California Instruments

Revision J
December 1986

P/N 4053-960

INSTRUCTION MANUAL

MODEL 503T

Invertron®

NOTE:

ASSEMBLIES, SCHEMATICS AND PARTS LISTS MAY DIFFER FROM THIS MANUAL IF MODEL NUMBER HAS A 3 OR 4 DIGIT SUFFIX. SEE SERIAL NUMBER TAG FOR PROPER IDENTIFICATION.

EXAMPLE

3001TCA-PC-3888

MODEL NUMBER — 3001TCA

OPTIONS (IF APPLICABLE) — PC

4 DIGIT SUFFIX — 3888

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SPECIFICATIONS

CALIFORNIA INSTRUMENTS MODEL 503T THREE PHASE AC POWER SOURCE

All specifications are tested in accordance with standard California Instruments test procedures and apply with a stable, low distortion input signal as supplied from a California Instruments 800T series oscillator.

POWER OUTPUT: 500 VA three phase at 105 to 135 volts rms line-to-neutral from unity to ± 0.7 power factor. See derating chart for operation at other output voltages and/or power factor.

OUTPUT VOLTAGE RANGES: (Normally wired for a 0 to 135 volt line-to-neutral three phase output but may be wired for any of the following five ranges, if requested at the time of shipment)

0 to 30 volts rms line-to-neutral (0 to 52 volts rms line-to-line with three phase input).

0 to 45 volts rms line-to-neutral (0 to 78 volts rms line-to-line with three phase input).

0 to 75 volts rms line-to-neutral (0 to 130 volts rms line-to-line with three phase input).

0 to 135 volts rms line-to-neutral (0 to 234 volts rms line-to-line with three phase input).

0 to 135 volts rms single phase (500 VA single phase from 105 to 135 volts rms).

TOTAL HARMONIC DISTORTION: Less than 0.40% distortion from 200 Hz to 1 KHz; less than .75% distortion from 45 Hz to 10 KHz.

AMPLITUDE STABILITY: (after one hour warm-up) ± 0.25% for 24 hours at constant line, load and ambient temperature conditions.

PHASE ACCURACY: ± (1.0 degree plus phase accuracy of plug-in oscillator) between any two phases of a three phase system with a symmetrical load.

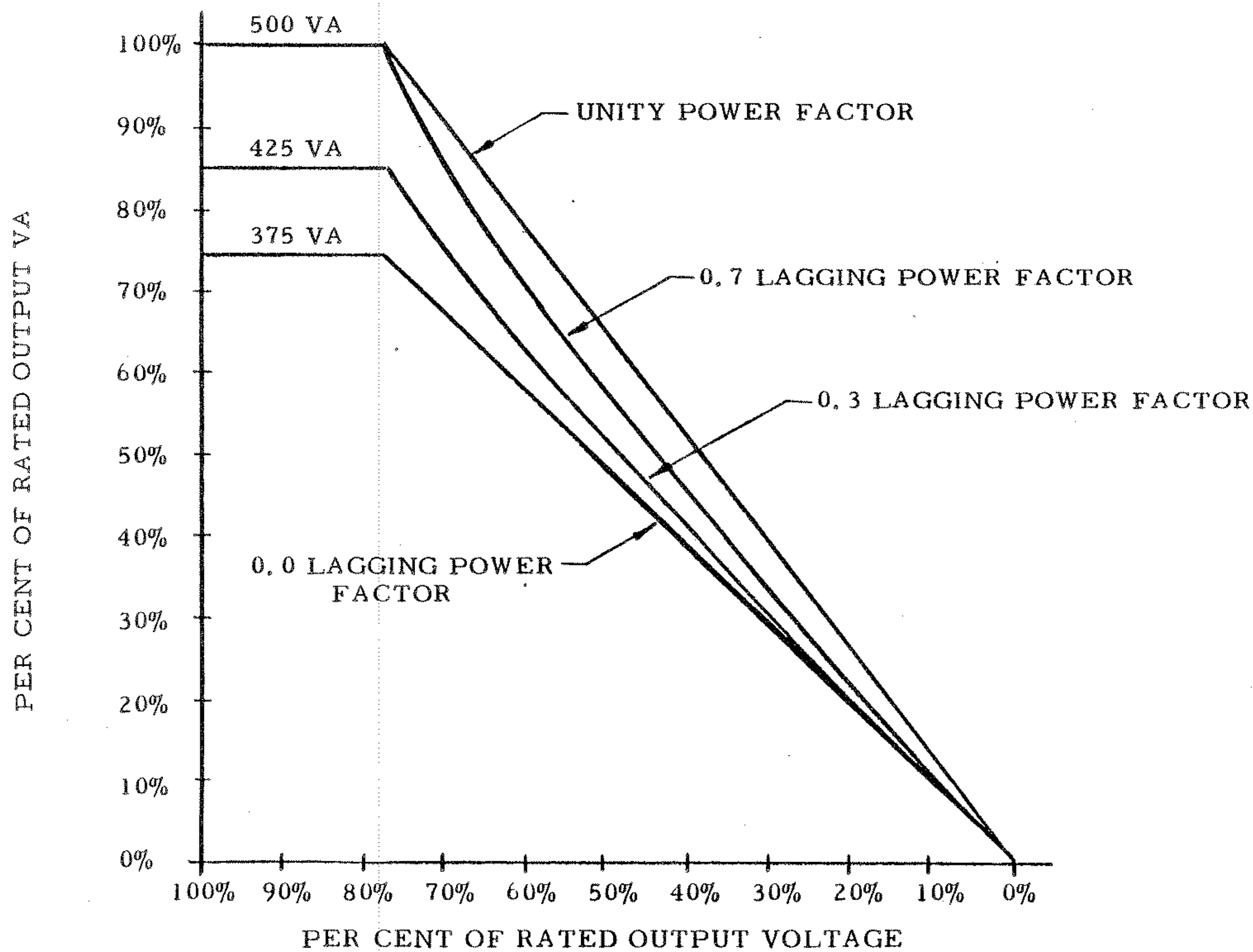
LOAD REGULATION: *	± 1% over the range from 45 Hz to 5 KHz and ± 2% over the range from 45 Hz to 10 KHz when tested at unity power factor. In addition, a load regulation adjustment permits the regulation to be adjusted to zero at any given line voltage, signal frequency and load conditions. Control resolution is 0.05%.
LINE REGULATION:	± 0.25% of full output for a ± 10% line change.
FULL POWER FREQUENCY RANGE: **	45 Hz to 5 KHz.
HALF POWER FREQUENCY RANGE:	5 KHz to 10 KHz.
FREQUENCY RESPONSE:	± 0.5 dB from 45 Hz to 5 KHz. ± 1.0 dB from 45 Hz to 10 KHz.
AC NOISE LEVEL:	60 dB below full output when tested at full rated power output; 80 dB below full output with shorted input.
OVERLOAD AND SHORT CIRCUIT PROTECTION:	Complete protection from overloads and short circuits is provided. Instantaneous automatic reset occurs when overload is removed.
AMPLIFIER DRIVE REQUIREMENTS: (Normally obtained from plug-in)	Multiphase 0 to 5 volt rms signal per phase produces full output voltage.
AC INPUT LINE:	105 to 125 volts rms. Unit may be wired for the following single phase voltages on special order: 208 VAC, 220 VAC, 230 VAC and 240 VAC.
AC INPUT FREQUENCY:	48 to 65 Hz. (400 Hz available on special order).
AC INPUT POWER:	2000 watts maximum under worst case line and full rated load conditions.
OPERATING TEMPERATURE RANGE:	0 to 55°C.

* Load regulation specification degrades slightly on the 30 volt and 45 volt ranges for operation above 2 KHz. See section 4.9.9 of the test procedure for load regulation on these ranges.

FRONT PANEL METER:	0 to 240 volt AC voltmeter provides ± 1% of full scale accuracy at 400 Hz and ± 3% of full scale accuracy over the range from 45 Hz to 10 KHz and may be switched to monitor any line-to-neutral or line-to-line voltage.
DIMENSIONS:	8 3/4" high x 19" wide x 21" deep.
NET WEIGHT:	110 lbs.
SHIPPING WEIGHT:	120 lbs.
FRONT PANEL FINISH:	Grey, 26440 per Federal Standard 595 with black silk-screened lettering.

** This power source may be used over the full 20 Hz to 20 KHz frequency range provided the output voltage and the output VA are derated according to Table 2-3 in this instruction manual; otherwise permanent damage to the unit may occur.

DERATING CHART FOR MODEL 503T THREE PHASE POWER SOURCE (Applies over the range from 45 Hz to 5 KHz. Derate the curve for output VA by 2.0 to 1.0 factor at 10 KHz; 3.0 to 1.0 factor at 15 KHz; and 4.0 to 1.0 factor at 20 KHz)



GENERAL DESCRIPTION

1.1 INTRODUCTION

This instruction manual contains information on the installation, operation, calibration and maintenance of the California Instruments Model 503T Three Phase Power Source. Detailed schematics, parts location drawings, calibration procedures and theory of operation are also contained for the aid of maintenance personnel.

1.2 GENERAL DESCRIPTION

The California Instruments Model 503T is a solid state, high performance, low distortion power source that provides up to 500 VA thr three phase power when used with the proper California Instruments oscillator. The Model 503T Three Phase Power Source is illustrated in Figure 1-1. Full power output is available in five different voltage ranges and over the frequency range from 45 Hz to 5 KHz. The output voltage range is normally determined at the factory prior to shipment of the unit, however it can be accomplished in the field, if required. The full power ranges are:

1) 23.4 to 30 volts rms line-to-neutral in a three phase output configuration. This provides 40.5 volts to 52 volts rms line-to-line at 167 VA per phase (500 VA total).

2) 35.1 to 45 volts rms line-to-neutral in a three phase output configuration. This provides 60.6 volts to 78 volts rms line-to-line at 167 VA per phase (500 VA total).

3) 58.5 to 75 volts rms line-to-neutral in a three phase output configuration. This provides 102 volts to 130 volts rms line-to-line at 167 VA per phase (500 VA total).

4) 105 to 135 volts rms line-to-neutral in a three phase output configuration. This provides 182 volts to 234 volts rms line-to-line at 167 VA per phase (500 VA total).

5) 105 to 135 volts rms single phase output at 500 VA.

The serial number tag, located on the rear of the Model 503T Power Source, indicates the output voltage range which the unit is wired for at the time of shipment.

Two of the three plug-in power amplifiers may be combined with the applicable plug-in oscillator to provide 334 VA of two phase power. In this case, the line-to-line voltage is 1.414 times the line-to-neutral voltage rather than 1.732 times the line-to-neutral voltage. Also each of the three 167 VA plug-in power amplifiers may be used independently of one another by removing the three jumper strips of the rear of the 12 pin connector and applying the desired input into each amplifier.

1.3 ACCESSORY EQUIPMENT

The following accessories are available for use with the California Instruments Model 503T Three-Phase Power Source.

1.3.1 Zero Mfg. Co. Model CTN-118 rack slides. These rack slides may be bolted directly to the sides of the unit, if required.

1.3.2 Model 4053-704 Extender Card. This card allows each of the amplifier printed circuit boards to be extended above the unit for service work.

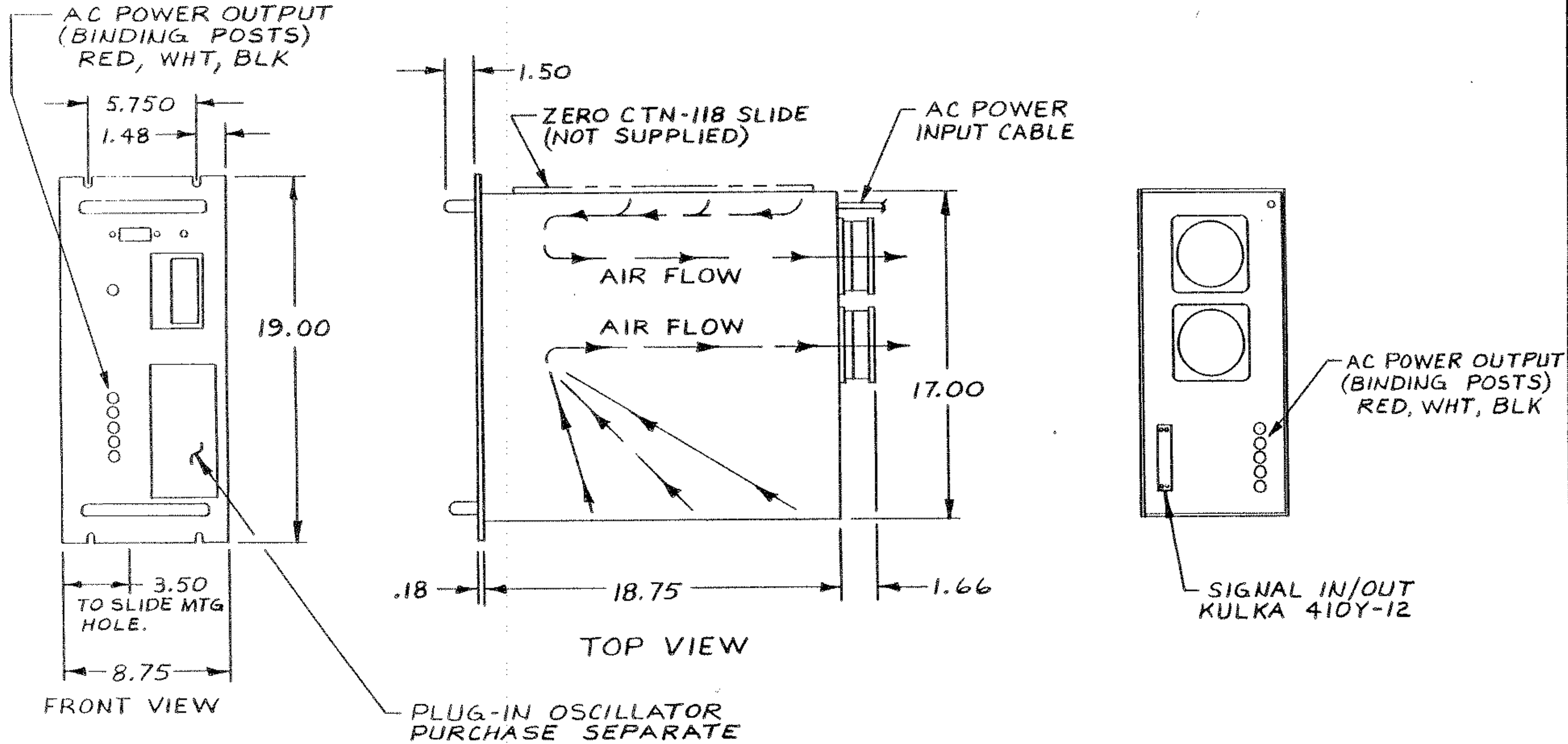
1.3.3 Series 800T Variable Frequency Oscillators. These general purpose Wien bridge oscillators provide one-phase, two-phase or three-phase outputs over the range from 20 Hz to 20 KHz in three bands. Units with single phase output are designated as 800T-20/20K-1-1ϕ; two-phase oscillators are designated as 800T-20/20K-1-2ϕ and three-phase oscillators are designated as 800T-1-3ϕ. Calibration accuracy is ±1 percent at 25°C and amplitude stability is 0.25 percent per 24 hours at 25°C. The total harmonic distortion is less than 0.25 percent from 20 Hz to 20 KHz. Several versions of the 800T Oscillator are also available which operate over a more restricted frequency range, but which provide improved frequency resolution.

1.3.4 Series 815T Fixed Frequency Oscillators. These low-cost fixed frequency oscillators provide one-phase, two-phase or three-phase outputs over the range from 45 Hz to 10 KHz. Units with single phase output are designated as 815T-Freq.-.1-1ϕ; two-phase oscillators are designated as 815T-Freq.-.1-2ϕ; and three-phase oscillators are designated as 815T-Freq.-.1-3ϕ. Frequency accuracy is ±0.1 percent at 25°C. Amplitude stability is ±.25 percent per 24 hours at 25°C and varies less than 0.02 percent per degrees centigrade. Harmonic distortion is less than 0.2 percent from 45 Hz to 10 KHz.

1.3.5 Series 835T Programmable Oscillators. These oscillators provide control of voltage amplitude, frequency, and phase angle in multiphase applications. Programming by either parallel BCD or IEEE-488 (1978) is available. These units are packaged in a separate 3.5 inch rack mountable chassis.

1.3.6 The Model 847T Programmable Oscillator is a digitally synthesized, crystal controlled oscillator featuring programmable amplitude and frequency via IEEE-488 BUS or BCD parallel. The 847T Oscillators are available in single-phase, two-phase 90°, three-phase 120° WYE, and three-phase 60° DELTA configurations.

1.3.7 Series 850T Oscillators. These oscillators are decade dialing, digitally synthesized, and crystal controlled. Basic accuracy is ±0.005% of set frequency. Amplitude stability is 0.02% per 24 hours 23°C, ±0.01% per C maximum average temperature coefficient from 0 to 55°C. The total harmonic distortion is less than 0.15 percent from 45 Hz to 999.9 Hz, less than 0.3 percent 45 Hz to 9999 Hz.



NOTES: (UNLESS OTHERWISE SPECIFIED)

1. FRONT PANEL DIMENSIONS PER W.E./E.I.A STD.

REVISIONS

REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD

REQD PER ASSY	ITEM NO.	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES.	ZONE

DIM IN INCHES TOLERANCES .XXX = .010 .XX = .03 X° = 30'

BREAK ALL SHARP CORNERS & EDGES MACH SURFACES ✓

DWG SIZE C

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TITLE: OUTLINE DRAWING 3 Ø 500 VA AMPLIFIER

MODEL 503T

RELEASE — CHECKER — PURCHASING
DESIGN: S. A. Dand 12/14/72 — PROJ ENGR
DRFTSMN: S. A. Dand 12/14/72 — CHF ENGR

DASH NO. | QTY REQD | NEXT ASSEMBLY | EFF ON | AUTH

CALIFORNIA INSTRUMENTS CORP. SAN DIEGO, CALIFORNIA

CONTRACT NO. — CODE IDENT 16067

DWG NO. C4053-900 REV /

SCALE 1/4 SHEET 1 OF 1

CALICO F-100

C4053-900 /

CAUTION

Voltages up to 250 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied. Avoid contact with pin C and pin D of the plug in oscillator, the primary power circuits, and the output circuits of the power source.

2.1 UNPACKING

The California Instruments Model 503T Power Source is shipped in a cardboard container with protective inner packing. Do not destroy the packing container until the unit has been inspected for possible damage in shipment.

2.2 POWER REQUIREMENTS

2.2.1 The Model 503T Three Phase Power Source has been designed to operate from any one of the following AC line voltages, 115 volts, 208 volts, 220 volts, 230 volts or 240 volts rms. The power transformer is normally wired at the factory for operation from the 115 volt line. Table 2-1 below indicates how the primary connections to the power transformer are made for various AC input line voltages.

TABLE 2-1

NOTE

Prior to reconnection power transformer T1, remove all existing jumpers from the primary winding.

Nominal Input Voltage	Operating Line Voltage Range	Power Transformer Connections	Front Panel Circuit Breaker Value
115 volts rms	105-125 volts rms	jumper pins 1 and 3; jumper pins 2 and 6; connect load side of circuit breaker to pin 6.	20 ampere
208 volts rms	190-226 volts rms	jumper pins 2 and 3; connect load side of circuit breaker to pin 4.	12 ampere
220 volts rms	201-239 volts rms	jumper pins 2 and 3; connect load side of circuit breaker to pin 5.	12 ampere
230 volts rms	210-250 volts rms	jumper pins 2 and 3; connect load side of circuit breaker to pin 6.	10 ampere
240 volts rms	219-261 volts rms	jumper pins 2 and 3; connect load side of circuit breaker to pin 7.	10 ampere

2.2.2 The Model 503T has been designed to operate over the line frequency range from 48 to 65 Hz. On special order, units will be supplied to operate from the 400 Hz line.

2.2.3 The normal input power, at rated output, is between 1200 and 2000 watts depending on line and load conditions. During "turn-on" the peak transient will generally exceed 3000 watts.

2.3 CIRCUIT BREAKER REQUIREMENTS

The Model 503T Power Source uses a 20 ampere Heinemann AM12-20A curve 5 circuit breaker for operation from the 115 volt AC line. A Heinemann AM12-12A curve 5 circuit breaker is used for operation from the 208 volt and 220 volt AC lines. A Heinemann AM12-10A curve 5 circuit breaker is used for operation from the 230 and 240 volt AC lines. Substitution of circuit breaker type or current rating may cause permanent damage to the unit.

2.4 OUTPUT VOLTAGE RANGE

The Model 503T Power Source is wired to provide a 105 volt to 135 volt line-to-neutral three phase output unless otherwise specified on the purchase order. If any of the other output voltage ranges, as listed in the SPECIFICATIONS, is desired, the secondary of all three output transformers must be rewired according to Table 2-2. The serial number tag, on the rear of unit, indicates the output voltage range of the power source at the time of shipment from the factory.

TABLE 2-2

NOTE

Prior to reconnection of output transformers T2, T3 and T4; remove all existing jumpers from the secondary windings. See Drawing 4053-072 for a schematic diagram.

Operating Output Voltage Range	Output Transformer Secondary Intra-Connections for T2, T3 and T4	Output Transformer Inner Connections to Output Power Terminals
23.4 to 30 volts rms line-to-neutral, three phase.	Jumper pins 5, 7, 9, 11 and 15 together; jumper pins 8 and 13; jumper pins 6, 10, 12, 14 and 16 together. Connect a 27 ohm 0.5 watt resistor from pin 5 to pin 17; connect .05 μfd 200 volt capacitor from pin 17 to pin 16.	Connect T2 pin 5 to J12; connect T3 pin 5 to J11; connect T4 pin 5 to J10; connect T2 pin 16 to J13; connect T3 pin 16 to J13; connect T4 pin 16 to J13.

TABLE 2-2 cont.

Operating Output Voltage Range	Output Transformer Secondary Intra-Connections for T2, T3 and T4	Output Transformer Inner Connections to Output Power Terminals
35 to 45 volts rms line-to-neutral, three phase.	Jumper pins 5, 8, 9, 11, 14 and 15 together; jumper pins 6, 10, 12 and 16 together; jumper pins 7 and 13. Connect a 62 ohm, 0.5 watt resistor from pin 13 to pin 17; connect a 0.022 μfd 200 volt capacitor from pin 16 to pin 17.	Connect T2 pin 7 to J12; connect T3 pin 7 to J11; connect T4 pin 7 to J10; connect T2 pin 16 to J13; connect T3 pin 16 to J13; connect T4 pin 16 to J13.
58.5 to 75 volts rms line-to-neutral, three phase.	Jumper pins 6 and 7; jumper pins 8 and 9; jumper pins 10 and 16; jumper pins 5 and 11; jumper pins 12 and 13; jumper pins 14 and 15. Connect a 180 ohm 0.5 watt resistor from pin 11 to pin 17; connect a 0.0082 μfd 400 volt capacitor from pin 16 to pin 17.	Connect T2 pin 5 to J12; connect T3 pin 5 to J11; connect T4 pin 5 to J10; connect T2 pin 16 to J13; connect T3 pin 16 to J13; connect T4 pin 16 to J13.
105 to 135 volts rms line-to-neutral, three phase.	Jumper pins 5, 8 and 14; jumper pins 6 and 9; jumper pins 10 and 11; jumper pins 12 and 15; jumper pins 7 and 13. Connect a 560 ohm 0.5 watt resistor from pin 7 to pin 17; connect a 0.0025 μfd 600 volt capacitor from pin 16 to pin 17.	Connect T2 pin 7 to J12; connect T3 pin 7 to J11; connect T4 pin 7 to J10; connect T2 pin 16 to J13; connect T3 pin 16 to J13; connect T4 pin 16 to J13.
105 to 135 volts rms, 500 VA single phase output.	Jumper pins 5, 8, 9, 11, 14 and 15 together; jumper pins 6, 10, 12 and 16 together; jumper pins 7 and 13. Connect a 62 ohm, 0.5 watt resistor from pin 13 to pin 17; connect a 0.022 μfd 200 volt capacitor from pin 16 to pin 17.	Connect T2 pin 7 to J12; connect T2 pin 16 to T3 pin 7; connect T3 pin 16 to T4 pin 7; connect T4 pin 16 to J13.

2.5 METER RANGE

The front panel voltmeter normally provides a full scale range of 240 volts AC. Other full scale ranges are available from the factory on special order.

2.6 ACCEPTANCE TEST PROCEDURE

Inspect the unit for any possible shipping damage immediately upon receipt. If damage is evident, notify the carrier. DO NOT return an instrument to the factory without prior approval. If the unit appears in good condition, perform the following:

2.6.1 Connect the AC line cord to an AC power line of the proper voltage and frequency as determined by either the serial number tag on the unit or by inspection of the wiring to the primary of the power transformer (see Section 2.2 of this instruction manual). Connect a 5 KW Variac and a 5 KW watt-meter in series with the AC line. The Model 503T Three Phase Power Source should draw less than 250 watts under no load conditions at mid-line voltage. If a problem is encountered, perform step 4.3.2 of the CALIBRATION PROCEDURE.

2.6.2 Using a California Instruments 800T Series Mutliphase Oscillator set the oscillator to the desired frequencv (between 45 Hz and 10 KHz) and adjust the amplitude of the oscillator fully counter clockwise to 0 volts. Tie a jumper strap from pin 2 to pin 3 of TB1, a second jumper from pin 4 to pin 5 of TB1, and a third jumper from pin 6 to pin 7 of TB1, if this has not been done at the factory.

2.6.3 Select the proper output voltage range as determined in Section 2.4 of this instruction manual. The following table lists the proper external load for full power output on each of the voltage ranges.

Output Voltage (line-to-neutral)	Full Power Load Resistance (line-to-neutral)	50 per cent Power Load Resistance (line-to-neutral)
30 volts rms, 3ϕ	5.4 ohms	10.8 ohms
45 volts rms, 3ϕ	12.12 ohms	24.24 ohms
75 volts rms, 3ϕ	33.6 ohms	67.2 ohms
135 volts rms, 3ϕ	109 ohms	218 ohms
135 volts 500 VA single phase	36.4 ohms	72.8 ohms

2.6.4 Connect a proper value 167 watt load resistor to each of the red binding posts on the rear of the power source, if the power source is internally connected for use with a three phase load. Connect the other end of each of the three load resistors to the white binding post on the rear of the power source. Connect a Tektronix Model 533A Oscilloscope or equivalent across each of these three load resistors in turn.

If the unit is connected for a 500 VA single phase output, connect a 500 VA load across the phase A output binding post (J12) and the white binding post (J13) on the rear of the power source. Connect the oscilloscope across the load resistor.

2.6.5 Using the AMPLITUDE control on the three phase oscillator, set the output voltage to the rated voltage of the unit as determined in Section 2.6.3 of this manual. The power line wattmeter should read 1200 to 1600 watts at mid-line. Check on the oscilloscope for peak clipping or excessive distortion of the sine wave output.

2.6.6 With the output still adjusted as determined in 2.6.5, place a resistor in parallel with each of the three external load resistors to provide a 50 per cent overload on the output of the power source. The value of these resistors is given in Section 2.6.3 of this manual. The signal on the oscilloscope should exhibit significant clipping on both the positive and negative peaks.

2.6.7 Remove the 50 per cent overload resistor and the output should automatically return to normal.

2.6.8. Place a short circuit in parallel with one of the external load resistors. The signal on the oscilloscope should go to zero. When the short circuit is removed, the output should automatically return to normal. Repeat for the other two phases of the output. Do not leave the short circuit across the output for greater than 10 seconds. If all three phases are shorted simultaneously, the front panel circuit breaker may be activated.

2.6.9 The CALIBRATION PROCEDURE given in Section 4.0 of this manual should be followed if a more detailed evaluation of the unit is required at this time.

2.7 MECHANICAL INSTALLATION

The Model 503T Three Phase Power Source has been designed for rack mounting in a standard 19 inch rack. The unit should be supported from the bottom with a shelf-track or supported from the sides with a pair of rack slides (Zero Mfg. Co. P/N CTN-118).

The cooling fan on the rear of the unit must be free of any obstructions which would interfere with the flow of air. A 2.5 inch clearance should be maintained between the rear of the fans and the rear door of the mounting cabinet. Also, the air intake holes on the sides and rear of the power source must not be obstructed.

2.8 INPUT POWER WIRING

The Model 503T Power Source will operate from single phase input voltages from 105 volts to 260 volts rms in five ranges as described in Section 2.2 of this manual. The power source should be used with 115 volt power lines with a capacity of 20 amperes or greater. If 200 to 260 volt AC lines are used, their capacity should be 10 amperes or greater.

2.9 OUTPUT POWER WIRING

The power output wires should be large enough to avoid excessive line voltage drops. The internal regulation controls are capable of providing greater than 2 per cent over-regulation for normal load conditions. If it is desired to provide a zero output impedance at the load side of the power wiring, it is necessary that these line drops be limited to approximately 1 to 2 per cent of the required output voltage. The following table lists the minimum acceptable wire size for a 1.0 per cent line drop assuming a 500 VA three phase symmetrical load at a distance of 20 feet from the power source to the load.

L-N Output Voltage	Maximum Line Drop	Line Current	Effective Loop Length	Minimum Required Wire Size
26 volts, 3φ	.26 volts	6.43 amperes	20 ft.	#13
40 volts, 3φ	.40 volts	4.18 amperes	20 ft.	#16
70 volts, 3φ	.70 volts	2.38 amperes	20 ft.	#21
115 volts, 3φ	1.15 volts	1.45 amperes	20 ft.	#26
115 volts, 1φ	1.15 volts	4.35 amperes	40 ft.	#18

The wire size should be reduced 3 sizes every time that the distance between the power source and load is doubled.

2.10 FRONT PANEL CONTROLS

2.10.1 The circuit breaker, located on the front panel of the Model 503T Power Source, is used to switch the POWER to the unit "ON". At this time the amber indicator lamp located above this circuit breaker should glow.

2.10.2 The six-position METER switch is used to select which of the three line-to-neutral or three line-to-line voltages is to be monitored by the front panel meter.

2.11 OPERATION OVER EXTENDED FREQUENCY RANGE

2.11.1 This power source must not be driven at signal frequencies below 20 Hz or above 20 KHz, otherwise permanent damage to the unit may occur. For operation in the region between 20 Hz and 45 Hz and between 5 KHz and 20 KHz, derate the output voltage and output power according to Table 2-2 in order to provide reliable operation of the power source.

TABLE 2-2

Output Frequency	Maximum Safe Sine Wave Output Voltage (rms)				Maximum VA Output per Phase at Maximum Safe Output Voltage with ±0.7 Power Factor Load
	30V L-N Range	45V L-N Range	75V L-N Range	135V L-N Range	
20 Hz	13.3V L-N	20V L-N	33V L-N	60V L-N	82VA Per Phase
30 Hz	20.0V L-N	30V L-N	50V L-N	90V L-N	128VA Per Phase
40 Hz	26.7V L-N	40V L-N	67V L-N	120V L-N	167VA Per Phase
45 Hz to 5 KHz	30.0V L-N	45V L-N	75V L-N	135V L-N	167VA Per Phase
10 KHz	30.0V L-N	45V L-N	75V L-N	135V L-N	83VA Per Phase
15 KHz	20V L-N	30V L-N	50V L-N	90V L-N	43VA Per Phase
20 KHz	15.0V L-N	22V L-N	37V L-N	67V L-N	24VA Per Phase

THEORY OF OPERATION

3.1 GENERAL

The California Instruments 503T Three Phase Power Source consists of three identical 167 VA power amplifiers and with companion oscillator, is designed to provide reliable sine wave AC power over the frequency range from 45 Hz to 10 KHz.

A block diagram for this three phase power source is shown in Figure 3-1. The phase "B" and "C" amplifiers are identical to the phase "A" amplifier and are shown as dotted boxes in Figure 3-1. The pre-amplifier A1G1 is used to amplify the input signal to such a level so as to supply adequate drive to the power amplifier A1G2.

The power amplifier A1G2 provides the necessary sine wave signal to drive the output transformer T2. The output transformer has floating secondary windings which allow the load to float from the amplifier and oscillator circuitry.

The power amplifier A1G2 contains the overload and short circuit protection circuitry. A local negative feedback loop is taken from the output of the power amplifier back to the pre-amplifier, A1G1.

The overall negative feedback is taken from the feedback winding of the output transformer back to the negative input of the pre-amplifier and provides a closed loop gain of 20 from the high side of A1R2 to the primary of T2.

The positive feedback signal is generated by sensing the IR drop across the primary of T2 and applying this signal to transformer A1T1. Transformer A1T1 converts this differential signal into a single ended signal and applies it to the input of the pre-amplifier through a divider network containing the regulation control A1R7. As this positive feedback is increased from zero with potentiometer A1R7, the output impedance of the power source is reduced toward zero.

The multiple secondary of transformers T2, T3 and T4 are wired according to Table 2-2 to provide either 30 volts, 45 volts, 75 volts, 135 volts output from line-to-neutral, or 135 volts 500 VA single phase output.

Power transformer T1, along with the associated rectifiers and filters, supply the operating voltages for the plug-in oscillator, and all three power amplifiers.

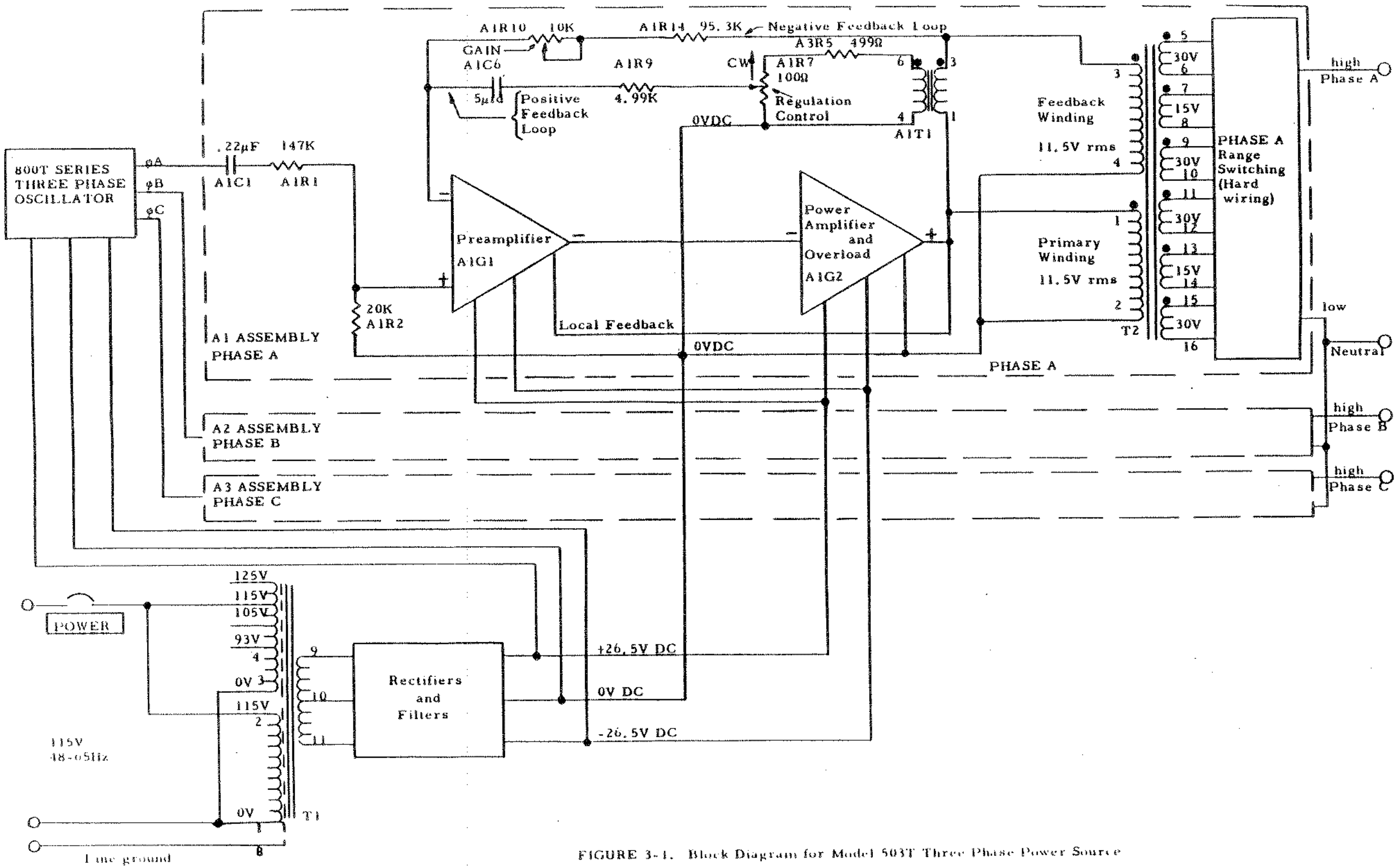


FIGURE 3-1. Block Diagram for Model 503T Three Phase Power Source

3.2 DETAILED CIRCUIT DESCRIPTION

A schematic diagram for the Model 503T Three Phase Power Source is shown in drawing E4053-070 with the exception that the circuitry contained on the pre-amplifier and power amplifier circuit boards (assembly A1, A2, A3), the output transformer secondary innerconnections, and the plug-in oscillator. A schematic for the amplifier circuit board is given in drawing D4053-071 and a schematic for the output transformer innerconnections is shown in drawing C4053-072. For information on the plug-in oscillator, consult the applicable oscillator manual. These drawings give typical voltage levels and waveforms for the various sections of the power source.

3.2.1 PRE-AMPLIFIER

The phase "A", phase "B" and phase "C" pre-amplifiers are identical. Therefore, it is only necessary to describe the operation of one of these pre-amplifiers. The phase "A" pre-amplifier is described below:

The pre-amplifier A1G1 is a part of the A1 assembly and consists of transistors A1Q1 through A1Q6 and associated components connected as a direct coupled differential amplifier. The open loop gain of this pre-amplifier is approximately 30 at 400 Hz and rolls off at 6 dB per octave above 30 KHz.

Transistor A1Q1 is a dual field effect transistor used in the differential source follower configuration to provide a high input impedance and a gain of approximately 1.0. Potentiometer A1R12 is used to adjust the DC bias at the primary of T2 to zero volts with no signal.

Transistor A1Q2 is a dual transistor used in a differential configuration and provides a gain of approximately 15 at 400 Hz. Capacitor A1C7 and resistor A1R20 provide a high frequency step roll off from 30 KHz to 300 KHz.

Transistor A1Q3 and associated components are connected as a constant current source which provides the emitter current for A1Q2. This current source is designed to sink 2 milliamperes from the junction of A1R16 and A1R17 to the -15.5 volt power supply.

Transistors A1Q4, A1Q5 are used in the differential amplifier configuration and provide an open loop gain of 2 at 400 Hz.

Transistor A1Q6 and associated components are connected as a constant current source which provides 8 milliamperes to the junction of A1R24 and A1R25.

3.2.2 POWER AMPLIFIER

The phase "A", phase "B" and phase "C" power amplifiers are identical. Therefore, it is only necessary to describe the operation of one of these power amplifiers. The phase "A" power amplifier is described below:

The power amplifier G2 mechanically consists of the remainder of the A1 board including the large heatsinks and the output transformer T2 mounted to the chassis. Electrically, the power amplifier consists of transistors A1Q7 through A1Q16 and associated components.

Transistor A1O7 and associated components are connected as a constant current source which provides 50 milliamperes to bias the output stage by means of diodes A1CR4 and A1CR5. This allows the output stage to operate as a Class A amplifier for no load or low VA load conditions and to operate nearly as a Class B amplifier for large load conditions.

Transistor A1Q8 and associated components are connected in the grounded emitter configuration. Local negative feedback is provided by A1C8, A1C9, A1C12, A1R27, A1R38 and A1R39. The local feedback limits the gain of this stage to 24 at 400 Hz and causes the gain to fall off at 6 dB per octave above 40 KHz.

The positive polarity output amplifier consists of A1Q9, A1O11, A1Q13 and A3Q15 connected as emitter followers. These transistors supply a total of 28 amperes peak during the positive one-half cycle of the output waveform when the phase "A" output is loaded to 167 VA output at 78 per cent of rated output voltage (worst case condition within specification limits). These positive output amplifier transistors and their associated heatsink can dissipate over 200 watts with less than a 40°C case temperature rise with an air flow of 30 cfm per heatsink.

The negative polarity output amplifier consists of A1Q10, A1Q12, A1Q14 and A1Q16 connected in the quasi complementary symmetry configuration. These transistors supply a total of 28 amperes peak during the negative one-half cycle of the output waveform when the power source is loaded to 167 VA output at 78 per cent of rated output voltage (worst case condition within specification limits). These negative output amplifier transistors and their associated heatsinks can dissipate over 200 watts with less than a 40°C case temperature rise with an air flow of 30 cfm per heatsink.

When the power source is delivering its full rated output voltage, the primary of the output transformer has an 11.5 volt rms signal.

The rated VA output of the power source is, to a large extent, determined by the power dissipation in the quasi complementary symmetry output stage. This power dissipation is determined by the power factor of the load, the output VA level of the amplifier, and to the actual output voltage expressed as a percentage of the rated output voltage. The derating chart, given in the specifications, expresses this derating in a graphical form.

3.2.3 OVERLOAD PROTECTION

The overload protection circuitry is also shown in drawing D4053-071 and consist of zener diode A1CR6, diode A1CR4, A1CR5 and emitter resistors A1R46, A1R48, A1R50, A1R43, and A1R44.

Diode A1CR6 is used in the zener mode to limit the positive voltage drive to the positive polarity output amplifier during periods of overload or short circuit. This, in turn, limits the output current of the positive polarity output amplifier as determined by the value of emitter resistors A1R46, A1R48 and A1R50.

Diodes A1CR6 and A1CR5 are used in the normal forward biased mode to limit the negative voltage drive to A1Q10 during periods of overload or short circuit. This, in turn, limits the collector current available from A1Q10 as determined by the value of emitter resistors A1R43 and A1R44. Since the base drive to A1Q12, A1Q14 and A1Q16 is limited, the corresponding collector current from A1Q12, A1Q14 and A1Q16 will also be limited. Resistor A1R44 is selected to provide symmetrical limiting for both the positive and the negative polarity output amplifiers.

In the region between 78 per cent of rated output voltage and 100 per cent of rated output voltage, the rated VA output of the power source is limited by an arbitrary rating and as a result, the overload circuit allows a somewhat greater power output than that specified for the power source. The unit will be reliable in this mode of operation, however, output distortion and/or other specifications may be somewhat excessive.

3.2.4 OVERALL NEGATIVE FEEDBACK

The overall negative feedback loop is a single-ended potentiometric feedback loop taken from the negative feedback winding of T2 to the gate of A1Q1B. The feedback network consists of A1R6, A1R9, A1R10, A1R14, A1C5, and A1C6 and limits the mid band closed loop voltage gain of the amplifier to 20 from the gate of A1Q1A to the primary of T2.

The overall feedback loop provides approximately 30 dB of negative feedback over the range from 45 Hz to 20 KHz. The feedback rolls off at approximately 9 dB per octave for frequencies greater than 20 KHz. The purpose of this feedback loop is to insure that the frequency response, distortion, gain and amplitude stability specifications are met and/or exceeded.

A low frequency negative feedback loop is taken from the power primary winding of T2 back to the gate of A1Q1B through A1R3 and A1R5. This loop limits the closed loop gain of the amplifier to approximately 1.5 at DC and thereby provides improved DC bias stability for the amplifier.

3.2.5 POSITIVE CURRENT FEEDBACK

The positive current feedback loop generates a positive feedback voltage proportional to the load current in the secondary of T2. This is accomplished in the following fashion:

The load current in the secondary of the output transformer T2 is reflected back into the power primary winding producing an IR drop across the power primary winding. The negative feedback winding is connected so as to buck out the $L\frac{di}{dt}$ drop in the power primary winding. The remaining differential signal is applied to the primary of transformer A1T1 and converted into a single-ended signal at the secondary of A1T1. This signal is then applied to the gate of A1Q1B through a divider network consisting of A1R4, A1R7, A1R8, A1R9, A1C4 and A1C6. Potentiometer A1R7, which is accessible from the top of the A1 printed circuit board, is used to adjust the amount of positive feedback and thereby adjust the output impedance of the power source.

3.2.6 POWER SUPPLY

A schematic diagram for the DC power supply is a part of drawing E4053-070. This power supply delivers ± 26.5 volts ± 5 per cent at 27 amperes DC with less than 3 volts peak-to-peak ripple from the 115 volt 60 Hz AC line. These unregulated supplies consist of rectifier diodes A4CR1 through A4CR4 and filter capacitors C1, C2, C3 and C4 connected in a conventional fashion.

3.2.7 FRONT PANEL METER

The front panel meter M1 has a full sensitivity of 0 to 1 milliampere DC and an internal resistance of approximately 100 ohms. The meter has a single scale with a full scale range of 240 volts AC. The meter rectifiers and scaling circuitry are mounted on the meter switch board, assembly A6.

The meter circuitry is also shown in drawing 4053-070. This circuitry consists of rectifier diodes A6CR1 through A6CR4, potentiometer A6R3 and associated components. The four rectifier diodes are connected so as to form a full wave bridge rectifier. Potentiometer A6R3 is used to shunt a small portion of the meter current and provide a full scale sensitivity adjustment.

The six-position rotary switch S1 on the front panel of the Model 503T Three Phase Power Source is used to switch the voltmeter so that it can be used to monitor any of the three line-to-line or three line-to-neutral voltages.

3.2.8 OUTPUT VOLTAGE RANGE

The multiple secondary windings of output transformer T2 are interconnected in various fashions depending on the desired output voltage range. Table 3-1 illustrates this interconnection from a conceptual view-point.

TABLE 3-1

Output Voltage Range (Line-to-Neutral)	Description of Interconnection
0 to 30 volts rms	The four 30 volt windings are connected in parallel. The two 15 volt windings are connected in series. These two groups are then connected in parallel to provide the 30 volt output.
0 to 45 volts rms	The four 30 volt windings are connected in parallel. The two 15 volt windings are connected in parallel. These two groups are then connected in series to provide the 45 volt output.
0 to 75 volts rms	The six secondary windings are split into two groups of two 30 volt and one 15 volt winding. The three windings in each group are connected in series. The two groups are then connected in parallel to provide the 75 volt output.
0 to 135 volts rms	All four 30 volt windings are connected in series. The two 15 volt windings are connected in parallel. These two groups are then connected in series to provide 135 volts output.

CAUTION

Voltages up to 250 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied. Avoid contact with pin C and pin D of the plug in oscillator, the primary power circuits, and the output circuits of the power source.

CALIBRATION PROCEDURE

4.1 GENERAL

The following calibration procedure, or any part of it, may be performed on a routine basis to insure that the Model 503T Three Phase Power Source remains within specified tolerances. This procedure should always be performed after any repairs have been made to the unit. Figure 4-2 shows the location of internal test points and adjustment potentiometers. This procedure also covers test methods for the following power source adjustments and specifications:

a) Initial Adjustments

b) Overload Adjustment

c) Gain Adjustment

d) AC Line Input Power

e) Output Voltage, Power Output, and Harmonic Distortion

f) Line Regulation

g) Load Regulation Adjustment

h) Amplitude Stability

i) Frequency Response

j) AC Noise Level

k) 0.7 Lagging Power Factor

l) 0.7 Leading Power Factor

m) Phase Accuracy

This calibration procedure assumes that the power source will be operated from the 115 volt 47 to 65 Hz AC line. For higher values of AC line voltage, a 240 volt variac and a 240 volt wattmeter must be substituted for those called out in this procedure. Consult Section 2.2.1 of this instruction manual for operation from other than the 115 volt AC line.

This calibration procedure further assumes that the power source is tested on the 0 to 135 volt L-N range. Performance is very similar on the other four ranges. Table 4-1 illustrates the change in measurement voltage and impedance level when evaluating the power source on various output voltage ranges.

TABLE 4-1

Rated Three Phase Line-to-Neutral Output Voltage	135 volts L-N	75 volts L-N	45 volts L-N	30 volts L-N	135 volts 500 VA Single Phase Output
78% of Three Phase Line-to-Neutral Output Voltage	105 volts	58.5 volts	35.1 volts	23.4 volts	105 volts
Line-to-Neutral Resistive Load for 167 VA Output (at 100% of rated Line-to-Neutral Output Voltage)	109Ω	33.7Ω	12.12Ω	5.39Ω	500 VA, 1φ 36.4Ω
Line-to-Neutral Resistive Load for 167 VA Output (at 78% of rated Line-to-Neutral Voltage)	66Ω	20.44Ω	7.38Ω	3.28Ω	500VA, 1φ 22.1Ω
Line-to-Neutral one-half power load for 83.5 VA output (at 78% of rated Line-to-Neutral Voltage)	132Ω	40.88Ω	14.76Ω	6.56Ω	250 VA, 1φ 44.2Ω

Section 2.4 of this instruction manual indicates the procedure required to change output voltage ranges and Section 2.9 indicates some potential problems associated with output wiring IR drop on the low voltage ranges. When checking load regulation and amplitude stability, care should be taken to use a four-wire connection such that the external load and the measurement equipment have completely separate wiring from the large binding posts at the rear of the power source.

4.2 TEST EQUIPMENT REQUIRED

The following test equipment is required to perform the calibration procedure assuming that the input line voltage has a nominal value of 115 volts rms and that the power source is tested on the 0 to 135 volt L-N range. Some equipment substitutions will be required if this is not the case.

a) Oscilloscope, Tektronix 533A with "W" plug-in.

b) 5.0 KVA Variac, General Radio W50M or equivalent.

c) 5.0 KVA Wattmeter, Simpson Electric or equivalent.

d) Distortion Analyser, H. P. 330B or equivalent.

e) Differential Voltmeter, Fluke 883A or equivalent.

f) Multi-range 167 watt load box, or individual 167 watt power resistors, as defined in Table 4-1. Dale type NHL or equivalent.

g) Expanded Scale (about 115 VAC) strip chart recorder, Voltron Model 89.038 or equivalent.

h) Multimeter, Simpson 260 or equivalent.

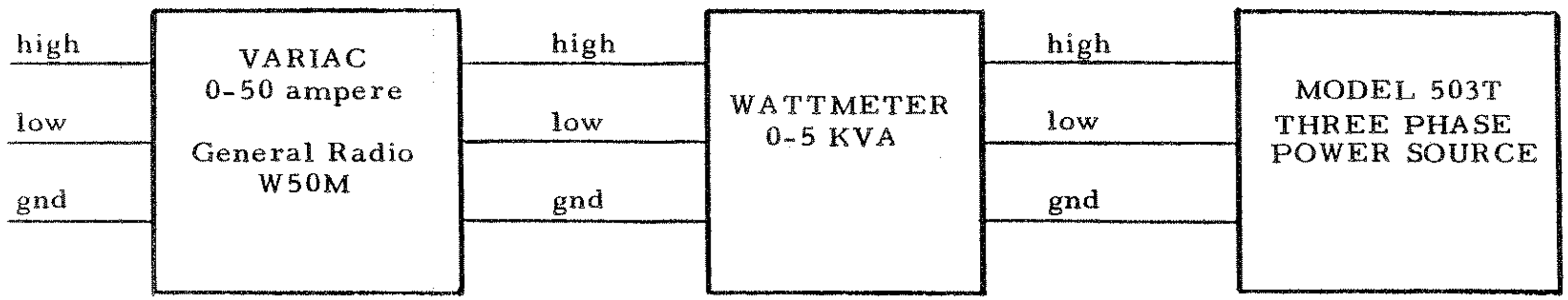
i) Phase Meter, Dranetz Model 301 or equivalent.

4.3 INITIAL ADJUSTMENTS

4.3.1 Connect the Model 503T Three Phase Power Source as shown in Figure 4-1. Turn the AMPLITUDE control on the associated multiphase oscillator fully counter clockwise. Adjust the line voltage to its nominal value with the variac. Turn the POWER switch "on". The wattmeter should indicate 250 watts or less at nominal line voltage. If a problem is encountered, perform step 4.3.2 below.

4.3.2 Remove the top cover from the unit and connect the differential voltmeter between test points A1TP1 and A1TP2. Adjust potentiometer A1R12 so that the DC voltage across the output of the phase "A" power amplifier is 0.00 volts ± 5 millivolts. Repeat this procedure except adjust the DC component in the phase "B" and phase "C" outputs to less than ± 5 millivolts with potentiometers A2R12 and A3R12, respectively.

4.3.3 Rotate the six-position METER switch so as to monitor the output voltage from phase "A" to phase "B". Connect the differential voltmeter and oscilloscope between the phase "A" output and the phase "B" output at the rear of the unit. Adjust the AMPLITUDE control on the associated three phase oscillator for a 240 volt L-L sinusoidal output at 400 Hz as indicated by the differential voltmeter. Adjust potentiometer A6R3 so that the front panel meter and the differential voltmeter correlate within one per cent.



See Table 2-1 for AC line input wiring to the Model 503T Power Source. Unit is normally wired for 105 to 125 volt AC line operation.

FIGURE 4-1. Test set up for initial adjustments of Model 503T Three Phase Power Source.

Vary the frequency from 45 Hz to 10 KHz and check that the front panel meter reads within ± 3 per cent of the correct value. If this step can not be performed due to inadequate output from the power source, proceed to 4.3.4 below.

4.3.4 If the power source has been such wired to an output voltage range so as not to be able to deliver a 240 volt L-L sinusoidal output, calibrate the front panel meter with the differential voltmeter as near to full scale as practical.

4.4 OVERLOAD ADJUSTMENT

4.4.1 Connect the Model 503T Three Phase Power Source as shown in Figure 4-3. Select the 135 volt L-N range according to the procedure given in section 2.4 of this instruction manual. Monitor the phase "A" to neutral output of the power source with the differential voltmeter, the distortion analyser, and the oscilloscope. Adjust the AMPLITUDE control on the associated three phase oscillator to provide a line-to-neutral output of 105 volts (78 per cent of rated output voltage) at 400 Hz. Close switch S2 (66 ohm load from line-to-neutral) and readjust the output voltage slightly, if required, in order to maintain a 105 volt output. The power source should deliver a clean sine wave output with less than 0.40 per cent distortion. Vary the frequency from 45 Hz to 5 KHz and check that the distortion does not exceed 0.75 per cent over the AC input line voltage range of 105-125 volts while maintaining the output voltage at 105 volts rms. Select zener diode A1CR6 so that no clipping or excessive distortion occurs on the positive peak of the output waveform under worst case conditions outlined above. Select resistor A1R44 so that no clipping or excessive distortion occurs on the negative peak of the output waveform under worst case conditions outlined above.

4.4.2 Adjust the AMPLITUDE control on the three phase oscillator to provide a line-to-neutral output of 105 volts at 400 Hz. Connect a short circuit across the phase "A" output-to-neutral for a few seconds. When the short circuit is removed, the line-to-neutral output voltage should immediately return to its previous value.

4.4.3 Repeat step 4.4.1 except monitor the phase "B" to neutral output of the power source with the differential voltmeter, the distortion analyser, and the oscilloscope. Select A2CR6 and A2R44 so that no excessive distortion occurs on the positive and negative peaks respectively of the output waveform under worst case conditions as outlined in step 4.4.1. Repeat step 4.4.2 except connect the short circuit from the phase "B" output-to-neutral.

4.4.4 Repeat step 4.4.1 except monitor the phase "C" to neutral output of the power source with the differential voltmeter, the distortion analyser, and the oscilloscope. Select A3CR6 and A3R44 so that no clipping or excessive distortion occurs on the positive and negative peaks respectively of the output waveform under worst case conditions as outlined in step 4.4.1. Repeat step 4.4.2 except connect the short circuit from the phase "C" output-to-neutral.

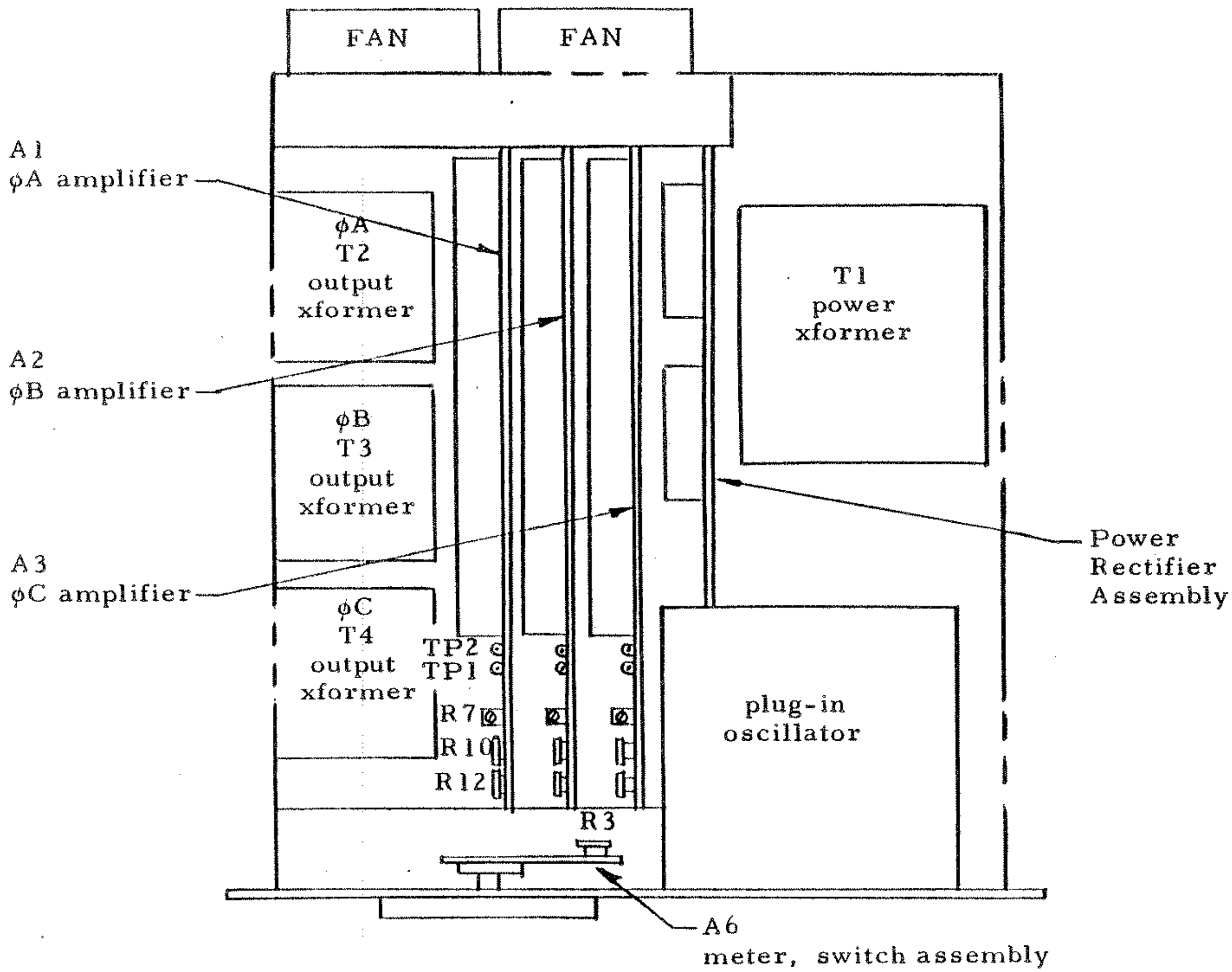


FIGURE 4-2. Internal Adjustments for Model 503T Three Phase Power Source.

4.4.5 This procedure may be performed for any of the other output voltage ranges, rather than the 0 to 135 volt line-to-neutral range, if desired. In this case, the load impedance and output voltage levels should be taken from those given in Table 4-1.

4.5 GAIN ADJUSTMENT

4.5.1 Connect the Model 503T Three Phase Power Source as shown in Figure 4-3. Adjust the AMPLITUDE control on the associated three phase oscillator to provide a phase "A" line-to-neutral output voltage of 135 volts (100 per cent of rated value) at 400 Hz with switch S1 and S2 both open so that there is no load on the output of the power source.

4.5.2 Adjust potentiometers A1R10, A2R10, and A3R10 so that all three line-to-neutral output voltages are exactly equal to each other. Vary the oscillator frequency from 45 Hz to 10 KHz and check that the line-to-neutral output voltages from all three phases remain within 3 per cent of each other.

4.5.3 This procedure may be performed for any of the other output voltage ranges, rather than the 0 to 135 volt line-to-neutral range, if desired.

4.6 AC LINE INPUT POWER

4.6.1 Connect the Model 503T Three Phase Power Source as shown in Figure 4-3. Select the 135 volt L-N range according to the procedure given in section 2.4 of this instruction manual.

4.6.2 Adjust the AMPLITUDE control on the associated three phase oscillator to provide an output of 105 volts line-to-neutral at 400 Hz with switch S2 closed so as to apply full load to the output of the power source. With the AC input line voltage adjusted to its maximum value (normally 125 volts AC), the AC line wattmeter should indicate less than 2000 watts.

4.6.3 Repeat step 4.6.2 except open switch S2 so that there is no load on the output of the power source. The AC line wattmeter should indicate less than 350 watts with a line voltage of 125 volts AC.

4.6.4 This procedure may be performed for any of the other output voltage ranges, rather than the 135 volt L-N range, if desired. In this case, the load impedance and output voltage levels should be taken from those given in Table 4-1.

4.7 OUTPUT VOLTAGE, POWER OUTPUT and HARMONIC DISTORTION

4.7.1 Connect the Model 503T Three Phase Power Source as shown in Figure 4-3. Select the 135 volt L-N range according to the procedure given in section 2.4 of this instruction manual. Adjust the variac to provide a 115 VAC line input and allow the power source to warm up for a few minutes. Set the oscillator output to 400 Hz and adjust the AMPLITUDE control to provide a 135 volt line-to-neutral output with switch S1 closed so that a 109 ohm load is across each phase of the output of the power source. Vary the AC line voltage from 105 volts to 125 volts with the variac and check that the harmonic distortion in each phase is less than 0.4 per cent over the full line voltage range. If problems are encountered, check that the overload adjustment procedure given in section 4.4 of this instruction manual has been followed.

4.7.2 Vary the oscillator frequency from 45 Hz to 5 KHz while maintaining the line-to-neutral output voltage at 135 volts rms. The harmonic distortion in each phase must be less than 0.4 per cent from 200 Hz to 1 KHz and less than 0.75 per cent from 45 Hz to 5 KHz over the full line voltage range.

4.7.3 Open switch S1 and replace the three phase full power load with a one-half power load (twice each resistance value). Vary the oscillator frequency from 5 KHz to 10 KHz while maintaining the line-to-neutral output voltage at 135 volts rms. The harmonic distortion in each phase must be less than .75 per cent over the full line voltage range.

4.7.4 Repeat steps 4.7.1 through 4.7.3 except set the output of the power source to 105 volts line-to-neutral (78 per cent of rated output) and close switch S2 rather than S1. The harmonic distortion in each phase must be less than 0.4 per cent from 200 Hz to 1 KHz, and less than 0.75 per cent from 45 Hz to 10 KHz.

4.7.5 This procedure may be performed for any of the other output voltage ranges, rather than the 0 to 135 volt L-N range, if desired. In this case, the load impedance and output voltage levels should be taken from those given in Table 4-1.

4.8 LINE REGULATION

4.8.1 Connect the Model 503T Three Phase Power Source as shown in Figure 4-3. Select the 135 volt L-N range according to the procedure given in section 2.4 of this instruction manual. Adjust the variac to provide 115 VAC line input. Set the oscillator frequency to 400 Hz and adjust the AMPLITUDE control to provide a 135 volt line-to-neutral output (100 per cent of rated output voltage) with switch S1 closed so that a 109 ohm load is across each phase of the output of the power source.

4.8.2 Vary the input line voltage from 105 volts to 125 volts AC and measure the change in output voltage of each phase of the power source. This change should be less than 0.68 volts rms.

4.8.3 Open switch S1 and replace the three phase full power load with a one-half power load (twice each resistance value). Set the oscillator frequency to 10 KHz and adjust the AMPLITUDE control to provide a 105 volt line-to-neutral output. Vary the input

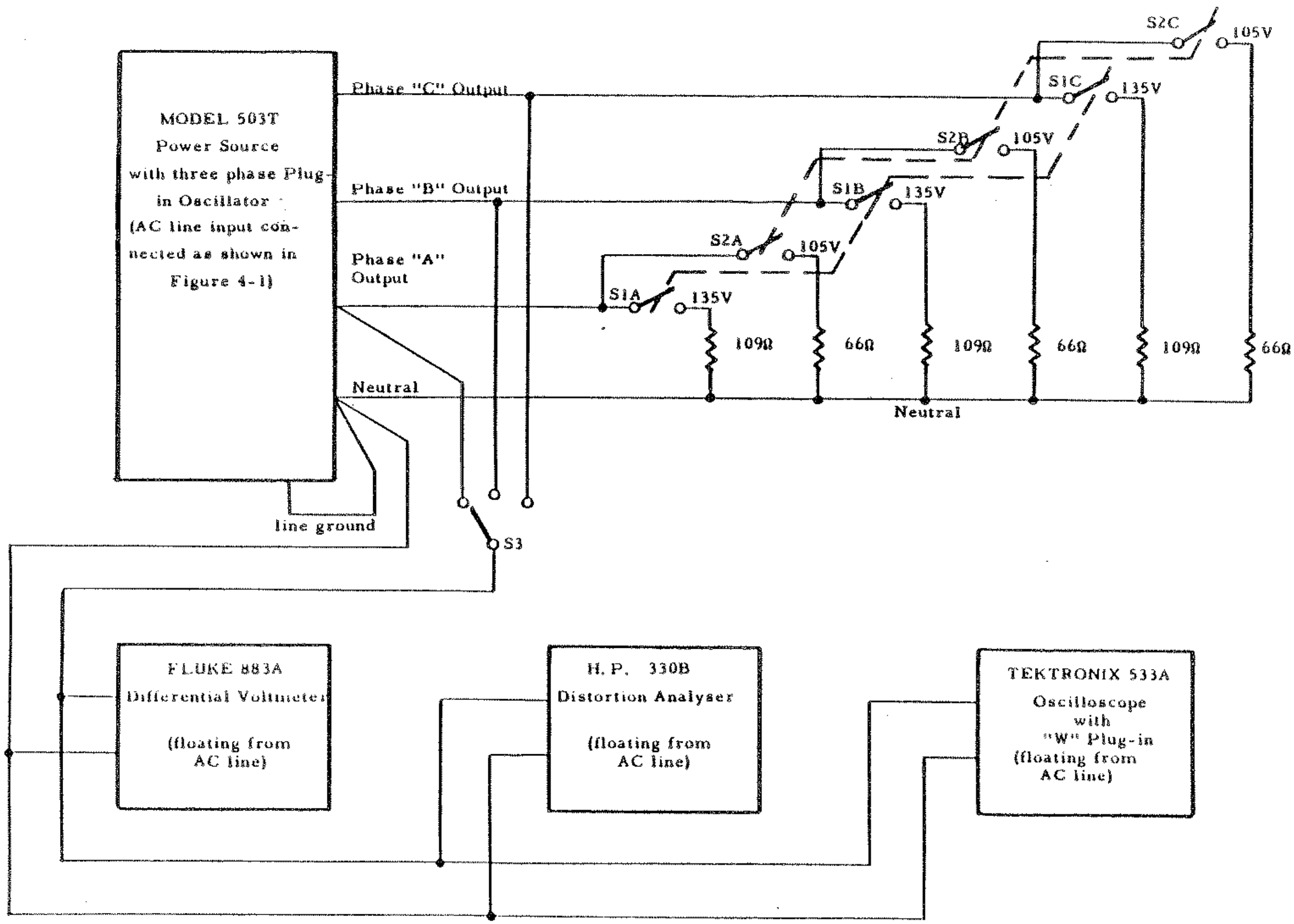


FIGURE 4-3. Test circuit for Model 503T Three Phase Power Source.

line voltage from 105 volts to 125 volts AC and measure the change in output voltage of each phase of the power source. This change should be less than 0.68 volts rms.

4.8.4 This procedure may be performed for any of the other output voltage ranges rather than the 0 to 135 volt L-N range, if desired. In this case, the load impedance and output voltage level should be taken from those given in Table 4-1. The output voltage must remain with a 0.5% band as the line voltage is varied from 105 to 125 VAC.

4.9 LOAD REGULATION ADJUSTMENT

The load regulation adjustment for each phase of the Model 503T Three Phase Power Source is internally available at the appropriate amplifier plug-in printed circuit board. These adjustments are usually set for zero regulation at 400 Hz and are somewhat sensitive to the output voltage range of the power source. They should be readjusted whenever the output voltage range is changed in order to achieve optimum load regulation.

4.9.1 Connect the Model 503T Three Phase Power Source as shown in Figure 4-3. Check that the load is connected to the three large red and the one large white binding post at the rear of the power source. The output voltage may be monitored either at the rear or the front of the power source. If it is monitored at the rear of the power source, care should be taken to use separate four-wire sensing. Adjust the output voltage of the power source to 105 volts line-to-neutral (78 per cent of rated output voltage) at 400 Hz.

4.9.2 Place the differential voltmeter on the 1000 VAC range and connect it across the phase "A" to neutral output terminals of the power source. Adjust A1R7 (accessible from the top of the power source with the top cover removed so that the output voltage variation is less than ± 50 millivolts) as the 66 ohm three phase load is added or removed. Maintain the AC input line voltage at 115 volts during this test.

4.9.3 Repeat step 4.9.2 except connect the differential voltmeter across the phase "B" to neutral output terminals of the power source. Adjust A2R7 so that the output voltage variation is less than ± 50 millivolts as the three phase load is added or removed.

4.9.4 Repeat step 4.9.2 except connect the differential voltmeter across the phase "C" to neutral output terminals of the power source. Adjust A3R7 so that the output voltage variation is less than ± 50 millivolts as the three phase load is added or removed.

4.9.5 Set the frequency of the oscillator to 5 KHz. Adjust the output amplitude of the power source to 105 volts rms with no load on the output of the power source. The output of each phase of the power source should change less than ± 1.05 volts when loaded with the 66 ohm three phase load resistors. Maintain the line voltage at 115 volts during this test.

4.9.6 Set the frequency of the oscillator to 45 Hz and repeat 4.9.5. The output of the power source should change less than ± 1.05 volts.

4.9.7 Set the oscillator frequency to 10 KHz and replace the three phase load with a one-half power load (twice each resistance value). Adjust the AMPLITUDE control so that the phase "A" output of the power source is 105 volts from line-to-neutral with one-half power load. Remove this one-half power load. The line-to-neutral output voltage should vary less than ± 2.10 volts rms.

4.9.8 Repeat step 4.9.7 while monitoring the phase "B" and the phase "C" output voltages. These line-to-neutral voltages should vary less than ± 2.10 volts rms as the three phase load is removed.

4.9.9 This procedure (steps 4.9.1 through 4.9.8) may be performed for any of the other output voltage ranges, rather than the 0 to 135 volt L-N range, if desired. In this case, the load impedance and output voltage levels should be taken from those given in Table 4-1. Care should be taken to use non-inductive load resistors, especially on the 30 volt L-N and 45 volt L-N ranges where load impedances are very low and a few microhenries of inductance will significantly influence the power factor at 5 KHz to 10 KHz. The load regulation must remain within a ± 1 per cent band from 45 Hz to 2 KHz and must remain within a ± 2 per cent band from 45 Hz to 5 KHz and within a ± 5 per cent band from 45 Hz to 10 KHz on the 30 volt L-N and 45 volt L-N output voltage ranges.

4.10 AMPLITUDE STABILITY

4.10.1 Connect the Model 503T Three Phase Power Source as shown in Figure 4-3. Adjust the AC input line voltage to 115 volts rms. Adjust the output of the power source to provide 115 volts line-to-neutral (85.3 per cent of rated output voltage) at 400 Hz. Connect a 79.2 ohm (167 VA) three phase load to the output terminals at the rear of the power source and check that the regulation control has been set to provide a zero output impedance.

4.10.2 Connect an AC expanded scale (about 115 volts rms) strip chart recorder from the phase "A" output terminal to the neutral terminal of the power source and record the drift during a 24 hour period. This drift should be less than ± .29 volts rms. Disregard the drift during the first hour, as this represents initial warm-up drift. Care should be taken to insure that the ambient temperature is held constant at ± 3 degrees C for this test. This procedure may be repeated with the expanded scale AC strip chart recorder connected across the phase "B"-to-neutral or the phase "C"-to-neutral output terminals, if desired.

4.10.3 This procedure may be performed for any of the other output voltage ranges, rather than the 0 to 135 volt L-N range, if desired. In this case, the load impedance and output voltage level should be taken from those given in Table 4-1 consistent with the dynamic range of the specific expanded scale strip chart recorder employed for the test.

4.11 FREQUENCY RESPONSE

4.11.1 Connect the Model 503T Three Phase Power Source as shown in Figure 4-3. Adjust the input AC line voltage to 115 volts rms. Adjust the output of the power source to provide 135 volts line-to-neutral (100 per cent of rated output voltage) at 400 Hz.

4.11.2 Vary the output frequency of the oscillator from 45 Hz to 10 KHz and monitor the phase "A" line-to-neutral output voltage of the power source with a differential voltmeter under no-load conditions. The line-to-neutral output of the power source should vary less than ± 8.0 volts rms from 45 Hz to 5 KHz and less than ± 16.5 volts rms from 45 Hz to 10 KHz. Repeat for the phase "B"-to-neutral output voltage and the phase "C"-to-neutral output voltage.

4.11.3 Close switch S1 and vary the output frequency from 45 Hz to 5 KHz. Each line-to-neutral output voltage should vary less than ± 8.0 volts rms.

4.11.4 Replace the three phase load with a one-half power load (twice each resistance value). Adjust the AMPLITUDE control so that the phase "A" output of the power source is 135 volts from line-to-neutral with a one-half power load. Vary the frequency from 45 Hz to 10 KHz. Each line-to-neutral output voltage should vary less than ± 16.5 volts rms.

4.11.5 This procedure may be performed for any of the other output voltage ranges, other than the 0 to 135 volt L-N range, if desired. In this case, the load impedance and output voltage level should be taken from those given in Table 4-1. The output must vary less than ± 0.5 dB from 45 Hz to 5 KHz and less than ± 1.0 dB from 45 Hz to 10 KHz with a one-half power load.

4.12 AC NOISE LEVEL

4.12.1 Connect the Model 503T Three Phase Power Source as shown in Figure 4-3. Adjust the line voltage to 115 volts rms. Adjust the output of the power source to provide 105 volts line-to-neutral (78 per cent of rated output voltage) at 400 Hz.

4.12.2 Close switch S2 and monitor each output of the power source with the Tektronix 533A Oscilloscope with a "W" plug-in. Using the offset feature of the "W" plug-in, observe the positive peak of the output voltage at a vertical sensitivity of .2 volt per centimeter and a sweep rate of 5 milliseconds per centimeter. The peak-to-peak noise and ripple should not exceed 0.297 volts (60 dB below full output).

4.12.3 Remove the plug-in oscillator and short pins 1, 2, 4 and 6 together of terminal strip TB1 located on the rear panel of the Model 503T. The AC rms noise in the output should now be less than 10.5 millivolts rms (80 dB below full output) when read on the differential voltmeter between each phase output and neutral. Remove the short from pins 1, 2, 4 and 6 of TB1 and then insert the plug-in oscillator into the 503T.

4.12.4 Steps 4.12.1 through 4.12.3 may be performed on any of the other output voltage ranges, if desired. The load impedance and output voltage level should be taken from those given in Table 4-1. The following chart gives the acceptable noise level output on each voltage range.

Rated Output Voltage	30 V L-N	45 V L-N	75 V L-N	135 V L-N
Peak-to-Peak Noise Level with 167 VA Load (see 4.12.2)	0.066 V p-p	0.099 V p-p	.166 V p-p	0.297 V p-p
Rms Noise Level at No Load (see 4.12.3)	2.34 mv rms	3.51 mv rms	5.85 mv rms	10.5 mv rms

4.13 0.7 LAGGING POWER FACTOR

4.13.1 Connect the Model 503T Three Phase Power Source as shown in Figure 4-3. Select the load circuit to correspond with the required output voltage range. Figure 4-4 illustrates the load circuit and gives load parameter values for a 167 VA per-phase 0.7 power factor load at 400 Hz with 78 per cent of rated output voltage from the power source. This represents the worst case inductive load for maximum power dissipation inside the power source.

4.13.2 Set the oscillator frequency to 400 Hz and adjust the AMPLITUDE control on the associated three phase oscillator for 78 per cent of rated output voltage. Check that the power source produces a stable output with no high-frequency oscillation or excessive distortion. Refer to Section 4.7 of this instruction manual for the procedure to measure harmonic distortion. This distortion must be less than 0.4 per cent at 400 Hz.

4.13.3 The regulation controls usually do not require significant readjustment in order to provide a zero regulation with a 0.7 power factor load at 400 Hz. If the unit is to be operated at a 0.7 power factor in the high frequency region, i.e., 5 KHz to 10 KHz, then it may be necessary to readjust the regulation controls. In this case, rotate the controls, A1R7, A2R7 and A3R7, until zero regulation is obtained at the specific frequency and load condition.

4.13.4 The AC line input power is 2000 watts maximum with an 0.7 power factor load at 78 per cent of rated output voltage and an input line voltage of 125 volts rms.

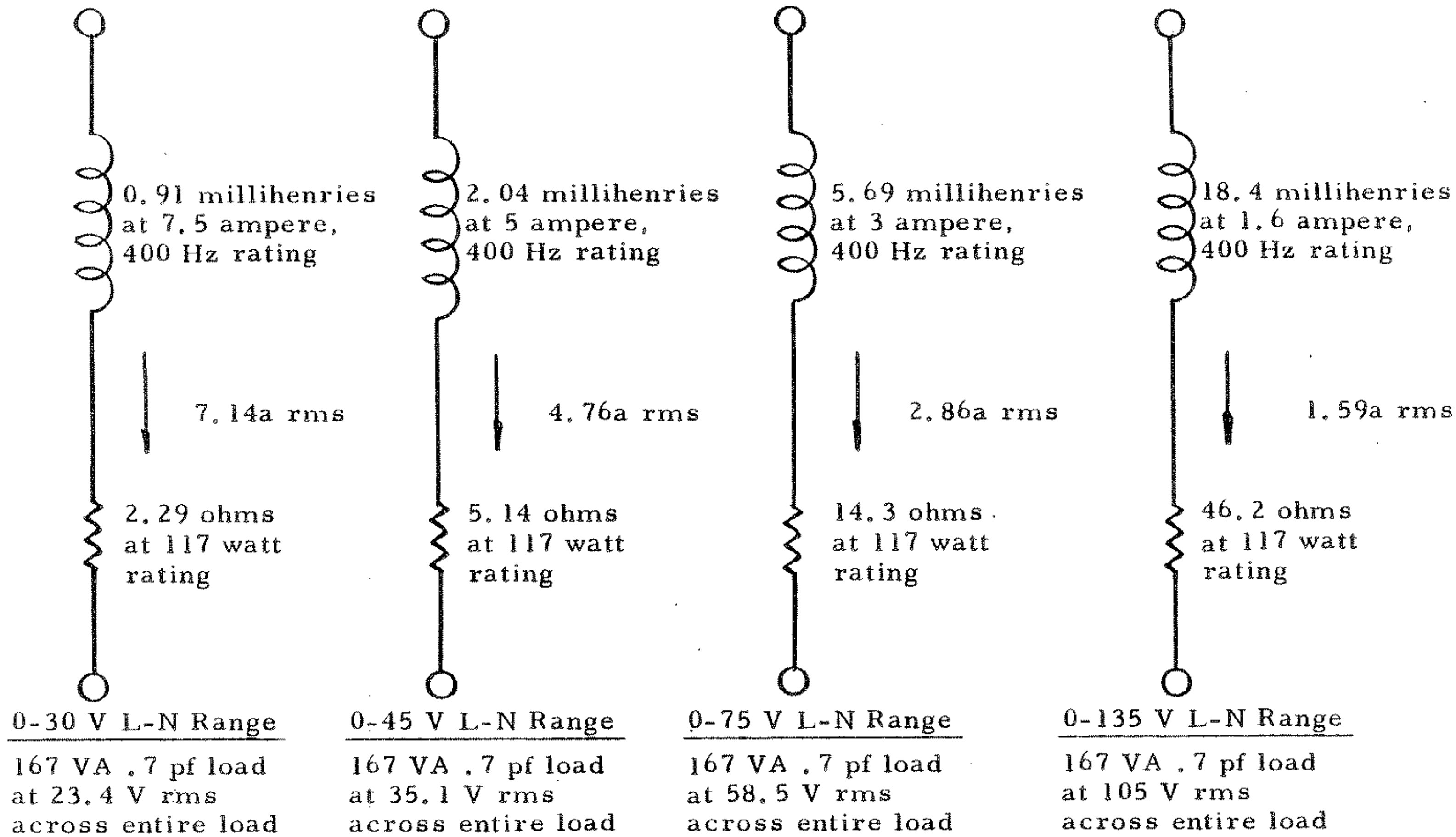


FIGURE 4-4. Circuit for 167 VA line-to-neutral 0.7 Lagging Power Factor Load at 400 Hz.

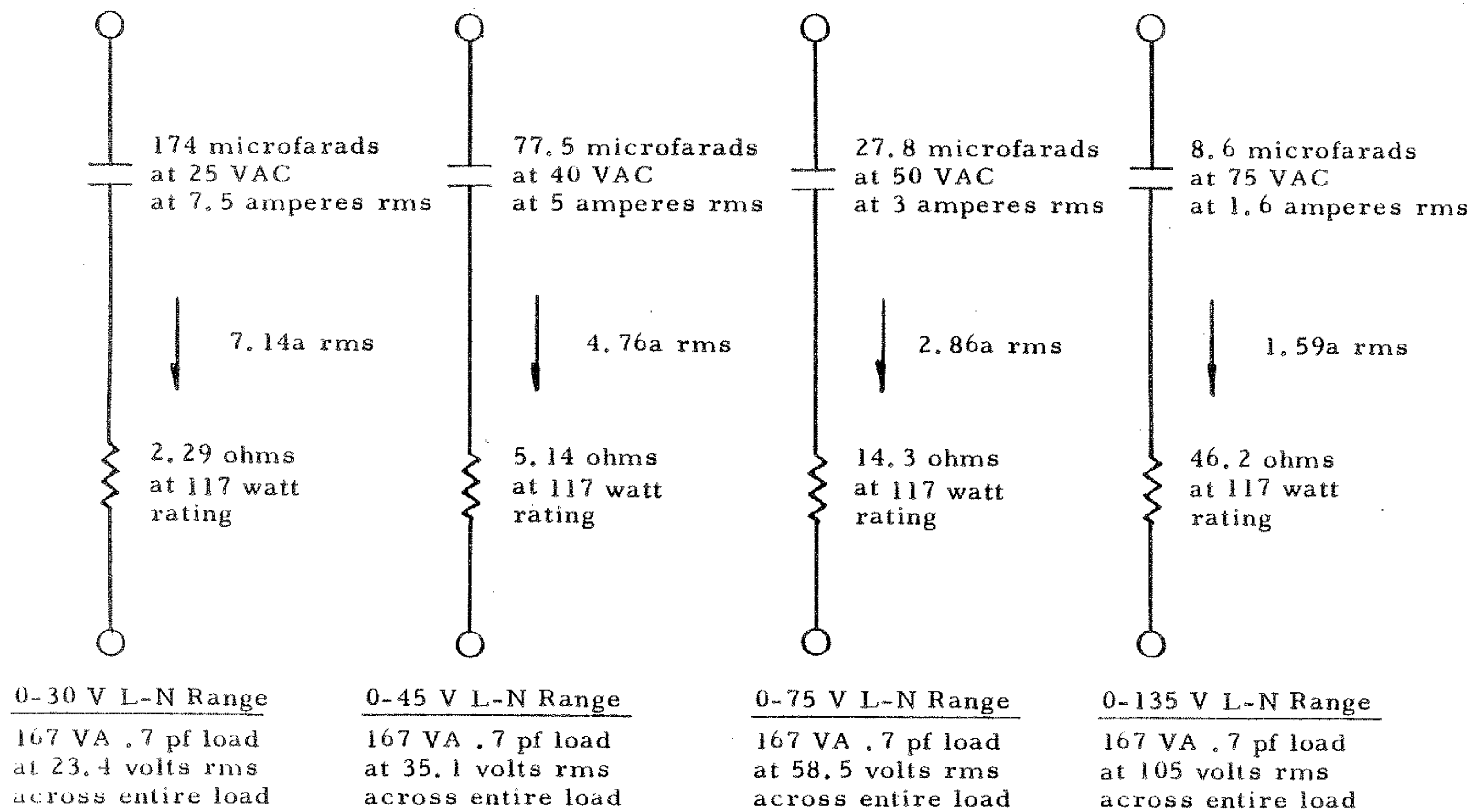


FIGURE 4-5. Circuit for 167 VA line-to-neutral 0.7 Leading Power Factor Load at 400 Hz.

4.13.5 The above tests may be repeated at frequencies other than 400 Hz provided that the inductance of the series inductor is changed inversely proportional to the absolute value of the test frequency. For example, at 1 KHz the inductance value must be divided by 2.5. The series resistance value remains unchanged.

4.14 0.7 LEADING POWER FACTOR

4.14.1 Connect the Model 503T Three Phase Power Source as shown in Figure 4-3. Select the load circuit to correspond with the required output voltage range. Figure 4-5 illustrates the load circuit and gives load parameter values for a 167 VA per phase line-to-neutral 0.7 power factor load at 400 Hz with 78 per cent of rated output voltage from the power source. This represents the worst case capacitive load for maximum power dissipation inside the power source.

4.14.2 Set the oscillator frequency to 400 Hz and adjust the AMPLITUDE control on the associated three-phase oscillator for 78 per cent of the rated output voltage. Check that the power source produces a stable output with no high frequency oscillation or excessive distortion. Refer to Section 4.7 of this procedure to measure harmonic distortion. This distortion must be less than 0.4 per cent at 400 Hz.

4.14.3 The regulation controls usually do not require significant readjustment in order to provide a zero regulation with a 0.7 power factor load at 400 Hz. If the unit is to be operated at a 0.7 power factor in the high frequency region, i.e., 5 KHz to 10 KHz, then it may be necessary to readjust the regulation controls. In this case, rotate the controls, A1R7, A2R7 and A3R7, until zero regulation is obtained at the specific frequency and load condition.

4.14.4 The AC line input power is 2000 watts maximum with an 0.7 power factor load at 78 per cent of rated output voltage and an input line voltage of 125 volts rms.

4.14.5 The above tests may be repeated at frequencies other than 400 Hz provided that the capacitance of the series capacitor is changed inversely proportional to the absolute value of the test frequency. For example, at 1 KHz the capacitance value must be divided by 2.5. The series resistance value remains unchanged.

4.15 PHASE ACCURACY

4.15.1 Connect the Model 503T Three Phase Power Source as shown in Figure 4-3. Select the 135 volt L-N range according to the procedure given in Section 2.4 of this instruction manual. Adjust the variac to provide a 115 volt AC line input. Set the oscillator output to 400 Hz and adjust the AMPLITUDE control to provide a 135 volt (100 per cent of rated output voltage) line-to-neutral output with switch S1 closed. This provides a 109 ohm symmetrical load across each phase of the output of the power source.

4.15.2 Connect the differential phase meter from the phase "A" output to the phase "B" output. The phase meter should indicate 120 degrees ± (1.0 degree plus phase error of plug-in). Reverse phase meter leads, if necessary.

4.15.3 Repeat step 4.15.2 except connect the differential phase meter from the phase "A" output to the phase "C" output. The phase meter should indicate 120 degrees ± (1.0 degree plus phase error of plug-in). Reverse phase meter leads, if necessary.

4.15.4 This procedure may be performed for any of the other output voltage ranges, rather than the 0 to 135 volt L-N range, if desired. In this case, the load impedance and output voltage level should be taken from those given in Table 4-1.

4.15.5 Steps 4.15.1 through 4.15.4 are not applicable if the Model 503T is connected in its 500 VA single phase output configuration.

MAINTENANCE AND TROUBLESHOOTING

5.1 GENERAL

The California Instruments Model 503T Three Phase Power Source is a solid state unit and should require a minimum of maintenance. However, it is forced air cooled and will accumulate some dust with time. The power transistor heatsinks should receive a forced air bath at intervals not to exceed 6 months.

CAUTION

Failure to keep the heatsinks clean will reduce their thermal transfer efficiency somewhat and could cause failure of the power source.

5.2 TROUBLE SHOOTING

5.2.1 If a problem appears in the power source, it must be isolated to a specific section of the unit. Before servicing the amplifier, check that the AC power input to the unit is of the proper amplitude and frequency. Check that the signal input to the power amplifier is also of the proper amplitude (approximately 5 volts rms) and frequency (45 Hz to 10 KHz). Check that the output load on the power amplifier is not excessive or that the load starting transients are not excessive. Check that the output of the oscillator is coupled to the input of the power amplifier through the 12 pin connector on the rear of the power source.

5.2.2 If the problem has been resolved to be in the power amplifier, first check all DC power supply voltages. Information concerning power supply ripple and voltage tolerance is given in section 3.2.6 of this instruction manual.

5.2.3 Check that the quasi complementary symmetry output amplifier is operating properly and is not drawing excessive current under no load conditions. Section 3.2.2 of this instruction manual describes the operation of this output amplifier.

5.2.4 Check that the overload circuitry is operating properly. The overload circuit may be disabled by removing A1CR6, A2CR6 and A3CR6.

5.2.5 If the problem has been resolved to be in the oscillator, consult the applicable oscillator instruction manual.

CIRCUIT DIAGRAM

6.1 GENERAL

This section contains schematics and mechanical diagrams necessary for operation and maintenance of the Model 503T AC Power Source. The schematic diagrams illustrate the circuit while the mechanical assemblies indicate the part placement.

6.2 REFERENCE DESIGNATIONS

Partial reference designators are shown on schematic and mechanical drawings. Prefix these reference designators with assembly and/or sub-assembly designation for the complete reference designator. For example:

Assembly/Sub-Assembly	Component	Component Designation
A1	C3	A1C3
None	T1	T1
A3	CR1	A3CR1

REPLACEABLE PARTS

7.1 GENERAL

This section contains ordering information and complete list of replaceable parts. Parts are listed by major assembly in alphanumerical order of their reference designators. Description, manufacturers' part number, manufacturers' code ident number (see Appendix A for list of manufacturers), and California Instruments' stock number are indicated.

7.2 ORDERING INFORMATION

In order to provide our customers with prompt service on replacement parts, please provide the following information, when applicable, for each part ordered:

a) Model number and serial number of the instrument.

b) California Instruments part number of the sub-assembly where component is located.

c) Component reference designator.

d) Component description.

e) Component manufacturer's number and code ident.

f) California Instruments stock number.

All replacement parts orders should be placed with California Instruments, Division of Amstar Technical Products Co., Inc., San Diego, California, 92111-1266.

7.3 COMPUTER GENERATED PARTS LISTS

The following information is included as an explanation of the computer formatted parts list column.

7.3.1 "Seq. No." - Sequence number; the reference designator or the component, or (if there is no reference designator) the balloon number (bubble or "find" number) on the face of the assembly drawing or the top assembly drawing. They are listed in alphanumerical order.

7.3.2 "Component Item No." - This is California Instruments part number. Please use this number when ordering spares.

7.3.3 "Description, Truncated" - A brief description of the item. Abbreviations are per MIL-STD-12 or industry accepted standards.

7.3.4 "Engineering Drawing No." - This is used for one of the following:

a) The document/specification number generated by California Instruments to control the part.

b) The generic part number (military specification or industry accepted stadard).

c) The primary vendor's catalog part number. An asterisk at the end of the number indicates number is longer than that shown (contact California Instruments if the full number is required).

7.3.5 "Vendor" - This is the FSCM code identification (see Appendix A).

7.3.6 "Quan" and "U/M" - The requirements per unit of measure such as: "2 each"; "1 lb."; "4 oz."; or "6 SI" (square inches).

PARENT ITEM NO. 4053-400-1

TOP ASSY,503T
ENGR DRAW NO. 4053-400 REV N

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
	4053-050-0	HARNESS ASSY,JUMPER	4053-050 REV B1	16067	1.0	EA
	4053-050-1	HARNESS ASSY	4053-050 REV B1	16067	1.0	EA
	4053-050-2	HARNESS ASSY	4053-050 REV B1	16067	1.0	EA
	4053-405-1	FRONT PANEL ASSY	4053-405	16067	1.0	EA
CB1	270039	CIRCUIT BREAKER,20A,250V	AM12-20-250-5-6	74193	1.0	EA
DS1	241021	LAMP,GAS,AMBER,120V	8G03ACSNE2H/33K	03797	1.0	EA
J5	240041	BINDING POST,RED	DF-31RC	58474	1.0	EA
J6	240041	BINDING POST,RED	DF-31RC	58474	1.0	EA
J7	240041	BINDING POST,RED	DF-31RC	58474	1.0	EA
J8	240090	BINDING POST,WHT	DF-31WTC	58474	1.0	EA
J9	240040	BINDING POST,BLK	DF-31BC	58474	1.0	EA
M1	CIC800	METER,DC,ANLG,MA,0-1	CIC800-0	16067	1.0	EA
M1	CIC800-9	MTR FACE,MTL,W/4053-101	CIC800/4995-285	16067	1.0	EA
TB3	250052	TERMINAL STRP, 2TERM,1MT	863	83330	1.0	EA
87	110242-1	PANEL,FRONT W/4053-201	4053-201-1	16067	1.0	EA
98	110203	BRACKET,PLUG-IN,OSC	4075-203-7	16067	1.0	EA
102	210191	KNOB,BLK,IND	PS-700-2-BLK	21604	1.0	EA
104	240224	HANDLE,FLT,S/S,6"	11520-S-0832-4	06540	2.0	EA
109	241124	GUIDE,PWB,4.15"	33-9016-12-01-*	91662	2.0	EA
118	110264	BRACKET,ANGLE	631	91833	1.0	EA
	4053-406-1	REAR PANEL ASSY	4053-406	16067	1.0	EA
B1	241063	FAN,4",115VAC,50/60HZ	WS2107F-110	99743	1.0	EA
B2	241063	FAN,4",115VAC,50/60HZ	WS2107F-110	99743	1.0	EA
J10	240041	BINDING POST,RED	DF-31RC	58474	1.0	EA
J11	240041	BINDING POST,RED	DF-31RC	58474	1.0	EA
J12	240041	BINDING POST,RED	DF-31RC	58474	1.0	EA
J13	240090	BINDING POST,WHT	DF-31WTC	58474	1.0	EA
J14	240040	BINDING POST,BLK	DF-31BC	58474	1.0	EA
P20	241078	PWR CORD,115V,14-3,6' W/	14-3-SJT	0000A	1.0	EA
TB1	241123	TERMINAL BLK,12TERM, 5A	410-Y-12	75382	1.0	EA
88	110243-1	PANEL,REAR W/4053-202	4053-202-1	16067	1.0	EA
103	241064	FAN GUARD	550481	82877	2.0	EA
106	250090	JUMPER,TERMINAL BLOCK	410J	75382	3.0	EA
108	210420	GROMMET,RUBBER,5/16"DIA	415	08065	1.0	EA
111	210361	STRAIN RELIEF	SR-7P-2	28520	1.0	EA
133	210396	SCREW,RDH,S/S,4-40X1/2	4-40X1/2 ROUND	81349	4.0	EA
	4053-407-1	ENCLOSURE ASSY	4053-407	16067	1.0	EA
C1	610755	CAP,AL,51000UF,40V	36DX513G040DC2A	56289	1.0	EA
C2	610755	CAP,AL,51000UF,40V	36DX513G040DC2A	56289	1.0	EA
C3	610755	CAP,AL,51000UF,40V	36DX513G040DC2A	56289	1.0	EA
C4	610755	CAP,AL,51000UF,40V	36DX513G040DC2A	56289	1.0	EA
TB2	240111	TERMINAL STRP, 5TERM,2MT	3005	83330	1.0	EA
85	210398	DECAL,VOLTAGE RANGE	4053-100	16067	1.0	EA
86	110241	ENCLOSURE	4053-200-1	16067	1.0	EA
90	110245	SUPPORT,PWB,REAR	4053-204-7	16067	1.0	EA
91	110246	SUPPORT,PWB,FRONT	4053-205-7	16067	1.0	EA
92	110247	BUS BAR	4053-206-7	16067	1.0	EA

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
93	110248	BUS BAR	4053-206-8	16067	1.0	EA
94	110249	BUS BAR	4053-206-9	16067	2.0	EA
95	110266	BUS BAR	4053-206-10	16067	1.0	EA
107	241052	CAP CLAMP, 3"	4586-2	56289	4.0	EA
109	241124	GUIDE,PWB,4.15"	33-9016-12-01-#	91662	4.0	EA
110	210340	GUIDE,PWB,6.65"	33-9016-12-01-#	91662	4.0	EA
118	110264	BRACKET,ANGLE	631	91833	1.0	EA
153	210462	BOLT,HEX,S/S,10-32X7/8	MS9489-12	96906	2.0	EA
A1	4053-700-1	PC ASSY,AMPLIFIER	4053-700 REV H	16067	1.0	EA
A2	4053-700-1	PC ASSY,AMPLIFIER	4053-700 REV H	16067	1.0	EA
A3	4053-700-1	PC ASSY,AMPLIFIER	4053-700 REV H	16067	1.0	EA
A4	4053-701-1	PC ASSY,POWER SUPPLY	4053-701 REV C2	16067	1.0	EA
A6	4053-702-1	PC ASSY,SW/METER RANGE	4053-702 REV C1	16067	1.0	EA
C5	610071	CAP,MYLAR,.0025UF,600V	6DP-1-252	72136	1.0	EA
C6	610071	CAP,MYLAR,.0025UF,600V	6DP-1-252	72136	1.0	EA
C7	610071	CAP,MYLAR,.0025UF,600V	6DP-1-252	72136	1.0	EA
R1	520030	RES,CARB,1/2W,560 OHM	RC20GF561J	81349	1.0	EA
R2	520030	RES,CARB,1/2W,560 OHM	RC20GF561J	81349	1.0	EA
R3	520030	RES,CARB,1/2W,560 OHM	RC20GF561J	81349	1.0	EA
T1	710204	TRANSFORMER,INPUT	4053-011-1	16067	1.0	EA
T2	710203	TRANSFORMER,OUTPUT	4053-010-1	16067	1.0	EA
T3	710203	TRANSFORMER,OUTPUT	4053-010-1	16067	1.0	EA
T4	710203	TRANSFORMER,OUTPUT	4053-010-1	16067	1.0	EA
89	210337	INSULATOR,HEATSINK	4053-203-7	16067	1.0	EA
96	110244	COVER,TOP	4053-207-7	16067	1.0	EA
97	110265	COVER,CONNECTOR	4053-208-7	16067	1.0	EA
99	210621	INSULATOR,HEATSINK	4053-213-7	16067	1.0	EA
119	210360	SPACER, #4 X 1/2"	8483 OR 2342	83330	6.0	EA
120	FS3000	GROMMET,STRIP,.052	CSG-06-NATURAL	95987	5.0	IN
121	FS4003	ADHESIVE,RUBBER	847	04963	.1	OZ
124	210132	NUT,HEX,S/S,3/8-16	MS35649-2384	81349	4.0	EA
125	210131	WASHER,SPLT,3/8	MS35338-141	81349	4.0	EA
128	210096	WASHER,FLAT,3/8	MS15795-813	81349	4.0	EA
130	FS1011	SCREW,PNH,S/S,4-40X1/4	MS51957-13	96906	4.0	EA
131	FS1018	SCREW,PNH,S/S,4-40X1/2	MS51957-17	96906	2.0	EA
132	FS1023	SCREW,FLH,S/S,4-40X1	MS24693-C10	81349	6.0	EA
137	FS1024	SCREW,PNH,S/S,6-32X3/16	MS51957-25	96906	20.0	EA
138	FS1027	SCREW,FLH,S/S,6-32X1/4	MS24693-C24	96906	2.0	EA
139	FS1028	SCREW,PNH,S/S,6-32X5/16	MS51957-27	81349	6.0	EA
140	FS1030	SCREW,PNH,S/S,6-32X3/8	MS51957-28	96906	29.0	EA
141	FS1005	SCREW,FLH,S/S,6-32X7/16	MS24693-C27	81349	4.0	EA
142	FS1032	SCREW,PNH,S/S,6-32X1/2	MS51957-30	96906	1.0	EA
143	FS1034	SCREW,PNH,S/S,6-32X5/8	MS51957-31	96906	12.0	EA
144	210354	BOLT,HEX,S/S,10-32X3/8	10-32X3/8	81349	10.0	EA
145	FS1037	SCREW,PNH,S/S,6-32X7/8	MS51957-33	96906	8.0	EA
147	FS1042	SCREW,PNH,S/S,8-32X3/8	MS51957-43	96906	15.0	EA
148	FS1049	SCREW,PNH,S/S,8-32X7/16	MS51957-44	81349	6.0	EA

EQ O.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
149	FS1046	SCREW,FLH,S/S,8-32X5/8	MS24693-C51	96906	6.0	EA
150	FS1046	SCREW,FLH,S/S,8-32X5/8	MS24693-C51	96906	4.0	EA
154	210233	BOLT,HEX,S/S,10-32X1/2	MS9489-06	96906	3.0	EA
155	FS1062	SCREW,PNH,S/S,10-32X3/4	MS51958-65	96906	2.0	EA
159	FS1068	WASHER,INTER,S/S,#4	MS35333-70	81349	10.0	EA
160	FS1072	WASHER,SPLT,S/S,#4	MS35338-135	96906	6.0	EA
161	FS1069	WASHER,INTER,S/S,#6	MS35333-71	96906	79.0	EA
162	FS1080	WASHER,FLAT,S/S,#6	MS15795-806	96906	22.0	EA
163	FS1070	WASHER,INTER,S/S,#8	MS35333-72	81349	21.0	EA
164	FS1071	WASHER,INTER,S/S,#10	MS35333-73	96906	21.0	EA
165	FS1081	WASHER,FLAT,S/S,#8	MS15795-841	96906	6.0	EA
168	FS1066	NUT,HEX,S/S,4-40	MS35649-244	96906	6.0	EA
169	FS1066	NUT,HEX,S/S,4-40	MS35649-244	96906	6.0	EA
170	FS1064	NUT,HEX,S/S,6-32	MS35649-264	96906	49.0	EA
172	FS1067	NUT,HEX,S/S,10-32	MS35650-304	96906	21.0	EA
173	FS1075	WASHER,SPLT,S/S,#10	MS35338-138	96906	6.0	EA

PARENT ITEM NO. 4053-050-0 — DESCRIPTION HARNESS ASSY,JUMPER — ENGR DRAW 4053-050 REV B1 — PAGE 1

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NUMBER	VENDOR	QTY	UM
1	FS2003	LUG,RING,CRIMP,8-10	R3031BF	14726	2.0	EA
3	FS2005	LUG,RING,CRIMP,16/14-10	R4161F	14726	4.0	EA
4	FS2001	LUG,RING,CRIMP,22/18-10	R4149SF	14726	5.0	EA

PARENT ITEM NO. 4053-050-1 DESCRIPTION HARNESS ASSY ENGR DRAW 4053-050 REV B1

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NUMBER	VENDOR	QTY	UM
1	FS2003	LUG,RING,CRIMP,8-10	R30313F	14726	4.0	EA
2	FS2012	LUG,RING,CRIMP,12/10-10	R4170F	14726	6.0	EA
3	FS2005	LUG,RING,CRIMP,16/14-10	R4161F	14726	4.0	EA
4	FS2001	LUG,RING,CRIMP,22/18-10	R4149SF	14726	1.0	EA
5	FS2006	LUG,RING,CRIMP,16/14-6	R61005GSF	14726	1.0	EA

PARENT ITEM NO. 4053-050-2 DESCRIPTION HARNESS ASSY ENGR DRAW 4053-050 REV B1

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NUMBER	VENDOR	QTY	UM
J1	410032	CONN,PC EDGE,10 PIN	88010S-0	81312	1.0	EA
J2	410158	CONN,PC EDGE,18 PIN	88018S-0	81312	1.0	EA
J3	410158	CONN,PC EDGE,18 PIN	88018S-0	81312	1.0	EA
J4	410158	CONN,PC EDGE,18 PIN	88018S-0	81312	1.0	EA
1	FS2003	LUG,RING,CRIMP,8-10	R30318F	14726	7.0	EA
2	FS2012	LUG,RING,CRIMP,12/10-10	R4170F	14726	4.0	EA
3	FS2005	LUG,RING,CRIMP,16/14-10	R4161F	14726	1.0	EA
4	FS2001	LUG,RING,CRIMP,22/18-10	R4149SF	14726	4.0	EA
5	FS2000	LUG,RING,CRIMP,22/18-4	R4265F	14726	1.0	EA

PARENT ITEM NO.
4053-700-1

PC ASSY,AMPLIFIER
ENGR DRAW NO. 4053-700 REV H

3/27/86

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
CR1	310118	DIODE,SWNG,75V,.5W,DO35	1N914	07263	1.0	EA
CR2	310118	DIODE,SWNG,75V,.5W,DO35	1N914	07263	1.0	EA
CR3	310118	DIODE,SWNG,75V,.5W,DO35	1N914	07263	1.0	EA
CR4	310062	DIODE,RECT,1A,400V,DO41	1N4004	81349	1.0	EA
CR5	310062	DIODE,RECT,1A,400V,DO41	1N4004	81349	1.0	EA
CR6	310129	DIODE,ZNR,3.3V,.5W,5%	1N5226B	04713	1.0	EA
CR7	310221	DIODE,RECT,40A,400V,DO5	1N1188A	07716	1.0	EA
CR8	310221	DIODE,RECT,40A,400V,DO5	1N1188A	07716	1.0	EA
C1	610566	CAP,MYLAR,.22UF,100V	10P-3-224	72136	1.0	EA
C2	610375	CAP,AL,100UF,6V	TE1102	56289	1.0	EA
C3	610375	CAP,AL,100UF,6V	TE1102	56289	1.0	EA
C4	610512	CAP,MYLAR,.033UF,100V	10P-1-333J	72136	1.0	EA
C5	610013	CAP,MICA,39PF,500V	CM05E390J03	81349	1.0	EA
C6	610708	CAP,AL,5UF,12V	TE1127	56289	1.0	EA
C7	610673	CAP,MICA,510PF,500V	DM15-551J	72136	1.0	EA
C8	610331	CAP,AL,5UF,50V	TE1303	56289	1.0	EA
C10	610187	CAP,AL,500UF,50V	TC50050C	90201	1.0	EA
C11	610187	CAP,AL,500UF,50V	TC50050C	90201	1.0	EA
C12	610041	CAP,MICA,300PF,500V	CM05F301J03	81349	1.0	EA
C13	610778	CAP,CER,.01UF,500V	5GAS-S10	56289	1.0	EA
C14	610721	CAP,MYLAR,1UF,100V	112A18105M	14752	1.0	EA
Q1	330293	TRANSISTOR,FET,N,DUAL	IT502	32293	1.0	EA
Q2	330012	TRANSISTOR,SS,NPN,DUAL	CIC333	16067	1.0	EA
Q3	330008	TRANSISTOR,SS,NPN,TO18	CIC330	16067	1.0	EA
Q4	330285	TRANSISTOR,SS,PNP,TO92	PN2907A	07263	1.0	EA
Q5	330285	TRANSISTOR,SS,PNP,TO92	PN2907A	07263	1.0	EA
Q6	330285	TRANSISTOR,SS,PNP,TO92	PN2907A	07263	1.0	EA
Q7	330106	TRANSISTOR,SS,PNP,TO39	2N4036	04713	1.0	EA
Q8	330075	TRANSISTOR,SS,NPN,TO39	2N2102	81349	1.0	EA
Q9	330220	TRANSISTOR,PWR,NPN,TO220*	CIC370	16067	1.0	EA
Q10	330221	TRANSISTOR,PWR,PNP,TO220	CIC371	16067	1.0	EA
Q11	330173	TRANSISTOR,PWR,NPN,TO3	61491 (2N3772)	86684	1.0	EA
Q12	330173	TRANSISTOR,PWR,NPN,TO3	61491 (2N3772)	86684	1.0	EA
Q13	330173	TRANSISTOR,PWR,NPN,TO3	61491 (2N3772)	86684	1.0	EA
Q14	330173	TRANSISTOR,PWR,NPN,TO3	61491 (2N3772)	86684	1.0	EA
Q15	330173	TRANSISTOR,PWR,NPN,TO3	61491 (2N3772)	86684	1.0	EA
Q16	330173	TRANSISTOR,PWR,NPN,TO3	61491 (2N3772)	86684	1.0	EA
R1	560140	RES,FILM,1/4W,200K,1%	RN60C2003F	81349	1.0	EA
R2	560239	RES,FILM,1/4W,20K,1%	RN60C2002F	81349	1.0	EA
R3	510076	RES,CARB,1/4W,10K OHM	RC07GF103J	81349	1.0	EA
R4	510041	RES,CARB,1/4W,330 OHM	RC07GF331J	81349	1.0	EA
R5	510093	RES,CARB,1/4W,51K OHM	RC07GF513J	81349	1.0	EA
R6	560196	RES,FILM,1/4W,9.09K,1%	RN60D9091F	81349	1.0	EA
R7	570144	POT,MT,PC,100 OHM,1/4W	ET34P101	30983	1.0	EA
R8	560017	RES,FILM,1/4W,681 OHM,1%	RN60D6810F	81349	1.0	EA
R9	560238	RES,FILM,1/4W,4.99K,1%	RN60C4991F	81349	1.0	EA
R10	570035	POT,1T,PC,10K,1/4W	U201R103B	71450	1.0	EA

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
R11	560114	RES,FILM,1/4W,49.9K,1%	RN60C4992F	81349	1.0	EA
R12	570035	POT,1T,PC,10K,1/4W	U201R103B	71450	1.0	EA
R13	560114	RES,FILM,1/4W,49.9K,1%	RN60C4992F	81349	1.0	EA
R14	560437	RES,FILM,1/4W,95.3K,1%	RN60C9532F	81349	1.0	EA
R15	510068	RES,CARB,1/4W,4.7K OHM	RC07GF472J	81349	1.0	EA
R16	510029	RES,CARB,1/4W,100 OHM	RC07GF101J	81349	1.0	EA
R17	510029	RES,CARB,1/4W,100 OHM	RC07GF101J	81349	1.0	EA
R18	510068	RES,CARB,1/4W,4.7K OHM	RC07GF472J	81349	1.0	EA
R19	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
R20	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
R21	510086	RES,CARB,1/4W,27K OHM	RC07GF273J	81349	1.0	EA
R22	510060	RES,CARB,1/4W,2.2K OHM	RC07GF222J	81349	1.0	EA
R23	510027	RES,CARB,1/4W,82 OHM	RC07GF820J	81349	1.0	EA
R24	510036	RES,CARB,1/4W,200 OHM	RC07GF201J	81349	1.0	EA
R25	510036	RES,CARB,1/4W,200 OHM	RC07GF201J	81349	1.0	EA
R26	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
R27	510046	RES,CARB,1/4W,510 OHM	RC07GF511J	81349	1.0	EA
R28	510041	RES,CARB,1/4W,330 OHM	RC07GF331J	81349	1.0	EA
R29	510080	RES,CARB,1/4W,15K OHM	RC07GF153J	81349	1.0	EA
R30	510031	RES,CARB,1/4W,120 OHM	RC07GF121J	81349	1.0	EA
R31	510075	RES,CARB,1/4W,9.1K OHM	RC07GF912J	81349	1.0	EA
R32	FS5118	WIRE,BUS,AWG 24,QQ-W-343E	QQW343S24S2B	81348	1.0	IN
R33	510007	RES,CARB,1/4W,12 OHM	RC07GF120J	81349	1.0	EA
R34	510009	RES,CARB,1/4W,15 OHM	RC07GF150J	81349	1.0	EA
R35	510007	RES,CARB,1/4W,12 OHM	RC07GF120J	81349	1.0	EA
R37	510009	RES,CARB,1/4W,15 OHM	RC07GF150J	81349	1.0	EA
R38	510078	RES,CARB,1/4W,12K OHM	RC07GF123J	81349	1.0	EA
R39	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
R41	510021	RES,CARB,1/4W,47 OHM	RC07GF470J	81349	1.0	EA
R42	520013	RES,CARB,1/2W,47 OHM	RC20GF470J	81349	1.0	EA
R43	540001	RES,CARB,2W,1 OHM	BWH 1 OHM	07716	1.0	EA
R44	540001	RES,CARB,2W,1 OHM	BWH 1 OHM	07716	1.0	EA
R45	520013	RES,CARB,1/2W,47 OHM	RC20GF470J	81349	1.0	EA
R46	550188	RES,PWR,3W,.1 OHM,5%	RW69VR10WL	81349	1.0	EA
R47	550188	RES,PWR,3W,.1 OHM,5%	RW69VR10WL	81349	1.0	EA
R48	550188	RES,PWR,3W,.1 OHM,5%	RW69VR10WL	81349	1.0	EA
R49	550188	RES,PWR,3W,.1 OHM,5%	RW69VR10WL	81349	1.0	EA
R50	550188	RES,PWR,3W,.1 OHM,5%	RW69VR10WL	81349	1.0	EA
R51	550188	RES,PWR,3W,.1 OHM,5%	RW69VR10WL	81349	1.0	EA
R52	540001	RES,CARB,2W,1 OHM	BWH 1 OHM	07716	1.0	EA
TP1	241089	TEST JACK,PC,DBL ENT,BRN	430-108	83330	1.0	EA
TP2	241085	TEST JACK,PC,DBL ENT,RED	430-102	83330	1.0	EA
T1	710130	TRANSFORMER	T31X	81095	1.0	EA
2	160129	PWB,AMPLIFIER	4053-750-1	16067	1.0	EA
127	210357	HEATSINK	4053-210-7	16067	2.0	EA
130	210154	BUMPER,RUBBER	2192	08065	1.0	EA
131	241050	HEATSINK,TO5	I207-CB	05820	2.0	EA

EQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
32	240296	SOCKET,XSTR,TO-5	RCTC5075-7A	19080	2.0	EA
33	210343	MOUSE TAIL	2829-75-3	98159	4.0	EA
34	210328	FSTNR,RVT,POP,3/32X.222	AAP-3-2	11815	8.0	EA
38	FS5123	WIRE,BUS,AWG 14,QQ-W-343E	QQW343S14S2B	81348	2.0	IN
39	FS5120	WIRE,BUS,AWG 20,QQ-W-343E	QQW343S20S23	81348	2.0	IN
40	FS5127	WIRE,BU,TWSTD SHIELDED #W	AWG 24,PAIR#	81349	15.0	IN
42	FS5128	WIRE,COAX,RG174/U	RG174/U	81349	15.0	IN
44	FS4001	THERMAL COMPOUND	351	13103	.1	OZ
48	FS1011	SCREW,PNH,S/S,4-40X1/4	MS51957-13	96906	2.0	EA
49	FS1018	SCREW,PNH,S/S,4-40X1/2	MS51957-17	96906	12.0	EA
50	FS1020	SCREW,PNH,S/S,4-40X5/8	MS51957-18	96906	2.0	EA
54	FS1068	WASHER,INTER,S/S,#4	MS35333-70	81349	16.0	EA
55	FS1076	WASHER,EXTER,S/S,#4	MS35335-57	81349	5.0	EA
58	FS1066	NUT,HEX,S/S,4-40	MS35649-244	96906	3.0	EA
59	210155	INSULATOR,MICA,.25X.75	MW-750-255	08289	1.0	EA

PARENT ITEM NO. DESCRIPTION PC ASSY,POWER SUPPLY
4053-701-1 ENGR DRAW 4053-701 REV C2

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NUMBER	VENDOR	QTY	UM
CR1	310167	DIODE,RECT,(USE 310221)	1N1186A	07716	1.0	EA
CR2	310192	DIODE,RECT,(USE 310257)	1N1186RA	07716	1.0	EA
CR3	310167	DIODE,RECT,(USE 310221)	1N1186A	07716	1.0	EA
CR4	310192	DIODE,RECT,(USE 310257)	1N1186RA	07716	1.0	EA
CR5	310173	DIODE,ZNR,16V,.5W,5%	1N5246B	04713	1.0	EA
CR6	310173	DIODE,ZNR,16V,.5W,5%	1N5246B	04713	1.0	EA
C1	610129	CAP,CER,.1UF,50V	CK104	71590	1.0	EA
C2	610129	CAP,CER,.1UF,50V	CK104	71590	1.0	EA
Q1	330075	TRANSISTOR,SS,NPN,TO39	2N2102	81349	1.0	EA
Q2	330106	TRANSISTOR,SS,PNP,TO39	2N4036	04713	1.0	EA
R1	530068	RES,CARB,1W,47 OHM	RC32GF470J	81349	1.0	EA
R2	530068	RES,CARB,1W,47 OHM	RC32GF470J	81349	1.0	EA
R3	530005	RES,CARB,1W,100 OHM	RC32GF101J	81349	1.0	EA
R4	510058	RES,CARB,1/4W,1.8K OHM	RC07GF182J	81349	1.0	EA
R5	510058	RES,CARB,1/4W,1.8K OHM	RC07GF182J	81349	1.0	EA
R6	530005	RES,CARB,1W,100 OHM	RC32GF101J	81349	1.0	EA
TP1	241089	TEST JACK,PC,DBL ENT,BRN	430-108	83330	1.0	EA
TP2	241085	TEST JACK,PC,DBL ENT,RED	430-102	83330	1.0	EA
TP3	241086	TEST JACK,PC,DBL ENT,ORN	430-106	83330	1.0	EA
TP4	241087	TEST JACK,PC,DBL ENT,YEL	430-107	83330	1.0	EA
TP5	241090	TEST JACK,PC,DBL ENT,GRN	430-104	83330	1.0	EC
2	160130	PWB,POWER SUPPLY	4053-701-7	16067	1.0	EA
37	241050	HEATSINK,TO5	I207-C8	05820	2.0	EA
38	240296	SOCKET,XSTR,TO-5	RCT05075-7A	19080	2.0	EA
39	210399	HEATSINK,DO10	HP3-TO15-8	98978	4.0	EA
40	110264	BRACKET,ANGLE	631	91833	1.0	EA
44	FS2003	LUG,RING,CRIMP,8-10	R30313F	14726	12.0	EA
45	FS2013	LUG,RING,CRIMP,8-1/4	R30329F	14726	4.0	EA
48	FS1080	WASHER,FLAT,S/S,#6	MS15795-806	81349	4.0	EA
49	FS1030	SCREW,PNH,S/S,6-32X3/8	MS51957-28	81349	6.0	EA
50	FS1069	WASHER,INTER,S/S,#6	MS35333-71	81349	6.0	EA
51	FS1064	NUT,HEX,S/S,6-32	MS35649-264	81349	6.0	EA
56	FS3000	GROMMET,STRIP,.052	CSG-06-NATURAL	95987	3.0	IN
57	FS5003	WIRE,DU,MIL-W-16878/4	AWG 8,WHT	81349	20.0	IN

PARENT ITEM NO. 4053-702-1   DESCRIPTION PC ASSY,SW/METER RANGE   ENGR DRAW 4053-702-1

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NUMBER	VENDOR	QTY	UM
CR1	310118	DIODE,SWNG,75V,.5W,DO35	1N914	07263	1.0	EA
CR2	310118	DIODE,SWNG,75V,.5W,DO35	1N914	07263	1.0	EA
CR3	310118	DIODE,SWNG,75V,.5W,DO35	1N914	07263	1.0	EA
CR4	310118	DIODE,SWNG,75V,.5W,DO35	1N914	07263	1.0	EA
R1	510071	RES,CARB,1/4W,6.2K OHM	RC07GF622J	81349	1.0	EA
R2	560146	RES,FILM,1/4W,200K,1%	RN60C2003F	81349	1.0	EA
R3	570132	POT,MT,PC,5K,1/4W,20%	ET34X502	30983	1.0	EA
R4	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
S1	240422	SWITCH,RTRY,DP,5P,1 SECT	T206	71450	1.0	EA
2	160158	PWB,SWITCH/METER RANGE	4053-702-7	16067	1.0	EA

Appendix A

Number	Vendor Name	City	State
0000A	Electrimend	Westfield	PA
0000C	Jackson Bros.	Weedon, Surrey	GB
0000F(28964)	OPCOA (Pulse Elect. Corp.)	Wineland	CT
0000W	Allison Ross Co.	Southampton	PA
0000E(52245)	Timco	Los Angeles	CA
000AC	Itac	Santa Clara	CA
000AD(55112)	Plessey (Westlake Cap. Inc.)	Westlake Village	CA
000AG	LaFrance	Philadelphia	PA
000AH(50161)	Jan Crystal	Ft. Myers	CA
000AL(33695)	Data Components, Inc.	Gardena	CA
000AM	Evans & Rotmer	Santa Monica	CA
000AN	Bitz Instrument Transformer	[illegible] Beach	CA
000AS	Switches Incorporated	Mt. View	CA
000AT(83043)	United Chemi-Con	Rosemont	IL
000AU	JMJ Technical Prod. Inc.	[illegible] Park	NJ
000AV(61837)	Semi Processes, Inc.	San Jose	CA
000AW	Mitsea	Chatsworth	CA
000AX(63858)	Aptronics	Mentor	OH
000AY	Silicon Power Cube Corp.	Long Beach	CA
000AZ(65271)	Fujitsu	Santa Clara	CA
000BA(61946)	Omron Electronics, Inc.	Schaumburg	IL
000BB	Hollmark Metals, Inc.	Glendora	CA
000BC	Toshiba America, Inc.	Tustin	CA
000BD(55993)	Electronic Concepts	Woodside	NY
000BE(37856)	Seiham	Eldon	MO
000BF(33205)	Bergquist	Minneapolis	MN
000BG	Panasonic	Secaucus	NY
000BH	Century Components	Canyon Country	CA
000BI(54158)	Micro Power Systems	Santa Clara	CA
000BJ(06776)	Seminole Magnet	New Albany	IN
000BK(13150)	Beau Products (Vernitron)	Laconia	NH
000BM(31725)	Corrwinder (Corrard AJ & Co.)	Des Plaines	IL
000BO	Mitsubishi Electronics Amer.	Sunnyvale	CA
000BP	Silicon Power Cube	Long Beach	CA
000BR	Secme	Baguetos	France
000BS	Panel Components Corp.	Santa Rosa	CA
00544	Metal-Cal Div., Avery Prod.	Inglewood	CA
00779	AMP Inc.	Harrisburg	PA
00853	Sangamo Electronic Co.	Pickens	SC
00946	Coe Eng. Co., Inc.	City of Industry	CA
01002	G.E. Co., Ind. & Pwr. Cap. Dept.	John St., Hudson Falls	NY
01121	Allen-Bradley Co.	Milwaukee	WI
01139	G.E. Co., Silicone Prod.	Waterford	NY
01295	Texas Instruments	Dallas	TX
01961	Pulse Engineering, Inc.	San Diego	CA
02111	Spectrol Electronics	City of Industry	CA
02113	Coilcraft, Inc.	Cary	IL
02335	Fairchild Controls Corp.	Hicksville, LI	NY
02375	American Insulating Mach. Co.	Philadelphia	PA
02538	Texas Electronics Co.	Dallas	TX
02660	Amphenol Corporation	Broadview	IL
02768	Illinois Tool Works, Inc.	Des Plaines	IL
02799	Use Code 172136		
03507	General Electric Company	Syracuse	NY
03508	General Electric Company	Syracuse	NY
03797	Eldema Corporation	Compton	CA
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls	NJ
03911	Clairex Corporation	New York	NY
04009	Arrow-Hart and Hegeman Elec.	Hartford	CT
04099	Capco, Inc.	Grand Junction	CO
04713	Motorola Semiconductor Prod.	Phoenix	AZ
04729	Universal Components Corp.	Green Brook	NJ
04963	3-M	St. Paul	MN
05245	Corcom Inc.	Chicago	IL
05276	Pomona Electronics, Inc.	Pomona	CA
05397	Kemet, Union Carbide Corp.	Cleveland	OH
05791	Lyn-Tron, Inc.	Burbank	CA
05820	Wakefield Engineering, Inc.	Wakefield	MA
05972	Loctite Corp.	Newington	CT
06383	Panduit Corp.	Tinley Park	IL
06514	Stanton, Wyco Metal Prod.	N. Hollywood	CA
06540	Amatom Elect. Hardware	New Rochelle	NY
06665	Precision Monolithics Inc.	Santa Clara	CA
06776	Robinson Nugent, Inc.	New Albany	IN
06915	Richco Plastics Co.	Chicago	IL
07088	Kelvin Electric Company	Van Nuys	CA
07263	Fairchild Camera & Instr.	Mt. View	CA
07387	Birtcher Corporation	Los Angeles	CA
07556	Unitrack Calabro Plastics	Upper Darby	PA
07633	Epoxy Prod. Co., Allied Prod. Corp.	New Haven	CT
07707	USM Corp. (USM Fastener Div)	Shelton	CT
07716	IRC Incorporated	Burlington	IA
07910	Use Code 015818		
08029	Loctite (Auto & Consumer Grp)	Mtn View	CA
08057	Spang Ind. (Magnetics Div)	Sandy Lake	PA
08065	Accurate Rubber and Plastics	San Diego	CA
08261	Spectra Strip (Amphenol)	Garden Grove	
08289	Blinn Delbert Co.	Pomona	CA
08353	Bristol Co. of Canada	Toronto, Ont	Canada
08730	Oshby & Sectmm (Vemaline Prod. Div.)	Norwich	RI
08779	Signal Transformer	Brooklyn	NY
09214	GE (Semiconductor Prod. Div)	Auburn	NY
09353	C & K Components	Newton	MA
09922	Burndy Corp.	Norwalk	CT
10389	Chicago Switch	Chicago	IL
11815	Cherry/Textron (Fastener Div)	Santa Ana	CA
12406	Elpac Electronics	Santa Ana	CA
12697	Clarostat Mfg.	Dover	NH
13103	Thermalloy Company	Dallas	TX
13150	Vernitron Corp (Beau Prod.)	Laconia	NH
13604	Sperry Corp. Elec. Systems	Great Neck	NY
13919	Burr-Brown	Tucson	AZ
14099	Semtech Corporation	Newbury Park	CA
14604	Elmwood Sensors Inc.	Cranston	RI
14655	Cornell-Dubilier Elect. Corp.	Newark	NJ
14726	Hollingsworth Co.	Phoenixville	PA
14752	Electro Cube, Inc.	San Gabriel	CA
14908	Electronic Instrument and Specialty Corp.	Stoneham	MA
15238	ITT Semiconductors	Lawrence	MA
15454	Amecom Inc (Baden Div)	Anaheim	CA
15476	Elec-trol	Northridge	CA
15801	Fenwal Electronics	Framingham	MA
15818	Amelco Teledyne, Inc.	Mt. View	CA
15912	Ansley	Los Angeles	CA
16067	California Instruments Co.	San Diego	CA
16758	Delco Radio Div., Gen. Mtrs.	Kokomo	IN
16956	Dennison	Framingham	MA
17856	Siliconix, Inc.	Santa Clara	CA
18076	Umaco	City of Industry	CA
18178	Vactec, Inc.	Maryland Heights	MO
18310	Concord Electronics Corp.	New York	NY
18324	Signetics	Sunnyvale	CA
18612	Vishay Instruments, Inc.	Malvern	PA
18677	Scanbe Mfg. Co. (Zero Corp.)	Monterey Park	CA
18722	RCA	Mountaintop	PA
18736	Voltronics Corp.	Hanover	NJ
19888	Robison Company	Hawthorne	CA
21604	Buckeye Stamping Company	Columbus	OH
21845	Solitron Devices (Semi-conductor Group)	Riviera Beach	FL
22599	Elastic Stop Nut Corp.	Van Nuys	CA
23096	Product Components Corp.	Hastings-on-Hudson	NY
23936	Pamotor, Inc.	San Francisco	CA
24011	TCC	Burlington	MA
24355	Analog Devices, Inc.	Norwood	MA
24444	General Semiconductor Ind.	Tempe	AZ
24796	Ferroice, Inc.	Paramount	CA
24931	Specialty Connector Co., Inc.	Greenwood	IN
24972	AEG-Telefunken Corp.	Somerville	NJ
25403	Amperex Electronic Corp.	Slatersville	RI
25497	Meter Master	Los Angeles	CA
26482	Marathon Electric Mfg. Corp.	Bowling Green	OH
26806	American Zettler, Inc.	Costa Mesa	CA
27014	National Semi-Conductor Crp.	Santa Clara	CA
27191	Cutler-Hammer, Inc.	Milwaukee	WI
27264	Molex	Downers Grove	IL
27335	B & B Motor & Control Corp.	New York	NY
27556	IMB Electronic Products	Santa Fe Springs	CA
27683	Vero, Inc.	Garland	TX
27735	F-Dyne Electronics	Bridgeport	CT
27832	Hughes Aircraft	Newport Beach	CA
28480	Hewlett-Packard Co.	Palo Alto	CA
28520	Heyman Mfg. Company (Heyco)	Kenilworth	NJ
28604	Ecolia Ltd.	Rexdale Ont.	Canada
29372	Bernard Inc. Trident Ind.	Torrance	CA
29593	Bussco Eng. Inc.	El Segundo	CA
30035	International Components Crp.	Asbury Park	NJ
30161	Aavid Engineering, Inc.	Laconia	NH
30897	Omeron Company	Irvine	CA
30983	Electro/Midland (Aepco/Electrol)	San Diego	CA
31077	Bodine Mfg. Co.	Pomona	CA
31951	Trilridge, Inc.	Pittsburg	PA
32293	Intersil	Cupertino	CA
32559	Bivar, Inc.	Santa Ana	CA
32997	Bourns Inc. (Trimpot Div)	Riverside	CA
33095	Jewell Electrical Inst. Inc.	Manchester	NH
33135	Lomis Dynamics, Inc.	Gardena	CA
33716	Einzenbacher Metrav Co.	Los Angeles	CA
33855	Ovenmaker, Inc.	Los Angeles	CA
33901	Caliber Corp.	Irvington	NJ
34238	Mills Resistor Co.	Los Alamitos	CA
34333	Silicon General	Westminster	CA
34649	Intel Corporation	Santa Clara	CA
35407	Aerovox Canada Ltd.	Amherst NS	Canada
35964	Linear Technology, Inc.	Burlington, Ont	CAN
36455	Ohmite Manufacturing Co.	Skokie	IL
45722	Parker-Kalon	Clifton	NJ
46384	Penn. Eng. and Mfg. Corp.	Doylestown	PA
50157	Midwest Components, Inc.	Muskegon	MI
50322	[illegible], Electronic Special Products	Cupertino	CA
50558	Electronic Concepts, Inc.	Eatontown	NJ
50811	Newcon Corp.	Santee	CA
51167	Aries Electronics, Inc.	Frenchtown	NJ
51506	Accurate Screw Machine Co.	Nutley	NJ
51705	ICO/Rally	Palo Alto	CA
52072	Circuit Assembly Corp.	Costa Mesa	CA
52763	Timco	Los Angeles	CA
53076	Kintex, Inc.	Buffalo	NY
53495	Data Components, Inc.	Gardena	CA
54361	Edwards Sheet Metal Works	Fredericktown	OH
54607	Power-One Co.	Camarillo	CA
55322	Samtec, Inc.	New Albany	NY
55566	RAF Electronic Hardware, Inc.	Seymour	CT
56289	Sprague Electric Company	North Adams	MA
56637	RCD Components, Inc.	Manchester	NH
57640	United Chem-Con Corp.	Philadelphia	PA
57856	Kol-Am, Inc.	Eldon	MO
58474	Superior Electric Company	Bristol	CT
59730	Thomas and Betts Company	Elizabeth	NJ
59993	International Rectifier Semiconductor Div.	El Segundo	CA
60395	Xicor, Inc.	Milpitas	CA
61394	Seeq Technology, Inc.	San Jose	CA
61641	Saronix	Palo Alto	CA
61529	Aromat Corp.	Mountainside	NJ
61735	Pulse Engineering, Inc.	College Park	MD
62483	Densitron Corp. of America	Torrance	CA
62643	United Chemicon, Inc.	Rosemont	IL
62786	Hitachi America Ltd.	San Jose	CA
63743	Ward Leonard Electric Co.	Mt. Vernon	NY
63791	Star Electronics, Inc.	New York	NY
70318	Allmetal Screw Prod. Co.	Garden City	NY
70903	Belden Manufacturing Co.	Chicago	IL
71218	Bud Industries, Inc.	Willoughby	OH
71279	Cambridge Thermionic Corp.	Cambridge	MA
71400	Bussmann Mfg. Div. McGraw-Edison Co.	St. Louis	MO
71450	CTS Corporation	Elkhart	IN
71468	ITT Cannon Electric, Inc.	Los Angeles	CA
71590	Centralab Div. Globe-Union	Milwaukee	WI
71707	Coto-Coil	Providence	RI
71744	Chicago Miniature Lamp Works	Chicago	IL
71785	Cinch Manufacturing Company	Chicago	IL
71984	Dow Corning Corp.	Midland	MI
72136	Elmenco (Electro Motive)	Willimantic	CT
72619	Dialight Corporation	Brooklyn	NY
72699	General Instruments	Newark	NJ
72982	Erie Technological Prod. Inc.	Erie	PA
73138	Beckman Instruments, Inc.	Fullerton	CA
73613	Consolidated Electronic Wire and Cable Corp.	Chicago	IL
73734	Federal Screw Products, Inc.	Chicago	IL
74193	Heinemann Electric Company	Trenton	NJ
74545	Harvey Hubbell, Inc.	Bridgeport	CT
74840	Illinois Condenser Co.	Chicago	IL
74970	E.F. Johnson Company	Waseca	MN
75042	TRW Electronic Components	Philadelphia	PA
75382	Kulka Electric Corporation	Mt. Vernon	NY
75582	Leviton Mfg. Co.	Little Neck	NY
75915	Littelfuse, Inc.	Des Plaines	IL
76385	Minor Rubber Co., Inc.	Bloomfield	NJ
77062	Poost Eng. Equipment Co.	Elizabeth	NJ
77132	United-Carr Inc., Fetvin Div	Waterbury	CT
77342	Potter and Brumfield Div. AMF	E. Princeton	IN
78189	Shakeproof Div. IL Tool Works	Chicago	IL
78553	Tinnerman Products, Inc.	Cleveland	OH
79130	Johns-Manville Products Corp	Chicago	IL
79136	Waldes Kohinoor Inc.	Long Island City	NY
79963	Zierick Mfg. Corp.	New Rochelle	NY
80031	Mepco/Electra	Morristown	NJ
80223	United Transformer Co.	New York	NY
80294	Bourns, Inc.	Riverside	CA
80495	High Voltage Engineering Corp (Anderson Pwr Prod. Div)	Brighton	MA
81095	Triad Transformer Corp.	Venice	CA
81312	Winchester Electronics	Oakville	CT
81348	(Fed. Specs) Promulgated by General Services Administration Washington DC		
81349	Military Specification or Commercial Generic Number		
81541	Airpax Corp.	Cambridge	MD
81603	Reco Products Co.	Chicago	IL
81891	Bentley-Harris Mfg Co.	Lionville	PA
82104	Standard Grigsby	Aurora	IL
82389	Switchcraft, Inc.	Chicago	IL
82877	Rotron Mfg. Co., Inc.	Woodstock	NY
82893	Vector Electronics, Inc.	Sylmar	CA
83330	Herman H. Smith, Inc.	Brooklyn	NY
83486	Elco Tool & Screw Corp.	Rockford	IL
85480	Brady W.H. Co.	Milwaukee	WI
86684	RCA	Harrison	NJ
86928	Seastrom Mfg. Co., Inc.	Glendale	CA
87034	Marco-Oak Industries	Anaheim	CA
88245	Useco Div., Litton Ind.	Van Nuys	CA
90201	Mallory Capacitor Co.	Indianapolis	IN
91506	Augat, Inc.	Attleboro	MA
91637	Dale Electronics, Inc.	Columbus	NE
91662	Elco Corporation	Willow Grove	PA
91802	Industrial Devices, Inc.	Edgewater	NJ
91833	Keystone Electronics Corp.	New York	NY
91967	National Tel-Tronics	Meadville	PA
92194	Alpha Wire Corp.	Elizabeth	NJ
93383	Pentagon Products Co.	Washington	DC
94222	Southco, Inc.	Lester	PA
94696	Magnecraft Electric Co.	Chicago	IL
95146	Alco Electronic Prod., Inc.	No. Andover	MA
95303	RCA	Cincinnati	OH
95354	Methode Manufacturing Corp.	Rolling Meadows	IL
95566	Arnold Engineering Co.	Marengo	IL
95987	Woodhead Company, Inc.	Chicago	IL
96906	Military Std		
97525	Electronic Engineering Co.	Santa Ana	CA
98159	Rubber Tech. Inc.	Gardena	CA
98291	Sealectro Corp.	Mamaroneck	NY
98376	Zero Mfg. Co. (West)	Burbank	CA
98978	IERC	Burbank	CA
99017	Protective Closures Co., Inc. (Caplugs Div)	Buffalo	NY
99217	Bell Industries, Inc.	Delevan	NY
99742	Permacoil	New Brunswick	NJ
99763	IMC	Hayward	CA
99800	Delevan Electronics Corp.	Aurora	NY

ONE YEAR WARRANTY

CALIFORNIA INSTRUMENTS, Division of Amstar Technical Products Company, Inc., warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are tubes, fuses, and batteries which carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS will service, replace, or adjust any defective part or parts, free of charge, when the instrument is returned freight prepaid, and when examination reveals that the fault has not occurred because of misuse, abnormal conditions of operation, user modification, or attempted user repair. Equipment repaired beyond the effective date of warranty or when abnormal usage has occurred will be charged at applicable rates. CALIFORNIA INSTRUMENTS will submit an estimate for such charges before commencing repair, if so requested.

PROCEDURE FOR SERVICE

If a fault develops, notify CALIFORNIA INSTRUMENTS or its local representative, giving full details of the difficulty, and including the model number and serial number. On receipt of this information, service data or a Return Material Authorization (RMA) number will be given. Fill in RMA No. blank on shipping label attached opposite these instructions, pack instrument carefully to prevent transportation damage, affix label to shipping container, and ship freight prepaid to the factory. CALIFORNIA INSTRUMENTS shall not be responsible for repair of damage due to improper handling or packing. Instruments returned without RMA No., or freight collect, will be refused. Instruments repaired under Warranty will be returned by prepaid surface freight. Instruments repaired outside the Warranty period will be returned freight collect, F.O.B. CALIFORNIA INSTRUMENTS, San Diego, CA. If requested, an estimate of repair charges will be made before work begins on repairs not covered by the Warranty.

DAMAGE IN TRANSIT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed immediately with the carrier. A full report of the damage should be obtained by the claim agent, and a copy of this report should be forwarded to us. CALIFORNIA INSTRUMENTS will prepare an estimate of repair cost, and repair the instrument when authorized by the claim agent. Please include model number and serial number when referring to the instrument.