NSTRUCTION MANUAL

SERIES 815T

PRECISION

Invertron®

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MANUAL ADDENDUM

MODEL 815T-50-0.1-1

The Model 815T-50-0.1-1 provides a single phase 50 Hz ±0.1% output to drive a California Instruments Solid State Invertron®.

See the frequency determining parts list for component values which change with operating frequency.

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SPECIFICATIONS

All specifications are tested in accordance with standard California Instruments test procedures. All specifications apply over the frequency range from 45Hz to 10KHz. Consult the manual addendum for the actual oscillator output frequency.

MODEL NUMBER:	815T-Freq-.1-1	815T-Freq-.1-3*	815T-Freq-.1-2
No. of Phases:	single phase	three phase	two phase
Nominal Phase Shigt:	Not applicable	± 120 degrees	+ 90 degrees
Phase Sequence:	Not applicable	ABC sequence	CA sequence
Amplitude Tracking: (with amplitude potentiometer adjusted from 75% of full output to full output)**	Not applicable	1.0 per cent of full scale	1.0 per cent of full scale
Phase Accuracy at 25°C: (with amplitude potentiometer adjusted from 75% of full output to full output)**	Not applicable	±1.0 degree maximum.	±1.0 degree maximum.

SPECIFICATIONS COMMON TO ALL MODELS

Frequency	Single Fixed Frequency, 45Hz to 10KHz.
Frequency Accuracy at 25°C:	±0.10 percent.
Frequency Temperature Coefficient:	±.02 percent/°C maximum
Output Amplitude:	5.0 volts rms minimum for single phase versions; 0 to greater than 5 volts rms for multiphase versions.
Amplitude Stability: (after one hour warm-up)	±0.25 percent for 24 hours at 25°C ±0.02 percent/°C maximum
Total Harmonic Distortion:	0.2 percent maximum

Input Power:	±25 volts DC at approximately 18 milliamperes available from power source for single phase versions:
	±25 volts DC at approximately 55 milliamperes available from power source for three phase versions.
Operating Temperature Range:	0 to 55°C for all versions.
Dimensions:	3-1/2" high x 8" wide x 7" deep for mounting into a California Instruments Solid State Invertron®.
Front Panel Finish:	Grey 26440. Federal Standard 595.

* Order Model 815T-Freq-.1-3D for use in the three phase open delta configuration.

** This is a new improved specification. Oscillators manufactured prior to October 1974 were specified at 2% amplitude tracking with the AMPLITUDE control fully clockwise and 2° phase error with the AMPLITUDE control fully clockwise. These early oscillators were not specified as to additional phase and amplitude tracking errors when the AMPLITUDE control was turned counter clockwise from the fully clockwise position.

Step 5.6.4 was added to this manual at the "D" Revision to test for these improved characteristics in oscillators manufactured after October, 1974.

GENERAL DESCRIPTION

1.1 INTRODUCTION

This instruction manual contains information on the installation, operation, calibration and maintenance of the California Instruments 815T Series Precision Oscillators. A detailed theory of operation is provided as an aid to maintenance personnel. A complete parts listing, schematics and component location drawings are also supplied.

1.2 MODEL NUMBER DESCRIPTION

All oscillators in the 815T Series have a four or five place model number which describes the following features: the oscillator series, the output frequency of the oscillator, the frequency tolerance of the oscillator, and the number of phases of the oscillator. In addition, a "D" is placed after the model number if the oscillator is to be used in the three phase, open delta configuration. The following examples illustrate this numbering system.

Example 1: 815T-400-0.1-3φ

This is a 400 Hz, three phase oscillator with a specified frequency accuracy ±0.1%

Example 2: 815T-50-0.1-3φD

This is a 50 Hz, three phase oscillator for use in the open delta configuration with a specified frequency accuracy of ±0.1%

1.3 GENERAL DESCRIPTION

The California Instruments 815T Series Oscillators provide a pure sine wave output for driving the California Instruments Solid State Invertrons.® This oscillator incorporates a unique F.E.T. amplitude regulator circuit.

The multi-phase versions of the 815T Series Oscillators are used to drive two or more Solid State Invertrons® connected so as to provide either two phase or three phase power.

1.4 ACCESSORY EQUIPMENT

The following equipment is available for use with the 815T Series Oscillators.

1.4.1 4800-703 Extender Assembly. This assembly allows the oscillator to be tested and adjusted outside of the associated Solid State Invertron®.

CAUTION

HIGH VOLTAGE

Voltages up to 500 VAC are available in certain associated Invertrons®. 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 connector pins C and D of the plug in oscillator, the primary power circuits, and output circuits of the associated Invertron® if oscillator is tested and adjusted with Invertron®.

2.1 UNPACKING

Individual oscillators are shipped in a cardboard container with protective inner packing. Do not destroy this packing container until the unit has been inspected for possible damage in shipment.

2.2 POWER REQUIREMENTS

Single phase versions of the California Instruments 815T Oscillator operate from plus (+) and minus (-) 25 volts DC at 0.018 amperes. This power is normally obtained from the associated Invertron.® Three phase versions of the 815T Oscillator require approximately 55 milliamperes at ± 25 volts D.C.

2.3 FUSE REQUIREMENTS

No separate fuse is required with the California Instruments 815T Series Precision Oscillators.

2.4 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:

Mount the oscillator in the appropriate rack housing or otherwise apply ± 25 volt DC power to the unit.

2.4.1 MODEL 815T-Freq-Tol-1ϕ FIXED FREQUENCY OSCILLATOR

Figure 5-1 shows a test circuit for the 815T Series Oscillators. The output of this single phase oscillator should be 5.0 volts rms minimum. Connect an oscilloscope to the output of the oscillator and check that the oscillator has a clean sine wave output with no clipping or other distortion. Check that the output frequency is within 0.1 per cent of that indicated in the manual addendum. Detailed test procedures are given in the TEST PROCEDURE of this manual if futher evaluation of the oscillator is required at this time.

2.4.2 MODEL 815T-Freq-Tol-3ϕ FIXED FREQUENCY OSCILLATOR

The output of this three phase oscillator is controlled by the front panel AMPLITUDE control. Rotate this control fully clockwise. The output amplitude of each phase of the oscillator should be at least 5 volts rms. See Figure 5-1 for a detailed test circuit.

Connect an oscilloscope to the output of the oscillator and check that each phase of the oscillator has a clean sine wave output with no clipping or other distortion. Check that the output frequency is within 0.1 per cent of that indicated in the manual addendum. Detailed test procedures are given in the TEST PROCEDURE of this manual if further evaluation of the oscillator is required at this time.

2.4.3 MODEL 815T-Freq-Tol-2ϕ FIXED FREQUENCY OSCILLATOR

The output of this two phase oscillator is controlled by the front panel AMPLITUDE control. Rotate this control fully clockwise. The output amplitude of each phase of the oscillator should be at least 5 volts rms. See Figure 5-1 for a detailed test circuit.

Connect the oscilloscope to the output of the oscillator and check that both phases of the oscillator have a clean sine wave output with no clipping or other distortion. Check that the output frequency is within 0.1 per cent of that indicated in the manual addendum. Detailed test procedures are given in the TEST PROCEDURE of this manual if further evaluation of the oscillator is required at this time.

2.5 MECHANICAL INSTALLATION AND WIRING

The 815T Series Precision Oscillators fit directly into the California Instruments Solid State Invertron® Series of power amplifiers. All power for the oscillator, as well as signal output, is coupled through the printed circuit connector at the rear of the oscillator. The following table lists the voltage and applicable connector pins.

Pin	Function	
1	Output signal low	Phase A
2	Output signal high	Phase A
3	Power Ground	
4	+25 volt input	
5	-25 volt input	
6	Output signal low	Phase B
7	Output signal high	Phase B
8	Output signal low	Phase C
9	Output signal high	Phase C
10	External sync input	
C	115 volts AC line high	
D	115 volts AC line low	

The single phase version of the 815T Series Oscillator only has an "A" phase output. The two phase version of the 815T Series Oscillator has an "A" and "C" phase output while the three phase version of this oscillator has all three outputs. The external sync input and 115 volt AC inputs are not used for the standard versions of this oscillator.

2.6 OPERATING CONTROLS

Single phase versions of the 815T oscillator have no front panel operating controls. Multiphase versions of this oscillator have an AMPLITUDE control which is used to vary the output voltage level of all phases of the oscillator from 0 volts to greater than 5.0 volts rms.

In a multiphase power source, the GAIN control on each of the associated power amplifiers is used as a trim control to adjust each of the output leg voltages so that they are precisely equal to each other.

CAUTION

REMOVE POWER FROM
CALIFORNIA INSTRUMENTS
SOLID STATE INVERTRON
BEFORE REMOVING OR
INSERTING PLUG-IN
OSCILLATOR

3.1 DESCRIPTION OF SINGLE PHASE OSCILLATOR

A block diagram for the basic single phase oscillator in the 815T Series is given in Figure 3-1. A schematic diagram for the oscillator printed circuit board (designated as the A1 Assembly) is given in drawing D4815-071. An inner connecting wiring diagram is given in drawing D4815-070 for single phase, two phase and three phase versions of this oscillator.

The frequency determining elements are arranged in a Wien bridge configuration which is connected as a positive feedback loop around an operational amplifier as illustrated in Figure 3-1. The frequency of oscillation f_o is given by the equation,

$$f_o = \frac{1}{2\pi RC}$$

where R is the total resistance in the positive feedback path and C is the total capacitance in the positive feedback path. At the frequency of oscillation f_o, the positive feedback loop has a transmission of 0.333 and a zero phase shift. The negative feedback loop must adjust the closed loop gain of the operational amplifier A1IC1 to exactly 3.00 in order for the Wien bridge oscillator to produce a pure sine wave output with a minimum of distortion. This is accomplished by means of a servo feedback loop consisting of the level detector, a DC amplifier and the amplitude regulator. Whenever there is a change in the amplitude of the oscillator, a correction signal appears at the output of the level detector circuit. This correction signal is amplified by the DC amplifier and applied to control the output impedance of the amplitude regulator. The output impedance of the amplitude regulator controls the closed loop gain of the operational amplifier A1IC1. Therefore, any variation in the output of the oscillator is corrected by this servo feedback. The detailed circuit description is given in Section 3.1.1.

3.1.1 DETAILED CIRCUIT OPERATION

A schematic diagram for the single phase oscillator is shown in drawing D4815-071. All components of this oscillator are mounted on circuit board 4815-700, designated as the A1 assembly.

3.1.1.1 LEVEL DETECTOR

The level detector consists of A1R13, A1R14, diodes A1CR3, A1CR4, A1CR1, A1CR2, transistor A1Q3 and capacitor A1C9. The series connected reference elements diodes A1CR3, A1CR4 and base-emitter diode of A1Q3 act so as to set the level of the oscillator output. Diode A1CR3 and A1CR4 conduct on the positive peak of the sine wave output and inject a current pulse into the emitter of A1Q3. The average value of this current pulse is approximately 1.6 microamperes DC when the oscillator has a 5.5 volt rms output at A1 pin 15.

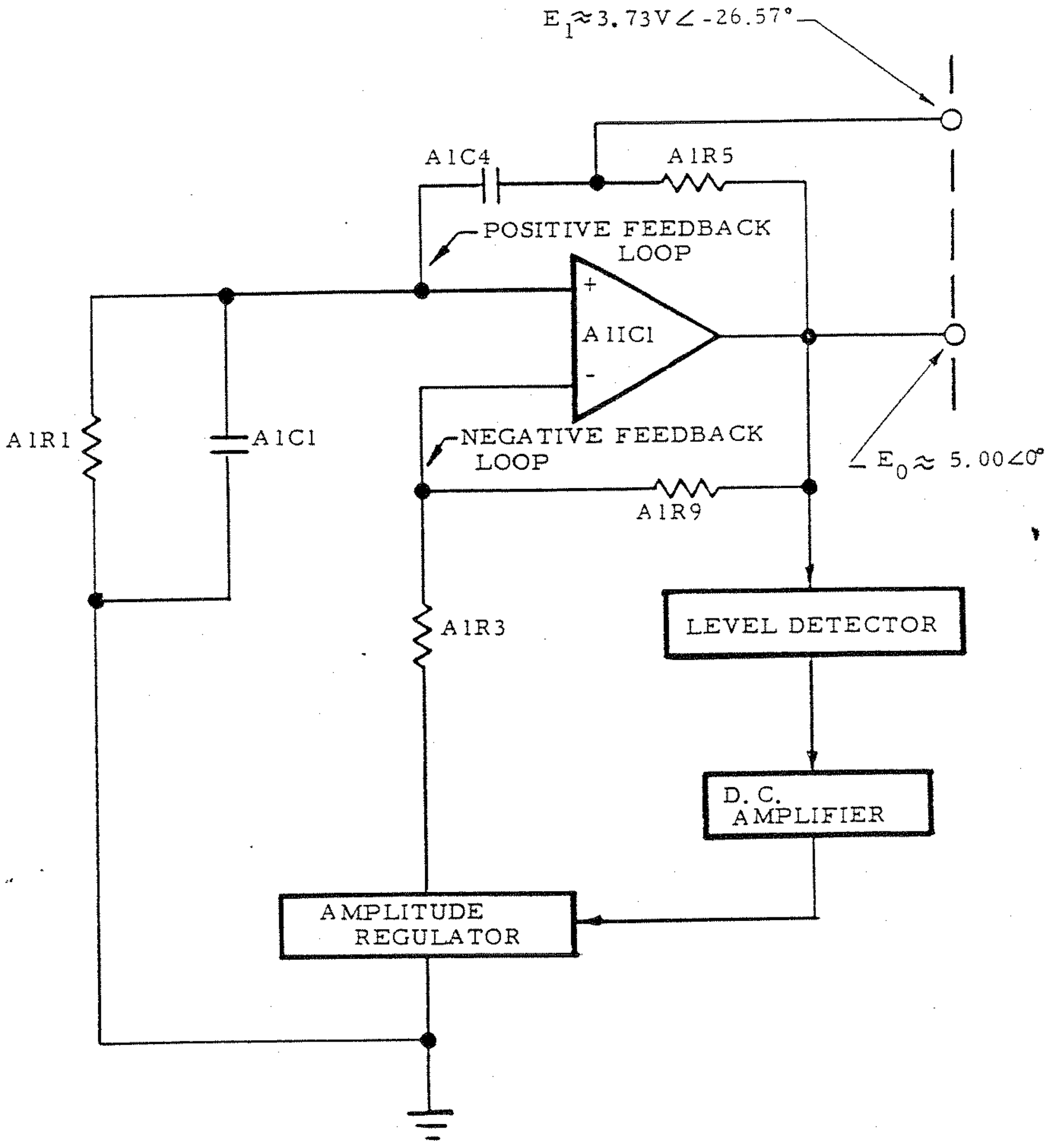


FIGURE 3-1. Block diagram of basic Wien Bridge Oscillator employed in 815T Series Oscillator.

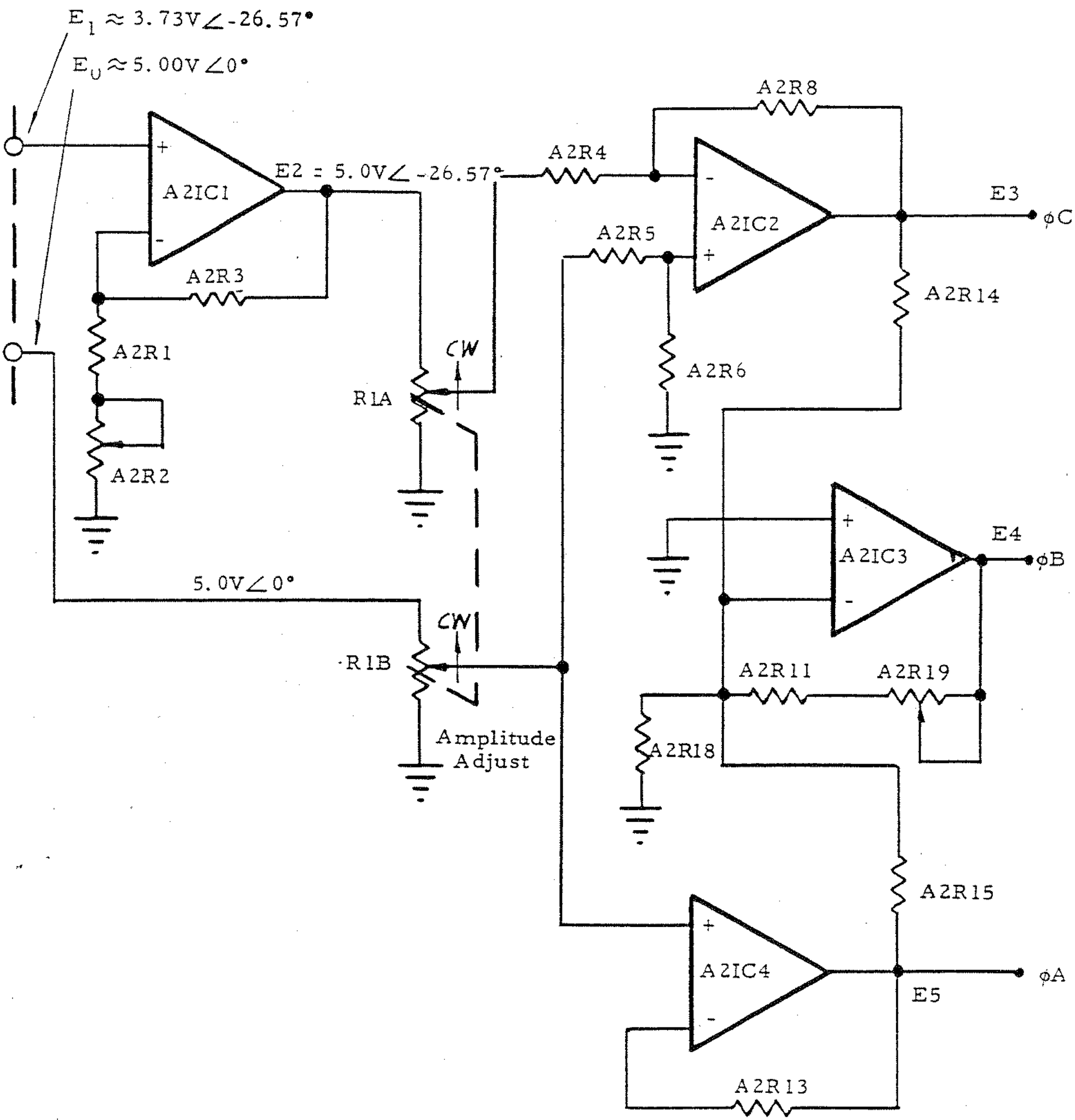


FIGURE 3-2. Block Diagram of Single to Multiphase Converter employed in 815T Series Oscillator.

This current pulse appears in the collector circuit of A1Q3 where it is filtered by capacitor A1C9 to form a DC level across the load circuit, A1R13 in series with A1CR1 and A1CR2. Any variation in the amplitude of the oscillator output will produce a change in the voltage drop across A1C9.

The level detector circuit is temperature compensated by selecting a zener diode A1CR4 with a positive temperature coefficient so as to cancel the negative temperature coefficients of diode A1CR3 and the emitter-base junction of transistor A1Q3.

3.1.1.2 DC AMPLIFIER

Transistor A1Q2 and associated components are connected so as to form a DC amplifier with a small signal gain of approximately five. The signal across A1C9 is amplified and level-shifted for application to the gate of A1Q1.

3.1.1.3 AMPLITUDE REGULATOR

Field effect transistor A1Q1 is connected so as to form an amplitude regulator. The bias at the gate of A1Q1 controls the output impedance (channel resistance) of the amplitude regulator. This output impedance, in turn, controls the closed loop gain of the operational amplifier, A1IC1.

If the sine wave output of the Wien bridge oscillator increases for any reason, the voltage drop across A1C9 also increases, which provides additional base drive to A1Q2. This causes the collector current of A1Q2 to increase and to cause the gate of A1Q1 to be biased more negatively. When the gate of A1Q1 is driven more negatively, the channel resistance of A1Q1 increases. This increase in channel resistance causes the closed loop gain of the operational amplifier A1IC1 to decrease, which in turn decreases the output amplitude of the Wien bridge oscillator and returns it to its original value.

3.2.1 POWER SUPPLY REGULATORS

The power supply regulators allow the oscillator to operate from the unregulated ± 25 volt DC power supply in all California Instruments solid state Invertron® power sources. The oscillator requires ±18 to ± 55 milliamperes with less than 2 volts of peak-to-peak ripple at the input to the regulator. The output of the regulators is ±15 volts ±10 per cent with less than 150 millivolts peak-to-peak ripple.

3.2 GENERAL DESCRIPTION OF SINGLE PHASE TO MULTI-PHASE CONVERTER

A block diagram for the single phase to multi-phase converter is given in Figure 3-2. This circuit employs an analog computer technique of generating the second and third phases of the multi-phase output. This technique requires no additional tuned circuits and provides the required phase shift independent of oscillator frequency.

The operation of this circuit is dependent on the signal E1 which is available at the junction of the resistive and capacitive elements in the positive feedback loop of the Wien bridge oscillator. A detailed analysis of the basic Wien bridge circuit configuration reveals that the voltage E1 at the frequency of the oscillation f_o is given by:

$$E1 = 0.745\ E0 \angle -26.57°$$

The above equation is valid regardless of the frequency of oscillation. Therefore, it is not necessary to vary these circuit parameters as the frequency oscillator is shifted.

The voltages, E0 and E1, are then processed through a sequence of operational amplifiers to provide the phase "A", phase "B" and phase "C" outputs. The vector diagram below describes how this is accomplished in graphical terms with the AMPLITUDE potentiometer R2 in the fully clockwise position.

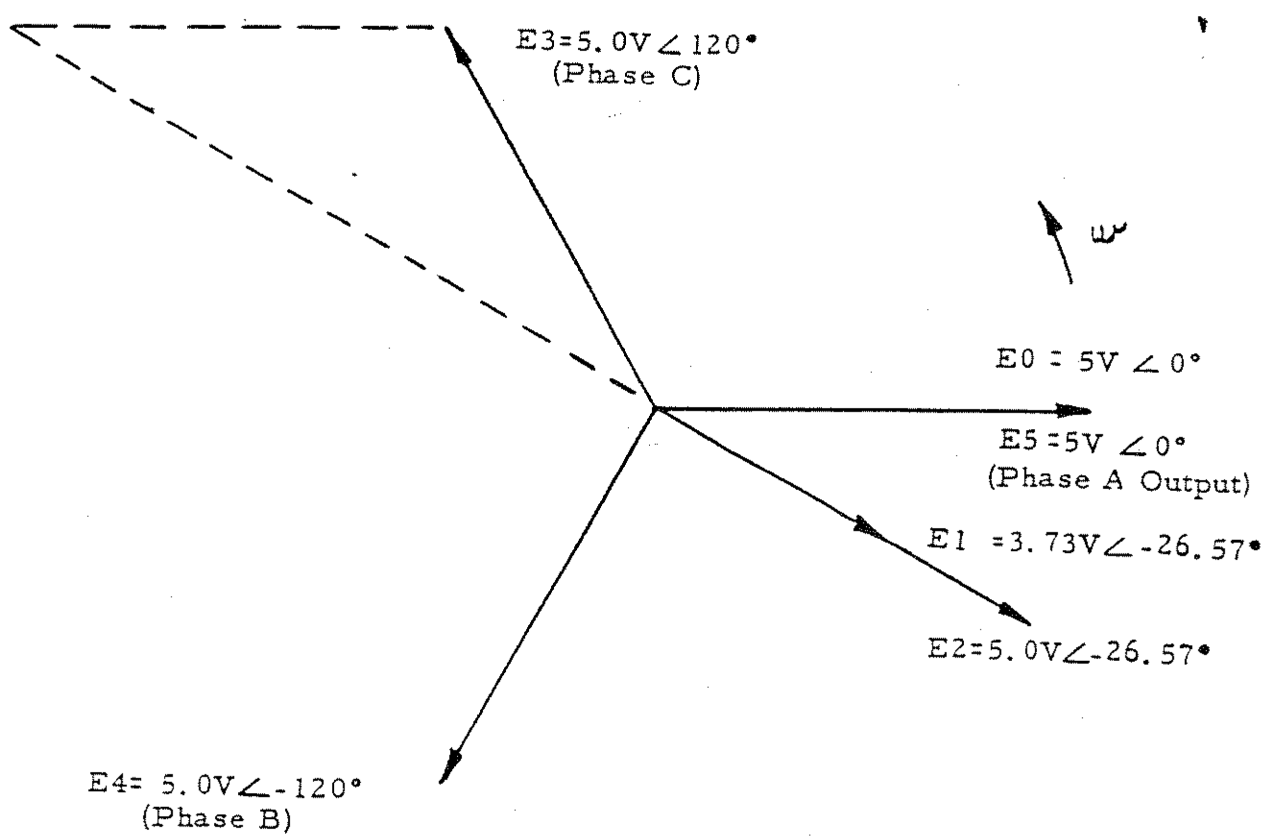


FIGURE 3-3. Vector Diagram for Generation of three-phase Output

First E1 is amplified by a factor of 1.34 to generate E2 at the output of A2IC1. Then E2 is inverted and amplified by a factor of -1.94 by means of the inverting input to A2IC2. The output of the Wien bridge is amplified by a factor of 1.23 with the non-inverting input to A2IC2. The resultant output from A2IC2 provides an E3 (or phase "C") output.

Then E0 is processed through a voltage follower to provide an E5 (or phase "A") output at the output of A2IC4.

Finally, E3 and E5 are added algebraically and then inverted to provide an E4 (or phase "B") output at the output of A2IC3.

For two phase operation, the gain of A2IC2, referenced to the E2 and E0 signals, is changed to -2.245 and 2.01 respectively. This provides a 90 degree phase lead for the phase "C" signal when referenced to the phase "A" signal. The phase "B" signal is not used in this application of the oscillator. For three phase open delta operation, the gain of A2IC2, referenced to the E2 and E0 signals, is changed to -1.94 and 2.24 respectively. This provides a 60 degree phase lead for the phase "C" signal when referenced to the phase "A" signal. The phase "B" signal is not used in this application of the oscillator.

CAUTION

HIGH VOLTAGE (115 AC)

Voltages up to 500VAC are available in certain associated Invertrons®. 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 connector pins C and D of the plug in oscillator, the primary power circuits, and output circuits of the associated Inventron® if oscillator is tested and adjusted with Invertron®.

ADJUSTMENT PROCEDURE

4.1 GENERAL

The following adjustment procedure, or any part of it, may be performed on a routine basis to insure that the oscillator remains within the specified performance limits. This procedure should always be followed after any service to the basic oscillator circuitry.

The adjustment procedure is divided into two sections. These are:

1) Adjustment procedure for Wien bridge oscillator.
2) Phase adjustments for single phase to multiphase converter.

4.2 TEST EQUIPMENT REQUIRED

The following test equipment is required to perform the adjustment procedure.

a) Oscilloscope, Tektronix 531A with general purpose plug-in or equivalent.

b) California Instruments Power Source or two H.P. 721A DC Power Supplies or equivalent.

c) Distortion Analyzer, H.P. H02-330B or equivalent.

d) Differential Voltmeter, Fluke 883A or equivalent.

e) Frequency Meter, H.P. 523CR or equivalent.

f) Differential phase meter, DRANETZ 301 or equivalent.

4.3 ADJUSTMENT PROCEDURE FOR WIEN BRIDGE OSCILLATOR

Connect the precision oscillator as shown in Figure 5-1 using either the ±25 volt power supply in the California Instruments Solid State Invertron® or a pair of external +25 volt and -25 volt DC power supplies. Each power supply should draw from 18 to 55 milliamperes. Allow the unit to warm up for one half hour.

4.3.1 Starting with potentiometers A1R2, A1R4 and A1R10, in a fully counter clock wise position, rotate A1R4 slowly in the clockwise direction until the oscillator output just builds up to full output. Rotating A1R4 too far clockwise will cause excessive distortion in the output wave form.

4.3.2 After determining the basic frequency and frequency accuracy of the oscillator from the manual addendum, set the basic Wien bridge oscillator frequency by rotating A1R2 and A1R10 equal amounts in the clockwise direction. The frequency may be monitored with the counter at the integrated circuit A1IC1 pin 6 or at the phase "A" output. The potentiometers A1R2 and A1R10 have sufficient resolution to allow the frequency to be set within 0.05 per cent.

4.3.3 Measure the output amplitude and distortion of the Wien bridge oscillator at the phase "A" output with the differential voltmeter and distortion analyzer. The output amplitude should be between 5 volts and 6 volts rms. The distortion should be less than 0.2 percent. If the phase "A" distortion is excessive, or if the oscillator will not start in a reliable fashion when DC power is applied to the oscillator, perform step 4.3.4 below.

4.3.4 Rotate A1R4 counter clockwise until the output amplitude drops by 1 to 5 percent. Then rotate A1R2 and A1R10 slightly in opposite directions until a peak in the output amplitude is obtained while maintaining the correct output frequency. Reset A1R4 so that the oscillator starts in a reliable fashion when DC power is applied to the oscillator and that the distortion is less than 0.2 per cent.

4.4 PHASE ADJUSTMENTS FOR MODEL 815T-Freq-Tol-2ϕ TWO PHASE OSCILLATOR

4.4.1 Connect the Model 815T-Freq-Tol-2ϕ Oscillator as shown in Figure 5-1 using either the ± 25 volt DC supplies in the California Instruments Invertron® or a pair of external ±25volt DC power supplies. Check that the procedure given in Section 4.3.1 through 4.3.4 of this instruction manual has been performed before proceeding further.

4.4.2 Rotate the front panel AMPLITUDE control fully clockwise. Connect a differential phase meter from the junction of A1R11 and A1R14 to the junction of A2R17 and A2R3. The phase shift must be -26.57 degrees ±0.25 degrees. Parameter unbalance in the basic Wien bridge feedback circuit can cause errors in this phase shift.

4.4.3 Adjust potentiometer A2R2 so that the amplitude of the AC voltage at the junction of A2R3 and A2R17 is equal to the voltage measured at the junction of A1R11 and A1R14.

4.4.4 Monitor the phase "A" output of the oscillator with the differential voltmeter and record the AC output voltage.

4.4.5 Monitor the phase "C" output of the oscillator with the differential voltmeter and record the AC output voltage. The amplitude of the phase "A" and phase "C" output voltages should now correspond within 50 millivolts rms of one another.

4.4.6 Connect the differential phase meter from the phase "A" output to the phase "C" output. Readjust potentiometer A2R2 slightly so that the phase "C" output leads the phase "A" output by 90 degrees ±1 degree and that the amplitude of the phase "A" and phase "C" outputs are within 10 millivolts rms of one another.

4.4.7 Capacitors A2C9 and A2C11 have been installed in the factory for improved phase shift characteristics on certain high-frequency versions of the 815T Series Oscillator.

4.5. PHASE ADJUSTMENTS FOR MODEL 815T-Freq-Tol-3φD THREE PHASE, OPEN DELTA OSCILLATOR

4.5.1 Connect the 815T-Freq-Tol-3φD oscillator as shown in Figure 5-1 and repeat step 4.4.1 through 4.4.7, except check that the phase shift is 60 degrees ±1 degree.

4.6 PHASE ADJUSTMENTS FOR MODEL 815T-Freq-Tol-3φ THREE PHASE OSCILLATOR

4.6.1 Connect the 815T-Freq-Tol-3φ oscillator as shown in Figure 5-1 and repeat steps 4.4.1 through 4.4.7, except check that the phase shift is 120 degrees ±1 degree.

4.6.2 Adjust A2R19 so that the phase "B" output amplitude is equal to the phase "A" output amplitude within 10 millivolts rms.

4.6.3 Check that the phase shift of phase "B" referenced to phase "A" is -120 degrees ±1 degree. Capacitor A2C10 (10 pf or less) has been selected at the factory for the best compromise phase shift and amplitude tracking on certain high-frequency versions of this oscillator.

TEST PROCEDURE

5.1 GENERAL

The following test procedure may be performed on a routine basis to insure that the 815T Series Oscillator remains within the specified performance limits. This test procedure is divided into several sections. These are:

1) Output voltage and amplitude stability

2) Harmonic distortion

3) Output frequency and frequency stability

4) Phase accuracy

5.2 TEST EQUIPMENT REQUIRED

The same test equipment is required for the test procedure as was required for the adjustment procedure as given in Section 4.2 of this manual.

5.3 OUTPUT VOLTAGE AND AMPLITUDE STABILITY

5.3.1 Connect the variable frequency oscillator as shown in Figure 5-1 and allow the unit to warm up for one hour in a 25°C environment. In the case of a multiphase oscillator, rotate the AMPLITUDE control fully clockwise.

5.3.2 The output of the oscillator should be measured with differential voltmeter connected to the phase "A" output (Pin 1 and Pin 2 of the printed circuit connector). The output voltage should be between 5.0 volts rms and 6.0 volts rms. Record the exact value of the output voltage.

5.3.3 Measure the phase "A" output voltage in 15 minute increments for two hours. The change in output voltage must not exceed ± 12.5 millivolts rms. This test may be continued for 24 hours if required. Maintain the ambient temperature at 25°C for this test.

5.3.4 Increase the ambient temperature to 50°C and allow the unit to stabilize for one hour. The output should change less than ±25 millivolts rms.

5.4 HARMONIC DISTORTION

Connect the precision oscillator as shown in Figure 5-1 and allow the unit to warm up for a few minutes. In the case of the multiphase oscillators, turn the AMPLITUDE control so that the output from each phase is approximately 5.0 volts rms.

5.4.1 Connect the distortion analyzer between the high output of phase "A" and the ground of phase "A". The distortion should be less than 0.2 per cent if the oscillator frequency is between 45 Hz and 10KHz.

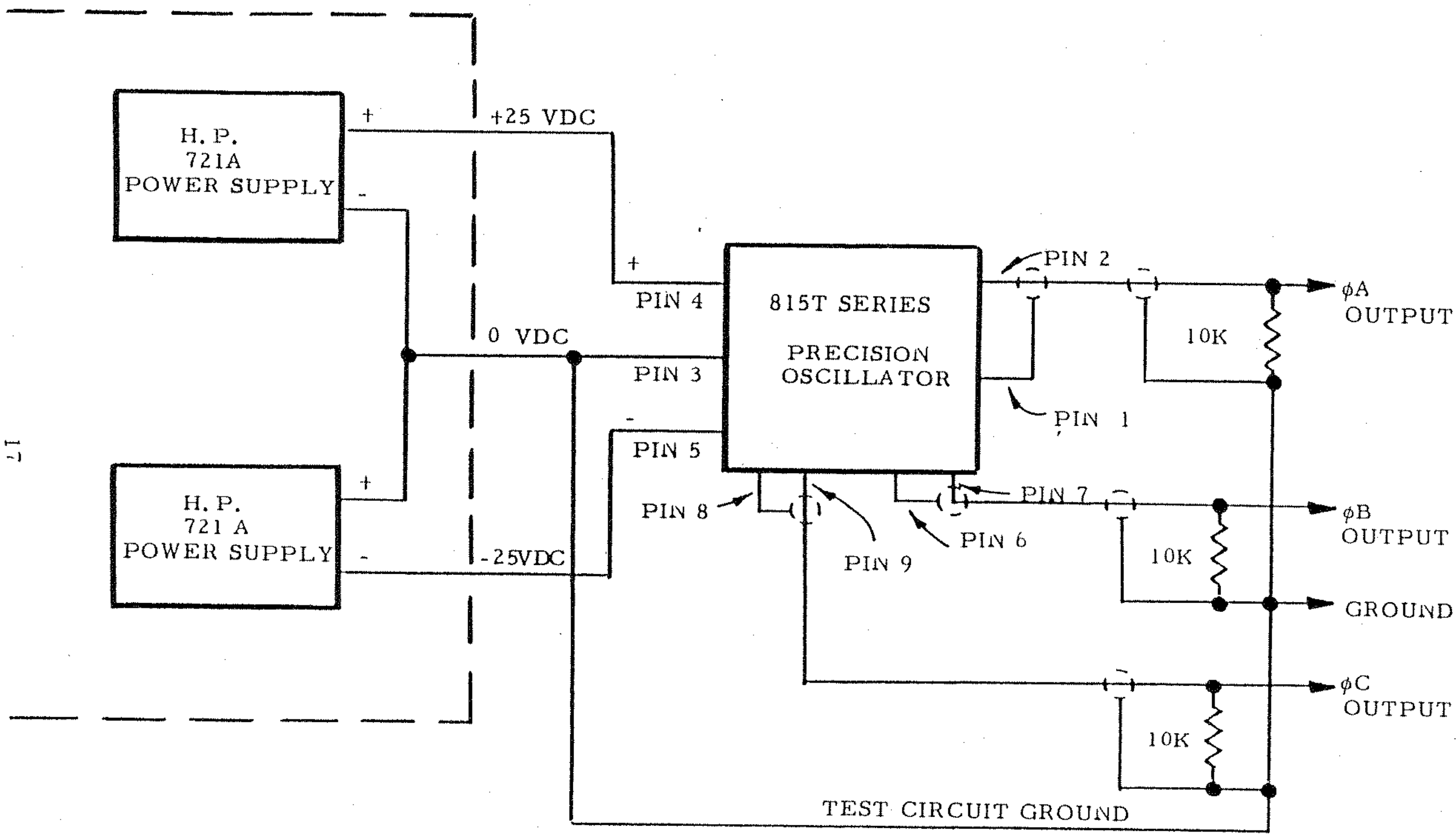


FIGURE 5-1. Test Circuit for 815T Series Oscillators

5.4.2 If the oscillator is a multiphase oscillator, then repeat 5.4.1 for the other phase or phases. The distortion should not exceed that specified in Section 5.4.1

5.5 OUTPUT FREQUENCY AND FREQUENCY STABILITY

Connect the unit as shown in Figure 5-1 and allow the unit to warm-up for one hour in a 25°C environment. The output voltage should be approximately 5 volts rms. Adjust the AMPLITUDE control on the multi-phase oscillator, as required.

5.5.1 Measure the phase "A" output frequency at 25°C with the counter. The frequency of the oscillator should be within ±0.1 percent of that indicated in the manual addendum. Record the frequency for reference in Section 5.5.2 below.

5.5.2 Increase the ambient temperature to 50°C and allow the unit to stabilize for one hour. The output frequency should change less than ±0.5 percent from that indicated at 25°C.

5.6 PHASE ACCURACY

This section of the manual is only applicable to multiphase versions of the 815T Series Oscillator. Connect the oscillator as shown in Figure 5-1 and allow the unit to warm-up for one hour in a 25°C environment.

5.6.1 Rotate the front panel AMPLITUDE control fully clockwise so that the output of phase "A" (Pin 1 and Pin 2 of the printed circuit connector) is greater than 5 volts rms.

5.6.2 Connect a differential phase meter between the phase "A" output and the phase "C" output so that the phase meter reads the phase "C" output referenced to the phase "A" output. The phase meter should indicate +60 ±1 degree for the three phase open delta oscillator; +90 ±1 degree for the two phase oscillator; and +120 ±1 degree for the standard three phase oscillator.

5.6.3 For the standard three phase oscillator, measure the phase shift of the phase "B" output referenced to the phase "A" output. This phase shift must be -120 ±1 degree. If problems are encountered, refer to Section 4.4 through 4.6 of this instruction manual.

5.6.4 Section 5.6.4 applies only to oscillators manufactured after October, 1974. See page ii for further information.
Vary the front panel AMPLITUDE potentiometer from 75 percent of full output to full output and check that all phases track within 50 millivolts rms of each other and that the phase angles remain within the ±1 degree tolerance.

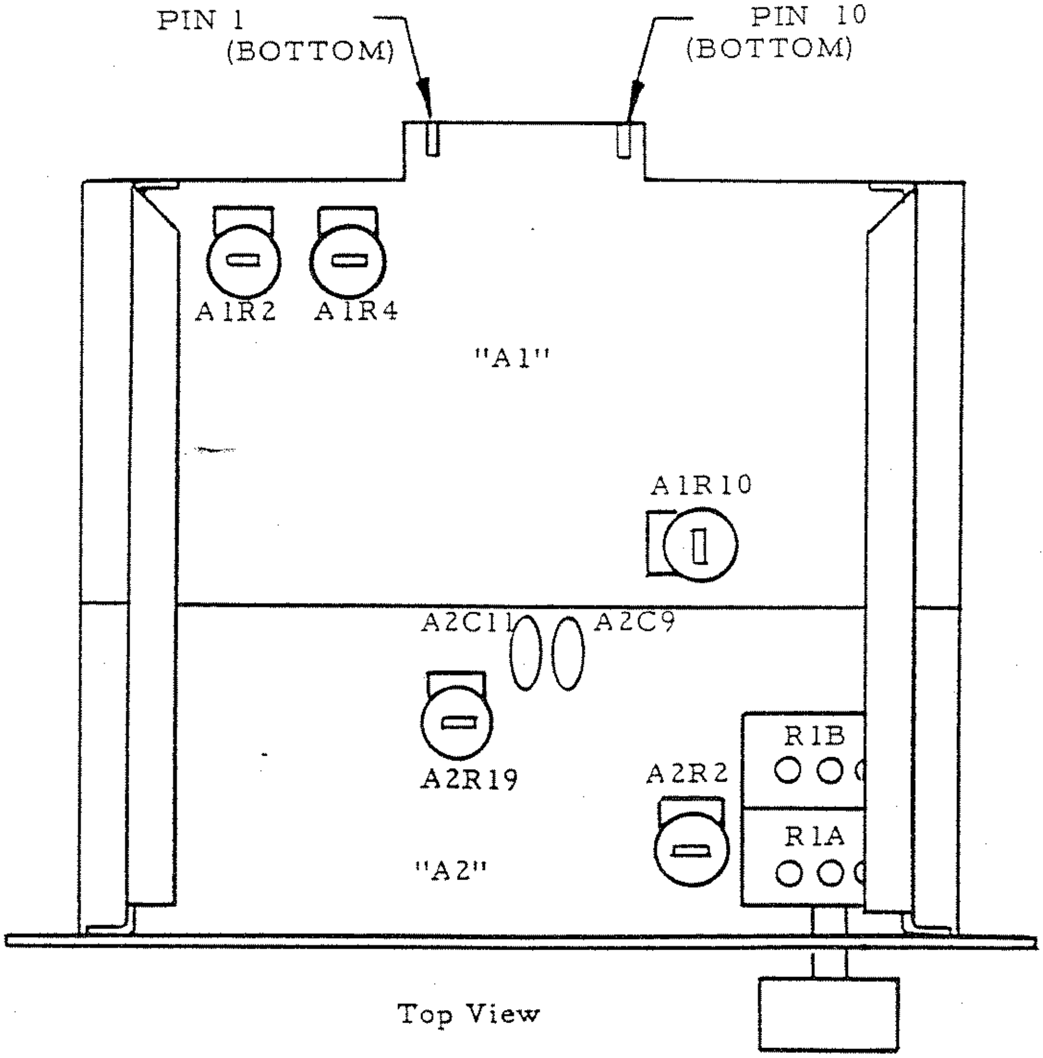


FIGURE 5-2. Locations of Internal Adjustment Potentiometers on Multiphase version of 815T Series Oscillator

MAINTENANCE AND TROUBLESHOOTING

6.1 GENERAL

The California Instruments 815T Series Precision Oscillators are completely solid state and should provide years of trouble-free service. Since the instrument contains no moving parts, periodic maintenance is limited to cleaning in accordance with good commercial shop practices, and a periodic check of frequency accuracy and distortion at six month intervals. If the oscillator is operated in heavy duty applications where severe temperature extremes or mechanical shock are encountered, it is recommended that a more frequent calibration schedule be established.

6.2 TROUBLESHOOTING

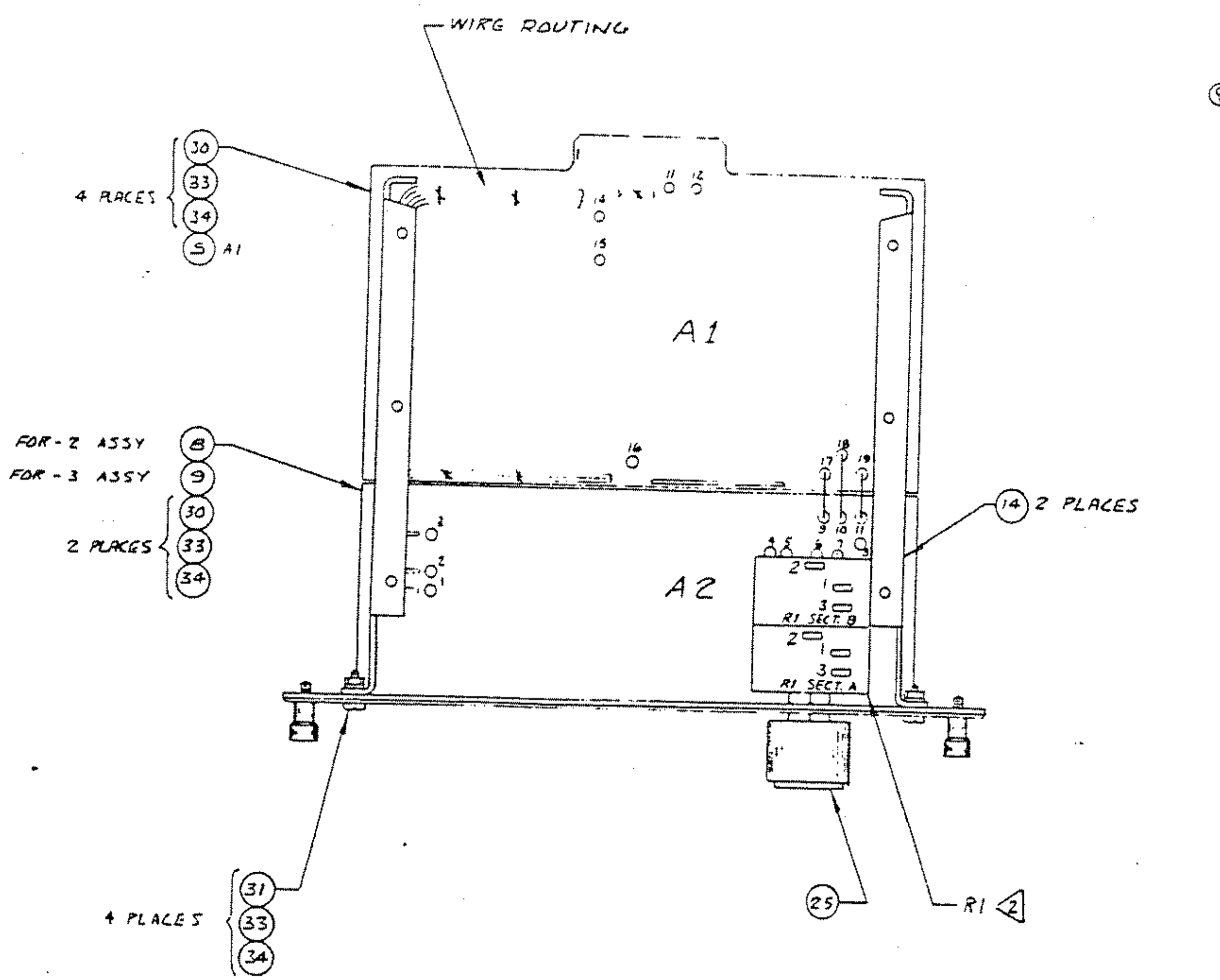
6.2.1 Before attempting to repair the oscillator, check that the controls are properly set, that the DC input power is correct and that an excessive load is not connected to the output of the oscillator. Any load impedance less than 5 K ohm per phase should be considered escessive.

6.2.2 Check that the ±15 volt regulator circuits are operating properly and that they have less than 150 millivolts peak-to peak ripple.

6.2.3 Check that the basic Wien bridge oscillator is operating satisfactorily. Detailed information on this circuit is given in Section 3.1 and Section 4.3 in this manual.

6.2.4 Check that the servo feedback loop is operating satisfactorily. Detailed information on this circuitry is given in Section 3.1 of this manual. If the problem appears to be in this area, disconnect transistor A1Q2 and apply -1 to -2 volt DC bias to the gate of A1Q1. This opens the servo feedback loop and allows servicing of this circuitry by conventional signal tracing methods.

6.2.5 If the problem is in the single phase to multiphase converter, the circuit may be checked by conventional signal tracing methods.



WIRING TABLE 1 (FOR 1φ UNITS)

WIRE #	FROM	TO	WIRE	REMARKS
1	A1-14	A1-15	24 AWG	BUSS

(9) WIRING TABLE 2 (FOR 2φ UNITS)

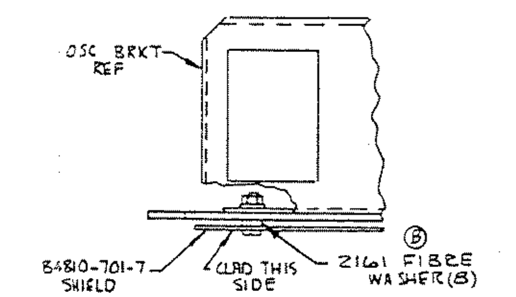
WIRE #	FROM	TO	WIRE	REMARKS
1	A1-12	A2-2	24 AWG	BLK
2	A1-15	R1 B-3	↑	BRN
3	A1-14	A2-1		RED
4	A1-16	A2-8		ORN
5	A1-17	A2-9		BUSS
6	A1-18	A2-10		BUSS
7	A1 19	A2-11		BUSS
8	A2-6	R1-A-3		YEL
9	A2-5	R1 A-2		GRN
10	A2-7	R1 B-1		BLU
11	A2-4	R1 B-2	↓	VIO
12	R1-A-1	R1-B-1	24 AWG	BUSS

WIRING TABLE 3 (FOR 3φ UNITS)

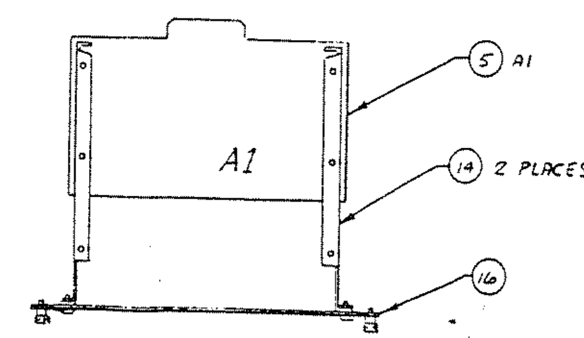
WIRE #	FROM	TO	WIRE	REMARKS
1	A1-11	A2-3	24 AWG	GRAY

REVISIONS

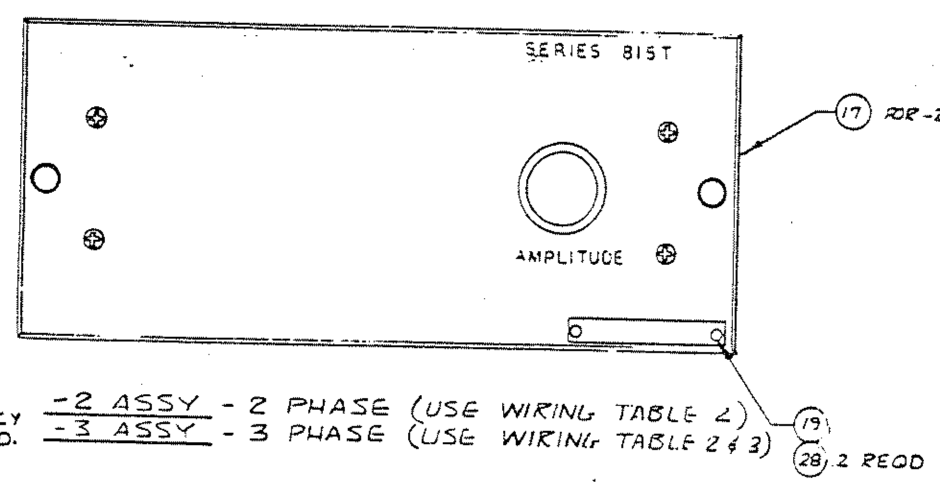
REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD



VIEW A
SIDE VIEW - FOR UNITS WITH 200Hz OR LESS FREQUENCY.



-1 ASSY - SINGLE PHASE
(USE WIRING TABLE 1)
SCALE 1:2 (FOR HARDWARE CALLOUTS SEE -2 & -3 ASSEMBLIES)



-2 ASSY - 2 PHASE (USE WIRING TABLE 2)
-3 ASSY - 3 PHASE (USE WIRING TABLE 2 & 3)

NOTES: (UNLESS OTHERWISE SPECIFIED)

1 FOR INNER CONNECTION DIAGRAM, SEE DWG D 4815-070.

2 INSTALL NUT ON POT. SIDE (BEHIND F/P) PRIOR TO INSTALLATION.

3. INSPECT GROUND CONTINUITY FROM FRONT PANEL CAPTIVE SCREW TO EACH SIDE RAIL, AND ON 200Hz OR LOWER FREQUENCY UNITS, CHECK TO GROUND SHIELD.

FOR PARTS LIST SEE PL 4815-400

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

DIM IN INCHES TOLERANCES .XXX = .010 .XX = .03 X° = .30° — BREAK ALL SHARP CORNERS & EDGES — MACH SURFACES ✓ — DWG SIZE D

EXCEPT AS OTHERWISE PROVIDED BY CONTRACT, THESE DRAWINGS AND SPECIFICATIONS ARE THE PROPERTY OF CALICO AND SHALL NOT BE REPRODUCED OR COPIED OR USED AS THE BASIS FOR THE MANUFACTURE OR SALE OF APPARATUS WITHOUT WRITTEN PERMISSION.

TITLE: SERIES 815T OSCILLATOR, 1φ, 2φ, & 3φ ASSY

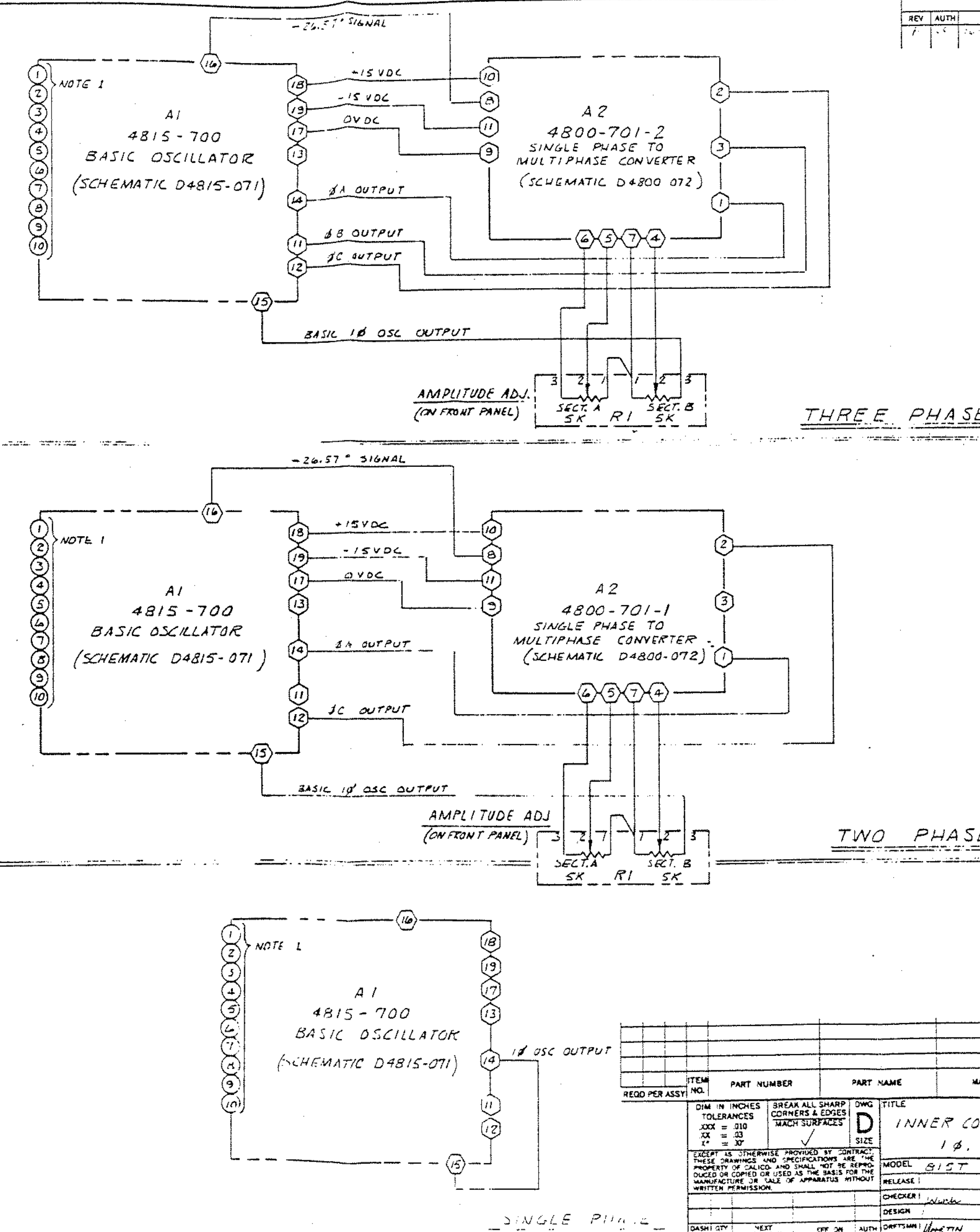
MODEL 815T

CALIFORNIA INSTRUMENTS CORP. SAN DIEGO, CALIFORNIA

CODE IDENT 16067

DWG NO. D4815-400 REV C

D4815-400 C



NOTES: (UNLESS OTHERWISE SPECIFIED)

1. (X) INDICATES CONNECTOR CONTACT.
2. ⟨X⟩ INDICATES TIE POINT EYELET ON P.C. BOARD.
3. FOR TOP ASSY, SEE DWG D4815-400.

REVISIONS						
REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD

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

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

BREAK ALL SHARP CORNERS & EDGES MACH SURFACES ✓

DWG SIZE D

EXCEPT AS OTHERWISE PROVIDED BY CONTRACT, THESE DRAWINGS AND SPECIFICATIONS ARE THE PROPERTY OF CALICO AND SHALL NOT BE REPRODUCED OR COPIED OR USED AS THE BASIS FOR THE MANUFACTURE OR SALE OF APPARATUS WITHOUT WRITTEN PERMISSION.

TITLE: INNER CONNECTING DIAGRAM 1Ø, 2Ø, & 3Ø

MODEL: 815T

CALIFORNIA INSTRUMENTS CORP. SAN DIEGO, CALIFORNIA

CONTRACT NO.

CODE IDENT: 16067

DWG NO. D4815-070

REV: A

SCALE: NONE

SHEET OF

D4815-070 A

CIRCUIT DIAGRAM

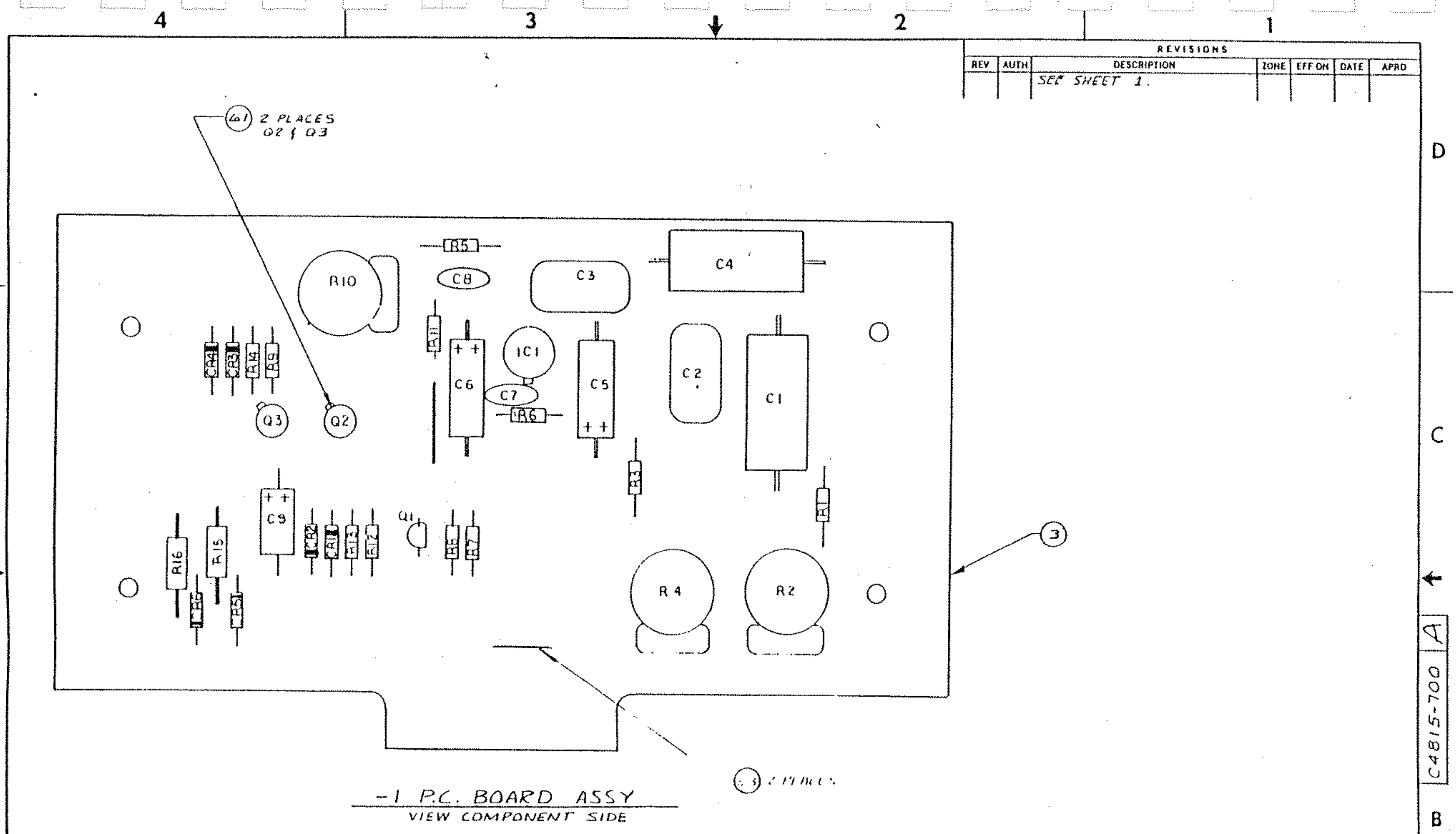
7.1 GENERAL

This section contains schematics and mechanical diagrams necessary for operation and maintenance of the 815T Series Precision Multiphase Oscillators. The schematic diagrams illustrate the circuit while the mechanical assemblies indicate the part placement.

7.2 REFERENCE DESIGNATIONS

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

Assembly/Sub-Assembly	Component	Complete Designation
A1	C30	A1C30
None	T1	T1
A2	R1	A2R1



REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD
		SEE SHEET 1.				

REQD PER ASSY	ITEM NO	PART NUMBER	PART NAME	MATERIAL – SPECIFICATION	CODE IDENT	FINISH	REF DES.	ZONE
		P/L 4815-100	PARTS LIST	SEE SHEETS 4 THRU —				

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

BREAK ALL SHARP CORNERS & EDGES MACH SURFACES √

DWG SIZE C

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DASH NO	QTY REQD	NEXT ASSEMBLY	EFF ON	AUTH
-1	1	4815-400		

TITLE: P.C. BOARD ASSY, BASIC OSC A1

MODEL 815T

RELEASE / CHECKER / DESIGN / DRFTSMN: [signatures] 6/4/76; MARTIN

PURCHASING / PROJ ENGR / CHF ENGR

CALIFORNIA INSTRUMENTS CORP
SAN DIEGO, CALIFORNIA

CONTRACT NO.

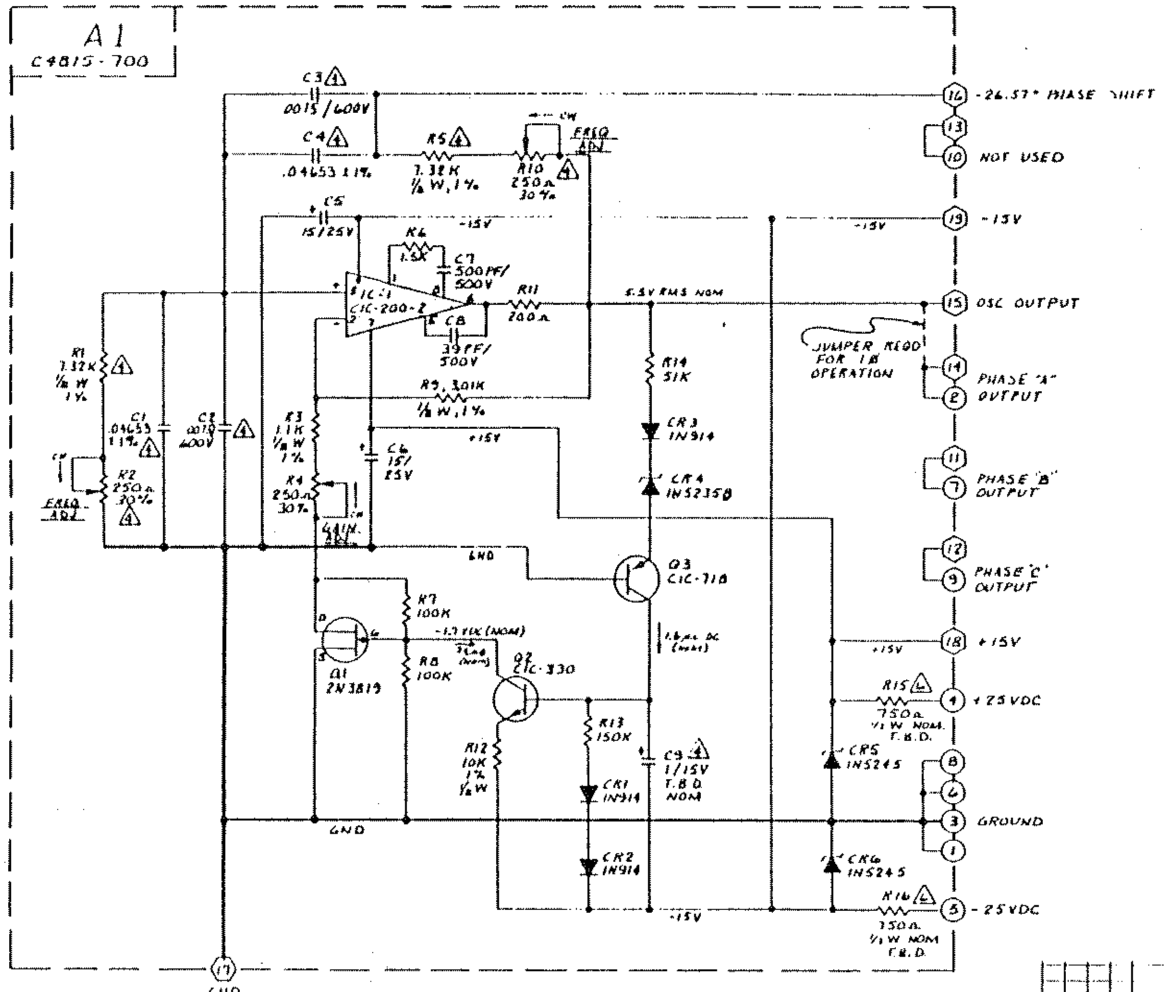
CODE IDENT 16067

DWG NO. C4815-700 REV A

SCALE 2X SHEET 2 OF —

1. FOR SCHEMATIC DIAGRAM, SEE DWG D4815-071.

NOTES. (UNLESS OTHERWISE SPECIFIED)



3 (1) INDICATES CONNECTOR CONTACTS
(1) INDICATES EYELET TIE POINT ON P.C. BOARD.

2 FOR P.C. BOARD ASSY, SEE DWG C4815-700.
FOR 2Ø & 3Ø INTERCONNECTION, SEE DWG D4815-070.
FOR FINAL ASSY, SEE DWG D4815-400.

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

NOTES: (UNLESS OTHERWISE SPECIFIED)

6 FOR 1Ø NOM VALUE IS AS SHOWN. FOR 2Ø & 3Ø NOM VALUE IS 220Ω, 1W.

5 CAPACITANCE IN MICROFARADS.

4 COMPONENT VALUES ARE SHOWN FOR 400Hz OPERATION ONLY. FOR OPERATIONS AT OTHER FREQUENCIES SEE APPLICABLE PARTS LIST: "FREQUENCY DETERMINING PARTS LIST".

SCHEMATIC DIAGRAM, BASIC OSCILLATOR

MODEL 815T

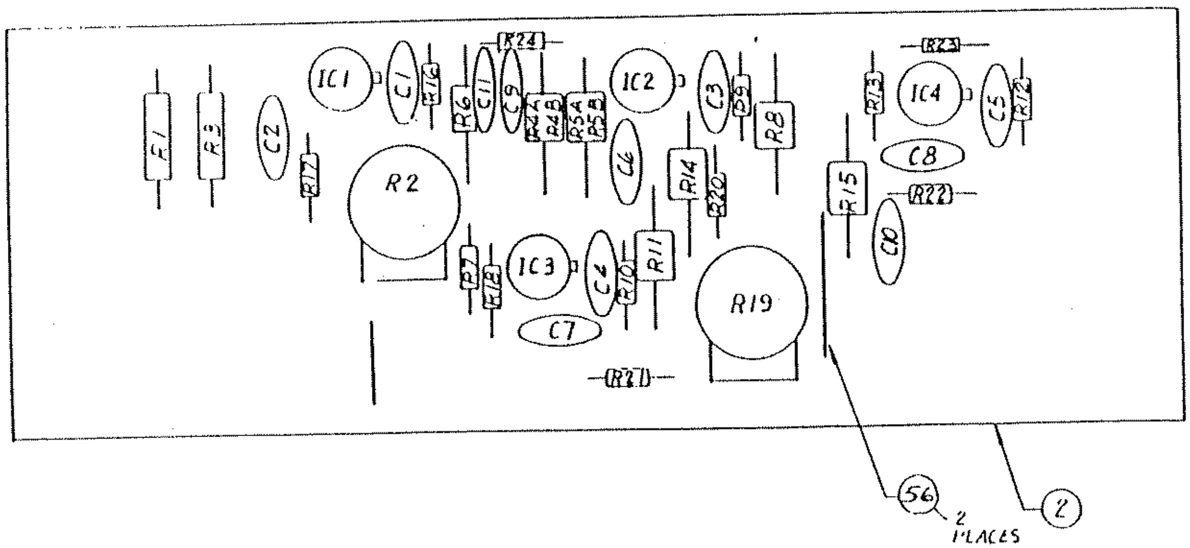
DWG NO D4815-071 REV C

SIZE D

CODE IDENT 16067

SCALE NONE

REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD



-1 P.C. BOARD ASSY
VIEW COMPONENT SIDE
A2

REQD PER ASSY	ITEM NO	PART NUMBER	PART NAME	MATERIAL – SPECIFICATION	CODE IDENT	FINISH	REF DES	ZONE
X	2	PL1900-701	PARTS LIST	SHEET 4 & 5				

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

BREAK ALL SHARP CORNERS & EDGES MACH SURFACES √

EXCEPT AS OTHERWISE PROVIDED BY CONTRACT, THESE DRAWINGS AND SPECIFICATIONS ARE THE PROPERTY OF CALICO AND SHALL NOT BE REPRODUCED OR COPIED OR USED AS THE BASIS FOR THE MANUFACTURE OR SALE OF APPARATUS WITHOUT WRITTEN PERMISSION.

DWG SIZE C

TITLE SINGLE PHASE TO [illegible] CONVERTER P.C. BOARD ASSY

MODEL 800 T

RELEASE

CHECKER

DESIGN

PURCHASING

PRODUCTION

CALIFORNIA INSTRUMENTS CORP SAN DIEGO, CALIFORNIA

CONTRACT NO

CODE IDENT 16067

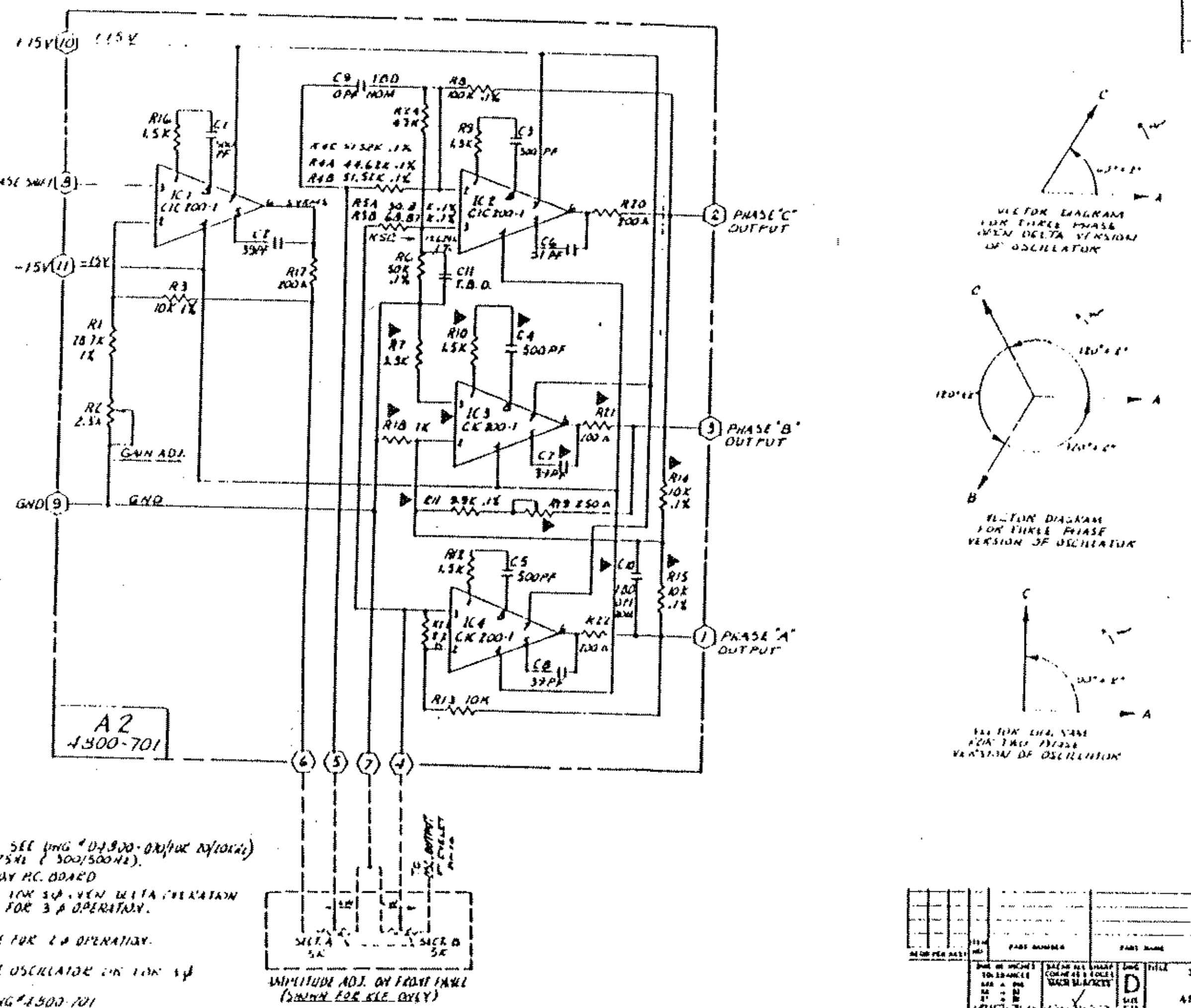
DWG NO C4800-701 REV E

SCALE 2/1 SHEET 2 OF 5

1. FOR SCHEMATIC DIAGRAM SEE DWG. No. D4800-072

NOTES: UNLESS OTHERWISE SPECIFIED

C4800-701 E



8. FOR INNER CONNECTING DIAGRAM SEE DWG # D4300-070 (FOR 20/20KHZ) AND # D4300-074 (FOR 45/75HZ & 300/500HZ).
7. (A) INDICATES TIE POINT (EYELET) ON P.C. BOARD
6. ALL REF DES. ENDING IN "C" ARE FOR 3φ OPEN DELTA OPERATION
5. ALL REF DES. ENDING IN "B" ARE FOR 3 φ OPERATION.
4. ALL REF. DES. ENDING IN "A" ARE FOR 2 φ OPERATION.
3. ▶ NOT USED FOR TWO PHASE OSCILLATOR OR FOR 3φ OPEN DELTA OSCILLATOR.
2. FOR P.C. BOARD ASS'Y SEE DWG # 4300-701
1. RESISTORS ARE 1/4W 5%

NOTES: UNLESS OTHERWISE SPECIFIED

SCHEMATIC DIAGRAM, SINGLE PHASE TO MULTIPHASE CONVERTER

800 L TWO & THREE PHASE

D

16067

D4300-072

REPLACEABLE PARTS

7.1 GENERAL

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

7.2 ORDERING INFORMATION

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

a) Model number and serial number of the instrument.

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

c) Component reference designator.

d) Component description.

e) Component manufacturer's number and code ident.

f) California Instruments stock number.

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

7.3 COMPUTER GENERATED PARTS LISTS

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

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

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

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

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

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

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

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

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

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

[illegible]

4815-400-106 ENGR DRAW 4815-400 REV C2

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NUMBER	VENDOR	QTY	UM
A1	4815-700-108	PC ASSY,1PH,50HZ	4815-700 REV L1	16067	1.0	EA
3	4815-400-1	CHASSIS ASSY,815T-1PH	4815-400 REV C2	16067	1.0	EA
14	160001	FRAME,PLUG-IN	4810-201-7	16067	2.0	EA
16	110192-5	PANEL,FRONT W/4815-100	4810-200-5	16067	1.0	EA
26	210024	SCREW,DRS,(U),CAD,00X1/8	#00X1/8 TYPE B	45722	2.0	EA
30	FS1011	SCREW,PNH,S/S,4-40X1/4	MS51597-13	81349	4.0	EA
31	FS1013	SCREW,PNH,S/S,4-40X3/8	MS51597-15	81349	4.0	EA
33	FS1068	WASHER,INTER,S/S,#4	MS35333-70	81349	8.0	EA
34	FS1066	NUT,HEX,S/S,4-40	MS35649-244	81349	8.0	EA
19	160000-32-1	NMPLT W/4810-202-32-1	4810-202-32-1	16067	1.0	EA

4815-400-1 ENGR DRAW 4815-400 REV C2

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NUMBER	VENDOR	QTY	UM
14	160001	FRAME,PLUG-IN	4810-201-7	16067	2.0	EA
16	110192-5	PANEL,FRONT W/4815-100	4810-200-5	16067	1.0	EA
26	210024	SCREW,DRS,(U),CAD,00X1/8	#00X1/8 TYPE B	45722	2.0	EA
30	FS1011	SCREW,PNH,S/S,4-40X1/4	MS51597-13	81349	4.0	EA
31	FS1013	SCREW,PNH,S/S,4-40X3/8	MS51597-15	81349	4.0	EA
33	FS1068	WASHER,INTER,S/S,#4	MS35333-70	81349	8.0	EA
34	FS1066	NUT,HEX,S/S,4-40	MS35649-244	81349	8.0	EA

4815-700-108 ENGR DRAW 4815-700-108

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NUMBER	VENDOR	QTY	UM
	4815-700-1	PC ASSY,OSCILLATOR,1PH	4815-700-1	16067	1.0	EA
	4815-700-8	FREQ DET ASSY,50HZ	4815-700-8	16067	1.0	EA

PARENT ITEM NO. 4815-700-1

DESCRIPTION PC ASSY,OSCILLATOR,1PH
ENGR DRAW 4815-700-1

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NUMBER	VENDOR	QTY	UM
CR1	310118	DIODE,SWNG,75V,.5W,DO35	1N914	07263	1.0	EA
CR2	310118	DIODE,SWNG,75V,.5W,DO35	1N914	07263	1.0	EA
CR3	310118	DIODE,SWNG,75V,.5W,DO35	1N914	07263	1.0	EA
CR4	310196	DIODE,ZNR,6.8V,.5W,5%	1N5235B	04713	1.0	EA
CR5	310067	DIODE,ZNR,15V,.5W,10%	1N5245	04713	1.0	EA
CR6	310067	DIODE,ZNR,15V,.5W,10%	1N5245	04713	1.0	EA
C5	610731	CAP,AL,15UF,25V	TE1205	56289	1.0	EA
C6	610731	CAP,AL,15UF,25V	TE1205	56289	1.0	EA
C7	610725	CAP,CER,500PF,1000V	DD501	71590	1.0	EA
C8	610013	CAP,MICA,39PF,500V	CM05E390J03	81349	1.0	EA
IC1	330006	IC,OP-AMP	CIC200-2	16067	1.0	EA
Q1	330197	TRANSISTOR,FET,N,JFET	2N3819	27014	1.0	EA
Q2	330008	TRANSISTOR,SS,NPN,TO18	CIC330	16067	1.0	EA
Q3	330041	TRANSISTOR,SS,PNP,TO18	CIC718	16067	1.0	EA
R3	560423	RES,FILM,1/4W,1.1K,1%	RN60C1101F	81349	1.0	EA
R4	570012	POT,1T,PC,250 OHM	U-201R251B	71450	1.0	EA
R6	510057	RES,CARB,1/4W,1.5K OHM	RC07GF152J	81349	1.0	EA
R7	510100	RES,CARB,1/4W,100K OHM	RC07GF104J	81349	1.0	EA
R8	510100	RES,CARB,1/4W,100K OHM	RC07GF104J	81349	1.0	EA
R9	560233	RES,FILM,1/4W,3.01K,1%	RN60C3011F	81349	1.0	EA
R11	510036	RES,CARB,1/4W,200 OHM	RC07GF201J	81349	1.0	EA
R12	560079	RES,FILM,1/4W,10K,1%	RN60D1002F	81349	1.0	EA
R13	510104	RES,CARB,1/4W,150K OHM	RC07GF154J	81349	1.0	EA
R14	510093	RES,CARB,1/4W,51K OHM	RC07GF513J	81349	1.0	EA
R15A	520031	RES,CARB,1/2W,750 OHM	RC20GF751J	81349	1.0	EA
R16A	520031	RES,CARB,1/2W,750 OHM	RC20GF751J	81349	1.0	EA
3	160109	PWB,OSCILLATOR	4815-700-7	16067	1.0	EA
61	240297	SOCKET,XSTR,TO-18	RCT018110-1A	19080	2.0	EA
63	FS5120	WIRE,BUS,MIL-W-3861 "S"	AWG 20	81349	1.0	IN

FREQUENCY DETERMINING
PARTS LIST

The following addendum parts list defines value and manufacturer's part number of components not listed in the preceeding parts list.

PARENT ITEM NO. 4815-700-8

DESCRIPTION FREQ DET ASSY,50HZ
ENGR DRAW 4815-700-8

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NUMBER	VENDOR	QTY	UM
C1	610552	CAP,PS,.047UF,+0-1%	PD1A473X +0-1%	12406	1.0	EA
C2	610545	CAP,MYLAR,.0062UF,600V	6MPD-1-622J	72136	1.0	EA
C3	610545	CAP,MYLAR,.0062UF,600V	6MPD-1-622J	72136	1.0	EA
C4	610552	CAP,PS,.047UF,+0-1%	PD1A473X +0-1%	12406	1.0	EA
C9	610335	CAP,AL,10UF,16V	TE1155	56289	1.0	EA
R1	560119	RES,FILM,1/4W,59K,1%	RN60C5902F	81349	1.0	EA
R2	570023	POT,1T,PC,2.5K,1/4W	U201R252B	71450	1.0	EA
R5	560119	RES,FILM,1/4W,59K,1%	RN60C5902F	81349	1.0	EA
R10	570023	POT,1T,PC,2.5K,1/4W	U201R252B	71450	1.0	EA
24	160115	PWB,SHIELD,OSCILLATOR	4810-701-7	16067	1.0	EA
25	210087	INSULATOR,FLAT,FBR,#4	2161	83330	8.0	EA
26	FS1004	SCREW,FLH,S/S,4-40X3/8	MS24693-C4	81349	6.0	EA

Code	Name	City	State
0000A	Electricord	Westfield	PA
0000C	Jackson Bros.	Waddon, Surrey	GB
0000S	OPCDA	Edison	NJ
0000W	Milton Ross Co.	Southampton	PA
0000Z	Timco	Los Angeles	CA
000AC	ITAC	Santa Clara	CA
000AD	Plessey	Westlake Village	CA
000AG	La France	Philadelphia	PA
000AH	Jan Crystal	Ft. Myers	CA
000AL	Data Components, Inc.	Santa Monica	CA
000AM	Kraus & Naimer	Santa Monica	CA
000AN	Ritz Instrument Transformer Co.	Redondo Beach	CA
000AS	Switches Incorporated	Mt. View	CA
00544	Metal-Cal Div., Avery Prod. Corp.	Inglewood	CA
00779	AMP Inc.	Harrisburg	PA
00853	Sangamo Electric Co.	Pickens	SC
00866	Goe Eng. Co., Inc.	City of Industry	CA
01002	G.E. Co., Ind. & Pwr. Cap. Dept.	John St. Hudson Falls	NY
01121	Allen-Bradley Co.	Milwaukee	WI
01139	G.E. Co., Silicone Products Dept.	Waterford	NY
01295	Texas Instruments	Dallas	TX
02111	Spectrol Electronics	City of Industry	CA
02335	Fairchild Controls Corp.	Hicksville, LI	NY
02375	American Insulating Machinery Co.	Philadelphia	PA
02538	Texas Electronics Co.	Dallas	TX
02660	Amphenol Corporation	Broadview	IL
02799	Use Code #72136		
03507	General Electric Company	Syracuse	NY
03508	General Electric Company	Syracuse	NY
03797	Eldema Corporation	Compton	CA
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls	NJ
03911	Clairex Corporation	New York	NY
04009	Arrow-Hart and Hegeman Elec. Co.	Hartford	CT
04713	Motorola Semiconductor Prod., Inc.	Phoenix	AZ
04963	3-M	St. Paul	MN
05245	Corcom Inc.	Chicago	IL
05276	Pomona Electronics Co., Inc.	Pomona	CA
05397	Kemet, Union Carbide Corp.	Cleveland	OH
05820	Wakefield Engineering, Inc.	Wakefield	MA
06383	Panduit Corp.	Tinley Park	IL
06314	Stantron, Wyco Metal Products	N. Hollywood	CA
06540	Amatham Elect. Hardware	New Rochelle	NY
06665	Precision Monolithics Inc.	Santa Clara	CA
06776	Robinson Nugent, Inc.	New Albany	IN
06915	Richco Plastics, Co.	Chicago	IL
07088	Kelvin Electric Company	Van Nuys	CA
07263	Fairchild Camera and Instr. Corp.	Mt. View	CA
07387	Birtcher Corporation	Los Angeles	CA
07556	Unitrack Calabro Plastics	Upper Darby	PA
07633	Epoxy Prod. Co., Allied Prod. Corp.	New Haven	CT
07716	IRC Incorporated	Burrington	IA
08065	Accurate Rubber and Plastics Co.	San Diego	CA
08261	Spectra Strip	Garden Grove	CA
08289	Blinn-Delbert Co., Inc.	Pomona	CA
08353	Bristol Co.	Toronto	CANADA
08524	Deutsch Fastener Corp.	Los Angeles	CA
08730	Vemaline Products Co.	Franklin Lakes	NJ
08779	Signal Transformer Co.	Brooklyn	NY
09353	C and K Components	Newton	MA
10389	Chicago Switch Inc.	Chicago	IL
11815	Cherry Rivet Div., Townsend Co.	Santa Ana	CA
12406	Elpac, Incorporated	Fullerton	CA
12697	Clarostat Mfg. Co., Incorporated	Dover	NH
13103	Thermalloy Company	Dallas	TX
14099	Semtech Corporation	Newbury Park	CA
14604	Elmwood Sensors Inc.	Cranston	RI
14655	Cornell-Dubilier Elect. Corp.	Newark	NJ
14726	Hollingsworth Co.	Phoenixville	PA
14752	Electro Cube, Incorporated	San Gabriel	CA
15238	ITT Semiconductors	Lawrence	MA
15636	Elec-trol	Northridge	CA
15801	Fenwall Electronics	Framingham	MA
15818	Amelco Teledyne, Incorporated	Mt. View	CA
15912	Ansley	Los Angeles	CA
16067	California Instruments Company	San Diego	CA
16758	Delco Radio Div., General Motors	Kokomo	IN
16956	Dennison	Framingham	MS
18076	Umoco	City of Industry	CA
18178	Vactec, Inc.	Maryland Heights	Mo
18324	Signetics	Sunnyvale	CA
18612	Vishay Instruments Inc.	Malvern	PA
18677	Scambe Mfg. Co.	Monterey Park	CA
18722	RCA	Mountaintop	PA
18736	Voltronics Corp.	Hanover	NJ
19080	The Robinson Company	Hawthorne	CA
21604	Buckeye Stamping Company	Columbus	OH
22599	Elastic Stop Nut Corporation	Van Nuys	CA
23050	Product Components Corp.	Hastings-on-Hudson	NY
23936	Pamotor, Incorporated	San Francisco	CA
24011	ECC	Burlington	MA
24444	General Semiconductor Industries Inc.	Tempe	AZ
24796	Parelco Inc.	Paramount	CA
25497	Meter Master	Los Angeles	CA
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	Garland	TX
27832	Hughes Aircraft	Newport Beach	CA
28480	Hewlett-Packard Co.	Palo Alto	CA
28520	Heyman Mfg. Company (Hevco)	Kenilworth	NJ
30039	International Components Corp.	Asbury Park	NJ
30983	Electra/Midland (Mepco/Electra)	San Diego	CA
30161	Aavid Engineering Inc.	Laconia	NH
30897	Dorann Company	Sylmar	CA
31951	Triridge Inc.	Pittsburgh	PA
32293	Intersil	Cupertino	CA
32559	Bivar, Inc.	Santa Ana	CA
33005	Jewell Electrical Instruments Inc.	Manchester	NH
33716	Kingsbacher Murray Co.	Los Angeles	CA
33855	Ducommun Inc.	Los Angeles	CA
34333	Silicon General	Westminster	CA
34649	Intel Corporation	Santa Clara	CA
44655	Ohmite Manufacturing Company	Skokie	IL
45722	Parker-Kalon	Clifton	NJ
46384	Penn. Eng. and Mfg. Corp.	Doylestown	PA
50522	Monsanto, Electronic Special Products	Cupertino	CA
51167	Aries Electronics Inc.	Frenchtown	NJ
51705	ICO/Rally	Palo Alto	CA
52072	Circuit Assembly Corp.	Costa Mesa	CA
54407	Power-One Co.	Camarillo	CA
56289	Sprague Electric Company	North Adams	MA
58474	Superior Electric Company	Bristol	CT
59730	Thomas and Betts Company	Elizabeth	NJ
63743	Ward Leonard Electric Co.	Mt. Vernon	NY
70318	Allmetal Screw Prod. Co.	Garden City	NY
70903	Belden Manufacturing Co.	Chicago	IL
71218	Bud Industries, Inc.	Willoughby	OH
71279	Cambridge Thermionic Corp.	Cambridge	MA
71400	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	TRW Cinch	Chicago	IL
71984	Dow Corning Corp.	Midland	MI
72136	Elmenco (Electro Motive)	Willimantic	CT
72619	Dialight Corporation	Brooklyn	NY
72699	General Instruments	Newark	NJ
72982	Erie Technological Products Inc.	Erie	PA
73138	Beckman Instruments, Inc.	Fullerton	CA
73734	Federal Screw Products, Inc.	Chicago	IL
74193	Heinemann Electric Company	Trenton	NJ
74545	Harvey Hubbell, Inc.	Bridgeport	CT
74840	Illinois Condenser Co.	Chicago	IL
74970	E.F. Johnson Company	Waseca	MN
75042	TRW Electronic Components	Philadelphia	PA
75382	Kulka Electric Corporaion	Mt. Vernon	NY
75915	Littlefuse Incorporated	Des Plaines	IL
77132	United-Carr Inc., Patwin Division	Waterbury	CT
77342	Potter and Brumfield Div., AMF	E. Princeton	IN
78189	Shakeproof Div., Illinois Tool Works	Chicago	IL
78553	Tinnerman Products, Inc.	Cleveland	OH
79130	Johns-Manville Products Corp.	Chicago	IL
79136	Waldes Kohinoor Inc.	Long Island City	NY
79963	Zierick Mfg. Corporation	New Rochelle	NY
80031	Mepco/Electra	Morristown	NJ
80223	United Transformer Co.	New York	NY
80294	Bourns, Incorporated	Riverside	CA
81095	Triad Transformer Corp.	Venice	CA
81312	Winchester Electronics	Oakville	CT
81349	Military Specification or Commercial Generic Number		
81603	Raco Products Co.	Chicago	IL
82104	Standard Grigsby	Aurora	IL
82389	Switchcraft, Incorporated	Chicago	IL
82877	Rotron Manufacturing Co., Inc.	Woodstock	NY
82893	Vector Electronics Inc.	Sylmar	CA
83330	Herman H. Smith, Inc.	Brooklyn	NY
83486	Elco Tool and Screw Corp.	Rockford	IL
86684	RCA	Harrison	NJ
87034	Marco-Oak Industries	Anaheim	CA
88245	Useco Div., Litton Industries	Van Nuys	CA
90201	Mallory Capacitor Company	Indianapolis	IN
91637	Dale Electronics, Inc.	Columbus	NE
91662	Elco Corporation	Willow Grove	PA
91833	Keystone Electronics Corp.	New York	NY
92194	Alpha Wire Corporation	Elizabeth	NJ
94222	Southco, Incorporated	Lester	PA
95303	RCA	Cincinnati	OH
95987	Weckesser Company, Inc.	Chicago	IL
97525	Electronic Engineering Co.	Santa Ana	CA
98159	Rubber Teck, Incorporated	Gardena	CA
98291	Sealecto Corp.	Mamaroneck	NY
98376	Zero Mfg. Co. (West)	Burbank	CA
98978	IERC	Burbank	CA
99743	IMC	Maywood	CA
99800	Delevan Electronics Corporation	Aurora	NY