Electro Optical Industries, Inc.

INSTRUCTION MANUAL

TEMPERATURE SOURCE
Model CDS100-02 S/N

with

TEMPERATURE CONTROLLER
Model 2477 S/N

Contract

Electro Optical Industries, Inc.
859 Ward Drive, Santa Barbara, California 93111
Telephone (805) 964-6701 FAX (805) (805) 967-8590

March 2006

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION 1

INTRODUCTION

1.1 GENERAL

The Model CDS100/200 Series 2477 is used to calibrate infrared systems, instruments and components, and may be used as a standard to calibrate other sources. It is one of a complete family of infrared radiation standards manufactured by Electro Optical Industries

The differential temperature source has a temperature-controlled square plate (source plate). The temperatures of the source plate and reference (or ambient) temperature probe are monitored by the controller, whose digital readout displays both temperatures and their difference.

Up to four (4) shutters and/or one (1) target wheel with multiple targets are options.

CAUTION

DO NOT TOUCH targets or temperature-controlled surfaces. Finger print oil will change their emissivity. The only way to restore their emissivity is to degrease and repaint them.

1.2 QUICK INSTALLATION, TEST AND OPERATING INSTRUCTIONS

This is a very brief summary of installation and operating instructions for initial equipment test, or for normal daily operation. More detailed instructions are in the rest of the manual.

Quick Operating Instructions

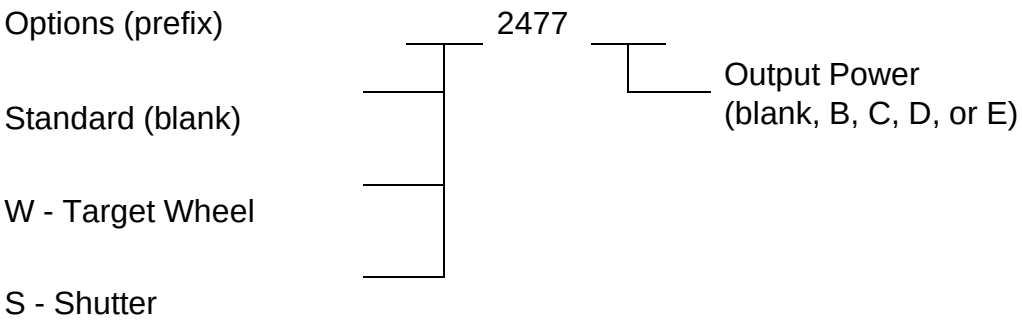
Turn on power switch. Press Esc button until set window displays “MAIN MENU”. Press “1" on keypad, then press “Enter”. Set window will display, “Temp Set”. Enter desired temperature on keypad and press, “Enter”. Wait until source stabilizes at desired temperature, which will vary in time according to circumstances.

1.3 LIST OF ITEMS FURNISHED

1) Source Assembly Model CDS (see Specifications)
2) Temperature Controller Model (see Specifications)
3) One System Interconnect Cable, source to controller

4) Reference PRT
5) One 8 ft. AC Power Cord
6) Instruction Manual

1.4 MODEL NUMBER SPECIFICATION



It is not necessary for the purchaser to specify the output power when ordering. The appropriate power level will be selected by Electro Optical Industries, Inc. based on the size and temperature range of the blackbody.

SECTION 2

SPECIFICATIONS

EOI Differential Temperature Source Model CDS100-02

EOI Temperature Controller Model 2477

Differential temperature range	-25° to + 75°C
Absolute temperature range	0° to + 100°C
Set point resolution	0.01°C or 0.001°C
Temperature display resolution	0.01°C
Stability	±0.01°C
Maximum useable area of aperture	2.0" x 2.0"
Power requirements	100/115/220/240 VAC, 50/60 Hz, 150 W. (voltage selection by module on rear of controller)
Controller:	
Size	5.0"UH x 19"W x 18"D
Remote Computer Interface	IEEE Standard 488.1 and RS-232 Serial Interface
Controllable Features	
Temperature	Standard

* Includes 2302B Power Amp.

SECTION 3

INSTALLATION

3.1 INITIAL INSPECTION

This instrument was carefully inspected before shipment. Shipping cartons should be inspected for damage before and after unpacking. Inspect instruments for physical damage incurred in transit or in storage. If damage occurred during shipping, notify the carrier and Electro Optical Industries Inc. at once. Inspect package for items listed in Section 1.3.

3.2 INSTALLATION

1) Carefully remove the control unit and source from the shipping cartons.

2) Connect the Differential Source and the Temperature Controller with the supplied cable. Connectors are on the backs of the Controller and Source. Additional connections, for optional wheels or shutters via their cables, are also on the back of the temperature controller and their respective assemblies.

3) Install the Reference Temperature Probe in the Target Holder Support. Make sure the probe is fully inserted. If the probe tip does not easily slide in, use a drop of Silicon oil to lubricate it.

CAUTION

DO NOT TOUCH targets or temperature-controlled surfaces. Finger print oil will change their emissivity. The only way to restore their emissivity is to degrease and repaint them.

NOTE: For systems that have the sources enclosed in a larger housing, such as a collimator, the reference temperature probe is normally pre-installed.

4) For remote operation, connect appropriate cables to the interface connector(s) on rear of the chassis. Remote operation is described in detail in Section 4.

CAUTION

Do not connect controller to AC power unless setting shown in power input module window matches the line voltage. Doing so may damage electronics.

5) Make sure the voltage wheel matches the operating line voltage to be used. The wheel is in the power entry module at the rear of the chassis. To change the voltage selection, remove the power cord from the power entry module. Open the cover by prying a small screwdriver into the slot at the top of the module. Put the screwdriver into the slot on the voltage selector wheel to remove the wheel from the module. Replace the wheel in the module with the desired voltage showing out through the cover window.

6) The fuse-holder is located beneath the voltage selector wheel. The plastic fuse carrier is pulled straight out to remove the fuse.

7) Use the appropriate power cord to connect the temperature controller to the correct source of AC power.

3.3 REPACKING FOR SHIPMENT OR STORAGE

Using the original cartons to ship or store these instruments is not recommended.
Use new cartons and follow the procedure below.

1) Wrap instruments in heavy plastic or other waterproof material before placing in inner container.

2) Fill space around panel to prevent damage to controls.

3) Place in outer container with packing between the containers. Seal with heavy tape or metal bands.

4) Mark containers "DELICATE INSTRUMENTS, FRAGILE".

5) DO NOT SHIP VIA PARCEL POST!

3.4 STORAGE

To store instruments, follow packing instructions in Section 3.5 and locate in approved area suitable for storing electronic instruments.

Storage temperature range: –40° to +50°C.

SECTION 4

OPERATION

4.1 MODEL 2477 CONTROLS

4.1.1 Front Panel Controls and Indicators

POWER switch — Turns line power ON [1] or OFF [0]. Front panel displays illuminate when power is on.

SET Display — 1 x 20 character display above keyboard is an editing window controlled by the keyboard. It is used to set up and control the operations of the Model 2477 temperature controller. This includes mode selection, temperature setting and calibration. This display is also used to select targets and shutter openings when options are installed.

STATUS Display — 2 x 20 character display, left side of front panel, displays status, measurements and messages for the user.

The STATUS symbols that appear on the display are:

◆ Indicates temperature ready, the temperature of the source is stable within the temperature ready window.

R Indicates remote control; the controller set points are determined by the remote host computer.

4.1.2 Keypad

7	8	9	ESC
4	5	6	▲
1	2	3	▼
±	0	HELP	ENTER

Keypad

16 keys, 0 - 9 numeric plus 6 function keys. Key functions are:

0 ... 9	10 keys used for numeric entries.
" ± "	This key is used to change the sign of a number.

HELP — HELP information will be displayed in the larger STATUS display corresponding to MENU selection on smaller display.

ESC — This key leaves the editor when examining or changing a set point without altering the original value. This key will also back up one level in the MENU.

ENTER — When editing a set point value, this key will make the entered value the new set point value. When paging through the MENU system, this key will either drop the MENU down one level (when at a submenu selection item indicated by the ellipsis set . . .) or switch to the editing mode (when at a set point control value in the menu).

▲, ▼ — These are cursor control keys. When paging through the MENU, these will display the next or previous items at the current level. When editing a set point which only allows one of a limited number of choices (as indicated by ▼▲), these keys will scroll through the choices available. When editing a numeric value which must be entered by the numeric keys, these controls allow the user to scroll to the left and right in the editing field.

4.1.3 MENU System

A user controls the instrument through a multi-level menu system with no more than 10 items at any level. Each item at a level is numbered from 0 to 9. Pressing 0 is always a command to back up a level. Pressing “Esc” also backs up one level. An item in the MENU will either be a set point value which the user can adjust, or a submenu title which will move the user down to the next MENU level when selected.

The items in the MENU can be selected by either scrolling through the MENU items using the cursor keys, (□ and □) or by pressing the number attached to each MENU item. A MENU item consists of items which can be logically grouped together for ease of use by the user.

The six (6) main levels are:

1) Set point controls - controls for setting temperature, selection of optional targets and/or shutters.
2) Operation controls - controls for setting control mode, units °F / °C / Kelvins and temperature to display.
3) Interface - LOCAL/REMOTE mode, IEEE Device Address
4) Configuration - display resolution, ready window tolerance, intensity of display.
5) Power-On configuration - sets up Power-ON default conditions.
6) Calibration - controls for examining and performing detailed calibration.

4.1.4 Error Message Display

Internal problems in the Model 2477 are displayed as error messages on the front panel display as well as being indicated on the computer interface. Reported errors are A/D converter time-out, open PRT condition, and a checksum error of the calibration data.

The front panel display message is as follows:

DISPLAY MESSAGE

ERROR - Open PRT

Identifies an open current loop condition for the PRT's. The source of the problem may be an open PRT itself, or a break in the wiring to either PRT.

DISPLAY MESSAGE

ERROR - ADC failure

Identifies an A/D converter time-out condition. The most probable cause for this error condition is an electronic failure in the A/D converter itself or its supporting circuitry.

DISPLAY MESSAGE

ERROR - DATA checksum

Identifies a checksum error in the calibration data table. The data table should be read from the 2477 with the ‘LR?’ command to try and determine which portion of the data has changed. The data table may be reloaded with the Load commands. This error condition can be reset by sending an LDT ‘date’ command.

4.2 BASIC OPERATING PROCEDURE IN LOCAL CONTROL

4.2.1 Power ON

Turn power ON. For maximum accuracy, allow controller thirty minute warm-up period. Source may take more or less time to reach set temperature, but controller needs to be on at least 30 minutes.
At startup, the controller first goes through a brief initialization and POWER ON sequence. Once initialized the SET display starts out at:

[0 MAIN MENU ▲▼ .. .]

During normal operation, you can get to MAIN MENU by pressing the ESC key three times.

4.2.2 Setting Modes and Temperature

a) Press the down arrow twice or press 2 on the keypad to get to the OPERATION level:

[2 OPERATION . . .]

Press the ENTER key to get into this level.

b) Press the down arrow key (▼) once to get to the control mode.

[2 - Control Mode: Diff]

Press ENTER key to get into this level.

c) Select the desired operating mode (differential, absolute or effective) by scrolling [▲ or ▼] through the available modes. When desired mode is displayed, press ENTER to accept the mode change. If no change in mode is wanted, press ESC to exit without changing the setting, or press the ESC key three times to return to MAIN MENU.

d) To change the temperature, go to MAIN MENU by pressing the ESC key three times. Press the 1 key to go to the Temp Set menu. Press ENTER, then enter desired temperature with number keys and press ENTER again to finalize and accept the change.

4.2.3 Shutter Selection (under SETPOINTS) (Option S)

Go to the SHUTTER sub-level of the SETPOINTS level by pressing the ▼ key until you come to the shutter you want to activate. To change the STATUS press ENTER to get the flashing symbol. Press the up or down key to change the setting. Press ENTER again to finalize and accept the change. (NOTE: The status display will be updated to the correct position).

4.2.4 Target Wheel Selection (under SETPOINTS)(Option W)

Go to the TARGET WHEEL sub-level of the SETPOINTS level by pressing the ▼ key until you come to the TARGET WHEEL. Press ENTER, and enter desired target with the number keys (0-11), then press ENTER again to finalize and accept the change.

4.3 REMOTE CONTROL

An IEEE Standard 488.1 and RS232 interface are provided with this temperature controller. These are discussed in more detail in later sections. (Sec. 4.5 & 4.6).

The remote interface utilizes a command set to operate the controller via a host computer as described briefly below. The temperature controller device address must be properly set before using the computer interface. All commands are terminated with an ASCII carriage return character indicated by **<cr>.** With the IEEE 488.1 interface the carriage return character may be sent with or without the EOI line asserted. Temperature control commands and front panel display commands may be sent when the instrument is in either LOCAL or REMOTE mode.

4.3.1 Temperature Control

The desired control mode (absolute or differential) should first be selected. To select the differential control mode, send the command **'SD<cr>'**. To select the absolute control mode, send the command **'S2<cr>'** and to select effective □T control mode, send the command **'SE<cr>'.**

TABLE 4.1 FRONT PANEL SET DISPLAY MENU LEVELS

TOP LEVEL	SUB-LEVEL	DESCRIPTION
0		(To return here, press “Esc” until “Main Menu is displayed in set window) 0 MAIN MENU ▲▼
1		SETPOINTS . . . (temperature, shutter, target)
	1 2	Temp Set - enter from numeric keypad Shutter or Targets (Option S or W)
2		OPERATION . . .
	2 3 4 5 6	Temp to display - T2, □T, T1 reference Control mode - differential, EFF, absolute (ABS) Units - °C, °F, K Time - XX:XX Date - XX/XX/XXXX Start Clock
3		INTERFACE . . .
	2 3 4 5 6	Mode - LOCAL, REMOTE IEEE Address Serial BAUD Serial Parity Serial Word Size Serial Stop Bits
4		CONFIGURATION . . .
	2 3	Display Res. - resolution Ready Window - tolerance Intensity - of display
5		POWER ON CONFIGURATION . . .
	2 3	PON State - last set/default Temp. Set - default setting Shutter, or Target (Option S or W)

6		CALIBRATE . . . (requires password)
	2	Temp. Calibrate Password - (initially set to 4660)

To set temperature while in the REMOTE mode, an ASCII character ' **D '** should be sent to the instrument, followed by a signed number with decimal point. For positive numbers, the sign may be omitted. Leading blanks and zeroes will be ignored. Digits past the second decimal place will be dropped. An embedded illegal character (anything other than the numeric digits 0 through 9 and the decimal point) will have the effect of truncating the string at that point. The decimal point may be omitted if the desired setting has no fractional portion. A carriage return must be used to terminate the message.

EXAMPLES:	**Command**	**Temperature Setting**
	D–5.43<cr>	**–5.43°C**
	D5.43<cr>	**+5.43°C**
	D0.0085<cr>	**0.00°C**
	D+18 53<cr>	**+18.00°C**
	D7.5<cr>	**+ 7.50°C**
	D<cr>	**0.00°C**
	D23<cr>	**+23.00°C**

4.3.2 Front Panel Display

While in REMOTE mode, the remote interface may be used to select the temperature reading to be displayed on the front panel.

Command	**Front Panel Display**
T1<cr>	Target baffle plate temperature (ref. temp.)
T2<cr>	Source plate temperature
TD<cr>	Differential temperature (T2-T1)
TF<cr>	As selected by front panel

4.3.3 Temperature Readout

The current temperatures as shown on the front panel display may be read from the 2477 in either the REMOTE or LOCAL modes. With the IEEE 488.1 interface, the 2477 will respond with the temperature readings when addressed as a talker.

Temperature information is sent from the temperature controller in the form shown in the following example:

T1+.2350000E+02,T2+.202100E+02,TD_.3290000E+01<cr>

The first portion of the message contains T1 (target baffle plate temperature) information. The temperature is in degrees Celsius and is expressed as a signed number between zero and one, with an exponent. A comma separates this information from the next portion of the message.

The second portion of the message contains T2 (source plate temperature) information, followed by a comma.

The third portion of the message contains differential temperature (T2-T1) information. An ASCII carriage return symbol, shown as <cr> in the above example, terminates the message.

The format of numeric data transmitted by the 2477 may be changed from the standard exponential form shown above to another more readable format. The alternate format transmits numeric data as signed floating decimal point numbers. The number of decimal places is determined by the current display resolution setting. (See Resolution Command.)

Fx<cr>

'F' is the command header followed by a single numeric digit. Valid input for x is either 0 or 1. The default setting is '0' which is the exponential format, and data is displayed as follows:

T1+.2313000E+02,T2+.2313000E+02,TD+.0000000E+00<cr>

After receiving an 'F1' command, and with the standard two decimal place resolution, the same data string would appear as follows:

T1 +23.13,T2 +23.13, TD +0.00<cr>

4.3.4 Target Wheel Option (Option W)

To select a desired target position while in the REMOTE mode, a Wxx<cr> must be sent. The range of values of the target position data is dependent upon the number of positions in the target wheel, and should be a positive integer. The following are examples of valid wheel position commands.

W05<cr>
W3<cr>
W10<cr>

The present target position information is included along with the standard temperature information data string 'WH' is the response header followed by the current target position. If target wheel is in motion, the response will read 'WH—'.

EXAMPLE:

T1+.3010000E+02,T2+.3012000E_02,TD+.2000000E_01,WH10<cr>
T1+.2500000E+02,T2+.10S0000E+03,TD+.8000000E+02,WH__<cr>
T1+.2350000E+.02,T2+.202100E+02,TD_.3290000E+01,WH00<cr>

4.3.5 Shutter Remote Control (Option S)

To control the SHUTTER while in the REMOTE mode a 'SHxn' command followed by a carriage return, <cr>, must be sent. 'x' represents the number of the SHUTTER; 'n' represents the position of the SHUTTER, n = 0 (OPEN), n = 1 (SHUT).

The general form of the shutter commands are as follows:

'SH' SHUTTER SELECTION COMMAND

To select a shutter (Option S) a command of the following format would be sent:

COMMAND FORMAT

SHxn<cr>

'SH' is the command header followed by the desired shutter (x) and whether it is to be opened (0) or closed (1). The following are examples of valid shutter commands.

SH10<cr> Shutter #1 OPENED
SH31<cr> Shutter #3 CLOSED

SHUTTER STATUS COMMAND (Option S)

The status of each shutter can be read back from the 2477 with the SHx? command, as shown in the following examples.

COMMAND FORMAT

SHx?<cr>

The question mark after the 'SH' command identifies it as a query to the 2477. The next time the 2477 is addressed as a 'talker' on the computer, it will respond with the shutter information.

SHX? RESPONSE

SHxn

here x = shutter queried, n = ' 0 ' = OPEN, ' 1 ' = CLOSED

If your controller only has one shutter, the proper number to use is 1, so the command syntax would be:

SH10<cr> Shutter OPEN
SH11<cr> Shutter CLOSED
SH1?<cr> Shutter status

After the SH1? command, address the 2477 as a talker and the response will be:

SH10 Shutter OPEN
SH11 Shutter CLOSED

The front panel STATUS display will show SHG when the shutter is OPEN, and will show SHO when the shutter is CLOSED.

4.5 IEEE STANDARD 488.1 REMOTE INTERFACE

4.5.1 Remote/Local Control

The temperature controller is placed under REMOTE control by IEEE Bus. The method is specified in IEEE Standard 488 - 1978 and uses the front panel REMOTE/LOCAL switch as the gtl source.

4.5.2 Computer Addressing

When shipped, the Model 2477 has its computer address set to 3 for both the talk and listen address. To alter this setting, the address can be changed via front panel menu.

4.5.3 IEEE Bus GET Command

The Group Execute Trigger (GET) command of the IEEE Bus is implemented in the Model 2477. The GET command will trigger several instruments connected together on the IEEE Bus to simultaneously perform the function for which they are programmed upon receipt of the GET.

4.5.4 Model 2477 Service Request

The 2477 differential temperature controller now more fully implements the Service ReQuest (SRQ) feature of the IEEE Bus. The SRQ is one signal line of the IEEE Bus which is used to signal the bus controller (host computer) that a device on the bus needs the controller's attention. The SRQ line may be asserted due to an error condition, a function complete condition, or for whatever reason the device has been programmed. The bus controller then polls each device connected to the bus to determine which device generated the SRQ. The polling of the device by the bus controller clears the SRQ line.

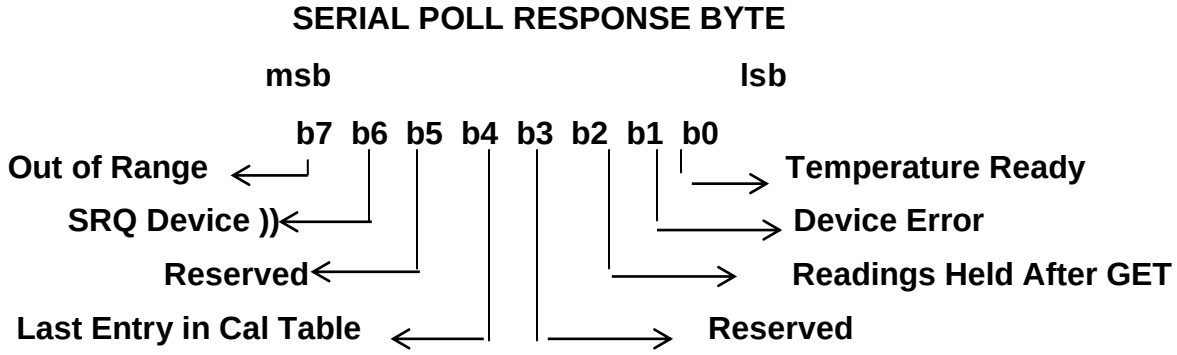
The Model 2477 generates an SRQ for several reasons:

A temperature setting out of range of the temperature controller, an error condition, when the blackbody source reaches the temperature set point, and when the temperature probe resistance and temperature readings are stored after a GET command (See Section 7.5) will each generate an SRQ. Each of these conditions is identified by a certain bit position in the serial Poll byte.

4.5.5 Serial Poll Responses

After a device on the IEEE Bus generates an SRQ, the reason for the Request may be determined by the bus controller performing a serial Poll. The serial Poll returns an 8_bit byte. Each individual bit position indicates a particular reason for the SRQ. By IEEE_488 standards, bit position b6 is the bit identifying the particular device on the bus that generated the SRQ. This bit, b6, as well as the SRQ line on the bus are cleared when the bus controller performs the serial Poll. The other bit positions are assigned specific functions by the device manufacturer.

In the Model 2477, the serial Poll response byte bit positions are defined as follows:



b7 - Out of Range

Set to ' 1 ' to indicate that the present temperature setting is out of the range of temperatures to which the 2477 has been calibrated.

b6 - SRQ Device

When set to ' 1 ', indicates that this is the device that generated the SRQ. Reset to ' 0 ' when the bus controller performs the serial Poll.

b5 - Temperature Data Ready (or Reserved)

Set to '1' when new temperature data is available to read over the IEEE Bus. This bit is reset to '0' when the temperature data is read. This interrupt will occur approximately once per second.

b4 - Last Entry in Cal Table

Set to '1' to indicate that the last entry in the calibration data table has been reached using the 'VN' command in calibration mode.

b3 - Undefined

Undefined at present time.

b2 - Readings Held After GET

Set to ’ 1 ’ after the present resistance and temperature readings have been stored internally in the 2477 after a GET has been issued. During the calibration procedure this indicates that it is now allowable to send the 2477 actual temperature readings from the calibration thermometer.

b1 - Device Error

Set to ’ 1 ’ when the Model 2477 has diagnosed an internal error. A checksum error in the calibration data, and A/D converter time_out, or an open PRT can generate this error condition. When this bit is set, the 2477 should be interrogated with the ' E? ’ command, page 19, to identify the exact error.

b0 - Temperature Ready

Set to ’ 1 ’ when the blackbody source has reached the current temperature set point. Set to ’ 0 ’ when the present source temperature does not equal the current temperature set point.

4.6 RS232 SERIAL INTERFACE

4.6.1 General

This feature provides the capability to receive and transmit messages to the temperature controller via a serial interface. Data is encoded as ASCII characters. Communication parameters (baud rate, number of data bits, number of stop bits, and parity) are user-selectable with the front panel keypad.

4.6.2 Communication Parameters

When shipped, the Model 2477 serial communication parameters are set at 9600 baud, 8 data bits, no parity, and 1 stop bit. These parameters may be changed using the front panel keypad.

The available baud rate choices are 300, 1200, 2400 and 9600 baud. The number of data bits is set to either 7 or 8. The parity may be set to NONE, ODD or EVEN. The stop bit choices are 1 or 2.
The serial port is updated "on the fly" with the new communication parameters as they are entered. If serial communication is taking place while a change is made, the communication will be disrupted as the serial port is reconfigured.

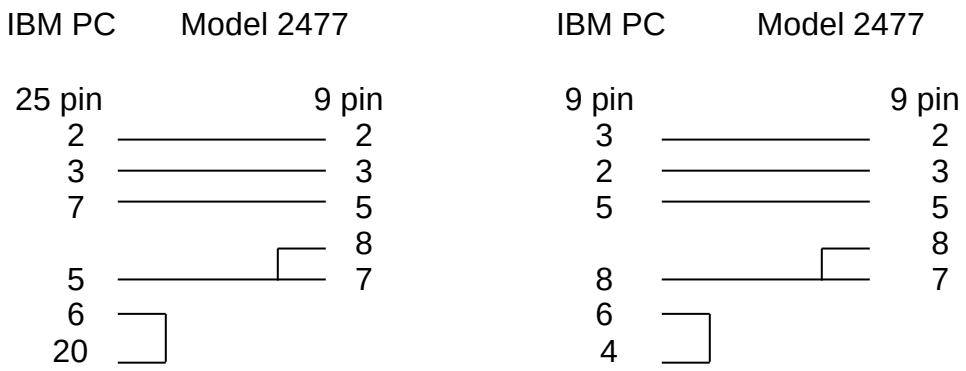
4.6.3 RS232 Cabling/Connector Pinout

The serial communication connector is a female 9 pin D-type connector located on the rear of the temperature controller chassis. Data is received by the temperature controller on pin 2, and transmitted by the temperature controller on pin 3. Pin 5 is the signal ground line. RTS is pin 7 and CTS is pin 8. Hardware handshaking is not used in the 2477, but the CTS line must be active to enable transmission from the temperature controller. The RTS line is set active by the 2477 and may be jumpered to the CTS line to enable transmission.

TEMPERATURE CONTROLLER SIGNAL

PIN #	DIRECTION	SIGNAL
2	←	data from computer to controller
3	→	data from Model 2477 to computer
5	↔	signal ground
7	→	RTS, always enabled
8	←	CTS, must be active for 2477 to transmit

Suggested Cabling from IBM PC Serial Port to Model 2477



4.6.4 Remote/Local Control

The temperature controller is placed under REMOTE control when the REMOTE ENABLE ("REN") command is sent to the temperature controller. The temperature controller may be returned to the LOCAL mode of operation by either sending the LOCAL ("LOC") command or by selecting the LOCAL option of the interface mode with the front panel keypad.

4.6.5 RS232 Commands

The commands used to communicate with the Model 2477 over the serial interface are almost identical to the commands used with the IEEE 488.1 interface. Five additional commands have been added to allow the serial interface to emulate IEEE 488 functions not normally available with the serial interface.

REMOTE ENABLE

The temperature controller is placed under REMOTE control when the REMOTE ENABLE ("REN") command is sent to the temperature controller. After receipt of this command, the Model 2477 will use the data received over the interface for set points and control functions.

COMMAND FORMAT

REN<cr>

LOCAL

The temperature controller may be returned to the LOCAL mode of operation by sending the LOCAL ("LOC") command. After receipt of the LOC command, the Model 2477 will return to the LOCAL mode of operation and respond to the front panel keypad.

COMMAND FORMAT

LOC<cr>

GENERAL QUERY

To read data from the Model 2477, the general query command must be sent. The message returned will be dependent upon the last command sent. If no specific query has been requested, the temperature data will be returned.

COMMAND FORMAT

??<cr>

After receipt of this query message, the Model 2477 will transmit an ASCII data string terminated by a carriage return. The standard response would be:

TA0100.0<cr>

SERIAL POLL

A Serial Poll ("SPL") of the Model 2477 may be performed over the serial interface to get the status of the 2477. The response will be a three digit integer whose hexadecimal representation will follow the pattern of the IEEE 488 serial Poll response (Sec. 4.5.5).

COMMAND FORMAT

SPL<cr>
??<cr>

The response will be:

SPL xxx<cr>

where xxx is an integer in the range of 0 to 255.

Example: SPL 065 response (41_{HEX}) Temperature Ready indicator.

GROUP EXECUTE TRIGGER

The Group Execute Trigger ("GET") command is used to emulate the command of the same name from the IEEE 488 interface (Sec. 4.5.3).

COMMAND FORMAT

GET<cr>

4.6.6 Sample BASIC Programs

Two example BASIC programs are below to demonstrate serial communication with the Model 2477 and an IBM PC type computer. The first program will read the calibration data from the Model 2477 and store the data in a user defined file. The second program will read the calibration data from a user defined file and transmit it to the Model 2477.

PROGRAM 1 – READ TABLE

```
10 INPUT "Enter filename to save data : "; FILENAME$
20 OPEN FILENAME$ FOR OUTPUT AS #2
30 OPEN "COM2:9600,N,8,1" FOR RANDOM AS #1   ' CONFIGURE COM PORT
40 PRINT #1, "LR?"                  ' SEND TABLE DOWNLOAD COMMAND
50 PRINT #1, "??"                   ' SEND GENERAL QUERY COMMAND
60 LINE INPUT #1, RESPONSE$              ' GET REPLY FROM CONTROLLER
70 IF LEFT$(RESPONSE$, 2) <> "LS" THEN 50    ' CHECK FOR BEGINNING OF TABLE
80 PRINT RESPONSE$: PRINT #2, RESPONSE$       ' PRINT RESPONSE TO SCREEN &
    FILE
90 PRINT #1, "??"                   ' START LOOP TO GET REST OF TABLE
100 LINE INPUT #1, RESPONSE$
110 PRINT RESPONSE$: PRINT #2, RESPONSE$
120 IF LEFT$(RESPONSE$, 4) = "LEND" THEN 140 ' IF END OF TABLE, DONE
130 GOTO 90                         ' GO GET MORE DATA
140 CLOSE : END                     ' CLOSE FILES, QUIT
```

PROGRAM 2 – WRITE TABLE

```
10 INPUT "Enter filename to save data : "; FILENAME$
20 OPEN FILENAME$ FOR OUTPUT AS #2
30 OPEN "COM2:9600,N,8,1" FOR RANDOM AS #1   ' CONFIGURE COM PORT
40 PRINT #1, "LR?"                  ' SEND TABLE DOWNLOAD COMMAND
50 PRINT #1, "??"                   ' SEND GENERAL QUERY COMMAND
60 LINE INPUT #1, RESPONSE$              ' GET REPLY FROM CONTROLLER
70 IF LEFT$(RESPONSE$, 2) <> "LS" THEN 50    ' CHECK FOR BEGINNING OF TABLE
80 PRINT RESPONSE$: PRINT #2, RESPONSE$       ' PRINT RESPONSE TO SCREEN &
    FILE
90 PRINT #1, "??"                   ' START LOOP TO GET REST OF TABLE
100 LINE INPUT #1, RESPONSE$
110 PRINT RESPONSE$: PRINT #2, RESPONSE$
120 IF LEFT$(RESPONSE$, 4) = "LEND" THEN 140 ' IF END OF TABLE, DONE
130 GOTO 90                         ' GO GET MORE DATA
140 CLOSE : END                     ' CLOSE FILES, QUIT
```

The programs have been tested using the cables described in Section 4.5.3 and using GWBASIC and QBASIC.

TABLE 4.2

QUICK SUMMARY OF COMMANDS
Model 2477

CONTROL COMMANDS

		Ref. Pg#
A1	**Dxxxx.x<cr>** sets absolute temperature **– D25<cr>** goes to 25°C in mode selected by Sx command.	14, 25
A2	**E?<cr>** gets error status next time 2477 addressed as "talker"	26
A3	**RWxx<cr>** sets allowable temperature tolerance (xx = 01 standard)	26
A4	**RW?<cr>** gets existing tolerance setting next time 2477 is addressed as "talker"	27
A5	**Sx<cr>** selects temperature mode: absolute, (S2)	27
A6	**Tx<cr>** selects temperature reading to be displayed. (x = 1,2,D,F)	27
A7	**Wxx<cr>** sends desired target wheel position (target wheel options) (xx = 0 to 11 standard)	28
A8	**SHxn<cr**> selects shutters (x = 1,2,3 or 4) n = O = OPEN, 1 = CLOSED	28
A9	**SHx?** Gets SHUTTER STATUS next time the 2477 is addressed as a "talker". (x = 1,2,3 or 4). Response format is **SHxn** where n = O for OPEN, 1 = CLOSED	29
B1	a) Normal readback message string when 2477 is addressed as talker. **T1+.2350000E+02,T2+2021000E+02,TD-.3290000E+01**	15
	b) Readback message string with target wheel option: **T1+.2350000E+02,T2+2021000E+02,TD-.3290000E+01,WH05<cr>**	15
B2	**Fx<cr>** determines format of numeric calibration data (x = 0 for exponential; x = 1 for signed floating decimal point format)	29

B3	**Rx<cr>** a) R0 or R1<cr> enables (R1) or disables (R0) additional field for TEMP.READY indication when enabled, (R1): the readback message string looks like:	30
	T1+.2350000+02,T2+.2021000E+02,TD-.3290000E+01,R0 or R1<cr> where R0 = NOT READY, R1 = READY	30
	b) **R2 or R3<cr**> establishes decimal place resolution (2 or 3 places) on front panel as well as output I/O data	

CALIBRATION COMMAND SET

C1	**Axxx.xxx<cr>** used to send Actual Temp. from outside measurement to Model 2477 (must be preceded by V?X? command)	30
C2	**DT?<cr**> get date of last calibration, next time 2477 is addressed as "talker"	31
C3	**L"X"?<cr>** downloads table list from Model 2477 host. X = 1,2, or R)	31-34
C4	**LS2xxx<cr>** sends SIZE of "X" table	34
C5	**LR2xxx xxx.xxx** sends RESISTANCE DATA TO TABLE	35
C6	**LT2XXX XXX.XXX** sends temperature data to table	35
C7	**LLAxxxxx<cr>** sends low absolute temperature limit.	36
C8	**LHAxxxxx<cr>** sends high absolute temperature limit	36
C9	**LSNxxxxx<cr>** sets serial number of 2477	36
C10	**LDTxxxxxxxx<cr>** sends date of calibration	37
C11	**SN?<cr>** sends back serial number of 2477 next time 2477 is addressed as "talker".	37
C12	**T2<cr>** sends back size of table next time 2477 is addressed as "talker"	37
C13	**V2<cr>** selects probe for verification, V refers to effective calibration.	37
C14	**VS<cr>** starts checking 1st entry in table chosen via V"X" command	37

C15	**VN<cr>** temperature steps to next calibration point in table chosen	38
C16	Vxxxx.x<cr> verifies existing CALIBRATION POINTS	38

For more discussion and examples see Ref. Pg. # listed.

4.7 MODEL 2477 REMOTE INTERFACE COMMAND SET

4.7.1 General

The commands used to communicate with and control the Model 2477 with a remote interface are divided into three main categories:

1) Control, 2) Data Format and 3) Calibration.

Control commands set basic operating functions such as control mode, set point, etc.

Data Format commands control the format of the data returned by the 2477.
Calibration commands are used to calibrate the 2477 to a known reference standard.

All commands sent and all data returned are terminated with an ASCII carriage return character indicated with the symbol <cr>. With the IEEE 488.1 interface, the <cr> may be sent to the 2477 with or without the EOI line asserted. The data returned by the 2477 has the EOI line asserted with the <cr>. The commands in each category are listed in alphabetical order.

4.7.2 Control Commands

KEYPAD COMMAND

The temperature setting of the blackbody source is established using this command. The setting is in degrees Celsius with .01°C resolution. This command functions as does the front panel keypad.

Dxxx.xx<cr>

'D' is the command header followed by the desired temperature setting in degrees

Celsius. The temperature setting data,**'xxx.xxx'**, is a signed number with decimal

point. The number of digits is arbitrary. For positive numbers, the sign may be

omitted. Leading blanks and zeroes will be dropped. Digits past the second decimal place will be truncated. An embedded illegal character (anything other than the numeric digits 0 thru 9 and decimal point) will have the effect of truncating the string at that point. The decimal point may be omitted if the data has no fractional portion.

The following examples on the next page demonstrate acceptable forms of input data strings.

D25<cr>
D+25.00<cr>
D+.2500000E+02<cr>
D 7.5<cr>
D_5.43<cr>

'E' ERROR INTERROGATION COMMAND

After an error has been indicated by bit b1 of the serial Poll byte, the 'E' command is used to identify the cause of the error. The 2477 will respond with an error code number which identifies the cause of the error condition.

COMMAND FORMAT

E?<cr>

'E' is the command header followed by the question mark identifying this command as a query to the 2477. The next time the 2477 is addressed as a talker on the computer, it will respond with one of the following message strings identifying the source of the error condition.

E0<cr>

Identifies that no error condition presently exists.

E1<cr>

Identifies an open current loop condition for the PRTs. The source of the problem may be an open PRT itself, or a break in the wiring to either PRT.

E2<cr>

Identifies an A/D converter timeout condition. The most probable cause for this error condition is an electronic failure in the converter itself.

E3<cr>

Identifies a checksum error in the calibration data table. The data table should be

read from the 2477 with the 'LR?' command to try and determine which portion of the data has changed. The data table may be reloaded with the Load commands.

READY WINDOW COMMANDS

The ready window is the allowable tolerance around the temperature set point within which the source is considered to be at the selected temperature.

The ready window is adjustable. The allowable range for the ready window is from ± .01°C to ± 5°C in .01°C increments. The ready window setting may be made using, front panel menu options or with the following command:

COMMAND FORMAT

RWxx<cr>

'RW' is the command header followed by the ready window size in hundredths of a degree Celsius. The ready window data 'xx' has an allowable input range of from 1-500. The following examples demonstrate acceptable inputs.

RW1<cr>	**(.01°)**
RW7<cr>	**(.07°)**
RW15<cr>	**(.15°)**

The size of the ready window currently in effect may be determined over the computer with the following command.

COMMAND FORMAT

RW?<cr>

'RW' is the command header followed by '?' identifying the command as a query to the 2477. The next time the 2477 is addressed as a talker on the computer, it will respond with the following data string:

RW? RESPONSE

RW +x.xx<cr>

'RW' is the response header followed by a space character and the present ready window setting. The response is fixed at two decimal place resolution regardless of

the present display resolution setting. The response format shown above is with the 'F1' data format in effect. If the standard 'F0' format is in effect, the data response

will be in exponential notation format. The following are examples of 'RW? 'responses.

RW +0.01<cr>
RW +0.10<cr>
RW +.3000000E_01<cr>

TEMPERATURE CONTROL MODEL SELECT

Either absolute temperature (T2), differential temperature (T2–T1), or the effective differential temperature maybe set. 'S' is the command header followed by the desired mode select command.

COMMAND FORMAT

S2<cr>	(Absolute, T2)
SD<cr>	(Differential, T1 and T2)
SE<cr>	(Effective)

TEMPERATURE DISPLAY SELECT

When in REMOTE mode, the computer may be used to select which temperature reading is displayed on the front panel. 'T' is the command header followed by the appropriate command selection for T1 (the reference probe measurement), T2 (the source plate temperature), □T (T2–T1), or front panel controlled display selection.

COMMAND FORMAT

T1<cr>	(Reference Probe)
T2<cr>	(Source/Emitter Plate)
TD<cr>	(Difference between T1 and T2)
TF<cr>	(Use front panel keys)

'W' TARGET WHEEL COMMAND

To select a target wheel position (Option W) a command of the following format would be sent:

COMMAND FORMAT

Wxx<cr>

'W' is the command header followed by the desired target position. The range of

values of the target position data is dependent upon the number of positions in the target wheel, and should be a positive integer. The following are examples of valid wheel position commands.

W05<cr>
W3<cr>
W10<cr>

The present target position information is included along with the standard temperature information data string 'WH' is the response header followed by the current target position. If target wheel is in motion, the response will read 'WH—'. The following are examples of target position responses of the Model 2477 when addressed as a talker on the computer.

T1+.2350000E+02,T2+.2021000E+02,TD-.3290000E+01,WH01<cr>
T1+.3010000E+02,T2+.3012000E+02,TD+.2000000E01,WH10<cr>
T1+.2500000E+02,T2+.2600000E+02,TD+.1000000E+01,WH--<cr>

'SH' SHUTTER SELECTION COMMAND

To select a shutter (Option S) a command of the following format would be sent:

COMMAND FORMAT

SHxn<cr>

'SH' is the command header followed by the desired shutter (x) and whether its to be opened (0) or closed (1). The following are examples of valid shutter commands.

SH10<cr> Shutter #1 OPENED
SH31<cr> Shutter #3 CLOSED

SHUTTER STATUS COMMAND (Option S)

The status of each shutter can be read back from the 2477 with the SHx? command,

as shown in the following examples.

COMMAND FORMAT

SHx?<cr>

The question mark after the 'SH' command identifies it as a query to the 2477. The next time the 2477 is addressed as a 'talker' on the computer, it will respond with the information stored.

SX? RESPONSE

SHxn

here x = shutter queried, n = ' 0 ' = OPEN, ' 1 ' = CLOSED

In your controller, the proper shutter number to use is 1, so the command syntax would be:

SH10<cr> Shutter OPEN
SH11<cr> Shutter CLOSED
SH1?<cr> Shutter status

After the SH1? command, address the 2477 as a talker and the response will be:

SH10 Shutter OPEN
SH11 Shutter CLOSED

The front panel STATUS display will show SHG when the shutter is OPEN, and will show SHO when the shutter is CLOSED.

4.7.3 Data Format Commands

'F' DATA FORMAT SETTING

This command determines the format of numeric data transmitted by the 2477 when addressed as a talker on the computer. The standard exponential number form is still supported as well as a new, more readable format. The new format transmits numeric data as signed floating decimal point numbers. The number of decimal places is determined by the current display resolution setting.

COMMAND FORMAT

Fx<cr>

'F' is the command header followed by a single numeric digit. Valid input for x is either 0 or 1. The default setting is '0' which is the exponential format, and data is displayed as follows:

T1+.2313000E+02,T2+.2313000E+02,TD+.0000000E+00<cr>

After receiving an 'F1' command, and with the standard two decimal place resolution, the same data string would appear as follows:

T1 +23.13,T2 +23.13, TD +0.00<cr>

READY STATUS COMMAND

An optional ready indicator is available over the computer as part of the message sent by the 2477 when addressed as a talker. The additional indicator is enabled with the following command:

COMMAND FORMAT

R+ or R—<cr> (Ready indicator on/off over Buss)

The additional field is added to end of the normal message string and reads 'R— 'for not ready and 'R+' when the source temperature is ready (at set point). The following examples demonstrate.

T1+.2350000E+02,T2+.2021000E+02,TD_.3290000E+01,R0<cr>
T1+.3010000E+02,T2+.3012000E+02,TD+.2000000E_01,R1<cr>

To disable this ready feature, the following command is sent:

COMMAND FORMAT

R—<cr>

This results in the normal message string with the ready indicator suppressed. This is also the power on default setting.

RESOLUTION COMMAND

The front panel display resolution (and resolution of temperature readings on the computer) can be controlled via the computer using this command.

COMMAND FORMAT

Rx<cr>

'R' is the command header followed by the number of decimal place display resolution desired. The resolution value 'x' has a range of 2 thru 3 inclusive. Values outside this range are ignored. The following examples show the only acceptable inputs.

R1<cr>	**(0.1)**
R2<cr>	**(0.01)**
R3<cr>	**(0.001)**

4.7.4 Calibration Command Set

'A' ACTUAL TEMPERATURE

This command is used to transfer the actual temperature, as measured by a calibrated thermometer to the 2477. This temperature is then used internally to correct the calibration data within the data table. The command must be preceded by a ' Vx ' command and a GET command to function properly.

COMMAND FORMAT

Axxx.xxx<cr>

'A' is the command header, followed by the actual temperature in degrees Celsius. The temperature data, 'xxx.xxx', is a signed number with decimal point. The number of digits is arbitrary. For positive numbers, the sign may be omitted. Leading blanks and zeroes will be dropped. Digits past the second decimal place will be truncated. An embedded illegal character (anything other than the numeric digits 0 thru 9 and decimal point) will have the effect of truncating the string at that point.

The decimal point may be omitted if the data has no fractional portion. The following examples demonstrate acceptable data strings.

A10<cr>

A10.00<cr>
A+.1000000E+02<cr>
A+10.000<cr>

DATE COMMAND

The date of the last calibration can be read back from the 2477 with the 'DT' command, as shown in the following example.

COMMAND FORMAT

DT?<cr>

The question mark after the 'DT' command identifies it as a query to the 2477. The next time the 2477 is addressed as a talker on the computer, it will respond with the information stored with the last 'LDT' command, as shown in the following example.

DT? RESPONSE

DT 11/11/88

The next time the 2477 is addressed as a talker, it will respond with its normal temperature data string.

LIST COMMANDS

The data contained in the 2477 calibration data tables may be downloaded to the host computer using the 'Lx?' command. The data contained in the T1 and R1 tables, or the T2 and R2 tables, or the data contained in the entire calibration table may be downloaded at the user's discretion. Once the data has been downloaded, the user may analyze or store the data as needed.

COMMAND FORMAT

Lx?<cr>

'L' is the command header followed by the desired table selection. To select the R1 and T1 tables, 'x' should be '1'. To select the R2 and T2 tables, 'x' should be '2'. To select the effective □T calibration table, 'x' should be 'E'. To select the entire calibration table, 'x' should be 'R'.

Following the 'Lx?' command, the 2477 will respond with one line of data from the selected table. The 2477 must be continuously addressed as a talker until all the

lines of the selected table have been read out, indicated by the message 'LEND'. This listing mode may be halted before the end of the selected table is reached by issuing any valid command to the 2477.

The 'L1?' and 'L2?' commands generate a list of, in order, the size of the T1/2 table, the elements of the T1/2 table, the elements of the R1/2 table, and the 'LEND'

message.

COMMAND FORMAT

L1?<cr>

L1? RESPONSE

LS1 013<cr>
LT1 000 +5.00<cr>
LT1 001 +13.00<cr>
...
LT1 012 +65.00<cr>
LR1 000 +101.9899<cr>
LR1 001 +103.5778<cr>
...
LR1 012 +133.2457<cr>
LEND<cr>

COMMAND FORMAT

L2?<cr>

L2? RESPONSE

LS2 013<cr>
LT2 000 +5.00<cr>
LT2 001 +13.00<cr>
...
LT2 012 +65.00<cr>
LR2 000 +101.9899<cr>
LR2 001 +103.5778<cr>
...
LR2 012 +133.2457<cr>
LEND<cr>

The ‘LE?’ command generates a list of, in order, the size of the effective □T table, the elements of the effective □T table, the elements of the actual temperature table and

the ‘LEND’ message corresponding.

COMMAND FORMAT

LE?<cr>

LE? RESPONSE

LSE 013<cr>
LTE 000 +5.00<cr>

LTE 001 +13.00<cr>
...
LTE 012 +65.00<cr>
LTA 000 +5.12<cr>
LTA 001 +13.50<cr>
...
LTA 012 +66.73<cr>
LEND<cr>

The entire calibration table consists of, in order, the size of the T1 table, the T1 table, the R1 table, the size of the T2 table, the T2 table, the R2 table, the lower absolute temperature limit of the controller, the upper absolute temperature limit of the controller, the lower differential temperature limit of the controller, the upper differential temperature limit of the controller, the serial number of the controller, the date of last calibration, the size of the effective □T table, the effective □T table, the corresponding actual temperature table and the 'LEND' message.

COMMAND FORMAT

LR?<cr>

LR? RESPONSE

LS1 013<cr>
LT1 000 +5.00<cr>
LT1 001 +13.00<cr>

LT1 012 +65.00<cr>
LR1 000 +101.9899<cr>
LR1 001 +103.5778<cr>

LR1 012 +133.2457<cr>
LS2 013<cr>

LT2 000 +5.00<cr>
LT2 001 +13.00<cr>

LT2 012 +65.00<cr>
LR2 000 +101.9899<cr>
LR2 001 +103.5778<cr>

LR2 012 +133.2457<cr>
LLA 00015<cr>

LHA 00055<cr>
LLL _00010<cr>
LHL 00030<cr>
LSN 12345<cr>
LDT 11/11/87<cr>
LSE 013<cr>
LTE 000 +5.00<cr>
LTE 001 +13.00<cr>

LTE 012 +65.00<cr>
LTA 000 +5.12<cr>
LTA 001 +13.50<cr>

LTA 012 +66.73<cr>
LEND<cr>

The format of the data of these lists is such that once it has been read from the 2477, it can be transmitted back to the 2477 without any reformatting. For example, the entire calibration table can be downloaded with the 'LR?' command to the host computer and stored on disk. If for some reason the calibration table data was destroyed, the entire data table could be read from disk and sent directly to the 2477, because the proper command headers are already in place.

LOAD COMMANDS

Existing entries in the calibration data table contained in the 2477 may be edited using the Load command. The selected entries in the calibration data table are overwritten and a new checksum is generated.
The primary purpose of these commands is to allow the reloading of data, rather than changing the values to try to calibrate. The generation of the values to correct

calibration is best left to the internal calibration routines of the 2477 via the □ V □ commands. They may also be used to load a "*generic* " data table to be used as the starting point for a new calibration run.

All the load commands have essentially the same format. The command begins with a three letter header to identify the entry, followed by, depending on the data entry, an identifying index number, and ending with the data itself.
The size of the T1/R1, T2/R2, and effective □T tables can be loaded with the

following commands:

COMMAND FORMAT

LS1 xxx<cr>	T1/R1 (reference probe)
LS2 xxx<cr>	T2/R2 (control probe)
LSE xxx<cr>	effective T/actual

'LS' is the command header followed by a '1' or '2' or 'E' indicating the T1/R1 (reference probe), T2/R2 (control probe), or effective T/actual tables respectively, followed by a space character and the size of the selected table. The size data is an integer number from 4 to 11, indicating the total number of entries in the selected table.

The data contained in the resistance portion of the calibration table may be loaded with the following commands:

COMMAND FORMAT

LR1 xxx xxx.xxx<cr>	R1 (reference probe)
LR2 xxx xxx.xxx<cr>	R2 (control probe)

'LR' is the command header followed by a '1' or '2' indicating the R1 (reference probe) table or the R2 (control probe) table respectively, followed by a space character, the index or table entry number, a space character, and the actual resistance value.

The index or table entry value 'xxx' is a positive integer in the range of 0 to 10 inclusive. The 2477 will accept any value in this range, but the only entries that will be utilized for determining temperatures during operation are those values within the range of 0 and the table size as stored in the data table. Entries above the stored table size must be set to zero.

The resistance value 'xxx.xxx' is a positive number with decimal point. The number of digits is arbitrary. For positive numbers, the sign may be omitted. Leading blanks and zeroes will be dropped. An embedded illegal character (anything other than the numeric digits 0 thru 9 and decimal point) will have the effect of truncating the string at that point. The decimal point may be omitted if the data has no fractional portion.

The following examples demonstrate acceptable input.

LR1 003 +101.234<cr>

LR2 5 107.00345<cr>
LR2 18 102<cr>
LR1 012 +.1021029E+03<cr>

The data contained in the temperature portion of the calibration table may be loaded with the following commands:

COMMAND FORMAT

LT1 xxx xxx.xxx<cr> T1 (reference probe)
LT2 xxx xxx.xxx<cr> T2 (control probe)

'LT' is the command header followed by a '1' or '2' indicating the T1 (reference probe) table or the T2 (control probe) table respectively, followed by a space character, the index or table entry number, a space character and the actual temperature value.

The index or table entry value 'xxx' is a positive integer in the range of 0 to 10 inclusive. The 2477 will accept any value in this range, but the only entries that will be utilized for determining temperatures during operation are those values within the range of 0 and the table size as stored in the data table.

The temperature value 'xxx.xxx' is a signed number with decimal point. The number of digits is arbitrary. For positive numbers, the sign may be omitted. Leading blanks and zeroes will be dropped. Digits past the second decimal place will be truncated. An embedded illegal character (anything other than the numeric digits 0 thru 9 and decimal point) will truncate the string at that point. The decimal point may be omitted if the data has no fractional portion. The following examples demonstrate acceptable input.

LT1 002 +10.23<cr>
LT2 5 27.00<cr>

LT2 18 12<cr>
LT1 012 +.1021000E+02<cr>

The upper and lower differential temperature limits may be loaded using the following commands:

COMMAND FORMAT

LLL xxxxx<cr>
LHL xxxxx<cr>
LLA xxxxx<cr>

LHA xxxxx<cr>

'LLL' is the command header for low end differential temperature limit and 'LHL' is the command header for the high end differential temperature limit.

'LLA' command header is the command header for the low end absolute temperature limit and 'LHA' is the command header for the high end absolute temperature limit.

The command header is followed by a space character and the appropriate temperature value.

The temperature data 'xxxxx' is a signed integer. The number of digits is arbitrary. For positive numbers, the sign may be omitted. Leading blanks and zeroes will be dropped. Digits past the decimal point will be truncated. An embedded illegal character (anything other than the numeric digits 0 thru 9 and decimal point) will truncate the string at that point. The following examples demonstrate acceptable input.

LLL _10<cr>
LHL 30<cr>
LLA 15<cr>
LHA 55<cr>

The serial number of the 2477 may be loaded using the following command:

COMMAND FORMAT

LSN xxxxxx<cr>

'LSN' is the command header followed by a space character and up to 6 digits. The serial number of the 2477 is used as data input with this command to identify the

source of the complete data table when it is downloaded for archival purposes. The following example demonstrates acceptable input.

LSN 12345<cr>

The date of calibration may be loaded using the following command:

COMMAND FORMAT

LDT xxxxxxxx<cr>

'LDT' is the command header followed by a space character and a string of 8

characters. Leading zeros are required as well as the ' / ' or ' – ' delimiters to pad the string to 8 characters. The following examples demonstrate acceptable input for this command.

LDT 11/11/88<cr>
LDT 11_12_13<cr>
LDT 07/04/76<cr>

The data contained in the effective □T portion of the calibration table may be loaded with the following commands:

COMMAND FORMAT

LTE xxx xxx.xxx<cr>

'LTE' is the command header followed by a space character, the index or table entry number, a space character and the effective □T value.

The index or table entry value 'xxx' is a positive integer in the range of 0 to 10 inclusive. The 2477 will accept any value in this range, but the only entries that will be utilized for determining temperatures during operation are those values within the range of 0 and the table size as stored in the data table. Entries above the stored table size must be set to zero.

The effective □T value, 'xxx.xxx' is a signed number with decimal point. The number of digits is arbitrary. For positive numbers, the sign may be omitted. Leading blanks and zeroes will be dropped. An embedded illegal character (anything other than the numeric digits 0 thru 9 and decimal point) will have the effect of truncating the string at that point. The decimal point may be omitted if the data has no fractional portion. The following examples demonstrate acceptable input.

LTE 003 +10.234<cr>
LTE 5 17.00345<cr>
LTE 18 10.2<cr>
LTE 012 +.1021029E+02<cr>

The data contained in the actual temperature portion of the calibration table may be loaded with the following commands:

COMMAND FORMAT

LTA xxx xxx.xxx<cr>

'LTA' is the command header followed by a space character, the index or table entry number, a space character, and the actual temperature value.

The index or table entry value 'xxx' is a positive integer in the range of 0 to 10 inclusive. The 2477 will accept any value in this range, but the only entries that will be utilized for determining temperatures during operation are those values within the range of 0 and the table size as stored in the data table. Entries above the stored table size must be set to zero.

The temperature value 'xxx.xxx' is a signed number with decimal point. The number of digits is arbitrary. For positive numbers, the sign may be omitted. Leading blanks and zeroes will be dropped. Digits past the second decimal place will be truncated. An embedded illegal character (anything other than the numeric digits 0 thru 9 and decimal point) will truncate the string at that point. The decimal point may be omitted if the data has no fractional portion. The following examples demonstrate acceptable input.

LTA 002 +10.23<cr>
LTA 5 27.00<cr>
LTA 18 12<cr>
LTA 012 +.1021000E+02<cr>

SERIAL NUMBER COMMAND

The serial number of the 2477 can be read back individually on the computer with the following command:

COMMAND FORMAT

SN?<cr>

'SN' is the command header followed by a '?' identifying the command as a query to the 2477. The next time the 2477 is addressed as a talker on the computer, it will respond with the following message:

SN? RESPONSE

SN 12345<cr>
SN 101<cr>
SN 3401<cr>

'SN' is the response header followed by a space character and the data stored in the calibration table.

DATA TABLE SIZE

The size of either the R1/T1 (reference probe) table, the R2/T2 (control probe), or the effective □T, actual temperature table may be examined over the computer with the following command:

COMMAND FORMAT

T1?<cr>
T2?<cr>
TE?<cr>

'T' is the command header followed by the desired table selection. The '?' identifies the command as a query to the 2477. The next time the 2477 is addressed as a talker on the computer, it will respond with the following message:

TX? RESPONSE

Tn_SIZE xx<cr>

The requested table is identified with the 'Tn' header, 'n' being '1' or '2' for the T1-table and T2-table, respectively, and 'E' for the effective □T table.

This header field is followed by a space and a positive integer indicating the size of the requested table stored in the calibration table.

The following are examples of responses to the table size command:

T1_SIZE 13<cr>
T2_SIZE 25<cr>

TE_SIZE 12<cr>

'V' VERIFY CALIBRATION COMMANDS

The 'VERIFY' commands form the base for the calibration procedure. They are used to select either or both probes to verify or correct. They are also used to select any or all existing calibration points to check or correct, as well as allowing new calibration points to be entered in the data table.

The 2477 needs to know if one or both temperature probes are going to be checked. If both probes are selected, the 2477 assumes that the reference probe is inserted in the source plate. 'V' is the command header followed by the probe selection '1', '2', or 'B'.

To select both temperature probes to be checked, the following command should be sent:

COMMAND FORMAT

VB<cr> (Both T1 and T2)

To check only the control probe, the following command should be sent:

COMMAND FORMAT

V2<cr> (T2 only)

To check only the reference probe, the following command should be sent:

COMMAND FORMAT

V1<cr> (T1 only)

To check the effective □T calibration, the following should be sent:

COMMAND FORMAT

VE<cr> (Effective Table)

To determine which probe is currently selected to be checked the following command may be sent:

COMMAND FORMAT

V?<cr>

'V' is the command header followed by a '?' identifying the command as a query to the 2477. The next time the 2477 is addressed as a talker following this command, it will respond with one of the following messages:

V? RESPONSE

V0<cr>
V1<cr>
V2<cr>
VB<cr>
VE<cr>

'V' is the response header followed by the current probe selection. Note that the responses are identical to the commands used to select the probe with the exception of 'V0' which indicates that no probe is currently selected. This is the default setting at power on. It is also reset to this state following the normal temperature setting 'D'

command.

To start checking at the first entry in the table, the following command would be sent:

COMMAND FORMAT

VS<cr>

'V' is the command header followed by 'S' for the start of the table.

Following receipt of this command, the source will be driven to its lowest calibrated setting. Once it reaches this temperature, it can be checked and corrected if necessary.

To step to the next calibration point in the table, the following command should be sent:

COMMAND FORMAT

VN<cr>

'V' is the command header followed by 'N' for the next calibration point. Following receipt of this command, the source will be driven to the next calibrated temperature setting as determined by the next entry in the calibration table.

The 'VN' command may also be used to check a limited portion of the calibration table. The starting point of the check could be entered with the 'Vxxx.xxx' command. Then the 'VN' could be used to step through the next few points.

SECTION 5

THEORY OF OPERATION

5.1 GENERAL

Figure 5.1 is a block diagram of the controller. There are three major functional groups: temperature measurement is provided by A7; temperature control is provided by A7, A8 and A9; input/output functions to front panel controls and the customer interface are provided by A3, A4 and A5.

All communication to and from the microprocessor (A2) within the controller is done through serial data ports via I/O plug-in connectors.
Customer interface to the controller is provided on the rear panel.

5.2 TEMPERATURE MEASUREMENT

5.2.1 ADC / DAC (900-312) (A7)

The 900-312 PCB measures the resistance of the two Platinum Resistance Thermometers (PRT's). This board has a digital output which can be read by the microprocessor. It can measure resistance between 95 (–12°C) to 145 ohms (115°C) using a 20 bit ADC, yielding a resolution of approximately 50 micro-ohms on standard controllers.

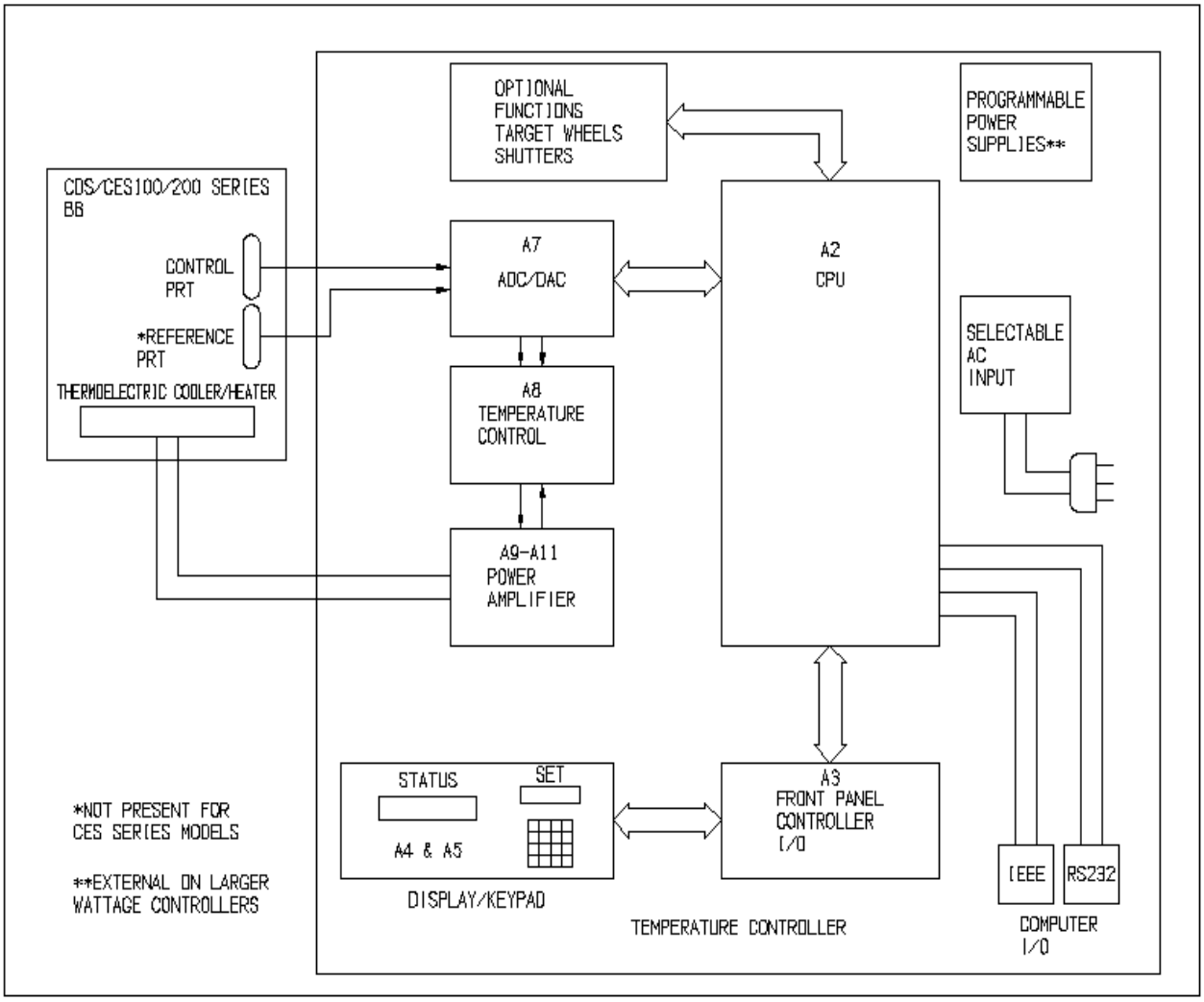
When making measurements at this low level, stability is very difficult to obtain. To overcome the problem of drift, two very stable resistors, are placed in series with the two PRT's via a multiplexer. By comparing the present reading of these calibration resistors to previous readings of these same resistors, the computer can compensate for gain and offset errors in the current source, the amplifier circuitry and the A/D converter.

The Z180 microprocessor is located on the 900-310 CPU/IO PCB. It takes the digital data from the resistance measurement circuitry, applies gain and offset corrections, and converts the PRT resistance to temperature using data in the calibration EEPROM (also located on the 900-310 CPU/IO board).

A 20 bit Digital-to-Analog Converter (DAC) programmable reference used in connection with the temperature controller PCB 900-318 to set and control the

temperature of the blackbody source. The ADC/DAC board gets its digital input data via opto-coupled serial data from the CPU board, 900-310. Control line LE goes and stays high during serial data transmission.

FIGURE 5.1 BLOCK DIAGRAM – CONTROLLER



5.3 TEMPERATURE CONTROL

5.3.1 Temperature Controller (900-318) (A8)

The 900-318 board has a 10 V reference and supplies a fixed voltage which is switched in place of the PRT 1 voltage when the instrument is controlling the absolute temperature, rather than the differential temperature, of the source.
The circuitry subtracts the PRT 2 voltage from the PRT 1 voltage, generating a voltage proportional to □T. In the absolute control mode, The circuitry subtracts the PRT 2 voltage from the fixed voltage, generating a voltage proportional to T2.
An operational amplifier sums the voltage proportional to □T (or to T2, depending on the mode) with the output of the D/A converter and also with an offset through R12 and R13. The output serves as the error voltage used to drive the power amplifier (900-329 PCB) which drive the thermoelectric heater/coolers in the source.

5.3.2 Power Amplifier Board (900-329) (A9)

The power amplifier board amplifies the signal from the temperature controller board so that it can drive the high current high voltage output power transistors located off the board.

5.3.3 Power Output Stage (STD) (A1)

Power transistors Q1 & Q2 on the Model 2477 provide power to cool. Power transistors Q3 & Q4 provide power to heat. Feed back from R3 & R4 goes to the power amplifier (900-329 PCB) to current limit the output stage during the cooling or heating process respectively.

5.4 INPUT/OUTPUT and CPU Operation

5.4.1 Front Panel Interface (900-311) (A3)

The microcontroller on the front panel of the interface board, handles all the processing related to the front panel displays, (A4, A5) and keypad entries plus provides a communication link to the main controller CPU board, 900-310. Since the microcontroller handles all the local front panel processing, it allows the main CPU to concentrate on high priority tasks.

5.4.2 CPU/I/O Board (900-310)

This board contains the main CPU, memory, and interface circuitry for the controller. The CPU is a Zilog Z80180 which can address up to 1 megabyte of memory via a ROM and RAM. Jumpers configure the memory map and device sizes of the memory.

The CPU communicates to the front panel controller (900-311) via a multi-drop RS-485 serial interface at J2.

The instrument can communicate with a user's computer through an IEEE 488 interface comprised of GPIB controller and connector J6.

5.4.3 Dual Wheel Control Board (800-434) (Option W)

This board can control two separate wheels of up to 32 positions each. An incremental encoder, or index and detent limit switches are used for feedback. A Microcontroller reads the position/count of the wheel and compares it to the desired position. A decision is made regarding motor drive and direction and the appropriate signals are sent to motor driver.

5.4.4 Solenoid (Shutter) Driver (Option S)

This board provides the drive circuitry for the solenoid operated shutter. The driver briefly supplies a high current to activate the solenoid quickly, and then reduces the drive current to a minimum holding level to reduce self-heating of the solenoid.

SECTION 6

MAINTENANCE

WARNING

These servicing instructions are for qualified service personnel only. To avoid electrical shock, do not perform any servicing other than that contained in the operating instructions unless you are qualified to do so.

CAUTION

Changing components or adjusting internal potentiometers may result in loss of calibration. Specifically, changing any resistors or integrated circuits on the 900-312 or 900-318 boards will require re-calibration of the instrument.

6.1 PREVENTIVE MAINTENANCE

Under normal conditions, no preventive maintenance procedures are necessary for operation of the temperature controller.

6.2 TROUBLESHOOTING

In a complex microprocessor-based instrument such as this, a specific troubleshooting guide cannot be generated. Repair of the instrument will require a thorough understanding of the circuitry and careful application of good troubleshooting techniques. A review of the schematics and of the THEORY OF OPERATION in Section 5, would be helpful before attempting repair.

For troubleshooting that portion of the circuitry driven by the microprocessor bus, a logic analyzer and/or a Z180 emulator are almost necessities.
Frequently, the symptoms point to failure of one specific card, and the most expedient repair would be replacement of the entire card.

If repair is necessary, it is strongly recommended that the instrument be returned to Electro Optical Industries, Inc. where appropriate test equipment, trained service personnel and a complete stock of replacement parts can assure a satisfactory repair.

SECTION 7

CALIBRATION

7.1 INTRODUCTION

Please read through the complete procedure before beginning calibration. When temperature settings are changed, allow sufficient time for blackbody to stabilize before correcting data.

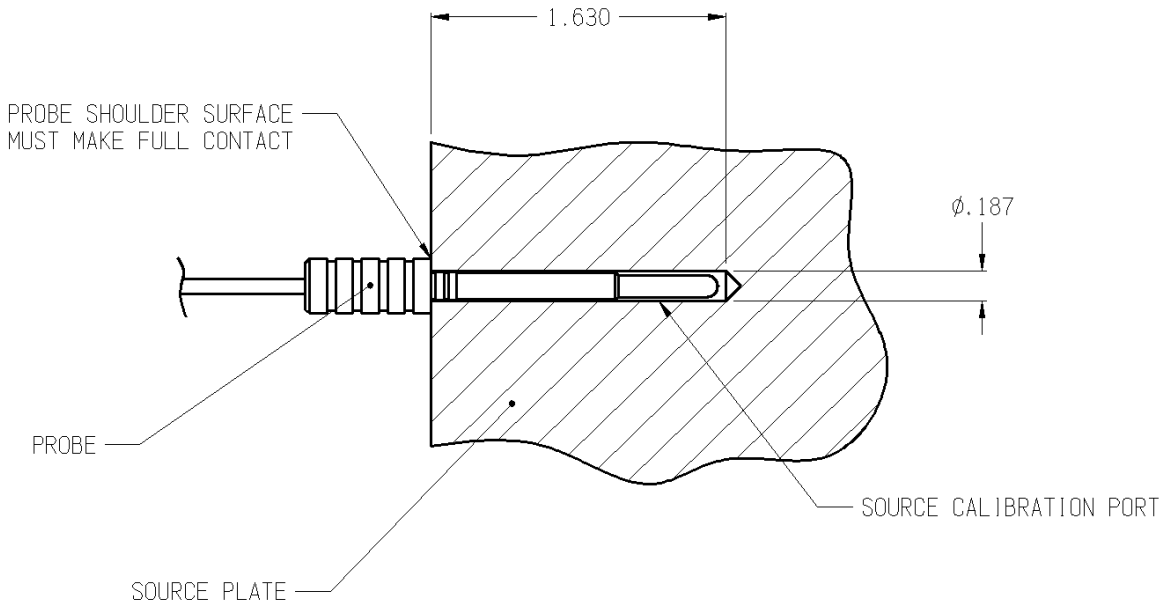
The calibration procedure is controlled either by the IEEE 488.1 interface, or by front panel MENU selection. The user may interactively check and correct any or all calibration points with the aid of the IEEE 488.1 interface, or with the front panel controls. The calibration procedure easily lends itself to becoming an automated procedure, if so desired, with the aid of a computer program that the user writes himself. A flow chart for the program is provided (Figure 7.5).

Existing calibration points are used as set points to be checked against a calibrated thermometer. No calculations or data logging are required on the user's part. Once the temperature of the blackbody source has stabilized, the actual temperature of the source (as measured by a calibrated thermometer) is transmitted via the computer interface to the Model 2477 or entered with the front panel controls. The temperature controller then uses this data to correct its own calibration data. Either one or both temperature probes may be corrected at the user's discretion.

7.2 CALIBRATION THERMOMETER PROBE

The standard calibration probe configuration is illustrated in Figure 7.2.

Figure 7.2 Calibration Probe Configuration



7.3 CALIBRATION

7.3.1 Set Up Requirements

Typically, a calibration configuration will consist of two instruments. The instrument to be calibrated is the 2477 Differential Temperature Controller. A reference instrument is required to check the calibration of the 2477. A calibrated thermometer with a computer interface is the preferred reference instrument, such as an Electro Optical Industries Model 6658, CT550 or LT100 Differential Thermometer.

A computer controller may also be connected to the computer to guide the flow of data between the instrument under test and the reference device to provide a completely computer-controlled calibration. A simpler configuration would have the 2477 connected to the IEEE bus with a computer controller. The reference thermometer would not have to be connected to the IEEE bus. The thermometer

data would be passed to the 2477 by manual entry of the data into the computer controller by the operator. The disadvantage of this set-up is that it does not lend itself to automatic operation, as does the first configuration.

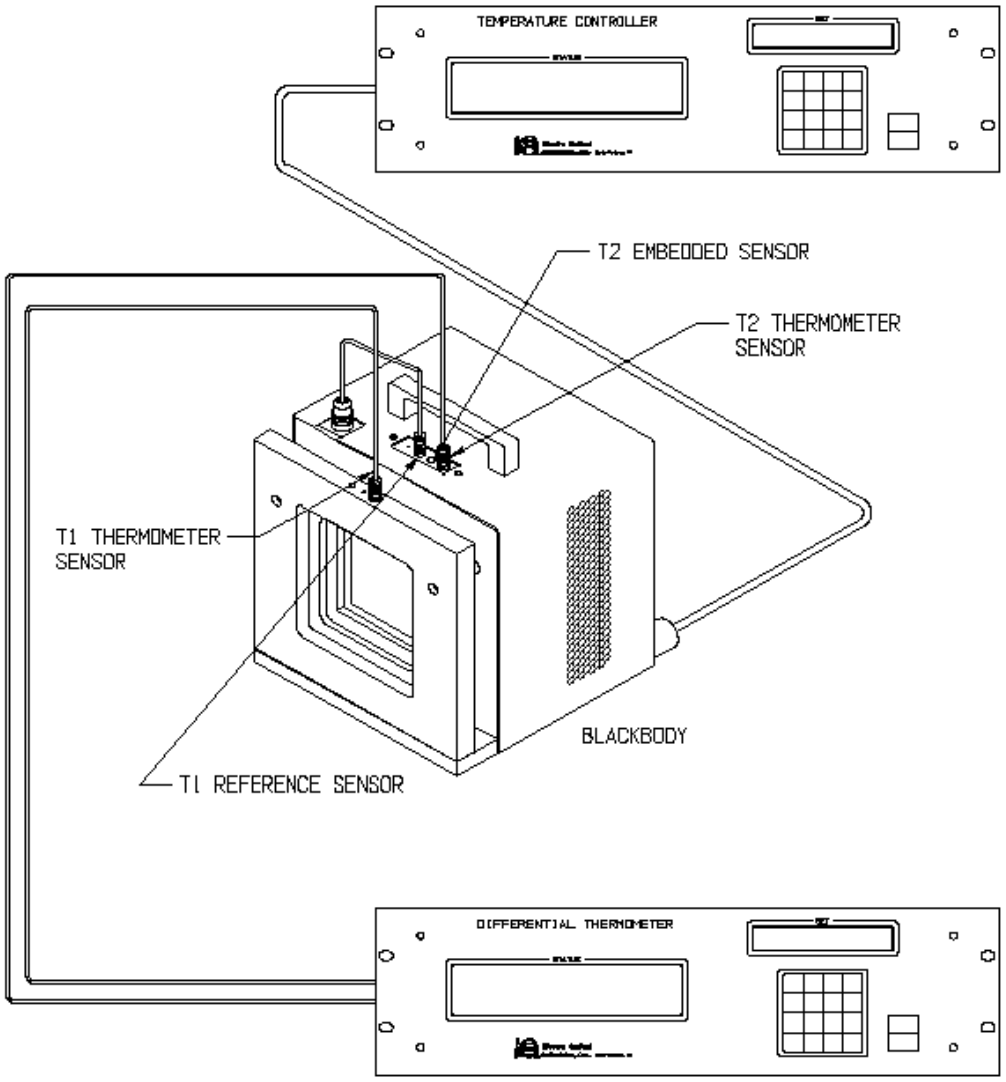
The standard calibration equipment setup is illustrated in Fig. 7.3. There is an access port on the top of the blackbody. Remove the cover from the port and insert the thermometer probe into the top edge of the source plate.

NOTE: A thermally conductive grease (Dow Corning 340 Silicon Heat Sink Compound, or equivalent) must be used to establish good thermal contact between the probes and their receptacles. However, an excess of heat sink compound may hinder full insertion. If it does, turn the probe while pushing it in until the compound oozes out and the probe is fully inserted. Wipe off any excess heat sink compound.

CAUTION

DO NOT TOUCH targets or temperature-controlled surfaces. Finger print oil will change their emissivity. The only way to restore their emissivity is to degrease and repaint them.

Figure 7.3 Calibration Setup



7.4 MANUAL CALIBRATION PROCEDURE

The 2477 Differential Temperature Controller may be calibrated easily without the aid of a computer by using the front panel keypad and calibration menu selections to check and correct all existing calibration points.

7.4.1 Correcting Existing Calibration Points

Step 1: Follow the set up procedure explained in Section 7.3.1.

Step 2: Press the ESC. key a few times to get to the MAIN MENU. Press the 6 key and you will be prompted to enter a Password to allow entry to the CALIBRATION menus. Enter the correct 4 digit Password (initial password is 4660) and press the ENTER key. When the correct password is entered, you will be at the TEMP CALIBRATE ... menu. Press the ENTER key to move down one menu level to the calibration menus. The first menu is an informative message displaying the date of the last calibration.

Step 3: Press the ▼ key to get to the Calibration Probe menu. Press the ENTER key and use the ▲and ▼ keys to select the probe to calibrate: T1 to calibrate only T1 (the reference PRT), T2 to calibrate only T2 (the source PRT), or both to calibrate both T1 and T2 simultaneously. To calibrate both T1 and T2 together, the reference probe must be inserted in the source plate of the blackbody as shown in Figure 7.3-1. Press the ENTER key to make the selection.

Step 4: Press the ▼ key to go to the CAL Temp. menu. Press the ENTER key and use the ▲ and ▼ keys to select the calibration temperature. Press the ENTER key to make the selection. The word CAL will appear on the STATUS display and the controller will now control the source at this selected temperature. The display resolution will change to three decimal place resolution and the temperature control mode will be set to ABSOLUTE as indicated on the STATUS screen.

NOTE: When calibrating both probes, the 2477 uses the data points from the T2 table for the temperature set points. It is assumed that both the T1 and T2 tables contain identical temperature entries. If not, the T1 probe will need to be calibrated separately, so that the T1 table temperatures will be used.

Step 5: Pressing the ▼ key will move to the Temp to display menu. You may use the arrow and ENTER keys to select the probe temperature to display, useful when calibrating both probes.

Step 6: Wait for READY symbol (◆) to appear indicating that the source has reached the selected temperature. Allow an extra minute or two to allow the source and the probes inserted into it to stabilize before recalibrating at this set point.

Step 7: Compare the front panel temperature display with the reading of the reference calibration thermometer. If the error between the controller and thermometer readings is less than .01 degrees, proceed to Step 11.

Step 8: If the temperature error is greater than .01 degrees and needs to be recalibrated, press the □ key to move to the True Temp menu. Press the ENTER key and enter the true temperature (as read from the calibration thermometer) using the number keys on the keypad. Press the ENTER key to make the correction.

Step 9: The READY indicator will turn off and the 2477 will make the correction to its calibration table. The display will change to the new corrected reading which should be equal to the present thermometer reading. The 2477 will then control at the set point once again with the corrected data.

Step 10: The READY indicator will come on and the 2477 reading should be compared to the thermometer reading once again. If calibrating both probes, you may use the ▲ key to return to the Temp to display menu and check both probes. If the error is less than .01 degrees, proceed to Step 11. If the error is still greater .01 degrees (sometimes the case with very large initial errors), repeat the correction procedure starting with Step 8.

Step 11: Use the ▼ key or press the 3 key to move to the CAL Temp. menu. Select the next calibration temperature set point and continue the calibration procedure beginning with Step 5.

Step 12: When the last entry has been calibrated, press the ESC. key twice to return to the MAIN MENU. Press the 1 key and use the number keys to enter a temperature set point and then press the ENTER key. The CAL indicator will be removed from the STATUS display and the controller will return to normal operation. This completes the calibration procedure.

7.5 COMPUTER CONTROLLED CALIBRATION PROCEDURE

The 2477 Differential Temperature Controller may be calibrated, and all existing calibration points may be checked and corrected, with the aid of a computer.

7.5.1 Calibration Of All Existing Points

NOTE: More detailed explanations of all the interface commands used in the following procedure may be found in Sec. 4. See Figure 7.5 for a flow chart of the following calibration procedure.

Step 1: Follow the set up procedure explained in Section 7.3.1.

Step 2: Press the ESC. key until you get to the MAIN MENU. Press the 6 key and you will be prompted to enter a Password to allow entry to the CALIBRATION menus. Enter the correct 4 digit Password (initial password is 4660) and press the ENTER key. When the correct password is entered, you will be at the TEMP CALIBRATE ... menu. Press the ENTER key to move down one menu level to the calibration menus. The first menu is an informative message displaying the date of the last calibration.

Step 3: Press the ▼ key twice to go to the CAL Temp. menu. Press the ENTER key and use the ▼ and ▲ keys to select the calibration temperature. Press the ENTER key to make the selection. The word CAL will appear on the STATUS display and the controller will now control the source at this selected temperature. The display resolution will change to three decimal place resolution and the temperature control mode will be set to ABSOLUTE as indicated on the STATUS screen. The exact temperature selected is not important; this procedure is only used to enter the CALIBRATION mode.

Step 4: The 2477 should be commanded to go into the REMOTE mode of operation by sending commands over the computer interface. When the 2477 is in the REMOTE mode of operation, the REMOTE indicator (ℝ) will appear on the STATUS display.

Step 5: The external computer must indicate to the 2477 which probe(s) will be calibrated. A ‘Vx’ command must be sent to the 2477 to identify the probe

selection. The ‘V1’ command will calibrate only the T1 probe, the ‘V2’ command will calibrate only the T2 probe, and the ‘VB’ command will

calibrate both T1 and T2 simultaneously.

NOTE: When calibrating both probes, the 2477 uses the data points from the T2 table for the temperature set points. It is assumed that both the T1 and T2 tables contain identical temperature entries. If not, the T1 probe will need to be calibrated separately, so that the T1 table temperatures will be used.

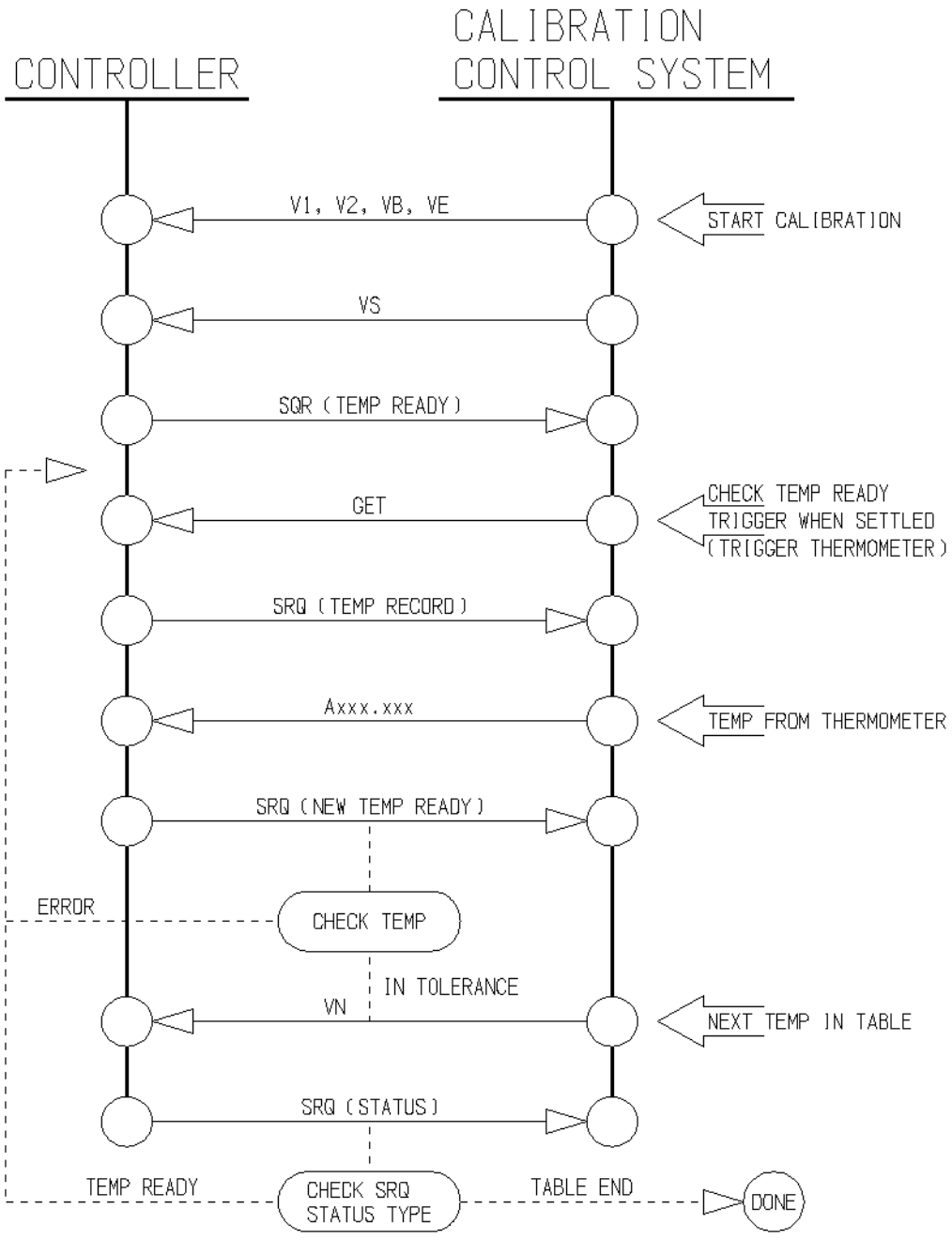


Figure 7.5 Calibration Software Flowchart

Step 6: The 2477 now needs to know at what temperature to control to check the selected probe.

A convenient method to check the entire calibration table is to have the computer controller send the 'VS' command. The source plate will now be driven to the lowest calibrated temperature in the selected calibration table.

Step 7: Wait for READY indicator (◆) to light indicating that the source has reached the selected temperature. Allow an extra minute or two to allow the source and the probes inserted into it to stabilize before calibrating at this set point. The computer controller can detect the ready condition in one of two ways: by polling or by an SRQ interrupt.

To Poll for the ready indication, the computer controller must first send the 'R1' command to the 2477 which will enable the ready indication in the standard data response of the 2477. The computer controller should wait for the last character of the response data string to change to a '1'. Alternatively, the computer controller can wait for an SRQ from the 2477 when the source is ready. The computer controller would then perform a serial Poll and verify that bit 0 of the response byte is set, indicating the ready condition.

Step 8: Compare the 2477 temperature reading with the reading of the reference calibration thermometer. Temperatures within ± .01°C are within the specifications of the 2477 (from 0° C to 100° C) and need not be corrected, but it is up to the user to determine the window within which to make a correction.

If no correction is necessary, proceed to Step 12.

If a correction needs to be made, first verify that the temperature of the source is stable by checking the ready condition as described in Step 7. If the source is not stable (ready), do not attempt to correct the calibration data.

With the source stable, the Bus controller issues a GET command. The Bus controller should read and store the temperature reported by the calibration thermometer immediately after issuing the GET command. This effort tries to get the thermometer and the 2477 temperature readings to correspond in

time as closely as possible.

Step 9: The computer controller should wait for an SRQ (IEEE only) from the 2477, or perform a serial Poll until bit 2 of the response byte is set, indicating the receipt of the GET in the 2477 and it is ready to perform the correction.

Step 10: After it has been established that the 2477 is ready to receive the correction data (Step 9), the actual source temperature (as reported by the calibration thermometer following the GET command) is sent to the 2477 with the 'Axx.xxx' command where 'xx.xxx' is the thermometer data.

Once the actual temperature information is received by the 2477, it recalculates the resistance readings for the selected probe(s), generates a new checksum value for the calibration data, clears the ready indicator, and then controls once again at the current set point. This process normally takes just a few seconds, and the front panel temperature display can be seen to jump as the correction is made.

Step 11: Repeat starting with Step 7.

Step 12: To move to the next calibration point, the computer controller will issue a 'VN' command which will automatically advance to the next temperature entry in the calibration data table.

Step 13: If the last entry of the calibration data has already been calibrated, upon receipt of the 'VN' command the 2477 will issue an SRQ to alert the computer controller that all entries have been calibrated. If the computer controller does not support SRQ interrupts then a serial Poll should be performed and bit 4 of the response byte should be checked. It will be set if the end of the table has been reached.

If bit 4 is not set, repeat the calibration procedure for the next point beginning with Step 7.

Step 14: If bit 4 is set, all points have been calibrated. The computer controller should download the entire calibration table from the 2477 for archival purposes using the 'LR?' command. This completes the calibration procedure.

7.5.2 Calibration of Selected Points

Rather than going through the entire calibration table point by point, one or only a few of the points may be selected for correction. The procedure is almost identical to the calibration procedure for all points described above with the exception of the ' V ' commands used.

NOTE: More detailed explanations of all the interface commands used in the following procedure may be found in Sec.4. See Figure 7.5-1 for a flow chart of the following calibration procedure.

Step 1: Follow the set up procedure explained in Section 7.3.1.

Step 2: Press the ESC. key until you get to the MAIN MENU. Press the 6 key and you will be prompted to enter a Password to allow entry to the CALIBRATION menus. Enter the correct 4 digit Password (initial password is 4660) and press the ENTER key. When the correct password is entered, you will be at the TEMP CALIBRATE ... menu. Press the ENTER key to move down one menu level to the calibration menus. The first menu is an informative message displaying the date of the last calibration.

Step 3: Press the ▼ key twice to go to the CAL Temp. menu. Press the ENTER key and use the ▲ and ▼ keys to select the calibration temperature. Press the ENTER key to make the selection. The word CAL will appear on the STATUS display and the controller will now control the source at this selected temperature. The display resolution will change to three decimal place resolution and the temperature control mode will be set to ABSOLUTE as indicated on the STATUS screen. The exact temperature selected is not important; this procedure is only used to enter the CALIBRATION mode.

Step 4: The 2477 should be commanded to go into the REMOTE mode of operation by sending commands over the computer interface. When the 2477 is in the REMOTE mode of operation, the REMOTE indicator (ℝ) will appear on the STATUS display.

Step 5: The external computer must indicate to the 2477 which probe(s) will be calibrated. A ‘Vx’ command must be sent to the 2477 to identify the probe selection. The ‘V1’ command will calibrate only the T1 probe, the ‘V2’ command will calibrate only the T2 probe, and the ‘VB’ command will calibrate both T1 and T2 simultaneously.

NOTE: When calibrating both probes, the 2477 uses the data points from the T2 table for the temperature set points. It is assumed that both the T1 and T2

tables contain identical temperature entries. If not, the T1 probe will need to be calibrated separately, so that the T1 table temperatures will be used.

Step 6: The 2477 now needs to know at what temperature to control to check the selected probe. Select the desired temperature set point with the 'Vxx.xxx' command, where 'xx.xxx' is one of the calibration temperatures from the selected calibration table. If the temperature setting selected by the 'Vxx.xxx' command is not found in the calibration table, it will be ignored.

Step 7: Wait for the READY indicator (◆) to light indicating that the source has reached the selected temperature. Allow an extra minute or two to allow the source and the probes inserted into it to stabilize before calibrating at this set point. The computer controller can detect the ready condition in one of two ways: by polling or by an SRQ interrupt.

To Poll for the ready indication, the computer controller must first send the 'R1' command to the 2477 which will enable the ready indication in the standard data response of the 2477. The computer controller should wait for the last character of the response data string to change to a '1'.

Alternatively, the computer controller can wait for an SRQ from the 2477 when the source is ready. The computer controller would then perform a serial Poll and verify that bit 0 of the response byte is set, indicating the ready condition.

Step 8: Compare the 2477 temperature reading with the reading of the reference calibration thermometer. Temperatures within ± .01°C are within the specifications of the 2477 and need not be corrected, but it is up to the user to determine the window within which to make a correction.

If no correction is necessary, proceed to Step 12.

If a correction needs to be made, first verify that the temperature of the source is stable by checking the ready condition as described in Step 7. If the source is not stable (ready), do not proceed with the correction.

When the source is stable, the Bus controller issues a GET command. The

Bus controller should then read and store the temperature reported by the calibration thermometer immediately after issuing the GET command. This effort tries to get the thermometer and the 2477 temperature readings to

correspond in time as closely as possible.

Step 9: The computer controller should wait for an SRQ (IEEE only) from the 2477, or perform a serial Poll until bit 2 of the response byte is set, indicating the 2477 received the GET and is ready to perform the correction.

Step 10: After it has been established that the 2477 is ready to receive the correction data (Step 9), the actual source temperature (as reported by the calibration thermometer following the GET command) is sent to the 2477 with the 'Axx.xxx' command where 'xx.xxx' is the thermometer data.

Once the actual temperature information is received by the 2477, it recalculates the resistance readings for the selected probe(s), generates a new checksum value for the calibration data, clears the ready indicator, and then controls once again at the current set point. This process normally takes just a few seconds, and the front panel temperature display can be seen to jump as the correction is made.

Step 11: Repeat starting with Step 7.

Step 12: To move to the next calibration point, the computer controller will issue a 'Vxx.xxx' or 'VN' command to move to another temperature. The calibration procedure is then repeated beginning with Step 7.

Step 13: Once all desired points have been calibrated, the computer controller should now download the entire calibration table from the 2477 for archival purposes using the 'LR?' command. This completes the calibration procedure.

7.6 DATA TABLE DOWNLOADING AND UPLOADING

7.6.1 Downloading Procedure

To retrieve the data from the calibration table of the Model 2477, either the 'L1?', 'L2?' or 'LR?' command is given by the computer controller. In response, the 2477 returns a multiple message format consisting of a header indicating the source of the data, and

then either the value of the indicated data or else an index into a table and the floating point value at that position in the table.

The number of message lines sent is dependent upon the number of calibration points

within the table (this information is also sent as a message line). When downloading an entire table ‘LR?’, the low limit, the high limit, the calibration resistor table, the serial number, the date of calibration, the effective □T and the checksum is also reported. See List commands in Operation, Section 4 of the manual for more information.

Each message line is terminated with a carriage return which simplifies the storage of the data strings in the host computer. In its simplest form, the host computer addresses the 2477 as a talker repeatedly until the ‘LEND’ message and then writes the data to a text file. The data could also be read into any number of programs and manipulated as the user desires for analysis purposes.

Note that the format of the data as sent from the 2477 is identical to the format required for sending back to the 2477 so it is advisable to retain one copy of the data "as is" for uploading if necessary.

7.6.2 Uploading Procedure

To transfer a table back to the 2477, a set of messages are sent following the ‘L’ command formats. These commands have exactly the same format as messages sent by the 2477 while responding to a ‘L1?’, ‘L2?’, ‘LE?’ or ‘LR?’ command.

This procedure is intended to allow the user the ability to recreate the calibration table of the 2477 following some catastrophic error that would destroy the contents of the table or replacement of the EEPROM.

The host computer would have the entire calibration data table (as downloaded with the ‘LR?’ command) saved as a file. When needed, the host computer would send the file back to the 2477 line by line exactly as recorded, to recreate the calibration data table.

The Model 2477 will accept the commands only if it is in the CAL mode. See Section 7.5.1 Step 2 and Step 3 to put the 2477 in the CAL mode.

SECTION 8

REPLACEABLE PARTS

8.1 ORDERING INFORMATION

To obtain replacement parts, order from the address on the front of the manual. Identify parts by EOI STOCK CODE, if this can be determined.

For non-listed parts, include the instrument Model and Serial numbers, the location of the part (Interconnect number or Component designator) and a description of the part (e.g., 10 µF 35 V Tantalum Capacitor).

Because of the complexity of our instruments, or the microelectronics in them, some parts are not available and repairs should, or must, be done in our facility.

For very old equipment, it is helpful to know the original purchaser name, the purchase order number and the purchase date. We keep records of everything we sell. We can investigate these records to satisfy your requests. The more information we have, the easier it is to find what you need. Some parts for old equipment are no longer available. In these cases, we can try to find compatible parts to get your system back in service.

Here is a list of information that will help us find your parts:

Model number
Serial number
Interconnect Number and revision letter
Component name and description
Any known specifications of component
Original purchaser name
Original purchase date
Purchase order number
Information on what the problem is, how often and under what circumstances it occurs.

Electro Optical Industries, Inc.

LIMITED WARRANTY

Electro Optical Industries, Inc. (EOI) warrants this new Product against defects in materials or workmanship as follows:

For a period of two (2) years from the date of shipment, EOI will repair or replace the Product, at EOI's option, without charge for parts or labor. After the period of two (2) years the purchaser must pay all parts and labor charges.

The limited warranty is extended only to the original purchaser. It does not cover damages or failure caused by or attributed to Acts of God, abuse, misuse, improper or abnormal usage, faulty installation, improper maintenance, war, lightning, or other incidences of excessive voltage, or any repairs or tampering by other than an EOI authorized repair facility. It does not cover replacement of consumable parts, transportation costs, or damage in transit. *For the purposes of this warranty heater elements, emitting surface coatings and re-calibration are considered consumables.* This warranty will become void if any factory seals are removed or broken, or the serial number or model number identification has been wholly or partially removed or erased. Repair or replacement under the terms of this warranty does not extend the terms of this warranty. The specific components that are repaired or replaced are warranted for a period of six months. This warranty may not be modified by any agent of EOI, except in writing and signed by an officer of EOI.

Should this product prove defective in workmanship or material, the purchaser's sole remedies shall be such repair or replacement as provided by the terms of this warranty. Under no circumstances shall EOI be liable for any loss or damage, direct, consequential, or incidental, arising out of the use of or inability to use this Product.

To obtain warranty services, call or write EOI for a Return Material Authorization (RMA) number. Packaging must be suitable for the form of shipment used. Mark the RMA number clearly on the outside of the package. Include a copy of a description of the symptoms, contact name, organization, address, phone number and any special return shipping instructions. Then deliver or ship the product, postage or shipping costs prepaid, to EOI.

If Product is returned to EOI during the limited warranty period, but problem with the Product is determined not to be covered under the terms and conditions of this limited warranty, the purchaser will be notified and given an estimate of the charges the purchaser must pay to have the Product repaired, with all shipping charges billed to the purchaser. If the estimate is refused, the Product will be returned COD for the standard evaluation charge, if any, freight collect. If the

Electro Optical Industries, Inc.

Product is returned to EOI after the expiration of the warranty period, EOI's normal service policies shall apply and the purchaser will be invoiced for all shipping charges.

Purchaser may also have other rights, which may vary from state to state.

ANY IMPLIED WARRANTY OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE OR USE, SHALL BE LIMITED TO THE DURATION OF THE FOREGOING WRITTEN WARRANTY, OTHERWISE, THE FOREGOING WARRANTY IS THE PURCHASER'S SOLE AND EXCLUSIVE REMEDY AND IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED. EOI SHALL NOT BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES OR LOSS OF ANTICIPATED BENEFITS OR PROFITS, RESULTING FROM THE PURCHASE OR USE OF THE PRODUCT ARISING FROM THE BREACH OF THE WARRANTY EVEN IF EOI KNEW OF THE LIKELIHOOD OF SUCH DAMAGES.

* * *