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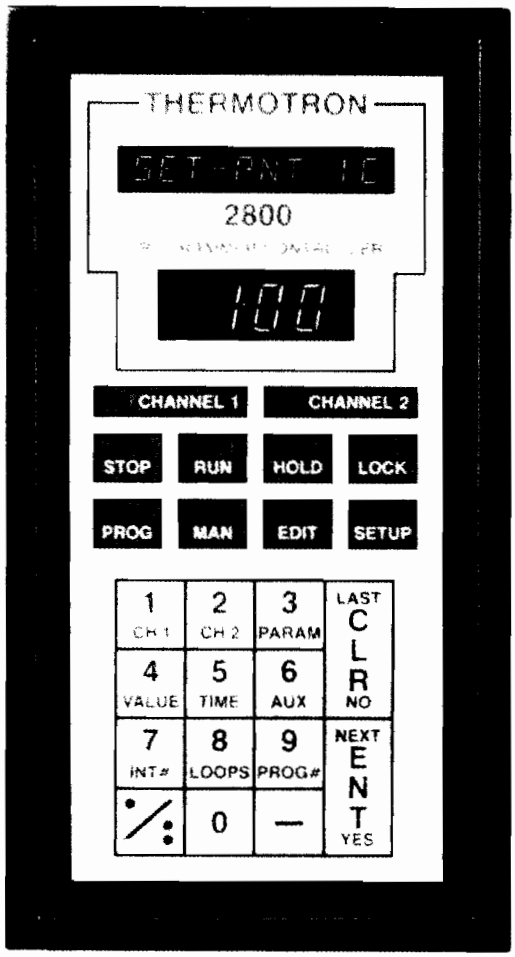
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THERMOTRON



This manual has important information for the safe operation of this instrument. Read this manual carefully and tell all operators to read this manual. If you do not follow the instructions, you can cause an injury or damage to the equipment, the product, and the building.

2800 PROGRAMMER/CONTROLLER
OPERATOR MANUAL

For new manuals contact:

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2800 PROGRAMMER/CONTROLLER OPERATOR'S MANUAL

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SAFETY INSTRUCTIONS

For the safe operation of this instrument, read and understand all warnings and cautions. Look for these symbols:

⚠ **WARNING:** **If you do not follow the instructions in a WARNING, injury can occur to you or to other personnel.**

⚠ **CAUTION:** **If you do not follow the instructions in a CAUTION, damage can occur to the equipment.**

⚠ 1. You must have training in the operation of this instrument before using it. **Read the instruction manual.**

⚠ 2. Do not operate this instrument unless it is completely assembled.

⚠ 3. Maintenance and repairs must be done by authorized personnel only. Make calibrations according to the specifications given in this manual.

⚠ 4. Use a mild soap and water solution to clean the control panel of the instrument.

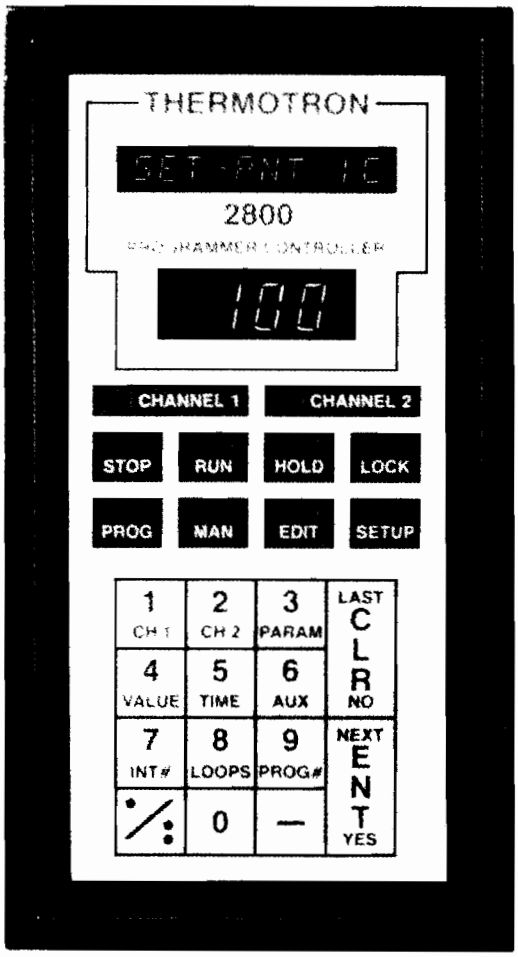
⚠ 5. To prevent electrical shock, do not touch the transformer and terminal block TB5 on the main board.

⚠ 6. To prevent damage to the instrument, do not connect AC power to the terminal blocks on the main board and the multioption board.

⚠ 7. Always use an electrical supply system with a separate electrical ground conductor. For maximum protection against electrical shock, use a circuit that is protected by a ground fault circuit interrupter.

SPECIFICATIONS

OPERATING TEMPERATURE:	$0^{o}C$ to $50^{o}C$ ($32^{o}F$ to $122^{o}F$).
POWER REQUIREMENTS:	117 volts AC ±10%, 50/60 hertz, 23.2 volts amperes.
CHANNELS:	One or two independently programmable channels.
TEMPERATURE RANGE:	$-87^{o}C$ to $+190^{o}C$ ($-125^{o}F$ to $+375^{o}F$).
HUMIDITY RANGE:	20% to 100% relative humidity.
INPUT:	Type "T" thermocouple (copper/constantan).
SAMPLING RATE:	Process sampled every 0.05 seconds.
MEASURING ACCURACY:	0.25% of span typical.
TEMPERATURE SCALE:	Celsius or Fahrenheit.
SETPOINT/DISPLAY RESOLUTION:	1^{o}Celsius or Fahrenheit, 1% relative humidity.
CONTROL METHOD:	Digital P.I. algorithm, unidirectional (heat only).
PROPORTIONAL BAND:	Programmable 1 to 100 units.
INTEGRAL TIME (Automatic Reset):	Programmable 10 to 1000 seconds or off.
OUTPUTS:	Time proportioning self-adjusting.
MACHINERY CYCLE TIME:	Software controlled.
AUXILIARY COOLING OUTPUT:	Programmable, 0 to 100% of 5 second time frame.
ALARM OUTPUTS:	Programmable, one process or deviation each channel, on/off TTL compatible. Display flashes.
EVENTS OUTPUTS:	4 on/off TTL compatible. Independently programmable for each interval, or manually.
INTERVALS:	Greater than 120.
INTERVAL LENGTH:	1 minute to 24 hours. 1 minute resolution.
PROGRAMS:	Up to 10. Intervals can be divided between programs.
LOOPS:	Up to 16 loops per program. Each loop can be repeated 255 times. Nesting of loops allowed.
PROGRAM MEMORY:	RAM. Dynamically allocated by program number up to maximum number of intervals. Lithium battery back up to 7 years without power. Battery shelf life 10 years.
COLD JUNCTION COMPENSATION:	Temperature stability better than ±0.05% of span/^{o}C from ambient over operating range.
OPEN THERMOCOUPLE PROTECTION:	Disables all outputs. Display reads "OPEN T/C".
OPTIONAL ACCESSORIES:	**Multioption Board** -Real time clock -Analog process-variable retransmit -Printer output: RS232C "talk only" port **Computer Interface Board** -RS232C or GPIB (IEEE-488, 1978 standard) **Solid State Relays**



2800 PROGRAMMER/CONTROLLER

The 2800 Programmer/Controller is a programmer and a controller combined. The 2800 Programmer/Controller is specifically designed for use with Thermotron Standard Products chambers. It has either one channel for control of temperature or two channels for control of temperature and direct percent relative humidity. The 2800 features a keypad, an alpha display for English language prompts, and a numeric display for data.

The 2800 Programmer/Controller can be equipped with option boards that increase the features and provide communication capabilities with other computers.

THE CONTROLS

The operator controls for the 2800 Programmer/Controller are on either the front or the side of a chamber or on a separate console. The controls consist of the alpha display, the numeric display and the keypad.

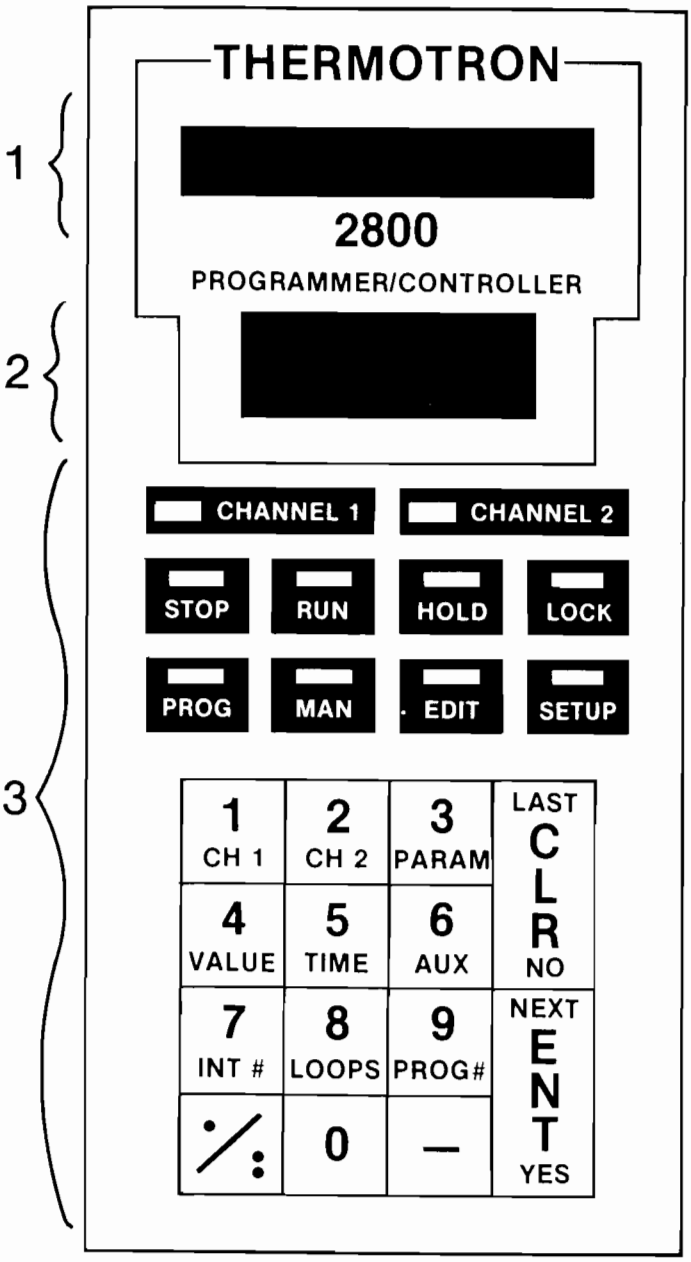


FIGURE 1

THE ALPHA DISPLAY

The alpha display (1) is on the top of the interface panel. This fourteen segment by ten character display is for English language prompts. See Figure 1.

THE NUMERIC DISPLAY

The numeric display (2) is below the alpha display. This display is a 4-digit display for numbers. A decimal point between the second and third digits separates hours and minutes or months and days.

THE KEYPAD

The keypad (3) allows the operator to program the equipment. The keypad contains the following keys:

The **STOP** key stops the functions of the 2800. It is also used to stop the program mode and the setup mode. The **STOP** key is used to display the stop code.

The **RUN** key starts the controller action in either the manual mode or the programmed mode.

The **HOLD** key holds a running program.

The **LOCK** key locks the keyboard from unauthorized use.

The **PROG** key starts the program or review mode. This key is also used with the **RUN** key to run a program.

The **MAN** key is used with the **RUN** key to operate in the manual mode.

The **EDIT** key is used to edit certain values of the 2800.

The **SETUP** key starts the setup mode.

The **CLR** (NO, LAST) key cancels the last numeric entry, answers NO to yes/no questions, and scrolls backward through the display data group.

The **ENT** (YES, NEXT) key completes a numeric data entry, answers YES to yes/no type questions, and scrolls forward through the display data group.

The **0** through **9** keys, the **./:** key and **-** key are for numeric input and selection of the data to be displayed in the stop, run, or hold states.

The **X** and **Y** keys are hidden under the interface panel. These keys are used for locking the keyboard and for accessing the setup mode.

THE CHAMBER FUNCTIONS CONTROLLED BY THE 2800

The 2800 is a proportional integral controller for heat. On S-series chambers, the refrigeration system and the auxiliary cooling system are controlled by the 2800. On SM-series chambers, the 2800 also controls the humidity system.

The 2800 starts the refrigeration system when the following conditions exist:

1. The setpoint is less than or equal to 122°F (50°C).*

2. The process variable is one degree greater than the setpoint and the heat throttle output is zero.

3. A negative temperature change is called for while a program is running.

* If the temperature is less than the setpoint minus the proportional band, a heating command exists.

NOTE: There is a two minute delay between the time the 2800 signals the refrigeration system off and the refrigeration system shuts off. After a power failure, there is a one minute delay in the refrigeration machinery on output.

The 2800 controls the auxiliary cooling system (LN_2 or CO_2 boost) in the following way:

1. When the refrigeration system is on and the heat throttle output is zero, the auxiliary cooling system is on. The auxiliary cooling output pulses every five seconds.

2. To adjust the auxiliary cooling duty cycle, change the percent in the **AUX CLG** parameter. See Pages 14 and 15.

    a. A percent of zero shuts the auxiliary cooling system off.

    b. A percent of 100 stops the pulsing and turns the auxiliary cooling on when the refrigeration system is on and the heat throttle is zero.

The humidity system on SM-series chambers is controlled by a two-channel 2800 in the following way:

1. When the humidity setpoint is non-zero, the humidity system is turned on.

2. When the humidity setpoint is zero, the humidity system is turned off.

3. When the dry bulb setpoint is outside of the range of 0^{o}-100^{o}C, the humidity system is off regardless of the value of the humidity setpoint.

The controller-on output of the 2800 turns the chamber on and off. This function is used to turn the chamber on for a delayed start.

HOW TO OPERATE

HOW TO SET THE ALARMS

If an alarm is needed, the alarm must be set before operating the instrument. The instrument can be programmed to alarm either on the limits of the process variable or on the deviation from the setpoint.

To select an alarm configuration, follow this procedure:

1. Press the **SETUP** key. The alpha display shows SETUP.

2. Press the **Y** key, hidden under the letters TROL between the two displays. See Figure 2. The alpha display shows ALARM COND. To end this procedure, press the **STOP** key. To continue, press the **ENT** key.

NOTE: The setup mode can be exited at the beginning of a function by pressing the STOP key. Once a function has been selected that function must be completed.

NOTE: For a 1-channel unit, omit Step 3.

3. For a two-channel unit, the alpha display shows SET CH1 AL. Press the **ENT** key to set an alarm for channel 1.

4. The alpha display will show PROCESS?.

5. To select a process alarm, press the **ENT** (YES) key. The alpha display shows CH1 LOW and CH1 HIGH. Enter the desired values.

6. If a process alarm is not desired, press the **CLR** key. The alpha display shows DEVIATION.

7. To select the deviation alarm, press the **ENT** key. The alpha display shows CH1 DV-BAND.

8. Enter the desired values. Use positive values only.

9. For units with two channels, the alpha display will show SET CH2 AL. If settings are desired for channel 2, press the **ENT** key. Repeat Steps 3 through 6. If settings are not desired for channel 2, press the **CLR** key.

10. To clear a previously set alarm, press the **CLR** key when the display shows PROCESS or DEVIATION.

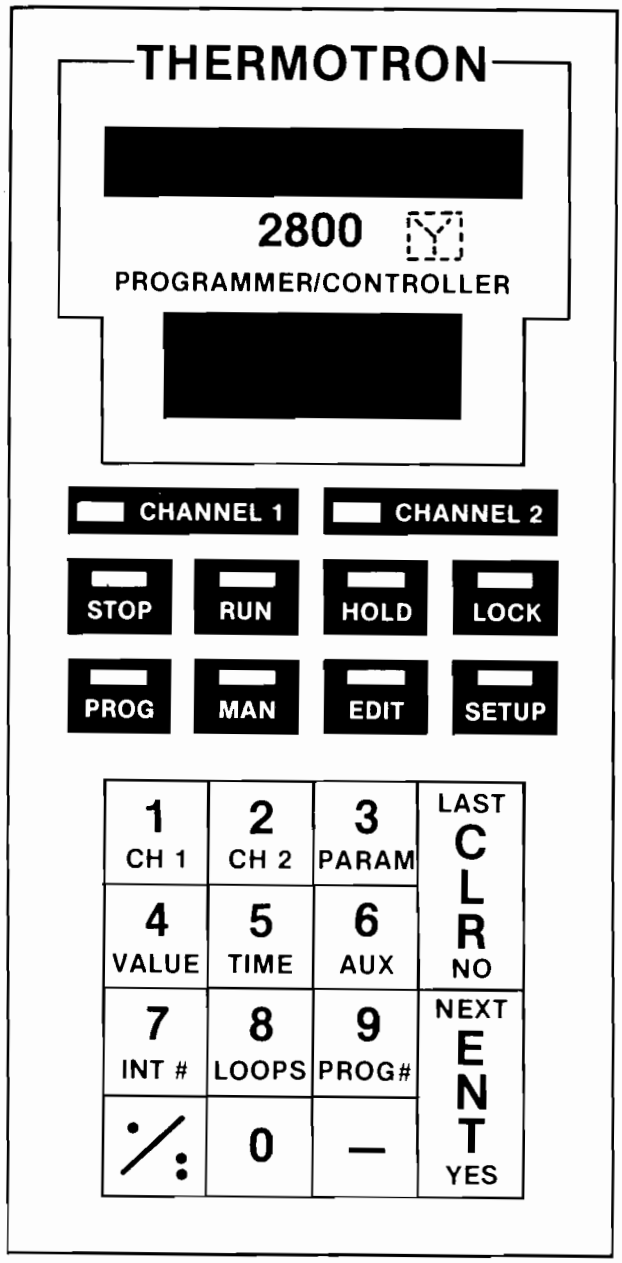


FIGURE 2

WHAT HAPPENS IN AN ALARM CONDITION

When the instrument detects a process alarm, the display flashes and the corresponding output terminal goes **HIGH.** The 2800 stops the test while the alarm condition exists.

When the instrument detects a deviation from the setpoint, the display flashes and the corresponding output terminal goes **ON.** The 2800 does not stop the test.

HOW TO PROGRAM

The 2800 Programmer/Controller has storage for ten different programs. The programs are numbered 1 through 10.

HOW TO PROGRAM

To enter a new program, follow this procedure:

1. When the 2800 is in STOP, press the **PROG** key. See Figure 3. The 2800 selects the lowest available program number. The display shows PROG NMBR.

2. Press either the **ENT** key to enter the program number chosen by the 2800 or press a numeric key(s) to enter an unused program number. The display shows INIT VAL1.

NOTE: If the value that the 2800 uses as a default is the desired entry, press the **ENT** key. Skip Steps 3, 4, and 5.

3. Press the appropriate numeric keys to enter the desired initial values for channel 1.

4. The following keys are helpful in entering the desired values:

   a. The - key can be pressed at any time during the entry process. The - key changes a negative value to a positive value as well as a positive value to a negative value.

   b. The **CLR** key resets the displayed value to 0.

5. When the desired value is correct, press the **ENT** key to enter that value.

6. For units with two channels, repeat Steps 3 through 5.

7. Initial values are entered before the first interval. All successive intervals use the final value of the previous interval as their initial value.

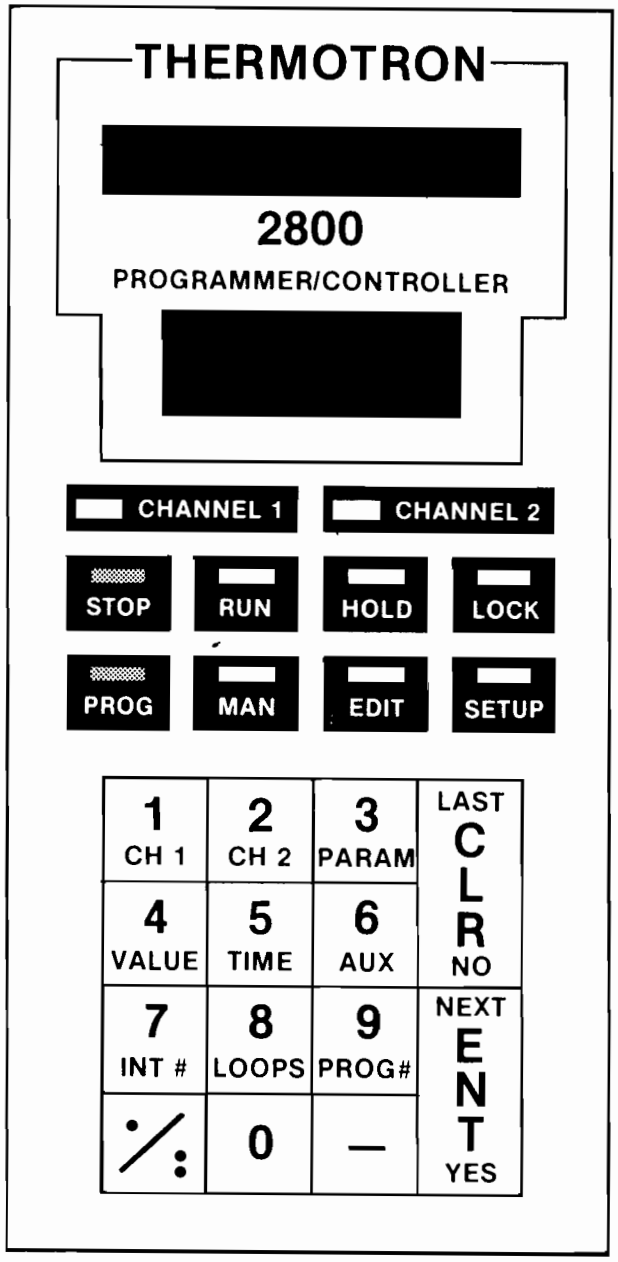


FIGURE 3

8. After the initial values have been entered, the alpha display shows INTERVAL and the numeric display shows 1.

9. Press the **ENT** key to continue programming.

10. The alpha display shows FINAL VAL1. To select the value of the set point for the end of the interval, repeat Steps 3 through 5 above.

11. For units with two channels, repeat Step 10.

12. After the setpoint values have been entered, the alpha display shows INT TIME. The unit needs to know how long the interval will be.

13. The maximum interval time is 24 hours, 59 minutes. Use the numeric keys to enter the hours, the ./: key to enter a period, and the numeric keys to enter the minutes.

    a. The time of 00.00 is entered when a timed soak period is desired on the next interval. The program time is held until the process variable is within the specified deviation from the set point. This is the continue deviation setting.

    b. The alpha display shows CONT DEV-1 for channel 1.

    c. Press the appropriate numeric keys to enter the desired continue deviation setting.

        1. The continue deviation numbers range from 0 to 15.

        2. Only positive numbers can be entered. The 2800 interprets the value as +/- values.

        3. If 0 is entered, the program continues into the next interval.

4. If either channel was preset to wait, the 2800 holds the program timer until that channel is within the selected deviation.

d. For units with two channels, repeat Step 13 for Channel 2 (CONT DEV-2).

14. The alpha display shows AUX EVENTS. Press the numeric keys 1 through 4 to enter the auxiliaries.

15. Press the **ENT** key to enter the desired auxiliary.

16. Press the **CLR** key to cancel the auxiliaries.

17. The alpha display shows NEXT INT.

18. Choose either looping or press the **ENT** key. See Page 11 for information on looping.

19. Select the next interval and the number of loops, if applicable. The alpha display shows INTERVAL and the next interval number to be programmed.

20. Press the **ENT** key to continue programming.

OR

Press the **STOP** key to stop programming. If Step 17 is not done, the unit deletes the last interval programmed.

21. The alpha display shows INT LEFT and the number display shows the number of intervals remaining in storage.

22. After 2 seconds, the 2800 returns to the stop state. The program can now be reviewed, edited or run.

NOTE: If during programming, the display shows OUT OF MEM, the 2800 stops programming. To continue programming, delete one or more programs from the memory. The 2800 stores what has been programmed up to the OUT OF MEM display.

HOW TO PROGRAM LOOPING

Looping is sending the program back to a previous interval or target interval.

To program the 2800 to do looping, follow this procedure:

1. When the alpha display shows NEXT INT, press the appropriate numeric key to indicate which interval is the target for the loop.

2. The following rules apply when looping:

   a. The target interval must be less than or equal to the current interval. See Figure 4.

   b. The target interval must not be within any other loop unless it is the target for that loop. See Figure 4.

   c. Loops can be nested. The maximum number of loops per program is 16.

   d. The final value of the looping interval must be the same as the final value of the interval which precedes the target interval.

3. When a loop has been programmed, the display shows NMBR LOOPS. A loop can be repeated 255 times.

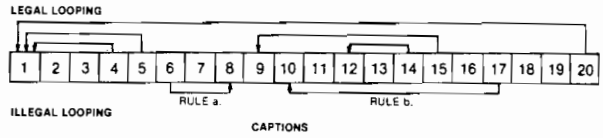


FIGURE 4

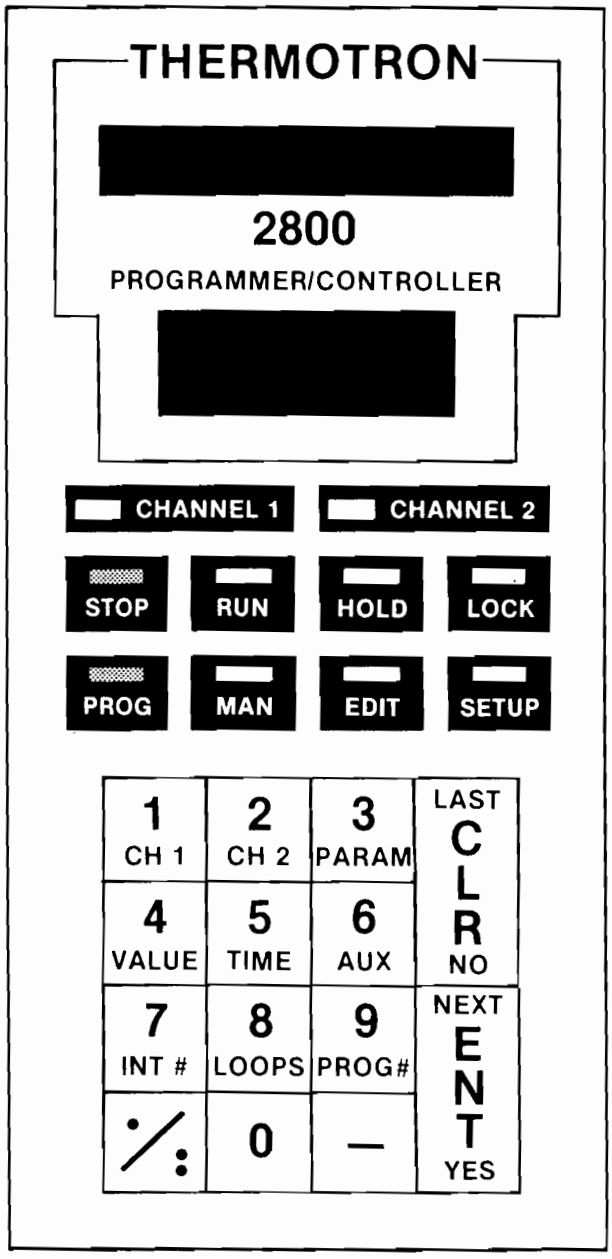


FIGURE 5

HOW TO REVIEW OR EDIT A PROGRAM

To either review or edit a program, follow this procedure:

1. While the program is in the STOP state, press the **PROG** key. See Figure 5.

2. The alpha display shows PROG NMBR.

3. Press the appropriate numeric key(s) to enter the number of the desired program.

4. If the program selected exists, the alpha display shows PROG/EDIT.

5. Press the **EDIT** key to edit or review a program. Press the PROG key to delete the existing program.

6. If the values in the program are correct, press the **ENT** key. If the values need to be changed, follow Steps 4 through 6 on Page 8.

7. After presenting all programmed intervals, the 2800 is in the program mode. Additional intervals can be added at this time.

8. Press the **STOP** key at any time during the review and edit function to cancel that function. The intervals left are displayed. The unit returns to the STOP state.

HOW TO DELETE A PROGRAM

To delete a program, see Figure 6 and follow this procedure:

1. To delete one specific program, press the **PROG** key when the alpha display shows PROG/EDIT.

2. To delete all programs, press the numeric **0** key when the alpha display shows PROG NMBR at the beginning of the program mode.

   a. The alpha display shows DEL ALL.

   b. To delete all programs, press the **ENT** key.

   c. To cancel the delete all programs command, press any key except the **ENT** key.

HOW TO RUN A PROGRAM

The 2800 can be run in either the programmed setpoint mode or in the manual setpoint mode. To run the 2800, see Figure 6 and follow this procedure.

1. With the 2800 in the stop state, press the **RUN** key.

2. The alpha display shows PROG/MAN.

3. To run a previously entered program, press the **PROG** key.

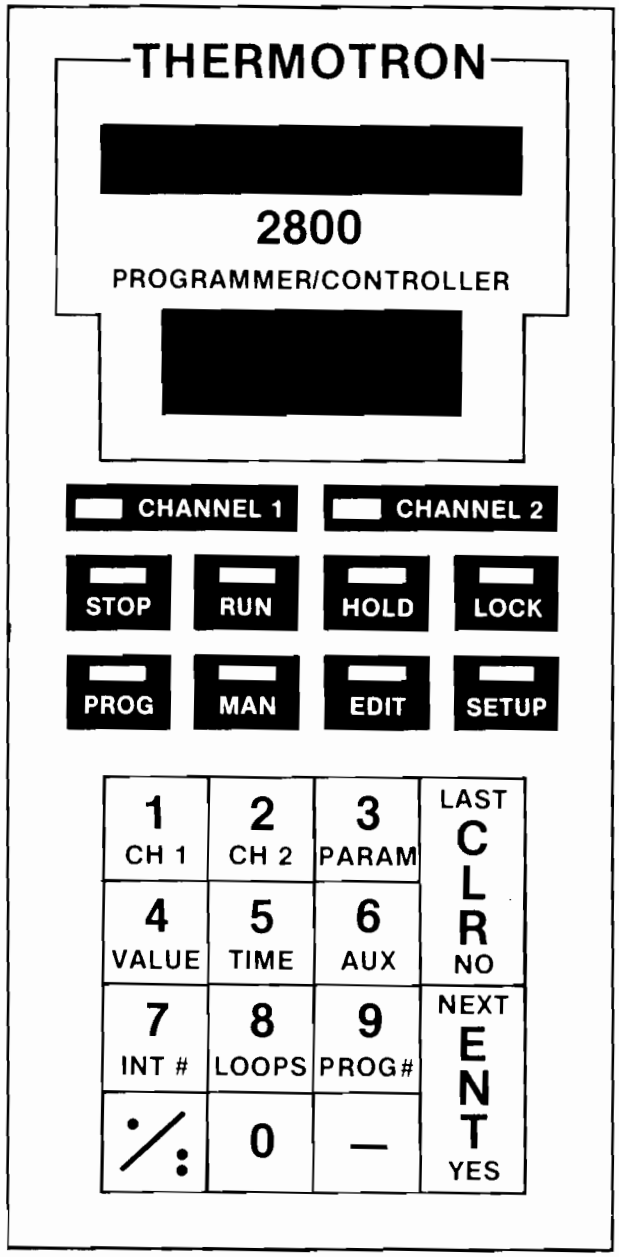


FIGURE 6

a. The alpha display shows PROG NMBR and INTV NMBR. If the instrument is equipped with the multioption board, the display asks for starting date and time. Enter the date and the time. See Page 23.

b. Enter the desired program number and interval number at which you want the program to start.

4. To manually run the unit, press the **MAN** key after Step 2 on Page 12.

   a. The setpoint can be edited any time while in the manual mode.

   b. Auxiliary events can be edited while in the manual mode.

5. To suspend a program, press the **HOLD** key. All program values are maintained.

   a. To change a setpoint value, press the **MAN** key. To enter the new value follow Steps 4 through 6 on Page 8.

   b. To return the program to the program setpoint, press the **PROG** key.

   c. To run the program from the suspended state, press the **RUN** key

HOW TO READ THE ALPHA AND NUMERIC DISPLAYS

When the 2800 is in either the run state or the hold state, the data for the current interval can be shown in the alpha and numeric displays. When the 2800 is in the stop state, some of the data shown refers to the last interval which was run.

Data is shown in groups. To show the data, follow this procedure:

1. While the 2800 is in either the stop state, the run state, or the hold state, press the appropriate numeric key. See Step 7 on Pages 14 and 15 to determine which numeric key to press.

2. Press the same numeric key again to scroll forward within the selected group.

3. Press the **ENT** (NEXT) key to display the next item in the group.

4. Press the **CLR** (LAST) key to display the previous item in the group.

5. Press the numeric **1** key to display the Channel 1 data.
   For units with two channels, press the numeric **2** key to display the Channel 2 data.

NOTE: The information displayed is for the parameter and value groups only.

6. The last letter of the alpha display means the following:

   F means degrees in Fahrenheit

   C means degrees in Celsius

   P means percent output

   H means humidity

   S means seconds

   The second to the last character in the alpha display indicates which channel.

   Example: VARIABL 1 F means the channel 1 variable is in degrees Fahrenheit. See Figure 8 on Page 15.

7. The following are the groups and the order they are in. The appropriate numeric key is also given.

   Parameter Group **Numeric key 3**

   THROTTL - The output of the throttle is displayed as a percent. See Figure 7.

   PRP-BAND - The proportional band setting is displayed in degrees Fahrenheit, Celsius or relative humidity.

   INTEGRL - Integral time parameter is displayed in seconds.

   AUX CLG - The auxiliary cooling duty cycle is displayed as a percent.

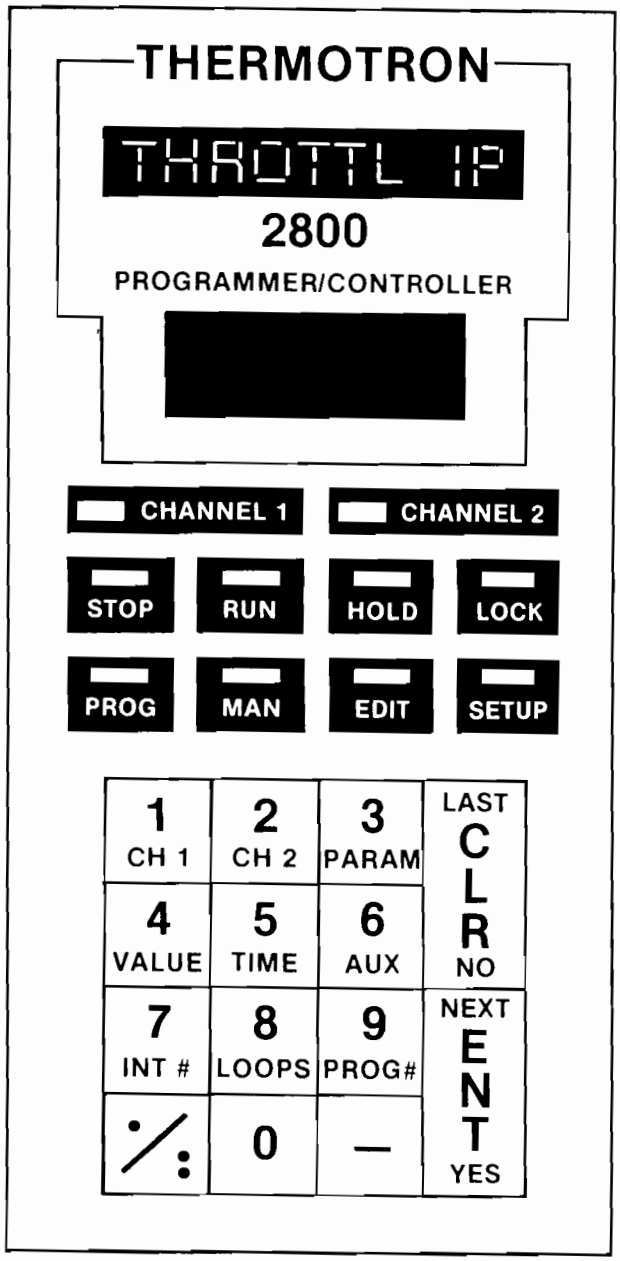


FIGURE 7

Value Group **Numeric key 4**

VARIABL - The current value of the process variable for the selected channel, either temperature or relative humidity, is displayed. See Figure 8.

SET PNT - The current setpoint for each channel is displayed.

DEVIATION - The actual deviation from the setpoint is displayed.

I-VALUE - The initial value of the setpoint for this interval is displayed. This is also the final value of the previous interval.

F-VALUE - This is the final value of the setpoint for this interval.

Time Group **Numeric key 5**

TIME LEFT - This is time left to go for this interval. (HH.MM)

INTVL TIME - This is programmed interval time (HH.MM)

TIME - The current time is displayed in hours and minutes. The time is displayed only if the instrument is equipped with the multioption board.

DATE - The current date is displayed as month and day. The date is displayed only if the instrument is equipped with the multioption board.

PRNT INT - The print interval time is displayed in seconds. Print interval time is displayed only if the instrument is equipped with the multioption board.

Auxiliary Group **Numeric key 6**

AUX EVENTS - The auxiliary outputs that have been programmed for this interval are displayed.

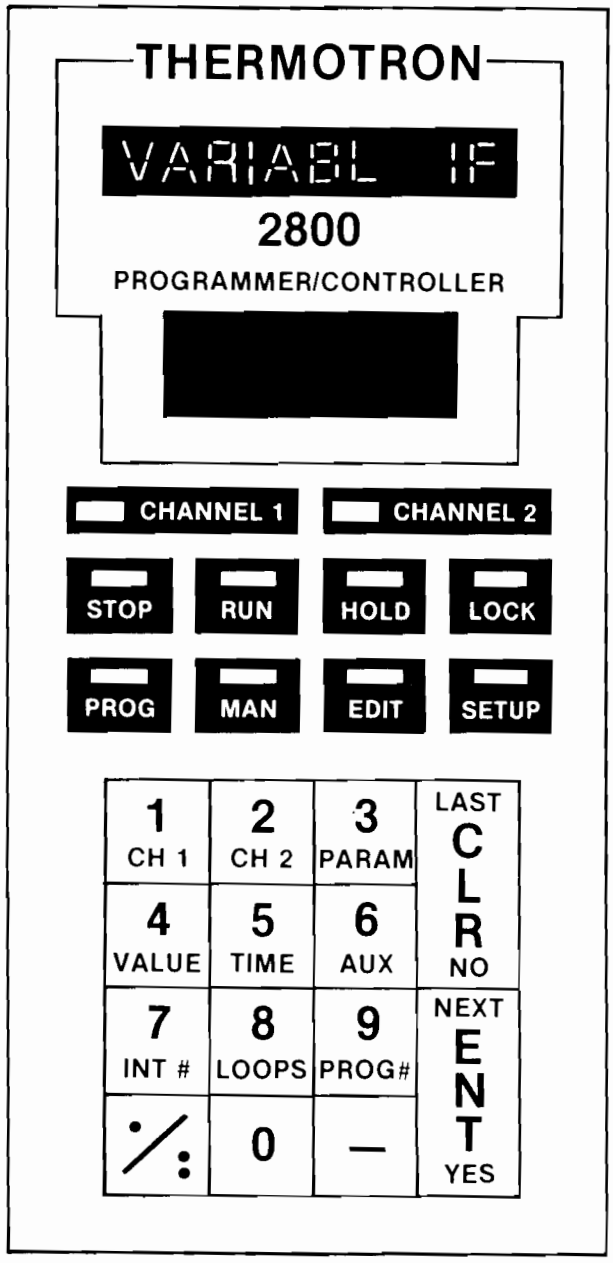


FIGURE 8

Interval Group **Numeric Key 7**

INTERVAL # - This is the current interval number.

NEXT INTVL - This is the next interval in the program. If the current interval has been programmed to loop, the target interval will be shown. Otherwise, the next interval is the successive interval number.

Loop Group **Numeric key 8**

LOOPS LEFT - If the current interval is within a loop, the loops remaining to be completed will be shown. With nested loops, only the innermost loop is available for display.

NMBR LOOPS - If the current interval is inside a loop, the number of loops which have been programmed will be shown.

Prog # Group **Numeric key 9**

PROG NMBR - The number for the program being executed will be shown.

HOW TO EDIT VALUES IN A PROGRAM

The values shown on Page 17 can be edited while the 2800 is in the stop state, the manual run state, or the program hold state. To edit the values, follow this procedure:

1. Select the value to be changed. See Page 17.
2. Press the **EDIT** key to change the value being displayed.
3. If the value selected can be edited from the current state, the EDIT light illuminates.
4. Press the appropriate numeric key(s) for inserting the new value. Press the **ENT** key when complete.
5. The edited program values are changed in the current interval only. The program memory has not been changed.

PROGRAM VALUES

TEMP RH%
CH1 CH2

Display Value	Program State	Changes Allowed		
PRP-BND	Stop Manual Run Program Hold	The proportional band can be edited to achieve proper control action	5	20
INTEGRL	Stop Manual Run Program Hold	The integral time can be edited to achieve proper control action.	100	200
SET-PNT	Stop Manual Run	The setpoint can be changed for each channel		
F-VALUE	Program Hold	The final value for each channel can be changed. This new value will become the initial value for the next interval.		
TIME LEFT	Program Hold	The time remaining in the current interval can be changed.		
TIME	Stop Manual Run Program Hold	If the 2800 is equipped with the multioption board the real time clock can be set by changing the time of day.		
DATE	Stop Manual Run Program Hold	If the 2800 is equipped with multioption board, the date can be changed or set.		
PRNT INT	Stop Manual Run Program Hold	If the 2800 is equipped with the multioption board, the time interval for printing can be changed. Remember that 0 seconds means that no date will print.		
AUX EVENTS	Manual Run Program Hold	The auxiliary outputs can be changed for the current interval. Press the **CLR** key to cancel all auxiliaries.		
LOOPS LEFT	Program Hold	The number of loops remaining to be completed can be changed. For nested loops, only the innermost loop can be changed.		

HOW TO USE THE STOP CODE

The stop code is used to know how the 2800 was put into the stop mode.

To display the stop code, follow this procedure:

1. With the 2800 in the stop state, press the **STOP** key.

2. For two seconds the alpha display shows STOP CODE and the numeric display shows a number.

3. Use the chart below to know what the stop code number means.

STOP CODE NUMBERS	EXPLANATION OF THE STOP CODE NUMBERS
0*	An unidentified error condition exists.
1	The **STOP** key was pressed.
2	A RAM error has occurred. (To clear the error, reprogram the 2800.)
3	The thermocouple on Channel 1 is open.
4	The thermocouple on Channel 2 is open.
5	The temperature limit has been exceeded for the 3.5 bench top model.
6	There is a process alarm on Channel 1.
7	There is a process alarm on Channel 2.
8	Stop command received from remote computer interface.
9	The program is finished.
99*	The watch-dog timer has detected an error and reset the 2800.

* The stop codes 0 and 99 can be caused by externally generated EMI/RFI electrical noise.

HOW TO LOCK THE KEYBOARD

The keyboard can be locked to provide security. The keyboard can be locked in either the stop state, the program run/hold state, the manual run state, or the delay start state.

To lock the keyboard, follow this procedure:

1. Press the **LOCK** key. The display shows ENTER KEY. See Figure 9.

2. Press the **X** key hidden just above the letters OGRA between the two displays. See Figure 9. The alpha display shows **-XXX-**.

3. Press the **Y** key hidden just above the letters TROL between the two displays. See Figure 9. The alpha display shows **-XXX-YYY-**.

4. Press the **LOCK** key again. The LOCK light illuminates. The keyboard is now locked.

5. The only active keys on the keyboard are those that change the display selection.

To unlock the keyboard, repeat Steps 1 through 4 listed above.

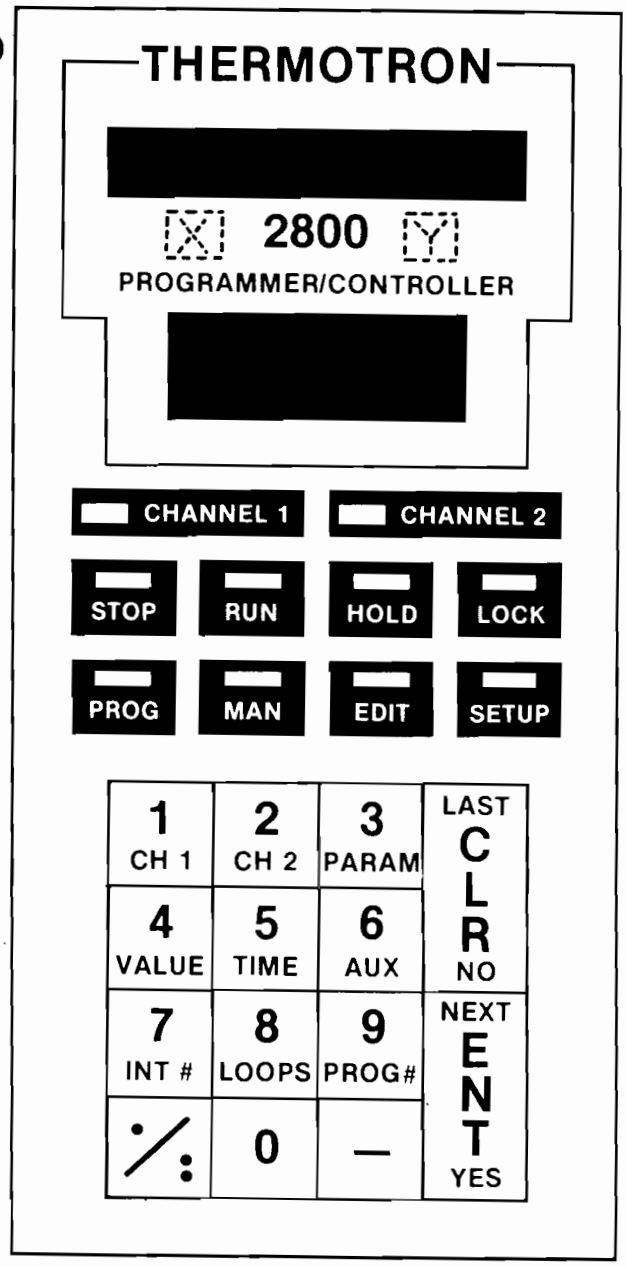


FIGURE 9

WHAT TO DO AFTER LOW VOLTAGE

The 2800 display shows LOW VOLTS when the 2800 detects AC line voltage that is lower than the preset level.

The 2800 remains in the LOW VOLTS state until the line voltage returns to normal.

The LOW VOLTS state does not destroy the memory. When the voltage returns to normal, the 2800 resets and continues with what it was doing.

If the 2800 does not reset, follow this procedure:

1. Have a variable AC power supply and an oscilloscope.
2. Connect the variable AC power supply to the 2800.
3. Press the **SETUP** key. The alpha display shows SETUP.
4. Press the **X** key hidden above the letters OGRA between the two displays. The alpha display shows CALIBRATE.
5. Press the **X** key again. The alpha display shows VOLT CAL.
6. Locate TP1 and TP4 on the main board. See Figure 9A.
7. Attach the ground probe of an oscilloscope to TP1. Attach the positive probe of an oscilloscope to TP4.
8. Set the oscilloscope for AC input, 100 millivolt range.
9. Adjust the AC power supply to 100 millivolts of ripple or until the AC power supply is less than 95 volts.
10. Press the **ENT** (NEXT) key. When the 2800 has completed the reading, the 2800 display shows OK TO SAVE.
11. Adjust the variable AC power supply to a normal operating level.

Continued on the next page.

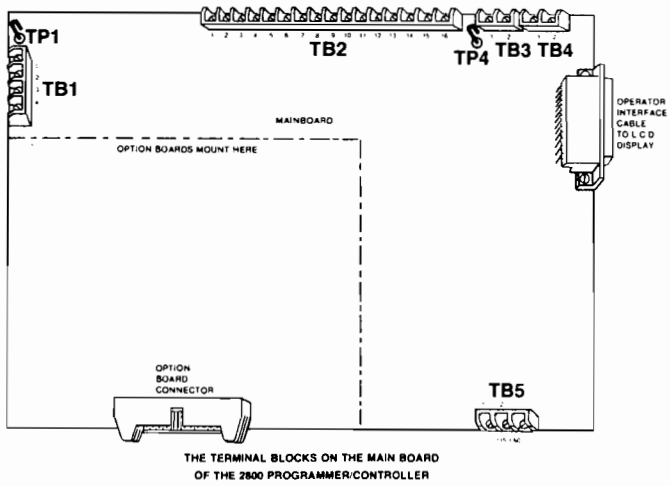


FIGURE 9A

12. Press the **ENT** (NEXT) key. The alpha display shows SAVING. The 2800 returns to the stop state.

13. If the instrument remains in the low voltage condition, turn the power to the 2800 **OFF.**

    a. Press the **SETUP** key and simultaneously turn **ON** the power to the 2800.

    b. Calibrate the 2800. See Pages 22 and 23, **How to Calibrate the 2800.**

    c. Program the 2800. See Pages 8 through 13 on **How to Program.**

HOW TO SET THE PROGRAM OPTIONS

To set the program options, follow this procedure:

1. Press both the **LOCK** key and the **CLR** key at the same time.

2. Press the **SETUP** key. The alpha display shows CONFIGURE. After two seconds the alpha display shows SLCT OPTNS.

3. Press the **X** key hidden above the letters OGRA. The alpha display shows CH TWO OFF.

4. Press the **CLR** key until the desired setting shows in the display.

5. Press the **ENT** key. The alpha display shows degrees F.

6. Press the **CLR** key until the desired setting shows in the display.

7. Press the **ENT** key.

    a. For a unit with one channel, the alpha display shows STD REFRIG. Press the **ENT** key. The alpha display shows --SAVING--.

    b. For a unit with two channels, the alpha display shows STD LIMIT.

        1. If the chamber is a model SM3.5, press the **X** key hidden above OGRA. The alpha display shows 3.5 LIMIT. Press the **ENT** key. The alpha display shows --SAVING--.

        2. For all other chamber models, press the **ENT** key. The alpha display shows --SAVING--.

HOW TO ADJUST THE 2800

As load requirements and other conditions change, the 2800 needs the control settings adjusted. There are two control settings. One setting is the proportional band setting. The other setting is the integral time setting.

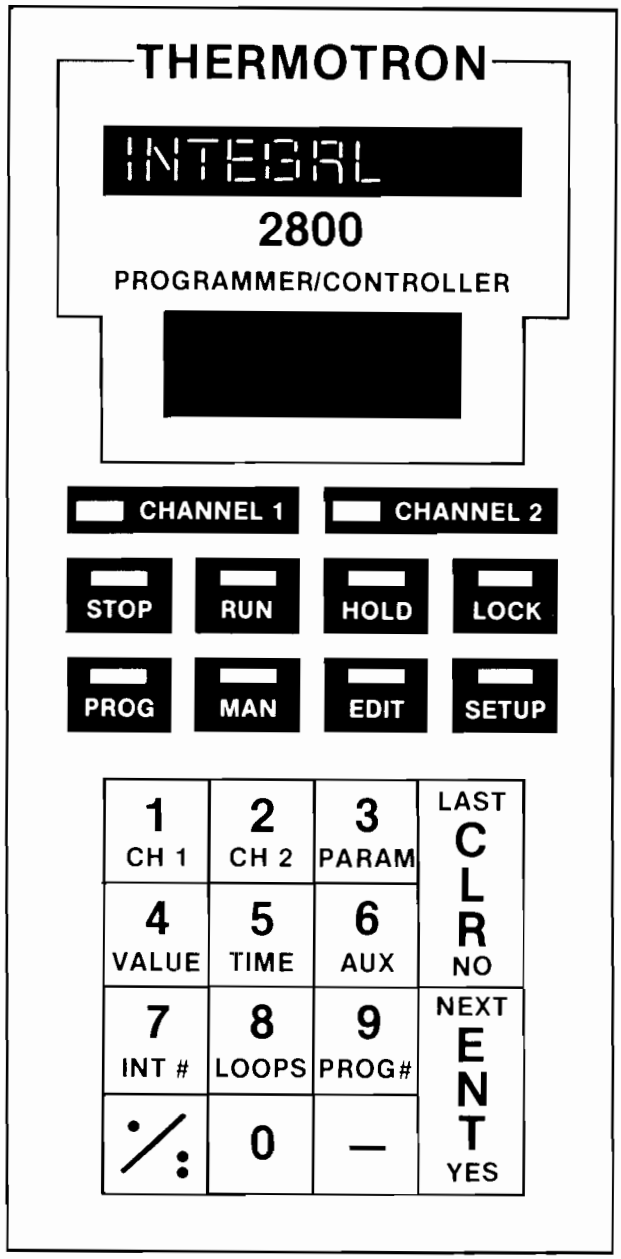


FIGURE 10

HOW TO TUNE THE PROPORTIONAL BAND

The proportional band setting allows the proportional action of the instrument to be adjusted. The units for the proportional band are the same as those for the process-variable for the channel. The proportional band has a range of 1 to 100 units in either degrees Celsius or Fahrenheit on Channel 1 or in percent relative humidity on Channel 2. The proportional band should be tuned with the integral function off.

To tune the settings for the proportional band, follow this procedure:

1. Press the **PARAM (3)** key.
2. To scroll through the display, press the **ENT** (NEXT) key until the display shows INTEGRL. See Figure 10.

NOTE: Record the existing value for use in setting the integral time.

3. Press the **EDIT** key, the **0** key, the **ENT** key to stop the integral function.
4. Use the manual run mode to start a step change in setpoint of approximately 10°C to 15°C. See Pages 8 through 10 on "How to Enter a New Program."
5. Watch the display to see if the chamber temperature oscillates near the setpoint.
6. If the chamber temperature oscillates, increase the proportional band by approximately 20%. If the temperature goes below the setpoint, decrease the proportional band by approximately 20%.

7. To either increase or decrease the proportional band, follow this procedure:

   a. Press the **PARAM (3)** key.

   b. Press either the **ENT** (NEXT) key or the **CLR** (LAST) key to scroll through the display until the display shows PRP-BND.

   c. Edit to the desired value. See Pages 16 and 17.

   d. At the end of the edit, the 2800 will display SAVING.

The ideal proportional band setting is achieved when the temperature within the chamber does not oscillate with minimum droop. Droop is when the temperature within the chamber reaches and holds a level other than setpoint.

HOW TO TUNE THE INTEGRAL TIME SETTING (OR PARAMETER)

The integral time setting allows the integral action to be adjusted. Integral time is given in seconds. The integral time has a range of 10 to 1000 seconds. A 0 setting stops the integral function.

To tune the integral time settings, follow this procedure:

1. Make sure the proportional band is tuned properly.

2. Put the 2800 in the STOP mode.

3. Press the **PARAM (3)** key.

4. To scroll through the display, press the **ENT** (NEXT) key until the display shows INTEGRL. See Figure 10 on Page 20.

5. Start with the original setting which was deleted in Step 3 on Page 20.

6. Use the manual mode to start a step change in the setpoint of approximately 10°C to 15°C. See Pages 8 through 10.

7. Watch the display to see if the temperature within the chamber oscillates.

8. If the temperature oscillates around the desired setpoint, the integral time is too fast. Increase the value by approximately 20 second increments until stable control is reached.

9. Edit to the desired value. See Pages 16 and 17.

NOTE: Repeat Step 6 after each adjustment.

10. If the chamber temperature is slow to approach the setpoint (droop), the integral time is too slow. Decrease the integral value by 20 second increments until stable control is reached.

HOW TO CALIBRATE THE 2800

A thermocouple potentiometer is required to calibrate the 2800. To calibrate the 2800, follow this procedure.

1. Press the **SETUP** key. The alpha display shows SETUP. See Figure 11.

2. Press the **X** key hidden above the letters OGRA between the two displays. See Figure 11. The alpha display shows CALIBRATE.

⚠ **CAUTION: To prevent loss of calibration, do not scroll through the calibration procedure unless calibration is desired.**

3. If calibration is desired, press the **ENT** key. If calibration is not desired, press the **CLR** key.

NOTE: The display shows INPUT CAL if the 2800 is equipped with the multioption board.

4. If the **ENT** key was pressed, the alpha display shows INPUT CAL. If input calibration is not desired, press the **CLR** key. Do not do Steps 5 through 10 on this page.

5. If the input calibration is desired, press the **ENT** key again. The alpha display shows ZERO VALUE.

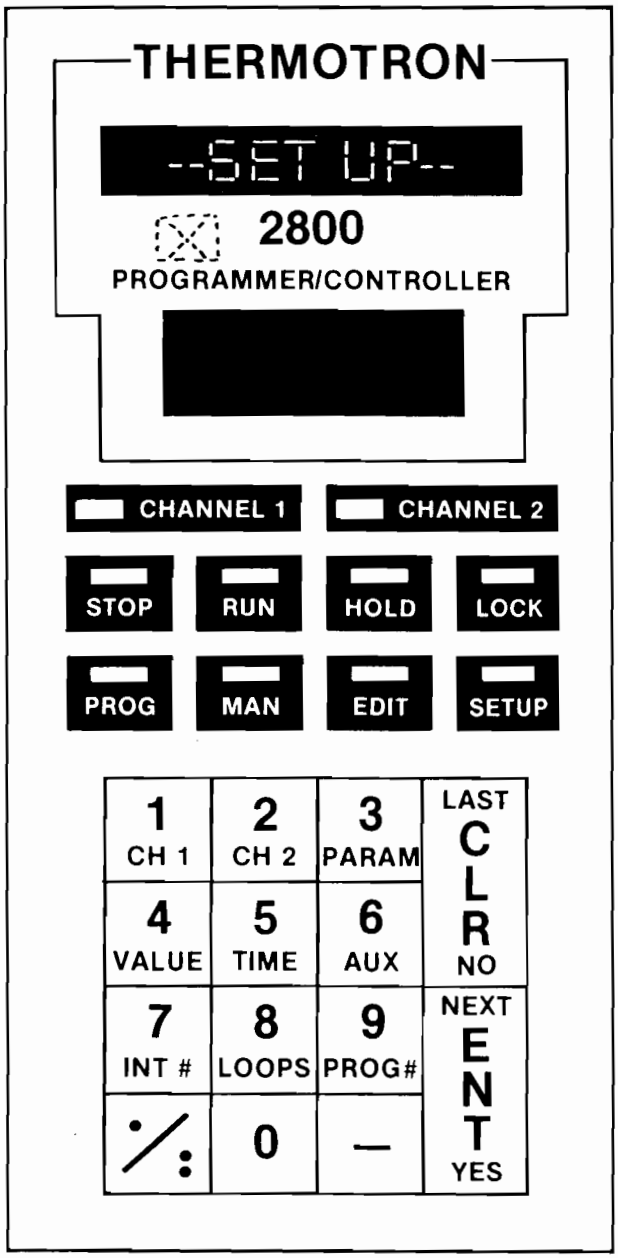


FIGURE 11

6. Connect a thermocouple potentiometer to both channel input terminals on the main board as shown in Figure 12.

7. Set the output of the potentiometer to the requested value shown on the numeric display.

8. Press the **ENT** key to start the data input.

9. The alpha display shows BUSY for 20 seconds while making a reading. Do not change the setting while the display shows BUSY.

10. Repeat Steps 5 through 9 for SPAN VALUE.

11. The display shows OK TO SAVE. Press the **ENT** key to save the new calibration factors.

12. The 2800 burns (loads) the memory and checks for a proper burn.

13. If the burn is bad, the display shows BAD BURN for two seconds. The display then shows TRY AGAIN.

14. Press the **ENT** key to repeat the burn.

NOTE: If the display shows BAD BURN more than twice, contact your local Thermotron field service office.

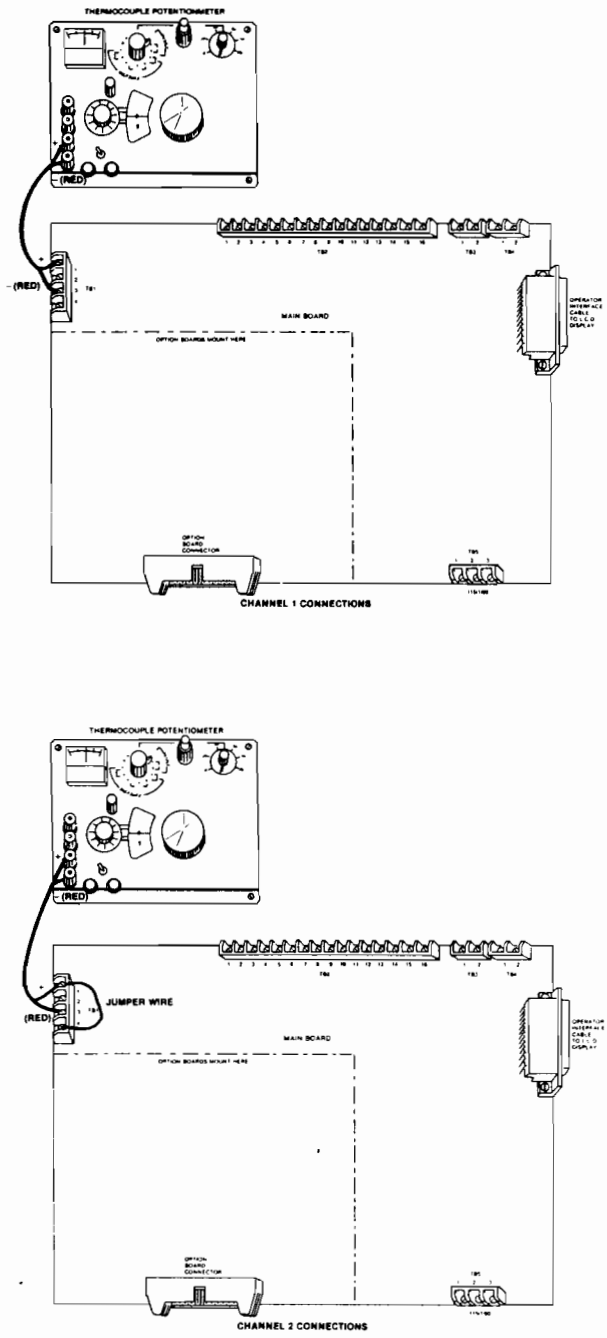


FIGURE 12

THE TERMINAL BLOCK CONNECTIONS

WARNING: To prevent electrical shock, do not touch the transformer and terminal block TB5 on the main board when power is connected.

TB1 Thermocouple Inputs See Figure 13.

1- Dry bulb thermocouple positive (blue).
2- No connection—ambient junction compensator.
3- Thermocouple negative (red)—both dry and wet bulbs.
4- Wet bulb thermocouple positive (blue).

TB2 Digital Input/Output See Figure 13.

1- Refrigeration machinery on output.
2- Alarm output Channel #1 (temperature).
3- Common.
4- Auxiliary output #4.
5- Auxiliary output #3.
6- Auxiliary output #2.
7- Auxiliary output #1.
8- Common.
9- Alarm output Channel 2 (relative humidity).
10- Humidity system on output.
11- Common.
12- Controller on status output.
13- Auxiliary cooling output.
14- No connection.
15- No connection.
16- Common.

TB3 Control Output See Figure 13.

1- Dry bulb heat control time proportion output.
2- Common.

TB4 Control Output See Figure 13.

1- Humidity system heat control time proportion output.
2- Common.

TB5 Power Connections See Figure 13.

1- Ground.
2- Neutral.
3- Line 115 Volts AC.

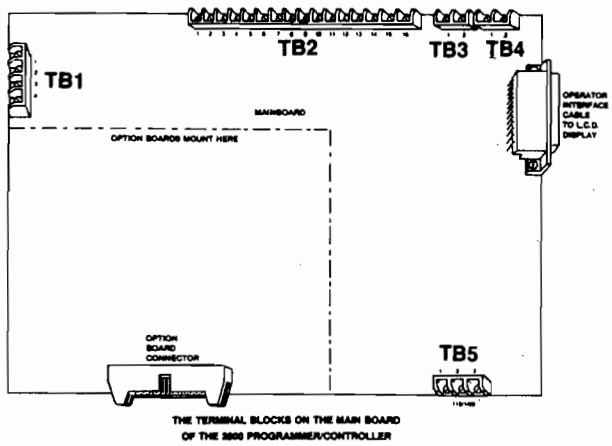


FIGURE 13

THE OPTIONAL FEATURES

THE MULTIOPTION BOARD

The multioption board is an optional feature on the 2800. The multioption board mounts to the main board of the 2800. The board is connected to the 2800 via a ribbon cable. See Figure 14. The 2800 automatically recognizes if the multioption board is connected.

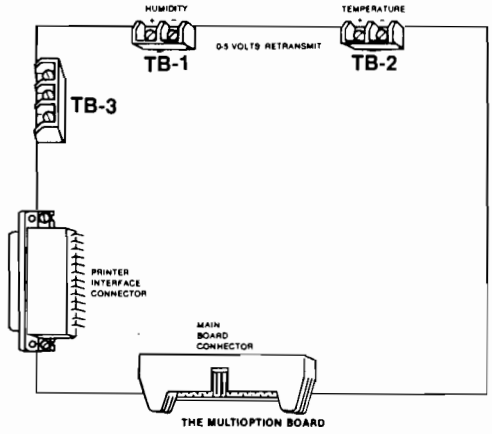


FIGURE 14

The multioption board for the 2800 has the following features:

1. A real time clock that displays the time in hours and minutes and the date in month and day, that provides timing for the data logging, and that provides a delayed start function.

2. A serial interface (RS-232) that connects a compatible printer to the 2800 for data logging. To be compatible the printer must have the following features:
   * DTE configuration with a DCE connector
   * 2400 Bits/per second
   * 8 bits/character
   * minimum 20 characters line length

3. An analog process-variable that retransmits the following output to a chart recorder:
   * 0 to 5 volt output
   * $-75^{o}C$ to $+175^{o}C$, linear Channel 1
     0-100% relative humidity Channel 2
   * Software calibration

HOW TO SET THE TIME AND THE DATE ON THE REAL TIME CLOCK

To set the time, follow this procedure:

1. Press the numeric key 5. Press either the **CLR** (LAST) or the **ENT** (NEXT) key. The alpha display shows TIME. See Figure 15.

2. Have the 2800 in either the Stop state, the Run Manual state, or the Hold Program state.

3. Press the **EDIT** key. The EDIT light emitting diode illuminates to show that the time is ready to be edited.

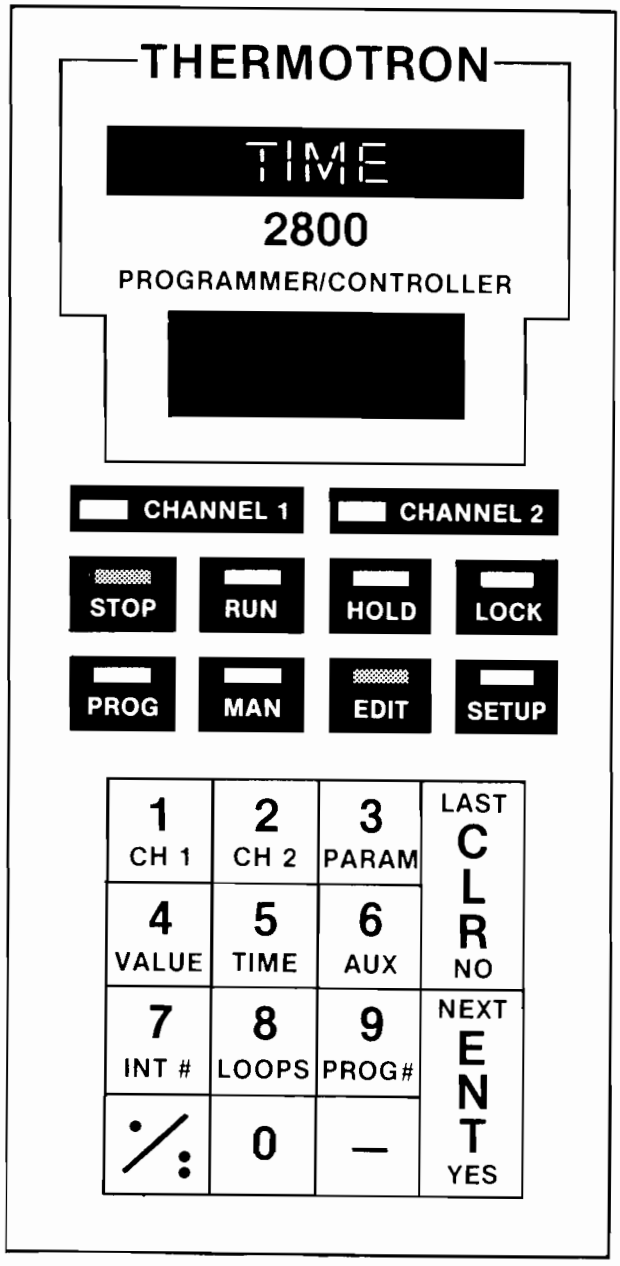


FIGURE 15

4. Use the numeric keys to enter the new time. Time is shown in military (24 hour) time. Example: 14.15 means 2:15 p.m. Use the **./:** key to separate the hours from the minutes.

5. To start the clock, press the **ENT** key. The clock will start at the entered time.

6. Use the above procedure to synchronize the real time clock with another clock.

To set the date, repeat Steps 2 through 4 above. Press the **ENT** key to enter the new date.

HOW TO PROGRAM THE DELAYED START

The delayed start allows a program to be started at a future date and time. To set the delayed start feature, follow this procedure:

1. Put the 2800 in the Stop state.

2. Press the **RUN** key. The display on the 2800 shows PROG/MAN.

3. Press the PROG key.

4. Press the numeric key(s) to enter the desired program number and interval number. See Pages 8, 9, and 10 for information on programming.

5. The 2800 recognizes that the real time clock is present. The display shows DLYD START. See Figure 16.

6. Press the **ENT** key to select the delayed function.

7. The display shows START DATE and the current date.

8. If this is the desired date, press the **ENT** key. If this is not the desired date, press the appropriate numeric keys and the **./:** key to separate the month and the day. When the desired date is displayed, press the **ENT** key.

9. The display shows START TIME.

10. Repeat Step 8 to enter the desired starting time.

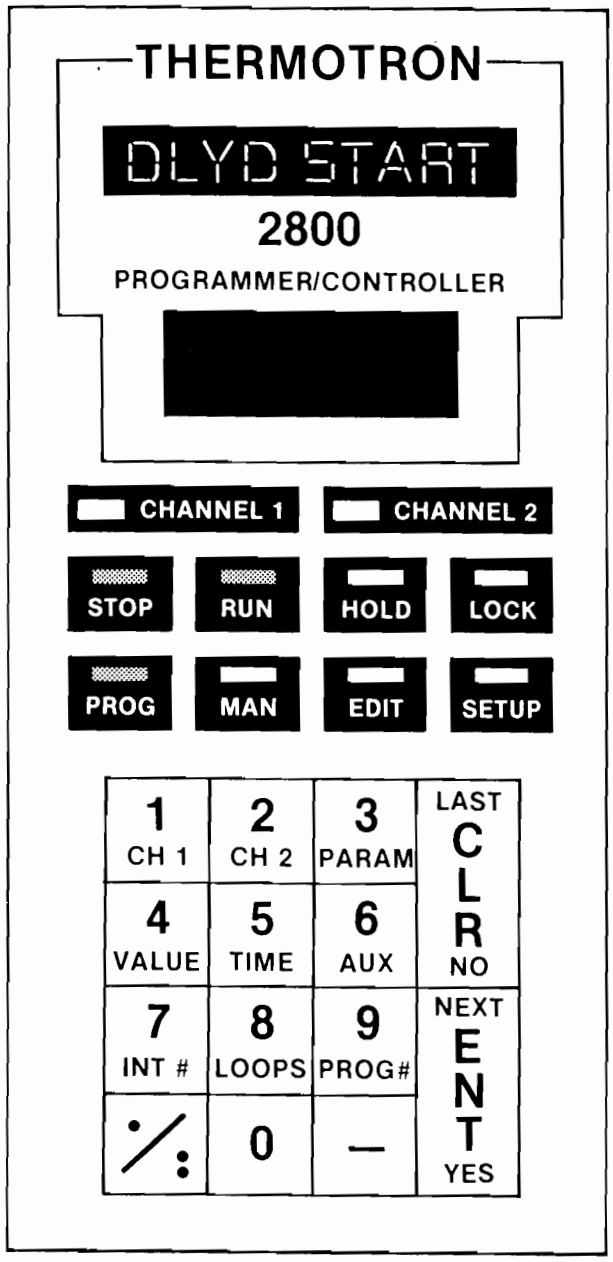


FIGURE 16

11. The light emitting diodes in the STOP, RUN, and PROG keys are illuminated. At the appropriate time the 2800 will start the selected program.

THE RS-232 SERIAL INTERFACE CONNECTIONS

The RS-232 serial interface allows the 2800 to send data to a compatible printer for logging. The parameters of the serial interface are preset to the requirements of the printer supplied by Thermotron Industries, Inc. These parameters are not changeable.

The RS-232 serial interface can be used with other compatible printers, if the printer allows the user to select the required serial configuration. See Figure 17 and Figure 18.

The serial interface configurations for the 2800 printer are:

Connector - DCE connector to conform with most printers

Data Transfer Rate - 2400 bits/second

Word Length - 8 bits/character (ASCII characters)

Stop Bits - one stop bit sent

Parity - No parity

Handshake line - RTS or DTR

Handshake Polarity - Active Low busy (BUSY NOT)

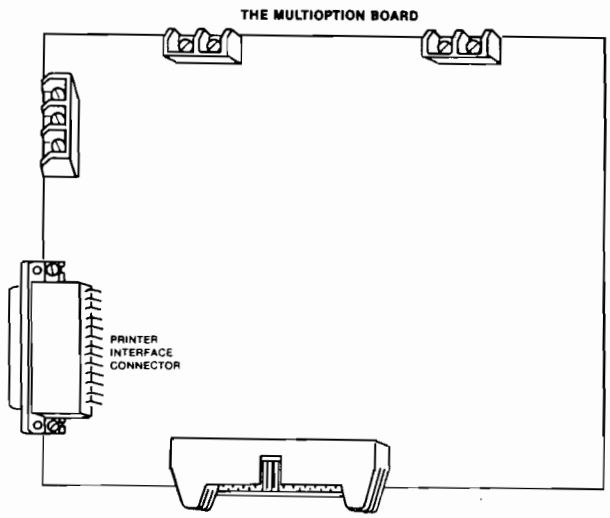


FIGURE 17

The connections made through the printer interface connector are:

1 - Shield

2 - Data input to 2800 (not used)

3 - Data output from 2800

4 - RTS handshake input to 2800 (printers busy signal)

5 - CTS output from 2800 (indicates that 2800 is present)

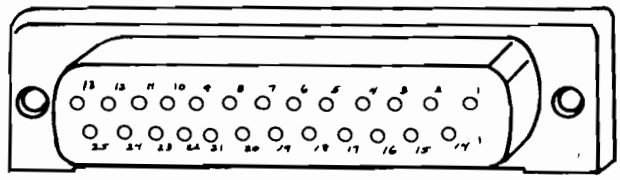


FIGURE 18

6 - DSR output from 2800 (indicates that 2800 is present)

7 - Signal common

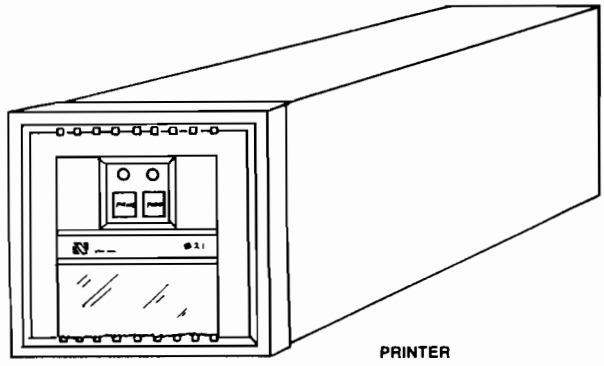
8-19 - No connection

20 - DTR handshake input to 2800 (printer busy signal)

21-25 - No connection

WHEN DATA GOES TO THE PRINTER

The 2800 sends data to the printer during print intervals and during a change in the alarm status conditions. During print intervals the time is in seconds. The print interval has a range of 0 to 1000 seconds (16 minutes, 40 seconds). For more information, see Pages 16 and 17.


PRINTER

When the print interval has been changed through editing, the data is printed immediately. Data is printed at every print interval thereafter in the program. A print interval time of 0 seconds stops the data print function.

When either channel goes beyond its settings or comes back into its settings, the printer prints data to indicate a change in the alarm status.

THE FORMAT OF THE DATA SENT TO THE PRINTER

The 2800 sends data to the printer in the following format:

Column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Line 1	M	M	/	D	D		H	H	:	M	M		R	P		0	2	1		T
Line 2	A	-	0	6	5		-	0	6	5	F			A	9	5		9	5	%

Line 1	Column	1-5	Date
		7-11	Time
		13-14	Status (Run, Stop, Hold, Program, Manual)
		16-18	Interval #
		20	Trigger source (T=time, A=Alarm)
Line 2	Column	1	Channel 1 Alarm Status (A=in alarm)
		2-5	Channel 1 Set Point
		7-11	Channel 1 Process Variable + Units (F or C)
		14	Channel 2 Alarm Status (A=in alarm)
		15-16	Channel 2 Set point
		18-20	Channel 2 Process Variable + Units (%RH)

HOW TO CALIBRATE THE ANALOG PROCESS-VARIABLE OUTPUTS

The analog process-variable retransmits a signal to an analog recorder. The analog outputs are calibrated using the software on the 2800.

The temperature output signal has
- a range of -75°C (-103°F) to +175°C (+347°F)
- a linear curve
- a level of from 0 to 5 volts.

The % relative humidity output signal has
- a range of 0 to 100% relative humidity
- a level of from 0 to 5 volts.

To calibrate the analog process-variable outputs, follow this procedure:

1. Calibrate the 2800. See Pages 22 and 23. After the **CLR** key is pressed in Step 4 or after completion of Step 10, the alpha display shows OUTPUT CAL. See Figure 19.

2. To exit the setup mode, press the **CLR** key. To continue with the calibrations press the **ENT** key. The alpha display shows CH1 ZERO. The numeric display shows -75°C (-103°F).

3. Verify that the recorder and the 2800 match.

4. If necessary, adjust the voltage using one of the following keys:

   a. The - key decreases the output by 0.001 volts.

   b. The **./:** key increases the output by 0.001 volts.

   c. The **9** key decreases the output by 0.012 volts.

   d. The **7** key increases the output by 0.012 volts.

   When the voltage is correct, press the **ENT** key.

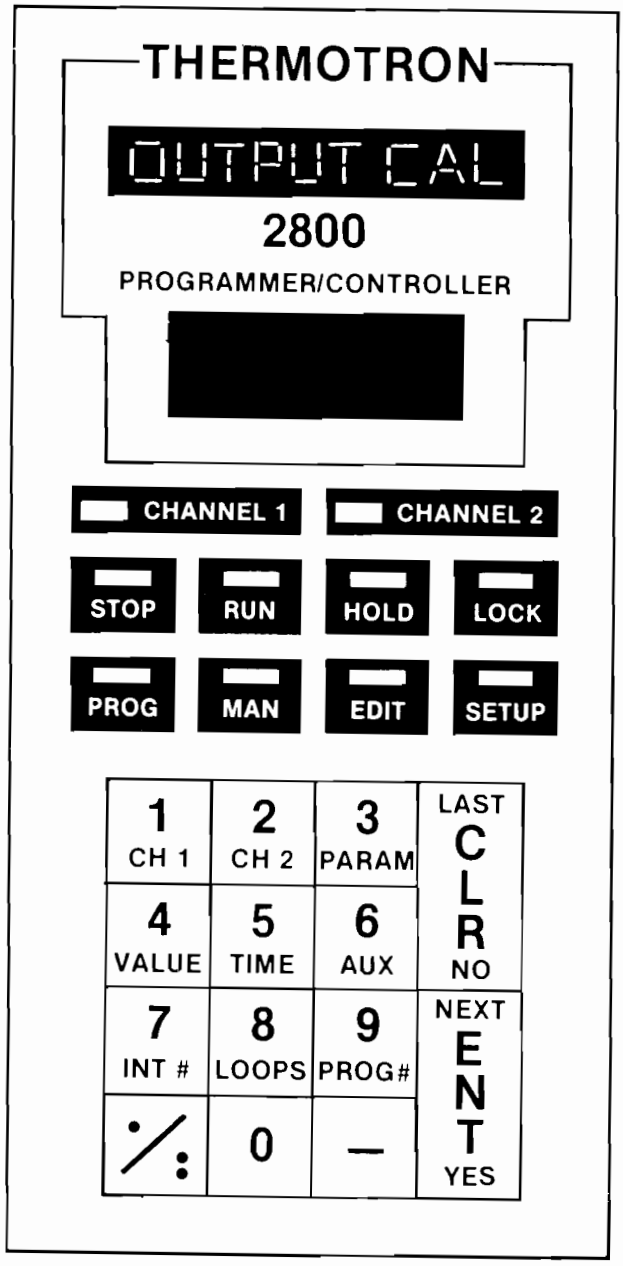


FIGURE 19

5. Repeat Steps 3 and 4 above for CH1 SPAN, CH2 ZERO, and CH2 SPAN.

6. The display shows OK TO SAVE. To save the new calibrations, press the **ENT** (YES) key. To use the old values, press the **CLR** (NO) key.

7. The 2800 burns (loads) the memory and checks for a proper burn.

8. If the burn is bad, the display shows BAD BURN for two seconds. The display then shows TRY AGAIN.

9. Press the **ENT** key to repeat the burn.

NOTE: If the display shows BAD BURN more than twice, contact your local Thermotron field service office.

THE COMPUTER INTERFACE BOARD OPTION

The computer interface board is an optional feature on the 2800. See Figure 20. The 2800 can be connected to a computer by either a GPIB (IEEE-488) board or a RS-232 board. The computer controls the operation of the 2800. The computer also gets data on the chamber from the 2800.

THE COMMANDS

The 2800 accepts three groups of commands from the computer. These groups are Control, Dump, and Load.

All communications are in upper case ASCII.

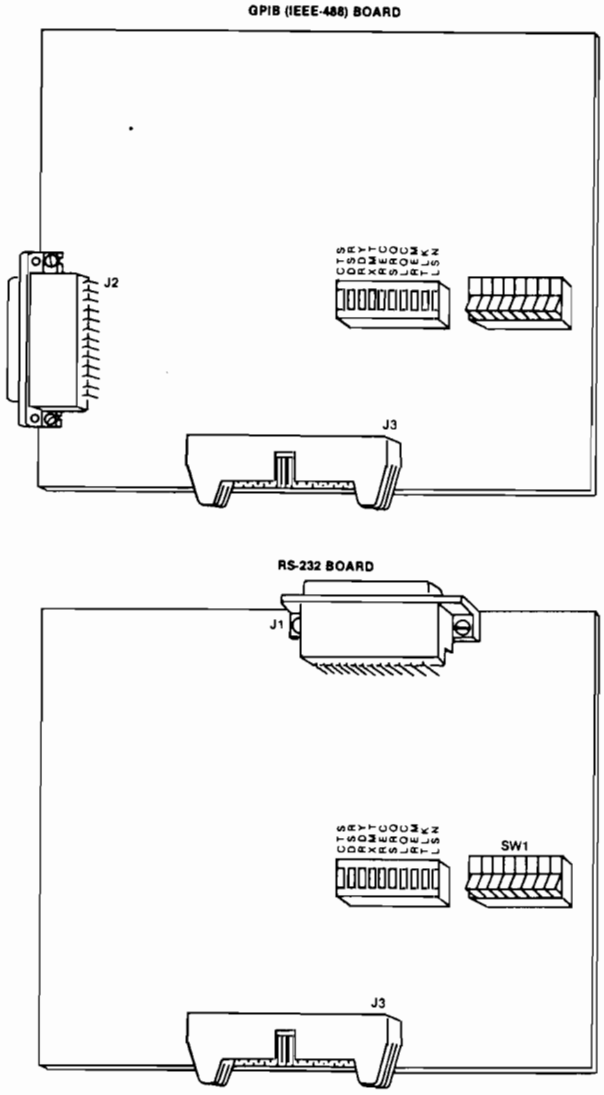


FIGURE 20

THE CONTROL GROUP COMMANDS

The control group commands operate the 2800. The commands in the control group are as follows:

R The R or **R**un command is used in conjunction with other commands to start the 2800. The R command is used without other commands to continue a program that was placed in hold.

RM The RM or **R**un **M**anual command causes the 2800 to go to the run manual state from the stop or hold program states.

RP The RP or **R**un **P**rogram command causes the 2800 to return to the program that was suspended during manual operation.

RPp,i See the description of the RP command. The lower case pi is not recognized by the 2800. The lower case p represents a variable entry (1-10) for the number of the program to be run. The lower case i represents a variable entry for the number of the starting interval.

S The S or **S**top command stops the 2800 from any running condition.

H The H or **H**old command puts the 2800 in the hold program state.

I The I or **I**nitialize command forces the 2800 to do a hardware reset. The reset takes three seconds. **Do not do any communications while the reset operation is being performed.**

EXAMPLES OF THE CONTROL GROUP COMMANDS

```
1ØØ  OUTPUT 7ØØ;"S"
```
(Continue a program that was placed in hold.)

```
1ØØ  OUTPUT 7ØØ;"S"
```
(Go to the run manual state from the stop state or the hold state.)

```
1ØØ  OUTPUT 7ØØ;"RP"
```
(Return to the program suspended during manual operation.)

```
1ØØ  OUTPUT 7ØØ;"RP2,1"
```
(Run program 2 interval 1.)

```
1ØØ  OUTPUT 7ØØ;"S"
```
(Stop.)

```
1ØØ  OUTPUT 7ØØ;"H"
```
(Hold the program.)

```
1ØØ  OUTPUT 7ØØ;"I"
```
(Do a hardware reset.)

THE DUMP GROUP COMMANDS

The dump group commands are used to send specific data to the host computer or to any addressed listener. All dump commands are preceeded by the letter D. The following are dump commmands:

DTV The DTV or **D**ump **T**emperature **V**alue command sends the current value of the temperature process variable. The value is in the same unit (Fahrenheit or Celcius) as the 2800.

DRV The DRV or **R**elative **H**umidity **V**alue command sends the current value of the relative humidity process variable. This is for two channel units only.

DTS The DTS or **T**emperature **S**etpoint command sends the current value of the temperature setpoint.

DRS The DRS or **R**elative **H**umidity **S**etpoint command sends the current value of the relative humidity setpoint. This is for two channel units only.

DST The DST or **S**tatus command sends the current status as a decimal value. See Page 34 for further information on the decimal value of the status command.

DSR The DSR or **S**ervice **R**equest command sends the value of the service request byte. This command is used only with the RS-232 interface option. See Page 41 for more information.

DIN The DIN or **I**nterval **N**umber command sends the current interval number.

DEC The DEC or **E**rror **C**ode determines the reason for an error as indicated by bit 5 of the SRq byte. See Pages 36 and 37.

EXAMPLES OF THE DUMP GROUP COMMANDS

```
1ØØ  OUTPUT 7ØØ;"DTV"
(Send the current temperature.)
1ØØ  ENTER 7ØØ;T
(Read back the temperature.)
```

```
1ØØ  OUTPUT 7ØØ;"DRH"
(Send the relative humidity.)
1ØØ  ENTER 7ØØ;R
(Read the relative humidity.)
```

```
1ØØ  OUTPUT 7ØØ;"DTS"
(Send the temperature setpoint.)
1ØØ  ENTER 7ØØ;S1
(Read the setpoint on Channel 1 (temperature).)
```

```
1ØØ  OUTPUT 7ØØ;"DRS"
(Send the relative humidity setpoint.)
1ØØ  ENTER 7ØØ;"S2"
(Read the setpoint on Channel 2 (relative humidity).)
```

```
1ØØ  OUTPUT 7ØØ;"DST"
(Send the status as a decimal.)
1ØØ  ENTER 7ØØ;S
(Read the status byte.
120 if bit (S,O) then Celsuis=True.)
```

```
1ØØ  OUTPUT 7ØØ;"DSR"
(Send the service request command.)
1ØØ  ENTER 7ØØ;B
(120 if bit (B,1) then (Alarm change).)
```

```
1ØØ  OUTPUT 7ØØ;"DIN"
(Send the current interval number.)
1ØØ  ENTER 7ØØ;I
(Read the internal number.)
```

```
1ØØ  OUTPUT 7ØØ;"DEC"
(Determine the reason for error.)
1ØØ  ENTER 7ØØ;E
(120 if E=6 then print Primary Command Error.)
```

THE LOAD GROUP COMMANDS

The load group commands give data to the 2800. All of the load group commands are preceeded by the letter L. The following are load commands:

LTS The LTS or **T**emperature **S**etpoint command gives temperature setpoint data to the 2800. The 2800 must be in the run manual state and the data must be within the limits of the instrument for this command to be accepted.

LRS The LRS or **R**elative **H**umidity **S**etpoint command allows the relative humidity setpoint to be loaded. The 2800 must be in run manual state. The data must be in the limits 0-100.

LAX The LAX or **AuX**iliaries allows the auxiliary outputs on the 2800 to be turned on or off. The 2800 must be in the run manual state. The data is sent as a decimal value that represents which auxiliary outputs are on or off.

LSM The LSM or Srq **M**ask command activates selected bits in the SRQ byte. The data must be sent as a decimal value that corresponds to the desired activated mask.

LIM The LIM or **I**nterval **M**atch commands prepares the match interval to be used by the 2800 if the match interval interrupt is activated.

LKS The LKS or **K**eyboard **S**tatus command changes the locked status of the keyboard. When the keyboard is locked with the LKS1 command, the normal unlock function of the 2800 does not work. The LKS0 command unlocks the keyboard.

EXAMPLES OF THE LOAD GROUP COMMANDS

```
1ØØ  OUTPUT 7ØØ;"LTS S1"
```
(Load the desired temperature setpoint.)

```
1ØØ  OUTPUT 7ØØ;"LRS 95"
```
(Load the relative humidity setpoint of 95.)

```
1ØØ  OUTPUT 7ØØ;"LAX Ø"
```
(All the outputs are turned off.)

```
1ØØ  OUTPUT 7ØØ;"LSM 178"
```
(The following bits are activated: Power on reset, bad command or data, end of program, and alarm change.)

```
1ØØ  OUTPUT 7ØØ;"LIM 3"
```
(When interval number 3 is entered, the host computer will be interrupted.)

```
1ØØ  OUTPUT 7ØØ;"LKS 1"
```
(The keyboard of the 2800 is locked.)

```
1ØØ  OUTPUT 7ØØ;"LKS Ø"
```
(The keyboard of the 2800 is unlocked.)

THE 2800 PROGRAMMING GUIDE

THE CONTROL GROUP COMMANDS

THE LOAD GROUP COMMANDS

R ..... Continue a program which was placed in Hold.
RM ..... Run in Manual mode from stop -or-
Go to Manual from a program in Hold.
RP ..... Return to a suspended program from Manual.
RPp,i..... Run Program #p at Interval #i from Stop.
S..... Stop Controller and Programmer.
H ..... Hold a Running Program.
I..... Initialize the 2800.

THE DUMP GROUP COMMANDS

DTV ..... Dump Temperature Value.
DRV ..... Dump Relative Humidity Value.
DTS..... Dump Temperature Setpoint.
DRS ..... Dump Relative Humidity Setpoint.
DST..... Dump Status Byte.
DSR ..... Dump Service Request Byte.
DIN..... Dump Interval Number.
DEC ..... Dump Error Code.

THE LOAD GROUP COMMANDS

LTSmddd..... Load Temperature Setpoint. (m=sign, ddd=data)
LRSmddd..... Load Relative Humidity Setpoint.
LAXdd..... Load Auxiliaries. (dd=0 thru 15)
LSMddd..... Load SRQ Mask. (ddd=decimal value of mask)
LIMddd ..... Load Match Interval.
LKSd..... Load Keyboard Status. (d=1 locks keyboard) (d=0 unlocks keys)

HOW TO DECODE THE STATUS BYTE

To know the status of the 2800, follow this procedure:

1. Convert the decimal value or the status byte to binary.
2. Use the following information to determine the value of the bit position in the status byte.

Bit 7 is set if the keyboard is locked

Bit 6 is set if Channel 2 (relative humidity) is in alarm. It is reset if Channel 2 is not in alarm.

Bit 5 is set if Channel 1 (temperature) is in alarm. It is reset if Channel 1 is not in alarm.

Bit 4 is set if the units of temperature are in degrees Celsius. Bit 4 is reset if the units of temperature are in degrees Fahrenheit.

Bit 3 is set if the 2800 is in the manual mode with a program suspended.

Bits 2, 1 and 0 indicate the state of the 2800 as follows:

000 - Stop
001 - Starting
010 - Run Manual
011 - Run Program
100 - Hold Program
101 - 2800 being programmed
110 - Set up mode

STATUS BYTE VALUES

7 - - - - - - - Keyboard locked is 1
- 6 - - - - - - Channel 2 in alarm is 1
- - 5 - - - - - Channel 1 in alarm is 1
- - - 4 - - - - Degrees C = 1 degrees F = 0
- - - - 3 - - - Program suspended is 1
- - - - - 2 - - } State of 2800
- - - - - - 1 - } State of 2800
- - - - - - - 0 } State of 2800

EXAMPLE

178 decimal = 10110010 binary
means
1 the keyboard is locked
0 channel 2 is not in alarm
1 channel 1 is in alarm
1 the degrees are in Celsius
0 no program is suspended
0 } the 2800 is in the Run Manual state
1 } the 2800 is in the Run Manual state
0 } the 2800 is in the Run Manual state

HOW TO USE THE SERVICE REQUEST (SRQ) BYTE

To use the service request (SRQ) byte, follow this procedure:

1. When the power is turned on, the SRQ enable mask is automatically 160 decimal (10100000 binary).

2. Use the serial poll DSR command or the GPIB to obtain the SRQ byte.

3. To change a bit in the SRQ enable mask, use the LSM command.

4. The bits in the SRQ byte, mean the following:

Bit 7 - Power On Reset - The 2800 has executed a power on reset

Bit 6 - Request for Service - This bit indicates that the 2800 does indeed require service. The remaining bits must be decoded to decipher what service is required.

Bit 5 - Error - The 2800 has received an illegal command or data, or there was an interface error.

Bit 4 - End of Program - The program which was running is finished.

Bit 3 - Match Interval - the current interval is equal to the interval number loaded with the (LIM) command. This interrupt occurs when the match interval is first loaded for running by the 2800.

Bit 2 - End of Interval - The current interval is completed.

Bit 1 - Alarm Change - There has been an alarm change. Note that this does not give alarm status, which must be read using the dump status command.

Bit 0 - Data Ready - The data requested from a dump command is ready for transmission.

THE SRQ BYTE VALUES

7 - - - - - - - Power On Reset
- 6 - - - - - - Request for Service
- - 5 - - - - - Error
- - - 4 - - - - End of Program
- - - - 3 - - - Match Interval
- - - - - 2 - - End of Interval
- - - - - - 1 - Alarm Change
- - - - - - - 0 Data Ready

EXAMPLE

160 decimal = 10100000
means

1	power on reset has occurred
0	this is not a request for service
1	there is an error
0	this is not end of program
0	there is no match interval
0	this is not end of interval
0	there has not been an alarm status change
0	no data ready

WHAT THE ERROR CODES MEAN

When the 2800 indicates that an error has occurred, follow this procedure:

1. The DEC command is used on the host computer to determine the cause of the error.

2. The host computer receives a code number from the 2800.

3. Use the following information to determine what the code number means.

    1- Input buffer overflow.
    The 2800 has an input buffer of 10 characters. Only upper case ASCII, numbers, the comma, and the selected terminating character are stored in the input buffer.

    2- Not in Stop for Trigger command.
    The 2800 received an illegal Group Execute Trigger (GET) command from the GPIB. The 2800 is attempting to start running Program #1 at Interval #1. The 2800 must be in stop when a GET is executed.

    3- Program does not exist for trigger.
    This error occurs if the 2800 receives the GET command and there is no Program #1 in memory.

    4- GPIB Bus Error.
    The GBIB interface driver in the 2800 detected a bus error condition, such as addressed to talk but no active listeners.

    5- Serial Input Error.
    The Serial interface driver detected an error on input, such as parity, stop bits, framing, etc.

    6- Illegal Primary Command.
    The 2800 received a primary command other than R, S, H, I, D, L.

7- Invalid Run Command.
The 2800 received an illegal run command.

8- Invalid Stop Command.
The 2800 received an illegal stop command.

9- Invalid Hold Command.
The 2800 received an illegal hold command, such as Hold from Run Manual.

10- Invalid Dump Secondary Command.
The 2800 received an illegal secondary command after the dump primary command.

11- Invalid Load Secondary Command.
The 2800 received an illegal secondary command after the load primary command.

THE GPIB INTERFACE BOARD

HOW TO USE THE GPIB INTERFACE

The GPIB interface option for the 2800 uses functions defined by the IEEE-488 (1978) Standard. To know which interface functions are used and what the functions mean, read and know the following:

1. The GPIB uses the interface functions as shown in Figure 21.

2. The **RL1** or the Remote/Local function is used in the following way:

   When the 2800 is placed in Remote by the GPIB controller, the keyboard is set to the lock state. Local control may be restored by using the standard unlock sequence for the 2800. If the GPIB controller sends the Local Lock-Out command over the bus, then the standard 2800 unlock feature is not in use.

THE GPIB FUNCTIONS USED BY THE 2800

FUNCTION	DESCRIPTION
SH1	Source Handshake
AH1	Acceptor Handshake
T6	Talker (6)
TE0	Extended Talker*
L4	Listener (4)
LE0	Extender Listener*
SR1	Service Request
RL1	Remote/Local
PP0	Parallel Poll*
DC1	Device Clear
DT1	Group Execute Trigger
C0	Controller*

* = not implemented

FIGURE 21

3. The **DC1** or the Device Clear function is used in the following way:

   The 2800 forces itself to do a hardware reset upon receipt of the Device Clear command. This function takes approximately 3 seconds to complete. **Do not do any communications while the reset function is being performed.** This command has the same function as the **I** primary command.

   One method of waiting for the 2800 to be reset is to trap the Power on Reset interrupt from the 2800. See Page 35, How to Use the Service Request (SRQ) Byte. This indicates that the 2800 has completed the reset function.

4. The **DT1** or the Group Execute Trigger function is used in the following way:

   The 2800 implements the GET command by running Program #1 at Interval #1. The 2800 must be in the Stop state when it receives the GET command and Program #1 must exist. An error results if these two conditions are not met.

5. The **T6** or the Talk function is used in the following way:

   When the 2800 is addressed to talk, it sends the data which corresponds to the last dump command received. If only one variable is of interest, send the particular dump command once. All future inputs from the 2800 will contain the latest available data for that variable.

6. The **SR1** or the Service Request function is used in the following way:

   The 2800 responds to a Serial Poll on the GPIB by sending back its SRQ Byte. See Page 35. If your GPIB controller does not support the Service Request Interrupt or Serial Poll functions, use the DSR command to get the SRQ Byte.

HOW TO USE THE GPIB CONFIGURATION SWITCH.

The GPIB Configuration switch (SW1) is located on the GPIB interface board. See Figure 22.

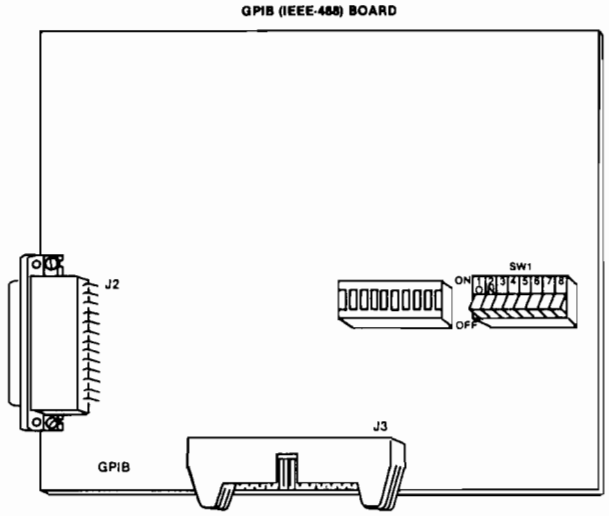


FIGURE 22

The GPIB switch is used to set the Talk/Listen address of the 2800 on the bus. The GPIB switch is also used to select the line terminating character used by the 2800 for receiving and transmitting data. See Figure 23 for the GPIB switch positions and what the positions mean.

GPIB SWITCH POSITION AND FUNCTIONS

POSITION	FUNCTION
1	Talk/Listen address*
2	Talk/Listen address*
3	Talk/Listen address*
4	Talk/Listen address*
5	Talk/Listen address*
6	not used
7	not used
8	Terminating character selection 0=LF, 1=CR

* Binary code (Sw1=bit 0, etc.)(0 to 30 allowed)

FIGURE 23

The default factory setting for the GPIB configuration switch is (00000000), all switches on == Talk/Listen address of 0, and ASCII Line Feed terminating character. See Figure 24.

EXAMPLE: Talk/Listen address 14 (decimal), Line Feed Terminator

Switch	Binary Weight	Position
1	1	0 (on)
2	2	1 (off)
3	4	1 (off)
4	8	1 (off)
5	16	0 (on)
6	x	x (not used)
7	x	x (not used)
8	x	0 (on)

FIGURE 24

WHAT THE GPIB LIGHT EMITTING DIODES MEAN

The GPIB interface board has light emitting diodes used in interface debugging. See Figure 25. The meaning of each of the GPIB light emitting diodes is as follows:

CTS Serial Handshake (RS-232 only)

DSR Serial Handshake (RS-232 only)

RDY Serial Handshake (RS-232 only)

XMT Transmit.
Data is being sent by the 2800. The 2800 is an active talker and provides the Source Handshake function.

REC Receive.
Data is being received by the 2800. The 2800 is an active listener and provides the Acceptor Handshake.

SRQ Service Request
The 2800 polled the GPIB SRQ line that indicated service is required. Bus controller executes a Serial Poll to determine the reason for SRQ.

LOC Local.
The 2800 is put on the Local state.

REM Remote
The 2800 is in the Remote state. The keyboard is locked.

TLK Talk.
The 2800 is addressed to talk. The 2800 is in the talk state until it is addressed to listen or it receives the Un-Talk command.

LSN Listen.
The 2800 is addressed to listen. The 2800 remains in the listen state until it is addressed to talk or it receives the Un-Listen command.

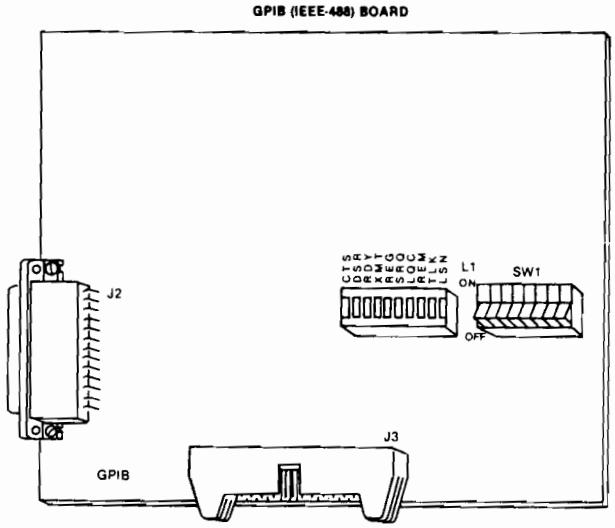


FIGURE 25

THE RS-232 INTERFACE BOARD

HOW TO USE THE RS-232 INTERFACE

The RS-232 serial interface is configured as a Data Communications Equipment device (DCE). Various interface parameters are set using the dip switch (SW1). The dip switch is located on the RS-232 computer interface board. See Figure 26.

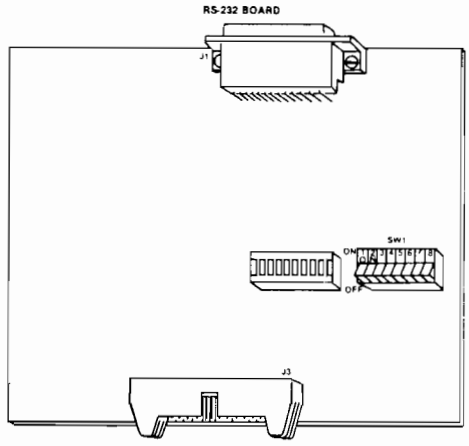


FIGURE 26

The 2800 can be set-up to communicate with a wide range of serial configurations. Handshaking is available using the RTS/CTS or DTR/DSR lines. Handshaking polarity can be set (Busy or Busy not). See Figure 27.

RS-232 SWITCH FUNCTIONS

Sw1,Sw2	**Data Transfer Rate Selection**
0, 0	9600
1, 0	2400
0, 1	1200
1, 1	300
Sw3,Sw4	**Parity Selection**
0, 0	no parity
1, 0	odd parity
1, 1	even parity
Sw5	**Handshake Line Selection**
0	use RTS/CTS
1	use DTR/DSR
Sw6	**Handshake Polarity**
0	busy not
1	busy
Sw7	**Character Word Length Selection**
0	8 bits/character
1	7 bits/character
Sw8	**Terminator Selector**
0	line feed (ASCII 10)
1	carriage return (ASCII 13)

FIGURE 27

The factory default setting of the dip switch is 9600 bits per second, odd parity, RTS/CTS handshake, Active high busy signal, 8 bits/character, line feed terminator. See Figure 28.

DEFAULT SETTING OF THE RS-232 SWITCH

Switch	Position
1	0 (on)(9600 baud)
2	0 (on)
3	1 (off)(odd parity)
4	0 (on)
5	0 (on)(RTS/CTS handshake)
6	1 (off)(busy high)
7	0 (on)(8 bits/char)
8	0 (on)(LF terminator)

FIGURE 28

The 2800 uses the connector lines shown in Figure 29.

RS-232 CONNECTOR LINES USED BY THE 2800

Line	Function
1	Shield
2	The 2800 receives data on this line.
3	The 2800 transmits data on this line.
4	RTS-Possible handshake input line (with CTS)
5	CTS-Possible handshake output line (with RTS)
6	DSR-Possible handshake output line (with DTR)
7	Signal Common
8	RLSD-not used
9-19	No Connection
20	DTR-Possible handshake line (with DSR)
21-25	No Connections

FIGURE 29

WHAT THE RS-232 LIGHT EMITTING DIODES MEAN

The RS-232 interface board has light emitting diodes for use in interface de-bugging. See Figure 30. The meaning of each of the RS-232 light emitting diodes is as follows:

CTS This light emitting diode shows the status of the imput CTS line. When the light is illuminated the CTS line is in the SPACE state (positive).

DSR This light emitting diode shows the status of the input DSR line.

RDY This light emitting diode shows the 2800's handshake output. When the light emitting diode is illuminated, the 2800 is ready to receive.

XMT Transmit. Data is being sent by the 2800.

REC Receive. Data is being received by the 2800.

SRQ Service Request. This light emitting diode shows that the 2800 requires service. Since there is no interrupt capability for RS-232 communication, the host computer polls the 2800 using the DSR command to check when the 2800 requires service.

LOC Local. The 2800 is in the local state.

REM Remote. The 2800 is in the Remote state. The keyboard must be locked when the 2800 is in the Remote state.

TLK Talk (GPIB communication only).

LSN Listen (GPIB communication only).

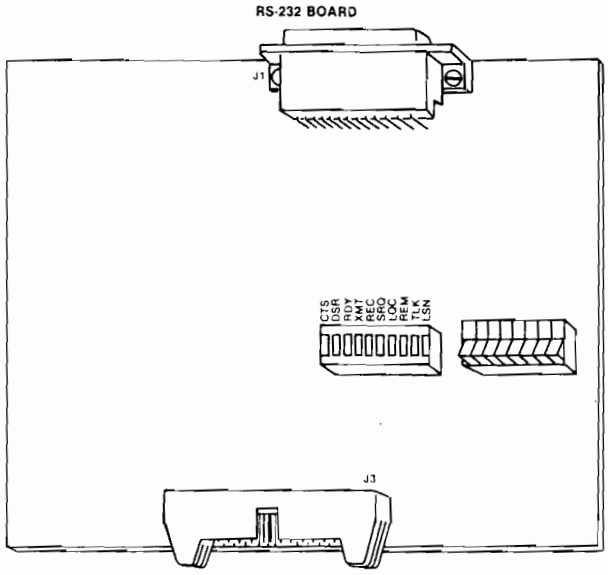


FIGURE 30

Keep your Thermotron equipment at top efficiency with our preventive maintenance program.

Our environmental simulation equipment and systems are designed to provide many years of dependable service. But for maximum efficiency at all times, each system must be properly maintained and serviced.



Our field service engineers are always on hand to provide emergency service, but with a Preventive Maintenance Agreement, it will seldom be necessary. You'll see:

- Improved operation with the system properly adjusted and calibrated (NBS traceability can be provided).
- Reduced operating costs due to fewer "crisis" situations.
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NOTICE

This machine has been modified from the original manufacturer's design. Changes have been made to enhance performance, modernize controls and/or improve safety. The modifications were integrated with as little compromise to the original design as possible.

Manuals and schematics have been provided for your convenience. In some cases, original manuals and schematics for this equipment are no longer available from the manufacturer. Substitutes with similar features are provided in these cases, therefore portions of the documentation may not apply. Operating instructions and schematics have been generated to reflect any modifications, and they are included in this documentation package, as well as new instrumentation manuals.

Should you require any further assistance, please contact our office.

EES# 2241

MODEL# Thermotron SM16-C

SER.# 29879

CUSTOMER Weldmuller

SHIP DATE 3-10-03

Warranty

Seller warrants products to be free from defects in materials and workmanship under normal use and proper maintenance for a period of ...90... days from the date of shipment.

If within such period any such products shall be proved to Sellers reasonable satisfaction to be defective, such products shall be repaired or replaced at sellers option.

Seller shall be responsible for labor charges, F.O.B. Sellers facility. (Buyer is responsible for any and all travel and lodging expenses and/or shipping costs), in connection with the repair for only a period of 90 days after shipment and only for repair or replacement; all other labor charges shall be billed to Buyer at Sellers then prevailing rate F.O.B. Sellers facility (Buyer is responsible for any and all travel and lodging expenses and/or shipping costs).

Sellers obligation and Buyers exclusive remedy hereunder shall be limited to such repair or replacement and shall be conditioned upon Sellers receiving written notice of any alledged defect no later than 7 days after its discovery within the warranty period and, at Sellers option, the return of such products to Seller when such return is feasible.

Seller reserves the right to satisfy its warranty obligation in full by reimbursing Buyer for all payments it makes hereunder, and Buyer thereupon shall return the products to seller.

The foregoing warranty is not applicable to (1) windows, glass, painted and/or polished finishes, oil, fluids and gases, or the loss, breakage or contamination thereof. These items are sold as is, (2) accessories and components not manufactured by Seller, which are warranted only to the extent, if any, of the manufacturers warranty for such accessories and components, (3) instrument calibration, lubrication, routine maintenance, or any service required as a result of negligent operation, handling or misuse.

This warranty is expressly in lieu of all other warranties, expressed or implied, and all other obligations or liabilities including merchantability and fitness for a particular purpose or use, or any consequential damage resulting from use or misuse, nor for any loss of profits or any other special damages.

THE THERMOTRON INSTRUCTION MANUAL,

Thermotron instruction manuals are dedicated to assisting the reader-user toward a better understanding of Thermotron Environmental Chambers and associated equipment. Most instruction manuals are seldom read except in the time of crisis when equipment malfunction is suspected. When this happens, the manual is usually missing, or at best, difficult to locate. So to start things off on the right foot, WHY NOT FIND A CONVENIENT SPOT TO KEEP THIS MANUAL?

We at Thermotron have tried to produce a usable manual. But being human, we are subject to frailties of behavior. Therefore, should you discover any errors or omissions, or should you wish to contribute any recommendations, send us your comments. We at Thermotron will be most appreciative.

WARNING

PRODUCT PROTECTION

When operating this chamber with a live load (heat dissipating product) or a dead load, auxiliary protection should be provided by the operator (customer). Provision must be made to remove power from the product on test and the chamber in the event the chamber temperature exceeds a predetermined safe limit for the product within the chamber.

Thermotron chambers are equipped with high heat limit, or safety devices. These safety devices are installed to protect the chamber from exceeding design limits. These safety devices remove power ONLY from the chamber heaters and DO NOT remove power from your product; therefore, a device such as the THERMOTRON PRODUCTSAVER, or equivalent, must be used to remove power from the product and the chamber should an "out of tolerance" condition occur.

The PRODUCTSAVER is designed with concealed setpoints for high and low temperatures. These can be precisely set at a temperature limit to permit safe operations. Power to the product and a circuit interrupting power to the chamber must both be wired through the output relays of the PRODUCTSAVER. The PRODUCTSAVER will then shut down chamber operation and product operation within the safe operating temperature limits of the product, either hot or cold.

THERMOTRON

PRODUCTSAVER (TM) TEMPERATURE LIMIT CONTROL AND ALARM SYSTEM MODEL 012005

Thermotron Industries, Inc.
291 Kollen Park Drive
Holland, Michigan 49423 U.S.A.
Phone (616) 392-1492 T.W.X. 810-292-6164

- Positive open sensor detection for product protection
- Visual and audible alarms with contact closures for individual alarm system
- Establishes *both* high and low temperature limits
- Selectable operating characteristics provide manual or automatic reset
- Tamper-resistant set point adjustments for your protection
- High electrical noise immunity for heavy industrial applications
- Fully solid-state for increased reliability

General Description

The Productsaver(TM) is an indispensable, bidirectional temperature limit alarm system to protect product or process from high and low temperatures. It is designed for applications where temperature must be maintained within prescribed limits and where extreme temperature conditions can damage the process or equipment.

Specifications — 012005

Input:
Thermocouples: type T, standard Thermocouples: type T standard, others optional. Not affected by thermocouple resistance of up to 1000 Ohms. Must be specified when ordering.

Range:
Many standard ranges immediately available, optional ranges can be specified.

Measuring/Alarm Accuracy:
± ¼ % typical.

Outputs:
Visual — Separate 'alarm' (yellow), 'high limit' (red) and 'low limit' (green) warning lights. **Audible** — Pulsing 2800 Hz, 70 dB warning tone. **Contacts** — Separate 'alarm', 'high limit' and 'low limit' SPDT contacts, rated 4A @ 115vac.

Sensor Break Protection:
Special circuit provides full-scale temperature indication, turns on 'alarm' light and turns off 'high' and 'low' limit contacts.

Cold Junction Compensation:
Precision oven type stabilization.

Alarm Set Points:
Screwdriver adjustable high-resolution (±0.2%) potentiometers. Adjustable from front panel.

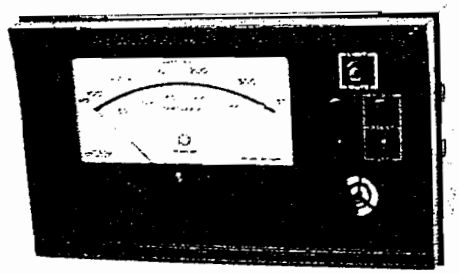
Indication:
6" (15.4cm) meter displays temperature, or set point levels when 'high' or 'low' pushbuttons are depressed at front panel.

Alarm Repeatability:
±0.1%.

Hysteresis:
Less than ±0.05%.

Operable Ambient Range:
+32F to +131F (0C to +55C).

Temperature Effect:
Less than ±0.01%/deg F. (from 77F) (±0.02%/°C) over operating range.



Power Requirements:
117vac 50/60 hz.

Line Voltage Effect:
Less than ±0.03% for ±15% line voltage changes within operating range.

Housing:
Panel mounting aluminum case, suitable for bench service.

Connectors:
Screw type barrier strips.

Dimensions:
5.8" (14.73cm) high, 9.6" (24.38cm) wide and 8.4" (21.34cm) deep. Protrudes 7.2" (18.29cm) behind mounting panels.

Weight:
6.5 lbs (2.95kg).

Form No. CSI-006-583 Printed in U.S.A.

SPARE PARTS and RETURN OF MATERIALS

SPARE PARTS:

Thermotron recommends that its customers maintain a minimum quantity of spare parts. These parts are essential to the proper care and maintenance of your equipment, which minimize costly down time. We strive to maintain an adequate parts inventory and will be pleased to serve you if we can.

RETURN OF MATERIALS:

In the event that you have a part that has failed under warranty, or a part which requires repair, call the Parts and Logistics Department at Thermotron. At this point an R.M.T. (Returned Material Tag) number will be issued, and authorization for the return of the item will be given to you. This number should be marked boldly on the outside of your package as well as recorded on your packing slip. When ordering the replacement part, the following information is required:

A. The complete part number.
B. The serial number of the corresponding Thermotron test unit.
C. The specific complaint regarding part failure.
D. A Purchase Order number is preferred, and in many cases required.

A telephone number and contact person should be listed on your packing slip so that we know who to contact in case of a question.

For warranty replacement parts, you will be invoiced upon the date of shipment and will be issued credit on that invoice upon

our receipt of the defective item. IT IS IMPORTANT THAT YOU IDENTIFY THE ITEM WITH THE R.M.T. NUMBER THAT IS ASSIGNED.

All parts are shipped F.O.B. Holland, MI.

Parts and Logistics Department
Phone: (616) 392-1491
Night Phone: (616) 392-1498

PROTECTIVE OR SAFETY DEVICES

The following are the protective or safety devices used in the refrigeration and electrical circuits (besides the branch circuit protection). Refer to electrical and refrigeration schematics.

RELIEF VALVES:

One is located in the high pressure piping of the R-13 system; one is located in the high pressure piping of the R-502 system; and one is located in the low pressure piping of the R-13 system, to protect the systems against excessive pressure. The valves in the high pressure piping are factory-designed to relieve at 400 P.S.I. and the valve in the low pressure piping is designed to relieve at 150 P.S.I.

PRESSURE SWITCHES:

One in each refrigeration system - R-13 primary cooling system and R-502 secondary cooling system. The R-13 switch is piped to sense the pressure of the discharge side of the refrigeration compressor, set to interrupt the control circuit of the compressor at abnormal pressure (cut in at 250#, cut out at 235#). The R-502 switch is piped to sense the pressure of the suction side of the R-13 compressor to momentarily delay starting (cut in at 25#, cut out at 35#). The switches are manually reset. (Factory set and adjustable.)

RECOMMENDED SPARE PARTS LIST

SM-16C and SM-32C Chambers

PART NO.	COMPUTER NO.	NOMENCLATURE	SPARES PER CHAMBER
151010	151010	Thermocouple	1
151012	151012	Thermocouple	1
32R2911T	567490	Lamp, Neon Pilot	1
100A	556278	Lamp, Chamber	1
WUY	534010	Heat Link	2
D2425	555751	Relay, Solid State	2
032-S	562774	Drier	1
163-F	562758	Drier	1
228RB-220/1/60	549115	Solenoid	2
A3F1	549425	Solenoid	1
0B9F2	549387	Solenoid	1
FNM5	544407	Fuse	1
FRN20	576147	Fuse	2
85	548372	Float Valve	1
T2TEC-2	526123	Thermotech	1
15663	578131	Can Vlave, Thermo*Tech	1
A1433	546795	Wet Wick	1
TMS3045	651109	Emersion Heater	1

GENERAL DESCRIPTION

This manual is provided to acquaint the operator with Thermotron equipment. The enclosed schematics will enable an understanding of how the various conditions and control functions are achieved. Thermotron engineering and "know how" are built into each assembly of environmental test equipment. This assures dependable operation of specific functional tests. Minimum maintenance will be achieved through periodic checks and proper care.

This chamber is completely self-contained and interconnected, capable of producing and maintaining the environmental conditions outlined. The materials, component parts, mechanical assemblies and workmanship used in the contruction of this chamber are of the best commercial quality. All protective features normally incorporated in electrical and mechanical apparatus of this type have been used. The system is completely safety interlocked to prevent damage to the chamber in case of failure of any part.

EXTREME TEMPERATUPE WARNING

This equipment is designed to operate at extreme high and low temperatures. Care should be taken to prevent exposure (opening the door or putting a hand through a port) at temperatures other than near ambient.

GENERAL DESCRIPTION

POWER:

The chamber is designed to operate on the specific service supplied by the customer. The source of power necessary for the operation of the chamber terminates at the main power terminal block located inside the electrical compartment.

All of the major components requiring large amounts of current are operated from the main power source. Each circuit has its branch circuit protection. The control circuit operates on 115 volts. (Refer to electrical schematic.)

Control function switches, equipped with neon indicating lights, are readily accessible, providing a means of selecting the desired operating conditions.

All electrical components, whenever possible, are contained in a separate panel. All wiring is identified and either laced or enclosed in conduit. All circuits are protected with heat links or fuses. Electrical system meets N.E.M.A. standards.

HIGH VOLTAGE WARNING

This equipment is supplied with a high voltage power source and should be serviced or adjusted only by qualified personnel.

INSTALLATION INSTRUCTIONS

To insure proper operation Thermotron chambers should be installed on a solid level foundation. Shim base of chamber as necessary to achieve this.

NOTE: In moving or relocating the chamber NEVER tip more than 45 degrees without special instructions from the manufacturer.

ELECTRICAL:

Refer to electrical schematic and provide proper power supply. Connect to terminals as indicated and check rotation of circulator motor for correct fan rotation.

REFRIGERATION:

1. When compressor body is externally spring-mounted, remove shipping blocks and loosen hold-down bolts or nuts so compressor floats freely on springs.
2. All refrigeration circuit service valves must be checked for correct operating position by a qualified refrigeration mechanic.
3. Make certain that the upper refrigeration enclosure panels maintain a moisture seal. Failure to properly seal the panels might result in leakage of water onto the chamber site, and could result in saturation of insulation, thereby reducing cooling efficiency.

INSTRUMENTS:

When instruments are shipped separately, the mounting clamps and bolts, with any accessories, will be found in the instrument package.

Refer to electrical schematic and connect wiring as indicated. Brackets or clamps are provided within the test space for locating and supporting the sensing elements--thermocouples or instrument sensing bulbs.

THERMOTRON CORPORATION

OB _____ MODEL SM-16C & SM-32C VOLTAGE 230/1/60 SHEET 1 OF _____

OPERATION REFRIGERATION ASSEMBLY MACHINERY B/M 5247-12-31

ITEM	SYMBOL	DESCRIPTION	MFG	PART NO	THERM NO	QTY
		MOTOR COMPRESSORS	BRISTOL	MINA143BBCA	653845	2
		SUCTION SERVICE VALVES	ROTOLOCK	24218-P	549042	2
		DISCHARGE RELIEF VALVES	HENRY	5221-400	545446	2
		DISCHARGE ACCESS VALVES	WATSCO	AVx4	561816	2
		R-13 SUCTION RELIEF VALVE	HENRY	5220-150	545365	1
		R-13 DUMP PRESSURE SWITCH	PENN	P70EA-6	567806	1
		PRESSURE SWITCH MOUNTING BRACKET	PENN	271-51	547600	1
		OIL SEPARATOR	AC & R	S-5585	558300	1
		R-13 COMP STAGING PRESSURE SWITCH	PENN	P70CA-1	567792	1
0		PRESSURE SWITCH MOUNTING BRACKET	PENN	271-51	547600	1
1		CONDENSER MOUNTING PAN	THERMOTRON	5247-12-24(X)	672599	1
2		CONDENSER FIN COIL	BOHN	3075-A	667064	1
3		FAN HOUSING	THERMOTRON	5247-12-25(X)	672602	1
4		FAN GUARD	HAPCO	5247-12-26(W)	672610	2
5		FAN BLADES	LAU	TO3P14-1420x5/16ST	672467	2
6		CONDENSER FAN MOTORS	EMS	ESP-OL50EMJR21	670626	2
7		RECEIVER TANK	REFRIG RES	1911	555514	1
8		DUMP SOLENOID 220V	SPORLAN	XRN-220V	549379	1
9		VAPOR TANK	REFRIG RES	1911	555514	1
0		DUMP-BLEED CAP TUBE	----	.055x8'	577771	1
1		R-502 FILTER-DRIER	SPORLAN	C-163-S	562693	1
2		DRIER MOUNTING BRACKET	VICTOR	14207S-2½	564882	1
3		LIQUID INDICATOR	SPORLAN	SA-13S	562758	1
4		R-502 EXPANSION VALVE	SPORLAN	GR-1-ZP	580373	1
5		R-502 DISTRIBUTOR	ALCO	4-4-2	560135	1
6		CASCADE CONDENSER	THERMOTRON	2240	526328	1
7		R-13 FILTER DRIER	SPORLAN	C-032-S	562774	1
8		R-13 INJECTION VALVE	SPORLAN	GR-1-Z	580411	1
9		R-13 CAP TUBE	----	.080x26"	577801	1
0		R-13 DISTRIBUTOR	ALCO	4-3-6	560178	1
1		CHAMBER FIN COIL	BOHN	2792-9	557460	1
2		HUMIDITY COOLING CAP TUBE	----	.055x72"	577771	1
3		HUMIDITY COOLING DISTRIBUTOR	ALCO	4-3-3	560151	1
4		EVAPORATOR PRESSURE REGULATOR	SPORLAN	ORIT-6-7/8	578271	1
5		DEHUMIDIFY SOLENOID 230V N.O.	SPORLAN	B6F1	549433	1
6		DEHUMIDIFY SOLENOID 230V N.O.	SPORLAN	0B9F2	549387	1

THERMOTRON CORPORATION

MODEL SM-16C & SM-32C VOLTAGE 230/1/60 SHEET 2 OF 2

ERATION REFRIGERATION ASSEMBLY MACHINERY B/M 5247-12-31

EM	SYMBOL	DESCRIPTION	MFG	PART NO	THERM NO	QTY
		DEHUMIDIFY CAP TUBE	----	.042x3'	577755	1
		DEHUMIDIFY COIL	THERMOTRON	R-5249-12-8	552345	1
		REFRIGERATION SCHEMATIC	THERMOTRON	R-5247-12-31(X)		
		A/C CONDENSER ASS'Y DWG	THERMOTRON	R-5247-12-27(X)		
		STAKING KIT	BRISTOL	650220	680664	1
		MOUNTING GROMMET	BRISTOL	236200	680672	4
		MOUNTING SPACER	BRISTOL	236400	680660	4

COOLING

TEMPERATURE OPERATION:

When operating this chamber for temperature simulation, the mechanical cooling is accomplished by a Thermotron cascade refrigeration system. The system consists of two interdependent refrigeration systems arranged to operate in unison in conjunction with a cascade condenser. The refrigerant 13 system (low temperature) is the primary and the refrigerant 502 system (high temperature) is the secondary cooling system. The cascade condenser is of concentric tube construction (tube within a tube) which functions as the condenser section of the R-13 system and the evaporator section of the R-502 system. This type of refrigeration system is designated as a cascade system.

Basically, the system operates in the following manner: The low temperature, R-13 unit, removes heat from the interior of the chamber and passes it to the cascade condenser where it is picked up by the high temperature R-502 system. This heat is passed to an air cooled condenser in the R-502 unit where the heat is removed by passing air through the air cooled condenser.

A closer look at the R-13 system will reveal the following changes taking place in the low temperature system. Low pressure, heat laden R-13 vapor is compressed by the compressor to a high pressure vapor. This high pressure vapor passes through the discharge service valve, desuperheater and the cascade condenser. Excess heat (commonly referred to as the heat of compression) is removed by the desuperheater. The major portion of the heat is removed from the high pressure vapor in the cascade condenser. The condenser removes a sufficient amount of heat to change the refrigerant from a high pressure vapor into a high pressure liquid. The high pressure liquid is then piped through the full flow filter drier which removes any moisture present in the system. The high pressure liquid then passes through the capillary tube.

The capillary tube, being a restriction in the liquid line, divides the refrigeration system into a high and low pressure side. The high pressure liquid, in passing through the capillary tube, changes state to a low pressure liquid. The low pressure liquid enters the chamber fin coil where it absorbs heat from the chamber. In absorbing the heat, the low pressure liquid changes state to a low pressure vapor. This low pressure vapor is returned to the suction side of the compressor through the suction line service valve and the cycle repeats.

Another possible path is through the injection expansion valve circuit. This expansion valve senses the heat of the suction gas as it is returned to the compressor. When this temperature is above the designed level, the injection valve opens admitting a cold liquid to the stream of hot suction gas returning to the compressor. This valve will modulate to control the temperature of the returning gas. When returning suction gas is cooler, the injection valve will shut OFF.

COOLING

TEMPERATURE OPERATION: (Continued)

If the operating pressure is above 235 PSI, part of the refrigerant is relieved through the bypass solenoid to the vapor tank. This refrigerant is slowly returned to the suction side of the R-13 compressor through the return line. This "dumping" process will continue until the operation pressure drops below 235 PSI.

The function of the refrigerant 502 secondary cooling system is to provide cooling for the cascade condenser, the dehumidify coil and a portion of the chamber fin coil (during humidity testing only). The high temperature R-502 system compressor compresses low pressure, heat laden vapor into a high pressure vapor. This high pressure vapor passes through the air cooled condenser where heat is removed as it passes through the fin coils. As the heat is removed, it changes state to a high pressure liquid. This high pressure liquid passes through the full flow filter drier. The drier removes any moisture that may be present in the system. The high pressure liquid then travels through a sightglass (liquid indicator) to the R-502 expansion valve. This valve modulates to control the flow of liquid R-502 into the evaporator section of the cascade condenser by measuring and maintaining a predetermined superheat of the R-502 vapor leaving the cascade. In this manner, the capacity requirements of the compressor are kept in balance with the system. In absorbing the heat from the R-13 system in the cascade condenser, the low pressure R-502 liquid expands and changes to a vapor.

This low pressure vapor is returned to the suction side of the R-502 compressor through the R-502 suction line service valve. This completes the R-502 cycle.

Both the R-13 and R-502 compressors are connected in parallel when the TEMPERATURE/HUMIDITY switch is in the TEMPERATURE position and will operate whenever the HEAT/COOL switch is in the COOL position. Cooling effect begins to lower the chamber temperature. When cooling demand is satisfied, the bypass solenoid is energized (open) through the solid state relay, which also turns ON the heater. At least 50% of the refrigerant will be dumped into the receiver tank. The heating will now override the cooling. The compressors continue to operate in a bypass condition (low cooling). With another cooling demand from the instrument, the sequence will repeat.

COOLING

HUMIDITY OPERATION:

When operating this chamber for humidity simulation, the mechanical cooling is accomplished by the R-502 refrigeration system. With the TEMPERATURE/HUMIDITY switch in the HUMIDITY position, the R-13 system will not be operating. The function of the R-502 refrigeration system during humidity operation is to provide chamber cooling by utilizing a portion of the fin coils and provide dehumidification by means of the dehumidify coil.

The compressor compresses low pressure, heat laden vapor into a high pressure vapor. This high pressure vapor passes through the air cooled condenser where heat is removed as it passes through the fin coils. As the heat is removed, it changes state to a high pressure liquid. This high pressure liquid passes through the full flow filter drier which removes any moisture that may be present in the system. The high pressure liquid then travels through a sightglass (liquid indicator) to the expansion valve. Only a small amount of the liquid flows through the expansion valve. The major portion of the liquid will flow through the dehumidify coil and the humidify cool solenoid, dependent upon the system demand. The humidity cool solenoid is always energized (open) during humidity testing and the liquid will flow through the humidity capillary tube.

The capillary tube, being a restriction in the liquid line, divides the refrigeration system into a high and low pressure side. The high pressure liquid, in passing through the capillary tube, changes state to a low pressure liquid. The low pressure liquid enters the chamber fin coil where it absorbs heat from the chamber. In absorbing the heat, the low pressure liquid changes state to a low pressure vapor. This low pressure vapor is returned to the suction side of the compressor through the suction line service valve and the cycle repeats.

The liquid refrigerant may also flow through the dehumidify expansion valve and the dehumidify coil. The amount of liquid flowing into the coil is regulated by the thermal-electric expansion valve which is controlled through the control circuit. As the cool liquid refrigerant flows into the coil, moisture is collected on the coil. In the coil, the liquid refrigerant expands and changes state to a vapor; thereby absorbing heat from the chamber. The heat laden vapor is returned to the compressor.

HIGH HEAT LIMIT

HUMIDITY GENERATOR HEAT LIMIT ADJUSTMENT:

The humidity heat limit should be adjusted to open at approximately +240°F. This will cause the humidity heat circuit to open if the humidity heater is energized when there is no water in the vapor generator, thus protecting the heater against burnout.

The heat limit is a manual reset type. Once the setting has been exceeded, the reset button must be manually depressed.

R-13 CHARGE STANDBY PRESSURE

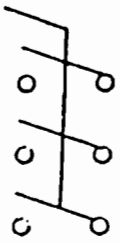
The R-13 system of the Thermotron cascade unit is charged by the "standby" method. The factory R-13 standby pressure is recorded on the equipment serial tag. This will allow a comparison to the present R-13 standby pressure in the system.

To read the R-13 standby pressure properly, two requirements must be met. First, the entire R-13 system (including the cascade) must be at or near ambient temperature. (70°F or 21°C.) Secondly, the R-13 system must be equalized. After the system has equalized, the standby pressure may be read on the R-13 discharge pressure gauge. If the gauge reading is approximately that of the recorded standby pressure, the system will meet the design requirements.

R-502 CHARGE:

A sightglass is used to check the charge in the R-502 system. To check the charge, watch the sightglass for bubbles during the pulldown. (The system should run a minimum of two minutes before checking for bubbles.) Bubbles indicate a low charge. Refer to page 7.2.1 for additional information.

ELECTRICAL SCHEMATIC SYMBOLS

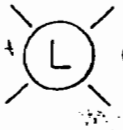

Disconnect Switch



Fuse


Heat Link

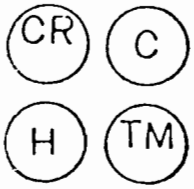

Heater



Chamber Interior Light

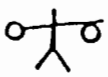


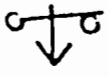
Panel Function Light

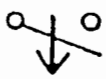


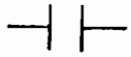
Energizing Coil (Contactor, Timer, Relay, etc.)

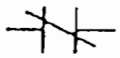

ON Delay Timer Contact (Timed to close)

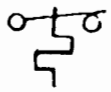

ON Delay Timer Contact (Timed to open)


OFF Delay Timer Contact (Timed to close)

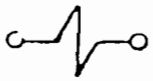

OFF Delay Timer Contact (Timed to open)


Normally Open Contact

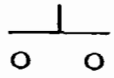

Normally Closed Contact


Thermal Actuated Switch (Heat & Cooling Limits, et


Pressure Actuated Switch


Refrigeration Solenoid


Switch


Pushbutton Switch

HIGH HEAT LIMIT

HUMIDITY GENERATOR HEAT LIMIT ADJUSTMENT:

The humidity heat limit should be adjusted to open at approximately +240°F. This will cause the humidity heat circuit to open if the humidity heater is energized when there is no water in the vapor generator, thus protecting the heater against burnout.

The heat limit is a manual reset type. Once the setting has been exceeded, the reset button must be manually depressed.

PROTECTIVE OR SAFETY DEVICES

HI-HEAT LINK: (Electrical Schematic)

Is wired in series with the heater to open the circuit to protect the chamber from exceeding designed temperature limits. This control will open when the chamber temperature reaches approximately 400°F. (Not resettable; replace.)

HUMIDITY GENERATOR HI-HEAT LIMIT: (Electrical Schematic, TH5)

Is wired in series with the humidity circuit to open the circuit to protect the vapor generator from exceeding designed temperature limits. This control is to be set to open when the vapor generator temperature exceeds 240°F. (Manual reset.)

INHERENT OVERLOAD PROTECTION:

One in each refrigeration motor compressor. These are factory designed to open the motor circuit within safe limits. (Non-adjustable; automatic reset.)

INTERLOCK:

The temperature/humidity switch is interlocked to the circulator motor circuit for protection of the heaters.

A GUARD is provided for the circulator fan.

ALL REFRIGERANTS used are non-toxic.

ALL ELECTRICAL CIRCUITS are separately fused.

MACHINERY is enclosed.

OPERATING INSTRUCTIONS

These operating instructions will tell the operator what must be done to place the chamber in operation. A thorough study of the electrical schematic and operating instructions of each control component should be made to become proficient in operating this chamber.

ONE SET POINT TEMPERATURE OPERATION:

1. Place all switches to the OFF, or center, positions.
2. Place the HUMIDITY/TEMP switch in the TEMP position.
3. Place the PROG/MAN switch in the MAN position.
4. Place the W.B./D.B. switch in the D. B. position.
5. Depress the S.P./TEMP switch and adjust the DRY BULB SET POINT control knob until the digital indicator displays the desired operating temperature. Release the S.P./TEMP switch. The indicator will now display the actual chamber temperature.
6. When the test program requires a temperature set point of less than +120°F or if the product under test dissipates heat and it is necessary for the cooling system to be in operation to maintain set point, place the COMP MODE switch in the RUN position.

OPERATING INSTRUCTIONS

ONE SET POINT HUMIDITY OPERATION:

1. Place all switches in the OFF, or center, positions.
2. Place the HUMIDITY/TEMP switch in the HUMIDITY position.
3. Place the PROG/MAN switch in the MAN position.
4. Place the W.B./D.B. switch in the D. B. position.
5. With the S.P./TEMP switch depressed, adjust the DRY BULB SET POINT CONTROL knob until the digital indicator displays the desired operating temperature.
6. Place the W.B./D.B. switch in the W.B. position.
7. With the S.P./TEMP switch depressed, adjust the WET BULB SET POINT control knob until the digital indicator displays the desired W.B. temperature.

   NOTE: Refer to the temperature/humidity chart. The wet bulb depression values are shown in one degree increments across the top of the table, dry bulb temperature values are in the left hand column; relative humidity values are in the major portion of the table. For example: 80% RH for +125°F dry bulb temperature is a wet bulb set point of +118°F.

8. With the S.P./TEMP switch released, the digital indicator will display the actual W.B. or D.B. chamber temperature as determined by the position of the W.B./D.B. switch.
9. Place the COMP MODE switch in the RUN position.

OPERATING INSTRUCTIONS

PROGRAMMED OPERATION:

Two point programming is limited to the temperature mode of the chamber. The following items provide for two point program operation.

LOW SET POINT POTENTIOMETER:

The low set point pot is used to select the low temperature.

HIGH SET POINT POTENTIOMETER:

The high set point pot is used to select the high temperature.

SET POINT SELECTOR SWITCH:

The set point selector switch is a three mode switch which will address either the low set point signal or the high set point signal for display.

Positioning the set point selector switch in the LOW mode will direct the signal from the low set point pot to the controller circuitry.

Positioning the set point selector switch in the HIGH mode will direct the signal from the high set point pot to the controller circuitry.

Positioning the set point selector switch in the PROGRAM mode will arm the LOW-HIGH set point pots for programming between the low and high temperatures.

> The set point selector switch MUST be placed in the PROGRAM mode for two point programming. Leaving the switch in either the LOW or HIGH mode will result in no change of set point signal.

OPERATING INSTRUCTIONS

PROGRAMMED OPERATION: (Continued)

COMPRESSOR MODE SWITCH:

This switch has three modes: RUN, OFF, and PROGRAM.

RUN Mode: The run mode will lock in the compressors to run 100% of chamber time. This position is selected when both the low and high set point temperatures are below 120°F.

OFF Mode: The off mode will lock out the compressors.

PROGRAM MODE: The program mode is selected when the compressors are to be energized and de-energized by the time clock.

1. Place all switches to the OFF, or center, positions.
2. Place the HUMIDITY/TEMP switch in the TEMP position.
3. Place the PROG/MAN switch in the PROG position.
4. Place the W.B./D.B. switch in the D.B. position.
5. With the SET POINT SELECTOR SWITCH in the HIGH position, depress the S.P./TEMP switch and adjust the HIGH SET POINT control until the digital indicator displays the desired high operating temperature.
6. Place the SET POINT SELECTOR SWITCH in the LOW position.
7. Adjust the LOW SET POINT control until the indicator displays the desired low operating temperature.
8. With the S.P./TEMP switch released, the indicator will display the actual chamber temperature.
9. Place the HUMIDITY/TEMP switch in the OFF position.

OPERATING INSTRUCTIONS

PROGRAMMED OPERATION: (Continued)

10. Set the time clock as follows:

    The time clock is a 24-hour time rotation with 96 tabs arranged on a timer circle. Each tab represents a 15 minute operation. By depressing one tab for every 15 minutes of operation, the time clock will close its n.o. contacts at the time index arrow to start refrigeration and switch to LOW set point. When the time clock reaches a tab which is not depressed at index arrow, the HIGH set point will come into play, energizing heating equipment. With the COMP MODE switch in the PROGRAM position, the time clock also controls the compressors. When setting the tabs, time must be allowed for chamber temperature to reach set point. This will depend on loads placed in the chamber. Transient times will have to be determined by trial. After the tabs have been set, the time clock may be rotated in a clockwise direction to the proper time index point.

11. Place the SET POINT SELECTOR switch in the PROGRAM position.

12. Place the HUMIDITY/TEMP switch in the TEMP position.

13. When operation requires two temperatures above +120°F, place the COMP MODE switch in the OFF position.

14. When one temperature is above and one temperature below +120°F, place the COMPRESSOR MODE switch in the PROGRAM position.

    The compressor will now cycle according to the time clock setting and automatic switching between the high and low set points will be in accordance with the time clock program.

15. When operation requires two temperatures below +120°F, place the COMPRESSOR MODE switch in the RUN position.

    The compressors will now run continuously and automatic switching between the high and low set points will be in accordance with the time clock program.

THERMOTRON

DIFFERENCE BETWEEN WET AND DRY BULB READINGS DEGREES FAHR. PRESSURE 30".

°F.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	52	54	56	58	60	62	64	66	68	70	75	80	85	
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180	98	96	94	92	89	87	85	83	81	79	77	75	73	72	70	68	66	64	63	61	59	58	57	55	53	52	51	50	48	47	45	44	43	42	41	40	38	37	36	35	34	33	32	31	30	30	29	28	27	26	24	23	21	20	18	17	15	14	13	11	9	5	2	
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205	98	96	94	92	90	88	86	84	83	81	79	77	76	74	72	71	69	68	66	65	63	62	60	59	57	56	55	54	53	51	50	49	48	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31	31	29	28	26	25	23	22	20	19	18	17	14	12	10	8
210	98	96	94	93	90	88	87	85	83	81	80	78	76	75	73	71	70	68	67	65	63	62	61	60	58	57	56	54	53	52	51	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32	32	30	29	27	26	24	23	22	20	19	18	16	13	11	10

World Headquarters: Kollen Park Drive, Holland, MI 49423, Phone: (616) 392-1492, TWX 810-292-6164

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FREON 13 SYSTEM

CHARGING PROCEDURE

WHEN TO ADD: Refrigerant will need to be added when the standby pressure of the system falls approximately 10 P.S.I. below the level recorded on the equipment serial tag (located on the electrical compartment door).

MATERIAL REQUIRED: 1 set of manifold refrigeration gauges, three charging hoses, one tank of Freon 13.

Note: Freon 13 at ambient temperature is at a pressure exceeding 450 P.S.I. Extreme care should be taken in handling this gas.

CHARGING PROCEDURE:

1. Connect the charging hoses to the refrigeration gauges.
2. Connect the center charging hose to the Freon 13 tank outlet valve. (Be sure the valve is OFF.)
3. Turn the compressor discharge and suction service valves all the way counter-clockwise; backseating the valves.
4. Connect the suction gauge hose to the compressor suction service valve. Connect the discharge gauge hose to the compressor discharge service valve.
5. Open the hand valves on the gauge manifold and bleed (purge) a small amount of gas through the charging hose.
6. After the hoses are purged, close the Freon 13 tank outlet valve and tighten the hose fittings on the compressor service valves.
7. Turn the compressor suction and discharge service valves clockwise (half turn only). Any charge in the system will be read on the gauges. This charge is referred to as the standby pressure. To read the proper pressure, the chamber and cascade compartment must be at ambient temperature.
8. To add gas, slowly open the outlet valve on the Freon 13 tank, allowing the higher pressure gas in the tank to flow into the refrigeration system; when the gauge reads the pressure indicated on the equipment serial tag (located on the electrical compartment door) close the outlet valve of the Freon 13 tank.
9. Allow the unit to stand for 15 minutes and recheck the standby. It will probably be necessary to add more gas. Again, open the outlet valve on the Freon 13 tank and raise the standby to the proper level. Close the valve.

10. Allow the chamber to stand approximately 15 minutes and recheck the standby. This procedure may be followed until the proper standby is reached.

11. After the standby is reached, turn both hand valves on the manifold all the way clockwise. (Frontseat.)

12. With the hand valves in this position, the operating pressures of the system may be read when the equipment is running.

13. If it is desired that the gauges be removed, backseat both compressor service valves (turned all the way counter-clockwise) and remove the charging hoses.

FREON 502 SYSTEM

CHARGING PROCEDURE

WHEN TO ADD: Refrigerant will need to be added when bubbles appear in the sightglass; during pulldown after 2 minutes of operation.

MATERIALS REQUIRED: One set of manifold refrigeration gauges, three charging hoses, one tank of Freon 502.

PROCEDURE:

1. Connect the three charging hoses to refrigeration gauge manifold.
2. Connect the center charging hose to the Freon 502 tank. (Outlet valve of tank must be OFF.)
3. Turn the suction and discharge service valves on the compressor all the way out (backseat).
4. Connect the hose from the suction gauge to the compressor suction service valve. Leave the fitting loose.
5. Connect the hose from the discharge gauge to the compressor discharge service valve. Leave the fitting loose.
6. Open both hand valves on the refrigeration gauge manifold.
7. Slowly open the outlet valve on the Freon 502 tank and purge the charging hoses.
8. Tighten the hose connections on the compressor suction and discharge service valves.
9. Turn the discharge hand valve on the refrigeration gauge manifold all the way clockwise (frontseat). The suction hand valve should remain open.
10. Turn the compressor section and discharge service valves clockwise (half turn only). Any charge in the system will be read on the gauges.
11. Start the R-502 compressor and watch for bubbles in the sightglass. This must be checked on the pulldown after a minimum of two minutes of running.
12. Open the outlet valve on the Freon 502 tank and allow the refrigerant to flow until there are no bubbles in the sightglass.

13. Turn OFF the outlet valve on the Freon 502 tank.

14. Continue to watch the sightglass for bubbles during normal pulldown operation. If bubbles appear, more Freon 502 may have to be added.

    NOTE: If bubbles appear during the bypass operation, this does not indicate a low charge.

15. To use the gauges during compressor operation, both hand valves should be turned all the way in (frontseated).

16. To remove the gauges, turn the compressor section and discharge service valves all the way counter-clockwise (backseat) and remove the charging hoses.

MAINTENANCE

TROUBLESHOOTING GUIDE

	Symptoms		Cause		Remedy
A.	Compressor does not run.	1.	Main power disengaged.	1.	Close main power disconnect or equipment disconnect switch.
		2.	Fuse blown.	2.	Replace fuse.
		3.	Compressor seized.	3.	If the compressor has caused the inherent overloads to trip, allow time for the compressor to cool and the inherent overloads to reset. Restart the compressor. If the compressor will not start, notify the factory for further assistance.
		4.	Compressor control circuit open.	4.	Check for open control circuit.
B.	Compressor will not start; hums intermittently. (cycling on overload.)	1.	Improperly wired.	1.	Check wiring against diagram.
		2.	Low line voltage.	2.	Check main line voltage; determine location of voltage drop.
		3.	Open starting capacitor.	3.	Replace starting capacitor.
		4.	Open circuits in starting winding	4.	Make a continuity chk of the starting winding.
		5.	Stator winding grounded.	5.	Make a continuity check from the stator winding to ground.
		6.	High discharge pressure.	6.	Check for refrigeration overcharge or non-condensables.

Symptoms	Cause	Remedy
C. Compressor starts, motor will not get off starting winding.	1. Low line voltage.	1. Bring up voltage.
	2. Improperly wired.	2. Check wiring against diagram.
	3. Defective start-run relay.	3. Check operation manually; replace relay if defective.
	4. Running capacitor.	4. Check by disconnecting running capacitor.
	5. Starting and running windings shorted.	5. Check resistances. replace stator if defective.
	6. Starting and running windings shorted.	6. Check capacitance; replace if low.
	7. High discharge pressure.	7. Check for refrigerant overcharge or non-condensables.
D. Start-run relay burnout.	1. Low line voltage.	1. Increase voltage to not less than 10% under compressor motor rating.
	2. Excessive line voltage.	2. Reduce voltage to maximum of 10% over motor rating.
	3. Incorrect running capacitor.	3. Replace running capacitor with correct mfd capacitance.
	4. Short cycling.	4. Reduce number starts per hour. (See Sect.B
	5. Incorrect mounting.	5. Mount relay in correct position.
	6. Incorrect relay.	6. Use relay properly selected for motor characteristics.
	7. Relay vibrating.	7. Mount relay in rigid location.

Symptoms	Cause	Remedy
E. Insufficient cooling effect.	1. Refrigerant shortage.	1. Repair leak and recharge.
	2. Frosted coil.	2. Defrost and dry coil.
	3. Air-cooled condenser obstructed.	3. Clear obstruction.
	4. Compressor inefficient.	4. Check for defective valves.
	5. Capillary tube obstructed.	5. Remove obstruction.
	6. Heat generating load is too great.	6. Consult factory for assistance.
F. R-13 head pressure too high.	1. Refrigerant overcharge.	1. Relieve some gas from system.
	2. Non-condensables in system.	2. Evacuate to recharge.
	3. R-502 system short of gas.	3. Repair leak and re-charge.
	4. Bypass solenoid not opening.	4. Replace.
	5. R-13 pressure switch defective.	5. Replace.
G. R-13 head pressure too low.	1. Refrigerant shortage.	1. Repair leak and re-charge.
	2. Compressor inefficient.	2. Replace.
	3. Bypass solenoid not closing.	3. Replace.

	Symptoms		Cause		Remedy
H.	R-502 head pressure too high.	1.	Condensing air too warm.	1.	Supply cooling air.
		2.	Restricted air-cooled condenser.	2.	Clean condenser.
		3.	Non-condensables in system.	3.	Evacuate and re-charge.
I.	R-502 head pressure too low.	1.	Condensing air too cold.	1.	Heat air.
J.	Noisy unit.	1.	Tubing rattle.	1.	Bend tubes away from contact.
		2.	Mountings loose.	2.	Tighten.
		3.	R-13 pressure switch defective.	3.	Replace.
		4.	Refrigerant flooding back.	4.	Consult factory for assistance.
K.	Compressor loses oil.	1.	Shortage of refrigerant.	1.	Repair leak and recharge.
		2.	Short cycling.	2.	Refer to Section B.
L.	Chamber will not control at ambient.	1.	Instrument misadjusted.	1.	Recalibrate
		2.	Defective thermocouple.	2.	Replace.
		3.	Low voltage.	3.	Consult factory for assistance.

DEHUMIDIFICATION

The dehumidification process is achieved by utilizing the dew point factor of basic psychrometry. This method of reducing and controlling the moisture content of the conditioned air within the test space allows the relative humidity to vary in a natural and governed process without introducing unnecessary air, heating, or cooling which would upset vapor pressures and temperatures.

Refrigerant flows through the dehumidify expansion valve and the dehumidify coil. The temperature of the dehumidify coil is maintained by the dehumidify expansion valve located in the dehumidify refrigeration circuit. The moisture in the chamber condenses on the surface of the dehumidify coil and the moisture is collected in a pan. The water is then removed from the chamber through a drain tube.

HUMIDIFICATION

GENERAL DESCRIPTION:

The humidity vapor generator is located outside of the chamber work space. It consists of an independent and automatic heating system combined with the chamber air circulation. All component parts are made of copper, brass, or stainless steel to prevent corrosion of the system. The entire assembly is easily removed to allow repair or cleaning of the unit on a bench.

The vapor generator assembly consists of a vapor tank, a water level control, and inconel sheath heater, and a safety heat limit for over temperature-low water protection. When power is applied to the heaters the temperature of the water in the vapor generator rises until it reaches the boiling point. The steam vapor that is generated migrates through a tube to the interior of the chamber. The vapor enters the chamber in the plenum area where it is mixed with the chamber air.

Level control of water in the wet bulb reservoir is maintained by an automatic feeder. The reservoir size is held to a minimum most suitable to the instrument bulb size. The shape of the reservoir insures against any damage by test chamber temperatures. The reservoir is heliarc welded, stainless steel.

THEORY:

The system operates on the basis of the immersion heater increasing the water vapor pressure in the vapor generator above that of the conditioning plenum, causing the vapor to migrate to the conditioning plenum, where it is mixed with the conditioned air and then delivered to the work space. This principle maintains proper control of wet temperature, with minimum influence on the dry bulb temperature.

HUMIDIFICATION

THEORY: (Continued)

When power is applied to the heaters, the temperature of the water in the vapor generator rises until it reaches the boiling point. The steam vapor that is generated migrates through a tube to the interior of the chamber. The vapor enters the chamber in the plenum area where it mixes with the chamber air. This chamber air passes over the humidity sensor, which in turn, supplies a signal to the wet bulb controller. The wet bulb controller compares this signal to the set point signal of the controller and supplies the proper command to the vapor generator. The heaters in the vapor generator either remain ON or are turned OFF, depending on the signal from the wet bulb controller, and the cycle repeats.

If there is no water in the vapor generator when power is applied to the heaters, the temperature of the vapor generator will begin to rise toward the skin temperature of the inconel sheath heater. To prevent this, a direct contact thermostat has been mounted on the side of the vapor generator. When the temperature of the vapor generator reaches the setting of the thermostat (225^{O}F.), the heat limit opens and removes power from the heater. The thermostat is manual reset type and cannot apply power to the heater until the thermostat is manually reset. As an added precaution, a heater with a low watt density has been used to assure the heater will not burn out if the heater is energized when there is no water in the vapor generator and the heat limit fails.

The water level in the vapor generator is maintained by the water boy float assembly attached to the side of the vapor generator. The float level is fixed, and the water level of the vapor generator is determined by the relative position of the fixed float assembly to the vapor generator. A pressure equalizer line has been installed between the float assembly and the vapor generator. This assures that the water levels in the two devices will be at the same level since there will be no pressure difference between them.

The wick well water level is controlled by a float assembly located on the side of the chamber. The wick well water level is maintained by adjustment of the ball float in the float assembly. This should be adjusted to maintain the water level about 1/4" from the top of the well. If the float should stick open, the float assembly is equipped with an over-flow tube.

To drain the wick well and the float assembly, close the water supply shutoff valve and open the drain valve. The water will drain from the wick well through a tube welded to the float assembly. This allows for fast fill and drain. To fill the system reverse the procedure.

HUMIDIFICATION

MAINTENANCE:

Weekly - Drain the vapor generator and the wick well until all traces of sediment disappear from the drain water.

Quarterly - Remove the vapor generator from the chamber and completely disassemble it. Remove any scaling or sediment present inside the vapor generator and float assembly.

NOTE: For this system to operate properly, with the carefree operation for which it was designed, use only distilled or demineralized water. This prevents scaling and mineral build-up which leads to a deterioration of system performance.

Thermotron also recommends the wet bulb wick be changed periodically to assure optimum system operation. The wick should be made of a light-weight cotton material. These wicks can be purchased directly from most control instrument manufacturers. (Such as Bristol, Part No. A-1433.) These wicks should be kept clean for proper wet bulb instrument operation.

The float assembly is constructed with a small clearance between the float and body of the valve. When working on the float assembly, or removing it for cleaning or repair, never hold the body of the float with any gripping device. Always use two wrenches on the hexagonal fittings provided.

VAPOR GENERATOR REMOVAL:

The vapor generator is supported by two end plates that are bolted to two hanger brackets.

To remove the vapor generator from the cabinet:

1. Turn OFF the supply water to the chamber and remove the 1/4" flare nut at the top of the water boy float assembly.

2. Turn the electrical power to the chamber OFF and remove the wire connections from the heater terminals, which are located inside the terminal box on the end of the vapor generator.

3. Loosen the connection in the vapor outlet tube.

4. Remove the four mounting bolts. The vapor generator is now free and may be removed from the cabinet.

HUMIDIFICATION

(Continued)

OPERATION:

To place the vapor generator in operation:

1. Connect a supply of demineralized or distilled water to the 1/4" coupling provided at the rear of the chamber. If the water supply exceeds 75 P.S.I. a pressure reducing valve must be used.

2. Control the ON time of the heaters to attain the proper humidity level in the chamber.

To place the wick tank in operation:

1. Close the water boy drain valve.

2. Open the water supply shutoff valve.

3. Adjust the water level on the wick tank float assembly to the desired level. (About 1/4" from top of well.)

4. Install a sock or cloth on the wet bulb sensor.

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