WARNING

ACCESSING THE WATLOW SERIES 942 PROGRAMMERS SETUP MENU OR CHANGING ANY OF THE FACTORIES PRESET VALUES WILL EFFECT THE OPERATION OF THE CHAMBER AND WILL VOID ANY WARRANTY.

CHANGING ANY OF THESE VALUES WILL VOID ANY WARRANTIES.

WARNING

TENNEY JR
W/942

TENNEY ENVIRONMENTAL

TENNEY JUNIOR
ENVIRONMENTAL TEST CHAMBER

MODEL NO. TJR

CHAMBER TYPE: TEMPERATURE

CONTROLLER TYPE: ☒ WATLOW 942 CONTROLLER
☐ WATLOW F4 CONTROLLER

CHAMBER OPTIONS

☐ Boost Heat	☐ TempGard IV - Watlow 93
☐ Boost Cooling	☐ Watlow 147 Limit Controller
☐ Purge Air System / Dryer	☐ Chart Recorder

L R TECHNOLOGIES INC.
12902 S SPRING ST
LOS ANGELES, CA 90061
www.lrtech.com
323-770-0634/0105 FAX

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INTRODUCTION

Congratulations on purchasing a Tenney Environmental test chamber. We truly hope that every aspect of design and quality will measure up to your strictest standards. Your chamber has been designed to operate with the reliability you expect for the demands you impose on your product and research testing.

Your environmental test chamber incorporates many different engineering technologies. Tenney Engineers have designed even the most complex chambers to operate in a way that the customer can competently understand, configure, and maintain. Anytime you have a question, you can phone, fax, or E-mail our dedicated service staff. Their diverse experience and knowledge will get you the answers you need. We have put the Parts And Service Inquiries section in the front of the manual for your convenience.

Like our test chambers, this manual has been designed with the customer in mind. Section General gives a brief overview of the chamber specifications, while the remaining sections detail the different functions and operating conditions and procedures. In the rear of the manual you'll find the Supplemental Instructions Section filled with a variety of information. As applicable to the chamber, this section includes separate vendor user manuals and cut-sheets, expanded instruction and information sections, drawings, tables, data sheets, the test inspection report, and the warranty. It is extremely important that you read the entire manual and all of the information contained therein before operating your equipment.

You must adhere to the warnings and safety procedures listed throughout this manual as well as to those listed in the vendor user manuals and cut-sheets. **Failure to follow the warnings, safety procedures and proper operating procedures listed throughout the manuals could result in damaged equipment, personal injury, or death.**

VERY IMPORTANT WARNING!

YOUR POWER SUPPLY LINE VOLTAGE MAY BE TOO LOW, OR TOO HIGH TO

PROPERLY AND SAFELY OPERATE YOUR CHAMBER.

BEFORE MAKING THE POWER SUPPLY CONNECTION TO YOUR CHAMBER,

YOU MUST FOLLOW THE SPECIFIC DIRECTIONS STATED UNDER

"POWER CONNECTION" IN THE INSTALLATION INSTRUCTIONS SECTION.

FAILING TO PERFORM THE DIRECTIONS STATED MAY VOID YOUR WARRANTY!!

GENERAL DESCRIPTION

Application:

This manual applies to the following reach-in temperature test chambers, which employ a capillary tube type refrigeration system.

- Model TJR: Tenney Junior - Benchtop Unit
- Model T-U JR: Tenney Junior - Upright Unit

Environmental Conditioning Functions:

- Temperature conditions are attained by recirculating chamber air through a refrigerated cooling coil and open air nichrome wire heater elements. Non-CFC refrigerants are used in the refrigeration systems of all Tenney chambers.
- Air circulation is generated by a propeller type fan, which is directly driven by an externally mounted motor.
- The chamber is equipped with a cascade refrigeration system, which employs two semi-hermetic compressors. This is a multiple design, consisting of a low stage system and a high stage system. Both are integrated in a highly efficient design to permit extreme low temperatures to be attained. This is accomplished by utilizing a cascade condenser in the low stage, where low stage refrigerant is cooled and condensed by high stage refrigerant. An air-cooled condenser is used in the high stage.

Specifications:

- Temperature Range: -75 to +200 degrees Celsius, ±0.3 degrees Celsius
- Workspace: 15-5/8" W x 11" D x 11-3/4" H (40 W x 28 D x 30 H Centimeters)

Temperature Controller:

One of the following temperature controllers is employed with the Tenney Junior. The type used is indicated on the cover of the manual.

- Temperature conditions are controlled by a Watlow 942 time/temperature profiling controller. Profile operations include 24 step program capability, time/temperature profile - rate, or time - based programming, guaranteed soak deviation, and program looping. The W942 can also be used for simple single, or fixed set point operation.

  An RTD sensor is used for temperature measurement. Dual outputs are configured in the time proportioned, On/Off, or switched dc modes. Two optional auxiliary outputs can be set up as alarms, or time-based events. Optional retransmit output allows retransmitting set point, or process variable. Data communications is optional using RS232/RS423, RS422, EIA-485, or IEEE interface.

- (Alternate Controller) Temperature conditions are controlled by a Watlow F4 Controller. Most chambers will utilize a one channel Model F4S. However, some applications will utilize a two channel Model F4D. The F4 is a powerful time / temperature profiling controller designed for demanding ramp and soak applications. Up to 256 steps can be programmed into as many as 40 variable-length, nameable profiles. A four line high definition LCD interface display enhances guided software to make profile programming and controller configuration faster and easier. A 16-bit microprocessor provides this operational versatility, along with precise process control. The F4 can also function as a static set point controller. EIA-232 and EIA-485 serial communications with Modbus RTU protocol is standard.

Chamber & Product Over/Under Temperature Protection:

Chamber overtemperature protection is provided with a heat limiter fuse. Product over/under temperature protection may be provided with an optional alarm output from the main controller. The optional TempGard IV feature with the Watlow 93 Controller may be used for redundant product over/under temperature protection. These devices are configured in a comprehensive alarm and shutdown circuit.

Additional Options:

Your Tenney chamber may include many other unique options such as boost heating, boost cooling using CO_2 or LN_2, a purge air system using compressed air or GN_2, and a chart recorder. Watlow 942 Controllers may include LinkTenn software that enables a computer to control up to ten chambers.

As you can see, Tenney Environmental Test Chambers are diversified tools designed to encompass a wide range of operating conditions and functions. If you come upon any questions as you continue on through the manual, please contact our Service Department.

SAFETY WARNINGS

1. Read the entire Tenney / Lunaire instruction manual as well as the vendor manuals and cut-sheets provided, before operating this chamber! Failure to adhere to the safety warnings, or to follow the proper operating procedures listed throughout the manuals and information provided, could cause damage to your equipment, personal injury, or death.

2. Do not use this chamber in any manner not specified in this manual. Improper use may impair the safety features employed.

3. Only Certified service personnel should ever be permitted to perform any service related procedure on this chamber!

4. A main power disconnect is not provided with your chamber. We recommend that a fused disconnect switch on a separate branch circuit be installed as the power source to your chamber, in accordance with all national and local electrical codes. If your chamber is equipped with a power cord and plug, you must utilize a receptacle with the appropriate rating, which is on a branch circuit of its own. Opening the branch circuit breaker(s) in the test chamber does not remove all power from the chamber.

5. Installation of chamber: Do not position the chamber in a manner that would make it difficult to operate your main power disconnect switch.

6. Electrical enclosures, gauge boxes, conditioning compartment, etc., contain exposed electrical connections. Disconnect and Lock-Out / Tag-Out all electrical power from the facility at its source before servicing or cleaning.

7. Do not attempt any service or adjustment to any electrical or mechanical components during operation.

8. Keep panels in place properly when the chamber is in operation.

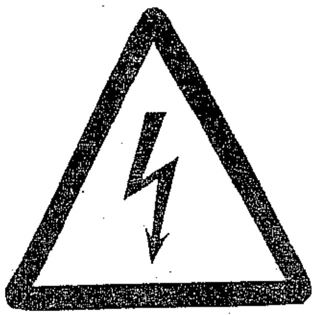
9. This chamber is not explosion proof. The air conditioning section contains low mass, open wire heating elements. Due to this low mass, the heater elements can readily attain temperatures sufficiently high to ignite gas vapors. Do not install test articles that may release explosive or flammable vapors in the chamber.

10. Refrigerants under high pressure are used. Service of the refrigeration system must only be carried out by a qualified refrigeration mechanic.

11. Human exposure to temperature extremes can cause injury. Take appropriate precautions before opening chamber doors and upon handling test specimens.

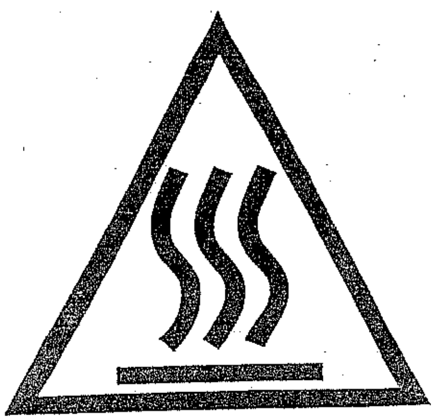
IMPORTANT! - - WARNING LABEL DEFINITIONS

The following international warning labels may be used on your equipment.
Definitions of each label symbol are provided below.

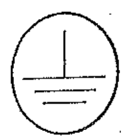


"WARNING OF DANGEROUS ELECTRIC VOLTAGE"

"WARNING OF HAZARDOUS AREA"



"WARNING OF HOT SURFACE"



EARTH (GROUND) PROTECTIVE CONDUCTOR TERMINAL

INSTALLATION INSTRUCTIONS

Read this section completely before attempting to install, or operate the equipment.

Delivery: Inspect equipment and shipping crate immediately upon receipt. If any damage is apparent, you should discuss it with the trucking delivery person, and contact the transportation company immediately. Make notes of any damage on the Bill Of Lading. Retain all shipping materials for inspection. Any claims for damage must start at the receiving point. Check packing slip carefully and make sure all materials have been received as indicated on the packing ticket. Unless otherwise noted, YOUR ORDER HAS BEEN SHIPPED COMPLETE.

Warning! -- ALL chambers and machinery skids should be handled and transported in an upright position. They must never be carried on their back, front, or any side.

Important! Inspect the circulation fan inside the chamber. This fan is driven by a motor that is mounted in isolation bushings. Sometimes during shipping, the motor is pushed out of vertical alignment. If this has occurred, the fan blade will strike the casing. Cure the interference by pushing the motor back into alignment on its rubber mounts. However, be sure that the shipping abuse was not so great that the extension shaft on the fan has been bent.

Installation of Chamber: Your equipment has been fully operated, tested, and balanced in our plant prior to shipment, unless notified otherwise. Follow the installation requirements below.

- Chamber Weight: Approximately 260 lbs.
- Environmental Specifications (For CE European Marked Chambers Only):

  Pollution Degree 2, Installation Category III
- Ventilation: The chamber should be installed in an area where there is good air ventilation, especially if an air-cooled condenser is used. Allow a minimum of 18 inches between any wall and chamber side.
- **Do not position the chamber in a manner that would make it difficult to operate your main power disconnect switch.** See "Power Connection" below.
- Make sure the chamber is leveled when set up.

Air Supply Connection: Your chamber will require a compressed air supply for the Purge Air System option, or for the Dry Air for Dehumidification (humidified chambers only!!) option. The supply should range from 80 PSIG min. to 100 PSIG max. Make sure that the air supply is clean (relatively oil free) and the connection is secure. Reference the corresponding "Optional" section in this manual, or your chamber specifications for more details.

GN_2 Connection: Your chamber will require a supply of gaseous nitrogen (GN_2) for the Purge Air System (using GN_2) option. The supply may range up to 100 PSIG maximum. Make sure the connection is secure. Reference the corresponding "Optional" section in this manual, or your chamber specifications for more details.

Warning! -- Gaseous nitrogen displaces oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the chamber vent port checkvalve!

<u>LN_2 / CO_2 Connection:</u> Your chamber will require a supply of liquid nitrogen (LN_2), or liquid carbon dioxide (CO_2) for the Boost Cooling option. When LN_2 is used, the supply may range up to 40 PSIG maximum. When using CO_2, the supply will be rated for either up to 300 PSIG, or up to 1000 PSIG, depending on which option is purchased. Make sure the connection is secure. Reference the corresponding "Optional" section in this manual, or your chamber specifications for more details.

Warning! -- The gases from these systems displace oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the chamber vent port checkvalve!

<u>Electrical Specifications:</u> 18 A Max., 100 / 120 V, 50 / 60 Hz, 1 PH

Your main power fused disconnect switch should be fused at 20 Amps.

<u>Power Connection:</u>

Warning! -- **BEFORE MAKING THE POWER SUPPLY CONNECTION TO YOUR CHAMBER YOU MUST DO THE FOLLOWING:**

1. Verify the power supply voltage rating established for your chamber. The voltage rating is listed above. It is also found on the serial tag on the side of the chamber.
   Please note the rated value here: ________

2. Measure and record the voltage source you intend to supply your chamber with. Please note the measured value here: ________

3. Go to the following manual section entitled "Line Voltage". Verify that the power supply voltage source you measured and recorded is within the minimum and maximum allowable operating voltages for your chamber rating. If it is not within this operating range, do not make the power connection! Otherwise, erratic operation and damage may occur to your chamber which may void your warranty. If you have any questions, please call the Lunaire Limited Service Department.

Warning! -- Do not position the chamber in a manner that would make it difficult to operate your main power disconnect switch.

Warning! -- High Accessible Current - Earth connection essential before connecting to supply. Make sure equipment is properly grounded in accordance with all codes.

A main power disconnect is not provided with your chamber. We recommend that a <u>fused</u> disconnect switch on a separate branch circuit be installed as the power source to your chamber, in accordance with all national and local electrical codes. Reference your Electrical, or Power Schematic for all electrical requirements.

Making The Power Supply Connection To The Chamber:

The power connection is made via a cord and plug for standard units. Connect to a receptacle that has the appropriate power supply on a branch circuit of its own.

For special units that have the power supply hard-wired to the chamber, connect incoming lines to the main input connections provided in the control cabinet.

Before Energizing Your Unit:

- Before energizing any equipment give it a visual inspection for loose components, electrical connections, fittings, etc. Shut all operating switches to the "off" position before energizing.
- Have trained personnel start and check out the equipment before its first cycle.

For CE European Marked Chambers Only: Chamber Fuse Type and Rating:

1FU (Qty. 1)	Gould Model GDG1/2	.5 A, 250 VAC Time-Lag

LINE VOLTAGE

One of the most common causes of chamber malfunction is low line voltage as the power source to the chamber. Ordinarily in this condition, the compressor motors would operate erratically, eventually overheat and shut down. You must be certain that your equipment is connected to a circuit with an adequate voltage and current source. An oversupply voltage would also cause erratic operation and eventual shutdown, or damage to your equipment.

Tenney Junior test chambers are designed to operate with a nominal 115 V, 60 Hz, 1PH power supply. Optional equipment is available to allow operation with 208 or 230VAC, 60 Hz supplies, or for outside The United States, operation with 200, or 220 VAC, 50 Hz power supplies. The allowable minimum and maximum voltages at each of these nominal voltages is tabulated below:

Nominal Voltage	Minimum Voltage	Maximum Voltage
	60 Hz Power Supplies	
115	104	127
208	198	218
230	207	253
	50 Hz Power Supplies	
200	180	220
220	198	242

Operation outside these limits can result in damage to the system's motors.

OPERATING WITH AN ACTIVE HEAT LOAD

Note: This feature is only available with the TempGard IV option.

When operating with an active heat load, such as introduced by a powered test unit, this heat must be removed or the chamber temperature will rise. The internal logic of the controller will automatically turn on the refrigeration system to maintain a set temperature. Although a cooling system failure is not likely to occur, it is always a possibility when mechanical systems are used. In the event of a cooling system failure that results in an out of limit over temperature condition, one or more of the system safeties will remove power from the system. However, heating will continue if power remains applied to the active load. To guard against this continued heating, the product should be powered through the spare contacts of the Master Contactor (CON) from the TempGard IV circuitry. This is described in the Alarm And Shutdown Circuit section.

TEMPERATURE CONTROL - WATLOW 942 CONTROLLER

Temperature conditions are controlled by a Watlow 942 time/temperature profiling controller. Profile operations include 24 step program capability, time/temperature profile - rate, or time - based programming, guaranteed soak deviation, and program looping. The W942 can also be used for simple single, or fixed set point operation.

A RTD is used for temperature measurement. Dual outputs are configured in the time proportioned, On/Off, or switched dc modes. Two optional auxiliary outputs can be set up as alarms, or time-based events. Optional retransmit output allows retransmitting set point, or process variable. Data communications is optional using RS232/RS423, RS422, EIA-485, or IEEE interface.

Data Communications:

As an option, your chamber may include data communications with the main controller's serial port. When employed, either a Data Communications manual, or a Computer Interface manual will be included in the Supplemental Instructions Section. As a reference, the available data types are listed and briefly described below. Please contact a Tenney Sales Engineer for more information.

RS232C / RS423A: Both interfaces are compatible and use 3 wires: a single transmit wire; a single receive wire; and a common line. The maximum wire length is 50 feet. Only a single chamber may be connected to your computer. Data signals are measured as plus and minus 12 volts to common with RS232C, and plus and minus 5 volts to common with RS423A.

RS422A: This interface uses 5 wires: a transmit pair; a receive pair; and a common line. Up to ten chambers may be connected to your computer on a multi-drop network up to 4,000 feet long. Data signals in each pair are measured as a plus or minus 5 volt differential.

EIA-485: This interface uses only 2 wires. Both wires are used for transmitting and receiving data, and therefore, only one device may talk at a time. Up to 10 chambers may be connected to your computer on a multi-drop network up to 4,000 feet long. Data signals are measured as a plus or minus 5 volt differential. An EIA-485 card must be installed for signal conversion.

IEEE-488: This is a parallel multi-drop interface with several control and data lines. Each device connected must be set to a unique address. Data from other test devices may also be collected. An IEEE-488 to serial converter card is installed. Max. cable length is approx. 33 ft.

Chamber Conditioning Control Functions:

The Main Power switch 1SS must be turned ON to enable the controller's outputs. Closing 1SS also starts the conditioner fan. The following descriptions detail the functions of the various outputs.

Event outputs are user entered outputs that must be turned ON to activate special control circuitry, or to operate an optional feature. Descriptions of events that operate optional features are described in the Options section.

Heat Control:

Output 1C-01 -- This time proportioned output will trigger triac 1TRC to conduct and provide power to the electric heaters.

Cooling Control:

Output 1C-02 -- This On/Off output will trigger triac 2TRC to conduct and energize the refrigeration system. The high stage compressor will immediately start. The low stage compressor will start after a slight delay from the Low Pressure Cut-In Switch PS2.

Event Output (Optional):

Output 1C-03 -- This is Event No. 1, which serves as a compressor shutoff when going from a very low to a vary high setpoint. In this scenario, any cycling of the compressors is not desired, and a heat overshoot is tolerated. 1C-03 contacts are normally closed. They will open when the event is turned ON to disable the Cooling Control Output.

Compressor Turn-On Logic:

In determining when to turn the refrigeration system On or Off, the controller's logic will compare the following signals and setpoints.

1. Actual Chamber Temperature
2. Setpoint Temperature
3. Hysteresis
4. Deadband

Hysteresis (**HYS**) and deadband (**db**) are parameters entered at the factory. Hysteresis is the temperature change necessary to change the output from full ON to full OFF, and is detailed in the Setup Menu section in the Watlow 942 Manual. Deadband is the span in which Output 1C-02 will remain ON below the controller's low setpoint, and is detailed in the Operation Menu section of the Watlow Manual. **HYS** and **db** are entered in degrees Celsius. Deadband is always entered as a (-) minus. The logic is:

- Measured temperature rises above setpoint: Refrigeration turn-on = hysteresis minus deadband.
- Measured temperature falls below setpoint: Turn-on is always above setpoint.
- Turn-off is always below setpoint: Turn-on is always above setpoint.

EXAMPLE SETTINGS FOR HYS AND db

	HYS	db	**Turn-On** (Above SP)	**Turn-Off** (Below SP)
Standard	4	-3	1	3
	5	-3	2	3
	5	-1	4	1
No Good	3	0	3	0

Chambers are shipped with HYS = 4, and db = - 3, as shown on the top line in the above examples. It is unlikely a change to these settings will be required. Fortunately, these settings are not subject to "cold start" default, and will remain valid after a power interruption. They are held in EEROM, not battery-backed RAM.

Controller Configuration:

The pre-programmed Watlow 942 configuration for your chamber is documented in the Test Report, which is located in the Supplemental Instructions Section. For complete programming information on the controller, please refer to the controller's User Manual located in the same section.

Important! The configuration set-up is mainly provided for your reference. Not all of the parameters shown apply to your chamber. Changes to some of the set-up parameters may drastically affect your chamber performance and void your warranty. Contact the Lunaire Service Department before attempting any changes.

TEMPERATURE CONTROL - WATLOW F4 CONTROLLER

The Watlow F4 Controller is a powerful time / temperature profiling controller designed for demanding ramp and soak applications. Most temperature-only applications utilize a single channel Model F4S. Special designs may utilize a two channel Model F4D. A 16-bit microprocessor provides simplified versatility with precise process control. The F4 can also function as a static set point controller. A four line high definition LCD interface display enhances guided software to make profile programming and controller configuration faster and easier. The Information Key is a unique feature that allows a wealth of information to be accessed about any feature or parameter.

Standard Features:

Many features are packed into the standard Model F4. Temperature measurement is made with a 100 ohm platinum RTD sensor. Control output types include dual solid state relays, and dual switched dc. Dual alarm outputs consist of Form "C" electromechanical relays, which can be programmed as process or deviation alarms.

Four digital event inputs can be programmed to remotely start, pause or terminate any of your preprogrammed process recipes. Eight digital event outputs are segment programmable, or three of them can be assigned to programmable compressor and boost heat / boost cool control. A real time clock (with battery backup) can be used to start a profile at any time.

F4 Data Communications:

Data communications utilizes EIA-232 and EIA-485 serial interface with Modbus RTU protocol. Modbus RTU enables a computer or PLC to read and write directly to registers containing the controller's parameters. These data interface types are briefly described below.

RS232C / RS423A: Both interfaces are compatible and use 3 wires: a single transmit wire; a single receive wire; and a common line. The maximum wire length is 50 feet. Only a single chamber may be connected to your computer. Data signals are measured as plus and minus 12 volts to common with RS232C, and plus and minus 5 volts to common with RS423A.

EIA-485: This interface uses only 2 wires. Both wires are used for transmitting and receiving data, and therefore, only one device may talk at a time. Up to 10 chambers may be connected to your computer on a multi-drop network up to 4,000 feet long. Data signals are measured as a plus or minus 5 volt differential.

Profiling Features:

Up to 256 steps can be programmed into as many as 40 variable-length, nameable profiles: A profile is a set of instructions programmed as a sequence of steps. Six different step types provide the building blocks for the ramping profiles. These include Autostart, Ramp Time, Ramp Rate, Soak, Jump, and End. Each step is described below.

<u>Autostart:</u> Pauses a profile until the specified date or day, and time (of a 24 hour clock).

<u>Ramp Time:</u> Changes the set point to a new value in a chosen period of time. Ramp Time is the same for both channels of a dual-channel controller.

<u>Ramp Rate:</u> For single channel only, changes the set point to a new value at a chosen rate.

<u>Soak:</u> Maintains the set point from the previous step for a chosen time in hrs/min/sec's.

<u>Jump:</u> Initiates another step or profile.

End: Terminates the profile in a chosen state. All profiles must have an End step.

Ramp and soak steps can be individually programmed to Wait For (not a step type) up to four events or three different process variables. This means the wait conditions must be satisfied before the time clock and the step activity proceeds.

Displays, Indicator Lights, and Keys:

Upper Display: Shows the actual process value of Channel 1. Channel 2 process value can be alternately displayed in a time selectable manner. This is selectable in Process Display of the Go To Setup Menu.

Lower Display: Displays information about the setup, operation, and programming. A Cursor (>) indicates the selected parameter or present value in memory. A Scroll Bar appears when the Up or Down keys can reveal more information. Channel 2 process value is accessible here.

Indicator Lights:

- Active Outputs: Lit when the corresponding channel output is active.
- Alarm Outputs: Lit during an alarm state.
- Communications: Lit (pulsates) when valid data is sent or received.
- Profile Indicator: Run/Hold status; Lit when a ramping profile runs. When blinking, profile is on hold. When not lit, the controller operates as a static set point controller.

Profile Key: (Profile Run/Hold) Summons a menu that allows you to start, hold, resume or terminate a profile.

Information Key: Provides information in the Lower Display about the cursor-selected parameter. Another press toggles the display back to the parameter.

Movement Keys:

- Up(▲), Down(▼): Move Up/Increase, Move Down/Decrease
- Right > Key: (Next) Move right to select the choice to the right of the cursor and proceed to the next screen.
- Left < Key: (Back Out) Move left to exit.

To Clear an Alarm or Error:

In an alarm condition, an alarm message will appear on the Main Page (if this option has been selected on the Setup Page). To silence it, move the cursor to the alarm message and press the Right Key >. A pop-up message will confirm the silencing of the alarm, and the indicator light will go off.

When the condition causing the error or alarm is corrected, return to the error or alarm message on the Main Page, and press the Right Key again. A pop-up message confirms the alarm is unlatched.

Cascade Temperature Control (Optional):

Note: Tenney chambers are set up to run in the "No Cascade" mode because of the many variations in customer products that require special tuning with this option.

Process Cascade control and Deviation Cascade control are available as an option on Channel 1. The primary purpose of cascade control is to get the product to the desired temperature in the quickest manner. Both types of cascade control simultaneously measure the conditioned air supply temperature (Analog Input 1) and the product temperature (Analog Input 3). Typically, when product conditioning is started, the product temperature is at a level higher or lower than the conditioned air supply (process air) being discharged into the chamber. The product temperature Input 3 takes precedence over the process air temperature Input 3 until the product temperature approaches a certain value. This value may be a PID value in Process Cascade, or a deviation limit in Deviation Cascade.

Chamber Conditioning Control Functions:

The following descriptions detail the functions of the various F4 outputs. Event outputs (user entered) are provided mainly for special applications. These features are normally described in the "Options" section of the manual.

Heat Control:

Output 1A - - This time proportioned output will trigger triac 1TRC to conduct and provide power to the electric heaters.

Cooling Control:

Dig. Out #8 - - This digital On/Off output will energize solid state relay SSRx and a control relay, which triggers triac 2TRC to conduct and provide power to the entire refrigeration system. The high stage compressor will immediately start. The low stage compressor will start after a slight delay from the Low Pressure Cut-In Switch PS2.

Note: Digital Output No. 8 serves as a Compressor Control output, which can save wear on a compressor and prevent it from locking up from short cycling. Compressor On % Power sets the power level that will switch this output (compressor & control circuitry) on. Compressor Off % Power sets the power level that will switch the compressor off.

The compressor(s) will not turn on until the output power exceeds the Compressor On % Power for a time longer than the Compressor On Delay. The compressor will not turn off until the output power exceeds the Compressor Off % Power for a time longer than the Compressor Off Delay.

Controller Configuration:

The pre-programmed Watlow F4 configuration for your chamber is documented in the Test Report, which is located in the Supplemental Instructions Section. For complete programming information on the Watlow F4, please refer to the Watlow F4 User's Manual located in the same section. The **User Profile Sheet** in the F4 manual should be copied and used for planning profiles.

Important! The configuration set-up is mainly provided for your reference. Not all of the parameters shown apply to your chamber. Changes to some of the set-up parameters may drastically affect your chamber performance and void your warranty. Contact the Lunaire Service Department before attempting any changes.

CHAMBER OVERTEMPERATURE PROTECTION

Note: This description applies to standard chambers <u>without</u> the CE Mark (European).

A heat limiter fuse is provided to protect the chamber against overtemperature conditions. It is mounted to the heater element bracket in the conditioning plenum at the top of the workspace. The heater limiter will permanently open and remove power from the heater elements when a temperature of approximately 221°C is reached. **Once it opens it must be replaced.**

WARNING! **Before replacing the heat limiter, you must disconnect your power supply cord and plug from the power supply receptacle. If your chamber is hard wired, you must open the closest main power disconnect switch. <u>Lockout / Tagout</u> all electrical power to the chamber before proceeding. Read the description below before attempting to replace the heat limiter.**

Heat Limiter Description:

This 1¼" long device has a white ceramic body with two copper forked terminals on both ends. It is wired in series with the heating elements, having one terminal attached to a heater element mounting stud, and the other connected to the neutral line with an 8-32 bolt and nut. This end hangs in free air to the left of the heater bracket. A copper metal strip on the back side of the heat limiter connects the two forked terminals and carries the heater current. When a temperature of approximately 221°C is reached, the copper strip will separate from the heat limiter body at the soldered connection on the one end. As a result, power is removed from the heater elements.

Removing the Heat Limiter:

1. Remove the conditioner (plenum) cover at the top of the workspace by removing the four mounting screws.
2. Remove the heater bracket from the plenum ceiling by removing the two mounting screws located at both ends. Once the screws are removed, the bracket can be left to hang.
3. Remove the heat limiter by loosening the No. 8-32 nut that secures the one end to the heater element mounting stud, and the No. 8-32 bolt/nut assembly that secures the opposite end to the neutral wire.
4. As you install the new heat limiter, **take great care in your replacement procedure!** Make sure all connections are secure.

Note: The heat limiter is not used when the Boost Heat option is employed. This option uses a Watlow 147 Limit Controller for overtemperature protection. Please reference that section for details.

CHAMBER OVERTEMPERATURE PROTECTION - CE Marked Chambers Only

Important Note: This description only applies to CE Marked (European) chambers!

A Heat Limiter (thermal cutoff) is provided to protect the chamber against overtemperature conditions. This is an axial leaded one shot protection device that is mounted in a small white ceramic terminal block. It is installed in the conditioning plenum at the top of the workspace.
The Heat Limiter will permanently open and remove power from the heater elements when the surrounding air temperature reaches 240°C. **Once it opens it must be replaced.**

WARNING! Before replacing the heat limiter, you must disconnect your power supply cord and plug from the power supply receptacle. If your chamber is hard wired, you must open the closest main power disconnect switch. Lockout / Tagout all electrical power to the chamber before proceeding. Read the description below before attempting to replace the heat limiter.

Replacing the Heat Limiter:

1. Remove the conditioner (plenum) cover at the top of the workspace by removing the four mounting screws.
2. Remove the heater bracket from the plenum ceiling by removing the two mounting screws located at both ends. Once the screws are removed, the bracket can be left to hang.
3. Remove the heat limiter from the white terminal block by loosening the corresponding screws in the block.
4. As you install the new heat limiter, **take great care in your replacement procedure!** Make sure all connections are secure.

Note: The heat limiter is not used when the Boost Heat option is employed. This option uses a Watlow 147 Limit Controller for overtemperature protection. Please reference that section for details.

HEATING DESCRIPTION

Heating of the chamber is accomplished with the use of open air low mass nichrome wire heating elements. These elements have low thermal lag and provide rapid response to the controller's demands. The elements are mounted in the conditioning section (plenum). They are isolated from the workspace to prevent direct radiation to the product. The heater bank is rated 500 Watts, consisting of two 250 Watt element racks.

Heater Control:

The heaters are controlled by a time proportioned output from the main controller. This output triggers a triac to conduct and provide power to the elements.

Note: When the optional Boost Heat feature is provided, please reference the corresponding "Options" section for a complete description.

CASCADE REFRIGERATION SYSTEM DESCRIPTION

Capillary Tube Control Description:

This system employs capillary tube type refrigerant control. A long length of seamless copper tubing with a small internal diameter is used to feed the Evaporator Coil. The tube acts as an automatic throttle in controlling refrigerant pressure and flow to the Evaporator Coil. With the compressor running, a high pressure is maintained on the inlet to the capillary tube, and a low pressure is maintained in the Evaporator Coil. The pressures will balance when the compressor is turned off. This places a low starting load on the compressor motor when turned back on. A fine filter, or filter-drier is provided at each capillary tube inlet to remove moisture and dirt from the refrigerant.

Basic System Description:

This is a multiple refrigeration system consisting of a low stage and a high stage system. These systems are integrated to efficiently provide very low temperature levels. This is accomplished by utilizing a cascade condenser in the low stage, where low stage refrigerant is cooled and condensed by the high stage refrigerant. The cooled low stage refrigerant now has greater cooling capacity in the chamber Evaporator Coil.

Low Stage Description:

The low stage system includes the compressor, the cascade condenser, an expansion tank, and the Evaporator Coil located in the chamber conditioning section.

Refrigerant flow in the low stage is from the compressor as a hot compressed gas and then through a desuperheater where most of the heat of compression is removed. The desuperheater is part of the high stage air cooled condenser. As a cooled gas, it then flows to the cascade condenser where it condenses to liquid form by heat exchange with circulating high stage refrigerant. The liquid refrigerant flows through a drier assembly, and is metered through a capillary tube to the evaporator cooling coil in the chamber conditioning section. Warm chamber air circulates through the cooling coil, and heat exchange occurs as the liquid refrigerant boils, vaporizes, and absorbs heat. The vaporized refrigerant returns to the compressor through the suction line. The cycle is repeated.

High Stage Description:

The high stage system includes the compressor, an air cooled condenser, and a suction line accumulator to guard against liquid refrigerant return to the compressor.

Refrigerant Flow:

Refrigerant flow in the high stage is from the compressor as a hot compressed gas, to the air cooled condenser where the gas cools and condenses to liquid form. It then flows to the cascade condenser, being metered by a capillary tube. In the cascade condenser, high stage refrigerant absorbs heat from the circulating low stage refrigerant. As it absorbs heat, the high stage refrigerant boils and vaporizes. It then returns to the compressor through the suction line accumulator SLA. The cycle is repeated.

Safety Devices

Low Pressure Cut-In Switch PS2:

The low stage compressor will start after a slight delay from the Low Pressure Cut-In Switch PS2, which monitors the suction pressure in the high stage compressor. This switch will close when the suction pressure reaches 20 PSIG. This delay prevents both compressors from hitting the power line at the same instant.

High Pressure Cut-In Switch PS1:

An Artificial Loading solenoid valve SV will be energized by the High Pressure Cut-in Switch PS1, when low stage compressor head pressures reaches 280 PSI. This action dumps refrigerant into the expansion tank for storage until the pressure drops to 240 PSI.

Compressor Motor Overloads:

A motor overload protective device is installed in the windings of each compressor, which will open if the motor windings exceed a preset temperature. Probable causes are insufficient flow across the motor due to a refrigerant loss, or a failure of the liquid injection valve provided for suction gas cooling. The motor overload will automatically reset and restart the compressor after the motor has cooled.

NOTE: Please reference the section entitled "Servicing Cascade Refrigeration Systems" for a more detailed description.

ALARM AND SHUTDOWN CIRCUIT (Optional)

A comprehensive alarm and shutdown circuit may be provided for protection against product over/under temperature. This optional feature utilizes a Watlow 93 Controller configured as a TempGard IV temperature protector. The Watlow 93 is a microprocessor based controller that incorporates programmable high and low temperature limits. A one hundred ohm platinum RTD is used for temperature measurement. It is placed at the plenum in the downstream airflow, which is the most responsive area of the chamber.

An electrical schematic of the TempGard IV circuitry will either be included on the main Electrical Schematic, or be on a separate drawing in the Supplemental Instructions Section.

Circuit Operation:

When chamber temperature is within the selected setpoints, the white NORMAL light 2LT is illuminated and Master Contactor CON is energized. The contacts of CON provide power to the conditioning control circuitry. **Note:** A spare set of CON contacts are provided for the customer's closure. It is recommended that these contacts be used to energize an active heat load if utilized.

When a preset temperature limit is reached within the Watlow 93, the alarm contacts TG will open and deenergize CON, which causes the following to occur.

- Power is removed from the main temperature controller and conditioning circuitry.
- Alarm buzzer sounds.
- Alarm and Chamber Overtemp lights on the TempGard IV panel will illuminate. The lower display of the Watlow 93 will blink with the corresponding alarm message, e.g., AHI and HI, or ALO & LO.

WARNING! When Master Contactor CON is deenergized due to an alarm condition, power is only removed from the conditioning control circuitry. The instrumentation and alarm circuitry will still be energized!

A Silence switch 3SS is provided to disable the alarm buzzer while corrective action is taken. When 3SS is activated, the white Silence light 5LT will illuminate. When conditions are corrected, you must reset the chamber power system.

RESET:

To reset the alarm circuitry and the main controller control circuitry, press the Chamber Power switch on the TempGard IV panel. (The Power switch also serves as a Reset switch.)

<u>Important:</u> If the alarm buzzer was disabled and the system was successfully reset with the Power switch 2SS, the alarm buzzer will now sound to alert the operator to place the silence switch 3SS in it's off position.

A 1.5 second timer TC is included in the reset circuit to provide for automatic start when power is applied to the system. This avoids the need for a manual reset each time that power is removed and reapplied.

The configuration for the TempGard IV option is detailed in the section entitled Watlow 93 - TempGard IV Configuration & Use. Please reference the Watlow 93 user manual for complete details of the controller, which is found in the Supplemental Instructions Section.

WATLOW 93 - TEMPGARD IV ALARM SETPOINT ENTRY (Optional)

The purpose of this section is to explain how to set your low & high temperature alarm setpoints with the optional TempGard IV. This feature is part of the optional Alarm And Shutdown Circuit described earlier.

Normal Conditions: When conditions are within the alarm setpoints, the upper display of the Watlow 93 will indicate the process temperature (normally in degrees Celsius), and the lower display will be blank. Temperature measurements are made with a 100 ohm platinum RTD sensor.

Alarm Setpoint Entry Procedure: Disregard parameters not listed. (You will be in the Operation Menu.)

- Press the Advance Key (key with two curved arrows) to scroll to the Alarm Low (ALO) parameter (lower display). Use the Up / Down arrow keys to set the desired low alarm setpoint (upper display).
- Press the Advance Key to scroll to the Alarm High (AHI) parameter (lower display). Use the Up / Down arrow keys to set the desired high alarm setpoint (upper display).
- After setting the low and high limit values, continue scrolling with the Advance Key until the Alarm Low setpoint that you just entered appears in the lower display. It will go blank after a few seconds.

Note: On the old style Watlow 965 Controller, you must press the "M" key to scroll in any menu.

Alarm Conditions: When an out of limit condition occurs, the lower display will flash "HI" or "LO".

Important: When the alarm has cleared, you must press either the Reset switch, or the Chamber Power switch (Models TJR & TUJR only). Both switches are on the TempGard IV panel.

Setup Menu: The Setup Menu is provided for reference only. It has already been configured. **Do not** change any values unless circumstances demand it, such as when you need to change controllers.

To access the Setup Menu, press the Up Arrow and the Down Arrow keys simultaneously. Setup parameters are shown in the lower display. Parameter values appear in the upper display. Press the Advance key to scroll through the menu. Values for the Low Range Limit (rL) and the High Range Limit (rH) are the low and high temperature ratings of your chamber, minus and plus 4 degrees, respectively.

SETUP MENU: WATLOW 93 - TEMPGARD IV			
Parameter	Value	Parameter	Value
LOC	1	Ot2	PrA
In	rtd	HSA	1
dEC	(default)	LAt	nLA
C-F	C	SIL	(default)
rL	Low Limit minus 4 deg.	rtd	din
rH	High Limit plus 4 deg.	LP	OFF
Ot1	ht	PL	100
HSC	(default)	dSP	Pro

BOOST HEAT (Optional)

As an option, your chamber may be equipped with the boost heat feature, which includes extra heaters to provide rapid increases in temperature. The boost heat will automatically turn on if a preset time delay relay times out, indicating that the desired temperature has not been achieved.

As heat output of the main controller energizes the main heater bank, it will at the same time energize time delay relay TC. When this relay times out it will energize mercury relay MR, which provides power to the boost heaters.

With this option the Heat Limiter fuse is not used. In its place, a Watlow 147 Limit Controller 1TS is used to monitor and protect the chamber against an overtemperature condition. This controller is an open board type with an adjustable dial and a calibrated scale for selecting the high limit temperature setpoint. It is installed inside the main control panel. A red LED on the Watlow 147 will illuminate in an alarm condition. A Type T thermocouple is used for temperature measurement. **Note:** The high limit is preset at the factory and should **never** be changed.

When the temperature is below the preset limit, 1TS contacts will be closed to energize contactor CON. Separate contacts of CON are wired in series with both the existing heater elements and the boost heater elements. When the Watlow 147 detects an overtemperature condition, 1TS will open to deenergize CON and all heaters.

The boost heat option is available in a 500 W, and a 1000 W version. A corresponding electrical schematic would be included with each type.

BOOST COOLING (Optional) - Using Liquid Nitrogen, or Carbon Dioxide

As an option, your chamber may be equipped with a boost cooling system utilizing either liquid nitrogen (LN_2), or liquid carbon dioxide (CO_2). When LN_2 is used, the supply may range up to 40 PSIG maximum. When using CO_2, the supply will be rated for either up to 300 PSIG, or up to 1000 PSIG, depending on which option is purchased.

Warning! The gases from these systems displace oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the chamber vent port checkvalve!

An Event output from the main controller must be turned ON to activate the system. For the event number assigned to this option, reference the Event / Function List label affixed to the side of the chamber, or your controller Setup page in the Test Report. Verify the event number assigned before operating your chamber.

Operation:

The boost cooling circuitry can be only be activated when the controller's heat output is in the OFF state. Control relay CR is used to either enable or disable the boost cooling circuitry, based on the heat output status. Turning ON the Boost Cooling Event will activate a ten second on-delay timer TC. After ten seconds, solenoid valve SOL will energize and open to permit the injection of LN_2 / CO_2 into the chamber.

LN_2 systems are provided with a manually set flow adjusting valve, which permits the adjustment of nitrogen flow to avoid incomplete evaporation at varying LN_2 supply pressures. **Incomplete evaporation of nitrogen may damage the door gasket.** A setting of 4 turns open generally provides good performance at a supply pressure of 20 to 25 PSIG. This valve may be readjusted as necessary to accommodate the supply pressure at the end use point.

CO_2 systems are provided with a manually set flow adjusting valve, which permits the adjustment of carbon dioxide flow to avoid incomplete evaporation at varying CO_2 supply pressures. **Incomplete evaporation of carbon dioxide may damage the door gasket.** This setting will vary, depending on the optional supply pressure used. The valve may be readjusted as necessary to accommodate the supply pressure at the end use point.

PURGE AIR SYSTEM (Optional) - Using Compressed Air, or Nitrogen

As an option, your chamber may be equipped with a purge air system utilizing either compressed air, or gaseous nitrogen (GN_2). When compressed air is used, the supply must range from 80 PSIG min. to 100 PSIG max. It should be relatively oil free. When GN_2 is used, the supply may range up to 100 PSIG max.

Warning! Gaseous nitrogen displaces oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the chamber vent port checkvalve!

An Event output from the main controller must be turned ON to activate the system. For the event number assigned to this option, reference the Event / Function List label affixed to the side of the chamber, or your controller Setup page in the Test Report. Verify the event number assigned before operating your chamber.

Compressed Air w/Dryer Purge:

This system incorporates a heatless desiccant dryer for the generation of a controlled flow of dry air into the chamber. When activated, the Event output will energize Solid State Relay SSRx, which then energizes the dryer and the Purge Air solenoid valve ASOL.

The dryer is a twin tower heatless desiccant type that is self regenerating. Each desiccant tower (chamber) contains a compression packed molecular sieve. As the compressed air passes through the sieve, moisture is picked up by the desiccant. The dried air is released through an outlet port and injected into the test chamber's conditioning airflow through solenoid valve ASOL. A small portion of the dried air is passed through a sized orifice to the other tower to purge the desiccant of moisture collected during the previous cycle. There are four distinct phases of the heatless dryer where the compressed air is alternately cycled and dried in each of the two desiccant towers. This is all controlled by integral timers and solenoid valves within the dryer.

A metering valve and flowmeter is supplied as part of the system to establish the design purge flow. The valve should be adjusted until the indicated flow is about 300 cubic feet per hour.

GN_2 Purge:

The GN_2 purge system is primarily utilized to provide an inert atmosphere which minimizes the buildup of moisture and prevents condensation on the product under test. Eliminating the oxygen in the chamber air helps prevent corrosion of the product under test.

When activated, the Event output will energize Solid State Relay SSRx, which then energizes and opens the GNSOL solenoid valve to permit the injection of GN_2. A metering valve and flowmeter is supplied as part of the system to establish the design purge flow. The valve should be adjusted until the indicated flow is about 300 cubic feet per hour.

CHART RECORDER (Optional)

As an option, your chamber may be provided with either a circular or strip type chart recorder to record temperature versus time. This recorder is typically a one pen type which also digitally displays the process value. A 100 ohm platinum RTD is used for temperature measurement and is normally placed in the plenum of the chamber.

The recorder configuration is documented in the Test Report, which is located in the Supplemental Instructions Section. For complete details on the operation of the recorder, please reference the recorder's user's manual which is located in the same section.

LinkTenn SOFTWARE - For Watlow 942 Controller Only (Optional)

Welcome to another unique optional feature developed by Lunaire Limited. LinkTenn software is designed to operate on a remote computer system and provide complete control of Tenney and Lunaire Environmental test chambers. This is accomplished by communicating through a RS232/RS422 interface with the VersaTenn III or Watlow 942, 945, and 988 Controllers. Up to ten chambers may be controlled from one computer with RS422 interface.

LinkTenn software is provided both in a DOS format and in a Windows format on 3½ inch diskettes. In the DOS format, "LinkTenn II" software is designed to work with the VersaTenn III Controller, and "LinkTenn 942" software is designed to work with the Watlow 942 Controller. In the Windows format, "LinkTenn For Windows" software is designed to work with the VersaTenn III and the Watlow 942, 945, and 988 Controllers.

The hardware and software requirements to run LinkTenn software in both formats are listed below.

DOS Format: LinkTenn II & LinkTenn 942

1. Any DOS based computer
2. 256K of RAM memory
3. CGA graphics card
4. DOS 2.0 or higher
5. RS232 computer interface for single chamber control
6. RS422 computer interface for multiple chamber control
7. With IEEE-488 communications, a National Instruments PC2A or compatible card

Windows Format: LinkTenn For Windows

1. Computer with 486 processor or higher
2. Eight Meg of hard drive memory
3. Eight Meg of RAM memory
4. Windows 3.X operating system or higher
5. RS232 computer interface for single chamber control
6. RS422 computer interface for multiple chamber control
7. Currently not available to work with IEEE-488 communications

A sample menu display screen entitled "Program Control" from the LinkTenn For Windows program, is provided in the Supplemental Instructions Section. This screen shows some of the unique features incorporated into the program along with sample setpoints.

When LinkTenn software is provided in either format, a corresponding LinkTenn User's Manual will be provided in the Supplemental Instructions Section.

SEQUENCE OF OPERATION

Make sure the Installation Instructions have been properly followed before operating the chamber. Make sure the power supply plug is secured in the receptacle. All switches should be in the Off position before starting the sequence below.

Chambers Without Watlow 93 TempGard IV Option:

1. Turn on the power source to the chamber (Customer supplied disconnect, or circuit breaker). The display of the main controller should be illuminated.

2. Make sure the door is securely closed.

3. Enter the desired temperature program, or manual setpoints into the main controller.

4. For chambers that include an optional feature, please refer to the appropriate "Optional" manual section for a detailed operational description.

5. Close the Power switch on the main controller panel. The switch green ON light should illuminate. The conditioner fan will start, and chamber conditioning will begin.

Chambers With Watlow 93 TempGard IV Option:

1. Turn on the power source to the chamber (Customer supplied disconnect, or circuit breaker).

2. Press the Chamber Power pushbutton on the TempGard IV panel. The Normal light and the displays of the main controller and the Watlow 93 should be illuminated.

3. Make sure the door is securely closed.

4. Enter the desired temperature program, or manual setpoints into the main controller.

5. Enter the desired high and low limits into the Watlow 93. Refer to the "Alarm And Shutdown Circuit" description, and the "TempGard IV Configuration And Use Instructions" for further details.

6. For chambers that include any other option, please refer to the appropriate "Optional" manual section for a detailed operational description.

7. Close the Power switch on the main controller panel. The switch green ON light should illuminate. The conditioner fan will start, and chamber conditioning will begin.

Important Note! For **complete** programming and/or operating instructions on any of the controllers, electrical / mechanical components, or optional equipment, you must refer to their operating manuals included with your Tenney Environmental manual.

PREVENTIVE MAINTENANCE GUIDE

Only Certified service personnel should ever be permitted to perform any service related procedure on this chamber!

Frequency of preventive maintenance procedures depends upon how the facility is used and upon other circumstances. Because of this, a hard and fast schedule of maintenance operations is difficult to present. Indeed, an inflexible schedule might be suitable for one user, but completely inadequate for another. Therefore, we have provided periodic figures when to perform maintenance procedures, based on the average chamber use.

We suggest that you maintain a preventive maintenance log. In this log you will record operating notes, pressures, temperatures, and electric readings. The log is valuable because it will help maintenance and service people by documenting long term trends and by showing parameter levels when the chamber is operating properly.

Since the refrigeration system is sealed and the instruments are solid state, little maintenance is required on the temperature chamber. However, the following preventive maintenance steps are suggested.

ALL INTERLOCKS AND SAFETY FEATURES SHOULD BE TESTED PERIODICALLY FOR PROPER OPERATION.

1. For air-cooled refrigeration systems, inspect the condenser coil for dust or dirt accumulation that would impede the flow of air. A dirty condenser will decrease system efficiency and drive up compressor head pressure, causing it to trip out. If necessary, clean with a brush or vacuum cleaner. Frequency of cleaning depends upon the air quality at the chamber.
   Period: approx. every 30 days.

2. For water-cooled refrigeration systems, make sure the condenser water supply is according to the specifications listed on the Refrigeration Drawing. If a closed-loop water supply system is not utilized and the water-out port connection is to an open drain, make sure that flow to the open drain is not restricted. Inadequate flow will decrease system efficiency and drive up compressor head pressure, causing it to trip out. **Period: approx. every 30 days.**

3. Inspect the chamber door gasket. Check to see if the door seals tightly around its perimeter. Replace gasket if significant wear is evident. If the gasket doesn't show any sign of wear, check the operation of the door latch. Adjust the door latch if necessary. **Period: approx. every 30 days.**

4. Only after disconnecting all power to the chamber, inspect and clean the conditioner fans / blower wheels, and the condenser fans (air-cooled units). Make sure they spin freely. Make sure that the conditioner fans / blower wheels are tight on their shafts. **Period: approx. every 6 months.**

5. Only after disconnecting all power to the chamber, clean the evaporator coil in the chamber conditioning plenum. **Period: approx. every 6 months.**

6. Only after disconnecting all power to the chamber, inspect inside the machinery compartment and look for loose electrical connections, frayed wires, loose components, or other potential problems.
   Period: approx. every 6 months.

7. Only after disconnecting all power to the chamber, inspect the electric heaters inside the chamber conditioning plenum and look for sagging elements, broken insulators, or other defects.
   Period: approx. every 6 months.

8. If your chamber has the optional TempGard IV, perform the procedure below. Reference the Watlow 93 - TempGard IV manual section. **Period: approx. every 6 months.**

a) **High Setpoint:** Select a temperature setpoint well below the actual workspace temperature in the Operation Menu. The Watlow 93 must transfer to an alarm state, disabling protected circuits.

b) **Low Setpoint:** Select a temperature setpoint well above the actual workspace temperature in the Operation Menu. The Watlow 93 must transfer to an alarm state, disabling protected circuits.

c) The alarm buzzer should sound.

d) If customer's contact closure is used to energize an externally powered heat source, make sure that the contact closure removes power when TempGard IV is in the alarm state.

Important Note: For **complete** preventative maintenance instructions or equipment maintenance instructions on any of the instruments, electrical or mechanical components, or electrical / mechanical machinery and motors, you must refer to their operating manuals included with your Tenney, or Lunaire Environmental manual. The smaller manuals and vendor cut-sheets are located in the Supplemental Instructions Section. Any large manuals that could not fit into this 3-ring blue binder are sent alongside of it.

NOTES:

- The refrigeration system is permanently sealed and a periodic oil change is NOT required.
- If a loss of cooling performance is noted, immediately check the condenser for restricted air or water flow.
- All motors are permanently lubricated; therefore, greasing or oiling is not required.

SERVICING CASCADE REFRIGERATION SYSTEMS

INTRODUCTION

Note: Only Certified service personnel should ever be permitted to perform any service related procedure on this chamber!

This information is written to help the refrigeration serviceman trouble-shoot and repair low temperature cascade systems. It is assumed that the reader is familiar with standard refrigeration practice and is interested in the special techniques applicable to cascade systems.

Important! Please remember that the following description may differ in some respects to the refrigeration system equipped with your particular chamber.

History:

Prior to the development of low boiling point refrigerants such as R13 (-114 deg. F) and R503 (-127 deg. F), reaching ultra low temperatures with mechanical refrigeration was difficult. R22 was used down to -80 deg. F, but its system had serious drawbacks. Large and cumbersome, the machinery was subject to the many troubles that afflict a compound system operating at suctions as low as 23 inches of vacuum. The modern cascade system can reach as low as -120 deg. F with suction pressures of 0 PSIG or higher. Compact, serviceable, and reliable, today's cascade system is found on thousands of environmental test chambers.

How It Works:

Two types of popular cascade systems are expansion valve and capillary tube. The system described in this manual is the capillary tube type.

Refrigerants with low boiling points have correspondingly high condensing pressures at normal ambients. They cannot be liquefied by conventional air or water-cooled condensing units. Therefore, low temperature refrigerants are condensed by a separate refrigeration system called "the high stage". The main job of the high stage in most cascade systems is to condense low stage refrigerant.

High Stage:

The high stage is a conventional single-stage system having a compressor, air or water cooled condenser, expansion valve, and evaporator. The evaporator is the cascade condenser, serving the low stage. Modern systems use R404a in the high stage, making -50 deg. F refrigerant temperature possible at 0 PSIG suction pressure.

Low Stage:

The low stage is charged with refrigerant in vapor phase only to a specified gauge pressure. When the low-stage is idle with all components stabilized at 70 deg. F, it will contain no liquid refrigerant. When the system is activated, the low stage compressor will pump hot gas through the discharge line to the de-superheater (on 1HP units only). The de-superheater (air or water-cooled) removes some heat from the refrigerant gas, lightening the heat load on the cascade condenser. Leaving the de-superheater, the gas passes through an oil separator and flows to the cascade condenser. Here it is liquefied by heat exchange with high stage refrigerant and flows to the expansion valve.

Cascade Condenser:

The cascade condenser is the high stage system's evaporator and low stage system's condenser. It can be either tube-in-tube with the low-stage refrigerant in the outside tube, or tube-in-shell with the low-stage refrigerant in the shell.

De - Superheater (only on 1HP units):

The de-superheater consists of coils as part of the high stage condenser with low stage discharge gas running through them. Its purpose is to remove some heat from the low stage discharge gas and thereby lighten the load on the high-stage system.

Evaporator Coil:

The evaporator coil is part of the low stage system in which the liquid refrigerant boils or evaporates, absorbing heat as it changes into a vapor. The refrigerant flow to the evaporator is metered by a capillary tube type valve.

Capillary Tube:

A capillary tube is a length of tubing of small diameter with the internal diameter held to extremely close tolerances. It is used as a fixed orifice to meter the proper feed of liquid refrigerant.

Thermostat:

A thermostat TS is mounted on the suction return line near the low stage compressor to monitor the temperature of the return gas flow. When a predetermined high temperature is reached, the thermostat will energize the Artificial Loading solenoid 14SOL. The setting is normally 70 degrees Fahrenheit.

Load Limit Switch:

A high pressure cut-in sensor monitors the pressure inside the low stage compressor and will activate the Load Limit Switch 4PS when the low stage discharge pressure reaches 280 PSIG. This will energize the Artificial Loading solenoid 14SOL. 4PS will be deactivated when the pressure falls to 240 PSIG.

Artificial Loading:

In response to the Thermostat switch TS or the Load Limit switch 4PS, the Artificial Loading solenoid will inject liquid refrigerant into the suction side of the low stage. It will first enter the expansion tank where the added volume permits the charging of additional refrigerant without increasing the standby or charging pressure beyond workable limits. Refrigerant gas is then sucked out of the expansion tank and metered through a capillary tube to the suction side of the low stage compressor. This action will maintain a positive cool refrigerant flow to the compressor, preventing overheating of the compressor and the discharge gas.

Expansion Tank:

An expansion tank is provided to add volume to the low stage. Added volume permits the charging of additional refrigerant without increasing the standby or charging pressure beyond workable limits. Refrigerant gas is sucked out of the expansion tank during system operation. It is metered through a capillary tube, regulating the rate of gas entry into the system.

Frosted Lines Are Typical:

A low-stage characteristic is frosted liquid and suction lines. In a normal cascade system, the liquid line is always below +32 deg. F. The suction line, returning from a -100 deg. F evaporator, assuming 15 degree superheat, will also be far below freezing.

Leak Testing:

Loss of refrigerant is the most common cause of refrigeration failure. Because of temperature extremes experienced by its metal parts, the cascade system is particularly susceptible to leaks.

Check the entire system with an electronic leak detector. If the system is empty or at low pressure, boost pressure to 200 PSIG with inert gas (not oxygen) diluted with a percentage of high stage refrigerant. Test again.

A leak check while the system is at low temperature, -80 deg. F or colder, is a necessity. Expansion valve flanges, superheat adjustment caps, and other mechanical joints should be tightened and checked for leaks while at low temperature.

You may use a Halide torch to locate large leaks, but make your final test with the more sensitive electronic leak detector. This is especially important on the low stage. The low stage is gas charged with a relatively small quantity of refrigerant. Because of this, small leaks can quickly incapacitate the system.

Testing by Static Charge:

One advantage of a gas charged system is that its tightness can be checked by periodic observation of static or standby pressure. You must read the pressure with all parts of the system at ambient temperature. This is important. The unit must be shut down at least 24 hours before a static pressure reading is taken. To eliminate the possibility of cooling the cascade condenser with the high-stage, pump-down cycle, all power to the unit must be off during the shut down period.

When reading static pressure, consider ambient temperature. Most static charge data are for a 10 deg. F decrease in temperature. Due to a large system's considerable thermal mass, several days may be required for all components to completely stabilize at a particular ambient.

Evacuation:

Granted, refrigerants R23 and R404a are expensive, but there are times when charges must be recovered. A contaminated system must be cleaned and evacuated regardless of refrigerant expense.

If there is a possibility that moisture, non-condensibles, or the wrong refrigerant contaminated a system, recover the charge and evacuate.

Select a two-stage pump capable of pumping the system down below 200 microns, and connect an appropriate gauge to ready system pressure. The ordinary compound refrigeration gauge is inadequate, however a thermocouple gauge is ideal. Evacuating a leaky system is an exercise in futility; therefore, make sure the system is absolutely tight before beginning evacuation.

Charging a Low Stage:

1. Do not charge liquid into the low stage.

2. Do not charge the system when it is below room temperature.

3. Do not use charging hoses on very high pressure refrigerants or low stage refrigerants. Cylinder pressure exceeds 500 PSIG.

4. Never charge the unit when it is running.

As you will note from the above, low stage charging procedure differs from the conventional method. Correct charging pressure will be noted on the equipment nameplate or in the instructions. Remember, it is important that you charge by pressure, not by volume of refrigerant.

Use 1/4 inch copper tube between refrigerant cylinder and system. Open the cylinder valve very slowly. Charge into the suction side while closely watching the discharge gauge. When correct pressure is reached, shut off the refrigerant cylinder valve, allowing the system to equalize from 10 to 15 minutes. If the pressure drops, crack open the cylinder valve, and slowly raise the pressure. Always take enough time: systems with expansion tanks connected by a capillary tube or restrictor valve may need several minutes for gas pressure to equalize.

Keep the refrigerant cylinder upright when charging. Above all, be careful. Do not over-pressurize. Disconnect the cylinder immediately when charging is complete. A leaky cylinder valve could continue to bleed high pressure refrigerant into the system, possibly causing it to rupture. Do not take chances. The saturation pressures of low temperature refrigerants are extremely high.

TROUBLESHOOTING GUIDE

Only Certified service personnel should ever be permitted to perform any service related procedure on this chamber!

This section does not propose to be a complete and comprehensive troubleshooting guide for the serviceman. However, it attempts to help you locate the causes of possible troubles so that you can make simple repairs or adjustments yourself. The information here should also help you in localizing trouble so that you can better describe the malfunction when contacting the Tenney Service Department. Refer to the appropriate electrical and refrigeration drawings when using these troubleshooting suggestions.

TROUBLESHOOTING GUIDE

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
1. Conditioner Fan Dead	Motor shaft frozen	Verify - rotate by hand carefully!
	Defective motor	Verify - feel for heat & measure current
2. Insufficient Heat	Chamber door is ajar	Close securely
	One heater element is burned out	Verify - measure current
	Controller Failure	Carefully check programming
3. No Heat	Heat Limiter opened	Replace
	Heater elements burned out/open	Replace
	Heat output failing to close	Verify - Call Tenney Service
	Triac 1TRC failed open	Replace
	Open temperature sensor	Replace
4. Excessive Heat	Triac 1TRC failed in conducting state (usual failure mode)	Replace
	Heat output failing to open	Verify - Contact Tenney Service
	Short circuited temperature sensor	Replace
5. Refrigeration System Dead	Cooling output failing to close	Verify - Contact Tenney Service
	Triac 2TRC failing to conduct	Replace
	Compressor motor overload protector has tripped	Wait 5 minutes, if overload does not close - replace it
6. Compressor hums but will not start	Low Line Voltage	Get proper electrical service
	Starting Capacitor is defective	Replace
	Compressor relay defective	Replace
	Internal compressor problem	measure winding resistance, test for grounds, contact Tenney

TROUBLESHOOTING GUIDE - Continued		
PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
7. Repeated shorting or blowing of start capacitors	Excessive start time, voltage too low	Correct low line voltage problem
8. Compressor starts, hums, runs slowly, staying on start winding	Low Line Voltage	Get proper electrical service
	Compressor relay is stuck	Replace
	Shorted winding	Test resistances, test for grounds, Notify Tenney
9. Low Stage Compressor Will Not Run	Pressure switch PS2 not closing	Contact Tenney Service
10. Low Stage Runs, But Little Or No Cooling	Low stage is low on refrigerant	Have system leak tested
	Artificial loading valve SV stuck open full time	Replace
	Main cooling coil badly frosted	Raise temperature to defrost
11. Compressor runs but cools inefficiently	Restricted ventilation, dirty condenser fins	Move unit away from wall, clean condenser fins
12. Refrigeration works long or continuously	Excessive heat load	Reduce load if possible
	Ice on evaporator coil	Defrost
	Low refrigerant Charge	Have charge checked by refrig. mechanic - charges are on ID label
13. Compressor repeatedly trips out overload protector	Pressure switch failure	Have refrigeration mechanic check switches. Contact Tenney Service
14. Noisy Compressors	Compressor loose on mounts	Tighten hold down nuts
15. Noisy compressors, even with secure hold-downs	Broken springs within compressor housing	Replace compressor - Call Tenney for assistance

NOTE: At site ambient temperature, if the chamber does not pull down substantially in temperature within 15 minutes, something is wrong. Turn the chamber off. Let it normalize and defrost. Then, try it again. If it still does not pull down to low temperature, shut it off and get technical help. A refrigeration system which does not cool properly should not be run for prolonged periods. It may have a leak and be low on refrigerant. Since the compressor depends upon cool returning refrigerant for cooling, it can be overheated when operated in an undercharged system.

Remember that the compressors have internal overloads with automatic reset; these are in addition to circuit breakers. Therefore, when a compressor cuts out, it must be given time to cool so that its internal protector has time to reset.

SUPPLEMENTAL INSTRUCTIONS SECTION

RESISTANCE TEMPERATURE TABLE
U.S. INDUSTRIAL SPEC. $R_{100C}/R_{0C} = 1.3911$
PLATINUM RESISTANCE THERMOMETER
100 OHMS AT 0°C.

TABLE 11-100

MINCO PRODUCTS, INC.

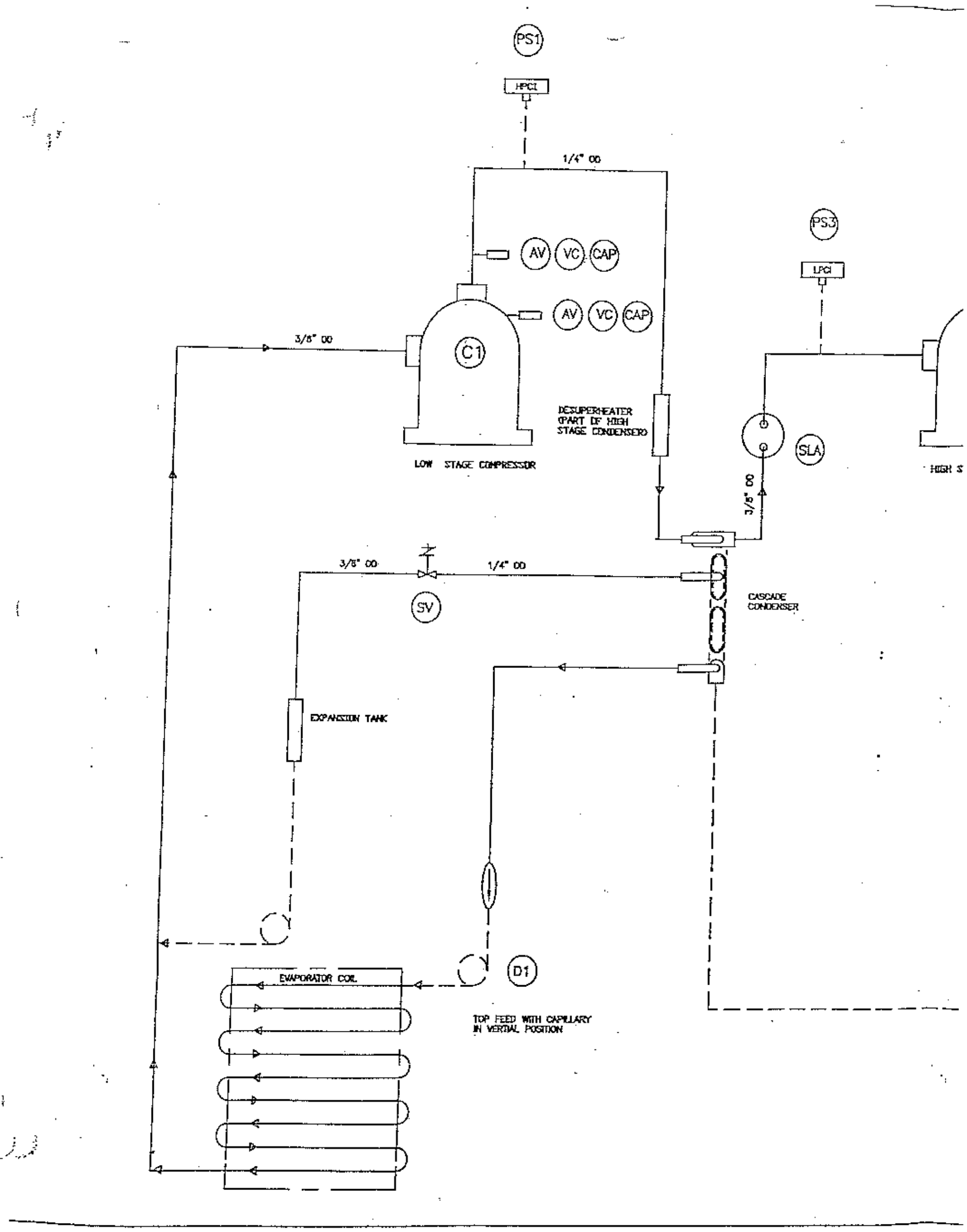
7300 Commerce Lane / Minneapolis, Minnesota 55432 U.S.A. / TWX: 910-576-2848 / Telephone: (612) 571-3121

T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)
-200.0	17.26	-155.0	36.67	-110.0	55.51	-65.0	73.93
-199.0	17.70	-154.0	37.09	-109.0	55.93	-64.0	74.34
-198.0	18.14	-153.0	37.52	-108.0	56.34	-63.0	74.74
-197.0	18.58	-152.0	37.94	-107.0	56.75	-62.0	75.15
-196.0	19.01	-151.0	38.37	-106.0	57.17	-61.0	75.55
-195.0	19.45	-150.0	38.79	-105.0	57.58	-60.0	75.96
-194.0	19.89	-149.0	39.21	-104.0	57.99	-59.0	76.36
-193.0	20.32	-148.0	39.63	-103.0	58.40	-58.0	76.77
-192.0	20.76	-147.0	40.06	-102.0	58.81	-57.0	77.17
-191.0	21.20	-146.0	40.48	-101.0	59.23	-56.0	77.58
-190.0	21.63	-145.0	40.90	-100.0	59.64	-55.0	77.98
-189.0	22.07	-144.0	41.32	-99.0	60.05	-54.0	78.39
-188.0	22.50	-143.0	41.74	-98.0	60.46	-53.0	78.79
-187.0	22.94	-142.0	42.16	-97.0	60.87	-52.0	79.19
-186.0	23.37	-141.0	42.59	-96.0	61.28	-51.0	79.60
-185.0	23.80	-140.0	43.01	-95.0	61.69	-50.0	80.00
-184.0	24.24	-139.0	43.43	-94.0	62.10	-49.0	80.40
-183.0	24.67	-138.0	43.85	-93.0	62.51	-48.0	80.81
-182.0	25.10	-137.0	44.27	-92.0	62.92	-47.0	81.21
-181.0	25.54	-136.0	44.69	-91.0	63.33	-46.0	81.61
-180.0	25.97	-135.0	45.10	-90.0	63.74	-45.0	82.01
-179.0	26.40	-134.0	45.52	-89.0	64.15	-44.0	82.42
-178.0	26.83	-133.0	45.94	-88.0	64.56	-43.0	82.82
-177.0	27.26	-132.0	46.36	-87.0	64.97	-42.0	83.22
-176.0	27.69	-131.0	46.78	-86.0	65.38	-41.0	83.62
-175.0	28.12	-130.0	47.20	-85.0	65.79	-40.0	84.03
-174.0	28.55	-129.0	47.62	-84.0	66.20	-39.0	84.43
-173.0	28.98	-128.0	48.03	-83.0	66.61	-38.0	84.83
-172.0	29.41	-127.0	48.45	-82.0	67.02	-37.0	85.23
-171.0	29.84	-126.0	48.87	-81.0	67.42	-36.0	85.63
-170.0	30.27	-125.0	49.28	-80.0	67.83	-35.0	86.03
-169.0	30.70	-124.0	49.70	-79.0	68.24	-34.0	86.43
-168.0	31.13	-123.0	50.12	-78.0	68.65	-33.0	86.84
-167.0	31.56	-122.0	50.53	-77.0	69.06	-32.0	87.24
-166.0	31.98	-121.0	50.95	-76.0	69.46	-31.0	87.64
-165.0	32.41	-120.0	51.37	-75.0	69.87	-30.0	88.04
-164.0	32.84	-119.0	51.78	-74.0	70.28	-29.0	88.44
-163.0	33.27	-118.0	52.20	-73.0	70.68	-28.0	88.84
-162.0	33.69	-117.0	52.61	-72.0	71.09	-27.0	89.24
-161.0	34.12	-116.0	53.03	-71.0	71.50	-26.0	89.64
-160.0	34.54	-115.0	53.44	-70.0	71.90	-25.0	90.04
-159.0	34.97	-114.0	53.86	-69.0	72.31	-24.0	90.44
-158.0	35.40	-113.0	54.27	-68.0	72.72	-23.0	90.84
-157.0	35.82	-112.0	54.68	-67.0	73.12	-22.0	91.24
-156.0	36.25	-111.0	55.10	-66.0	73.53	-21.0	91.64

T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)
-20.0	92.04	25.0	109.89	70.0	127.50	115.0	144.87
-19.0	92.44	26.0	110.28	71.0	127.89	116.0	145.26
-18.0	92.84	27.0	110.67	72.0	128.28	117.0	145.64
-17.0	93.24	28.0	111.07	73.0	128.66	118.0	146.02
-16.0	93.63	29.0	111.46	74.0	129.05	119.0	146.41
-15.0	94.03	30.0	111.86	75.0	129.44	120.0	146.79
-14.0	94.43	31.0	112.25	76.0	129.83	121.0	147.17
-13.0	94.83	32.0	112.64	77.0	130.22	122.0	147.55
-12.0	95.23	33.0	113.03	78.0	130.60	123.0	147.94
-11.0	95.63	34.0	113.43	79.0	130.99	124.0	148.32
-10.0	96.02	35.0	113.82	80.0	131.38	125.0	148.70
-9.0	96.42	36.0	114.21	81.0	131.77	126.0	149.08
-8.0	96.82	37.0	114.61	82.0	132.15	127.0	149.47
-7.0	97.22	38.0	115.00	83.0	132.54	128.0	149.85
-6.0	97.62	39.0	115.39	84.0	132.93	129.0	150.23
-5.0	98.01	40.0	115.78	85.0	133.32	130.0	150.61
-4.0	98.41	41.0	116.18	86.0	133.70	131.0	150.99
-3.0	98.81	42.0	116.57	87.0	134.09	132.0	151.37
-2.0	99.21	43.0	116.96	88.0	134.48	133.0	151.76
-1.0	99.60	44.0	117.35	89.0	134.86	134.0	152.14
0.0	100.00	45.0	117.74	90.0	135.25	135.0	152.52
1.0	100.40	46.0	118.13	91.0	135.64	136.0	152.90
2.0	100.79	47.0	118.53	92.0	136.02	137.0	153.28
3.0	101.19	48.0	118.92	93.0	136.41	138.0	153.66
4.0	101.59	49.0	119.31	94.0	136.79	139.0	154.04
5.0	101.98	50.0	119.70	95.0	137.18	140.0	154.42
6.0	102.38	51.0	120.09	96.0	137.57	141.0	154.80
7.0	102.78	52.0	120.48	97.0	137.95	142.0	155.18
8.0	103.17	53.0	120.87	98.0	138.34	143.0	155.56
9.0	103.57	54.0	121.26	99.0	138.72	144.0	155.94
10.0	103.96	55.0	121.65	100.0	139.11	145.0	156.32
11.0	104.36	56.0	122.04	101.0	139.49	146.0	156.70
12.0	104.75	57.0	122.43	102.0	139.88	147.0	157.08
13.0	105.15	58.0	122.82	103.0	140.26	148.0	157.46
14.0	105.55	59.0	123.21	104.0	140.65	149.0	157.84
15.0	105.94	60.0	123.60	105.0	141.03	150.0	158.22
16.0	106.34	61.0	123.99	106.0	141.42	151.0	158.60
17.0	106.73	62.0	124.38	107.0	141.80	152.0	158.98
18.0	107.13	63.0	124.77	108.0	142.19	153.0	159.36
19.0	107.52	64.0	125.16	109.0	142.57	154.0	159.74
20.0	107.92	65.0	125.55	110.0	142.95	155.0	160.12
21.0	108.31	66.0	125.94	111.0	143.34	156.0	160.50
22.0	108.70	67.0	126.33	112.0	143.72	157.0	160.87
23.0	109.10	68.0	126.72	113.0	144.11	158.0	161.25
24.0	109.49	69.0	127.11	114.0	144.49	159.0	161.63

T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)
160.0	162.01	205.0	178.91	250.0	195.57	295.0	212.00
161.0	162.39	206.0	179.28	251.0	195.94	296.0	212.36
162.0	162.77	207.0	179.66	252.0	196.31	297.0	212.73
163.0	163.14	208.0	180.03	253.0	196.68	298.0	213.09
164.0	163.52	209.0	180.40	254.0	197.04	299.0	213.45
165.0	163.90	210.0	180.77	255.0	197.41	300.0	213.81
166.0	164.28	211.0	181.15	256.0	197.78	301.0	214.17
167.0	164.65	212.0	181.52	257.0	198.15	302.0	214.54
168.0	165.03	213.0	181.89	258.0	198.51	303.0	214.90
169.0	165.41	214.0	182.26	259.0	198.88	304.0	215.26
170.0	165.79	215.0	182.63	260.0	199.25	305.0	215.62
171.0	166.16	216.0	183.01	261.0	199.61	306.0	215.98
172.0	166.54	217.0	183.38	262.0	199.98	307.0	216.34
173.0	166.92	218.0	183.75	263.0	200.34	308.0	216.70
174.0	167.29	219.0	184.12	264.0	200.71	309.0	217.06
175.0	167.67	220.0	184.49	265.0	201.08	310.0	217.42
176.0	168.05	221.0	184.86	266.0	201.44	311.0	217.79
177.0	168.42	222.0	185.23	267.0	201.81	312.0	218.15
178.0	168.80	223.0	185.60	268.0	202.17	313.0	218.51
179.0	169.17	224.0	185.98	269.0	202.54	314.0	218.87
180.0	169.55	225.0	186.35	270.0	202.90	315.0	219.23
181.0	169.93	226.0	186.72	271.0	203.27	316.0	219.59
182.0	170.30	227.0	187.09	272.0	203.64	317.0	219.95
183.0	170.68	228.0	187.46	273.0	204.00	318.0	220.31
184.0	171.05	229.0	187.83	274.0	204.37	319.0	220.67
185.0	171.43	230.0	188.20	275.0	204.73	320.0	221.03
186.0	171.80	231.0	188.57	276.0	205.09	321.0	221.38
187.0	172.18	232.0	188.94	277.0	205.46	322.0	221.74
188.0	172.55	233.0	189.31	278.0	205.82	323.0	222.10
189.0	172.93	234.0	189.68	279.0	206.19	324.0	222.46
190.0	173.30	235.0	190.05	280.0	206.55	325.0	222.82
191.0	173.68	236.0	190.42	281.0	206.92	326.0	223.18
192.0	174.05	237.0	190.78	282.0	207.28	327.0	223.54
193.0	174.43	238.0	191.15	283.0	207.64	328.0	223.90
194.0	174.80	239.0	191.52	284.0	208.01	329.0	224.26
195.0	175.18	240.0	191.89	285.0	208.37	330.0	224.61
196.0	175.55	241.0	192.26	286.0	208.74	331.0	224.97
197.0	175.92	242.0	192.63	287.0	209.10	332.0	225.33
198.0	176.30	243.0	193.00	288.0	209.46	333.0	225.69
199.0	176.67	244.0	193.37	289.0	209.82	334.0	226.05
200.0	177.04	245.0	193.73	290.0	210.19	335.0	226.40
201.0	177.42	246.0	194.10	291.0	210.55	336.0	226.76
202.0	177.79	247.0	194.47	292.0	210.91	337.0	227.12
203.0	178.16	248.0	194.84	293.0	211.28	338.0	227.48
204.0	178.54	249.0	195.21	294.0	211.64	339.0	227.83

T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)
340.0	228.19	385.0	244.14	430.0	259.86	475.0	275.34
341.0	228.55	386.0	244.50	431.0	260.21	476.0	275.68
342.0	228.91	387.0	244.85	432.0	260.55	477.0	276.02
343.0	229.26	388.0	245.20	433.0	260.90	478.0	276.36
344.0	229.62	389.0	245.55	434.0	261.25	479.0	276.70
345.0	229.98	390.0	245.90	435.0	261.59	480.0	277.05
346.0	230.33	391.0	246.25	436.0	261.94	481.0	277.39
347.0	230.69	392.0	246.60	437.0	262.28	482.0	277.73
348.0	231.04	393.0	246.96	438.0	262.63	483.0	278.07
349.0	231.40	394.0	247.31	439.0	262.98	484.0	278.41
350.0	231.76	395.0	247.66	440.0	263.32	485.0	278.75
351.0	232.11	396.0	248.01	441.0	263.67	486.0	279.09
352.0	232.47	397.0	248.36	442.0	264.01	487.0	279.43
353.0	232.82	398.0	248.71	443.0	264.36	488.0	279.77
354.0	233.18	399.0	249.06	444.0	264.70	489.0	280.11
355.0	233.54	400.0	249.41	445.0	265.05	490.0	280.45
356.0	233.89	401.0	249.76	446.0	265.39	491.0	280.79
357.0	234.25	402.0	250.11	447.0	265.74	492.0	281.13
358.0	234.60	403.0	250.46	448.0	266.08	493.0	281.47
359.0	234.96	404.0	250.81	449.0	266.43	494.0	281.80
360.0	235.31	405.0	251.16	450.0	266.77	495.0	282.14
361.0	235.67	406.0	251.51	451.0	267.11	496.0	282.48
362.0	236.02	407.0	251.86	452.0	267.46	497.0	282.82
363.0	236.37	408.0	252.21	453.0	267.80	498.0	283.16
364.0	236.73	409.0	252.56	454.0	268.15	499.0	283.50
365.0	237.08	410.0	252.90	455.0	268.49	500.0	283.84
366.0	237.44	411.0	253.25	456.0	268.83	501.0	284.18
367.0	237.79	412.0	253.60	457.0	269.18	502.0	284.51
368.0	238.15	413.0	253.95	458.0	269.52	503.0	284.85
369.0	238.50	414.0	254.30	459.0	269.86	504.0	285.19
370.0	238.85	415.0	254.65	460.0	270.21	505.0	285.53
371.0	239.21	416.0	255.00	461.0	270.55	506.0	285.87
372.0	239.56	417.0	255.34	462.0	270.89	507.0	286.20
373.0	239.91	418.0	255.69	463.0	271.24	508.0	286.54
374.0	240.27	419.0	256.04	464.0	271.58	509.0	286.88
375.0	240.62	420.0	256.39	465.0	271.92	510.0	287.22
376.0	240.97	421.0	256.74	466.0	272.26	511.0	287.55
377.0	241.33	422.0	257.08	467.0	272.61	512.0	287.89
378.0	241.68	423.0	257.43	468.0	272.95	513.0	288.23
379.0	242.03	424.0	257.78	469.0	273.29	514.0	288.56
380.0	242.38	425.0	258.13	470.0	273.63	515.0	288.90
381.0	242.74	426.0	258.47	471.0	273.97	516.0	289.24
382.0	243.09	427.0	258.82	472.0	274.32	517.0	289.57
383.0	243.44	428.0	259.17	473.0	274.66	518.0	289.91
384.0	243.79	429.0	259.51	474.0	275.00	519.0	290.25


PS1
HPCI
1/4" OD
AV
VC
CAP
AV
VC
CAP
3/8" OD
C1
LOW STAGE COMPRESSOR
DESUPERHEATER (PART OF HIGH STAGE CONDENSER)
PS3
LPCI
SLA
3/8" OD
3/8" OD
1/4" OD
SV
CASCADE CONDENSER
EXPANSION TANK
EVAPORATOR COIL
D1
TOP FEED WITH CAPILLARY IN VERTIAL POSITION

Operation and Maintenance Manual

Tenney Junior with Watlow 942

Tenney
ENVIRONMENTAL

Lunaire Limited

ON and OFF Switch

The ON and OFF switch only controls the circuits described below. It does not disconnect power. The only way to disconnect all power is to disconnect the power cord.

Circuits energized by the On switch

1. fan motor for conditioner
2. pilot light
3. Arms temperature output #1, which arms the heating elements, relay 1CR, and the artificial loading valve.
4. Arms output # 2, which energizes the high-stage compressor, allows the low-stage cut-in switch to start the low-stage compressor, and energizes the coil to relay 1CR (This relay's contacts then reduce heater power from 500 to 250 watts, and simultaneously place the artificial loading valve under command of the controller's output #1. In this configuration, when the controller calls for heat, the controller energizes the 250-watt heater and simultaneously opens the artificial loading valve to reduce refrigeration capacity).

Controller
Watlow 942
made by Watlow Controls
Phone 507-454-5300

The Watlow 942 is a sophisticated device, capable of executing a number of complicated tasks. A great deal of information must be transmitted through a limited display. As a result, many messages in the display are written in a form of alphanumeric shorthand. It is important that you understand the meaning of the symbols. This information is presented in the Watlow manual.

We will give you the basic concepts, but you will need the Watlow manual for the details and more esoteric information.

We suggest that you start with chapter 5.

REFRIGERATION CHARGE AND SET-UP

High stage: 14 oz; Low stage: 78 psig @ 72° F

PRESSURE SWITCHES
Low stage: suction @ 20 psi
By-pass (to prevent high head pressure): releases at 280 psi.

In addition to ordinary cleaning, oiling hinges, and general housekeeping maintenance, we suggest a few simple, periodic preventive maintenance measures.

The refrigeration compressors are hermetically sealed, internally sprung, and are not user serviceable. However, examine them occasionally, making sure they are well secured and that vibration has not chafed pressure or suction lines. Be sure each starting capacitor, relay, and thermal overload are firmly clipped in place on the hermetic unit.

Once or twice a year, clean the condenser coil with a vacuum cleaner and brush. Frequency of cleaning depends upon the dustiness of your location. To get at the coil, remove the right panel.

As required, clean the inside of the chamber. Carefully clean the blades of the conditioner fan. Tenney's Humiclean is an excellent metal cleaner for use in all environmental chambers and is available from our service department.

Inspect the door seals, making sure the door closes tightly. Even the smallest leak can degrade thermal performance.

Make sure the chamber has not been pushed into a tight corner where its refrigeration system cannot breathe. Also, see that it is not operating on an extension cord, and finally, make sure the chamber is well grounded.

Electrical

Item	Measurement	Resistance
Compressor	common term	4.8 Ohms
Compressor	common term	1 Ohms
Compressor	common term	Infinite
Conditioner	across terminals	20 Ohms
Heater element	HL to 3	55 Ohms
Heater element	HL to 4	55 Ohms
Solenoid valve	across coil	80 Ohms
Temperature	across terminals	100 Ohms
Condenser fan	across terminals	37 Ohms

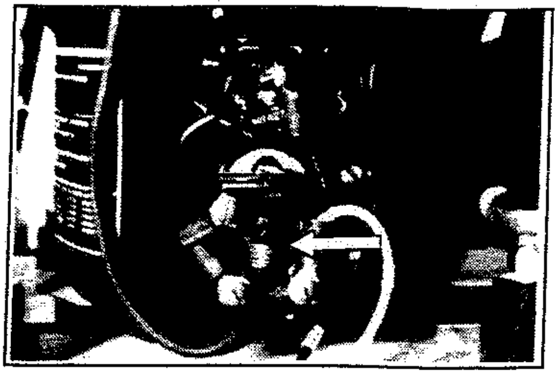
A good ohmmeter is a great help in trouble shooting the electrical and control system. The use of an ohmmeter and reference to the schematic drawing included with this manual should help you locate difficulties.

The Chart is a tabulation of more important "normal" resistances measured on new equipment at room temperature. Remember, though, that resistances vary considerably from item to item and ohmmeters deviate from one instrument to another. Use the table of values as a guide, realizing that moderate variations do not necessarily indicate trouble.

Satisfactory refrigeration performance depends on good line voltage at all times. Incoming power lines should be heavy enough that voltage never drops below 104 volts measured close to the compressor motor terminals. If the compressors seem to struggle when starting, measure this important voltage.

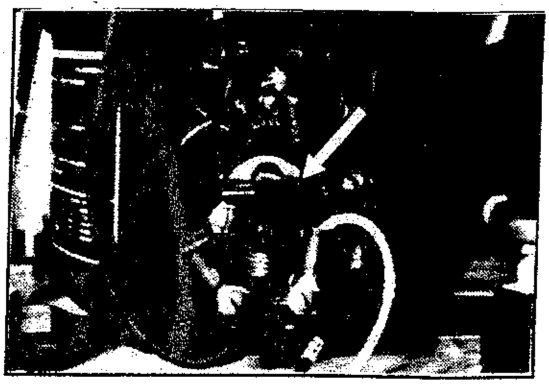
Note: Terminal arrangement on the Copeland compressor units is as follows: There are 3 terminals. Center top one (12 o'clock position) is common. Going clockwise to the 4 o'clock position is the run winding terminal. Around the 8 o'clock position is the start winding terminal. All are insulated from ground. See photos under specific tasks.

003 Replacement of compressor relay

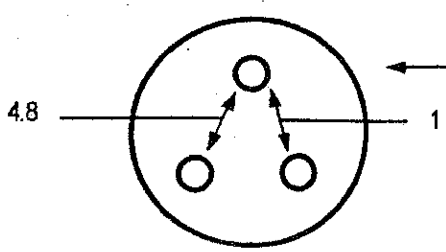


Unplug unit from power outlet and remove side panel.
Remove relay cover by releasing the spring clip.
Disconnect and mark wires. Note wiring description that is printed in relief on the inside of the relay cover.
Pull relay off of its mounting pins.
Installation is the reversal of this procedure.

004 Measurement of winding resistances



Unplug from power outlet.
Remove right hand side panel.
Locate relay, which is attached to compressor housing. *The compressor wiring is always described in a diagram that is printed on the inside of the relay cover.* The relay cover is easily removed by releasing the spring clip that holds it in place. Once the cover has been removed, you shall see the compressor relay, as shown. Pull the relay away from the pin connexions to which it is affixed. The pins shall be arranged as depicted in the drawing. Use an Ohm meter. Note: see page 8 for other resistance checks.



Item	Measure	Resistance
Compressor Start	common	4.8 Ohms
Compressor Run	common	1 Ohms
Compressor	common	Infinite

005 Location of pressure switches

The Tenney Jr is equipped with two pressure switches, located just above each of the compressors, as shown. The low stage switch is set for 20 psi, and the other switch, which by passes the second stage when high chamber temperatures might induce excessive head pressure, is set to dump at 280 psi.
Examination of the switches can only be carried out by refrigeration mechanic. If you suspect a problem, call Tenney.

SUPPLEMENTAL USE INSTRUCTION

for

OPTIONAL BOOST COOLING

using

LIQUID NITROGEN or CARBON DIOXIDE

Boost cooling systems are activated by an event output from the VersaTenn II or Watlow 942 controller (depending on the type chamber purchased). Cooling is achieved by injecting either LN2 or CO2, depending on the option purchased, into the chamber through a solenoid valve.

To use the system, the event must be turned on as explained in the appropriate instument manual.

Event No. 1 is generally used for this function. However, a reference table defining the function of each event is affixed to the control panel of each chamber. Please check this table before operating the chamber. NOTE: Altitude chambers use Events No. 1 and No 2 for altitude operation; the boost cooling system will therefore generally be activated by Event No. 3.

Once enabled through the event, the cooling will turn on if a demand for cooling exists for a preset time period. A timer connected to the time proportioned output of the controller "times out" and energizes the cooling solenoid valve if the output is 100 percent "ON" indicating a need for additional cooling.

When the desired temperature is attained and the controller output begins to turn on and off, the boost cooling function will cease to come on.

LN2 systems are provided with a manually set flow adjusting valve provided to allow for adjusting the flow to avoid incomplete evaporation at varying LN2 supply pressures. A setting of 4 turns open generally provides good performance at a supply pressure of 20 to 25 PSIG. This valve may be readjusted as necessary to accomodate the supply pressure at the end use point.

Tenney Environmental
1090 Springfield Road
Union, N.J.

SERVICING

CASCADE REFRIGERATION SYSTEMS

TENNEY ENVIRONMENTAL
1090 Springfield Road
Union, N.J

Introduction

This information is written to help the refrigeration serviceman repair and trouble-shoot low temperature cascade systems. It is assumed that the reader is familiar with standard refrigeration practice and is interested in the special techniques applicable to cascade systems.

History

Prior to the development of low boiling point refrigerants such as R 13 (-114°F) and R 503 (-127°F), reaching ultra low temperatures via mechanical refrigeration was difficult. R 22 was used down to -80°F, but its system had serious drawbacks. Large and cumbersome, the machinery was subject to the many trouble which afflict a compound system operating at suctions as low as 23" of vacuum.

The modern cascade system can reach as low as -120°F with suction pressures of 0 PSIG or higher. Compact, serviceable, and reliable, today's cascade system is found on thousands of environmental test chambers.

How It Works

Two types of cascade systems are popular expansion valve and capillary tube. Both are discussed in the text, and capillary systems are shown in the schematics which comprise part of this paper.

Refrigerants with low boiling points have correspondingly high condensing pressures at normal ambients. They cannot be liquefied by conventional air or water cooled condensing units. Therefore, low temperature refrigerants are condensed by a separate refrigeration system called "the high stage". The sole job of the high stage in most cascade systems is to condense low stage refrigerant.

High Stage

The high stage is a conventional single stage system having a compressor, air or water cooled condenser, expansion valve , and evaporator. The evaporator is the cascade condenser, serving the low stage. Modern systems use R 502 in the high stage, making -50°F refrigerant temperature possible at 0 psig suction pressure.

Low Stage

The low stage is charged with refrigerant in vapor phase only, to a specified gauge pressure. When the low stage is idle with all components stabilized at 70°F, it will contain no liquid refrigerant. When the system is activated, the low stage compressor will pump hot gas through the discharge line to the de-superheater. The de-superheater, air or water cooled, removes some heat from the refrigerant gas, lightening the heat load on the cascade condenser. Leaving the de-superheater, the gas passes through an oil separator, then flows to the cascade condenser where it is liquefied by heat exchange with high stage refrigerant flows to the expansion valve.

Expansion Valve

The expansion valve meters refrigerant to the cooling coil located in the workspace. In the coil, refrigerant evaporates, absorbs heat, then returns to the compressor as a cold gas.

Frosted Lines Are Typical

A low stage characteristic is frosted liquid and suction lines. In a normal cascade system, the liquid line is always below +32°F. The suction line, returning from a -100°F evaporator, assuming 15° superheat, will also be far below freezing.

Expansion Tank

An expansion tank is provided to add volume to the low stage. Added volume permits the charging of additional refrigerant without increasing the stand-by or charging pressure beyond workable limits. Refrigerant gas is sucked out of the expansion tank during system operation: It is metered through a constant pressure valve, capillary tube, or needle valve, the valve or restriction regulating rate of gas entry into the system.

Load Limit Valve

Connected between expansion tank and discharge side of the low stage, a load limit valve acts as a relief device. It bleeds down or dumps gas into the expansion tank when low stage discharge pressure reaches valve setting, usually 185 to 240 psig. High pressures are generated when the low stage starts up but the load limit valve, acting as a relief, prevents the compressor from cycling on and off in response to signals from the high pressure cutout.

Leak Testing

Loss of refrigerant is the most common cause of refrigeration failure. Because of temperature extremes felt by its metal parts, the cascade system is particularly susceptible to leaks.

Check the entire system with an electronic leak detector. If the system is empty or at low pressure, boost pressure to 200 psig with inert gas (not oxygen!) diluted with a percentage of R 12. Test again.

A leak check while the system is at low temperature, -80°F or colder, is a must. Tighten and leak check expansion valve flanges, superheat adjustment caps and other mechanical joints while at low temperature.

You may used a halide torch to locate large leaks, but make your final test with the more sensitive electronic leak detector. This is especially important on the low stage. The low stage is gas charged with a relatively small quantity of refrigerant. Because of this, small leaks can quickly incapacitate the system.

Testing By Static Charge

One advantage of a gas charged system is that its tightness can be checked by periodic observation of static or standby pressure. You must read the pressure with all parts of the system at ambient temperature. This is important. The unit must be shut down at least 24 hours before a static pressure reading is taken. To eliminate the possibility of cooling the cascade condenser via the high stage pump-down cycle, all power to the unit must be off during the shut down period.

When reading static pressure, consider ambient temperature. Most static charge data are for a 10°F decrease in temperature. Due to a large system's considerable thermal mass, several days may be required for all components to completely stabilize at a particular ambient.

Evacuation

Granted, refrigerants 13 and 503 are expensive, but there are times when charges must be reclaimed. A contaminated system must be cleaned and evacuated regardless of refrigerant expense.

If there is a possibility that moisture , non-condensibles or the wrong refrigerant contaminate a system, reclaim the charge and evacuate.

Select a two-stage pump capable of pumping the system down below 200 microns, and connect and appropriate gauge to read system pressure. The ordinary compound refrigeration gauge is inadequate, but a thermocouple gauge is ideal. Evacuating a leaky system is an excerise in futility; therefore, make sure the system is absolutely tight before beginning evacuation.

Charging a Low Stage

1. Do not charge liquid into the low stage.

2. Do not charge the system when it is below room temperature.

3. Do not use charging hoses on R 13 or R 503. Cylinder pressure exceeds 500 psig.

4. Never charge the unit when it is running.

As you will note from the above, low stage charging procedure differs from the conventional method. Correct charging pressure will be noted on the equipment nameplate or in the instructions. Remember, it is important that you charge by pressure, not by volume of refrigerant.

Use 1/4" copper tube between refrigerant cylinder and system. Open the cylinder valve very slowly. Charge into the suction side while closely watching the discharge gauge. When correct pressure is reached, shut off the refrigerant cylinder valve, allowing the system to equalize from 10 to 15 minutes. If the pressure crops crack open the cylinder valve, slowly raise the pressure. Always take enough time: System with expansion tanks connected by a capillary tube or restrictor valve may need several minutes for gas pressure to equalize.

Keep the refrigerant cylinder upright when charging. Above all, be careful! Don't over-pressurize. Disconnect the cylinder immediately when charging is complete. A leaky cylinder valve could continue to bleed high pressure refrigerant into the system, possibly causing it to rupture. Don't take chances; the saturation pressures of low temperature refrigerants are extremely high.

Drawing No. 1

A small cascade system, using two 1/3 hp hermetic compressors is delineated in this schematic. The high stage is charge with 14 oz. of R 12 the low stage carrying a static pressure of 52 psig at room temperature. 10 c. c. of pentane is added to the low stage charge to help prevent waxing of the lubricant at extremely low temperatures.

Flow of refrigerant in the high stage is from compressor C2 to the air cooled condenser. As a liquid R 12 flows from condenser to capillary tube direr assembly D2 which meters refrigerant to the cascade condenser. After evaporating in the condenser assembly, which is a heat-exchanger, R 12 returns to the compressor C2 via the suction line and accumulator ACC.

Function of pressure switch PS2 is to energize the low stage compressor after the high stage has started. Purpose of the arrangement is to prevent both compressors from hitting the power line at the same instant.

Refrigerant flow in the low stage is from the compressor through the de-superheater to the cascade condenser where gaseous R 503 is cooled and liquefied. Capillary tube assembly D1 meters R 503 into the evaporator 11771-2 which cools the chamber. From the evaporator, refrigerant returns to the compressor via the suction line.

Excess refrigerant is stored in the expansion tank and is fed back to the system on demand through capillary tube 5.

Solenoid valve SV serves two purposes: On a cooling "off" cycle it functions as an artificial loading valve, partially by-passing the evaporator and reducing cooling capacity. Refrigeration is modulated through this valve, not by cycling of the compressors. Valve SV also functions as a dump valve. Responding to signals from pressures with PS1, it opens when head pressure exceeds a predetermined pressure setpoint, typically 280 psig.

Drawing No. 2

The refrigeration system shown is similar to the described on drawing No. 1. Hot gas from high stage compressor C2 is used to heat the chamber door mullion before entering air cooled condenser CON/20/ Switch PS2 energizes the low stage compressor, and switch PS1 operates the dump valve SV14, that valve also being under command of the temperature controller which uses it to modulate refrigeration capacity.

Drawing No. 3

When operated in cascade mode, the system shown on this schematic functions essentially the same as the two systems previously described. R 502 flow is from compressor C2, through mullion heater to condenser, then through cap tube assembly D/9 to the cascade condenser. Return flow is via the suction line and accumulator ACC/21. Flow of R 503 is from compressor through cascade condenser and cap tube D/8 to the low temperature coil, then back to the compressor through the suction line. Valve SV14 functions as modulating (artificial loading) and dump valve in the usual manner.

Low stage R 503 compressor C1 is shut down when the system operates in single stage mode for "ambient" cooling and workspace de-humidification. R 502 flow is then as follows:

After being liquefied in the condenser CON/20, refrigerant flow to solenoid valves SV1 and SV4. When the dry bulb temperature controller calls for cooling, it opens valve SV1, admitting refrigerant to the ambient cooling coil. After evaporating, the R 12, as a cool gas, returns to the compressor via evaporator pressure regulator AEV/6 and suction line Purpose of the regulator AEV/6 is to prevent the ambient coil from operating too cold, a condition which is undesirable when the chamber is being operated at high humidity.

When the wet bulb controller or humidity control signals for decreased workspace humidity, control voltage is applied to solenoid valve SV4. Refrigerant is admitted to the de-humidification coil, returning to the high stage compressor via the suction line.

Capillary tube D/9 which feeds the cascade condenser is not valved off while the high stage operates in "ambient" single stage configuration. It functions as a by-pass so that when solenoid valves SV1 and SV4 are both closed there remains a path through which refrigerant can circulate. On most larger systems, this line is valved off, and other forms of by-pass are provided.

CASCADE REFRIGERATION GLOSSARY

Cascade Condenser - is the high stage system's evaporator and low stage system's condenser. Can be either tube in tube with the low stage refrigerant in the outside tube or tube in shell with the low stage refrigerant in the shell.

De-superheater - can be either air or water cooled. Its purpose is to remove some heat from the low stage discharge gas and thereby lighten the load on high stage condenser are used as the de-superheater. Water cooled de-superheaters are either tube in tube or shell in tube. The water flow is usually in series with the high stage condenser.

Low Stage - is the low temperature stage or system that cools the chamber or work space evaporator. Common low stage refrigerants are R 13, R 503, and R 14. Low stage refrigerants have low boiling points and correspondingly low condensing temperatures.

High Stage - usually R 12, or R 22, is used to cool the low stage condenser. Some high stage systems are used, as a separate function, to provide moderate cooling for the chamber work space.

Load Limit Valve - is sometimes called dump or blow dow valve. Located between the discharge side of the low stage sand the expansion tank, this valve opens, allowing gas to flow into the tank, thereby reducing head pressure.

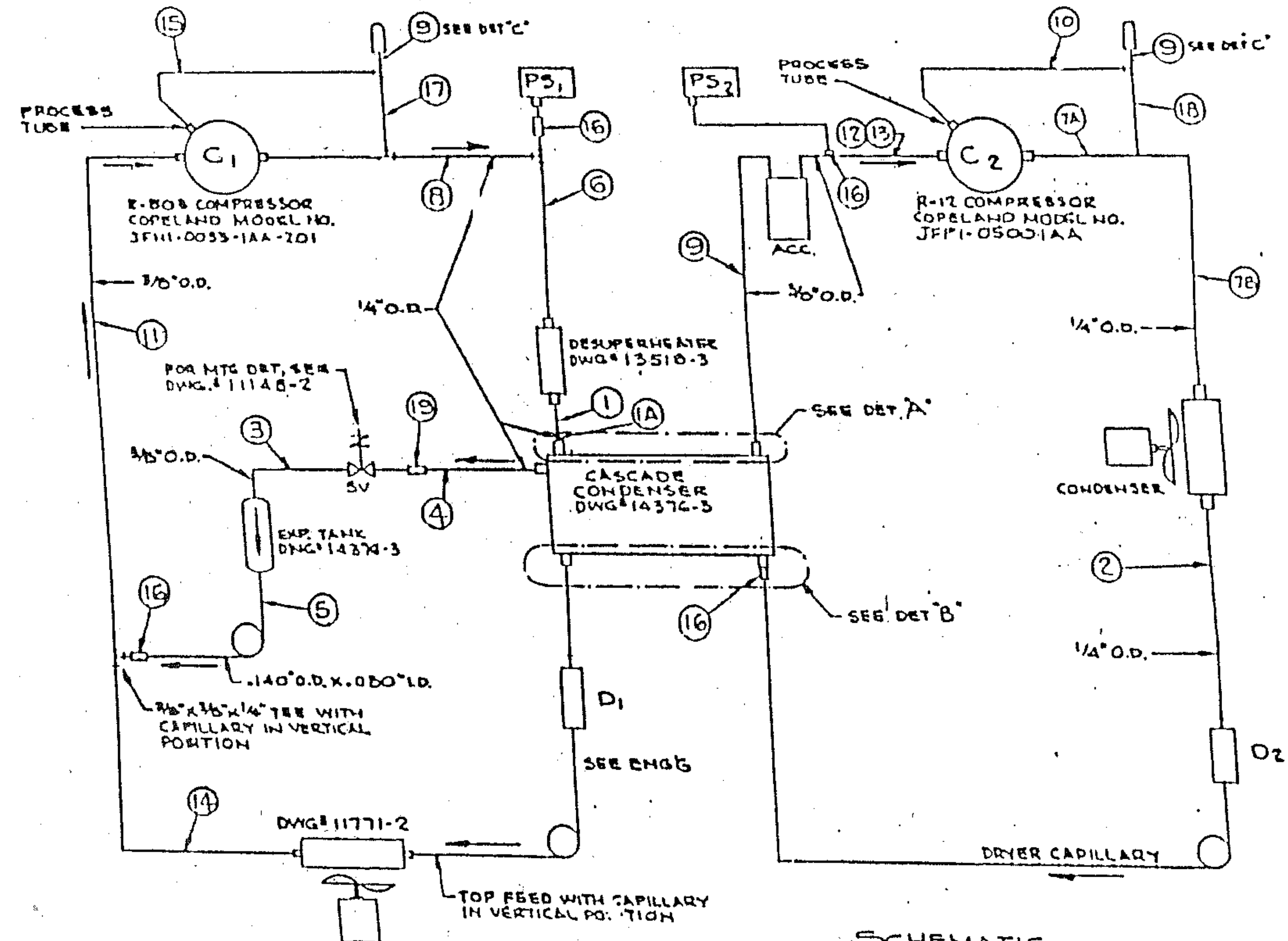
Expansion Tank - is used in the low stage to provide additional system volume. It allows the use of sufficient refrigerant charge, while maintaining reasonable standby or static pressure.

Static Charge - is the gauge pressure indicated in the low stage. The equipment manufacturer will designate proper static or stand-by pressure for a particular unit. A typical nameplate will specify low stage R 13, 7 lbs. static 120 psig. This means that if you add R 13 gas to an evacuated unit, until system pressure is 120 psig, you will have removed 7 lbs. from your cylinder.

Pull Down Time - is the length of time required to lower air in the chamber work space from ambient, a nominal 70°F, to desired low temperature. The temperature is measured at the discharge of the fan. Air is normally drawn over the evaporator and discharged into the work space.

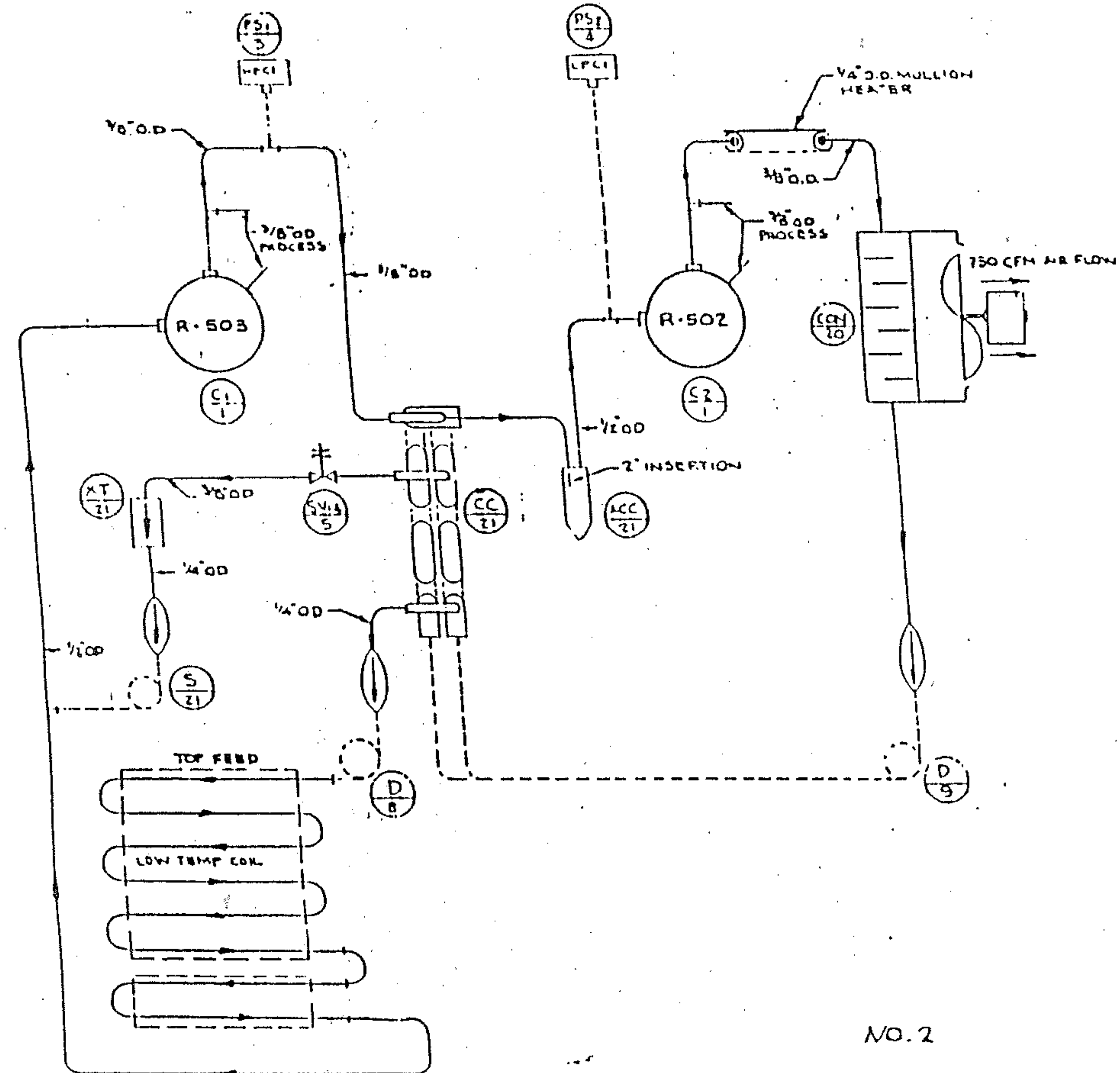
Sub Zero Cooling - is the term used to describe the mode of cooling wherein the low stage refrigerant is used to cool the work space.

Ambient Cooling - describes the high stage unit being used to cool the work space via its own evaporator.



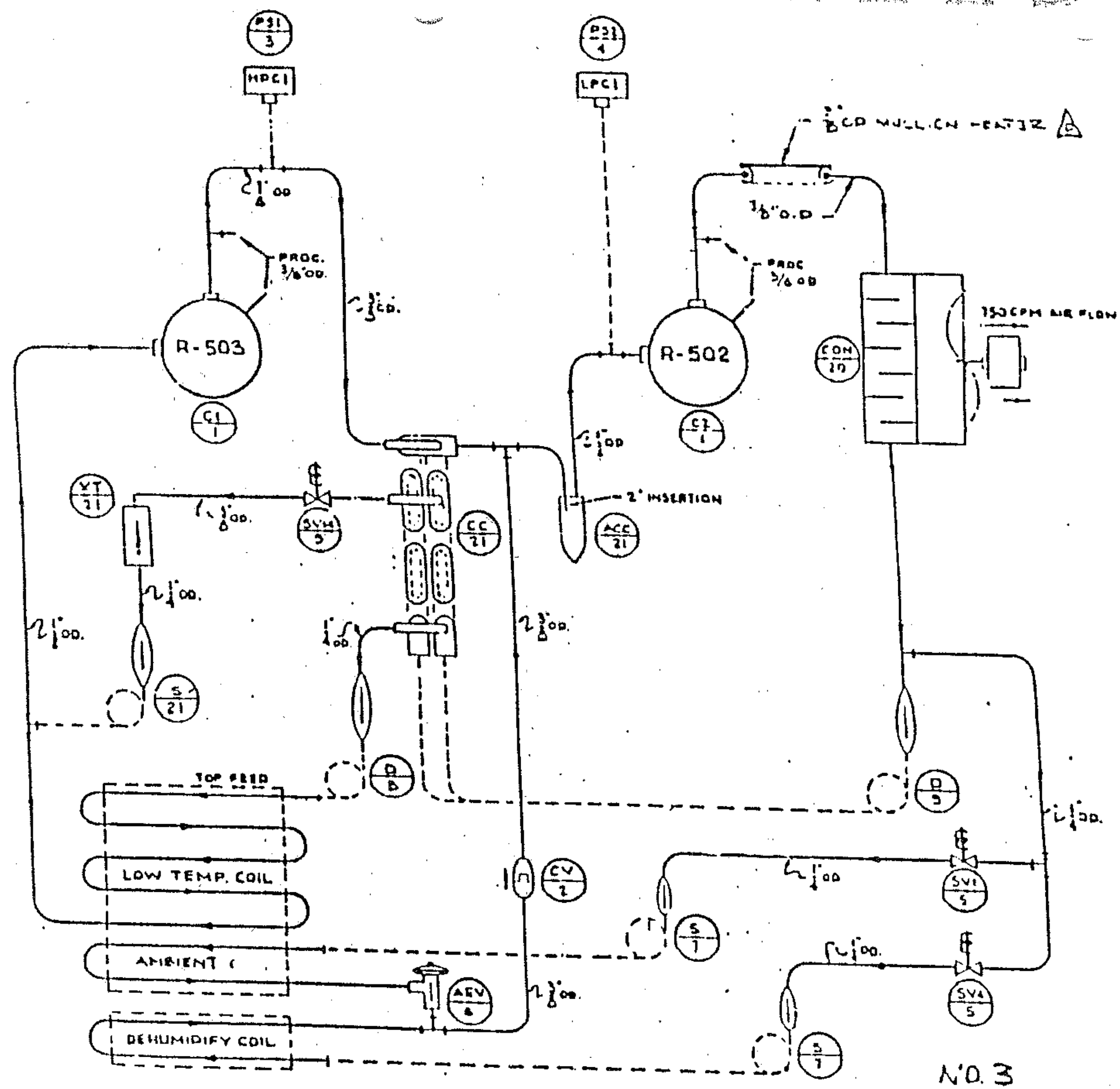
SCHEMATIC

NO.1



PSI 3
HPCI
PSI 4
LPCI
1/4" O.D. MULLION HEATER
3/8" O.D.
3/8" OD PROCESS
3/8" O.D
7/8" OD PROCESS
1/8" OD
R-503
R-502
C1 1
C2 1
750 CFM AIR FLOW
CON 20
1/2" OD
2" INSERTION
ACC 21
CC 21
XT 21
3/8" OD
SV13 5
1/4" OD
1/2" OD
S 21
D 8
D 9
TOP FEED
LOW TEMP COIL

NO. 2



R-503
R-502
HPC1
LPC1
PROC. 3/8" OD.
PROC 3/8 OD
2" INSERTION
LOW TEMP. COIL
AMBIENT
DEHUMIDIFY COIL
TOP FEED

NO. 3

WARNING

ACCESSING THE WATLOW SERIES 942 PROGRAMMERS SETUP MENU OR CHANGING ANY OF THE FACTORIES PRESET VALUES WILL EFFECT THE OPERATION OF THE CHAMBER AND WILL VOID ANY WARRANTY.

CHANGING ANY OF THESE VALUES WILL VOID ANY WARRANTIES.

WARNING

A1HI

Alarm 1 High: This parameter represents the high process alarm or high deviation alarm for Alarm 1. This parameter appears if your unit has an auxiliary output and Ot3 = AL. See the model number. If AL 1 = Pr: **Range:** A1LO to rH **Default:** rH
AL 1 = dE: **Range:** 0 to -999°F/0 to -999°C/0 to -999 Units **Default:** -999°F

A2LO

Alarm 2 Low: Represents the low process alarm or low deviation alarm for Alarm 2. Appears if your unit has an auxiliary output and Ot4 = AL. See the model number. If AL 2 = Pr: **Range:** rL to A2HI **Default:** rL
If AL 2 = dE: **Range:** 0 to -999°F/0 to -999°C/0 to -999 Units **Default:** -999°F.

A2HI

Alarm 2 High: Represents the high process alarm or high deviation alarm for Alarm 2.. Appears if your unit has an auxiliary output and Ot4 = AL. See the model number. If AL 2 = Pr: **Range:** A2LO to rH **Default:** rh
If AL 2 = dE: **Range:** 0 to -999°F/0 to -999°C/0 to -999 Units **Default:** -999°F

CAL

Calibration Offset: Adds or subtracts degrees from the input signal.
Range: -99°F to 99°F/-55°C to 55°C/-99 Units to 99 Units; or -99.9°F to 99.9°F/-55.5°C to 55.5°C **Default:** 0

AUt

Auto-Tune: This parameter initiates auto-tune for Output 1 in the heating mode only. This parameter appears if Ot1 = ht. For more information on Tuning see Chapter 6. **Range:** 0 = off, 1 = slow, 2 = medium, 3 = fast **Default:** 0

Table 3 -
Operation Menu Parameters and Descriptions.

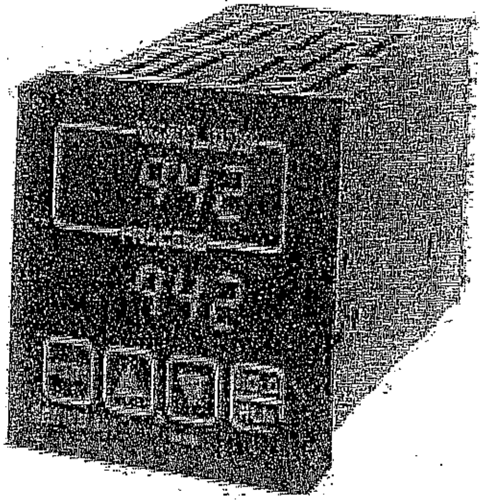
Operation Parameters	Value	Range	Factory Default
SP		OFF/rL to rH	75°F
Prog		YES or no	no
Ent1		On or OFF	OFF
Ent2		On or OFF	OFF
Pb1	4	If dFL = US: 0 - 999°F/0 - 555°C/0 - 999 Units 0 - 99.9°F/0 - 55.5°C/0 - 99.9 Units If dFL = SI: 0 to 999.9% 0 = ON/OFF control. HYS1 = switch. diff.	25°F 3.0%
Pb2 DO NOT CHANGE	0	Same as Pb1. Will not appear if Ot 2 = no.	0°
rE1/It1	.10	Reset: 0.00 to 9.99 repeats/min. Integral: 0 and 00.1 to 99.9 min./repeat 0.00 = no reset. Will not appear if Pb1 = 0.	0.00 repeats/min.
rE2/It2	N/A	Same as rE1. Will not appear if Pb2 = 0.	0.00 repeats/min.
rA1/dE1	.05	0.00 to 9.99 min. 0.00 = No Rate. Will not appear if Pb1 = 0	0.00 min.
rA2/dE2	N/A	Same as rA1. Will not appear if Pb2 = 0.	0.00 min.
Ct1	3.0	1 to 60 seconds Won't appear if Pb1 = 0, or output 1 is 4-20	5 seconds
Ct2	N/A	1 to 60 seconds Will not appear if Pb2 = 0 or Ot2 = no.	5 seconds
db DO NOT CHANGE	-5	± 0 - 99°F/± 0 - 55°C/0 - 99 Units. ± 0.0 - 9.9°F/0.0 - 5.5°C/0.0 - 9.9 Units Appears if ht/CL or CL/ht.	0
A1LO - Deviation dE Process Pr	N/A	-999° to 0° rL to A1HI Appears if auxiliary output and Ot3 = AL.	-999° rL
A1HI - Deviation dE Process Pr	N/A	0° to 999° A1LO to rH Appears if auxiliary output and Ot3 = AL.	999° rH
A2LO- Deviation dE Process Pr	N/A	-999° to 0° rL to A2HI Appears if auxiliary output and Ot4 = AL.	-999 rL
A2HI- Deviation dE Process Pr	N/A	0° to 999° A2LO to rH Appears if auxiliary output and Ot4 = AL.	999° rH
CAL		± 99°F/± 55°C/± 99 Units	0
AUt NEVER USE	NO	0 to 3	0

Table 2 -
Setup Menu Parametersand Descriptions.

Setup Parameters	Value	Range	Factory Default
LOC	/	0 to 3	0
In		J, K (appears as H), t, n, c, r, S, b, Pt2, rtd1, rtd.1, 0-5, 420 Dependent on model number.	J or r
dEC		0, 0.0, or 0.00 Dependent on input type.	0
C _ F	C	C or F Will not appear if In = 0-5 or 420.	F
rL		rL to rH	Input selection dependent.
rH		rH to rL	Input selection dependent.
Ot1	ht	ht or CL	ht
HYS1	3.0	1°F - 999°F, 1°C - 540°C, 1U - 999U 0.1°F - 99.9°F, 0.1°C - 54.0°C, 0.1U - 99.9U	3°F
Ot2 Do Not Change	CL	ht, CL or no	CL
HYS2 Do Not Change	7	1°F - 999°F, 1°C - 540°C, 1U - 999U 0.1°F - 99.9°F, 0.1°C - 54.0°C, 0.1U - 99.9U	3°F
Ot3	N/A	AL, Ent or no	AL
AL1	N/A	Pr or dE	Pr
LAt 1	N/A	LAt or nLA Dependent on AL 1 = Pr or dE.	nLA
HYS3	N/A	1°F - 999°F, 1°C - 540°C, 1U - 999U 0.1°F - 99.9°F, 0.1°C - 54.0°C, 0.1U - 99.9U	3°F
SIL	N/A	On or OFF	OFF
Ot4	N/A	AL, Ent, no, PrOC or StPt	AL or PrOC
AL 2	N/A	Pr or dE	Pr
LAt 2	N/A	LAt or nLA	nLA
HYS4	N/A	1°F - 999°F, 1°C - 540°C, 1U - 999U 0.1°F - 99.9°F, 0.1°C - 54.0°C, 0.1U - 99.9U	3°F
rtd		JIS or din	din
PtYP	ti	ti or rAtE	ti
gSd	0.0	0 - 99°F, 0 - 55°C, 0 - 99U 0.0 - 9.9°F, 0.0 - 5.5°C, 0.0U - 9.9U	0
POUt	Cont	Cont, HOLd, Abrt or rSET	Cont
PStr	StPt	Proc or StPt	StPt
bAUd		300, 600, 1200, 2400, 4800, 9600	1200
dAtA		7 o = Odd parity, 7 E = Even parity 8 n = 8 data bits and no parity	7 o
Prot		FULL or On	FULL
Addr		0 to 31	0
Log		On or OFF	OFF
Int		0.0 to 60.0 minutes	0.0
tag		PSA, PS-, P-A, P--, -SA, -S-, --A, --- P = Process, S = Set point A = Auxiliary Status	---

Series 942

User's Manual



TOTAL
CUSTOMER
SATISFACTION

OPERATIONAL

1/4 DIN
Microprocessor-Based
Ramping Control

WATLOW

Watlow Controls

1241 Bundy Blvd., P.O. Box 5580, Winona, MN 55987-5580, Phone: 507/454-5300, Fax: 507/452-4507

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Figures, Tables, Charts

Chapter 1

The Watlow Series 942, A Microprocessor-Based Control

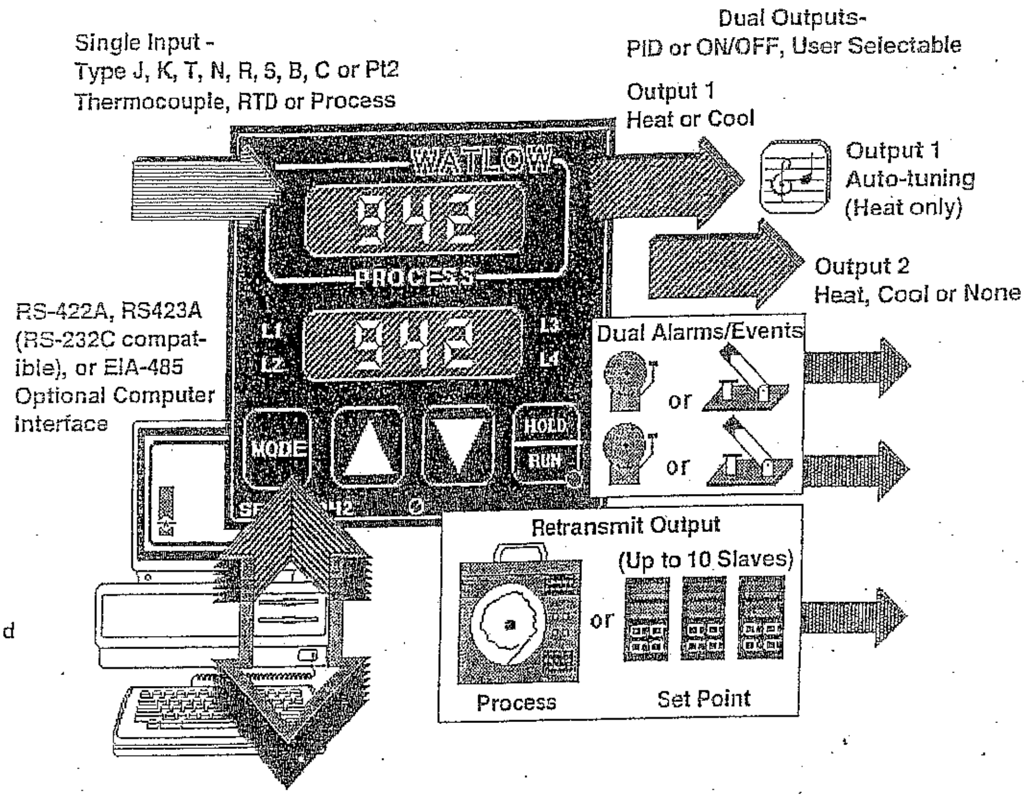


Figure 1 -
Series 942 Input and Output Overview.

General Description

Welcome to the Watlow Series 942, a 1/4 DIN microprocessor-based ramping temperature control. It is a single input, dual output, auto-tuning control with 24 step program capability and easy fixed set point operation. The 942 accepts a Type J, K, T, N, R, S, B, C or Platinel 2 thermocouple, RTD, or process input. The primary output is heating or cooling, while the secondary output can be heating, cooling or none.

With the Series 942 you can select either PID or ON/OFF for Output 1 or 2. You can input a complete set of PID parameters for both outputs, including proportional band, reset/integral and rate/derivative. You can also select automatic tuning for Output 1 while in the heating mode. By setting either output's proportional band to zero, the Series 942 becomes a simple ON/OFF control with the switching differential selectable under the HYS Setup parameter.

Two optional auxiliary outputs may be alarms or events. An event is an ON/OFF mechanical relay output. Events are based on time, and can trigger peripheral equipment or processes. An optional retransmit output is offered in lieu of one of the auxiliary outputs. Select either retransmit of process variable or set point.

Operator-friendly features include automatic LED indicators to aid in monitoring and setup, as well as a calibration offset at the front panel. The Watlow Series 942 automatically stores all information in a non-volatile memory.

How to Open the 942

Before going further, open the Series 942 and pull the control chassis from its case. Here's how:

The control chassis fastens to the case with a single standard screw located on the

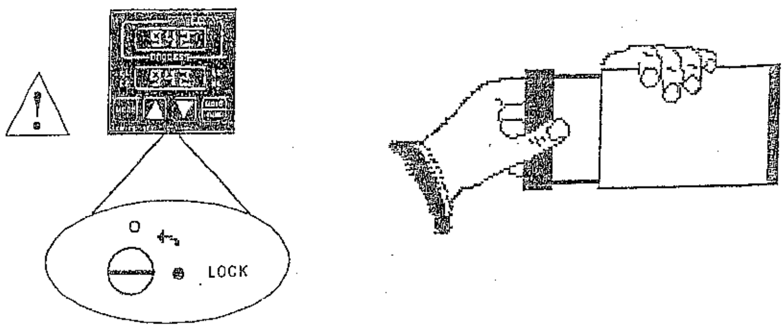


Figure 2 - How to Open the Series 942.

WARNING: The front panel screw turns 90° only. Do not apply excessive force or turn the screw more than 90°.

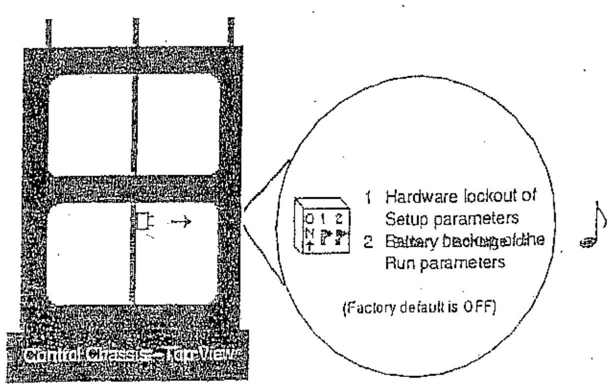
Three strip connector plugs, in the rear of the control chassis, feed power and signals through the back of the case to the terminal strips. These plugs will let go as you pull.

When removing the Series 942 control from its case, pull firmly but gently. When returning the control to the case, be sure you have the top up to match the plugs with the case. The 942 will not fit in the case upside down, but check to be sure it is oriented correctly. Press the unit in firmly, then turn the front panel screw clockwise to secure it. This insures proper electrical contact.

How to Set the DIP Switches

The Watlow Series 942 has a Dual In-line Package (DIP) switch inside the control on the A007-1954 circuit board (middle board). The location of the board and switch appear below. The switches are clearly numbered. When Switch #1 is ON, the Setup parameters can be viewed but not changed. When Switch #2 is ON, it provides battery backup of the Run parameters. When the control leaves the factory, both switches are OFF.

Figure 3 - DIP Switch Location and Orientation.



NOTE: The lithium battery has a life of approximately ten years. When the battery expires, Pout and Run are affected (see Chapters 4 & 5). Return the unit to the factory for a replacement.

Operation Menu

In the Operation menu, the 942 operates as a digital set point control. Select a set point and the 942 attains that value on a non-linear ramp. If your unit has auxiliary outputs programmed as events, they can be selected as ON or OFF. All outputs are turned OFF when set point is set to OFF.

NOTE:
The Upper display always returns to the process value after 1 minute without key strokes.

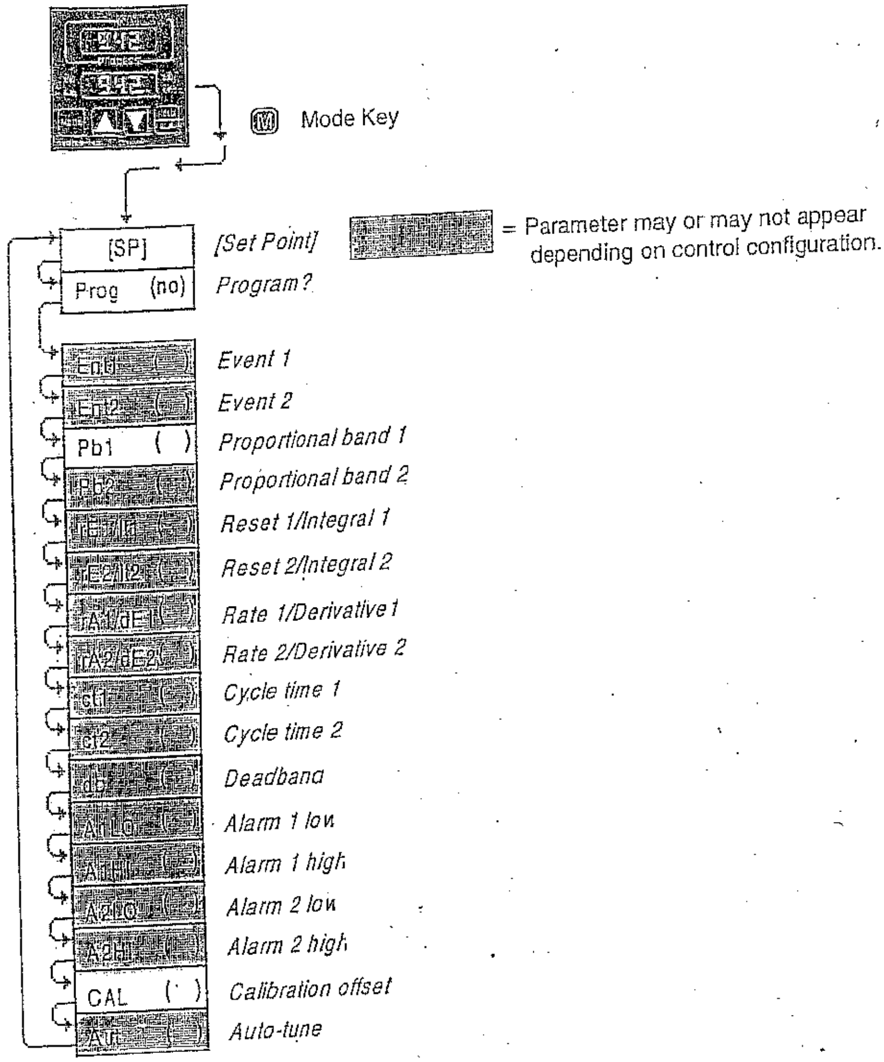


Figure 34 -
The Operation Menu.

Operation Parameters

[SP]

Set Point: Sets the operating set point for the control outputs. "SP" does not appear, the control set point value will. Decrementing the set point below rL displays OFF in the lower display. This disables all outputs except deviation alarm outputs, which remain energized.
Range: OFF/ rL to rH **Default:** Dependent on input range

Prog (no)

Program: Select whether you want to enter the Program menu or enter the Operation menu. By selecting no, you continue to the Operation menu.
Range: YES or no **Default:** no

Ent1

Ent1: Select whether Event 1 (Output 3) is ON or OFF. When a profile is complete or has been put on hold, it holds at its previous state. Only appears if Ot3 = Ent, and your unit has auxiliary outputs. For more information on events see Chapter 6. **Range:** On or OFF **Default:** OFF

Ent2

Ent2: Select whether Event 2 (Output 4) is ON or OFF. When a profile is complete or has been put on hold, it will hold at its previous state. This parameter only appears if Ot4 = Ent, and your unit has auxiliary outputs. For more information on events see Chapter 6. **Range:** On or OFF **Default:** OFF

Pb1

Proportional Band 1: A proportional band expressed in degrees or process units, or % of span, within which a controller proportioning function is active for Output 1. When Pb1 = 0, it functions as an ON/OFF control. The switching differential is then determined by the HYS1 parameter. If dFL = US: **Range:** 0 to 999°F/0 to 555°C/0 to 999 Units; 0.0 to 99.9°F/0.0 to 55.5°C/0.0 to 99.9 Units **Default:** 25°F/2.5°F
If dFL = SI: **Range:** 0 to 999.9% of span **Default:** 3.0%
Span is defined as the operating range of the input sensor or rL to rH if the input type is 0-5 or 420.

Pb2

Proportional Band 2: A proportional band expressed in degrees or process units, or in % of span, within which a controller proportioning function is active for Output 2. When Pb2 = 0, it functions as an ON/OFF control. The switching differential is determined by the HYS2 parameter. This parameter will not appear if your unit does not have a secondary output or Ot2 = no. If dFL = US: **Range:** 0 to 999°F/0 to 555°C/0 to 999 Units; 0.0 to 99.9°F/0.0 to 55.5°C/0.0 to 99.9 Units **Default:** 0°
If dFL = SI: **Range:** 0 to 999.9% of span **Default:** 0.0%

rE1/It1

Reset /Integral1: A reset (integral) control action for Output 1 automatically eliminating offset, or "droop," between set point and actual process temperature in a pro-portional control. Will not appear if your unit does not have a secondary output, or Pb1 = 0. **Reset Range:** 0.00 to 9.99 repeats/minute **Integral Range:** 0 and 00.1 to 99.9 minutes/repeat **Default:** 0.00

rE2/It2

Reset /Integral 2: A reset (integral) control action for Output 2 that automatically eliminates offset, or "droop," between set point and actual process temperature in a proportional control. This parameter will not appear if your unit does not have a secondary output, or Pb 2 = 0, or if Ot 2 = no. **Reset Range:** 0.00 to 9.99 repeats/minute **Integral Range:** 0 and 00.1 to 99.9 minutes/repeat **Default:** 0.00

rA1/dE1

Rate /Derivative 1: The rate (derivative) function for Output 1 of the Series 942. The rate is determined by how fast the error is changing. This parameter will not appear if Pb 1 = 0. **Range:** 0.00 to 9.99 minutes **Default:** 0.00

rA2/dE2

Rate/Derivative 2: Rate (derivative) function for Output 2. Rate is determined by how fast the error is changing. Does not appear if your unit does not have a secondary output, Pb 2 = 0, or Ot 2 = no. **Range:** 0.00 to 9.99 min. **Default:** 0.00

Ct1

Cycle Time 1: Expressed in seconds, time for a controller to complete one ON/OFF cycle for Output 1. Time between successive turn ons. This parameter will not appear if Pb 1 = 0, or Output 1 is a process output.
Range: 1 to 60 seconds **Default:** 5

Ct2

Cycle Time 2: Expressed in seconds, time for a controller to complete one ON/OFF cycle for Output 2. Time between successive turn ons. This parameter will not appear if your unit does not have a secondary output, Pb 2 = 0, or Ot 2 = no.
Range: 1 to 60 seconds **Default:** 5

db

Dead Band: The area between Output 1 and 2 where no heating or cooling takes place in a heat/cool proportional control. This parameter only appears if your unit is set up as a ht/CL or CL/ht unit. **Range:** ±0 to 99°F/0 to 55°C/0 to 99 Units; or ±0.0 to 9.9°F/0.0 to 5.5°C/0.0 to 9.9Units **Default:** 0

A1LO

Alarm 1 Low: Represents the low process alarm or low deviation alarm for Alarm 1. This parameter only appears if you have an auxiliary output and Ot3 = AL. See the model number. If AL 1 = Pr: **Range:** rL to A1HI **Default:** rL
If AL 1 = dE: **Range:** 0 to -999°F/0 to -999°C/0 to -999 Units **Default:** -999°F

A1HI

Alarm 1 High: This parameter represents the high process alarm or high deviation alarm for Alarm 1. This parameter appears if your unit has an auxiliary output and Ot3 = AL. See the model number. If AL 1 = Pr: **Range:** A1LO to rH **Default:** rH
AL 1 = dE: **Range:** 0 to -999°F/0 to -999°C/0 to -999 Units **Default:** -999°F

A2LO

Alarm 2 Low: Represents the low process alarm or low deviation alarm for Alarm 2. Appears if your unit has an auxiliary output and Ot4 = AL. See the model number. If AL 2 = Pr: **Range:** rL to A2HI **Default:** rL
If AL 2 = dE: **Range:** 0 to -999°F/0 to -999°C/0 to -999 Units **Default:** -999°F.

A2HI

Alarm 2 High: Represents the high process alarm or high deviation alarm for Alarm 2. Appears if your unit has an auxiliary output and Ot4 = AL. See the model number. If AL 2 = Pr: **Range:** A2LO to rH **Default:** rh
If AL 2 = dE: **Range:** 0 to -999°F/0 to -999°C/0 to -999 Units **Default:** -999°F

CAL

Calibration Offset: Adds or subtracts degrees from the input signal.
Range: -99°F to 99°F/-55°C to 55°C/-99 Units to 99 Units; or -99.9°F to 99.9°F/-55.5°C to 55.5°C **Default:** 0

AUt

Auto-Tune: This parameter initiates auto-tune for Output 1 in the heating mode only. This parameter appears if Ot1 = ht. For more information on Tuning see Chapter 6. **Range:** 0 = off, 1 = slow, 2 = medium, 3 = fast **Default:** 0

Table 3 -
Operation Menu Parameters and Descriptions.

Operation Parameters	Value	Range	Factory Default
SP		OFF/rL to rH	75°F
Prog		YES or no	no
Ent1		On or OFF	OFF
Ent2		On or OFF	OFF
Pb1		If dFL = US: 0 - 999°F/0 - 555°C/0 - 999 Units 0 - 99.9°F/0 - 55.5°C/0 - 99.9 Units If dFL = SI: 0 to 999.9% 0 = ON/OFF control. HYS1 = switch. diff.	25°F 3.0%
Pb2		Same as Pb1. Will not appear if Ot 2 = no.	0°
rE1/It1		Reset: 0.00 to 9.99 repeats/min. Integral: 0 and 00.1 to 99.9 min./repeat 0.00 = no reset. Will not appear if Pb1 = 0.	0.00 repeats/min.
rE2/It2		Same as rE1. Will not appear if Pb2 = 0.	0.00 repeats/min.
rA1/dE1		0.00 to 9.99 min. 0.00 = No Rate. Will not appear if Pb1 = 0	0.00 min.
rA2/dE2		Same as rA1. Will not appear if Pb2 = 0.	0.00 min.
Ct1		1 to 60 seconds Won't appear if Pb1 = 0, or output 1 is 4-20	5 seconds
Ct2		1 to 60 seconds Will not appear if Pb2 = 0 or Ot2 = no.	5 seconds
db		± 0 - 99°F/± 0 - 55°C/0 - 99 Units. ± 0.0 - 9.9°F/0.0 - 5.5°C/0.0 - 9.9 Units Appears if ht/CL or CL/ht.	0
A1LO - Deviation dE Process Pr		-999° to 0° rL to A1HI Appears if auxiliary output and Ot3 = AL.	-999° rL
A1HI - Deviation dE Process Pr		0° to 999° A1LO to rH Appears if auxiliary output and Ot3 = AL.	999° rH
A2LO- Deviation dE Process Pr		-999° to 0° rL to A2HI Appears if auxiliary output and Ot4 = AL.	-999 rL
A2HI- Deviation dE Process Pr		0° to 999° A2LO to rH Appears if auxiliary output and Ot4 = AL.	999° rH
CAL		± 99°F/± 55°C/± 99 Units	0
AUt		0 to 3	0

Chapter 5

How to Program & Run the Series 942

We begin this chapter by introducing the Program menu. Each parameter is clearly defined. A description of a few Series 942 features follows, along with a sample profile to experiment with programming the Series 942. You will quickly grasp the necessary terms and concepts by entering and observing your profiles. Enter your profile values in the Master Step Chart at the end of the chapter.

PROGRAM Menu

Create your profiles here in the Program menu. Your profile can have up to 24 steps. Choose one step type per step.

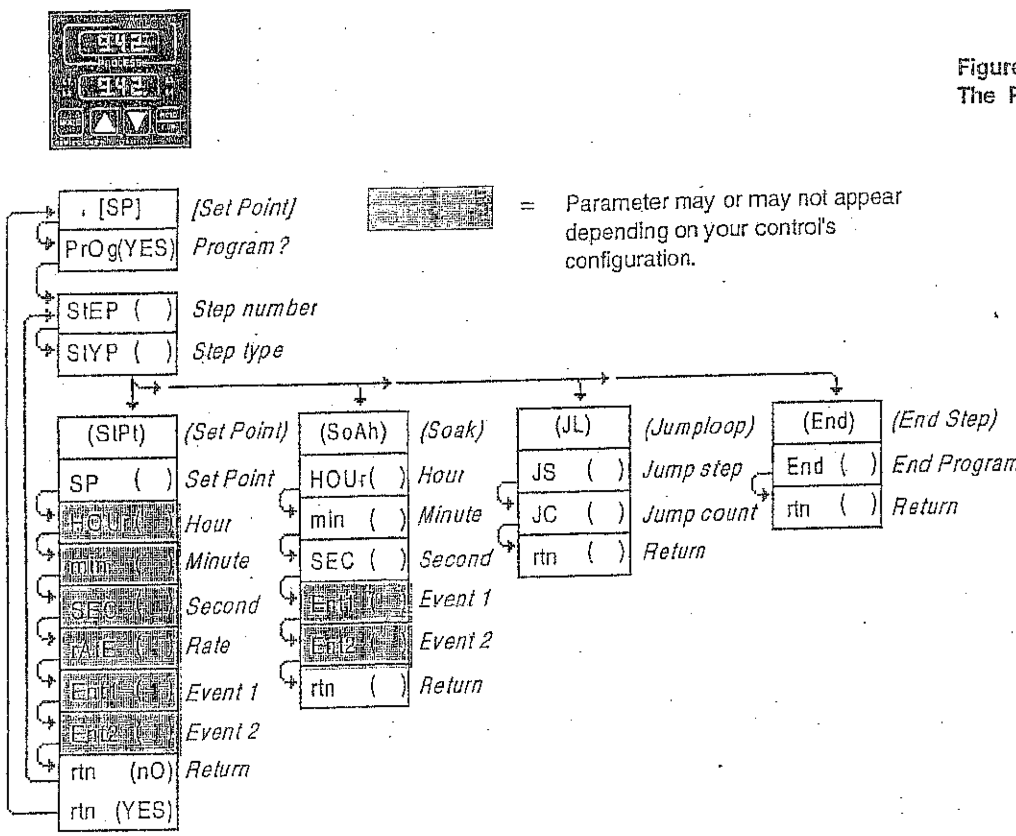


Figure 35 -
The Program Menu.

Program Parameters

Prog (YES)

Program: Select whether you want to enter the Operation or the Program menu. Selecting YES continues into the Program menu.
Range: YES or no **Default:** no

StEP

Step: Represents the current step of the profile to be edited or viewed. When selecting Step 1, you will not see the JL step type.
Range: 1 to 24 **Default:** 1 then automatic increment

StYP

Step Type: Choose from four different step types.
Range: StPt, SoAh, JL or End **Default:** End

(StPt)

Set Point Step (StPt) : The following parameters are associated with the set point step.

SP

Set Point: Represents the temperature the system tries to achieve. This is done linearly, producing a ramp from a beginning set point to an end set point.
Range: rL to rH **Default:** 75°F/24°C or rL value if rL ≥ 75°F/24°C or if rH≤ 75°F/24°C

HOUr

Hour: The number of hours, in combination with the Min and SEC parameters, equaling total step time to achieve the temperature under the StPt step type. This parameter only appears if PtYP = ti.
Range: 0 to 23 **Default:** 0

Min

Minutes: The number of minutes, in combination with the HOUr and SEC parameters, equaling total step time to achieve the temperature under the StPt step type. This parameter only appears if PtYP = ti.
Range: 0 to 59 **Default:** 0

SEC

Seconds: The number of seconds, in combination with the HOUr and Min parameters, equaling total step time to achieve the temperature under the StPt step type. This parameter only appears if PtYP = ti.
Range: 0 to 59 **Default:** 0

rAte

Rate: Represents the rate at which the set point changes in degrees per minute. This parameter only appears if PtYP = rAte.
Range: 0 to 360°F/0 to 200°C or 0.0 to 360.0°F/0.0 to 200.0°C **Default:** 0.0

Ent1

Event 1: Selects whether Event 1 is on or off. This parameter only appears if Ot3 = Ent.
Range: On or OFF **Default:** OFF

Ent2

Event 2: Selects whether Event 2 is on or off. This parameter only appears if Ot4 = Ent.
Range: On or OFF **Default:** OFF

rtn

Return: Select no and you return to the StEP parameter to continue programming. By selecting YES, you exit the program menu and return to the control set point.
Range: YES or no **Default:** no

Soak (SoAh) : The following parameters are associated with the soak step. (SoAh)

Hour: The number of hours, in combination with the Min and SEC parameters, equaling total step time to achieve the temperature under the SoAh step type. This parameter only appears if PtYP = ti. HOUr
Range: 0 to 23 **Default:** 0

Minutes: The number of minutes, in combination with the HOUr and SEC parameters, equaling total step time to achieve the temperature under the SoAh step type. This parameter only appears if PtYP = ti. Min
Range: 0 to 59 **Default:** 0

Seconds: The number of seconds, in combination with the HOUr and Min parameters, equaling total step time to achieve the temperature under the SoAh step type. This parameter only appears if PtYP = ti. SEC
Range: 0 to 59 **Default:** 0

Event 1: Selects whether Event 1 is on or off. Only appears if Ot3 = Ent. Ent1
Range: On or OFF **Default:** OFF

Event 2: Selects whether Event 2 is on or off. Only appears if Ot4 = Ent. Ent2
Range: On or OFF **Default:** OFF

Return: Select no and you return to the StEP parameter to continue programming the 942. By selecting YES, you exit the program menu and return to the control set point. rtn
Range: YES or no **Default:** no

Jumploop Step (JL) : The following parameters are associated with the jumploop step. When StEP = 1, JL will not appear. (JL)

Jump Step: The Series 942 jumps backwards to any step in your file. JS
Range: 1 to 23 **Default:** 1

Jump Count: The number of times the Series 942 jumps to the step specified by the JS (jump step) parameter. 0 = infinite number of jumps. JC
Range: 0 to 100 **Default:** 0

Return: Select no and you return to the StEP parameter to continue programming the Series 942. By selecting YES, you exit the program menu and return to the control set point. **Range:** YES or no **Default:** no rtn

End Step (End) : The following parameters are associated with the end step. (End)

End: When HOLd is selected, the control and auxiliary outputs are enabled and maintain the same state as in the last set point and/or soak step before the End step was encountered. When selected as OFF, the control and auxiliary outputs (except for deviation alarms) are de-energized and OFF is shown in the lower display. When selected as OFFA, the control outputs are de-energized and OFF is shown in the lower display. Deviation alarms are inactive (relay energized) and process alarms are active (relay energized in non-alarm conditions). End
Range: HOLd or OFF **Default:** HOLd

Return: Select no and you return to the StEP parameter to continue programming the 942. By selecting YES, you exit the program menu and return to the control set point. **Range:** YES or no **Default:** no rtn

Running a Series 942 Profile

You can run your Series 942 profile from anywhere except the Setup menu. Press the HOLD/RUN key. The RUN LED begins flashing, and the lower display flashes and asks what StP (step) to begin on. Use the UP/DOWN key to enter the step and press the HOLD/RUN key once again, your profile begins, and the RUN LED is lit. If the HOLD/RUN key is not pressed twice within 1 minute, the RUN function will abort. **While the profile is RUNning, you can only view the RUN menu.** Press the MODE key to advance you through the RUN menu. For more information on Pout (power outages) see Page 25.

Resume a Profile

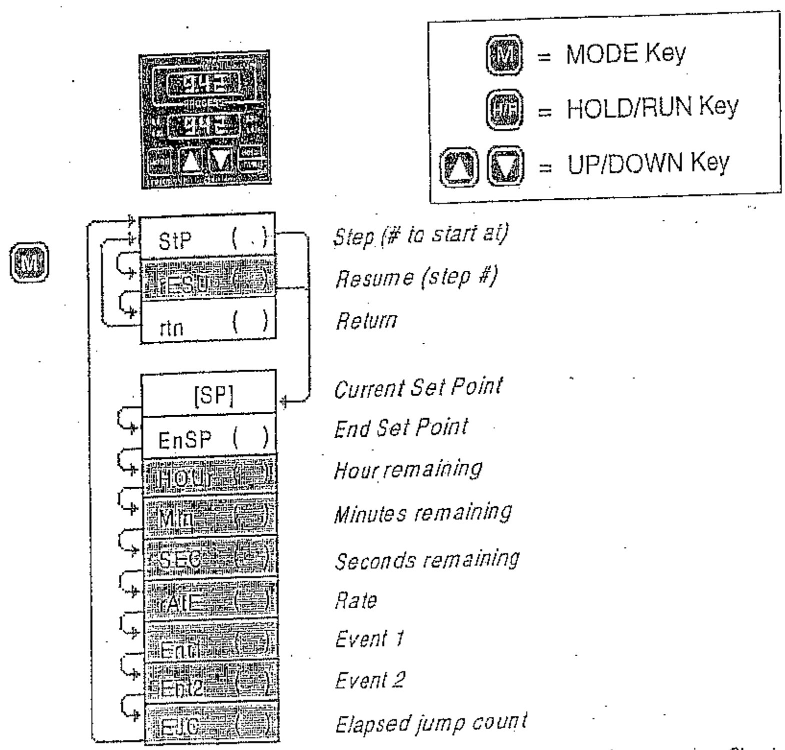
To resume a halted profile, press the HOLD/RUN key once. Press the MODE key to advance to the rESU parameter, and press the HOLD/RUN key again, the profile resumes, and the RUN LED is lit. You can only resume at the **exact** step you left off on. If you halt a running profile and make changes, you **cannot** resume running. The rESU parameter only appears when a running profile is halted.

To **Run** your profile... Press the key twice.

To **Stop** a running profile... Press the key once.

To **Resume** a halted profile... Press the key, press the key to advance to the rESU parameter, and press the key.

Figure 36 -
The Run Menu.



NOTE:

Shaded parameters may not appear on your control. These parameters are dependent on how your control is configured.

Chart 1 - Master Step Chart

Make photocopies, keep original clean.

Step #	√ Step Type	Values		Time			On Events OFF	
	StPt	SP		HOUr	Min	SEC	Ent1	Ent2
				rAtE				
	SoAh			HOUr	Min	SEC	Ent1	Ent2
	JL	JS	JC					
	End	OFF		OFFA	HOLd			

Step #	√ Step Type	Values		Time			On Events OFF	
	StPt	SP		HOUr	Min	SEC	Ent1	Ent2
				rAtE				
	SoAh			HOUr	Min	SEC	Ent1	Ent2
	JL	JS	JC					
	End	OFF		OFFA	HOLd			

Step #	√ Step Type	Values		Time			On Events OFF	
	StPt	SP		HOUr	Min	SEC	Ent1	Ent2
				rAtE				
	SoAh			HOUr	Min	SEC	Ent1	Ent2
	JL	JS	JC					
	End	OFF		OFFA	HOLd			

Step #	√ Step Type	Values		Time			On Events OFF	
	StPt	SP		HOUr	Min	SEC	Ent1	Ent2
				rAtE				
	SoAh			HOUr	Min	SEC	Ent1	Ent2
	JL	JS	JC					
	End	OFF		OFFA	HOLd			

Step #	√ Step Type	Values		Time			On Events OFF	
	StPt	SP		HOUr	Min	SEC	Ent1	Ent2
				rAtE				
	SoAh			HOUr	Min	SEC	Ent1	Ent2
	JL	JS	JC					
	End	OFF		OFFA	HOLd			

Step #	√ Step Type	Values		Time			On Events OFF	
	StPt	SP		HOUr	Min	SEC	Ent1	Ent2
				rAtE				
	SoAh			HOUr	Min	SEC	Ent1	Ent2
	JL	JS	JC					
	End	OFF		OFFA	HOLd			

Event Outputs

One of the features of the Series 942 is its capability for two event outputs. An "event output" is simply a pre-programmed ON/OFF event per profile step. The event may turn any number of peripheral devices ON or OFF to assist you in controlling your process, system or environment.

For instance, in an environmental chamber, you might wish to circulate air at a given time in your profile for one or more steps. You might want to turn lights on or off, or signals, or lock out your humidifier, or you could activate a video recorder.

Ent1 and Ent2 are not visible under the Operation menu unless your unit has auxiliary outputs and you Setup Ot3 and Ot4 as events.

To select auxiliary outputs as events, enter the Setup menu by pressing the UP/DOWN keys simultaneously for 3 seconds. The LOC parameter appears. Press the MODE key until you reach the Ot3 parameter. The default for Ot3 is AL (alarms). Change the value to Ent (event) if it hasn't already been done. Press the MODE key to continue on to the Ot4 parameter. Do the same for this parameter also. Continue pressing the MODE key to exit the Setup menu.

If you return to the Operation menu, Ent1 and Ent2 are visible, and can be turned ON or OFF from here. Ent1 and Ent2 can also be viewed under the StPt (Set Point) and SoAh (Soak) parameters in the Program menu.

These event outputs are mechanical relays rated at 6 amps up to 240VAC.

Guaranteed Soak Deviation

The Series 942 Guaranteed Soak Deviation (gSd) feature insures that the actual temperature tracks a programmed profile within a window around set point. See the example on the next page. If the deviation is exceeded, the time clock stops and the lower display alternately flashes gSd and the current parameter until the process variable returns within the window. Programmed in degrees or units, gSd is located in the Setup menu. Entering a value of (0) disables the Guaranteed Soak Deviation function.

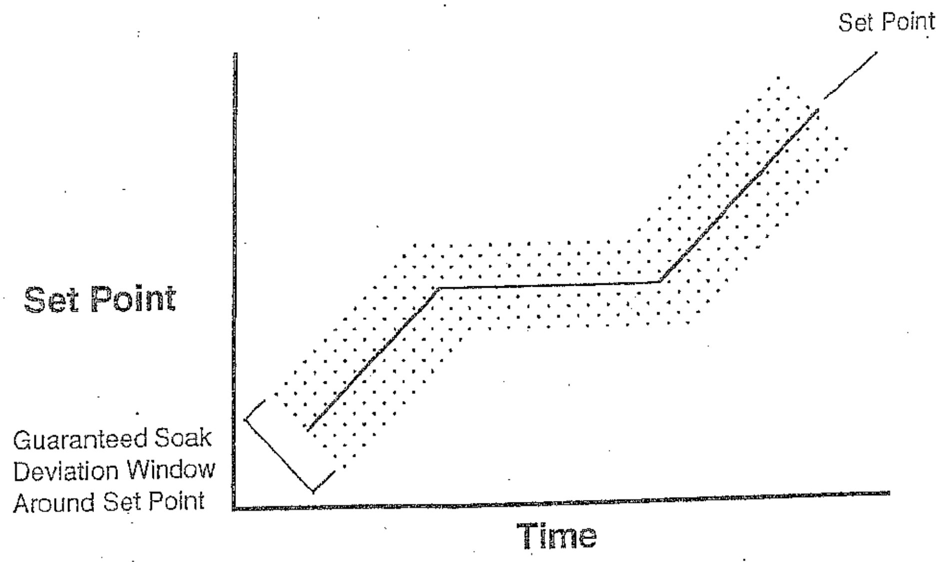


Figure 37 - Guaranteed Soak Deviation Example

Multiple Profiles

The Series 942 is a single profile control, but can be programmed for multiple profiles. To do this, enter your first profile; the next step you enter following the End step is the start of another profile. You can continue entering profiles until you run out of steps, remember there are a total of 24 steps.

Jumploop

The Series 942 can only jump backwards. A jump forces you to a step already performed. The Jump Step (JS) must be less than the current step. You cannot jumploop to the step that you are on.

Step 2	StPt		
Step 3	StPt		
Step 4	StPt		
Step 5	Jumploop	JS - 02	JC - 01
Step 6	End		

Your Jump Count (JC) can be anything from 0 - 100. If you enter 0, this will be an infinite loop and never progresses to Step 6.

This is a sample program. Depending on your application and parameter settings, your system may not respond like this.

Programming a Ramping Profile

Our first step in programming is to make a short ramp and soak profile. Step 1 initializes the set point to a known starting point for the ramp, Step 2 is a short ramp, and Step 3 is a soak step, which holds the programmed set point constant for the programmed time. Step 4 is an end step signalling the end of the profile.

1. When the lower display reads set point, press MODE once and you see the Prog parameter. Select YES in the upper display. Press the MODE key once again.

2. The Series 942 asks you for a StEP. The upper display reads (1).

3. Press the MODE key and you are asked for a step type (StYP). The default is End. Use the UP/DOWN keys to select StPt (set point) then press MODE if it is not already there.

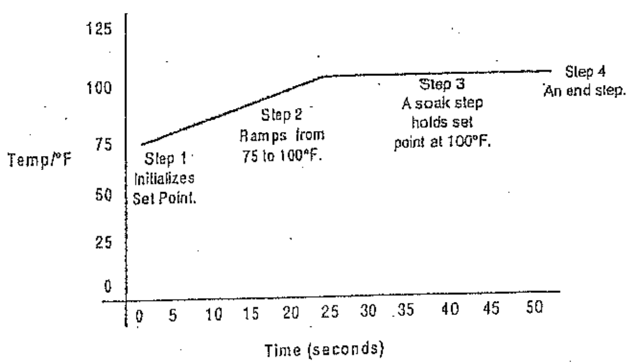
4. Use Table 4 to enter the corresponding parameters and values. The parameters appear from left to right on the table. Remember that the MODE key is used to progress through the menu, and the UP/DOWN keys are used to select parameters and values.

Table 4 - Series 942 Ramp and Soak Profile

StEP	StYP (Step Type)	SP (Set Point)	HOUr	Min	SEC	Ent1	Ent2	End	rtn
1	StPt	75	0	0	1	OFF	OFF	--	nO
2	StPt	100	0	0	25	On	OFF	--	nO
3	SoAh	--	0	0	25	On	OFF	--	nO
4	End							OFF	YES

NOTE:

If auxiliary outputs are not present or Ot3 and Ot4 are selected as alarms, the Ent1 and Ent2 parameters will not appear in the program menu.



Running Your Profile

1. Start your profile by pressing the HOLD/RUN key. You can be at any point except the Setup menu.

2. The RUN LED begins flashing. The upper display shows the step to begin on, and the bottom display shows the StEP parameter.

3. Press the HOLD/RUN key again. If not pressed within approximately 1 minute, the RUN procedure will abort. The profile starts running.

The RUN LED is continually lit. The upper display shows the PROCESS value, and the lower display shows the current set point.

You may step through the Run menu parameters with the MODE key to see what the step type is and what the parameters are set at. At any time you may press the HOLD/RUN key to stop the profile. To resume running the profile where it was stopped, press the HOLD/RUN key once; the RUN LED begins flashing. Now, press the MODE key to advance to the rESU parameter; once again, press the HOLD/RUN key. After the profile has ended the Run LED is off and the lower display reads OFF. This means the End step was selected as OFF, disabling all outputs.

Editing Your Profile

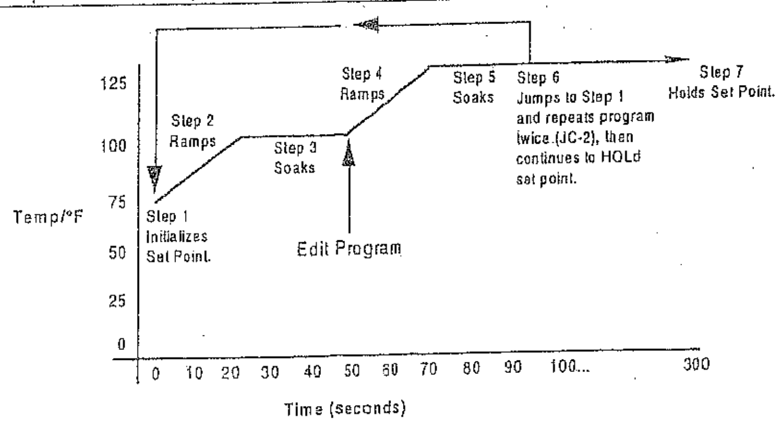
Now let's try editing the profile by expanding it with another ramp and soak step, adding a jumploop and programming the End step to hold. We'll jump to Step 1 and repeat Steps 1 through 6 two more times. This is accomplished by programming a Jump Step (JS) = 1 and Jump Count (JC) = 2. This means that once the 942 goes through the profile and reaches Step 6, it jumps back to Step 1 and repeats the profile two more times (Steps 1 - 5). It then continues to Step 7 and holds the set point and event status of the last step of the profile before the end step was encountered.

By this time you should understand the basic concept of the Series 942 and be able to get around on your own. Remember that the MODE key takes you through the menus and the UP/DOWN keys select parameters and values.

1. Return to the PROGRAM menu by selecting YES when Prog appears.
2. Press the MODE key and select (4) when StEP appears. We are going to change this step type from an End step to a Set Point step. This is our second ramp. Use Table 5 to enter values into the corresponding parameters.
3. Once you have edited your profile, run it again and watch its progress.

Table 5 - Editing Your Profile, Steps 4 - 7.

StEP	StYP (Step Type)	SP (Set Point)	HOUr	Min	SEC	Ent1	Ent2	JS	JC	End	rtn
4	StPt	125	0	0	25	OFF	On	--	--	--	nO
5	StPt	125	0	0	25	On	OFF	--	--	--	nO
6	JL	--	--	--	--	--	--	1	2	--	nO
7	End	--	--	--	--	--	--	--	--	HOLd	YES



NOTE:

If auxiliary outputs are not present or Ot3 and Ot4 are selected as alarms, the Ent1 and Ent2 parameters will not appear in the Program menu.