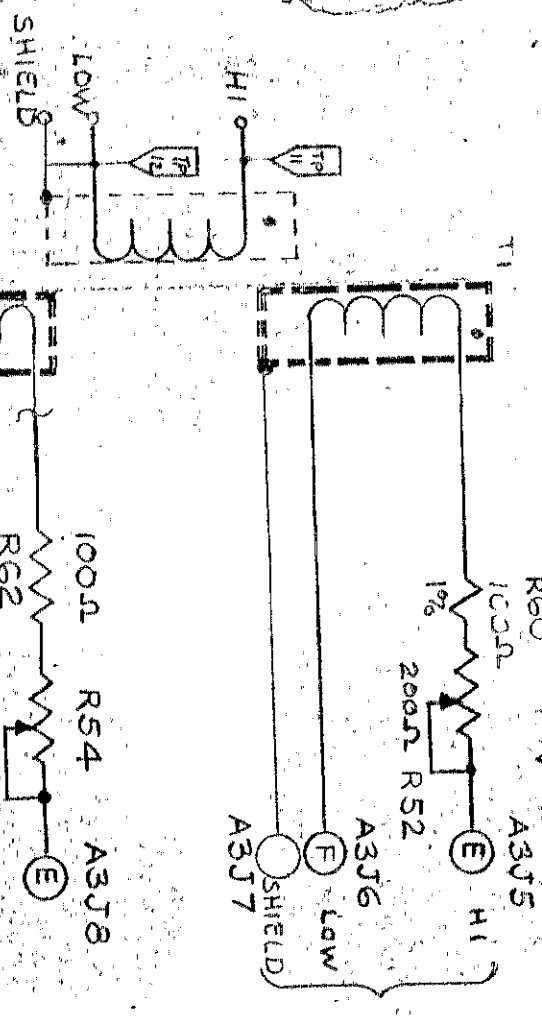
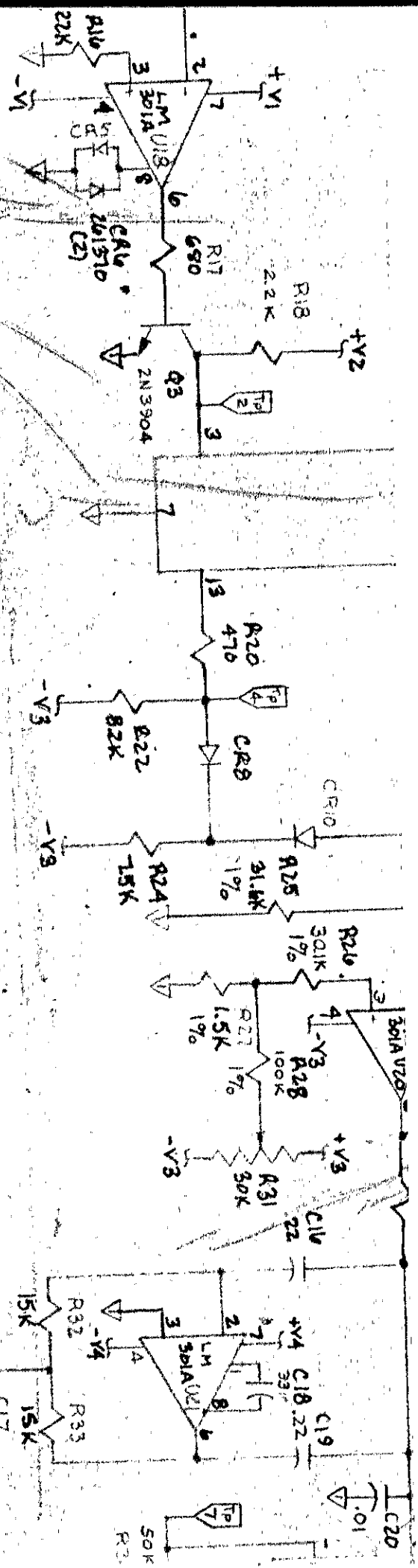
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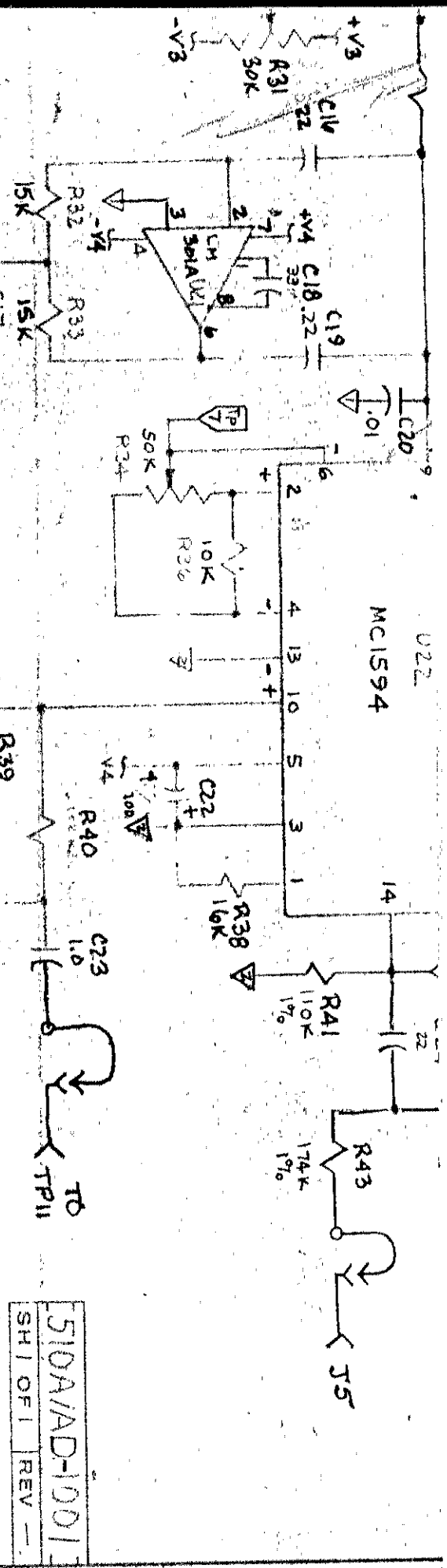
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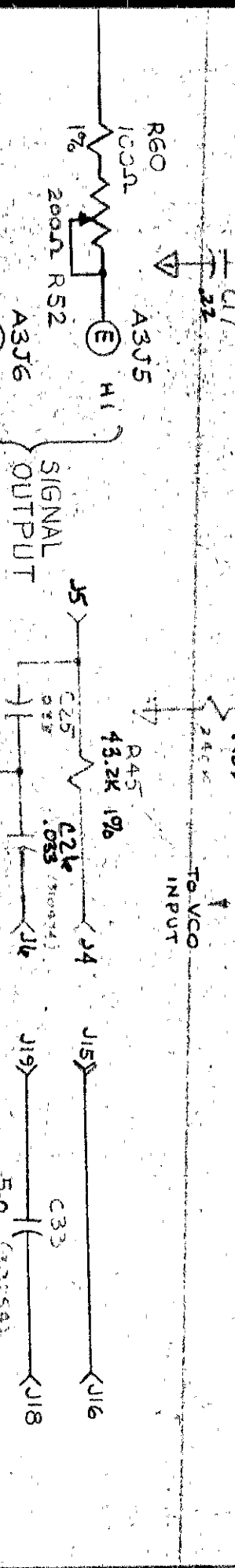




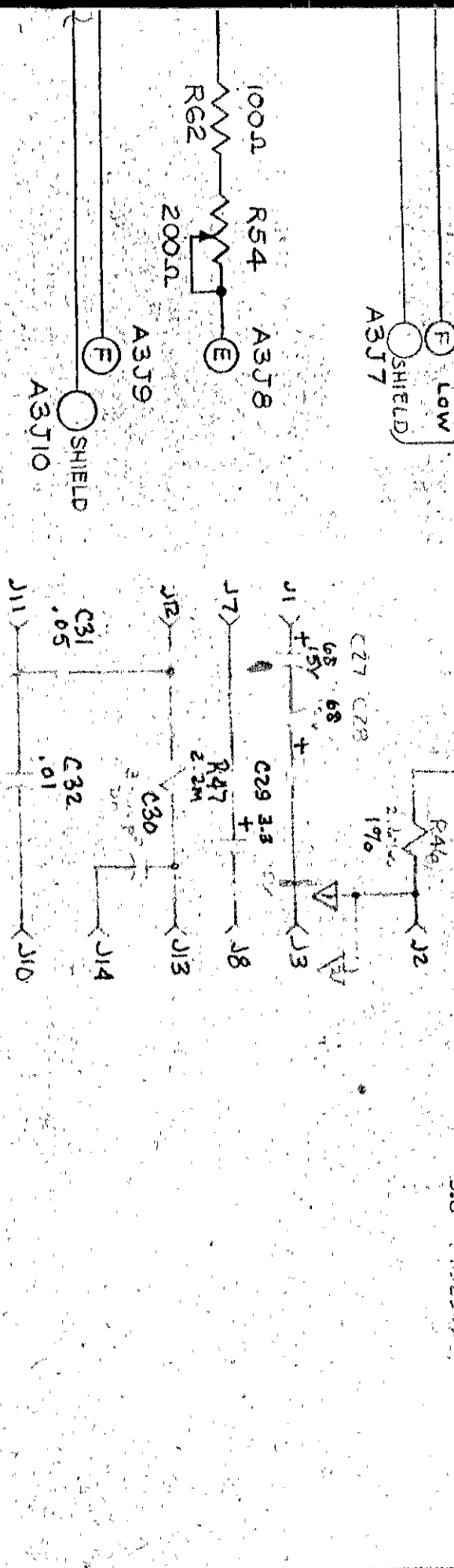
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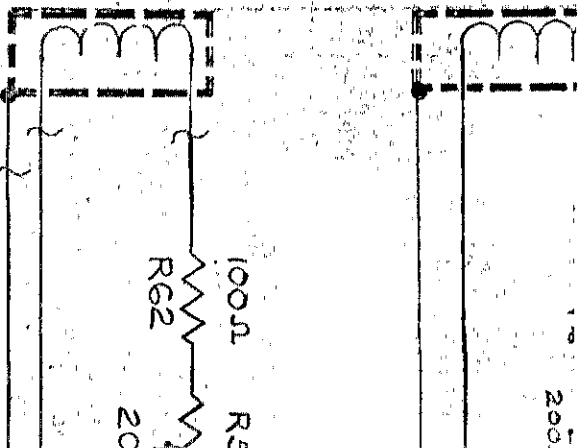
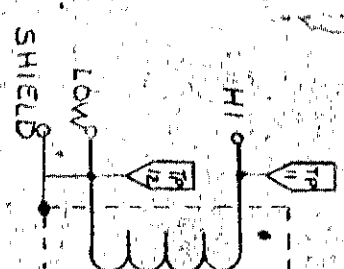


510A/AD-1001
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89536

XX ± 020

XXX ± 010

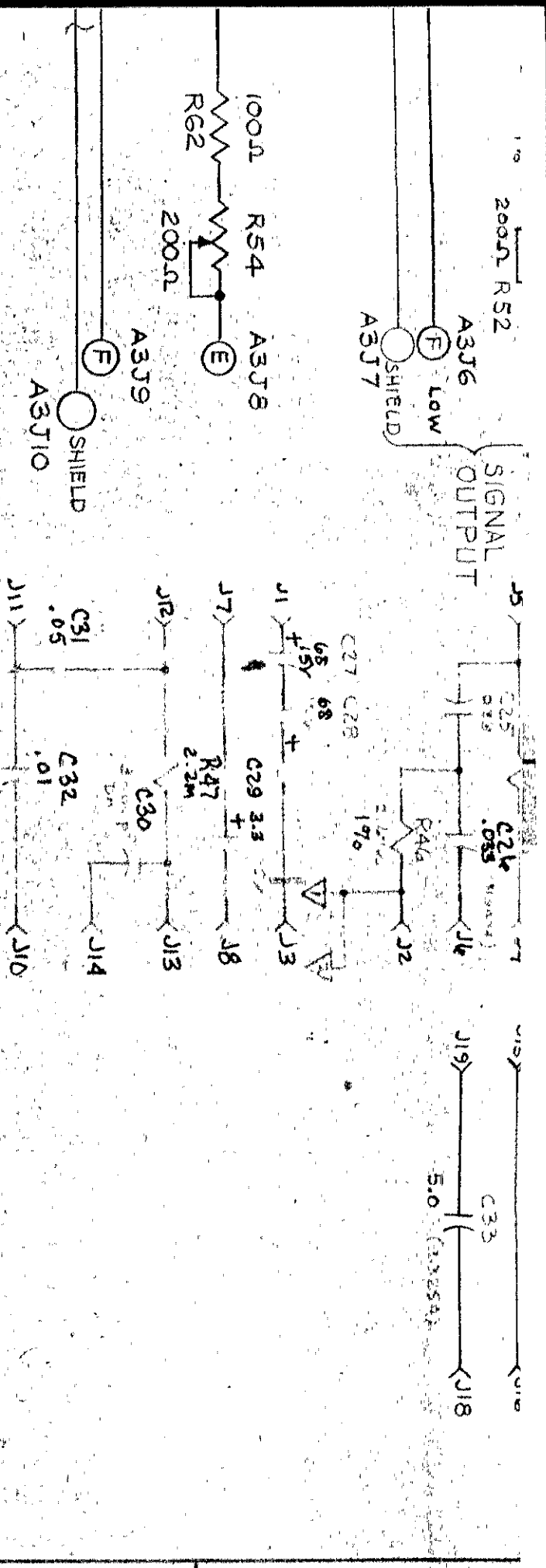
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		JOHN FLUKE MFG. CO., INC. P.O. BOX 7428, SEATTLE, WA.		DR. D. WALTER 10-30-73		SPECIALS RELEASE PER ECO 7141 10-30-73		DR. D. WALTER 10-30-73		DR. D. WALTER 10-30-73	
89536		DO NOT SCALE DRAWING DIMENSIONS IN INCHES		ENG		CHANGE DESCRIPTION		DR. D. WALTER 10-30-73		DR. D. WALTER 10-30-73	
TOLERANCES		.000- .100 DIA .010- .200 DIA .201- .500 DIA .501- 1.00 DIA		+.003- .002 +.004- .002 -.006- .003 -.010- .005		MATERIAL		PART NO		SIZE	
XX ± .020 XXX ± .010 ANGLES ±		FINISH		SCALE		DRAWING NO		C 510AVAD-1001		SHI OF REV	

QIST 933

PHASE LOCK PCB ASSY

A

B

Change/Errata Information

Issue No: 3 6/79

This change/errata contains information necessary to ensure the accuracy of the following manual. Enter the corrections in the manual if either one of the following conditions exist:

1. The instrument's pcb revision letter is equal to or higher than that which is indicated at the beginning of the change.
2. No revision letter is indicated at the beginning of the change/errata.

MANUAL

Title: MODEL 510A AC REFERENCE STANDARD
Print Date: NOVEMBER 1971
Rev and Date: 2 - 11/75

C/E PAGE EFFECTIVITY

Page No.	Print Date
1	2/79
2	6/79

CHANGE #1-8993

On page 5-7, change the stock no of diode CR1 from 309617 to 428623.

CHANGE #2-11381

On page 5-10, delete Q26 from the REF DESIG column Q17, Q26 and change the tot qty from 2 to 1.
Add the new entry: Q26; Tstr, Si; 477695; 1; 1.

On page 5-28, add the listing 477695; 07910; 02377.

CHANGE #3-12151

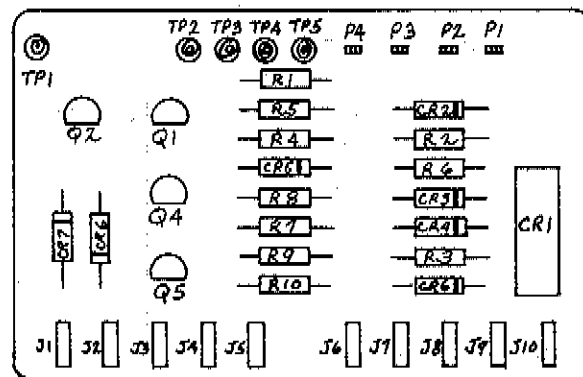
Rev. -B, A3 Rechargeable Battery Kit (-01 Option)

On page 5-23, make the following changes:

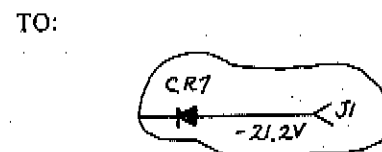
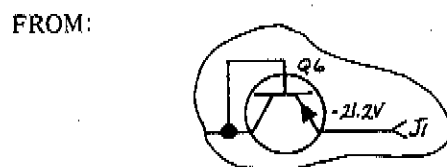
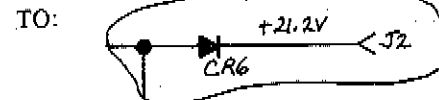
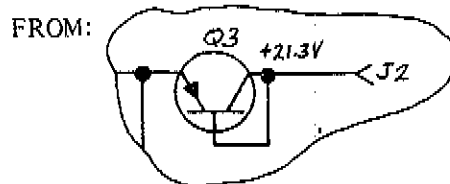
FROM: Q3, Q6/Tstr, Semicon, germanium PNP/148619/2/1

TO: CR6, CR7/Diode, Germanium, 80 mA/149187/2/1

On page 5-22, Figure 5-12, and page 6-1, Figure 6-1, replace the PCB with the following:



On page 8-3/8-4, Figure 8-1 (Detail 1, A3 Battery Pack PCB) make the following changes:



510A

CHANGE #5 - 12285

Rev.-C, A1 Front Panel Assembly (510A-4051)

On page 5-7, make the following changes:

FROM: Decal, Front Panel /309351/1
TO: Decal, Front Panel/508234/1
ADD: J4/Binding Post, Green/275586/1

Rev.-B, A4 Rear Panel Assembly (510A-4052)

On page 5-25, make the following changes:

FROM: J2/Binding Post, White/275586/1
TO: J2/Binding Post, Green/275586/1
DELETE: Decal/313064/1

ERRATA #1

On page 1-1, under SPECIFICATIONS, add the following information:

Protection Class #1 (Relates solely to insulation or grounding properties further defined in IEC 348.)

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Section 1

Introduction & Specifications

1-1. INTRODUCTION

1-2. The Model 510A is a precision ac reference standard. It produces a fixed frequency output having an amplitude of 10V rms. Standard frequencies and accuracies are given in Table 1-1. Other frequencies are available upon special request. The center frequency can be varied $\pm 1\%$ with a control on the front panel. Frequency resolution with this control is better than $\pm 0.05\%$.

Table 1-1. STANDARD FREQUENCIES AND ACCURACY

24 HOUR ACCURACY	30 DAY ACCURACY	STANDARD FREQUENCY
$\pm 0.01\%$	$\pm 0.015\%$	50 Hz, 60 Hz, 400 Hz, 1 kHz, 2.4 kHz, 5 kHz, 19.2 kHz
$\pm 0.04\%$	$\pm 0.05\%$	100 kHz

1-6. SPECIFICATIONS

OUTPUT VOLTAGE
 OUTPUT CURRENT
 SINGLE FIXED FREQUENCY OUTPUT

1-3. Output current is fully protected from overloads and short circuits. Maximum load current for rated accuracy is 10 mA. Visual indication of an overload is provided by a light emitting diode (LED) on the front panel. Two sets of parallel connected binding posts on the front and rear panel provide load connection.

1-4. The ac reference standard can be operated from line power or it can be battery powered through an optional rechargeable battery pack. Line voltage requirement is 115/230 vac, 50 to 500 Hz, single phase. The rechargeable battery pack is available as the -01 Option. It allows at least 16 hours of continuous operation without line power. Battery charging is done whenever line power is applied.

1-5. The Model 510A is designed for bench top use or it can be installed in a standard 19 inch equipment rack. Rack mounting kits are available as accessories to permit single, dual, triple, and quadruple side-by-side rack installation.

10V rms

10 mA rms, short circuit protected

Any single fixed frequency from 50 Hz to 100 kHz. Standard frequencies are: 50; 60; 400; 1,000; 2,400; 5,000; 19,200 and 100,000 Hertz.

Amplitude Accuracy	24 Hours	30 Days	90 Days
50 Hz - 20 kHz	$\pm 0.01\%$	$\pm 0.015\%$	$\pm 0.02\%$
20 kHz - 50 kHz	$\pm 0.015\%$	$\pm 0.025\%$	$\pm 0.035\%$
50 kHz - 100 kHz	$\pm 0.04\%$	$\pm 0.05\%$	$\pm 0.06\%$

Above accuracy applies after 10 minutes warmup, operating temperature of $23 \pm 2^\circ\text{C}$, and includes worst case deviations of the output caused by line, load, stability, and noise conditions. Assumes calibration against an AC-DC transfer standard with an AC-DC difference of 50 ppm from 50 Hz to 50 kHz and 300 ppm from 50 kHz to 100 kHz.

Amplitude Accuracy Using DC Calibration

Using a DC reference accurate to ± 15 ppm and standard laboratory equipment, the 510A may be calibrated to achieve the following accuracies at standard operating temperatures of $23 \pm 2^\circ\text{C}$, and worst case deviations caused by line, load, stability and noise conditions.

	<u>30 Days</u>	<u>90 Days</u>	
50 Hz – 5 kHz	$\pm 0.01\%$	$\pm 0.02\%$	
5 kHz – 10 kHz	$\pm 0.02\%$	$\pm 0.03\%$	
10 kHz – 30 kHz	$\pm 0.05\%$	$\pm 0.07\%$	
30 kHz – 100 kHz	$\pm 0.15\%$	$\pm 0.17\%$	
Amplitude Stability	<u>24 Hours</u>	<u>30 Days</u>	<u>90 Days</u>
50 Hz – 20 kHz	$\pm 0.002\%$	$\pm 0.005\%$	$\pm 0.01\%$
20 kHz – 100 kHz	$\pm 0.004\%$	$\pm 0.01\%$	$\pm 0.02\%$

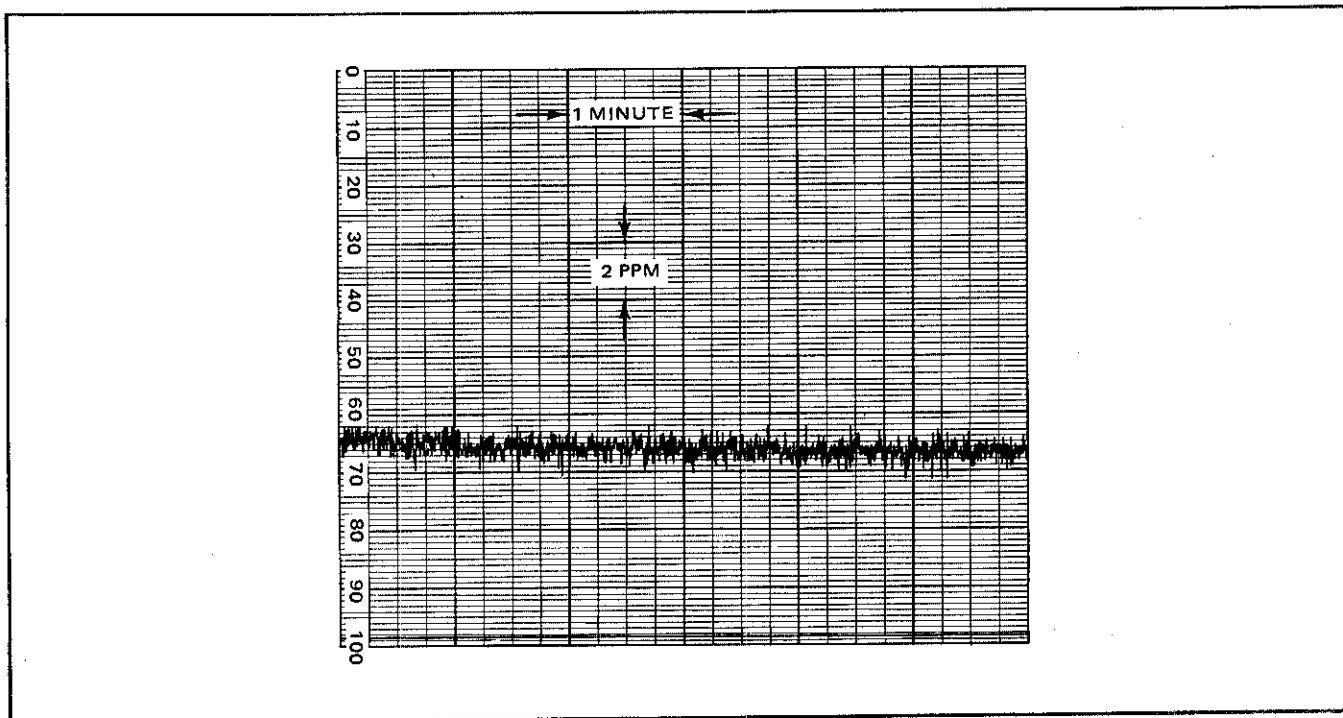


Figure 1-1. TYPICAL SHORT TERM STABILITY

AMPLITUDE NOISE

Amplitude deviation due to noise is less than 20 ppm peak-to-peak through a 1 Hz bandwidth over a 1 minute interval.

AMPLITUDE TEMPERATURE COEFFICIENT

50 Hz – 5 kHz	<u>15° – 50°C</u>	<u>0° – 15°C</u>
5 kHz – 10 kHz	5 ppm/°C	12 ppm/°C
10 kHz – 30 kHz	7 ppm/°C	15 ppm/°C
30 kHz – 100 kHz	10 ppm/°C	17 ppm/°C
	15 ppm/°C	22 ppm/°C

TOTAL HARMONIC DISTORTION	(See Figure 1-2).
CENTER FREQUENCY ACCURACY	±0.1%
FREQUENCY RESOLUTION	±0.05% using front panel vernier
FREQUENCY VERNIER	Screwdriver adjustment, ±1% of center frequency
FREQUENCY STABILITY	500 ppm per month
Frequency Temperature Coefficient	Less than 150 ppm/°C
Common Mode Rejection	Common Mode Rejection is defined as the affect on the rms or average value of the 10V rms output due to a common mode signal between the low terminal and chassis. This rejection is:

Greater than 100 db for common mode signals from 1 Hz to 500 Hz, 10V peak-to-peak maximum.

Greater than 70 db for common mode signals from 500 Hz to 1 MHz, 3V peak-to-peak maximum.

Maximum allowable dc potential between output low and chassis ground is 100 volts.
(See Figure 1-3).

LOAD REGULATION

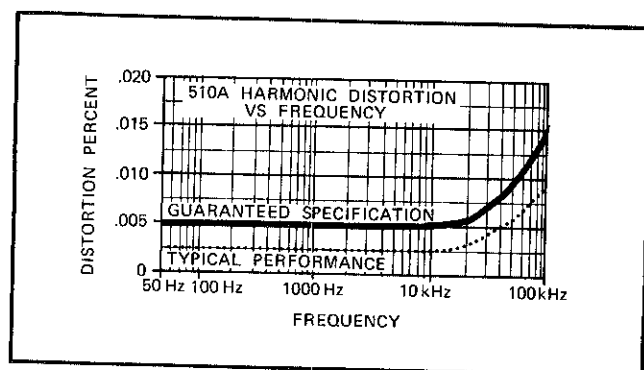


Figure 1-2. TOTAL HARMONIC DISTORTION

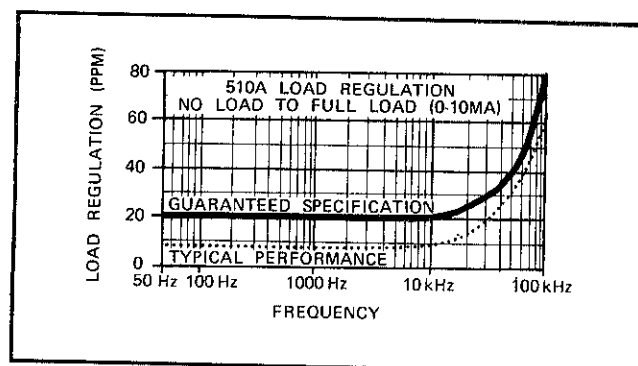


Figure 1-3. LOAD REGULATION

LINE REGULATION	< 10 ppm, ±10% line change
OUTPUT CONNECTIONS	High, Low and Chassis binding posts on front and rear panels.
UNCALIBRATED INDICATION	Front panel display labeled "UNCAL" indicates when load exceeds 10 mA.
ENVIRONMENTAL	
Operating Temperature Range	0°C to 50°C
Storage Temperature	-40°C to +75°C; -40°C to +60°C with batteries
Humidity Range	Up to 80% relative humidity, 0°C to 35°C
Shock	Up to 70% relative humidity, 35°C to 50°C
Vibration	20g, 11 millisecc half-sine wave
Altitude	4.5g, 10 Hz - 55 Hz
INPUT POWER	0 to 10,000 feet - Operating
115/230V ac ±10%, 50 - 500 Hz, Single Phase	50,000 feet - Non-Operating
SIZE	An optional rechargeable battery pack will power the AC Reference Standard for 16 hours. The battery pack is field installable.
MOUNTING	3-1/2" high x 4-1/4" wide x 12" deep
	Up to four 510A's can be mounted side by side and installed in a standard 19" EIA rack with optional accessory ears.

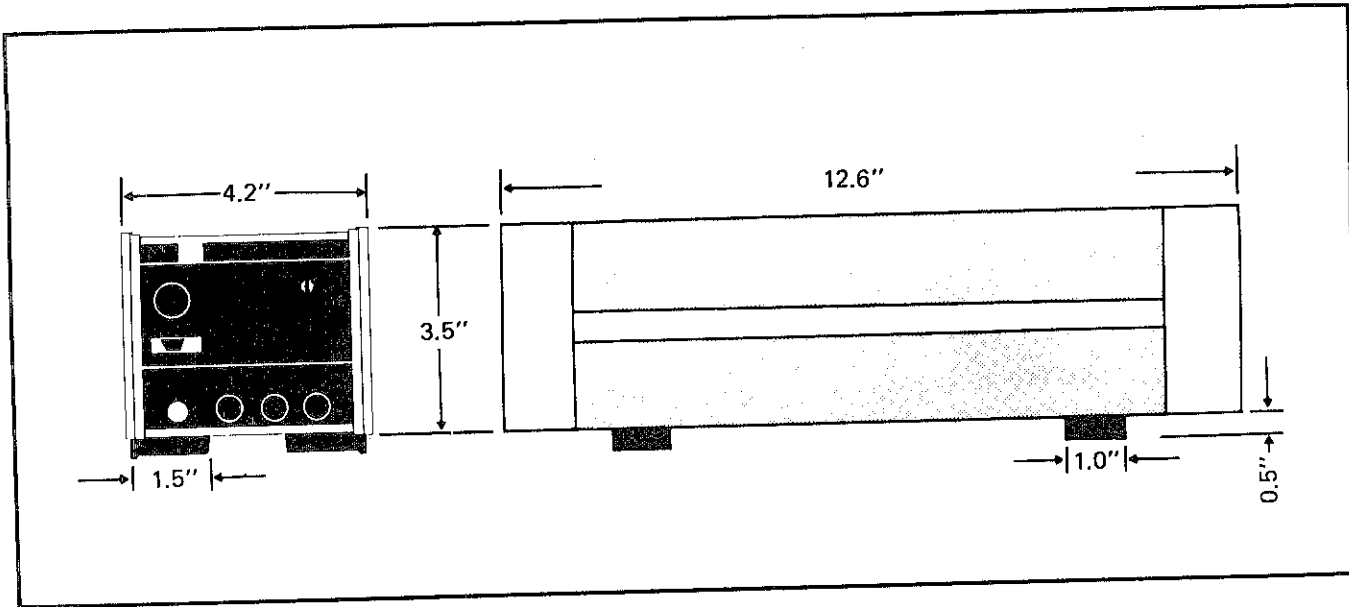


Figure 1-4. OUTLINE DRAWING

Section 2

Operating Instructions

2-1. INTRODUCTION

2-2. This section contains operating instructions for the Model 510A. If any difficulties are encountered, contact the nearest John Fluke Sales Representative or write directly to the John Fluke Mfg. Co., Inc. Please include the instrument serial number when writing.

2-3. SHIPPING INFORMATION

2-4. The Model 510A was packaged and shipped in a foam packed cardboard carton. Upon receipt, a thorough inspection should be performed to reveal any damage in transit. Special instructions for inspection and claims are included in the carton.

2-5. If reshipment is necessary, the original container should be used. If the original container is not available, a new one can be obtained from the John Fluke Mfg. Co., Inc. Please reference the Model number when requesting a new container.

2-6. INPUT POWER

2-7. This instrument can be operated from either a 115 or 230V ac, 50 to 500 Hz, single phase power line. A slide switch on the rear panel allows selection of the appropriate line voltage. The rated value of the rear panel fuse F1 is as follows:

<u>115 VAC</u>	<u>230 VAC</u>
1/4A, 3AG	1/8A, 3AG

2-8. INSTALLATION

2-9. The Model 510A is designed for bench-top use or it

can be installed in a standard 19 inch equipment rack with Accessory rack mounting brackets. Up to four units can be rack mounted in side-by-side positions. Rack installation procedures are located in Section 6.

2-10. OPERATING FEATURES

2-11. The location and function of all controls, connectors, and indicators is shown in Figure 2-1.

2-12. OPERATING NOTES

2-13. AC Line Connection

2-14. The input power cord has a three prong, polarized connector. This plug allows connection to either a 115 or 230V ac, 50 to 500 Hz, single phase power line. The round pin connects the chassis to earth ground; therefore, ensure that the round pin is connected to a high quality earth ground. The instrument is energized through a POWER switch on the front panel. A front panel meter indicates LINE OPR when the instrument is energized.

2-15. Battery Power (-01 Option)

NOTE

Battery manufacturers recommend that nickel-cadmium batteries should not be stored for extended periods of time without recharging at least every 90 days. Storage temperatures below 25°C are recommended.

2-16. When the -01 Option is installed, the Model 510A can be operated from an internal rechargeable battery. Battery operation is activated by disconnecting the power

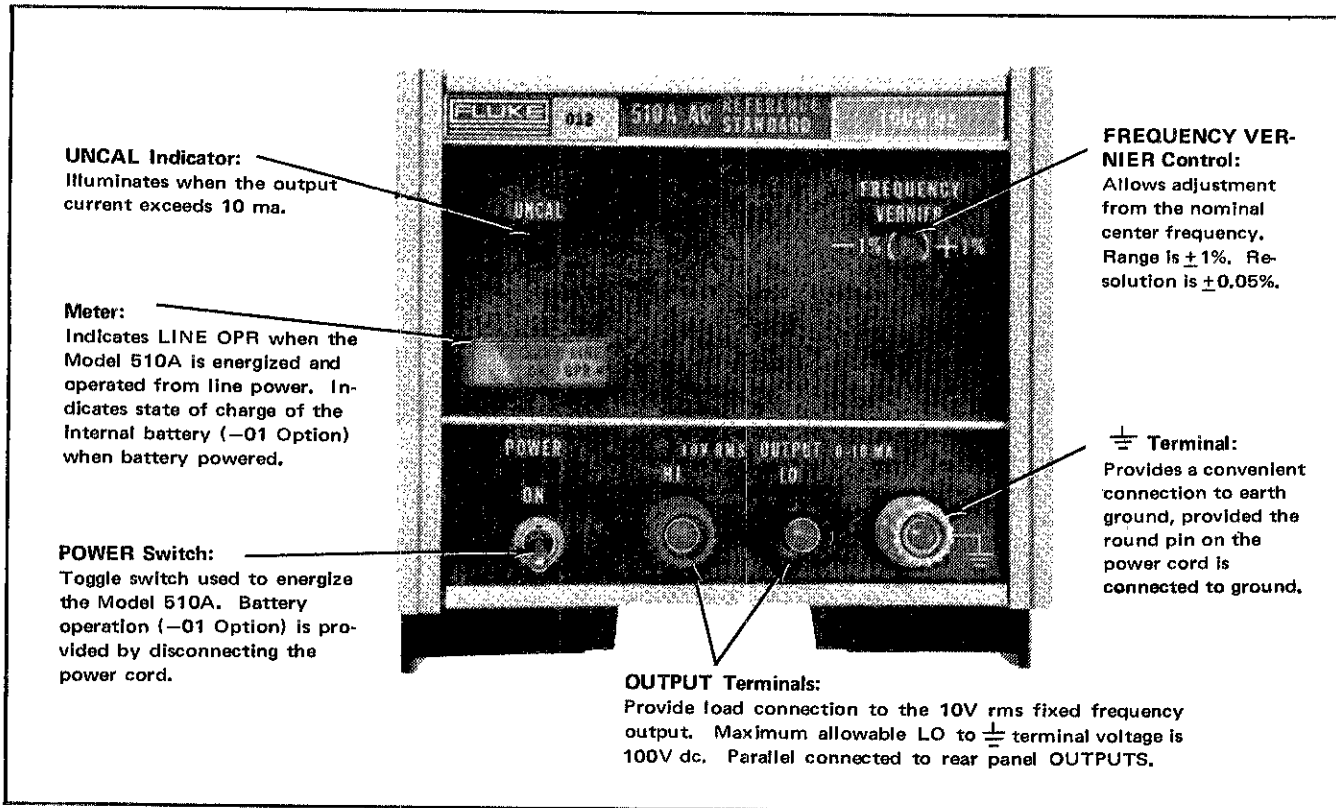


Figure 2-1. OPERATING FEATURES (1 of 2)

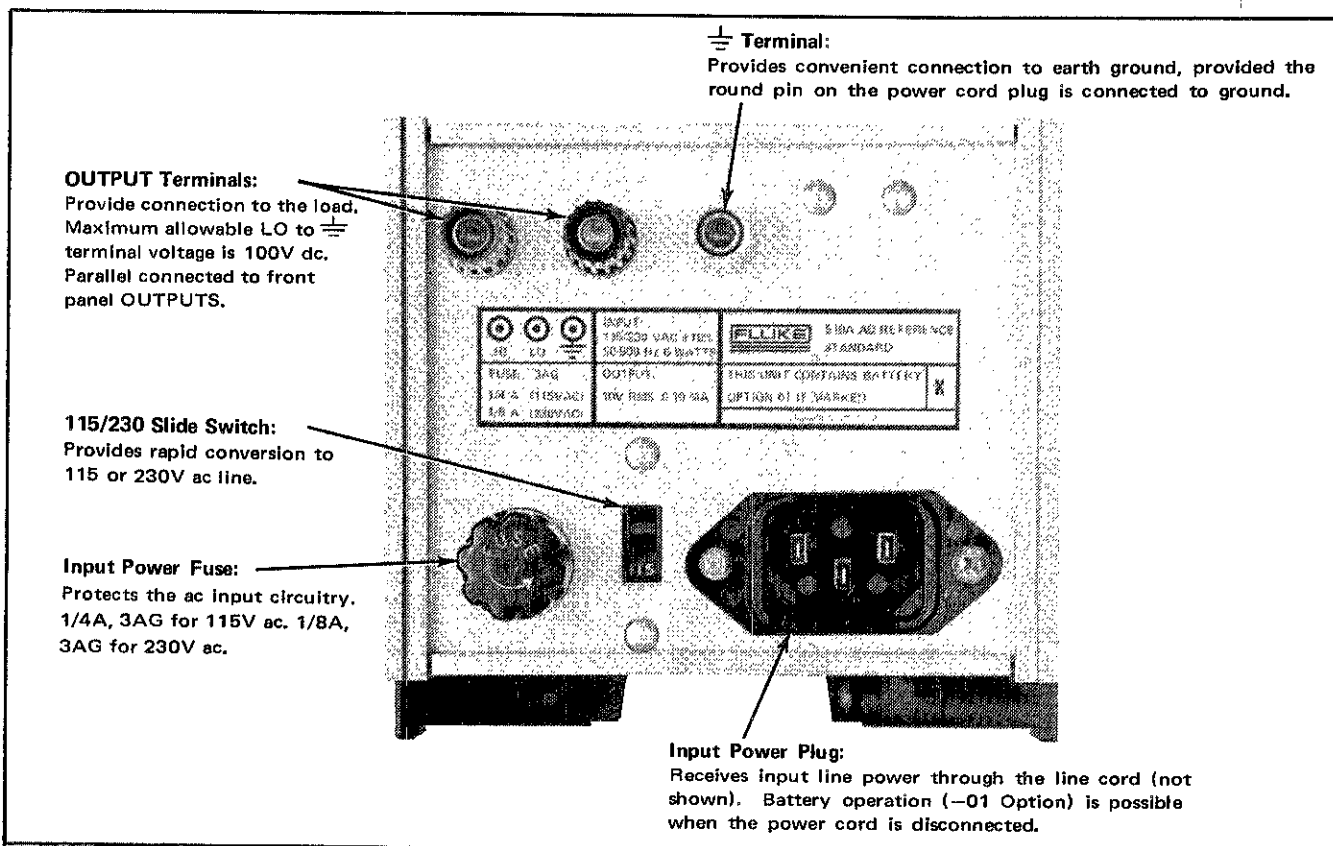


Figure 2-1. OPERATING FEATURES (2 of 2)

cord from line power and turning the instrument on with the POWER switch on the front panel. Relative state of charge (BAT OK) is indicated by a meter on the front panel. The battery is automatically charged whenever the instrument is operated from line power.

NOTE!

The chassis of the instrument and the \perp terminal are connected to ground through the power cord. When battery operation is used and the chassis is isolated from ground, this ground connection will be broken.

2-17. Load Connections

2-18. Output load connection is done using HI and LO OUTPUT terminals on the front or rear panel. These OUTPUT terminals are parallel connected and only one set should be connected to a load at one time. A \perp terminal is included for convenient connection to ground (see preceding note). Maximum allowable potential between the LO OUTPUT and \perp terminal is 100V dc.

2-19. The following rules should be observed for all load connections.

- a. AC power to the Model 510A and associated equipment should be derived from the same power line. Line power connections should be as close together as possible.
- b. Shielded, twisted pair load cables should be used. Typical load connections are shown in Figure 2-2.
- c. Load cables should be kept as short as possible. Maximum lead resistance should be less than 20 m Ω .

2-20. Overload Protection

2-21. The maximum output current is limited by the power capability of the internal circuitry. This circuitry will not be damaged even if the OUTPUT terminals are short circuited. However, when the output current exceeds 10 mA, the output will not be within its specified accuracy. Visual indication of an output current greater than 10 mA is provided by an UNCAL lamp (LED) on the front panel.

2-22. OPERATING PROCEDURES

2-23. The Model 510A produces a fixed frequency output having an amplitude of 10V rms. Frequency accuracy is

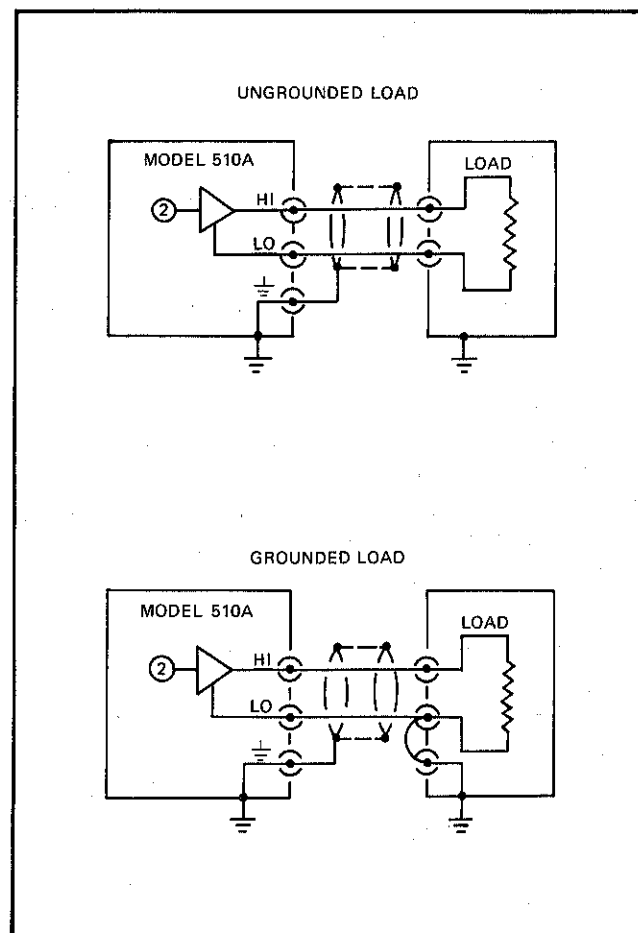


Figure 2-2. LOAD CONNECTIONS

$\pm 0.1\%$, adjustable $\pm 1\%$ with a FREQUENCY VERNIER on the front panel. Amplitude accuracy is given in Section 1.

2-24. To operate the instrument, proceed as follows:

- a. Connect the power cord to line power. See paragraph 2-6 and 2-13.
- b. Make the desired load connections at the front or rear panel OUTPUT terminals.
- c. Set the POWER switch to ON and allow the instrument to operate for ten minutes. The meter on the front panel should indicate LINE OPR and the UNCAL indicator should be out.
- d. After ten minutes of operation, the output is at its specified accuracy.

NOTE!

Battery operation (-01 Option) is described in paragraph 2-15.

2-25. APPLICATIONS

2-26. Introduction

2-27. The Model 510A can be used in a number of ways as a precise ac reference. The following paragraphs describe a few of its applications.

2-28. Precision AC Source for Automatic Test Systems

2-29. Automated test systems containing Fluke 4200 series voltage sources can use the Model 510A as an external reference to produce precise ac voltages. Figure 2-3 shows such a system. System ac output is from 0 to 45V ac rms at up to 0.7 amperes rms. Overall system accuracy of $\pm 0.02\%$ can be achieved for frequencies up to 5 kHz.

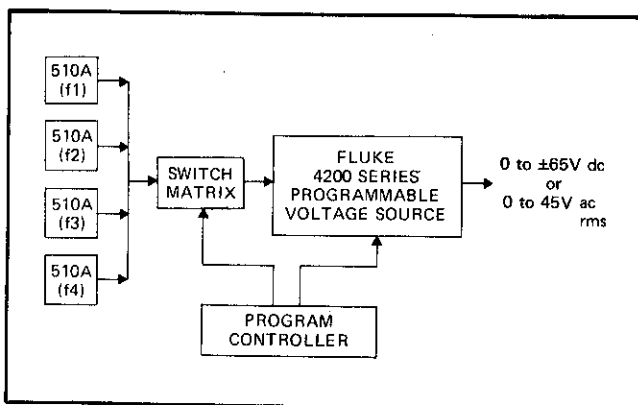


Figure 2-3. AUTOMATED TEST SYSTEM AC REFERENCE

2-30. Phase Locked AC Reference Standard

2-31. A Model 510A can be modified to phase lock with an external signal and provide multiple outputs. Figure 2-4 shows the modified Model 510A/AA which is designed to synchronize with an external 400 Hz signal and provide eight transformer coupled outputs. Programmable phase reversal at each output is also provided. The outputs can be used as external references in the system application described in paragraph 2-28. Typical specifications for the Model 510A/AA are as follows:

FREQUENCY	400 Hz $\pm 5\%$ (other frequencies can be specified)
OUTPUT VOLTAGE	10V rms (eight outputs, transformer coupled)
OUTPUT ACCURACY	$\pm 0.1\%$
OUTPUT PHASE RELATIONSHIP	$0^\circ \pm 1^\circ$ or $180^\circ \pm 1^\circ$ (programmable)
TOTAL HARMONIC DISTORTION	0.2%
PHASE LOCK CAPTURE RANGE	$\pm 5\%$ about center frequency
SYNC INPUT VOLTAGE	24V rms

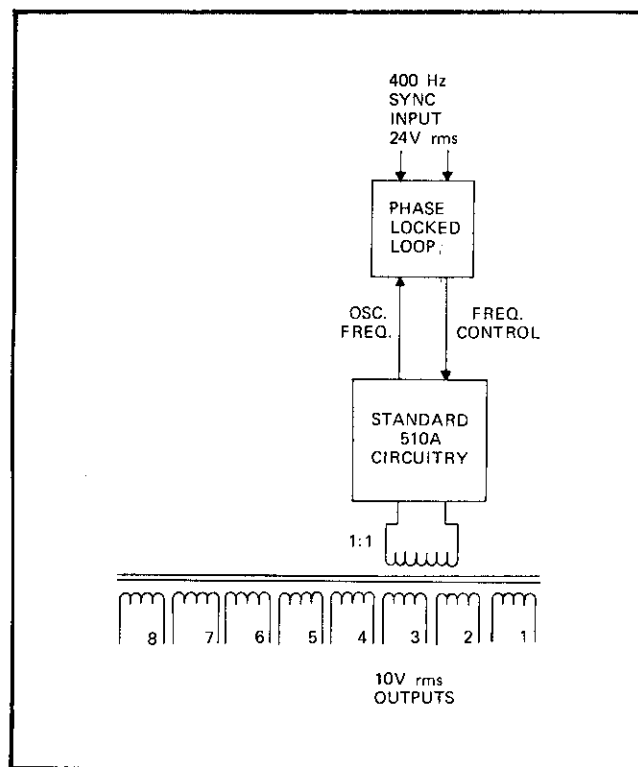


Figure 2-4. MODEL 510A/AA BLOCK DIAGRAM

Section 3

Theory of Operation

3-1. INTRODUCTION

3-2. This section contains the theory of operation for the Model 510A. The information is arranged under headings of "BLOCK DIAGRAM ANALYSIS and CIRCUIT DESCRIPTIONS." It is recommended that this section be thoroughly read and understood before any attempt is made at servicing this instrument.

3-3. BLOCK DIAGRAM ANALYSIS

3-4. The Model 510A produces an extremely stable 10V rms signal at a fixed frequency. Five major circuits are used to produce and control the output. These circuits and their interconnection are shown in Figure 3-1.

3-5. The DC Reference Supply produces an accurate, low temperature coefficient, dc voltage of +14.14214V. This voltage is applied to one end of a divider at the input of the Peak AC to DC Converter and also functions as a reference for the -18V Regulator. The other end of the divider receives the 10V rms output of the Model 510A, thus producing a 0V condition at its center when the peak of the output signal is equal to minus the Reference Supply voltage. The Peak AC to DC Converter produces an amplified signal that is equal to the negative difference between the output signal and the +14.14214V reference. This signal charges a capacitor at the output of the Peak AC to DC Converter which is then transferred to a capacitor at the input of the Integrator by the Sample and Hold. Transfer is done only during the positive peak excursion of

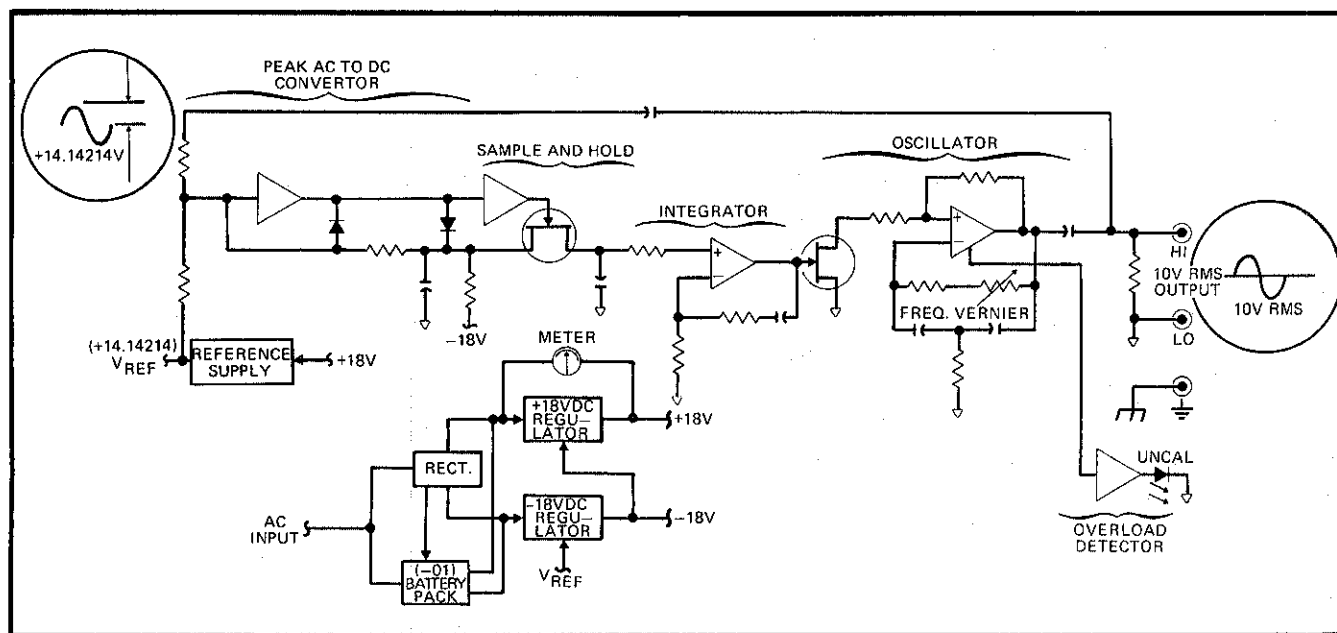


Figure 3-1. MODEL 510A BLOCK DIAGRAM

the signal. The Integrator produces a dc output proportional to the time integral of the voltage stored on its input capacitor. This dc output is applied to the Oscillator where it causes the peak output amplitude to maintain a near 0V condition at the input to the Integrator. The Overload Detector monitors the output of the Model 510A and turns on the UNCAL indicator when the output current exceeds 10 mA.

3-6. All operating voltages are produced by the $\pm 18V$ DC Regulators. Reference voltage for the +18V DC Regulator is derived from the -18V DC Regulator. The -18V DC Regulator receives a reference voltage from the Reference Supply. Unregulated inputs to each regulator are derived from the Rectifier or the -01 Option Battery Pack. The Battery Pack operates in the absence of line power to the Rectifier. Relative charge state of the batteries is indicated by a meter connected across the +18V DC Regulator. A rectifier located in the -01 Battery Pack circuitry provides recharging of the batteries whenever line power is applied.

3-7. CIRCUIT DESCRIPTIONS

3-8. The following paragraphs describe the circuitry in the Model 510A. Each description is keyed to the schematic diagram located at the rear of the manual.

3-9. Input Power

3-10. AC line power from A4J1 is applied to A4T1 through the POWER switch A1S1A and the 115/230 slide switch A4S1. The primary of A4T1 consists of two windings which are interconnected through A4S1 for operation from either a 115 or 230V ac line. Parallel connection is used for 115V ac line operation while series connection is used for 230V ac line operation. Both primary windings are completely shielded to reduce capacitive coupling between the power line and the floating circuitry in the instrument. The shield is connected to chassis ground and power line ground through the power cord. The secondary of A4T1 consists of two separate windings both of which are shielded to eliminate the generation of common mode signals that could appear at the OUTPUT terminals. This shield is connected to the center-tap of a secondary winding and power supply common. The center-tapped secondary winding provides ac power to rectifiers CR2 and CR3, CR4. The other secondary winding supplies ac power to the Battery Pack PCB (-01 Option) and the meter, A1M1. Diode CR1 rectifies the ac voltage present during line operation to provide a full-scale LINE OPR indication on A1M1. A2DS1 and DS2 function to stabilize and limit the maxi-

mum current used by the Battery Pack PCB during charging of the batteries.

3-11. A3 Battery Pack

3-12. The A3 Battery Pack is installed as the -01 Option. It consists of a Battery Pack PCB and two batteries, BT1 and BT2. This circuitry provides operation from the batteries in absence of line power, disconnects the batteries when they are in a low charge-state to prolong battery life, limits the maximum battery current drain should a circuit malfunction occur, and disconnects the batteries from the instrument circuitry and recharges them during line operation.

3-13. BATTERY OPERATION. When line power is removed and the POWER switch is ON, the batteries BT1 and BT2 are connected to the inputs of the $\pm 18V$ Regulators through the Battery Pack PCB. The positive output of BT1 is applied through S1B to J5 where a divider consisting of R2, CR3 and R4 supplies the base of Q2 with a positive voltage. This voltage turns on Q2 which supplied base current to Q1 and also turns it on. Conduction of Q1 applies the positive output of BT1 through the series transistor Q3 to the input of the +18V Regulator. The diode connection of Q3 prevents reverse current flow from the +18V Regulator to the battery. The negative output of BT2 is applied through S1C to the series transistors Q5. Since a positive voltage is available at the emitter of Q4 through R8, Q4 is turned on in sequence with the conduction of Q1. This condition turns on Q5 and applies the negative output of BT2 through the series transistor Q6 to the input of the -18V Regulator. The diode connection of Q6 prevents reverse current flow from the -18V Regulator to the battery.

3-14. Should the batteries discharge to a state where they can no longer furnish adequate power, the series transistors Q1 and Q5 are automatically switched off. This is made possible through the use of zener diode CR3. As the output of BT1 decreases, the voltage at the base of Q2 reaches a point where the transistor can no longer furnish enough base current for Q1 to maintain conduction. Q1 is therefore cut-off and disconnects the output of BT1 from the -18V Regulator. Sharp cut-off for Q1 is ensured by R6 which provides some of the base current for Q2. Once the voltage at the collector of Q1 begins to drop, base current to Q2 is further reduced, this sharply cutting-off Q1. Since the conduction of Q4 and Q5 is slaved to the conduction of Q1, as described in the preceding paragraph, the negative output of BT2 is also disconnected from the -18V Regulator.

3-15. The maximum current drain from the batteries is limited by the selection of the value of R5 and R9. These resistors limit the maximum base current to Q1 and Q5. Should a short circuit appear at either output, the maximum current is therefore dependent upon the base current of Q1 or Q5 times their current gain.

3-16. **LINE OPERATION.** When line power is applied, the batteries are disconnected from the $\pm 18V$ Regulators and are recharged. Battery disconnection is caused by a $-22V$ battery disconnect voltage produced by CR3, CR4 and C1. This voltage is applied to a divider consisting of R3 and R4 in the Battery Pack PCB. Presence of a negative voltage at the base of Q2 turns it off and causes Q1 to turn off. Since Q4 and Q5 are slaved to Q1, they are also turned off and both batteries are disconnected from the $\pm 18V$ Regulators. Diodes CR4 and CR5 limit the maximum negative base and emitter voltage at Q2 and Q5 during line operation.

3-17. Charging of the batteries is provided through full-wave rectifier CR1 in the Battery Pack PCB. AC power for this rectifier is derived from the untapped secondary of T1. A2DS1 and DS2 function as a ballast to limit the maximum charging current. Zeners CR2 and CR6 in the Battery Pack PCB limit the maximum battery voltage during charging.

3-18. $\pm 18V$ Regulator

3-19. The $\pm 18V$ Regulators produce low ripple operating voltages for the instrument. Input voltage to the regulators is derived from full-wave rectifiers when the instrument is line powered or from batteries if the -01 Option is installed. The $-18V$ Regulator receives its reference from the Reference Supply. Reference voltage for the $+18V$ Regulator is derived from the $-18V$ Regulator; thus, should any malfunction occur in one supply, all will be affected.

3-20. **+18V REGULATOR.** The $+18V$ Regulator consists of Q1 through Q3. Q1 is the series-pass element. Q2 and Q3 control the base current of Q1 to maintain the $+18V$ dc output. Resistor R3 ensures initial turn-on of Q2 and Q3. The base of Q3 is referenced to the $-18V$ Regulator through R10 and receives a sample of the $+18V$ dc output through R8 and R9. Any change in the $+18V$ dc output is therefore amplified by Q2 and Q3, which then alters the conduction of Q1 to maintain the regulated output. Variable resistor R9 allows adjustment of the $+18V$ dc output.

3-21. **$-18V$ REGULATOR.** The $-18V$ Regulator consists of Q4 through Q6. Q4 is the series-pass element. Q5 and Q6 control the base current of Q4 to maintain the $-18V$ dc output. R12 ensures initial turn-on of Q5 and Q6.

The base of Q6 is referenced to the Reference Supply (V_{REF}) through R18, CR5, and CR6 and receives a sample of the $-18V$ dc output through R17. CR5 and CR6 compensate for the voltage temperature coefficient at the base of Q6 as well as its base emitter voltage drop. Output voltage from this supply is therefore dependent upon V_{REF} and the ratio of R17 to R18.

3-22. Reference Supply

3-23. The Reference Supply produces an extremely stable reference voltage (V_{REF}) upon which the accuracy and stability of the rms output is based. It consists of a high gain, high input impedance, differential amplifier U1 and a reference amplifier U2. The temperature coefficient of the base/emitter voltage for U2 is accurately matched to the temperature coefficient of the zener element through factory selection of R22 and R23. Output voltage of this supply is scaled to $+14.14214V$ dc through selection of R30 and R31. Variable resistor R27 allows adjustment of V_{REF} . The adjustment range of R27 is compensated through jumper selection of R25 and R29. The resulting stable reference at the collector of U2 is applied to the non-inverting input of U1. The other input to U1 receives an equivalent voltage from the divider composed of R20 and R21. Any change in V_{REF} is sensed at the base of U2 which produces an amplified change at the non-inverting input to U1. This change then alters the conduction of U1 such that V_{REF} is maintained at $+14.14214V$ dc.

3-24. Peak AC to DC Convertor

3-25. The Peak AC to DC Convertor is a video amplifier which compares the amplitude of the output signal to V_{REF} and produces a dc voltage equal to four times any negative difference. The circuitry consists of input divider R37 through R42, differential amplifiers U3 and Q8 through Q10, and emitter followers Q11, Q12. A simplified diagram is shown in Figure 3-2.

3-26. The input divider R37 through R42 receives the rms output signal and V_{REF} through S2. The center of this divider is tapped at the junction of R40 and R41 and applied to one input of U3. Unity ratio is made possible at this tap by reversal of the inputs through S2 and adjustment of R37. Except for a small interval of time during the negative most peak of the rms signal, a positive current is flowing into the input of the video amplifier; however, since the input resistance of U3 is extremely high and the current is of proper polarity of forward bias CR9, it is conducted through CR9 and Q11 to $-18V$. When the peak of the rms signal is more negative than V_{REF} , the input cur-

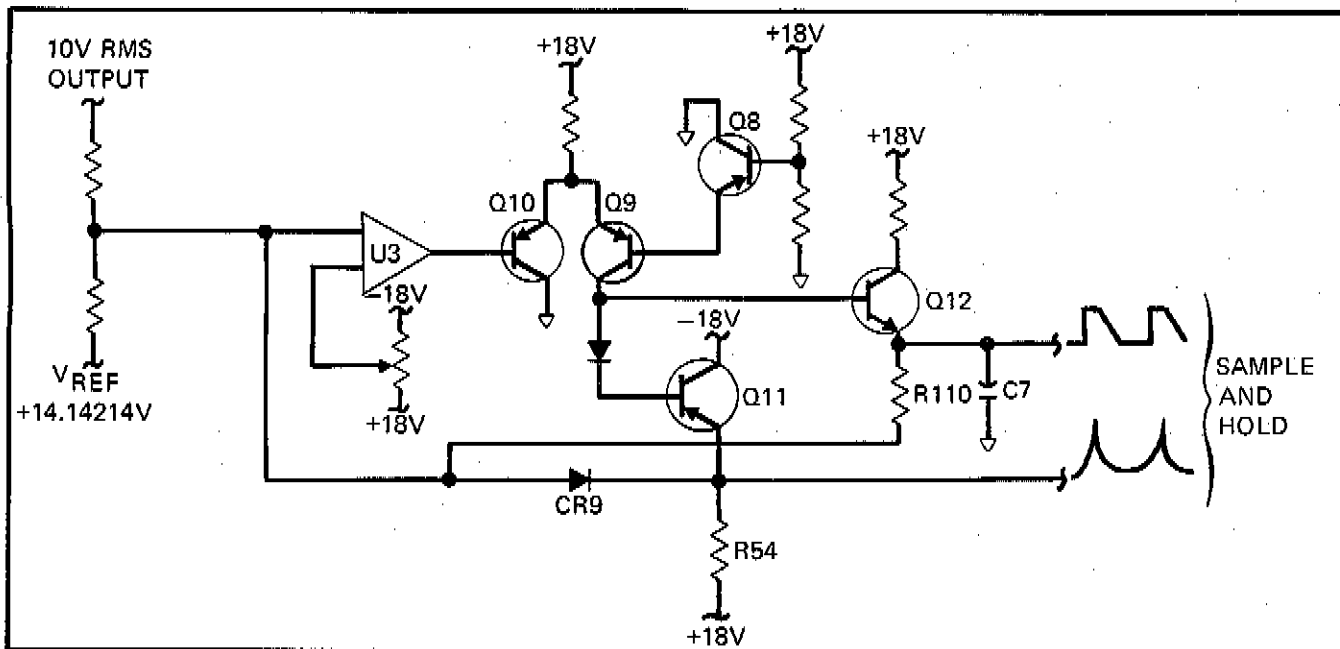


Figure 3-2. PEAK AC TO DC CONVERTOR (SIMPLIFIED)

rent reverses direction and CR9 is cut-off. This signal condition is then amplified by U3 and Q8 through Q10, which produces an emitter current in Q12. The resulting current produces a voltage charge on C7 in the A2A1 PCB that is four times the negative peak difference between the rms output and V_{REF} . Variable resistor R60 allows adjustment of the bias on CR9. R49 allows zero adjustment of the video amplifier input offset voltage.

3-27. Sample and Hold

3-28. The Sample and Hold circuit transfers the charge on C7 in the A2A1 PCB to the input of the Integrator. This circuit is operational only at output frequencies below 20 kHz. It is disabled on output frequencies above 20 kHz because the overall detection is sufficiently fast without sample and hold. The circuitry consists of Schmitt Trigger Q13, Q14, inverter amplifiers Q7 and Q15, Q16, and FET gate Q17.

3-29. Positive excursions of the pulse wave form at the base of Q13 correspond to when CR9 in the Peak AC to DC Convertor is cut-off and a negative peak difference signal is being stored on C7 in the A2A1 PCB. This positive going pulse is shaped by Schmitt Trigger Q13 and Q14. Normally, Q14 is conducting and Q13 is cut-off. Presence of a positive going input to Q13 turns it on and turns off Q14. The resulting positive pulse at the collector of Q14 subsequently has a duration equal to the conduction interval of Q13. This pulse is coupled through C29 and turns on inverter Q15, Q16. The conduction of Q15 and the clamping action of Q16 produces a positive pulse through C8 in

the A2A1 PCB and CR13, which is applied to the gate of Q17. This positive pulse occurs at the trailing edge of the Schmitt Trigger pulse and turns on Q17. Conduction of Q17 then transfers the voltage charge on C7 in the A2A1 PCB to C9, which is at the input of the Integrator. The rectifier action of CR13 and C40 produces a zero volt turn on signal at the gate of Q17 in the absence of pulses from the Schmitt Trigger. This is necessary because the Schmitt Trigger of Q13 and Q14 is disabled on output frequencies above 20 kHz by a jumper between P9 and P17. Inverter Q7 provides a positive pulse to Q17 which compensates for the small error caused by the gate to drain capacitance.

3-30. Integrator

3-31. The Integrator consisting of U4 and associated components produces an amplitude control voltage for the Oscillator that is dependent upon the error signal from Peak AC to DC Convertor. U4 is a high gain, non-inverting amplifier. One input is derived from C9 in the A2A1 PCB and the other from divider R72 through R75. Variable resistor R72 allows offset voltage compensation for U4. The network consisting of CR14 through CR16 and R78 functions as a clamping circuit which limits the maximum output voltage from U4. This circuit improves the recovery time of the Integrator upon initial turn-on and fault (UNCAL) conditions.

3-32. Oscillator

3-33. The Oscillator produces the constant amplitude 10V rms, fixed frequency output signal. It is a bridge "T"

oscillator formed by input amplifier Q18 through Q24, voltage controlled resistor FET Q26, and output amplifier Q25, Q27, Q28. Output amplitude is precisely maintained at 10V rms by the integrator output voltage applied to Q26. Output frequency is dependent upon the component values in the bridge "T" feedback network.

3-34. Input amplifier Q18 through Q24 is the heart of the Oscillator. The differential pair of Q19 and Q21 receives two inputs derived from feedback networks connected to the Oscillator output. The input to the base of the Q19 is through a bridge "T" network in the A2A1 PCB. Component values of A2A1C1 C2, R1 and R2 determine the center output frequency. The input to the base of Q21 is through the positive feedback network composed of R95 and R96. This feedback signal together with the conduction level of Q26 controls the output amplitude. Adjustment of R95 and R96 allows offsetting the output frequency. Conduction of Q26 is dependent upon the voltage control signal applied to its gate. This signal is derived from the Integrator and is of such a level as to maintain the output signal at precisely 10V rms. Q18 and Q20 combine the collector signals of Q19 and Q20 in the appropriate phase so that the output signal to Q22 base is twice that of what is normally obtained from a differential input stage. This configuration provides minimum ac current flow in Q19 and Q21. The collector signal at Q23 is the first point at which a 10V rms signal is available. Emitter follower Q24 drives the following output stage of Q27 and Q28. AC current in Q23 and Q24 is minimized by bootstrapping R88 and the emitter load of Q24 through C35 to

the output. Overall open loop forward gain of the input amplifier is determined by the ratio of C33 (X_c) in ratio with the sum of R82 and R83 times two.

3-35. The output amplifier of Q25 and Q27, Q28 is a complementary output stage. Temperature compensation of the bias current for Q27 and Q28 is provided through Q25 and the divider network of R99 through R101. Variable resistor R100 allows adjustment of this bias current. Output amplifiers Q27 and Q28 produce the output signal of the instrument. Maximum output current is limited by the collector load resistors and the supply voltage. The output signal is specified to 10 mA, above which clipping and distortion may result.

3-36. Overload Indicator

3-37. The Overload Indicator consists of Q29 and the light emitting diode CR23. This circuit illuminates the UNCAL indicator whenever the output current exceeds 10 mA.

3-38. Q29 monitors the voltage drop across R106. When the output current is greater than 10 mA, the voltage drop across R106 will be greater than 0.6 volts. This voltage turns on Q29 whose conduction path is through the UNCAL indicator CR23. Since CR23 acts similar to a zener, the first 1 mA of collector current of Q29 is bypassed around CR23 through R113. Any further increase in current is through CR23, thus assuring rapid turn on of the UNCAL indicator.

Section 4

Maintenance

4-1. INTRODUCTION

4-2. This section contains service and maintenance information for the Model 510A. The information is arranged under headings of "SERVICE INFORMATION, GENERAL MAINTENANCE, MAINTENANCE ACCESS, PERFORMANCE CHECKS, CALIBRATION PROCEDURES, COMPENSATING COMPONENT SELECTION, and TROUBLESHOOTING." Equipment required to service this instrument is listed in Table 4-1. If the recommended equipment is not available, substitute equipment having equivalent specifications can be used.

4-3. SERVICE INFORMATION

4-4. Each instrument that is manufactured by the John Fluke Mfg. Co., Inc. is warranted for a period of one year upon delivery to the original purchaser. The WARRANTY is located at the front of the manual.

4-5. Factory authorized calibration and service for each Fluke product is available at various world-wide locations. A complete list of these authorized service centers is located at the rear of the manual. Shipping information is given in Section 2 paragraph 2-3. If requested, an estimate will be provided to the customer before any repair work is begun on instruments that are beyond the warranty period.

4-6. GENERAL MAINTENANCE

4-7. Cleaning

4-8. The Model 510A should be cleaned periodically to remove accumulation of any dust or other contaminants. The exterior should be cleaned using a cloth moistened with ordinary soap and water. Cleaning of the interior should be done with clean, dry air at low pressure. If the printed circuit boards require cleaning, first spray them with Freon T.F. Degreaser (Miller Stephenson Co., Inc.) and then remove the dirt with clean, dry air at low pressure.

4-9. Fuse Replacement

4-10. Input line power to the instrument is overload protected by a fuse installed on the rear panel. A decal giving the type and rating of the fuse is also located on the rear panel. If replacement is necessary, use only the type fuse specified on the decal for 115 or 230V ac line power.

4-11. Lamp Replacement

4-12. An UNCAL status indicator (LED) is located on the front panel. This indicator is accessible after removing the top dust cover and requires no special tools to replace. If replacement is necessary, use a Fairchild, type FLV 102 (FLUKE PART NO. 309617) or equivalent.

TABLE 4-1. REQUIRED TEST EQUIPMENT

NOMENCLATURE	RECOMMENDED EQUIPMENT	TEST FUNCTION
Autotransformer	Variac	Performance checks Calibration Troubleshooting
Multimeter	FLUKE 853A	Troubleshooting
AC/DC Differential Voltmeter	FLUKE 887AB	Performance checks Calibration Troubleshooting
DC Voltage Standard/Null Detector	FLUKE 335D	Performance checks Calibration
Thermal Transfer Standard	FLUKE 540B, A54-2 (Certified to $\pm 0.04\%$ at 50 kHz - 100 kHz)	Performance checks Calibration
Frequency Counter	HP 5245L	Performance checks Calibration Troubleshooting
Oscilloscope	Tektronix 543, 1A1, X10 Probe	Calibration Troubleshooting
Resistive Loads	700, 900, 1k $\pm 2\%$ (Usable to 100 kHz)	Performance checks

4-13. Two ballast lamps designated DS1 and DS2 that are part of the -01 Option are installed on the A2 Main PCB. These lamps are mounted in clip holders attached to the inner rear panel. Access to the lamps is provided after removal of the top dust cover. Replacement requires no special tools. If replacement is necessary, use only GE757 (FLUKE PART NO. 175265) or equivalent.

4-14. MAINTENANCE ACCESS

4-15. The following procedure is to be used to gain access to the interior sections of the Model 510A.

4-16. Major Section Access

- a. Turn off the Model 510A and remove the top dust cover. Access is provided to all adjustments and test points shown in Figure 4-1.
- b. Remove the bottom dust cover. Access is now provided to assemblies shown in Figure 4-2.

4-17. Plug-In Assembly Removal and Installation

- a. Locate the assembly to be removed using Figure 4-2.
- b. Disconnect any wiring and then remove mounting screws.
- c. Remove the plug-in assembly using a gentle rocking motion and an even pulling force.
- d. Install the plug-in assembly in its correct position using a gentle rocking motion and steady downward pressure. Ensure that each mating connector is correctly aligned during installation.
- e. Reconnect any wiring disconnected in step c. Each wire is labeled with a number which corresponds to a connector on the PCB.

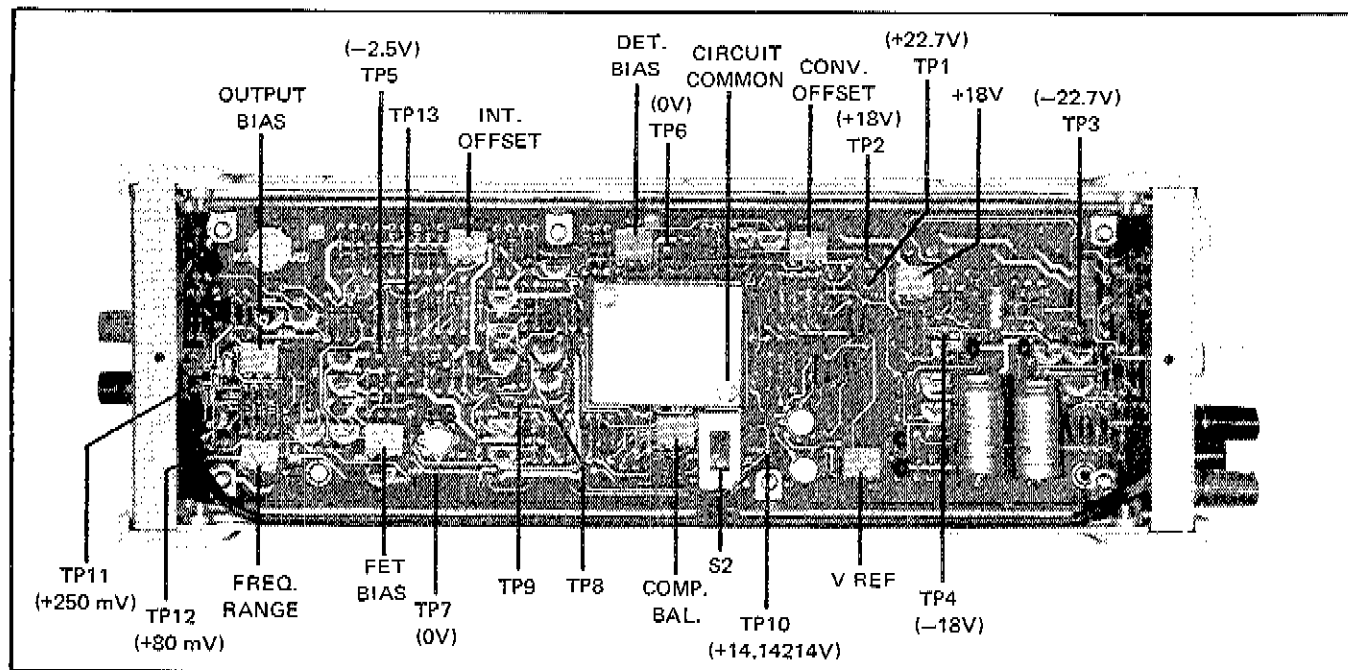


Figure 4-1. ADJUSTMENT AND TEST POINT LOCATIONS

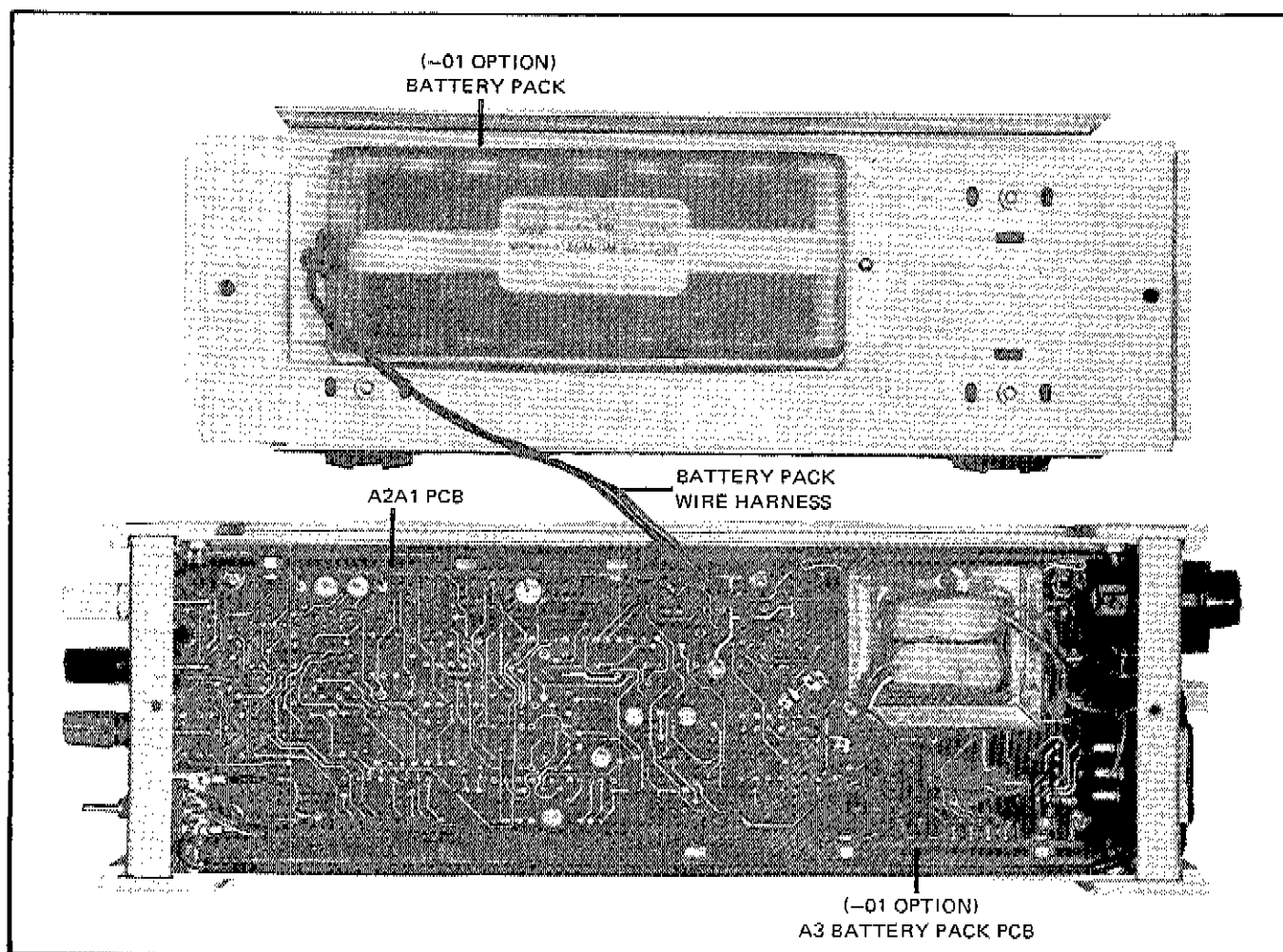


Figure 4-2. ASSEMBLY LOCATIONS (BOTTOM COVER REMOVED)

4-18. Battery Removal and Replacement (-01 Option)

4-19. The batteries for the -01 Option are installed on the inside of the bottom dust cover as shown in Figure 4-2. If replacement is necessary, the entire Battery Pack, FLUKE PART NO. 284356, should be replaced. Proceed as follows:

- Disconnect the four wires labeled 1 through 4 from A3 Battery Pack PCB. Refer to Figure 4-2 for location.
- Remove the screws which secure the Battery Pack to the bottom dust cover and then remove the Battery Pack.
- Install a new Battery Pack, FLUKE PART NO. 284356, on the bottom dust cover using the mounting screws removed in step b.
- Connect the four Battery Pack wires to the A3 Battery Pack PCB. Each wire is labeled with a number which corresponds to a connector on the PCB.

4-20. PERFORMANCE CHECKS

4-21. The following checks can be used to verify most electrical specifications on the Model 510A. Each check includes an introduction which states the objectives and lists the required test equipment. Refer to Table 4-1 for the recommended equipment.

4-22. Should a trouble be discovered, first determine that the instrument does not require calibration. If calibration does not correct the problem, troubleshoot the instrument and repair as necessary.

4-23. Preliminary Operation

- Connect the power cord through an autotransformer to line power. Set the autotransformer output to 115V ac.
- Set the POWER switch on the front panel to ON. The meter should indicate LINE OPR.
- Allow the instrument to operate for at least 10 minutes.

4-24. Line and Load Regulation Checks

4-25. This check provides a means of verifying the line and load regulation performance. Line voltage changes should not cause output variations greater than 10 ppm under full load. No load to full load changes should not cause output variations greater than those given in Figure 4-3. The following test equipment is required to perform these checks:

- Autotransformer
- AC Differential Voltmeter
- 1k Resistive Load

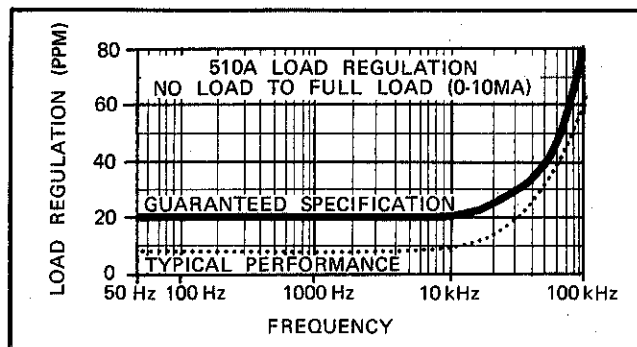


Figure 4-3. LOAD REGULATION

- Perform the steps given in paragraph 4-23.
- Connect the 1k load to the front panel OUTPUT terminals.
- Connect an ac differential voltmeter to the front panel OUTPUT terminals and record its indication.
- Vary the autotransformer output setting from 102 to 128V ac, observing that the output voltage does not change more than ± 100 μ V.
- Return the autotransformer setting to 115V ac and disconnect the 1k load from the OUTPUT terminals.
- Record the OUTPUT terminal voltage with the ac differential voltmeter.
- Reconnect the 1k load to the OUTPUT terminals, observing that the output voltage does not change more than the limit specified in Figure 4-3.
- Disconnect the test equipment from the front panel OUTPUT terminals.
- Repeat steps b through g at the rear panel OUTPUT terminals.

- j. Disconnect the test equipment.

4-26. UNCAL Indicator Check

4-27. This check verifies correct operation of the UNCAL indicator on the front panel. This indicator should illuminate when the output load current exceeds 10 ma. The test equipment required to perform this check is a 700 and 900 ohm resistive load.

- Connect a 700 ohm load to the OUTPUT terminals, observing that the UNCAL indicator illuminates.
- Disconnect the 700 ohm load.
- Connect a 900 ohm load to the OUTPUT terminals, observing that the UNCAL indicator remains out.
- Disconnect the 900 ohm load.

4-28. Frequency Accuracy and Resolution Checks

4-29. This check provides a means of verifying the output frequency accuracy and resolution capability. The output frequency should be within $\pm 0.1\%$ of its specified value. It should be adjustable $\pm 1\%$ with the FREQUENCY VERNIER control on the front panel. Resolution capability of this adjustment is $\pm 0.05\%$. The only equipment required to perform this check is a frequency counter.

- Connect the frequency counter to the front panel OUTPUT terminals. The output frequency should be within $\pm 0.1\%$ of the frequency labeled on the front panel.

NOTE!

Use period mode on the frequency counter to increase measurement resolution.

- Adjust the FREQUENCY VERNIER control on the front panel to each limit, observing that the output frequency changes $\pm 1\%$. Resolution with this control should be $\pm 0.05\%$.
- Adjust the FREQUENCY VERNIER control for the output frequency labeled on the front panel.
- Disconnect the frequency counter.

4-30. Output Accuracy Check

4-31. This check provides a means of verifying the amplitude accuracies given in Table 4-2. It consists of two different methods: dc reference and thermal transfer. The test equipment required to perform these checks is listed at the beginning of each method.

TABLE 4-2. OUTPUT AMPLITUDE ACCURACY

DC REFERENCE			
OUTPUT FREQ.	AMPLITUDE ACCURACY		
	30 days	90 days	
50 Hz-5 kHz	$\pm 0.01\%$	$\pm 0.02\%$	
5 kHz-10 kHz	$\pm 0.02\%$	$\pm 0.03\%$	
10 kHz-30 kHz	$\pm 0.05\%$	$\pm 0.07\%$	
30 kHz-100 kHz	$\pm 0.15\%$	$\pm 0.17\%$	
THERMAL TRANSFER			
OUTPUT FREQ.	AMPLITUDE ACCURACY		
	24 Hrs	30 days	90 days
50 Hz-20 kHz	$\pm 0.01\%$	$\pm 0.015\%$	$\pm 0.02\%$
20 kHz-50 kHz	$\pm 0.015\%$	$\pm 0.025\%$	$\pm 0.035\%$
50 kHz-100 kHz	$\pm 0.04\%$	$\pm 0.05\%$	$\pm 0.06\%$

4-32. DC REFERENCE.

TEST EQUIPMENT:

1. DC Voltage Standard/Null Detector

- a. Turn off the Model 510A and remove the top dust cover.
- b. Make the equipment connections shown in Figure 4-4.
- c. Set the dc voltage standard output to +14.14214V dc with a null detector sensitivity of 1V.
- d. Turn on the Model 510A and allow it to operate for at least 10 minutes.
- e. Increase the null detector sensitivity and record its indication. Maximum offset is ± 140 μ V.
- f. Turn off the Model 510A and disconnect the test equipment. Replace the upper dust cover.

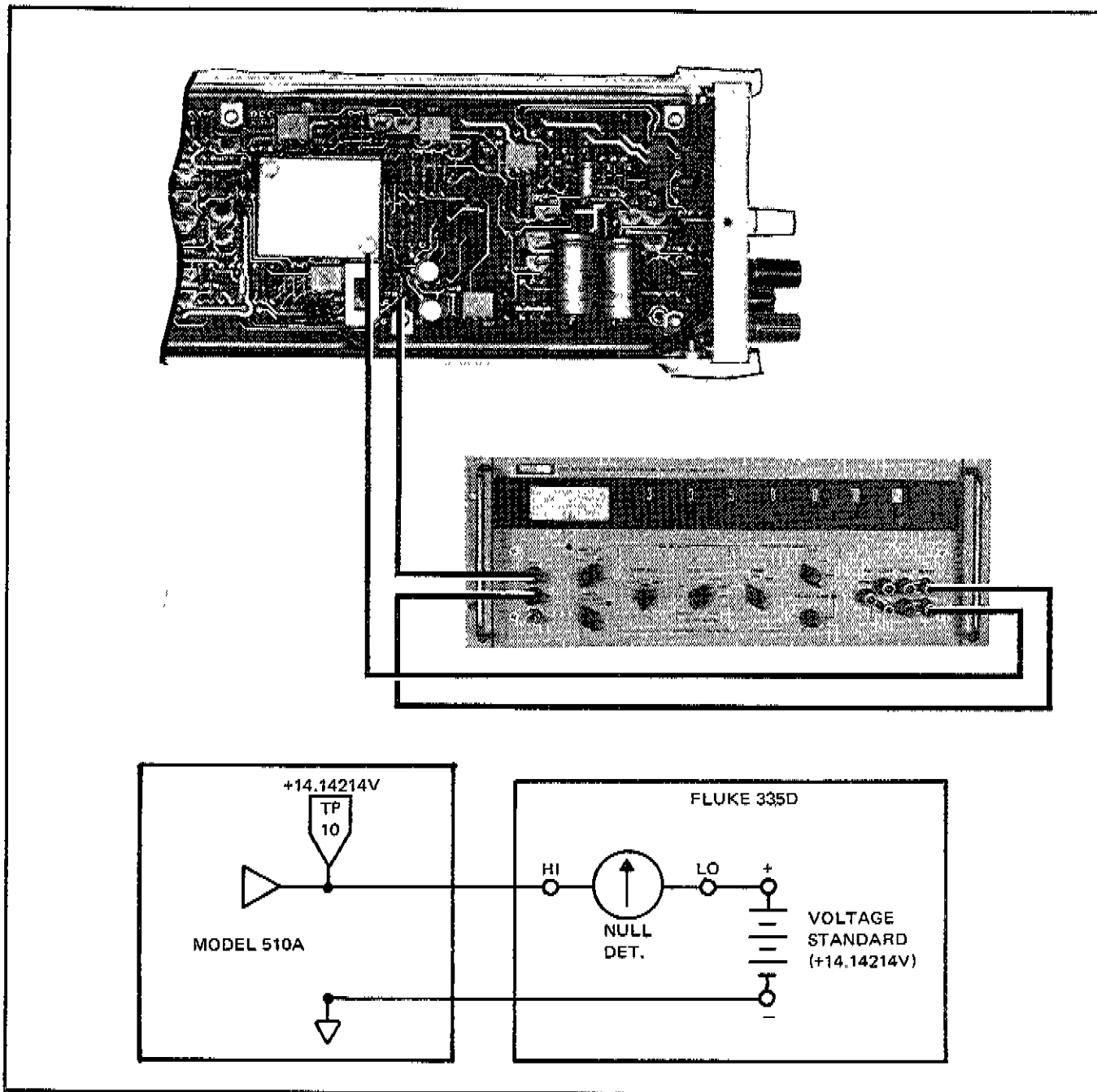


Figure 4-4. DC REFERENCE EQUIPMENT CONNECTIONS

4-33. THERMAL TRANSFER.

TEST EQUIPMENT:

1. DC Voltage Standard
2. Thermal Transfer Standard (Certified to $\pm 0.04\%$ at 50 KHz - 100 KHz)

a. Make the equipment connections shown in Figure 4-5.

b. Set the dc voltage standard output to 10V dc.

c. Perform dc to ac transfer, observing that the thermal transfer, amplitude accuracy given in Table 4-2 is achieved.

d. Disconnect the test equipment.

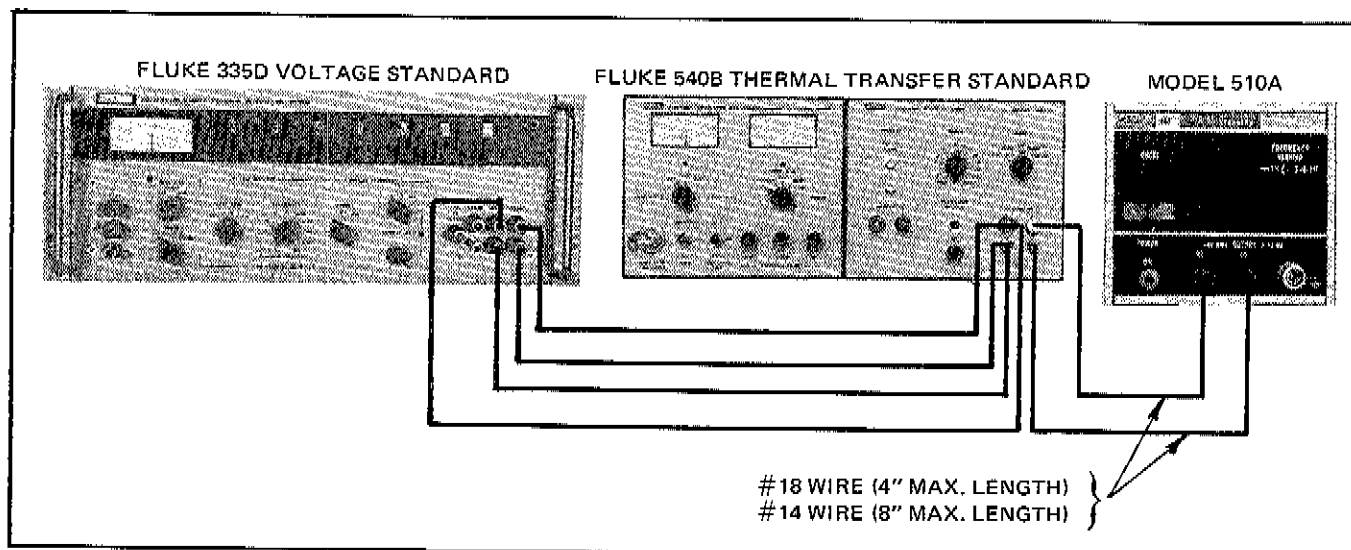


Figure 4-5. THERMAL TRANSFER EQUIPMENT CONNECTIONS

4-34. CALIBRATION PROCEDURES

4-35. Introduction

4-36. The Model 510A should be checked for calibration every 24 hours or 60 or 90 days, as desired, or whenever repairs have been made which affect the electrical characteristics. Calibration should be performed after a 10 minute operating period and at an ambient temperature of $23^{\circ}\text{C} \pm 5^{\circ}$.

4-37. All calibration test points and adjustments are shown in Figure 4-1. These calibration points are accessible after removal of the top dust cover. Required test equipment is listed in Table 4-1.

4-38. Regulator Alignment

a. Remove the top dust cover. Adjustment and test point locations are shown in Figure 4-1.

b. Connect the power cord through an autotransformer to line power. Set the autotransformer output to 115V ac.

c. Turn on the Model 510A and allow it to operate for 10 minutes.

d. Connect the input of a dc voltmeter to TP2 (+) and circuit common.

e. Adjust +18V (R9) for $+18 \pm 0.2\text{V}$ dc at TP2.

f. Connect the dc voltmeter input to TP4, observing that the voltage is $-18 \pm 0.5\text{V}$ dc.

g. Disconnect the dc voltmeter input from TP4.

4-39. Reference Supply Alignment

- Make the equipment connections shown in Figure 4-6.
- Set the voltage standard output to +14.14214V dc with a null detector sensitivity of 1V.
- Increase the null detector sensitivity and adjust

V REF (R27) for a $0 \pm 70 \mu\text{V}$ indication on the null detector.

NOTE!

If this adjustment cannot be made, refer to paragraph 4-47 for range compensation of R27.

- Disconnect the test equipment.

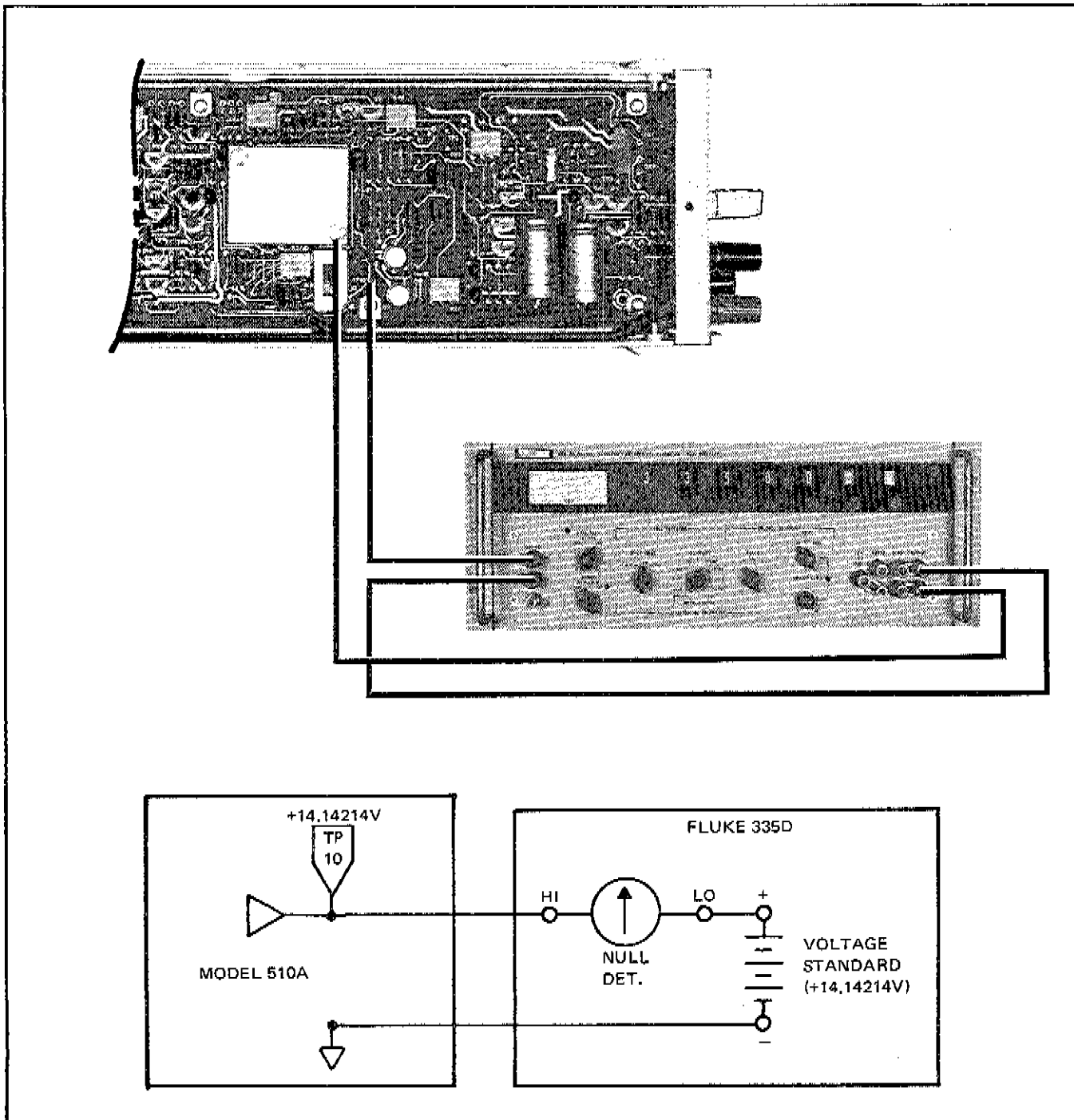


Figure 4-6. DC REFERENCE EQUIPMENT CONNECTIONS

4-40. FET Bias

- a. Connect the input of the dc voltmeter to TP5 (+) and circuit common.
- b. Adjust FET BIAS (R90) for $-2.5 \pm 0.2V$ dc at TP5.
- c. Disconnect the dc voltmeter input from TP5.

4-41. Zero Set

- a. Connect the dc voltmeter input to TP6.
- b. Adjust CONV. OFFSET (R49) for 0 ± 100 μV at TP6.
- c. Connect the dc voltmeter input to TP7.
- d. Adjust INT. OFFSET (R72) for 0 ± 100 μV at TP7.
- e. Disconnect the dc voltmeter from the instrument.

4-42. Output Bias

- a. Connect a shorting jumper between TP13 and circuit common.
- b. Connect the input for a dc voltmeter to TP11 (+) and TP4 (-).
- c. Adjust OUTPUT BIAS (R100) for $+250$ mV dc between TP11 and TP4.
- d. Disconnect the dc voltmeter and shorting jumper from the instrument.

4-43. Detector Bias

- a. Set the controls of a dc coupled oscilloscope to provide a .01V vertical sensitivity with an established 0V reference (Model 510A circuit common) on the display.

- b. Connect the input through X10 probe to TP8. Connect the probe ground clip to circuit common.

- c. Adjust the oscilloscope sweep speed to view at least two complete cycles of the peaked waveform at TP8.

- d. Adjust DET BIAS (R60) until the peak of the waveform is at 100 ± 10 mV in respect to circuit common.

- e. Disconnect the oscilloscope.

4-44. Comparator Balance

- a. Connect the input of an ac differential voltmeter to the front panel OUTPUT terminals.

- b. Record the ac output voltage.

- c. Switch S2 to the opposite position (white dot not showing) and record the ac voltmeter indication.

- d. Adjust COMP BAL (R37) for a maximum shift of 0 ± 50 μV in output voltage of each setting of S2.

- e. Set S2 to "white dot position" and disconnect the ac differential voltmeter.

4-45. Frequency Adjust

- a. Connect the input of a frequency counter to the front panel OUTPUT terminals. Use period mode for maximum resolution.

- b. Set the FREQUENCY VERNIER control (R96) on the front panel to the center of its adjustment range.

- c. Adjust FREQ. RANGE (R95) for the output frequency labeled on the front panel. If necessary, refine the FREQUENCY VERNIER setting slightly to obtain the appropriate frequency.

- d. Disconnect the frequency counter.

- 4-46. The Model 510A is now calibrated to meet amplitude accuracy specifications related to a dc reference accurate to ± 15 ppm. If an amplitude accuracy related to a thermal transfer is required, perform the following procedure:
- Make the equipment connections shown in Figure 4-7.
 - Set the dc voltage standard output to the 10V dc.
 - Perform dc to ac transfer, observing the ac amplitude error.
 - Adjust COMP. BAL. (R37) for a 10V rms output from the Model 510A.

NOTE!

Transfer accuracy of the thermal transfer standard must be certified to at least $\pm 0.04\%$ from 50 KHz to 100 KHz.

- Disconnect the test equipment and replace the top dust cover. The Model 510A is now fully calibrated.

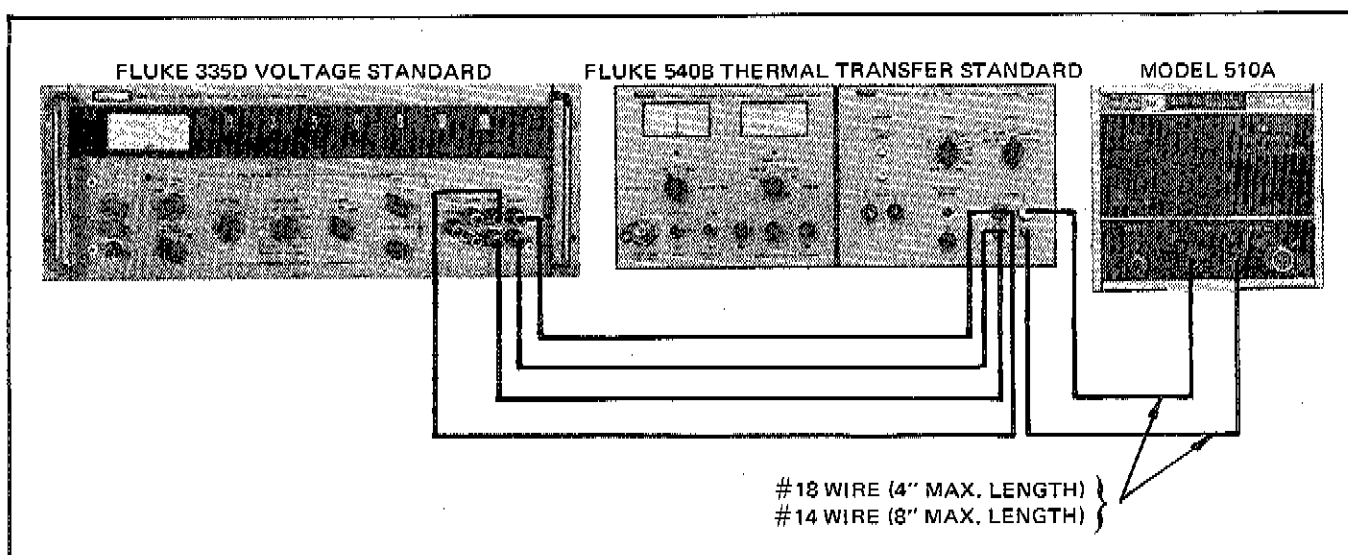


Figure 4-7. THERMAL TRANSFER EQUIPMENT CONNECTIONS

4-47. COMPENSATING COMPONENT SELECTION

4-48. Replacement of U2 and associated matched components in the Reference Supply will require selection of jumpers A and B. These jumpers compensate the adjustment range of V REF (R27). Selection of jumpers is done as follows:

- Turn off the Model 510A and set V REF (R27) fully counterclockwise.
- Locate jumpers A and B using Figure 4-8 and reconnect any cut jumpers.
- Turn on the Model 510A and make the equipment connections shown in Figure 4-6.
- Set the voltage standard output to +14.14214V dc with a null sensitivity of 1V.

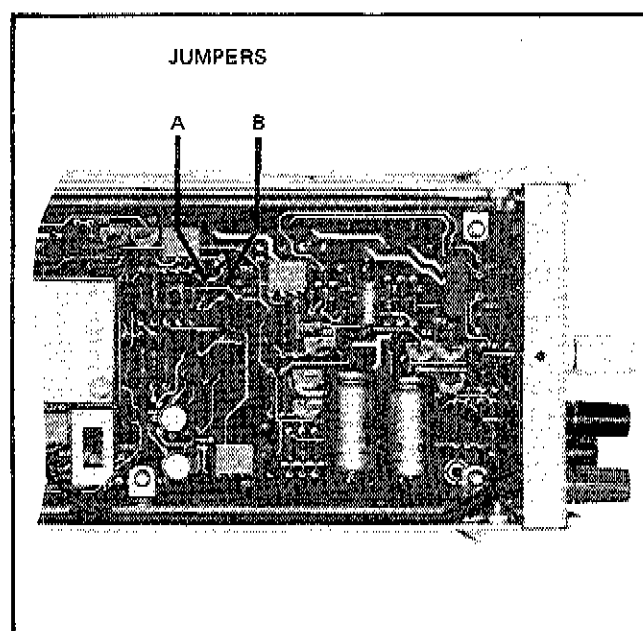


Figure 4-8. V_{REF} JUMPER LOCATIONS

- e. Increase the null detector sensitivity and record the offset voltage.
- f. Cut jumpers A and B per Table 4-3.
- g. Adjust V REF (R27) for a $0 \pm 70 \mu\text{V}$ indication on the null detector.

TABLE 4-3. A & B JUMPER SELECTION

OFFSET VOLTAGE (TP 10)	CLIP JUMPER
0 to 0.00571	None
0.00572 to 0.01141	A
0.00142 to 0.01712	B
0.01713 to 0.02182	A and B

NOTE!

The Model 510A should be recalibrated using the procedures given in paragraph 4-34 through 4-46.

4-49. TROUBLESHOOTING

4-50. The following information is provided to assist in locating troubles in the Model 510A. It is recommended that the theory of operation in Section 3 be completely understood before attempting any troubleshooting.

4-51. Initial Troubleshooting

4-52. Troubleshooting begins by first performing a thorough inspection for improperly seated plug-in assemblies, loose wires, physically damaged parts, or other obvious problems. The next step is to insure that the instrument is being operated correctly, but fails to meet specifications. Performance checks especially designed for this purpose are given in paragraphs 4-20 through 4-33.

4-53. Once it is determined that a malfunction exists, all operating voltages should be checked as shown in Figure 4-9. During these checks, the instrument must be operated from nominal line power. If the Rechargeable Battery Pack (-01 Option) is installed, the optional circuitry can be checked using the information in paragraph 4-54.

TEST POINT	VOLTAGE (VDC)	CIRCUITRY CHECKED
① TP1	+23V	AC INPUT (T1, CR2)
② TP3	-23V	AC INPUT (T1, CR2)
③ TP4	$-18 \pm 0.5\text{V}$	-18V REGULATOR
④ TP2	$+18 \pm 0.2\text{V}$	+18V REGULATOR
⑤ TP10	+14, 14214V	REFERENCE SUPPLY

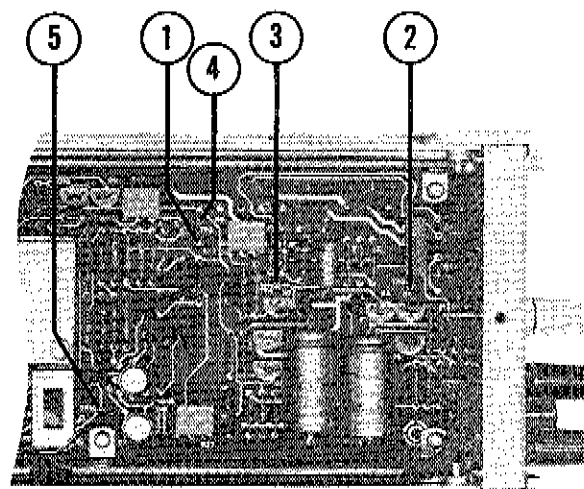


Figure 4-9. OPERATING VOLTAGE CHECK POINTS

4-54. Rechargeable Battery Pack (-01 Option)

4-55. Operating voltages for the optional battery pack circuitry can be checked using the following procedure:

- a. Connect the power cord through an autotransformer to line power. Set the autotransformer output to 0V.
- b. Make the voltage checks on the A3 Battery Pack PCB as shown in Figure 4-10.

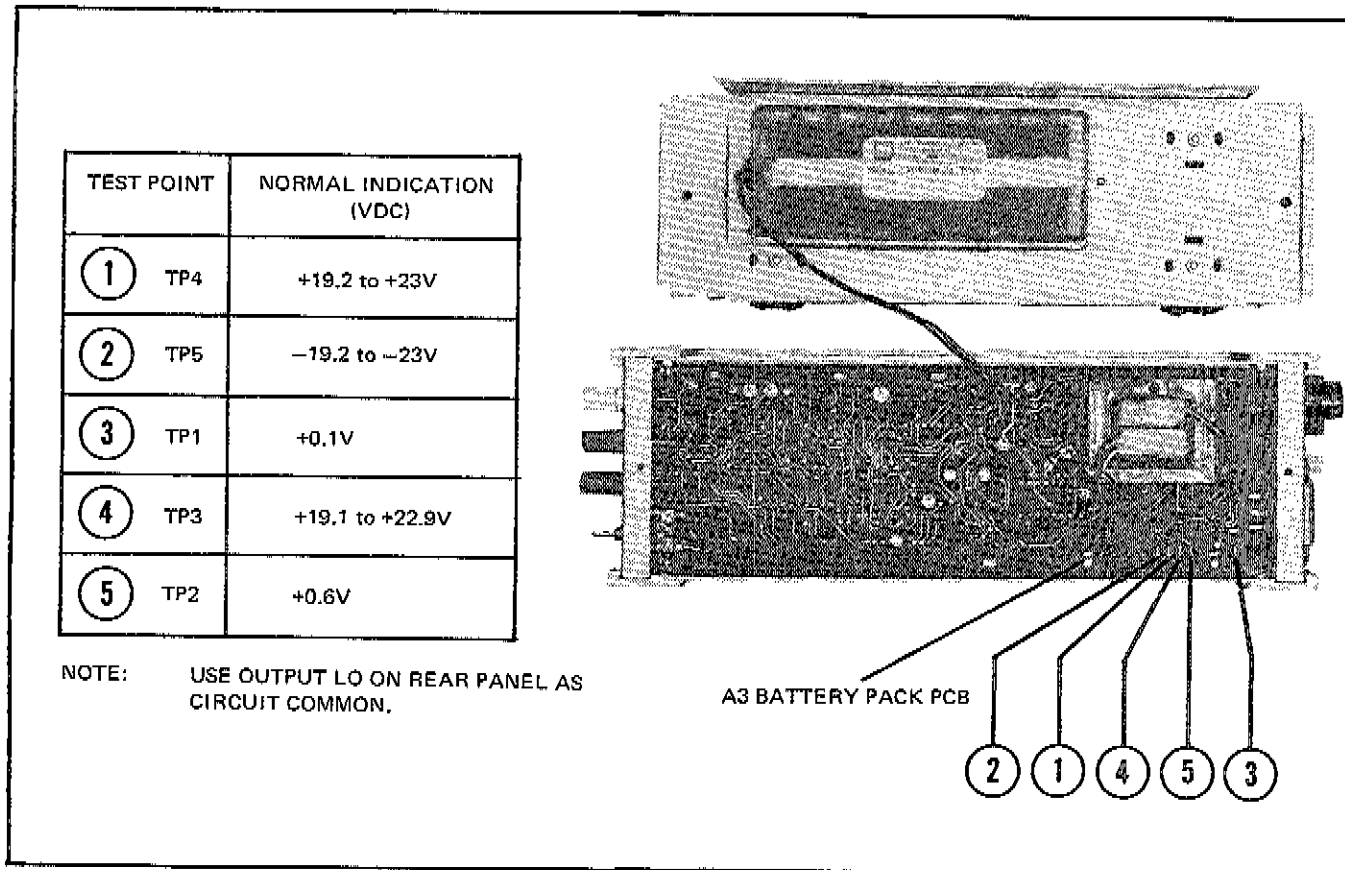


Figure 4-10. A3 BATTERY PACK PCB CHECKS

- c. Connect the dc voltmeter to A3TP1 and slowly increase the autotransformer output. The voltage at TP1 should increase from +0.1V dc to approximately +25V dc at a line voltage between 30 and 90V ac.
- d. Set the autotransformer output to 115V ac.
- e. Connect the dc voltmeter input to A3TP2 and slowly decrease the autotransformer output. The voltage at TP2 should increase from -25V dc to +0.6V dc at a line voltage between 90 and 30V ac.
- f. Turn off the Model 510A and disconnect the power cord.
- g. Disconnect wire #1 from P1 on the A3 Battery Pack PCB.
- h. Connect the output of a dc power supply set to +24V dc to P1 on the A3 Battery Pack PCB.
- i. Turn on the Model 510A and slowly decrease the power supply output until the meter on the front panel swings abruptly to the left.
- j. Record the power supply output voltage. The Model 510A should turn-off at a power supply output between 18.5 and 19.5V dc.
- k. Increase the power supply output until the meter on the front panel abruptly swings to the right. The Model 510A should turn on at a power supply output that is 1.2V above the value recorded in step j.
- l. Turn off the Model 510A and disconnect the power supply. Reconnect wire #1 to P1 on the A3 Battery Pack PCB.

4-56. Circuit Isolation Checks

4-57. The voltage checks given in Figure 4-11 can be used to isolate a trouble to a major circuit. General troubleshooting of the major circuit should then reveal the exact source of trouble. Circuit voltages are given on the schematic diagram.

CHECK POINT	NORMAL INDICATION	FAULT ANALYSIS
① TP12	10V RMS	IF ABNORMAL CHECK ②, TP5.
② TP5	$-2.5 \pm 0.2V$ dc	A. IF TP12 IS HIGH OR LOW AND TP5 IS $\pm 0.6V$, TROUBLE IS IN THE OSCILLATOR. B. CHECK ③, TP7, IF TP5 IS AT SOME OTHER VOLTAGE.
③ TP7	$0 \pm 100 \mu V$	A. IF TP5 IS NOT $+0.6V$ AND TP7 IS $+10$ mV OR MORE, TROUBLE IS IN THE INTEGRATOR. B. IF TP5 IS MORE POSITIVE THAN $-5V$ AND TP7 IS -10 mV OR MORE, TROUBLE IS IN THE INTEGRATOR. C. IF TP5 IS NOT $+0.6V$ AND TP7 IS $0V$ OR NEGATIVE, TROUBLE IS IN THE PEAK AC TO DC CONVERTER. D. IF TP5 IS MORE POSITIVE THAN $-5V$ AND TP7 IS $0V$ OR POSITIVE, TROUBLE IS IN THE PEAK AC TO DC CONVERTER.

NOTE!

SAMPLE AND HOLD IS CONSIDERED PART OF PEAK AC TO DC CONVERTER.

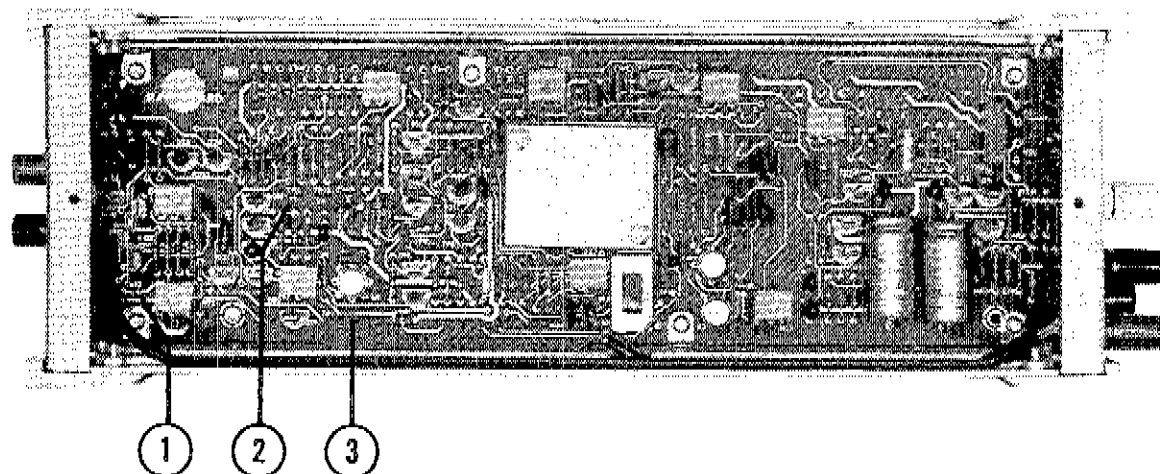


Figure 4-11. CIRCUIT ISOLATION CHECKS

Section 5

List of Replaceable Parts

5-1. INTRODUCTION

5-2. This section contains an illustrated parts breakdown list of the instrument and a Cross Reference List of FLUKE stock numbers to original MANUFACTURERS' part numbers. It also lists recommended spare parts and contains part ordering information. The starting page number of each major listing is given in the Table of Contents.

5-3. The parts list shows the location of all assemblies and the replaceable components. Major assemblies are identified by a designation beginning with the letter A followed by a number (e.g., A1 etc). Subassemblies are identified in the same manner; however, the parent assembly designator precedes this designator (e.g., A1A1 etc.). Electrical components are identified by their schematic diagram designator and listed hardware parts are identified by the FLUKE stock number. All listed components are described, and the FLUKE stock number is given. The original MANUFACTURER'S part number for each listed item is given in the Cross Reference List at the rear of this section.

5-4. PARTS LIST COLUMN DESCRIPTIONS

- a. The REF DESIG column indexes the item description to the associated illustration. In general the reference designations are listed under each assembly in alpha-numeric order. Subassemblies of minor proportions are sometimes listed with the assembly of which they are a part. In this case, the reference designations may appear out of order.
- b. The DESCRIPTION column describes the salient characteristics of the component. Indention of the description indicates the relationship to other assemblies, components, etc. In many cases it is necessary to abbreviate in this column. For abbreviations and symbols used, refer to Appendix B located at the rear of the manual.
- c. The six-digit part number, by which the item is identified at the John Fluke Mfg. Co., Inc. is listed in the STOCK NO. column. Use this number when ordering parts from the factory or authorized representatives. In the case where a flag note is used, special ordering is required. Flag note explanations are located as close as possible to the flag note.
- d. The TOT QTY column lists the total quantity of the item used in each particular assembly. This quantity reflects only the latest Use Code. Second and subsequent listings of the same item are referenced to the first listing with the abbreviation REF.
- e. Entries in the REC QTY column indicate the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of each assembly in the instrument be stocked. In

the case of optional subassemblies, plug-ins, etc. that are not always part of the instrument, or are deviations from the basic instrument model, the REC QTY column lists the recommended quantity of the item in that particular assembly.

- f. The USE CODE column identifies certain parts which have been added, deleted or modified during the production of the instrument. Each part for which a Use Code has been assigned may be identified with a particular instrument serial number by consulting the Serial Effectivity List, paragraph 5-9. Sometimes when a part is changed, the new part can and should be used as a replacement for the original part.

5-5. MANUFACTURERS' CROSS REFERENCE LIST COLUMN DESCRIPTIONS

- a. The six-digit part number, by which the item is identified at the John Fluke Mfg. Co., Inc. is listed in the FLUKE STOCK NO. column. Use this number when ordering parts from the factory or authorized representatives.
- b. The Federal Supply Code for the item manufacturer is listed in the MFG column. An abbreviated list of Federal Supply Codes is included in Appendix A.
- c. The part number which uniquely identifies the item to the original manufacturer is listed in the MFG PART NO. column. If a component must be ordered by description, the type number is listed.

5-6. HOW TO OBTAIN PARTS

5-7. Standard components have been used whenever possible. Standard components may be ordered directly from the manufacturer by using the manufacturer's part number, or parts may be ordered from the John Fluke Mfg. Co., Inc. factory or authorized representative by using the FLUKE stock number. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-8. You can insure prompt and efficient handling of your order to the John Fluke Mfg. Co., Inc. if you include the following information:

- a. Quantity.
- b. FLUKE Stock Number.
- c. Description.
- d. Reference Designation.
- e. Instrument model and serial number.

Example: 2 each, 215897, Transistor, 2N4126
A2A1Q1 & Q2 for 645A, S/N 123.

If you must order structural parts not listed in the parts list, describe the part as completely as possible. A sketch of the part, showing its location to other parts of the instrument is helpful.

5-9. SERIAL NUMBER EFFECTIVITY

5-10. A Use Code column is provided to identify certain parts that have been added, deleted or modified during production of the Model 510A. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity List below. All parts with no code are used on all instruments with serial numbers above 123.

USE
CODE SERIAL NUMBER EFFECTIVITY

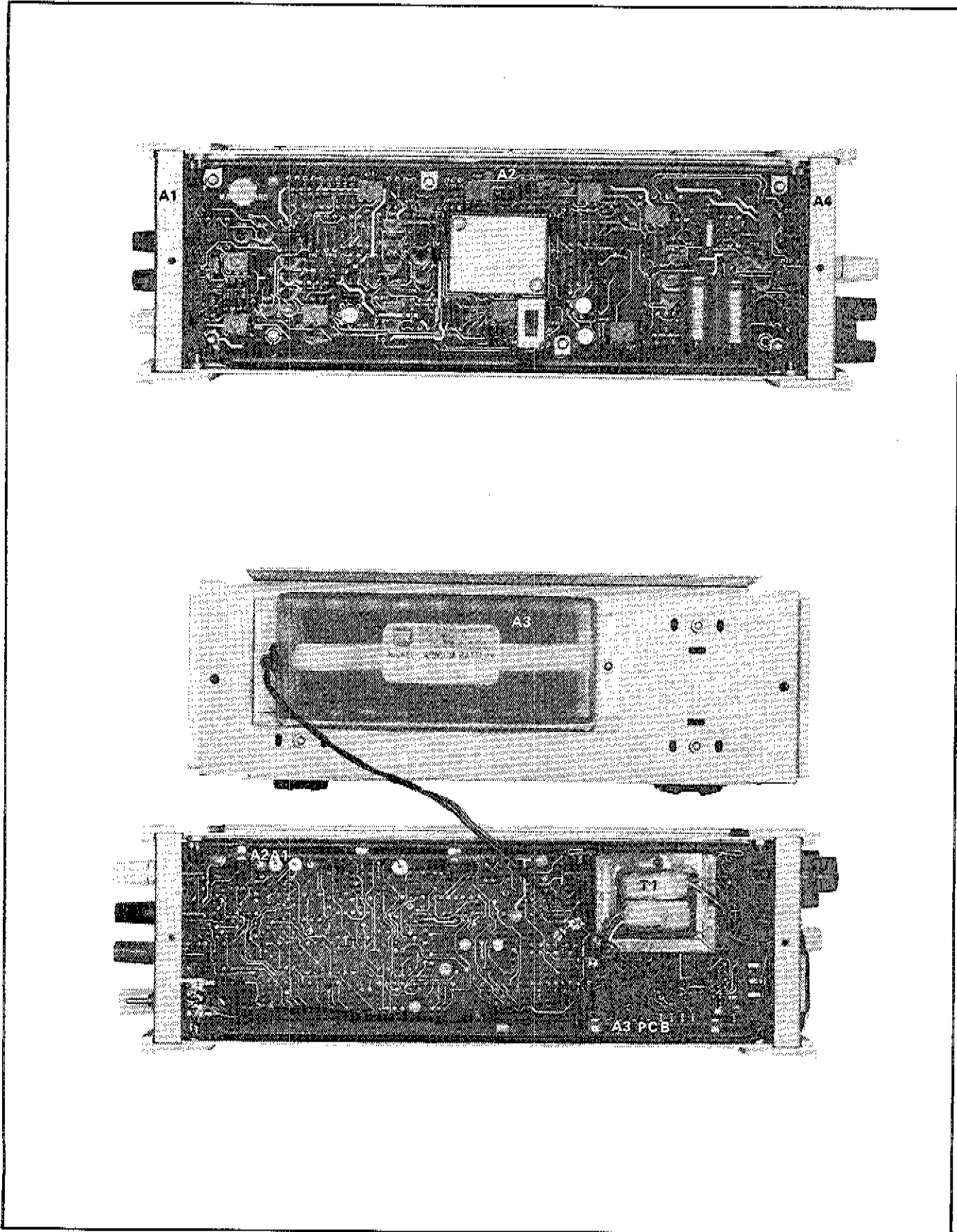




Figure 5-1. AC REFERENCE STANDARD

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
	AC REFERENCE STANDARD Figure 5-1	510A			
A1	Front Panel Assembly (Figure 5-2)		1		
A2	Main PCB Assembly (Figure 5-3)	307868	1		
A2A1	PCB Assembly, 50 Hz, 60 Hz, 400 Hz, 1000 Hz, 2400 Hz, 5000 Hz, 19.2 KHz, 100 KHz (Figure 5-4)		1		
A3	Rechargeable Battery Kit (-01 Option) Figure 5-5				
A4	Rear Panel Assembly (Figure 5-6)	307892	1		
T1	Xfmr, Power	304097	1		
	 Field installation Kit P/N is 510A-01k				

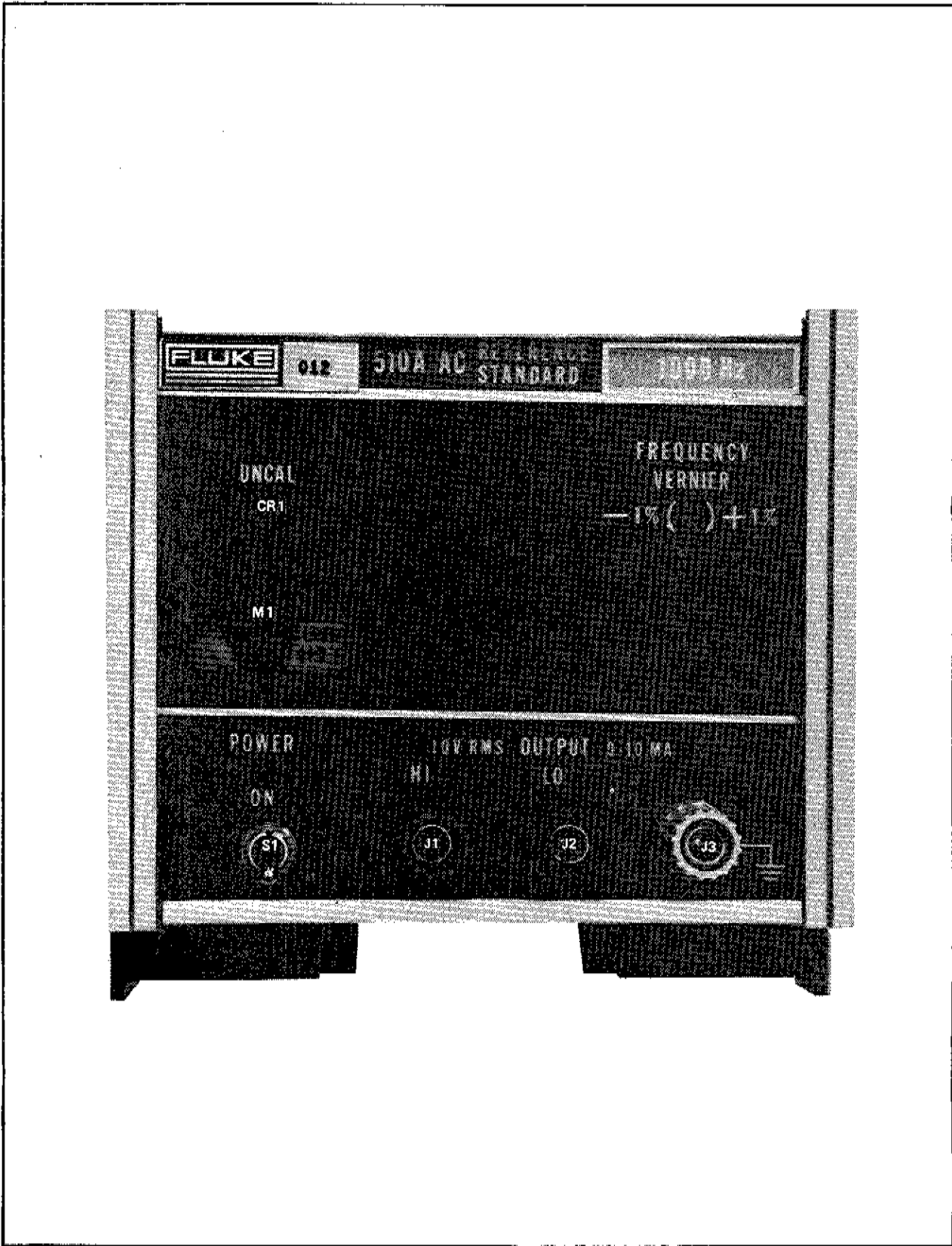


Figure 5-2. FRONT PANEL ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A1	FRONT PANEL ASSEMBLY Figure 5-2	307686	REF		
CR1	Diode, light emitting, 50 mA	309617	1	1	
J1	Binding post, red, HI	275552	1		
J2	Binding post, black, LO	275560	1		
J3	Binding post, white	275586	1		
M1	Meter, 0-1 mA, $\pm 10\%$	266494	1		
S1	Switch, toggle, mini, 3 PDT	284299	1	1	
	Decal, front panel	309351	1		
	Meter, retainer	307322	1		

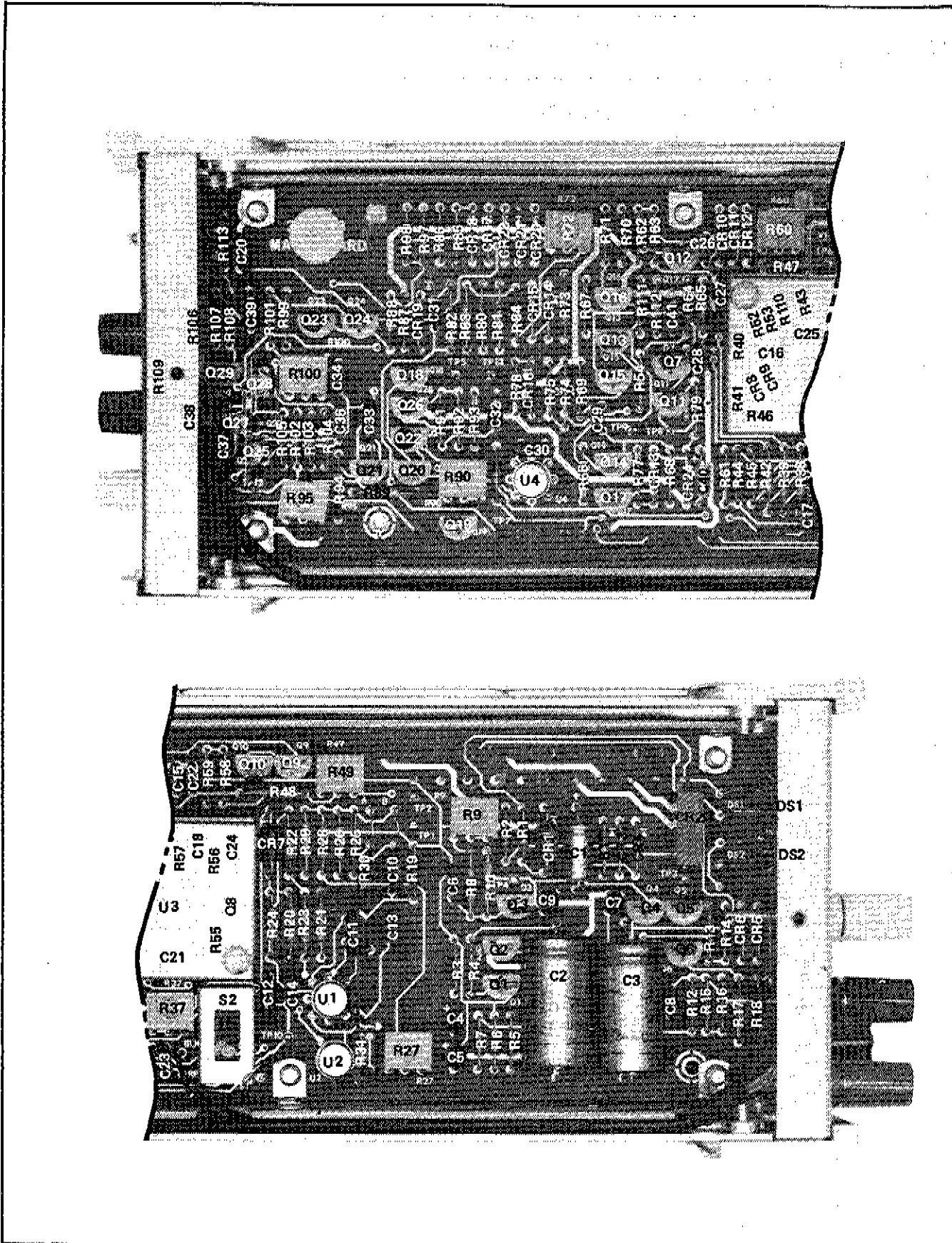





Figure 5-3. MAIN PCB ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A2	MAIN PCB ASSEMBLY Figure 5-3	307868	REF		
C1	Cap, elect, 2 uf +75/-10%, 50V	105197	1	1	
C2, C3	Cap, elect, 250 uf +50/-10%, 40V	178616	2	1	
C4, C5, C7, C9, C28, C32	Cap, Ta, 2.2 uf ±20%, 20V	161927	6	1	
C6, C8, C10, C12 thru C14, C17, C20, C23, C37, C38	Cap, cer, 0.05 uf +80/-20%, 25V	148924	11	1	
C11, C18, C30	Cap, mica, 33 pf ±5%, 500V	160317	3	1	
C15, C21, C22, C24, thru C26, C34, C36	Cap, fixed, cer, 0.01 uf ±20%, 100V	149153	8	1	
C16	Cap, mica, 4 pf ±5%, 500V	190397	1	1	
C19	Not used				
C27	Cap, mica, 47 pf ±5%, 500V	148536	1	1	
C29	Cap, cer, 180 pf ±10%, 1 kV	105890	1	1	
C31	Cap, cer, 20 pf ±10%, 500V	106369	1	1	
C33	Cap, mica, 10 pf ±10%, 500V	175216	1	1	
C35	Cap, Ta, 4.7 uf ±20%, 20V	161943	1	1	
C39	Cap, Ta, 39 uf ±20%, 20V	163915	1	1	
C40	Cap, Ta, 3.3 uf ±10%, 15V	182808	1	1	
C41	Cap, cer, 3.3 uf ±10%, 500V	106377	1	1	
C42	Cap, cer, var, 1.7 to 10 pF (100 kHz version only)	321109	1	1	
CR1, CR7	Diode, silicon, 1 amp, 100 piv	116111	2		
CR2	Diode, bridge, 2 amp, 100 piv	296509	1		
CR3 thru CR6, CR13, thru CR15, CR17, CR18, CR20 thru CR22, CR24	Diode, silicon, 150 MA	203323	13	2	
CR8	Diode, semicon, silicon, 100 MA at 1.5V	161810	1	1	
CR9	Diode, high speed, switching	256339	1	2	

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
CR10, CR11, CR12	Diode, germanium, 80 MA, 100 piv	149187	3		
CR16, CR19 CR23	Diode, zener, 6.2V Not used	180497	2	1	
DS1, DS2	Lamp, incandesant, 28V, 80 MA	175265	2	1	
Q1, Q5, Q7 thru Q10 Q27	Tstr, silicon, PNP	195974	7	1	
Q2, Q4, Q12 thru Q16, Q24, Q25, Q28	Tstr, silicon, NPN	218396	10	2	
Q3, Q19, Q21	Tstr, semicon, silicon NPN	218081	3	1	
Q6, Q11, Q18, Q20 Q29	Tstr, silicon, PNP	229898	5	1	
Q17, Q26	Tstr, FET, N-channel	261388	2	1	
Q22, Q23	Tstr, silicon, PNP	225599	2	1	
R1, R2, R65, R67, R78, R87, R91, R92, R109	Tes, comp, 10k $\pm 5\%$, 1/4w	148106	9		
R3, R7, R16 R68, R107, R108, R113	Res, comp, 1.8k $\pm 5\%$, 1/4w	175042	7		
R4, R13, R101	Res, comp, 6.8k $\pm 5\%$, 1/4w	148098	3		
R5, R14, R19	Res, comp, 270 Ω $\pm 5\%$, 1/4w	160804	3		
R6, R15	Res, comp, 180k $\pm 5\%$, 1/4w	193441	2		
R8	Res, met flm, 54.9k $\pm 1\%$, 1/8w	271353	1	1	
R9, R95	Res, var, cermet 10k $\pm 10\%$, 1/2w	309674	2	1	
R10	Res, met flm, 63.4k $\pm 1\%$, 1/8w	235382	1	1	
R11, R75 R76, R84	Res, comp, 22k $\pm 5\%$, 1/4w	148130	4		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R12, R97	Res, comp, 5.6k \pm 5%, 1/4w	148080	2		
R17	Res, met flm, 57.6k \pm 1%, 1/8w	289116	1	1	
R18	Res, met flm, 45.3k \pm 1%, 1/8w	234971	1	1	
R20	Res, met flm, 51.1k \pm 1%, 1/8w	309757	1	1	
R21	Res, met flm, 49.9k \pm 1%, 1/8w	293456	1	1	
R22, R23, R30, R31	Res, ref amp, matched set		1	1	
R24	Res, met flm, 2.49k \pm 1%, 1/8w	309732	1	1	
R25	Res, met flm, 1.05k \pm 1%, 1/8w	293530	1	1	
R26	Res, met flm, 107 Ω \pm 1%, 1/8w	309716	1	1	
R27	Res, var, 100 Ω \pm 10%, 1/2w	275735	1		
R28	Res, met flm, 200 Ω \pm 1%, 1/8w	309724	1	1	
R29	Res, met flm, 10 Ω \pm 1%, 1/8w	268789	1	1	
R32 thru R36	Not used				
R37	Res, var, cermet, 20 Ω \pm 20%, 1/2w	275727	1	1	
R38	Res, met flm, 40.2 Ω \pm 1%, 1/8w	245373	1	1	
R39	Res, met flm, 100 Ω \pm 1%, 1/8w	168195	1	1	
R40, R41	Res, network (2 resistors)	293506	1	1	
R42	Res, met flm, 33.2 Ω \pm 1%, 1/8w	199950	1	1	
R43, R54, R57, R64	Res, comp, 100k \pm 5%, 1/4w	148189	4		
R44, R45 R93	Res, comp, 1k \pm 5%, 1/4w	148023	3		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R46	Res, met flm, 13.7k \pm 1%, 1/8w	236752	1	1	
R47, R74	Res, met flm, 453 Ω \pm 1%, 1/8w	267393	2	1	
R48, R73	Res, met flm, 1M \pm 1%, 1/8w	268797	2	1	
R49, R72	Res, var, 1M \pm 10%, 1/2w	276691	2	1	
R50, R51	Not used				
R52	Res, comp, 2.4M \pm 5%, 1/4w	221945	1	1	
R53	Res, comp, 470k \pm 5%, 1/4w	188441	1		
R55, R58, R70, R111, R112	Res, comp, 47k \pm 5%, 1/4w	148163	5		
R56	Res, comp, 360k \pm 5%, 1/4w	234690	1		
R59	Res, comp, 12k \pm 5%, 1/4w	159731	1		
R60, R90	Res, var, cermet, 1k \pm 10%, 1/2w	275750	2	1	
R61	Res, comp, 27k \pm 5%, 1/4w	148148	1		
R62, R85, R99	Res, comp, 8.2k \pm 5%, 1/4w	160796	3		
R63, R105	Res, comp, 100 Ω \pm 5%, 1/4w	147926	2		
R66	Res, comp, 91 Ω \pm 5%, 1/4w	221887	1		
R69	Res, comp, 820k \pm 5%, 1/4w	220541	1		
R71	Res, comp, 6.2k \pm 5%, 1/4w	221911	1		
R77	Res, comp, 2.2M \pm 5%, 1/4w	198390	1		
R79	Res, comp, 36k \pm 5%, 1/4w	221929	1		
R80, R81	Res, met flm, 1k \pm 1% 1/8w	168229	2	1	
R82, R83	Res, met flm, 1.47k \pm 1%, 1/8w	293654	2	1	
R86	Res, comp, 510 Ω \pm 5%, 1/4w	218032	1		
R88	Res, comp, 18k \pm 5%, 1/4w	148122	1		
R89	Res, met flm, 4.53k \pm 1%, 1/8	260331	1	1	

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R94	Res, met flm, 41.2k \pm 1%, 1/8w	289538	1	1	
R96	Res, var, cermet, 2k \pm 10%, 1/2w	285163	1	1	
R98	Res, comp, 4.7k \pm 5%, 1/4w	148072	1		
R100	Res, var, cermet, 2k \pm 10%, 1/4w	309666	1	1	
R102, R104	Res, comp, 5.6 Ω \pm 5%, 1/4w	208033	2		
R103	Res, comp, 10 Ω \pm 5%, 1/4w	147868	1		
R106	Res, met flm, 84.5 Ω \pm 1%, 1/8w	236851	1	1	
R110	Res, comp, 56k \pm 5%, 1/4w	170738	1		
S1	Switch, double pole, double throw	234278	1	1	
U1	IC, operational amplifier	271502	1	1	
U2	Ref, amp assembly, matched set		1	1	
U3, U4	IC, operational amplifier	284760	2	1	
	Socket, tstr	285262	25		
	R22, R23, R30, R31 and U2 are a matched set. For replacement order ref amp set P/N 4842-307918.				

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A2A1	PCB ASSEMBLY 50 Hz (-02 Option) Figure 5-4	307926	REF		
C1, C2	Cap, fxd, met poly, 0.27 uf $\pm 5\%$, 100V	310466	2	1	
C3	Cap, Ta, 330 uf $\pm 10\%$, 6V	193011	1	1	
C4, C5	Cap, Ta, 220 uf $\pm 10\%$ 10V	182840	2	1	
C6	Cap, Ta, 5.6 uf $\pm 10\%$ 6V	198259	1	1	
C7	Cap, Ta, 0.47 uf $\pm 10\%$ 250V	184366	1	1	
C8	Cap, cer, 0.025 uf $\pm 2\%$, 100V	168435	1	1	
C9	Cap, cer, 0.1 uf $\pm 20\%$, 100V	149146	1	1	
C10	Cap, plstc 0.1 uf $\pm 10\%$, 250V	161992	1	1	
J1 thru J19	Amp, receptacle	267617	19	5	
R1	Res, met flm, 2.67k $\pm 1\%$, 1/8w	312173	1	1	
R2	Res, met flm, 42.2k $\pm 1\%$, 1/8w	312215	1	1	
R3	Res, comp, 47k $\pm 5\%$, 1/4w	148163	1		
R4	Res, comp, 2.2M $\pm 5\%$, 1/4w	198390	1		

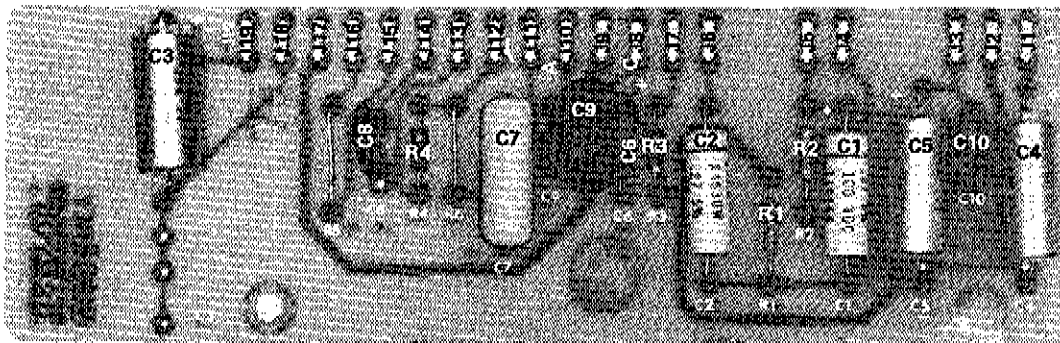


Figure 5-4. PCB ASSEMBLY, 50 Hz (-02 Option)

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A2A1	PCB Assembly, 60 Hz (-03 Option) Figure 5-5	307934	REF		
C1, C2	Cap, fxd, met poly, 27 uf ±5%, 100V	310466	2	1	
C3	Cap, Ta, 330 uf ±10%, 6V	193011	1	1	
C4, C5	Cap, Ta, 220 uf ±10%, 10V	182840	2	1	
C6	Cap, Ta, 5.6 uf ±10%, 6V	198259	1	1	
C7	Cap, Ta, 0.47 uf ±10%, 250V	184366	1	1	
C8	Cap, cer, 0.025 uf ±2%, 100V	168435	1	1	
C9	Cap, cer, 0.1 uf ±20%, 100V	149146	1	1	
C10	Cap, plstc, 0.1 uf ±10%, 250V	161992	1	1	
J1 thru J19	Connector, receptacle	267617	19	5	
R1	Res, met flm, 2.21k ±1%, 1/8w	310508	1	1	
R2	Res, met flm, 34.8k ±1%, 1/8w	312181	1	1	
R3	Res, comp, 47k ±5%, 1/4w	148163	1		
R4	Res, comp, 2.2M ±5%, 1/4w	198390	1		

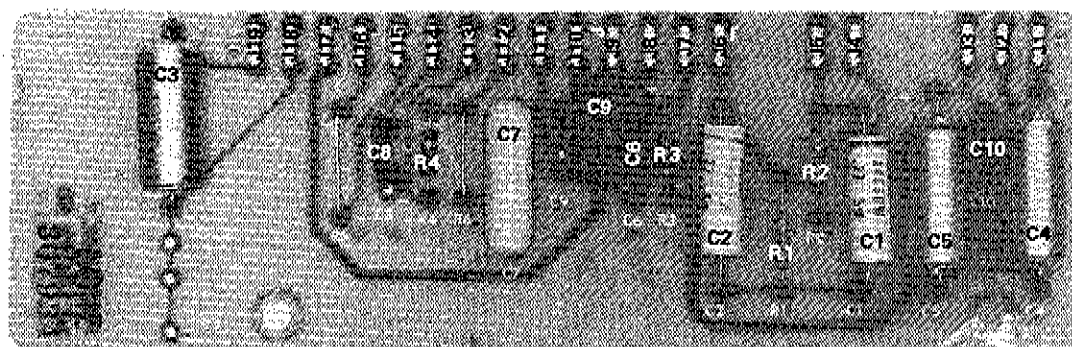


Figure 5-5. PCB ASSEMBLY, 60 Hz (-03 Option)

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A2A1	PCB Assembly, 400 Hz (-04 Option) Figure 5-6	307942	REF		
C1, C2	Cap, fxd, met poly, 0.033 \pm 5%, 100V	310474	2	1	
C3	Cap, fxd, met poly, 5 uf \pm 10%, 50V	313254	1	1	
C4, C5	Cap, Ta, 68 uf \pm 10%, 15V	182824	2	1	
C6	Cap, Ta, 3.3 uf \pm 10%, 15V	182808	1	1	
C7	Cap, cer, 0.05 uf \pm 20%, 100V	149161	1	1	
C8	Cap, mica, 3000 pf \pm 5%, 500V	161786	1	1	
C9	Cap, fxd, cer, 0.01 uf \pm 20%, 100V	149153	1	1	
J1 thru J19	Connector, receptacle	267617	19	5	
R1	Res, mct flm, 2.67k \pm 1%, 1/8w	312173	1	1	
R2	Res, met flm, 43.2k \pm 1%, 1/8w	312223	1	1	
R3	Not used				
R4	Res, comp, 2.2M \pm 5%, 1/4w	198390	1		

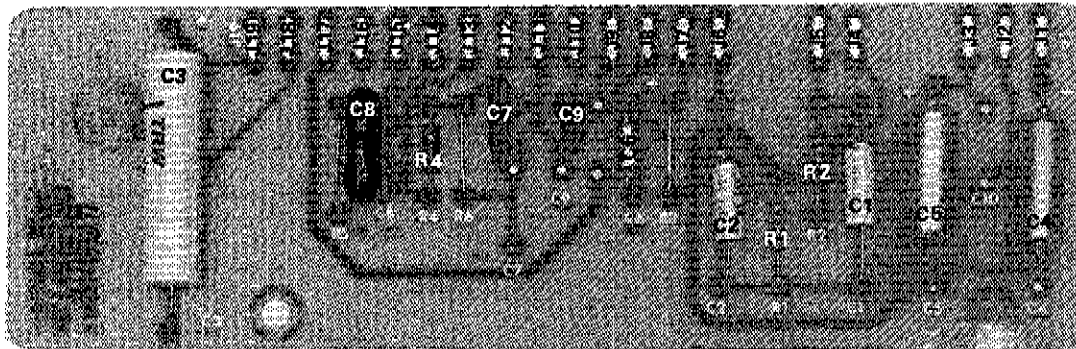


Figure 5-6. PCB ASSEMBLY, 400 Hz (-04 Option)

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A2A1	PCB Assembly, 1000 Hz (-05 Option) Figure 5-7	307959	REF		
C1, C2	Cap, fxd, met poly, 0.015 uf \pm 5%, 100V	310482	2	1	
C3	Cap, fxd, met poly, 2 uf \pm 10%, 50V	284687	1	1	
C4, C5	Cap, Ta, 68 uf \pm 10%, 15V	182824	2	1	
C6	Cap, Ta, 2.2 uf \pm 20%, 20V	161927	1	1	
C7	Cap, cer, 0.05 uf \pm 20%, 100V	149161	1	1	
C8	Cap, mica, 1200 pf \pm 5%, 500V	148379	1	1	
C9	Cap, fxd, cer, 0.01 uf \pm 20%, 100V	149153	1	1	
J1 thru J19	Connector, receptacle	267617	19	5	
R1	Res, met flm, 2.43k \pm 1%, 1/8w	310524	1	1	
R2	Res, met flm, 39.2k \pm 1%, 1/8w	312207	1	1	
R3	Not used				
R4	Res, comp, 1.2M \pm 5%, 1/4w	188425	1		

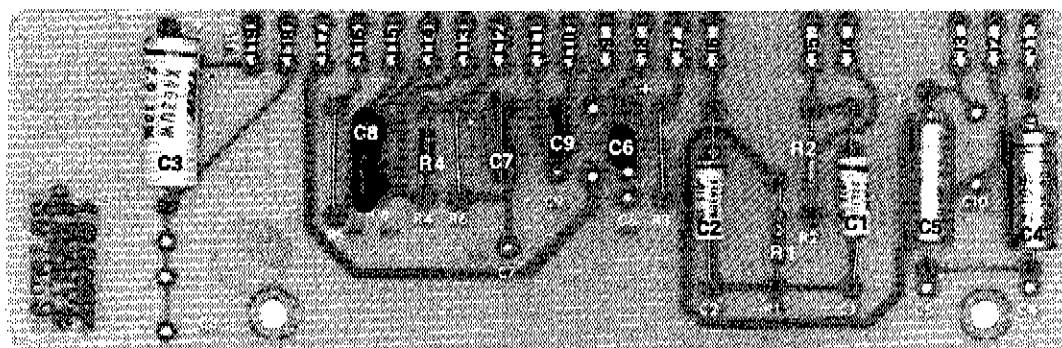


Figure 5-7. PCB ASSEMBLY, 1000 Hz (-05 Option)

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A2A1	PCB ASSEMBLY, 2400 Hz (-06 Option) Figure 5-8	307967	REF		
C1, C2	Cap, mica, 6200 pf $\pm 5\%$, 300V	310490	2	1	
C3	Cap, fxd, met poly, 1.0 uf $\pm 10\%$, 100V	313262	1	1	
C4, C5	Cap, Ta, 68 uf $\pm 10\%$, 15V	182824	2	1	
C6	Cap, Ta, 0.68 uf $\pm 10\%$, 35V	182790	1	1	
C7	Cap, cer, 0.05 uf $\pm 20\%$, 100V	149161	1	1	
C8	Cap, mica, 510 pf $\pm 5\%$, 500V	148411	1	1	
C9	Cap, Fxd, cer, 0.01 uf $\pm 20\%$, 100V	149153	1	1	
J1 thru J19	Connector, receptacle	267617	19	5	
R1	Res, met flm, 2.43k $\pm 1\%$, 1/8w	310524	1	1	
R2	Res, met flm, 39.2k $\pm 1\%$, 1/8w	312207	1	1	
R3	Not used				
R4	Res, fxd, comp, 750k $\pm 5\%$, 1/4w	221937	1		

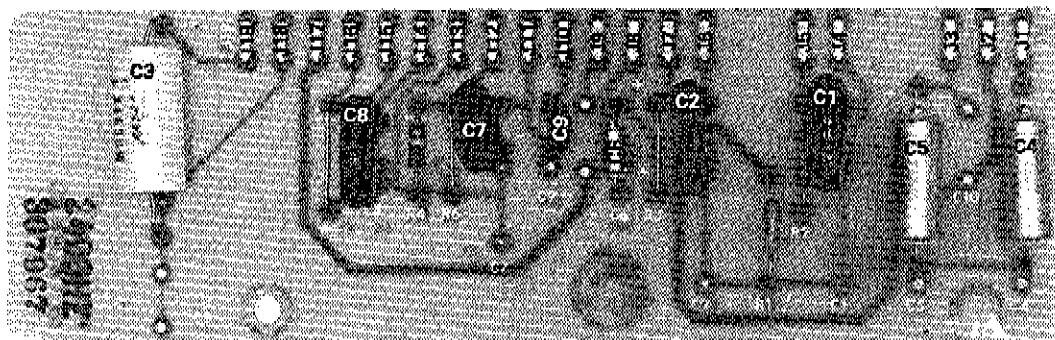


Figure 5-8. PCB ASSEMBLY 2400 Hz (-06 Option)

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
	PCB Assembly, 5000 Hz (-07 Option) Figure 5-9	307975	REF		
C1, C2	Cap, mica, 3000 pf $\pm 5\%$, 500V	161786	2	1	
C3	Cap, fxd, met poly, 1 uf $\pm 10\%$, 100V	313262	1	1	
C4, C5	Cap, Ta, 68 uf $\pm 10\%$, 15V	182824	2	1	
C6	Cap, Ta, .33 uf $\pm 5\%$, 20V	271338	1	1	
C7	Cap, cer, 0.05 uf $\pm 20\%$, 100V	149161	1	1	
C8	Cap, mica, 220 pf $\pm 5\%$, 500V	170423	1	1	
C9	Cap, fxd, cer, 0.01 uf $\pm 20\%$, 100V	149153	1	1	
J1 thru J19	Connector, receptacle	267617	19	5	
R1	Res, met flm, 2.43k $\pm 1\%$, 1/8w	310524	1	1	
R2	Res, met flm, 39.2k $\pm 1\%$, 1/8w	312207	1	1	
R3	Not used				
R4	Res, comp, 360k $\pm 5\%$, 1/4w	234690	1		

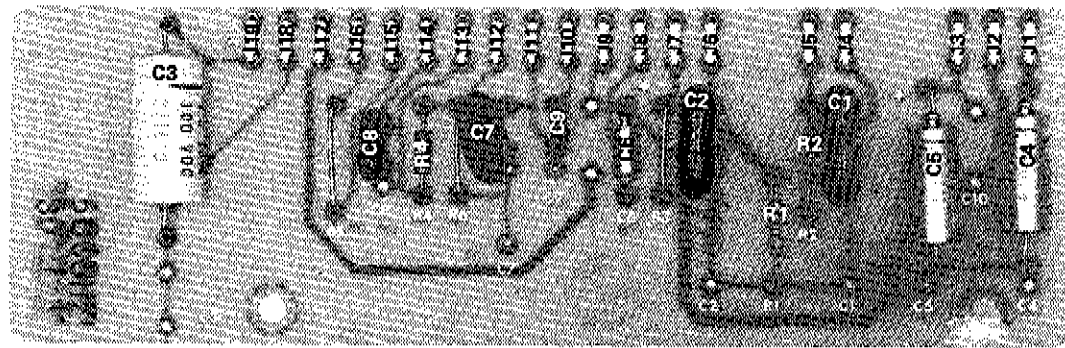


Figure 5-9. PCB ASSEMBLY, 5000 Hz (-07 Option)

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
	PCB Assembly, 19.2 KHz (-08 Option) Figure 5-10	307983	REF		
C1, C2	Cap, mica, 750 pf $\pm 5\%$, 500V	208983	2	1	
C3	Cap, fxd, met poly, 1 uf $\pm 10\%$, 100V	313262	1	1	
C4, C5	Cap, Ta, 68 uf $\pm 10\%$, 15V	182824	2	1	
C6	Cap, plstc, 0.068 uf $\pm 10\%$, 100V	182170	1	1	
C7	Cap, cer, 0.05 uf $\pm 20\%$, 100V	149161	1	1	
C8	Cap, mica, 68 pf $\pm 5\%$, 500V	148510	1	1	
C9	Cap, fxd, cer, 0.01 uf $\pm 20\%$, 100V	149153	1	1	
J1 thru J19	Connector, receptacle	267617	19	5	
R1	Res, met flm, 2.49k $\pm 1\%$, 1/8w	309732	1	1	
R2	Res, met flm, 39.2k $\pm 1\%$, 1/8w	312207	1	1	
R3	Not used				
R4	Res, comp, 100k $\pm 5\%$, 1/4w	148189	1		
R5	Not used				
R6	Res, comp, 5.1 Ω $\pm 5\%$, 1/4w	281832	1		

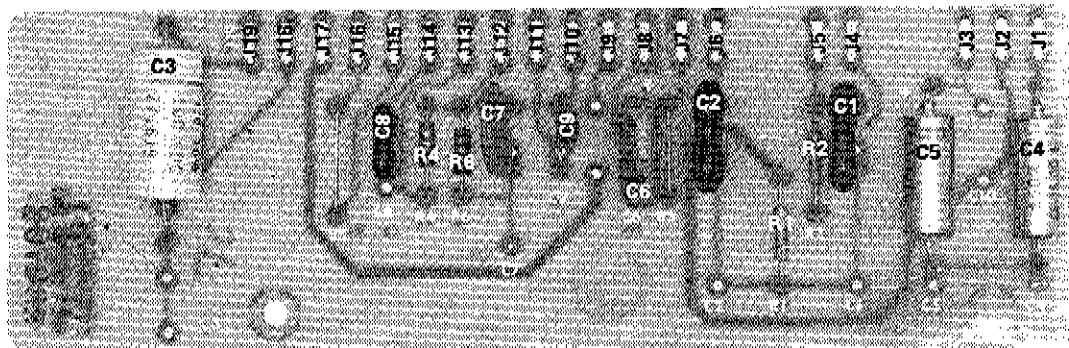


Figure 5-10. PCB ASSEMBLY, 19.2 kHz (-08 Option)

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
	PCB Assembly, 100 KHz (-09 Option) Figure 5-11	307991	REF		
C1, C2	Cap, mica, 150 pf $\pm 5\%$, 500V	148478	2	1	
C3	Cap, fxd, met poly, 1 uf $\pm 10\%$, 100V	313262	1	1	
C4, C5	Cap, Ta, 68 uf $\pm 10\%$, 15V	182824	2	1	
C6	Cap, cer, 0.05 uf $\pm 20\%$, 100V	149161	1	1	
C7, C9	Cap, fxd, cer, 0.01 uf $\pm 20\%$, 100V	149153	2	1	
C8	Not used				
J1 thru J19	Connector, receptacle	267617	19	5	
R1	Res, fxd, met flm, 2.26k $\pm 1\%$, 1/8w	310516	1	1	
R2	Res, fxd, met flm, 36.5k $\pm 1\%$, 1/8w	312199	1	1	
R3	Not used				
R4	Res, comp, 4.7M $\pm 5\%$, 1/4w	220046	1	1	

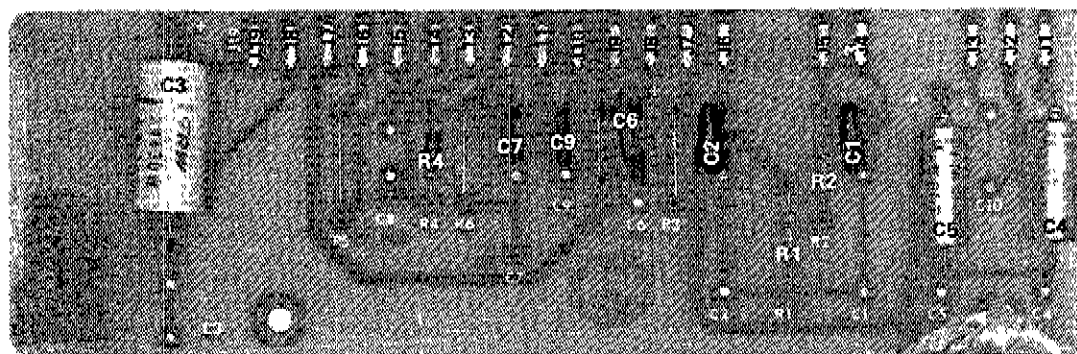


Figure 5-11. PCB ASSEMBLY, 100 kHz (-09 Option)

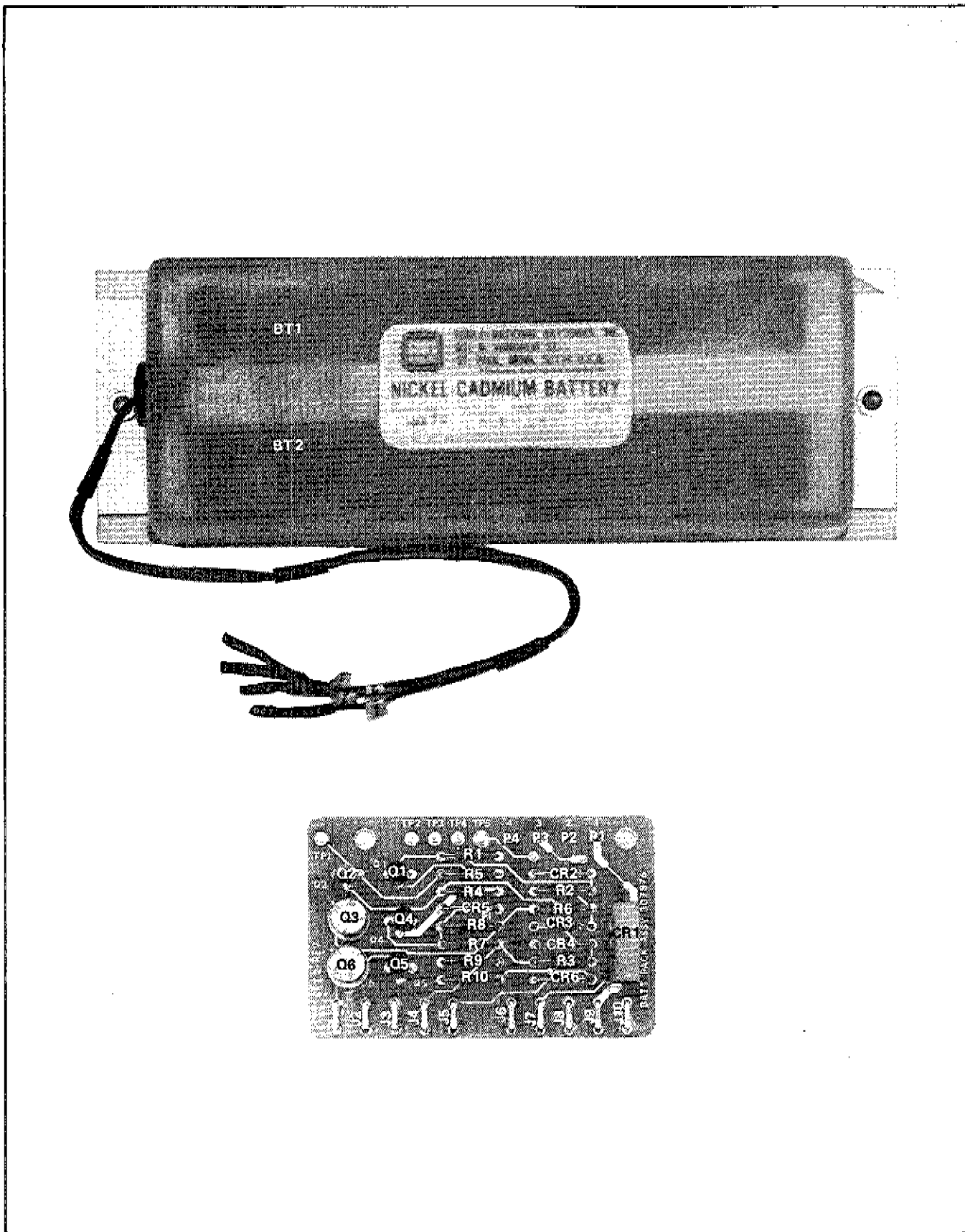


Figure 5-12. RECHARGEABLE BATTERY KIT (-01
OPTION)

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A3	RECHARGEABLE BATTERY Kit (-01 Option) Figure 5-12	510A-01K	Ref		
	Battery Pack	307900	1		
BT1, BT2	Battery	284356	1	2	
	Battery Pack PCB	307876	1	1	
CR1	Diode, bridge, 2 amp, 200 piv	296509	1		
CR2, CR6	Diode, zener, 36V $\pm 5\%$, 1w	284364	2	1	
CR3	Diode, zener, 18.5V	309450	1	1	
CR4, CR5	Diode, silicon, 150 mA	203323	2	1	
J1 thru J10	Connector, receptacle	267617	10	3	
P1 thru P4	Connector, post	267500	4		
Q1, Q4	Tstr, silicon, PNP	195974	2	1	
Q2, Q5	Tstr, silicon, NPN	218396	2	1	
Q3, Q6	Tstr, semicon, germanium, PNP	148619	2	1	
R1, R10	Res, comp, 1M $\pm 5\%$, 1/4w	182204	2		
R2	Res, comp, 15k $\pm 5\%$, 1/4w	148114	1		
R3	Res, comp, 27k $\pm 5\%$, 1/4w	148148	1		
R4	Res, comp, 150k $\pm 5\%$, 1/4w	182212	1		
R5	Res, comp, 30k $\pm 5\%$, 1/4W	193417	1		
R6, R7	Res, comp, 330k $\pm 5\%$, 1/4W	192948	2		
R8	Res, comp, 56k $\pm 5\%$, 1/4W	170738	1		
R9	Res, comp, 68k $\pm 5\%$, 1/4W	148171	1		

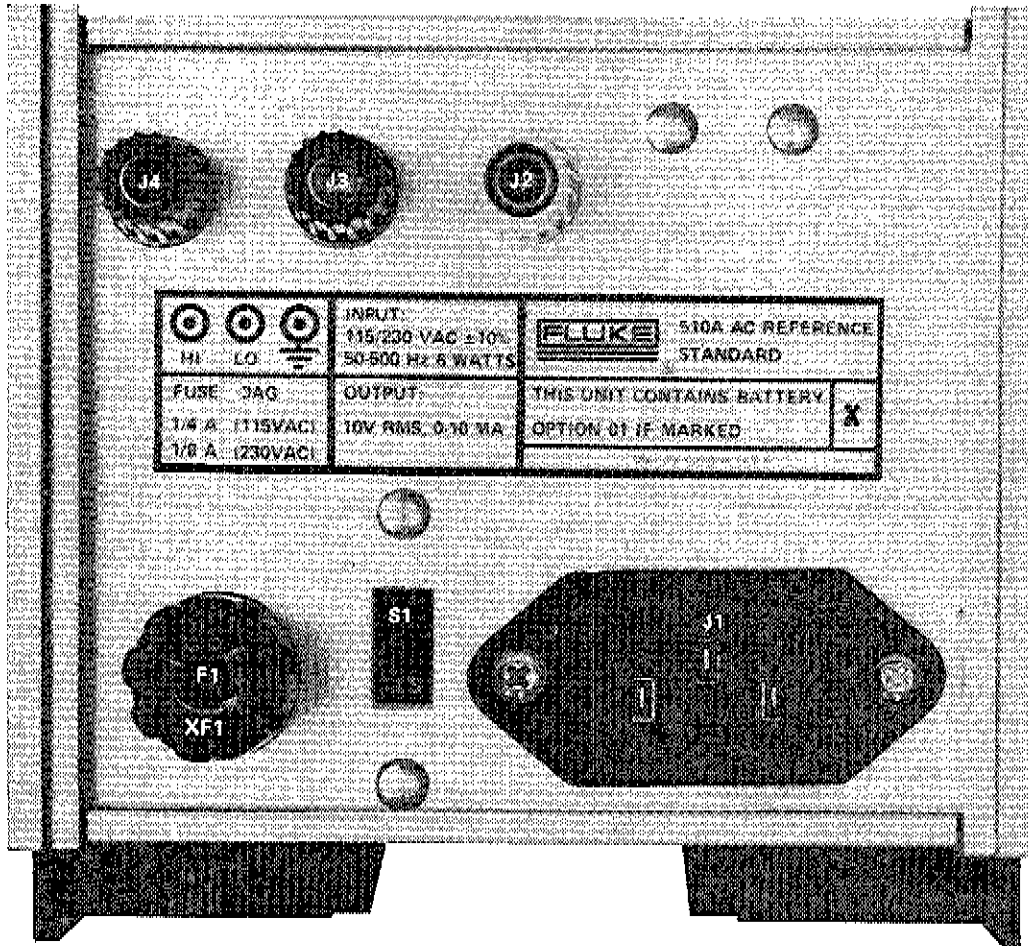


Figure 5-13. REAR PANEL ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4	REAR PANEL ASSEMBLY Figure 5-13	307884	REF		
F1	Fuse, fast acting, 1/4 amp, 250V (for 115V operation)	109314	1		
F1	Fuse, fast acting, 1/8 amp, 250V (for 230V operation)	196790			
J1	Connector, male, 3 pin	284166	1		
J2	Binding post, white	275586	1		
J3	Binding post, black, LO	275560	1		
J4	Binding post, red, HI	275552	1		
S1	Switch, slide	226274	1		
XF1	Fuse holder	160846	1		
	Decal	313064	1		
	Rear panel	307694	1		

MANUFACTURERS' CROSS REFERENCE LIST

FLUKE STOCK NO.	MFR.	MFR. PART NO.	FLUKE STOCK NO.	MFR.	MFR. PART NO.
105197	56289	30D205G-050BA4	160804	01121	CB2715
105890	71590	BB60181KS3N	161810	03877	SG5658
106369	32897	831-000-T2HO-200	161927	56289	196D225X0020
106377	32897	861-000-T2HO-3R3	161943	56289	196D475X0020
1166111	05279	1N4817	161992	73445	C280AEA100K
147868	01121	CB1005	163915	56289	196D396X0006
147926	01121	CB1015	168195	91637	TYPE MFF 1/8
148023	01121	CB1025	168229	91637	TYPE MFF1/8
148072	01121	CB4725	168435	56289	C128B101H253M
148080	01121	CB5625	170423	14655	CD15F221J
148098	01121	CB6825	170738	01121	CB5635
148106	01121	CB1035	175042	01121	CB1825
148114	01121	CB1535	175216	14655	CD15C200K
148122	01121	CB1835	175265	08806	757
148130	01121	CB2235	178616	73445	C437ARG250
148148	01121	CB2735	180497	07910	1N753
148163	01121	CB4735	182170	14655	DMF1568
148171	01121	CB6835	182204	01121	CB1055
148189	01121	CB1045	182212	01121	CB1545
148379	14655	CD19F122J	182790	56289	150D684X9035A2
148478	14655	CD15F151J	182808	56289	150D330X9A2
148510	14655	CD15F680J	182824	56289	150D686X9015R2
148536	14655	CD15E470J	182840	56289	150D227X9010S2
148619	01295	2N1303	184366	73445	C280AE/A470K
148924	72982	5855-Y5U-5032	188441	01121	CB4745
149146	56289	33C41B6	190397	14655	CD15C40K
149153	56289	C023B101F103M	192948	01121	CB3315
149161	56289	55C23A1	193011	56289	150D330X9006S2
149187	93332	1N270	193417	01121	CB3035
159731	01121	CB1235	193441	01121	CB1845
160317	14655	CD15E330J	195974	04713	2N3906
160796	01121	CB8225	196790	71400	TYPE AGC

MANUFACTURERS' CROSS REFERENCE LIST

FLUKE STOCK NO.	MFR.	MFR. PART NO.	FLUKE STOCK NO.	MFR.	MFR. PART NO.
198390	01121	CB2255	275560	32767	820-45
199950	91637	TYPE MFF1/8	275586	32767	820-25
203323	03508	DHD1105	275727	11236	360T200B
208033	01121	CB5615	275735	11236	360T101A
208983	14655	CD19F751J	275750	11236	360T102A
218032	01121	CB5115	276691	11236	360T105A
218081	04713	MPS6520	281832	01121	CB5105
218396	04713	2N3904	284166	82389	EAC301
220046	01121	CB4755	284299	09353	7301
220541	01121	CB8245	284364	12969	UZ8736
221911	01121	CB6225	284760	12040	LM308H
221929	01121	CB3635	285163	11236	360S202A
221937	01121	CB7545	285262	71785	133-23-92-039
221945	01121	CB2415	289116	91637	TYPE MFF1/8
229898	04713	MPS6522	289538	91637	TYPE MFF1/8
234690	01121	CB3645	293456	91637	TYPE MFF1/8
234971	91637	TYPE MFF1/8	293506	18612	310865
235382	91637	TYPE MFF1/8	293530	91637	TYPE MFF1/8
236752	91637	TYPE MFF1/8	293654	91637	TYPE MFF1/8
236851	91637	TYPE MFF1/8	296509	09423	FB100
245373	91637	TYPE MFF1/8	309450	15818	TD333379
256339	28480	5082-2900	309617	31718	FLV102
260331	91637	TYPE MFF1/8	309666	11236	360T202A
266494	32539	TYPE TS-10	309674	11236	360T103A
267393	91637	TYPE MFF1/8	309716	91637	TYPE MFF1/8
267617	00779	85863-5	309724	91637	TYPE MFF1/8
268789	91637	TYPE MFF1/8	309732	91637	TYPE MFF1/8
271338	56289	150DX5020A2	309757	91637	TYPE MFF1/8
271353	91637	TYPE MFF1/8	310466	01281	X4630W27
271502	12040	LM301A	310474	01281	X463UW33351
275552	32767	820-65	310482	01281	X4630W15051
			310490	14655	CD19F622J

MANUFACTURERS' CROSS REFERENCE LIST

FLUKE STOCK NO.	MFR.	MFR. PART NO.	FLUKE STOCK NO.	MFR.	MFR. PART NO.
310508	91637	TYPE MFF1/8			
310524	91637	TYPE MFF1/8			
312173	91637	TYPE MFF1/8			
312181	91637	TYPE MFF1/8			
312207	91637	TYPE MFF1/8			
312215	91637	TYPE MFF1/8			
312223	91637	TYPE MFF1/8			
313262	01281	X4630W10091			
321109	73899	DVJ300A			

Section 6

Option & Accessory Information

6-1. INTRODUCTION

6-2. This section of the manual contains information pertaining to the accessories and options available for your instrument.

6-3. ACCESSORY INFORMATION

6-4. The accessory information, if applicable, will contain details concerning accessories that may be used with this particular instrument.

6-5. OPTION INFORMATION

6-6. Each of the options available for this instrument, if any, are described separately under headings containing the option number. The option descriptions contain applicable operating and maintenance instructions and field installation procedures. A complete list of replaceable parts for each option is contained at the end of that option description.

Accessory

Rack Mounting Fixtures

6-1. INTRODUCTION

6-2. The FLUKE quarter-rack instruments can be installed in a 19 inch equipment rack in various combinations and in conjunction with other FLUKE half-rack instruments. Figure 6-1 shows various mounting configurations.

6-3. Instructions for attaching rack mounting brackets are given in Figure 6-2. Figure 6-3 gives instructions for dual, triple, quadruple rack mounting.

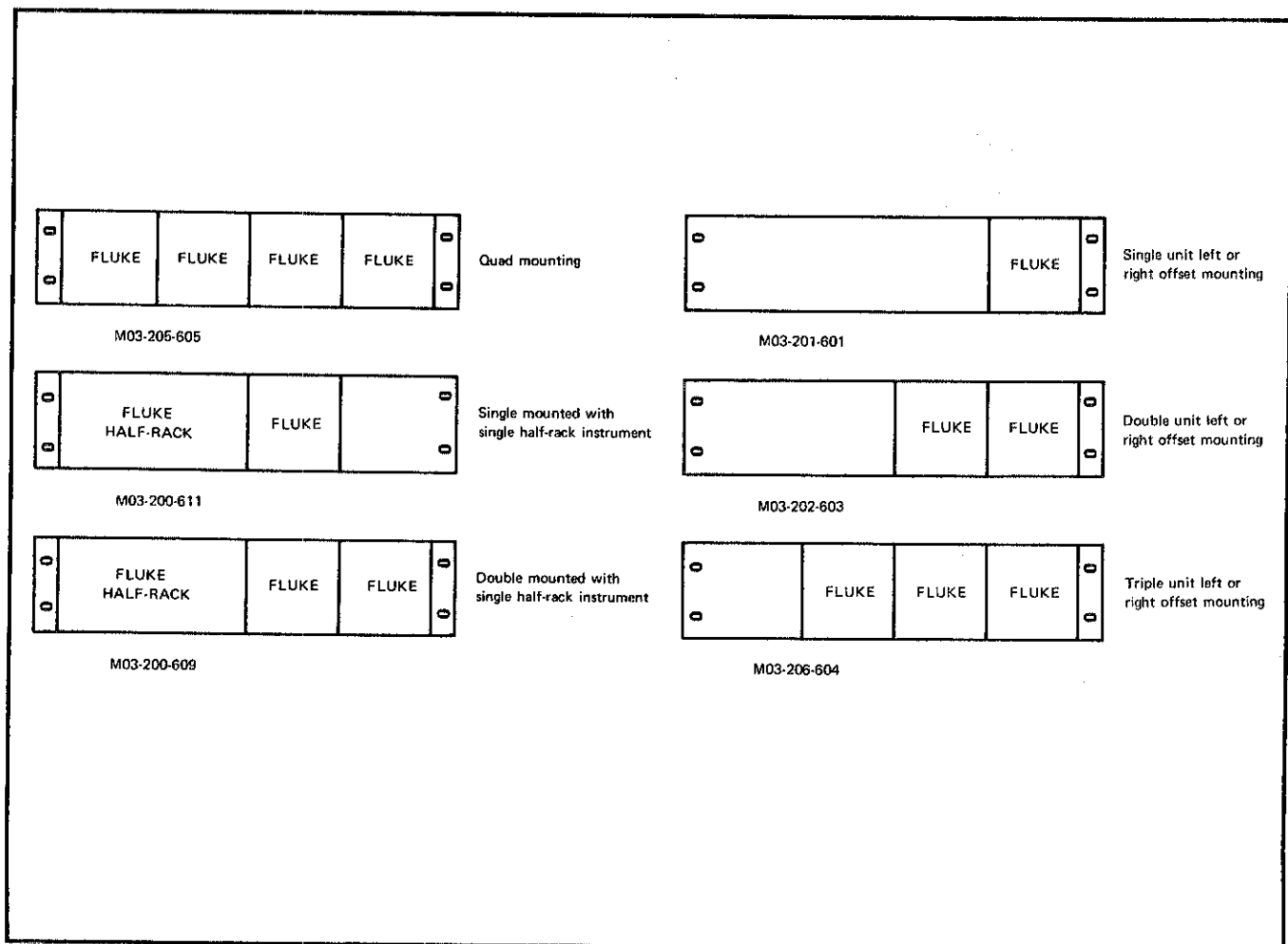
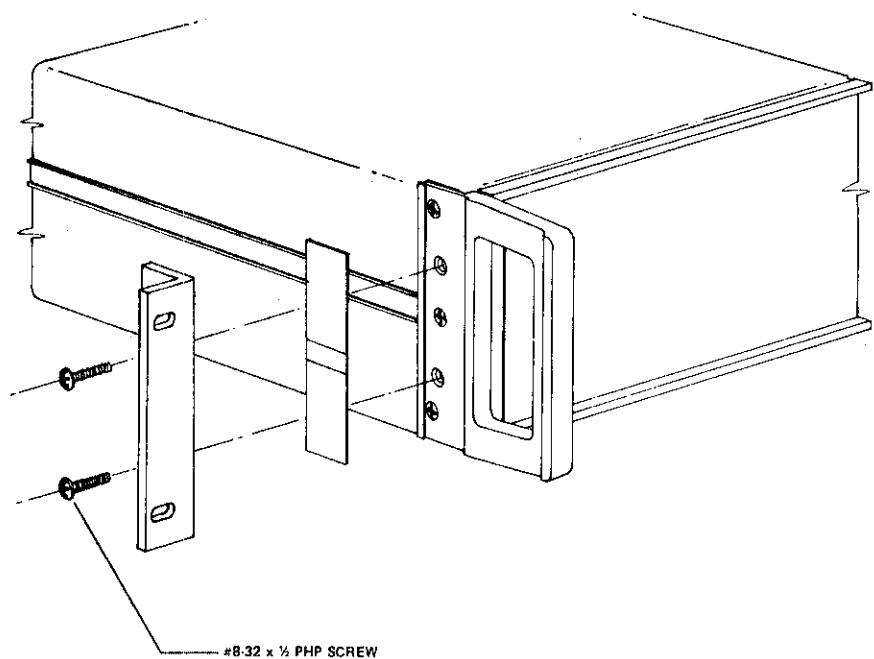


Figure 6-1. RACK MOUNTING CONFIGURATIONS

RACK MOUNTING PROCEDURE FOR MODULAR SERIES INSTRUMENTS



1. REMOVE THE FOUR MOLDED FEET AND BAIL FROM BOTTOM COVER.
2. REMOVE THE NAMEPLATE DECALS FROM THE FRONT CORNERS.
3. REMOVE THE SCREWS FROM CORNERS WHICH MATCH HOLE PATTERNS IN RACK MOUNTING EARS.
4. ATTACH RACK MOUNTING EARS WITH PAN HEAD SCREWS (ENCLOSED).

Figure 6-2. RACK EAR INSTALLATION

Option -01

Rechargeable Battery Pack

OPTION -01 RECHARGEABLE BATTERY PACK

INTRODUCTION

6-2. The Rechargeable Battery Pack shown in Figure 6-1 is installed as the -01 Option. It provides at least 16 hours of continuous operation in the absence of line power. The battery is automatically recharged during line operation.

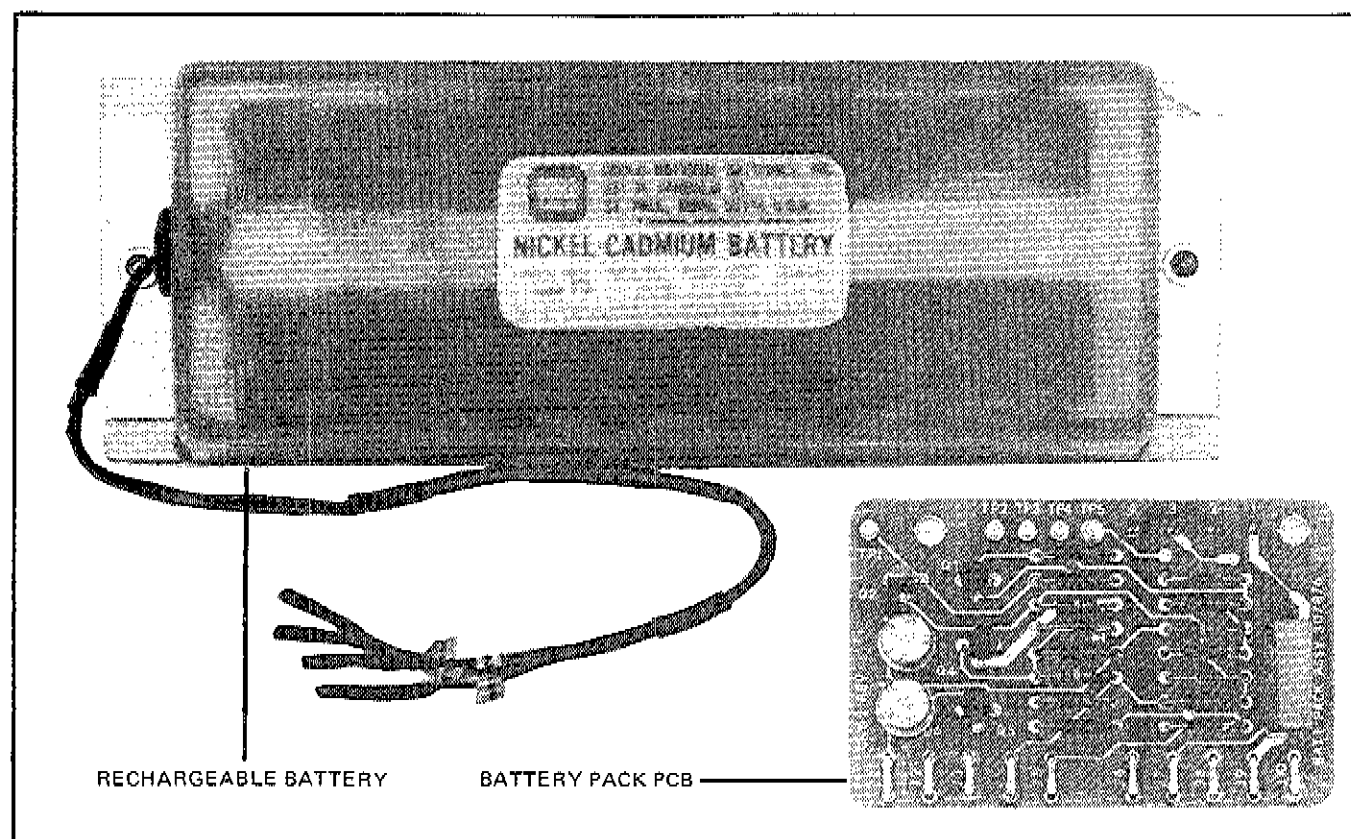


Figure 6-1. 510A-01K BATTERY PACK

6-3. INSTALLATION

6-4. The Rechargeable Battery Pack can be ordered installed at the factory during manufacture by requesting the -01 Option. Field installation of this option is also possible at any time. The field installation kit can be obtained by ordering FLUKE KIT 510A-01K. Installation is as follows:

- a. Turn off the Model 510A and disconnect the power cord.
- b. Remove the bottom dust cover.
- c. Install the Battery Pack (BT1, BT2) on the bottom dust cover as shown in Figure 6-2.

- d. Install the Battery Pack PCB in the position shown in Figure 6-2. Ensure that the mating connectors are correctly aligned during installation.
- e. Connect the four (4) Battery Pack wires to the Battery Pack PCB. Each wire is labeled with a number which corresponds to a connector on the PCB.
- f. Install the bottom dust cover.

NOTE!

Operating instructions, theory of operation maintenance, and parts list are located in the Model 510A Instruction Manual.

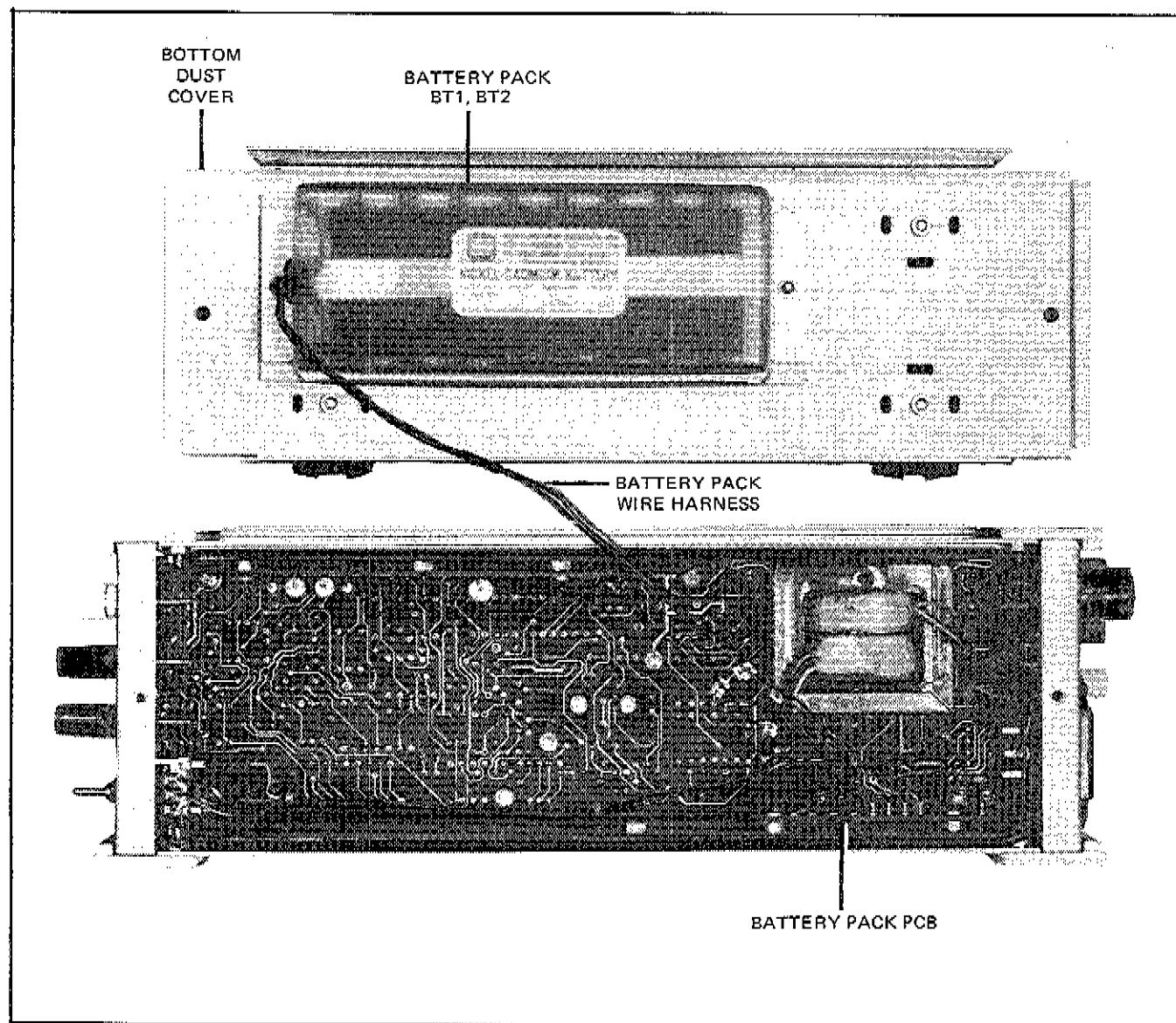
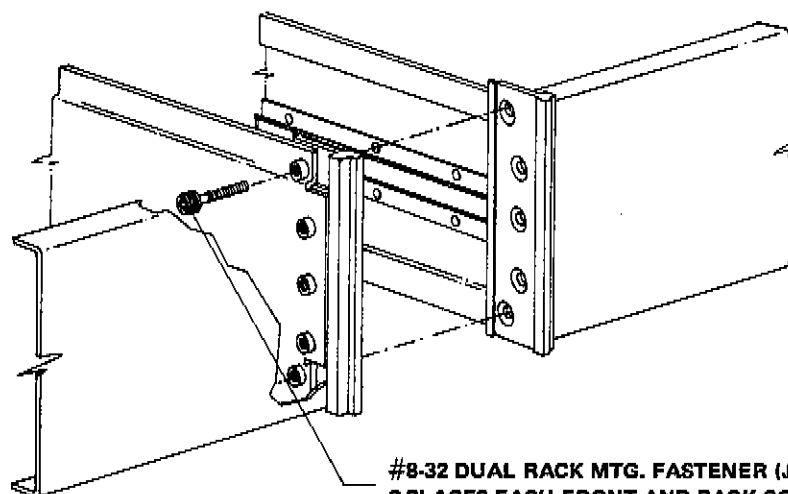


Figure 6-2. BATTERY PACK KIT LOCATIONS

DUAL, TRIPLE & QUAD MOUNTING FOR MODULAR SERIES INSTRUMENTS



#8-32 DUAL RACK MTG. FASTENER (J.F. #309708)
2 PLACES EACH FRONT AND BACK CORNERS.

FLUKE PART NO.	DESCRIPTION	QUANTITY		
		DUAL RACK KIT #304816 #304808 #304782 #304360	TRIPLE RACK KIT #308130	QUAD RACK KIT #304980
#309708	DUAL RACK MTG. FASTENER	4	8	12

1. REMOVE TOP & BOTTOM COVERS FROM BOTH INSTRUMENTS.
2. REMOVE NAMEPLATE DECALS FROM CORNERS.
3. REMOVE TOP & BOTTOM SCREWS FROM BOTH FRONT & REAR CORNERS ON THE MATING SIDE OF THE INSTRUMENTS.
4. INSERT NO. 8-32 DUAL MOUNTING FASTENER, THROUGH THE P-NUTS IN BOTH FRONT & REAR CORNERS.
5. REMOVE FEET FROM BOTTOM COVERS AND REPLACE TOP & BOTTOM COVERS.

Figure 6-3. DUAL, TRIPLE AND QUAD MOUNT

Section 7

General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable parts contained in Section 5. The following information is presented in this section:

List of Abbreviations

Federal Supply Codes for Manufacturers

Fluke Technical Service Centers — U.S. and Canada

Sales and Service Locations — International

Sales Representatives — U.S. and Canada

List of Abbreviations and Symbols

A or amp	ampere	H	henry	pF	picofarad
ac	alternating current	hd	heavy duty	pn	part number
af	audio frequency	hf	high frequency	(+) or pos	positive
a/d	analog-to-digital	Hz	hertz	pot	potentiometer
assy	assembly	IC	integrated circuit	p-p	peak-to-peak
AWG	american wire gauge	if	intermediate frequency	ppm	parts per million
B	bel	in	inch(es)	PROM	programmable read-only memory
bcd	binary coded decimal	intl	internal	psi	pound-force per square inch
°C	Celsius	I/O	input/output	RAM	random-access memory
cap	capacitor	k	kilo (10 ³)	rf	radio frequency
ccw	counterclockwise	kHz	kilohertz	rms	root mean square
cer	ceramic	kΩ	kilohm(s)	ROM	read-only memory
cermet	ceramic to metal (seal)	kV	kilovolt(s)	s or sec	second (time)
ckt	circuit	lf	low frequency	scope	oscilloscope
cm	centimeter	LED	light-emitting diode	SH	shield
cmrr	common mode rejection ratio	LSB	least significant bit	Si	silicon
comp	composition	LSD	least significant digit	serno	serial number
cont	continue	M	mega (10 ⁶)	sr	shift register
crt	cathode-ray tube	m	milli (10 ⁻³)	Ta	tantalum
cw	clockwise	mA	milliampere(s)	tb	terminal board
d/a	digital-to-analog	max	maximum	tc	temperature coefficient or temperature compensating
dac	digital-to-analog converter	mf	metal film	texo	temperature compensated crystal oscillator
dB	decibel	MHz	megahertz	tp	test point
dc	direct current	min	minimum	u or μ	micro (10 ⁻⁶)
dmm	digital multimeter	mm	millimeter	uhf	ultra high frequency
dvm	digital voltmeter	ms	millisecond	us or μs	microsecond(s) (10 ⁻⁶)
elect	electrolytic	MSB	most significant bit	uut	unit under test
ext	external	MSD	most significant digit	V	volt
F	farad	MTBF	mean time between failures	v	voltage
°F	Fahrenheit	MTTR	mean time to repair	var	variable
FET	Field-effect transistor	mV	millivolt(s)	vco	voltage controlled oscillator
ff	flip-flop	mv	multivibrator	vhf	very high frequency
freq	frequency	MΩ	megohm(s)	vlf	very low frequency
FSN	federal stock number	n	nano (10 ⁻⁹)	W	watt(s)
g	gram	na	not applicable	ww	wire wound
G	giga (10 ⁹)	NC	normally closed	xfmr	transformer
gd	guard	(-) or neg	negative	xstr	transistor
Ge	germanium	NO	normally open	xtal	crystal
GHz	gigahertz	ns	nanosecond	xtlo	crystal oscillator
gmV	guaranteed minimum value	opnl ampl	operational amplifier	Ω	ohm(s)
gnd	ground	p	pico (10 ⁻¹²)	μ	micro (10 ⁻⁶)
		para	paragraph		
		pcb	printed circuit board		

Federal Supply Codes for Manufacturers (Continued)

00213 Nytronics Comp. Group Inc. Subsidiary of Nytronics Inc. Formerly Sage Electronics Rochester, New York	03797 Eidema Div. Genisco Technology Corp. Compton, California	05574 Viking Industries Chatsworth, California	07597 Burndy Corp. Tape/Cable Div. Rochester, New York
00327 Welwyn International, Inc. Westlake, Ohio	03877 Transistron Electronic Corp. Wakefield, Massachusetts	05704 Replaced by 16258	07792 Lerma Engineering Corp. Northampton, Massachusetts
00656 Aerovox Corp. New Bedford, Massachusetts	03888 KDI Pyrofilm Corp. Whippany, New Jersey	05820 Wakefield Engineering Inc. Wakefield, Massachusetts	07910 Teledyne Semiconductor Formerly Continental Device Hawthorne, California
00686 Film Capacitors, Inc. Passaic, New Jersey	03911 Clairex Electronics Div. Clairex Corp. Mt. Vernon, New York	06001 General Electric Co. Electronic Capacitor & Battery Products Dept. Columbia, South Carolina	07933 - use 49956 Raytheon Co. Semiconductor Div. HQ Mountain View, California
00779 AMP Inc. Harrisburg, Pennsylvania	03980 Muirhead Inc. Mountainside, New Jersey	06136 Replaced by 63743	08225 Industro Transistor Corp. Long Island City, New York
01121 Allen-Bradley Co. Milwaukee, Wisconsin	04009 Arrow Hart Inc. Hartford, Connecticut	06383 Panduit Corp. Tinley Park, Illinois	08261 Spectra Strip Corp. Garden Grove, California
01281 TRW Electronic Comp. Semiconductor Operations Lawndale, California	04062 Replaced by 72136	06473 Bunker Ramo Corp. Amphenol SAMS Div. Chatsworth, California	08530 Reliance Mica Corp. Brooklyn, New York
01295 Texas Instruments, Inc. Semiconductor Group Dallas, Texas	04202 Replaced by 81312	06555 Beede Electrical Instrument Co. Penacook, New Hampshire	08806 General Electric Co. Miniature Lamp Products Dept. Cleveland, Ohio
01537 Motorola Communications & Electronics Inc. Franklin Park, Illinois	04217 Essex International Inc. Wire & Cable Div. Anaheim, California	06739 Electron Corp. Littleton, Colorado	08863 Nylomatic Corp. Norrisville, Pennsylvania
01686 RCL Electronics Inc. Manchester, New Hampshire	04221 Aemco, Div. of Midtex Inc. Mankato, Minnesota	06743 Clevite Corp. Cleveland, Ohio	08988 - use 53085 Skottle Electronics Inc. Archbald, Pennsylvania
01730 Replaced by 73586	04222 AVX Ceramics Div. AVX Corp. Myrtle Beach, Florida	06751 Components, Inc. Semcor Div. Phoenix, Arizona	09214 G.E. Co. Semi-Conductor Products Dept. Power Semi-Conductor Products OPN Sec. Auburn, New York
01884 - use 56289 Sprague Electric Co. Dearborn Electronic Div. Lockwood, Florida	04423 Telonic Industries Laguna Beach, California	06880 Gould Automotive Div. City of Industry, California	09353 C and K Components Watertown, Massachusetts
02114 Ferroxcube Corp. Saugerties, New York	04645 Replaced by 75376	06961 Vernitron Corp., Piezo Electric Div. Formerly Clevite Corp., Piezo Electric Div. Bedford, Ohio	09423 Scientific Components, Inc. Santa Barbara, California
02131 General Instrument Corp. Harris ASW Div. Westwood, Maine	04713 Motorola Inc. Semiconductor Products Phoenix, Arizona	06980 Eimac Div. Varian Associates San Carlos, California	09922 Burndy Corp. Norwalk, Connecticut
02395 Rason Mfg. Co. Brooklyn, New York	04946 Standard Wire & Cable Los Angeles, California	07047 Ross Milton, Co., The South Hampton, Pennsylvania	09969 Dale Electronics Inc. Yankton, S. Dakota
02533 Snelgrove, C.R. Co., Ltd. Don Mills, Ontario, Canada M3B 1M2	05082 Replaced by 94988	07115 Replaced by 14674	10059 Barker Engineering Corp. Formerly Amerace, Amerace ESNA Corp. Kenilworth, New Jersey
02606 Fenwal Labs Div. of Travenal Labs. Morton Grove, Illinois	05236 Jonathan Mfg. Co. Fullerton, California	07138 Westinghouse Electric Corp., Electronic Tube Division Horsehead, New York	11236 CTS of Berne Berne, Indiana
02660 Bunker Ramo Corp., Conn Div. Formerly Amphenol-Borg Electric Corp. Broadview, Illinois	05245 Components Corp. now Corcom, Inc. Chicago, Illinois	07233 TRW Electronic Components Cinch Graphic City of Industry, California	11237 CTS Keene Inc. Paso Robles, California
02799 Aero Capacitors, Inc. Chatsworth, California	05277 Westinghouse Electric Corp. Semiconductor Div. Youngwood, Pennsylvania	07256 Silicon Transistor Corp. Div. of BBF Group Inc. Chelmsford, MA	11358 CBS Electronic Div. Columbia Broadcasting System Newburyport, MN
03508 General Electric Co. Semiconductor Products Syracuse, New York	05279 Southwest Machine & Plastic Co. Glendora, California	07261 Aumet Corp. Culver City, California	11403 Best Products Co. Chicago, Illinois
03614 Replaced by 71400	05397 Union Carbide Corp. Materials Systems Div. New York, New York	07263 Fairchild Semiconductor Div. of Fairchild Camera & Instrument Corp. Mountain View, California	11503 Keystone Columbia Inc. Warren, Michigan
03651 Replaced by 44655	05571 - use 56289 Sprague Electric Co. Pacific Div. Los Angeles, California	07344 Bircher Co., Inc. Rochester, New York	11532 Teledyne Relays Hawthorne, California

Federal Supply Codes for Manufacturers (Continued)

11711 General Instrument Corp Rectifier Division Hickville, New York	14099 Semtech Corp. Newbury Park, California	17069 Circuit Structures Lab. Burbank, California	24655 General Radio Concord, Massachusetts
11726 Qualidyne Corp. Santa Clara, California	14140 Edison Electronic Div. Mc Gray-Edison Co. Manchester, New Hampshire	17338 High Pressure Eng. Co., Inc. Oklahoma City, Oklahoma	24759 Lenox-Fugle Electronics Inc. South Plainfield, New Jersey
12014 Chicago Rivet & Machine Co. Bellwood, Illinois	14193 Cal-R Inc. formerly California Resistor, Corp. Santa Monica, California	17545 Atlantic Semiconductors, Inc. Asbury Park, New Jersey	25088 Siemen Corp. Isilen, New Jersey
12040 National Semiconductor Corp. Danbury, Connecticut	14298 American Components, Inc. an Insilco Co. Conshohocken, Pennsylvania	17856 Siliconix, Inc. Santa Clara, California	25403 Amperex Electronic Corp. Semiconductor & Micro-Circuits Div. Slatersville, Rhode Island
12060 Diodes, Inc. Chatsworth, California	14655 Cornell-Dublier Electronics Division of Federal Pacific Electric Co. Govt. Control Dept. Newark, New Jersey	17870 Replaced by 14140	27014 National Semiconductor Corp. Santa Clara, California
12136 Philadelphia Handle Co. Camden, New Jersey	14752 Electro Cube Inc. San Gabriel, California	18178 Vactec Inc. Maryland Heights, Missouri	27264 Molex Products Downers Grove, Illinois
12300 Potter-Brumfield Division AMF Canada LTD. Guelph, Ontario, Canada	14869 Replaced by 96853	18324 Signetics Corp. Sunnyvale, California	28213 Minnesota Mining & Mfg. Co. Consumer Products Div. St. Paul, Minnesota
12323 Presin Co., Inc. Shelton, Connecticut	14936 General Instrument Corp. Semi Conductor Products Group Hicksville, New York	18612 Vishay Resistor Products Div. Vishay Intertechnology Inc. Malvern, Pennsylvania	28425 Serv-/Link formerly Bohannon Industries Fort Worth, Texas
12327 Freeway Corp. formerly Freeway Washer & Stamping Co. Cleveland, Ohio	15636 Elec-Trol Inc. Saugus, California	18736 Voltronics Corp. Hanover, New Jersey	28478 G T E Sylvania Inc. Precision Material Group Parts Division Titusville, Pennsylvania
12443 Budd Co. The, Polychem Products Plastic Products Div. Bridgeport, PA	15801 Fenwal Electronics Inc. Div. of Kidde Walter and Co., Inc. Frammingham, Massachusetts	18927 G T E Sylvania Inc. Precision Material Group Parts Division Titusville, Pennsylvania	28480 Hewlett Packard Co. Corporate H.Q. Palo Alto, California
12615 U.S. Terminals Inc. Cincinnati, Ohio	15818 Teledyne Semiconductors, formerly Amelco Semiconductor Mountain View, California	19451 Perine Machinery & Supply Co. Seattle, Washington	28520 Heyman Mfg. Co. Kenilworth, New Jersey
12617 Hamlin Inc. Lake Mills, Wisconsin	15849 Litton Systems Inc. Useco Div. formerly Useco Inc. Van Nuys, California	19701 Electro-Midland Corp. Mapco-Electra Inc. Mineral Wells, Texas	29083 Monsanto, Co., Inc. Santa Clara, California
12697 Clarostar Mfg. Co. Dover, New Hampshire	15898 International Business Machines Corp. Essex Junction, Vermont	20584 Enochs Mfg. Inc. Indianapolis, Indiana	29604 Stackpole Components Co. Raleigh, North Carolina
12749 James Electronics Chicago, Illinois	15909 Replaced by 14140	20891 Self-Organizing Systems, Inc. Dallas, Texas	30148 A B Enterprise Inc. Ahoskie, North Carolina
12856 Micrometals Sierra Madre, California	16258 Space-Lok Inc. Burbank, California	21604 Buckeye Stamping Co. Columbus, Ohio	30323 Illinois Tool Works, Inc. Chicago, Illinois
12954 Dickson Electronics Corp. Scottsdale, Arizona	16299 Corning Glass Electronic Components Div. Raleigh, North Carolina	21845 Solitron Devices Inc. Transistor Division Riviera Beach, Florida	31091 Optimax Inc. Colmar, Pennsylvania
12969 Unitrode Corp. Watertown, Massachusetts	16332 Replaced by 28478	22767 ITT Semiconductors Palo Alto, California	32539 Mura Corp. Great Neck, New York
13103 Thermalloy Co., Inc. Dallas, Texas	16473 Cambridge Scientific Ind. Div. of Chemed Corporation Cambridge, Maryland	23050 Product Comp. Corp. Mount Vernon, New York	32767 Griffith Plastic Corp. Burlingame, California
13327 Solitron Devices Inc. Tappan, New York	16742 Paramount Plastics Fabricators, Inc. Downey, California	23732 Tracor Inc. Rockville, Maryland	32879 Advanced Mechanical Components Northridge, California
13511 Amphenol Cadre Div. Bunker-Ramo Corp. Los Gatos, California	16758 Delco Electronics Div. of General Motors Corp. Kokomo, Indiana	23880 Stanford Applied Engrng. Santa Clara, California	32897 Erie Technological Products, Inc. Frequency Control Div. Carlisle, Pennsylvania
13606 - use 56289 Sprague Electric Co. Transistor Div. Concord, New Hampshire	17001 Replaced by 71468	23936 Pamotor Div., Wm. J. Purdy Co. Burlingame, California	32997 Bourns Inc. Trimpot Products Division Riverside, California
13839 Replaced by 23732		24248 Replaced by 94222	33173 General Electric Co. Products Dept. Owensboro, Kentucky

Federal Supply Codes for Manufacturers (Continued)

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc.
Kenilworth, New Jersey

37942
Mallory, P.R. & Co., Inc.
Indianapolis, Indiana

42498
National Radio
Melrose, Massachusetts

43543
Nytronics Inc.
Transformer Co. Div.
Geneva, New York

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp.
Carrollton, Texas

50579
Litronix Inc.
Cupertino, California

51605
Scientific Components Inc.
Linden, New Jersey

53021
Sangamo Electric Co.
Springfield, Illinois

54294
Cutler-Hammer Inc. formerly
Shallcross, A Cutter-Hammer Co.
Selma, North Carolina

55026
Simpson Electric Co.
Div. of Am. Gage and Mach. Co.
Elgin, Illinois

56289
Sprague Electric Co.
North Adams, Massachusetts

58474
Superior Electric Co.
Bristol, Connecticut

60399
Torin Corp. formerly
Torrington Mfg. Co.
Torrington, Connecticut

63743
Ward Leonard Electric Co., Inc.
Mount Vernon, New York

64834
West Mfg. Co.
San Francisco, California

65092
Weston Instruments Inc.
Newark, New Jersey

66150
Winslow Tele-Tronics Inc.
Eaton Town, New Jersey

70485
Atlantic India Rubber Works
Chicago, Illinois

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71002
Birnbach Radio Co., Inc.
Freeport, LI New York

71400
Bussmann Mfg.
Div. of McGraw-Edison Co.
Saint Louis, Missouri

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Electric Inc.
Santa Ana, California

71482
Clare, C.P. & Co.
Chicago, Illinois

71590
Centralab Electronics
Div. of Globe Union Inc.
Milwaukee, Wisconsin

71707
Coto Coil Co., Inc.
Providence, Rhode Island

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Cinch Connector Operations Div.
Elk Grove Village, Chicago, Illinois

72005
Driver, Wilber B., Co.
Newark, New Jersey

72092
Replaced by 06980

72136
Electro Motive Mfg. Co.
Williamantic, Connecticut

72259
Nytronics Inc.
Pelham Manor, New Jersey

72619
Dialight Div.
Amperex Electronic Corp.
Brooklyn, New York

72653
G.C. Electronics
Div. of Hydrometals, Inc.
Brooklyn, New York

72665
Replaced by 90303

72794
Dzus Fastener Co., Inc.
West Islip, New York

72928
Gulton Ind. Inc.
Gudaman Div.
Chicago, Illinois

72982
Erie Tech, Products Inc.
Erie, Pennsylvania

73138
Beckman Instruments Inc.
Helipot Division
Fullerton, California

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrance, California

73445
Amperex Electronic Corp.
Hicksville, LI, New York

73559
Carling Electric Inc.
West Hartford, Connecticut

73586
Circle F Industries
Trenton, New Jersey

73734
Federal Screw Products, Inc.
Chicago, Illinois

73743
Fischer Special Mfg. Co.
Cincinnati, Ohio

73899
JFD Electronics Co.
Components Corp
Brooklyn, New York

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74199
Quan Nichols Co.
Chicago, Illinois

74217
Radio Switch Corp.
Marlboro, New Jersey

74276
Signalite Div.
General Instrument Corp.
Neptune, New Jersey

74306
Piezo Crystal Co.
Carlisle, Pennsylvania

74542
Hoyt Elect. Instr. Works
Penacook, New Hampshire

74970
Johnson E.F., Co.
Waseca, Minnesota

75042
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75376
Kurz-Kasch Inc.
Dayton, Ohio

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
Mount Vernon, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

76854
Oak Industries Inc.
Switch Div.
Crystal Lake, Illinois

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, Indiana

77638
General Instrument Corp.
Rectifier Division
Brooklyn, New York

77969
Rubbercraft Corp. of CA. LTD.
Torrance, California

78189
Shakeproof
Div. of Illinois Tool Works Inc.
Elgin, Illinois

78277
Sigma Instruments, Inc.
South Braintree, Massachusetts

78488
Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553
Eaton Corp. Engineered
Fastener Div.
Tinnerman Plant
Cleveland, Ohio

79136
Waldes Kohinoor Inc.
Long Island City, New York

79497
Western Rubber Company
Goshen, Indiana

79963
Zierick Mfg. Corp.
Mt. Kisko, New York

80031
Electro-Midland Corp., Mecco Div.
A North American Phillips Co.
Morristown, New Jersey

80145
LFE Corp., Process Control Div.
formerly API Instrument Co.
Chesterland, Ohio

80183 - use 56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc., Instrument Div.
Riverside, California

80583
Hammarlund Mfg. Co., Inc.
Red Bank, New Jersey

80640
Stevens, Arnold Inc.
South Boston, Massachusetts

81073
Grayhill, Inc.
La Grange, Illinois

81312
Winchester Electronics
Div. of Litton Industries Inc.
Oakville, Connecticut

81439
Therm-O-Disc Inc.
Mansfield, Ohio

81483
International Rectifier Corp.
Los Angeles, California

81590
Korry Mfg. Co.
Seattle, Washington

81741
Chicago Lock Co.
Chicago, Illinois

82305
Palmer Electronics Corp.
South Gate, California

82389
Switchcraft Inc.
Chicago, Illinois

Federal Supply Codes for Manufacturers (Concluded)

82415
North American Phillips
Controls Corp.
Frederick, Maryland

82872
Roanwell Corp.
New York, New York

82877
Rotron Inc.
Woodstock, New York

82879
ITT Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83058
Carr Co., The United Can Div.
of TRW
Cambridge, Massachusetts

83298
Bendix Corp.
Electric Power Division
Eastontown, New Jersey

83330
Smith, Herman H., Inc.
Brooklyn, New York

83478
Rubbercraft Corp. of America, Inc.
West Haven, Connecticut

83594
Burrroughs Corp.
Electronic Components Div.
Plainfield, New Jersey

83740
Union Carbide Corp.
Battery Products Div.
formerly Consumer Products Div.
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
TRW Capacitors
Ogallala, Nebraska

84613
Fuse Indicator Corp.
Rockville, Maryland

84682
Essex International Inc.
Industrial Wire Div.
Peabody, Massachusetts

86577
Precision Metal Products,
of Malden Inc.
Stoneham, Massachusetts

86684
Radio Corp. of America
Electronic Components Div.
Harrison, New Jersey

86928
Seastrom Mfg. Co., Inc.
Glendale, California

87034
Illuminated Products Inc.
Subsidiary of Oak Industries Inc.
Anahiem, California

88219
Gould Inc.
Industrial Div.
Trenton, New Jersey

88245
Litton Systems Inc.
Useco Div.
Van Nuys, California

88419
Cornell-Dubilier Electronic Div.
Federal Pacific Co.
Fuquay-Varian, North Carolina

88486
Plastic Wire & Cable
Jewitt City, Connecticut

88690
Replaced by 04217

89536
Fluke, John Mfg. Co., Inc.
Seattle, Washington

89730
G.E. Co., Newark Lamp Works
Newark, New Jersey

90201
Mallory Capacitor Co. Div of
P.R. Mallory Co., Inc.
Indianapolis, Indiana

90211 - use 56365
Square D Co.
Chicago, Illinois

90215
Best Stamp & Mfg. Co.
Kansas City, Missouri

90303
Mallory Battery Co.
Div. of Mallory Co., Inc.
Tarrytown, New York

91094
Essex International Inc.
Suglex/IWP Div.
Newmarket, New Hampshire

91293
Johanson Mfg. Co.
Boonton, New Jersey

91407
Replaced by 58474

91502
Associated Machine
Santa Clara, California

91506
Augat Inc.
Attleboro, Massachusetts

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
Willow Grove, Pennsylvania

91737 - use 71468
Gremar Mfg. Co., Inc.
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91836
King's Electronics Co., Inc.
Tuckahoe, New York

91929
Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

91934
Miller Electric Co., Inc.
Div of Aunet
Woonsocket, Rhode Island

92194
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, Massachusetts

94145
Replaced by 49956

94154 - use 94968
Wagner Electric Corp.
Tung-Sol Div.
Newark, New Jersey

94222
Southco Inc. formerly
South Chester Corp.
Lester, Pennsylvania

95146
Alco Electronic Products Inc.
Lawrence, Massachusetts

95263
Leecraft Mfg. Co.
Long Island City, New York

95264
Replaced by 98278

95275
Vitramon Inc.
Bridgeport, Connecticut

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, Ohio

95348
Gordo's Corp.
Bloomfield, New Jersey

95354
Methode Mfg. Corp.
Rolling Meadows, Illinois

95712
Bendix Corp.
Electrical Components Div.
Microwave Devices Plant
Franklin, Indiana

95987
Weckesser Co. Inc.
Chicago, Illinois

96733
San Fernando Electric Mfg. Co.
San Fernando, California

96853
Gulton Industries Inc.
Measurement and Controls Div.
formerly Rustrak Instruments Co.
Manchester, New Hampshire

96881
Thomson Industries, Inc.
Manhasset, New York

97540
Master Mobile Mounts
Div. of Whitehall Electronics Corp.
Ft. Meyers, Florida

97913
Industrial Electronic Hdware Corp.
New York, New York

97945
Penwalt Corp.
SS White Industrial Products Div.
Piscataway, New Jersey

97966
Replaced by 11358

98094
Replaced by 49956

98159
Rubber-Teck, Inc.
Gardena, California

98278
Malco A Microdot Co., Inc.
Connector & Cable Div.
Pasadena, California

98291
Sealectro Corp.
Mamaroneck, New York

98388
Royal Industries
Products Div.
San Diego, California

98743
Replaced by 12749

98925
Replaced by 14433

99120
Plastic Capacitors, Inc.
Chicago, Illinois

99217
Bell Industries Elect. Comp. Div.
formerly Southern Elect. Div.
Burbank, California

99392
STM
Oakland, California

99515
ITT Jennings Monrovia Plant
Div. of ITT Jennings formerly
Marshall Industries Capacitor Div.
Monrovia, California

99779 - use 29587
Bunker-Ramo Corp.
Barnes Div.
Landsdowne, Pennsylvania

99800
American Precision Industries Inc.
Delevan Division
East Aurora, New York

99942
Controlab Semiconductor
Controlab Electronics Div. of
Globe-Union Inc.
El Monte, California

Toyo Electronics
(R-Ohm Corp.)
Irvine, California

National Connector
Minneapolis, Minnesota

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Santa Clara

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Jesse Morse, Service Manager
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Bill Fetrow, Tech. Service Spvr.
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Gottfried-Keller-Gasse 2/9
A-1030 Vienna, Austria
Tel: 734294, 725746

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C.N. Rood S/A
37 Place de Jamblinne de Meux
B-1040 Brussels, Belgium
Tel: 02-27352135

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Chris Radiovision Ltd.
P.O. Box 1989
Nicosia, Cyprus
Tel: 66121

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Tage Olsen A/S
Tagelvaerksgade 37
DK-2100 Copenhagen Ø, Denmark
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Oy Findip AB
Teollisuustie 7
02700 Kauniainen, Finland
Tel: 080-502255

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M.B. Electronique S.A.
Rue Fournay
ZAC de BUC
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78530 BUC, France
Tel: 9563130

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Fluke (Deutschland) GmbH

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West Germany
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Ramat Hasharon 47235, Israel
Tel: 463211

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Sistrel S.p.A.
Via Giuseppe Armellini No. 37
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Sistrel S.p.A.
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20099 Sesto S. Giovanni (Milan)
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Tel: 02-2485233

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Oslo 5, Norway
Tel: 02-366110

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P.O. Box 1100
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Tel: 019-976551

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Ataio Ingenieros S.A.
Enrique Larreta 10-12
Madrid 16, Spain
Tel: 01-7330562

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Teleinstrument AB
P.O. Box 490
S-162 Vällingby-4
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Tel: 08-380370

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8002 Zurich, Switzerland
Tel: 01 360711

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M. Süheyl Erkman
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Tel: 441546, 447651

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Garnet Close
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Buenos Aires, Argentina
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P.O. Box 30
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Australia 2137
Tel: (02) 736-2888

Elmeasco Instruments Pty Ltd.
P.O. Box 107
Mt. Waverly, VIC. 3149
Australia

Tel: 233-4044

BOLIVIA

Coasin Bolivia S.R.L.
Casilla 7295
La Paz, Bolivia
Tel: 40982

BRAZIL

Arotec S.A.
Industrial e Comercio
Av. Pacaembu 811
Sao Paulo S.P., Brazil

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& CENTRAL AMERICA**

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Miami, FL 33166
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Casilla 14588—Correo 15
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Apartado Aereo 12322
Bogotá 1, Colombia
Tel: 419331

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Prototec Coasin CIA, Ltda.
Apartado 228A
Quito, Ecuador
Tel: 526759

EGYPT

Lotus Engineering Organisation
P.O. Box 1252
Cairo, Egypt
Tel: 71617

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Gilman & Co., Ltd.
P.O. Box 56
Hong Kong
Tel: 794266

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Hinditron Services Pvt. Ltd.
69/A L. Jagmohandas Marg
Bombay 400 006, India
Tel: 365344, 381615

Hinditron Services Pvt. Ltd./
Hinditron Computers Pvt. Ltd.
"Hinditron House"
412 Rajmahal Vilas Extension
Bangalore 560 006, India
Tel: 32852

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P.T. United Dico-Citas Co., Ltd.
JLN Penjarangan 39A
Jakarta, Indonesia
Tel: 21380

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20 Salm Road, Roosevelt Avenue
Tehran, Iran
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P.O. Box 5014
Tokyo International
Tokyo 100-81, Japan
Tel: (03) 279-0771

Toyo Trading Company, Ltd.
Suzuki Building
2-38 Junkeicho-dori
Minami-ku, Osaka, Japan
Tel: (06) 262-3471

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Trading & Agricultural
Development Co.
P.O. Box 567
Amman, Jordan
Tel: 23052

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P.O. Box 30635
Nairobi, Kenya
Tel: 31955

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Nsouli Building
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Eugenia 408
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Mexico 12, D.F., Mexico
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y Representaciones
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Longueuil, P.Q. J4G 1A2
Tel. (514) 670-1212

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All of the above Fluke Sales Offices carry local stocks of low-cost Digital Multimeters (Models 8000A, 8030A, 8040A), Counters (Model 1900A), Digital Thermometers (Models

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Charlotte, NC (704) 394-4341
Memphis, TN (901) 323-8554
Nashville, TN (615) 889-8230
Orlando, FL (305) 843-6770
Mobile, AL (205) 479-5405

The Mancib Company
Boston, MA (617) 272-9450
Middletown, CT (203) 346-6646

Elmar Electronics
San Francisco, CA (415) 961-3611
Denver, CO (303) 287-9611

Pioneer-Standard
Cleveland, OH (216) 587-3600
Dayton, OH (513) 236-9900
Indianapolis, IN (317) 849-7300
Pittsburgh, PA (412) 782-2300
Detroit, MI (313) 525-1800

Liberty Electronics
El Segundo, CA (213) 822-8100
San Diego, CA (714) 565-9171
Phoenix, AZ (602) 257-1272
Seattle, WA (206) 763-8200
Albuquerque, NM (505) 299-8298
Beaverton, OR (503) 644-4783

Section 8
Schematic Diagrams

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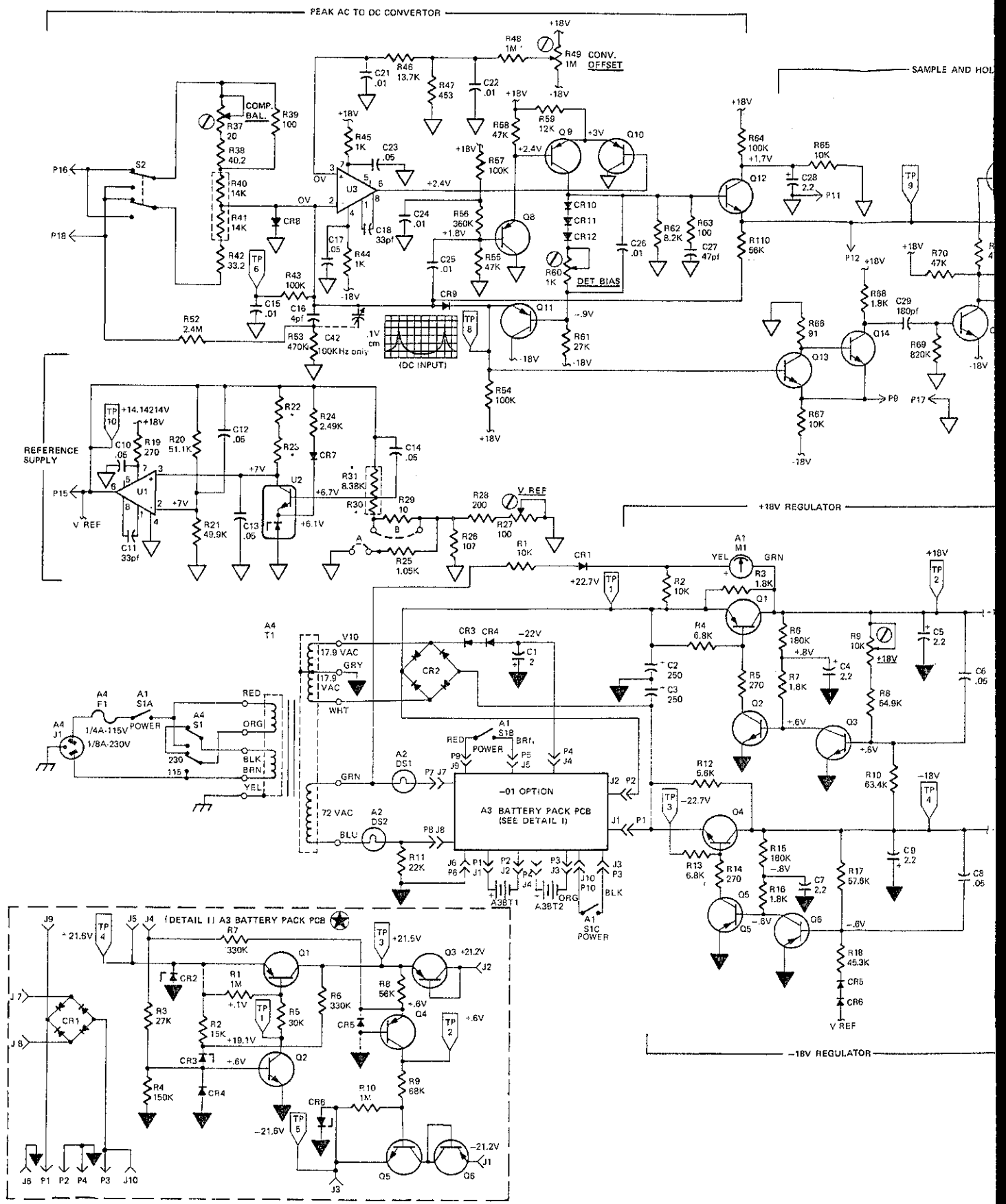
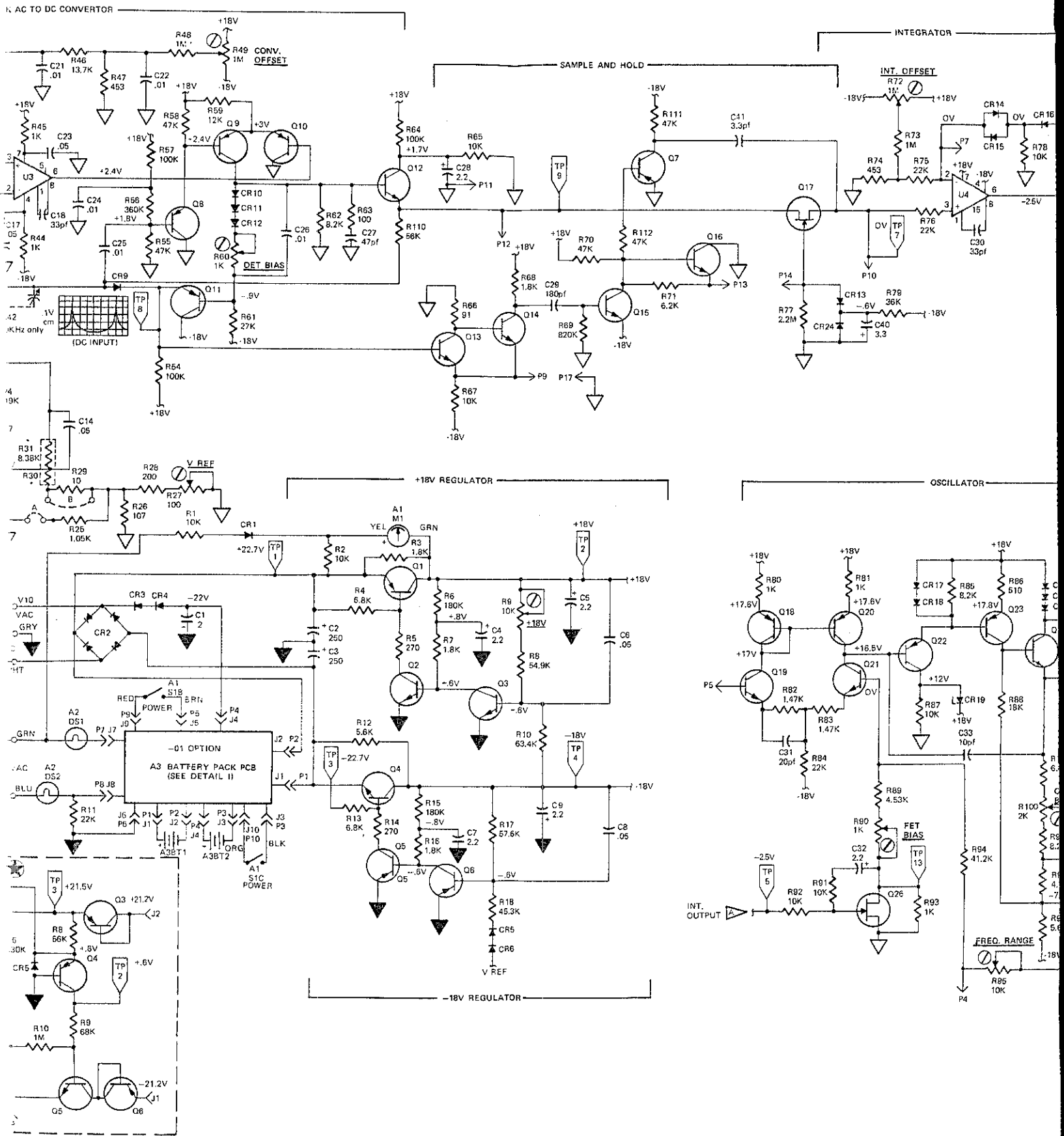


FIG. 8-1
SHT. 2 OF 3



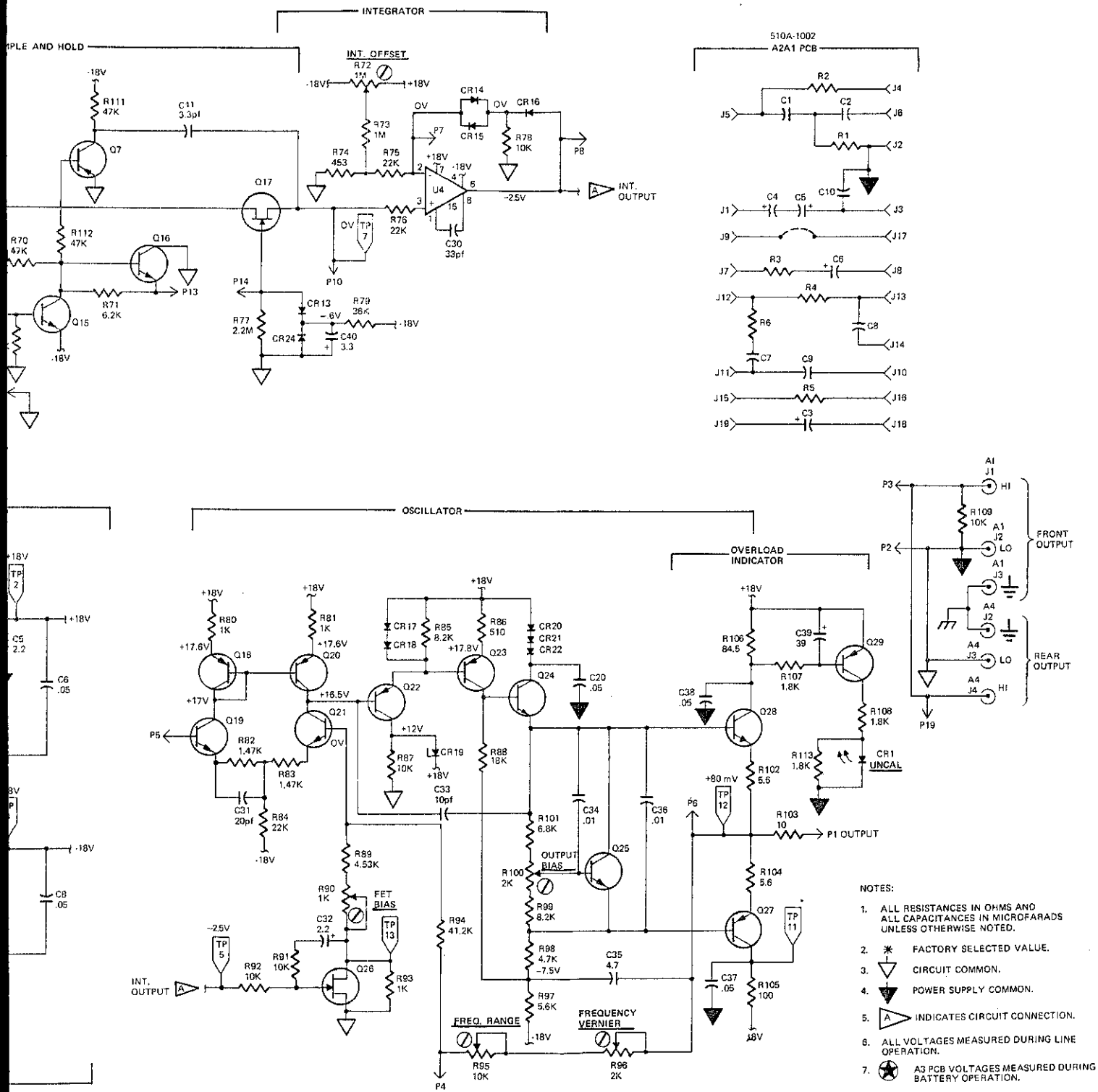


FIGURE 8-1. AC REFERENCE STANDARD (510A-1001/1002)