CALIFORNIA INSTRUMENTS
a division of
AIKEN INDUSTRIES, INC.

Revision B
September 1977

INSTRUCTION MANUAL

MODEL 1503T

AC POWER SOURCE

SOLID STATE *Invertron*®

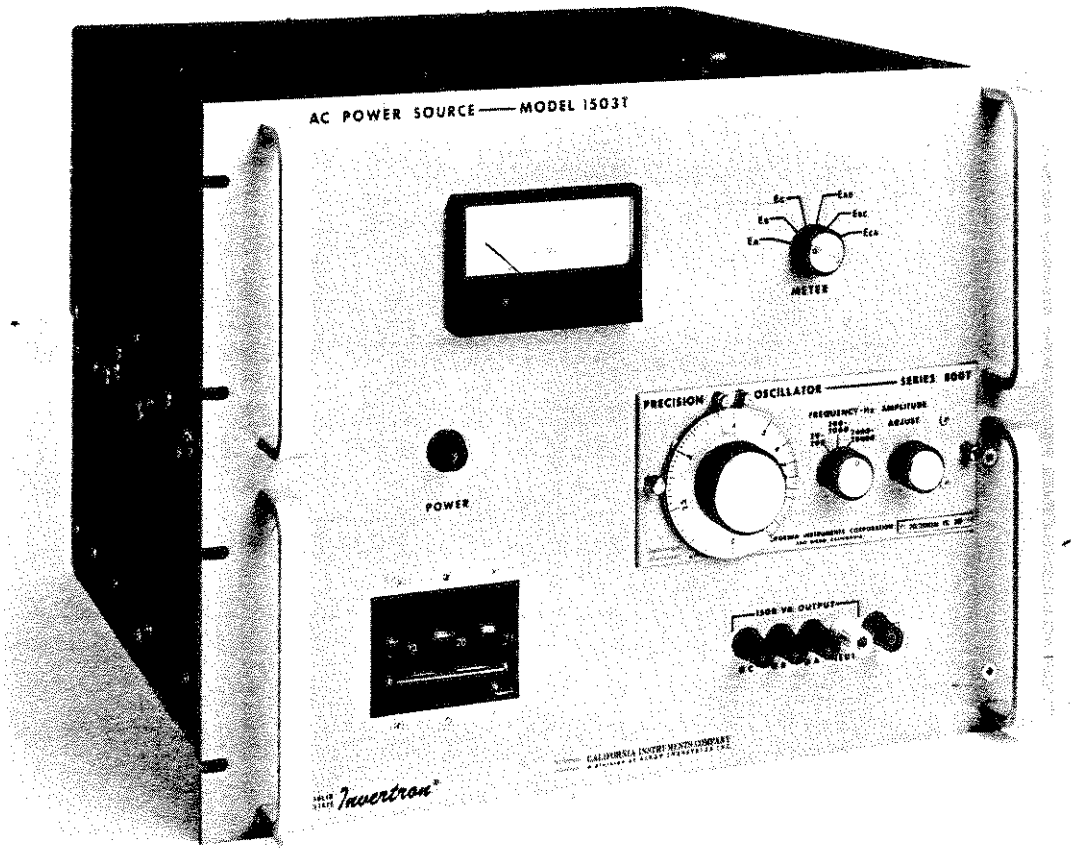

FIGURE 1-1

LIST OF ILLUSTRATIONS

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WARNING

If at any time, during the performance of this procedure, the possibility exists to come in contact with exposed live hazardous voltage (voltage over 50 volts and 30 milliamps); the following precautions must be taken.

During the portion of the procedure where this possibility exists, appropriate PPE (Personnel Protective Equipment) must be used. Appropriate PPE includes insulating gloves, and/or insulated tools, and/or insulating and shielding materials. This is to prevent personnel from coming in contact with the exposed live hazardous voltage. PPE must have a voltage safety rating that exceeds the voltage being worked with.

SPECIFICATIONS

MODEL 1503T 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 generated from an 800T series oscillator.

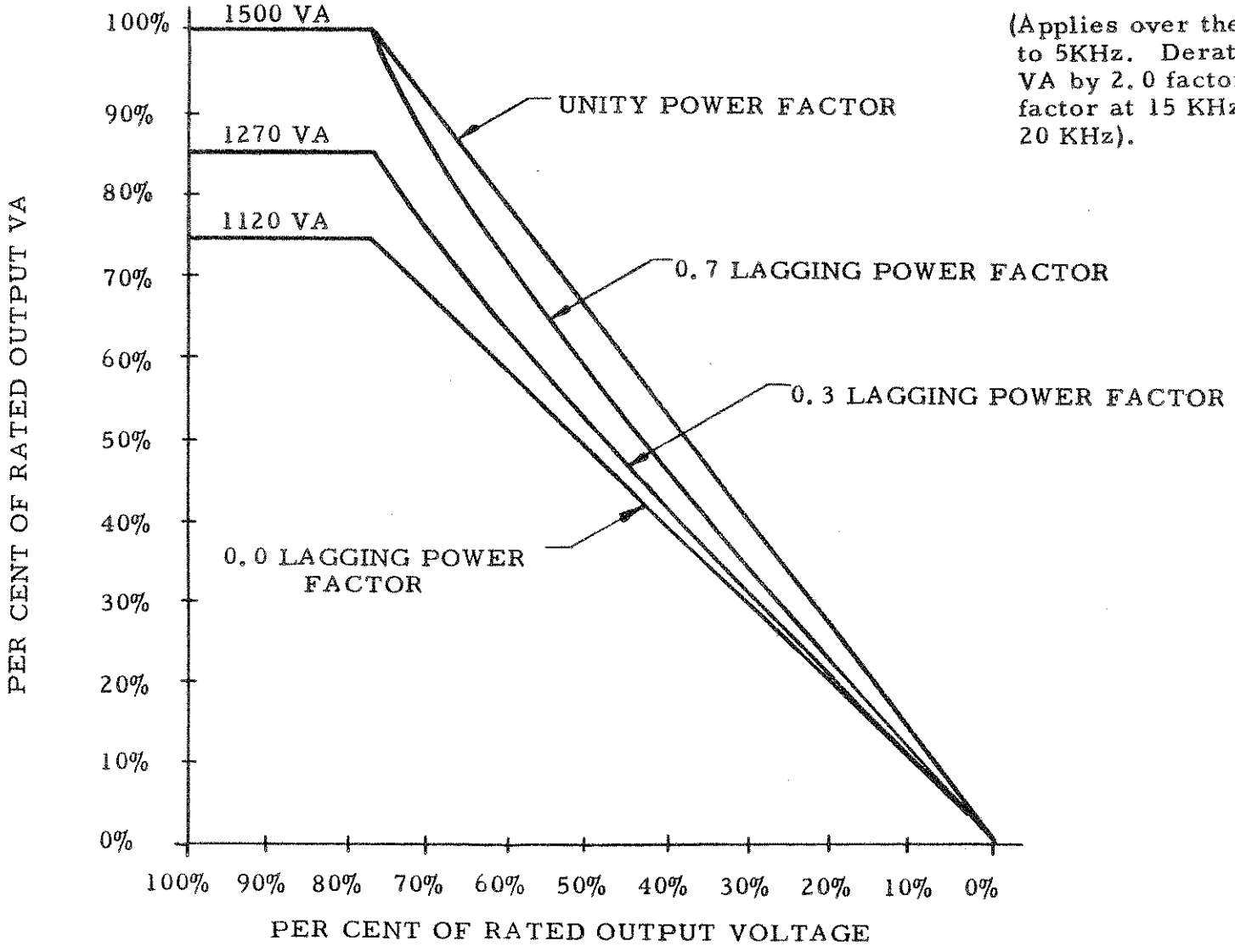
POWER OUTPUT:	1500 VA three phase at 105 to 135 volts rms line-to-neutral from unity to ± 0.7 power factor. See derating chart for operation at other output voltages and/or power factor.
OUTPUT VOLTAGE RANGES: (Normally wired for a 0 to 135 volt line-to-neutral three phase output but may be wired for either range, if requested at the time of shipment.)	0 to 75 volts rms line-to-neutral. (0 to 130 volts rms line-to-line). 0 to 135 volts rms line-to-neutral. (0 to 234 volts rms line-to-line).
TOTAL HARMONIC DISTORTION:	Less than 0.30% distortion from 200 Hz to 1 KHz; less than .75% distortion from 45 Hz to 5 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 2 KHz and ± 3% over the range from 45 Hz to 5 KHz when tested at unity power factor. In addition, an internal load regulation adjustment permits the regulation of each phase to be adjusted to zero at any given line voltage, signal frequency and load conditions. Control resolution is 0.1%.
LINE REGULATION:	± 0.25% of full output for a ± 10% line change.
*FULL POWER FREQUENCY RANGE:	45 Hz to 5 KHz.

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

FREQUENCY RESPONSE:	±0.5 dB from 45 Hz to 5 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:	208 volts L-L three phase, three wire. Unit may be wired for the following three phase three wire voltages on special order: 220 VAC, 230 VAC, 416 VAC, 440 VAC or 460 VAC. Also the unit may be wired for three phase, four wire operation from 380 volts L-L.
AC INPUT FREQUENCY:	48 to 65 Hz. (400 Hz available on special order).
AC INPUT CURRENT:	15 amperes rms per line maximum under high line and full rated load conditions from the 208 volt three phase 60 Hz AC line. 16 amperes rms per line maximum under high line and full rated load conditions from the 208 volt three phase 50 Hz AC line.
OPERATING TEMPERATURE RANGE:	0 to 55°C.
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 5 KHz and may be switched to monitor any line-to-neutral or line-to-line voltage.
DIMENSIONS:	14" high x 19" wide x 21" deep.
NET WEIGHT:	200 lbs.
SHIPPING WEIGHT:	215 lbs.
FRONT PANEL FINISH:	Grey, 26440 per Federal Standard 595 with black silk-screened lettering.

DERATING CHART FOR
1503T THREE
PHASE POWER AMPLIFIER

(Applies over the range from 45 Hz to 5KHz. Derate curve for output VA by 2.0 factor at 10 KHz, 3.0 factor at 15 KHz, and 4.0 factor at 20 KHz).



1.1 INTRODUCTION

This instruction manual contains information on the installation, operation, calibration and maintenance of the California Instruments Model 1503T 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 1503T is a solid state, high performance, low distortion power source that provides up to 1500 VA three phase power when used with the proper California Instruments oscillator. The Model 1503T Three Phase Power Source is illustrated in Figure 1-1. Full power output is available in two 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) 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 500 VA per phase (1500 VA total).

2) 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 500 VA per phase (1500 VA total).

The serial number tag, located on the rear of the Model 1503T Power Source, indicates the output voltage range which the unit is wired for at the time of shipment.

Two of the three power amplifiers may be combined with the applicable plug-in oscillator to provide 1000 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 500 VA power amplifiers may be used independently of one another by removing the three jumper strips on 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 1503T 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 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-20/20K-1-3ϕ. Calibration accuracy is ±1 per cent at 25°C and amplitude stability is 0.25 per cent per 24 hours at 25°C. The total harmonic distortion is less than 0.25 per cent 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.

1.3.3 Series 810T Fixed Frequency Oscillators. These 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 810T-Freq-.1-1ϕ, two phase oscillators are designated as 810T-Freq-.1-2ϕ and three phase oscillators are designated as 810T-Freq-.1-3ϕ. Frequency accuracy is ±0.1 per cent at 25°C. Amplitude stability is ±0.01 per cent per 24 hours at 25°C and varies less than .0025 per cent per degree centigrade. Harmonic distortion is less than 0.1 per cent from 45 Hz to 5 KHz.

1.3.4 Series 812T Open Delta Servo Oscillators. These oscillators provide a three phase output for driving two Invertron® power sources in an open delta configuration. The Model 812T oscillator contains two amplitude servos and one angle servo to provide a closed loop three-phase AC power system with ±0.01% line and load regulation. Units normally incorporate three front panel selectable output frequencies of 50, 60 and 400 Hz. The system output voltage can be varied from 110 to 120 volts with ±0.1 per cent amplitude tracking and less than 0.25 per cent system distortion. Crystal controlled versions of this oscillator are available on special order.

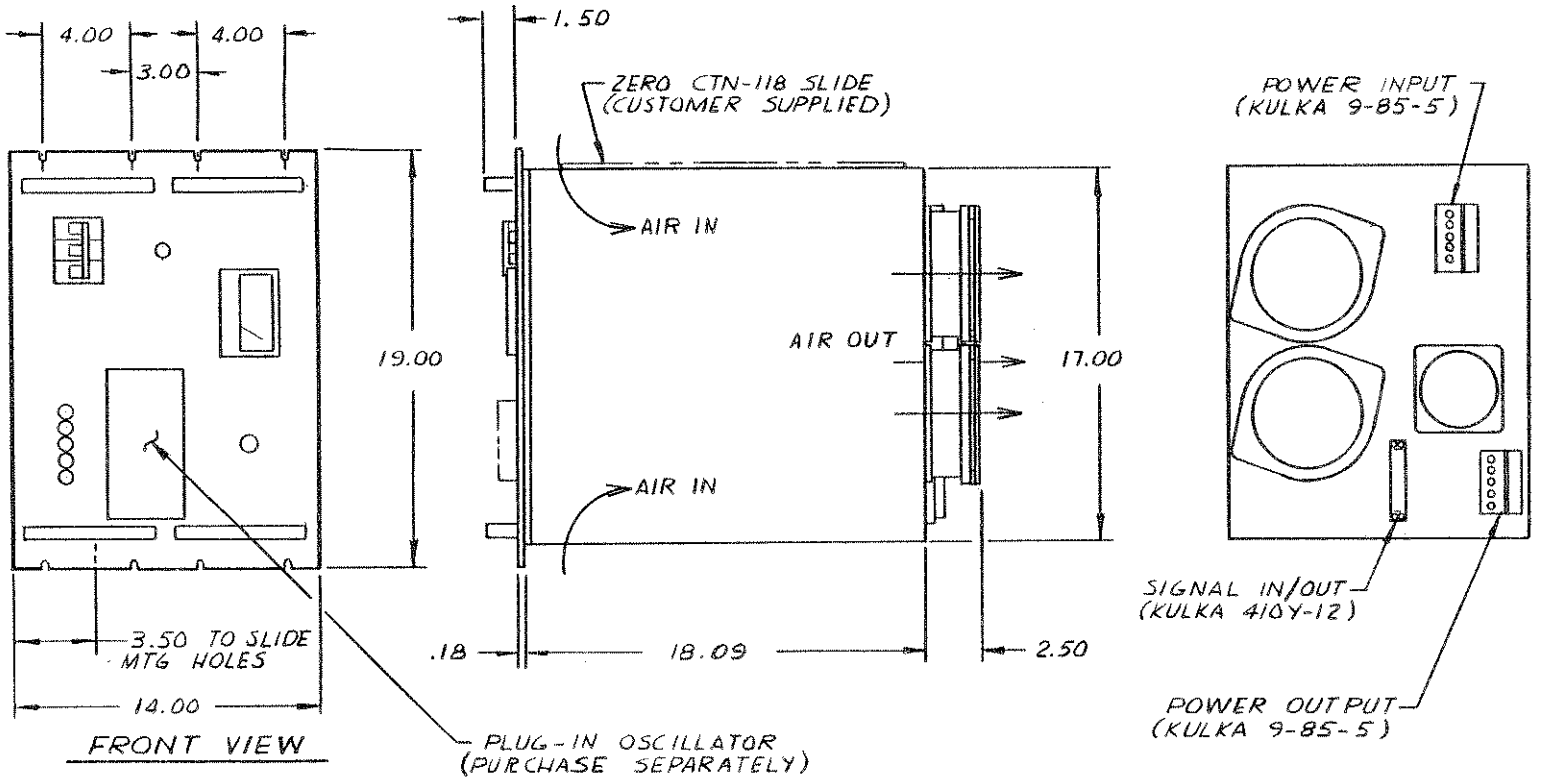
1.3.5 Series 815T Fixed Frequency Oscillators. These low-cost fixed frequency oscillators provide one phase, two phase or three phase outputs over the range from 45 Hz to 10 KHz. Units with single phase output are designated as 815T-Freq-.1-1ϕ, two phase oscillators are designated as 815T-Freq-.1-2ϕ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

1.3.6 Series 820T Fixed Frequency Crystal Oscillators. These oscillators provide one phase, two phase or three phase outputs over the range from 45 Hz to 20 KHz. Units with single phase output are designated as 820T-Freq-Accuracy-1ϕ, two phase oscillators are designated as 820T-Freq-Accuracy-2ϕ and three phase oscillators are designated as 820T-Freq-Accuracy-3ϕ. Frequency accuracy is ±0.01 per cent or ±0.0001 per cent. Amplitude stability is ±0.25 per cent per 24 hours at 25°C. The total harmonic distortion is less than 0.15 per cent from 45 Hz to 5 KHz.

1.3.7 Series 830T Programmable Oscillators. These oscillators provide one phase, two phase or three phase outputs over the range from 45 Hz to 9.99 KHz. These units are packaged in a separate 5 1/4 inch package which may be mounted below/above the associated power amplifier.

1.3.8 Series 840T Programmable Oscillators. These plug-in oscillators provide one phase, two phase or three phase output at 380, 400 and 420 Hz. Frequency accuracy is ±0.1 per cent of programmed value. Servo feedback is taken from the output of each phase back to the 840T programmable plug-in oscillator and provides an accuracy of ±0.1 per cent of programmed value.

REVISIONS						
REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD



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

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

BREAK ALL SHARP CORNERS & EDGES
MACH SURFACES ✓

DWG SIZE: C

TITLE: OUTLINE DRAWING, 1500VA, 3Ø POWER SOURCE

MODEL: 1503T

DASH NO.	QTY REQD	NEXT ASSEMBLY	EFF ON	AUTH

RELEASE
CHECKER — PURCHASING
DESIGN — PROJ ENGR
DRFTSMN MARTIN M 8/3/71 — CHF ENGR

CALIFORNIA INSTRUMENTS CORP.
SAN DIEGO, CALIFORNIA

CONTRACT NO. — CODE IDENT 16067

DWG NO. C4153-900 — REV -

SCALE 1:4 — SHEET 1 OF 1

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

NOTES: (UNLESS OTHERWISE SPECIFIED)

C4153-900 -

CAUTION

Voltages up to 480 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.

INSTALLATION AND OPERATION

2.1 UNPACKING

The California Instruments Model 1503T 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 is shipment.

2.2 POWER REQUIREMENTS

2.2.1 The Model 1503T Three Phase Power Source has been designed to operate from any one of the following AC line voltages. 208 volts, 220 volts, 230 volts, 380 volts, 416 volts, 440 volts or 460 volts, three phase. The power transformer is normally wired at the factory for operation from the 208 volt three phase three wire AC 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 except those to pins 1, 10, and 19. Connect CB1 phase "A" load terminal to T1-pin 2; connect CB1 phase "B" load terminal to T1-pin 20; connect CB1 phase "C" load terminal to T1-pin 11.

Nominal Input Voltage	Operating AC Line Voltage Range	Power Transformer Connections	Front Panel Circuit Breaker Value
208 volts L-L three phase, three wire.	190-226 volts L-L	Jumper pins 2, 6, 21 and 25; jumper pins 3, 7, 11, and 15; jumper pins 12, 16, 20 and 24.	20 ampere three phase, 250 volt circuit breaker.
220 volts L-L three phase, three wire.	201-239 volts L-L	Jumper pins 2, 6, 22 and 26; jumper pins 4, 8, 11 and 15; jumper pins 13, 17, 20 and 24.	20 ampere three phase, 250 volt circuit breaker.
230 volts L-L three phase, three wire.	210-250 volts L-L	Jumper pins 2, 6, 23 and 27; jumper pins 5, 9, 11 and 15; jumper pins 14, 18, 20 and 24.	20 ampere three phase, 250 volt circuit breaker.
380 volts L-L three phase, four wire.	347-414 volts L-L	Jumper pin 2 to 6; jumper pin 11 to 15; jumper pin 20 to 24; jumper pins 4, 8, 13, 17, 22 to 26 and connect to neutral of TB2 through #12 wire.	12 ampere three phase, 480 volt circuit breaker.

TABLE 2-1 cont.

Nominal Input Voltage	Operating AC Line Voltage Range	Power Transformer Connections	Front Panel Circuit Breaker Value
416 volts L-L three phase, three wire.	380-452 volts L-L	Jumper pin 2 to 25; jumper pin 3 to 6; jumper pin 7 to 11; jumper pin 12 to 15; jumper pin 16 to 20; jumper pin 21 to 24.	10 ampere three phase, 480 volt circuit breaker.
440 volts L-L three phase, three wire.	402-478 volts L-L	Jumper pin 2 to 26; jumper pin 4 to 6; jumper pin 8 to 11; jumper pin 13 to 15; jumper pin 17 to 20; jumper pin 22 to 24.	10 ampere three phase, 480 volt circuit breaker.
460 volts L-L three phase, three wire.	420-500 volts L-L	Jumper pin 2 to 27; jumper pin 5 to 6; jumper pin 14 to 15; jumper pin 23 to 24; jumper pin 9 to 11; jumper pin 18 to 20.	10 ampere three phase, 480 volt circuit breaker.

2.2.2 The Model 1503T 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 rms input current on the 208 volt L-L range, at rated output power, is between 10 amperes and 16 amperes per leg depending on line and load conditions. During "turn-on" the peak transient will generally exceed 20 amperes per leg.

2.3 CIRCUIT BREAKER REQUIREMENTS

The Model 1503T Power Source uses a 20 ampere Heinemann CF3-G3-U-20-240-3 circuit breaker for operation from the 208 through 230 volt three phase AC lines. A Heinemann CF3-G3-U-12-480-3 circuit breaker is used for operation from the 380 volt three phase four wire AC line. A Heinemann CF3-G3-U-10-480-3 circuit breaker is used for operation from the 416 through 460 volt three phase AC lines. Substitution of circuit breaker type or current rating may cause permanent damage to the unit.

2.4 OUTPUT VOLTAGE RANGE

The Model 1503T 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 the 75 volt L-N voltage range, 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 the 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 4153-070 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
58.5 to 75 volts rms line-to-neutral, three phase.	Jumper pins 7 and 9. Connect a 20 ohm 1.0 watt resistor from pin 6 to a 0.075 μfd 400 volt capacitor. Connect the other side of the capacitor to pin 10.	Connect T2 pin 6 to TB3 phase A; connect T3 pin 6 to TB3 phase B; connect T4 pin 6 to TB3 phase C; connect T2 pin 10 to TB3 neutral; connect T3 pin 10 to TB3 neutral; connect T4 pin 10 to TB3 neutral.
105 to 135 volts rms line-to-neutral, three phase.	Jumper pins 7 and 8. Connect a 68 ohm 1.0 watt resistor from pin 5 to a 0.022 μfd 600 volt capacitor. Connect the other side of the capacitor to pin 10.	Connect T2 pin 5 to TB3 phase A; connect T3 pin 5 to TB3 phase B; connect T4 pin 5 to TB3 phase C; connect T2 pin 10 to TB3 neutral; connect T3 pin 10 to TB3 neutral; connect T4 pin 10 to TB3 neutral.

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 Power Input (TB2) to a three phase 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 15KW three phase Variac and a 0 to 20 ampere meter in series with each leg of the three phase AC line. The Model 1503T Three Phase Power Source should draw less than 1.5 ampere per leg under no load conditions at mid-line voltage from the 60 Hz AC line. If a problem is encountered, perform step 4.3.2 of the CALIBRATION PROCEDURE.

2.6.2 Using a California Instruments 800T Series Multiphase Oscillator, set the oscillator to the desired frequency (between 45 Hz and 5 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)
75 volts rms, 3ϕ	11.2 ohms	22.4 ohms
135 volts rms, 3ϕ	36.4 ohms	72.8 ohms

2.6.4 Connect one end of three proper value 500 watt load resistors to each of the phase A, the phase B and the phase C outputs located on the large terminal board (TB3) on the rear of the 1503T Power Source. Connect the other end of each of the three load resistors to the neutral terminal of TB3 on the rear of the power source. Connect a Tektronix Model 533A Oscilloscope or equivalent across each of these three load resistors in turn.

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 rms input current line meters should indicate between 10 and 12 amperes per leg at 208 volts L-L input. 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. Remove the short circuit after a few seconds and check that the output automatically returns to normal. Repeat for the other two phases of the output. 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 1503T 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 fans 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 1503T Power Source will operate from three phase input voltages from 208 volts to 460 volts L-L in seven ranges as described in Section 2.2 of this manual. The power source should be used with 208 volt three phase lines with a capacity of 20 amperes or greater. If 380 to 460 volt AC lines are used, their capacity should be 12 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 1500 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
70 volts, 3ϕ	.70 volts	7.15 amperes	20 ft.	#16
115 volts, 3ϕ	1.15 volts	4.35 amperes	20 ft.	#21

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 three phase circuit breaker, located on the front panel of the Model 1503T 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 for operation in the region between 10 KHz and 20 KHz, derate the output voltage and output power according to Table 2-3 in order to provide reliable operation of the power source.

TABLE 2-3

Output Frequency	Maximum Safe Output Voltage (rms)		Maximum VA Output per phase at Maximum Safe Output Voltage with ± 0.7 Power Factor Load.
	75 Volt L-N Range	135 Volt L-N Range	
20 Hz	33.4 Volts L-N	60 Volts L-N	260 VA per phase.
30 Hz	50.0 Volts L-N	90 Volts L-N	410 VA per phase.
40 Hz	66.6 Volts L-N	120 Volts L-N	500 VA per phase.
45 Hz to 5 KHz	75 Volts L-N	135 Volts L-N	500 VA per phase.
10 KHz	37.5 Volts L-N	67.5 Volts L-N	145 VA per phase.
15 KHz	25.0 Volts L-N	45.0 Volts L-N	67 VA per phase.
20 KHz	18.7 Volts L-N	33.8 Volts L-N	35 VA per phase.

3.1 GENERAL

The California Instruments 1503T Three Phase Power Source consists of three identical 500 VA power amplifiers and with companion oscillator, is designed to provide reliable sine wave AC power over the frequency range from 45 Hz to 5 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 G2.

The power amplifier G2 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 pre-amplifier A1G1 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 4.3 from the input side of A1R4 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 A1R15. As this positive feedback is increased from zero with potentiometer A1R15, 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 75 volts or 135 volts output from line-to-neutral.

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

3.2 DETAILED CIRCUIT DESCRIPTION

A schematic diagram for the Model 1503T Three Phase Power Source is shown in drawing E4153-070 with the exception that the circuitry contained on the pre-amplifier (assembly A1) and power amplifier circuit boards (assembly A3, A4, A5, A7, A8, A9), and the plug-in oscillator. A schematic for the amplifier circuit board is given in drawing D4153-071 and a schematic diagram for the heatsink assemblies is shown in drawing D4153-072. For information on the plug-in oscillator, consult the

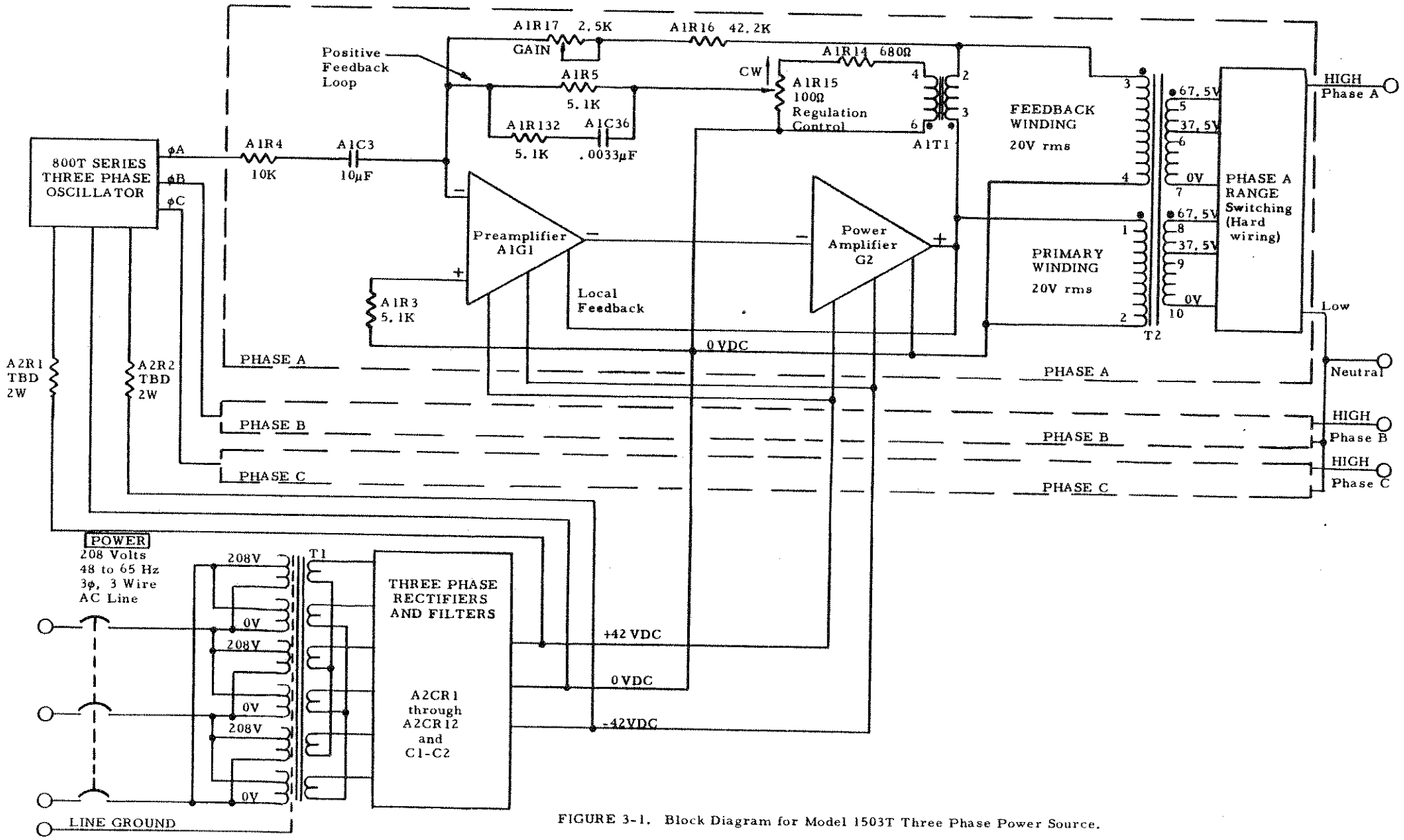


FIGURE 3-1. Block Diagram for Model 1503T Three Phase Power Source.

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 phase A pre-amplifier A1G1 is a part of the A1 assembly and consists of transistors A1Q1 through A1Q3 and associated components. Transistors A1Q1 through A1Q3 are connected as a direct coupled differential amplifier. The open loop gain of this pre-amplifier is approximately 25 at 400 Hz and rolls off at 6 dB per octave above 5 KHz.

Transistor A1Q1 is a transistor array used in the differential amplifier configuration to provide a gain of approximately 7.0. Capacitor A1C6 and resistor A1R21 provide a high frequency step roll off from 5 KHz to 70 KHz. Potentiometer A1R7 is used to adjust the DC bias at the primary of T2 to zero volts with no signal.

Transistor A1Q1C and associated components are connected as a zener diode voltage regulator which provides a -6.2 volt DC reference for A1Q1A and A1Q1B. Resistor A1R11 supplys approximately 1.0 milliampere to the emitter of A1Q1A and A1Q1B.

Transistors A1Q2 and A1Q3 are used in the differential amplifier configuration and provide an open loop gain of 3.5 at 400 Hz. Resistor A1R23 provides approximately 5 milliamperes to the junction of A1R25 and A1R26.

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, the large heatsinks (A3 and A7), and the output transformer T2 mounted to the chassis. Electrically, the power amplifier consists of transistors A1Q4, A1Q5, A1Q6, A3Q1 through A3Q10, A7Q1 through A7Q10 and associated components.

Resistors A1R30, A1R31 and capacitor A1C10 are connected as a constant current source which provides 20 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 A1Q4 and associated components are connected in the grounded emitter configuration. Local negative feedback is provided by A1C8, A1C9, A1C11, A1R27, A1R28 and A1R29. This local feedback limits the gain of this stage to 22 at 400 Hz and causes the gain to fall off at 6 dB per octave above 10 KHz.

The positive polarity output amplifier consists of A7Q1 through A7Q10 connected as emitter followers. These transistors supply a total of 50 amperes peak during the positive one-half cycle of the output waveform when the phase "A" output is loaded to 500 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 600 watts with less than a 40°C case temperature rise with an air flow of 70 cfm per heatsink.

The negative polarity output amplifier consists of A3Q1 through A3Q10 connected in the quasi complementary symmetry configuration. These transistors supply a total of 50 amperes peak during the negative one-half cycle of the output waveform when the power source is loaded to 500 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 600 watts with less than a 40°C case temperature rise with an air flow of 70 cfm per heatsink.

When the power source is delivering its full rated output voltage, the primary of the output transformer has an 20.0 volt rms signal.

3.2.3 OVERLOAD PROTECTION

The overload protection circuitry is shown in drawing E4153-071 and consists of A1Q5, A1Q6 and associated components.

Transistor A1Q5 and associated components are connected as a clamp circuit which is used to protect the positive polarity output amplifier (assembly A7) during periods of overload or short circuit. This is accomplished by sensing the load current flowing through A7R3 and applying the resultant voltage drop to the emitter-base junction of A1Q5 through a suitable attenuator network. During periods of overload, the emitter-base junction of A1Q5 is forward biased sufficiently to allow the collector circuit of A1Q5 to conduct a significant portion of the base drive normally available to A7Q1. This limits the base drive to A7Q2 and hence limits the available current from the positive polarity output amplifier during periods of overload. Potentiometer A1R42 is used to set the current level where the overload protection circuit is activated.

Transistor A1Q6 and associated components are used in a similar fashion to protect the negative polarity output amplifier (assembly A3). The only differences are that the control voltage for A1Q6 is sensed across A3R12 and potentiometer A1R45 is used to set the overload current level.

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.

The design of the overload circuitry is such that the overload level is determined by the same three parameters that determine the power dissipation in the push-pull output stage. Resistors A1R36, A1R37, A1R40, A1R41, A1R43 and A1R44 have been selected so that the overload protection circuit and the power factor derating chart track one another quite closely in the region between 0 volts output and 78 per cent of rated output voltage. 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 excessive.

3.2.4 OVERALL NEGATIVE FEEDBACK

The overall negative feedback loop is a single-ended operational feedback loop taken from the feedback winding of T2 back to the base of A1Q1B via resistors A1R12, A1R16, A1R17, and capacitor A1C5. This feedback network limits the mid-band closed loop voltage gain of the amplifier to 4.3 from A1 Pin V to the primary of T2.

This overall feedback loop provides approximately 30 dB of negative feedback over the range from 45 Hz to 5 KHz. The feedback rolls off at approximately 9 dB per octave for frequencies greater than 5 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 amplifier primary winding of T2 back to the base of A1Q1B through A1R18 and A1R19. This loop limits the closed loop voltage gain of the amplifier to approximately 5.0 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 current feedback 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 base of A1Q1B through a divider network consisting of A1R5, A1R13, A1R14, A1R15, A1R132, and capacitors A1C4 and A1C36. Potentiometer, A1R15, 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 E 4153-070. This power supply delivers ± 42 volts ± 5 per cent at 37.5 amperes DC with less than 4 volts peak-to-peak 360 Hz ripple from the 208 volt 60 Hz three phase AC line. These unregulated supplies consist of rectifier diodes A2CR1 through A2CR12 and filter capacitors C1 and C2 connected in a pair of three phase full wave bridge configurations.

The ripple frequency is six times the AC line input frequency provided that the line-to-line input voltages are equal for all three phases of the incoming AC line. If these line-to-line voltages are not equal, then ripple at twice the line frequency will also appear on the output of the DC power supply.

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 4153-070. 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 1503T 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 split secondary windings of output transformer T2 are interconnected so as to provide either a 0 to 75 volt or a 0 to 135 volt line-to-neutral output voltage from phase A of the Model 1503T Three Phase AC Power Source. Transformers T3 and T4 function in a similar manner for the phase B and phase C outputs, respectively.

CAUTION

Voltages up to 480 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 1503T 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 Current.

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 208 volt 47 to 65 Hz three phase, three wire AC line. For 370 volts or higher values of AC line voltage, a 480 volt variac must be substituted for that called out in this procedure. Consult Section 2.2.1 of this instruction manual for operation from other than the 208 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 0 to 75 volt L-N range. Table 4-1 illustrates the change in measurement voltage and impedance level when evaluating the power source on both output voltage ranges.

TABLE 4-1		
Rated Three Phase Line-to-Neutral Output Voltage	135 volts L-N	75 volts L-N
78% of Three Phase Line-to-Neutral Output Voltage	105 volts	58.5 volts
Line-to-Neutral Resistive Load for 500 VA Output (at 100% of rated Line-to-Neutral Output Voltage)	36.4 ohms	11.2 ohms
Line-to-Neutral Resistive Load for 500 VA Output (at 78% of rated Line-to-Neutral Voltage)	22 ohms	6.85 ohms

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. 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 output terminals (TB3) 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 three phase input line voltage has a nominal value of 208 volts L-L 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) 15 KVA Variac, General Radio 3XW50M or equivalent.

c) True Rms voltmeter, H.P. 3400A or equivalent.

d) Three 0.1 ohm ± 1% 25 watt resistors, Dale Type HG10 or equivalent.

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

f) Differential Voltmeter, Fluke 883A or equivalent.

g) Multi-range 500 watt load box, or individual 500 watt power resistors, as defined in Table 4-1. Dale type NHL or equivalent.

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

i) Multimeter, Simpson 260 or equivalent.

j) Phase Meter, Dranetz Model 301 or equivalent.

4.3 INITIAL ADJUSTMENTS

4.3.1 Connect the Model 1503T Three Phase Power Source as shown in Figure 4-1. Turn the AMPLITUDE control on the associated multiphase oscillator fully counter clockwise. Adjust the three phase line voltage to its nominal value with the variac. Turn the POWER switch "on". The line current meters should each indicate 1.5 ampere (0.15 volt across 0.1 ohm) or less at nominal line voltage. If a problem is encountered, perform step 4.3.2 through 4.3.4 below.

4.3.2 Remove the top cover from the unit and connect the differential voltmeter between test points A1TP1 and A1TP2. Adjust potentiometer A1R7 so that the DC voltage across the output of the phase "A" power amplifier is 0.00 volts ± 5 millivolts.

4.3.3 Repeat step 4.3.2 except monitor the voltage from A1TP3 to A1TP4 and adjust the DC component in the phase "B" output to less than ± 5 millivolts with potentiometers A1R51.

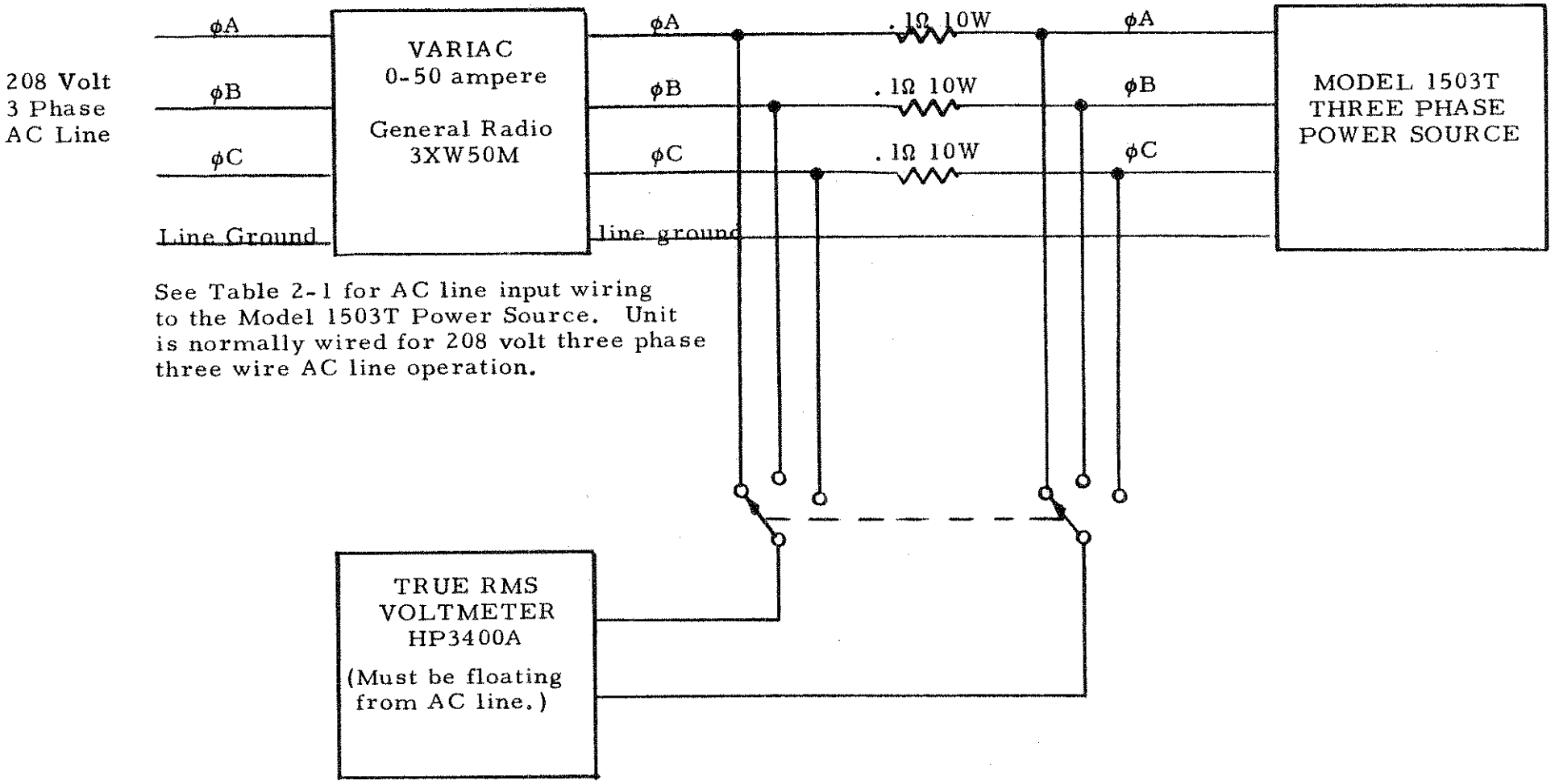


FIGURE 4-1. Test set up for initial adjustment of Model 1503T Three Phase Power Source.

4.3.4 Repeat step 4.3.2 except monitor the voltage from A1TP5 to A1TP6 and adjust the DC component in the phase "C" output to less than ± 5 millivolts with potentiometer A1R94.

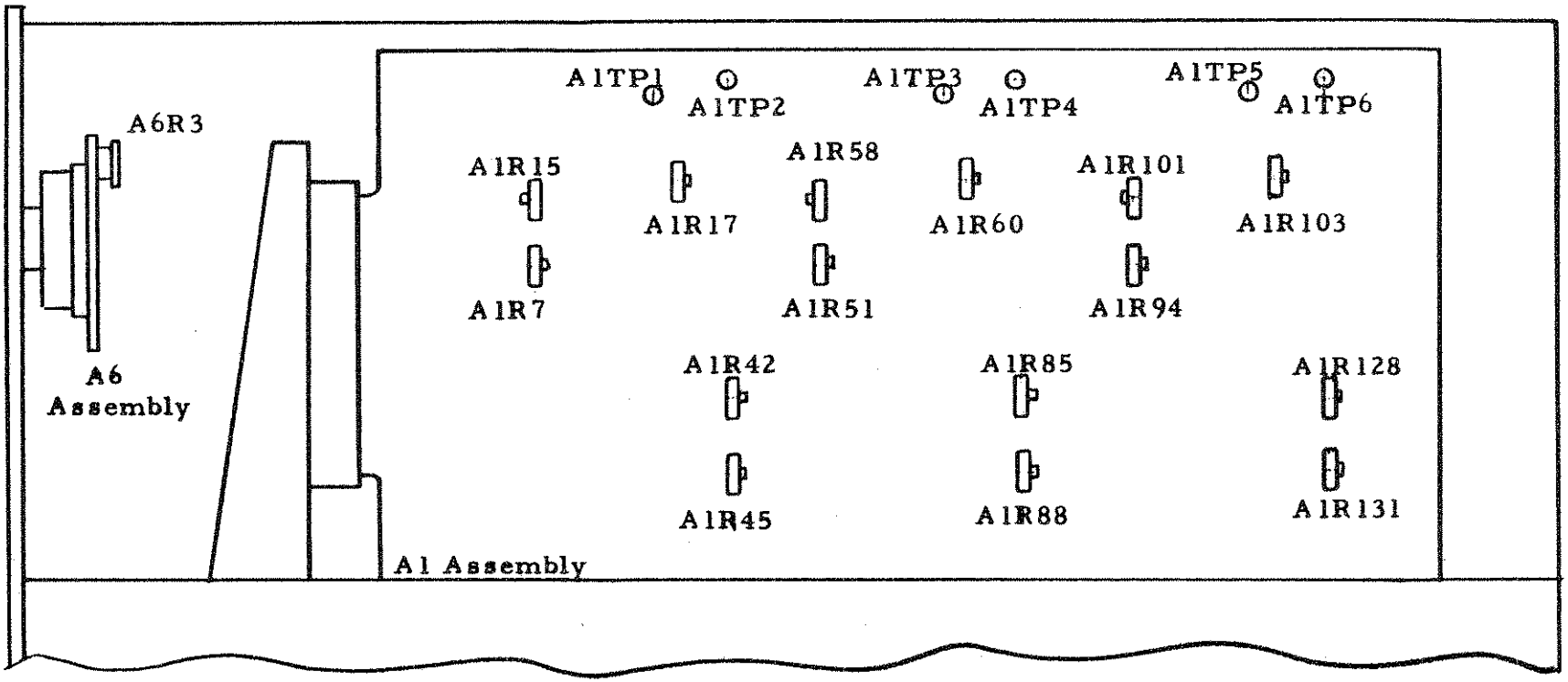
4.3.5 Check that the unit is on the 0 to 135 volt L-N output voltage range. If this is not the case proceed to step 4.3.6 below; otherwise proceed as follows: rotate the six-position METER switch so as to monitor the output voltage from phase "A" to phase "B". Connect the differential voltmeter and oscilloscope 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. Vary the frequency from 45 Hz to 5 KHz and check that the front panel meter reads within ± 3 per cent of the correct value.

4.3.6 If the power source has been wired to the 75 volt L-N 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 at an output voltage of 130 volts L-L.

4.4 OVERLOAD ADJUSTMENT

4.4.1 Connect the Model 1503T 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 (22 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 0.30 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 three phase AC input line voltage range of 190-226 volts L-L while maintaining the output voltage at 105 volts rms. Adjust potentiometer A1R42 so that no clipping or excessive distortion occurs on the positive peak of the output waveform under worst case conditions outlined above. Adjust potentiometer A1R45 so that no clipping or excessive distortion occurs on the negative peak of the output waveform under worst case conditions outlined above. These two adjustments may interact somewhat, so care should be taken not to move one adjustment excessively without checking the effect on the other adjustment.

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 several seconds. When the short circuit is removed, the line-to-neutral output voltage should immediately return to its previous value.



SIDE VIEW OF TOP PORTION

FIGURE 4-2. Internal Adjustments for Model 1503T Three Phase Power Source.

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. Adjust potentiometers A1R85 and A1R88 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. Adjust potentiometers A1R128 and A1R131 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.

4.4.5 This procedure may be performed for the 0 to 75 volt L-N range, 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.

4.5 GAIN ADJUSTMENT

4.5.1 Connect the Model 1503T 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 A1R17, A1R60, and A1R103 so that all three line-to-neutral output voltages are exactly equal to each other. Vary the oscillator frequency from 45 Hz to 5 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 the 0 to 75 volt L-N range, rather than the 0 to 135 volt L-N range, if desired.

4.6 AC LINE INPUT CURRENT

4.6.1 Connect the Model 1503T 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 three phase AC input line voltage adjusted to its maximum value (226 volts AC on 208 volt range), the AC input line rms current should be less than 15 amperes and all three readings should be within 20 per cent of the average line current. When operating from the 60 Hz AC line, The average AC input line rms should be less than 16 amperes when operating from the 50 Hz AC line.

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 rms line current should be less than 2 ampere and all three readings should be within 50 per cent of the average line current when operating from the 60 Hz AC line. The rms line current should be less than 4.5 amperes and all three readings should be within 50 per cent of the average line current when operating from the 50 Hz AC line.

4.6.4 This procedure may be performed for the 0 to 75 volt L-N range, 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 1503T 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 208 volt three phase AC 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 36.4 ohm load is across each phase of the output of the power source. Vary the AC input L-L voltage from 190 volts to 226 volts with the variac and check that the harmonic distortion in each phase is less than 0.3 per cent over the full input 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 0.3 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 Repeat steps 4.7.1 through 4.7.2 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 0.3 per cent from 200 Hz to 1 KHz, and less than 0.75 per cent from 45 Hz to 5 KHz.

4.7.4 This procedure may be performed for the 0 to 75 volt L-N range, 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 1503T 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 208 volt three phase AC 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 36.4 ohm load is across each phase of the output of the power source.

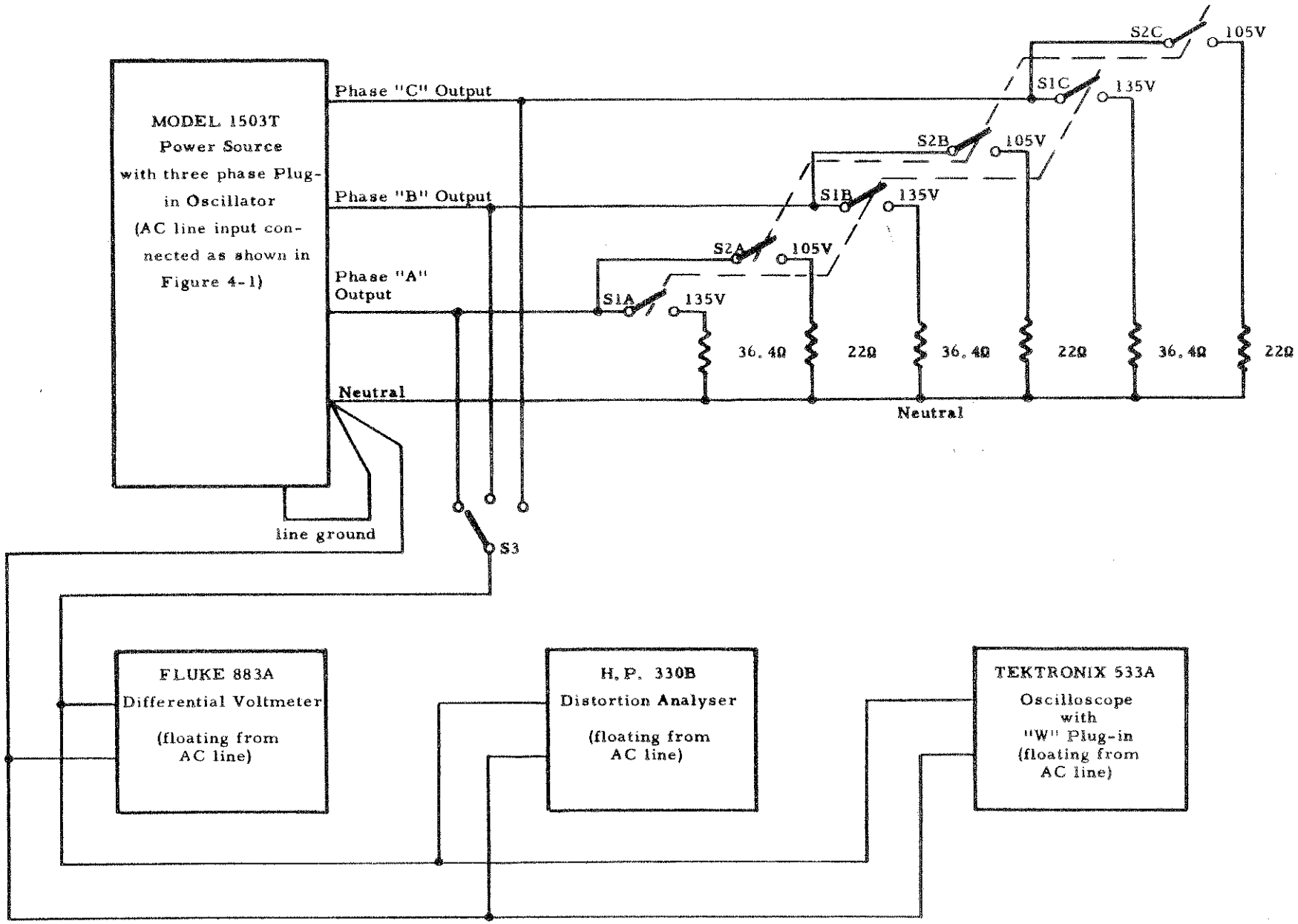


FIGURE 4-3. Test circuit for Model 1503T Three Phase Power Source.

4.8.2 Vary the AC input L-L voltage from 190 volts to 226 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 Set the oscillator frequency to 5 KHz and adjust the amplitude control to provide a 135 volt L-N output and repeat 4.8.2. The change in output voltage should be less than 0.68 volts rms.

4.8.4 This procedure may be performed for the 0 to 75 volt L-N range, 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 190 to 226 volts L-L.

4.9 LOAD REGULATION ADJUSTMENT

The load regulation adjustment for each phase of the Model 1503T Three Phase Power Source is internally available on the A1 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 1503T Three Phase Power Source as shown in Figure 4-3. Check that the load is connected to the large output terminals(TB3) 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 A1R15 (accessible from the top of the power source with the top cover removed) so that the output voltage variation is less than ± 100 millivolts as the 22 ohm three phase load is added or removed. Maintain the AC input line voltage at 208 volts L-L 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 A1R58 so that the output voltage variation is less than ± 100 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 A1R101 so that the output voltage variation is less than ± 100 millivolts as the three phase load is added or removed.

4.9.5 Set the frequency of the oscillator to 2 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 22 ohm three phase load resistors. Maintain the line voltage at 208 volts L-L during this test.

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

4.9.7 Set the oscillator frequency to 5 KHz and repeat 4.9.5. The L-N output of each phase of the power source should change less than 3.15 volts.

4.9.8 This procedure (steps 4.9.1 through 4.9.7) may be performed for the 0 to 75 volt L-N range, 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 75 volt L-N range where load impedances are low and a few microhenries of inductance will significantly influence the power factor at 5 KHz. The load regulation must remain within a ± 1 per cent band from 45 Hz to 2 KHz and must remain within a ± 3 per cent band from 45 Hz to 5 KHz.

4.10 AMPLITUDE STABILITY

4.10.1 Connect the Model 1503T Three Phase Power Source as shown in Figure 4-3. Adjust the three phase AC input line voltage to 208 volts L-L. 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 26.4 ohm (500 VA) three phase four-wire 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 the 0 to 75 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 1503T Three Phase Power Source as shown in Figure 4-3. Adjust the three phase input AC line voltage to 208 volts L-L. 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 5 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. 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 This procedure may be performed for the 0 to 75 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.

4.12 AC NOISE LEVEL

4.12.1 Connect the Model 1503T Three Phase Power Source as shown in Figure 4-3. Adjust the three phase input line voltage to 208 volts L-L. 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 1503T. 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 1503T.

4.12.4 Steps 4.12.1 through 4.12.3 may be performed on the 0 to 75 volt L-N range, 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	75 V L-N	135 V L-N
Peak-to-Peak Noise Level with 500 VA Load (see 4.12.2)	.166 V p-p	0.297 V p-p
Rms Noise Level at No Load (see 4.12.3)	5.85 mv rms	10.5 mv rms

4.13 0.7 LAGGING POWER FACTOR

4.13.1 Connect the Model 1503T 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 500 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 0.3 per cent at 400 Hz. The over load adjustments, A1R42 and A1R45 for phase "A", A1R85 and A1R88 for phase "B", and A1R128 and A1R131 may have to be adjusted slightly with a 0.7 power factor load to meet the 0.3 per cent distortion specification.

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., 2 KHz to 5 KHz, then it may be necessary to readjust the regulation controls. In this case, rotate the controls, A1R15, A1R58 and A1R101, until zero regulation is obtained at the specific frequency and load condition.

4.13.4 The three phase AC line rms input current is 15 amperes per leg maximum with an 0.7 power factor load at 78 per cent of rated output voltage and an input L-L voltage of 226 volts at 60 Hz (on 208 volt L-L range).

4.13.5 The above test 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.

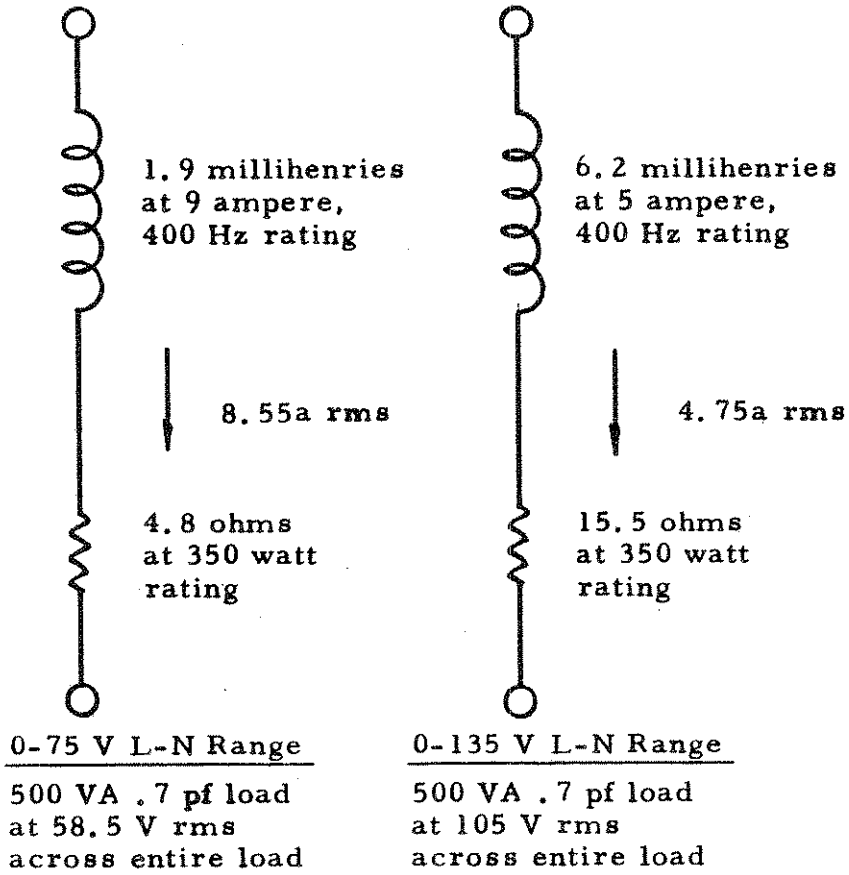


FIGURE 4-4. Circuit for 500 VA line-to-neutral 0.7 Lagging Power Factor Load at 400 Hz.

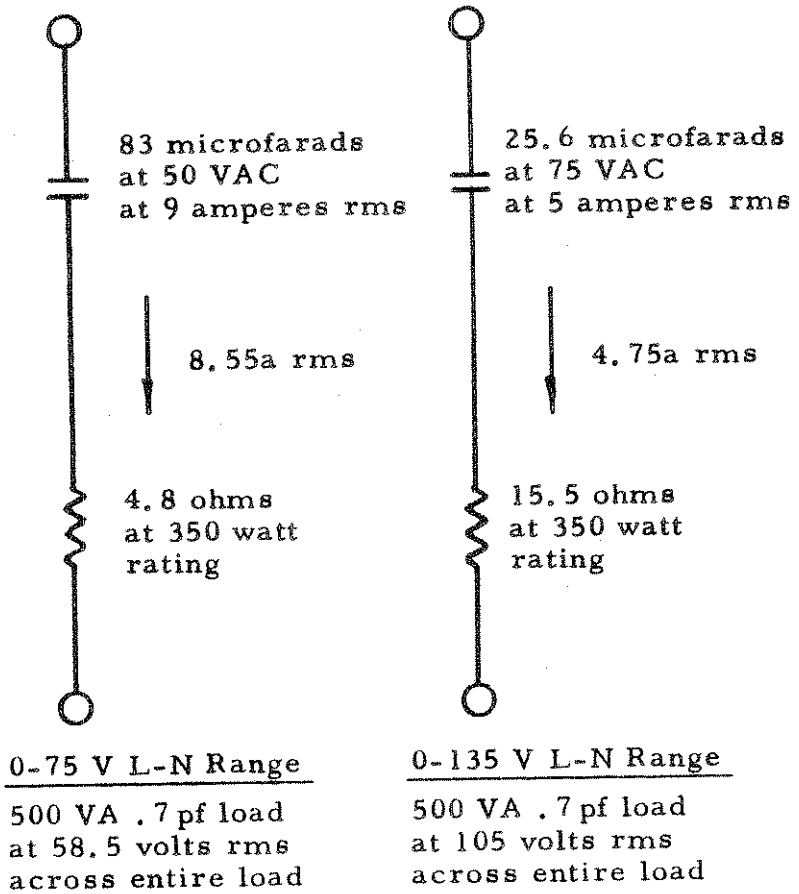


FIGURE 4-5. Circuit for 500 VA line-to-neutral 0.7 Leading Power Factor Load at 400 Hz.

4.14 0.7 LEADING POWER FACTOR

4.14.1 Connect the Model 1503T 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 500 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 0.3 per cent at 400 Hz. The overload adjustments A1R42 and A1R45 for phase "A", A1R85 and A1R88 for phase "B", and A1R128 and A1R131 may have to be adjusted slightly with a 0.7 power factor load to meet the 0.3 per cent distortion specification.

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., 2 KHz to 5 KHz, then it may be necessary to readjust the regulation controls. In this case, rotate the controls, A1R15, A1R58 and A1R101, until zero regulation is obtained at the specific frequency and load condition.

4.14.4 The three phase AC line rms input current is 15 amperes per leg maximum with a 0.7 power factor load at 78 per cent of rated output voltage and an input L-L voltage of 226 volts at 60 Hz (on 208 volt L-L range).

4.14.5 The above test 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 1503T 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 three phase variac to provide a 208 volt L-L 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 36.4 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 on the 0 to 75 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.

CAUTION

Voltages up to 480 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.

MAINTENANCE AND TROUBLE SHOOTING

5.1 GENERAL

The California Instruments Model 1503T 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 three phase 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 5 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, A1CR7, A1CR11, A1CR12, A1CR16 and A1CR17.

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

CIRCUIT DIAGRAM

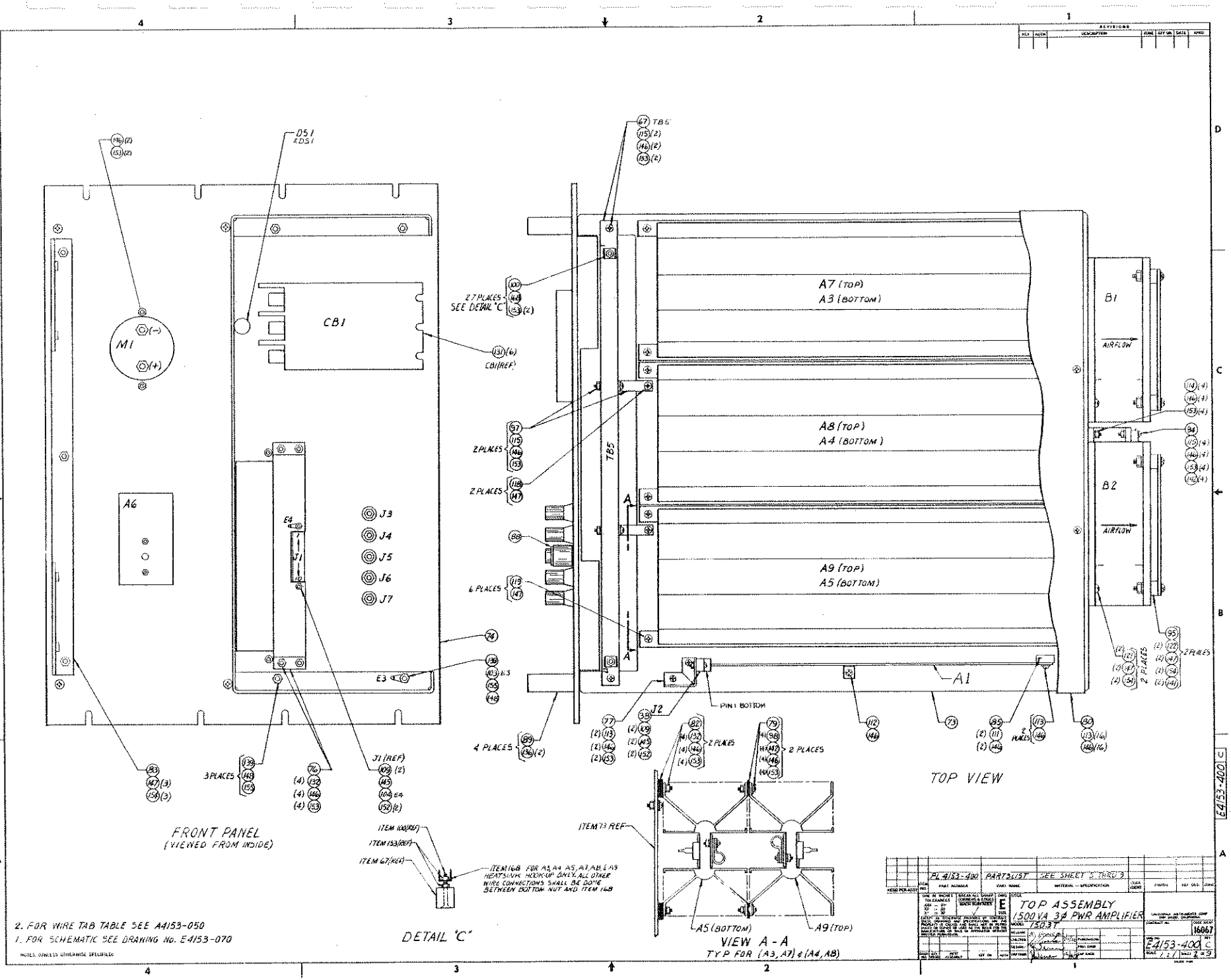
6.1 GENERAL

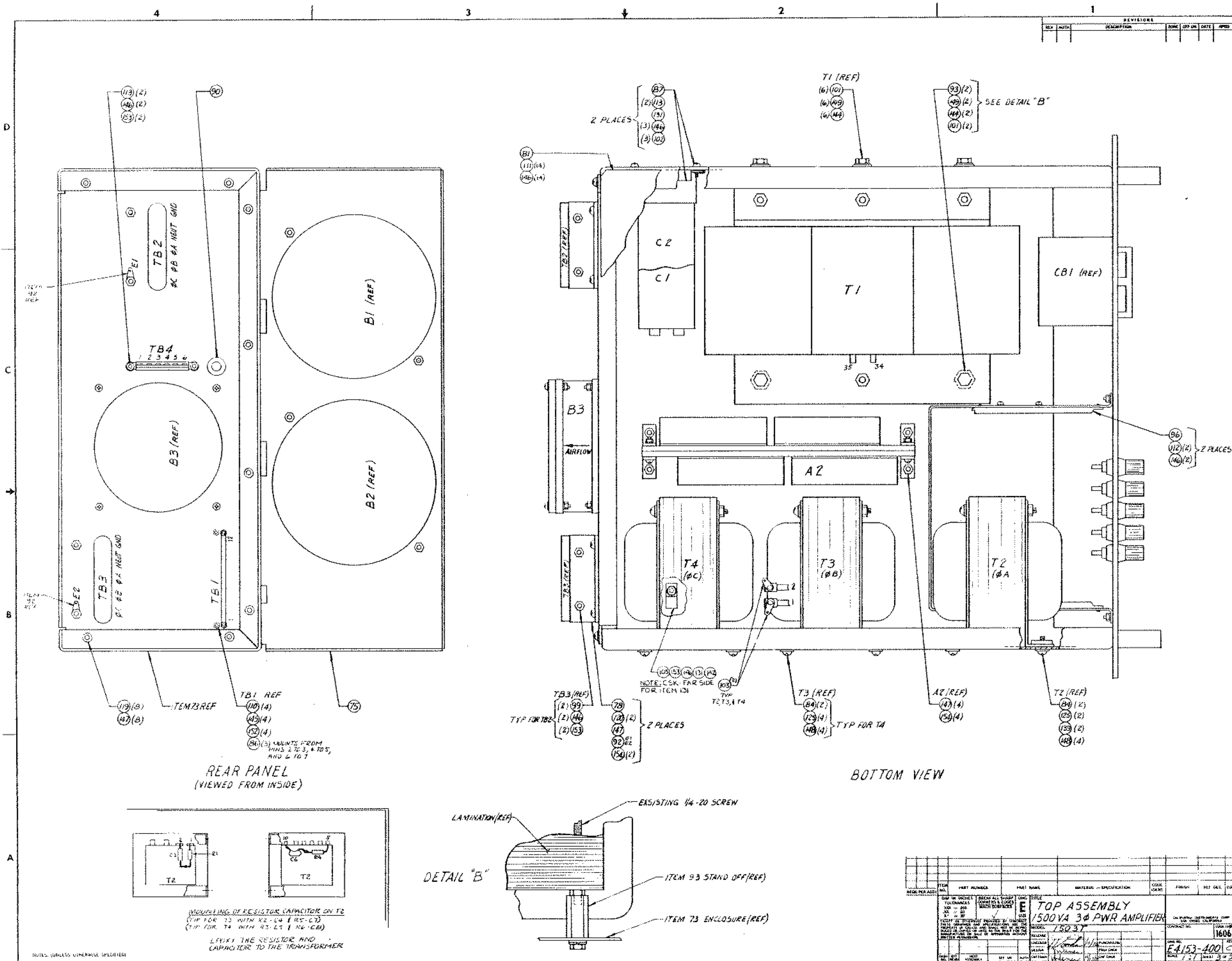
This section contains schematics and mechanical diagrams necessary for operation and maintenance of the Model 1503T AC Power Source. The schematic diagrams illustrate the circuit while the mechanical assemblies indicate the part placement.

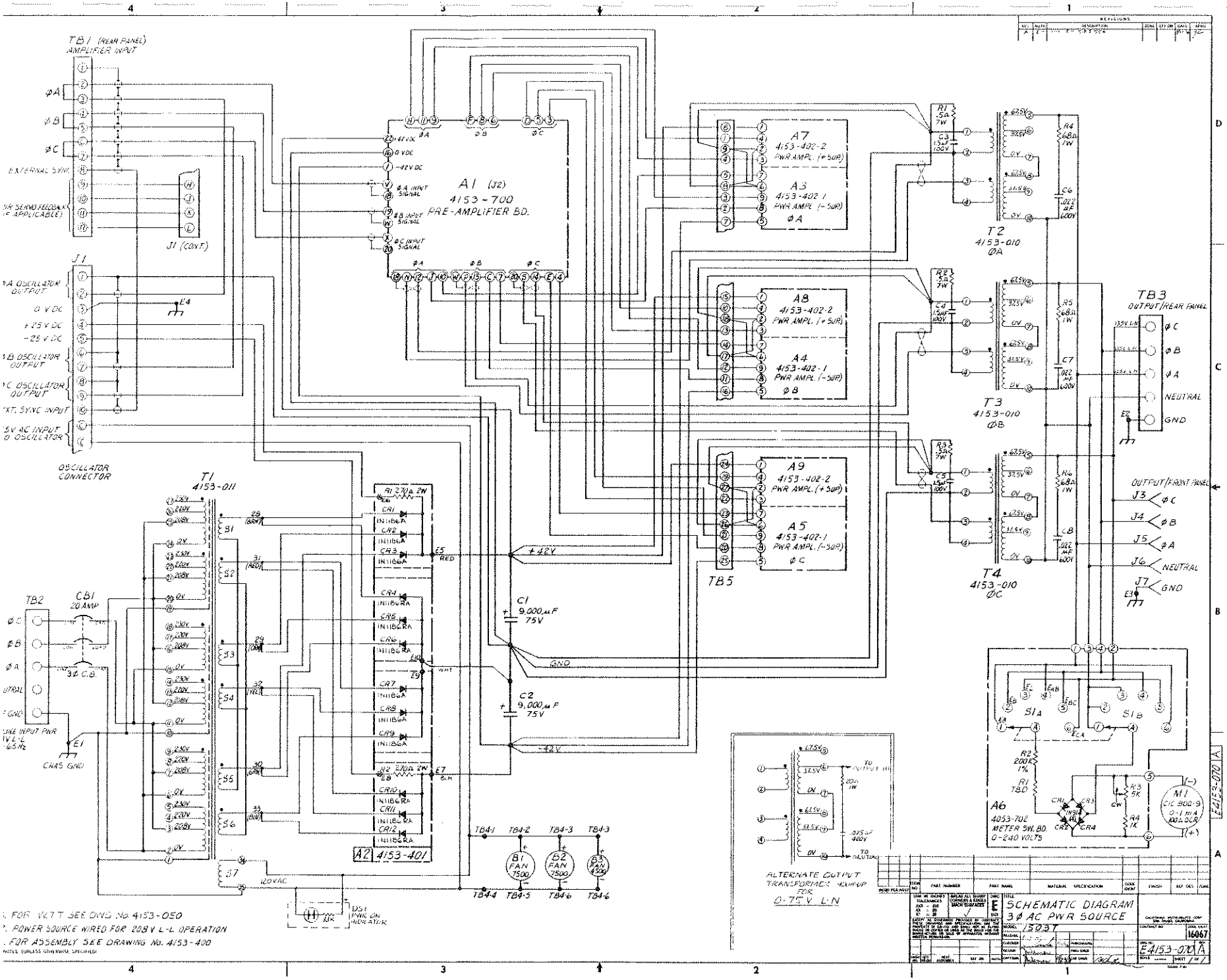
6.2 REFERENCE DESIGNATIONS

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	R1	A3R1

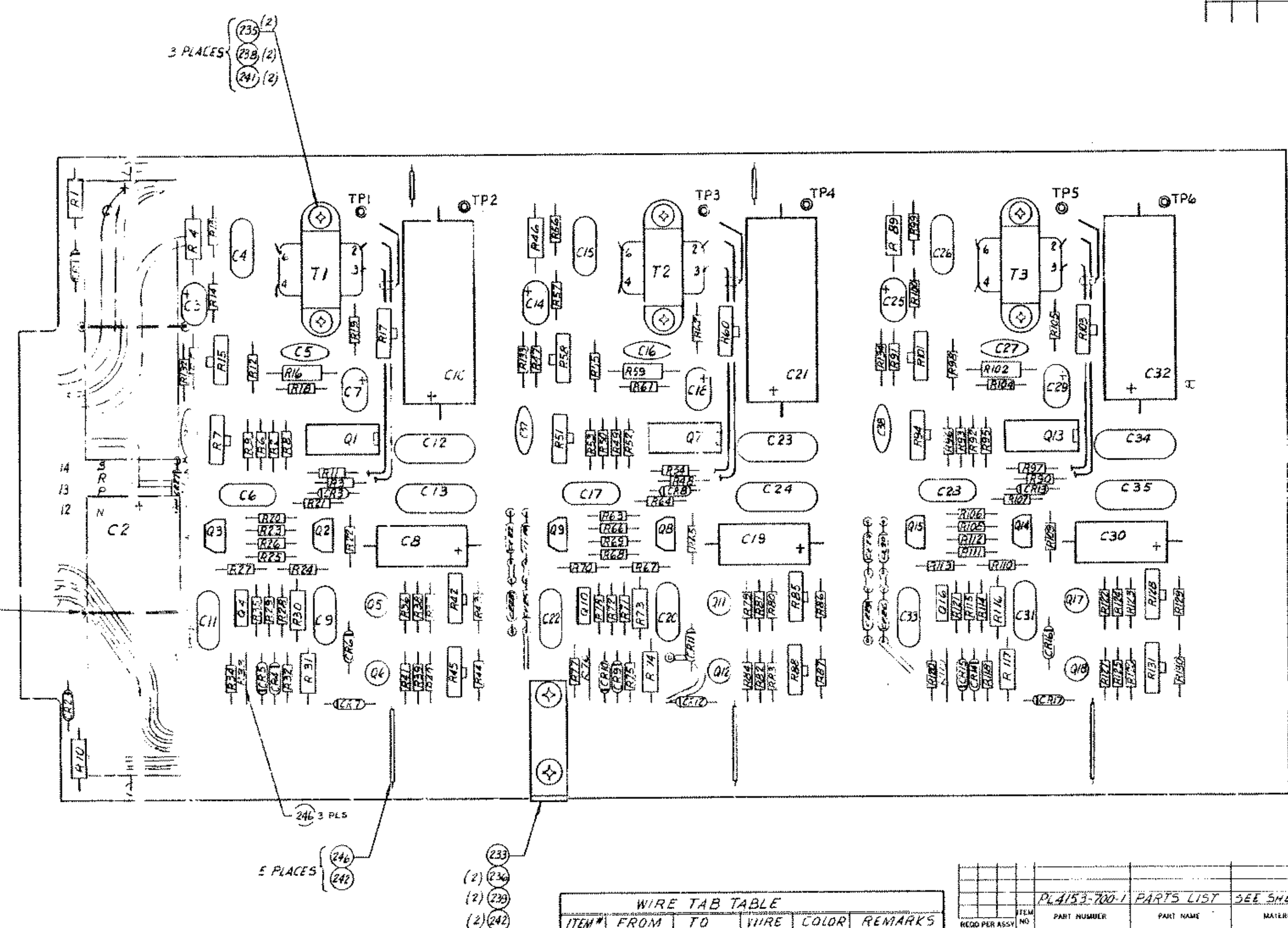

FRONT PANEL
(VIEWED FROM INSIDE)
TOP VIEW
DETAIL 'C'
VIEW A - A
TYP FOR (A3, A7) & (A4, A8)
CB1
M1
A6
A7 (TOP)
A3 (BOTTOM)
A8 (TOP)
A4 (BOTTOM)
A9 (TOP)
A5 (BOTTOM)
A1
B1
B2
AIRFLOW
TB5
J1
J2
J3
J4
J5
J6
J7
E3
E4
PIN 1 BOTTOM
ITEM 100(REF)
ITEM 153(REF)
ITEM 67(REF)
ITEM 73 REF
ITEM 168 FOR A3, A4 A5, A7, A8 & A9 HEATSINK HOOK-UP ONLY. ALL OTHER WIRE CONNECTIONS SHALL BE DONE BETWEEN BOTTOM NUT AND ITEM 168
2. FOR WIRE TAB TABLE SEE A4153-050
1. FOR SCHEMATIC SEE DRAWING No. E4153-070
NOTES: UNLESS OTHERWISE SPECIFIED:
PL 4153-400 PARTS LIST SEE SHEET 2 THRU 3
TOP ASSEMBLY
1500 VA 3Ø PWR AMPLIFIER
150.3T
16067
E4153-400 C
SHEET 2 OF 3


REVISIONS
REAR PANEL
(VIEWED FROM INSIDE)
TB2
ØC ØB ØA NEUT GND
TB3
ØC ØB ØA NEUT GND
TB4
1 2 3 4 5 6
TB1
B1 (REF)
B2 (REF)
B3 (REF)
E1
E2
ITEM 73 REF
TB1 REF
MOUNTS FROM PINS 2 TO 3, 4 TO 5, AND 6 TO 7
BOTTOM VIEW
SEE DETAIL "B"
2 PLACES
T1 (REF)
T1
C2
C1
CB1 (REF)
B3
AIRFLOW
A2
T2 (ØA)
T3 (ØB)
T4 (ØC)
TB2 (REF)
TB3 (REF)
NOTE: CSK. FAR SIDE FOR ITEM 131
TYP T2, T3, & T4
T3 (REF)
TYP FOR T4
A2 (REF)
T2 (REF)
TYP FOR TB2
DETAIL "B"
EXSISTING 1/4-20 SCREW
LAMINATION (REF)
ITEM 93 STAND OFF (REF)
ITEM 73 ENCLOSURE (REF)
MOUNTING OF RESISTOR CAPACITOR ON T2
(TYP FOR T3 WITH R2-C4 & R5-C7)
(TYP FOR T4 WITH R3-C5 & R6-C8)
EPOXY THE RESISTOR AND CAPACITOR TO THE TRANSFORMER
NOTES: UNLESS OTHERWISE SPECIFIED
TOP ASSEMBLY
1500VA 3Ø PWR AMPLIFIER
16067
E4153-400 C



NOTES: UNLESS OTHERWISE SPECIFIED

1. FOR WATT SEE DWG No. 4153-050
2. POWER SOURCE WIRED FOR 208 V L-L OPERATION
3. FOR ASSEMBLY SEE DRAWING No. 4153-400



ITEM #	FROM	TO	WIRE	COLOR	REMARKS
1	T1-2	A1-N	TWISTED	WHT	SHLD. ONE END TO TP1
2	T1-3	A1-12	SHLD. PAIR	BLK	OTHER END FLOATING
3	T2-2	A1-P	TWISTED	WHT	SHLD. ONE END TO TP3
4	T2-3	A1-13	SHLD. PAIR	BLK	OTHER END FLOATING
5	T3-2	A1-3	TWISTED	WHT	SHLD. ONE END TO TP5
6	T3-3	A1-14	SHLD. PAIR	BLK	OTHER END FLOATING

WIRE TAB TABLE

1. FOR SCHEMATIC SEE DRAWING No. E4153-071

NOTES: (UNLESS OTHERWISE SPECIFIED)

REVISIONS

REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APVD

PL4153-700-1 PARTS LIST SEE SHEET 4 thru 16

P.C. BOARD ASSEMBLY
3 PHASE PREAMPLIFIER

MODEL 1503T, 2253T (A1)

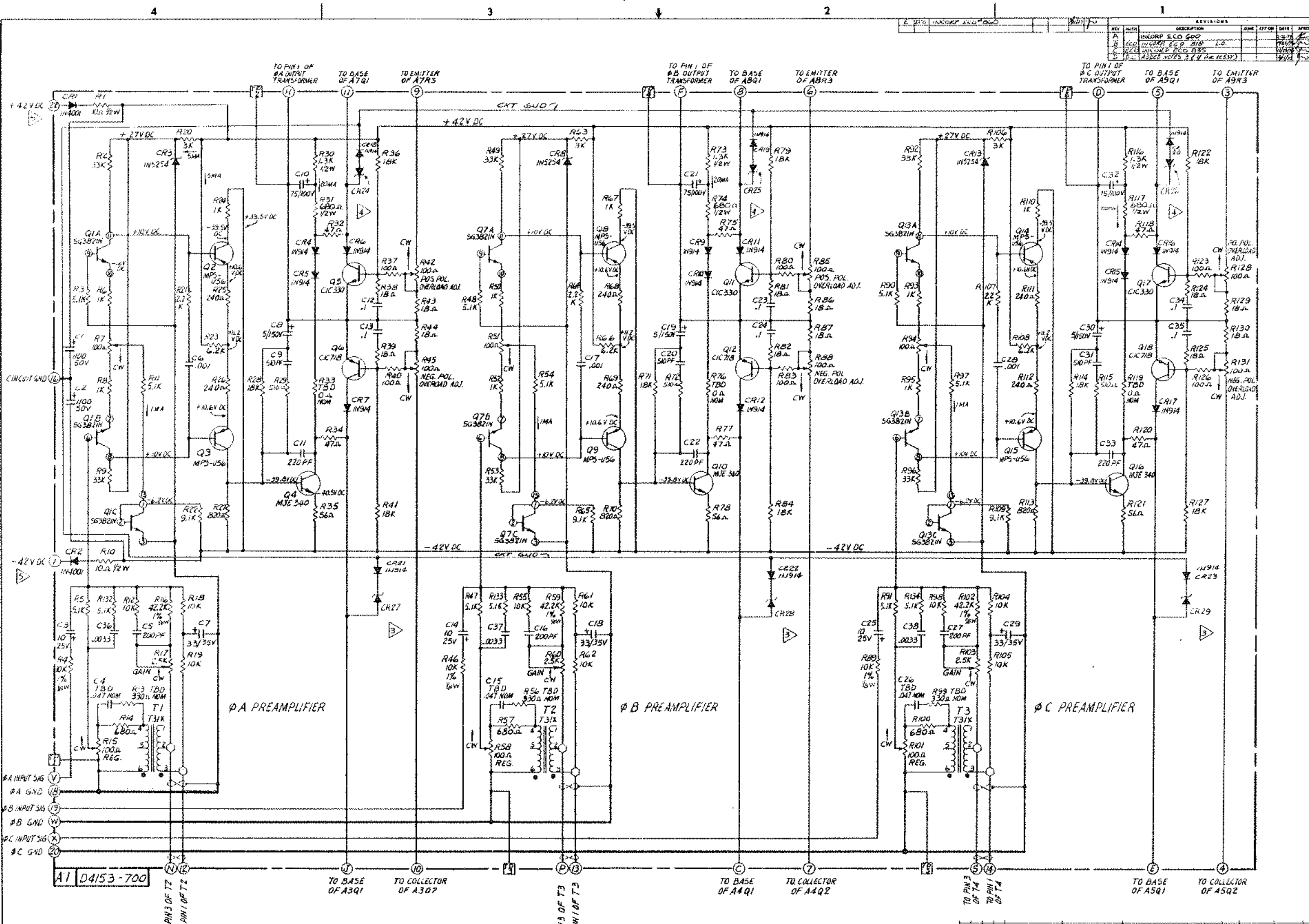
CALICO
CALIFORNIA INSTRUMENTS CORP.
SAN DIEGO, CALIFORNIA

DWG SIZE D

CODE IDENT 16067

D4153-700 REV C

SCALE 2:1 SHEET 2 OF



5. THE DC SUPPLY VOLTAGE AT NOMINAL INPUT LINE UNDER FULL LOAD CONDITION IS ±42 VOLTS DC FOR THE MODEL 1503T AND ±40 VOLTS DC FOR THE MODEL 2253T.

4. CR24, CR25 & CR26 ARE 0.5M32.6Z5Z 32.6V ±2%

3. CR27, CR28 & CR29 ARE 0.5M30.0Z5Z 30V ±2%

2. CAPACITANCE IN MICROFARADS

1. RESISTORS ARE 1/4W, 5%. VALUE IN OHMS

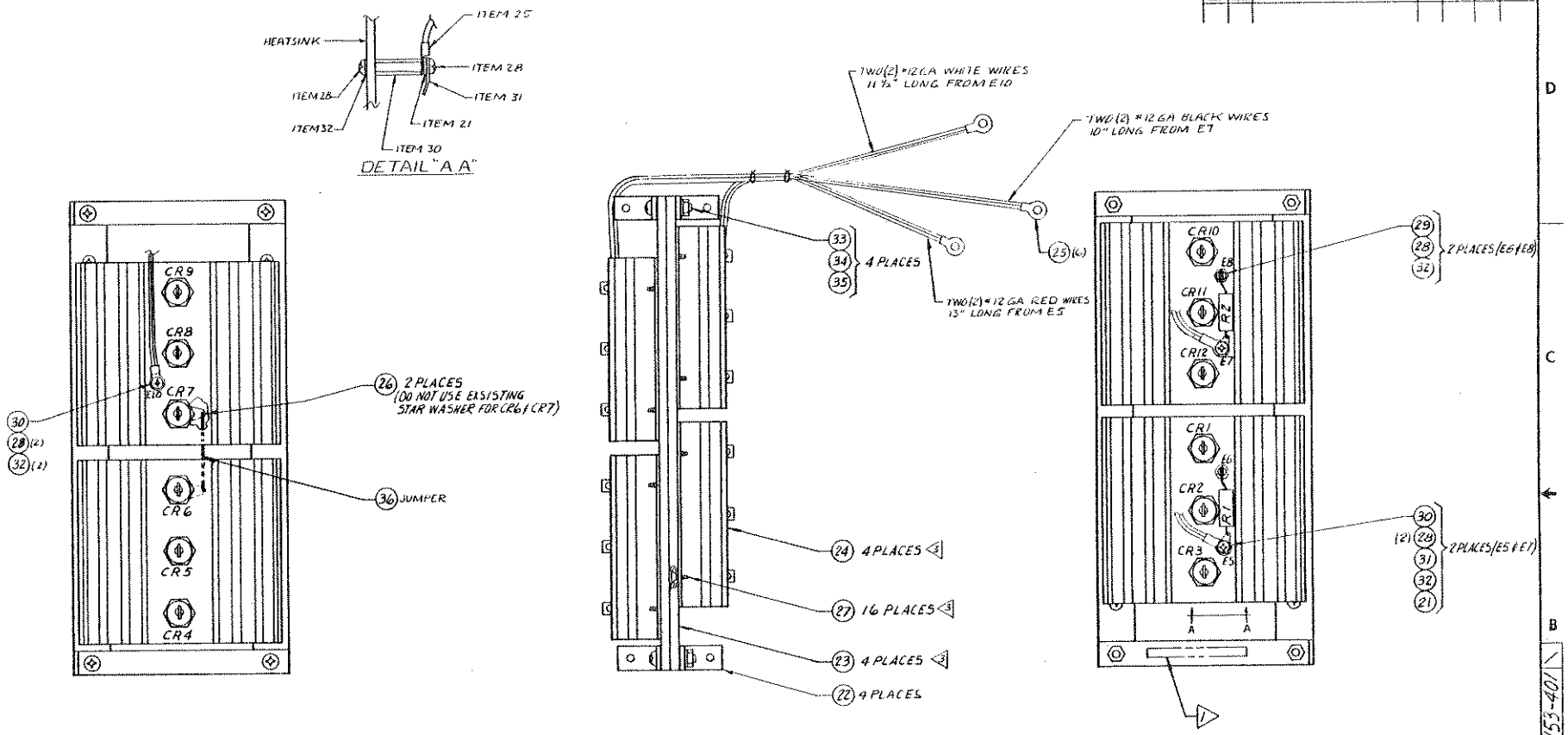
NOTES: (UNLESS OTHERWISE SPECIFIED)

SCHEMATIC DIAGRAM
3 Ø PRE-AMPLIFIER

MODEL 1503T/2253T

16067

E4153-071 E



-1 PWR RECTIFIER ASSY

3. MOUNT ITEM 24 HEATSINK TO ITEM 23 INSULATOR USING ITEM 27 SELF TAPPING SCREWS.

2. FOR SCHEMATIC SEE DRAWING No. E4153-070

1 INK STAMP ASSEMBLY No. & REF DES "A2" APPROX AS SHOWN (NEAR SIDE)

NOTES: (UNLESS OTHERWISE SPECIFIED)

REVISIONS

REV	AUTH	DESCRIPTION	ZONE	LTR ON	DATE	APVD

PL4153-401-1 PARTS LIST SEE SHEET 3

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

DIM IN INCHES TOLERANCES XXX ± .010 XX ± .03 X ± .1

BREAK ALL SHARP CORNERS & EDGES MACH SURFACES √

SIZE D

TITLE 3 PHASE POWER RECTIFIER ASSEMBLY A2

MODEL 1503

CALIFORNIA INSTRUMENTS CORP. SAN DIEGO, CALIFORNIA

CONTRACT NO.

GOOD IDENT 16067

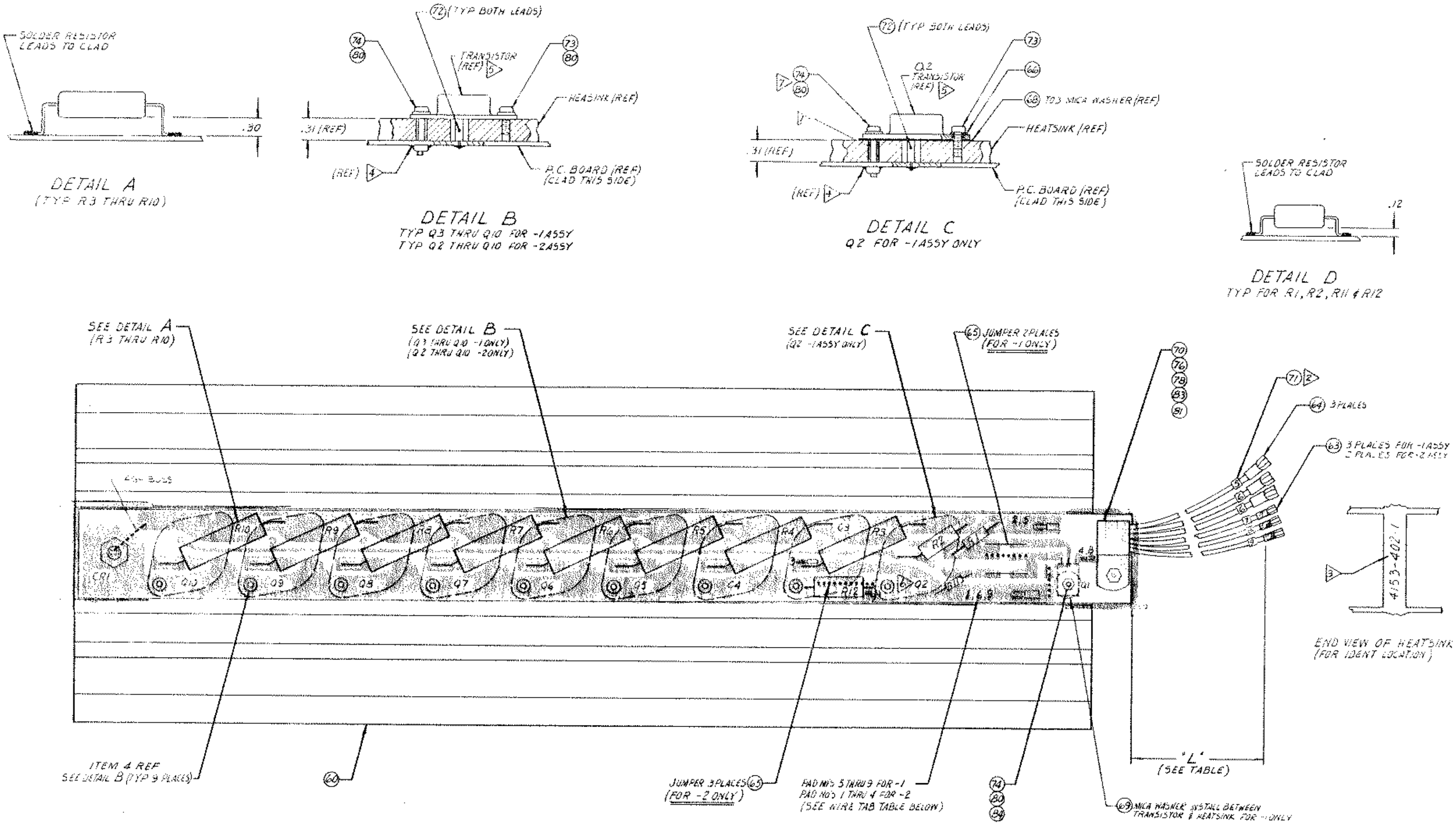
DWG NO. D4153-401

REV 1

SCALE 1:1 SHEET 2 of 3

DASH NO.	QTY REQD	NEXT HIGHER ASSEMBLY	LTR ON	AUTH
-1	1	4153-401		

D4153-401 1



-1 ASSY SHOWN

-2 ASSY SAME AS -1 EXCEPT AS NOTED

WIRE TAB TABLE						
-1	-2	WIRE NO.	FROM PAD NO.	WIRE GA & COLOR		"L" LENGTH IN INCH
	X	1	1	#12-RED		7
	X	2	2	2x#12-BLK		7
	X	3	3	#18-RED		7
	X	4	4	#18-BRN		7
X		5	5	#12-BLK		5
X		6	6	2x#12-BLK		5
X		7	7	#18-YEL		5
X		8	8	#18-ORN		5
X		9	9	#18-GRN		5

7. ITEM 74 TO BE INSULATED FROM HEATSINK, USING TEFLON SLEEVING, CVC'E STRE IN THIS. (FOR Q2)
6. Q2 MUST BE INSULATED FROM HEATSINK PER DETAIL C (-1ASSY ONLY)
5. APPLY ITEM 67 BETWEEN TRANSISTORS AND HEATSINK
4. SOLDER CLINCH NUT TO CLAD (TYP 9 PLACES)
3. METAL STAMP ASSY PART No. APPROX AS SHOWN.
2. IDENTIFY WIRES [illegible]
1. FOR SCHEMATIC SEE DRAWING No. D4153-072

NOTES: UNLESS OTHERWISE SPECIFIED

PL 4153-402-2	PARTS LIST	SEE SHT. 2 THRU 5	
PL 4153-402-1	PARTS LIST	SEE SHT. 2 THRU 5	
PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	

TITLE: HEATSINK ASSEMBLY +42V AND -42V

MODEL 1503T

-2 | 4153-400-1

-1 | 4153-400-1

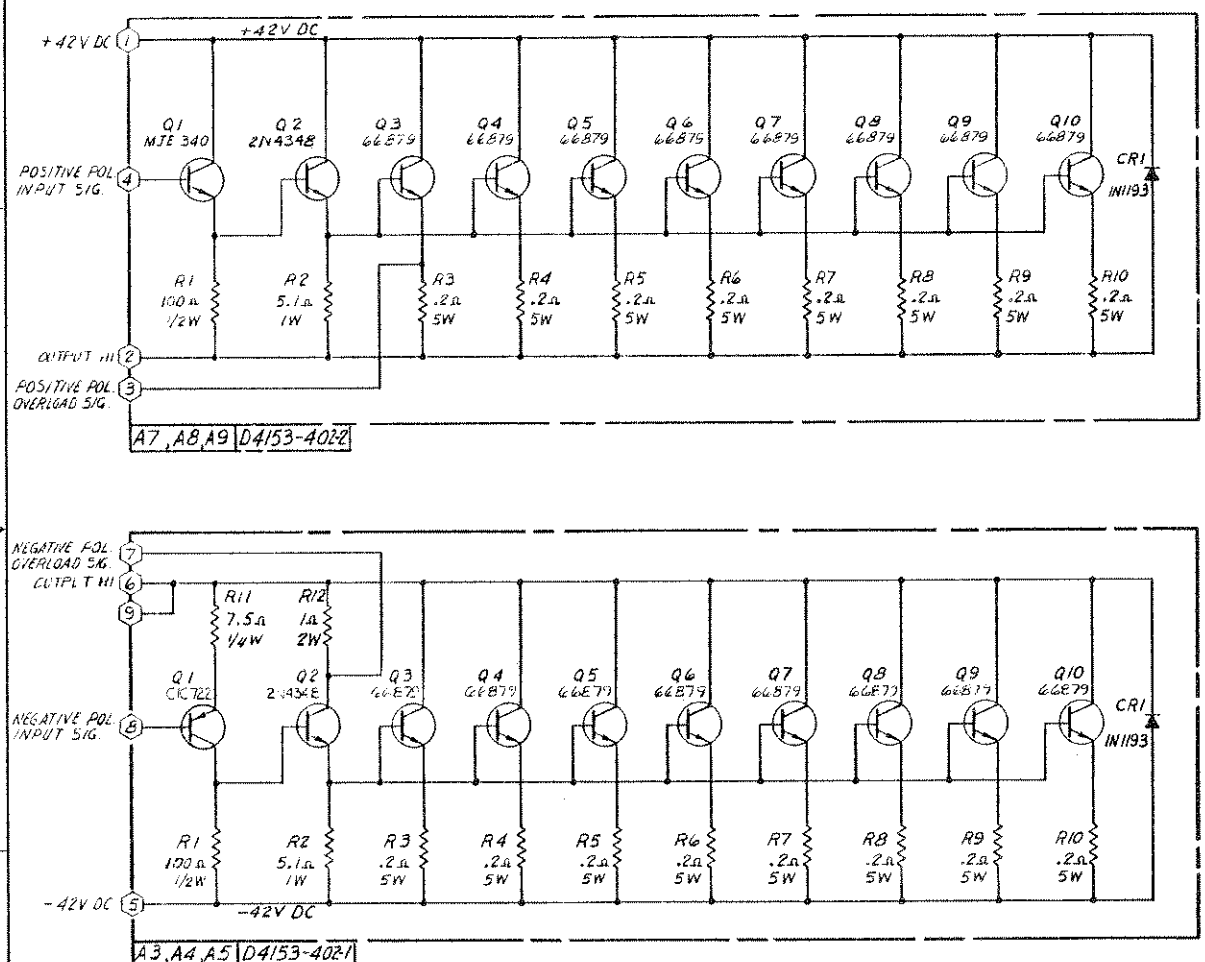
CODE IDENT 16067

DWG NO. E4153-402

SCALE 2:1 SHEET 2 OF 5

E4153-402 A

REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APPD
A		INCORP E.O. 489				
B	ECO	INCORP. ECO # 813				
C	ECO	INCORP. ECO # 835				
D	DC	A7, A8, A9 Q3 THRU Q10 CHANGE PN FROM C1C302 TO 66879				



2. Q1 OF A3 A4, & A5 ASSY IS A 2N4920 SELECTED FOR LEAKAGE. CURRENT I_{CE} NOT TO EXCEED 1.0 MA AT V_{CE}=100V WITH BASE OPEN @25°C

1. FOR UNIT SCHEMATIC SEE DRAWING No. 4153-070

NOTES: (UNLESS OTHERWISE SPECIFIED)

DIM IN INCHES TOLERANCES XXX ± .010 XX ± .03 X° ± 30'	BREAK ALL SHARP CORNERS & EDGES MACH SURFACES √	DWG SIZE D
TITLE	SCHEMATIC DIAGRAM HEATSINK ASSY +42V/-42V	
MODEL	1503T	
	CALIFORNIA INSTRUMENTS CORP SAN DIEGO, CALIFORNIA	CODE IDENT 16067
DWG NO.	D4153-072	REV D
SCALE —	SHEET 1 OF 1	

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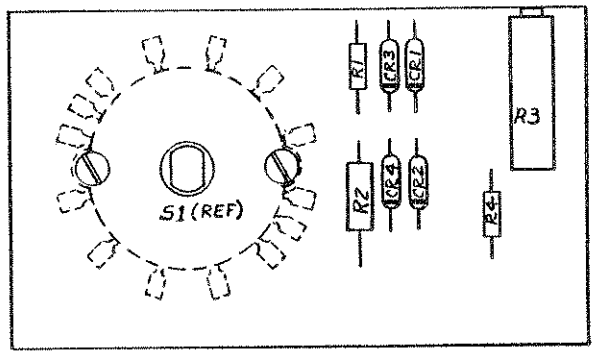
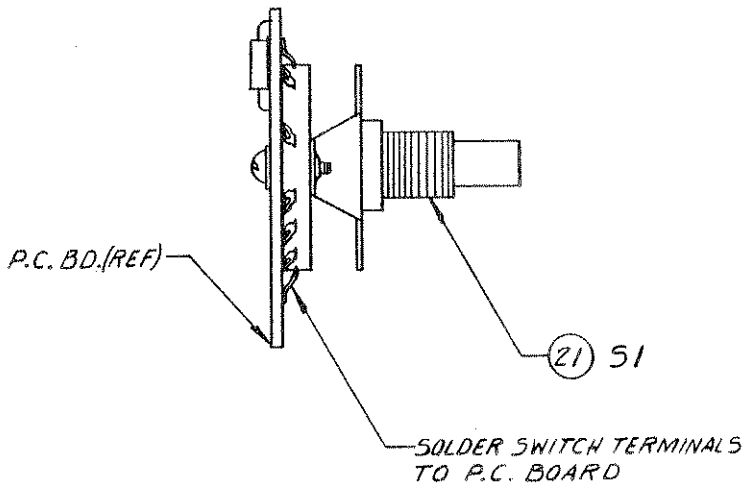
D4153-072 D

REVISIONS						
REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD





-1 P.C. BOARD ASSY

CLAD FAR SIDE

ITEM NO.	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES.	ZONE	REQD PER ASSY
	PL 4053-701	PARTS LIST	SHEET 4					

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

BREAK ALL SHARP CORNERS & EDGES
MACH SURFACES ✓

DWG SIZE C

TITLE
P.C. BOARD ASSEMBLY
METER - SWITCH BD. (A6)

MODEL 503T, 1503T, 153T-737, 2253T

RELEASE	[illegible]	5/5/11	
CHECKER	[illegible]	5/4/11	PURCHASING
DESIGN			PROJ ENGR
DRFTSMN	[illegible]	7/20/11	CHF ENGR

DASH NO.	QTY REQD	NEXT ASSEMBLY	EFF ON	AUTH

CALIFORNIA INSTRUMENTS CORP.
SAN DIEGO, CALIFORNIA

CONTRACT NO.

CODE IDENT 16067

DWG NO. C4053-702 REV B

SCALE 2/1 SHEET 2 OF 4

CALICO F-108

1. SEE MAIN ASSEMBLY FOR SCHEMATIC CALLOUT.

NOTES: (UNLESS OTHERWISE SPECIFIED)

C4053-702 B

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 numbers 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 COMPANY, a division of Aiken Industries, San Diego, California, 92111.

CALIFORNIA INSTRUMENTS CO.
SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
	E4153-400-1	POWER AMPLIFIER	16067		1
					2
					3
					4
A1	D4153-700-1	PREAMPLIFIER	16067		5
A2	D4153-401-1	RECTIFIER ASSEMBLY	16067		6
A3	D4153-402-1	HEATSINK ASSY (-)	16067		7
A4	D4153-402-1	HEATSINK ASSY (-)	16067		8
A5	D4153-402-1	HEATSINK ASSY (-)	16067		9
A6	C4053-702-1	METER SWITCH BD. 0-240V	16067		10
A7	D4153-402-2	HEATSINK ASSY (+)	16067		11
A8	D4153-402-2	HEATSINK ASSY (+)	16067		12
A9	D4153-402-2	HEATSINK ASSY (+)	16067		13
					14
					15
					16
B1	7500	FAN (265CFM)	23936	2-10055	17
B2	7500	FAN (265CFM)	23936	2-10055	18
B3	4500	FAN (115CFM)	23936	2-41063	19
					20
					21
C1	FAH-902-75	CAPACITOR 9000μF 75V	14655	6-10817	22
C2	FAH-902-75	CAPACITOR 9000μF 75V	14655	6-10817	23
C3	ZA2B155	CAPACITOR 1.5μF 100V	27556	6-10429	24
C4	ZA2B155	CAPACITOR 1.5μF 100V	27556	6-10429	25
C5	ZA2B155	CAPACITOR 1.5μF 100V	27556	6-10429	26
C6	6DP-1-223	CAPACITOR .022μF 600V	72136	6-10104	27
C7	6DP-1-223	CAPACITOR .022μF 600V	72136	6-10104	28
C8	6DP-1-223	CAPACITOR .022μF 600V	72136	6-10104	29
					30
					31
CB1	CF3-G3-U-20-240-3	CIRCUIT BREAKER	74193	2-70025	32
					33
DS1	NE51H(B2A)	LAMP, NEON	71744	2-41107	34
					35
					36

MODEL 1503T | CALICO P/N 4153-400 | ASSY R.D.

TITLE 1500VA 3φ POWER AMPLIFIER | SHT 5 OF 9

CALIFORNIA INSTRUMENTS CO.
SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
J1	8BD10S0	CONNECTOR (10 PIN)	81312	4-10032	37
J2	8BD22S0	CONNECTOR (22 PIN)	81312	4-10083	38
J3	DF-31-RC	BINDING POST (RED)	58474	2-40041	39
J4	DF-31-RC	BINDING POST (RED)	58474	2-40041	40
J5	DF-31-RC	BINDING POST (RED)	58474	2-40041	41
J6	DF-31-WTC	BINDING POST (WHT)	58474	2-40090	42
J7	DF-31-BC	BINDING POST (BLK)	58474	2-40040	43
					44
					45
M1	CIC800-9	METER 0-240V	16067	2-50169	46
					47
					48
R1	RS7-0R5-3%	RESISTOR .5Ω 7W 3%	91637	5-50143	49
R2	RS7-0R5-3%	RESISTOR .5Ω 7W 3%	91637	5-50143	50
R3	RS7-0R5-3%	RESISTOR .5Ω 7W 3%	91637	5-50143	51
R4	RC32GF680J	RESISTOR 68Ω 1W 5%	81349	5-30004	52
R5	RC32GF680J	RESISTOR 68Ω 1W 5%	81349	5-30004	53
R6	RC32GF680J	RESISTOR 68Ω 1W 5%	81349	5-30004	54
					55
					56
T1	A4153-011	TRANSFORMER, POWER	16067	7-10220	57
T2	A4153-010	TRANSFORMER, OUTPUT	16067	7-10219	58
T3	A4153-010	TRANSFORMER, OUTPUT	16067	7-10219	59
T4	A4153-010	TRANSFORMER, OUTPUT	16067	7-10219	60
					61
					62
TB1	410-12	TERMINAL BLOCK	75382	2-41123	63
TB2	9-85-5	TERMINAL BLOCK	75382	2-50172	64
TB3	9-85-5	TERMINAL BLOCK	75382	2-50172	65
TB4	3006	TERMINAL STRIP	83330	2-40110	66
TB5	C4153-211-7	TERMINAL STRIP	16067	2-10417	67
					68
					69
XDS1	TAG-6022-TA160-AC	LAMP HOLDER	03797	2-41113	70
					71
					72

MODEL 1503T | CALICO P/N 4153-400 | ASSY R.D.

TITLE 1500VA 3φ POWER AMPLIFIER | SHT 6 OF 9

CALIFORNIA INSTRUMENTS CO.
SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
	E4153-200-1	ENCLOSURE	16067	1-10306	73
	D4153-201-1	FRONT PANEL	16067	1-10307	74
	D4153-202-1	REAR PANEL	16067	1-10308	75
	D4153-203-7	BRACKET, PLUG-IN	16067	1-10309	76
	C4153-204-7	BRACKET, CONNECTOR	16067	1-10310	77
	B4153-210-7	BRACKET, TERM BLOCK	16067	1-10311	78
	C4153-212-7	INSULATOR, PWR. H.S.	16067	1-10312	79
	D4100-204-1	TOP COVER	16067	1-10127	80
	D4100-205-7	BOTTOM COVER	16067	1-10128	81
	D4100-206-10	INSULATOR, HEATSINK	16067	2-10045	82
	D4100-218-1	SUPPORT ASSY, COVER	16067	1-10194	83
	B4153-213-7	NUT STRIP	16067	1-10315	84
	B4153-214-7	MOUNTING BAR	16067	1-10316	85
	410J	MECH. JUMPER	75782	2-50090	86
	CMC32	CLAMP, CAPACITOR	56289	6-10717	87
	PS-70D-2-BLK	KNOB	21604	2-10191	88
	FCA3	HANDLE	08730	2-40224	89
	3241	GROMMET	08065	2-10173	90
					91
E1, E2	1416-8	SOLDER LUG	83330	2-50053	92
	8942-SS-2520	STAND OFF 1/4-20 x 1 9/16LG	06540	2-10418	93
	550481	FINGER GUARD	82877	2-41064	94
	5506	FINGER GUARD	23936	2-10074	95
	5005-02P	CARD GUIDE	13103	2-41124	96
	620	ANGLE BRACKET	91833	1-10317	97
6-32 x 3/8 LG.	NYLON INS.	SCREW ST. CORE FIL. HD.	23050	2-10411	98
	6-32 x 1 3/8 LG.	SCREW, PAN HD.	81349	2-10067	99
	6-32 x 1 1/4 LG.	SCREW, FLAT HD.	81349	2-10419	100
	1/4-20 x 1/2 LG.	SCREW, HEX HEAD	81349	2-10271	101
	C8020-632	SPEED NUT	78553	2-10091	102
E3	1486-10	SOLDER LUG	83330	2-50055	103
E4	1416-4	SOLDER LUG	83330	2-50094	104
	837	CABLE CLAMP			105
					106
					107
					108

MODEL 1503T | CALICO P/N 4153-400 | ASSY R.D.

TITLE 1500VA 3φ POWER AMPLIFIER | SHT 7 OF 9

CALIFORNIA INSTRUMENTS CO.
SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
	4-40 x 1/2 LG.	SCREW, PAN HD.			109
	4-40 x 1/2 LG.	SCREW, ROUND HD.		2-10396	110
	6-32 x 5/16 LG.	SCREW, PAN HD.			111
	6-32 x 1/4 LG.	SCREW, PAN HD.			112
	6-32 x 3/8 LG.	SCREW, PAN HD.			113
	6-32 x 5/8 LG.	SCREW, PAN HD.			114
	6-32 x 7/8 LG.	SCREW, PAN HD.			115
					116
					117
	8-32 x 3/16 LG.	SCREW, PAN HD.			118
	8-32 x 5/16 LG.	SCREW, PAN HD.			119
	8-32 x 1/2 LG.	SCREW, PAN HD.			120
	8-32 x 5/8 LG.	SCREW, PAN HD.			121
	8-32 x 3/4 LG.	SCREW, PAN HD.			122
					123
					124
	10-32 x 1/2 LG.	SCREW, PAN HD.			125
					126
					127
					128
					129
					130
	6-32 x 3/8 LG.	SCREW, FLAT HD.			131
	6-32 x 1/2 LG.	SCREW, FLAT HD.			132
					133
					134
					135
	8-32 x 5/8 LG.	SCREW, FLAT HD.			136
					137
					138
	10-32 x 1/2 LG.	SCREW, FLAT HD.			139
					140
	#8	WASHER, FLAT			141
	#6	WASHER, FLAT			142
	#10	WASHER, FLAT			143
	#1/4	WASHER, FLAT			144

MODEL 1503T | CALICO P/N 4153-400 | ASSY R.D.

TITLE 1500VA 3φ POWER AMPLIFIER | SHT 8 OF 9

CALIFORNIA INSTRUMENTS CO.
SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
	#4	WASHER, INT. STR.			145
	#6	WASHER, INT. STR.			146
	#8	WASHER, INT. STR.			147
	#10	WASHER, INT. STR.			148
	#1/4	WASHER, SPLIT LOCK			149
					150
					151
	#4-40	NUT, HEX			152
	#6-32	NUT, HEX			153
	#8-32	NUT, HEX			154
	#10-32	NUT, HEX			155
					156
					157
					158
					159
	R3031	RING LUG 10/8	14726		160
	R4142	RING LUG 6/22-18	14726		161
	R4148	RING LUG 8/22-18	14726		162
	R4149	RING LUG 10/22-18	14726		163
	R4161	RING LUG 10/16-14	14726		164
	R4170	RING LUG 10/12-10	14726		165
	R4183	RING LUG 6/12-10	14726		166
	R4189	RING LUG 8/12-10	14726		167
	KT75	MALE TAB	75382		168
					169
					170
					171
					172
					173
					174
					175
					176
					177
					178
					179
					180

MODEL 1503T | CALICO P/N 4153-400 | ASSY R.D.

TITLE 1500VA 3φ POWER AMPLIFIER | SHT 9 OF 9

CALIFORNIA INSTRUMENTS CO.
SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A2	D4153-401-1	RECTIFIER ASSEMBLY	16067		1
					2
					3
A2CR1	1N1186A	RECTIFIER	95303	3-10167	4
A2CR2	1N1186A	RECTIFIER	95303	3-10167	5
A2CR3	1N1186A	RECTIFIER	95303	3-10167	6
A2CR4	1N1186RA	RECTIFIER	95303	3-10192	7
A2CR5	1N1186RA	RECTIFIER	95303	3-10192	8
A2CR6	1N1186RA	RECTIFIER	95303	3-10192	9
A2CR7	1N1186A	RECTIFIER	95303	3-10167	10
A2CR8	1N1186A	RECTIFIER	95303	3-10167	11
A2CR9	1N1186A	RECTIFIER	95303	3-10167	12
A2CR10	1N1186RA	RECTIFIER	95303	3-10192	13
A2CR11	1N1186RA	RECTIFIER	95303	3-10192	14
A2CR12	1N1186RA	RECTIFIER	95303	3-10192	15
					16
					17
A2R1	RC42GF271J	RESISTOR 270Ω 5% 2W	81349	5-40025	18
A2R2	RC42GF271J	RESISTOR 270Ω 5% 2W	81349	5-40025	19
					20
	#6	WASHER, FLAT			21
	C4153-205-7	BRACKET	16067	1-10313	22
	C4153-206-7	INSULATOR	16067	1-10314	23
	C4153-207-7	HEATSINK	16067	2-10421	24
	R3031	RING LUG 10-8	14726		25
	1410-14	SOLDER LUG	83330	2-50082	26
#6 x 3/8 LG. TYPE B SELF		TAP FLAT HEAD SCREW	45722	2-10414	27
	6-32 x 5/16 LG.	SCREW, PAN HEAD			28
	1601A	TERMINAL, INSULATED	88245	2-40317	29
	2322	STAND OFF 1/2 LG.	83330	2-10063	30
	1416-6	SOLDER LUG	83330	2-50047	31
	#6	WASHER, INT. STR.			32
	#8-32 x 3/4 LG.	SCREW, PAN HEAD			33
	#8	WASHER, INT. STR.			34
	#8-32	NUT, HEX			35
	#12AWG	BUSS WIRE			36

MODEL	CALICO P/N	ASSY R.D.
1503T/2253T	4153-401	A2

TITLE	SHT	OF
3 PHASE POWER RECTIFIER ASSY	3	3

CALIFORNIA INSTRUMENTS CO.
SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A3	E4153-402-1	HEATSINK ASSY -42V	16067		1
A7	E4153-402-2	HEATSINK ASSY +42V	16067		2
	D4153-701-7	P. C. BOARD MECH.	16067	1-60164	3
	22NCFMA1-40	CLINCH NUT	22599	2-10185	4
	NOTE: A3, A4, and A5 ARE IDENTICAL (-42V SUPPLY)				5
					6
A3CR1	1N1193	DIODE	04713	3-10190	7
					8
A3Q1	CIC 722 (SELECTED 2N4920)	TRANSISTOR (RED DOT)	16067	3-30231	9
A3Q2	2N4348	TRANSISTOR	95303	3-30174	10
A3Q3	66879	TRANSISTOR	95303	3-30298	11
A3Q4	66879	TRANSISTOR	95303	3-30298	12
A3Q5	66879	TRANSISTOR	95303	3-30298	13
A3Q6	66879	TRANSISTOR	95303	3-30298	14
A3Q7	66879	TRANSISTOR	95303	3-30298	15
A3Q8	66879	TRANSISTOR	95303	3-30298	16
A3Q9	66879	TRANSISTOR	95303	3-30298	17
A3Q10	66879	TRANSISTOR	95303	3-30298	18
					19
A3R1	RC20GF101J	RESISTOR 100Ω 1/2W 5%	81349	5-20018	20
A3R2	RC32GF5R1J	RESISTOR 5.1Ω 5% 1W	81349	5-30050	21
A3R3	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	22
A3R4	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	23
A3R5	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	24
A3R6	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	25
A3R7	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	26
A3R8	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	27
A3R9	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	28
A3R10	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	29
A3R11	RC07GF7R5J	RESISTOR 7.5Ω 5% 1/4W	81349	5-10004	30
A3R12	BWH 1Ω 5% 2W	RESISTOR 1Ω 5% 2W	07716	5-40001	31
					32
					33
	NOTE: A7, A8 and A9 ARE IDENTICAL (+42V SUPPLY)				34
					35
A7CR1	1N1193	DIODE	04713	3-10190	36

MODEL 1503T	CALICO P/N 4153-402	ASSY R.D. A3, 4, 5 A7, 8, 9
TITLE HEATSINK ASSEMBLY -42V and +42V	SHT 3 OF 5	

CALIFORNIA INSTRUMENTS CO.
SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A7Q1	MJE340	TRANSISTOR	04713	3-30199	37
A7Q2	2N4348	TRANSISTOR	95303	3-30174	38
A7Q3	66879	TRANSISTOR	95303	3-30298	39
A7Q4	66879	TRANSISTOR	95303	3-30298	40
A7Q5	66879	TRANSISTOR	95303	3-30298	41
A7Q6	66879	TRANSISTOR	95303	3-30298	42
A7Q7	66879	TRANSISTOR	95303	3-30298	43
A7Q8	66879	TRANSISTOR	95303	3-30298	44
A7Q9	66879	TRANSISTOR	95303	3-30298	45
A7Q10	66879	TRANSISTOR	95303	3-30298	46
					47
A7R1	RC20GF101J	RESISTOR 100Ω 1/2W 5%	81349	5-20018	48
A7R2	RC32GF5R1J	RESISTOR 5.1Ω 5% 1W	81349	5-30050	49
A7R3	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	50
A7R4	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	51
A7R5	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	52
A7R6	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	53
A7R7	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	54
A7R8	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	55
A7R9	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	56
A7R10	RW55GR20WL	RESISTOR .2Ω 5% 5W	63743	5-50144	57
					58
					59
	D4153-208-7	HEATSINK	16067	2-10422	60
					61
					62
	RA-257	FEMALE SNAP ON TERMINAL	59730		63
	RC-257	FEMALE SNAP ON TERMINAL	59730		64
	AWG16	BUSS WIRE			65
	NY04-040	NYLON BUSHING	08239	2-10076	66
	THERMATE	COMPOUND, SILICONE			67
	DM-123	WASHER, MICA	08289	3-30192	68
	MW-500-125	WASHER, MICA	08289	2-10405	69
	834	CABLE CLAMP	83330		70
	B-500+	WIRE MARKER	53209		71
	AWG14	SLEEVING TEFLON			72

MODEL 1503T | CALICO P/N 4153-402 | ASSY R.D. A3, 4, 5 A7, 8, 9

TITLE HEATSINK ASSEMBLY -42V and +42V | SHT 4 OF 5

CALIFORNIA INSTRUMENTS CO.
SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
	4-40 x 5/16 LG.	SCREW, PAN HD.			73
	4-40 x 5/8 LG.	SCREW, PAN HD.			74
					75
	6-32 x 3/8 LG.	SCREW, PAN HD.			76
					77
	#6	WASHER, FLAT			78
					79
	#4	WASHER, INT. STR.			80
	#6	WASHER, INT. STR.			81
					82
	#6-32	NUT, HEX			83
	#4-40	NUT, HEX			84
					85
					86
					87
					88
					89
					90
					91
					92
					93
					94
					95
					96
					97
					98
					99
					100
					101
					102
					103
					104
					105
					106
					107
					108

MODEL 1503T

CALICO P/N 4153-402

ASSY R.D. A 3, 4, 5 A 7, 8, 9

TITLE HEATSINK ASSEMBLY -42V and +42V

SHT 5 OF 5

CALIFORNIA INSTRUMENTS CO.
SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A1	D4153-700-1	P.C. BOARD ASSY, 1503T	16067		1
	-7	P.C. BOARD MECH	16067	1-60163	2
	SEE SHT. 3	EYELET			3
	SEE SHT. 3	TERMINAL			4
					5
					6
A1C1	39D118G050HP4	CAPACITOR 1100μF 50V	56289	6-10818	7
A1C2	39D118G050HP4	CAPACITOR 1100μF 50V	56289	6-10818	8
A1C3	T360B106M025AS	CAPACITOR 10μF 25V	05397	6-10738	9
A1C4	1DP-2-473	CAPACITOR .047μF 100V	72136	6-10116	10
A1C5	CM05F201J03	CAPACITOR 200PF 500V	81349	6-10282	11
A1C6	CM06F102J03	CAPACITOR 1000PF 500V	81349	6-10051	12
A1C7	T360D336M035AS	CAPACITOR 33μF 35V	05397	6-10804	13
A1C8	TE-1504	CAPACITOR 5μF 150V	56289	6-10533	14
A1C9	CM06F511J03	CAPACITOR 510PF 500V	81349	6-10046	15
A1C10	39D756F100FJ4	CAPACITOR 75μF 100V	56289	6-10819	16
A1C11	CM05F221J03	CAPACITOR 220PF 500V	81349	6-10036	17
A1C12	TG-P10	CAPACITOR .1μF 100V	56289	6-10127	18
A1C13	TG-P10	CAPACITOR .1μF 100V	56289	6-10127	19
A1C14	T360B106M025AS	CAPACITOR 10μF 25V	05397	6-10738	20
A1C15	1DP-2-473	CAPACITOR .047μF 100V	72136	6-10116	21
A1C16	CM05F201J03	CAPACITOR 200PF 500V	81349	6-10282	22
A1C17	CM06F102J03	CAPACITOR 1000PF 500V	81349	6-10051	23
A1C18	T360D336M035AS	CAPACITOR 33μF 35V	05397	6-10804	24
A1C19	TE-1504	CAPACITOR 5μF 150V	56289	6-10533	25
A1C20	CM06F511J03	CAPACITOR 510PF 500V	81349	6-10046	26
A1C21	39D756F100FJ4	CAPACITOR 75μF 100V	56289	6-10819	27
A1C22	CM05F221J03	CAPACITOR 220PF 500V	81349	6-10036	28
A1C23	TG-P10	CAPACITOR .1μF 100V	56289	6-10127	29
A1C24	TG-P10	CAPACITOR .1μF 100V	56289	6-10127	30
A1C25	T360B106M025AS	CAPACITOR 10μF 25V	05397	6-10738	31
A1C26	1DP-2-473	CAPACITOR .047μF 100V	72136	6-10116	32
A1C27	CM05F201J03	CAPACITOR 200PF 500V	81349	6-10282	33
A1C28	CM06F102J03	CAPACITOR 1000PF 500V	81349	6-10051	34
A1C29	T360D336M035AS	CAPACITOR 33μF 35V	05397	6-10804	35
A1C30	TE-1504	CAPACITOR 5μF 150V	56289	6-10533	36

MODEL 1503T/2253T | CALICO P/N 4153-700 | ASSY R.D. A1

TITLE 3 PHASE PREAMPLIFIER P.C. BD. ASSY | SHT 4 OF 10

Aiken Industries	California Instruments Division	CODE IDENT 16067	PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A1C31	CM06F511J03	CAPACITOR 510PF 500V	81349	6-10046	37
A1C32	39D756F100FJ4	CAPACITOR 75μF 100V	56289	6-10819	38
A1C33	CM05F221J03	CAPACITOR 220PF 500V	81349	6-10036	39
A1C34	TG-P10	CAPACITOR .1μF 100V	56289	6-10127	40
A1C35	TG-P10	CAPACITOR .1μF 100V	56289	6-10127	41
A1C36	5GA-D33	CAPACITOR .0033μF 1KV	56289	6-10072	42
A1C37	5GA-D33	CAPACITOR .0033μF 1KV	56289	6-10072	43
A1C38	5GA-D33	CAPACITOR .0033μF 1KV	56289	6-10072	44
					45
A1CR1	1N4001	DIODE	04713	3-10172	46
A1CR2	1N4001	DIODE	04713	3-10172	47
A1CR3	1N5254	DIODE, ZENER	04713	3-10210	48
A1CR4	1N914	DIODE	81349	3-10118	49
A1CR5	1N914	DIODE	81349	3-10118	50
A1CR6	1N914	DIODE	81349	3-10118	51
A1CR7	1N914	DIODE	81349	3-10118	52
A1CR8	1N5254	DIODE, ZENER	04713	3-10210	53
A1CR9	1N914	DIODE	81349	3-10118	54
A1CR10	1N914	DIODE	81349	3-10118	55
A1CR11	1N914	DIODE	81349	3-10118	56
A1CR12	1N914	DIODE	81349	3-10118	57
A1CR13	1N5254	DIODE, ZENER	04713	3-10210	58
A1CR14	1N914	DIODE	81349	3-10118	59
A1CR15	1N914	DIODE	81349	3-10118	60
A1CR16	1N914	DIODE	81349	3-10118	61
A1CR17	1N914	DIODE	81349	3-10118	62
A1CR18-A1CR23	1N914	DIODE	81349	3-10118	63
A1CR24	0.5M32.6ZS2	DIODE, ZENER	04713	3-10258	64
A1CR25	0.5M32.6ZS2	DIODE, ZENER	04713	3-10258	65
A1CR26	0.5M32.6ZS2	DIODE, ZENER	04713	3-10258	66
A1CR27	0.5M30.0ZS2	DIODE, ZENER	04713	3-10259	67
A1CR28	0.5M30.0ZS2	DIODE, ZENER	04713	3-10259	68
A1CR29	0.5M30.0ZS2	DIODE, ZENER	04713	3-10259	69
A1Q1	SG3821N	TRANSISTOR ARRAY	0000J	3-30203	70
A1Q2	MPS-U56	TRANSISTOR	04713	3-30222	71
A1Q3	MPS-U56	TRANSISTOR	04713	3-30222	72

MODEL 1503T-2253T	CALICO P/N 4153-700	ASSY R.D. A1
TITLE 3 PHASE PREAMPLIFIER P.C. BD. ASSY	SHT 5 OF 10	

Aiken Industries	California Instruments Division	CODE IDENT 16067	PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A1Q4	MJE340	TRANSISTOR	04713	3-30199	73
A1Q5	CIC330	TRANSISTOR	16067	3-30008	74
A1Q6	CIC718	TRANSISTOR	16067	3-30041	75
A1Q7	SG3821N	TRANSISTOR ARRAY	0000J	3-30203	76
A1Q8	MPS-U56	TRANSISTOR	04713	3-30222	77
A1Q9	MPS-U56	TRANSISTOR	04713	3-30222	78
A1Q10	MJE340	TRANSISTOR	04713	3-30199	79
A1Q11	CIC330	TRANSISTOR	16067	3-30008	80
A1Q12	CIC718	TRANSISTOR	16067	3-30041	81
A1Q13	SG3821N	TRANSISTOR ARRAY	0000J	3-30203	82
A1Q14	MPS-U56	TRANSISTOR	04713	3-30222	83
A1Q15	MPS-U56	TRANSISTOR	04713	3-30222	84
A1Q16	MJE340	TRANSISTOR	04713	3-30199	85
A1Q17	CIC330	TRANSISTOR	16067	3-30008	86
A1Q18	CIC718	TRANSISTOR	16067	3-30041	87
					88
A1R1	RC20GF100J	RESISTOR 10Ω 5% 1/2W	81349	5-20006	89
A1R2	RC07GF333J	RESISTOR 33K 5% 1/4W	81349	5-10088	90
A1R3	RC07GF512J	RESISTOR 5.1K 5% 1/4W	81349	5-10069	91
A1R4	RN60C1002F	RESISTOR 10K 1% 1/8W	81349	5-60081	92
A1R5	RC07GF512J	RESISTOR 5.1K 5% 1/4W	81349	5-10069	93
A1R6	RC07GF102J	RESISTOR 1K 5% 1/4W	81349	5-10053	94
A1R7	X-201R101B	POTENTIOMETER 100Ω	71450	5-70153	95
A1R8	RC07GF102J	RESISTOR 1K 5% 1/4W	81349	5-10053	96
A1R9	RC07GF333J	RESISTOR 33K 5% 1/4W	81349	5-10088	97
A1R10	RC20GF100J	RESISTOR 10Ω 5% 1/2W	81349	5-20006	98
A1R11	RC07GF512J	RESISTOR 5.1K 5% 1/4W	81349	5-10069	99
A1R12	RC07GF103J	RESISTOR 10K 5% 1/4W	81349	5-10076	100
A1R13	RC07GF331J	RESISTOR 330Ω 5% 1/4W	81349	5-10041	101
A1R14	RC07GF681J	RESISTOR 680Ω 5% 1/4W	81349	5-10049	102
A1R15	X-201R101B	POTENTIOMETER 100Ω	71450	5-70153	103
A1R16	RN60C4222F	RESISTOR 42.2K 1% 1/8W	81349	5-60434	104
A1R17	X-201R252	POTENTIOMETER 2.5K	71450	5-70177	105
A1R18	RC07GF103J	RESISTOR 10K 5% 1/4W	81349	5-10076	106
A1R19	RC07GF103J	RESISTOR 10K 5% 1/4W	81349	5-10076	107
A1R20	RC07GF302J	RESISTOR 3K 5% 1/4W	81349	5-10063	108

MODEL 1503T-2253T	CALICO P/N 4153-700	ASSY R.D.
TITLE 3 PHASE PREAMPLIFIER P.C. BOD. ASSY	SHT 6 OF 10	A1

CALIFORNIA INSTRUMENTS CO.
SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A1R21	RC07GF222J	RESISTOR 2.2K 5% 1/4W	81349	5-10060	109
A1R22	RC07GF912J	RESISTOR 9.1K 5% 1/4W	81349	5-10075	110
A1R23	RC07GF622J	RESISTOR 6.2K 5% 1/4W	81349	5-10071	111
A1R24	RC07GF102J	RESISTOR 1K 5% 1/4W	81349	5-10053	112
A1R25	RC07GF241J	RESISTOR 240Ω 5% 1/4W	81349	5-10038	113
A1R26	RC07GF241J	RESISTOR 240Ω 5% 1/4W	81349	5-10038	114
A1R27	RC07GF821J	RESISTOR 820Ω 5% 1/4W	81349	5-10051	115
A1R28	RC07GF183J	RESISTOR 18K 5% 1/4W	81349	5-10082	116
A1R29	RC07GF511J	RESISTOR 510Ω 1/4W	81349	5-10046	117
A1R30	RC20GF132J	RESISTOR 1.3K 5% 1/2W	81349	5-20037	118
A1R31	RC20GF681J	RESISTOR 680Ω 5% 1/2W	81349	5-20119	119
A1R32	RC07GF470J	RESISTOR 47Ω 5% 1/4W	81349	5-10021	120
A1R33	RC07GF---	RESISTOR T B D			121
A1R34	RC07GF470J	RESISTOR 47Ω 5% 1/4W	81349	5-10021	122
A1R35	RC07GF560J	RESISTOR 56Ω 5% 1/4W	81349	5-10023	123
A1R36	RC07GF183J	RESISTOR 18K 5% 1/4W	81349	5-10082	124
A1R37	RC07GF101J	RESISTOR 100Ω 5% 1/4W	81349	5-10029	125
A1R38	RC07GF180J	RESISTOR 18Ω 5% 1/4W	81349	5-10011	126
A1R39	RC07GF180J	RESISTOR 18Ω 5% 1/4W	81349	5-10011	127
A1R40	RC07GF101J	RESISTOR 100Ω 5% 1/4W	81349	5-10029	128
A1R41	RC07GF183J	RESISTOR 18K 5% 1/4W	81349	5-10082	129
A1R42	X-201R101B	POTENTIOMETER 100Ω	71450	5-70153	130
A1R43	RC07GF180J	RESISTOR 18Ω 5% 1/4W	81349	5-10011	131
A1R44	RC07GF180J	RESISTOR 18Ω 5% 1/4W	81349	5-10011	132
A1R45	X-201R101B	POTENTIOMETER 100Ω	71450	5-70153	133
A1R46	RN60C1002F	RESISTOR 10K 1% 1/8W	81349	5-60081	134
A1R47	RC07GF512J	RESISTOR 5.1K 5% 1/4W	81349	5-10069	135
A1R48	RC07GF512J	RESISTOR 5.1K 5% 1/4W	81349	5-10069	136
A1R49	RC07GF333J	RESISTOR 33K 5% 1/4W	81349	5-10088	137
A1R50	RC07GF102J	RESISTOR 1K 5% 1/4W	81349	5-10053	138
A1R51	X-201R101B	POTENTIOMETER 100Ω	71450	5-70153	139
A1R52	RC07GF102J	RESISTOR 1K 5% 1/4W	81349	5-10053	140
A1R53	RC07GF333J	RESISTOR 33K 5% 1/4W	81349	5-10088	141
A1R54	RC07GF512J	RESISTOR 5.1K 5% 1/4W	81349	5-10069	142
A1R55	RC07GF103J	RESISTOR 10K 5% 1/4W	81349	5-10076	143
A1R56	RC07GF331J	RESISTOR 330Ω 5% 1/4W	81349	5-10041	144

CALIFORNIA INSTRUMENTS CO.
SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A1R57	RC07GF681J	RESISTOR 680Ω 5% 1/4W	81349	5-10049	145
A1R58	X-201R101B	POTENTIOMETER 100Ω	71450	5-70153	146
A1R59	RN60C4222F	RESISTOR 42.2K 1% 1/8W	81349	5-60434	147
A1R60	X-201R252B	POTENTIOMETER 2.5K	71450	5-70177	148
A1R61	RC07GF103J	RESISTOR 10K 5% 1/4W	81349	5-10076	149
A1R62	RC07GF103J	RESISTOR 10K 5% 1/4W	81349	5-10076	150
A1R63	RC07GF302J	RESISTOR 3K 5% 1/4W	81349	5-10063	151
A1R64	RC07GF222J	RESISTOR 2.2K 5% 1/4W	81349	5-10060	152
A1R65	RC07GF912J	RESISTOR 9.1K 5% 1/4W	81349	5-10075	153
A1R66	RC07GF622J	RESISTOR 6.2K 5% 1/4W	81349	5-10071	154
A1R67	RC07GF102J	RESISTOR 1K 5% 1/4W	81349	5-10053	155
A1R68	RC07GF241J	RESISTOR 240Ω 5% 1/4W	81349	5-10038	156
A1R69	RC07GF241J	RESISTOR 240Ω 5% 1/4W	81349	5-10038	157
A1R70	RC07GF821J	RESISTOR 820Ω 5% 1/4W	81349	5-10051	158
A1R71	RC07GF183J	RESISTOR 18K 5% 1/4W	81349	5-10082	159
A1R72	RC07GF511J	RESISTOR 510Ω 5% 1/4W	81349	5-10046	160
A1R73	RC20GF132J	RESISTOR 1.3K 5% 1/2W	81349	5-20037	161
A1R74	RC20GF681J	RESISTOR 680Ω 5% 1/2W	81349	5-20119	162
A1R75	RC07GF470J	RESISTOR 47Ω 5% 1/4W	81349	5-10021	163
A1R76	RC07GF---	RESISTOR T B D			164
A1R77	RC07GF470J	RESISTOR 47Ω 5% 1/4W	81349	5-10021	165
A1R78	RC07GF560J	RESISTOR 56Ω 5% 1/4W	81349	5-10023	166
A1R79	RC07GF183J	RESISTOR 18K 5% 1/4W	81349	5-10082	167
A1R80	RC07GF101J	RESISTOR 100Ω 5% 1/4W	81349	5-10029	168
A1R81	RC07GF180J	RESISTOR 18Ω 5% 1/4W	81349	5-10011	169
A1R82	RC07GF180J	RESISTOR 18Ω 5% 1/4W	81349	5-10011	170
A1R83	RC07GF101J	RESISTOR 100Ω 5% 1/4W	81349	5-10029	171
A1R84	RC07GF183J	RESISTOR 18K 5% 1/4W	81349	5-10082	172
A1R85	X-201R101B	POTENTIOMETER 100Ω	71450	5-70153	173
A1R86	RC07GF180J	RESISTOR 18Ω 5% 1/4W	81349	5-10011	174
A1R87	RC07GF180J	RESISTOR 18Ω 5% 1/4W	81349	5-10011	175
A1R88	X-201R101B	POTENTIOMETER 100Ω	71450	5-70153	176
A1R89	RN60C1002F	RESISTOR 10K 1% 1/8W	81349	5-60081	177
A1R90	RC07GF512J	RESISTOR 5.1K 5% 1/4W	81349	5-10069	178
A1R91	RC07GF512J	RESISTOR 5.1K 5% 1/4W	81349	5-10069	179
A1R92	RC07GF333J	RESISTOR 33K 5% 1/4W	81349	5-10088	180

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TITLE 3 PHASE PREAMPLIFIER P.C. BD. ASSY | SHT 8 OF 10

CALIFORNIA INSTRUMENTS CO.
SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A1R93	RC07GF102J	RESISTOR 1K 5% 1/4W	81349	5-10053	181
A1R94	X-201R101B	POTENTIOMETER 100Ω	71450	5-70153	182
A1R95	RC07GF102J	RESISTOR 1K 5% 1/4W	81349	5-10053	183
A1R96	RC07GF333J	RESISTOR 33K 5% 1/4W	81349	5-10088	184
A1R97	RC07GF512J	RESISTOR 5.1K 5% 1/4W	81349	5-10069	185
A1R98	RC07GF103J	RESISTOR 10K 5% 1/4W	81349	5-10076	186
A1R99	RC07GF331J	RESISTOR 330Ω 5% 1/4W	81349	5-10041	187
A1R100	RC07GF681J	RESISTOR 680Ω 5% 1/4W	81349	5-10049	188
A1R101	X-201R101B	POTENTIOMETER 100Ω	71450	5-70153	189
A1R102	RN60C4222F	RESISTOR 42.2K 1% 1/8W	81349	5-60434	190
A1R103	X-201R252B	POTENTIOMETER 2.5K	71450	5-70177	191
A1R104	RC07GF103J	RESISTOR 10K 5% 1/4W	81349	5-10076	192
A1R105	RC07GF103J	RESISTOR 10K 5% 1/4W	81349	5-10076	193
A1R106	RC07GF302J	RESISTOR 3K 5% 1/4W	81349	5-10063	194
A1R107	RC07GF222J	RESISTOR 2.2K 5% 1/4W	81349	5-10060	195
A1R108	RC07GF622J	RESISTOR 6.2K 5% 1/4W	81349	5-10071	196
A1R109	RC07GF912J	RESISTOR 9.1K 5% 1/4W	81349	5-10075	197
A1R110	RC07GF102J	RESISTOR 1K 5% 1/4W	81349	5-10053	198
A1R111	RC07GF241J	RESISTOR 240Ω 5% 1/4W	81349	5-10038	199
A1R112	RC07GF241J	RESISTOR 240Ω 5% 1/4W	81349	5-10038	200
A1R113	RC07GF821J	RESISTOR 820Ω 5% 1/4W	81349	5-10051	201
A1R114	RC07GF183J	RESISTOR 18K 5% 1/4W	81349	5-10082	202
A1R115	RC07GF511J	RESISTOR 510Ω 5% 1/4W	81349	5-10046	203
A1R116	RC20GF132J	RESISTOR 1.3K 5% 1/2W	81349	5-20037	204
A1R117	RC20GF681J	RESISTOR 680Ω 5% 1/2W	81349	5-20119	205
A1R118	RC07GF470J	RESISTOR 47Ω 5% 1/4W	81349	5-10021	206
A1R119	RC07GF---	RESISTOR T B D			207
A1R120	RC07GF470J	RESISTOR 47Ω 5% 1/4W	81349	5-10021	208
A1R121	RC07GF560J	RESISTOR 56Ω 5% 1/4W	81349	5-10023	209
A1R122	RC07GF183J	RESISTOR 18K 5% 1/4W	81349	5-10082	210
A1R123	RC07GF101J	RESISTOR 100Ω 5% 1/4W	81349	5-10029	211
A1R124	RC07GF180J	RESISTOR 18Ω 5% 1/4W	81349	5-10011	212
A1R125	RC07GF180J	RESISTOR 18Ω 5% 1/4W	81349	5-10011	213
A1R126	RC07GF101J	RESISTOR 100Ω 5% 1/4W	81349	5-10029	214
A1R127	RC07GF183J	RESISTOR 18K 5% 1/4W	81349	5-10082	215
A1R128	X-201R101B	POTENTIOMETER 100Ω	71450	5-70153	216

MODEL 1503T/2253T | CALICO P/N 4153-700 | ASSY R.D. A1

TITLE 3 PHASE PREAMPLIFIER P.C. BD. ASSY | SHT 9 OF 10

CALIFORNIA INSTRUMENTS CO.
SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A1R129	RC07GF180J	RESISTOR 18Ω 5% 1/4W	81349	5-10011	217
A1R130	RC07GF180J	RESISTOR 18Ω 5% 1/4W	81349	5-10011	218
A1R131	X-201R101B	POTENTIOMETER 100Ω	71450	5-70153	219
A1R132	RC07GF512J	RESISTOR 5.1K 5% 1/4W	81349	5-10069	220
A1R133	RC07GF512J	RESISTOR 5.1K 5% 1/4W	81349	5-10069	221
A1R134	RC07GF512J	RESISTOR 5.1K 5% 1/4W	81349	5-10069	222
					223
					224
					225
A1T1	T31X	TRANSFORMER	81095	7-10130	226
A1T2	T31X	TRANSFORMER	81095	7-10130	227
A1T3	T31X	TRANSFORMER	81095	7-10130	228
					229
					230
					231
					232
	1570	BRACKET	91833	1-10299	233
					234
	4-40 x 1/4 LG	SCREW, PAN HEAD			235
	6-32 x 5/16 LG	SCREW, PAN HEAD			236
					237
	#4	WASHER, INT. STR.			238
	#6	WASHER, INT. STR.			239
					240
	#4-40	NUT, HEX			241
	#6-32	NUT, HEX			242
					243
	2829-75-3	MOUSE TAIL	98159	2-10343	244
					245
	#22 AWG	BUSS WIRE			246
	#22 AWG	SLEEVING			247
					248
					249
					250
					251
					252

MODEL	CALICO P/N	ASSY R.D.
1503T/2253T	4153-700	
TITLE 3 PHASE PREAMPLIFIER P.C. BD. ASSY	SHT 10 OF 10	A1

CALIFORNIA INSTRUMENTS CO.
SAN DIEGO, CALIFORNIA

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A6	4053-702-1	P. C. BOARD ASSY	16067		1
	4053-702-7	P. C. BOARD MECH	16067	1-60158	2
	SEE SHEET 3	EYELET			3
					4
					5
					6
A6CR1	1N914	DIODE	81349	3-10118	7
A6CR2	1N914	DIODE	81349	3-10118	8
A6CR3	1N914	DIODE	81349	3-10118	9
A6CR4	1N914	DIODE	81349	3-10118	10
					11
					12
					13
A6R1	RC07GF622J	RESISTOR 6.2K 1/4W 5%	81349	5-10071	14
A6R2	RN60C2003F	RESISTOR 200K 1/8W 1%	81349	5-60146	15
A6R3	ET34X502	POTENTIOMETER 5K	30983	5-70132	16
A6R4	RC07GF102J	RESISTOR 1K 1/4W 5%	81349	5-10053	17
					18
					19
					20
A6S1	T206	SWITCH (MODIFY--CUT	71450	2-40422	21
		SHAFT 3/8" FROM THREADS)			

MODEL	CALICO P/N 4053-702 B	ASSY R.D.
TITLE METER - SWITCH BOARD ASSY	SHT 4 OF 4	A6

APPENDIX A

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbook H4-1 and its latest supplement. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 Handbook.

0000A	ElectriCord	Westfield	PA
0000AA	OK Machine and Tool Corp.	New York	NY
0000AB	Falmat	Harbor City	CA
0000B	Tech. Prod. Sales	Sorrento Valley	CA
0000C	Jackson Bros.	Waddon, Surrey	GB
0000D	Chicago Std. Transformer Co.	Chicago	IL
0000E	Use Code #08289		
0000F	Colvern	Santa Monica	CA
0000G	Use Code #30983		
0000H	Mial S.Italy c/o Q.C. Components	Los Angeles	CA
00001	Use Code #50522		
0000J	Use Code #34333		
0000K	Elma	Schweiz	GE
0000L	Use Code #32293		
0000M	Use Code #16950		
0000N	Use Code #15912		
0000P	Mesa Office Supply	San Diego	CA
0000R	American Handle	Philadelphia	PA
0000S	OPCDA	Edison	NJ
0000T	Use Code #31743		
0000U	Use Code #32293		
0000V	Falmat	Los Angeles	CA
0000W	Milton Ross Co.	Southampton	PA
0000X	Use Code #32072		
0000Y	Use Code #29990		
0000Z	Timco	Los Angeles	CA
00141	Pic Design Corp.	E. Rockaway	NY
00194	Waisco Electronics Corporation	Los Angeles	CA
00544	Metal-Cal Div., Avery Prod. Corp.	Inglewood	CA
00656	Aerovox Corporation	New Bedford	MA
00779	AMP, Inc.	Harrisburg	PA
00853	Sangamo Electric Company	Pickens	SC
00866	Goe Eng. Co., Inc.	City of Industry	CA
01121	Allen-Bradley Company	Milwaukee	WI
01179	Ajax Magnethermic Corp.	NE Warren	OH
01255	Litton Industries, Inc.	Beverly Hills	CA
01281	T R W Semiconductors, Inc.	Lawndale	CA
*01295	Texas Instruments, Inc.	Dallas	TX
02111	Spectrol Electronics	City of Industry	CA
02114	Ferroxcube Corp.	Saugerties	NY
02335	Fairchild Controls Corp.	Hicksville, LI	NY
02660	Amphenol Corporation	Broadview	IL
02799	Use Code #72136		
03507	General Electric Company	Syracuse	NY
03508	General Electric Company	Syracuse	NY
03516	General Electric Company	Somersworth	NH
03797	Eldema Corporation	Compton	CA
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls	NJ
03911	Glairex Corporation	New York	NY
04009	Arrow-Hart and Hegeman Elec. Co.	Hartford	CT
04062	Use Code #72136		
04713	Motorola Semiconductor Prod., Inc.	Phoenix	AZ
04963	3-M	St. Paul	MN
05236	Jonathan Mfg. Co.	Fullerton	CA
05276	Pomona Electronics Co., Inc.	Pomona	CA
05347	Ultronix	Grand Junction	CO
05397	Kemet, Union Carbide Corp.	Cleveland	OH
05820	Wakefield Engineering, Inc.	Wakefield	MA
06046	Dixson Meter	Grand Junction	CO
06184	Caneico Components	San Bernadino	CA
06223	Kooltronic Fan Company	Princeton	NJ
06229	Electrovert, Incorporated	Mt. Vernon	NY
06383	Panduit Corp.	Tinley Park	IL
06514	Stantron, Wyco Metal Products	N. Hollywood	CA
06540	Amathom Elect. Hardward	New Rochelle	NY
06682	Magnetic Shield Div.	Chicago	IL
06776	Robinson, Nugent, Inc.	New Albany	IN
06915	Richco Plastics, Co.	Chicago	IL
07088	Kelvin Electric Company	Van Nuys	CA
07115	Use Code #14674		
07255	Siliconx Transistor Corp.	Garden City	NY
07263	Fairchild Camera and Instr. Corp.	Mt. View	CA
07387	Birtcher Corporation	Los Angeles	CA
07556	Unitrack Calabro Plastics	Upper Darby	PA
07633	Epoxy Prod. Co., Div. of Allied Prod. Corp.	New Haven	CT
07713	Sperry Rand Corporation	Norwalk	CT
07716	I R C Incorporated	Burrington	IA
07910	Continental Devices	Hawthorne	CA
08065	Accurate Rubber and Plastics Co.	San Diego	CA
08261	Spectra Strip	Garden Grove	CA
08289	Bliss-Delbert Co., Inc.	Pomona	CA
08594	Eimac Div. of Varian Associates	Salt Lake	UT
08718	Use Code #71468		
08730	Vemaline Products Co.	Franklin Lakes	NJ
09026	Babcock Electronics Corp.	Costa Mesa	CA
09145	Atohm, Technical Industries, Inc.	Burbank	CA
09353	C and K Components, Inc.	Newton	MA
11432	Diamond Metal Sales	Gardena	CA
11815	Cherry Rivet Div., Townsend Co.	Santa Ana	CA
12020	Owensire, Incorporated	Charlottesville	VA
12143	Bendix Corporation	Santa Ana	CA
12405	Hysol Corporation	El Monte	CA
12406	Elpac, Incorporated	Fullerton	CA
12443	Omtronics Mfg., Incorporated	Omaha	NE
12673	Wesco Electrical Co.	Greenfield	MA
12697	Clarostat Mfg. Co., Incorporated	Dover	NH
13103	Thermalloy Company	Dallas	TX
13454	Texas Crystals	River Grove	IL
13571	Electronic Research	Overland Park	KS
13919	Burr-Brown Research Corp.	Tucson	AS
14099	Semtech Corporation	Newbury Park	CA
14193	Cal-R Inc.	Santa Monica	CA
14604	Elmwood Sensors Inc.	Cranston	RI
14655	Cornell-Dubilier Elect. Corp.	Newark	NJ
14674	Corning Glass Works	Corning	NY
14726	Hollingsworth Co.	Phoenixville	PA
14752	Electro Cube, Incorporated	San Gabriel	CA
14907	Cramer Div. of Conrac	Old Saybrook	CT
15112	Electra Scientific Corporation	Fullerton	CA
15636	Elec-trol	Northridge	CA
15801	Fenwall Electronics	Framingham	MA
15818	Ameleo Teledyne, Incorporated	Mt. View	CA
15909	Use Code #17870		
15912	Ansley	Los Angeles	CA
16067	California Instruments Company	San Diego	CA
16758	Delco Radio Div., General Motors	Kokomo	IN
16795	Bristol Electronics Inc.	Bedford	MA
16902	Simpson Instruments, Inc.	Escondido	CA
16950	Precision Dynamics Corp.	Burbank	CA
16956	Dennison	Framingham	MS
17745	Angstrohm Precision, Inc.	Van Nuys	CA
17838	Mektron, California General, Inc.	Chula Vista	CA
17856	Siliconix	Santa Clara	CA
17870	Daven Div., Thomas A. Edison	Manchester	NH
18076	Umpco	City of Industry	CA
18121	Willshire Foam Products, Inc.	Gardena	CA
18178	Vactec Inc.	Maryland Heights	MO
18324	Signatics	Sunnyvale	CA
18612	Vishay Instruments Inc.	Malvern	PA
18677	Scambe Mfg. Co.	Monterey Park	CA
18702	Ducommun Metals and Supply Co.	Los Angeles	CA
18722	R C A	Mountaintop	PA
19080	The Robinson Company	Hawthorne	CA
19781	Potter Company	Sun Valley	CA
20857	South Bay Cable Corp.	Gardena	CA
21270	Behr-Manning	Watervliet	NY
21604	Buckeye Stamping Company	Columbus	OH
22045	Jordan Elect.	Van Nuys	CA
22599	Elastic Stop Nut Corporation	Van Nuys	CA
23039	Deccofelt Products Company	Glendora	CA
23050	Product Components Corp.	Hastings-on-Hudson	NY
23095	Aztec Electronics In.	Anaheim	CA
23783	British Radio Electric Ltd.	Washington	DC
23936	Pamotor, Incorporated	San Francisco	CA
24011	E C C	Burlington	MA
24655	General Radio	Concord	MA
24796	Pareico Inc.	Paramount	CA
24931	Specialty Connector Co., Inc.	Indianapolis	IN
25403	Amperex (Diodes)	Slaterville	RI
25684	Victoreen Instrument Co., Inc.	Oak Lawn	IL
25706	Daburn Electronics and Cable Corp.	New York	NY
*01963	Cherry Electronical Prod. Corp.	Waukegan	IL
26528	Lamcor Incorporated	Anaheim	CA
26533	Use Code #98376		
26806	American Zettler Inc.	Costa Mesa	CA
27014	National Semi-Conductor Corp.	Santa Clara	CA
27191	Cutler-Hammer, Inc.	Milwaukee	WI
27264	Molex	Downers Grove	IL
27556	IMB Electronic Products	Santa Fe Springs	CA
27683	Varo, Incorporated	St. Garland	TX
27832	Hughes Aircraft	Newport Beach	CA
28480	Hewlett-Packard Co.	Palo Alto	CA
*28520	Heyman Mfg. Company (Heyco)	Kenilworth	NJ
30086	I-T-E Circuit Breaker Co.	Philadelphia	PA
30817	Instrument Specialties Co.	Little Falls	NJ
30897	Dorann Co.	Sylmar	CA
30983	Electra/Midland (Mepco/Electra)	San Diego	CA
31643	Elpower	Santa Ana	CA
31951	Trimfge Inc.	Pittsburgh	PA
32293	Intersil	Cupertino	CA
34333	Silicon General	Westminister	CA
34649	Intel Corp.	Santa Clara	CA
35929	Constanta	Quebec	CN
42190	Muter Company	Chicago	IL
44655	Ohmite Manufacturing Company	Skokie	IL
45722	Parker-Kalon	Clifton	NJ
46384	Penn. Eng. and Mfg. Corp.	Doylestown	PA
49956	Raytheon Co.	Lexington	MA
50522	Monsanto, Electronic Special Products	Cupertino	CA
50558	Electronic Concepts Inc.	Eatontown	NJ
51706	ICO/Rally	Palo Alto	CA
52072	Circuit Assembly Corp.	Costa Mesa	CA
53109	W. H. Brady Co.	Milwaukee	WI
56289	Sprague Electric Company	North Adams	MA
57971	Stimson	Bayport	NY
58474	Superior Electric Company	Bristol	CT
59730	Thomas and Bette Company	Elizabeth	NJ
60741	Triplett Electrical Instrument Co.	Bluffton	OH
63743	Ward Leonard Electric Co.	Mt. Vernon	NY
70318	Allmetal Screw Prod. Co.	Garden City	NY
70903	Belden Manufacturing Co.	Chicago	IL
71002	Birnbach Radio Company, Inc.	New York	NY
71218	Bud Radio	Willoughby	OH
71279	Cambridge Thermionic Corp.	Cambridge	MA
71400	Bussman 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, Inc.	Milwaukee	WI
71707	Coto-Coil	Providence	RI
71744	Chicago Miniature Lampworks	Chicago	IL
71785	Cinch Manufacturing Company	Chicago	IL
72136	Elmenco (Electro Motive)	Willimantic	CT
72259	Nytronics, Incorporated	Pelham Manor	NY
72619	Dialight Corporation	Brooklyn	NY
72699	General Instruments	Newark	NJ
72982	Erie Technological Products, Inc.	Erie	PA
73138	Beckman Instruments, Inc.	Fullerton	CA
73445	Amperex (Capacitors)	Long Island	NY
73559	Carling Electric, Inc.	West Hartford	CT
73734	Federal Screw Products, Inc.	Chicago	IL
73899	J F D Electronics Company	Brooklyn	NY
73949	Guardian Electric Mfg. Co.	Chicago	IL
73957	Groov-Pin Corporation	Ridgefield	NJ
74193	Heinemann Electric Company	Trenton	NJ
74276	Signalite, Incorporated	Neptune	NJ
74542	Hoyt Electrical Instrument Works	Penacook	NH
74545	Harvey Hubbel, Inc.	Bridgeport	CT
74970	E. F. Johnson Company	Waseca	MN
75382	Kulka Electric Corporation	Mt. Vernon	NY
75915	Littlefuse, Incorporated	Des Plaines	IL
75987	Use Code #95987		
76055	Mallory Controls	Frankfort	IN
76348	Miller Products Company	New York	NY
76385	Minor Rubber Co.	Bloomfield	NJ
76493	J. W. Miller Company	Los Angeles	CA
76854	Oak Manufacturing Company	Crystal Lake	IL
77342	Potter and Brumfield Div., Amer. Machine and Foundry Company	E. Princeton	IN
77638	General Instruments	Brooklyn	NY
77969	Rubber Craft Corp. of California	Torrance	CA
78189	Shakeproof Div., Illoms Tool Works	Chicago	IL
78299	Struthers-Dunn, Incorporated	Pitman	NJ
78488	Stackpole Carbon Company	St. Marys	PA
78526	Stanwick Winding Company, Inc.	Newburgh	NY
78553	Tinnerman Products, Inc.	Cleveland	OH
78947	Ucinite Company	Newtonville	MA
79136	Johns-Manville Products Corp.	Chicago	IL
79727	Continental-Wirt Electronics Corp.	Warminister	PA
79963	Zierick Mfg. Corporation	New Rochelle	NY
80031	Mepco/Electra	Morristown	NJ
80112	G. C. Electronics Company	Los Angeles	CA
80223	United Transformer Co.	New York	NY
80294	Bourns, Incorporated	Riverside	CA
80368	Sylvania Electric Products, Inc.	New York	NY
80583	Hammarlund Mfg. Co.	Red Bank	NJ
81073	Grayhill, Incorporated	La Grange	IL
81095	Triad Transformer Corp.	Venice	CA
81312	Winchester Electronics	Oakville	CT
81349	Military Spec., Standardization Division Directorate of Logistic Services DSA		
82104	Standard Grigsby	Aurora	IL
82389	Switchcraft, Incorporated	Chicago	IL
82877	Rotron Manufacturing Co., Inc.	Woodstock	NY
82893	Vector Electronics Inc.	Sylmar	CA
83058	Car Fastener Company	Cambridge	MA
83125	Nytronics Inc. Cap. Division	Darlington	SC
83324	Rosan, Incorporated	Newport Beach	CA
83330	Herman H. Smith, Inc.	Brooklyn	NY
83594	Burroughs Corporation	Plainfield	NJ
83701	Electronic Devices, Incorporated	Yonkers	NY
83781	Natl. Electronics	Geneva	IL
83827	Resistors Inc.	Chicago	IL
84171	Arco Electronics, Inc.	Great Neck	NY
86684	R C A	Harrison	NJ
86928	Seastrom Mfg. Co.	Glendale	CA
87034	Marco-Oak Industries	Anaheim	CA
88026	Use Code #27191		
88245	Useco Div., Litton Industries	Van Nuys	CA
89536	Fluke	Seattle	WA
90030	USM Corp.	Beverly	MA
90201	Mallory Capacitor Company	Indianapolis	IN
91459	Alcon Metal Prod. Inc.	Chicago	IL
91506	Augat	Attleboro	MA
91637	Dale Electronics, Inc.	Columbus	NE
91662	Elco Corporation	Willow Grove	PA
91812	Janco Corporation	Burbank	CA
91833	Keystone Electronics Corp.	New York	NY
91929	Micro Switch Div., Honeywell, Inc.	Freeport	IL
92194	Alpha Wire Corporation	Elizabeth	NJ
92219	Waldom Electronics, Inc.	Chicago	IL
93332	Sylvania Electric Products, Inc.	Woburn	MA
94222	Southco, Incorporated	Lester	PA
95146	Alco Electronics Products	Lawrence	MA
95503	R C A	Cincinnati	OH
95348	Gordos Corp.	Bloomfield	NJ
95416	Use Code #95146		
95987	Weckesser Company, Inc.	Chicago	IL
96682	Genisco, Incorporated	Compton	CA
96733	San Fernando Electric Mfg. Co.	San Fernando	CA
97525	Electronic Engineering Co.	Santa Ana	CA
97918	Linemaster Switch Corp.	Woodstock	CT
97954	U.S. Components, Incorporated	Bronx	NY
98159	Rubber Teck, Incorporated	Gardena	CA
98278	Microdot, Incorporated (Lerco)	S. Pasadena	CA
98291	Sealecto Corp	Mamaroneck	NY
98376	Zero Mfg. Co. (West)	Burbank	CA
98978	IERC	Burbank	CA
99028	Globe	Gardena	CA
99378	Atlee Corp.	Woburn	MA
99392	STM Corporation	Oakland	CA
99515	Marshall Industries	Monrovia	CA
99517	Vacco Industries	El Monte	CA
99742	Permacel Div., Johnson and Johnson	New Brunswick	NJ
99743	I M C	Maywood	CA
99800	Delevan Electronics Corporation	Aurora	NY
*29990	American Technical Ceramics	Huntington Station	NY

Revision I
October 26, 1976

ONE YEAR WARRANTY

CALIFORNIA INSTRUMENTS, A NORLIN TECHNOLOGY COMPANY 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 to the Company freight prepaid, and when examination reveals that the fault has not occurred because of misuse or abnormal conditions of operation. 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 shipping instructions will be furnished. If shipment is indicated, forward the instrument, freight prepaid, to the authorized repair station indicated in the instruction. If requested, an estimate of the charges will be made before the work begins, provided the instrument is 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 with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. CALIFORNIA INSTRUMENTS will advise the disposition to be made of the equipment and arrange for repair or replacement. Please include model number and serial number when referring to the instrument.