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Instruments Division
A Mark IV Company

MODIFICATION AND REPAIR

PRICE $25.00

958-31 REV B
1689

SERIES 2000
PROCESS MICROPROCESSOR
CONTROLLER



** WARNING **

THESE INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL. TO AVOID HAZARDOUS POTENTIALS, DO NOT PERFORM ANY MODIFICATION OR SERVICING UNLESS YOU ARE QUALIFIED.

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SECTION 1 - SERIES 2000 CONTROLLERS

1.1 INTRODUCTION

This manual contains detailed information on the modification, ranging, calibration and servicing of Series 2000 microprocessor-based controllers.

The Series 2000 family of controllers possess extensive capability to control a multitude of different single and two loop systems. While temperature control is the most popular application, the Series 2000 instruments can control any process or machine that provides a current or voltage measurement input signal and can function from a relay or analog output signal in a variety of control forms. These output functions may be alarm, on-off, or PID. This manual is structured to allow a modification center to change one of the standard stocked controllers to match a wide variety of user requirements by following the detailed instructions given herein.

This REPAIR & MODIFICATION MANUAL (958-31) is directed to the Modification Center personnel who have been trained and are qualified to work on this type of instrument. The INSTALLATION AND WIRING INSTRUCTIONS normally supplied with the controllers should be read first to familiarize oneself with the Series 2000 instruments before proceeding with this manual.

This manual contains a description of the controller, parts lists, schematics, PC board layouts and detailed modification and servicing procedures. Where practical, charts and tables are provided to simplify understanding.

Only special parts and assemblies are specified as "Purchase from LFE". Standard items such as resistors and capacitors may be procured locally. The table in Section 1.15 contains the specifications for range resistors required for the modifications described in this manual.

Because of their limited and special nature, Models 2016, 2019 and 2031 are not covered by this manual. Consult the factory for information on these products. The Model 2040 Limit Controller is covered in MOD MANUAL 958-33.

1.2 CONTROLLER SERVICING

This manual includes detailed troubleshooting and repair information to allow the MOD CENTER to repair a malfunctioning controller. If the unit cannot be repaired, contact the factory to obtain authorization to return the unit to the factory for repairs.

Following proper authorization, the controller should be adequately packed with a brief description of the observed problem and shipped prepaid to:

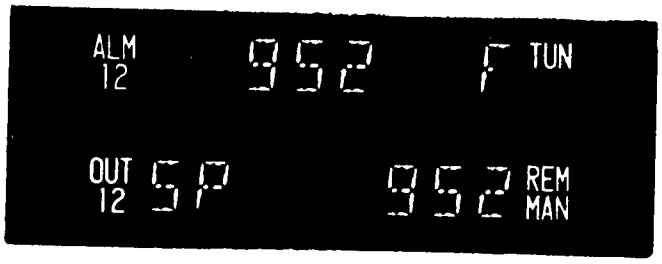
LFE Instruments Division
Repair Department
11655 Chillicothe Road
Chesterland, Ohio 44026-1994
(216) 729-1681

1.3 DISPLAY CHANGE - MODEL 2010

For the Model 2010 only, two different designs are in use. The differences are in the appearance of the illuminated vacuum fluorescent display and in the corresponding EPROM containing the controlling programming. The initial display was supplied with an EPROM marked with the part number 1685-1. Starting about September 1983, the display was changed and this new display has been supplied with EPROMs 1685-2, 1685-5 and higher part numbers.

The controllers with the old display and 1685-1 EPROM have a vacuum fluorescent display in which the 1 and 2 indicators for Alarms ad Outputs are close together so that when illuminated together, they appear to look like a 12.

The controllers with the new display and 1685-2 or higher EPROMS have a vacuum fluorescent display where the a and 2 indicators for Alarms and Outputs are separated. This display also has decimal point capability in the upper line of characters.



OLD DISPLAY & 1685-1 EPROM



NEW DISPLAY & 1685-2,-5,ETC.

** NOTE **

INFORMATION ON EARLY MODEL 2010 CONTROLLERS WITH THE OLDER DISPLAY AND 1685-1 EPROM ARE NOT CONTAINED IN THIS MANUAL. REFER TO MANUAL 958-27 FOR THIS INFORMATION.

1.4 CONTACT PLATING AND COMPENSATOR CHANGE - ALL MODELS

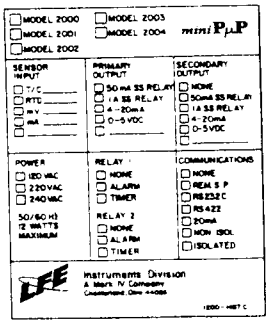
Beginning early in 1986, the cold junction compensating resistor was moved from mounting on the rear of the case to place it on a support assembled to the I/O board so that the compensating resistor is now an integral part of the I/O board. At the same time, a change was made to add gold plating to the edge card fingers and also to the case terminals. Although the I/O board with gold fingers and board mounted compensator cannot be installed in an older case without gold terminals and a clearance hole for the compensator, care must be taken to prevent gold plated CPU boards from being mixed with I/O board with solder plated fingers.

** CAUTION **

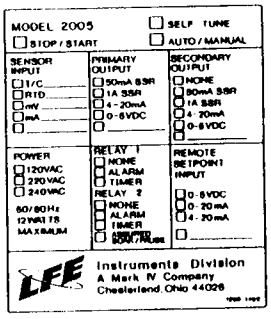
TO PREVENT CONTACT DETERIORATION DUE TO DISSIMILAR METALS, DO NOT INTERMIX I/O BOARD AND CPU BOARD GOLD AND SOLDER PLATED TERMINALS. ALSO MAKE SURE THAT THE EDGE CARD AND CASE TERMINALS ALSO HAVE THE SAME TYPE OF PLATING. FAILURE TO FOLLOW THIS INSTRUCTION MAY CAUSE CONTROLLER MALFUNCTION.

1.5 CONTROLLER IDENTIFICATION

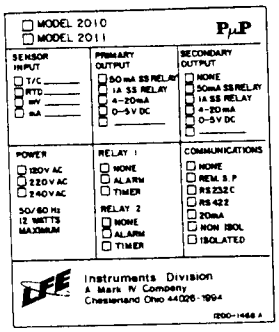
Four labels are used to identify a Series 2000 Controller.



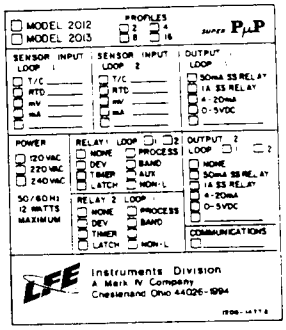
Mod 2000-2004
P/N 1200-1457



Mod 2005
P/N 1200-1499

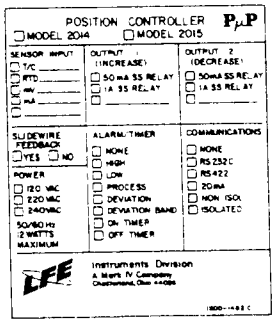


Mod 2010,2011
P/N 1200-1468

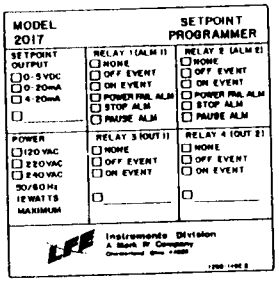


Mod 2012,2013
P/N 1200-1477

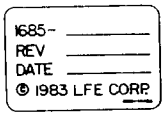
CASE LABELS



Mod 2014,2015
P/N 1200-1482



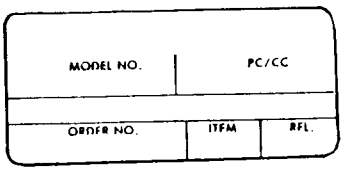
Mod 2017
P/N 1200-1492



EPROM LABEL



PART NUMBER LABEL
P/N 1200-1409



PRODUCTION LABEL

The CASE LABEL is located on the outside top of the Series 2000 case. This label has space for identifying the primary and secondary output, alarm, sensor and supply voltage specifications. Any input or output hardware modification to these controllers requires that this label be remarked or replaced with a new label and the appropriate configuration marked.

The controller PART NUMBER LABEL is located on the mother board at the rear of the front bezel assembly. Any modification to a Series 2000 controller requires that this label be changed to indicate the part number shipped. The SPAN is also listed on this label and must be changed when the span limits are changed.

The EPROM LABEL is attached to the EPROM at the time of manufacture and specifies the EPROM part number, its revision letter and date. This label is NOT to be removed or changed in any way. Reprogramming the EPROM is a factory procedure. If a replacement EPROM is required,the new EPROM will have its own label.

The PRODUCTION LABEL is located on the outside top of the Series 2000 controller case next to the front flange. This is the production control label used by the factory. It identifies data relevant to the manufacturing cycle and may be covered up after a modification has been completed since the data will no longer be needed.

1.6 CONTROLLER PART NUMBERS

Each Series 2000 controller is assigned a ten digit number that specifies its hardware and software configuration. The MOD CENTER can change this part number to suit the application and the required modifications using the following description.

PART NUMBER Digit Number	X X - X X X X - X X X X 1. 2. 3. 4. 5. 6. 7. 8. 9. 10.

1.6.1 MODELS 2000,2001,20022003,2004,2005,2010,2011

1. & 2. - MODEL NUMBER AND COMMUNICATIONS

MODELS								
2000	2001	2002	2003	2004	2005	2010	2011	DESCRIPTION
E0	*	Z0	EA	ZA	*	D0	*	Standard Model -No Communications
E1	*	Z1	EB	ZB	*	D1	*	Unit with Remote Set Point (ALM2 not available)
*	E2	Z2	EC	ZC	*	*	D2	With Non-isolated RS232 Communications
*	E3	Z3	ED	ZD	*	*	D3	With Isolated RS232 Communications
*	E4	Z4	EE	ZE	*	*	D4	With Non-isolated RS422 Communications
*	E5	Z5	EF	ZF	*	*	D5	With Isolated RS422 Communications
*	E6	Z6	EG	ZG	*	*	D6	With Isolated Current Loop Communications
*	*	*	*	*	E7	*	*	Model 2005 with Start/Stop
*	*	*	*	*	Z7	*	*	Model 2005 with Auto/Manual
*	*	*	*	*	EH	*	*	Model 2005 Self Tune with Start/Stop
*	*	*	*	*	ZH	*	*	Model 2005 Self Tune with Auto/Manual

3. - PRIMARY OUTPUT

0	NO PRIMARY
1	PRI. HEAT SSR ON/OFF
2	PRI. COOL SSR ON/OFF
3	PRI. HEAT SSR TPR
4	PRI. COOL SSR TPR
5	PRI. HEAT 4/20 MADC
6	PRI. COOL 4/20 MADC
7	PRI. HEAT 0/5 VDC
8	PRI. COOL 0/5 VDC

4. - SECONDARY OUTPUT

0	NO SECONDARY
1	SEC. HEAT SSR ON/OFF
2	SEC. COOL SSR ON/OFF
4	SEC. COOL SSR TPR
6	SEC. COOL 4/20 MADC
7	SEC. COOL 0/5 VDC
9	ANALOG RETRANSMITTING 4/20 MADC

TABLE 1-1

1.6.1 MODELS 2000,2001,2002,2003,2004,2005,2010,2011(continued)

5. & 6. - INPUT CODE

00	J THERMOCOUPLE
01	K THERMOCOUPLE
02	R THERMOCOUPLE
03	S THERMOCOUPLE
04	T THERMOCOUPLE
05	N THERMOCOUPLE
06	E THERMOCOUPLE
07	B THERMOCOUPLE
08	PLATINEL II THERMOCOUPLE
09	Ni/Ni18Mo THERMOCOUPLE
10	W5%Re/W26%Re THERMOCOUPLE
11	W3%Re/W25%Re THERMOCOUPLE
12	W/W26%Re THERMOCOUPLE
20	100Ω Pt RTD 1° RESOLUTION
21	100Ω Pt RTD 0.1° RESOLUTION
40	0/5 VDC
60	4/20 mADC
61	4/20 mADC SELF POWERED

7. OR 8. - ALARM CODE

0	NO ALARM
1	HIGH PROCESS
2	LOW PROCESS
3	HIGH DEVIATION
4	LOW DEVIATION
5	ON TIMER *
6	OFF TIMER *
7	DEVIATION BAND
9	REMOTE PAUSE #

* Not available on Models 2002, 2004 or 2005 (Z7 or ZH).

\# Model 2005 only.

7. & 10. - SPECIAL CODE

00 = STANDARD UNIT
ALL OTHERS - ASSIGNED BY FACTORY

NOTE: EARLY CONTROLLERS MAY NOT HAVE THERMOCOUPLE TYPES 05, 09, 10, 11 OR 12.

TABLE 1-1 (CONTINUED)

1.6.2 MODELS 2012 & 2013

1. & 2. - MODEL & PROFILE SELECTION

MODELS				
2012		2013		DESCRIPTION
W/O COMM.	WITH COMM.	W/O COMM.	WITH COMM.	
B1	B5	C1	C5	2 PROFILES
B2	B6	C2	C6	4 PROFILES
B3	B7	C3	C7	8 PROFILES
B4	B8	C4	C8	16 PROFILES

3. - PRIMARY OUTPUT

	(LOOP #1 ONLY)
0	NO OUTPUT
1	HEAT SSR ON/OFF
2	COOL SSR ON/OFF
3	HEAT SSR TPR
4	COOL SSR TPR
5	HEAT 4/20 mADC
6	COOL 4/20 mADC
7	HEAT 0/5 VDC
8	COOL 0/5 VDC
A	EVENT RELAY
B	RETRANSMIT PV
C	RETRANSMIT SP

4. - SECONDARY OUTPUT

	(LOOP #1 ONLY)
0	NO OUTPUT
1	HEAT SSR ON/OFF
2	COOL SSR ON/OFF
4	COOL SSR TPR
6	COOL 4/20 mADC
8	COOL 0/5 VDC
A	EVENT RELAY
B	RETRANSMIT PV
C	RETRANSMIT SP

TABLE 1-2

1.6.2 MODELS 2012 & 1012 (continued)

4. - SECONDARY OUTPUT (cont>)

(LOOP #2 ONLY)	
D	HEAT SSR ON/OFF
E	COOL SSR ON/OFF
F	HEAT SSR TPR
G	COOL SSR TPR
H	HEAT 4/20 mADC
J	COOL 4/20 mADC
K	HEAT 0/5 VDC
L	COOL 0/5 VDC
N	EVENT RELAY
P	RETRANSMIT PV
Q	RETRANSMIT SP

5. & 6. - INPUT CODE (LOOP1 & LOOP2 RESPECTIVELY)

0	J THERMOCOUPLE
1	K THERMOCOUPLE
2	R THERMOCOUPLE
3	S THERMOCOUPLE
4	T THERMOCOUPLE
5	N THERMOCOUPLE
6	E THERMOCOUPLE
7	B THERMOCOUPLE
8	PLATINEL II THERMOCOUPLE
9	Ni/Ni18%Mo THERMOCOUPLE
A	W5%Re/W26%Re THERMOCOUPLE
B	W3%Re/W25%Re THERMOCOUPLE
C	W/W26%Re THERMOCOUPLE

K	100Ω Pt RTD - 1° RESOLUTION
L	100Ω Pt RTD- 0.1° RESOLUTION
R	0/5 VDC
W	4/20 mADC
Z	NO INPUT (MODEL 2012 - LOOP 2)

NOTE: EARLY CONTROLLERS MAY NOT HAVE THERMOCOUPLE TYPES 5, 9, A, B OR C.

7. - ALARM 1 CODE

(LOOP 1 - NON LATCHING)	
0	NO ALARM
1	HIGH PROCESS
2	LOW PROCESS
3	HIGH DEVIATION
4	LOW DEVIATION
5	EVENT RELAY
6	DEVIATION BAND
(LOOP 1 - LATCHING)	
9	POWER FAIL
A	HIGH PROCESS
B	LOW PROCESS
C	HIGH DEVIATION
D	LOW DEVIATION
E	DEVIATION BAND

(LOOP 2 - NON LATCHING)	
G	HIGH PROCESS
H	LOW PROCESS
J	HIGH DEVIATION
K	LOW DEVIATION
N	DEVIATION BAND
P	AUXILIARY HEAT
Q	AUXILIARY COOL
(LOOP 2 - LATCHING)	
R	HIGH PROCESS
S	LOW PROCESS
T	HIGH DEVIATION
U	LOW DEVIATION
V	DEVIATION BAND

TABLE 1-2 (CONTINUED)

1.6.2 MODELS 2012 & 2013 (continued)

8. - ALARM 2 CODE

(LOOP 1 - NON LATCHING)		(LOOP 1 - LATCHING)	
0	NO ALARM	9	ERROR ALARM
1	HIGH PROCESS	A	HIGH PROCESS
2	LOW PROCESS	B	LOW PROCESS
3	HIGH DEVIATION	C	HIGH DEVIATION
4	LOW DEVIATION	D	LOW DEVIATION
5	EVENT RELAY	E	DEVIATION BAND
7	DEVIATION BAND		

9. & 10. - SPECIAL CODE

00 = STANDARD UNIT
ALL OTHERS - ASSIGNED BY FACTORY

TABLE 1-2 (CONTINUED)

1.6.3 MODELS 2014 & 2015

1. & 2. - MODEL & COMMUNICATIONS

MODELS		DESCRIPTION
2014 W/O R&S	2015 W/ R&S	
J1	JA	Standard Model No Communications
J2	JB	With Non-isolated RS232 Communications
J3	JC	With Isolated RS232 Communications
J4	JD	With Non-isolated RS422 Communications
J5	JE	With Isolated RS422 Communications
J6	JF	With Isolated Current Loop Communications

3. - PRIMARY OUTPUT

W/SLIDEWIRE	W/O SLIDEWIRE	
1	A	INCREASE/DECREASE SSR - HEATING
2	B	INCREASE/DECREASE - COOLING

4. - UNUSED

0 FOR ALL UNITS

5. & 6. - INPUT CODE

00	J THERMOCOUPLE	09	Ni/Ni18%Mo THERMOCOUPLE
01	K THERMOCOUPLE	10	W5%Re/W26%Re THERMOCOUPLE
02	R THERMOCOUPLE	11	W3%Re/W25%Re THERMOCOUPLE
03	S THERMOCOUPLE	12	W/W26%Re THERMOCOUPLE
04	T THERMOCOUPLE		
05	N THERMOCOUPLE	20	100Ω Pt RTD - 1° RESOLUTION
06	E THERMOCOUPLE	21	100Ω Pt RTD - 0.1° RESOLUTION
07	B THERMOCOUPLE		
08	PLATINEL II THERMOCOUPLE	40	0/5 VDC
		60	4/20 mADC

TABLE 1-3

1.6.3 MODELS 2014 & 2015 (continued)

7. - ALARM/TIMER 1

0	NO ALARM
1	HIGH PROCESS
2	LOW PROCESS
3	HIGH DEVIATION
4	LOW DEVIATION
5	ON TIMER
6	OFF TIMER
7	DEVIATION BAND

8. - ALARM/TIMER 2

SAME AS ALARM/TIMER 1 FOR CONTROLLERS WITHOUT SLIDEWIRE FEEDBACK ONLY. THIS DIGIT MUST BE "0" FOR SLIDEWIRE UNITS.

9. & 10. - SPECIAL CODE

00 = STANDARD UNIT
ALL OTHERS - ASSIGNED BY FACTORY

TABLE 1-3 (CONTINUED)

1.6.4 MODEL 2017

1. & 2. - MODEL & PROFILE CODE

A5	1 PROFILE WITH 255 SEGMENTS
A6	2 PROFILES - 127 SEGMENTS EACH
A7	4 PROFILES - 63 SEGMENTS EACH
A8	8 PROFILES - 31 SEGMENTS EACH
A9	16 PROFILES - 15 SEGMENTS EACH

3. - COMMUNICATIONS OPTION

0	NO COMMUNICATIONS
1	RS232C NON-ISOLATED (N-I)
2	RS232C ISOLATED
3	RS422 NON-ISOLATED (N-I)
4	RS422 ISOLATED
5	20 mA CURRENT LOOP (ISOLATED)
A	REMOTE PAUSE, NO COMMUNICATIONS
B	REMOTE PAUSE & RS232C NON-ISOLATED
C	REMOTE PAUSE & RS232C ISOLATED
D	REMOTE PAUSE & RS422 NON-ISOLATED
E	REMOTE PAUSE & RS422 ISOLATED
F	REMOTE PAUSE & 20 mA CURRENT LOOP (I)

4. - ANALOG PROFILE OUTPUT

0	4-20 mA
A	0-5 VDC
B	0-10 VDC
C	0-20 mA

5., 6., 7. & 8. - RELAY OUTPUTS

5. - RELAY 1 = ALM1 (EMR)
6. - RELAY 2 = ALM2 (EMR)
7. - RELAY 3 = OUT1 (SSR1)
8. - RELAY 4 = OUT2 (SSR2)

OUTPUT RELAY CODING

0	NO RELAY
1	OFF EVENT
2	ON EVENT
3	POWER FAIL LATCH
4	STOP ALARM
5	PAUSE ALARM
6	PAUSE/STOP ALARM

9. & 10. - SPECIAL CODE

00 = STANDARD UNIT
ALL OTHERS - ASSIGNED BY FACTORY

TABLE 1-4

1.7 SERIES 2000 CONTROLLER SPECIFICATIONS

1.7.1 MODEL DESCRIPTION

MODEL 2000 — Standard single loop microprocessor based PID process controller utilizing a 6 switch front panel keypad including START/STOP key.

MODEL 2001 — Same as Model 2000 except supplied with digital communications capability.

MODEL 2002 — Standard single loop microprocessor based PID process controller utilizing a 6 switch front panel keypad including AUTO/MANUAL key. This model with digital communications is also identified as Model 2002.

MODEL 2003 — Self tuning single loop microprocessor based PID process controller utilizing a 6 switch front panel keypad including START/STOP key. This model with digital communications is also identified as Model 2003.

MODEL 2004 — Self tuning single loop microprocessor based PID process controller utilizing a 6 switch front panel keypad including AUTO/MANUAL key. This model with digital communications is also identified as Model 2004.

MODEL 2005 — Single loop zone controller with isolated remote setpoint input for use with Model 2017 setpoint programmer. There are four versions of this model which are - START/STOP, AUTO/MANUAL, self tune with START/STOP and self tune with AUTO/MANUAL.

MODEL 2010 — Standard single loop microprocessor based PID process controller utilizing an 8 switch front panel keypad including both START/STOP and AUTO/MANUAL keys. This controller can be user programmed for up to 9 preselected multisetpoints or a single ramp and soak profile having up to 8 ramp and soak segments for up to 100 hours per interval. The ramp and soak control includes assured soak and repeat cycle capability.

MODEL 2011 — Same as Model 2010 except supplied with digital communications capability.

MODEL 2012 — Standard single loop microprocessor based PID profile controller utilizing an 8 switch front panel keyboard including PAUSE/RESUME and START/RESET keys. This controller can be set up for 2 profiles of 99 segments each, 4 profiles of 64 segments each, 8 profiles of 32 segments each or 16 profiles of 16 segments each. Ramp and soak segments may be up to 100 hours per interval. Assured soak and repeat cycle capability is included. The controller may also be configured to lock out the UP/DOWN arrow keys to prevent an unauthorized user from changing the set point value. Communications options are available on this model.

1.7.1 MODEL DESCRIPTION (CONTINUED)

MODEL 2013 Standard 2-loop microprocessor based PID profile controller utilizing an 8 switch front panel keypad including PAUSE/RESUME and START/RESET keys. This controller is identical to Model 2012 except that it can control two independent process loops and is supplied with one alarm/event relay. Communications options are available on this model.

MODEL 2014 Standard single loop microprocessor based PID position controller utilizing an 8 switch front panel keypad including START/STOP and AUTO/MANUAL keys. This controller is specifically designed for use with an external AC reversible electric motor operator having a feedback potentiometer. A separate version of the Model 2014 is available for use in applications without a feedback potentiometer. The outputs are 1A solid state relays to drive the motor operator. One alarm/timer relay is supplied. This model with digital communications is also identified as Model 2014.

MODEL 2015 This model is identical to Model 2014 except that it also has the multisetpoint and ramp and soak capabilities as described for Model 2010. This model with digital communications is also identified as Model 2015.

MODEL 2017 Setpoint programmer to provide a common remote setpoint for Model 2005 zone controllers. This programmer may be set up for a single profile with 255 segments or up to 16 profiles with 15 segments each. Four event/alarm outputs are provided. There is no input to these controllers. This model is available with digital communications.

1.7.2 GENERAL SPECIFICATIONS

** NOTE **

BECAUSE THE SERIES 2000 CONTROLLERS HAVE COMMON HARDWARE, THESE GENERAL SPECIFICATIONS HAVE ALL BEEN COLLECTED TOGETHER FOR EASE OF PRESENTATION. A PARTICULAR CONTROLLER MAY NOT HAVE ALL OF THE FEATURES DESCRIBED BELOW BUT IF A FEATURE IS SUPPLIED, IT WILL OPERATE AS DETAILED BELOW.

All specifications are under reference conditions of +23 ±2 degrees C; 117 VAC ±1 VAC; 50 or 60 Hz ±1Hz.

DISPLAY: Blue vacuum fluorescent display with two rows of eight alphanumeric characters. Multicolored alarm, output and status indicators.

DECIMAL POINTS: selectable in software programming for current and voltage input types; fixed by program on all temperature input controllers.

LEGEND UNITS: Two character alphanumeric legend selectable in software programming for current or voltage inputs. Also used to select F or C for temperature units.

POLARITY: Positive assumed, negative sign displayed.

OVERRANGE: Displays "INPUT OPEN" error message for either negative or positive overrange on temperature input controllers.

RESPONSE TIME: The standard controller is supplied as described below. Special shorter or longer responses are available for some models, contact the factory. The response is affected by three items:

1. Analog input filter - approx. 0.3 sec. for 10-90%
2. Conversion rate - 0.6 seconds per sample
3. Digital filter - "Box Car" integration - ten samples. (For some models, the digital filter is software selectable.)

OPERATING TEMPERATURE RANGE: +5 to +55 degrees C.

STORAGE TEMPERTAURE RANGE: -20 to +85 degrees C.

HUMIDITY: 0-90% non-condensing.

SHOCK: 10 shocks in each of three mutually perpendicular planes. Shock amplitude shall be 50g's half sine, 7 milliseconds.

VIBRATION: .020 inch double amplitude from 10 to 50 to 10 hertz in one minute. 20 minutes in each of three mutually perpendicular planes.

WARM-UP TIME: Less than 5 minutes.

POWER: 117 VAC ±10%; 50-60 Hz; (220 V or 240 VAC optional)

POWER CONSUMPTION: 10 Watts typical; 13.5 Watts maximum.

HOUSING: Plug-in molded ABS to fit 1/4 DIN. Connections through 16 - #6 screw terminals on rear barrier.

NOISE REJECTION:

Common Mode: 140 dB typical - 120 dB minimum @ 60 Hz.

Normal Mode: 65 dB typical - 60 dB minimum @ 60 Hz.

TEMPERATURE STABILITY: ±2 µV/°C typical - ±6 µV/°C maximum. RTD ranges - 40 PPM/°C typical, 115 PPM/°C maximum.

RESOLUTION: A/D converter - 1 part in 32,000.

MEMORY PROTECTION: RAM with Lithium battery backup.

INPUTS

CURRENT OR VOLTAGE INPUTS: May be supplied with current inputs from 0/100 uA to 0/100 mADC. Voltage inputs may be from 0/10 mV to 0/300 VDC.

Maximum error is ±2 counts. Maximum display span is -3200 to +3200 counts.

THERMOCOUPLE TEMPERATURE INPUTS:

THERMOCOUPLE BREAK: Displays "INPUT OPEN" message for open thermocouple, Alarm outputs are turned on; control outputs are turned off.

THERMOCOUPLE RESISTANCE: Maximum thermocouple loop resistance must not exceed 100Ω.

TC TYPE	SPAN	TYPICAL ERROR	MAX. ERROR
J	-299/-250 °F -250/+1402 °F	± 2 °F ± 1 °F	± 4 °F ± 3 °F
	-184/-152 °C -152/+761 °C	± 1 °C ± 1 °C	± 2 °C ± 2 °C
K	-341/-100 °F -100/+2482 °F	± 11 °F ± 1 °F	± 13 °F ± 3 °F
	-207/-73 °C -73/+1361 °C	± 6 °C ± 1 °C	± 7 °C ± 2 °C
R	+32/200 °F +200/+490 °F +490/+3199 °F	-8,+1 °F -3,+1 °F ± 1 °F	-10,+3 °F -5,+3 °F ± 3 °F
	0/+93 °C +93/+254 °C +254/+1759 °C	-5,+1 °C -2,+1 °C ± 1 °C	-6,+2 °C -3,+2 °C ± 2 °C

THERMOCOUPLE TEMPERATURE RANGES - (continued)

TC TYPE	SPAN	TYPICAL ERROR	MAX. ERROR
S	+32/+185 °F +185,+450 °F +450/+3181 °F	-6,+1 °F -3,+1 °F ± 1 °F	-8,+3 °F -5,+3 F ± 3 F
	0/+85 °C +85/+232 °C +232/+1750 °C	-4,+1 °C -2,+1 °C ± 1 °C	-8,+3 °C -3,+2 °C ± 2 °C
T	-380/-300 °F -300/+741 °F	-6,+3 °F ± 1 °F	-8,+5 °F ± 3 °F
	-230/-184 °C -184/+394 °C	-4,+2 °C ± 1 °C	-5,+3 °C ± 2 °C
N	-200/-50 °F -50/+2300 °F	± 6 °F ± 1 °F	± 8 °F ± 3 °F
	-130/-46 °C -46/+1260 °C	± 4 °C ± 1 °C	± 5 °C ± 2 °C
E	-179/+1610 °F	± 1 °F	± 3 °F
	-117/+870 °C	± 1 °C	± 2 °C
B	+32/+212 °F +121/+590 °F +590/+950 °F +950/+3259 °F	-0,+170 °F -47,+7 °F ± 6 °F -1,+2 °F	-0,+180 °F -52,+9 °F ± 8 °F -3,+4 °F
	0/+100 °C +100/+310 °C +310/+510 °C +510/+1793 °C	-0,+94 °C -25,+5 °C ± 4 °C ± 1 °C	-0,+100 °C -27,+6 °C ± 5 °C ± 2 °C
PLATINEL II	-115/+85 °F +85/+2500 °F	± 6 °F ± 1 °F	± 8 °F ± 3 °F
	-82/+29 °C +29/+1375 °C	± 4 °C ± 1 °C	± 5 °C ± 2 °C
Ni/Ni18%Mo	0/+110 °F +225/+2390 °F	± 2 °F ± 1 °F	± 4 °F ± 3 °F
	-15/+1310 °C	± 1 °C	± 2 °C
W5%Re/W26%Re	+32/+3260 °F	± 2 °F	± 4 °F
	0/+2315 °C	± 1 °C	± 2 °C

THERMOCOUPLE TEMPERATURE RANGES - (continued)

TC TYPE	SPAN	TYPICAL ERROR	MAX. ERROR
W3%Re/W25%Re	+32/+225 °F +225/3260 °F	-8,+2 °F ± 2 °F	-10,+4 °F ± 4 °F
	+32/+107 °C +107/+2240 °C +2240/+2371 °C	-5,+1 °C ± 1 °C ± 5 °C	-6,+2 °C ± 2 °C ± 6 °C
W/W26%Re	+32/+220 °F +220/+480 °F +480/3260 °F	-0,+100 °F ± 12 °F ± 3 °F	-0,+110 °F ± 15 °F ± 5 °F
	0/+104 °C +104/+249 °C +249/+2315 °C	-0,+55 °C ± 7 °C ± 2 °C	-0,+60 °C ± 8 °C ± 3 °C

RTD TEMPERATURE INPUTS:

SENSOR BREAK: Displays "INPUT OPEN" message for open RTD sensor element. Alarm outputs are turned on; control outputs are turned off.

SENSOR: 100Ω Platinum, 3850 PPM/°C for 3-wire connection.

RTD TYPE	SPAN	TYPICAL ERROR	MAX. ERROR
1 DEGREE RESOLUTION	-300/-240 °F -240/+1500 °F	± 2 °F ± 1 °F	± 4 °F ± 3 °F
	-180/+800 °C	± 1 °C	± 2 °C
0.1 DEGREE RESOLUTION	-148.0/999.9 °F	± .2 °F	± 1.3 °F
	-100.0/+540.0 °C	± .1 °C	± .2 °C

OUTPUT OPTIONS: Up to two control (primary and secondary) outputs and up to two alarm/timer outputs may be supplied. Contol outputs may be on/off heat or cool acting, time proportioning heat or cool acting or analog heat or cool acting. Alarm outputs may be high or low deviation, process or deviation band (on some models only).

SOLID STATE RELAY: Optically coupled isolated, zero crossing triac (SPNO) rated 0.1 to 50 mA @ 260 VRMS max. or 0.03 to 1 A @ 260 VRMS.

ANALOG OUTPUT: 4 to 20 mA into a 1KΩ maximum load resistance or 0 to 5 VDC (100Ω source resistance) into a 1kΩ minimum load resistance. Resolution is 1 part in 256. (Optional 0 to 10 VDC output is also available.) Model 2017 analog output has a resolution of 1 part in 2048.

OUTPUTS (continued)

ALARM/TIMER RELAY: SPDT rated 1 A @ 120 VRMS, non- inductive. Timer may be set up for time in minutes/seconds or hours/minutes.

TUNING PARAMETERS: These parameters are accessible through the keypad in the tune loop using a security coded sequence.

Proportioning band: Adjustable in 1% steps from 1 to 200% of span. Primary and secondary outputs have separately specified PR bands. (Models 2003, 2004 and self tune 2005 have this range in manual tuning but are limited to 0-50% for self tuning primary output only.)

Reset: Adjustable in .01 steps from 0.01 to 20 resets per minute. Primary and secondary channels have separate settings. A value of zero turns the reset action off.

Rate: Adjustable in .01 steps from 0.01 to 5 minutes. Primary and secondary channels have separate settings. A value of zero turns the rate action off.

Cycle Time: Adjustable in 1 second steps from 1 to 60 seconds per cycle.

On/off Dead Band: Adjustable in steps of 0.25, 0.5 and 1% of span.

AUTO/MANUAL: Bumpless transfer algorithm used to move from manual to automatic control.

ALARM DEAD BAND: 0.4% of span.

SETPOINT RESOLUTION AND COINCIDENCE: ±1 count.

ANTI-RESET WINDUP: Reset is inhibited when the process variable is outside of the plus and minus one proportioning band, centered at set point. Magnitude of the reset action is limited to keep the process variable within the proportioning band.

RAMP AND SOAK OPERATION: Number of ramp segments and time intervals are as described by the model description (see Section 1.6.1). Ramp and soak intervals may be set up to either 99 hours/ 59 minutes or 99 minutes/59 seconds. Assured soak is selectable by the user. Cycle repeat may be either set for continuous or from 1 to 255 complete cycles.

SELF TUNING OPERATION: Characterizes the load by measuring the response during start up. Self tuning operates only on primary heating outputs and with PID constants limited as follows:

Proportioning Band - 1 to 50 percent of span
Reset - 0 to 10 resets per minute
Rate - 0 to 3 minutes

If the calculated values fall outside of the above limits, the constants are clamped to the appropriate limit. Values outside of these values may be entered manually. Secondary PID constants are entered manually.

POSITION CONTROL PARAMETERS: Increase and decrease solid state relays are provided to operate the external motor operator. A standard controller may be used with a 1000Ω slidewire (or modified for use with a 100Ω or 135Ω slidewire). Drive unit deadband is selectable from 0.0 to 25.5 percent of span. Controller will detect open slidewire connections. Slidewire calibration can be either manual or a unique automatic slidewire calibration routine.

COMMUNICATION OPTIONS: All Series 2000 controllers except model 2005 may be supplied with digital communications option. Baud rate, parity, handshake parameters and unit number are settable with internal DIP switch. Host computer may read and write most operating parameters. Connections for communications are through rear 25 pin "D" connector. (Refer to the installation manual for more details on communications operation.) The following communication interfaces are available:

RS232 isolated or non-isolated
RS422 isolated or non-isolated
Isolated 20 mA current loop

1.8 ASSEMBLY DIAGRAM

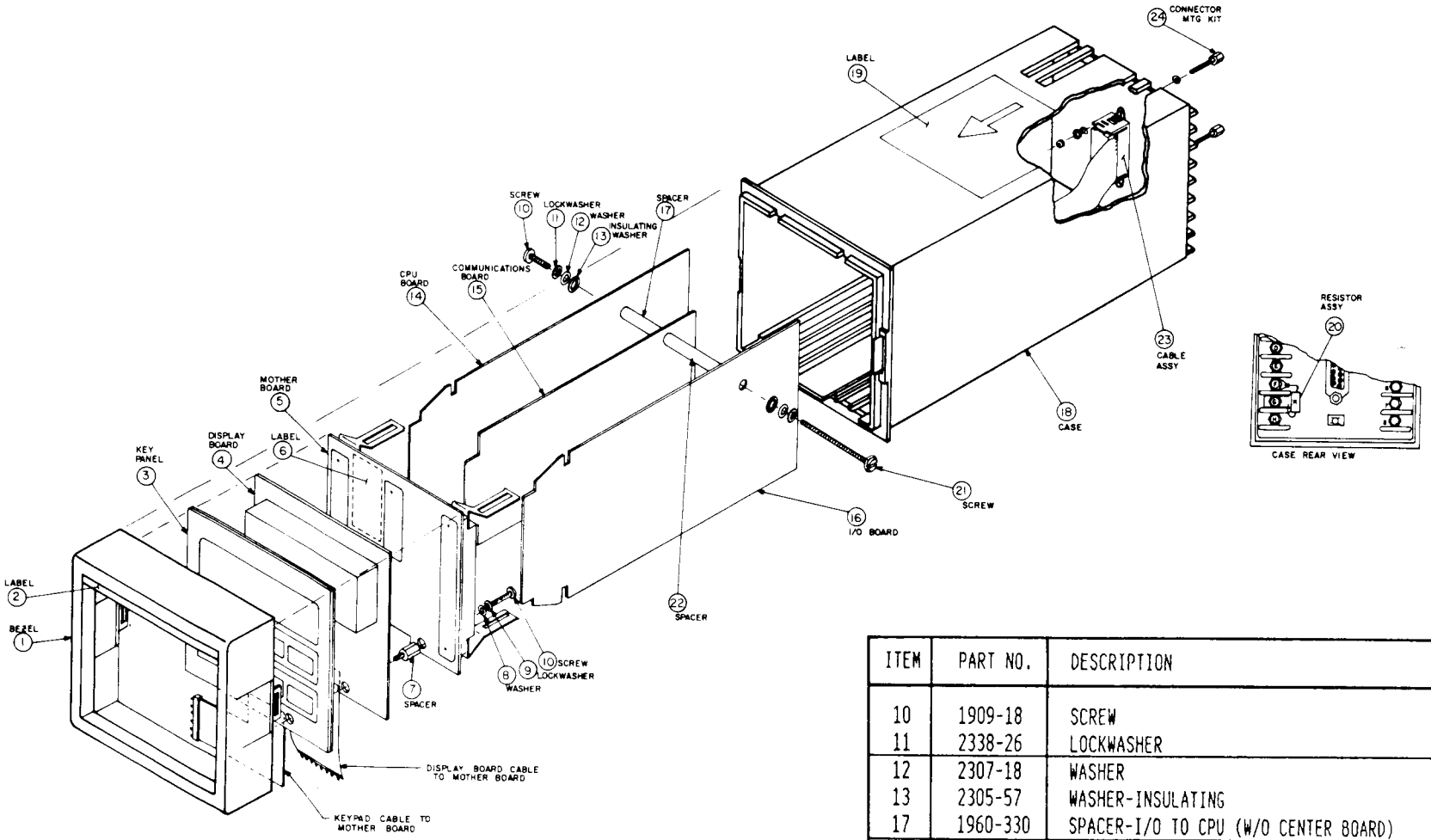
Figure 1-1 is a mechanical assembly diagram of the Series 2000 controllers. This exploded view of the Series 2000 controller shows the five major subassemblies: the case, the front bezel assembly, the input-output (I/O) board, the central processor unit (CPU) board and the center communications or options board. The 2000 Series controllers have been designed so that the entire electronic asembly can be easily removed from the case by pressing the tabs on the sides of the bezel and pulling the assembly forward. (Refer to Section 1.10.)

The I/O and CPU board assemblies are easily removed from the bezel assembly by releasing the spring loaded clips from the notches and pulling the boards out of their connectors. The communications or accessory board may be removed by first disconnecting any leads and cable connectors, removing the screws and spacers that hold the boards together near the rear of the board and pulling the board out of its edgecard connector. The bezel assembly can be disassembled by removing the two screws at the bottom of the bezel assembly. Most modifications described in this manual do not require any changes to the bezel assembly. However, it may be necessary to disassemble this part for servicing.

1.9 BOARD CONFIGURATION

The two circuit boards of the electronic assembly that may require modification are the input-output (I/O) and the central processing (CPU) boards. Some modifications require actual component changes and changes to the circuit boards. Other modifications require only a reprogramming or software configuration change. All software changes may be accomplished through the keypad. Each board has provisions for designated output functions as shown in Figure 1-2. There can be only one primary output: either a solid-state relay (SSR1) or an analog output (ANA1). There can only be one secondary output: either a solid-state relay (SSR2) or an analog output (ANA2).

The MOD CENTER can add SSR2, but cannot add ANA1 or ANA2 to the Series 2000 stocked units. The analog ouputs can only be provided by the factory or from stocked units that were ordered with analog output(s). Alarms, indicated as ALM1 and ALM2 are provided as standard on models 2010,2011 and 2012. ALM1 is standard on models 2013, 2014 and 2015. On all other models, alarms are optional and may be added by the MOD CENTER.



ITEM	PART NO.	DESCRIPTION
1	241-88	BEZEL
2	1405-274	NAMEPLATE
3	1604-561	KEYPAD ASSY-MODELS 2000-1-3-5(S-S)
3	1604-566	KEYPAD ASSY-MODELS 2002-4-5(A-M)
3	1604-558	KEYPAD ASSY-MODELS 2010-11-14-15
3	1604-568	KEYPAD ASSY-MODELS 2012-13-17
7	1960-328	SPACER-DISPLAY
8	2307-5	WASHER
9	2338-6	LOCKWASHER

ITEM	PART NO.	DESCRIPTION
10	1909-18	SCREW
11	2338-26	LOCKWASHER
12	2307-18	WASHER
13	2305-57	WASHER-INSULATING
17	1960-330	SPACER-I/O TO CPU (W/O CENTER BOARD)
17	1960-332	SPACER (USE WITH CENTER BOARD)
18	395-539	CASE ASSY-W/TIN PLATED CONTACTS
18	395-555	CASE ASSY-W/GOLD PLATED CONTACTS-ONE INPUT
18	395-556	CASE ASSY-W/GOLD PLATED CONTACTS-TWO INPUTS
21	1906-112	SCREW (USE WITH CENTER BOARD)
22	1960-331	SPACER (USE WITH CENTER BOARD)
23	300-264	CABLE ASSEMBLY (FOR COMMUNICATIONS BOARD)
24	345-777	CONNECTOR MOUNTING KIT
-	2010-386	SPARE TIN PLATED CONTACTS
-	2010-436	SPARE GOLD PLATED CONTACTS
-	265-332	U BRACKET-MOUNTING
-	1125-407	HARDWARE KIT-MOUNTING

CONTROLLER ASSEMBLY - SERIES 2000
FIGURE 1-1

BOARD CONFIGURATION

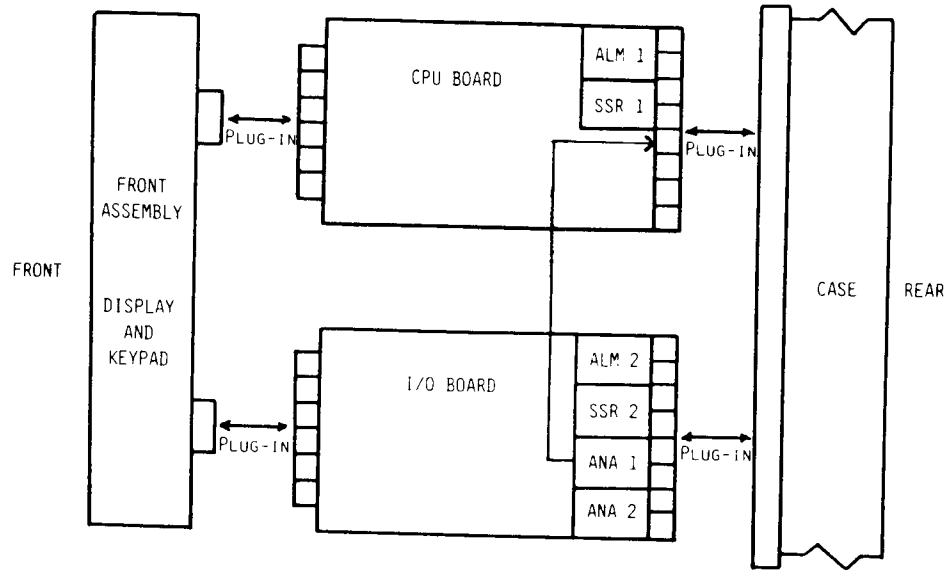


Figure 1-2

1.10 BOARD REMOVAL

-WARNING-

THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID HAZARDOUS POTENTIALS, DO NOT PERFORM ANY SERVICING OTHER THAN THAT REFERENCED IN THE OPERATING INSTRUCTIONS UNLESS QUALIFIED TO DO SO.

To remove the two circuit boards, the I/O and the CPU boards,proceed as follows:

CAUTION: MOS static discharge handling procedure must be followed when handling these boards. See Section 1.13 for details.

1. With all power off, remove the entire electronic assembly from the case by pressing the tabs on each side of the bezel inward and carefully pulling the electronic assembly out of the case. If the communications option is supplied, the communications edge card connector must be disconnected from the center board prior to removing the electronic assembly.

2. Disassemble the spacer rod separating the I/O and CPU boards (and center board, if supplied) by removing the screw and washer on the I/O board side.

3. Disconnect any flexible push-on cables from the connector on the I/O (or center) boards.

4. Gently lift the two retaining springs from the notches of the I/O board and pull the I/O board out of its connector.

5. Gently lift the two retaining springs from the notches of the CPU board and pull the CPU board out of its connector.

1.11 WIRING PRECAUTIONS

Because of the high resolution and low level signals, and to minimize noise pickup that can be encountered during the calibration or installation of these instruments, the use of short twisted pair or shielded signal input leads is recommended.

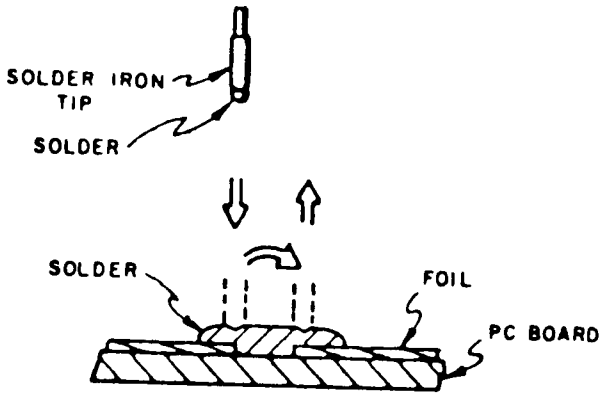
Care must be taken on all units to ensure that a good earth ground connection is made.

1.12 SOLDER BRIDGING TECHNIQUE

The following method is recommended for bridging solder pads.

a) Locate pad to be bridged and, with a clean hot soldering iron, melt a drop of solder on the tip of the iron.

b) Quickly place the tip of the iron down to one side of the gap and swing it over to the other side bridging the gap as illustrated in the sketch below:



If the iron is held to the foils too long, they will heat up enough to cause the solder to flow on the foil and will not allow the bridging to occur.

A solder bridge should only be opened up by heating the area and removing the solder with "Solder-Wick" or equivalent.

PCB foil bridges may be opened using a sharp knife or small portable grinding tool such as a "Dremel Tool".

1.13 MOS STATIC DISCHARGE HANDLING PRECAUTIONS

** CAUTION **

IN HANDLING MOS INTEGRATED CIRCUITS AND THE UNITS INTO WHICH THEY HAVE BEEN INSTALLED, SPECIAL PRECAUTIONS MUST BE OBSERVED IN THE WORK AREA TO PREVENT STATIC CHARGES FROM CAUSING DEVICE FAILURES.

The precautions listed below are recommended to minimize these failures:

* All benches used for assembly or test of MOS circuits are to be covered with conductive antistatic material.

* Conductive wrist straps properly grounded should be worn by all operators so that body charges are grounded.

  WARNING: NEVER EXPOSE AN OPERATOR DIRECTLY TO A HARD ELECTRICAL GROUND. FOR SAFETY REASONS, THE OPERATOR MUST HAVE A RESISTANCE OF AT LEAST 100K OHMS BETWEEN HIMSELF AND HARD ELECTRICAL GROUND.

* Anti-static neutralized smocks are worn to eliminate static charges generated by friction of clothing layers during normal wear.

* Cotton gloves are worn when handling MOS devices. Nylon gloves or finger cots can NOT be used.

* All MOS parts must be left in conductive trays. The use of plastic containers is not allowed. The use of a conductive foam such as Velofoam #7611 is suggested.

* Soldering irons must have grounded tips. Attention should be given to any equipment that may be inductively coupled that can generate stray voltages.

* MOS parts should be handled on grounded conductive surfaces and the operator must touch the conductive surface before touching the parts.

* MOS devices should not be handled by their leads but by their packages instead. In general, materials prone to static charge accumulation should not come into contact with MOS devices.

1.14 CALIBRATION/TROUBLESHOOTING CONNECTORS

The only internal potentiometer adjustments in a Series 2000 controller are for the 4/20 mADC and 0-5 VDC analog outputs. In these cases, the output board must be accessible for pot adjustment which cannot be done through the case. A special connector assembly (P/N 345-826) consisting of the rear portion of the case with terminals installed is available for calibration and troubleshooting. Order this part from the factory if needed.

For calibration and service of older thermocouple input controllers, a cold junction compensator resistor assembly (P/N 344-1199) can be ordered from the factory to mount onto the rear terminals. Each particular resistor must stay with the controller as a set after calibration in order to retain the original calibration accuracy. All older MOD controllers are factory supplied with this assembly. When modifying a MOD controller for non-thermocouple input, this assembly must be removed. Newer controllers have the cold junction compensating resistor mounted on the I/O board and this paragraph does not apply.

1.15 SPECIFICATIONS FOR RANGE RESISTORS

The range components indicated in the parts lists are specified according to the component accuracy and stability required in the circuit. In many cases, substituting components of lesser quality may severely limit the performance of the instrument. A summary of component specifications is given below.

RESISTORS

LFE PART SERIES	SPECIFICATION	ALTERNATE SOURCES
1822-XXX	0.5W @ 70C,+/-5% tolerance, Carbon Film or Composition	1) ROHM Type R50(J) 2) KOA SPEER TypeCF 1/2 3) MEPCO/ELECTRA 5053CX-J 4) STACKPOLE RC-1/2 5) DALE Type SBD 6) PANASONIC Type ERD-50TJ
1837-XXX	0.25W @ 70C,+/-1% tolerance, 100PPM Coated Metal Film	1) CORNING Type NA55 2) IRC Type TO-55 (TRW) 3) MEPCO/ELECTRA Type 5033R 4) KOA SPEER Type MF55
1846-XXX	0.25W @ 70C,+/-5% tolerance, Carbon Film or Composition	1) ROHM Type R25J 2) IRC Type RG 1/4 (TRW) 3) KOA SPEER Type CF 1/4 4) RCD Type CF25
1847-XXX	1.0W @ 25C,+/-1% tolerance, 10 PPM Wirewound	1) RCD Type 125 2) TEL-LABS Type Q126A
1849-XXX	0.25W @ 70C,+/-1% tolerance,50 PPM Coated Metal Film	1) DALE Type RN55C or CMF55 2) CORNING Type NC4 3) ROHM Type CRB14FY 4) IRC Type T2-25 (TRW) 5) MEPCO/ELECTRA 5033R 6) PRP Type GP 1/4 TC50
1855-XXX	0.1W @ 70C,+/-0.1% tolerance, 10 PPM Coated Metal Film	1) MEPCO/ELECTRA Type UPR5023ZB 2) IRC Type MAR5-T13 (TRW) 3) DALE Type PTF56-T13 4) PRP Type PR 1/10 TC10
1856-XXX	0.125W @ 70C,+/-1% tolerance, 25PPM Coated Metal Film	1) TI Type MC55E 2) CORNING Type RN55E or RN60E 3) DALE Type MMF-1/8-T9 4) TRW Type 55-T9 or 60-T9 5) MEPCO Type MF4-C-CHAR "E"

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SECTION 2 - MODIFICATION UNITS AND KITS

All MODIFICATION CONTROLLERS are supplied with a type J thermocouple input. Section 3 details modification of the input to provide for other input types. MODIFICATION CONTROLLERS are provided with either one SSR (Models 2014 and 2015 have two SSR outputs), one 4/20 mA process or two 4/20 mA process outputs. Sections 4 and 5 detail modification of these outputs to other output types. Section 6 details the software configuration and calibration programming. Section 7 details final adjustments and testing. Standard resistors and capacitors needed for modification are not included in kits as the Modification Center is expected to maintain an inventory of these parts.

2.1 MOD CONTROLLERS

The basic MODIFICATION CONTROLLERS are used to produce many variations and options. Most applications can be satisfied by modifying one of these controllers.

MODELS 2000 AND 2001 (WITH START/STOP)

E0-3000-0000	PRIMARY SSR OUTPUT
E0-5000-0000	PRIMARY ANALOG OUTPUT
E0-5600-0000	PRIMARY AND SECONDARY ANALOG OUTPUT

MODEL 2002 (WITH AUTO/MANUAL)

Z0-3000-0000	PRIMARY SSR OUTPUT
Z0-5000-0000	PRIMARY ANALOG OUTPUT
Z0-5600-0000	PRIMARY AND SECONDARY ANALOG OUTPUT

MODEL 2003 (SELF TUNE WITH START/STOP)

EA-3000-0000	PRIMARY SSR OUTPUT
EA-5000-0000	PRIMARY ANALOG OUTPUT
EA-5600-0000	PRIMARY AND SECONDARY ANALOG OUTPUT

MODEL 2004 (SELF TUNE WITH AUTO/MANUAL)

ZA-3000-0000	PRIMARY SSR OUTPUT
ZA-5000-0000	PRIMARY ANALOG OUTPUT
ZA-5600-0000	PRIMARY AND SECONDARY ANALOG OUTPUT

MODEL 2005 (ZONE CONTROLLER)

NO MODIFICATION UNIT - ORDER ALL UNITS FROM FACTORY

MODELS 2010 AND 2011 (WITH RAMP AND SOAK)

D0-3000-1200	PRIMARY SSR OUTPUT
D0-5000-1200	PRIMARY ANALOG OUTPUT
D0-5600-1200	PRIMARY AND SECONDARY ANALOG OUTPUT

MODEL 2012 (SINGLE LOOP PROFILE)

B4-300Z-1200	PRIMARY SSR OUTPUT
B4-500Z-1200	PRIMARY ANALOG OUTPUT
B4-560Z-1200	PRIMARY AND SECONDARY ANALOG OUTPUT

MODEL 2013 (TWO LOOP PROFILE)

NO MODIFICATION UNIT - ORDER ALL UNITS FROM FACTORY

MODEL 2014 (POSITION CONTROL)

J1-1000-1000 INCREASE/DECREASE SSR OUTPUTS

MODEL 2015 (POSITION CONTROL WITH RAMP AND SOAK)

MODIFY FROM MODEL 2014 CONTROLLER

MODEL 2017 (SETPOINT PROGRAMMER)

NO MODIFICATION UNIT - ORDER ALL UNITS FROM FACTORY

2.2 INPUT MODIFICATION KITS

The input may be modified for special measuring inputs by adding the following kits.

1821-118	To add self-powered 4/20 mA input
1821-119	To add bridge transducer supply - 5V
1821-120	To add bridge transducer supply - 10V
1821-121	For 0.1 degree RTD

2.3 OUTPUT MODIFICATION KITS

The output of the various controllers may be modified by adding components contained in the following kits:

1821-79	To add SSR2
1821-86	To add ALM1
1821-87	To add ALM2
1821-122	To add isolated 4/20 mA output
1821-123	For DC trigger output
1821-124	For open collector output

2.4 COMMUNICATION KITS

All Series 2000 controllers (except Models 2005, 2012, 2013 and 2017) may have digital communications added using the following kits:

COMM I	COMM II		
1821-88	1821-142	Non-isolated RS232	NOTE: Models 2012, 2013, 2016 & 2017 require COMM III communications not listed.
1821-89	1821-143	Isolated RS232	
1821-90	1821-144	Non-isolated RS422	
1821-91	1821-145	Isolated RS422	
1821-92	1821-146	Isolated 20 mA current loop	

2.5 OTHER KITS

One option kit and three kits used to suppress external noise are listed below:

1821-98	Kit with 130 V MOV
1821-99	Kit with 250 V MOV
1821-100	Kit with R-C snubber components
1821-125	To add remote Start/Stop, Remote Auto/Manual (Models 2002 & 2004) or Remote Pause (Model 2012) option

SECTION 3 - INPUT MODIFICATION

BEFORE STARTING ANY INPUT MODIFICATIONS, first select the proper MODIFICATION CONTROLLER according to the output type required for the application as detailed in Section 4. Because the hardware for all Series 2000 controllers is similar, these input modifications apply to all controllers in the series except Model 2013 which is a factory special. After input modification, all units must be configured and calibrated per Section 6 and adjusted and tested per Section 7.

3.1 MODIFICATION OF THERMOCOUPLE INPUT TYPE

All MODIFICATION CONTROLLERS are supplied calibrated for type J (Iron/Constantan) thermocouple. The change to another thermocouple type is a configuration or software change (see Section 6). No component or board changes are required. The controller does not need to be recalibrated when changing thermocouple type.

3.2 MODIFICATION FROM THERMOCOUPLE INPUT TO 100Ω PLATINUM RTD INPUT WITH 1 DEGREE RESOLUTION

Remove the Input/Output (I/O) board from the electronic assembly per instructions in Section 1.10 and make the following changes. (LFE P/N's in brackets.)

1. REMOVE R3, R15
2. REPLACE resistor R16 with a jumper (1835-106).
3. REPLACE resistor R5 with 2K-1% (1849-23).
4. REPLACE resistor R7 with 12.7K-1% (1849-1272).
5. REPLACE resistor R18 with 11K-1% (1849-113) for Models 2014 and 2015 only.
6. REPLACE resistor R3 on the small adder board with 10.5K-1% for Models 2014 and 2015 only.
7. OPEN J26 foil bridge (on component side).
8. SHORT J27 solder bridge (on component side).
9. REPLACE choke L3 in input circuit on 1650-437A (437A is screened on component side under VR3) with jumper (1835-106). This does not apply to boards 1650-415 (any revision) or 1650-437B or later revision except to some 1650-415E boards (415E in foil on solder side under VR3) which have been reworked to add L3.
10. REMOVE the Cold Junction Compensator Resistor assembly from the rear terminals of the controller case (terminals F & G) for older controllers or remove the compensating resistor (CJC1) and its support from the I/O board of newer controllers.

3.3 MODIFICATION FROM THERMOCOUPLE INPUT TO 100Ω PLATINUM RTD INPUT WITH 0.1 DEGREE RESOLUTION

Remove the Input/Output (I/O) board from the electronic assembly per instruction in Section 1.10 and, using kit 1821-121, make the following changes. (LFE P/N's in brackets.)

1. REMOVE R3,R5
2. REPLACE resistor R6 with 23.2k-0.1% (1855-2322).
3. REPLACE R7 with 1k-0.1% (1855-13)
4. REPLACE resistor R16 with 10k-1% (1849-14).
5. REPLACE capacitors C3,C27 & C28 with 4.7µF-50V (305-340).
6. REPLACE resistor R18 with 5.23k-1% (1849-5231) for Models 2014 and 2015 only.
7. REPLACE resistor R3 on the small slidewire adder PCB with 5.23k-1% (1849-5231) for Models 2014 and 2015 only.
8. OPEN J26 foil bridge (on component side).
9. ADD small constant current PCB (1651-1971) per Figure 3-1 below.
10. REPLACE choke L3 in input circuit on 1650-437A (437A is screened on component side under VR3) with jumper (1835-106). This does not apply to boards 1650-415 (any revision) except to some 1650-415E boards (415E in foil on solder side under VR3) which have been reworked to add L3.
11. REMOVE the Cold Junction Compensator Resistor assembly from the rear terminals of the controller case (terminals F & G) for older controllers or remove the compensating resistor (CJC1) and its support from the I/O board of newer controllers.

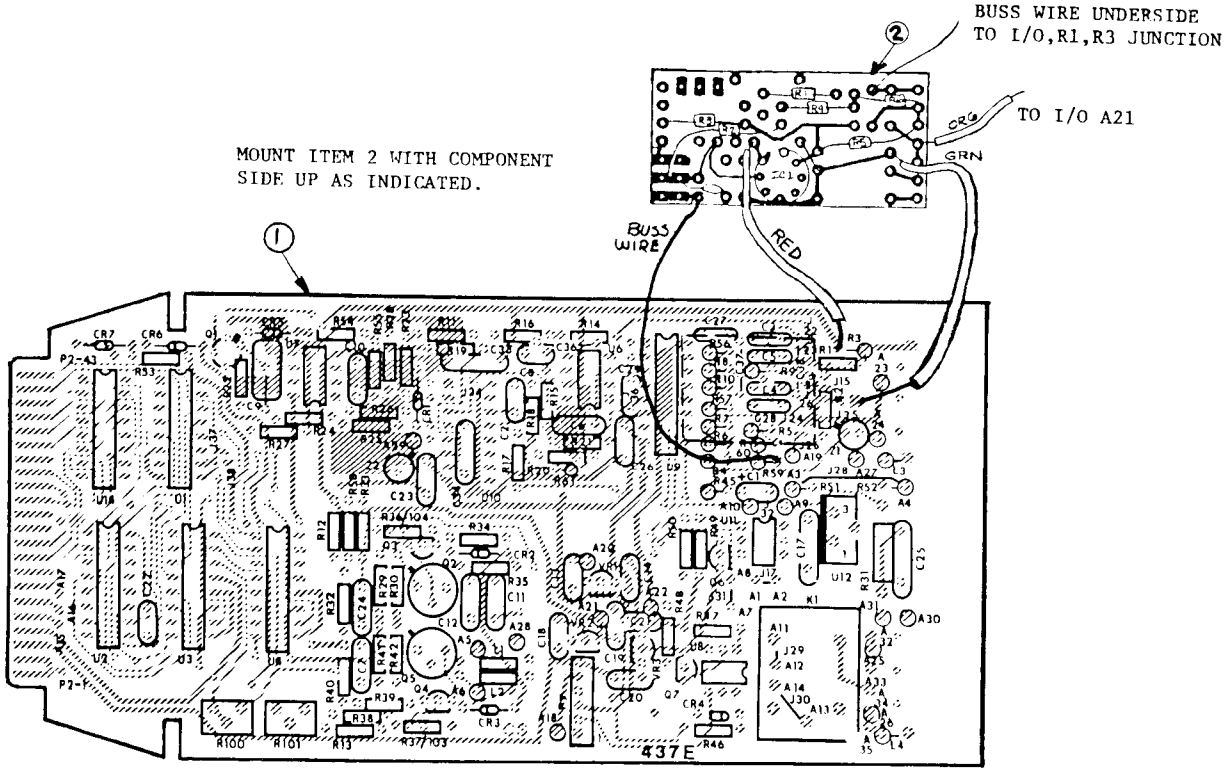


Figure 3-1 MOUNTING OF CONSTANT CURRENT ADDER PCB

3.4 MODIFICATION FROM THERMOCOUPLE INPUT TO DC VOLTAGE INPUT

Remove the Input/Output (I/O) board from the electronic assembly per instruction in Section 1.10 and make the following changes.

Refer to the DC VOLTAGE INPUT RANGE RESISTORS chart (Table 3-1) for values selected for standard ranges. The values for the attenuator resistor R1 & R2 are based on a full range dc input of 50 mV at the junction of R1 & R2.

1. REMOVE resistors R3, R5.
2. OPEN J15 if noted in Table 3-1. (NOTE: Make sure that the entire length of the foil bridge between pads is removed to achieve proper spacing.
3. ADD resistors R1 and R2 (see Table 3-1).
4. REPLACE capacitors C4 and C5 as listed in Table 3-1.
5. SHORT J35 solder bridge (on component side).
   ALTERNATIVE: On older PCB's, ADD a wire jumper from the feed through at terminal G to the feed through at terminal F (GND).
6. REMOVE the Cold Junction Compensating Resistor assembly from the rear terminals of the controller case (terminals F & G) for older controllers or remove the compensating resistor (CJC1) and its support from the I/O board of newer controllers.

DC VOLTAGE INPUT RANGE	R1 (LFE P/N)	R2 (LFE P/N)	J15 SOLDER BRIDGE	REPLACE C4 (LFE P/N)	REPLACE C5 (LFE P/N)
0 to 50 mV	NONE	NONE	SHORTED	NO	NO
0 to 100 mV	499K-1% (1849-4993)	499K-1% (1849-4993)	OPEN	1µF (305-324)	2.2µF (305-188)
0 to 500 mV	750K-1% (1849-754)	84.5K-1% (1849-8452)	OPEN	2.2µF(305-188)	2.2µF (305-188)
0 to 1.0 V	750K-1% (1849-754)	39.2K-1% (1849-3922)	OPEN	2.2µF(305-188)	NO
0 to 5.0 V	750K-1% (1849-754)	7.5K-1% (1849-752)	OPEN	NO	NO
0 to 10 V	750K-1% (1849-754)	3.74K-1% (1849-3741)	OPEN	NO	NO
0 to 50 V	750K-1% (1849-754)	750Ω-1% (1849-751)	OPEN	NO	NO
0 to 100 V	750K-1% (1849-754)	365Ω-1% (1849-3650)	OPEN	NO	NO

Table 3-1 DC VOLTAGE INPUT RANGE RESISTORS

3.5 MODIFICATION FROM THERMOCOUPLE INPUT TO DC CURRENT INPUT

Remove the Input/Output (I/O) board from the electronic assembly per instruction in Section 1.10 and make the following changes.

Refer to the DC CURRENT INPUT RANGE RESISTOR chart (Table 3- 2) for the values selected for standard ranges. The value for resistor R2 is calculated to supply an input signal of 50 mV using the following formula:

$$R2(\text{shunt}) = \frac{50\text{mV}}{\text{Input Milliamperes}}$$

** CAUTION **

THE MAXIMUM INPUT CURRENT SHALL BE LIMITED TO 500 mADC.

1. REMOVE resistors R3, R5
2. SHORT J35 solder bridge (on component side).
   ALTERNATIVE: On older PCB's, ADD a wire jumper from the feed through at terminal G to the feed through at terminal F (GND).
3. ADD resistor R2 (see Table 3-2).
4. REMOVE the Cold Junction Compensating Resistor assembly from the rear terminals of the controller case (terminals F & G) for older controllers or remove the compensating resistor (CJC1) and its support from the I/O board of newer controllers.

DC CURRENT FULL RANGE INPUT	R2 (LFE P/N)
5 mA	10Ω-1% (1849-11)
20 mA	2.5Ω-1% (1847-259)
100 mA	0.5Ω-1% (1847-59)

Table 3-2 DC CURRENT INPUT RANGE RESISTORS

NOTE: Use the 20 mA range resistor for 4/20 mA input.

3.6 MODIFICATIONS TO ADD REMOTE SETPOINT INPUT

The remote setpoint input option can be added to all Series 2000 controllers except an early Model 2010 with 1685-1 EPROM or Models 2005, 2012, 2013, 2014, 2015 and 2017. Early Model 2010's with 1685-2 EPROM and using raw I/O board 1650-415 Rev. C and earlier require special procedures. Contact the factory for special instructions.

Remove the Input/Output (I/O) board from the electronic assembly per instruction in Section 1.10 and make the following changes. (LFE P/N's in brackets.)

1. ADD capacitor C1, C2 .47µF-50V (305-250).
2. ADD capacitor C29 4.7µF (305-340).
3. REMOVE jumper J36.
4. REMOVE relay K1 (if ALM2 is present).
5. ADD jumpers J29, J30 (1835-106).
6. ADD resistor R45 1k-1% (1849-13).
7. ADD resistor R61 40.2k-1% (1849-4022).
8. ADD resistors R17,R18 for voltage or current input ranges per Table 3-3.
9. ADD jumper wire from A26 to ground end of R21.

NOTE: Modification for remote setpoint input requires removing an alarm relay (ALM2) to provide input terminals for the remote input.

FULL RANGE SETPOINT INPUT	R17 (LFE P/N)	R18 (LFE P/N)		
		0.1° RESOLUTION RTD	1° RESOLUTION RTD	ALL OTHERS
1 VDC	200k-1% (1849-25)	66.5k-1% (1849-6652)	200k-1% (1849-25)	10.5k-1% (1849-1052)
5 VDC	100k-1% (1849-15)	5.23k-1% (1849-5231)	11k-1% (1849-113)	1k-1% (1849-13)
10 VDC	200k-1% (1849-25)	5.11k-1% (1849-5111)	10.5k-1% (1849-1052)	1k-1% (1849-13)
5 mADC	JUMPER (1835-106)	49.9Ω-1% (1849-4999)	100Ω-1% (1849-12)	10Ω-1% (1847-11)
20 mADC	JUMPER (1835-106)	12.4Ω-1% (1849-1249)	24.9Ω-1% (1849-2499)	2.5Ω-1% (1847-259)
100 mADC	JUMPER (1835-106)	2.5Ω-1% (1847-259)	5Ω-1% (1847-50)	0.5Ω-1% (1847-59)

Table 3-3 DC REMOTE SETPOINT INPUT RESISTORS

NOTE: Use 5V range values for 1/5 VDC input ranges.

3.7 MODIFICATIONS FROM THERMOCOUPLE INPUT TO SELF-POWERED 4/20 mA INPUT

This modification provides a separate non-regulated isolated power supply to produce the excitation for an external 2- wire transmitter. The power supply PCB and other parts needed to make this modification are contained in kit 1821-118. This modification may not be added to controllers with digital communications, input or analog output isolation or remote start/stop option.

3.7 MODIFICATIONS FROM THERMOCOUPLE INPUT TO SELF-POWERED 4/20 mA INPUT (CONTINUED)

Remove the Input/Output (I/O) board from the electronic assembly and the Mother board from the bezel assembly per instruction in Sections 1.8 and 1.10 and make the following changes. (LFE P/N's in brackets.)

1. ADD center board connector P3 (345-764) to Mother board (not needed if unit already has center board connector installed).

2. SOLDER the stripped end of the black lead assembly (2379-197) in CPU board hole A15.

3. SOLDER the stripped end of the black/white lead assembly (2379-216) in CPU board hole A16.

4. SOLDER the stripped end of the green lead assembly (2379-201) in CPU board hole A17.

5. ADD resistor R2 2Ω-1% (1826-20) on I/O board.

6. REMOVE resistors R3 and R5 on I/O board.

7. OPEN J24 foil bridge (on component side) of I/O board.

8. SOLDER bridge I/O board J35. On newer I/O boards, solder the yellow lead (2378-247) from I/O board hole R5 (top end) to I/O board hole A24. For earlier boards where A24 does not appear, use the feed through hole at terminal F (GND).

9. SOLDER the red lead (2378-75) from I/O board connector pin P7-5 (or A18) to the I/O hole A23. For earlier boards where A23 does not appear, use the feed through hole at terminal G.

10. INSERT the power supply board (1651-1940) in the center board connector.

11. CONNECT the black lead from the CPU board to center board pin A1. CONNECT the black/white lead from the CPU board to center board pin A2. CONNECT the green lead from the CPU board to center board pin A3.

12. ASSEMBLE rear ends of PCB's together using new shorter spacers and hardware supplied in the kit. (see Figure 1-1)

13. REMOVE the Cold Junction Compensating Resistor assembly from the rear terminals of the controller case (terminals F & G) for older controllers or remove the compensating resistor (CJC1) and its support from the I/O board of newer controllers.

14. CALIBRATE as a standard 4-20 mA input per instructions in Section 6.12.3.

15. SHIP copy of supplementary instruction 956-646 along with standard manual. (A copy of this instruction may be found in Section 13.2.)

3.8 MODIFICATION FROM THERMOCOUPLE INPUT TO BRIDGE TRANSDUCER INPUT

This modification provides a separate regulated and isolated power supply to produce excitation for an external 4-wire bridge transducer. The power supply PCB and other parts needed to make this modification are contained in either of two kits: 1821-119 for 5 VDC at 50 mA max or 1821-120 for 10 VDC at 100 mA max (some other voltages are available - check the factory for information). If intermediate or higher power supply voltages are specified by the transducer manufacturer, use the 5V supply for ratings between 5 and 10 V or use the 10V supply for ratings over 10V. When using transducers at lower supply voltages than recommended, scale the bridge output back in the same ratio as the actual vs rated supply voltages. Make sure that the current drawn by the transducer does not exceed the power supply maximum rating. This modification may not be added to controllers with digital communications, input or analog output isolation or remote start/stop option.

Because extra terminals are required to connect the power supply output to the external transducer, it is necessary to restrict the number of optional outputs. This instruction assumes that the secondary output is not supplied. Other arangements such as using the ALARM2 terminals for the power supply output are possible but not covered by this instruction.

Remove the Input/Output (I/O) board from the electronic assembly and the Mother board from the bezel assembly per instruction in Sections 1.8 and 1.10 and make the following changes. (LFE P/N's in brackets.)

1. ADD center board connector P3 (345-764) to Mother board (not needed if unit already has center board connector installed).

2. SOLDER the stripped end of the black lead assembly in CPU board hole A15 (2379-197).

3. SOLDER the stripped end of the black/white lead assembly in CPU board hole A16 (2379-216).

4. SOLDER the stripped end of the green lead assembly in CPU board hole A17 (2379-201).

5. DETERMINE the approximate transducer output at the applied power supply voltage. Range the input circuit according to Section 3.4 or 3.5.

6. INSERT power supply board (supplied in kit 1821- 119 or kit 1821-120)in the center board connector.

7. CONNECT the black lead from the CPU board to center board pin A1. CONNECT the black/white lead from the CPU board to center board pin A2. CONNECT the green lead from the CPU board to center board pin A3.

8. CONNECT the red lead from the center board to I/O board pin A7 and the black lead from the center board to I/O board pin A9.

9. ASSEMBLE rear ends of PCB's together using new shorter spacers and hardware supplied in the kit. (see Figure 1-1)

3.8 MODIFICATION FROM THERMOCOUPLE INPUT TO BRIDGE TRANSDUCER INPUT (continued)

10. REMOVE the Cold Junction Compensating Resistor assembly from the rear terminals of the controller case (terminals F & G) for older controllers or remove the compensating resistor (CJC1) and its support from the I/O board of newer controllers.

11. Connect the flex cable from the CPU board to the accessory board and connect the flex cable from the accessory board to the I/O board.

12. SHIP a copy of supplementary instruction 956-667 along with the standard manual. (A copy of this instruction may be found in Section 13.2.)

3.9 MODIFICATION FROM THERMOCOUPLE INPUT TO ADD INPUT ISOLATION

In most applications, input isolation is not needed. Where ground loops in multiple controller systems appear to be a problem, first try to isolate the output as that is usually easier to do. (Note that units with SSR, DC trigger or open collector outputs have internal optical isolation as standard. Instructions for 4/20 mA isolated output are given in Section 4.3.6.) For those applications where input isolation is required (where remote setpoint input and/or non-isolated analog outputs are also provided), a modification for input isolation is available as a built-to-order special. ORDER THESE UNITS FROM THE FACTORY.

3.10 MODIFICATIONS FOR 135Ω SLIDEWIRE (MODELS 2014 & 2015 ONLY)

A modification is required when the feedback slidewire resistance is other than the standard 1000Ω. This modification is for use with a 135Ω slidewire only.

Remove the I/O board from the electronic assembly per instructions in Section 1.10 and make the following changes:

1. Replace resistor R1 on the small adder board with 825Ω-1% (1849-8250)

2. Recheck the controller operation at the low supply voltage condition with a 135Ω dummy resistor across terminals A and C.

3.11 MODIFICATIONS FOR 100Ω SLIDEWIRE (MODELS 2014 & 2015 ONLY)

This modification converts a Model 2014 or 2015 fitted for a standard 1000Ω slidewire for use with a non-standard 100Ω slidewire.

Remove the I/O board from the electronic assembly per instructions in Section 1.10 and make the following changes:

1. Replace resistor R17 on the I/O board with 24.9k-1% (1849-2492)

2. Recheck the controller operation at low supply voltage conditions with a 100Ω dummy resistor across terminals A and C.

SECTION 4 - CONTROLLER SELECTION AND OUTPUT MODIFICATION

The Series 2000 controllers have three distinct types of output: solid-state relay (SSR) output(s), analog output(s) and electromechanical relay alarm/timer output(s). Except for certain models where the circuit board or output terminals are reserved for special functions, a wide variety of combinations of these outputs are available either from the factory or by modifying one of the stocked controllers following instructions in this section. All models use the same hardware and these modifications apply to all models unless specifically exempted.

4.1 CONTROLLER SELECTION

When selecting a MODIFICATION CONTROLLER for an application, it is first necessary to identify the correct model to fulfill the required functions. Refer to the controller specifications in Section 1.7 in order to match the customer's requirements against the appropriate LFE model numbers. For each model except models 2005,2013, 2014, 2015 and 2017, controllers are stocked with three basic configurations of output. These stocked output configurations are as follows: primary SSR, primary analog, and primary analog and secondary analog outputs. While these standard combinations will fill many orders without modification, the instructions in this Section detail MODIFICATION CENTER changes to add or change the outputs to match the customer requirements. Refer to Section 2 for stocked unit part numbers. After ranging per Section 3, modifying the outputs per Sections 4 and 5, all controllers must be configured and calibrated per Section 6 and adjusted and tested per Section 7.

There are no stocked MODIFICATION CONTROLLERS for Models 2005, 2013, 2015 or 2017. Refer to Section 4.5.3 for instruction for the modification of a Model 2015 from a Model 2014. Models 2005, 2013 and 2017 must be ordered from the factory.

4.2 SOLID-STATE RELAY AND RELATED OUTPUTS

4.2.1 PRIMARY 1 AMP SSR OUTPUT

Select a controller from the list in Section 2 having a part number of the type XX-3000-XX00. The 1 ampere primary SSR relay is factory installed and no modification is required.

4.2.2 MODIFICATION FROM 1 AMP SSR TO 50 mA SSR

When the internal SSR is used to operate an external solid- state relay or sensitive coil AC relay, two potential problems may affect the operation of the relay.

1. The leakage current through the internal SSR when it is turned OFF may be high enough that the external relay is turned ON continuously.

2. The low power consumption of the external SSR may cause the internal SSR to turn OFF due to insufficient holding current.

When either of these problems occurs, the following modification is suggested. This modification may be performed on either the primary or secondary SSR.

Remove the Input/Output (I/O) board and/or the CPU board from the electronic assembly per instruction in Section 1.10 and make the following changes. (LFE P/N's in brackets.)

		CPU BOARD FOR SSR1	I/O BOARD FOR SSR2
1.	REMOVE triac assembly	U11	U12
2.	REMOVE resistor 390Ω	R15	R51
3.	REMOVE resistor 2.2k	R16	R52
4.	REMOVE capacitor .04 µF	C7	C17
5.	ADD jumpers (1835-106)	J7 & J8	J17 & J28
6.	REPLACE capacitor with .002µF (305-439)	C17	C25
7.	REPLACE resistor with 390Ω (1822-391)	R18	R31

4.2.3 MODIFICATION TO ADD A SECONDARY SOLID-STATE RELAY (SSR2)

Kit 1821-79 is available from the factory containing all the parts necessary to add a solid-state relay (SSR2 with 1 Amp output) to the I/O board. This kit may be added to a basic controller with a part number of XX-3000-XX00 or XX-5000- XX00.

Remove the Input/Output (I/O) board from the electronic assembly per instruction in Section 1.10 and make the following changes. (LFE P/N's in brackets.)

1.	ADD optical isolator U11	(2036-320)
2.	ADD resistor R31 - 47Ω 1/2W 5%	(1822-470)
3.	ADD capacitor C25- .04 µF 600V	(305-97)
4.	ADD triac U12	(2036-458)
5.	ADD triac heatsink	(1951-125)
6.	ADD resistor R51 - 390Ω 1/4W	(1846-391)
7.	ADD capacitor C17-.04 µF 600V	(305-97)
8.	ADD resistor R52-2.2K 1/4W	(1846-222)
9.	CHANGE resistor R49 to 180Ω 1/4W	(1846-181)
10.	OPEN solder bridge J33	---
11.	ADD resistor R50 - 7.5k 1/4W	(1846-752)
12.	ADD transistor Q6 - 2N3904	(2036-76)

4.2.4 MODIFICATION OF SSR TO DC TRIGGER OUTPUT

Many applications require a 3 to 32 VDC output for driving an external higher current solid-state relay module. Kit 1821-123 may be added to either of the internal 1 amp solid- state relays (SSR1 or SSR2) to provide an approximate 18 VDC trigger output. The part number or configuration number must also be set for any of the solid state relay codes for this option to work.

Note that this modification does not provide isolation since the external solid state relay is expected to provide the isolation.

Remove the Input/Output (I/O) board or CPU board(as appropriate) from the electronic assembly per instruction in Section 1.10 and make the following changes. (LFE P/N's in brackets.)

		CPU BOARD FOR SSR1	I/O BOARD FOR SSR2
1.	REPLACE optical isolator with MOC8050 (2036-328)	U8	U11
2.	REMOVE resistor	R15	R31
3.	REMOVE capacitor	C7	C17
4.	REMOVE capacitor	C17	C25
5.	REMOVEtriac	U11	U12
6.	ADD resistor 1k 5% (1846-13)	CR7	on solder side from U11-5 to VR1-IN --- (use tubing)
7.	ADD jumper (1835-106)	R22	none
8.	ADD wire jumper - Green (2378-127)	A5 to A7	A1 to A2
9.	ADD wire jumper - Yellow (2378-191)	A8 to GND	none
10.	ADD jumper (1835-106)	none	J32
11.	ADD solder bridge	none	J14
12.	SHIP a copy of supplementary instructions 956-670 with the standard manual. (A copy of this manual may be found in Section 13.2.)	yes	yes

4.2.5 MODIFICATION OF SSR TO OPEN COLLECTOR OUTPUT

For some applications it is necessary to provide a switching output that can be integrated with an external circuit. For this modification, the emitter and collector of an internal photo-coupled NPN output transistor are brought out for customer use. An external supply of up to 24VDC may be switched. Kit 1821-124 may be added to either of the internal 1 amp solid-state relays (SSR1 or SSR2) to provide for an open collector output. The part number or configuration number must also be set for any of the solid state relay codes for this option to work.

Remove the Input/Output (I/O) board or CPU board as appropriate from the electronic assembly per instruction in Section 1.10 and make the following changes. (LFE P/N's in brackets.)

		CPU BOARD FOR SSR1	I/O BOARD FOR SSR2
1.	REPLACE optical isolator with MOC8050 (2036-328)	U8	U11
2.	REMOVE resistor	R15	R51
3.	REMOVE capacitor	C7	C17
4.	REMOVE capacitor	C17	C25
5.	REMOVEtriac	U11	U12
6.	ADD wire jumper - White (2378-151)	U8-5 to A7	U11-5 to A4
7.	ADD jumper (1835-106)	J8	J17
8.	SHIP a copy of supplementary instructions 956-673 with the standard manual. (A copy of this manual may be found in Section 13.2.)	yes	yes

4.3 ANALOG OUTPUTS

4.3.1 PRIMARY 4/20 mA ANALOG OUTPUT

Select a controller from the list in Section 2 having a part number of the type XX-5000-XX00 (primary 4/20 mA) or XX- 5600-XX00 (primary and secondary 4/20 mA). The 4/20 mA output is factory installed and no modification is required.

4.3.2 SECONDARY 4/20 mA ANALOG OUTPUT

Select a controller from the list in Section 2 having a part number of the type XX-5600-XX00. These units have both primary and secondary 4/20 mA analog output factory installed and no modification is required. If a secondary analog output is required with a primary SSR output, this is a factory combination and the unit must be ordered from the factory as a built-to-order special.

4.3.3 MODIFICATION OF 4/20 mA ANALOG OUTPUT TO 0/5 VDC OUTPUT

The standard analog output controllers are supplied with 4/20 mA output. The changes needed to modify a standard analog output controller to 0/5 VDC are listed below. This modification may be made to controllers with part numbers of XX-5000-XX00 or XX-5600-XX00.

Remove the Input/Output (I/O) board from the electronic assembly per instruction in Section 1.10 and make the following changes. (LFE P/N's in brackets.)

		I/O BOARD FOR ANA1	I/O BOARD FOR ANA2
1.	ADD resistor 100Ω (1846-12)	R39	R33
2.	ADD capacitor .002μF (305-439)	C7	C24
3.	REMOVE resistor	R38	R58
4.	REMOVE resistor	R41	R29
5.	REMOVE resistor	R42	R30
6.	OPEN foil bridge	J7	J11
7.	OPEN foil bridge	J9	J13
8.	SHORT solder bridge	J8	J12
9.	SHORT solder bridge	J10	J14

4.3.4 MODIFICATION OF 4/20 mA ANALOG OUTPUT TO 0/10 VDC OUTPUT

The standard analog output controllers are supplied with 4/20 mA output. The changes needed to modify a standard analog output controller to 0/10 VDC are listed below. This modification may be made to controllers with part numbers of XX-5000-XX00 or XX-5600-XX00.

Remove the Input/Output (I/O) board from the electronic assembly per instruction in Section 1.10 and make the following changes. (LFE P/N's in brackets.)

		I/O BOARD FOR ANA1	I/O BOARD FOR ANA2
1.	REMOVE potentiometer	R101	R100
2.	REMOVE resistor	R38	R58
3.	REMOVE resistor	R41	R29
4.	REMOVE resistor	R42	R30
5.	OPEN foil bridge	J5	J2
6.	OPEN foil bridge	J7	J11
7.	OPEN foil bridge	J9	J13
8.	SHORT solder bridge	J4	J1
9.	SHORT solder bridge	J6	J3
10.	SHORT solder bridge	J8	J12
11.	SHORT solder bridge	J10	J14
12.	ADD resistor 100Ω 1/4W 5% (1846-12)	R39	R33
13.	ADD capacitor .002 uF (305-439)	C7	C24

NOTE: Early versions of the I/O board require that a jumper be installed from the wiper of R101 to the J4 side (Analog Output 1) when making this modification.

4.3.5 MODIFICATION TO PROVIDE RETRANSMITTING ANALOG OUTPUT

Some applications require an analog output that is proportional to the input signal. (Temperature ranges have an output that is proportional to the linearized value of the input.) This modification is available in all of the Series 2000 models except models 2014 and 2015. When retransmitting output is provided, the output is in place of a secondary output. The unit must have analog secondary output components installed. The only stocked standard controller to which this modification may be made is XX- 5600-XX00. All other requirements must be ordered from the factory as a built-to-order special.

The above stocked unit is supplied with standard secondary 4/20 mA analog ouput. This output may also be changed to 0/5 VDC or 0/10 VDC. See Sections 4.3.3 or 4.3.4 for modification details. Configuration programming is also required per Section 6. A zero adjustment pot is recommended to be added for 4/20 mA retransmitting analog outputs (See Section 4.3.7).

Supplementary manual 956-671 should be shipped along with the standard manual for all units with retransmitting analog output. (A copy of this manual may be found in Section 13.2.)

4.3.6 MODIFICATION TO PROVIDE ISOLATED 4/20 mA ANALOG OUTPUT

This modification provides an isolation circuit and separate isolated power supply. The isolation PCB and other parts needed to make this modification are contained in kit 1821- 122. Only one 4/20 mA analog output may be isolated with this modification. This modification may not be added to controllers with digital communications, input isolation, self-powered 4/20 mA input, bridge transducer input or remote start/stop option.

Remove the Input/Output (I/O) and CPU boards from the electronic assembly and the Mother board from the bezel assembly per instruction in Sections 1.8 and 1.10 and make the following changes. (LFE P/N's in brackets.)

1. ADD center board connector P3 (345-764) to Mother board (not needed if unit already has center board connector installed). Reassemble the Mother board into the bezel assembly.

2. SOLDER the stripped end of the black lead assembly in CPU board hole A15. (2379-197).

3. SOLDER the stripped end of the black/white lead assembly in CPU board hole A16 (2379-216).

4. SOLDER the stripped end of the green lead assembly in CPU board hole A17 (2379-201).

5. REMOVE potentiometer R101 (ANA1) or R100 (ANA2) on I/O board.

6. REMOVE R38,R41,R42 (ANA1) or R29,R30,R58 (ANA2) on I/O board.

7. OPEN foil bridges J5, J7, J9 (ANA1) or J2, J11, J13 (ANA2) on I/O board.

8. SHORT solder bridge J4, J6, J8, J10 (ANA1) or J1, J3, J12, J14 (ANA2) on I/O board.

9. ADD resistor 100Ω 1/4 W 5% (1846-12) R39 (ANA1) or R33 (ANA2) on I/O board.

10. ADD capacitor .002μF (305-439) C7 (ANA1) or C24 (ANA2) on I/O board.

11. SOLDER green wire lead from I/O board A6 (ANA1) or A8 (ANA2) to A18 of center isolation board.

12. CUT off blue lead from I/O board A5 (ANA1) only.

13. SOLDER red wire lead from center isolation board A25 to CPU board A7 (ANA1) or I/O board A7 (ANA2).

14. SOLDER white wire lead from center isolation board A24 to CPU board A8 (ANA1) or I/O board A9 (ANA2).

15. CONNECT the black lead from the CPU board to center board pin A1. CONNECT the black/white lead from the CPU board to center board pin A2. CONNECT the green lead from the CPU board to center board pin A3.

16. ASSEMBLE rear ends of PCB's together using new shorter spacers and hardware supplied in the kit. (see Figure 1-1).

4.3.7 MODIFICATION TO ADD ZERO ADJUSTMENT POT TO 4/20 mA ANALOG OUTPUT

Because of parts tolerences, zero output does not always correspond to 4 mA. In most application, the slight offset difference is not important. However, there are applications where zero output must be exactly at 4 mA. For these cases, a zero pot may be added to either OUT1 or OUT2 4/20 mA analog outputs to provide this feature.

There are several I/O board configurations in the field. Early I/O boards were not provided with mounting for the pot(s). A pot location (R103) was then added for analog OUT1 (1650-415E). Lastly, a second pot location for analog OUT2 was added (R104). One must first determine if the controller to be modified has provisions for installing a pot before proceeding with this modification. NOTE: 1650- 415E does not show the pot (R103) location on the stencil. Use the 3 holes at the forward end of R37 (Q4 end).

Remove the Input/Output (I/O) board from the electronic assembly per instruction in Section 1.10 and make the following changes. (LFE P/N's in brackets.)

	I/O BOARD FOR ANA1	I/O BOARD FOR ANA2
1. REMOVE resistor- 23.7K	R37	R36
2. ADD pot - 25K (1675-285)	R103	R104

4.4 ALARM/TIMER RELAY OPTIONS

Models 2010, 2011 and 2012 have two alarm/timer relays installed at the factory. Models 2013, 2014 and 2015 have ALM1 only factory installed (ALM2 has been removed to allow the terminals to be used for input wiring.) (ALM2 may also be installed in non-slidewire versions of models 2014 and 2015.) All other Series 2000 controllers (except those with remote setpoint input) may have either one (ALM1) or two (ALM1 & ALM2) alarm/timer relay(s) added by the MOD CENTER. Units with remote setpoint input may have only ALM1 added. The relay functions such as alarm or timer, high or low and process or deviation are set in configuration software programming per Section 6.

Remove the Input/Output (I/O) and/or CPU boards from the electronic assembly per instruction in Section 1.10 and make the following changes. (LFE P/N's in brackets.)

	CPU BOARD FOR ALM1 KIT 1821-86	I/O BOARD FOR ALM2 KIT 1821-87
1. REMOVE resistor 390Ω	R21	NONE
2. ADD relay (1819-146)	K1	K1
3. ADD transistor 2N3904 (2036-76)	NONE	Q7
4. ADD opto-isolator MOC8050 (2036-328)	U9	U8
5. ADD diode 1N4148 (2036-276)	CR6	CR4
6. ADD resistor 430Ω 1/4W 5% (1846-431)	R9	R46
7. ADD resistor 750Ω 1/4W 5% (1846-751)	NONE	R47
8. ADD resistor 7.5k 1/4W 5% (1846-752)	NONE	R48

4.5 OTHER OPTIONS

4.5.1 MODIFICATION FOR 220VAC OR 240 VAC SUPPLY

Remove the CPU board from the electronic assembly per instructions in Section 1.10 and make the following changes.

1. CHANGE the power transformer on the CPU board from the 117 VAC unit normally supplied to one listed below:

SUPPLY VOLTAGE	PART NUMBER
220 VAC	2060-275
240 VAC	2060-276

2. MARK the case label with the new supply voltage rating.

4.5.2 MODIFICATION TO ADD REMOTE START/STOP, REMOTE AUTO/MANUAL (MODELS 2002 & 2004) OR REMOTE PAUSE/RESUME (MODEL 2012) OPTION

This option provides for start/stop control of the instrument from a remote location. The start/stop key on the Series 2000 controller remains active. This option is most commonly used for Ramp & Soak Profile control where several controllers must start simultaneously. This modification may be added to Models 2000, 2003, 2005 with STOP/START, 2005 with self tune and STOP/START, 2010, 2012 and 2013.

The parts to add this option are contained in kit 1821-125. This modification may not be added to controllers with digital comminications, input or output isolation, self- powered 4/20 mA input or bridge transducer input options.

Remove the Input/Output (I/O) board from the electronic assembly and the Mother board from the bezel assembly per instruction in Sections 1.8 and 1.10 and make the following changes. (LFE P/N's in brackets.)

1. ADD center board connector P3 (345-764) to Mother board (not needed if unit already has center board connector installed).

2. SOLDER white wire lead (2378-151) on the solder side of the Mother board from center board connector pin P3-9 to keyboard connector pin P4-6.

3. SOLDER green wire lead (2378-127) on the solder side of the Mother board from center board connector pin P3-12 to keyboard connector pin P4- 3. (For Remote Pause/Resume on Model 2012, P3-12 is connected to P4-2.)

4. REASSEMBLE the Mother board into the bezel assembly.

5. SOLDER bridge TP5, TP8 and TP10 on Start/Stop board.

6. DECIDE if this option is to be provided in place of OUT2 or ALM2. The next several steps have alternative procedures depending on which option is selected.

Steps 7 and 8 have alternative parts. Steps 7A and 8A are used if wiring is to the ALM2 terminals. If wiring to OUT2 terminals, use only step 8.

7A. REMOVE relay K1 from I/O board. (This step is to be followed only if the Start/Stop wiring is to use terminals normally used for ALM2 and if ALM2 has been supplied on the board.)

8. SOLDER the stripped ends of the yellow wire assemblies (2379-146) in I/O board holes A4 and A7. (This step is to be followed only if there is no secondary output - OUT2.)

8A. SOLDER the stripped ends of the yellow wire assemblies (2379-146) in I/O board holes A11 and A13. (This step is to be followed only if ALM2 terminals are to be used for the START/STOP wiring.)

9. INSTALL Start/Stop board into center Mother board slot and connect flat ribbon cables between CPU and center board and center board and I/O board.

10. CONNECT the yellow wires from the I/O board to Start/Stop board pins A10 and A11.

11. ASSEMBLE rear ends of PCB's together using new shorter spacers and hardware supplied in the kit. (see Figure 1-1).

12. SHIP a copy of supplementary instruction 956-655 if the wiring is brought out the secondary output terminals (OUT2) or 956-684 if the wiring is brought out the ALM2 terminals.

4.5.3 MODIFICATIONS TO MAKE A MODEL 2014 INTO A MODEL 2015

The Model 2015 is not stocked. To make a Model 2015 from part number J1-1000-1000, proceed as follows:

1. REPLACE EPROM U2 on the CPU board with part number 1685-27.

2. Be sure to proceed to CONFIGURATION programming in Section 7 to change the part number to correspond to Model 2015.

3. REMARK the case label to indicate the change in model.

SECTION 5 - MODIFICATIONS TO ADD COMMUNICATIONS OPTION

The standard communications option may be added to any Series 2000 controller except models 2012 2013 or 2017 (Models 2012, 2013, 2016 and 2017 are supplied with a modified version of the COMM II communications not covered by this manual). Two versions of communication kits are available. The older standard COMM I kits are being updated to COMM II kits but either kit will work in all controllers except those listed above. The communications option also cannot be used with input or output isolation, self-powered 4/20 mA input, bridge transducer input or remote start/stop options as they all occupy the same center board location. An early model 2010 with a 1685- 1 or 1685-2 EPROM may not be upgraded to add communications. Communications kits are listed in Section 2.3.

Remove the Input/Output (I/O) and CPU boards from the electronic assembly and the Mother board from the bezel assembly per instruction in Sections 1.8 and 1.10 and make the following changes. (LFE P/N's in brackets.)

1. ADD center board connector P3 (345-764) to Mother board (not needed if unit already has center board connector installed). Reassemble the Mother board into the bezel assembly.

2. INSTALL the communications cable assembly in the case with the "D" connector positioned so that the side with the fewer number of pins is toward case terminals 1-8. The "D" connector flange shall be on the outside of the case. Use the connector mounting hardware provided with the spacer screw on the outside of the connector.

3. ADD a wire jumper J9 (from A11 to A12) on the CPU board as shown in either Figures 5-1 or 5-2 except on boards labeled 1650-445. Do not add this unnecessary jumper to these new (-445) boards to reduce the potential for shorting at A11.

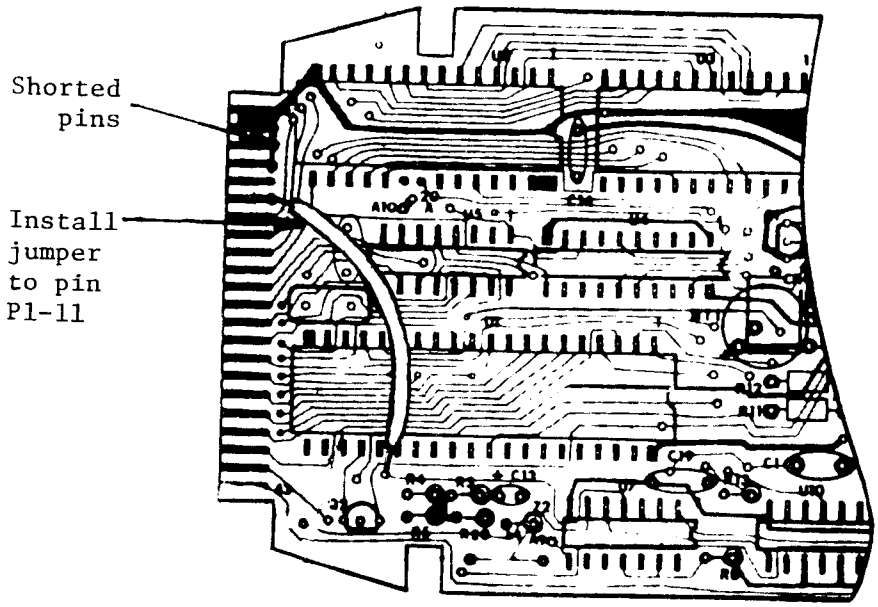


Figure 5-1 (Original CPU board layout - 1650-416)

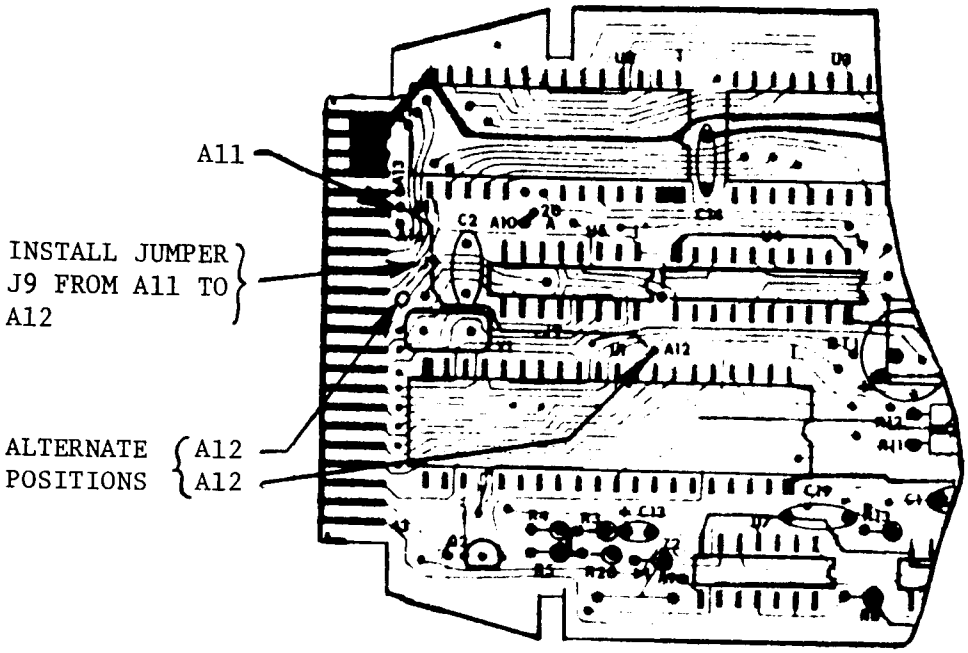


Figure 5-2 (Revised CPU board layout - 1650-431)
(Do not add jumper to boards numbered -445 or higher.)

4. Check the CPU board to ensure that edge card pins P1-3, P1-5 and p1-7 (mother board end) have been shorted to p1-1 on the component side.

5. REINSTALL the CPU board.

6. MOUNT the short spacer with tapped ends to the CPU board using the hardware removed initially.

7. INSTALL the communications PCB in the center position and assemble the long screw with the short through hole spacer to fasten the I/O board and the communications board to the short spacer installed in step 6.

8. CONNECT the flat ribbon cables between the CPU and communications boards and the communications and I/O board.

9. POSITION the communications cable for non-interference and insert the controller into the housing leaving it out about 1-1/2 inches.

10. INSTALL the communications edge card connector to the bottom edge of the center communications PC board and complete the insertion of the controller into the housing.

SECTION 6 - SOFTWARE PROGRAMMING IN THE CONFIGURATION/CALIBRATION LOOP

This section is based on using the standard EPROMs listed below. If any other EPROM is used for special characteristics, these instructions may vary and the factory should be contacted for special instructions.

MODEL	EPROM PART NUMBER
2000	1685-9
2001	1685-9
2002	1685-19
2003	1685-28
2004	1685-29
2005	1685-9 (START/STOP)
2005	1685-19 (AUTO/MANUAL)
2005	1685-28 (SELF TUNE WITH START/STOP
2005	1685-29 (SELF TUNE WITH AUTO/MANUAL)
2010	1685-5
2011	1685-5
2012	1685-22
2013	1685-22
2014	1685-17
2015	1685-27
2017	1685-63

The CONFIGURATION/CALIBRATION LOOP is entered by using a three key security code. While in the OPERATOR LOOP, press PARAM CHECK, TUNE/RETURN and LAST keys simultaneously. (NOTE: Controllers having only six keys require pressing an unmarked key. See Figure 6-1 for key locations.)

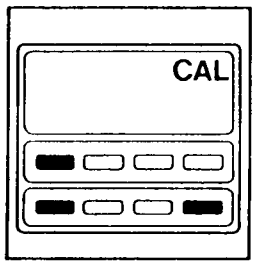


Figure 6-1

A yellow indicator light "CAL" will illuminate indicating that the CONFIGURATION/CALIBRATION LOOP is active. If the indicator light does not illuminate, press the return key and press the three key code again.

While in the CONFIGURATION/CALIBRATION LOOP, all control outputs are off but all alarm outputs function normally.

PN XX XX XX XX XX

The first display that should appear is shown at the left. (Models 2012 and 2013 have a different system. See Section 6.3.) If it does not appear, press the LAST key until it does appear.

This display is the ten digit part number and the first display in the CONFIGURATION/CALIBRATION LOOP. The PARAM CHECK key advances the steps within the loop and the LAST key returns to the previous step.

All controllers have been manufactured with specific hardware that determines its input and output capability. The PART NUMBER defines that capability. Since the software cannot tell if the correct hardware has been installed, it is up to the MOD CENTER to make sure that the hardware modifications match the software configuration code.

Since new data is not stored until the end of the CONFIGURATION/CALIBRATION LOOP, it is necessary to advance to the display "CAL COMPLETE" and RETURN to the OPERATOR LOOP to save any values or software changes that are made while in this loop.

** CAUTION **

DO NOT ALLOW THE AC SUPPLY POWER TO BE DISCONNECTED WHILE A CONTROLLER IS IN THE CONFIGURATION/CALIBRATION LOOP. IF THIS DOES HAPPEN, IT WILL BE NECESSARY TO RESTART AT THE BEGINNING OF THE CONFIGURATION/CALIBRATION LOOP AND PROCEED THROUGH ALL OF THE ENSUING STEPS INCLUDING THE CALIBRATION SUB-LOOP.

6.1 CHANGING THE PART NUMBER

For all models except Models 2012 and 2013, the part number is the configuration code providing the software instructions to match the controller to the application. If the original part number supplied by the factory does not need changing, press the PARAM (CHECK) key to advance to the next display.

An additional security code protects the part number. To access the portion of the program to change the part number, press the two keys indicated in Figure 6-2 simultaneously.

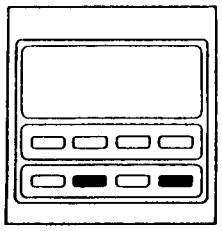


Figure 6-2

A flashing digit will appear at the first digit that may be changed. The digit that is flashing can be changed by using the UP or DOWN ARROW keys. The PARAM (CHECK) key advances the flashing digit(s) and the LAST key backs up to the previous digit(s). Be careful not to enter illegal part numbers. After the part number is correct, move to the last character of the part number and press the PARAM (CHECK) key to advance to the next display.

6.2 PART NUMBER RULES

All valid part numbers for models 2000, 2001, 2002, 2003, 2004, 2005, 2010 and 2011 are listed in Section 1.6.1. Part numbers for Models 2014 and 2015 are listed in Section 1.6.3. Part numbers for model 2017 are in Section 1.6.4. The following general rules are to be used to apply these numbers to cover the standard and optional features of Series 2000 controllers.

1. Any change in the second digit from the standard part number for Mod Controllers always requires a hardware change.

2. Primary or secondary solid state relays and related outputs may all be configured for heat or cool and on/off or time proportioning functions by part number changes only. The proper hardware must be installed on the I/O or CPU boards. (Secondary outputs are not available on Models 2014 and 2015.)

3. Primary or secondary analog outputs may be configured for either heating or cooling action using the part number only. The analog output hardware must be installed on the I/O board. (Analog outputs are not available on Models 2014 and 2015.)

4. Analog retransmitting output must be installed as ANA2 and no secondary output can be provided. (Exception: Models 2012, 2013, 2014, 2015 and 2017.)

5. Changes in thermocouple type requires only a part number change. Conversion to RTD or process inputs also require hardware changes.

6. Analog voltage outputs other than the standard 0-5 V are part numbered the same as for the 0-5V.

7. Analog current outputs other than the standard 4/20 mA are part numbered the same as for 4/20 mA.

8. Outputs with 50 mA SSR are coded the same as for a standard 1A SSR.

9. DC trigger outputs are coded the same as for 1A SSR outputs.

10. Open collector outputs are coded the same as for 1A SSR outputs.

11. Isolated 4/20 mA output is coded the same as for a standard 4/20 mA output.

12. All alarm/timer configurations (if installed) are through part number changes only.

13. Changes in Model 2017 Relay 1 (ALM1) and Relay 3 (OUT1) between OFF EVENT and ON EVENT or ALARM to ON or OFF EVENT usually also requires a hardware change. (Consult the factory.)

Please note that any changes in part number made in the CONFIGURATION/CALIBRATION LOOP must also be transfered to the label on the Mother board. Changes in input and output type must also be indicated on the case label.

6.3 CONFIGURATION NUMBER - MODELS 2012 AND 2013

Entry into the CONFIGURATION/CALIBRATION LOOP is as described at the beginning of Section 6. For Models 2012 and 2013, the part number is not the same as the configuration number used in the CONFIGURATION/CALIBRATION LOOP. The part number coding is specified in Section 1.6.2.

1 23 455
66 77 89

The first display that should appear for Models 2012 and 2013 is shown at the left. If it does not appear, press the LAST key until it does appear.

This display is the configuration number and the first display in the CONFIGURATION/CALIBRATION LOOP. The PARAM CHECK key advances the steps within the loop and the LAST key returns to the previous step. The same security code for access to the configuration change procedure is used as described in Section 6.1 for part number changing. All of the part number rules described in Section 6.2 apply to the CONFIGURATION number.

1 - MODEL NUMBER AND PROFILES

MODEL 2012	MODEL 2013	DESCRIPTION
0	4	2 PROFILES - 99 SEGMENTS EACH
1	5	4 PROFILES - 64 SEGMENTS EACH
2	6	8 PROFILES - 32 SEGMENTS EACH
3	7	16 PROFILES - 16 SEGMENTS EACH

1 23 455
66 77 89

2 - INPUT 1 CODE

0	J THERMOCOUPLE
1	K THERMOCOUPLE
2	R THERMOCOUPLE
3	S THERMOCOUPLE
4	T THERMOCOUPLE
5	N THERMOCOUPLE
6	E THERMOCOUPLE
7	B THERMOCOUPLE
8	PLATINEL II THERMOCOUPLE
9	Ni/Ni18%Mo THERMOCOUPLE
A	W5%Re/W26%Re THERMOCOUPLE
B	W3%Re/W25%Re THERMOCOUPLE
C	W/W26%Re THERMOCOUPLE

K	100Ω PT RTD - 1 DEGREE RESOLUTION
L	100Ω PT RTD - 0.1 DEGREE RESOLUTION
R	PROCESS INPUT

NOTE: EARLIER CONTROLLERS MAY NOT HAVE THERMOCOUPLE TYPES 9, A, B OR C.

3 - INPUT 2 CODE

Same code as for INPUT 1 except that this character is always "Z" for Model 2012.

6.3 CONFIGURATION NUMBER - MODELS 2012 AND 2013 (CONTINUED)

1 23 455
66 77 89

4 - FIRST OUTPUT (OUT1)

(LOOP 1)	
0	NO OUTPUT
1	HEAT SSR ON/OFF
2	COOL SSR ON/OFF
3	HEAT SSR TPR
4	COOL SSR TPR
5	HEAT ANALOG
6	COOL ANALOG

55 - SECOND OUTPUT (OUT2)

(LOOP 1)		(LOOP 2)	
00	NO OUTPUT 2	21	PRIMARY HEAT SSR ON/OFF
11	SECONDARY HEAT SSR ON/OFF	22	PRIMARY COOL SSR ON/OFF
12	SECONDARY COOL SSR ON/OFF	23	PRIMARY HEAT SSR TPR
14	SECONDARY COOL SSR TPR	24	PRIMARY COOL SSR TPR
16	SECONDARY COOL ANALOG	25	PRIMARY HEAT ANALOG
17	EVENT RELAY	26	PRIMARY COOL ANALOG
18	RETRANSMITTING PROCESS VARIABLE	27	EVENT RELAY
19	RETRANSMITTING SET POINT	28	RETRANSMITTING PROCESS VARIABLE
		29	RETRANSMITTING SET POINT

66 - ALARM RELAY 1

00	NO ALARM/EVENT RELAY
01	LATCHING POWER FAILURE

(LOOP 1 - NON LATCHING)		(LOOP 2 NON LATCHING)	
11	HIGH PROCESS	21	HIGH PROCESS
12	LOW PROCESS	22	LOW PROCESS
13	HIGH DEVIATION	23	HIGH DEVIATION
14	LOW DEVIATION	24	LOW DEVIATION
15	DEVIATION BAND	25	DEVIATION BAND
17	EVENT RELAY	27	EVENT RELAY
18	HEAT AUX. OUTPUT	28	HEAT AUX. OUTPUT
19	COOL AUX. OUTPUT	29	COOL AUX. OUTPUT

(LOOP 1 - LATCHING)		(LOOP 2 -LATCHING)	
31	HIGH PROCESS	41	HIGH PROCESS
32	LOW PROCESS	42	LOW PROCESS
33	HIGH DEVIATION	43	HIGH DEVIATION
34	LOW DEVIATION	44	LOW DEVIATION
35	DEVIATION BAND	45	DEVIATION BAND

6.3 CONFIGURATION NUMBER - MODELS 2012 AND 2013 (CONTINUED)

7 - ALARM/EVENT RELAY 2

1 23 455
66 77 89

00	NO ALARM/EVENT RELAY
01	ERROR ALARM-NON LATCHING

(LOOP 1 - NON LATCHING)		(LOOP 1 - LATCHING)	
11	HIGH PROCESS	31	HIGH PROCESS
12	LOW PROCESS	32	LOW PROCESS
13	HIGH DEVIATION	33	HIGH DEVIATION
14	LOW DEVIATION	34	LOW DEVIATION
15	DEVIATION BAND	35	DEVIATION BAND
17	EVENT RELAY		
18	HEAT AUX. OUTPUT		
19	COOL AUX. OUTPUT		

8 & 9 - REVISION AND SPECIAL OPTIONS CODE

ASSIGNED BY THE FACTORY - DO NOT CHANGE

6.4 SETTING THE LEGEND AND TIME BASE (ALL MODELS EXCEPT MODELS 2012 AND 2013)

UNITS UU TIME X:X

For all models except 2012 and 2013, the legend UNITS and the TIME base are combined in one display which is shown at the left. Refer to Sections 6.6 and 6.5 for a detailed discussion of the setting parameters. Press the PARAM key to advance to the next display.

6.5 SETTING THE TIME BASE - MODELS 2012 & 2013 ONLY

The time base in 2012 and 2013 controllers is used for the timing of ramp and soak profiles. For all other Models in the 2000 series, the time base is also used to set the clock for (timed) event relays. (See Section 6.6.)

TIME X:X

One can select the time base in HOURS:MINUTES (H:M) or MINUTES:SECONDS (M:S). Press the NO key to change the selection. When the time base is correct, press the PARAM (CHECK) key to advance to the next display.

6.6 SETTING THE DISPLAY LEGEND - MODELS 2012 & 2013 ONLY

The controller will accept any combination of two alphanumeric characters (Model 2017 accepts up to three characters) for the display legend. The only limitation on these characters is that for temperature input ranges (thermocouple or RTD) the legend F or C must be the character on the right.

UNITS UU

The best way to see how the legend units are set is to press the arrow key while watching the display. All numbers and letters are available in both positions. UNITS legend setting starts with the left hand digit. Press the PARAM (CHECK) key to move to the right hand digit. The LAST key will back up right to left if needed. The DOWN key will scroll the digit in reverse to the UP key. A blank is available in the sequence for single character legends or blank legends. After the legend UNITS are correct, press the PARAM (CHECK) key to advance to the next display.

NOTE: Changing units between F and C does not convert the numerical value of any set points, alarms or span limits. Each setpoint, alarm or span limit must be individually changed to correspond to the new units of measurement. When no units are specified, the controller uses the degrees C linearization table for thermocouple or RTD inputs. To display temperature in Fahrenheit degrees, the legend must contain an "F" in the right character.

6.7 SETTING THE PV FILTER (MODELS 2014 & 2015 ONLY)

A digital filter is included in the controller software to reduce the affects of external noise. This will average between one and ten readings of the Process Variable input. It is factory set at ten readings for maximum filtering but the slowest response. For the models 2014 and 2015 only, this filtering may be reduced by changing the number of readings with the arrow keys.

PV FILTERXX

If PV FILTER is set to 1, no digital filtering is done and the response is the quickest. The response speed of this controller with maximum filtering (10) will usually be much faster than the system response. A setting of 10 is recommended unless extraordinary circumstances exist. Press the PARAM (CHECK) key to advance to the next display.

6.8 SETTING THE SLIDEWIRE FILTER (MODELS 2014 & 2015 ONLY)

A slidewire filter is included in the controller to reduce electrical noise influence or instability in the slidewire feedback circuit. This filter will average ten readings for maximum filtering but the slowest response to changes in the slide wire position. For the models 2014 and 2015 only, this filtering may be reduced by changing the number of readings with the ARROW keys.

SLIDEWIR
FILTERXX

If SLIDEWIRE FILTER is set to 1, no filtering is done and the slidewire response is the quickest. The response speed of this controller with maximum filtering (10) will usually be much faster than the drive unit (motor operator) speed. A setting of 10 is recommended unless extraordinary circumstances exist. Press the PARAM (CHECK) key to advance to the next display.

6.9 SETTING THE SPAN

LO SPAN
XXXX UU

The next two displays are the LO SPAN and the HI SPAN. These values set the effective range of the controller and are used internally for calculations of parameters such as PR Band. The controller automatically limits all set points and alarms so that they must be contained within the SPAN.

HI SPAN
XXXX UU

The controller stores in permanent memory the maximum values for the LO and HI SPAN limits for thermocouple and RTD ranges. These default values (refer to Section 1.7 Specifications for a listing of the default values) will appear and may be changed per the customer application requirements. Any values within the default limits may be selected by using the UP or DOWN ARROW keys.

For controllers with thermocouple or RTD ranges, this step completes the CONFIGURATION programming. If recalibration is not required, press the PARAM (CHECK) key to advance to the display shown at the left. The new values will then be stored when the RETURN key is pressed which also exits the CONFIGURATION/CALIBRATION LOOP and returns the display to the OPERATOR LOOP. Mark the selected SPAN limits on the part number label located on the Mother board. If recalibration is required, do not press the PARAM (CHECK) key and proceed to Section 6.12.

CAL
COMPLETE

Controllers with process type inputs may have the LO and HI SPAN limits set to any value between -3200 and +3200 counts. Press the PARAM (CHECK) key to advance to the next display.

** SPECIAL NOTES **

Controllers with thermocouple and RTD input ranges that have had the RAM (U3 on the CPU board) or EPROM (U2 on the CPU board) replaced may not recognize the PARAM (CHECK) key press because they must first be recalibrated. If this occurs, proceed to Section 6.12.

Several tuning parameters are affected by span changes. Both the proportional and on/off dead bands as well as the alarm relay dead bands are computed as a percentage of span. Special attention should be made to these values when selecting the span.

Changing the LO and HI SPAN limits do not automatically change the numerical values of any setpoint or alarms that were previously already set outside of the new SPAN limits. Each setpoint or alarm must be individually reset to be within the new SPAN limits. Once they are set within the new SPAN limits, they cannot be reset outside of the limits.

6.10 SETTING THE DECIMAL POINT (PROCESS RANGES AND MODEL 2017 ONLY)

DECIMAL PLACES X

This display allows the selection of the decimal point position from 0 (no decimal point) to 3 (the third place from the right, ie, 1.732). Use the UP or DOWN ARROW keys to select the decimal point position. When the decimal position is correct, press the PARAM (CHECK) key to advance to the next display.

6.11 SETTING THE DISPLAY RANGE (PROCESS RANGES AND MODEL 2017 ONLY)

LO VAL XXXX UU

The next two displays are the LO VAL and the HI VAL. These values establish the points for which calibration data will be entered in later steps.

HI VAL XXXX UU

Controllers with process type inputs may have the LO and HI VAL limits set to any value between - 3200 and +3200 counts. The maximum difference between the HI and LOW VAL cannot exceed a total of 3200 counts. The controller will interpolate the display of intermediate values between the HI and LO VAL on a linear basis. Both direct and reverse (positive and negative slopes) spans are allowable for process ranges.

The LO VAL equates to the electrical input value used for LO CAL in the CALIBRATION SUB-LOOP. The HI VAL equates to the electrical input value used for HI CAL in the CALIBRATION SUB-LOOP. The HI and LO VAL values may be changed for display ranging without entering the CALIBRATION SUB-LOOP provided the original calibration values do not have to be changed. For example, a controller previously ranged with a 4/20 mA input calibration and a display range of 0-1000, may be reranged for a new display of 0-2500 for the same 4/20 mA input range without recalibration.

Use the UP and DOWN ARROW keys to change range values. Advance from the LO to HI VAL display using the PARAM (CHECK) key. The LAST key will back up from HI to LO VAL.

CAL COMPLETE

For controllers with process input ranges, this step completes the CONFIGURATION programming. If recalibration is not required, press the PARAM (CHECK) key to advance to the display shown at the left. The new values will then be stored when pressing the RETURN key which exits the CONFIGURATION/CALIBRATION LOOP and returns the display to the OPERATOR LOOP. If recalibration is required, do not press the PARAM (CHECK) key and proceed to Section 6.12.

** SPECIAL NOTE **

Controllers with process input ranges that have had the RAM (U3 on the CPU board) or EPROM (U2 on the CPU board) replaced may not recognize the PARAM (CHECK) key press because they must first be recalibrated. If this occurs, proceed to Section 6.12.

6.12 INPUT CALIBRATION SUB-LOOP

** CAUTION **

ENTRY INTO THE INPUT CALIBRATION SUB-LOOP WITHOUT PROPER CALIBRATION EQUIPMENT AVAILABLE WILL DESTROY THE FACTORY CALIBRATION AND WILL RENDER THE INSTRUMENT UNUSABLE. DO NOT ENTER THE INPUT CALIBRATION SUB-LOOP IF RECALIBRATION IS NOT REQUIRED. IF RECALIBRATION IS NOT NEEDED, PRESS THE RETURN KEY IMMEDIATELY. ONCE THIS SUB-LOOP HAS BEEN ENTERED, IT IS NOT POSSIBLE TO EXIT WITHOUT COMPLETING THE ENTIRE SUB-LOOP.

Input calibration is required if----

1. Any hardware changes have been made to convert from the standard factory supplied thermocouple input.

2. Any components such as the battery, EPROM or RAM have been replaced while repairing the controller.

3. When the display flashes DATA LOST/PLEASE CAL.

The CALIBRATION SUB-LOOP refers to the procedure for calibrating the controller using an external precision calibration source. Before starting this calibration, one should see one of these two displays:

HI SPAN XXXX UU	or	HI VAL XXXX UU

A security access code protects the CALIBRATION SUB-LOOP procedures. To enter the CALIBRATION SUB-LOOP, press the two keys indicated in Figure 6-3 simultaneously.

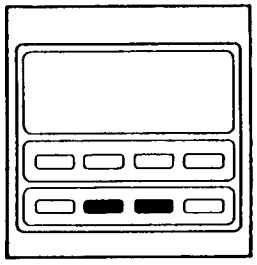


Figure 6-3

NOTE:

ALLOW AT LEAST A 20 MINUTE WARMUP PERIOD BEFORE ATTEMPTING CALIBRATION.

There are three separate stored calibration routines that depend on the controller input type. The controller will automatically call the appropriate instruction routine as selected by the input CONFIGURATION programming. The three routines are as follows:

6.12.1 Thermocouple input calibration
6.12.2 RTD input calibration
6.12.3 Process input calibration
6.12.5 Output Calibration - Model 2017 Only

6.12.1 THERMOCOUPLE INPUT CALIBRATION

** NOTES **

All thermocouple input controllers must be calibrated with a type J thermocouple even though the part number or configuration number selected in Section 6.1 or 6.3 may specify a different thermocouple type.

For older controllers, a cold junction compensator resistor assembly is provided at the rear terminals of each thermocouple input controller. (Two compensator resistors are supplied on Model 2013 with dual thermocouple input.) These calibration steps must be performed with the specific compensator resistor(s) to be used in the final installation. This resistor(s) must be transfered with the electronic assembly if the controller is installed in another case. For newer controllers, the compensator resistor(s) is mounted internally on the I/O board and will automatically be transfered with the electronic assembly.

All thermocouple input controllers are calibrated in the same manner. A precision 50.000 mVDC calibration source and a type J thermocouple in an ice bath or a type J ice bath simulator are required.

INPUT 50.000MV

The display at the left is the first to appear in the calibration sub-loop. It indicates that a precision, distortion-free 50.000 mVDC calibration source must be connected to rear case terminals F(-) and H(+). Allow a 2 minute interval for the controller to stabilize after applying the 50.000 mV signal and then press the PARAM (CHECK) key to advance to the next display.

This display appears next in the calibration sub-loop. Without removing the AC supply power, remove the connections to the calibrator in the previous step and connect the input to a type J thermocouple in an ice bath or its equivalent. Allow a 2 minute interval for the controller to stabilize after connecting the type J thermocouple and then press the PARAM (CHECK) key to advance to the next display. Proceed to Section 6.12.4.

J T/C IN ICE BATH

6.12.2 RTD INPUT CALIBRATION

All RTD input controllers are calibrated using a precision decade resistance box. Connect as shown in Figure 6-4. Be sure to use short low resistance leads and good tight connections. Three wire connections are required to minimize lead resistance errors. All three wires must be the same gauge and length.

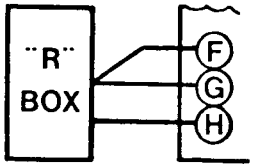


Figure 6-4

INPUT 100 OHMS

The display at the left is the first to appear in the calibration sub-loop. Connect the precision resistance box and set it for 100.00 ±0.05Ω. Allow a 2 minute interval for the controller to stabilize and then press the PARAM (CHECK) key to advance to the next display.

INPUT 300 OHMS

This display appears next in the calibration sub-loop. Reset the precision resistance box for 300.00 ±0.05Ω. (Some earlier controllers with 0.1 degree resolution, require 200Ω instead of 300Ω. Use this value if the display requires it.) Allow 2 minutes for the controller to stabilize and then press the PARAM (CHECK) key to advance to the next display. Proceed to Section 6.12.4.

6.12.3 PROCESS INPUT CALIBRATION

An appropriate precision current or voltage calibration source is required for process input calibration.

INPUT LO CAL

The display at the left is the first to appear in the calibration sub-loop. Connect a precision calibrator to rear case terminals H(+) and F(-). Set the calibrator to the LO calibration value corresponding tothe LO VAL display selected in Section 6.11. Allow a 2 minute interval for the controller to stabilize and then press the PARAM (CHECK) key to advance to the next display.

INPUT HI CAL

This display appears next in the calibration sub-loop. Reset the precision calibrator to the HI calibration value corresponding to the HI VAL display selected in Section 6.11. Allow a 2 minute interval for the controller to stabilize and then press the PARAM (CHECK) key to advance to the next display. Proceed to Section 6.12.4.

6.12.4 REMOTE SETPOINT INPUT CALIBRATION

The remote setpoint input option may be installed on any controller except Models 2012,2013,2014,2015 and 2017. Remote setpoint input is standard on Model 2005. If this option is not installed, proceed directly to Section 6.12.6

An appropriate precision current or voltage calibration source is required for remote setpoint input calibration unless the internal supply is used to power the remote setpoint pot. Connect the remote setpoint circuit as shown in Figure 6-5, 6-6 or 6-7 as appropriate.

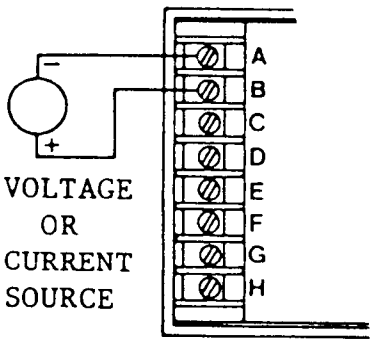


Figure 6-5
External Source

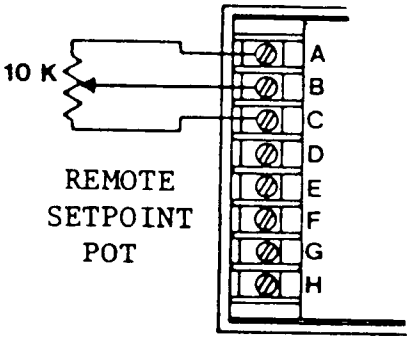


Figure 6-6
Remote Pot

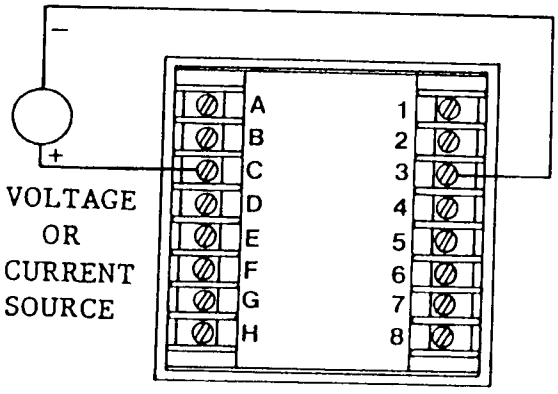


Figure 6-7
Model 2005

INPUT LO REMSP

The display at the left is the first to appear for remote setpoint calibration. Set the precision calibrator to the low value that will equate to the low end of the SPAN or adjust the remote setpoint pot to the position that equates to the low end of the SPAN. Allow a 2 minuteinterval for the controller to stabilize and then press the PARAM (CHECK) key to advance to the next display.

INPUT HI REMSP

This display appears next for INPUTremote setpoint calibration. Reset the precision calibrator to the high value that equates to the high end of the SPAN or adjust the remote setpoint pot to the position that equates to the high end of the SPAN. Allow a 2 minute interval for the controller to stabilize and then press the PARAM (CHECK) key to advance to the next display. Proceed to Section 6.12.6.

6.12.5 OUTPUT CALIBRATION (MODEL 2017 ONLY)

For programmers with an analog current output, connect a suitable precision current meter in series in the output current loop. Make sure that the current loop resistance including the meter is less than 750Ω. For instruments with analog voltage output, connect a suitable precision voltmeter across the output terminals.

SET OUT LO XXXX

Use the arrow keys to adjust the output to the desired reading on the voltage or current meter. This value will correspond to the LO SPAN value of the display range. (The numbers on the lower right side of the display are for reference only; they do not relate to any absolute output level.) When the desired output level is obtained, press the PARAM CHECK key to proceed to the next step.

SET OUT HI XXXX

The HI OUTPUT calibration is performed in the same manner as the previous step. Use the arrow keys. This output value will correspond to the HI SPAN of the display range. When the desired output level is obtained, press the PARAM CHECK key to proceed to the next step.

6.12.6 CALIBRATION COMPLETE

CAL COMPLETE

This is the final display in the CALIBRATION SUB-LOOP. In order to enter and store the calibration data, one MUST press the the RETURN key. All the CONFIGURATION changes and CALIBRATION are not valid until this step is completed. After pressing the RETURN key, the CAL indicator goes out and the controller is returned to the OPERATOR LOOP.

If the controller has had hardware modifications, it is recommended that the completed controller be tested per Section 7 to confirm that the controller performs to specification.

SECTION 7 - ADJUSTMENT AND TEST

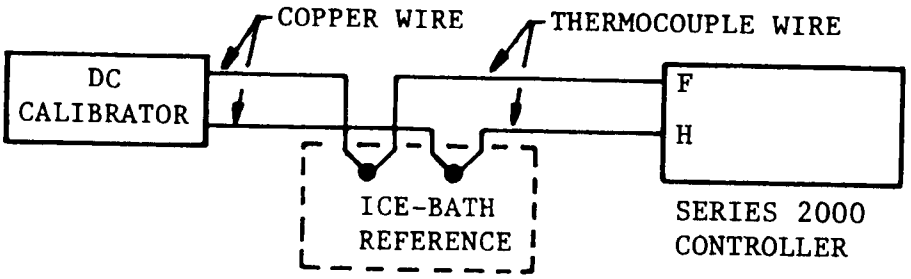
7.1 INPUT TEST

7.1.1 THERMOCOUPLE INPUT

7.1.1.1 TEST EQUIPMENT

DC MILLIVOLT CALIBRATOR - A stable distortion free calibrator with a minimum of 10 microvolt resolution accurate to ±0.01%, and with an output impedance of less than 100Ω.

Verification calibration must be performed using a suitable thermocouple simulator whose output is referenced to 0°C (32°F). An ice-bath reference may be established using special copper vs thermocouple wire assemblies and a thermos containing distilled water and crushed ice as indicated in the sketch below. The ice/water solution must be circulated continuously.



7.1.1.2 INPUT CALIBRATION CHECK

1. Connect a calibrator and an ice-bath reference to the controller as shown in Section 7.1.1.1.

2. Using a standard thermocouple table such as NBS Monograph 125, apply the millivolt equivalent for a particular temperature within the controller's span using the calibrator.

3. The controller display should indicate the selected temperature within its rated tolerance after 2 minutes.

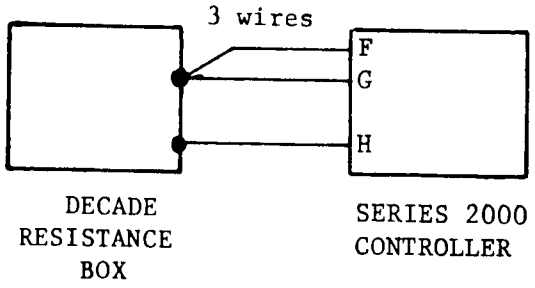
4. Repeat for other temperatures within the controller span.

7.1.2 RTD INPUT

7.1.2.1 TEST EQUIPMENT

Precision decade resistance box with a resolution and accuracy suitable for the resistance range required (0.01Ω).

High impedance digital voltmeter for voltage measurements. Connect the decade resistance box using short low resistance leads and good tight connections. Three wire connections to decade resistance box are required to minimize lead resistance errors. All wires must be the same gauge and length. Do not use clip leads.



7.1.2.2 INPUT CALIBRATION CHECK

1. Connect a decade resistance box as shown in Section 7.1.2.1.
2. Using a table of resistance vs temperature for a 100Ω platinum 3850 ppm RTD element, set the decade resistance box for a value corresponding to a temperature within the controller span.
3. The controller display should indicate the selected temperature within its rated tolerance after 2 minutes.
4. Repeat for other temperatures within the controller span.

7.1.3 PROCESS INPUTS

7.1.3.1 TEST EQUIPMENT

DC VOLTAGE/CURRENT SOURCE - A suitable distortion free calibrator with a minimum of 10 microvolt voltage resolution accurate to ±0.01% and a suitable output impedance.

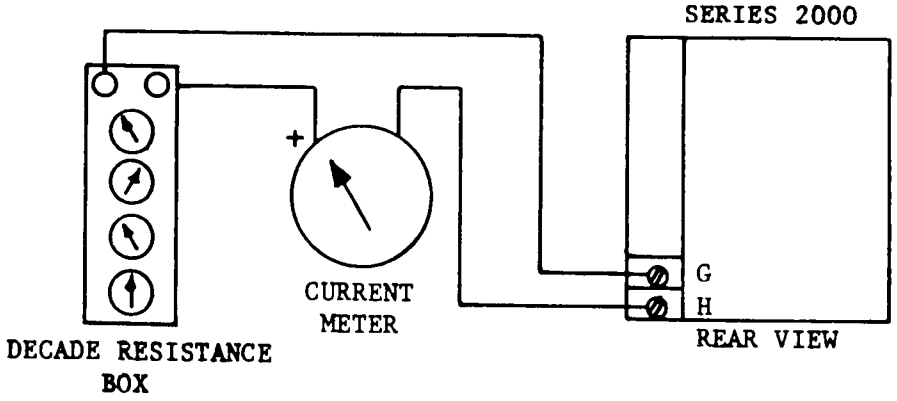
7.1.3.2 INPUT CALIBRATION CHECK

1. Connect a calibrator as described in Section 7.1.3.1 to terminals F(+) and H(-).
2. Set the calibrator for an input value within the controller's input span.
3. The controller display should indicate the required value within the controller's rated tolerance after 2 minutes. NOTE: The display may vary from the input value for process ranges.
4. Repeat for other values of input within the controller span.

7.1.4 SELF-POWERED 4/20 mA INPUT

7.1.4.1 TEST EQUIPMENT

Connect a decade resistance box and a current measuring instrument as shown below:



7.1.4.2 INPUT CALIBRATION CHECK

1. Connect the controller as shown in Section 7.1.4.1.
2. With the decade resistance box set as approximately 11k, the current meter should indicate 4 mA and the controller display should indicate the LO VAL.
3. With the decade resistance box set at approximately 1650Ω, the current meter should indicate 20 mA and the controller should display the HI VAL.
4. Using decade resistance box setting between steps 2 and 3, other intermediate values may be checked.

7.1.5 BRIDGE TRANSDUCER INPUT

There is no special test for this input as it is covered by Section 7.1.3. The bridge supply is brought out to terminals D(+) and E(-) and may be checked to assure correct modification.

7.1.6 REMOTE SETPOINT INPUT

1. Connect a current/voltage calibrator (as required) to terminals B(+) and B(-).
2. Set the calibrator for the low setpoint input value.
3. The controller setpoint display should be the LOW VAL.
4. Set the calibrator for the high setpoint input value.
5. The controller setpoint display should be the HI VAL.
6. Set the calibrator for other intermediate setpoint input value and the controller setpoint display should indicated proportional values between the HI and LO VAL.

7.2 OUTPUT ADJUSTMENT AND TEST

** NOTE **

FOR MODELS 2012 AND 2013, MANUAL CONTROL USED IN THE PROCEDURES BELOW FOR CONTROLLERS WITH AUTO/MANUAL CONTROL IS ACCESSIBLE BY ANSWERING YES TO THE "MANUAL 1 CONTROL ?" OR "MANUAL 2 CONTROL ?" DISPLAYS FROM THE TUNE LOOP.

7.2.1 4-20 mA ANALOG OUTPUT 1 AND ANALOG OUTPUT 2 ADJUSTMENT

7.2.1.1 CONTROLLERS WITH AUTO/MANUAL FEATURE

1. Install the electronics assembly into a CALIBRATION CONNECTOR (LFE P/N 345-826). This connector provides access to the analog circuit potentiometers R100 and R101 located on the top edge of the I/O board while the controller is energized.

2. Connect a 1000Ω 1/2W 1% resistor across output terminals 4 and 5 for ANALOG OUTPUT 1 and/or another 1000Ω resistor across terminals D and E for ANALOG OUTPUT 2. Then connect a digital voltmeter across OUTPUT 1 or OUTPUT 2 rear terminals. Allow a 5 minute warmup before proceding with the next step.

3. Advance the display in the OPERATOR LOOP until OUT 1 X% or OUT 2 X% is displayed. If MAN indicator is flashing, press START/STOP key and then press AUTO/MANUAL key until the MAN indicator is illuminated continuously.

4. Reduce the OUTPUT to 0% with the DOWN ARROW key. The digital voltage indication should be approximately +1 to +4 VDC. (If the zero adjustment pot option has been installed per Section 4.3.7, adjust pot R103 or R104 as appropriate for 4 VDC.

5. Press the UP ARROW key until the OUTPUT 1 or 2 indicates 100%.

6. Adjust potentiometer R101 for ANALOG OUTPUT 1 or R100 for ANALOG OUTPUT 2 for a digital voltage indication of +21 ±0.2 VDC.

7. Repeat the above adjustment procedure for the second 4-20 mA DC Analog Output as required.

8. Check the performance by varying the percent (%) OUTPUT POWER and noting that ANALOG OUT digital voltage indication varies accordingly.

9. Following calibration remove the controller from the calibration connector and reinstall into its controller case. (NOTE: Make sure that the electronic assembly is mated with the same compensation resistor that was used for calibration. Otherwise, the controller must be recalibrated per Section 6.12.)

7.2.1.2 MODELS WITHOUT AUTO/MANUAL FEATURE

1. Install the electronics assembly into a CALIBRATION CONNECTOR (LFE P/N 345-826). This connector provides access to the analog circuit potentiometers R100 and R101 located on the top edge of the I/O board while the controller is energized.

2. Connect a 1000Ω 1/4W 1% resistor across output terminals 4 and 5 for ANALOG OUTPUT 1 and/or another 1000Ω resistor across terminals D and E for ANALOG OUTPUT 2. Then connect a digital voltmeter across OUTPUT 1 or OUTPUT 2 rear terminals. Allow a 5 minute warmup before proceding with the next step.

3. Connect a suitable calibration source to the input terminals and adjust the input so that the display reads about half span, i.e., halfway between LO SPAN and HI SPAN.

4. Enter the TUNE LOOP and push the PARAM DISPLAY button several times until the display reads TUNE? OUTPUTS. Answer YES to the question.

5. Following the TUNE LOOP flow chart, set the PR BAND 1 to 25%, RESET 1 to 0.00 R/M (off) and RATE 1 to 0.00 (off).

6. If OUTPUT 2 is also being adjusted, set AUXSP to 0 and repeat Step 5 for OUTPUT 2.

7. Press RETURN to return to the OPERATOR LOOP.

8. Advance the DISPLAY to show the setpoint on the bottom line. Using the UP and DOWN ARROWS, adjust the setpoint to the same value as the process variable shown on the top line. Press the PARAM/DISPLAY key until the bottom line shows OUT1 XXX%.

9. If the MAN indicator is blinking, press the START/STOP button to turn the indicator off.

10. Adjust the calibration source until the display shows OUT1 0% or OUT2 0%. The digital voltage indication should be approximately +1 to +4 VDC. (If the zero adjustment pot option has been installed per Section 4.3.7, adjust pot R103 or R104 as appropriate for 4 VDC.

11. Adjust the calibration source until the display shows OUT1 100% OR OUT2 100%.

12. Adjust potentiometer R101 for ANALOG OUTPUT 1 or R100 for ANALOG OUTPUT 2 for a digital voltage indication of +21 ±0.2 VDC.

13. Repeat steps 10 through 12 for the second 4/20 mA DC Analog Output as required.

14. Check the performance by varying the input to change the percent (%) OUTPUT POWER and noting that ANALOG OUT digital voltage indication varies accordingly.

15. Following calibration remove the controller from the calibration connector and reinstall into its controller case. (NOTE: Make sure that the electronic assembly is mated with the same compensation resistor that was used for calibration. Otherwise, the controller must be recalibrated per Section 6.12.)

7.2.2 0/5 VDC ANALOG OUTPUT1 AND ANALOG OUTPUT 2 ADJUSTMENT

7.2.2.1 CONTROLLERS WITH AUTO/MANUAL FEATURE

1. Install the electronics assembly into a CALIBRATION CONNECTOR (LFE P/N 345-826). This connector provides access to the analog circuit potentiometers R100 and R101 located on the top edge of the I/O board while the controller is energized.

2. Most analog loads are high impedance. It is therefore normal to calibrate the output without a load. When it is known that the load will be lower, that specific load resistance (minimum 1000Ω) should connected across output terminals 4 and 5 for ANALOG OUTPUT 1 and/or across terminals D and E for ANALOG OUTPUT 2. Then connect a digital voltmeter across OUTPUT 1 or OUTPUT 2 rear terminals. Allow a 5 minute warmup before proceding with the next step.

3. Advance the display in the OPERATOR LOOP until OUT 1 X% or OUT 2 X% is displayed. If MAN indicator is flashing, press START/STOP key and then press AUTO/MANUAL key until the MAN indicator lamp is illuminated.

4. Press the UP ARROW key until the OUTPUT 1 or 2 indicates 100%.

5. Adjust potentiometer R101 for ANALOG OUTPUT 1 or R100 for ANALOG OUTPUT 2 for a digital voltage indication of +5 ±0.1 VDC.

6. Then reduce the OUTPUT to 0% with the DOWN ARROW key. The digital voltage indication should change correspondingly.

7. Repeat steps 4 through 6 for the second 0-5 VDC Analog Output as required.

9. Following calibration remove the controller from the calibration connector and reinstall into its controller case. (NOTE: For older controllers, make sure that the electronic assembly is mated with the same compensation resistor that was used for input calibration. Otherwise, the controller must be recalibrated per Section 6.12.)

7.2.2.2 MODELS WITHOUT AUTO/MANUAL FEATURE

1. Install the electronics assembly into a CALIBRATION CONNECTOR (LFE P/N 345-826). This connector provides access to the analog circuit potentiometers R100 and R101 located on the top edge of the I/O board.while the controller is energized.

2. Most analog loads are high impedance. It is therefore normal to calibrate the output without a load. When it is known that the load will be lower, that specific load resistance (minimum 1000Ω) should connected across output terminals 4 and 5 for ANALOG OUTPUT 1 and/or across terminals D and E for ANALOG OUTPUT 2. Then connect a digital voltmeter across OUTPUT 1 or OUTPUT 2 rear terminals. Allow a 5 minute warmup before proceding with the next step.

3. Connect a suitable calibration source to the input terminals and adjust the input so that the display reads about half span, i.e., halfway between the LO SPAN and HI SPAN.

4. Enter the TUNE LOOP and press the DISPLAY key several times until the display reads TUNE? OUTPUTS. Answer YES to this question.

5. Following the TUNE LOOP flow chart, set the PR BAND 1 to 25%, RESET 1 to 0.00 R/M (off) and RATE 1 to 0.00 (off).

6. If OUTPUT 2 is also being adjusted, set AUXSP to 0 and repeat step 5 for OUTPUT 2.

7. Press RETURN to return to the OPERATOR LOOP.

8. Advance the display to show the setpoint on the bottom line. Using the UP and DOWN arrows, adjust the setpoint to the same value as the process variable shown on the top line. Press the DISPLAY key until the bottom line shows OUT1 XXX% or OUT2 XXX%.

9. If the MAN indicator is blinking press the START/STOP key to turn the indicator off.

10. Adjust the calibration source until the Display shows OUT1 100%.

11. Adjust potentiometer R101 for analog OUTPUT 1 or R100 for analog OUTPUT 2 for a digital voltage indication of 5V ±0.1 VDC.

12. Adjust the calibration source until the display shows OUT1 0% or OUT2 0%. The digital voltmeter reading should be approximately 0.

13. Repeat steps 10 through 12 for the second 0/5 VDC Analog Output as required.

14. Check the performance by varying the percent (%) OUTPUT POWER and noting that ANALOG OUT digital voltage indication varies accordingly.

15. Following calibration remove the controller from the calibration connector and reinstall into its controller case. (NOTE: For older controllers, make sure that the electronic assembly is mated with the same compensator resistor that was used for input calibration. Otherwise, the controller must be recalibrated per Section 6.12.

7.2.3 0/10 VDC ANALOG OUTPUT 1 AND ANALOG OUTPUT 2 TEST

7.2.3.1 CONTROLLERS WITH AUTO/MANUAL FEATURE

1. The 0/10 VDC analog output circuit has no calibration adjustments. Therefore, installation into the calibration case is not required.

2. Most analog loads are high impedance. It is therefore normal to calibrate the output without a load. When it is known that the load will be lower, that specific load resistance (minimum 2000Ω) should connected across output terminals 4 and 5 for ANALOG OUTPUT 1 and/or across terminals D and E for ANALOG OUTPUT 2. Then connect a digital voltmeter across OUTPUT 1 or OUTPUT 2 rear terminals. Allow a 5 minute warmup before proceding with the next step.

3. Advance the display in the OPERATOR LOOP until OUT 1 X% or OUT 2 X% is displayed. If the MAN indicator is flashing, press START/STOP key and then press AUTO/MANUAL key until the MAN indicator lamp is illuminated.

4. Press the UP ARROW key until the OUT 1 or OUT 2 display indicates 100%.

5. The digital voltmeter should now read 10 ±1 VDC.

6. Reduce the % OUTPUT with the DOWN ARROW key and note that the digital voltmeter reading changes accordingly.

7. Repeat steps 4 through 6 for the second 0/10 VDC analog output as required.

7.2.3.2 MODELS WITHOUT AUTO/MANUAL FEATURE

1. The 0/10 VDC analog output circuit has no calibration adjustments. Therefore, installation into the calibration case is not required.

2. Most analog loads are high impedance. It is therefore normal to calibrate the output without a load. When it is known that the load will be lower, that specific load resistance (minimum 2000Ω) should be connected across output terminals 4 and 5 for ANALOG OUTPUT 1 and/or across terminals D and E for ANALOG OUTPUT 2. Then connect a digital voltmeter across OUTPUT 1 or OUTPUT 2 rear terminals. Allow a 5 minute warmup before proceding with the next step.

3. Connect a suitable calibration source to the input terminals and adjust the input so that the display reads about half span, i.e., halfway between the LO SPAN and HI SPAN.

4. Enter the TUNE LOOP and press the PARAM DISPLAY key several times until the display reads TUNE? OUTPUTS. Answer YES to this question.

5. Following the TUNE LOOP flow chart, set the PR BAND 1 to 25%, RESET 1 to 0.00 R/M (off) and RATE 1 to 0.00 (off).

6. If OUTPUT 2 is also being adjusted, set AUXSP to 0 and repeat step 5 for OUTPUT 2.

7. Press RETURN to return to the OPERATOR LOOP.

8. Advance the display to show the setpoint on the bottom line. Using the UP and DOWN arrows, adjust the setpoint to the same value as the process variable shown on the top line. Press the PARAM/DISPLAY key until the bottom line shows OUT1 XXX% or OUT2 XXX%.

9. If the MAN indicator is blinking press the START/STOP key to turn the indicator off.

10. Adjust the calibration source until the Display shows OUT1 100%.

11. The digital voltmeter should now indicate 10V ±0.1 VDC.

12. Adjust the calibration source until the display shows OUT1 0% or OUT 2 0%. The digital voltmeter reading should be approximately 0.

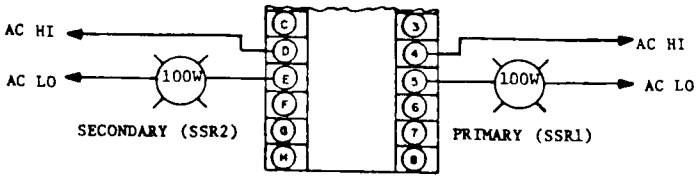
13. Repeat steps 10 through 12 for the second 0/10 VDC Analog Output as required.

14. Check the performance by varying the percent (%) OUTPUT POWER and noting that ANALOG OUT digital voltage indication varies accordingly.

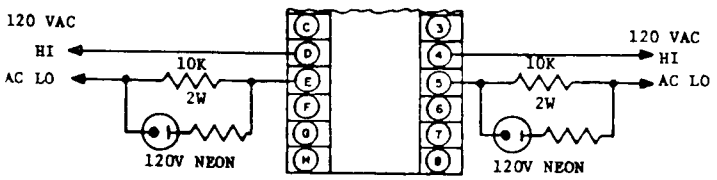
15. Following calibration remove the controller from the calibration connector and reinstall into its controller case. (NOTE: For older controllers, make sure that the electronic assembly is mated with the same compensator resistor that was used for input calibration. Otherwise, the controller must be recalibrated per Section 6.12.

7.2.4 SOLID STATE RELAY OUTPUT 1 AND OUTPUT 2 TEST ON/OFF AND PROPORTIONING OUTPUTS

Connect the solid state OUTPUT 1 and/or OUTPUT 2 to a load as indicated below:



FOR 1A SS RELAY



FOR 50 mA SS RELAY

7.2.4.1 ON/OFF SOLID STATE RELAY OUTPUTS

7.2.4.1.1 CONTROLLERS WITH AUTO/MANUAL FEATURE

1. PRESS the DISPLAY key until OUT1 X% for SSR1 or OUT2 X% for SSR2 is indicated on the display. If the MAN indicator is flashing, press START/STOP key. Press AUTO/MANUAL key until the MAN indicator is illuminated.

2. Press the UP arrow key and note that the external lamp, and the display OUT1 or OUT2 indicator both illuminate.

3. Press the DOWN keypad and note that the external lamp and display OUT1 or OUT2 indicators both extinguish.

4. If the second SSR output is ON/OFF action, repeat the procedure above.

7.2.4.1.2 CONTROLLERS WITHOUT AUTO/MANUAL FEATURE

1. Connect a suitable calibration source to the input terminals and adjust the input so that the display reads about half span, ie, halfway between the LO SPAN and HI SPAN.

2. Enter the TUNE LOOP and press the PARAM DISPLAY key several times until the display reads TUNE? OUTPUTS. Answer YES to this question.

3. Following the TUNE LOOP flow chart, set the PR BAND 1 to 25%, RESET 1 to 0.00 R/M (off) and RATE 1 to 0.00 (off).

4. If OUTPUT 2 is also being adjusted, set AUXSP to 0 and repeat step 3 for OUTPUT 2.

5. Press RETURN to return to the OPERATOR LOOP.

6. Advance the display to show the setpoint on the bottom line. Using the UP and DOWN arrows, adjust the setpoint to the same value as the process variable shown on the top line. Press the DISPLAY key until the bottom line shows OUT1 XXX%.

7. If the MAN indicator is blinking press the START/STOP key to turn the indicator off.

8. Adjust the calibration source until the Display shows OUT1 100%. Note that the external lamp and the display OUT1 or OUT2 indicators both illuminate.

9. Adjust the calibration source until the display shows OUT1 0% or OUT 2 0%. The external lamp and the display OUT1 or OUT2 indicators both extinguish.

10. If the second SSR output is ON/OFF action, repeat the procedure above.

7.2.4.2 PROPORTIONING SOLID STATE RELAY OUTPUTS

7.2.4.2.1 CONTROLLERS WITH AUTO/MANUAL FEATURE

1. PRESS the DISPLAY key until OUT1 X% for SSR1 or OUT2 X% for SSR2 is indicated on the display. If the MAN indicator is flashing, press START/STOP key. Press AUTO/MANUAL key until the MAN indicator lamp is illuminated.

2. Press the UP arrow key until OUTPUT 1 or OUTPUT 2 has cycled up from 0% to 100% output.

3. After an approximate 15 second time delay (will vary depending on the cycle time setting), the external lamp load and display OUT 1 or OUT 2 will illuminate.

4. Reduce the OUTPUT from 100% to 0% with the DOWN key and note that the load lamp and display indicator both extinguish at some point during this transition. Repeat this procedure a few times.

5. Set the OUTPUT to 50% and note that it cycles on and off with approximately a 50% duty cycle and a time base equal to the cycle time.

6. If the second SSR OUTPUT is proportioning action, repeat the above procedure.

This verifies the SSR circuit outputs. Turn off the AC power and remove the load lamp circuitry.

7.2.4.2.2 CONTROLLERS WITHOUT AUTO/MANUAL FEATURE

1. Connect a suitable calibration source to the input terminals and adjust the input so that the display reads about half span, ie, halfway between the LO SPAN and HI SPAN.

2. Enter the TUNE LOOP and press the PARAM DISPLAY key several times until the display reads TUNE? OUTPUTS. Answer YES to this question.

3. Following the TUNE LOOP flow chart, set the PR BAND 1 to 25%, RESET 1 to 0.00 R/M (off) and RATE 1 to 0.00 (off).

4. If OUTPUT 2 is also being adjusted, set AUXSP to 0 and repeat step 3 for OUTPUT 2.

5. Press RETURN to return to the OPERATOR LOOP.

6. Advance the display to show the setpoint on the bottom line. Using the UP and DOWN arrows, adjust the setpoint to the same value as the process variable shown on the top line. Press the DISPLAY key until the bottom line shows OUT1 XXX% or OUT2 XXX%.

7. If the MAN indicator is blinking press the START/STOP key to turn the indicator off.

8. Adjust the calibration source until the Display shows OUT1 100%. After an approximate 15 second time delay (will vary depending on the cycle time setting) the external lamp and the display OUT1 or OUT2 indicators should illuminate.

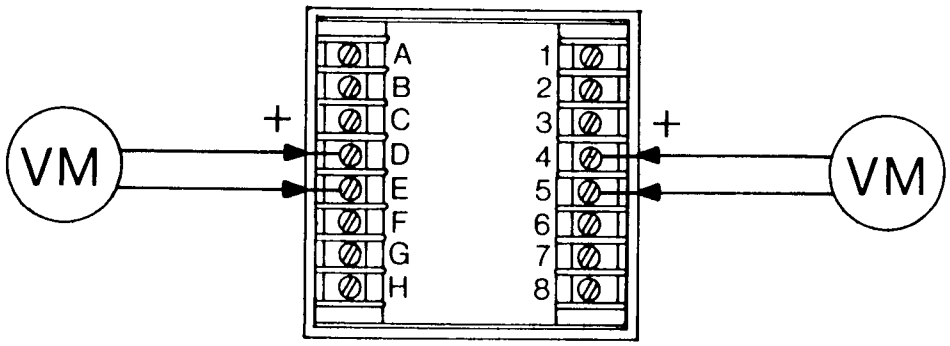
9. Adjust the calibration source until the display shows OUT1 50% or OUT2 50%. Note that the output indicators and the external load lamps cycle with an approximate 50% duty cycle and tha the time base is equal to the cycle time.

10. If the second SSR output is proportioning action, repeat the procedure above.

    This verifies the SSR circuit outputs. Turn off the AC power and remove the load lamp circuitry.

7.2.5 DC TRIGGER OUTPUT TEST

Connect the DC trigger OUTPUT 1 and/or OUTPUT 2 as shown in the circuit below:

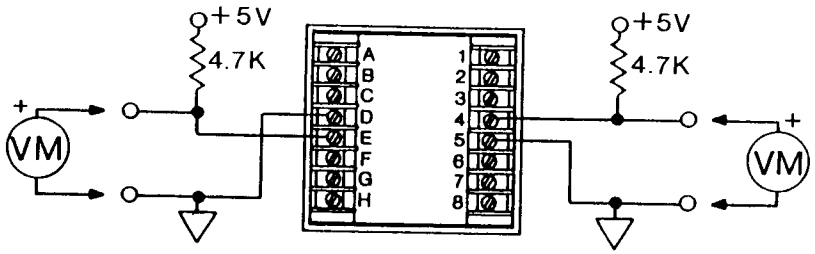


Press the DISPLAY key until OUT1 X% or OUT2 X% is indicated on the display. If the MAN indicator is flashing, press START/STOP key. Press AUTO/MANUAL key until the MAN indicator is illuminated.

Using the criteria in either 7.2.4.1 (ON/OFF) or 7.2.4.2 (TPR), test the trigger output which will provide a DC output voltage of approximately 18V.

7.2.6 OPEN COLLECTOR OUTPUT TEST

Connect the open collector OUTPUT 1 and/or OUTPUT 2 as shown in the circuit below:



Press the DISPLAY key until OUT1 X% or OUT2 X% is indicated on the display. If the MAN indicator is flashing, press the START/STOP key. Press the AUTO/MANUAL key until the MAN indicator is illuminated.

Using the criteria of 7.2.4.1 (ON/OFF) or 7.2.4.2 (TPR) test the open collector output which will switch the external circuit.

7.2.7 RETRANSMITTING OUTPUT TEST (SETPOINT OR PV)

1. Connect a suitable calibration source to the controller input terminals.

2. Connect a 1000Ω 1/2W 1% resistor across output terminals D and E for a 4/20 mA output. Most voltage output loads are high impedance. It is therefore normal to calibrate the voltage output without a load. When it is known that the load is not a high impedance, that specific load resistance (minimum of 1000Ω for 0-5V or a minimum of 2000Ω for 0-10V) should be connected across terminals D and E. Connect a digital voltmeter across terminals D(+) and E(-).

3. Vary the input calibration source and observe the digital voltmeter. The digital voltmeter should change reading corresponding to the input change; linearly reaching the minimum and maximum output values at the corresponding limits of the span. For 4-20 mA and 0-5 V outputs, pot R100 may be used to calibrate the full scale output. The 0-10 V output is not adjustable. (Note that for both thermocouple and RTD ranges, the output should be linearized within the accuracy limits listed in the specifications (see Section 1.7.2) and the converter output resolution of 1 part in 256.)

7.2.8 ALARM/TIMER RELAY OUTPUT TESTS

1. Connect a continuity tester across the alarm/timer relay terminals to be tested.

2. Enter the TUNE LOOP and determine the setting of the alarm/timer relay to be tested.

3. For an alarm relay, connect a suitable calibration source to the input terminals and vary the input around the setpoint value determined in step 2. The alarm relay should actuate and deactuate accordingly. The difference between actuation and deactuation is the relay beadband.

4. For a timer relay, use the START/STOP or START/RESET key to initiate the timer test. The measured value should agree with the value determined in step 2.

NOTE: The event relay(s) in models 2012 and 2013 trigger at the end of the segment at which they have been set in the TUNE LOOP. After setting the event relay(s) to operate at a specific segment, run through a sample profile in order to check the event relay operation.

7.2.9 COMMUNICATIONS TESTING

Units which have had a communications board added by the MOD CENTER should be tested to make sure that the communications circuitry is functional. In order to make these tests, it is necessary for the MOD CENTER to have some sort of terminal such as a personal computer with a RS232 port and a "converter/power supply" box between the terminal and the controller. (Only the non-isolated RS232 option can be tested without the converter/power supply box.)

Providing the terminal or personal computer is the responsibility of the MOD CENTER. However, LFE has a Basic program on a 5 1/4" diskette that will provide menu driven commands to the PC RS232 port for an IBM-PC or equivalent machine using the MS-DOS operating system. A listing of the program is also available for use on non-DOS machines with Basic language capability provided that the operating system supports both read and write functions through the RS232 port. The program has been well commented to provide aid to the user in constructing a program that will work on his machine.

The "converter/power supply" box is needed to convert the RS232 output from the terminal into the RS422 or Current Loop inputs needed by those communications options. It must also contain the external power supplies needed for isolated communications. If help is needed, contact the factory for information.

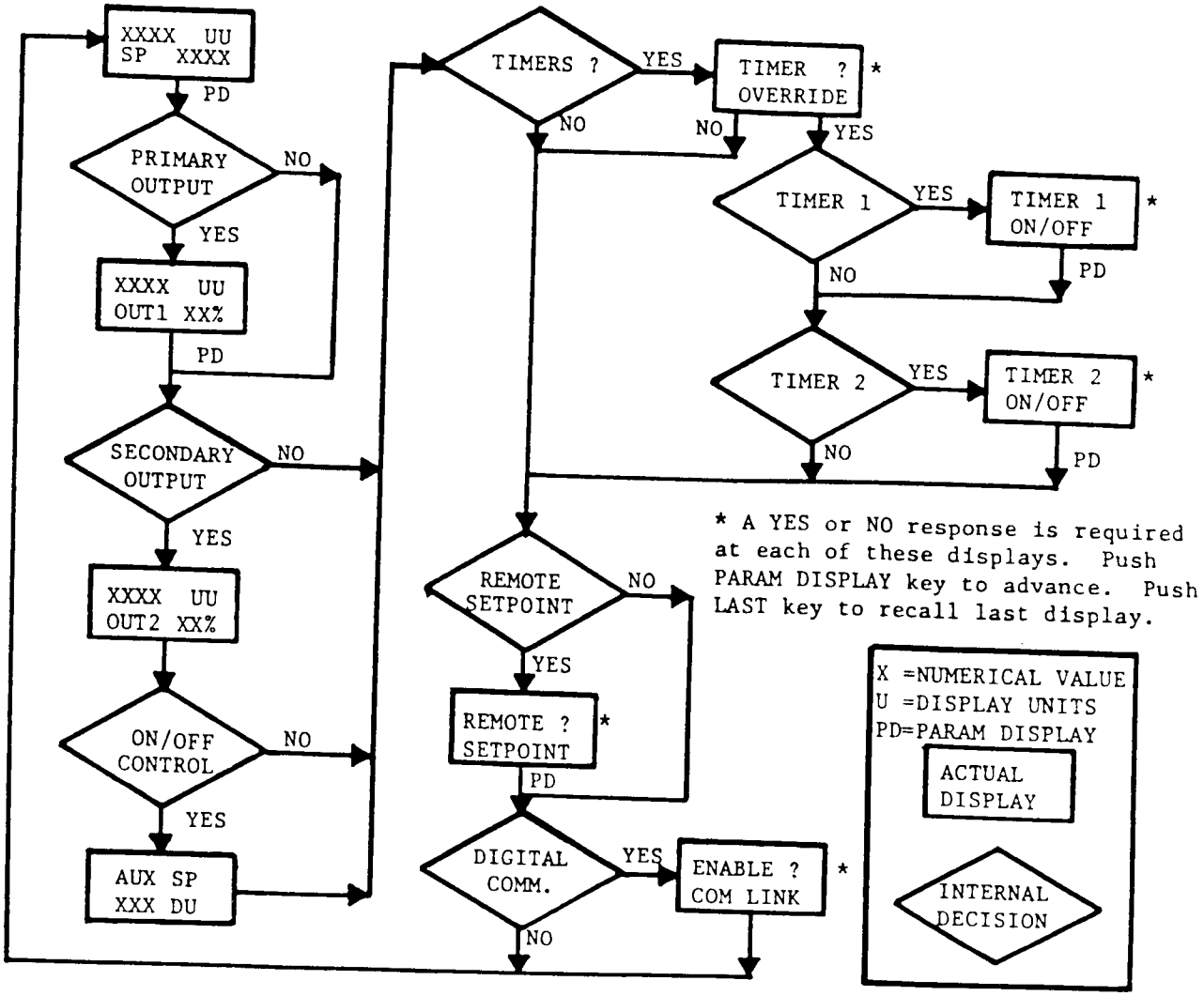
1. Connect the controller to a terminal through a converter/power supply box. Make sure that the controller DIP switches have been set properly to match the equipment used for the test. (See the installation manual.)

2. Using the installation manual for information on the communications format or, using the special program diskette, send several commands to the controller and observe the controller response to ensure that the cummunications loop is performing correctly.

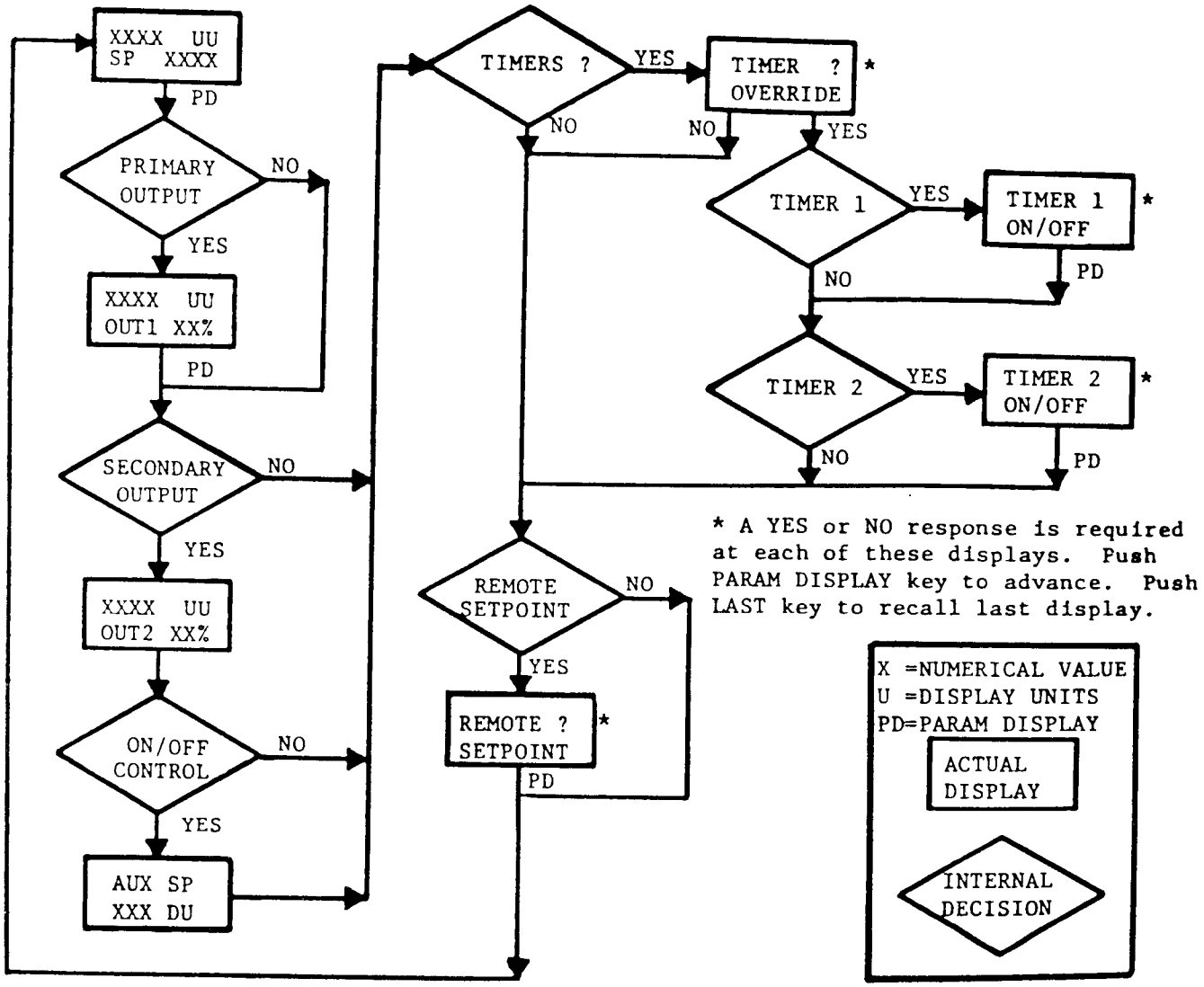
Dow

SECTION 8 - FLOW CHARTS

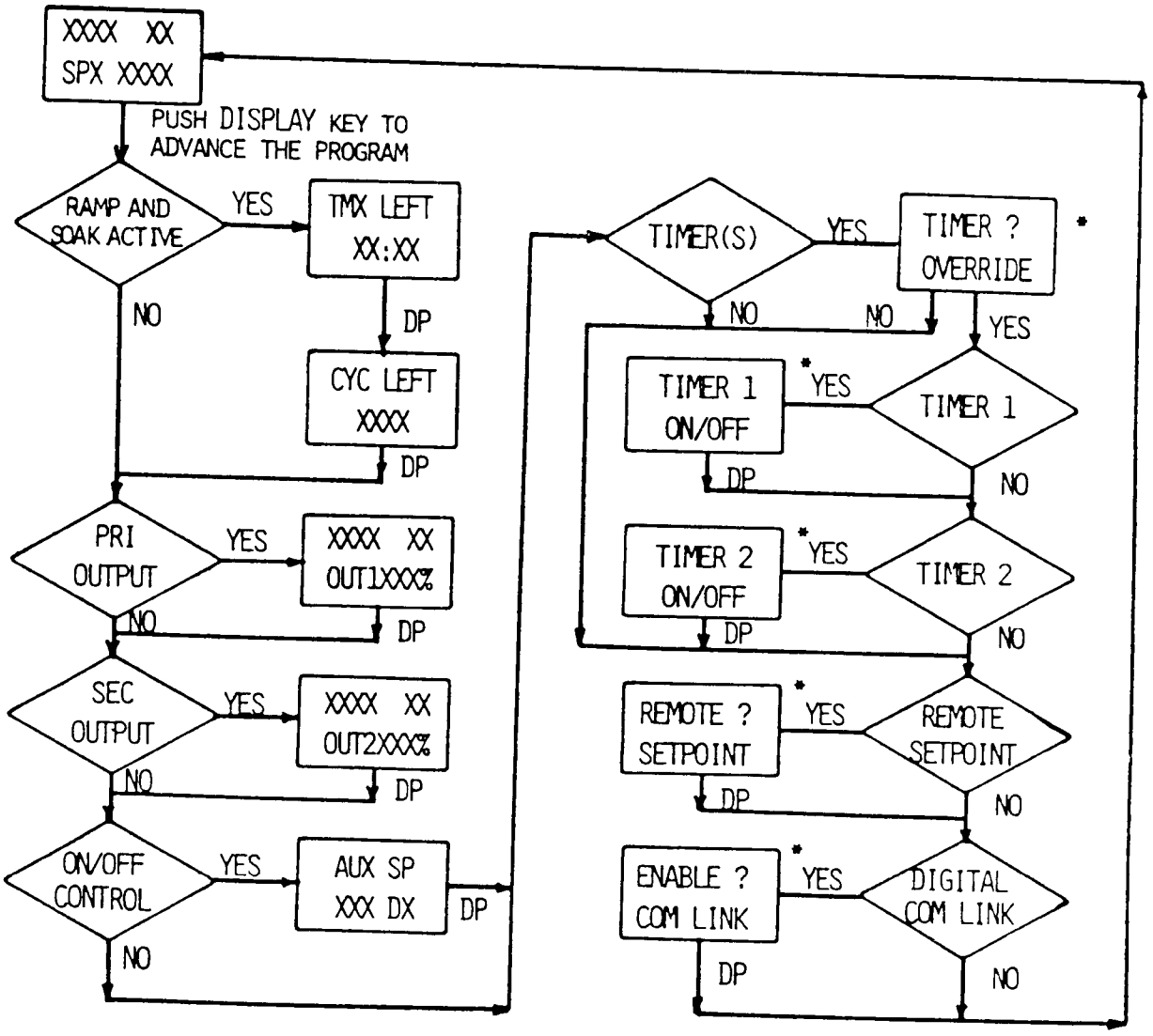
THIS SECTION CONTAINS SOFTWARE FLOW DIAGRAMS FOR EACH OF THE CONTROLLERS TO ASSIST IN REVIEWING THE VARIOUS STEPS AND DISPLAYS THAT OCCUR DURING THE OPERATOR, TUNE AND CAL LOOPS.



OPERATOR LOOP - MODELS 2000, 2001, 2002, 2003 AND 2004
FIGURE 8-1

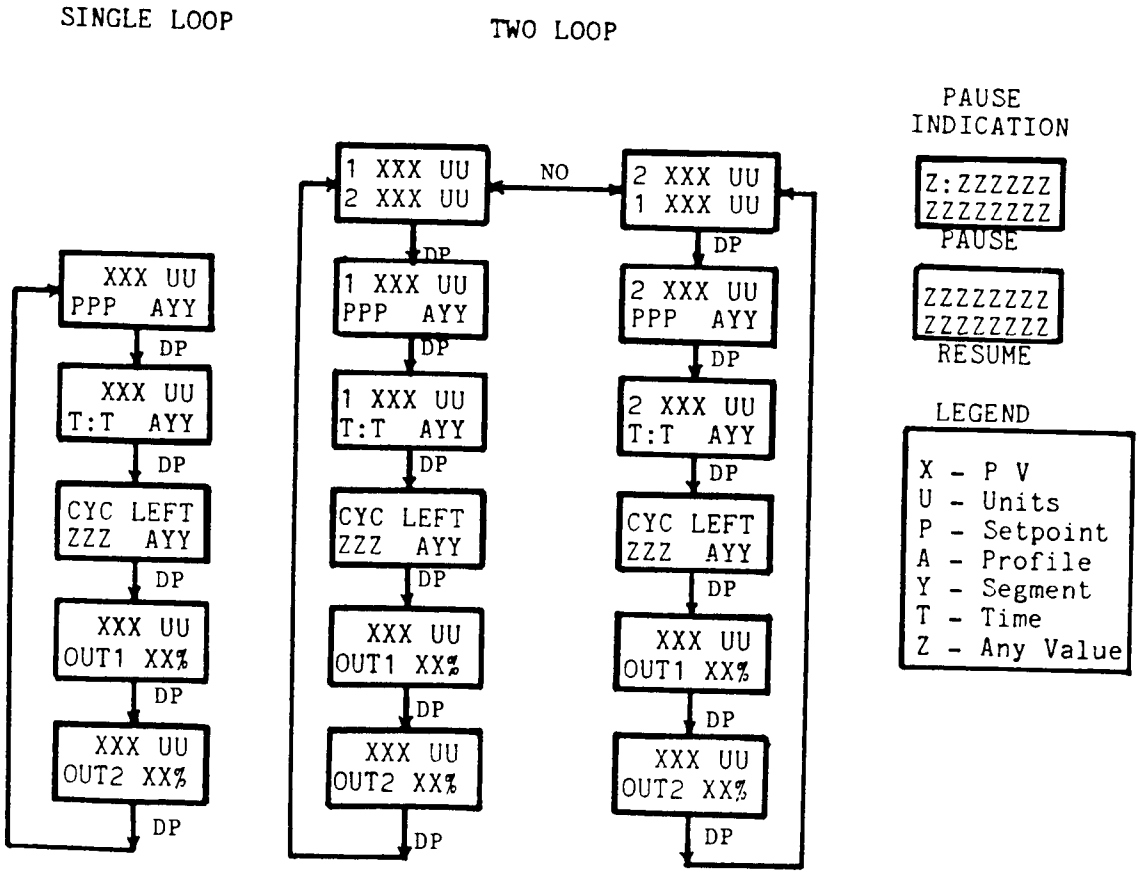


OPERATOR LOOP - MODEL 2005
FIGURE 8-2



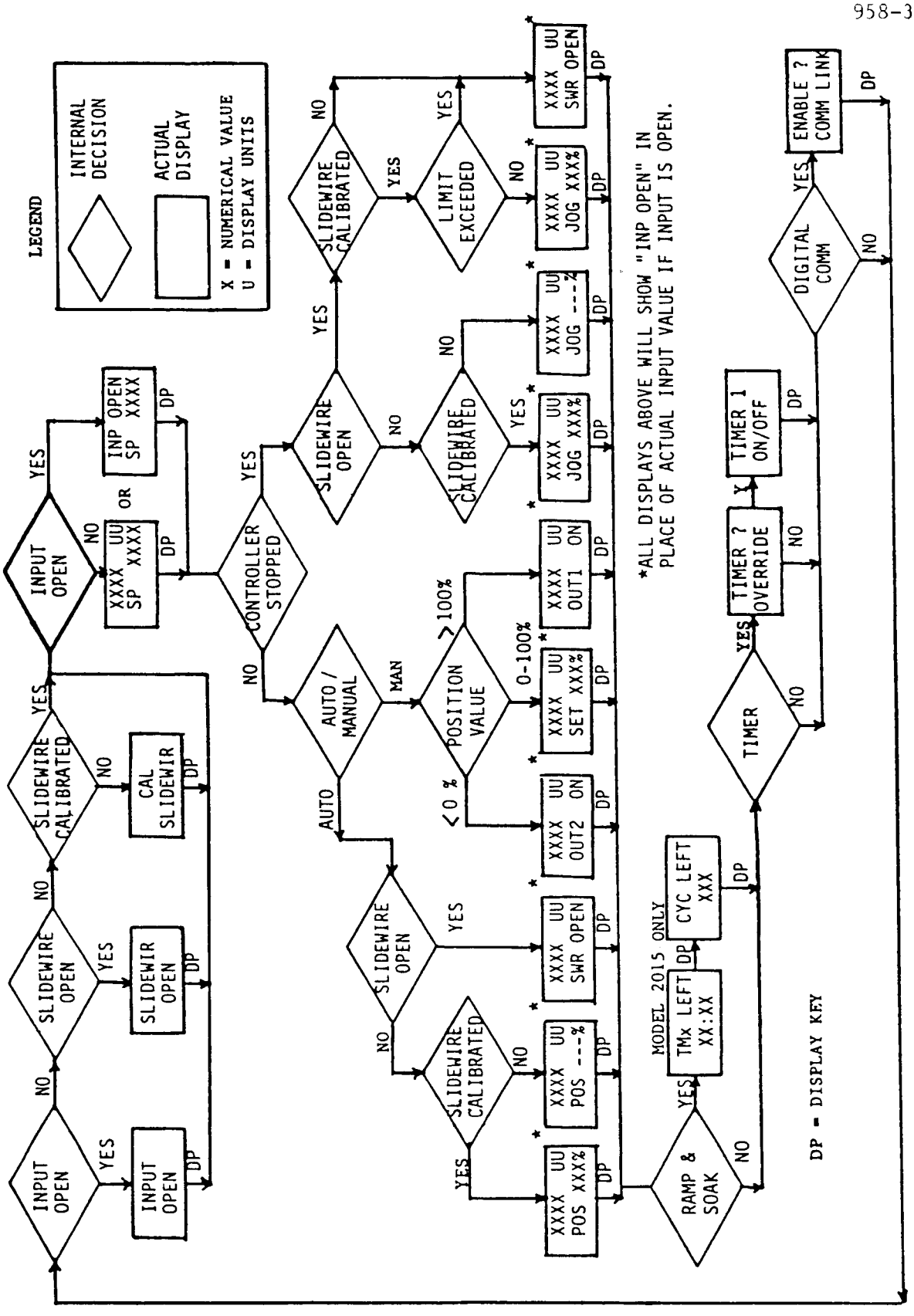
*A YES OR NO RESPONSE IS REQUIRED AT EACH OF THESE DISPLAYS;
PUSH DISPLAY KEY TO ADVANCE TO THE NEXT DISPLAY,
PUSH LAST KEY TO RECALL THE PREVIOUS DISPLAY.

OPERATOR LOOP - MODELS 2010 AND 2011
FIGURE 8-3

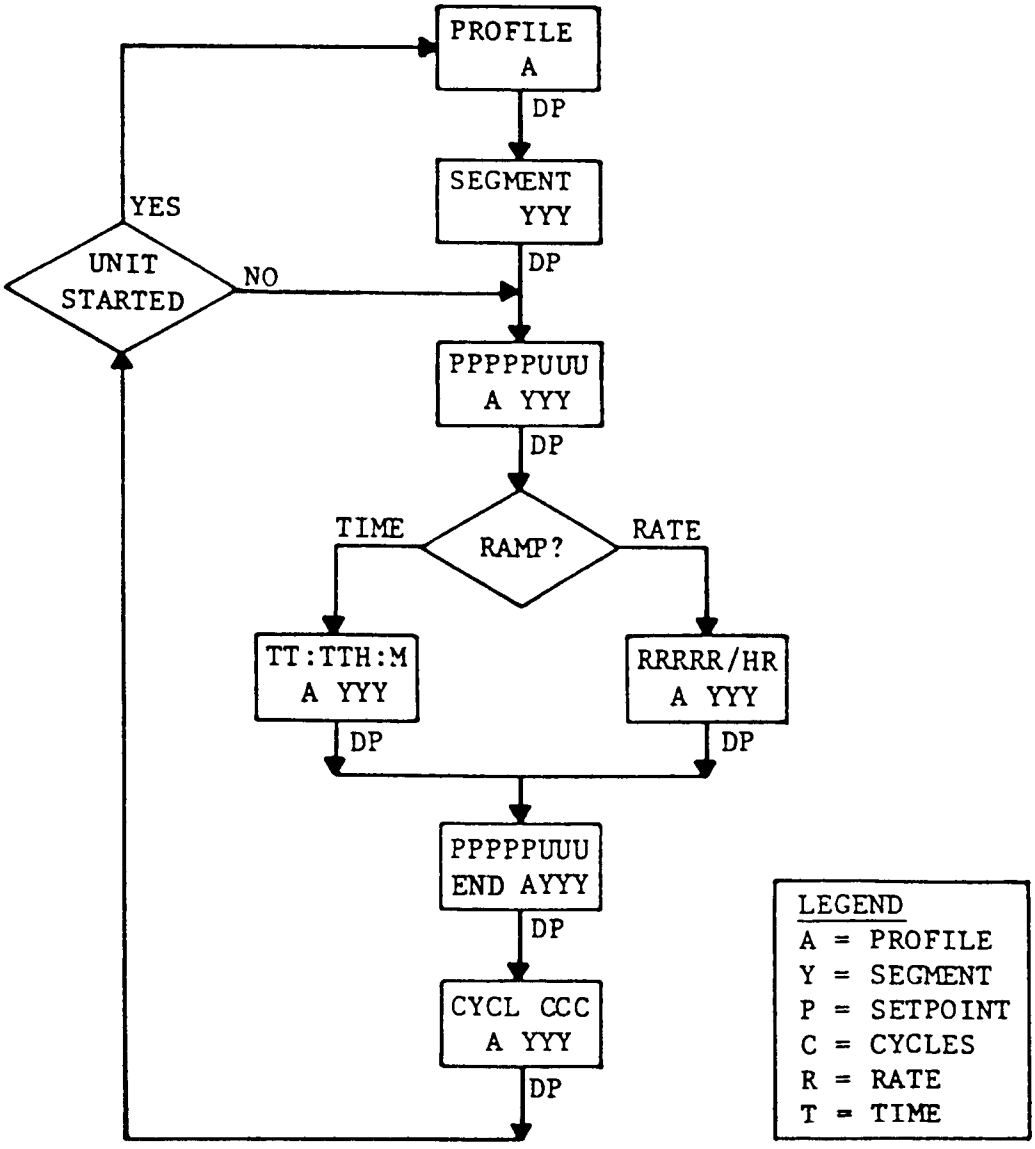


PUSH DISPLAY KEY TO ADVANCE TO THE NEXT DISPLAY,
PUSH LAST KEY TO RECALL THE PREVIOUS DISPLAY.

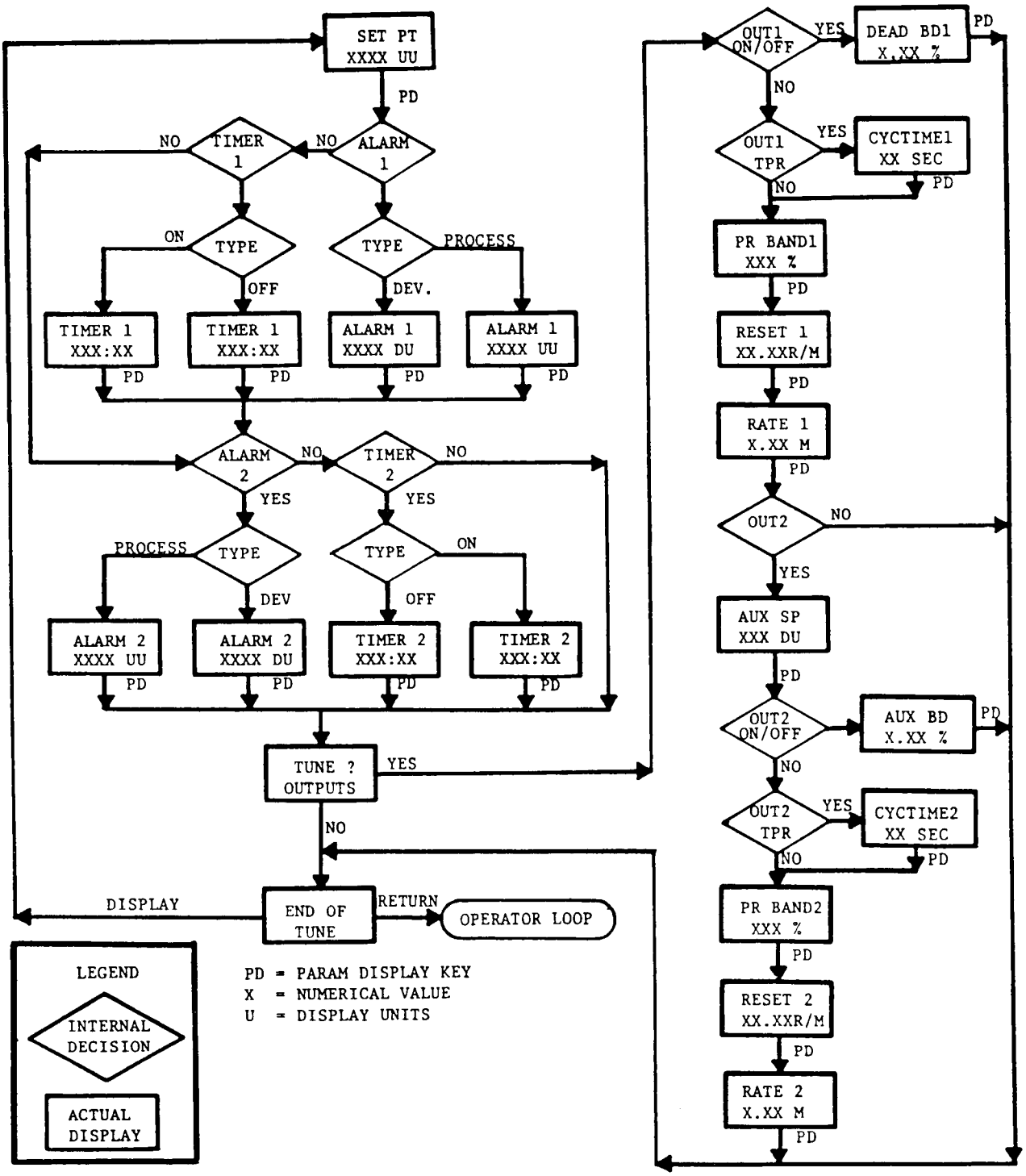
OPERATOR LOOP - MODELS 2012 AND 2013
FIGURE 8-4



OPERATOR LOOP - MODELS 2014 AND 2015
FIGURE 8-5

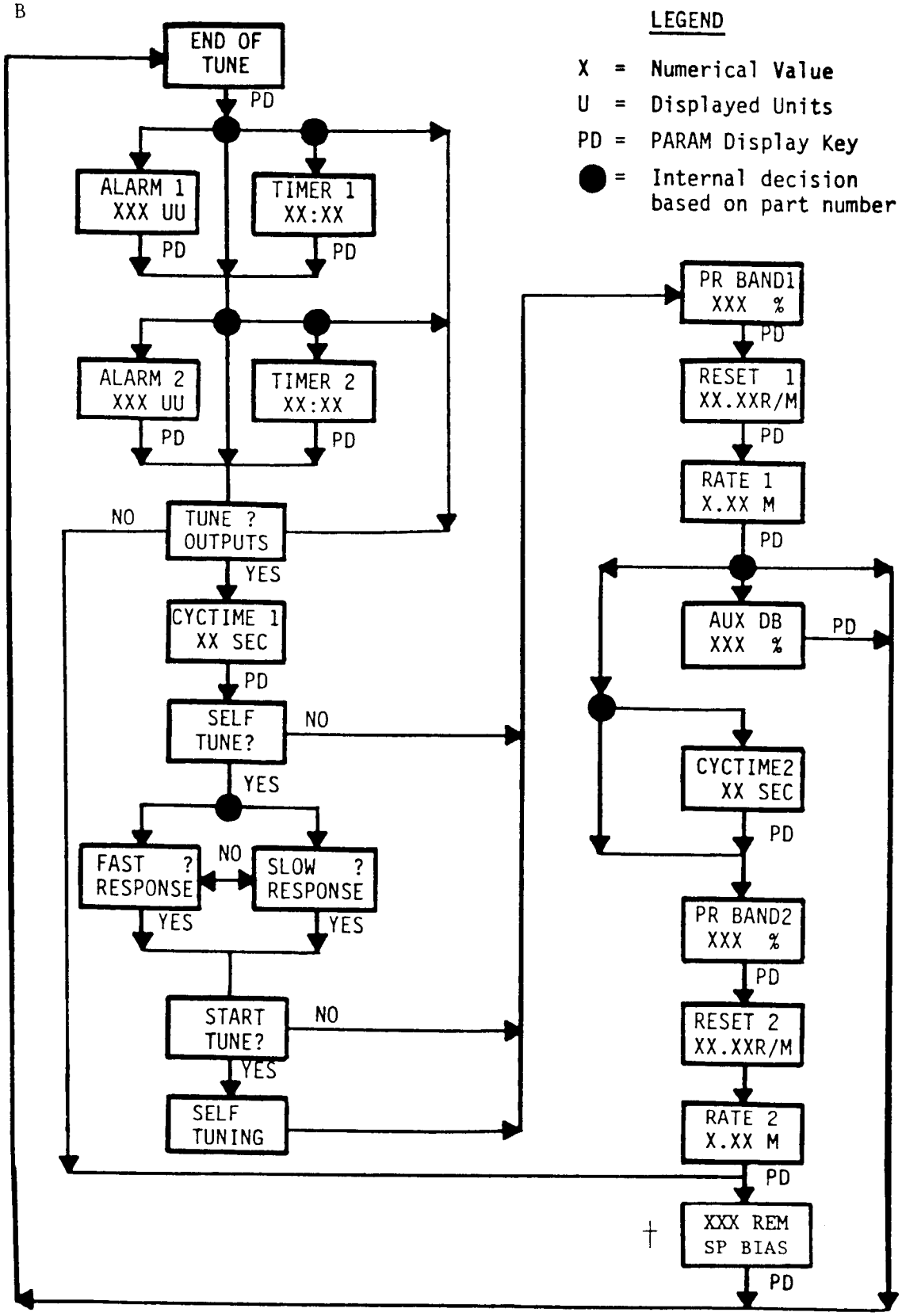


OPERATOR LOOP - MODEL 2017
FIGURE 8-6



* Timers not available in Models 2002 and 2005 with AUTO/MANUAL

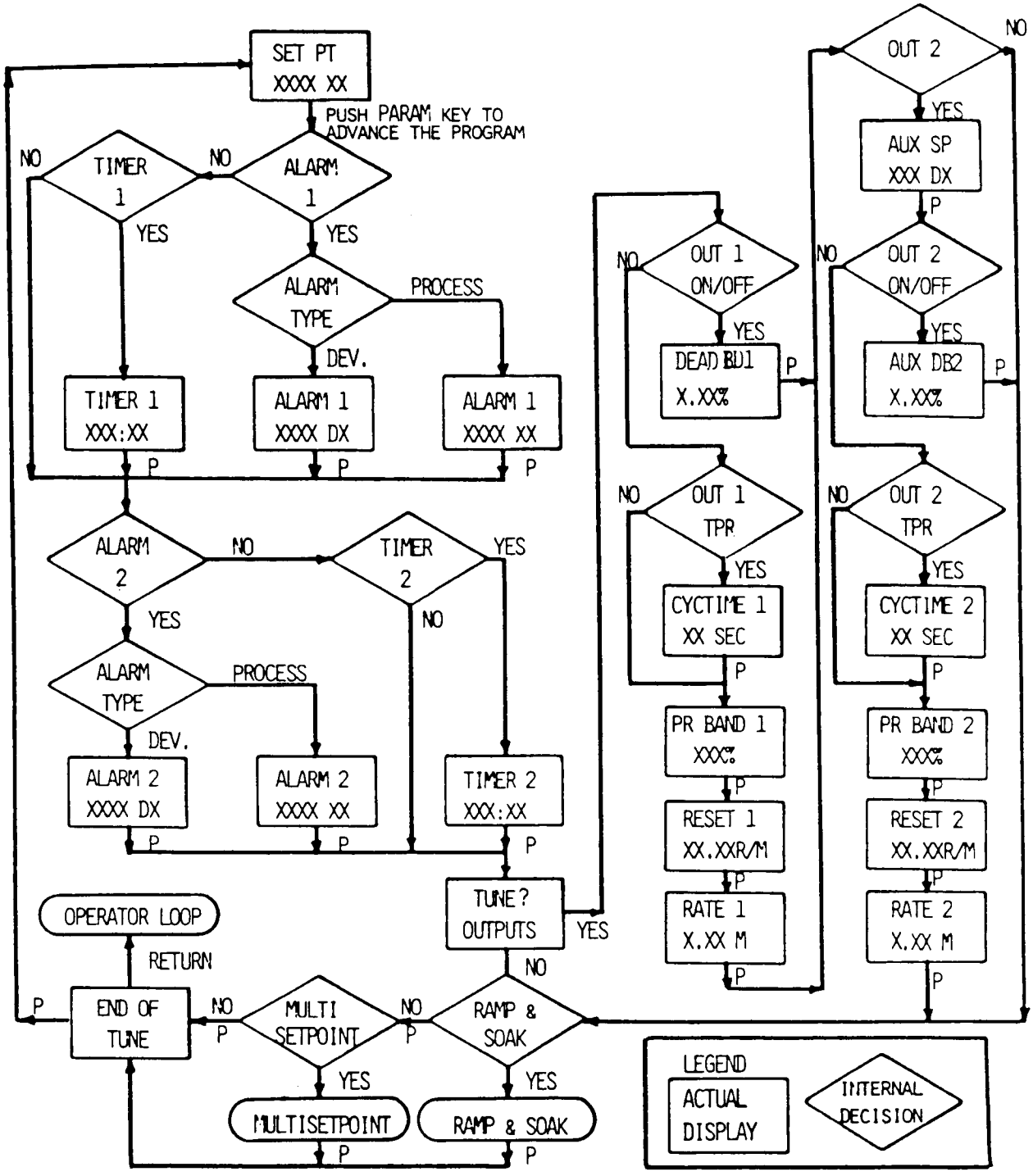
TUNE LOOP - MODELS 2000,2001,2002 AND 2005 WITH START/STOP AND AUTO/MANUAL
FIGURE 8-7



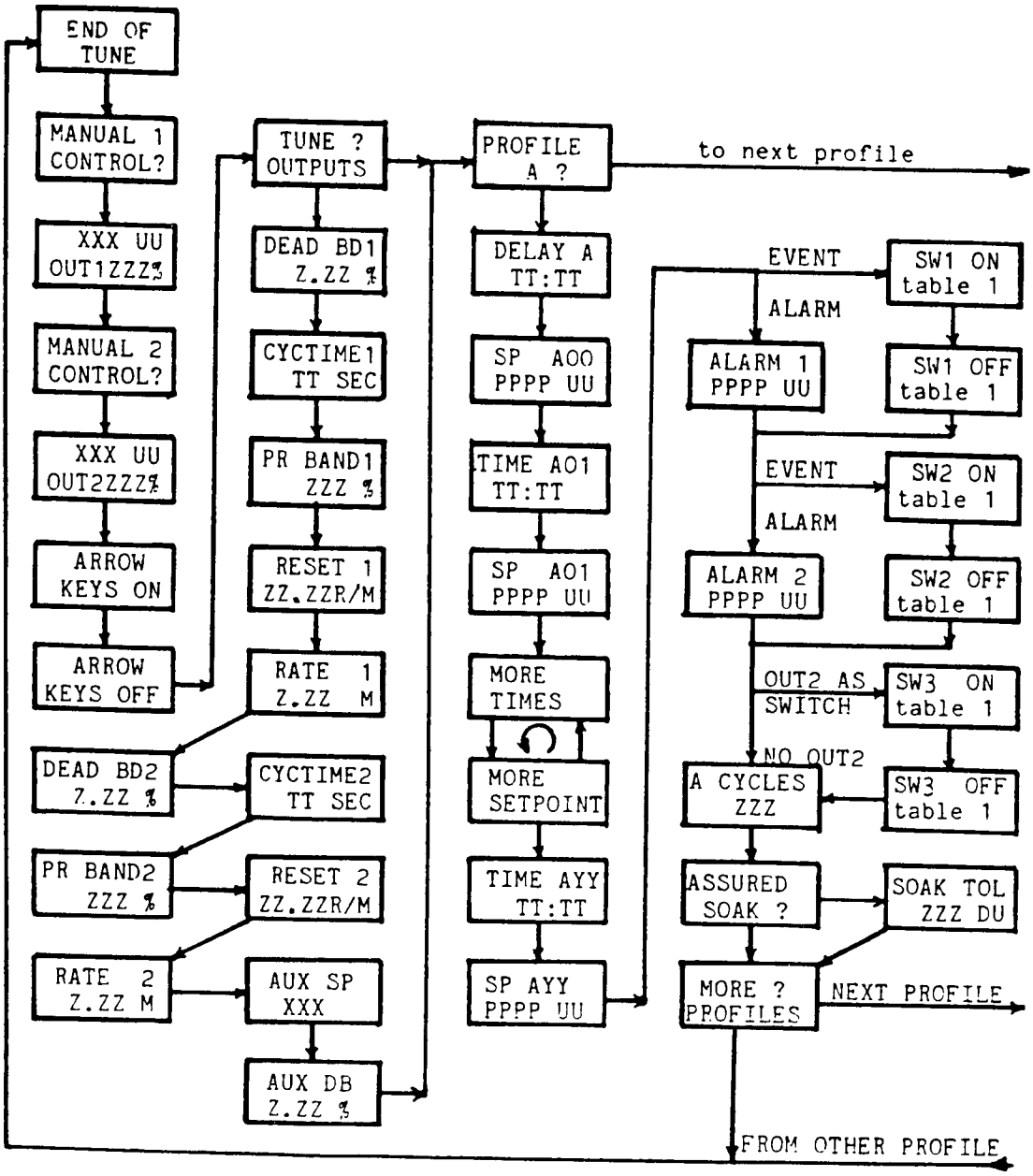
* Timers not available in Models 2004 and 2005 AUTO/MANUAL with self tune

† Models 2003 and 2004 do not have remote SP bias. (Bypass this block.)

TUNE LOOP - MODELS 2003, 2004 AND 2005 WITH SELF TUNE
FIGURE 8-8



TUNE LOOP - MODELS 2010 AND 2011
FIGURE 8-9



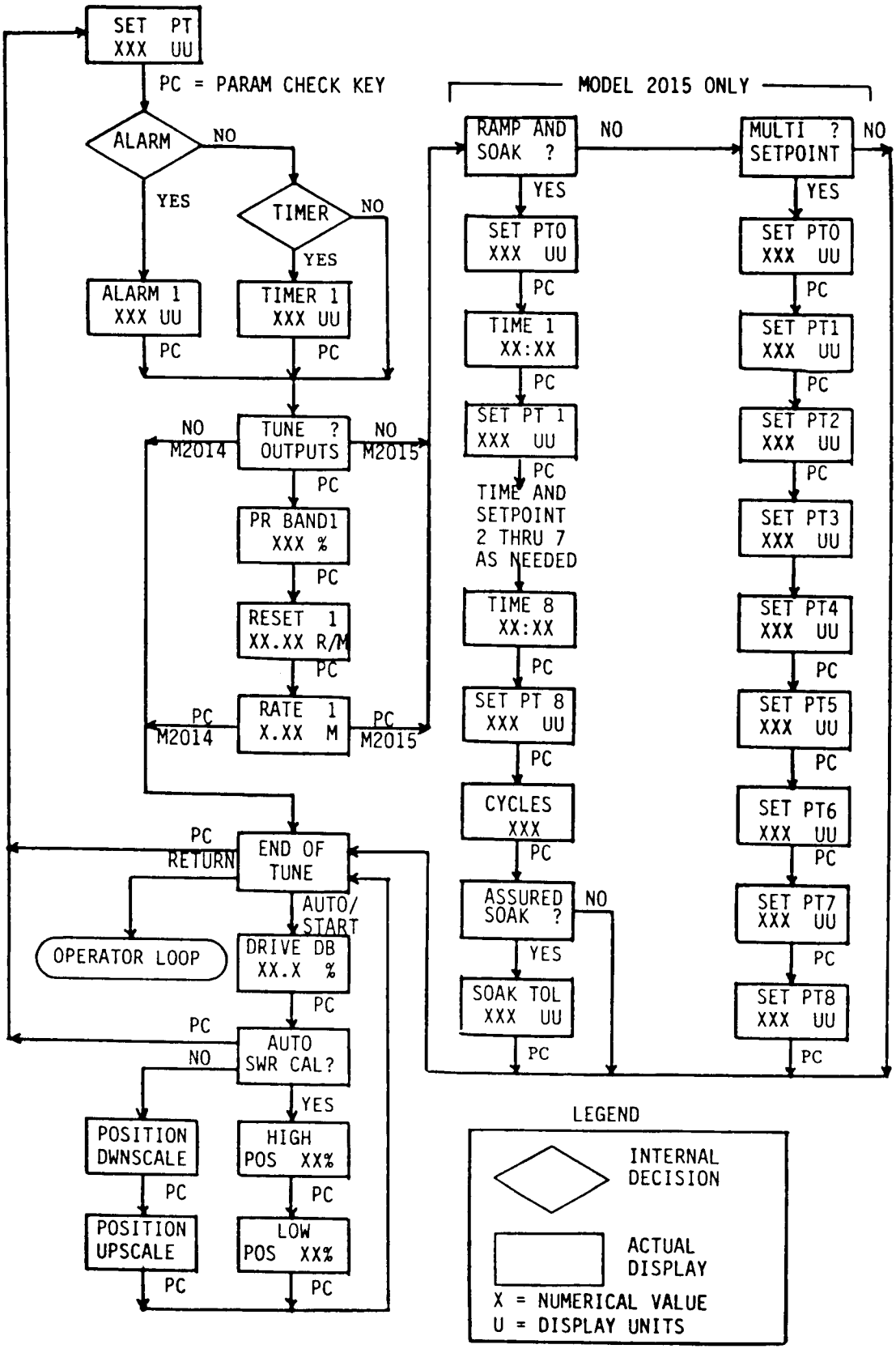
LEGEND

X	P V
U	Units
Z	Any Value
T	Time
A	Profile
Y	Segment
P	Setpoint

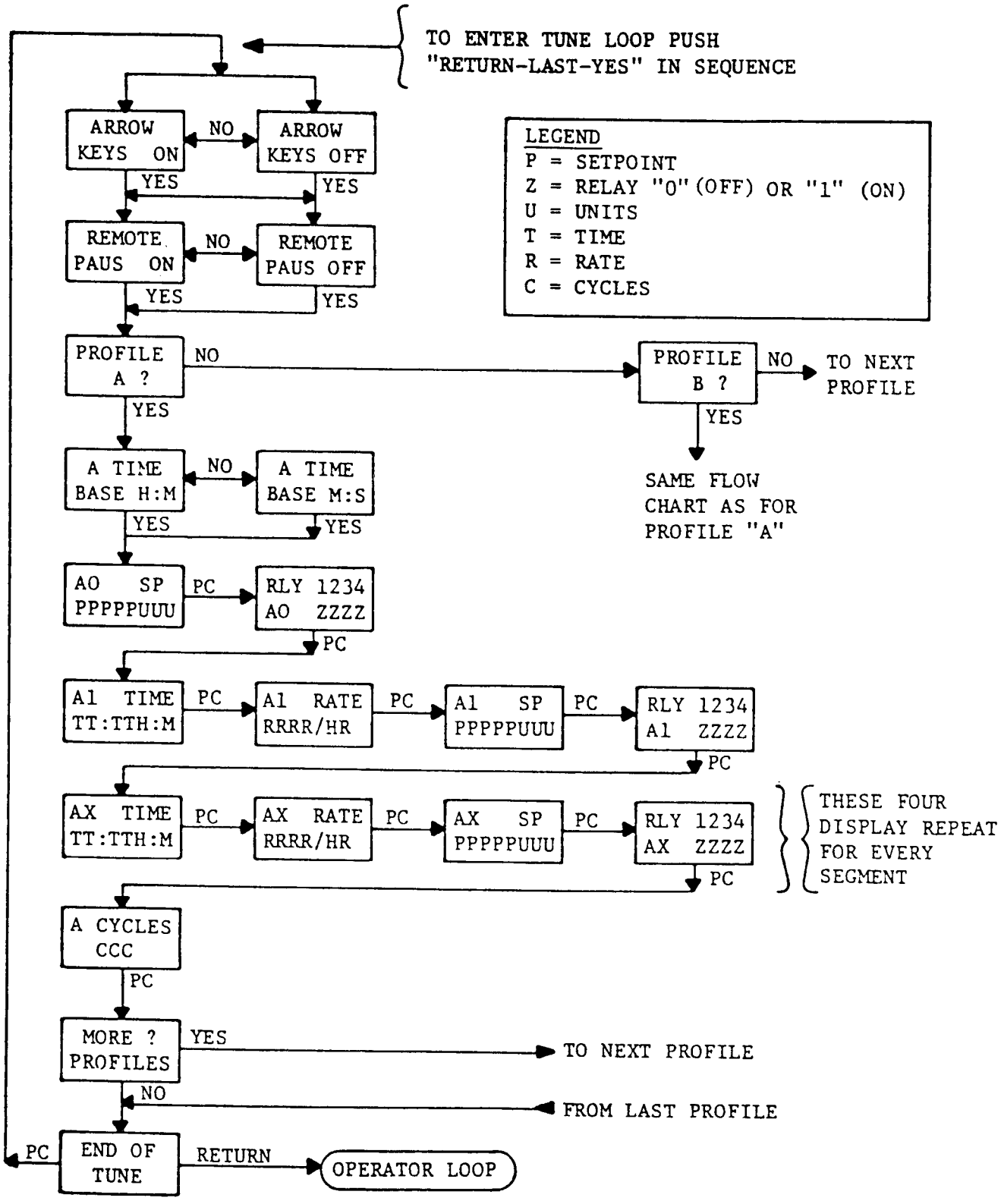
TABLE 1

Not used
Start
SP 0
SP 1
SP 2
"
SP Z

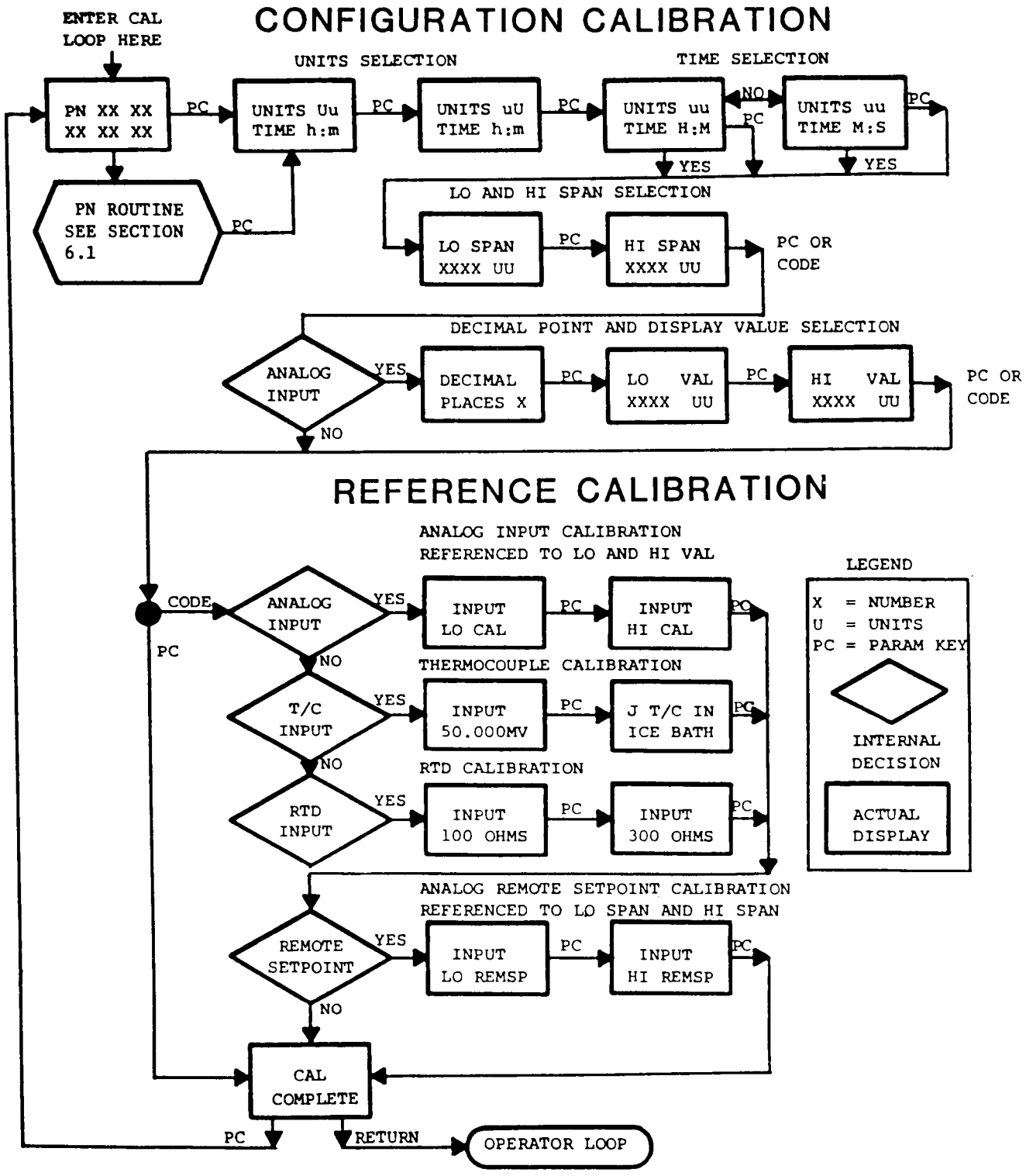
TUNE LOOP - MODELS 2012 AND 2013
FIGURE 8-10



TUNE LOOP - MODELS 2014 AND 2015
FIGURE 8-11

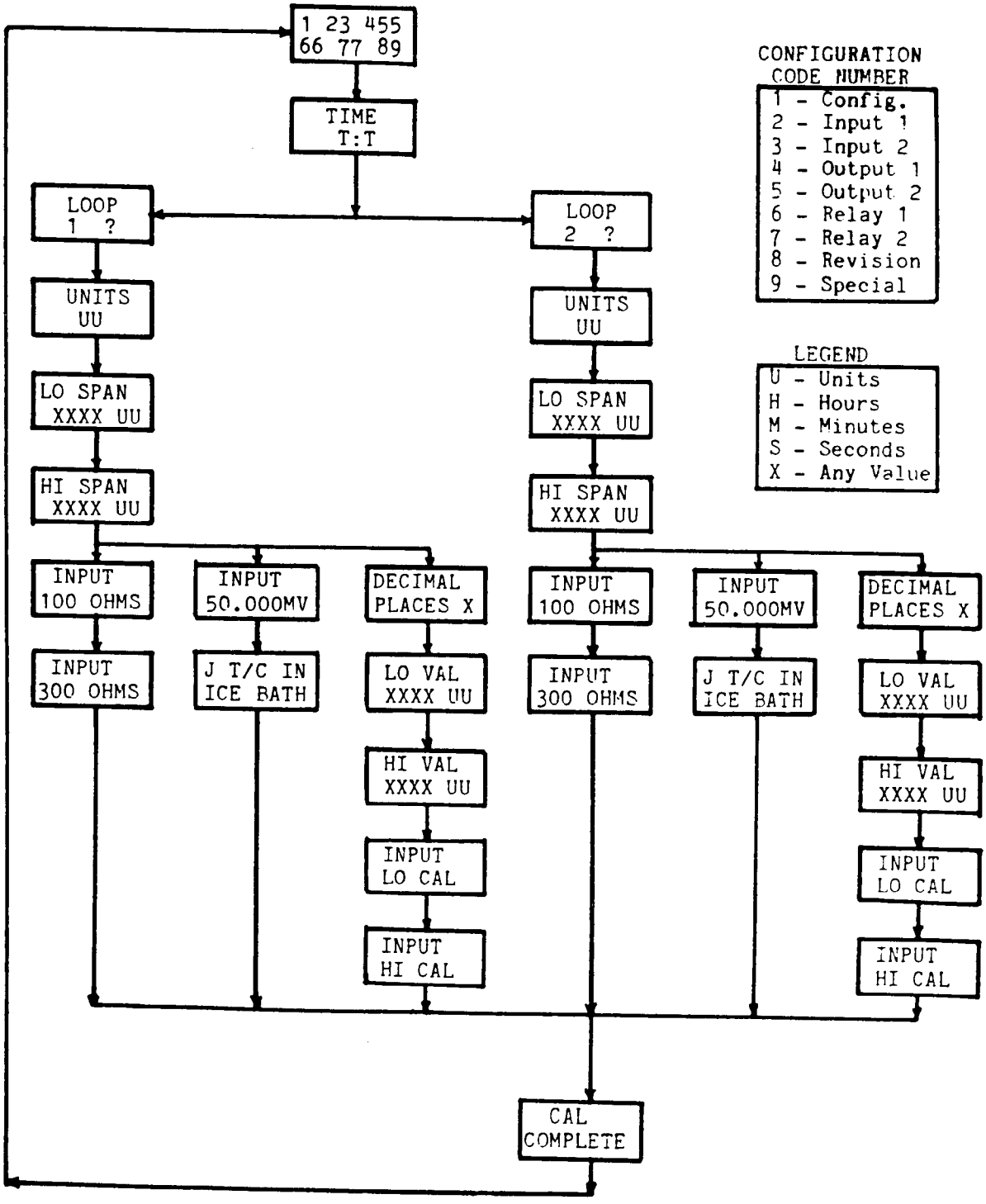


TUNE LOOP - MODEL 2017
FIGURE 8-12

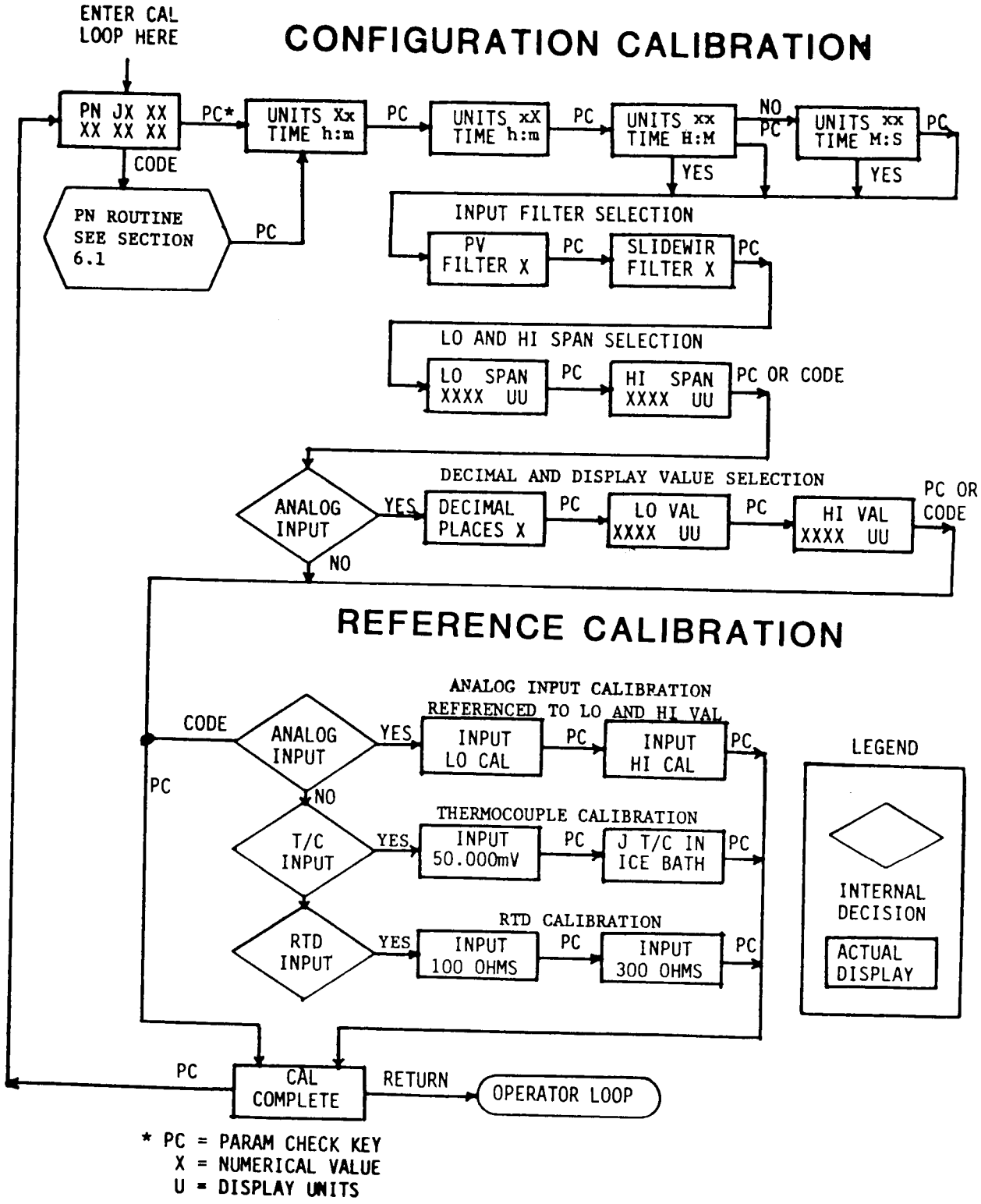


CAUTION: DO NOT TURN OFF POWER WHILE IN CAL LOOP.

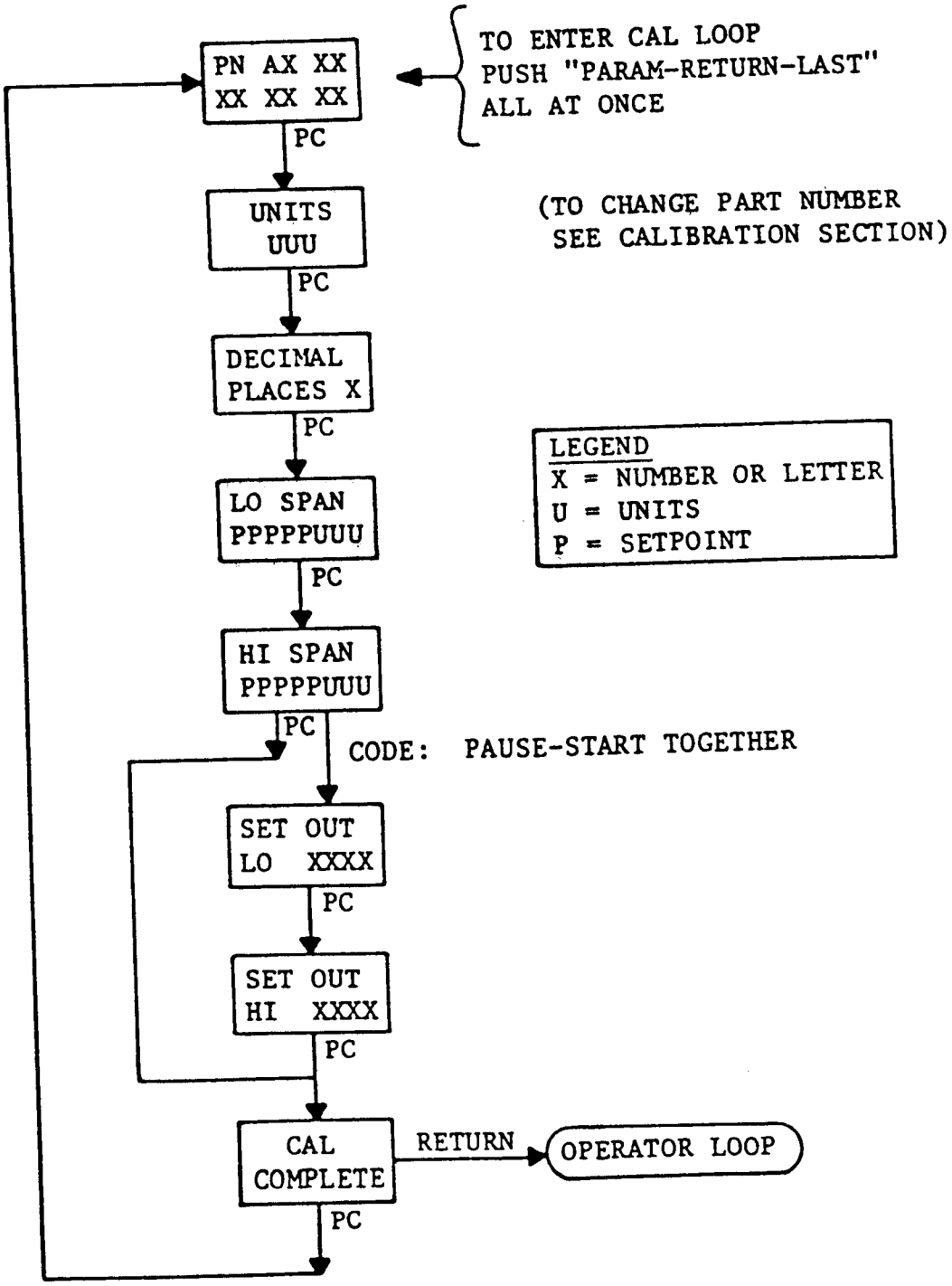
CAL LOOP - MODELS 2000, 2001, 2002, 2003, 2004, 2005, 2010 AND 2011
FIGURE 8-13



CAL LOOP - MODELS 2012 AND 2013
FIGURE 8-14



CAL LOOP - MODELS 2014 AND 2015
FIGURE 8-15



CAL LOOP - MODEL 2017
FIGURE 8-16

SECTION 9 - SERVICE & REPAIR

9.1 CHANGING/ADDING COMPONENTS

The modification of the printed circuit boards in the series 2000 controllers requires that certain precautions be taken in the removal/addition of components. The use of a low wattage iron with an appropriate tip taking care not to expose the circuit board to unnecessary heat is highly recommended. The use of desoldering aids such as vacuum type tools and "Solder-Wick" for the removing and cleaning of circuit board holes should be performed prior to the installation of new components.

9.2 EPROM REPLACEMENT (U-2 CPU BOARD) (See Note 1)

The EPROM is a digital memory device that permanently stores instructions and information programmed into it at the factory. This device (U-2 on the CPU board) is socket mounted and can be removed with the proper IC extraction tool.

The EPROM can be replaced if a failure should occur, or if a special application requires a new program. A new EPROM can be ordered by the MOD CENTER from the factory.

Because of the hazard of static discharge when handling MOS integrated circuits, special precautions must be taken in the work area to prevent static charge from causing device failures. Refer to MOS STATIC DISCHARGE HANDLING PRECAUTIONS (section 1.13).

Each EPROM ordered from the factory will have mounted to its top surface a label that will indicate the following:

PART NUMBER 1685-(X) REVISION (Letter) DATE

This label is a means of identifying the program configurations of the EPROM. Contact the factory for details on part numbers not shown in this manual.

When replacing the EPROM in the socket be sure that it is correctly oriented and then firmly pressed into its socket. The controller must now be completely recalibrated and tuned following the procedure in the applicable sections.

After replacement of an EPROM, the remote possibility exists that the controller will not function correctly. This will be evident by the irregular indication on the display and where normal operation cannot be performed by the keypad controls. Contact the factory for help in these instances.

** NOTE 1 **

> Different numbered EPROMS ARE NOT INTERCHANGEABLE. EPROMS with the same part number but different revision letter and date are interchangeable.

The standard EPROMs used for the models covered by this manual are listed in the table at the beginning of Section 6.

9.3 MEMORY CLEAR PROCEDURE

** NOTE **

This process should only be performed as a last ditch effort to correct the controller display operation. In normal operation the replacement of the EPROM will not cause any problems.

The following procedure must be followed in order to correct the temporary problem caused by replacing the EPROM when the earlier program does not use the same memory locations as the new EPROM.

A) Turn on the controller and follow the procedure to indicate the part or configuration number on the display in the CONFIGURATION/CALIBRATION LOOP. (See Section 6.)

B) Enter the Part Number change code so that the cursor is blinking on and off on the first changeable digit of the part or configuration number.

C) Change the blinking digit using the UP/YES or DOWN/NO keys to zero (Model 2015 to "@"; Models 2003 and 2004 to "A"). Continue through each digit of the part or configuration number to set each of the remaining digits to zero.

D) At this point, while in the CAL LOOP, turn off the AC power to the unit and then reapply power. The controller will now indicate DATA LOST, PLEASE CAL on the display. The controller memory is now cleared.

E) The controller must be RECONFIGURED and RECALIBRATED per Section 6. (Parameters entered by the user in the TUNE LOOP must also be reentered.)

F) If the above procedure does not correct the problem, contact the factory.

9.4 MICROPROCESSOR REPLACEMENT (U1 - CPU BOARD)

The microprocessor chip (U1) is an 8 bit computer chip that utilizes program instructions from the EPROM (U2) and data stored in the RAM integrated circuit (U3) to perform all control and display decisions. The microprocessor device (8031) can be replaced if a failure should occur and can be ordered from the factory by part number 2036-330.

Static discharge precautions should be taken when handling any MOS device. Refer to the MOS STATIC DISCHARGE HANDLING PRECAUTIONS (see Section 1.13.

This device is socket mounted and can be removed with IC extraction tools. When replacing the "µP" be sure that it is correctly oriented and then firmly pressed into its socket.

The controller after reinstallation into its case may have to be recalibrated if the display "DATA LOST - PLEASE CAL" appears, but normally recalibration is not necessary if no other devices other than U-1 were removed.

9.5 BATTERY REPLACEMENT (BT-1 - CPU BOARD)

The CPU board includes as part of the digital microprocessor circuitry, a RAM integrated circuit that is volatile. Unlike the "µP" and the EPROM, the RAM must have a power source at all times to retain its data. An on board long life lithium battery (BT-1) is provided to ensure RAM data retention when the power is turned off or when the external power source has been interrupted. This means that the Series 2000 controller can lose AC supply power without losing its memory.

The nominal 3.0 volt DC battery is soldered onto the CPU board and is capable of many years of reliable service. If a battery should require replacement, the electronics assembly must be removed from the controller case so that the CPU board surface is accessible.

Carefully unsolder the 3 terminals of the battery using a low wattage iron and solder wicking braid to clear the mounting holes.

A new battery can be ordered from the factory (P/N 525-29) and reinstalled onto the printed circuit board. DO NOT SHORT OUT THE TERMINALS OF THE NEW BATTERY DURING REPLACEMENT.

Because of the loss of power to the RAM IC during battery replacement, the display will, in most instances, indicate "DATA LOST-PLEASE CAL". The CONFIGURATION/CALIBRATION and TUNE loops must be repeated in their entirety to reprogram the data into the controller RAM. Follow the instructions in Section 6 and the appropriate INSTALLATION MANUAL (for user data in the TUNE LOOP).

****
* CAUTION *
****

THE DISPOSAL OF LITHIUM CELL BATTERIES REQUIRES SPECIAL PRECAUTIONS. THESE BATTERIES SHOULD NOT BE INCINERATED, CRUSHED OR PUNCTURED SO AS TO RELEASE THE ELECTROLYTE AND EXPOSE POTENTIALLY FLAMMABLE MATERIALS.

9.6 KEYPAD REPLACEMENT

The keyboard panel assembly can be disassembled from the bezel assembly and replaced by the MOD center if found to be faulty.

Remove the electronics assembly from the case and remove the I/O and CPU boards from the MOTHER board assembly. (See Section 1.10.)

Unscrew the two screws on the mother board and carefully unplug the mother and display board as well as the keyboard connector.

Unscrew the two spacer studs from the bezel and carefully remove the keyboard panel. Reassemble the instrument by reversing the above procedure.

9.7 VACUUM DISPLAY REPLACEMENT

The multicolored vacuum display is soldered into the display board and cannot be replaced in the field. The unit must be returned to the factory for repair, or the entire display board replaced. Order part number 1651-1890 for the current version of the display board. Refer to Section 1.3 to determine correct controller version.

9.8 SYSTEM BLOCK DIAGRAM - SERIES 2000 CONTROLLERS

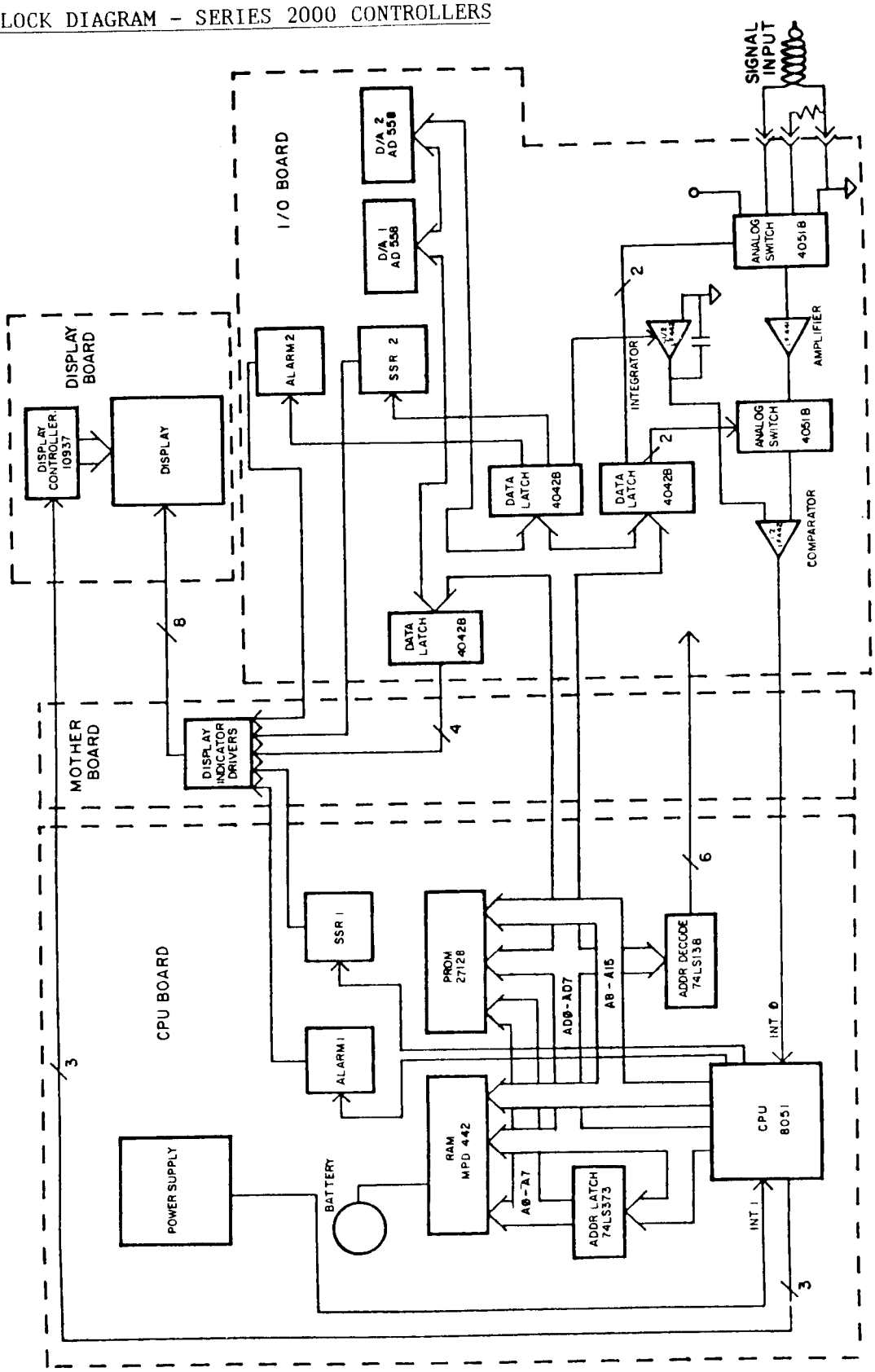


FIGURE 9-1

SECTION 10 - TROUBLESHOOTING GUIDE

10.1 GENERAL

This section along with the calibration information in the previous sections is intended to provide information to aid in diagnosing the cause of failure in the controller as well as a checkout guide after repairs have been performed.

Many failures may result from misoperation rather than actual equipment failure. All connections and settings should be carefully evaluated prior to any troubleshooting on the controller itself.

****
* WARNING *
****

INADVERTENT EXPOSURE TO LINE POTENTIAL IS POSSIBLE. TO INSURE SAFETY IN TROUBLESHOOTING, REMOVE ALL POWER PRIOR TO MAKING CONNECTIONS OF TEST EQUIPMENT OR BEFORE TRACING WIRING ITSELF.

****
* CAUTION *
****

MOS STATIC DISCHARGE HANDLING PRECAUTIONS MUST BE TAKEN IN THE WORK AREA TO PREVENT STATIC DISCHARGES FROM CAUSING DEVICE FAILURES. NO MODIFICATION OR REPAIR SHOULD BE PERFORMED UNTIL PROPER PRECAUTIONS HAVE BEEN TAKEN. (See Section 1.13 - MOS handling precautions)

It is recommended that the electronics package be removed from the controller case for troubleshooting. The use of a calibration connector (LFE P/N 345-826) available from the factory is recommended for easy access to printed circuit board surfaces and components. Further disassembly may be required for removal/replacement of some components.

The test equipment required for troubleshooting should include an oscilloscope to monitor wave forms up to 20 MHz, a high impedance digital voltmeter, and a variable AC power source (variac) of 120±15 VAC. This is in addition to the test equipment prescribed for unit calibration.

The Series 2000 controller includes a digital computer containing high speed memory devices. If a controller begins acting abnormally, the cause may be an erroneous data pattern set into a memory device by a static discharge, electro-magnetic field, or other factor. Such an occurance may damage the data in a controller without actually damaging the controller hardware. The memory clear procedure described in Section 9.3 will erase all data and start the controller in a precalibration mode. This procedure should be attempted on units that act abnormally before trouble-shooting begins.

The last part of this section includes typical waveforms as observed on an oscilloscope. These waveforms are intended to provide an aid to the repair personnel with a good comprehension of modern analog/digital circuits and components. Troubleshooting and repair at the circuit level should not be attempted by unqualified personnel.

10.2 TYPES OF FAILURE

While the unit is still assembled, determine/and or verify the failure mode. Connect the proper type of input sensor and apply power to the unit.

Observe the display:

1. If the display is stable and shows a failure message such as INPUT OPEN, POWER FAILURE, RTC FAILURE, or RAM FAILURE or if the display is flashing the DATA LOST/PLEASE CAL message, refer to the Section 10.3, ERROR MESSAGES.

2. If the display looks normal (Shows a normal OPERATOR LOOP or TUNE LOOP message), determine whether or not the display will respond to the keypad. If keypad response appears normal, proceed to step 3 below. If the display will not respond to the keypad, troubleshoot the keypad circuit.

NOTE: Some features such as Remote Setpoints do disable portions of the keypad. Some models also have an arrow key ON/OFF feature. Check the TUNE LOOP to verify that arrow keys are not turned off.

3. Advance the display so that the process variable is displayed in the OPERATOR LOOP. If the reading appears to be accurate and reacts to input changes, the A/D conversion circuitry is working, proceed to step 4. If the reading does not respond to input changes, or if the reading is changing and inaccurate, verify that the input circuitry and jumpers, the input sensor, and the input part number digits displayable from the CAL LOOP are consistent. If no discrepancies are found, a problem exists in the A/D conversion circuitry on the I/O board. If the reading is changing and inaccurate, the unit may have been stepped through the input calibration sub-loop without applying the calibration voltage. Recalibration with proper equipment should be attempted before assuming a hardware failure.

4. Check the outputs and alarms present in the unit (refer to part number in CAL LOOP) for proper operation. Outputs can be checked by varying the process or alarm setpoints with respect to the process variable. Observe display indicators, check continuity through relay contact, check voltage and current values of analog outputs, check solid state outputs using an AC load. (See Section 7.)

10.3 ERROR MESSAGES

Series 2000 controllers have built in self diagnostic programming that will halt operation in the event of a problem. A list of these is provided below along with the possible causes.

DATA LOST/PLEASE CAL

DATA LOST

This display signals that information has been lost from the RAM circuit on the CPU board. The most common causes of DATA LOST are improper wiring practices (causing noise pickup) and inadequate noise suppression. In rare cases, the fault may be due to a weak battery. To check the battery voltage, remove power from the unit and remove the unit from its case. Measure the battery voltage present on the CPU board at U3 pin 24 to digital ground (A2) using a digital voltmeter across a 1000Ω load resistor. Do not leave the load connected for more than 5 seconds and do not measure more than two times to prevent excessive battery drain. A minimum level of 2.8 VDC is required. If the voltage is low, replace the battery. Recalibration is required whenever DATA LOST appears.

INPUT OPEN

INPUT OPEN

This display indicates that a signal being supplied to the A/D conversion circuitry is out of range. This is probably caused by the input sensor (Thermocouple, RTD, etc.) not being properly connected to the case terminals or by an open circuit in the input sensor wiring.

Try connecting a shorting wire across the input sensor terminals on the rear of the Series 2000 case. If the input open display goes away, the input sensor is defective or not properly connected. If the INPUT OPEN display does not go away, remove the shorting wire and instead, connect it across the cold junction compensator (CJC1 or CJC2), also on the rear of the case. If the INPUT OPEN display goes away (wait at least 30 seconds), replace the CJC assembly (P/N 344-1199) for older controllers or CJC1 on the I/O board for newer controllers.

Check A/D conversion circuitry starting on CPU board at U1-12.

POWER FAILURE

POWER FAILURE

This display signals that the half wave rectified AC voltage produced from the secondary transformer winding supplying the 5 volt power supply on the CPU board is low. This is probably caused by the amplitude of the AC power source voltage being too low. Power source voltage must be 117 VAC ±10% for proper operation.

Check for signal on CPU board at U1-13 (Refer to waveform section).

RTC FAILURE

RTC FAILURE

This display should appear on power up if the AC power source voltage is too low or if the real time clock interrupt circuit is defective. Check signals on CPU board at U1-4 and U1-13 (Refer to waveform Section 10.6).

RAM FAILURE

RAM FAILURE — This display should appear on power up if the unit is unable to write to and/or read from the CPU RAM (memory) chip (U3). This is probably caused by a defective RAM circuit. Check signals on the CPU board.

10.4 POWER SUPPLY VOLTAGES

CPU BOARD

AC INPUT=117VAC (220V or 240V if alternate transformer is installed)

DESIGNATION	MEASURING POINT	VOLTAGE RANGE
+9 VDC	P7-1	+7.5 to +10.5 VDC
DIGITAL (+5VDC)	P7-5	+4.75 to +5.25 VDC
ANALOG (+18 VDC)	P7-3	+14.5 to +20.0 VDC
ANALOG (-18 VDC)	P7-2	-21.0 to -14.5 VDC
ANODE SUPPLY (-35 VDC)	P1-43	-35 VDC
FILAMENT SUPPLY(3.05 VAC)	T1-5 to T1-8	2.6 to 3.4 VRMS

I/O BOARD	MEASURING POINT	VOLTAGE RANGE
+5 VDC	VR3/C21 JCTN	+4.75 to 5.25 VDC
+12 VDC	VR1/C13 JCTN	+11.4 to +12.6 VDC
-12 VDC	VR2/C19 JCTN	-12.6 to -11.4 VDC

If the voltages are out of tolerance, further investigation and repair is required.

NOTE: All voltages are referenced to power supply ground (T1-11) unless otherwise indicated.

10.5 WAVEFORM REFERENCE

The oscilloscope waveforms illustrated are dependent upon the input signal type and amplitude as well as keyboard functions such as START/STOP. In addition, a DATA LOST/PLEASE CAL display will affect the typical waveform shown.

CPU BOARD WAVEFORMS AND TEST POINTS

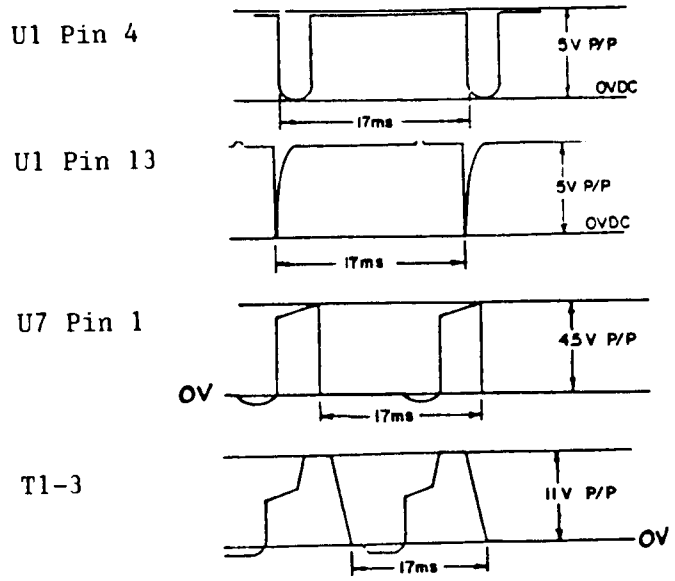
10.5.1 RAM FAILURE DISPLAY

U3 Pin 24 (Vcc)

With AC power applied, the DC level should be +5 VDC. With no AC power, battery voltage should be a minimum of 2.8VDC. If below this level the battery must be replaced. Check Q1 and CR4 for short or open if U3-Pin 24 is not correct.

Verify that U3 ground (Pin 12) is at 0 VDC potential.

10.5.2 POWER FAILURE OR RTC FAILURE DISPLAY (Real Time Clock)



10.5.3 DATA LOST - PLEASE CAL DISPLAY

If the controller display does not hold calibration following a power interruption, then check the following voltage levels and waveforms in the designated section of the manual.

A) BT1 - Battery Circuit - RAM FAILURE Section.
B) Q2 - Emitter Circuit - RAM FAILURE Section.

10.5.4 DISPLAY IS ERRATIC

If the display is changing continuously and or shows an unreadable message, then the following points must be monitored with the oscilloscope to observe that a good logic signal appears on each line. Also check VCC and GND for each IC. The waveform will vary depending upon the input type and the key pressed. If a logic waveform is not present investigate and locate the source of the problem. Check ribbon cable between the I/O and the CPU boards.

U1 - Pin 9 (RST) Reset Pulse/U7 - Pin 4

Pulse starts as DC level at OVDC with no AC power applied, as the AC power is applied increases to an approximate +2.8 VDC level then will drop back to a OVDC level as the AC power input level goes above a safe level for normal controller operation.

U7 - Pin 3

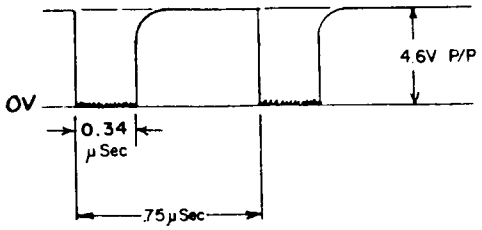
Pulse starts at OVDC level with no AC power then steadily increases to a +4.OVDC level at 120 VAC power input.

10.5.5 DISPLAY STABLE, BUT WRONG

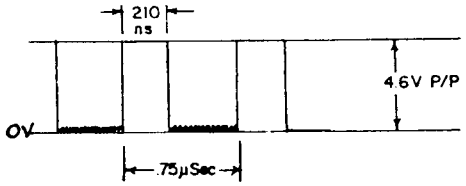
Check ribbon cable between the I/O and the CPU boards. Monitor the following points and note that the waveform indicated appears. If not, investigate and correct.

CAUTION: DO NOT PROBE U1 - Pin 18. This is a very high impedance point. The added capacitance of the scope prove MAY temporarily load down the 8 MHZ oscillator and cause display "DATA LOST/PLEASE CAL" to appear.

U1 - Pin 29 (PSENL)



U1-Pin 30 (ALE)



Verify that logic signals are present at each address and data line on IC1 to IC4.

AD0 to AD7
A0 to A13
D0 to D7

U5 IC (Address Decoder) - Chip Select Outputs

Verify that logic signals are present at U5 Pins 12 to 15. These pulses can vary from line to line depending upon the PART NUMBER as well as keypad functions. (CS4L to CS6L are nonfunctioning).

ALARM 1 INDICATOR (ALM1L) P1 - Pin 44 Connector

If the display ALM 1 lamp does not illuminate when the ALARM 1 display is exercized with the arrow keys, check the following:

U7 Pin 5 - LAMP ON WHEN HI (+4.2 VDC)
U7 Pin 5 - LAMP OFF WHEN LO (OVDC)
U7 Pin 6 - LAMP OFF WHEN HI
U7 Pin 6 - LAMP ON WHEN LO
U10 Pin 9 - LAMP ON WHEN HI (+4.2 VDC)
U10 Pin 9 - LAMP OFF WHEN LO (OVDC)

If lamp circuit is operational but relay (K1) is not switching, check U9 opto-isolator circuit.

ALARM 2 INDICATOR (ALM2L) P2 - Pin 43 Connector

If ALM2 lamp does not illuminate when ALARM 2 display is exercised with the arrow keys, check the following:

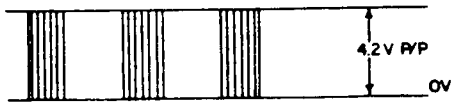
U1 - Pin 10 - LAMP is OUT when HI (+4.2 VDC)(Q7 Collector is LO)
U1 - Pin 10 - LAMP is ON when LO (O VDC)(Q7 Collector is HI)

If lamp circuit is operational, but relay is not switching check Q7 and U8 circuit as well as relay circuit (K1)

DISPLAY RESET U1 - Pin 14 (DRSTL)

DRSTL is initially LO (OVDC) when AC power is first applied, then pulse up to HI (+5 VDC) and remains there until AC power is removed.

U1 - Pin 10 (DISPLAY DATA)



U1 - Pin 11 (DSCKH) Display Serial Clock to Display Board
Same essential waveform as U1 - Pin 10 above.

OUT1L (SSR1 OUTPUT INDICATOR LAMP)

Display OUT 1 XX% and in MANUAL (MAN lamp on) vary the percentage output with the arrow keys above and below setpoint.

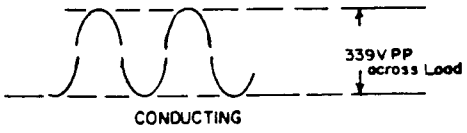
U10 Pin 2 is LO - LAMP IS ON (OVDC)
U10 Pin 2 is HI - LAMP IS OFF (+4.2 VDC)
U10 Pin 3 is LO - LAMP IS ON (OVDC)
U10 Pin 3 is HI - LAMP IS OFF (+4.2 VDC)

If logic levels are correct and indicator lamp does not operate, refer to Display and Mother Board Sections.

P8 Pins 4 and 5 Connector - SSR1 OUTPUT

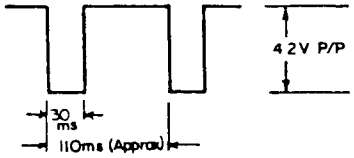
Connect the AC load appropriate to the triac (terminals P8 - 4+5). Use standard troubleshooting procedures to check out the solid state relay circuit.

WAVEFORM ACROSS OUTPUT TERMINALS WHEN SSR1 IS OFF.



10.6 I/O BOARD WAVEFORMS AND TEST POINTS

START CONVERSION PULSE (STCONL) U1 - Pin 2



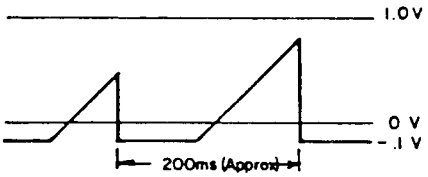
OUT2L (SSR2 OUTPUT INDICATOR LAMP) (U11-Pin 2)

At U11 - Pin 2 monitor. Press DISPLAY key until OUT2 % appears and in MANUAL (MAN lamp on). Vary the percentage output with the arrow keys above and below setpoint.

U11 - Pin 2 is LO - OUT2 Lamp is ON
U11 - PIN 2 is HI - OUT2 Lamp is OFF

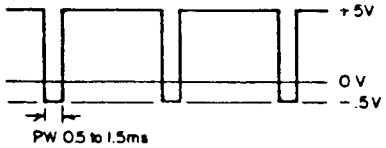
If logic levels are correct and indicator lamp does not operate refer to Mother and Display Board Troubleshooting Sections.

R27/R28 Junction - Integrator Ramp



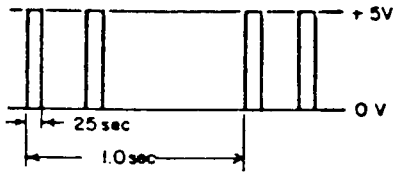
NOTE: The amplitude and width of this Ramp depends upon the signal input type and the voltage or temperature input level.

CR5/CR6 Junction INTOL Comparator Output



Pulse rep. rate APPROX. 250 ms.

U2 - Pin 1 & Pin 11 (ASW1B) Analog Switch



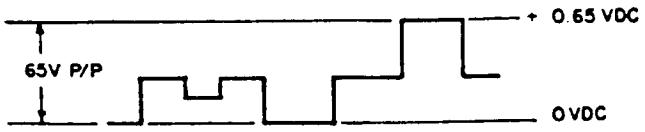
(No signals on Pins 2 & 10)

INDICATOR LAMP DISPLAYS

U14 - Pin 2 - REML (Remote Indicator)
U14 - Pin 10 - TUNL (Tune Indicator)
U14 - Pin 11 - CALL (Calibrate Indicator)
U14 - Pin 1 - MANL (Manual Indicator)

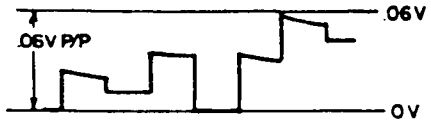
The display lamp indicators may be checked for each of the above functions by setting in the appropriate part number for pressing the appropriate key(s). If the signal (logic level) is correct and the indicator still does not work refer to the Mother Board and Display Board troubleshooting sections.
For the above (U14 - Pin 1 - MAN, Pin 2 - REM, Pin 10 - TUN, when LAMP is ON - Logic level is LO (OVDC) Pin 11 - CAL. When LAMP is OFF - Logic level is HI (+5 VDC)

U6 - Pin 6 (IN1) Analog Switch



Pulse Amplitude increases as signal input level increase.

U9 - Pin 3 (OUT/IN) Analog Switch



Pulse amplitude increases as signal input level increases.

ANALOG SWITCH INPUT - U9

U9 - Pin 13 - (IN1) - Varies with SIGNAL INPUT
U9 - Pin 14 - Approx. +15 mV level
U9 - Pin 14 - Approx. +49 mV level (REFERENCE)

+2.45 VDC at R5/R6 Junction
-2.45 VDC at Z2/R19 Junction

10.6.1 ANALOG OUTPUT 1/ANALOG OUTPUT 2 WITH 4/20 mA OUTPUT CIRCUITRY

U3 or U4 - Pin 16 (Vout)

0 to +3 VDC (Approx.) output level as output current is changed from 4 mA to 20 mA DC.

CONNECT DIGITAL VOLTMETER ACROSS R30 RESISTOR.

DC voltage level can vary from 0.8 V to +4 VDC as input current is changed 4 to 20 mA DC.

Connect 1000Ω 1/4W resistor across rear terminals P9-E and P9-D (OUT 2) (I/O Board Analog Output) and a 1000Ω resistor across P8 - Pin 4 and P5. (CPU Board Output). (OUT1)

With either OUT1 or OUT2 on the display, vary the percentage OUTPUT with the arrow keys and note that the OUTPUT changes from +4V to +20 VDC (Approx.)

10.6.2 SOLID STATE RELAY OUTPUT 2 CIRCUIT

With the display in OUT2 XX% and MAN indicator ON vary the percentage OUTPUT with the arrow keys.

Q6 Base switching from OVDC to +0.75 VDC
Q6 Collector switches from +4.2 VDC with 0%
OUT TO 2.0 VDC as % OUT is increased
Then the OUT 2 lamp will illuminate

P9 Pins D and E (SSR2) REAR TERMINAL CONNECTORS

Connect appropriate AC load to the output terminals (1AMP or 50 mA) and check out the circuit.

10.7 MOTHER BOARD TEST POINTS

The Mother Board is the interconnect junction for each of the 4 electronic assemblies. The 8 transistors driving the indicator for each of the following functions are located on this board:

CAL - Q1	OUT2 - Q5
TUN - Q2	ALM2 - Q6
MAN - Q3	OUT1 - Q7
REM - Q4	ALM1 - Q8

If the logic signal level is normal on P1 or P2 connector and the indicator lamp does not operate trace the signal through RN1 resistor network to the base and then collector Q1 - Q8 transistor to the display board connector - P6.

Q1 - Q8 TRANSISTOR COLLECTOR

LAMP ON = +5 VDC
LAMP OFF = -38 VDC

10.8 KEYPAD CIRCUIT (P4 Connector)

P4 - Pins 5 and Pin 6 (KRO, KR1) Connector

Pulses will ALWAYS be present on KRO and KR1 and Pins 5 and 6 of P4 connector.

No pulses should appear at P4 Pins 1 to 4 until a key is pressed. KRO and KR1 timing interval is different.

P4 Connector - Keypad Input

PRESS	PULSES APPEAR AT P4
DISPLAY OR LAST	- Pin 4 (KC3)
NO or START/STOP/RESET/AUTO	- Pin 3 (KC2)
YES or AUTO/MANUAL/PAUSE/PARAM	- Pin 2 (KC1)
PARAM CHK OR RETURN	- Pin 1 (KC0)

If pulses do not appear as indicated then perform a continuity check with P4 removed and the AC power off. Replace keypad if defect is verified.

10.9 COMMUNICATION TROUBLESHOOTING

The repair of a communications board is a factory procedure. However, schematics and parts lists have been provided. Most problems with the communications option result from the installation. To aid in troubleshooting the application, the following most common installation faults are listed:

1. Make sure that the format switches on the COMM board have been set with the baud rate, parity, handshake and unit address to match the host. Refer to the installation manual for setting information.

2. Make sure that the line drop in the leads from the external power supply for isolated communications to the Series 2000 controller is not excessive and that the pulse levels at the recievers are sufficient to be recognized.

3. Communication leads can pick up noise which may be interpeted as data bits. Refer to Section 10.10 for suggestions on noise suppression, lead cabling and shielding.

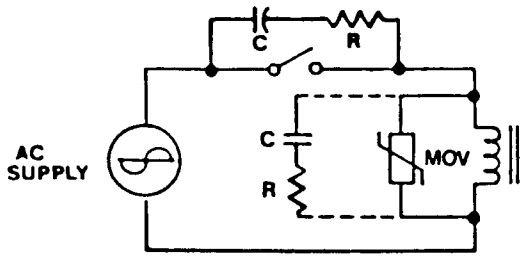
4. A confusion exists between Data Communication Equipment (DCE) and Data Terminal Equipment (DTE). Recheck the communications connections. If the controller still does not communicate, it is suggested that the Series 2000 controller have the handshake turned off, the DATA SET READY and DATA TERMINAL READY leads tied high at the host and the SEND DATA and RECEIVE DATA leads interchanged to see if the controller will recognize signals. If it does, the handshaking can be turned back on (if needed) and then try interchanging the following sets of leads to determine the correct connections.

   REQUEST TO SEND and CLEAR TO SEND
   DATA SET READY and DATA TERMINAL READY

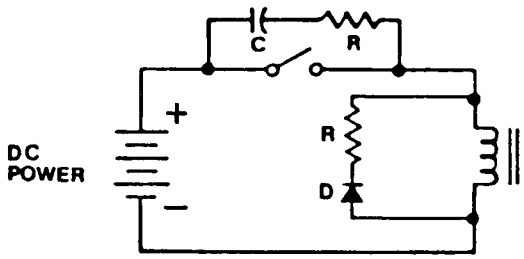
5. The controller does not reject data in an incorrect format. Recheck the data format to ensure that the data is being sent correctly.

10.10 NOISE SUPPRESSION

The primary sources of electrical interference (EMI) that can impact any microprocessor controller are inductors most commonly found as coils and windings in relays, transformers and solenoids or arcs resulting from welding equipment or across opening contacts. It is important to suppress any potential for electrical noise at its source to ensure reliable operation of controllers and other electronic equipment. If a particular application causes the controller to act strangely, the entire system must be evaluated for noise producers and suitable suppression devices installed.



NOISE SUPPRESSION
AC CIRCUITS



NOISE SUPPRESSION
DC CIRCUITS

In most cases, RC supressors should be used across inductive loads and for arc supression. MOV's may be used across supply lines and power transformers. If the necessary components are not readily available, they may be purchased in kit form from the factory.

KIT	ITEM	MAX AC	RATING
1821-100	RC KIT	240 VAC	0.1μF/220Ω/47Ω
1821-98	MOV KIT	130 VAC	35 Joules
1821-99	MOV KIT	250 VAC	70 Joules

Low level signal leads and high voltage power cables MUST not be run in the same conduit or cable tray. Care when wiring means better system reliability.

When wiring to the controller, twisted pair with insulated shield is recommended for all signal leads. Make sure that the shield is grounded ONLY AT THE CONTROLLER. Be sure to protect against ground loops in signal leads, shields and all other input and output wiring.

SECTION 11 - CHECKLIST

Before shiping any controller that has been modified or recalibrated, make sure that:

1) APPLICATION CONFIGURATION agrees with customer specifications.

2) CASE and PART NUMBER labels include all modifications made including SPAN (and CAL values for voltage or current Inputs).

3) EPROM and uP are firmly in their sockets.

4) I/O and CPU boards are firmly in their bezel assembly connectors.

5) Spacer rod(s) between I/O and CPU boards is firmly in place.

6) All other plug-in connections are tight.

7) Electronic assembly is properly mounted in the case, right side up and snug.

8) Rear terminal screws (see note) are in place. Cold Junction resistor in place on thermocouple input units or removed from RTD and DC input units.

9) Older units with the cold junction thermocouple compensator mounted on the rear case terminals, have the same cold junction resistor installed on the rear that was used for input calibration.

10) All control functions and outputs have been properly tested. (See section 7).

** NOTE **

MOST REAR TERMINAL SCREWS ARE IN A SEPARATE KIT AND NOT INSTALLED AT THE FACTORY.

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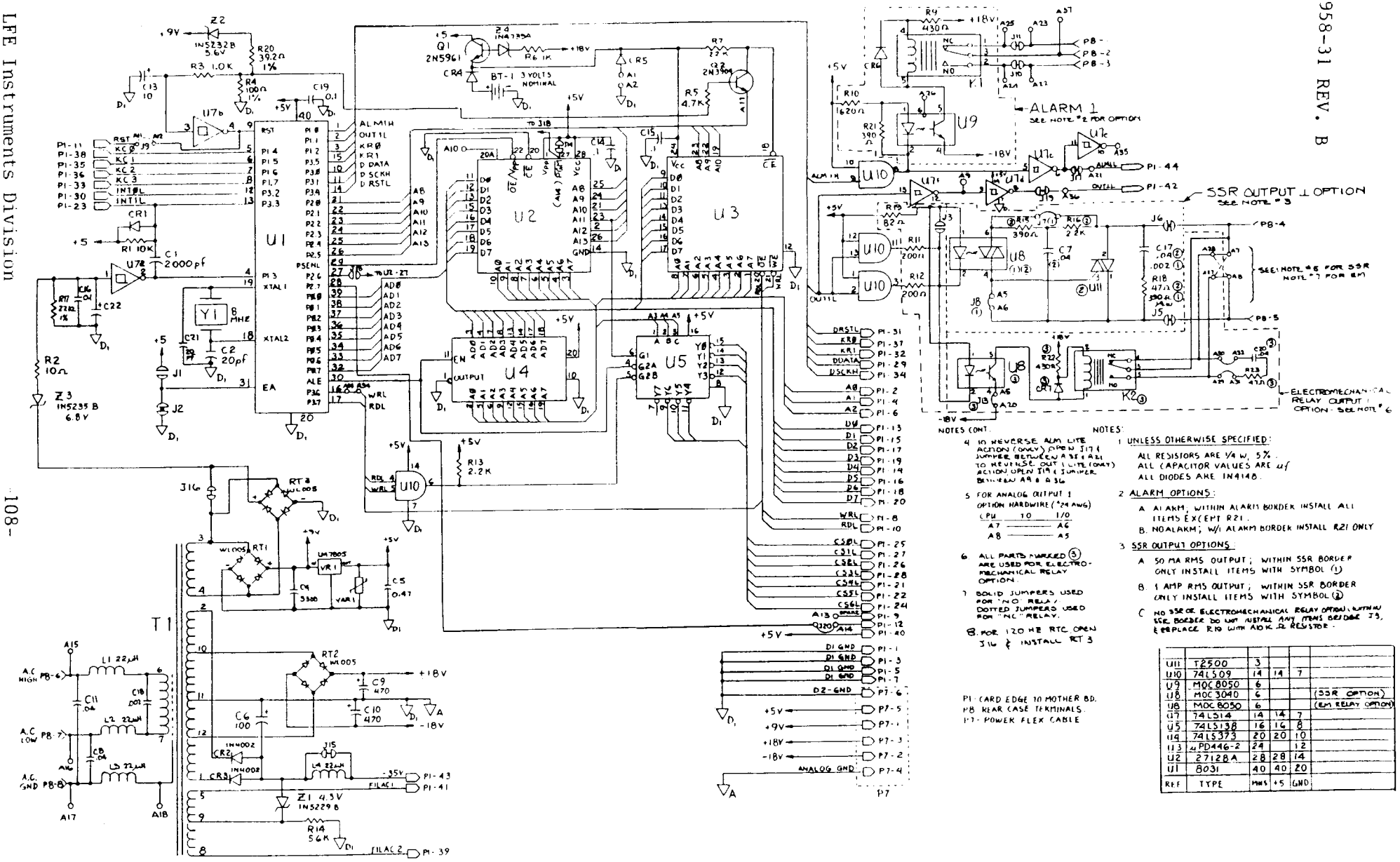
SECTION 12

SCHEMATICS

LAYOUTS

ELECTRONIC PARTS LISTS

(SEE FIGURE 1-1 FOR MECHANICAL PARTS LISTS)



NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   ALL RESISTORS ARE 1/4 W, 5%.
   ALL CAPACITOR VALUES ARE uf
   ALL DIODES ARE IN4148.
2. ALARM OPTIONS:
   A. ALARM; WITHIN ALARM BORDER INSTALL ALL ITEMS EXCEPT R21.
   B. NO ALARM; W/I ALARM BORDER INSTALL R21 ONLY
3. SSR OUTPUT OPTIONS:
   A. 50 MA RMS OUTPUT; WITHIN SSR BORDER ONLY INSTALL ITEMS WITH SYMBOL (1)
   B. 1 AMP RMS OUTPUT; WITHIN SSR BORDER ONLY INSTALL ITEMS WITH SYMBOL (2)
   C. NO SSR OR ELECTROMECHANICAL RELAY OPTION; WITHIN SSR BORDER DO NOT INSTALL ANY ITEMS BESIDE J3, & REPLACE R10 WITH A 10K Ω RESISTOR.
4. TO REVERSE ALM LITE ACTION (ONLY) OPEN J17 & JUMPER BETWEEN A35 & A21 TO REVERSE OUT 1 LITE (ONLY) ACTION OPEN J19 & JUMPER BETWEEN A9 & A36
5. FOR ANALOG OUTPUT 1 OPTION HARDWIRE (#24 AWG)

CPU	TO	I/O
A7		A6
A8		A5

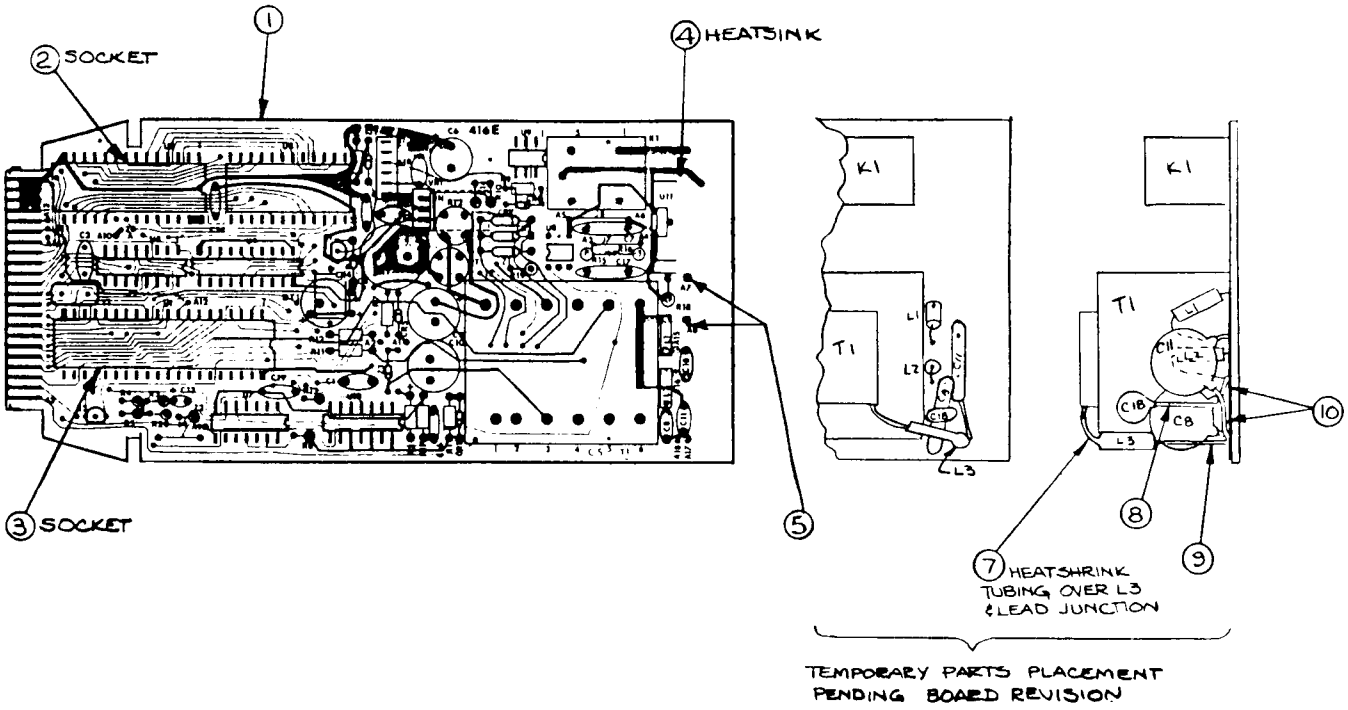
6. ALL PARTS MARKED (3) ARE USED FOR ELECTRO-MECHANICAL RELAY OPTION.
7. SOLID JUMPERS USED FOR "NO" RELAY. DOTTED JUMPERS USED FOR "NC" RELAY.
8. FOR 120 HZ RTC OPEN J16 & INSTALL RT3

NOTES CONT.

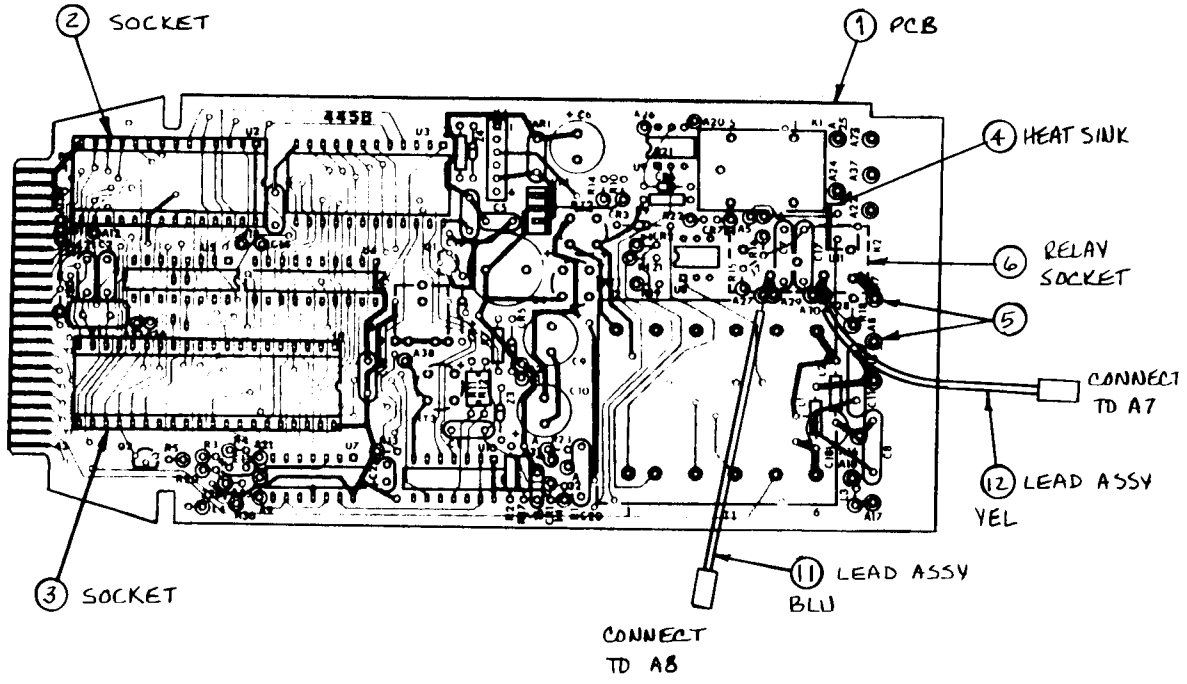
U11	T2500	3		
U10	74LS09	14	14	7
U9	MOC8050	6		
U8	MOC3040	6		(SSR OPTION)
U8	MOC8050	6		(EM RELAY OPTION)
U7	74LS14	14	14	7
U5	74LS138	16	16	8
U4	74LS373	20	20	10
U13	μPD446-2	24		12
U2	27128A	28	28	14
U1	8031	40	40	20
REF	TYPE	MMS	+5	GND

SCHEMATIC - CPU BOARD
FIGURE 12-1

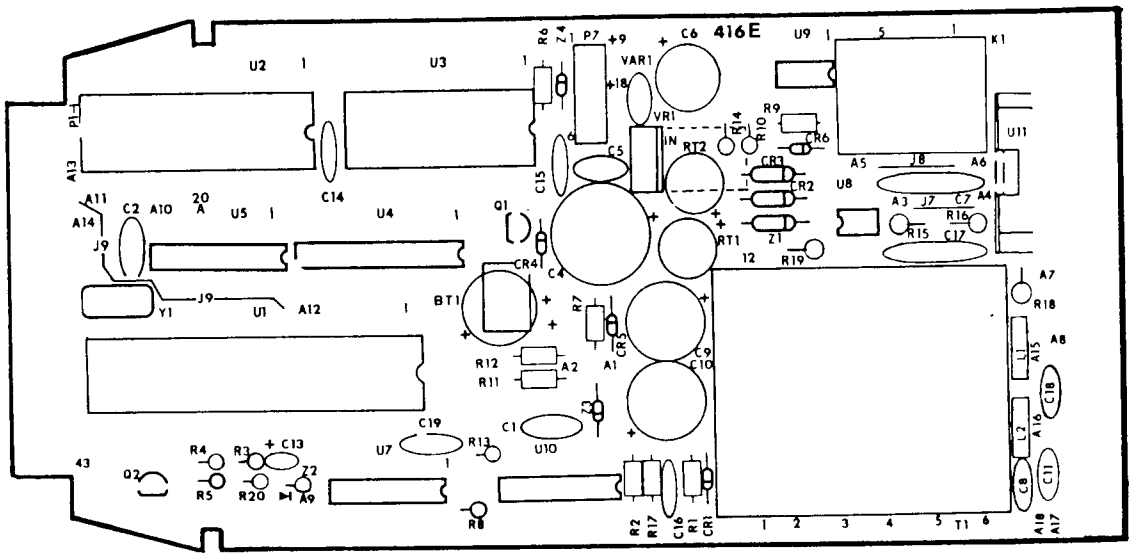
2757-127 REV P



CPU BOARD OUTLINE - EARLY VERSION
FIGURE 12-2 1653-247 REV B

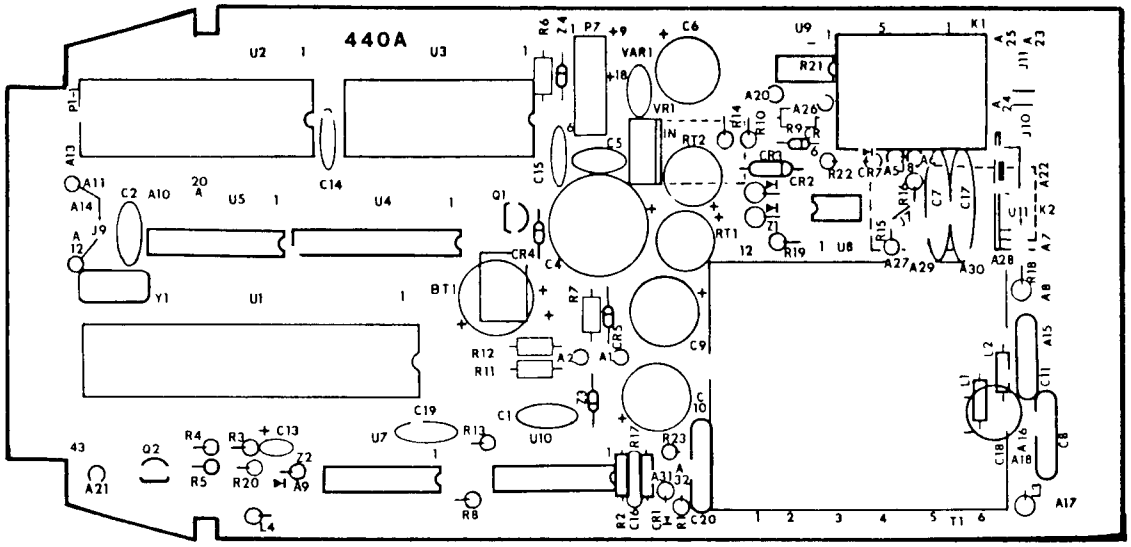


CPU BOARD OUTLINE - LATER VERSION
FIGURE 12-3 1653-269 REV B



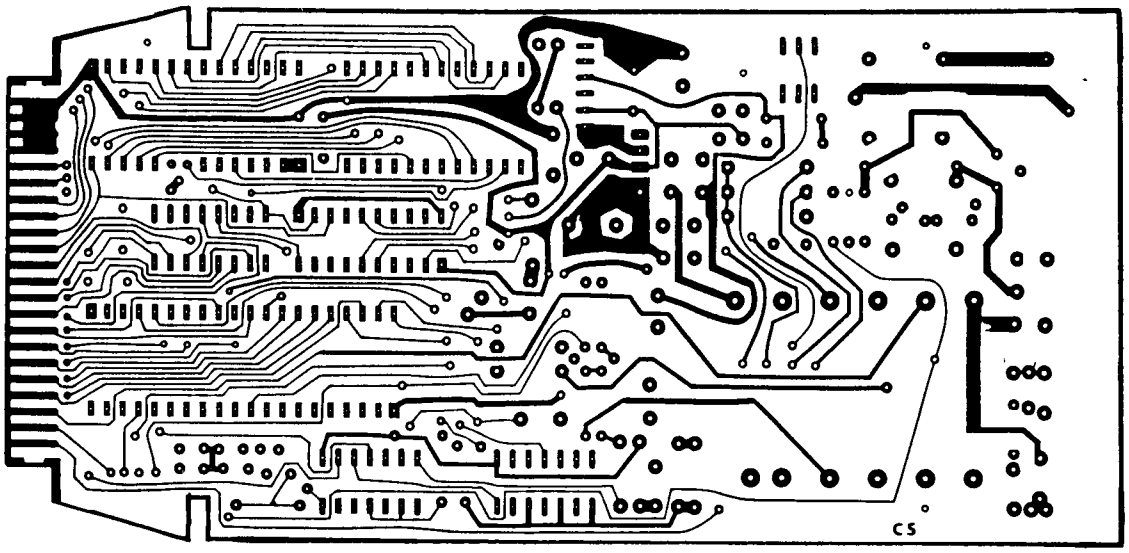
CPU BOARD COMPONENT LAYOUT - EARLY VERSION
FIGURE 12-4

1977-416 REV E

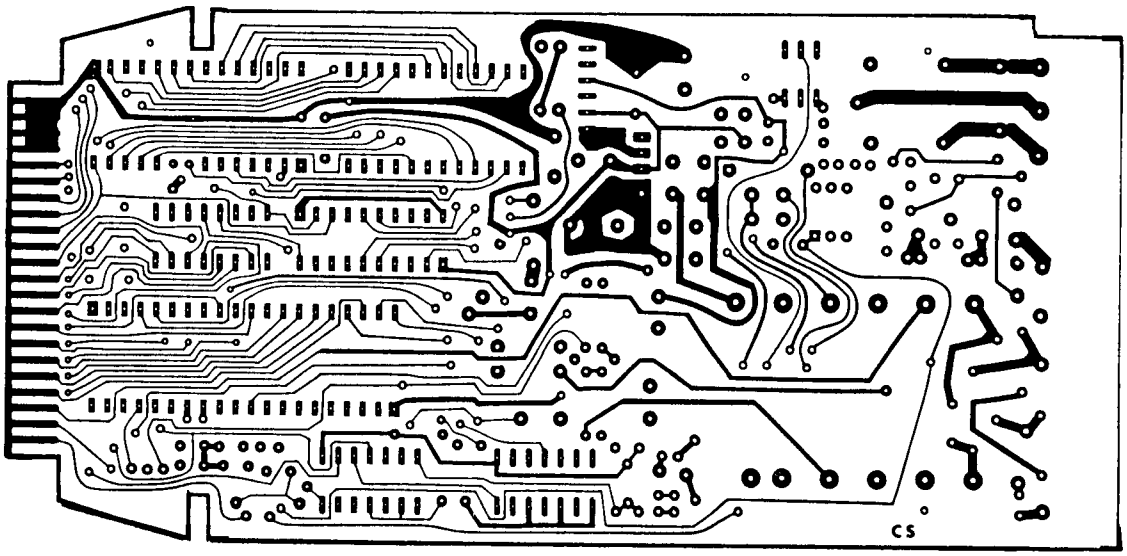


CPU BOARD COMPONENT LAYOUT - LATER VERSION
FIGURE 12-5

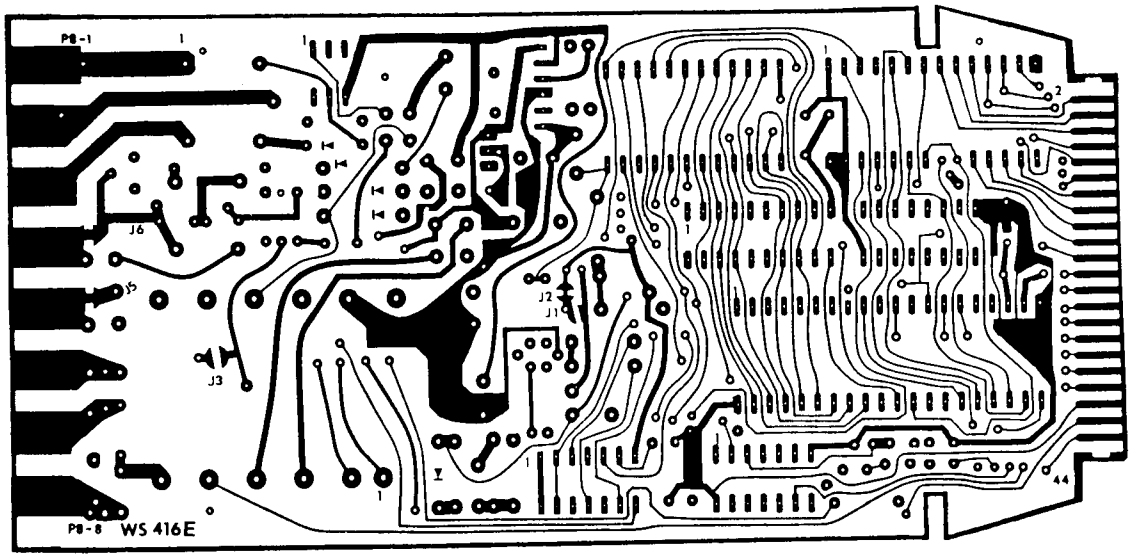
1977-440 Rev A



CPU BOARD - COMPONENT SIDE
SOLDER BRIDGING - EARLY VERSION 1649-416 REV E
FIGURE 12-6

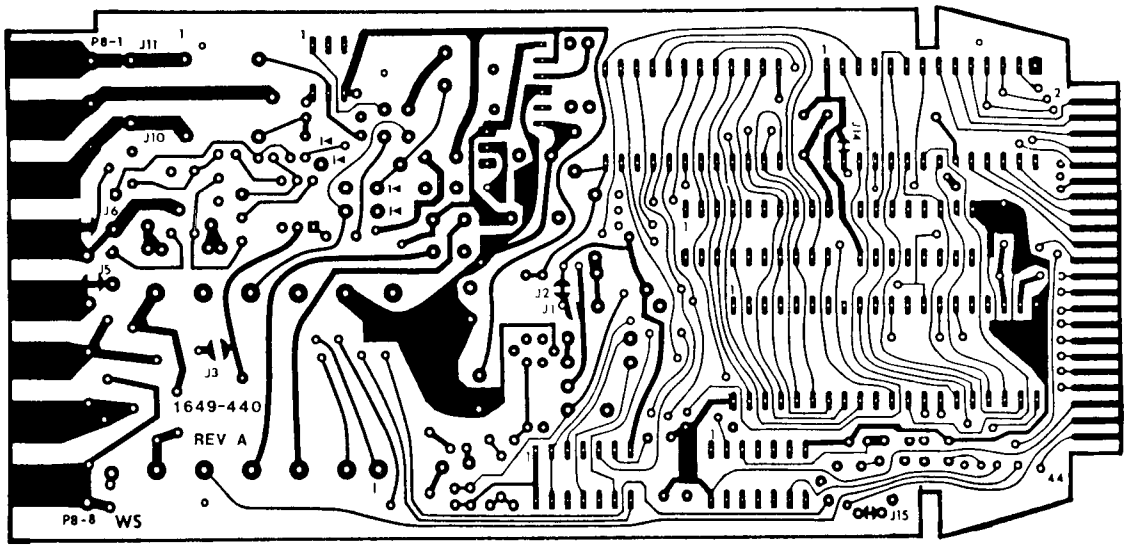


CPU BOARD - COMPONENT SIDE
SOLDER BRIDGING - LATER VERSION 1649-440
FIGURE 12-7



CPU BOARD - SOLDER SIDE
SOLDER BRIDGING - EARLY VERSION
FIGURE 12-8

1649-416 REV E



CPU BOARD - SOLDER SIDE
SOLDER BRIDGING - LATER VERSION
FIGURE 12-9

1649-440 REV A

ITEM	PART NUMBER	COLUMN / DESCRIPTION	A QTY	B QTY	C QTY	D QTY	E QTY	F QTY	G QTY	H QTY
2	345-771	SOCKET - 28 PIN	1	1	1	1	1	1	1	1
3	345-774	SOCKET - 40 PIN	1	1	1	1	1	1	1	1
4	1951-125	HEATSINK	1	0	0	0	1	0	0	0
BT1	525-29	BATTERY	1	1	1	1	1	1	1	1
C1	305-165	CAP-2000 pF	1	1	1	1	1	1	1	1
C2,C21	307-108	CAP-20 pF	2	2	2	2	2	2	2	2
C4	305-438	CAP-3300 µF-16V	1	1	1	1	1	1	1	1
C5	305-250	CAP-0.47 µF	1	1	1	1	1	1	1	1
C6	305-441	CAP-100 µF-50V	1	1	1	1	1	1	1	1
C7	305-97	CAP-.04 µF-600V	1	0	0	0	1	0	0	0
C8,C11	305-97	CAP-.04 µF	2	2	2	2	2	2	2	2
C9,C10	305-437	CAP-470 µF-25V	2	2	2	2	2	2	2	2
C13	305-93	CAP-10 µF-10V	1	1	1	1	1	1	1	1
C14,C15,C16,C19	305-153	CAP-0.1 µF-10V	4	4	4	4	4	4	4	4
C17	305-97	CAP-.04 µF-600V	1	0	0	0	1	0	0	0
C17	305-439	CAP-0.002 µF-125VAC	0	0	1	0	0	0	1	0
C18	305-439	CAP-0.002 µF-125 VAC	1	1	1	1	1	1	1	1
C22	305-340	CAP-4.7 µF	1	1	1	1	1	1	1	1
CR1,CR4	1811-276	DIODE-1N4148	2	2	2	2	2	2	2	2
CR6	1811-276	DIODE-1N4148	0	0	0	0	1	1	1	1
CR2,CR3	1811-282	DIODE-1N4004	2	2	2	2	2	2	2	2
J7,J8	1835-106	JUMPER	0	0	2	0	0	0	2	0
K1	1819-146	RELAY	0	0	0	0	1	1	1	1
K2	1819-153	RELAY	0	0	0	1	0	0	0	1
L1,L2,L3	2060-229	CHOKE	3	3	3	3	3	3	3	3
P7	300-220	CABLE-6 CONDUCTOR	1	1	1	1	1	1	1	1
Q1	2036-334	TRANSISTOR-2N5961	1	1	1	1	1	1	1	1
Q2	2036-76	TRANSISTOR-2N3904	1	1	1	1	1	1	1	1
R1	1846-14	RES-10K 1/4W 5%	1	1	1	1	1	1	1	1
R2	1846-11	RES-10Ω 5%	1	1	1	1	1	1	1	1
R3,R6	1846-13	RES-1K 1/4W 5%	2	2	2	2	2	2	2	2
R4	1849-12	RES-100Ω 1/8W 1%	1	1	1	1	1	1	1	1
R5	1846-472	RES-4.7K 5%	1	1	1	1	1	1	1	1
R7	1846-223	RES-22K 5%	1	1	1	1	1	1	1	1
R8	1846-222	RES-2.2K 5%	1	1	1	1	1	1	1	1
R9	1846-431	RES-430Ω 5%	0	0	0	0	1	1	1	1
R10	1846-621	RES-620Ω 5%	1	1	1	1	1	1	1	1
R11,R12	1846-22	RES-200Ω 5%	2	2	2	2	2	2	2	2
R13	1846-222	RES-2.2K 5%	1	1	1	1	1	1	1	1
R14	1846-562	RES-5.6K 5%	1	1	1	1	1	1	1	1
R15	1846-391	RES-390Ω 5%	1	0	0	0	1	0	0	0
R16	1846-222	RES-2.2K 5%	1	0	0	0	1	0	0	0
R17	1849-2210	RES-221Ω 1%	1	1	1	1	1	1	1	1
R18	1822-470	RES-47Ω 5%	1	0	0	0	1	0	0	0
R18	1822-391	RES-390Ω 5%	0	0	1	0	0	0	1	0
R19	1846-820	RES-82Ω 5%	1	0	1	1	1	0	1	1
R19	1846-14	RES-10K 5%	0	1	0	0	0	1	0	0
R20	1849-3929	RES-39.2Ω 1%	1	1	1	1	1	1	1	1
R21	1846-391	RES-390Ω 5%	1	1	1	1	0	0	0	0
RT1,RT2	1811-279	RECTIFIER-WL005	2	2	2	2	2	2	2	2
T1	2060-283	POWER TRANSFORMER	1	1	1	1	1	1	1	1

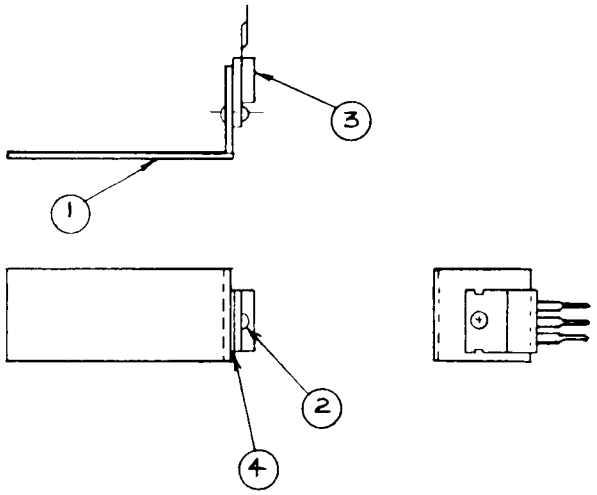
(continued on next page)

ITEM	PART NUMBER	DESCRIPTION	COLUMN	A QTY	B QTY	C QTY	D QTY	E QTY	F QTY	G QTY	H QTY
U1	2036-330	uP-8031		1	1	1	1	1	1	1	1
U3	2036-326	RAM-PD446		1	1	1	1	1	1	1	1
U4	2036-311	IC-74LS373		1	1	1	1	1	1	1	1
U5	2036-313	IC-74LS138		1	1	1	1	1	1	1	1
U7	2036-325	IC-74LS14		1	1	1	1	1	1	1	1
U8	2036-320	IC-MOC3040		1	0	1	0	1	0	1	0
U8	2036-328	IC-MOC8050		0	0	0	1	0	0	0	1
U9	2036-328	IC-MOC8050		0	0	0	0	1	1	1	1
U10	2036-314	IC-74LS09		1	1	1	1	1	1	1	1
U11	1811-458	TRIAC-T2500D		1	0	0	0	1	0	0	0
VAR1	1811-461	VARISTOR		1	1	1	1	1	1	1	1
VR1	344-1194	REGULATOR ASSY		1	1	1	1	1	1	1	1
Y1	388-2	CRYSTAL-8mHz		1	1	1	1	1	1	1	1
Z1	1811-274	ZENER-1N5229B		1	1	1	1	1	1	1	1
Z2	1811-260	ZENER-1N5232B		1	1	1	1	1	1	1	1
Z3	1811-460	ZENER-1N5235B		1	1	1	1	1	1	1	1
Z4	1811-184	ZENER-1N4739A		1	1	1	1	1	1	1	1

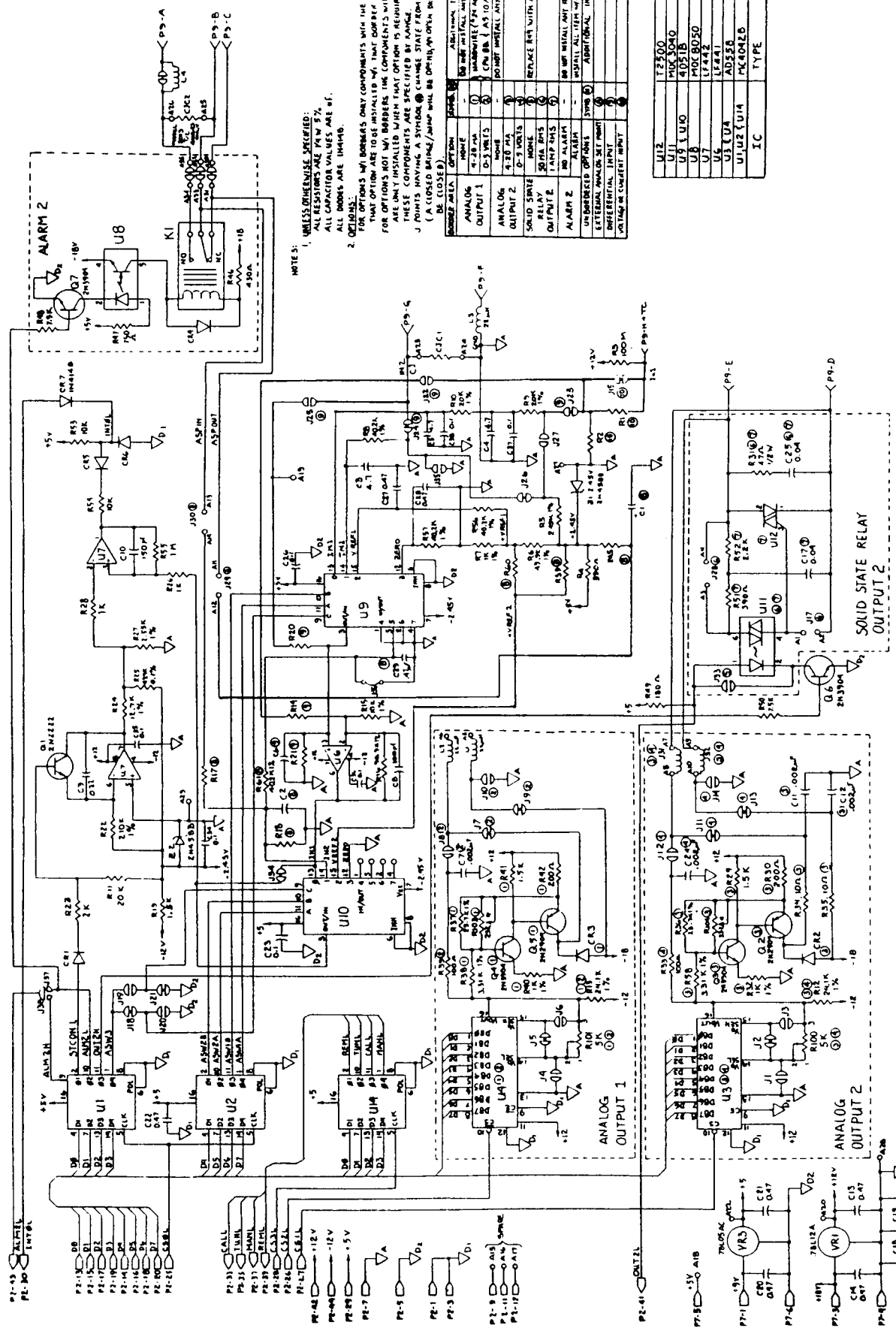
COLUMN	DESCRIPTION	PCB PART NUMBER W/SOLDER CONTACTS	PCB PART NUMBER W/GOLD CONTACTS
A	W/1A SSR1-W/O ALM1	1651-1909	1651-2076
B	W/O SSR1-W/O ALM1	1651-1910	1651-2077
C	W/50mA SSR1-W/O ALM1	1651-1911	1651-2078
D	W/5A RY2-W/O ALM1	1651-1972	1651-2080
E	W/1A SSR1-W/ALM1	1651-1904	1651-2072
F	W/O SSR1-W/ALM1	1651-1905	1651-2073
G	W/50mA RRS1-W/ALM1	1651-1906	1651-2074
H	W/5A RY2-W/ALM1	1651-1973	1651-2081

BILL OF MATERIAL - CPU BOARD
FIGURE 12-10

ITEM	PART NO.	DESCRIPTION
1	1951-130	HEAT SINK
2	1850-59	RIVET
3	2036-138	IC-7805
4	1241-167	THERMAL COMPOUND

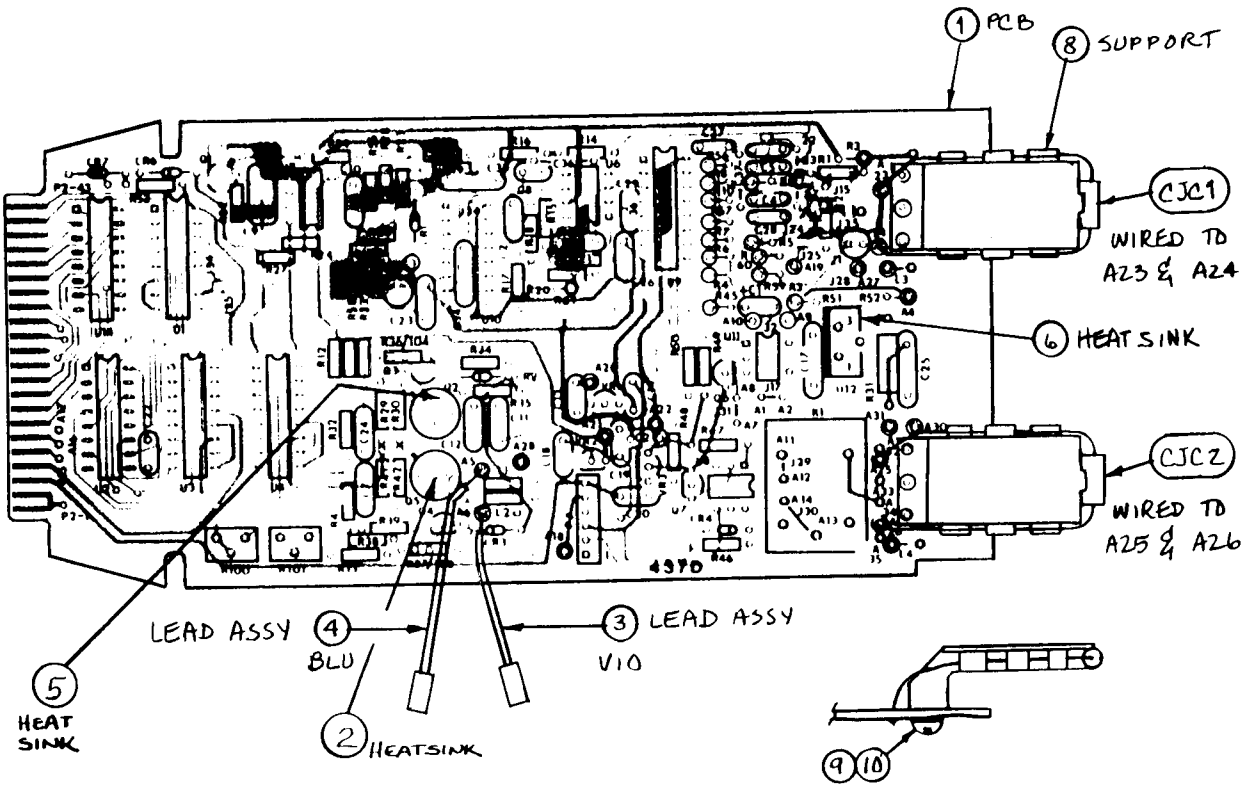


P/N 344-1194
VR1 VOLTAGE REGULATOR ASSEMBLY
FIGURE 12-11

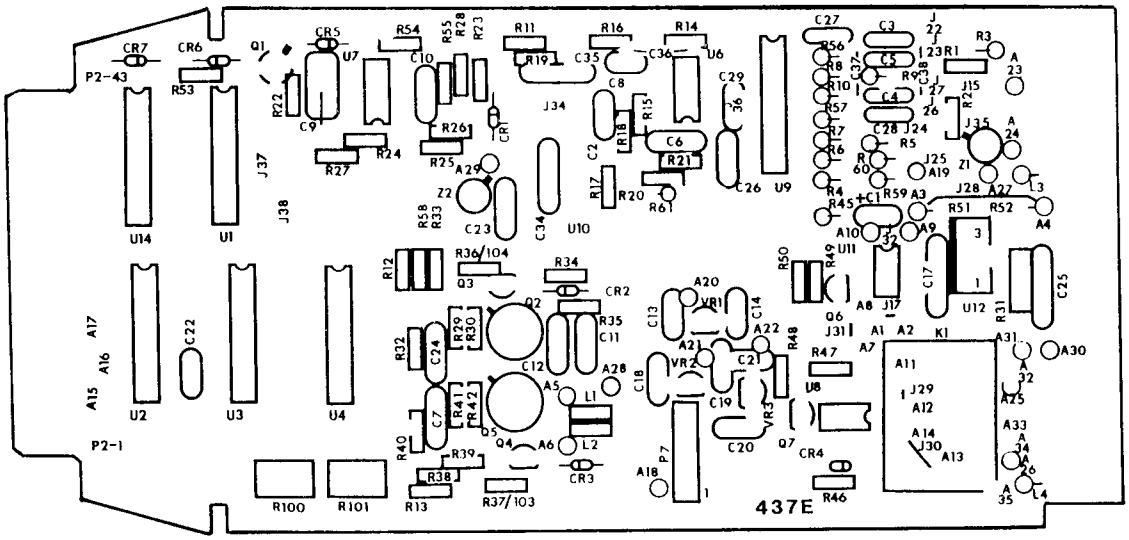


SCHEMATIC - I/O BOARD
FIGURE 12-12

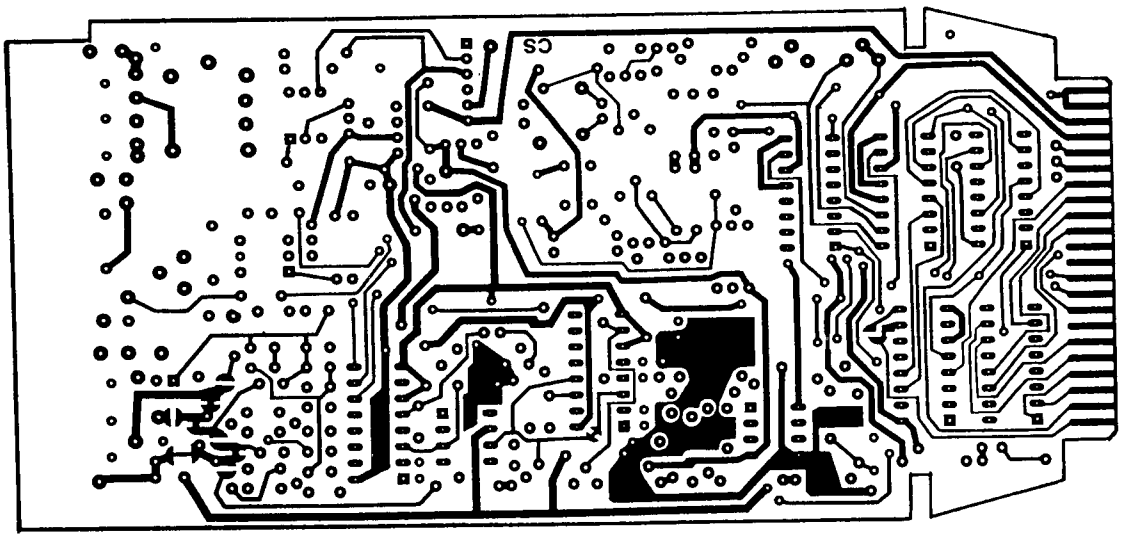
2757-131 REV I



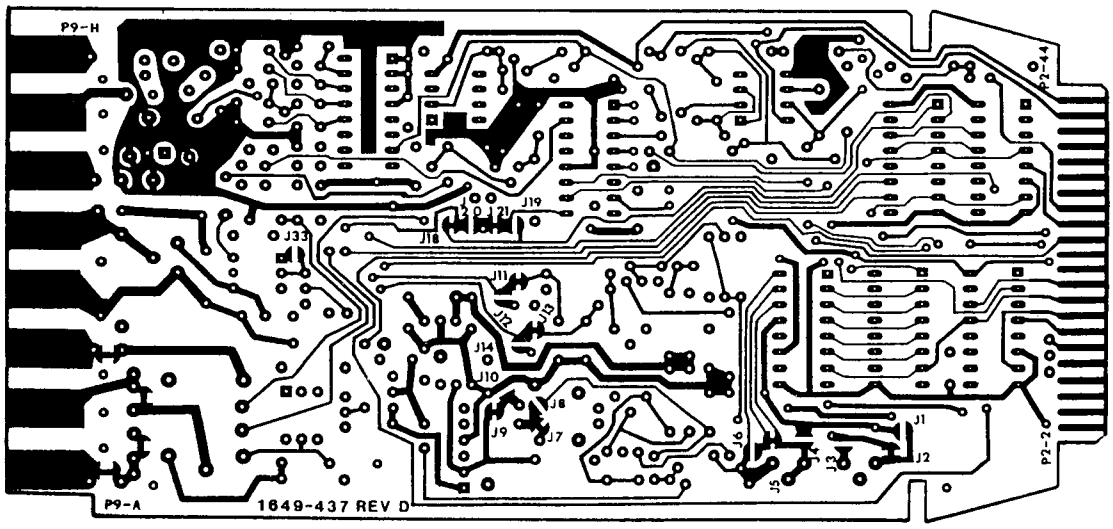
I/O BOARD OUTLINE
FIGURE 12-13 1653-278 REV B



I/O BOARD COMPONENT LAYOUT
FIGURE 12-14 1977-437 REV E



I/O BOARD - COMPONENT SIDE
SOLDER BRIDGING
FIGURE 12-15 1649-437 REV D



I/O BOARD - SOLDER SIDE
SOLDER BRIDGING
FIGURE 12-16 1649-437 REV D

ITEM	PART NUMBER	COLUMN / DESCRIPTION	A QTY	B QTY	C QTY	D QTY	E QTY	F QTY	G QTY	H QTY
2	1951-123	HEATSINK	0	1	0	1	0	1	0	1
5	1951-123	HEATSINK	0	0	0	1	0	0	1	0
6	1951-123	HEATSINK	1	1	0	0	0	0	0	0
8	1990-92	SUPPORT	1	1	1	1	1	1	1	1
9	1903-43	SCREW	1	1	1	1	1	1	1	1
C3,C4,C5	305-340	CAP-4.7 µF	3	3	3	3	3	3	3	3
C13,18,19,20,21 C22,C27,C28,C14	305-250	CAP-0.47 µF-25V	9	9	9	9	9	9	9	9
C8	307-125	CAP-100 pF	1	1	1	1	1	1	1	1
C9	305-185	CAP-0.22 µF-100V	1	1	1	1	1	1	1	1
C10	305-151	CAP-150 pF-1kV	1	1	1	1	1	1	1	1
C11,C12	305-439	CAP-.002 µF-125 VAC	0	0	0	2	0	0	2	0
C15,C16	305-439	CAP-,002 µF-125 VAC	0	2	0	2	0	2	0	2
C17	305-97	CAP-.04 µF-600 V	1	1	0	0	0	0	0	0
C23,C26	305-153	CAP-0.1 µF-10V	2	2	2	2	2	2	2	2
C25	305-97	CAP-.04 µF-600 V	1	1	0	0	0	0	0	0
C25	305-439	CAP-.002 µF	0	0	0	0	1	1	0	0
C34,C35,C36	305-156	CAP-0.1 µF-20V	3	3	3	3	3	3	3	3
CJC1	1835-317	RES-Ni 15.02Ω	1	1	1	1	1	1	1	1
CR1,CR5,CR6	1811-276	DIODE-1N4148	3	3	3	3	3	3	3	3
CR2	1811-276	DIODE-1N4148	0	0	0	1	0	0	1	0
CR3	1811-276	DIODE-1N4148	0	1	0	1	0	1	0	1
CR7	1811-276	DIODE-1N4148	1	1	1	1	1	1	1	1
J17,J28	1835-106	JUMPER	0	0	0	0	2	2	0	0
J31,J32	2060-229	CHOKE	0	0	0	2	0	0	2	0
J34	1835-106	JUMPER	1	1	1	1	1	1	1	1
J36	1835-106	JUMPER	1	1	1	1	1	1	1	1
L1,L2	2060-229	CHOKE	0	2	0	2	0	2	0	2
L3	2060-229	CHOKE	1	1	1	1	1	1	1	1
P7	345-766	CONNECTOR-6 PIN	1	1	1	1	1	1	1	1
Q1	2036-104	TRANSISTOR-2N2222	1	1	1	1	1	1	1	1
Q2	2036-321	TRANSISTOR-2N2904	0	0	0	1	0	0	1	0
Q3	2036-76	TRANSISTOR-2N3904	0	0	0	1	0	0	1	0
Q4	2036-76	TRANSISTOR-2N3904	0	1	0	1	0	1	0	1
Q5	2036-321	TRANSISTOR-2N2904	0	1	0	1	0	1	0	1
Q6	2036-76	TRANSISTOR-2N3904	1	1	1	1	1	1	1	0
R3	1846-107	RES-100M 5%	1	1	1	1	1	1	1	1
R4	1846-391	RES-390Ω 5%	1	1	1	1	1	1	1	1
R5	1849-2491	RES-2.49K 1%	1	1	1	1	1	1	1	1
R6	1849-4992	RES-49.9K 1%	1	1	1	1	1	1	1	1
R7	1849-13	RES-1K 1%	1	1	1	1	1	1	1	1
R8,R56,R57	1849-4022	RES-40.2K 1%	3	3	3	3	3	3	3	3
R9,R10	1849-24	RES-20K 1%	2	2	2	2	2	2	2	2
R11	1846-24	RES-20K 5%	1	1	1	1	1	1	1	1
R12	1849-2432	RES-24.3K 1%	0	0	0	1	0	0	1	0
R13	1849-2432	RES-24.3K 1%	0	1	0	1	0	1	0	1
R15	1849-14	RES-10K 1%	1	1	1	1	1	1	1	1
R16	1849-9092	RES-90.9K 1%	1	1	1	1	1	1	1	1
R19	1846-152	RES-1.5K 5%	1	1	1	1	1	1	1	1
R22	1849-214	RES-210K 1%	1	1	1	1	1	1	1	1

(continued on next page)

ITEM	PART NUMBER	COLUMN / DESCRIPTION	A QTY	B QTY	C QTY	D QTY	E QTY	F QTY	G QTY	H QTY
R23	1846-23	RES-2K 5%	1	1	1	1	1	1	1	1
R24	1849-1272	RES-12.7K 1%	1	1	1	1	1	1	1	1
R25	1855-4992	RES-49.9K 0.1%	1	1	1	1	1	1	1	1
R26,R28	1846-13	RES-1K 5%	2	2	2	2	2	2	2	2
R27	1849-2551	RES-2.55K 1%	1	1	1	1	1	1	1	1
R29	1846-152	RES-1.5K 5%	0	0	0	1	0	0	1	0
R30	1846-22	RES-200Ω 5%	0	0	0	1	0	0	1	0
R31	1822-470	RES-47Ω 5%	1	1	0	0	0	0	0	0
R31	1822-391	RES-390Ω 5%	0	0	0	0	1	1	0	0
R32	1849-13	RES-1K 5%	0	0	0	1	0	0	1	0
R34,R35	1846-11	RES-10Ω 5%	0	0	0	2	0	0	2	0
R36	1849-2372	RES-23.7K 1%	0	0	0	1	0	0	1	0
R37	1849-2372	RES-23.7K 1%	0	1	0	1	0	1	0	1
R38	1849-3321	RES-3.32K 1%	0	1	0	1	0	1	0	1
R40	1849-13	RES-1K 1%	0	1	0	1	0	1	0	1
R41	1846-152	RES-1.5K 5%	0	1	0	1	0	1	0	1
R42	1849-22	RES-200Ω 1%	0	1	0	1	0	1	0	1
R43,R44	1846-11	RES-10Ω 5%	0	2	0	2	0	2	0	2
R49	1846-181	RES-180Ω 5%	1	1	0	0	1	1	0	0
R49	1846-431	RES-430Ω 5%	0	0	1	1	0	0	0	0
R49	1846-222	RES-2.2K 5%	0	0	0	0	0	0	1	0
R50	1846-752	RES-7.5K 5%	1	1	1	1	1	1	1	0
R51	1846-391	RES-390Ω 5%	1	1	0	0	0	0	0	0
R52	1846-222	RES-2.2K 5%	1	1	0	0	0	0	0	0
R53,R54	1846-14	RES-10K 5%	2	2	2	2	2	2	2	2
R55	1846-16	RES-1M 5%	1	1	1	1	1	1	1	1
R58	1849-3321	RES-3.32K 1%	0	0	0	1	0	0	1	0
R100	1675-429	POT-5K	0	0	0	1	0	0	1	0
R101	1675-429	POT-5K	0	1	0	1	0	1	0	1
U1,U2,U14	2036-324	IC-CD4042B	3	3	3	3	3	3	3	3
U3	2036-323	IC-AD558J	0	0	0	1	0	0	1	0
U4	2036-323	IC-AD558J	0	1	0	1	0	1	0	1
U6	2036-322	IC-LF441	1	1	1	1	1	1	1	1
U7	2036-309	IC-LF442	1	1	1	1	1	1	1	1
U8	2036-328	IC-MOC8050	0	0	0	0	0	0	0	1
U9	2036-318	IC-14051	1	1	1	1	1	1	1	1
U11	2036-320	IC-MOC3040	1	1	0	0	1	1	0	0
U12	1811-458	TRIAC-T2500D	1	1	0	0	0	0	0	0
VR1	2036-337	REGULATOR-78L12	1	1	1	1	1	1	1	1
VR2	2036-269	REGULATOR-79L12	1	1	1	1	1	1	1	1
VR3	2036-239	REGULATOR-78L05	1	1	1	1	1	1	1	1
Z1	2036-296	IC-ZN458B	1	1	1	1	1	1	1	1
Z2	2036-336	IC-ZN458	1	1	1	1	1	1	1	1

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COLUMN	DESCRIPTION	PCB PART NUMBER	
		W/SOLDER CONTACTS	W/GOLD CONTACTS
A	W/1A SSR2-W/O ANA1-W/O ANA2	1651-1898	1651-2055
B	W/1A SSR2-W/ANA1-W/O ANA2	1651-1899	1651-2056
C	W/O SSR2-W/O ANA1-W/O ANA2	1651-1900	1651-2057
D	W/O SSR2-W/ANA1-W/ANA2	1651-1901	1651-2058
E	W/50mA SSR2-W/O ANA1-W/O ANA2	1651-1902	1651-2059
F	W/50mA SSR2-W/ANA1-W/O ANA2	1651-1903	1651-2060
G	W/O SSR2-W/O ANA1-W/ANA2	1651-1915	1651-2068
H	W/O SSR2-W/ANA1-W/O ANA2	1651-1917	1651-2070

PARTS LIST - I/O BOARD - W/O ALARM 2
FIGURE 12-17

ITEM	PART NUMBER	COLUMN / DESCRIPTION	A QTY	B QTY	C QTY	D QTY	E QTY	F QTY	G QTY	H QTY
2	1951-123	HEATSINK	0	1	0	1	0	1	0	1
5	1951-123	HEATSINK	0	0	0	1	0	0	1	0
6	1951-123	HEATSINK	1	1	0	0	0	0	0	0
8	1990-92	SUPPORT	1	1	1	1	1	1	1	1
9	1903-43	SCREW	1	1	1	1	1	1	1	1
C3,C4,C5	305-340	CAP-4.7µF	3	3	3	3	3	3	3	3
C13,18,19,20,21 C22,C27,C28,C14	305-250	CAP-0.47 µF-25V	9	9	9	9	9	9	9	9
C8	307-125	CAP-100 pF	1	1	1	1	1	1	1	1
C9	305-185	CAP-0.22 µF-100V	1	1	1	1	1	1	1	1
C10	305-151	CAP-150 pF-1kV	1	1	1	1	1	1	1	1
C11,C12	305-439	CAP-.002 µF-125 VAC	0	0	0	2	0	0	2	0
C15,C16	305-439	CAP-,002 µF-125 VAC	0	2	0	2	0	2	0	2
C17	305-97	CAP-.04 µF-600 V	1	1	0	0	0	0	0	0
C23,C26	305-153	CAP-0.1 µF-10V	2	2	2	2	2	2	2	2
C25	305-97	CAP-.04 µF-600 V	1	1	0	0	0	0	0	0
C25	305-439	CAP-.002 µF	0	0	0	0	1	1	0	0
C34,C35,C36	305-156	CAP-0.1 µF-20V	3	3	3	3	3	3	3	3
CJC1	1835-317	RES-Ni 15.02Ω	1	1	1	1	1	1	1	1
CR1,CR5,CR6	1811-276	DIODE-1N4148	3	3	3	3	3	3	3	3
CR2	1811-276	DIODE-1N4148	0	0	0	1	0	0	1	0
CR3	1811-276	DIODE-1N4148	0	1	0	1	0	1	0	1
CR7	1811-276	DIODE-1N4148	1	1	1	1	1	1	1	1
J17,J28	1835-106	JUMPER	0	0	0	0	2	2	0	0
J31,J32	2060-229	CHOKE	0	0	0	2	0	0	2	0
J34	1835-106	JUMPER	1	1	1	1	1	1	1	1
J36	1835-106	JUMPER	1	1	1	1	1	1	1	1
L1,L2	2060-229	CHOKE	0	2	0	2	0	2	0	2
L3	2060-229	CHOKE	1	1	1	1	1	1	1	1
P7	345-766	CONNECTOR-6 PIN	1	1	1	1	1	1	1	1
Q1	2036-104	TRANSISTOR-2N2222	1	1	1	1	1	1	1	1
Q2	2036-321	TRANSISTOR-2N2904	0	0	0	1	0	0	1	0
Q3	2036-76	TRANSISTOR-2N3904	0	0	0	1	0	0	1	0
Q4	2036-76	TRANSISTOR-2N3904	0	1	0	1	0	1	0	1
Q5	2036-321	TRANSISTOR-2N2904	0	1	0	1	0	1	0	1
Q6	2036-76	TRANSISTOR-2N3904	1	1	1	1	1	1	1	0
R3	1846-107	RES-100M 5%	1	1	1	1	1	1	1	1
R4	1846-391	RES-390Ω 5%	1	1	1	1	1	1	1	1
R5	1849-2491	RES-2.49K 1%	1	1	1	1	1	1	1	1
R6	1849-4992	RES-49.9K 1%	1	1	1	1	1	1	1	1
R7	1849-13	RES-1K 1%	1	1	1	1	1	1	1	1
R8,R56,R57	1849-4022	RES-40.2K 1%	3	3	3	3	3	3	3	3
R9,R10	1849-25	RES-200K 1%	2	2	2	2	2	2	2	2
R11	1846-24	RES-20K 5%	1	1	1	1	1	1	1	1
R12	1849-2432	RES-24.3K 1%	0	0	0	1	0	0	1	0
R13	1849-2432	RES-24.3K 1%	0	1	0	1	0	1	0	1
R15	1849-14	RES-10K 1%	1	1	1	1	1	1	1	1
R16	1849-9092	RES-90.9K 1%	1	1	1	1	1	1	1	1
R19	1846-152	RES-1.5K 5%	1	1	1	1	1	1	1	1
R22	1849-214	RES-210K 1%	1	1	1	1	1	1	1	1

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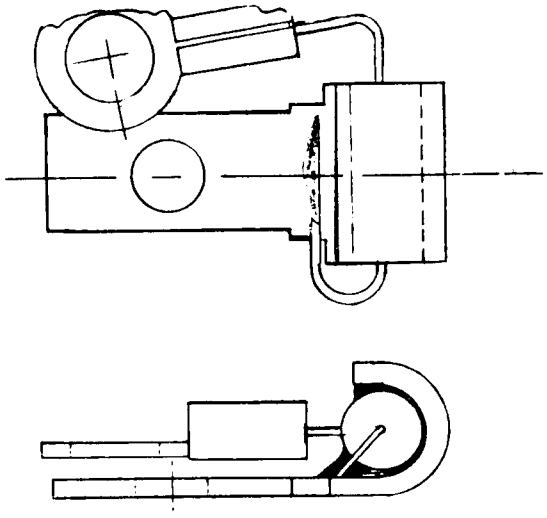
ITEM	PART NUMBER	DESCRIPTION / COLUMN	A QTY	B QTY	C QTY	D QTY	E QTY	F QTY	G QTY	H QTY
R23	1846-23	RES-2K 5%	1	1	1	1	1	1	1	1
R24	1849-1272	RES-12.7K 1%	1	1	1	1	1	1	1	1
R25	1855-4992	RES-49.9K 0.1%	1	1	1	1	1	1	1	1
R26,R28	1846-13	RES-1K 5%	2	2	2	2	2	2	2	2
R27	1849-2551	RES-2.55K 1%	1	1	1	1	1	1	1	1
R29	1846-152	RES-1.5K 5%	0	0	0	1	0	0	1	0
R30	1846-22	RES-200Ω 5%	0	0	0	1	0	0	1	0
R31	1822-470	RES-47Ω 5%	1	1	0	0	0	0	0	0
R31	1822-391	RES-390Ω 5%	0	0	0	0	1	1	0	0
R32	1849-13	RES-1K 5%	0	0	0	1	0	0	1	0
R34,R35	1846-11	RES-10Ω 5%	0	0	0	2	0	0	2	0
R36	1849-2372	RES-23.7K 1%	0	0	0	1	0	0	1	0
R37	1849-2372	RES-23.7K 1%	0	1	0	1	0	1	0	1
R38	1849-3321	RES-3.32K 1%	0	1	0	1	0	1	0	1
R40	1849-13	RES-1K 1%	0	1	0	1	0	1	0	1
R41	1846-152	RES-1.5K 5%	0	1	0	1	0	1	0	1
R42	1849-22	RES-200Ω 1%	0	1	0	1	0	1	0	1
R43,R44	1846-11	RES-10Ω 5%	0	2	0	2	0	2	0	2
R49	1846-181	RES-180Ω 5%	1	1	0	0	1	1	0	0
R49	1846-431	RES-430Ω 5%	0	0	1	1	0	0	0	0
R49	1846-222	RES-2.2K 5%	0	0	0	0	0	0	1	0
R50	1846-752	RES-7.5K 5%	1	1	1	1	1	1	1	0
R51	1846-391	RES-390Ω 5%	1	1	0	0	0	0	0	0
R52	1846-222	RES-2.2K 5%	1	1	0	0	0	0	0	0
R53,R54	1846-14	RES-10K 5%	2	2	2	2	2	2	2	2
R55	1846-16	RES-1M 5%	1	1	1	1	1	1	1	1
R58	1849-3321	RES-3.32K 1%	0	0	0	1	0	0	1	0
R100	1675-429	POT-5K	0	0	0	1	0	0	1	0
R101	1675-429	POT-5K	0	1	0	1	0	1	0	1
U1,U2,U14	2036-324	IC-CD4042B	3	3	3	3	3	3	3	3
U3	2036-323	IC-AD558J	0	0	0	1	0	0	1	0
U4	2036-323	IC-AD558J	0	1	0	1	0	1	0	1
U6	2036-322	IC-LF441	1	1	1	1	1	1	1	1
U7	2036-309	IC-LF442	1	1	1	1	1	1	1	1
U8	2036-328	IC-MOC8050	0	0	0	0	0	0	0	1
U9	2036-318	IC-14051	1	1	1	1	1	1	1	1
U11	2036-320	IC-MOC3040	1	1	0	0	1	1	0	0
U12	1811-458	TRIAC-T2500D	1	1	0	0	0	0	0	0
VR1	2036-337	REGULATOR-78L12	1	1	1	1	1	1	1	1
VR2	2036-269	REGULATOR-79L12	1	1	1	1	1	1	1	1
VR3	2036-239	REGULATOR-78L05	1	1	1	1	1	1	1	1
Z1	2036-296	IC-ZN458B	1	1	1	1	1	1	1	1
Z2	2036-336	IC-ZN458	1	1	1	1	1	1	1	1

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ITEM	PART NUMBER	DESCRIPTION / COLUMN	A QTY	B QTY	C QTY	D QTY	E QTY	F QTY	G QTY	H QTY
U1,U2,U14	2036-324	IC-CD4042B	3	3	3	3	3	3	3	3
U3	2036-323	IC-AD558J	0	0	0	1	0	0	1	0
U4	2036-323	IC-AD558J	0	1	0	1	0	1	0	1
U6	2036-322	IC-LF441	1	1	1	1	1	1	1	1
U7	2036-309	IC-LF442	1	1	1	1	1	1	1	1
U8	2036-328	IC-MOC8050	0	0	0	0	0	0	0	1
U9	2036-318	IC-14051	1	1	1	1	1	1	1	1
U11	2036-320	IC-MOC3040	1	1	0	0	1	1	0	0
U12	1811-458	TRIAC-T2500D	1	1	0	0	0	0	0	0
VR1	2036-337	REGULATOR-78L12	1	1	1	1	1	1	1	1
VR2	2036-269	REGULATOR-79L12	1	1	1	1	1	1	1	1
VR3	2036-239	REGULATOR-78L05	1	1	1	1	1	1	1	1
Z1	2036-296	IC-ZN458B	1	1	1	1	1	1	1	1
Z2	2036-336	IC-ZN458	1	1	1	1	1	1	1	1

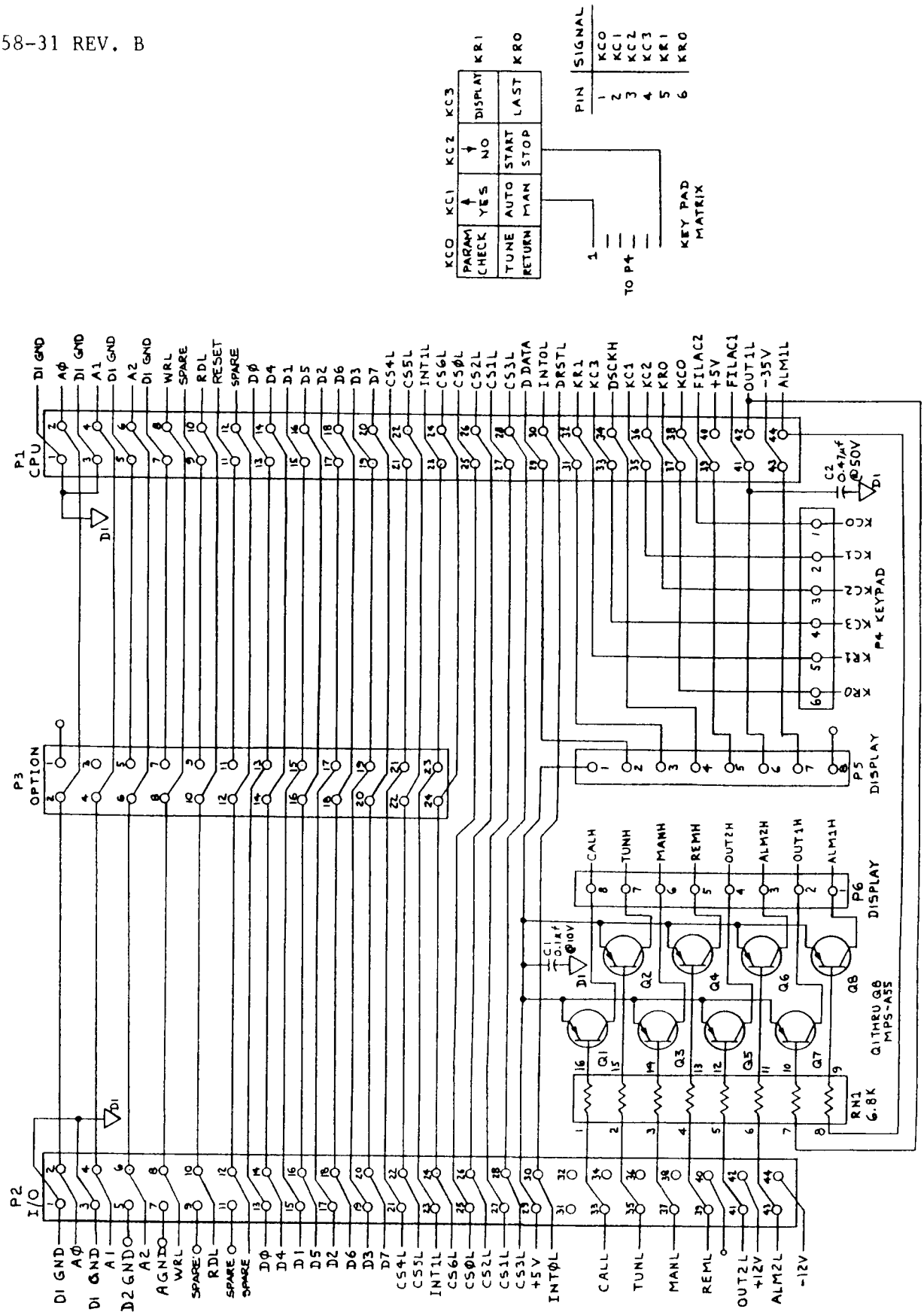
COLUMN	DESCRIPTION	PCB PART NUMBER W/SOLDER CONTACTS	PCB PART NUMBER W/GOLD CONTACTS
A	W/1A SSR2-W/O ANA1-W/O ANA2	1651-1892	1651-2061
B	W/1A SSR2-W/ANA1-W/O ANA2	1651-1893	1651-2062
C	W/O SSR2-W/O ANA1-W/O ANA2	1651-1894	1651-2063
D	W/O SSR2-W/ANA1-W/ANA2	1651-1895	1651-2064
E	W/50mA SSR2-W/O ANA1-W/O ANA2	1651-1896	1651-2065
F	W/50mA SSR2-W/ANA1-W/O ANA2	1651-1897	1651-2066
G	W/O SSR2-W/O ANA1-W/ANA2	1651-1914	1651-2067
H	W/O SSR2-W/ANA1-W/O ANA2	1651-1916	1651-2069

PARTS LIST - I/O BOARD - W/ALARM 2
FIGURE 12-18



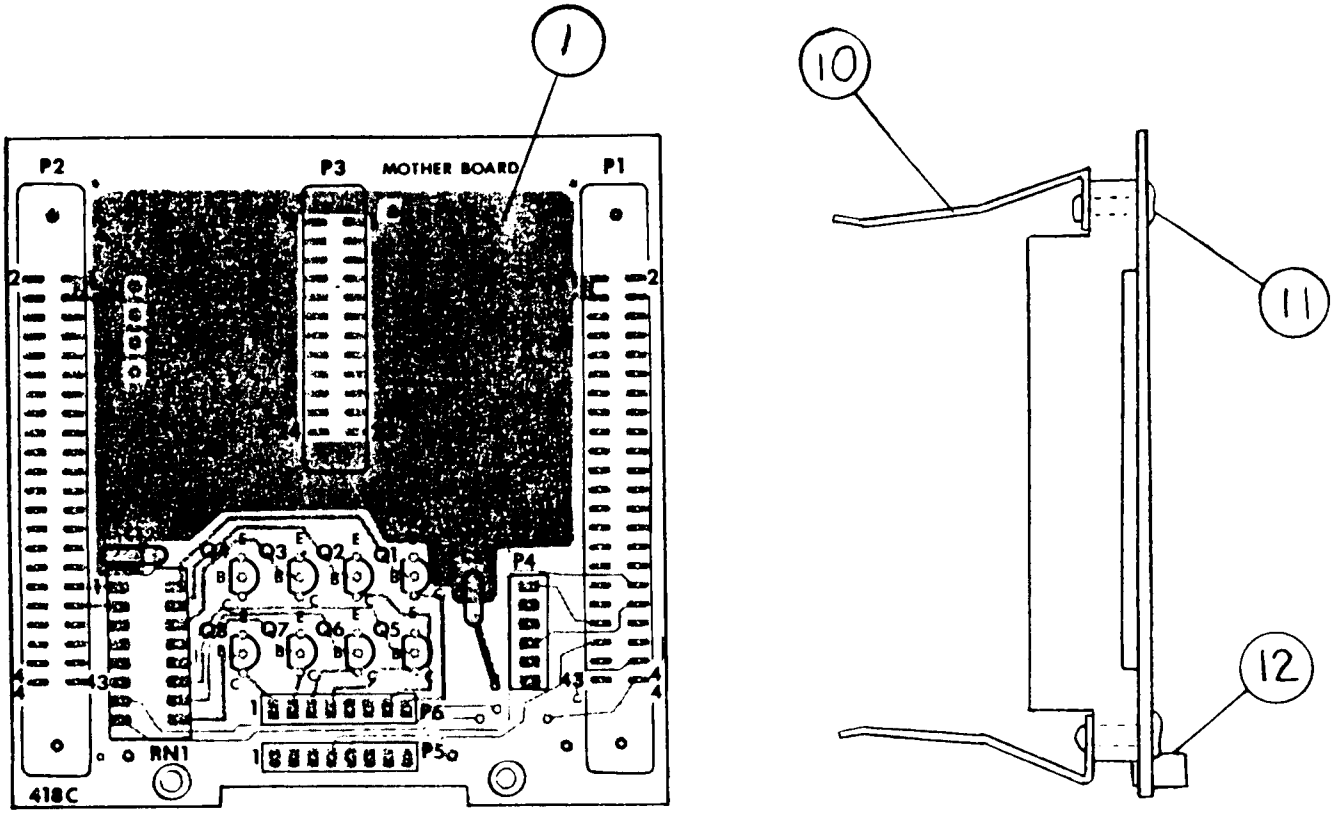
THERMOCOUPLE COLD JUNCTION COMPENSATING RESISTOR ASSY
(USED WITH CONTROLLERS HAVING SOLDER PLATED CONTACTS ONLY)
FIGURE 12-19

P/N 344-1199



SCHEMATIC - MOTHER BOARD
FIGURE 12-20

2757-129 REV B



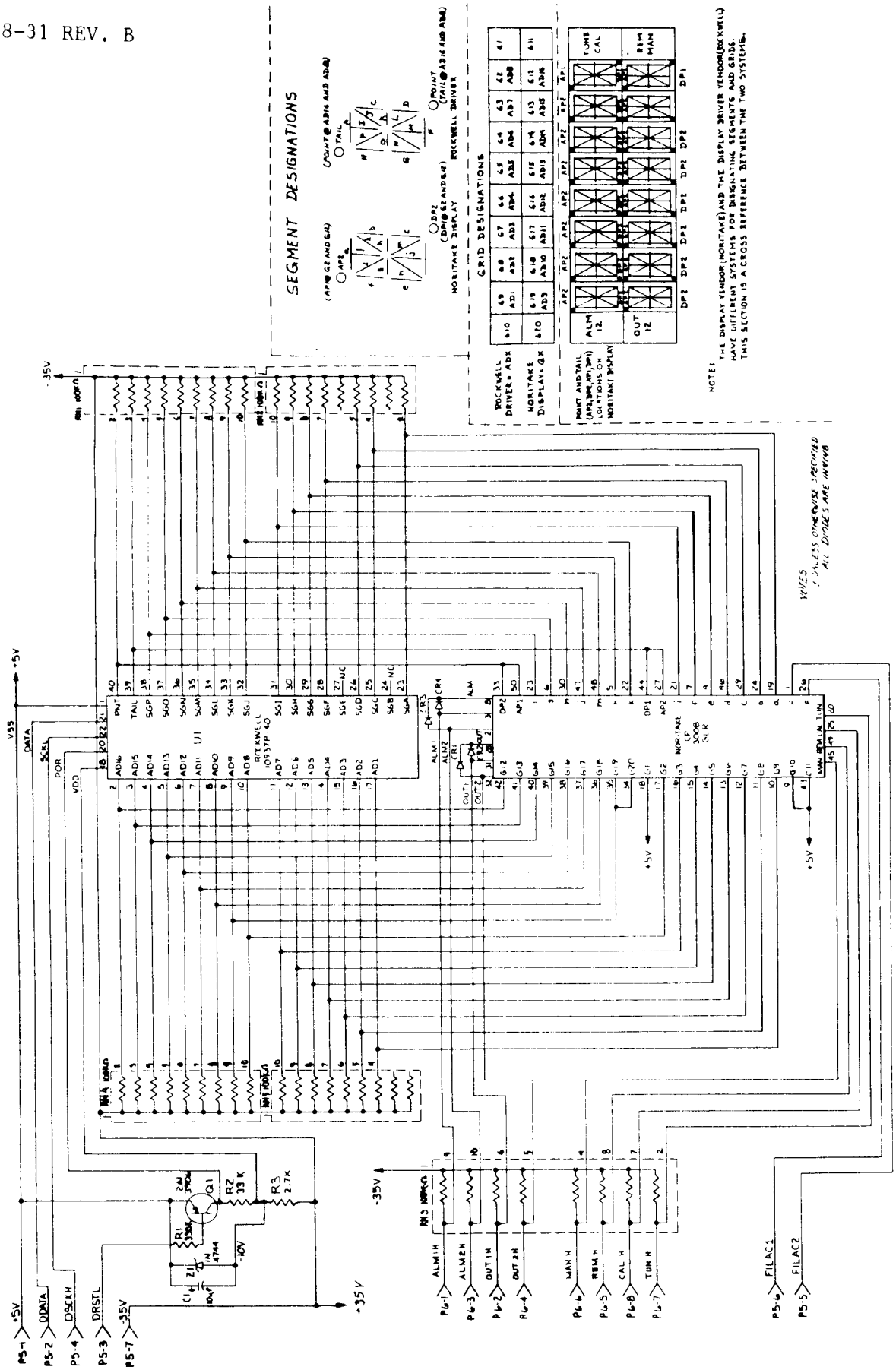
MOTHER BOARD PCB OUTLINE
FIGURE 12-21

1653-249

ITEM	PART NO.	DESCRIPTION
2,3	345-765	CONNECTOR-44 PIN (P1,P2)
4	345-764	CONNECTOR-24 PIN (P3)
5	345-770	CONNECTOR-6 TERMINAL (P4)
6,7	345-769	CONNECTOR-6 PIN (P5,P6)
10	330-101	CLIP, PCB RETAINER
11	1850-64	RIVET
12	1960-329	SPACER
C1	305-153	CAP-0.1 µF-10V
C2	305-250	CAP-.47 µF-50V
Q1,Q2,Q3,Q4 Q5,Q6,Q7,Q8	2036-335	TRANSISTOR-MPSA55
RN1	1843-54	RESISTOR NETWORK-6.8k

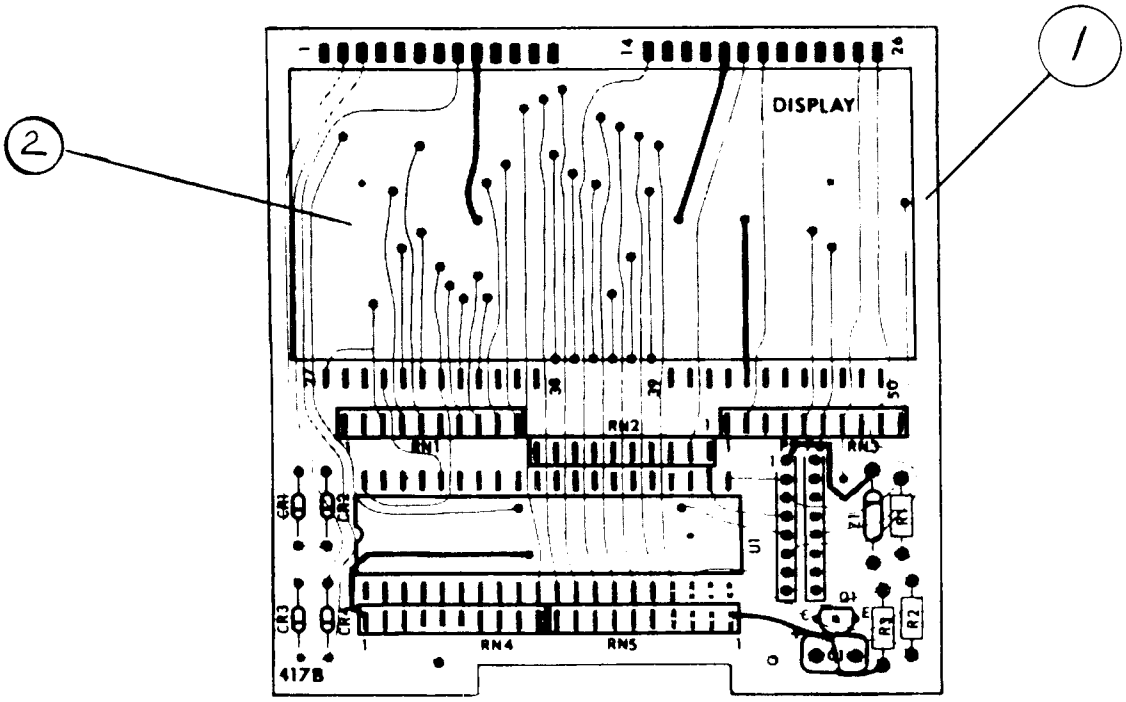
MOTHER BOARD PARTS LIST
FIGURE 12-22

1651-1891 (W/O CNTR CONN.)
1651-1941 (W/CNTR CONN.)



SCHEMATIC - DISPLAY BOARD
FIGURE 12-23

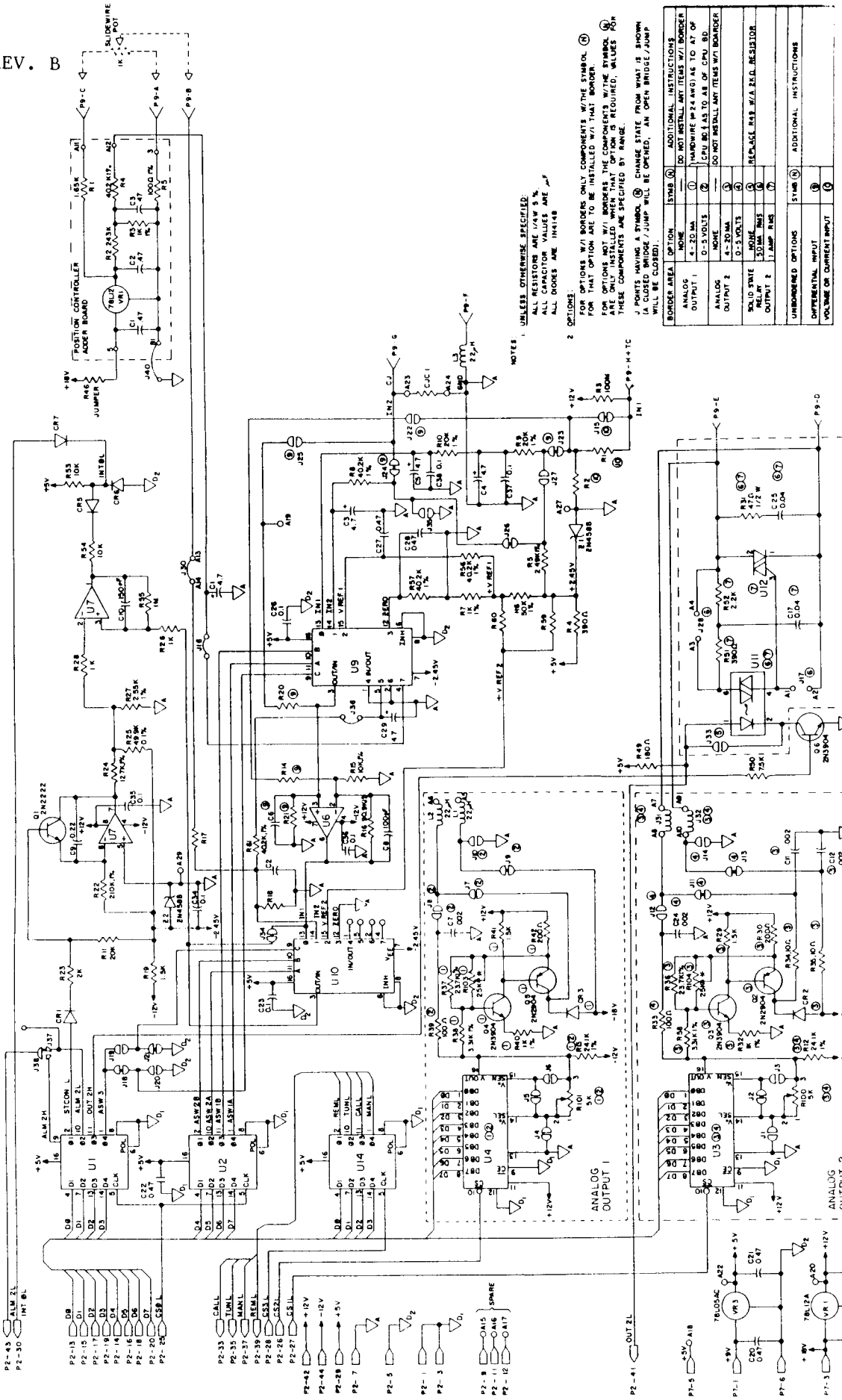
2757-128 REV B



DISPLAY BOARD PCB OUTLINE
FIGURE 12-24 1653-248

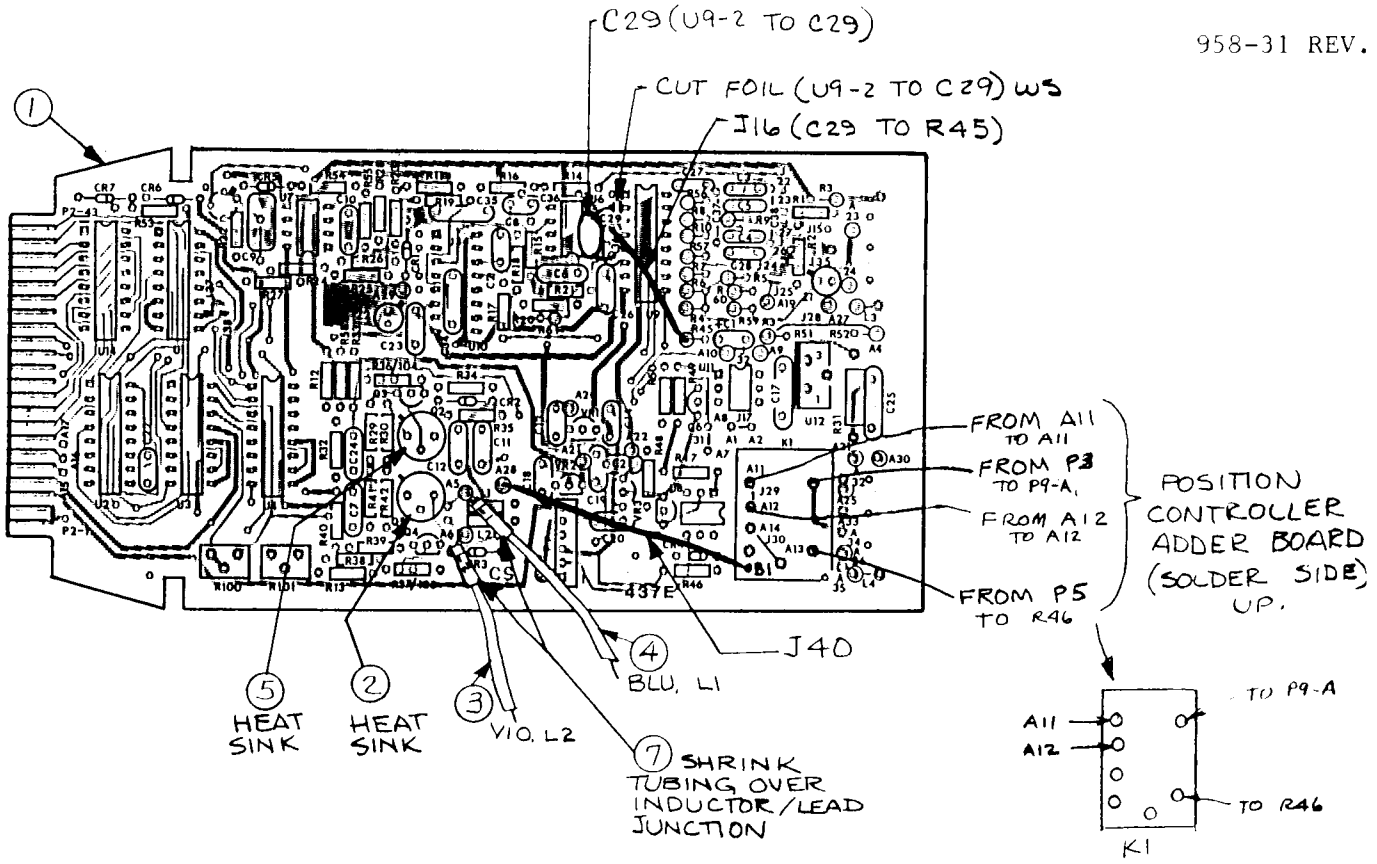
ITEM	PART NO.	DESCRIPTION
2	470-2	DISPLAY
3	300-258	CABLE-8 CONDUCTOR-3.5"
4	300-259	CABLE-8 CONDUCTOR-4"
C1	305-93	CAP-10 µF-25V
CR1,CR2,CR3,CR4	1811-276	DIODE-1N4148
Q1	2036-77	TRANSISTOR-2N3906
R1	1846-334	RES-330k 5%
R2	1846-333	RES-33k 5%
R3	1846-272	RES-2.7k 5%
RN1,RN2 RN3,RN4 RN5	1843-53	RESISTOR NETWORK-100k
U1	2036-333	IC-DISPLAY CONTROLLER
Z1	1811-189	ZENER-1N4744A

DISPLAY BOARD PARTS LIST
FIGURE 12-25 1651-1890 REV. D



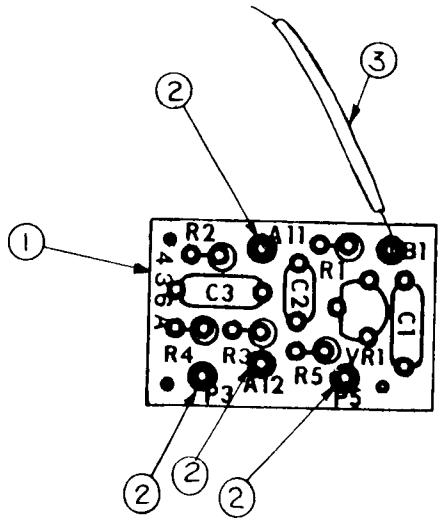
SCHEMATIC - MODEL 2014 & 2015 I/O BOARD
FIGURE 12-26

2757-152 REV C



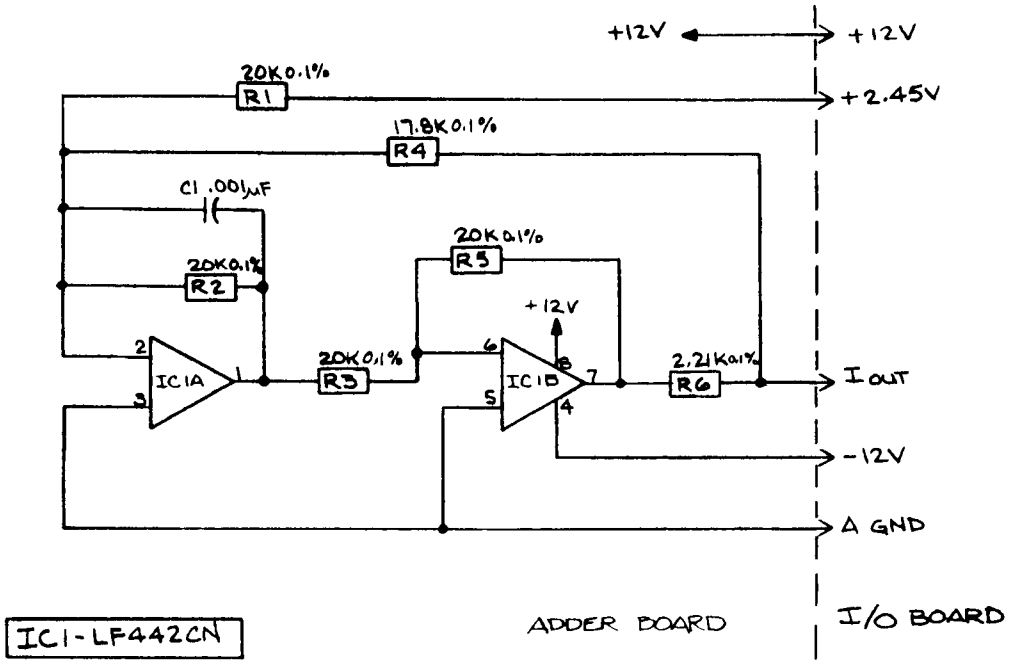
MODEL 2014 I/O BOARD OUTLINE
FIGURE 12-27 1653-270 REV A

ITEM	PART NO.	DESCRIPTION
C1,C2,C3	305-250	CAP-.47 µF
R1	1849-1651	RES-1.65K 1%
R2	1849-2433	RES-243K 1%
R3	1849-13	RES-1K 1%
R4	1849-4022	RES-40.2K 1%
R5	1849-12	RES-100Ω 1%
VR1	2036-337	REGULATOR-78L12



NOTE:
ALL ITEM (2) BUSS WIRE TO EXTEND FROM COMPONENT SIDE OF PCB.

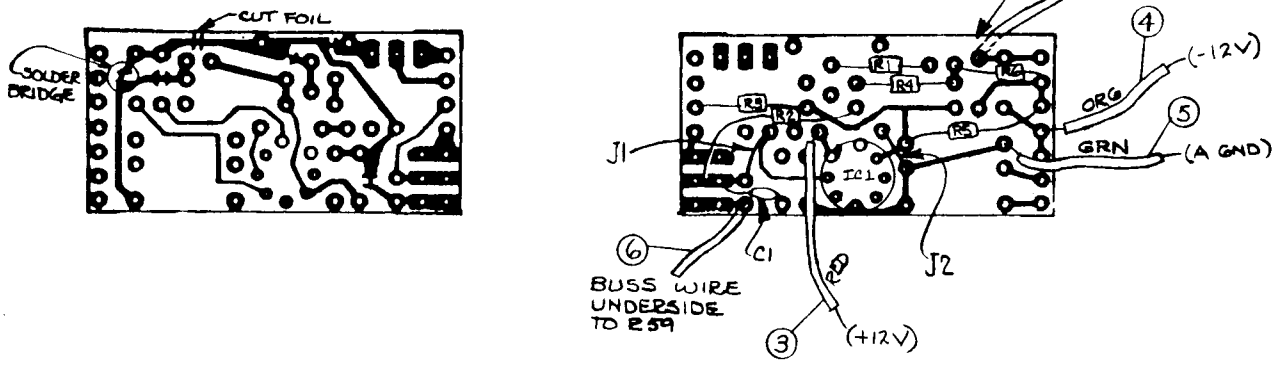
PCB ASSEMBLY - MODEL 2014 SLIDEWIRE ADDER
FIGURE 12-28 1651-2038 REV C



SCHEMATIC - 0.1 DEGREE ADDER
Figure 12-29

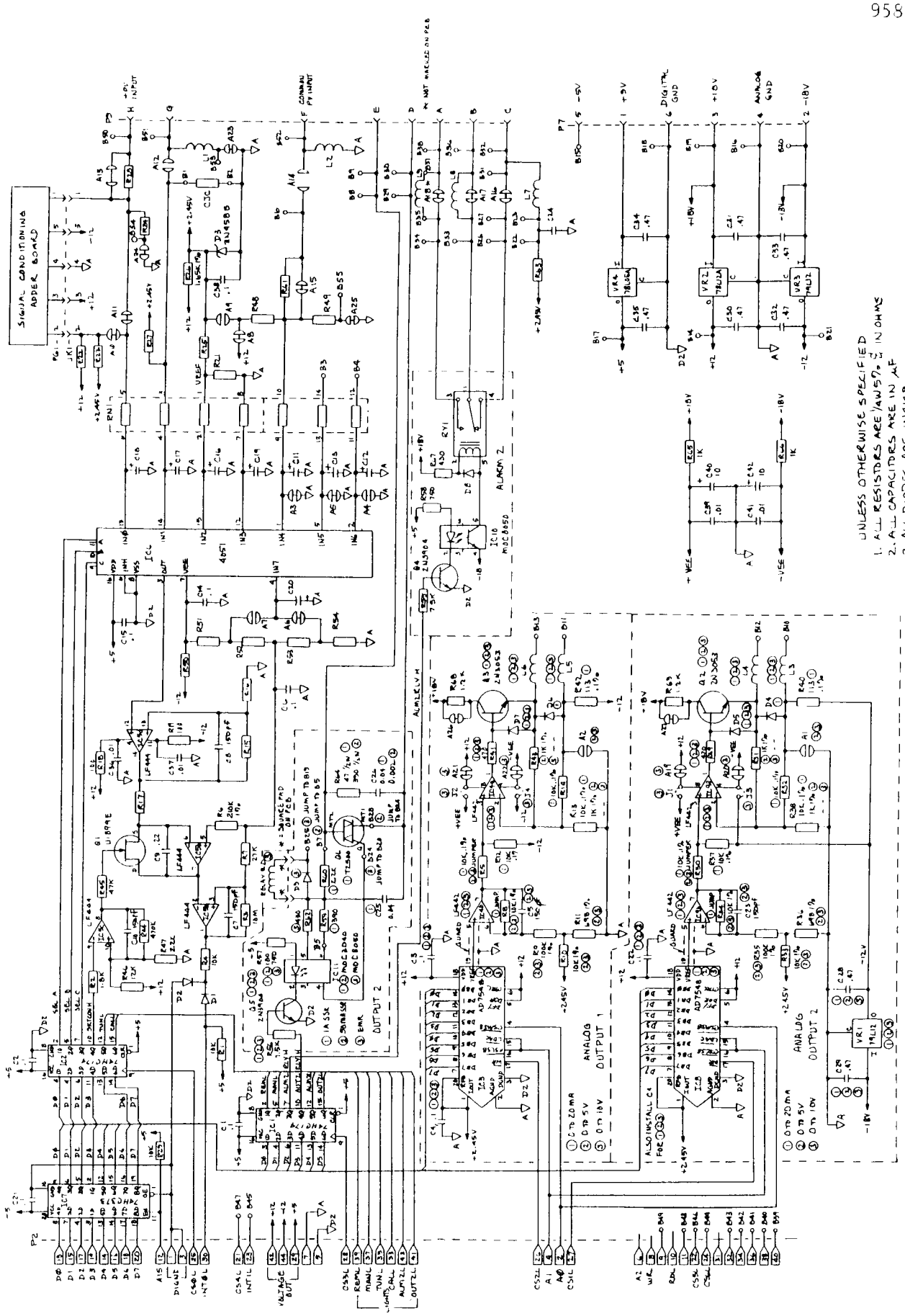
2757-159

ITEM	PART NO.	DESCRIPTION
C1	305-155	CAP-.001 µF
IC1	2036-358	IC-LF442
R1,R2,R3,R5	1855-24	RES-20k 10ppm
R4	1855-1782	RES-17.8k .1%
R6	1855-2211	RES-2.21k .1%



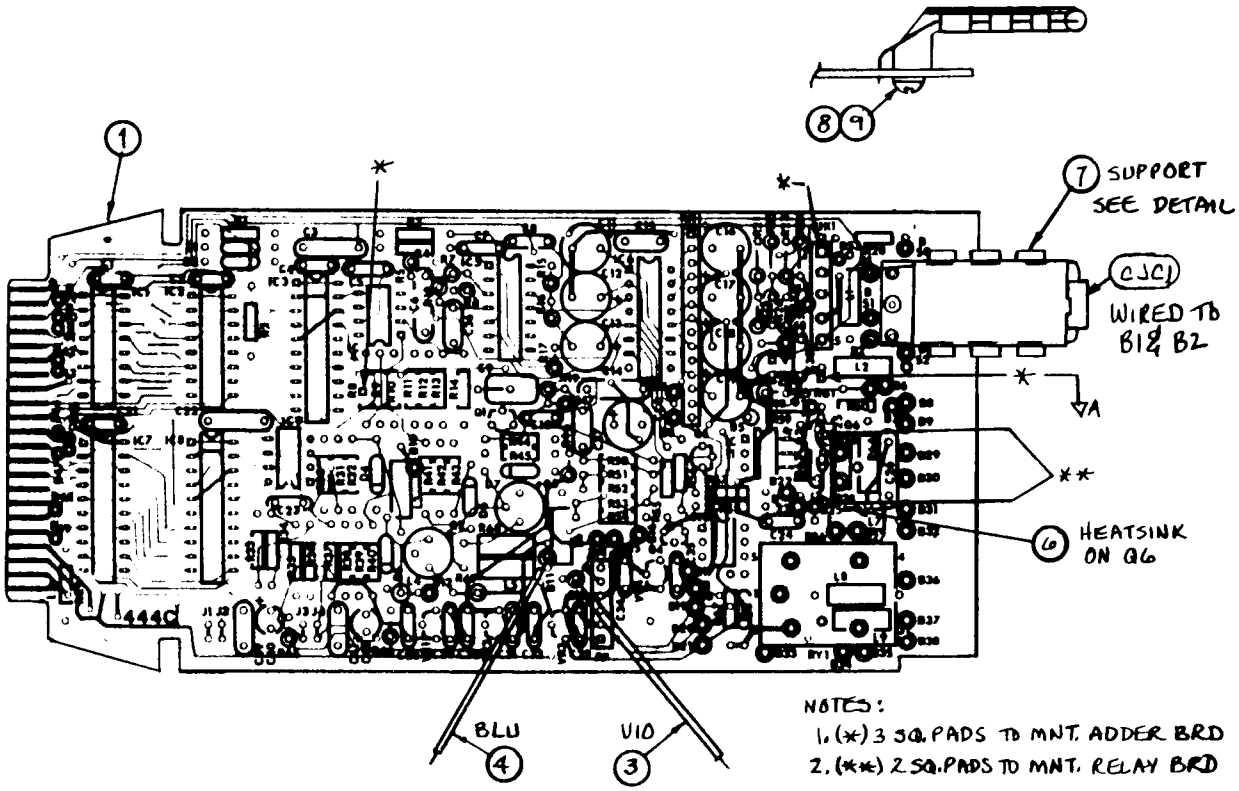
PCB ASSEMBLY -0.1 DEGREE CURRENT SOURCE ADDER
FIGURE 12-30

1651-1971 REV B



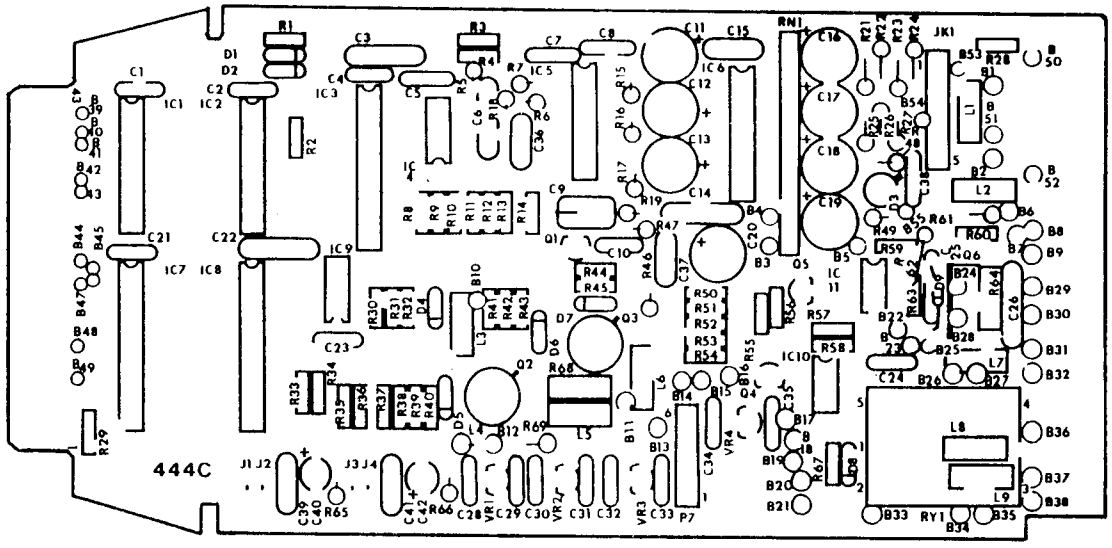
2757-160 REV A

SCHEMATIC - MODEL 2017 I/O BOARD
FIGURE 12-31



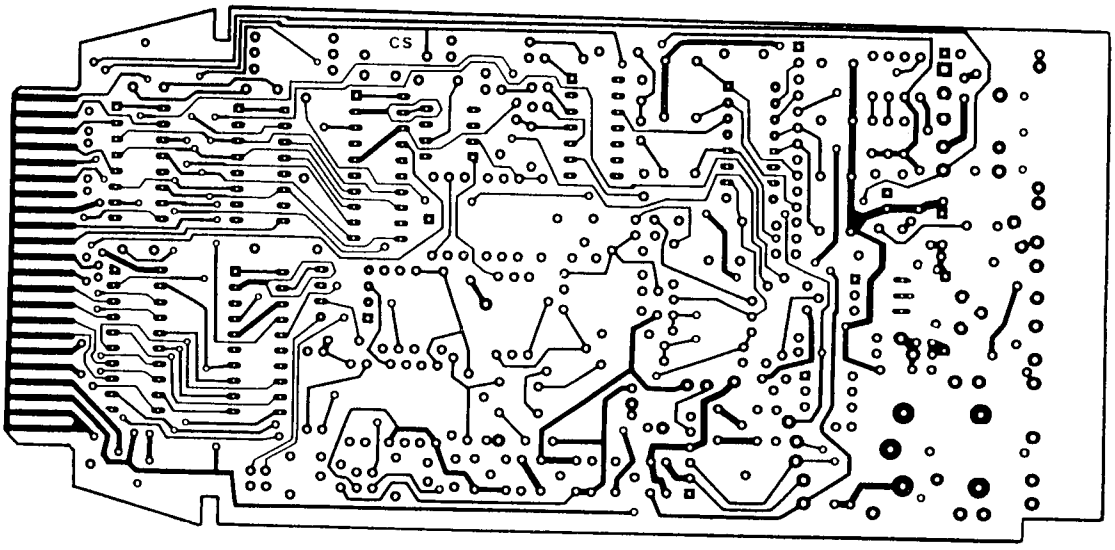
MODEL 2017 I/O BOARD OUTLINE
FIGURE 12-32

1653-282

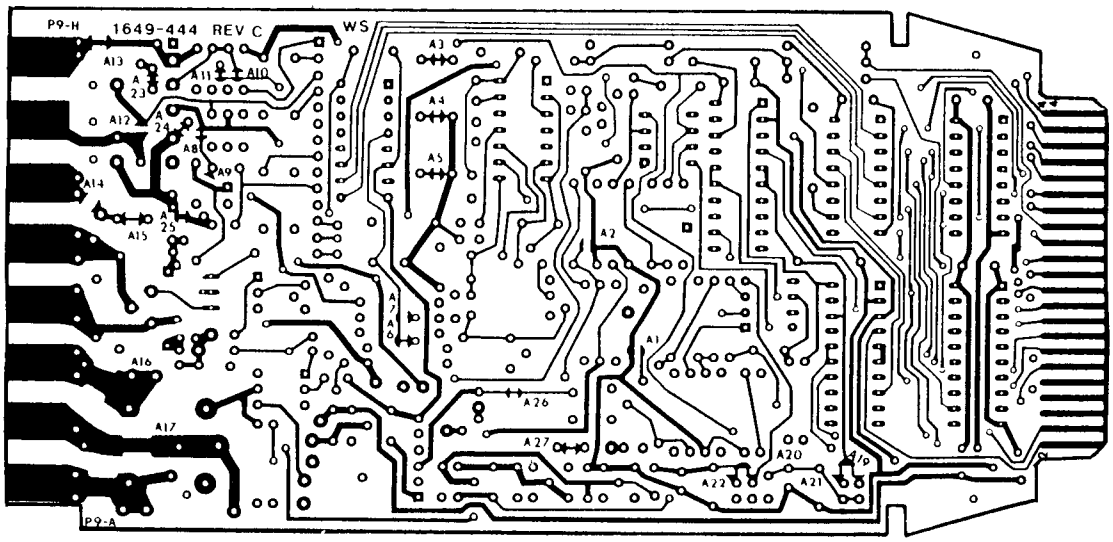


MODEL 2017 I/O COMPONENT LAYOUT
FIGURE 12-33

1977-444



MODEL 2017 I/O BOARD - COMPONENT SIDE
SOLDER BRIDGING
FIGURE 12-34 1649-444

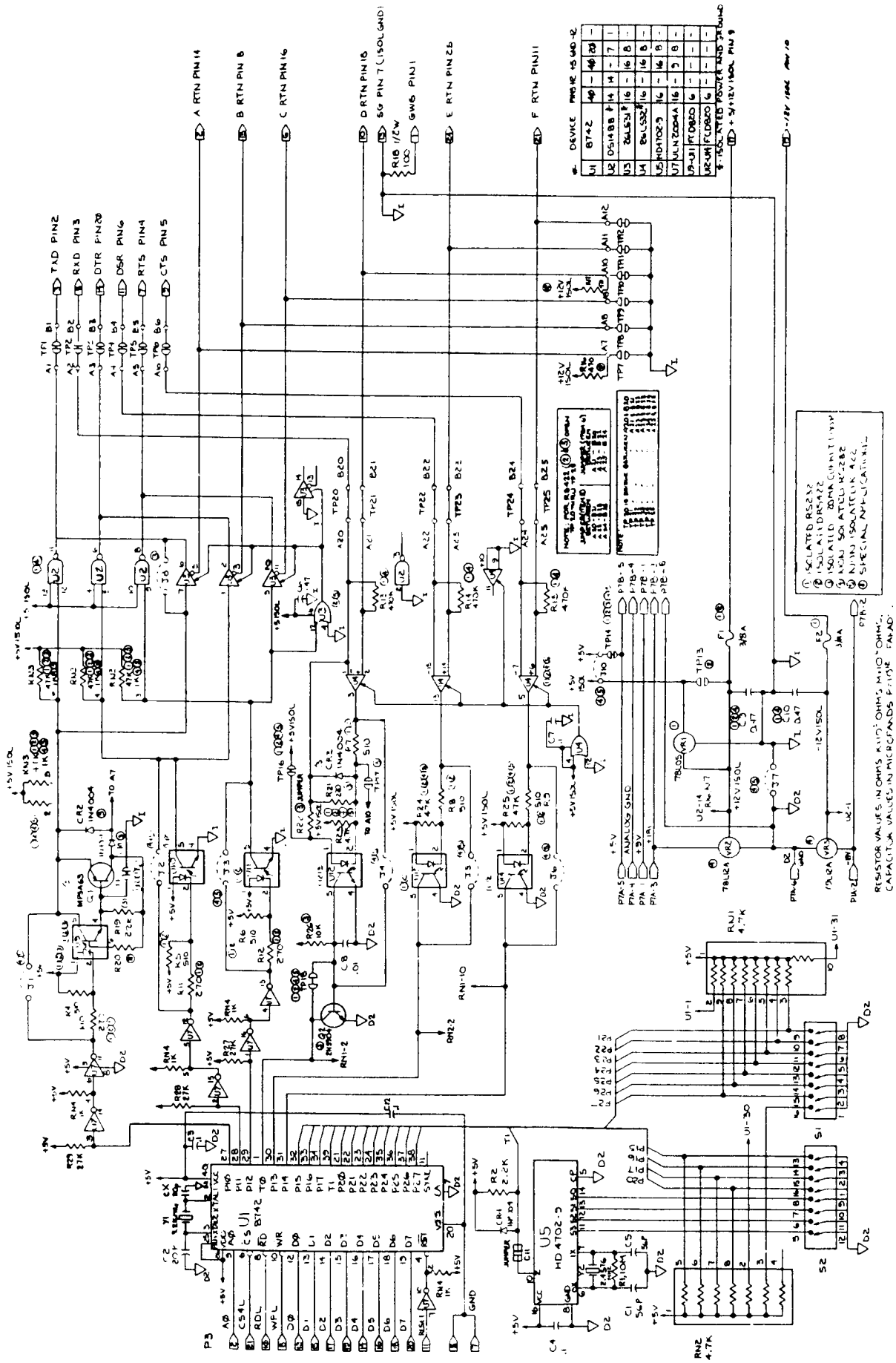


MODEL 2017 I/O BOARD - SOLDER SIDE
SOLDER BRIDGING
FIGURE 12-35 1649-444

ITEM	PART NUMBER	COLUMN / DESCRIPTION	A QTY	B QTY
2	1951-123	HEATSINK	1	1
6	1951-125	HEATSINK	1	0
11	1835-106	JUMPER	0	1
C1,C2,C4,C21,C38	305-153	CAP - 0.1µF - 10V	5	5
C3	305-156	CAP - 0.1 µF, 20V	1	1
C30,C31,C32 C33,C34,C35 }	305-250	CAP - .01 µF, 25V	6	6
C25,C26	305-97	CAP - .04 µF	2	0
C26	305-439	CAP - .002 µF	0	1
C41	305-213	CAP - .01 µF	1	1
C42	305-93	CAP - 10 µF	1	1
D3	2036-296	REFERENCE-ZN458B	1	1
D6,D7,D8	1811-276	DIODE-1N4148	3	3
IC1,IC2	2036-377	IC - 74HC174	2	2
IC3	2036-379	IC - AD7548	1	1
IC4	2036-309	IC - LF442	1	1
IC7	2036-378	IC - 74HC373	1	1
IC10	2036-328	IC - MOC8050	1	1
IC11	2036-320	IC - MOC3040	1	1
L5,L6	2060-229	INDUCTOR - 22 µH	2	2
P7	345-766	CONNECTOR - 6 PIN	1	1
Q3	2036-5	TRANSISTOR - 2N3053	1	1
Q4,Q5	2036-76	TRANSISTOR - 2N3904	2	2
Q6	1811-458	TRIAC - T2500	1	0
R1,R29	1846-14	RES-10k, 5%	2	2
R5,R12,R13,R14	1855-14	RES-10k, 10 ppm	4	4
R8	1835-106	JUMPER	1	1
R26	1849-1651	RES-1.65k, 1%	1	1
R41	1846-471	RES-470Ω, 5%	1	1
R42	1855-1130	RES-113k, 10 ppm	1	1
R55,R56	1846-752	RES-7.5k, 5%	2	2
R57	1846-181	RES-180Ω, 5%	1	1
R58	1846-751	RES-750Ω, 5%	1	1
R59	1846-391	RES-390Ω, 5%	1	0
R60	1846-222	RES-2.2k, 5%	1	0
R64	1822-470	RES-47Ω, 5%	1	0
R64	1822-391	RES-390Ω, 5%	0	1
R66	1846-13	RES-1k, 5%	1	1
R67	1846-431	RES-430Ω, 5%	1	1
R68	1822-122	RES-1.2k, 5%, 1/2w	1	1
RY1	1819-146	RELAY	1	1
VR2	2036-337	VOLT. REG. - 78L12	1	1
VR3	2036-269	VOLT. REG. - 79L12	1	1
VR4	2036-239	VOLT. REG. - 78L05	1	1

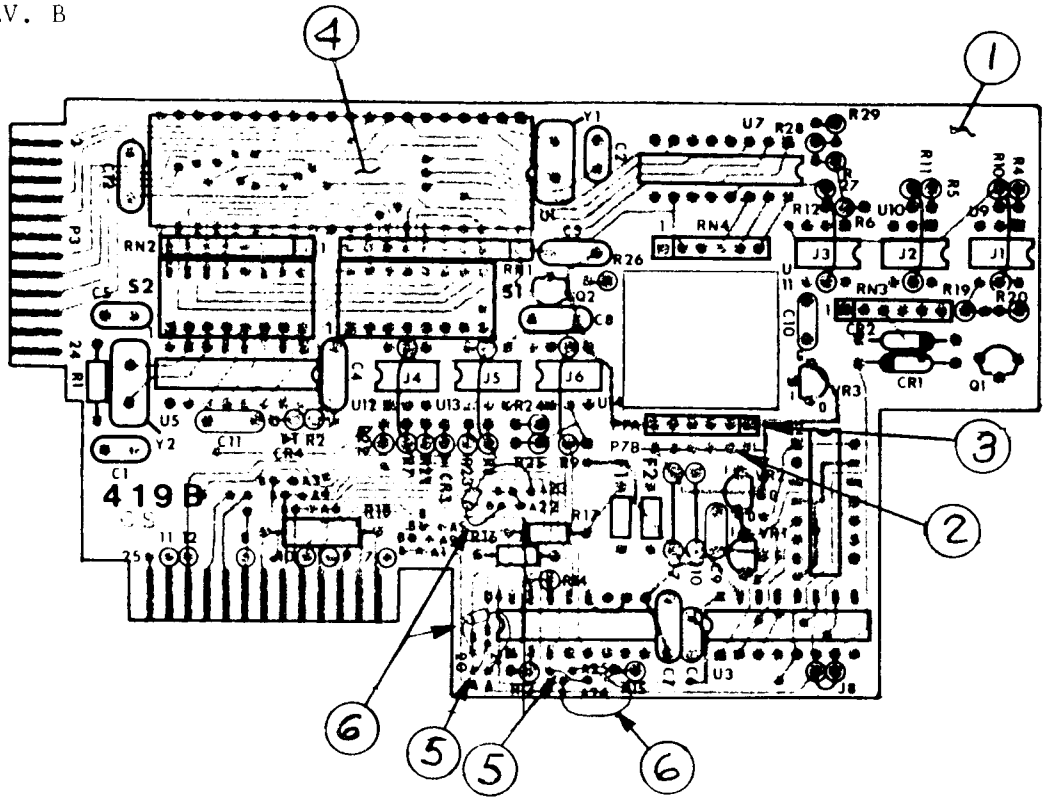
MODEL 2017 I/O BOARD PARTS LIST
FIGURE 12-36

COLUMN	DESCRIPTION	PCB PART NUMBER
A	W/1A SSR2-W/ALM2-W/ALA2	1651-2115
B	W/50mA SSR-W/ALM2-W/ALA2	1651-2116

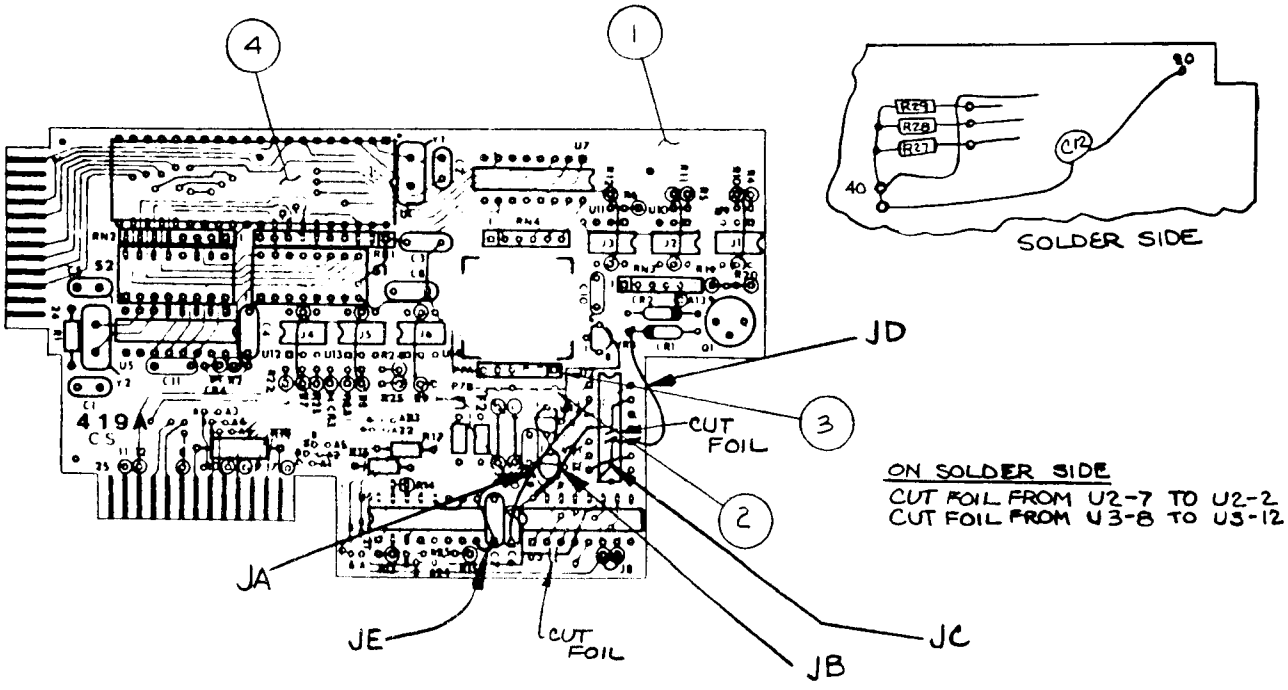


SCHEMATIC - ORIGINAL COMMUNICATIONS BOARD (COMM I)
FIGURE 12-27

2757-130 REV D



PCB OUTLINE - COMM I COMMUNICATIONS BOARD
FIGURE 12-38 1653-266 REV B



PCB OUTLINE - COMM I COMMUNICATIONS BOARD
REWORK FOR EARLY RS422 UNITS
FIGURE 12-39 1653-266 REV -

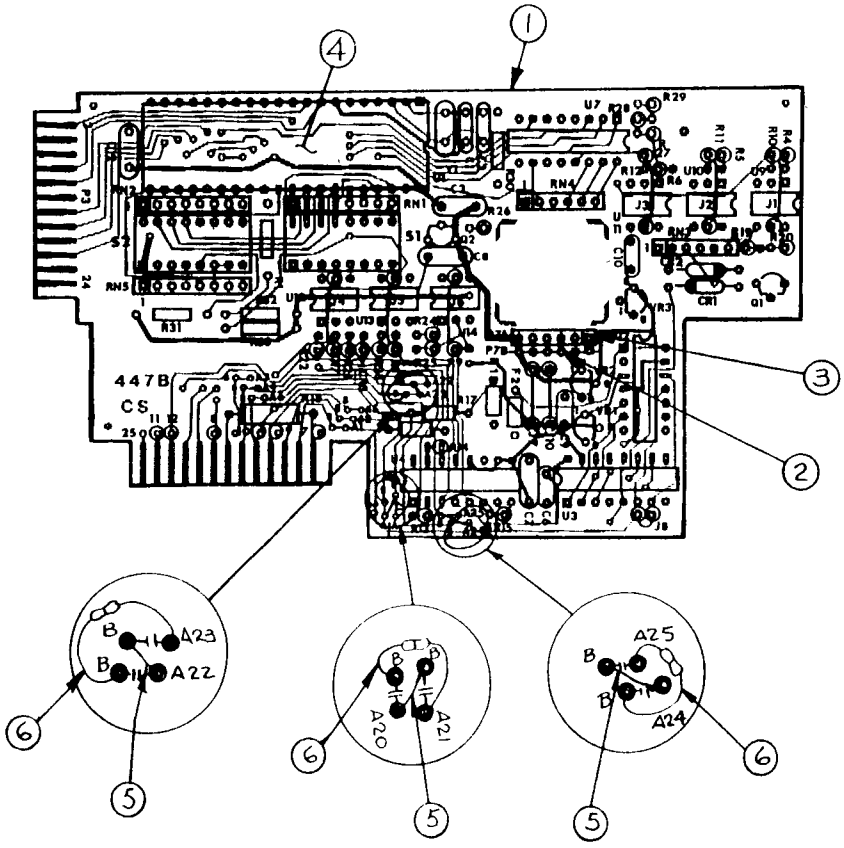
ITEM	PART NUMBER	DESCRIPTION / COLUMN	A QTY	B QTY	C QTY	D QTY	E QTY
2	300-220	CABLE-6 CONDUCTOR	1	1	1	1	1
3	345-766	CONNECTOR-6 PIN	1	1	1	1	1
4	345-774	SOCKET-40 PIN	1	1	1	1	1
5	1835-106	JUMPER	0	0	3	3	0
C1,C5	307-119	CAP-56 pF-35V	2	2	2	2	2
C2,CX	307-108	CAP-20 pF	2	2	2	2	2
C3,C4	305-153	CAP-.1 µF-10V	2	2	2	2	2
C7	305-153	CAP-.1 µF-10V	1	1	1	1	0
C8	305-213	CAP-.01 µF-25V	0	0	0	0	1
C6,C9,C12	305-250	CAP-.47 µF-25V	0	0	3	3	0
C6,C9,C10,C12	305-250	CAP-.47 µF-25V	4	4	0	0	0
C11	1835-106	JUMPER	0	0	0	0	1
C12	305-250	CAP-.47 µF-25V	0	0	0	0	1
CR1,CR2,CR3,CR4	1811-282	DIODE-1N4004	0	0	0	0	4
CR4	1811-282	DIODE-1N4004	1	1	1	1	0
F1	690-49	FUSE-3/8A	0	1	1	1	0
F2	690-49	FUSE-3/8A	0	1	0	0	0
J1,J2,J3,J4	1835-106	JUMPER	4	0	4	0	0
J5,J6,J7	1835-106	JUMPER	3	0	3	0	0
J8	1835-106	JUMPER	0	0	0	0	1
J10	1835-106	JUMPER	1	0	1	0	0
Q1	2036-346	TRANSISTOR-MPSA63	0	0	0	0	1
Q2	2036-76	TRANSISTOR-2N3904	0	0	0	0	1
R1	1846-106	RES-10M 5%	1	1	1	1	1
R2	1846-222	RES-2.2K 5%	1	1	1	1	1
R4	1846-511	RES-510Ω 5%	0	0	0	0	1
R4,R5,R6 R7,R8,R9 }	1846-511	RES-510Ω 5%	0	6	0	6	0
R7	1835-106	JUMPER	0	0	0	0	1
R10	1846-271	RES-270Ω 5%	0	0	0	0	1
R10,R11,R12	1846-271	RES-270Ω 5%	0	3	0	3	0
R13,R14,R15	1846-474	RES-470K 5%	3	3	3	3	0
R18	1822-12	RES-100Ω 5%	1	1	1	1	1
R19	1846-333	RES-33K 5%	0	0	0	0	1
R21	1846-221	RES-200Ω 5%	0	0	0	0	1
R22	1835-106	JUMPER	0	0	0	0	1
R23,R24,R25	1846-473	RES-47K 5%	3	3	3	3	0
R26	1846-14	RES-10K 5%	0	0	0	0	1
R27,R28,R29	1846-273	RES-27K 5%	3	3	3	3	3
RN1	1843-55	RES. NETWORK-4.7K	1	1	1	1	1
RN2	1843-58	RES. NETWORK-4.7K	1	1	1	1	1
RN3	1843-59	RES. NETWORK-47K	0	1	0	1	0
RN3	1843-57	RES. NETWORK-1K	1	0	1	0	0
RN4	1843-57	RES. NETWORK-1K	1	1	1	1	1
S1,S2	1995-360	SWITCH-8 POS. DIP	2	2	2	2	2
U1	1685-6	IC-8742 (PROGRAMMED)	1	1	1	1	1
U2	2036-315	IC-DS1488	1	1	0	0	0
U3	2036-319	IC-26LS31	0	0	1	1	0
U4	1835-106	JUMPER (PIN 2 TO PIN 3)	0	0	0	0	1
U4	2036-339	IC-26LS32	1	1	1	1	0
U5	2036-341	IC-4702	1	1	1	1	1

(continued on next page)

ITEM	PART NUMBER	DESCRIPTION	COLUMN A QTY	B QTY	C QTY	D QTY	E QTY
U7	2036-347	IC-ULN2004A	1	1	1	1	1
U9,U12	2036-165	IC-FCD820	0	0	0	0	2
U9,U10,U11 U12,U13,U14	2036-165	IC-FCD820 or 4N26	0	6	0	6	0
VR1	2036-239	REGULATOR-78L05	0	1	0	0	0
VR2	2036-337	REGULATOR-78L12	1	0	0	0	0
VR3	2036-269	REGULATOR-79L12	1	0	0	0	0
Y1	388-5	CRYSTAL-12.000 MHz	1	1	1	1	1
Y2	388-4	CRYSTAL-2.4576 MHz	1	1	1	1	1

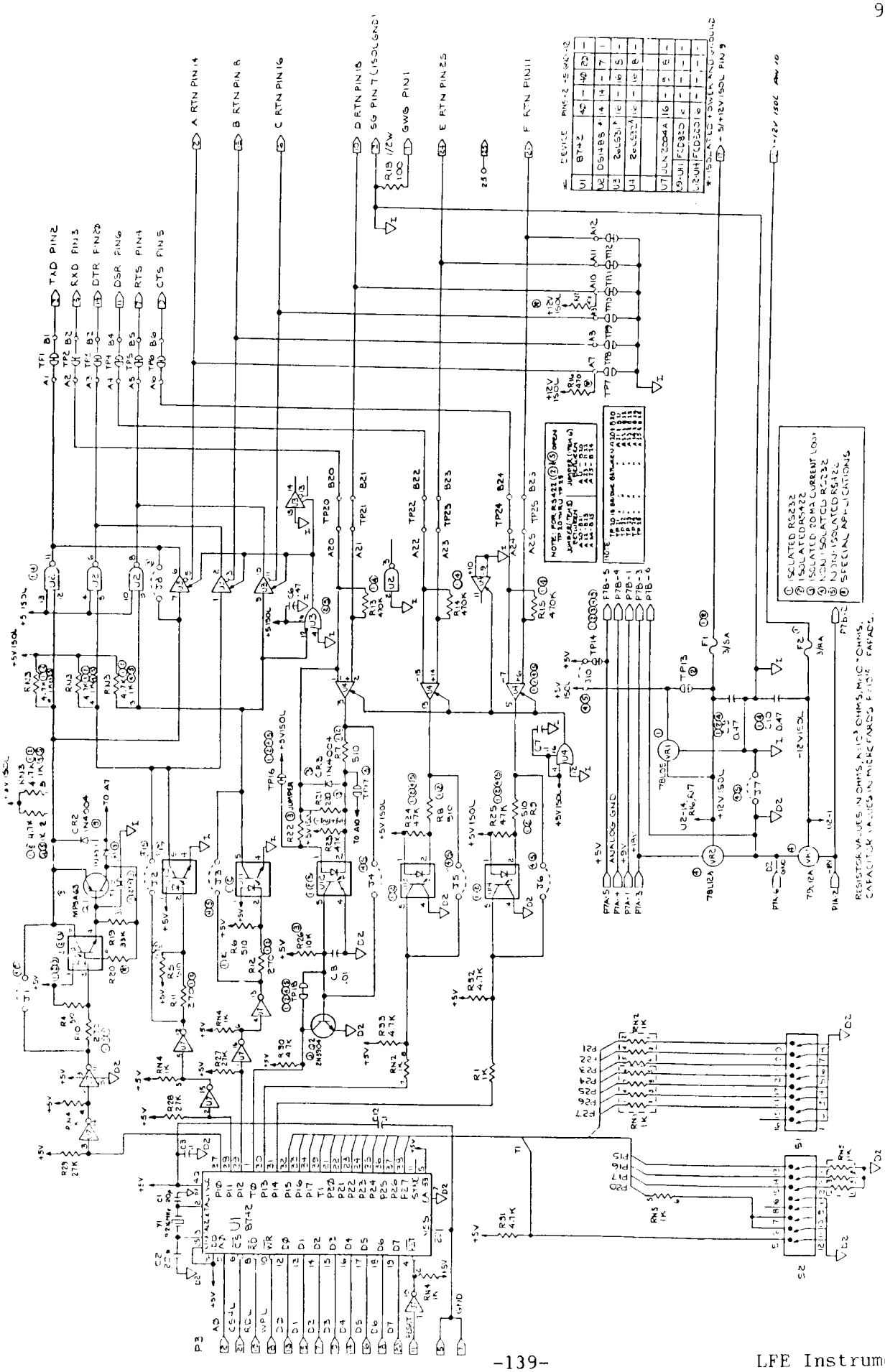
COLUMN	DESCRIPTION	P/N PCB ASSEMBLY
A	RS232 - NON ISOLATED	1651-1930
B	RS232 - ISOLATED	1651-1931
C	RS422 - NON ISOLATED	1651-1934
D	RS422 - ISOLATED	1651-1935
E	20 mA ISOLATED CURRENT LOOP	1651-1889

PARTS LIST - COMM I COMMUNICATIONS BOARD
FIGURE 12-40



PCB OUTLINE - COMM II & COMM III COMMUNICATIONS
FIGURE 12-41

1653-288



SCHEMATIC - NEW COMMUNICATIONS BOARD (COMM II & III)
FIGURE 12-42

2757-130 REV G

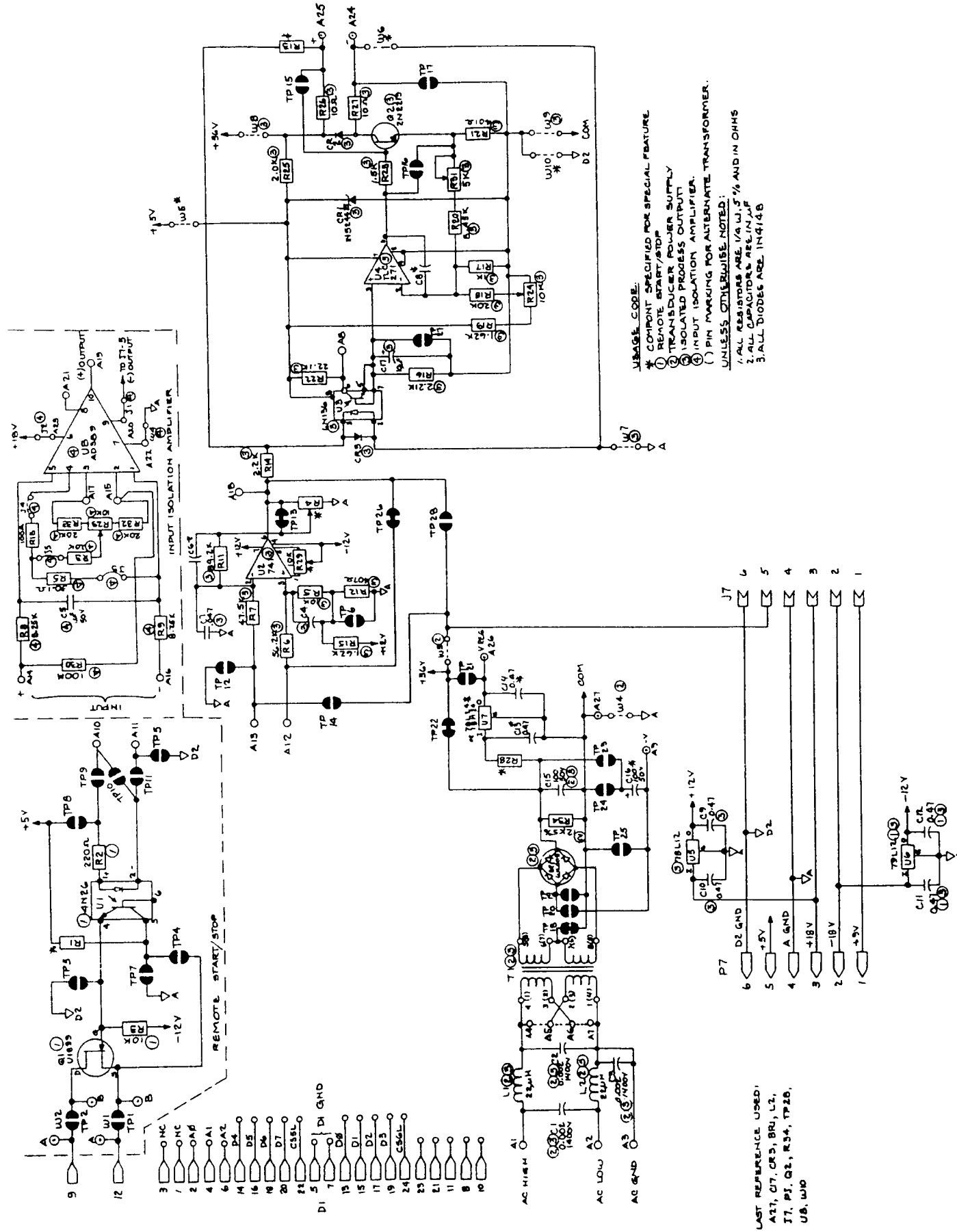
ITEM	PART NUMBER	COLUMN / DESCRIPTION	A QTY	B QTY	C QTY	D QTY	E QTY
2	300-220	CABLE-6 CONDUCTOR	1	1	1	1	1
3	345-766	CONNECTOR-6 PIN	1	1	1	1	1
4	345-774	SOCKET-40 PIN	1	1	1	1	1
5	1835-106	JUMPER	0	0	3	3	0
C1,C2	307-108	CAP-20 pF	2	2	2	2	2
C3	305-153	CAP-.1 µF-10V	1	1	1	1	1
C7	305-153	CAP-.1 µF-10V	1	1	1	1	0
C8	305-213	CAP-.01 µF-25V	0	0	0	0	1
C6,C9	305-250	CAP-.47 µF-25V	2	2	2	2	0
C10	305-250	CAP-.47 µF-25V	1	1	0	0	0
C12	305-250	CAP-.47 µF-25V	0	0	1	1	1
CR1,CR2,CR3	1811-282	DIODE-1N4004	0	0	0	0	3
F1	690-49	FUSE-3/8A	0	1	0	1	0
F2	690-49	FUSE-3/8A	0	1	0	0	0
J1,J2,J3,J4	1835-106	JUMPER	4	0	4	0	0
J5,J6,J7	1835-106	JUMPER	3	0	3	0	0
J8	1835-106	JUMPER	0	0	0	0	1
J10	1835-106	JUMPER	1	0	1	0	0
Q1	2036-346	TRANSISTOR-MPSA63	0	0	0	0	1
Q2	2036-76	TRANSISTOR-2N3904	0	0	0	0	1
R1	1846-106	RES-10M 5%	1	1	1	1	1
R4	1846-511	RES-510Ω 5%	0	0	0	0	1
R4,R5,R6 R7,R8,R9 }	1846-511	RES-510Ω 5%	0	6	0	6	0
R7	1835-106	JUMPER	0	0	0	0	1
R10	1846-271	RES-270Ω 5%	0	0	0	0	1
R10,R11,R12	1846-271	RES-270Ω 5%	0	3	0	3	0
R13,R14,R15	1846-474	RES-470K 5%	3	3	3	3	0
R18	1822-12	RES-100Ω 5%	1	1	1	1	1
R19	1846-333	RES-33K 5%	0	0	0	0	1
R21	1846-221	RES-200Ω 5%	0	0	0	0	1
R22	1835-106	JUMPER	0	0	0	0	1
R23,R24,R25	1846-473	RES-47K 5%	3	3	3	3	0
R26	1846-14	RES-10K 5%	0	0	0	0	1
R27,R28,R29	1846-273	RES-27K 5%	3	3	3	3	3
R30,31,32	1846-472	RES-4.7k 5%	3	3	3	3	3
R33	1846-473	RES-47k 5%	1	1	1	1	1
RN1,RN2,RN5	1843-63	RES. NETWORK-1K	3	3	3	3	3
RN3	1843-59	RES. NETWORK-4.7K	0	1	0	1	1
RN3	1843-57	RES. NETWORK-1K	1	0	1	0	0
RN4	1843-57	RES. NETWORK-1K	1	1	1	1	1
S1,S2	1995-360	SWITCH-8 POS. DIP	2	2	2	2	2
U2	2036-315	IC-DS1488	1	1	0	0	0
U3	2036-319	IC-26LS31	0	0	1	1	0
U4	2036-339	IC-26LS32	1	1	1	1	0

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ITEM	PART NUMBER	COLUMN DESCRIPTION	A QTY	B QTY	C QTY	D QTY	E QTY
U7	2036-347	IC-ULN2004A	1	1	1	1	1
U9,U12	2036-165	IC-FCD820	0	0	0	0	2
U9,U10,U11	2036-165	IC-FCD820	0	3	0	3	0
U12,U13,U14	2036-165	IC-FCD820 or 4N26	0	3	0	3	0
VR1	2036-239	REGULATOR-78L05	0	1	0	0	0
VR2	2036-337	REGULATOR-78L12	1	0	0	0	0
VR3	2036-269	REGULATOR-79L12	1	0	0	0	0
Y1	388-6	CRYSTAL-9.216 MHz	1	1	1	1	1

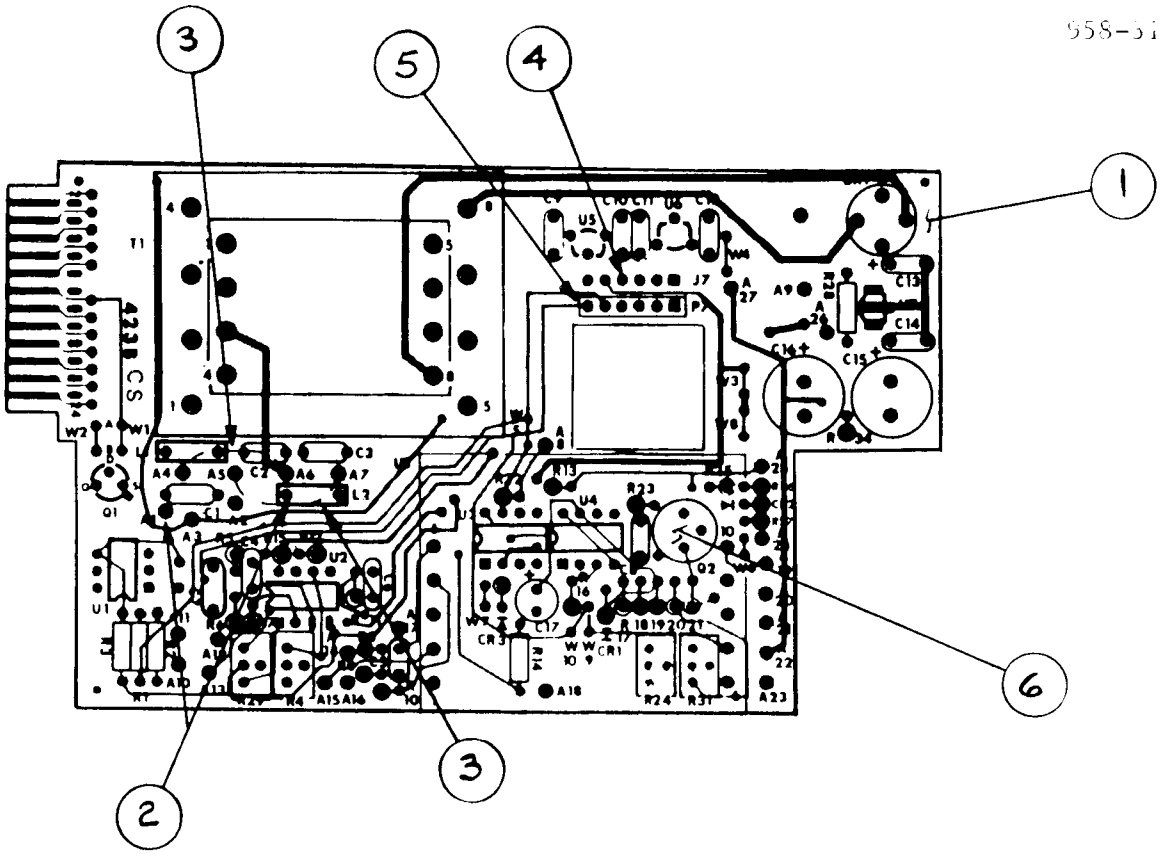
COLUMN	DESCRIPTION	P/N PCB ASSEMBLY
A	RS232 - NON ISOLATED	1651-2144
B	RS232 - ISOLATED	1651-2145
C	RS422 - NON ISOLATED	1651-2147
D	RS422 - ISOLATED	1651-2148
E	20 mA ISOLATED CURRENT LOOP	1651-2146

PARTS LIST - COMM II & COMM III COMMUNICATIONS BOARD
FIGURE 12-43



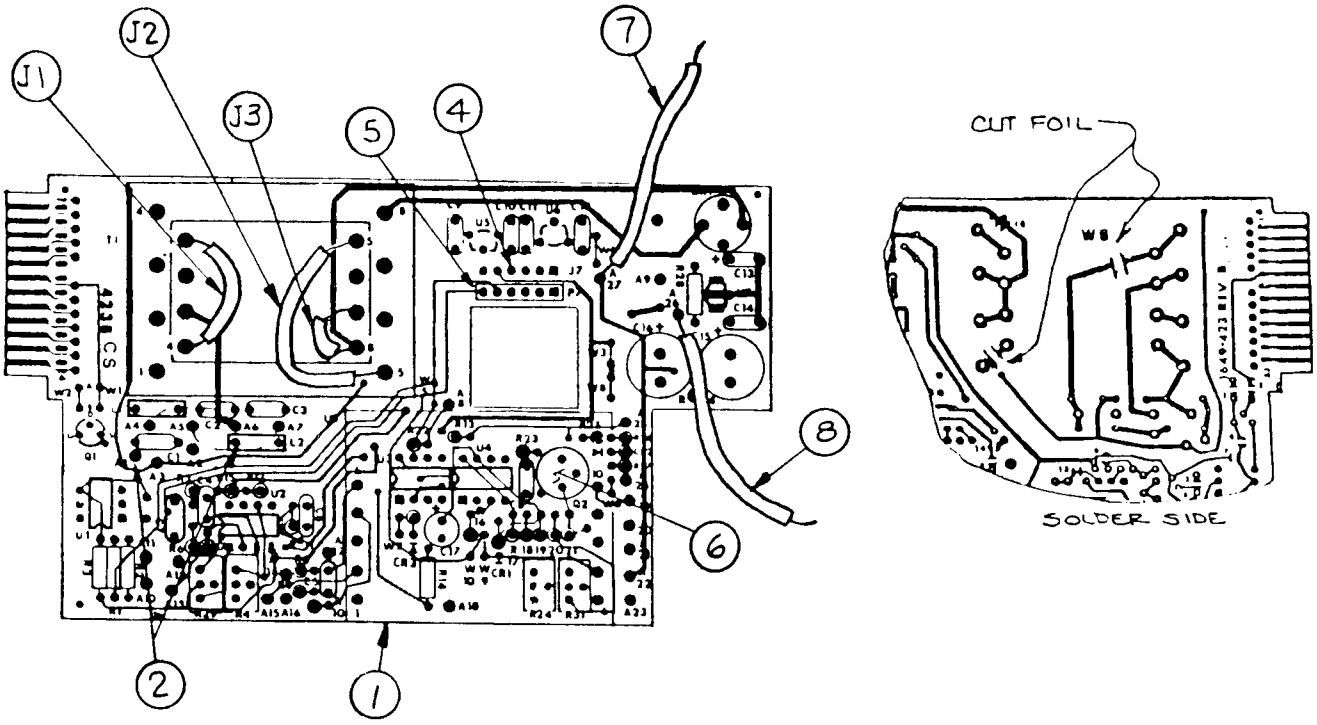
2757-146 REV F

SCHEMATIC - ACCESSORY BOARD
FIGURE 12-44



PCB OUTLINE - ACCESSORY BOARD
FIGURE 12-45

1653-260 REV A



PCB OUTLINE - ACCESSORY BOARD
4-WIRE TRANSDUCER POWER SUPPLY
FIGURE 12-46

1653-273 REV -

ITEM	PART NUMBER	COLUMN / DESCRIPTION	A QTY	B QTY	C QTY	D QTY	E QTY
4	300-220	CABLE-6 CONDUCTOR (J7)	1	1	1	1	1
5	345-766	CONNECTOR-6 PIN (P7)	1	1	1	1	1
6	1951-123	HEATSINK	0	0	0	0	1
BR1	1811-279	RECTIFIER-WL005	0	1	1	1	1
C1,C2,C3	305-439	CAP-.002 µF-1400V	0	3	3	3	3
C7	305-114	CAP-.047 µF-50V	0	0	0	0	1
C9,C10	305-250	CAP-.47 µF-50V	0	0	0	0	2
C11,C12	305-250	CAP-.47 µF-50V	2	0	0	0	2
C13,C14	305-250	CAP-.47 µF-50V	0	0	2	2	0
C15	305-70	CAP-100 µF-50V	0	1	1	1	1
C17	305-93	CAP-10 µF-25V	0	0	0	0	1
CR1	1811-464	ZENER-1N5244B	0	0	0	0	1
CR2,CR3	1811-276	DIODE-1N4148	0	0	0	0	2
L1,L2	2060-271	INDUCTOR	0	2	2	2	2
R2	1846-221	RES-220Ω 5%	1	0	0	0	0
R3	1846-14	RES-10k 5%	1	0	0	0	0
R5	1849-14	RES-10k 1%	0	0	0	0	1
R6	1849-5622	RES-56.2k 1%	0	0	0	0	1
R7	1849-4752	RES-47.5k 1%	0	0	0	0	1
R11	1849-3922	RES-39.2k 1%	0	0	0	0	1
R12	1849-4870	RES-487Ω 1%	0	0	0	0	1
R14	1846-222	RES-2.2k 5%	0	0	0	0	1
R15	1849-1621	RES-1.62k 1%	0	0	0	0	1
R16	1849-2211	RES-2.21k 1%	0	0	0	0	1
R17	1849-13	RES-1k 1%	0	0	0	0	1
R18	1849-24	RES-20k 1%	0	0	0	0	1
R19	1849-1621	RES-1.62k 1%	0	0	0	0	1
R20	1849-8451	RES-8.45k 1%	0	0	0	0	1
R21	1849-4020	RES-402Ω 1%	0	0	0	0	1
R22	1849-2212	RES-22.1k 1%	0	0	0	0	1
R23	1846-152	RES-1.5k 5%	0	0	0	0	1
R24	1675-54	POT-10k	0	0	0	0	1
R25	1849-23	RES-2k 1%	0	0	0	0	1
R26,R27	1846-11	RES-10Ω 5%	0	0	0	0	1
R28	1835-106	JUMPER	0	0	1	1	0
R31	1674-53	POT-5k	0	0	0	0	1
R34	1846-123	RES-12k 5%	0	1	0	0	0
Q1	2036-89	TRANSISTOR-U1899	1	0	0	0	0
Q2	2036-345	TRANSISTOR-2N2219	0	0	0	0	1
T1	2060-272	TRANSFORMER	0	1	1	0	1
T1	2060-286	TRANSFORMER	0	0	0	1	0
U1	2036-165	IC-4N26 or FCD820	1	0	0	0	0
U2	2036-247	IC-741	0	0	0	0	1
U3	2036-343	IC-6N136	0	0	0	0	1
U4	2036-344	IC-TLC271	0	0	0	0	1
U5	2036-337	REGULATOR-78L12	0	0	0	0	1
U6	2036-269	REGULATOR-79L12	1	0	0	0	1
U7	2036-138	REGULATOR-7805	0	0	1	0	0

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ITEM	PART NUMBER	DESCRIPTION / COLUMN	A QTY	B QTY	C QTY	D QTY	E QTY
U7	2036-365	REGULATOR-7810	0	0	0	1	0
W3,W4	1835-106	JUMPER	0	2	0	0	0
W7,W8,W9	1835-106	JUMPER	0	0	0	0	3

COLUMN	DESCRIPTION	P/N PCB ASSEMBLY
A	REMOTE START/STOP	1651-1942
B	2-WIRE 4/20 mA POWER SUPPLY	1651-1940
C	4-WIRE TRANSDUCER SUPPLY-5V	1651-2009
D	4-WIRE TRANSDUCER SUPPLY-10V	1651-2010
E	ISOLATED 4/20 mA OUTPUT	1651-1943

PARTS LIST - ACCESSORY BOARD
FIGURE 12-47

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SECTION 13 - INSTRUCTION MANUALS

13.1 INSTALLATION & OPERATION MANUALS

All controllers have an appropriate installation and operation manual shipped with each controller inside of the individual carton. Extra manuals are available from the factory as listed below:

MODEL NO	PART NUMBER
2000	955-241
2001	955-241
2002	955-241
2003	955-251
2004	955-251
2005	955-265
2010	955-239
2011	955-239
2012	955-249
2013	955-249
2014	955-252
2015	955-252
2017	955-256

13.2 SUPPLEMENTARY INSTRUCTION MANUALS

Some options require a supplementary manual to aid in installation or operation of the modified controller. The following manuals are included in this section. They may be photocopied for shipment with modified controllers.

INSTRUCTION NO.	DESCRIPTION
956-646	SELF-POWERED CURRENT LOOP FOR 2-WIRE TRANSDUCERS
956-655	REMOTE START/STOP ON SECONDARY OUTPUT PINS
956-667	BRIDGE TRANSDUCER POWER SUPPLY
956-670	NON-ISOLATED DC TRIGGER OUTPUT
956-671	RETRANSMITTING ANALOG OUTPUT
956-673	OPEN COLLECTOR OUTPUT
956-684	REMOTE START/STOP ON ALARM 2 PINS

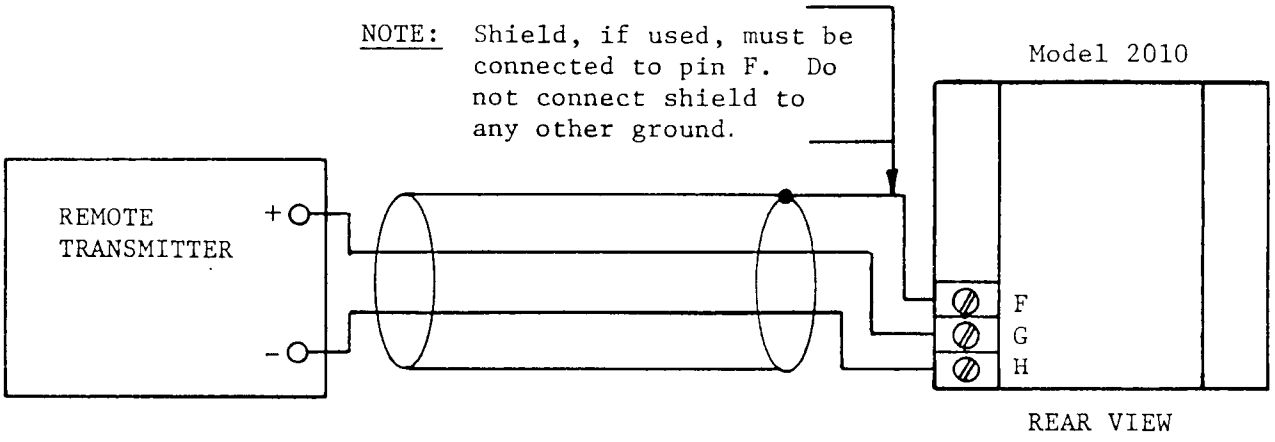
Instruments Division
A Mark IV Company

SUPPLEMENTAL MANUAL

956-646 Rev. A
4884

SUPPLEMENTARY INSTRUCTIONS FOR SERIES 2000 WITH SELF-POWERED CURRENT LOOP INPUT FOR 2-WIRE TRANSDUCERS

Series 2000 controllers with this modification are equipped to receive signals from remote 2-wire 4/20 mA transmitters. The internal power supply in the Series 2000 controller will supply approximately 36 VDC (or other voltage per special order) to the remote transmitter. The wiring to terminals F, G & H shall be as shown below. All other wiring shall be as described in the standard installation manual shipped with the unit.



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