THERMTRONIX®

QUALITY ALUMINUM MELTING SYSTEMS

THERMTRONIX

SOLID STATE ELECTRIC FURNACE

INSTRUCTION AND SERVICE MANUAL

MODEL NO. SF-2300

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"SAFETY FIRST"

CAUTION - EXPLOSION HAZARD

THE PLACEMENT OF WET, DAMP, OR MOISTURE BEARING MATERIALS INTO MOLTEN METAL WILL CAUSE AN EXPLOSION WHICH MAY RESULT IN DEATH AND/OR SERIOUS INJURY AND PROPERTY DAMAGE.
BE CERTAIN ALL MATERIALS ENTERING MOLTEN METAL ARE COMPLETELY DRY AND FREE OF ALL MOISTURE.
PRE-HEAT IF NECESSARY.

DO NOT REMOVE THIS SIGN

PLEASE NOTE THE ABOVE WARNING PLATE IS ATTACHED TO EVERY THERMTRONIX FURNACE.

BE CERTAIN THAT ALL EMPLOYEES WHO OPERATE THIS EQUIPMENT HAVE READ AND UNDERSTAND THIS IMPORTANT SAFETY INFORMATION.

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INTRODUCTION

The Thermtronix Melting System is a 100% Solid State Melting System which combines state-of-the-art electronic power and control systems with the most advanced electric heating element chamber design, insulating system, and furnace construction available on the market today.

You will find that this instruction and service manual goes into much greater detail than is required for routine operation and maintenance. Experience has shown that plant operating and maintenance personnel can obtain a good working knowledge of a Thermtronix Furnace in just a few hours, and the Thermtronix representative present at start-up will be able to assist you and answer any questions you may have and insure that you have a thorough understanding of the furnace before leaving.

SECTION I INSPECTION AND INSTALLATION

A. Carefully inspect all parts of shipment for any possible damage which may have occurred in transit. Any visible signs of damage to the outside of shipment should be noted on the bill of lading and acknowledged by the carriers driver or representative. Any concealed damaged discovered during unpacking should be reported immediately to the freight carrier.

B. Move all crates to an area near the installation site and carefully remove all packing material from furnace and power control cabinet. It is suggested that all crates and packing materials be retained until after installation is complete and furnace is operating to insure that no parts have been accidentally discarded with these materials.

C. Check that all dimensions of the furnace site match those on the installation drawings provided and set furnace in place. If furnace is to be lowered into a pit be sure it is rigged securely and level with heavy slings or chains and slowly lower furnace in place with an overhead crane or forklift as required.

D. Be sure furnace is level and does not "rock" or tilt from side to side. Adjust or shim feet at the bottom of stationary furnaces to make allowances for a slightly uneven or rough floor surface. Hydraulic Tilt Furnaces have predrilled holes at the front and rear of tilt base which must be used to securely fasten furnace base to floor to insure stability during tilting operations.

E. Check that spill pits are free of water, other moisture or foreign matter, and filled with approximately two inches of dry sand.

F. Securely mount Power Control Cabinet to the wall or other permanent support structure nearby the furnace for operator convenience. (Six to ten feet is common practice.)

BE SURE the Power Control Cabinet is not located in an area where it will be adversely affected by radiant heat when the furnace lid is open, or by any other source of heat such as other furnaces, ovens, ladle heaters, etc.

G. The electrical interconnect drawing should be used as a reference for all furnace and power control panel wiring and electrical connections. Refer to the serial number tag affixed to the lower right side of the power control cabinet for the proper operating voltage, KVA requirements and maximum current. All electrical wiring should comply with NEC (National Electrical Code) and local zoning codes. **DO NOT** apply electrical power until a Thermtronix Field Service Engineer or other authorized Thermtronix employee has checked all electrical and wiring connections.

H. A heavy gauge ground wire should be connected between the furnace ground terminal and the power control cabinet ground terminal and a solid earth ground such as a copper water pipe. Note: On Transport Ladles and other Mobile furnaces where a quick-connect plug is used the service cord contains the necessary ground wire between furnace and control cabinet.

I. Proper size conduit and copper wire for the connected load should be run from plant electrical power source and brought through the top, bottom, or side of power control cabinet as required. **BEFORE** making entrance into power control cabinet **BE SURE** sufficient room exists inside cabinet where you plan to make entrance. A second run of conduit and copper wire also sized for the connected load should be connected between the bottom right side of power control cabinet and the furnace power entrance on stationary furnaces or the rear electrical box on the frame of hydraulic tilt furnaces. On Mobile furnaces this electrical connection is factory installed and on Transport Ladles a factory installed quick-connect plug and service cord is supplied.

NOTE: If local codes permit many customers prefer the use of properly sized welding cable, with high voltage insulation, because of it increased flexibility and ease of installation.

J. Two (2) separate half (1/2) inch conduits should be run from the bottom side of the power control cabinet to the furnace per the instructions shown on the interconnect drawing. One conduit is for the 24-volt metal leak detector system and contains two (2) 14 gage wires which run from the power control cabinet to a terminal strip on the furnace. The other half (1/2) inch conduit contains all of the type "K" thermocouple extension wires which run between the power control cabinet and the furnace. Each pair of thermocouple extension wires must be long enough to run directly between the thermocouple and its respective temperature controller. The metal "bath" thermocouple connects to the "bath" temperature controller located in the center of the front operator control panel and the "element" thermocouples connect to the POWERGUARD temperature controllers located in the top of the front operator control panel. The red wire is negative and the yellow wire is positive.

K. Thermtronix has provided all thermocouple extension wires which are located inside the power control cabinet with one end already connected to the proper temperature controller. All other conduit and wiring is to be provided by the customer. On Mobile furnaces the above referenced wiring is factory installed and on Transport Ladles quick-connect plugs are factory supplied.

L. Connect your plant compressed air, (on Hydraulic Tilt furnaces and Transport Ladles **no** compressed air is necessary, refer to hydraulic interconnect drawing) to the female NPT port on the pressure regulator mounted at the rear of furnace. Plant air pressure should be between 70 and 100 PSI. Set the furnace lid for a slow, smooth, and steady raising and lowering motion by adjusting the pressure regulator and the exhaust port flow control located on the operator's hand or foot valve.

SECTION II - CRUCIBLE INSTALLATION

A. Make certain that the crucible has received a "double-glaze" "oxidation resistant treatment" from the crucible manufacturer and is designed for use in an electic resistance furnace. Check all dimensions to be sure crucible is the proper size.

B. A sling should be used when lowering the crucible in place. A common method is to form a closed loop of heavy rope or chain around the bottom outside diameter of crucible. Now, take another rope, or sling, and attach to this closed loop and bring it up and over the top of the crucible and attach it to the other side. Attach a second rope or sling in the same fashion but at right angles to the first. You can now use an overhead hoist or forklift to carefully raise the crucible and lower it into place. **MAKE CERTAIN** that your sling has a firm and secure grip on the crucible **before** lifting. If the crucible should be accidentally dropped, bumped, or abused in anyway it **should not** be installed the in furnace even if it shows no apparent signs of damage.

NOTE: At the back of this manual you will find a fabrication drawing for a permanent and more secure crucible handling device which was supplied by a major crucible manufacturer.

C. Remove furnace lid assembly and take care to place furnace lid in an area where its insulating material will not be damaged. Remove eight (8) bolts from furnace top plate. Eye bolts can now be secured to the furnace top plate and it can be carefully lifted off furnace with an overhead hoist or forklift. Take care not to damage the vacuum formed insulating panel under furnace top plate. Carefully remove top insulating panel and place in a clean, flat, level area where it will not be damaged.

Remove any additional blanket insulation taking note of its location for replacement. (If insulating panel should separate or break during removal or installation it can be "fitted" back together and "gasketed" with excess blanket insulation.) Place refractory separation sheet on floor of stationary furnace, (See items "F" and "G" below for Hydraulic Tilt furnaces and Transport Ladles) and center the base block (if used) on top of separation sheet. Carefully lower crucible and center on base block.

D. Use a tape measure and level to insure that crucible is centered and level in the heating chamber.

E. Carefully reinstall insulating blanket material, top insulating panel, furnace top plate, and furnace lid to their original positions.

F. **Hydraulic Tilt Furnaces and Transport Ladles,** are factory supplied with support blocks and a recessed cast furnace base. Care must be taken that the blocks are properly placed in the base recess to support and prevent the crucible from moving forward during normal tilting operations. **No** refractory separation sheet should be used between the crucible and the furnace base.
With a new crucible installed in the above manner the furnace **must** be kept in the fully lowered position until it has been charged and brought up to maximum operating temperature with a full heat of metal. This procedure will insure that the crucible glaze has melted which helps secure the crucible to the furnace base block prior to tilting.

G. **Hydraulic Tilt Furnaces and Transport Ladles,** require a refractory cast top cap and pour spout which is supplied with the furnace. When replacement is necessary Thermtronix high alumina refractory no. **A75** (or other suitable refractory) is recommended. Thermtronix no. **A77** wash can be used for repairs of top cap cracks.

SECTION III - THERMOCOUPLE PROBE INSTALLATION

A. Your furnace has been provided with a properly sized thermocouple protection tube assembly with an internal steel support tube for molten metal bath temperature control.

B. Install the bath thermocouple probe assembly with the protection tube approximately one (1) to two (2) inches from the rear crucible wall and place the horizonal pipe section in the clamp supports provided and tighten all clamps securely.

C. Be sure to observe proper polarity when connecting thermocouple extension wire. Red is negative and yellow is positive.

SECTION IV - ELECTRICAL CHECKS

NOTE: Electrical power should not be applied to a new furnace until a Thermtronix field service engineer or other authorized Thermtronix employee has arrived on the site and personally checked all electrical and wiring connections to be in compliance with factory standards. After this check has been made the following functions can be performed and the Thermtronix employee present will be able to assist you and answer any questions you may have.

A. Begin by setting the manual/reset/auto switch to "manual" and adjusting the manual power dial to "zero", (fully counter clockwise). Set the 7-day timer switch to "off" and the demand limit switch to "off".

B. Insure the power control cabinet door is properly closed and raise the main power disconnect switch operating arm on the right side of cabinet to the "on" position. The Powerguard temperature controllers and the metal bath front panel temperature controller will light for a visual test. All controllers will indicate both the process temperature (upper display) and temperature set point (lower display). Complete details on the operation, programming, and service of these temperature controller can be found in Section IX and X of this manual.

C. Slowly turn the manual power control to "full power" (fully clockwise). Note that all three of the panel ammeters raise to maximum current appropriate for the kilo-watt size and voltage level of furnace. Now, lower the power level back to "zero" (fully counter-clockwise).

D. Momentarily switch the 7-day timer switch to "on" to insure its light is working, then back to "off." Now, adjust the temperature controller set point to 1200 F (650 C) by indexing the "increase" and "decrease" keys on front of controller and enter into controller memory by depressing the "enter" key. Turn manual/reset/auto switch to the "auto" position and note that all three panel ammeters raise to maximum current. Turn demand limit switch to "on" position and note that all three ammeter readings reflect a decrease in power output when the front panel demand limit control is a adjusted. Further details on setting the 7-day timer can be found in the rear of this manual.

E. When all of the above tests have been successfully performed turn the manual/reset/auto switch to the "manual" position, set the demand limit switch to "off", decrease the manual power dial to zero, (fully counter-clockwise) and lower the main power disconnect switch operating arm to the off position.

SECTION V - NORMAL MELTING OPERATIONS

A. Upon the initial start-up of furnace the Thermtronix service engineer present will adjust the maximum and minimum temperature limits required for your melting operation and set the controller to indicate in your preference of degrees Fahrenheit or Celsius. Should it be required, complete details on all programing and adjustments to the front panel bath temperature controllers can be found in Section IX of this manual.

B. Open the furnace lid and carefully place ingot or other clean and dry charge material into furnace crucible taking care not to "wedge" or "pack" material which will cause crucible cracking when metal is heated and expands. Charge material should be filled to the top of crucible so that when melted it will form a sufficient molten heel to rise above the bottom of bath thermocouple tube.

C. CAUTION should be used in the selection of all charge material to see that it contains no surface or entrapped moisture. Charging wet or moisture bearing material into a molten metal bath can cause an explosion resulting in serious injury, death, and/or property damage.

D. Turn power control panel main disconnect switch on and adjust front panel temperature controller set point for desired temperature. The Thermtronix temperature controller is a solid state microprocessor based P.I.D. (proportional, integral, and derivative) system which automatically self-corrects itself to maintain accurate temperature control. During the first melts the microprocessor is in a "learning" mode and it may be necessary to adjust set point 100 F to 200 F below desired temperature to avoid temperature overshoot.

E. Although all Thermtronix Furnace linings are completely dried at the factory and ready for use when shipped, during the first melt steam may be seen coming from the top or sides of the furnace due to moisture absorbed in the lining materials. When this is observed power should be shut off for 10 to 15 minutes or so and then restarted. This step should be repeated as often as necessary during the first melt until a full molten bath has formed in crucible.

NOTE: This action may also be necessary whenever furnace has been out of service for extended lengths of time, especially in areas where moisture can easily be absorbed from the atmosphere.

F. Keeping the furnace lid closed at all times when metal is not being taken out or charged into furnace will greatly reduce heat-loss and improve overall operating efficiency.

G. A solid state seven-day timer is located inside the power control cabinet and allows automatic on-off cycling during the day, night, or over the weekends. This function is normally used for early morning start-ups before operating personnel arrive where the furnace has been previously emptied and pre-charged. The timer is equipped with a battery back-up so that its clock keeps time even during power failures. Complete operating details on the seven-day timer can be found in the rear of this manual.

H. The demand switch can be used to restrict electrical demand of furnace during peak periods. It is particularly useful on multiple furnace installations where some furnaces are only holding while others are melting and also during long periods of holding which may occur during a peak energy demand period, a low demand setting can be used to further reduce electrical utility demand charges.

I. Unlike many manufacturers Thermtronix has experienced very few problems with furnace damage due to customer fluxing procedures and therefore we make no special recommendations for fluxing or degassing. This is due, in part, to our design of a well-sealed heating chamber and our use of rugged heavy-gage heating elements. The only suggestion we make is that the furnace lid be left fully open during degassing and that it remain so for approximately 15 minutes after the process is completed. If possible, non-reactive fluxes are always preferred over reactive fluxes and, in general, you will find that a great deal less fluxing of any type is required due to the very nature of the electric resistance furnace and the elimination of combustion by-products. Taking advantage of this fact can greatly reduce your overall melting costs.

J. Low temperature holding is recommended for off-shift, weekend, and holiday periods. 1200 F is common practice, and the furnace should be kept <u>full</u> during these periods to help increase crucible life by reducing cracking in the top area of crucible. Most customers report that the Thermtronix Solid State Furnace is so energy efficient that its cost for holding metal overnight, weekends, and even holiday periods is far less than the labor required to remove and recharge the metal. This practice also results in considerably longer crucible life.

K. If a power failure should occur during normal melting or holding operations your Thermtronix furnace will <u>automatically restart</u> with <u>no loss of control</u> and <u>without</u> the aid of an operator. With the furnace lid closed the Thermtronix furnace is so energy efficient that it will maintain a molten bath even during a power failure of several hours duration. If power failures are a common occurrence and of long duration, the Thermtronix furnace can be easily wired into a central alarm system. One set of normally open and normally closed contacts have been provided for this purpose as standard equipment.

L. Shutting down the furnace is a very simple procedure of removing the metal until little or no metal is left in the bottom of crucible and disconnecting the power.

SECTION - VI - PREVENTIVE MAINTENANCE

A. **ALL** Thermtronix Solid State Melting Furnaces are factory equipped with a non-resettable elapsed time hour meter. Maintenance programs of electrical and mechanical equipment which are geared to weekly, monthly, and annual checks with no respect to actual operating hours are of little value to a comprehensive engineering program which seeks to constantly improve its products. We strongly recommend that a log be kept of all maintenance functions performed on your Thermtronix furnace which is referenced to the hour meter.

B. Every 24 hours the operator should make a quick visual inspection of the operator's control panel to insure that all lights, switches, meters, etc., are in good working order. Any problems should be noted and reported to the maintenance department.

C. Every 24 hours the operator should make a quick, visual inspection of the furnace crucible and bath thermocouple protection tube, paying particular attention to the top of crucible where cracks often develop and enlarge down to the molten metal bath line. If cracks are detected, further investigation is required and the run-out ports should be inspected for any signs of metal leakage. Whenever unusual cracking or metal leakage is discovered the crucible should be changed as soon as possible to avoid a severe failure and possible furnace damage. If the thermocouple protection tube shows signs of cracking, it should be replaced with the same type and size of protection tube to include type "K" (Chromel/Alumel) thermocouple wire only.

D. Every 1000 hours (or 45 days) the pneumatic regulator, filter, and oiler assembly should be inspected, cleaned, and serviced if necessary. All electrical connections in the power control cabinet should be visually inspected for any signs of overheating and cleaned and tightened if necessary. The hydraulic filter should be changed on hydraulic tilt furnaces.
On Transport Ladles the oil level of the gear box should be checked, fittings on the lifting bail and lid mechanism must be greased and set screws on the drag brake, lifting bail and gear box must be checked.

E. Every 2500 hours (or 90 days) check the three filter screens in the power control cabinet and clean if necessary. (This will vary with environmental conditions and in most instances filter cleaning or replacement will be necessary only once a year). Also check furnace run-out ports for any signs of metal leakage.

F. Every 4000 hours (or 6 months) furnace side panels should be removed to thoroughly inspect heating element terminations and wires. If any signs of overheating are apparent, connections should be cleaned and tightened where necessary.

G. Every 9000 hours (or 12 months) it is recommended that a complete inspection be made of all heating element thermocouple connectors and extension wires. This procedure will help to avoid unexpected failures and disruption to production schedules. It also insures continuous protection of heating elements from possible damage caused by overheating. Nine-thousand hours represents over one year of continuous twenty-four hour a day operation and it is recommended at this time that if the original crucible is still in use that it also be replaced to avoid unexpected failures and disruption to plant production.

Note: The above procedures are minimum recommendations and may need to be adjusted based on furnace usage, environmental conditions, and general equipment maintenance history within a particular facility.

SECTION - VII - TROUBLESHOOTING

A. Due to the rugged design and heavy-gage heating elements used in every Thermtronix furnace power panel failures are very rare. However, if a failure is suspected the following test should be preformed. With all electrical power turned off measure the resistance between the two power panel termination ends. This preliminary check can be made without disconnecting any electrical wires. Depending on size each panel will measure between 0.5 and 2.2 ohms. More importantly each power panel in a furnace should measure the same. If one or more power panels are found to have a much higher resistance than the others the following check should be made. Remove all electrical connections from both termination ends and measure between the two ends, if an open circuit is found the power panel should be replaced. Remove the furnace top plate and top insulating panel and lift the power panel vertically out of the furnace.

B. If a failure should occur in the front panel bath temperature controller or its associated circuits an "error message" will be displayed and details on these error messages can be found in Section IX of this manual.

C. Main power circuit breaker tripping can be caused by either a heating element over temperature condition, or a ground fault condition. Open the power cabinet door and locate the ground fault relay and note if the toggle switch is in the "tripped" position and reset if necessary. While watching the toggle switch on the relay engage the main circuit breaker. If the toggle trips just before the breaker trips again a ground condition exists and all power should be disconnected and the cause of the fault investigated and corrected.

If the toggle switch on the ground fault relay does not trip and the circuit breaker does trip, observe the POWERGUARD temperature controllers located in the top of the front operator control panel. When the main power is engaged if the temperature indicator rises rapidly above the set point and the main power circuit breaker trips this is an indication of an open thermocouple circuit and both the heating element thermocouple assembly, connector and extension wire should be checked.

D. The POWERGUARD temperature controllers are an on-off dual set point device. The first set point will automatically turn the power controller off removing power from the heating elements until they drop below this limit then automatically restoring power, if required to maintain bath temperature. However, if the power controller should fail to turn off due to a malfunction and second set point is reached the controller will trip the main power circuit breaker removing all power to the system. Complete details on the operation, maintenance, and troubleshooting of the POWERGUARD temperature controllers can be found in Section X of this manual.

E. The Thermtronix power control module is a 100% solid state SCR system and complete details on its operation, maintenance, and troubleshooting can be found on the following page in Section VIII of this manual.

1. GENERAL DESCRIPTION

The DPAC is an SCR or thyristor power control utilizing the zero crossover firing method. The single phase DPAC (DPAC-1) uses only one set of back-to-back SCR's. The three phase DPAC (DPAC-3 utilizes the master/slave technique for three phase power control. It incorporates two sets of back-to-back SCR's to control the power in an ungrounded delta or Y three phase load. L1 to T1 is the master or controlled section, L3 to T3 is the slave section, and L2 to T2 is a direct connection and is not controlled.

The DPAC-43 (4 wire, three phase) utilizes three sets of back-to-back SCR's and controls all three legs of a four wire (Y) grounded load.

Troubleshooting of the DPAC in the field should be restricted to changing of fuses, SCR's or the plug-in printed circuit board. Any other troubleshooting should be done on a test bench.

2. INDICATIONS OF MALFUNCTION

A malfunction is present if:

a. The output is full on and not conrollable.
b. No output is obtained under any input condition.(Check to see that the interlock cirtuit is not open.)
c. Output voltage is not approximately proportional to the command signal.
d. Operation is erratic or inconsistent.
e. The DPAC-3 has unbalanced outputs. This is usually due to wrong phase rotation of L1, L2, and L3 connections. Correct by reversing any two leads to L1, L2, or L3.
f. There is indication of over-heated or broken silicon controlled rectifiers or wiring.
g. Testing indicates half wave output.

3. TEST EQUIPMENT REQUIRED

a. VOM (volt ohm milliammeter)
b. Half wave detector (can be easily made; (see figure 3)
c. Clamp on ammeter

4. SYSTEM TROUBLESHOOTING CHART

PROBLEM	PROBABLE CAUSE	ACTION
No output	No power input	Check for proper voltage L1 to L2, L2 to L3, & L1 to L3.
No output	Improper command signal	Check command signal for proper control input (see pg. 2)

SYSTEM TROUBLESHOOTING CHART (Cont'd)

PROBLEM	PROBABLE CAUSE	ACTION
No output	Blown fuses	Check fuses
No output	Open load contactor	Check load contactor
No output	Open heaters	Check heaters
No output	Bad PC Board	See Below
Partial output or partial heat	Improper or low command signal	Check for proper or full command signal
Partial output or partial heat	Loss of 1 phase (DPAC-3 only)	Check all phases for ouput with volt meter and clamp-on ammeter
Unbalanced output (3 phase only)	Phase rotation not correct	Interchange any 2 L side lines
Partial output or partial heat	Half wave operation	Check output with half wave detector; T1 to T2, T1 to T3, T2 to T3 (see Fig. 3 & 4)
Uncontrolled Full output	Shorted SCR	See Below
Uncontrolled Full output	Bad PC Board	See Below

5. CHECKING SCR's

Note: Remove POWER AND DISCONNECT LOAD

TESTING SCR's:

A shorted SCR will give full uncontrollable line voltage at the T terminals. Turn off the main power and remove the L wires and T wires. On a DPAC-1, measure the resistance from L1 to T1. On a DPAC-3, measure the resistance from L1 to T1, and from L3 to T3. On a DPAC-43, measure the resistance from L1 to T1, L2 to T2, and L3 to T3. The resistance of 5 ohms or less indicates that at least one of the SCR's in the pair is shorted. A high resistance means that they are normal or O.K.

Typically only one SCR in a pair will be defective. If a low reading is obtained it will be necessary to disassemble the DPAC in order to isolate one SCR from the other one since they are wired in inverse parrallel (back-to-back).

6. DISASSEMBLING OF DPAC

The following procedure should be used when disassembling the DPAC for access to the SCR's.

a. Remove the two each #6-32 screws from the low voltage terminal strip and unplug the firing board.
b. Remove the red wire from the underside of the L2 or common connection.
c. Remove the fuses, lugs, and all of the large nuts and washers from the top of the cover.
d. Remove the 4 each #10 screws and nuts from the sides.
e. Remove the top cover by lifting straight up.
f. Stand the unit on end with the 1 lugs on the bottom.
g. Remove the #10 flat head screws and nuts from the under side of the unit.
h. If the unit includes fans leave the fans connected by their wires but physically loose.
i. Stand the unit on the other end so that the T terminals are up and remove the #10 flat head screws and nuts from the bottom cover.
j. Lay the unit down on the bottom cover and slide the sub base out of the bottom cover.
k. 100 amp and smaller SCR's can be changed in this state. For larger SCR's proceed to the next step.
l. Remove the 3/8" nuts that hold the PC Board to the Heat Sink completely from both short 3/8" bolts (T side heat sink).
m. Loosen the 3/8" nuts from the short and long 3/8" bolt on the L side of the Heat Sink.
n. Lay the unit on its side and remove the #10 flat head screws from the T side Heat Sink on a single phase or the outside Heat Sink on a three phase. Any SCR can be removed and replaced in this state.
o. To reassemble follow the reverse of the above procedure.

7. INSTALLING SCR's

After removing the old SCR throughly clean the Heat Sink and new SCR to be installed. Put a thin uniform coating of DOW DC-4 thermal joint compound on the base of the SCR to be installed. Tighten the nut finger tight and then torque per table 1.

NOTE: It is very important that the torque be accurate as not enough torque will result in the SCR burning up due to insufficient heat being transferred to the Heat Sink, and too tight a torque will result in cracking the silicon chip inside the SCR.

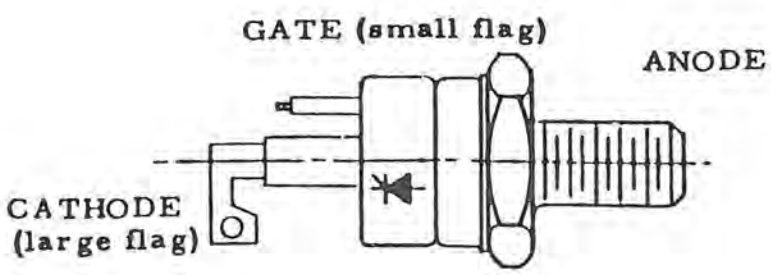


Fig. 1

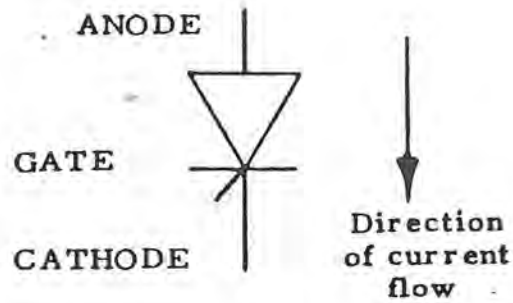


Fig.2

8. TORQUE VALUES FOR MOUNTING SCR's

UNIT AMPERE RATING	STUD SIZE	INCH LBS.	FEET LBS.	Kg m
75-100 Amps	1/2 inch	125-150	12	1.440--1.728
150-300 Amps	3/4 inch	280-300	25	3.266--3.456

9. CHECK OUT OF ENTIRE UNIT

a. Connect a "Dummy" Load per-single phase; Fig. 4, three phase; Fig. 5, or three phase 4 wire; Fig. 6.

b. Connect a jumper from terminal 1 to terminal 2.

c. Connect a potentiometer between terminals 3, 4, and 5, per the instruction manual. (the potentiometer can be anywhere from 135 ohms up to 5,000 ohms)

d. Set the potentiometer all the way counter-clockwise.

e. Apply power. No output should appear at the load.

f. Slowly increase the potentiometer clockwise. As the power is increased the lights in the dummy load should become brighter or flash at a faster repretition rate (with the standard firing board) or should be on longer and longer periods of time (with the slow cycle firing board).

g. With the potentiometer fully clockwise the dummy load should be full on all of the time. If not, re-adjust R44 which is located between terminals 2 and 3 on the low voltage terminal strip.

10. TROUBLESHOOTING OF BOARDS

Equipment Required:

a. Volt Ohm Milliammeter
b. Oscilloscope
c. 10 pin extender, for .062 PC Board on .156 centers

Troubleshooting of the standard input PC Board (#08-5071) or the slow cycle "H" PC Board part #08-5072 should be done with an extender with long enough leads to get the PC Board away from all of the high voltage components. This a-lows you to work on the board in a safe environment as there is no high voltage on either input PC Board. For troubleshooting refer to the waveform and voltage charts for the proper low voltage board used.

EXTREME CARE should be used when troubleshooting the high voltage boards (bolted to the heat sinks). When making scope measurements on the high voltage board the scope ground must be isolated and the scope case will be at line voltage potential. DO NOT TOUCH THE OSCILLOSCOPE WHILE POWER IS ON.

11. DPAC REPLACEMENT PARTS

PC BOARD ASSEMBLIES:	PART NUMBER
Main Board DPAC-1 or Master Board DPAC-3 or DPAC-43 Less Power and Fan Transformers	08-5070
Slave #1 (with Phase sequence detector) DPAC-3 or DPAC-43 Less Fan Transformer	08-5073
Slave #2 (without phase sequence detector) DPAC-43 only Less Fan Transformer	08-5074
Standard Firing Board	08-5071
Slow Cycle Firing Board	08-5072

TRANSFORMERS:

Voltage	Power(T1)	Pulse(T2)	Slave(T3)	Fan
120 V	16-0155	16-0145	16-0153	Not used
280/240 V	16-0156	16-0145	16-0153	Not used
277 V	16-0157	16-0145	16-0153	16-0161
480V	16-0158	16-0145	16-0153	16-0158

FAN'S for 150,200,and 300 AMP UNITS ONLY:	PART NUMBER
120 V or with Fan Transformer	25-0020
208/240 V. only without Transformer	25-0022

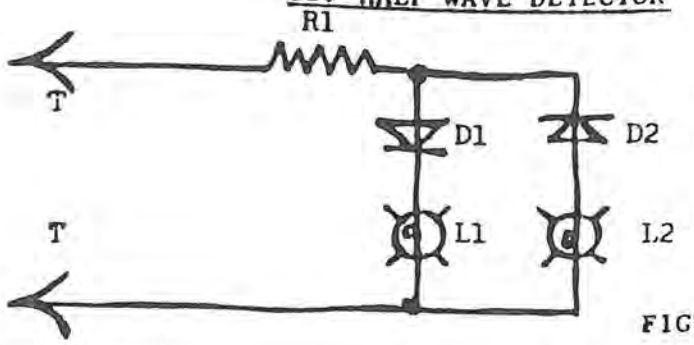
FUSES: (All Voltages)

	75A	100A	150A	200A	300A
Gould Part #	A50P100-4	A50P125-4	A50P200-4	A50P250-4	A50P400
Loyola Part #	17-7050	17-7051	17-7053	17-7054	17-7056

SCR'S

Voltage	75A	100A	150A	200A	300A
120	18-5078	18-5092	N/A	N/A	N/A
208/240	18-5088	18-5093	18-5146	18-5033	18-5033
277/480	18-5090	18-5051	18-5147	18-5052	18-5052

12. HALF WAVE DETECTOR



R1 1K ohm 10w Resistor

D1-D2 500MA 400v Silicone Diode

L1-L2 7.5w 120v Nite Light Bulb

FIGURE 3.

Connect "T" leads to output terminals of DPAC. On 3 phase units each phase must be checked. If both lights light equally, both SCR'S are firing normally. If only one light is lit, only one SCR is operating.

13. DUMMY LOADS

SINGLE PHASE

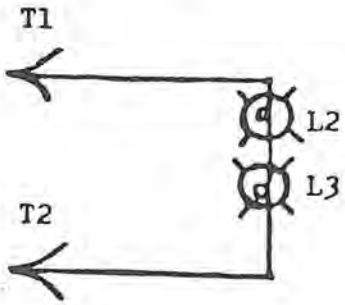


FIGURE 4.

THREE PHASE THREE WIRE

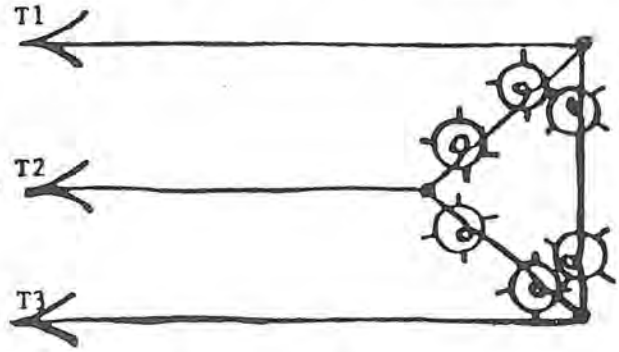


FIGURE 5.

THREE PHASE FOUR WIRE

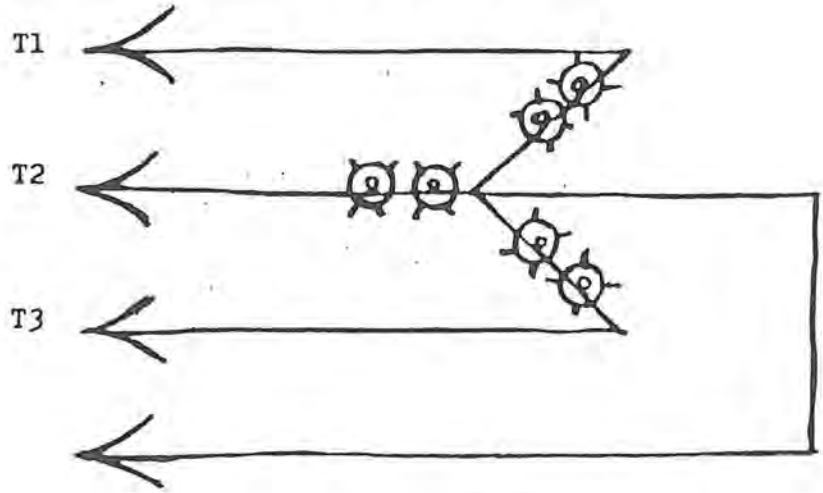


FIGURE 6.

Note:
All lamps 150W 240V.On 120 or 240V units, only one line is required per phase.

14. DPAC-1, 3, 43 WAVEFORMS AND VOLTAGE MEASUREMENTS

Test Points 1 thru 7 are measured with scope common at ▭ on the schematic. Probe tip at appropriate ○ for test point.

A. STANDARD FIRING BOARD #08-5071

TEST POINT	DESCRIPTION	0 OUTPUT POT FULLY CCW	50% OUTPUT POT CENTERED	100% OUTPUT POT CW
1.	Power Supply Across C9	33V 0V	SAME	SAME
2.	Put (programmable unijunction T transistor) gate	21V 0V	21V 0V	21V 0V
3.	6 Volt Square wave for potentiometer excitation	6V 0V	SAME	SAME
4.	Q3 Emitter (common signal)	0V	2V TO 2.5V 0V	4.5V TO 5V 0V
5.	Q3 Collector	33V 0V	30V 0V	30V 0V
6.	Q5 Base Zero crossover Detector	.5V 6.5V TO -8V	SAME	SAME
7.	C7 Timing Signal	1V TO 15V 0V	23V 0V	23V 0V

B. SLOW CYCLE FIRING BOARD #08-5072

1 Scope or Voltmeter common □.

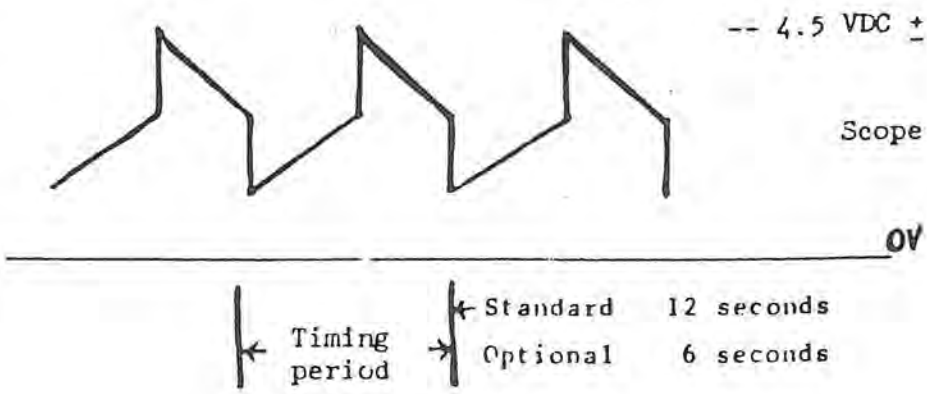
Scope tip or Voltmeter positive ○.

Voltmeter Measurements:

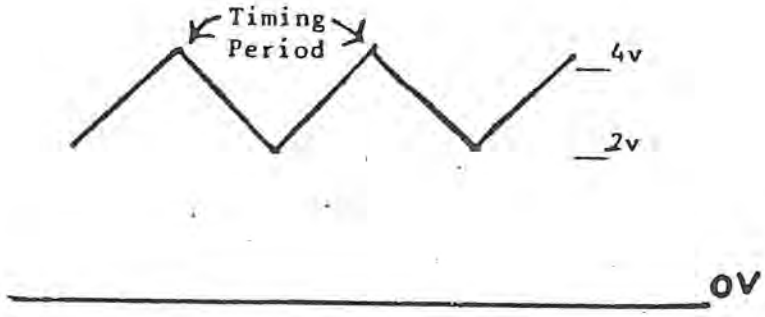
a.	B+ (unregulated)	30 VDC ± 20%
b.	B+ (regulated)	6.2 VDC ± 10%
c.	Bias Pot Setting	0 to 6VDC
d.	Input Signal	Varies depending on input and range card

Scope Measurements:

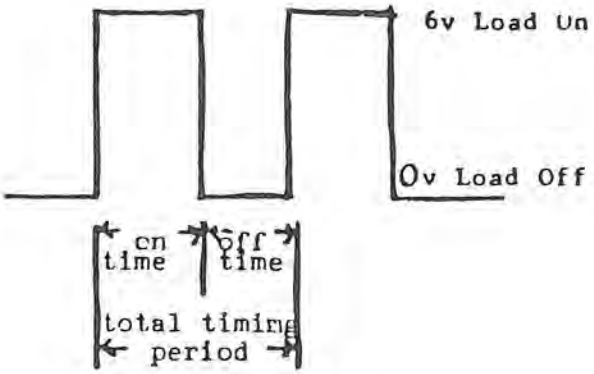
1. TIME BASE GENERATOR



2. SAWTOOTH OUTPUT OF TIME BASE GENERATOR (Linearized)

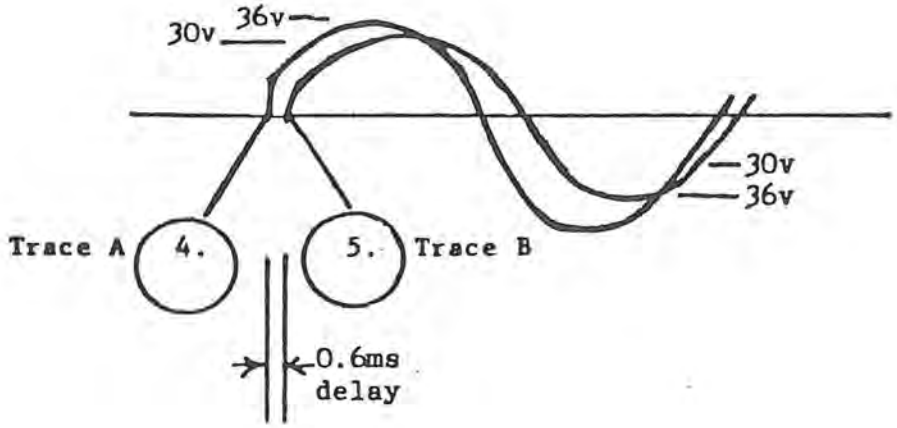


3. GATING OUTPUT (sum of input signal and sawtooth)

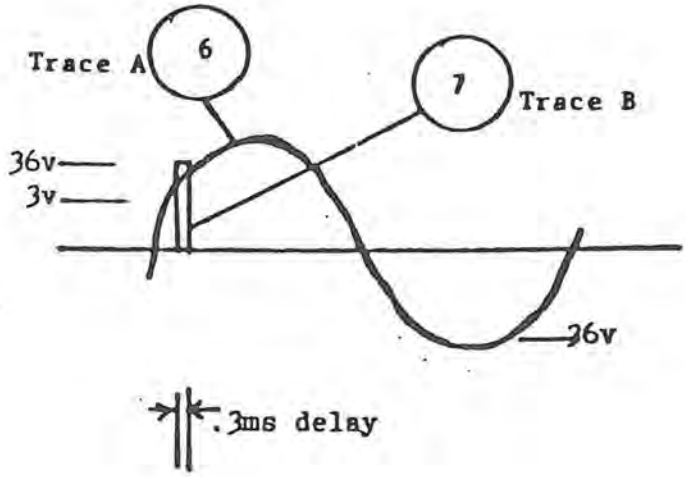


Scope Measurements:
(continued)

4. - 5. PHASE SHIFT NETWORK

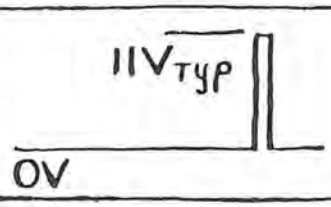
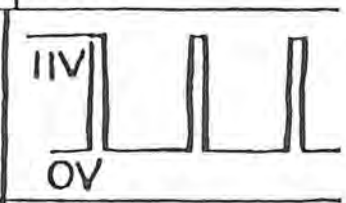
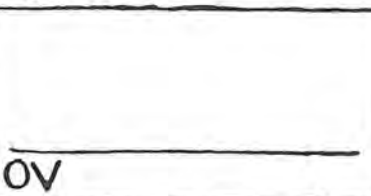
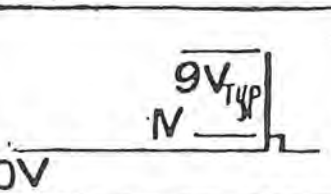
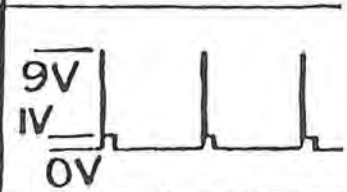
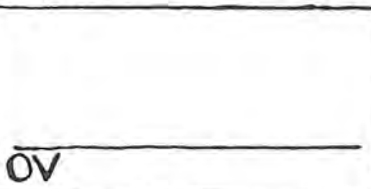
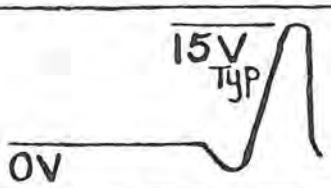
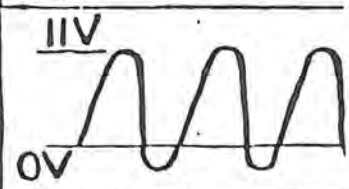
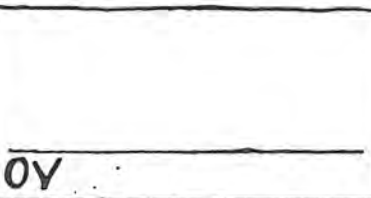
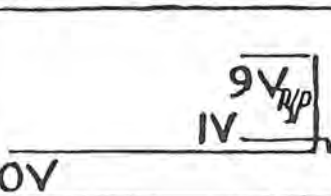
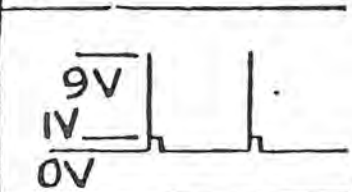
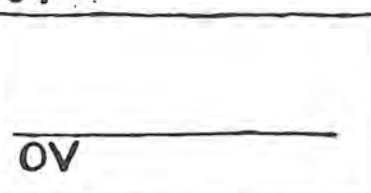
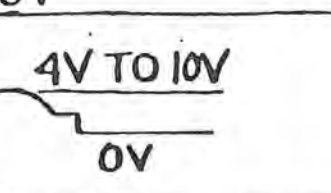
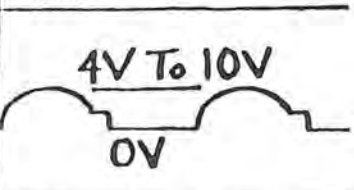
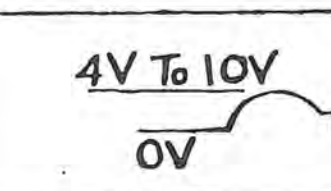
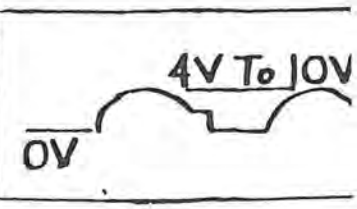


6. - 7. FIRING PULSE TIMING



C. HIGH VOLTAGE SECTION

USE CAUTION
DO NOT GROUND SCOPE
SCOPE CASE WILL BE HOT
USE ONE TRACE ONLY

TEST PT.	DESCRIPTION	0 OUTPUT POT FULLY CCW	50% OUTPUT POT CENTERED	100% OUTPUT POT CW
8.	Timing pulse stored on C1.it will be dischg into SCR 2 on next 0 x'ing			
9.	Gate Pulse for SCR #2 (Master SCR)			
10.	Pulse stored on C4. Fire into SCR1 (slave) on next 0 x'ing			
11.	Gate pulse for SCR#1 Slave			
12.	Gate signal for SCR 4 or 6 3Ø or 3Ø 4 wire only.			
13.	Gate signal for SCR 3 or 5 3Ø 4 wire only			

SECTION IX - BATH TEMPERATURE CONTROLLER

The model number appears on the label affixed to the top of the controller. The output module present in your control is as shown by the marked square on the label affixed to the side of the control.
The model number is made up as follows:

MODEL 3 [ ] [ ] [ ] 0- [ ] - [ ]

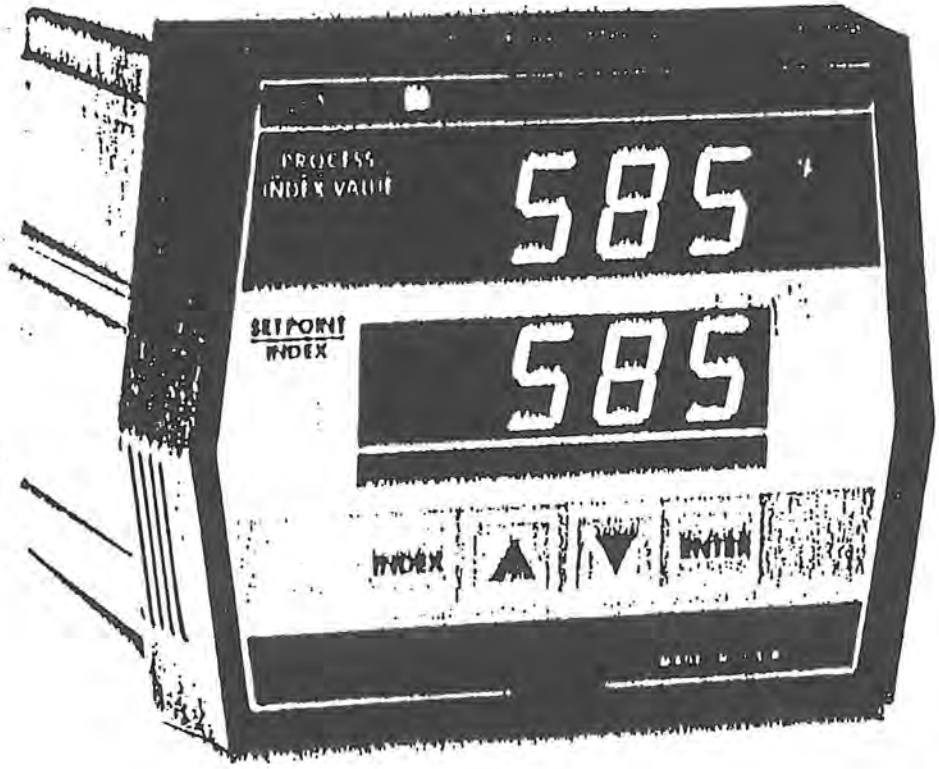
ALARMS
0 = NONE
2 = TWO

INPUT
1 - THERMOCOUPLE J,K AND E
2 - THERMOCOUPLE T,R, AND S
4 - 1.0° RTD (CAL. 104, 105 AND 106)
5 - 0.1° RTD (CAL. 104, 105 AND 106)
6 = D.C. VOLTAGE
7 = D.C. CURRENT

OUTPUT MODULE
1 = 9.5A RELAY
2 = TRIAC DRIVER, 0.1A SOLID STATE SWITCH
3 = 24 V.D.C. VOLTAGE SWITCH (NON-ISOLATED).
4 = 0 TO 20 mA D.C. PROPORTIONAL CURRENT (NON-ISOLATED). INTO 0 TO 1000 OHMS MAX.
5 = 0 TO 10 V.D.C. PROPORTIONAL VOLTAGE (NON-ISOLATED). INTO 500 OHMS MIN. (20 mA MAX).
*6 = 0 TO 20 mA D.C. PROPORTIONAL CURRENT (ISOLATED). INTO 0 TO 1000 OHMS MAX.
*7 = 0 TO 5 V.D.C. PROPORTIONAL VOLTAGE (ISOLATED). INTO 250 OHMS MIN. (20 mA MAX.).
8 = 1.0A TRIAC SOLID STATE SWITCH. NOT FOR DRIVING SSR's.

OPTION NUMBERS
SEE "OPTIONS" LIST

*NOTE: Option 550, Isolated power supply must be ordered if these output modules are selected.



Front Panel Presentation

Status Lights. Indicate status of main set point output, alarm 1 and alarm 2 outputs.

Upper display. Continuously indicates the process value in "home" position and value or condition of index (menu) item while programming or viewing items chosen.

Descriptor lights in this area indicate condition or function selected for certain options.

°F/°C Descriptors for temperature controls.

Lower display. Continuously indicates the process set value in "home" position and index (menu) items when programming or viewing items chosen.

Index key pad. Advances index (menu) through all items that can be programmed or viewed for a particular security level or set-up. Used together with the decrement key to reset an alarm programmed for manual reset.

Enter key pad. Enters into memory new setting or commands chosen. If not pressed, previous setting or command will be retained.

Jack screw. Allows removal of control from housing.

Increment key pad. Raises value or turns "on" index item chosen. May also be used to choose any one of many functions.

Decrement key pad. Lowers value or turns "off" index item chosen. May also be used to choose any one of many functions. Used together with the index key to reset an alarm programmed for manual reset.

Temperature Ranges

Thermocouple		
Ordering Code	Sensor Type	Range
1	J	−100 to +1600°F/−73 to +871°C
	K	−200 to +2500°F/−129 to +1371°C
	E	−100 to +1800°F/−73 to +982°C
2	T	−350 to +750°F/−212 to +398°C
	R	0 to 3200°F/−17 to +1760°C
	S	0 to 3200°F/−17 to +1760°C

RTD		
Ordering Code	Sensor Type	Range
4 1.0° Resolution	100 ohm Plat. .00385, Cal. 106	−328 to +1607°F/−200 to +875°C
	100 ohm Plat. .00392, Cal. 104	−328 to +1607°F/−200 to +875°C
	120 ohm Nickel, Cal. 105	−112 to +608°F/−80 to +320°C
5 0.1° Resolution	100 ohm Plat. .00385, Cal. 106	−200.0 to +990.0°F/−128.9 to +532.2°C
	100 ohm Plat. .00392, Cal. 104	−200.0 to +990.0°F/−128.9 to +532.2°C
	120 ohm Nickel, Cal. 105	−112.0 to +385.0°F/−80.0 to +196.1°C

Description

Model 300 Series controls are microprocessor based and include selectable Self-Tune or manual tune P.I.D. functions: gain (band width), reset (integral) and rate (derivative).

Two large LED displays indicate all controller parameters as well as process temperature (or other input variable) and set point value.

A wide selection of inputs are offered with multiple choice thermocouple or RTD selection in the same control. Input scaling may be field programmed for voltage or current inputs.

Output plug-in modules, that can be changed in the field, provide complete output versatility.

Status lights indicate output conditions at all times.

Every parameter of the control may be field adjusted, if desired. Two levels of security are also provided. Four front panel membrane key pads are used to view or change all selected index (menu) items.

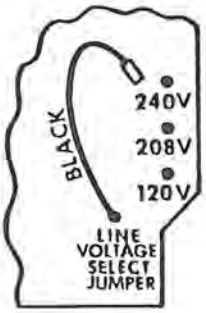
Complete non-volatile memory eliminates the need for battery back-up and attendant battery problems.

Many options are available, including two alarm outputs.

Voltage Selection. FAILURE TO SELECT PROPER VOLTAGE CAN RESULT IN TRANSFORMER BURN-OUT.

Check the label affixed to the top of the controller housing to determine the line voltage for which the unit will operate as shipped. This is usually 240 V.A.C. 50/60 HZ.

To change this input voltage, remove the controller from its housing as described under "Removal from the Housing". There is a black jumper located along the right edge of the circuit board as you are facing the rear of the control. This jumper is soldered to one terminal and plugged on to one of the voltage select terminals. These terminals are marked 120V, 208V, or 240V. If you wish to change the voltage input, unplug the jumper from the terminal that it is on, using a long-nosed plier and pulling straight up. Plug it on to the desired voltage terminal. Replace controller into its housing.



Removal from the Housing

The controller does not have to be removed from its housing for mounting. However, if security switch or alarm jumper changes are required, it will have to be removed.

To remove the controller from its housing, turn the jack screw, located in the center of the bottom edge of the controller face, in a counter-clockwise direction until loose. Pull the control forward to slide out of the housing.

To replace, slide the control chassis into the housing in its proper slots until the jack screw is engaged. Turn the jack screw clockwise, while at the same time pushing gently on the top edge of the controller, until tight. **Do not** over tighten.

Mounting

Select a location for mounting where the control will not be subject to excessive temperature, shock, vibration, dust, moisture, oil or other liquids.

All models are designed for mounting in an enclosed panel through a 3⅝ in. x 3⅝ in. (92 mm x 92 mm) cutout. No other holes are required.

Remove the U bracket from the housing by removing the two mounting screws from the rear of the controller housing. Slip the control through the cutout from the front of the panel and replace the U bracket. Tighten bracket screws until the controller is secure in its cutout. **Do not** over tighten these screws.

Mount the 3137-0405 or 3137-0406 power units, used with triac driver output module, to a large metal surface within the control panel. The fins must be oriented perpendicular to ground level for best heat radiation.

Power Wiring

Wire in accordance with the wiring diagrams shown for your specific output module.

Make all wiring connections in accordance with the National Electrical Code and local regulations. Use N.E.C. Class 1 wiring for all power terminals. Use No. 14 AWG copper conductors only.

Grounding of the control is not required.

It is advisable to fuse the incoming power line to terminal 8 with a type 3AG or MDL, ⅛A SLO-BLO fuse. Be sure that it fuses the instrument power input only and not the load also.

For all output modules, other than relay, output terminals may be wired with No. 20 AWG copper conductors only. Use No. 14 AWG for relay output terminals.

Input Wiring

Do not run thermocouple or other input wiring in the same conduit as power leads. Use only the type of thermocouple or RTD probe for which the control has been programmed. The type may be viewed by stepping through the menu using the Index key pad. Voltage or current input values are shown on the serial number label inside the instrument.

For thermocouple input, always use extension leads of the type designated for your thermocouple. Generally, the red wire from the thermocouple is *negative*.

On thermocouple input units, do not remove reference junction compensator assembly connected under terminals 15 and 16 by a tab terminal and red wire.

Input Selection

Where displays are shown in these instructions, a heavy line at the top [ ] indicates the upper display, while a heavy line at the bottom [ ] indicates the lower display.

Inputs appear as follows:

Temperature:

Upper display —

[J-IC] = Iron/Constantan	[t-] = Copper/Constantan
[CA] = Chromel/Alumel	[r-13] = Plat. 13% R.H./Plat.
[E-] = Chromel/Constantan	[S-10] = Plat. 10% R.H. /Plat.

[104] = PLT. 100 OHM .00392 N.B.S. Curve RTD

[105] = NICKEL 120 OHM RTD

[106] = PLT. 100 OHM .00385 DIN curve RTD

Lower display—

[InP] = Input

Voltage and Current:
Almost any Linear Scale may be programmed by the user (including decimal point positioning).

The scale range must fall within a 4000 or less count range. The term "count" in this case means the amount of numbers that can be displayed regardless of the position of the decimal point.

For example; 0 to 4000, −2000 to +2000, −10.0 to 390.0,
1.000 to 5.000 and 30.00 to 70.00 are all at the 4000 count maximum.

The minimum value for any range must be 100 counts or more.

For example; −50 to +50, 0 to 100, 2.5 to 12.5, .50 to 1.50 and −.010 to .090 are all at the 100 count minimum.

If the scale low value [SCAL] and the scale high value [SCAH] are greater than 4000 counts or less than 100 counts, then, either [CHEC] [SCAL] or [CHEC] [SCAH] will show up on the display, depending on which one is presently being programmed (opposite one shows the error).

Examples of typical programming for [SCAL] & [SCAH] for various scale ranges are;

SCALE RANGE	[SCAL] VALUE	[SCAH] VALUE
−350 +999	−350	999
−67 +113	−67	113
	or −67.0	113.0
−2 +0	−2.00	0
	or −2.000	0.000
−0.1 +0.4	−.100	.400
0 +15,000	0	150 (×100)
	or 0	1500 (×10)

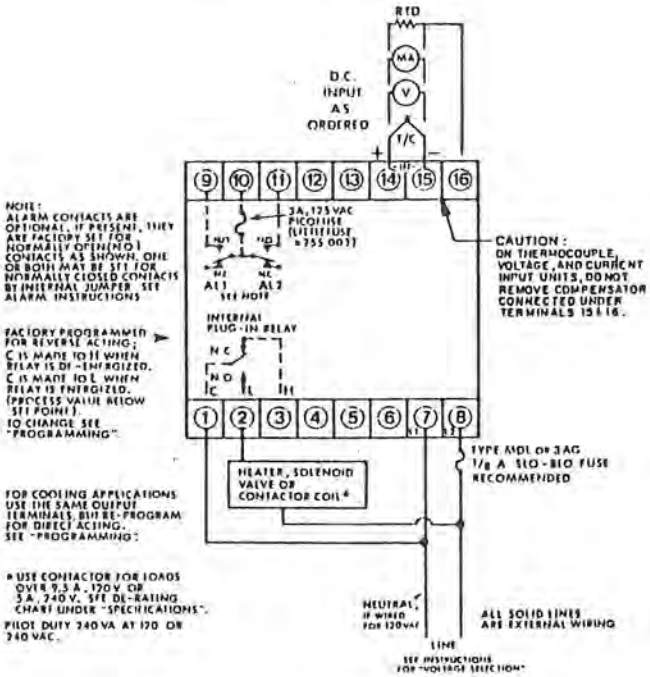
All standard ranges may be programmed for 0 suppression ([0SUP]) (20% range elevation) by the user for Process Signals.

INPUT FOR STANDARD RANGES	INPUT FOR 0 SUPPRESSION [0SUP] PROGRAMMED [On]	INPUT IMPEDANCE
0 to 1 MA	0.2 to 1 MA	100 ohms
0 to 5 MA	1 to 5 MA	20 ohms
0 to 20 MA	4 to 20 MA	5 ohms
0 to 50 MA	10 to 50 MA	2 ohms
0 to 10 MV	2 to 10 MV	10K ohms
0 to 20 MV	4 to 20 MV	10K ohms
0 to 50 MV	10 to 50 MV	10K ohms
0 to 100 MV	20 to 100 MV	10K ohms
0 to 250 MV	50 to 250 MV	10K ohms
0 to 500 MV	100 to 500 MV	10K ohms
0 to 1 V	0.2 to 1 V	20K ohms
0 to 5 V	1 to 5 V	100K ohms
0 to 10 V	2 to 10 V	200K ohms
>10	USE 10 V RANGE & EXTERNAL VOLTAGE DIVIDER	

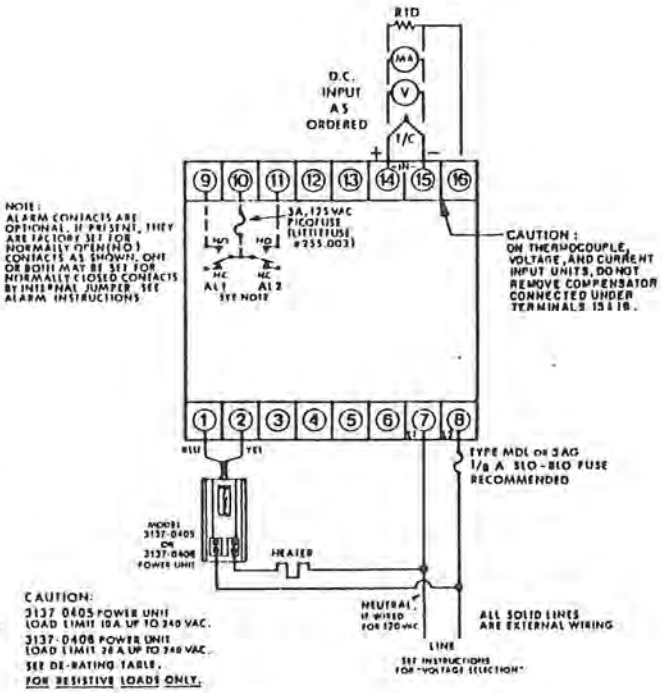
°F and °C descriptors as well as no descriptors at all may be programmed by the user. A multiple Engineering Units Label Card is provided with each instrument. The card has labels of the most common Engineering Units on it as well as blanks to create your own. The appropriate label is applied to the upper R.H. corner of the silver area opposite "SET POINT/INDEX" on the front of the instrument.

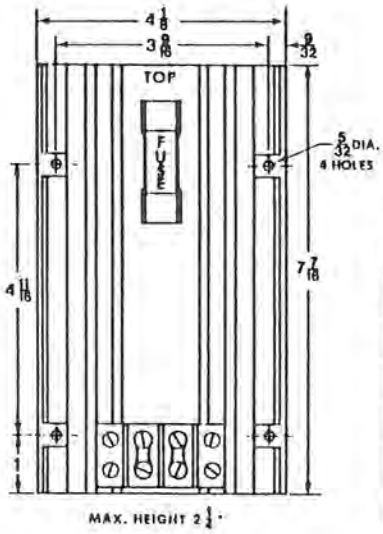
Overflow and Underflow protection may be manipulated by the user to protect from 1.) A shorted input line, 2.) Suppressed range inputs which require some time before entering the instrument scale range and 3.) Potential runaway input conditions (like overrange) and other time related input fault conditions (See "Diagnostic Error Messages").

RELAY OUTPUT MODULE (CODE 1)
EXTERNAL WIRING



TRIAC DRIVER MODULE (CODE 2)
EXTERNAL WIRING

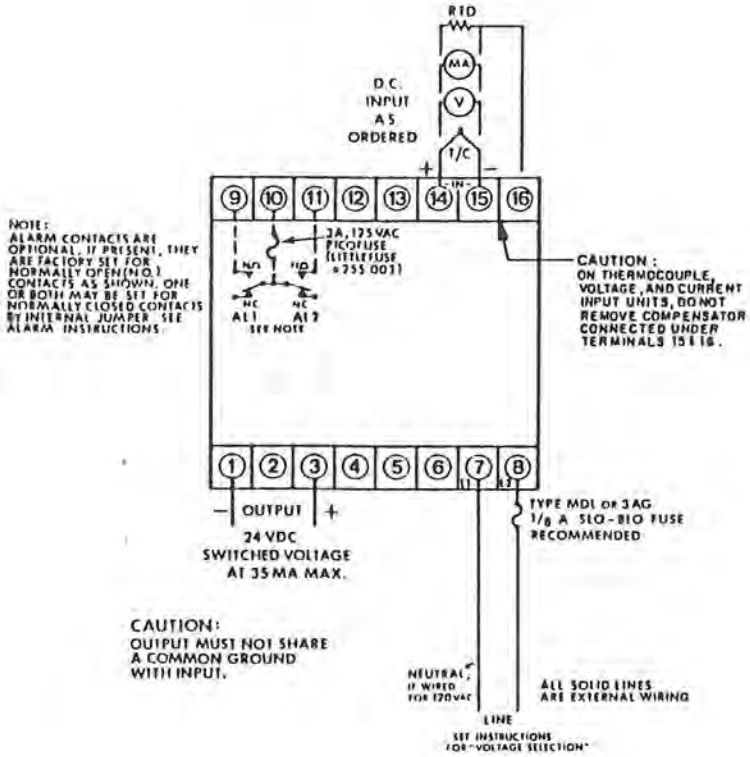




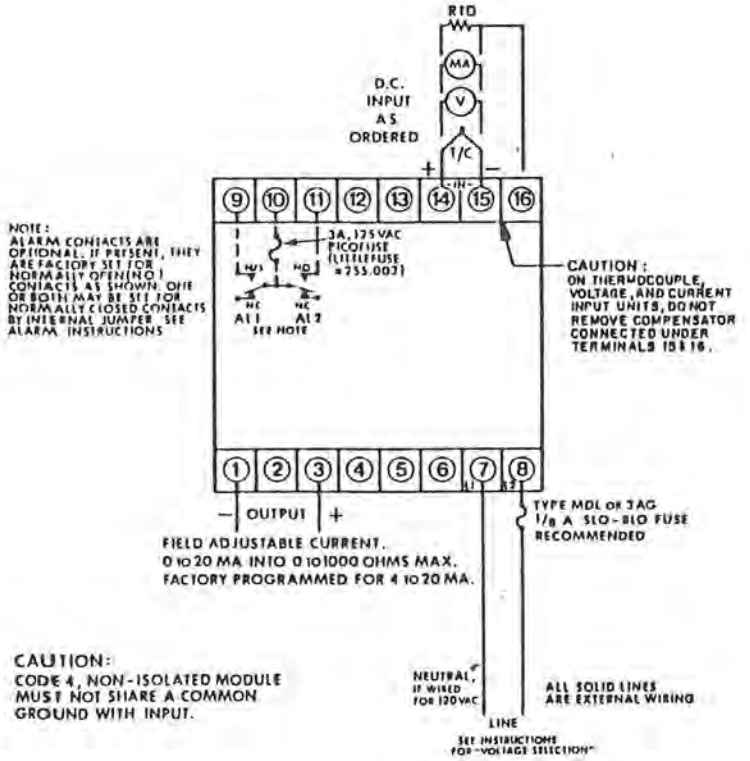
DE-RATING TABLE

AMBIENT °C	AMBIENT °F	3137-0405	3137-0406
25	77	10A.	28A.
40	104	10A.	25A.
44.4	112	9.5.	24A.
48.9	120	8.5	21.5
55	131	7.7A.	18.5

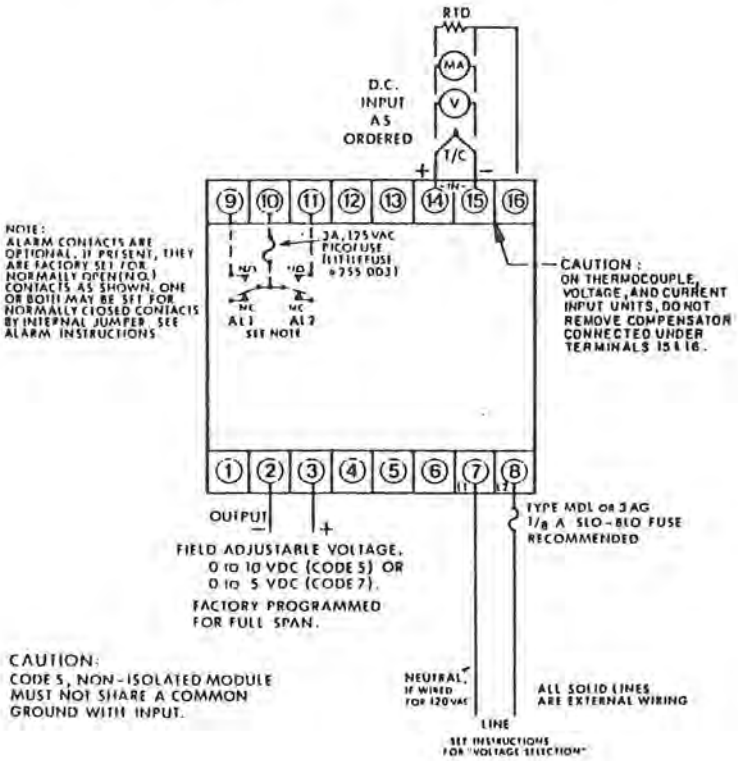
24 VDC VOLTAGE SWITCH MODULE (CODE 3) EXTERNAL WIRING



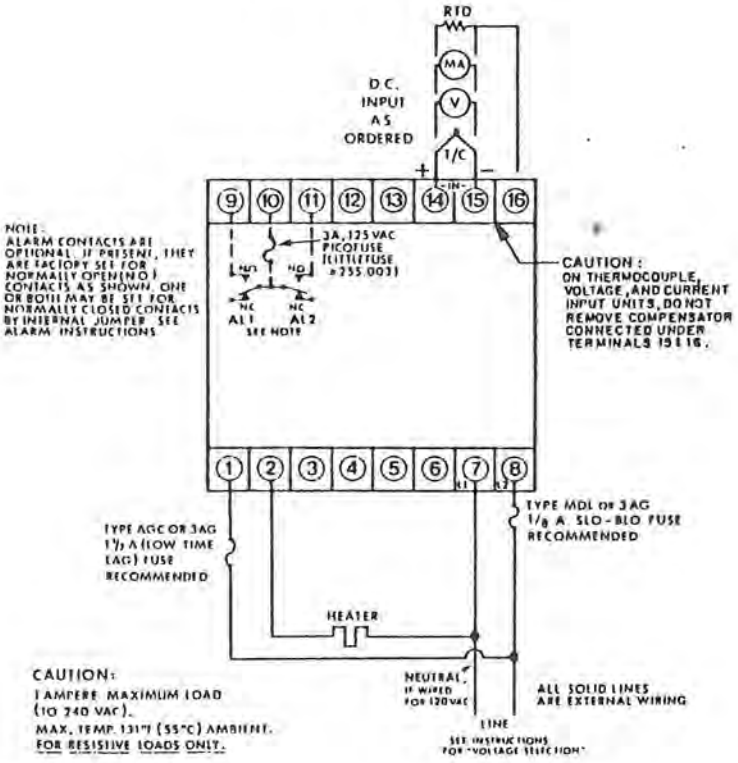
PROPORTIONAL CURRENT OUTPUT MODULE (CODE 4, NON-ISOLATED OR CODE 6, ISOLATED) EXTERNAL WIRING



PROPORTIONAL VOLTAGE OUTPUT MODULE (CODE 5, NON-ISOLATED OR CODE 7, ISOLATED) EXTERNAL WIRING



1.0 A TRIAC SOLID STATE SWITCH MODULE (CODE 8) EXTERNAL WIRING



The Security Switch

The security switch allows the user to limit the changes that may be made while the control is in operation. This will help prevent unauthorized personnel from changing important settings.

The security switch allows three conditions to be selected.

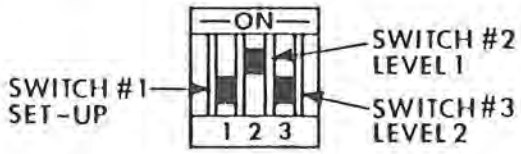
1. Set-up: Allows all programmable functions to be viewed and changed.

2. Level 1: Allows changes to control set points, alarm set points and cycle rate (if time proportioning). The following may be viewed, but *not* changed: output type, lowest set point value, highest set point value, lowest output available (in percent), highest output available (in percent) and T/C or RTD type.

3. Level 2: *No* changes may be made. The following may be viewed: all control and alarm set points, cycle rate (if time proportioning), output type, lowest and highest set point value, lowest and highest output available (in percent) and T/C or RTD type.

The security switch is located inside the controller. It is set for security level 1 as shipped from the factory. To change the setting, remove the control from its housing as described under "Removal from the Housing". The switch is mounted on the right hand side of the processor printed circuit board near the front of the instrument.

Looking from the rear of the control, look between the upper and lower PCBs to the right of the transformer. The switch has three slide actuators as shown below:



Select the slide actuator for the security condition desired. With a small screw driver move the selected slide actuator to the ON (up) position. Move the other slide actuators to the OFF (down) position. If two or more slide actuators are left in the ON position, security will be set for the lowest position. If all slide actuators are left in the OFF position, FRIL LESE will appear on the displays upon power up.

See the section "Programming in the Set-up Mode" for further instructions for the Set-up Mode.

Operation Common to All Models

In showing what the displays may indicate in these instructions, a heavy line at the top of the displayed item means that it appears on the upper display ; heavy line at the bottom, the lower display .

After mounting and wiring, power the system. All lamps and display segments come on for 2 seconds for a lamp test for visual test to determine if they are all operative. Turn off, then on, if more time is needed. Then SELF LESE is displayed, indicating that an internal diagnostic test is taking place. If FRIL LESE is then displayed, service and /or recalibration is required. Outputs remain off during this time. When the control passes the diagnostic test, the displays will then indicate both the process value and the set value. If the security switch is in the level 1 condition (as shipped from the factory) or in the level 2 condition, the outputs will be active. If left in the set-up condition, the outputs will remain off.

For all instructions following, other than under "Programming in the Set-up Mode", it is assumed that the security switch is in the level 1 condition.

When the displays indicate the process and set point values respectively, that is considered to be "home" position.

Press the "Index" key pad each time to advance through the various programmable or viewable parameters for a particular security condition.

When stepping through the various "Index" positions, if no keys are pressed for 4 to 5 seconds, the displays will revert to "Home" position. This can be defeated by keeping either the "Index" or "Enter" key pad depressed.

The "Increment" [▲] key pad is used to raise a setting. The "Decrement" [▼AL] key pad is used to lower a setting. They both operate at a variable speed to allow rapid setting. Settings change faster as the key is depressed longer. These keys are also used to turn certain functions on or off or to choose any one of many conditions for certain functions. This would be done while programming.

The "Index" [INDEX/AL] and "Decrement" [▼AL] key pads are also used to manually reset an alarm. See "Alarm Operation".

No settings will be entered into memory without depressing the "Enter" [ENTER] key pad. The previous setting will be retained if not entered. The outputs are not disturbed unless a new setting is entered. Pressing the "Enter" key will cause the displays to momentarily blank, indicating that the new data has been entered into memory.

Before adjusting for the PID control functions, refer to "PID Tuning Procedure (Quick Method)" and/or "PID Tuning Procedure (Exact Method)". If reset (integral) is to be turned off, see PD4 of "Programming in the Set-Up mode."

If thermocouple short protection is desired, see "Set-up for T/C Short Protection."

Electrical Noise

Model 300 Series controls have been designed with a high level of electrical noise immunity. As with any microprocessor based device, however, excessive noise levels can interfere with proper operation.

A common source of electrical noise is generated by the field coils of contactors and solenoids. Where external contactors (mechanical or mercury) or solenoids are used in Load circuits, it is recommended that an R/C Snubber Network (Love part number 2481-00-2400) be used to suppress the noise spikes generated by the field coils. The Snubber installs easily, directly across the coil terminals.

There may be other sources of electrical noise that could affect your system. These include lightning, line faults, power switching, motors, motor controllers, or other SCR devices. To protect your system from this type of interference use a Love Line Cure™ as described in Bulletin 9490. Consult your local representative or the factory for more details.

Using Self-Tune®

The user has the choice of selecting either Self-Tune® or manual PID tune.

If manual PID is selected, follow the tuning procedures on page 11 or 12.

Self-Tune® is a continuously active function that changes the P, I and D parameters as the control sees the process change. The system's performance is monitored through the process input and changes made as necessary to keep the system running smoothly. If the information received is incorrect, the control output can be seriously affected. It is therefore necessary to avoid certain conditions that would detract from the performance of the control if the Self-Tune® mode has been selected.

1.) Never turn off power to the heaters without turning off the power to the control as this will cause the control to tune to a condition that does not exist.

2.) The set point must be at least 50° F above ambient for start up with no loss of power or turn-off while approaching the set point on the first time rise to set point.
3.) In multi-zone applications for first time warm up, all zones should warm up simultaneously because of the influence of adjoining zones.
4.) If items 2 or 3 above are not possible, then select suitable values of P, I and D and switch to Self-Tune® after selection.

Any of the above conditions can cause the control to learn (and try to control) a process using the wrong PID values so that in normal operation the control will take a long time to return to the correct values.

There are other types of processes that may require special handling. If you have questions about your particular application, consult your local representative or the Factory.

The contol must be in the Start Learn mode during the initial heat up of the process. If you bench test the control before installation, or if you are moving the control to a new process, be sure to put the control in Start Learn (see Condition PD 6 under "Programming in the Set-up Mode").

If Self-Tune® in initially selected, the PID settings may be read out by selecting the manual PID mode. Any of the parameters may then be changed. If Self-Tune® is later initiated, it will start with the manually selected settings.

PID Tuning Procedure
(Quick Method)

Index	Initial Settings		
	Slow Response System	Medium Response System	Fast Response System
Pb Prop Band	12	8	6
rES Reset	20.0	7.0	3.0
rEE Rate	1.67	0.58	0.25
Output	CYI =15	CYI =10	CYI =6

Fine tuning the Initial settings:

1) Increase Pb and/or decrease CYI if temperature excursions are greater than desired.
2) Decrease reset rES time (in steps) for best (quickest) response when returning to the set point. If temperature excursions begin to show up at the set point, then, reset time is too fast (increase reset time).
3) Rate rEE time should be approximately 1/12 of the reset time. If the process hesitates when returning to the set point, then, decrease the rate time slightly (in steps) until little or no hesitation is discernable.

PID Tuning Procedure (Exact Method)

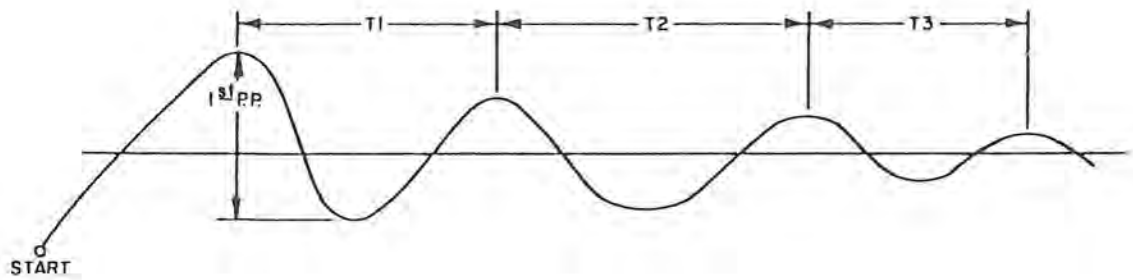


Fig. 1-Use 3 or more excursions in step 2.

1.) In Set-up Mode:
   A.) Set Reset & Rate functions to Off.
   B.) Set Control Output to On/Off. Set SP1d to -2.
2.) Obtain Heating Data (in Lev 1). Refer to Fig. 1:
   A.) Start at least 20 degrees below the Set Point. Record Excursions & Time.
   B.) Measure the 1st P.P. cycle excursion = Nom. Pb. =
   C.) Measure T1, T2, T3, etc.;
   T1= T2= T3=
   Rt min. = Lowest of T1 or T2 or T3=
   Rt max. = Highest of T1 or T2 or T3=
3.) Calculate P I D Settings:
   A.) Pb = Nom. Pb × 1.1=
   B.) Start with Reset = Rt max × 2 =
   C.) Rate = Rt max./8 =
   D.) Enter the Pb, Reset & Rate values previously calculated into the Controller & start the process.

Fine Tuning The PID Values

4.) Increase Pb if Temperature Excursions are greater than desired.
5.) Decrease Reset time (changing Rate = New Reset Time/8 each time) for best response when returning to the Set Point. Reset should not be less than Rt min. calculated in Step 2. If the Process Value hesitates when returning to the Set Point, then, decrease the Rate time slightly until little or no hesitation is discernable.

Programmable Functions

The programmable functions in your control are as outlined in the following chart. Normal factory programming for a particular output module is as shown in the chart. If it is satisfactory, no programming change is necessary. If programming must be changed or if a different output module is installed, see "Programming".

All instructions following, for each type of output module, assumes factory programming.

Programmable Functions Chart

Inputs

Programmable Items		Input Type Ordered: Thermocouple J, K and E — Can Be Programmed For	Thermocouple J, K and E — Normal Factory Program	Thermocouple T, R and S — Can be Programmed For	Thermocouple T, R and S — Normal Factory Program	RTD — Can Be Programmed For	RTD — Normal Factory Program	Voltage or Current — Can Be Programmed For	Voltage or Current — Normal Factory Program
Type J Thermocouple		✓	As Ordered					These Inputs Not Programmable	As Ordered
Type K Thermocouple		✓							
Type E Thermocouple		✓							
Type T Thermocouple				✓	As Ordered				
Type R Thermocouple				✓					
Type S Thermocouple				✓					
RTD 100 Ω Plat. 00385						✓	As Ordered		
RTD 100 Ω Plat. 00392						✓			
RTD 120 Ω Nickel						✓			
T/C Short Protection	On	✓		✓					
	Off	✓	✓	✓	✓				
Display	°F	✓	As Ordered	✓	As Ordered	✓	As Ordered	✓*	As Ordered
	°C	✓		✓		✓		✓*	

*For voltage or current input, °F/°C display only for temperature scaling. Other engineering units may be used for various scaling.

Outputs

Programmable Items		Output Module Ordered: Relay — Can Be Programmed For	Relay — Normal Factory Program	Triac Driver — Can Be Programmed For	Triac Driver — Normal Factory Program	24 V.D.C. — Can Be Programmed For	24 V.D.C. — Normal Factory Program	Proportional Current — Can Be Programmed For	Proportional Current — Normal Factory Program	Proportional Voltage — Can Be Programmed For	Proportional Voltage — Normal Factory Program
On-Off		✓		✓		✓					
On-Off Differential (if On-Off)		✓		✓		✓					
Time Proportioning (Slow) Cycle Rate Adjustable 2 to 80 sec.		✓	✓ 10 sec.	✓		✓	✓ 10 sec.				
Pulse		✓		✓		✓					
Pulse Rate (if Pulse) Adjustable 1 to 7		✓		✓		✓					
Fast Triac				✓	✓	✓					
Current Proportional								✓	✓		
Voltage Proportional										✓	✓
Set Point Minimum Setting		✓	Min.	✓	Min.	✓	Min.	✓	Min.	✓	Min.
Set Point Maximum Setting		✓	Max.	✓	Max.	✓	Max.	✓	Max.	✓	Max.
Output	Reverse Acting	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Direct Acting	✓		✓		✓		✓		✓	
Output Adjustment Minimum 0 to 90%		✓	0%	✓	0%	✓	0%	✓	20% (4 mA)	✓	0% 0 V.D.C.
Output Adjustment Maximum 10 to 100%		✓	100%	✓	100%	✓	100%	✓	100% (20 mA.)	✓	100% **
Set Point Status Light	Lit When Output Is "On"	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Lit When Output Is "Off"	✓		✓		✓		✓		✓	

**For non isolated proportional voltage output modules, "output adjustment maximum" is factory set for 100% (10 V.D.C.); for isolated, 100% (5 V.D.C.)

Operational Suggestions and Hints

1. If thermocouple short protection is desired, see "Set-up for T/C Short Protection".
2. If input correction is desired, see "Set-up for Input Correction".
3. For Relay or 24 V.D.C. output modules, start with a cycle rate [CY1] at [10] seconds. Vary the cycle rate faster [10] → [2] seconds if control excursion is greater that 4° around the set value. Cycle rate can be slower [10] → [80] seconds if control excursion is less than 2° around the set value.
4. For Current or Voltage output modules, "Set point 1 Output Low" end [S1OL] and "Set point 1 Output High" end [S1OH] may be changed as required, but, when changed, will not go over the complete range which may be desired. For example: controller initially "Set up" for [S1OL] = [20] percent, [S1OH] = [100] percent for a 4 to 20 mA output range. [S1OL] is later changed to [25] and [S1OH] changed to [90] now represents a 5 to 18 mA range. See " [S1OL] and [S1OH] Selection".
5. For Relay, 24 V.D.C. or Triac Driver output modules, leave [S1OL] at [0] and [S1OH] at [100] → [102] until sure that changing these values is necessary.

Operation With Relay or 24 V.D.C. Voltage Switch Module

Read instructions given under "Operation Common to All Models".

Depress "Index" key pad. [####] [SP1] appears on displays. The control set point may now be changed using the "Increment" [▲] or "Decrement" [▼] key pads. When the desired set point is reached, depress "Enter" to retain.

Depress "Index" key pad. If alarms are in your model, [####] [AL1] will be indicated and the alarm 1 set point may be set in the same manner as for the control set point. Be sure to depress "Enter" after the set point has been selected.

Depress "Index" key pad. [####] [AL2] indication allows selection of alarm 2 set point.

Be sure to read the instructions given under "Alarm Operation".

Depress "Index". Select [SELF] [tunE] or [P.d] [tunE] by depressing [▲] or [▼] respectively. Depress "Enter" to retain. If [P.d] [tunE] is selected, set [Pb], [rES] and [rtE] to desired settings.

Depress "Index". [#] [Pb] proportional band adjustable from 6 to 1000 deg. F (or equivalent deg. C) for temp inputs or 6 to 4000 counts for current or voltage inputs. Depress "Enter" to retain.

Depress "Index" [###] [rES] reset (intregral) adjustable 0.1 to 99.9 minutes in 6 second (0.1 minute) increments or [OFF] turns off the reset function and [###] [OFS] appears and can be adjusted from 0.1 to 99.9% of proportional band at the set point. If [OFF] [OFS] is selected, then displays return to [###] [rES] and a reset value must be selected. Depress "Enter" to retain.

Depress "Index" [####] [rtE] rate (derivative) adjustable 0.01 to 99.99 minutes in 0.6 second (0.01 minute) increments or [OFF] turns off the rate function. Press "Enter" to retain.

Depress "Index". [10] [CY1] indicates time proportioning cycle rate in seconds. This is adjustable from 2 to 80 seconds in 2 second intervals. The time set is total time of on time plus off time at 50% duty cycle (equal on-off times). Setting too short a time will wear out mechanical contactors, while too long a time may cause process cycling around the set point. A setting of 10 seconds or more is good for contactors. Where operating directly into heating loads a shorter time can be considered but may reduce the life of the relay module. The 24 V.D.C. module can be cycled as fast as can be set.

Depress "Index". [####] [SPL] is displayed. This indicates the lowest set value that may be set for any setable function like control set point or alarm settings. This cannot be set in level 1. It may only be viewed.

Depress "Index". [####] [SPH] is displayed. The highest set value that may be set. Viewed only.

Depress "Index". [0] [S:0L] is shown, indicating the lowest output (in percent) available. This cannot be set in level 1. It may be viewed only.

Depress "Index". [100] [S:0H] is displayed. The highest output (in percent) available. Viewed only.

Depress "Index." [J-K] [InP] indicates input calibration. See "Input Wiring" for designations of various input calibrations. This cannot be changed in level 1. It may be viewed only.

For temperature ranges, the °F/°C descriptor alongside the upper display will indicate which temperature scale that the control is programmed for. This may be changed in the set-up condition only.

When the set point is set above the process value, the red status light will be lit, indicating that the output is energized. The heating system is now active. As the temperature rises towards the set point, the process value indicator will continue to indicate the changes taking place in the process. When the edge of the proportional band is reached, the red status light will start to alternate from on to off. This is the time proportioning action. This action continues at the set point to maintain a stable control temperature.

If your control is equipped with alarms, see "Alarm Operation".

Operation With Triac Driver Module or Triac Module

Read instructions given under "Operation Common to All Models".

Depress "Index" key pad. [####] [SP1] appears on displays. The control set point may now be changed using the "Increment" [▲] or "Decrement" [▼A1] key pads. When the desired set point is reached, depress "Enter" to retain.

Depress "Index" key pad. If alarms are in your model, [####] [AL1] will be indicated and the alarm 1 set point may be set in the same manner as for the control set point. Be sure to depress "Enter" after the set point has been selected.

Depress "Index" key pad. [####] [AL2] indication allows selection of alarm 2 set point.

Be sure to read the instructions given under "Alarm Operation".

Depress "Index".Select [SELF] [tunE] or [P.d] [tunE] by depressing [▲] or [▼A1] respectively. Depress "Enter" to retain. If [P.d] [tunE] is selected, set [Pb], [rES] and [rtE] to desired setting.

Depress "Index". [#] [Pb] proportional band adjustable from 6 to 1000 deg. F (or equilavent deg. C) for temp inputs or 6 to 4000 counts for current or voltage inputs. Depress "Enter" to retain.

Depress "Index". [###] [rES] reset (integral) adjustable 0.1 to 99.9 minutes in 6 seconds (0.1 minute) increments or [OFF] turns off the reset function and [###] [OFS] appears and can be adjusted from 0.1 to 99.9% of proportional band at the set point. If [OFF] [OFS] is selected, then displays return to [###] [rES] and a reset value must be selected. Depress "Enter" to retain.

Depress "Index". [####] [rtE] rate (derivative) adjustable 0.01 to 99.99 minutes in 0.6 second (0.01 minute) increments or [OFF] turns off the rate function. Press "Enter" to retain.

Depress "Index." [Ft] [Out 1] appears on the display, indicating the controller has been programmed for fast triac output (time proportioning rate as fast as 1/20 second on and 1/20 second off).

Depress "Index". [####] [SPL] is displayed. This indicates the lowest set value that may be set for any setable function like control set point or alarm settings. This cannot be set in level 1. It may only be viewed.

Depress "Index". [####] [SPH] is displayed. The highest set value that may be set. Viewed only.

Depress "Index". [0] [S.OL] is shown, indicating the lowest output (in percent) available. This cannot be set in level 1. It may be viewed only.

Depress "Index". [100] [S.OH] is displayed. The highest output (in percent) available. Viewed only.

Depress "Index". [J-K] [inP] indicates input calibration. See "Input Wiring" for designations of various input calibrations. This cannot be changed in level 1. It may be viewed only.

For temperature ranges, the °F/°C descriptor alongside the upper display will indicate which temperature scale that the control is programmed for. This may be changed in the set-up condition only.

With the set point set above the process value, the red status light will be lit, indicating that power is being supplied to the heaters.

As the temperature rises towards the set point, the process indicator will continue to indicate the change taking place in the process. When the edge of the proportional band is reached, the red status light will start to alternate from on to off. This is the time proportioning action. This action continues at the set point to maintain a stable control temperature.

If your control is equipped with alarms, see "Alarm Operation".

Operation With Proportional Current Output Module

Read instructions given under "Operation Common to All Models".

Depress "Index" key pad. [####] [SP1] appears on displays. The control set point may now be changed using the "Increment" [▲] or "Decrement" [▼] key pads. When the desired set point is reached, depress "Enter" to retain.

Depress "Index" key pad. If alarms are in your model, [####] [AL1] will be indicated and the alarm 1 set point may be set in the same manner as for the control set point. Be sure to depress "Enter" after the set point has been selected.

Depress "Index" key pad. [####] [AL2] indication allows selection of alarm 2 set point.

Be sure to read the instructions given under "Alarm Operation."

Depress "Index". Select [SELF] [tunE] or [P.d] [tunE] by depressing [▲] or [▼] respectively. Depress "Enter" to retain. If [P.d] [tunE] is selected, set [Pb], [rES] and [rEE] to desired settings.

Depress "Index". [#] [Pb] proportional band adjustable from 6 to 1000 deg. F (or equivalent deg. C) for temp inputs or 6 to 4000 counts for current or voltage inputs. Depress "Enter" to retain.

Depress "Index". [###] [rES] reset (intregral) adjustable 0.1 to 99.9 minutes in 6 second (0.1 minute) increments or [OFF] turns off the reset function and [###] [OFS] appears and can be adjusted from 0.1 to 99.9% of proportional band at the set point.

If [OFF] [OFS] is selected, then displays return to [###] [rES] and a reset value must be selected. Depress "Enter" to retain.

Depress "Index". [###] [rtE] rate (derivative) adjustable 0.01 to 99.99 minutes in 0.6 second (0.01 minute) increments or [OFF] turns off the rate function. Press "Enter" to retain.

Depress "Index". [CP] [Out 1] appears on the display, indicating the controller has been programmed for proportional current output.

Depress "Index". [####] [SPL] is displayed. This indicates the lowest set value that may be set for any setable function like control set point or alarm settings. This cannot be set in level 1. It may only be viewed.

Depress "Index". [####] [SPH] is displayed. The highest set value that may be set. Viewed only.

Depress "Index". [20] [S:OL] is shown, indicating the lowest output (in percent) available. This cannot be set in level 1. It may be viewed only.

Depress "Index". [100] [S:OH] is displayed. This highest output (in percent) available. Viewed only.

Depress "Index". [J-tC] [InP] indicates input calibration. See "Input Wiring" for designations of various input calibrations. This cannot be changed in level 1. It may be viewed only.

For temperature ranges, the °F/°C descriptor alongside the upper display will indicate which temperature scale that the control is programmed for. This may be changed in the set-up condition only.

With the set point set above the process value, the red status light will be lit, indicating that there is a current output signal. This light stays on as long as there is any current output at all. Since the control is programmed at the factory for 4 to 20 mA output, the red status light will always be on. If the output is re-programmed for 0 to 20 mA or any other current output starting at zero, the light would go out upon the current output signal becoming zero. If light is desired to be off with 4 to 20mA output, re-program [SP tL] to [OoFF] in "Set-up" mode. See "Programming in the Set-up Mode."

The current output will vary from 20mA to 4mA within the proportional band to maintain stable control.

If your control is equipped with alarms, see "Alarm Operation".

Operation With Proportional Voltage Output Module

Read instructions given under "Operation Common to All Models."

Depress "Index" key pad. [####] [SP 1] appears on displays. The control set point may now be changed using the "Increment" [▲] or "Decrement" [▼AL] key pads. When the desired set point is reached, depress "Enter" to retain.

Depress "Index" key pad. If alarms are in your model, [####] [AL 1] will be indicated and the alarm 1 set point may be set in the same manner as for the control set point. Be sure to depress "Enter" after the set point has been selected.

Depress "Index" key pad. [####] [AL2] indication allows selection of alarm 2 set point.

Be sure to read the instructions given under "Alarm Operation".

Depress "Index". Select [SELF] [tunE] or [P.d] [tunE] by depressing [▲] or [▼AL] respectively. Depress "Enter" to retain. If [P.d] [tunE] is selected, set [Pb], [rES] and [rtE] to desired settings.

Depress "Index". [#] [Pb] proportional band adjustable from 6 to 1000 deg. F (or equivalent deg. C) for temp inputs or 6 to 4000 counts for current or voltage inputs. Depress "Enter" to retain.

Depress "Index". [###] [rES] reset (intregral) adjustable 0.1 to 99.9 minutes in 6 second (0.1 minute) increments or [OFF] turns off the reset function and [###] [OFS] appears and can be adjusted from 0.1 to 99.9% of proportional band at the set point. If [OFF] [OFS] is selected, then displays return to [###] [rES] and a reset value must be selected. Depress "Enter" to retain.

Depress "Index". [###] [rtE] rate (derivative) adjustable 0.01 to 99.99 minutes in 0.6 second (0.01 minute) increments or [OFF] turns off the rate function. Press "Enter" to retain.

Depress "Index". [EP] [Out] appears on the display, indicating the controller has been programmed for proportional voltage output.

Depress "Index". [####] [SPL] is displayed. This indicates the lowest set value that may be set for any setable function like control set point or alarm settings. This cannot be set in level 1. It may only be viewed.

Depress "Index". [####] [SPH] is displayed. The highest set value that may be set. Viewed only.

Depress "Index". [0] [SOL] is shown, indicating the lowest output (in percent) available. This cannot be set in level 1. It may be viewed only.

Depress "Index". [100] [SOH] is displayed. The highest output (in percent) available. Viewed only.

Depress "Index". [U-tC] [InP] indicates input calibration. See "Input Wiring" for designations of various input calibrations. This cannot be changed in level 1. It may be viewed only.

For temperature ranges, the °F/°C descriptor alongside the upper display will indicate which temperature scale that the control is programmed for. This may be changed in the set-up condition only.

With the set point set above the process value, the red status light will be lit, indicating that there is a voltage output signal. This light stays on as long as there is any voltage output at all. The voltage output control is programmed at the factory for 0 to 10 V.D.C. for non-isolated modules and 0 to 5 V.D.C. for isolated modules. Therefore the red status light will go out when the output voltage is zero. If re-programmed to an output range starting above zero, such as, 1 to 5 V.D.C., the light will never go out. If light is desired to be off with output ranges starting above zero, re-program [SP tL] to [OoFF] in "Set-up" mode. See "Programming in the Set-up Mode".

The voltage output will vary over its range within the proportional band to maintain stable control.

If your control is equipped with alarms, see "Alarm Operation".

Alarm Operation and Alarm Programmable Functions

If your control is equipped with alarms, they may be programmed for various types of operation as described in the following chart. Normal factory programming is as shown in the chart. If it is satisfactory, no programming change is necessary. If programming must be changed, see "Programming in the Set-up Mode".

CAUTION: In any critical application where failure could cause expensive product loss or endanger personal safety, a second redundant limit controller is recommended.

Programmable Functions for Alarms

Alarms (Optional)

Programmable Items		Alarm 1 Can Be Programmed For	Alarm 1 Normal Factory Program	Alarm 2 Can Be Programmed For	Alarm 2 Normal Factory Program
Alarm Type (Both Alarms Must Be Same Type)	Absolute (Non-Tracking)	✓	✓	✓	✓
	Deviation (Tracking)	✓		✓	
Alarm Reset	Automatic	✓	✓	✓	✓
	Manual	✓		✓	
Alarm Action	Reverse Acting (Low Alarm)	✓	✓	✓	
	Direct Acting (High Alarm)	✓		✓	✓
Alarm Power Interrupt Circuit	Off	✓	✓	✓	✓
	On	✓		✓	
Alarm Status Lights	Lit When Alarm Output Is "On"	✓	✓	✓	✓
	Lit When Alarm Output Is "Off"	✓		✓	
Alarm Light Behavior	Flashing	✓	✓	✓	✓
	Steady	✓		✓	
Alarm Output Contacts (Selected by Internal Jumper)	Normally Open with No Power	✓	✓	✓	✓
	Normally Closed With No Power	✓		✓	

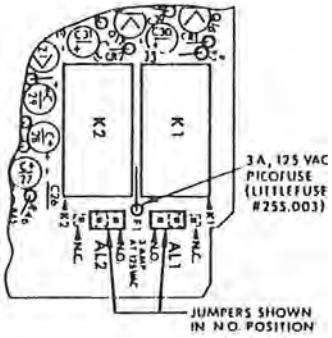
When programmed for manual alarm reset, the "Index" [INDEX AL] and "Decrement" [▼AL] key pads act as a manual reset switch when both are depressed at the same time.

Reset will occur only if there is no alarm condition.

Alarm output contacts may be re-programmed for normally closed operation (one or both) by internal jumper.

To change the jumper position, remove the control from its housing as described under "Removal from the Housing". On the left side of the upper PCB, as viewed from the rear, near the rear terminals, the ALI and AL2 jumpers can be seen. See sketch below. There are three posts in the PCB for each jumper. The center post is common. The outer posts are marked N.O. (normally open) and N.C. (normally closed). Change the jumper position by pulling it straight up from the PCB and off the posts. Replace it in the desired position by pushing it over the posts.

As received from the factory, the control is programmed for absolute (non-tracking) alarms. When setting the alarm set point, set for the process value where an alarm must be initiated.
If programmed for deviation (tracking) alarms, set the alarm set points for the deviation from set value. Example: high alarm point, +5, +10, +15, or other value; low alarm, −5, −10, −15, or other value; 0 represents the same set value as SPI (main set point). If SPI is changed, the alarms will continue to hold the same relationship as originally set.



Options

Option 520. Factory Programming. Set-up menu pre-programmed to customer specifications instead of the standard factory programs as outlined in the "Programmable Functions Chart". Program may be checked by placing the security switch in the set-up condition and stepping through each "Index" position.

Option 550. Isolated Power Supply. This option *must* be present in the control when Isolated Current Output Module 3308-145 or Isolated Voltage Output Module 3308-155 is used. Other modules may also be used with this option.

Option 617. Rear Terminal Enclosure. The enclosure may be used to simply cover the rear terminals or to surface mount the controller. To mount the enclosure to the controller, follow the instructions packaged with the enclosure.

Option 6156. Splash and Dust Resistant Construction. Consists of a gasketed splash resistant cover which snaps over the bezel, a gasket between the bezel and housing and a gasket between the housing and customer panel. Follow the instructions packaged with the cover.

Option 6162. Tamper Resistant Cover. Similar to Option 6156, except screws are provided (top and bottom) that lock into two blind holes in the instrument bezel. The instrument must be supplied with these holes. See Option 6166 below. Gasketed cover only. No extra gaskets provided. Follow the instructions packaged with the cover.

Option 6166. Blind Holes for Option 6162. Blind holes are provided in the instrument bezel to accept the tamper resistant cover.

Other Options
For other options, see separate instruction sheet furnished if that option was ordered.

Specifications
Input: Thermocouple, RTD, current or voltage.
Input Impedance: 15 megohms minimum.
Accuracy: ±0.25% of span ± 1 least significant digit.
Resolution: 1 or 0.1 degree.
Process Capability: Unique algorithms for controlling extremely slow to extremely fast processes.
Line Voltage Stability: +10%, −15% change in line voltage from nominal will not shift the control point by more than 0.05% of span.
Temperature Stability: 3 uV/°C typical, 6 uV/°C maximum.
Maximum Thermocouple Resistance: 1000 ohms. 200 ohms equals less than ±0.1% of span error.
Humidity Conditions: 0 to 90% up to 40°C non-condensing. 10 to 50% at 55°C non-condensing.
Common Mode Rejection: 140 DB minimum at 60 Hz.
Normal Mode Rejection: 65 DB typical, 60 DB minimum at 60 Hz.
Supply Voltage: 120/208/240/V.A.C., 50/60 Hz by jumper selection.
Power Consumption: 10 V.A. nominal.
Ambient Temperature Range: 0 to 55°C (32 to 130 °F).
Storage Temperature: −40 to +80°C (−40 to +175°F).
Displays: 0.56" high LED displays indicate Process Value/Set Point or Index Value/Index.
Display Update: Greater than 10 times per second.
Status Lights: All output, descriptor and alarm conditions are indicated. Output and descriptors by red LED's, alarm conditions by yellow LED's.
Backup: Non-volatile memory. No batteries required.
Input Protection: Outputs turn off and error message appears on the display for either open or shorted sensor input and for either over or under range current or voltage inputs.
Other Protection: Error messages are displayed also for the following reasons: self diagnostic test has failed, internal reference is out of specification, pre-set set point limits have been exceeded, ambient temperature at the control is out of the specification range or process heater is inoperative (T/C input only).

Diagnostics: Self-check, display and lamp test and full array of error messages.
Programmability: See programmable functions chart.
Control Functions:
P.I.D.: Proportional, integral (reset) and derivative (rate).
Cycle-Rate: Adjustable, 2 to 80 seconds full time of on time plus off time at 50% duty cycle (equal on and off times). In the time proportioning mode only.
On-Off Differential: Adjustable, from 2° to full scale in 1° steps or 0.5° to 999.0° in 0.1° steps. In the on-off mode only.
Pulse Rate: Adjustable pulse rate in 7 steps. In the pulse mode only.
Output Modules:
Relay: Plug-in, 9.5A (120 V.A.C.) up to 30 °C ambient, de-rated to 8.0A at 55°C. Also 5.0 A (240 V.A.C.) up to 55°C. Ratings are for resistive loads. Pilot duty, 240 V.A. at 120 or 240 V.A.C. Relay output contacts are single pole, double throw.

Relay de-rating chart for 120 V.A.C. loads is shown below. For 240 V.A.C. loads, current rating is 5A to 55°C (131°F).

Ambient °C	Ambient °F	Current Rating Amperes
Up to 30	Up to 86	9.5
35	95	9.2
40	104	8.9
45	113	8.6
50	122	8.3
55 max.	131 max.	8.0

Triac Driver: Solid state switch rated at 0.1 A to drive external power units 3137-0405 and 3137-0406.
24 V.D.C. Voltage Switch: Supplies 24 V.D.C. @ 35 mA max. to drive solid state contactors.
Proportional Current, Non-Isolated: 0 to 20.4 mA into 0 to 1000 ohms max. Span programmable through front panel key pads, such as 4 to 20 mA. 1 to 5 mA, 2 to 12 mA, etc. Control input must not share common grounds with the output.
Proportional Current, Isolated: Same as the non-isolated, except that control inputs may share common grounds with the output.
Proportional Voltage, Non-Isolated: 0 to 10.2 V.D.C. at 20 mA max. (500 ohms min.). Span programmable through front panel key pads, such as 0 to 1 V.D.C., 1 to 5 V.D.C., 4 to 7 V.D.C., 0 to 5 V.D.C., etc. Control input must not share common grounds with the output.
Proportional Voltage, Isolated: 0 to 5.1 V.D.C. at 20 mA max. (250 ohms min.). Span programmable through front panel key pads, such as 0 to 1 V.D.C., 1 to 5 V.D.C., 0 to 5 V.D.C., etc.
Triac Solid State Switch: Rated at 1.0 A, 240 VAC max. (resistive). Not used to drive contactors or SSR's.
Alarms: Two optional. Full selection of alarm actions.
Alarm Relays: 1.0 A at 120 V.A.C. only. For resistive loads. Normally open or normally closed output contacts selected by internal jumper. Alarm relays are fused.
Security: Three conditions selected by internal switch.
Housing: Flame retardant U.L. rated plastic. Sealed membrane switch front panel is moisture and oil resistant. Wiring terminals are located on the rear. Full plug-in construction.
Weight: Approx. 2.5 lbs.

Diagnostic Error Messages

The 300 Series Controller will display several error messages in accordance with its diagnostics to give appropriate warning when necessary.

When the chart below shows Outputs "Turned off", this means that relays are de-energized, 24 V.D.C. or triac driver modules turn off and current or voltage modules go to zero as if power was turned off.

Display	Meaning	Outputs	Action Required
	Both displays blank (unlit). Control is not getting any power or voltage supply is too low.	Turned off.	Check to make sure power supply is turned on. Check voltage selection jumper inside control (see "Voltage Selection"). Check fuses external to the control. Failure to select proper voltage to the controller can result in transformer burn-out.
FAIL test	Fail test. Appears upon power up if internal diagnostics detects a failure. Failure may be circuit related or if one of the security switches is not in the "on" position. This is also displayed if, during the course of normal operation, a catastrophic event occurs. Displays flash.	Turned off.	First check to see if the security switch of your choice is "on". If it isn't, turn it on. Replacing the control back into its housing and turning the power on will reset the control. If one of the security switches is on and this message occurs, remove the controller from service.
CHEC or CHEC SP1 SP1d or CHEC or CHEC AL1 AL2	One or more of these messages will appear upon power up, if any of these set points or differentials are set either below or above the SPL or SPH programmed values or beyond the input range ends. SP1 = Set point one. SP1d = Off/On differential. AL1 = Alarm one set point. AL2 = Alarm two set point.	Turned off.	In the "Set-up" mode, correct SP1 or SP1d or AL1 or AL2 to be within the SPL or SPH limits or re-program SPL or SPH to be at or beyond the selected set points, but not beyond the input range. See "Programming in the Set-up Mode."

Display	Meaning	Outputs	Action Required
CHEC SPL or CHEC SPH	Check 'Set Point Low' value or check 'Set Point High' value appears upon power-up, if SPL or SPH is programmed either below or above the input range ends. See "Temperature Ranges".	Turned off.	Correct SPL or SPH by re-programming in the "Set-up" mode to within the input range. See "Programming in the Set-up Mode".
CHEC SPH	Check 'Set Point High' value. Appears when, in the "Set-up" mode, one or more of the set points, differentials or alarm points is set above the maximum value entered for SPH . It will also appear if any set point, control or alarm, is set above SPH while in security Level 1. The set point will not be accepted and the previously entered set point will be retained. The displays return to home position.	Turned off during "Set-up". Remain active in security Level 1.	In "Set-up", select a set point, differential or alarm point below the 'Set Point High' value or re-program SPH to a new value above the highest set point, differential or alarm point, but not beyond the input range. In security Level 1, select a set point or alarm point below the 'Set Point High' value or re-program SPH to a new value. See "Programming in the Set-up Mode".
CHEC SPL	Check 'Set Point Low' value. Appears when in the "Set-up" mode, one or more of the set points, differentials or alarm points is set below the minimum value entered for SPL .It will also appear if any set point, control or alarm, is set below SPL while in security Level 1. The set point will not be accepted and the previously entered set point will be retained. The displays return to home position.	Turned off during "Set-up". Remain active in security Level 1.	In "Set-up", select a set point, differential or alarm point above the 'Set Point Low' value or re-program SPL to a new value below the lowest set point, differential or alarm point, but not below the input range. In security Level 1, select a set point or alarm point above the 'Set Point Low' value or re-program SPL to a new value. See "Programming in the Set-up Mode".

Display	Meaning	Outputs	Action Required
UFL or OFL #### ###=	Underflow or overflow of current or voltage input. UFL flashes under low end of zero suppressed range OSUP or under the first 0.1% of zero start range. OFL flashes at 0.5% above the top of the range. Lower display continues to indicate the set value.	Remain active	Input signal may normally go above or below range ends. If not, check input and correct. If the condition is corrected before sequencing to bad input, the displays will go back to normal indication (home position) without further attention.
sequencing to bAd inP	When inPt (input fault time) has been programmed for 0.1 min. (6 sec.) to 5400 min. (9 hrs.), then outputs will remain active until the end of this time, when, bAd inP will flash and outputs are turned off.	Remain active to Turned off.	Correct input. Turn power to the control off, then on, to reset.
	When inPt (input fault time) has been programmed for OFF, then outputs remain active indefinitely.	Remain active	Underflow and/or overflow is normal. No action required.
	bAd inP is displayed on input polarity reversal or beyond the underflow or overflow minimal limits when inPt has been programmed as described above. Displays flash.	Turned off.	Correct input. Turn power to the control off, then on, to reset.
bAd inP	Bad input. RTD sensor open or shorted, T/C shorted or heater is not working. For thermocouple input tCS (T/C short protection) must be turned "on" to warn of shorted T/C or heater not working. Displays flash.	Turned off.	Correct sensor or heater condition. Turn power to the control off, then on, to reset.

Display	Meaning	Outputs	Action Required
OPEn inP	Open input. T/C circuit open. For T/C input only. Displays flash.	Turned off	Correct T/C or T/C leads. Turn power to the control off, then on, to reset.
#### ArEA	Area appears if the controller ambient temperature nears either extreme of its specification of 0°C (32°F) or 55°C (131°F). Upper display continues to indicate the process value. Both displays flash.	Remain active	Correct ambient temperature conditions by eliminating cause (too near heated area, cabinet filters clogged, poor location, etc.). Will reset to home position when condition is corrected.
[ ] ArEA	Area appears with blank upper display if the controller ambient temperature reaches 5°C (9°F) beyond the extreme of its specification. This occurs at −5° C (23°F) or +60°C (140°F). Lower display remains steady. This condition will also occur if ambient temp compensator connected between terminals 15 and 16 is dis-connected or the wire is broken (present for all inputs except RTD).	Turned off.	Correct ambient temperature conditions by eliminating cause (too near heated area, cabinet filters clogged, poor location, etc.) or reconnect ambient temp compensator. Turn power to the control off, then on, to reset.
CHEC CAL	Check calibration. Appears during normal operation if internal reference or associated circuitry is out of tolerance. Intermittant flashing occurs at edge of specification, alternating with home position. When over specification, display flashes continuously without alternating.	Remain active at edge of specification. Turned off when over specification.	Remove controller for service and/or recalibration.
CHEC or CHEC SCAL SCAH	The difference between "Scale Low Value" SCAL and "Scale High Value" SCAH is programmed for greater then 4000 or less than 100 counts during programming of voltage or current input scale range.	Turned off	Program within the allowable count range.

Programming In the Set-up Mode

As an aid to programming, a blank "Programming Selection Table" is located in the back of this instruction booklet. It may be used to pre-select your program choices.

During programming, in the "Set-up" condition, all outputs will be off.

Remove the controller from its housing as described under "Removal From the Housing".

Set the security switch to "Set-up". Switch #1 "ON", switches #2 and #3 off (down) as described under "The Security Switch".

Replace the controller into its housing and power the instrument.

All lamps and display segments come on for 2 seconds for a lamp test for user examination to determine if they are all operative. Turn power off, then on, if more time is needed.

In showing what the displays may indicate in these instructions, a heavy line at the top of the displayed item means that it appears on the upper display [ ] ; heavy line at the bottom, the lower display [ ] .

[SELF] [EESE] is then displayed, indicating that an internal diagnostic test is taking place. If [FRIL] [EESE] is then displayed, service and/or recalibration is required.

When the control passes the diagnostic test, the displays will then indicate both the process value and the set value. This is considered "home" position. The controller will return to the "home" position if no keys are pressed for 8-10 seconds. This can be defeated by holding in either the "Index" or "Enter" key pads.

Repeated actuation of the "Index" key pad advances the various programmable functions onto the displays for either viewing or changing. At each function display, if nothing is done, the controller will return to the "home" position unless the "Index" or "Enter" key pads are continually depressed as described above.

The " Increment" [▲] key pad is used to raise a setting, turn certain functions "on" or to choose any one of many conditions for certain functions. The "Decrement" key pad [▼] is used to lower a setting, turn certain functions "off" or to choose any of many conditions for certain functions. They both operate at a variable speed to allow rapid setting. Settings change faster as the key is depressed longer.

Index items may be presented in reverse order by depressing the "Decrement" key pad and then depressing the "Index" key pad.

No settings can be entered into memory without depressing the "Enter" key pad. The previous setting will be retained if not "Entered". When depressing the "Enter" key pad the displays will momentarily go blank, indicating that the new data has been "Entered" into memory.

Programmable data will be presented as shown in the following chart. At each step press "Enter" if you wish to retain that particular data choice that is being newly entered. If no change is desired, press "Index" to proceed to next programmable function. If the displays automatically return to the "home" position before being able to make changes, simply repeatedly depress the "Index" key until back to the function of interest.

Set Point Changes

CON-DITION	Display Reads	Change Value in Upper Display by Pressing	Comments
A.	### SP1 Set Point #1	▲ or ▼AL Variable Speed	Press "Enter" to retain. Press "Index" to proceed to next programmable function. This function may also be changed in "level 1 security."
B.	### AL1 Alarm #1 Set Point (if equipped)	▲ or ▼AL Variable Speed	Press "Enter" to retain. Press "Index" to proceed to next programmable function. This function may also be changed in "level 1 security".
C.	### AL2 Alarm #2 Set Point (if equipped)	▲ or ▼AL Variable Speed	Press "Enter" to retain. Press "Index" to proceed to next programmable function. This function may also be changed in "level 1 security."

Programming For Self-Tune® or PID Control

CON-DITION	Display Reads	Change Value in Upper Display by Pressing	Comments
PD1.	SELF tunE or P.d Select Self-Tune® or manual tune PID	▲ to select SELF turns Self-Tune® function "on". ▼AL to select P.d turns manual PID tune "on".	If SELF (Self-Tune® feature) is desired, press "Enter" and "Index" to condition PD6. If P.d manual adjustment is desired, press "Enter". Condition PD2, PD3 or PD4, and PD5 can now be indexed to and changed directly without having to "Enter" P.d tunE again. This function may also be changed in "level 1 security".

Programming For Self-Tune® or P.I.D. Control (Cont.)

CON-DITION	Display Reads	Change Value in Upper Display by Pressing	Comments
PD2.	[#] [Pb] to [####] Set proportional band (in degrees or counts.	[▲] or [▼] Variable Speed	Proportional band can be selected from 6 (2 on 0.1° ranges) to 1000 Deg. F (or equivalent Deg. C) for temperature inputs or 6 to 4000 counts for current or voltage inputs. Press "Enter" to retain. Press "Index" to proceed to next programmable function (PD3).
PD3.	[OFF] [r.05] to [999] Automatic Reset. Set reset time (minutes).	[▲] or [▼] Variable Speed	Automatic Reset can be selected from 0.1 to 99.9 minutes in 6 second increments. If Automatic Reset is desired, press "Enter' and proceed to condition PD5. If [OFF] is "Entered", then Automatic Reset is turned "Off". Condition PD4 will be displayed.
PD4.	[OFF] [OFS] to [999] Manual Offset Correct	[▲] or [▼] Variable Speed	Manual Offset can be selected from 0.1 to 99.9% output at the set point. To correct offset, start at 50%. If the Process Value (PV) settles out below the set point increase the Manual Offset value above 50% and wait each time. Repeat until the PV settles out at the set point. If the PV settles out above the set point decrease the Manual Offset value below 50% and repeat if necessary. If [OFF] is "Entered" then proceed back to condition PD3 (Automatic Reset).

Programming For Self-Tune® or P.I.D. Control (Cont.)

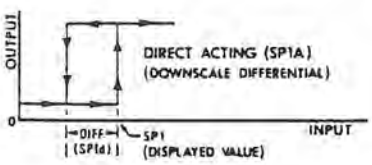
CON-DITION	Display Reads	Change Value in Upper Display by Pressing	Comments
PD5.	OFF rtE to 99.99 Automatic Rate. Set Rate time (minutes)	▲ or ▼ Variable Speed	Automatic Rate can be selected from 0.01 to 99.99 minutes in 0.6 second increments. If OFF is selected, Rate is turned "Off". Press "Enter" and proceed to condition D1.
PD6.	Strt LErn or Cont Re-start Self-Tune function when changing control process and indicates when initial PID values have been calculated.	Set-up mode only: ▲ to select Strt	In Set-up Mode: When this menu item is selected, Cont will automatically appear in the upper display if the Self-Tune function has learned the process and has set the proper PID parameters. If not, Strt will appear. Once a process has been learned (maybe during bench testing) and the control instrument is subsequently moved to a new process, always select Strt to avoid a long delay in learning the new process. This selection removes the old PID parameters from memory and the Self-Tune is free to immediately learn the new ones for the new process. Press "Enter" to retain. In Level 1 or 2 Mode: Displays Strt LErn until initial values have been calculated, then displays Cont LErn as it continues to tune the process. This function can only be changed in Set-up as above.
PD7.	OFF dAmC to 7 Damping Factor. For selecting the ratio of Rate to Reset in the Self-Tune mode.	Set-up mode only: ▲ or ▼ Single step OFF thru 7.	Use OFF for PI control only (no Rate term). Factory set at 3. For fast response (underdamped) decrease this number. For slow response (overdamped) increase this number. Press "Enter" to retain. Press "Index" to proceed to the next function. Condition PD7 is not equipped in some controls.

Control Output Functions

CON-DITION	Display Reads	Change Value in Upper Display by Pressing	Comments
D1.	2 Cy1 to 80 Set Point #1 cycle time in seconds For relay, 24 V.D.C. and triac output modules only	▲ or ▼ Single step by 2	If time proportioning is not desired, depress "Decrement" key one step below 2 on the upper display. The next programmable function (D2) will be displayed. If this output is desired, press "Enter" to retain and proceed to condition E.
D2.	Ft Out1 Fast triac for triac and 24 V.D.C. output modules only. or CP Out1 for current proportional output modules only. or EP Out1 for voltage proportional output modules only.	▲ or ▼ Single step.	If these output functions are not desired, depress "Decrement" key one step below EP on the upper display. The next programmable function (D3) will be displayed. If one of these outputs is desired, press "Enter" to retain the one selected and proceed to condition E.
D3.	PUL Out1 Pulse proportioning for water or oil cooling applications only. For relay, triac and 24 V.D.C. output modules only.	—	If this output function is not desired, depress the "Decrement" key one step below PUL on the upper display. The next programmable function (D5) will be displayed. If this output is desired, depress the "Enter" key, D4 will be displayed.

Control Output Functions (Cont.)

CON-DITION	Display Reads	Change Value in Upper Display by Pressing	Comments
D4.	[ ] [PUL] To Pulse rate [ ] for pulse output. Arbitrary setting. Set for best control results.	[▲] or [▼AL] Single step 1 thru 7.	For "Oil" cooling, use 1 thru 4. For "Water" cooling, use 3 thru 7. Press "Enter" to retain and proceed to condition E.
D5.	[On.OF] [Out 1] On/Off control for relay, triac and 24 V.D.C. output modules only.	—	If on-off control is not desired, depress "Index" key and proceed to condition E. If on/off control is desired, depress the "Enter" key, D6 will be displayed.
D6.	[####] [SP 1d] On/Off Differential for Set Point #1 if set for D5 condition. 2 degrees to full scale in one degree increments, or 0.5 to 999.0 degrees in 0.1 degree increments, limited by condition G.	[▲] or [▼AL] variable speed.	Number of degrees displayed remain the same regardless of F or C selection. Press "Enter" to retain and proceed to condition E. See Figure D6 for modes of operation.



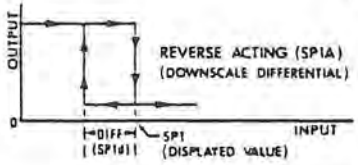


FIG. D6 [SP 1d] Modes of Operation
Note: For upscale differential — SPI (displayed value) =Desired set point + differential (SP1d).

Other Control Functions

CON-DITION	Display Reads	Change Value in Upper Display by Pressing	Comments
E.	F F-C or C temperature scale selection.	▲ Selects °F. ▼ Selects °C.	All temperature values converted and displayed in chosen scale (except SP:d differential and certain options). Press "Enter" to retain and proceed to condition F. Descriptor °F or °C to the right of the upper display will light. **This condition not present on current or voltage inputs. See condition T8.**
G.	#### SPL Lowest set point desired for Set Point #1, Alarm #1, Alarm #2 or on/off differential.	▲ or ▼ variable speed.	This function sets the low end of the desired set point span of the control.
H.	#### SPH Highest set point desired for Set Point #1, Alarm #1, Alarm #2 or on/off differential.	▲ or ▼ variable speed	This function sets the high end of the desired set point span of the control.
I.	0 S:OL to 90 in percent Low end output restriction	▲ or ▼ variable speed	Usually used to select Current or Voltage output ranges desired when Current or Voltage output modules are used. Also used for time proportioning output with relay, 24 V.D.C. or triac driver output modules to restrict duty cycle so that the lowest power output may be increased for under powered heating systems. Adjustable from 0 to 90% of output or S:OH value, whichever is lowest. See " S:OL and S:OH Selection".

Other Control Functions (Cont.)

CON-DITION	Display Reads	Change Value in Upper Display by Pressing	Comments
J.	[102] [S:OH] to [10] in percent High end output restriction	[▲] or [▼AL] variable speed	Same as [S:OL] except adjusts high end of output. Also restricts duty cycle so that the highest power output may be decreased for over powered heating systems. Adjustable from 102 to 10% of output or [S:OL] value, whichever is highest. See " [S:OL] and [S:OH] Selection".
K.	[dir] [SP:R] or [rE] Set Point #1 action-direct or reverse	[▲] to select [dir] [▼AL] to select [rE]	Direct acting: Relay, 24 V.D.C. or triac output energized *above* the set point. Current or Voltage output highest above the set point. Reverse acting is normally used for "heating" and direct acting for cooling. When controller reverts to "safe" conditions due to certain diagnostic information, all outputs turn off. See explanation under "Diagnostic Error Messages".
L.	[O on] [SP:L] or [OoFF] Set Point #1 status light "lit".	[▲] lit when S.P. #1 output is "on". [▼AL] lit when S.P. #1 output is "off".	If your controller is not equipped with alarms, proceed to Condition T.

Alarm Functions (If Equipped)

CAUTION: In any critical application where failure could cause expensive product loss or endanger personal safety, a second redundant limit controller is recommended.

	Display Reads	Change Value in Upper Display by Pressing	Comments
M.	[AbS] [AL E] or [dE] Alarm Type: Absolute or deviation	[▲] to select [AbS] [▼AL] to select [dE] Affects both alarms	If absolute is selected, alarms stay at whatever set value is entered and do not follow the control set point if it is changed (non-tracking). If deviation is selected, the alarms, once set, will hold the same relationship to the control set point and will follow if the control set point is changed (tracking).
N.	[d ir] [AL iA] or [rE] Alarm #1 action direct or reverse	[▲] to select [d ir] Direct Acting [▼AL] to select [rE] Reverse Acting	Direct acting: relay coil energized when the process value is *above* the alarm set point. Usually used for high alarm. Reverse acting: relay coil energized when the process value is *below* the alarm set point. Usually used for low alarm.
O1.	[O on] [AL iL] or [OoFF] Alarm #1 status light "lit"	[▲] lit when alarm #1 output is "ON". [▼AL] lit when alarm #1 output is "OFF".	
O2.	[On] [AL iF] or [OFF] Alarm #1 status light flasher.	[▲] to select [On] [▼AL] to select [OFF]	When "ON" is selected, the alarm status light will flash when it is lit. When "OFF" is selected, the alarm status light will stay on steadily when lit.
P1.	[OnOF] [AL ir] or [AL] Alarm #1 reset choice. Automatic or manual	[▲] to select [OnOF] automatic reset. [▼AL] to select [AL] manual reset	If automatic reset is selected, press "Enter" to retain and "Index" to condition Q. If manual reset is selected, press "Enter" to condition P2. With manual reset, once the alarm has been initiated, the condition must return to normal and the [INDEX] and [▼AL] keys must be depressed at the same time to reset.

Alarm Functions (If Equipped) (Cont.)

CON-DITION	Display Reads	Change Value in Upper Display by Pressing	Comments
P2.	On AL1P or OFF Alarm #1 power interrupt function	▲ to select On turns function "ON". ▼AL to select OFF turns function "OFF".	Used only with manual alarm reset. If "ON" is selected, will automatically reset an alarm after a power failure and subsequent restoration if no alarm condition exists. Press "Enter" and proceed to condition Q.
Q.	dir AL2A or rE Alarm #2 action direct or reverse	▲ to select dir Direct Acting ▼AL to select rE Reverse Acting	Direct Acting: relay coil energized when the process value is *above* the alarm set point. Usually used for high alarm. Reverse Acting: relay coil energized when the process value is *below* the alarm set point. Usually used for low alarm.
R1.	On AL2L or OoFF Alarm #2 status light "lit"	▲ lit when alarm #2 output is "ON". ▼AL lit when alarm #2 output is "OFF"	
R2.	On AL2F or OFF Alarm#2 status light flasher	▲ to select On ▼AL to select OFF	When "ON" is selected, the alarm status light will flash when lit. When "OFF" is selected, the alarm status light will stay on steadily when lit.

Alarm Functions (If Equipped) (Cont.)

CON-DITION	Display Reads	Change Value in Upper Display by Pressing	Comments
S1.	[On OF] [AL 2r] or [AL] Alarm #2 reset choice automatic or manual	[▲] to select [On OF] automatic reset. [▼AL] to select [AL] manual reset	If automatic reset is selected, press "Enter" to retain and "Index" to condition T. If manual reset is selected, press "Enter" to condition S2. With manual reset, once the alarm has been initiated, the condition must return to normal and the [INDEX AL] and [▼AL] keys must be depressed at the same time to reset.
S2.	[On] [AL 2P] or [OFF] Alarm #2 power interrupt function	[▲] to select [On] Turns function "ON". [▼AL] to select [OFF] Turns function "OFF".	Used only with manual alarm reset. If "ON" is selected, will automatically reset an alarm after a power failure and subsequent restoration if no alarm condition exists. Press "Enter" and proceed to Condition T.

Input Selection (Thermocouple and RTD only)

CON-DITION	Display Reads	Change Value in Upper Display by Pressing	Comments
T1.	Thermocouple E, J or K [E-] [inP] or [J-K] or [CA] or [----]	[▲] or [▼AL] Single Step	*Do not* "Enter" [----]. For factory use only. See "Input Wiring" for input type identification. Proceed to Condition U.

Input Selection (Thermocouple and RTD Only) (Cont.)

CON-DITION	Display Reads	Change Value in Upper Display by Pressing	Comments
T2.	Thermocouple T, R OR S t- InP or r-13 or S-18 or ----	▲ or ▼ Single Step	*Do not* "Enter" ---- . For factory use only. See "Input Wiring" for input type identification. Proceed to Condition U.
T3.	RTD CAL. 104, 105, or 106 104 InP or 105 or 106 or ----	▲ or ▼ Single Step	*Do not* "Enter" ---- . For factory use only. See "Input Wiring" for input type identification. Programming is complete. "Index" to "home" position or wait 8-10 seconds and "home" position will come automatically.
U.	On tCS or OFF Thermocouple short protection	▲ to select On Instrument constantly checks for a shorted thermocouple or an inoperative heater. ▼ to select OFF Turns this function "OFF".	Before turning this function "ON", see "Set-up for T/C Short Protection". This completes programming. "Index" to "home" position or wait 8-10 seconds and "home" position will come automatically.

Input Selection (Thermocouple and RTD Only) (Cont.)

CON-DITION	Display Reads	Change Value in Upper Display by Pressing	Comments
V.	– [####] [InPC] to [####] Input Correction	[▲] or [▼AL] Variable Speed	See "Set-up for Input Correction". The value of the Input Correction may be changed from −100 to +100°F or −56 to +56°C for temperature ranges with 1° resolution. For ranges with 0.1° resolution it may be changed from −100.0 to +100.0°F or −55.6 to +55.6°C. Condition V is not equipped in some controls.

After programming, turn the power to the instrument off, then on, and verify each programmed value or function. After verification, the program may be secured in either "level 1" or "level 2" security. See "The Security Switch".

Input Selection (Current & Voltage Ranges Only) Viewable & changeable in "Setup" Mode only

CON-DITION	Display Reads	Change Value in Upper Display by Pressing	Comments
T4.	[####] [SCRL] Display low value	[▲] or [▼AL] Variable Speed	This function sets the low end of the scale range. Any [####] from 100 to 4000 counts below [SCRH]
T5.	[####] [SCRH] Display high value	[▲] or [▼AL] Variable Speed	This function sets the high end of the scale range. Any [####] from 100 to 4000 counts above [SCRL]
T6.	[.] [dP] or [.] or Decimal point position [.] or [ ] ← No decimal pt. or [----]	[▲] or [▼AL] Single step.	This function sets the decimal point for 1, 2 or 3 numbers beyond the decimal point. Do not "Enter" [----]. For factory use only.

Input Selection
(Current & Voltage Ranges Only) Viewable & changeable in "Setup" Mode only

CON-ITION	Display Reads	Change Value in Upper Display by Pressing	Comments
T7.	On OSUP or OFF Zero Suppression	▲ to select On turns function "ON". ▼AL to select OFF turns function "OFF".	Low end of scale range starts 20% above low end of input range. i.e., 0 to 20 MA input range becomes 4 to 20 MA input for scale.
T8.	0 Unit or 1 or 2 Engineering units descriptor	▲ or ▼AL Single step.	Select Engineering Units Descriptors: 0 = No descriptors. Apply appropriate label from multiple Engineering Units Label Card supplied with instrument in upper R.H. corner of silver area opposite "Set Point/Index" on the front of the instrument. 1 = °F descriptor. 2 = °C descriptor.
T9.	OFF InPt to 0.1 to 540.0 Input fault time	▲ or ▼AL Variable Speed	Outputs remain active for this time after UFL or OFL begins flashing. 0.1 min. (6 sec.) to 540.0 min. (9 hrs.) can be selected in 6 sec. increments. After this time outputs turn off (safe) and bAd InP is displayed. When OFF has been selected the outputs remain active when UFL or OFL is flashing.
T10.	– #### InPC to #### Input Correction	▲ or ▼AL Variable Speed	See "Set-up for Input Correction". The value of the input correction may be changed from −1000 to +1000 counts on current or voltage ranges. Condition T10 is not equipped in some controls.

After programming, turn the power to the instrument off, then on, and verify each programmed value or function. After verification, the program may be secured n either "level 1" or "level 2" security. See "The Security Switch".

Set-up for T/C Short Protection

1. Leave [tCS] [OFF] under the following conditions:
   a. Control set value is not greater than 190°F.
   b. If the control application is "cooling".
   c. Where there is more than one controller on a machine and adjacent zones will keep the heat from dropping even through one zone fails to heat.
   d. If [bAd] [inP] appears and [tCS] is [On], then, control power is turned off, then on, and the process returns to the control set point.
   e. While performing calibration or testing.
   f. When using "ON-OFF" control.
2. Other considerations with [tCS] [On]
   a. If T/C short or heater malfunction is intermittant, [bAd] [inP] may not appear until the controller can no longer do its best to keep the process under control.
   b. If power to the controller is turned off and then turned on again and the process value is less than 10° below the set value, [bAd] [inP] may appear. Wait until the process value is greater than 10° below the set value or program [tCS] [OFF].
   c. If controller is moved from one process to another process [tCS] must be set up again.
3. To Set Up [tCS], proceed as follows:
   a. Security switch #1 must be in the up (on) position for "Set-up".
   b. Actuate the "Index" key pad repeatedly until [tErn] appears on the lower display. Depress the [▲] key pad so that [StrE] appears on the upper display. Press the "Enter" key pad to retain.
   c. Turn power to the controller off, then on, and verify each programmed value or function.
   d. Return to either "level 1" or "level 2" security. See "The Security Switch."

Set-up for Input Correction

This feature allows the input value to be changed to agree with an external reference or to compensate for sensor error.

For example:

Assume that the controller Process Value (PV) reads 200° and an external reference instrument monitoring the same temperature reads 210°. In the "Set-up" mode Index to [inPC] (usually last menu item). Change the value in the upper display by pressing the [▲] or [▼] keys until the value reads +10. Press "Enter". Return the control to the Level 1 or Level 2 security mode. Now, when the controller PV reads 200° the reference should also read 200°.

S10L and S10H Selection

Mode Selected In Condition D1 or D2	Output Range Desired	Set S10L Condition I to	Set S10H Condition J to	For other Output Values
CP Current Proportional (Non-Isolated or Isolated)	0 TO 5 mA.	0	25	Multiply current (in mA.) desired by 5. S1OH can be incremented to 102 (max.) = 20.4 mA.
	1 TO 5 mA.	5	25	
	2 TO 12 mA.	10	60	
	0 TO 20 mA.	0	100	
	4 TO 20 mA.	20	100	
EP Voltage proportional (Non-Isolated)	0 TO 1 V.D.C	0	10	Multiply voltage (in V.) desired by 10. S1OH can be incremented to 102 (max.) =10.2 V.
	0 TO 2 V.D.C.	0	20	
	0 TO 5 V.D.C.	0	50	
	1 TO 5 V.D.C.	10	50	
	4 TO 7 V.D.C.	40	70	
	0 TO 10 V.D.C.	0	100	
EP Voltage proportional (Isolated)	0 TO 1 V.D.C.	0	20	Multiply voltage (in V.) desired by 20. S1OH can be incremented to 102 (max.) = 5.1 V.
	0 TO 5 V.D.C.	0	100	
	1 TO 5 V.D.C.	20	100	
CY1 * Time proportioning, fast triac or pulse	0 TO 100% DUTY CYCLE	0	100	Multiply duty cycle by 1. Increment to 100, 101, or 102 is still 100%.
	10 TO 90% DUTY CYCLE	10	90	

*Varying cycle rate will usually produce better control than varying S10L or S10H

Changing Sensors

Your controller is calibrated for three sensor types. See "Model Identification" for your input. To change from one type to another is done in programming. See Condition T1, T2 or T3 under "Programming in the Set-up Mode" and follow instructions for programming to your desired sensor.

Changing Output Modules

Remove the controller from its housing as described under "Removal From the Housing". Locate the plug-in module and remove it by un-plugging both the small cable (if present) and the module from its socket.

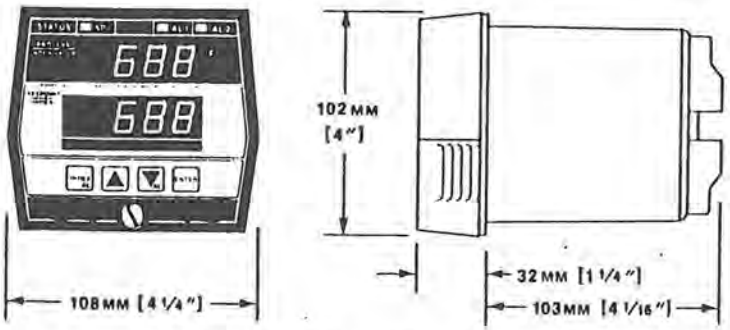
Install new module and cable (if present).

Re-wire rear terminals of control for the external wiring proper for the newly installed module.

Place the internal security switch into the "Set-Up" condition as described under "The Security Switch".

Re-install the control into its housing and re-program "Control Output Functions" as outlined under "Programming in the Set-up Mode".

DIMENSIONS



CUTOUT FOR ALL MODELS
92mm x 92mm (3⅝" x 3⅝")

PROGRAM SELECTION TABLE

Use this table to fill in programming choices as an aid when programming your controller. Make copies of this blank table or request additional copies from the factory.

SET POINTS

Index Item	Choices	Choice
[####] [SP1] Set Point 1	Any value within [SPL] and [SPH]	
[####] [AL1] Alarm Point 1	Any value within [SPL] and [SPH] If alarms are present	
[####] [AL2] Alarm Point 2	Any value within [SPL] and [SPH] . If alarms are present	

PROGRAMMING FOR SELF-TUNE® OR PID CONTROL

Index Item	Choices	Choice
[SELF] [tunE] or [P.d] Self-Tune® or manual tune PID	[SELF] or [P.d]	
[#] [Pb] Proportional Band (Heating)	6 to 1000°F (or equivalent °C) for temp inputs or 6 to 4000 counts for current or voltage inputs.	
[OFF] [rES] to [999] Automatic Reset time	Off=no reset or select from 0.1 to 99.9 minutes in 6 second increments.	
[OFF] [OFS] to [999] Manual offset Correct	Select from 0.1 to 99.9%. OFF=Must select reset time.	
[OFF] [rtE] to [9999] Automatic Rate time	Off=no rate or select from 0.01 to 99.99 minutes in 0.6 second increments.	
[Strt] [LErn] or [Cont] Restart self-tune learn Continue self-tune learn	[Strt] or [Cont]	

CONTROL OUTPUT FUNCTIONS

Relay Output Module

Index Item	Choices	Choice
## CY1 Cycle rate (time proportioning)	2 to 80 seconds.	
or PUL Out1 * Pulse output (Pulse proportioning)	1 to 7	
or OnOF Out1 * on-off output	SP1d set point on-off differential 2 degrees to SPH or 0.5 degrees to 999.0	

*When confirming these functions after programming, press "Enter" to display the pulse output or on-off differential choice.

Triac Output Module and 24 V.D.C. Output Module

Index Item	Choices	Choice
## CY1 cycle rate (time proportioning)	2 to 80 seconds	
or Ft Out1 fast triac output	no other adjustment necessary for this index item	
or PUL Out1 * Pulse output (pulse proportioning)	1 to 7	
or OnOF Out1 * on-off output	SP1d set point on-off differential 2 degrees to SPH or 0.5 degrees to 999.0	

*When confirming these functions after programming, press "Enter" to display the pulse output or on-off differential choice.

Current Proportional Output Modules

Index Item	Choices	Choice
CP Out1 Current proportional output	No other adjustment necessary for this index item	

Voltage Proportional Output Modules

Index Item	Choices	Choice
EP Out1 Voltage proportional output	No other adjustment necessary for this index item	

OTHER CONTROL FUNCTIONS

Index Item	Choices	Choice
F or F-C C Degrees fahrenheit or degrees celcius	F or C This condition not present on current or voltage inputs. See "Input Selection (Current and Voltage Ranges)."	
#### SPL Set Point low end	any #### within range span	
#### SPH Set Point high end	any #### within range span	
## S1OL Set Point 1 output low end restriction	0 to 90 percent	
## S1OH Set Point 1 output high end restriction	102 to 10 percent	
dir or SP1A rE Set Point 1 action direct or reverse acting	dir or rE	
O on or SP1L OoFF Set Point 1 status light lit with output on or with output off	O on or OoFF	

ALARM FUNCTIONS (IF PRESENT)

Index Item	Choices	Choice
AbS or AL t dE Alarm type absolute (non-tracking) or deviation (tracking)	AbS or dE	
dir or AL 1A rE Alarm 1 action direct acting (high alarm) or reverse acting (low alarm)	dir or rE	
On or AL 1L OoFF Alarm 1 status light lit with output on or with output off	On or OoFF	
On or AL 1F OFF Alarm 1 status light flasher on or off	On or OFF	
OnOF or AL 1r AL Alarm 1 reset type, on-off (automatic) or alarm (manual)	OnOF or AL * IF AL is selected, then also	
	select AL 1P, alarm 1 power interrupt function On or OFF.	
dir or AL2A rE Alarm 2 action direct acting (high alarm) or reverse acting (low alarm)	dir or rE	
On or AL2L OoFF Alarm 2 status light lit with output on or with output off	On or OoFF	
On or AL2F OFF Alarm 2 status light flasher on or off	On or OFF	

ALARM FUNCTIONS (IF PRESENT) (Continued)

Index Item	Choices	Choice
[OnOF] or [AL2r] [AL] Alarm 2 reset type, on-off (automatic) or alarm (manual)	[OnOF] or [AL] * if [AL] is selected, then also	
	select [AL2P], alarm 2 power interrupt function [On] or [OFF]	

*When confirming these functions after programming, if [AL] has been selected, press "Enter" to display the alarm power interrupt function choice.

INPUT SELECTION (THERMOCOUPLE AND RTD ONLY)

Thermocouple Types E, J or K

Index Item	Choices	Choice
[E-] or [J-tC] [inP] or [CR] Thermocouple input	[E-] =Type E, Chromel/Constantan [J-tC] =Type J, Iron/Constantan [CR] =Type K, Chromel/Alumel	
[On] or [tCS] [OFF] Thermocouple short protection	[On] or [OFF]	
– [####] to [inPC] [####] Input Correction	Any [####] within the input correction range.	

Thermocouple Types T, R or S

Index Item	Choices	Choice
[t-] or [r-13] [inP] or [S-10] Thermocouple input	[t-] =Type T, Copper/Constantan [r-13] =Type R, Plat, 13% RH./Plat. [S-10] =Type S, Plat, 10% RH./Plat.	
[On] or [tCS] [OFF] Thermocouple short protection	[On] or [OFF]	
– [####] to [inPC] [####] Input Correction	Any [####] within the input correction range.	

RTD Calibrations 104, 105 or 106

Index Item	Choices	Choice
104 or 105 InP or 106 RTD input	104 =Platinum 100 OHMS at 0°C. (American curve) alpha =.00392 OHMS/OHM/°C. 105 =nickel 120 OHMS at 0°C. 106 =platinum 100 OHMS at 0°C. (DIN curve) alpha=.00385 OHMS/OHM/°C.	
– #### to InPC #### Input Correction	Any #### within the input correction range.	

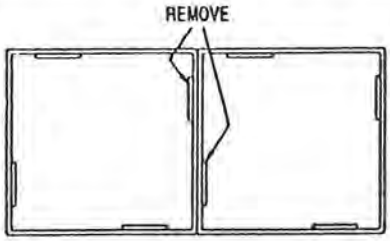
Input Selection (Current and Voltage Ranges Only)

Index Item	Choices	Choice
#### SCRL Display low value.	Any #### from 100 to 4000 counts below SCRH	
#### SCRH Display high value	Any #### from 100 to 4000 counts above SCRL	
. or . or dP . or Decimal point position	.1 resolution or .01 resolution or .001 resolution or 1 unit resolution. No decimal point	
On or OSUP OFF 20% zero suppression	On or OFF	
0 or 1 Unit or 2 Engineering units descriptor	0 no descriptor (apply label) or 1 °F descriptor or 2 °C descriptor	
OFF to 0.1 InPt to 5400 Input fault time	OFF to 5400 minutes in 0.1 minute (6 second) increments	
– #### to InPC #### Input Correction	Any #### within the input correction range.	

SECTION X - POWERGUARD TEMPERATURE CONTROLLERS

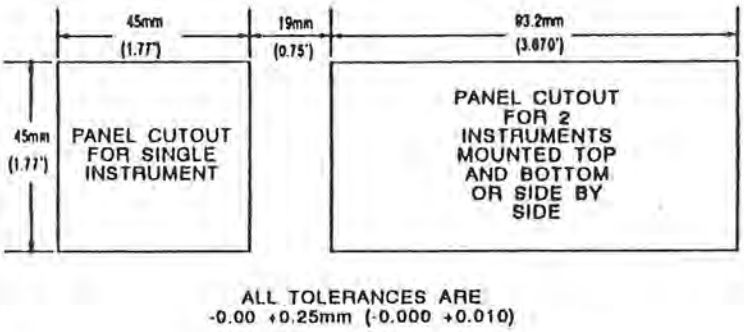
INSTALLATION

Mount the instrument in a location that will not be subject to excessive temperature, shock, or vibration. All models are designed for mounting in an enclosed panel.



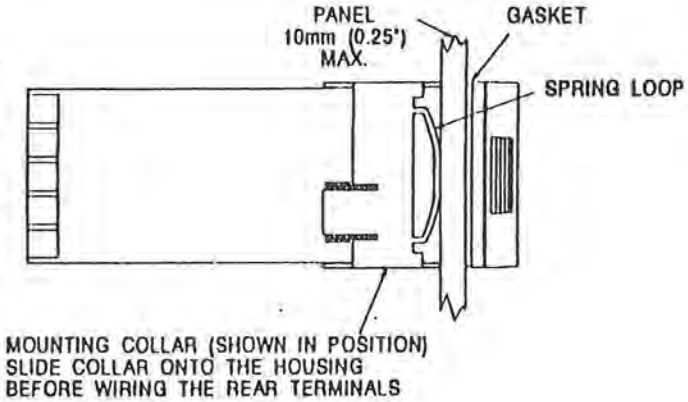
Select the position desired for the instrument on the panel. If more than one instrument is required, only two units can be mounted closely together, either one above the other or side by side. When mounted together, the mounting collar will require modification by removing the inside tab from each collar.

Prepare the panel by cutting and deburring the required opening.



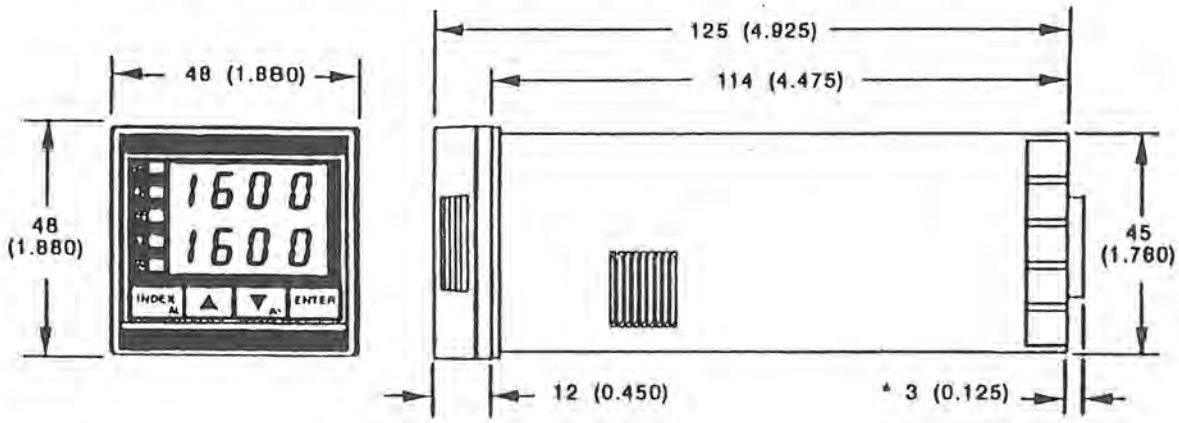
From the front of the panel, slide the housing through the cut out. The housing gasket should be against the housing flange before installing.

From the rear of the panel slide the mounting collar over the housing. Hold the housing with one hand and using the other hand, push the collar evenly against the panel until the spring loops are slightly compressed. The ratchets will hold the mounting collar and housing in place.



DIMENSIONS

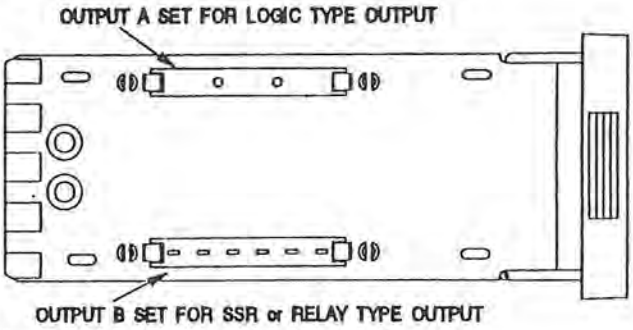
(ALL DIMENSIONS IN MM WITH INCHES IN PARENTHESIS)



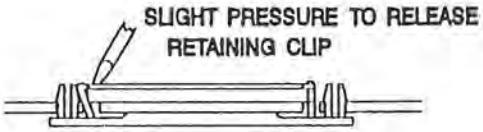
LOGIC JUMPER SELECTION

Instruments with **SSR** or **RELAY** type outputs can be changed to and from a **LOGIC** output in the field.

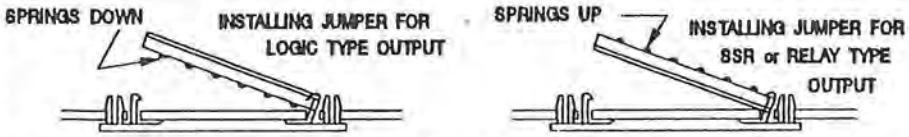
CAUTION: Damage to the instrument may result from an incorrectly installed jumper strip. Follow the instructions carefully.



1. Remove the instrument from its housing. Grasp the front bezel sides and pull forward to release it from the housing lock.
2. Locate the desired logic jumper strip on the left printed circuit board. The **OUTPUT A** jumper strip is always located near the top edge
3. To remove the logic jumper strip, carefully insert a small flat blade screwdriver between the retaining clip and the jumper at one end of the jumper strip. Apply slight pressure to move the clip away from the jumper end until it is released, then lift it up and out of the clip.



4. To re-install the jumper strip, hold it with the spring contacts in the desired position. Face springs **up** for **SSR** or **RELAY** outputs, or face springs **down** for **LOGIC** outputs. Insert one end of the jumper strip under the retaining clip and press the other end down until the remaining clip engages the jumper.

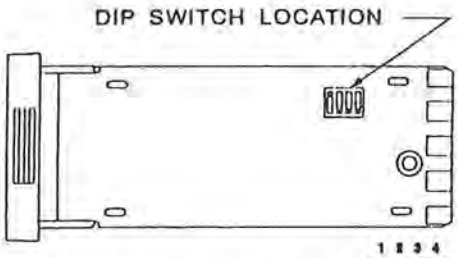


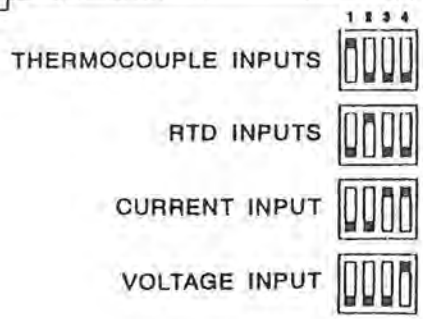
5. To avoid any damage, recheck the jumper installation and the housing rear terminal panel output wiring.
6. Replace the instrument into its housing.

INPUT SELECTION

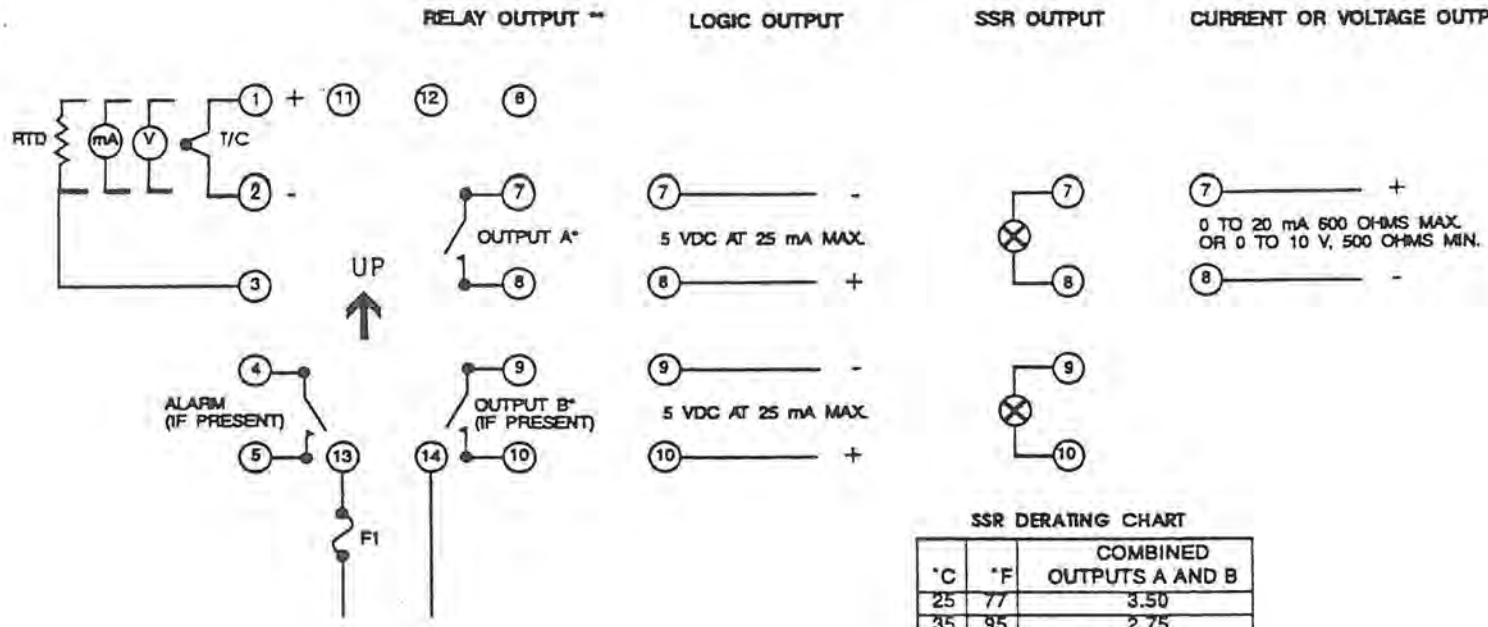
To change the input type, remove the instrument from its housing. Grasp the front bezel sides and pull forward to release it from the housing lock. Locate the dip switch on the right pcb. Determine the input type desired and change the dip switch setting as shown below.

After changing input selection with the DIP switches, be sure to change the InP menu item (page 11) in the Secure Menu.

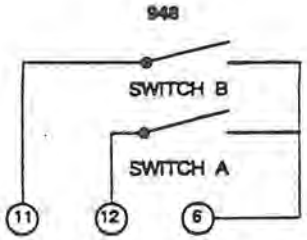


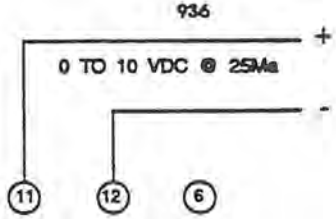


WIRING



OPTIONS





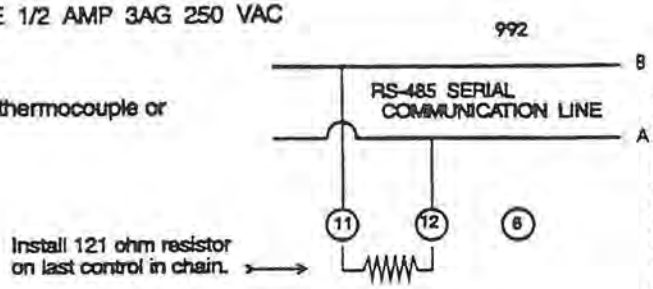
SSR DERATING CHART

°C	°F	COMBINED OUTPUTS A AND B
25	77	3.50
35	95	2.75
45	113	2.00
55	131	1.25

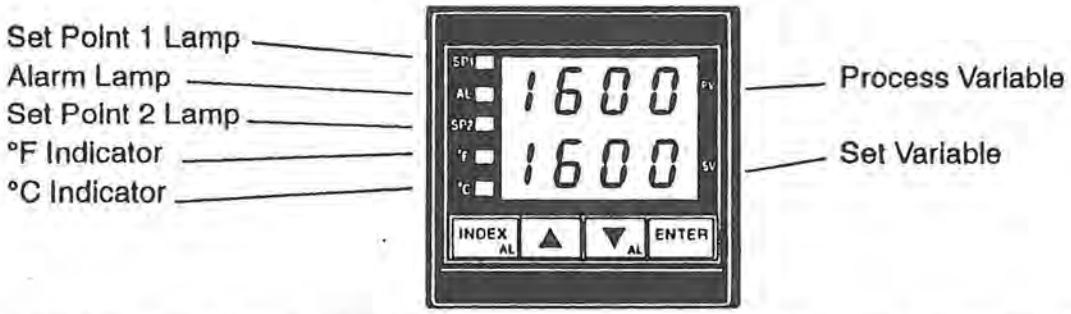
F1: FOR LINES OVER 85 V USE 1/4 AMP 3AG 250 VAC, FOR LINES LESS THAN 30 V (OPTIONAL), USE 1/2 AMP 3AG 250 VAC
LOAD POWER: SEE SPECIFICATIONS FOR OUTPUT RATINGS
FOR RELAY OR SSR OUTPUTS: TYPE MDA OR 3AB 3.5A MEDIUM LAG FUSE RECOMMENDED

INPUT WIRING: Do not run thermocouple or other input wiring in the same conduit as power leads. Use only the type of thermocouple or RTD probe for which the control has been programmed. See the "Secure Menu" for input selection.
For thermocouple input always use extension leads of the same type designated for your thermocouple.

* SOFTWARE CONFIGURABLE AS SP1 OR SP2
** R/C SNUBBER RECOMMENDED FOR DRIVING SOLENOID OR CONTACTOR LOADS



FRONT PANEL KEY FUNCTIONS



1. **INDEX:** Pressing the INDEX key advances the display to the next menu item. May also be used in conjunction with other keys as noted below.
2. **UP ARROW:** Increments a value, changes a menu item, or selects the item to ON in the upper display.
3. **DOWN ARROW:** Decrements a value, changes a menu item, or selects the item to OFF in the upper display.
4. **ENTER:** Pressing ENTER stores the value or the item changed. If not pressed, the previously stored value or item will be retained.
5. **UP ARROW & ENTER:** Pressing these keys simultaneously brings up the **secondary menu** starting at the auto/manual selection. Pressing these keys for 5 seconds will bring up the **secure menu.**
6. **INDEX & DOWN ARROW:** Pressing these keys simultaneously will allow backing up one menu item, or if at the first menu item they will cause the display to return to the **primary menu.** If an alarm condition has occurred, these keys may be used to reset the alarm.
7. **INDEX & ENTER**: Pressing these keys simultaneously and holding them for 5 seconds allows recovery from the various error messages. The following menu items will be reset:

   LPbr: Loop break
   SEnC: Sensor rate of change
   ALIH: Alarm inhibit
   OPEn InP: Open input error message
   bAd InP: Bad input error message
   ArEA: Area error message
   CHEC CAL: Check calibration error message

Correct the problems associated with the above conditions first before using these reset keys. More than one error could be present. Caution is advised since several items are reset at one time.

While in the **Primary or Secondary menu,** if no key is pressed for a period of 30 seconds, the display will return to the HOME position displaying the PV and SV values. The time is increased to 1 minute when in the **Secure menu.**

NOTE: To move to the **primary menu** quickly from any other menu, press the **UP ARROW & ENTER** keys followed by pressing the **INDEX & DOWN ARROW** keys.

METHOD FOR SET UP OF A HEAT / COOL CONTROL WITH SELF TUNE

Determine if the process is predominantly heating or cooling. An extruder, for example, is predominantly cooling when running product. An environmental chamber can be either heating or cooling. (For explanation of terms see pages 12 & 13.)

If the process is predominantly cooling, set S1St to dir and S2St to rE. If the process is predominantly heating, set S1St to rE and S2St to dir. Redirect SP1 to output A or B as required by the hardware (see SP1o). Set S2t to dE. Set SP2 for zero (no overlap of bands, no deadband). Set Pb2 to a desired value (default is 12° F). Set tunE to SELF, Strt to YES, and LErn to End.

Start the process and wait for it to come to stability. Occasionally check that the Self Tune has completed the learning process by INDEXing to Strt in the secondary menu. If the YES value has changed to no, then the process has been learned. Once learning is complete, you may adjust SP2 to either overlap the SP1 band (SP2 value less than zero), or add some separation between them (deadband -- SP2 greater than zero) if required to optimize control.

SECURITY LEVEL SELECTION

Four levels of security are provided. The display shows the current security level. To change security levels change the password value using the **UP & DOWN ARROW** keys and pressing the **ENTER** key. Refer to the password table below for the correct value to enter for the security level desired. The **SECr** menu item security level may be viewed or changed at any time regardless of the present security level. The password values shown in the table cannot be altered, so retain a copy of this page for future reference. This will be the only reference made to password values in this instruction book.

PASSWORD TABLE

SECURITY LEVEL MENU	SECURITY	DISPLAYED VALUE WHEN VIEWED	PASSWORD VALUE TO ENTER
Primary Secondary Secure	Locked Locked Locked	1	1110
Primary Secondary Secure	Unlocked Locked Locked	2	1101
Primary Secondary Secure	Unlocked Unlocked Locked	3	1011
Primary Secondary Secure	Unlocked Unlocked Unlocked	4	111

MENU SELECTIONS

PRIMARY MENU
Press **INDEX** to scan the Lower Display. Press **UP ARROW** or **DOWN ARROW** to change the value in the upper display.

In the following the symbol "#" will be used before a letter to indicate the set point value to be viewed and/or modified. (Applies to Option 948 only.)

SECONDARY MENU

Hold **UP ARROW & ENTER.** Press **INDEX** to scan the Lower Display. Press **UP ARROW** or **DOWN ARROW** to change the value in the upper display.

Auto Auto/Manual Control: Select On or OFF.

- **On** Automatic Control
- **OFF** Manual Control is enabled. The lower display in the HOME position will display the output in percent for SP1 or SP2, and is adjustable for each from 0.0 to 100 percent. SP1 appears first with a flashing "o" on the right hand corner of the lower display to represent percent. Press INDEX to display SP2 output. A flashing "ō" will appear on the right hand corner of the lower display to represent percent. When Manual is enabled, the present control outputs are held (bumpless transfer) and displayed. The output for SP1 or SP2 can then be manually adjusted while displayed by pressing the **UP** or **DOWN Arrow** key to change the value, and then the **ENTER** key. The Upper display will normally indicate the Process Value. Since Manual will override most fault messages the upper display could indicate a fault message. Refer to the Diagnostic Error Message Section for further explanation.

ALLo Alarm Low: The Low Alarm point is usually set below the Main Set Pt.

ALHI Alarm High: The High Alarm Point is usually set above the Main Set Pt.

SP *Active set point (948): Select **1SP1, 2SP1, 3SP1,** or **4SP1**. Allows setting of the multiple stages of SP1, and SP1 tuning constants.*

#SP1 *Set Point Value # (948): Select desired value.*

#tun *(948) or*

tunE Tuning Choice: Select **SELF, PId, SLO, nor,** or **FASt.**

- **SELF** The Controller will evaluate the Process and select the PID values to maintain good control. Active for SP1 only.
  - **Strt** Select **YES** or **no**
    - **YES** Start Learning the Process. After the process has been learned the menu item will revert to **no**.
    - **no** Learning will stay in present mode.
  - **LErn** Select **Cont** or **End**
    - **Cont** Continuously adjust the PID values to maintain the best control. The Process is being monitored at all times by collecting and analyzing the data to adjust the PID values. (adaptive control).
    - **End** The Process data is collected once and then the PID values are saved, tuning is stopped.
  - **dFAC** Damping factor, Select **OFF, 1** to **7**. Sets the ratio of Rate to Reset for the SELF tunE mode. 7 = most Rate. Factory set to 3. For a fast response process the value should be lowered (less Rate). For a slower process the value should be increased (more Rate).
- **PId** Manually adjust the PID values. PID control consists of three basic parameters, Proportional Band (Gain), Reset Time (Integral), and Rate Time (Derivative).
  - ***#Pb1*** *(948) or*
  - **Pb1** Proportional Band (Bandwidth). Select **6** to **5000** °F, **3** to **2778** °C, or **6** to **9999** counts.
  - **Pb2** Proportional Band (Bandwidth). Select **6** to **5000** °F, **3** to **2778** °C, or **6** to **9999** counts. *(Appears after **#rtE** when Option 948 is selected.)*
  - ***#rES*** *(948) or*
  - **rES** Automatic Reset Time. Select **OFF, 0.1** to **99.9** minutes. Select **OFF** to switch to **OFS**.
  - ***#OFS*** *(948) or*
  - **OFS** Manual Offset Correction Select **OFF, 0.1** to **99.9%**. Select **OFF** to switch to **rES**.
  - ***#rtE*** *(948) or*
  - **rtE** Rate Time. Select **OFF, 0.01** to **99.99** minutes, Derivative.
- **SLO** PID values are preset for a slow response process.
- **nor** PID values are preset for a normal response process.

FASt PID values are preset for a fast response process.

PId2 Linkage of PID parameters between SP1 and SP2: Select **On** or **OFF**.
On Links SP2 to SP1 *or #SP1* rEs and rtE terms for heat/cool applications.
OFF Sp2 functions without rEs and rtE.

ArUP Anti- Reset Wind-up Feature: Select **On** or **OFF**.
On When ArUP is **On** the accumulated Reset Offset value will be cleared to 0% when the process input is not within the Proportional Band.
OFF When ArUP is **OFF**, the accumulated Reset Offset Value is retained in memory when the process input is not within the Proportional Band.

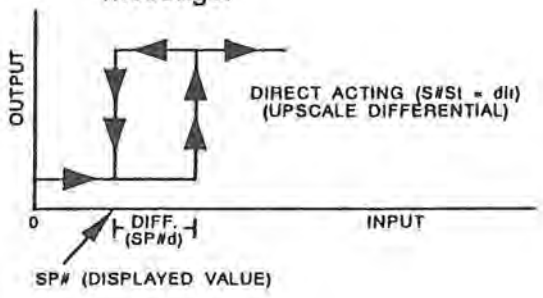
ArtE Approach Rate Time: Select **OFF, 0.01** to **99.99** minutes. The function defines the amount of Rate applied when the input is outside of the Proportional Band. The ArtE time and the rtE time are independent and have no effect on each other. To increase damping effect and reduce overshoot set the approach rate time for a value greater than the natural rise time of the process (natural rise time = process value time to set point).

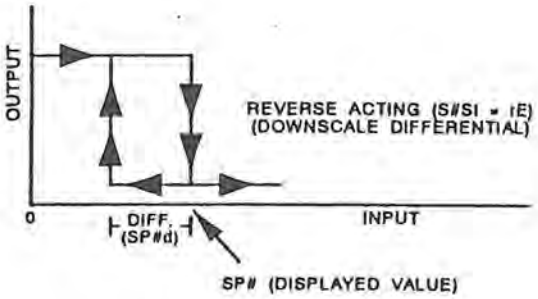
PEA Peak and Valley feature will remember the Highest (**PEA**) and lowest (**VAL**) input the Instrument has had since the last reset or Power On. At Power On they are reset to the present input, and **VAL** therefore may have to be manually reset. To manually reset the value, PEA or VAL must be in the lower display and then press the **ENTER** key. This will cause the item to be reset to the present input value.

In the following the symbol "#" will be used following letters to refer to either a number "1" or number "2". The "1" will relate to SP1 functions, the "2" for SP2. If your control is not equipped with a second set point, no SP2 functions will appear. The appearance of **CY#**, **SP#d**, or **PUL#** is dependent upon the output type selected in the Secure Menu item S#Ot. If time proportioning (cycle time) was selected, then CY# is adjustable. If On - Off was selected, then SP#d is adjustable. If pulsed time proportioning was selected then PUL# is adjustable. If none of the above are selected the menu indexes directly to S#Ot.

CY# Cycle Rate: Select **2** to **80** sec. Time Proportioning Control is adjustable in 2 sec. steps. For best contact life, a time should be selected as long as possible without causing the process to wander.

SP#d Set Point On-Off Differential. Select **1** to **1999** deg. or counts. When adjusting SP#d keep in mind that SPL and SPH have to be considered to avoid a CHEC error message.





PUL# Pulsed Time Proportioning Output: Select **1** to **7**. 1 = Linear and 7 = most non-linear. Changes output linearly for use in cooling applications or for an extremely fast response processes. At the center of the proportional band, a pulse value of 1 provides an output of one second on and one second off (50% output). A pulse value of 2 provides an output of one second on and two seconds off (33% output). Output at center of band equals one second on, $2^{(\text{pulse value}-1)}$ seconds off.

S#Ot Set Point Output Type. FT, Curr, or Volt.
Ft refers to Fast Time Proportioning, for Solid State Relay or 5V Logic Outputs. Timing is fixed at 1 sec.
Curr refers to Proportional Current Output of 0 to 20 mA.
Volt refers to Proportional Voltage Output of 0 to 10 V.
Both Curr & Volt are selected by the Hardware Configuration Code and cannot be changed.

PctO Percent Output Feature: Select **On** or **OFF**.
- **On** When selected **On,** the HOME lower display will indicate the output of the controller in percent. An "o" will appear in the right hand side of the lower display to indicate percent output for SP1. An "ō" will appear on the right hand corner of the lower display to represent percent output for SP2. The display will alternate between these values.
- **OFF** Percent Output display is disabled.

Prog Ramp/Soak Feature: Select **On** or **OFF**

StAt Status Display in the HOME Position when Prog (above) is On: Select **On** or **OFF**. When selected OFF, the HOME display will alternately indicate the normal HOME and the Ramp/Soak partial status in the Lower Display. The partial status display sequences with the set value showing the ramp (S1rA) or soak (S1So) segment being processed at that moment. It will also show the Program output status if at Hold or OoFF.
When selected On, the HOME Display will alternately indicate the normal HOME and the Ramp/Soak full status in both the upper and lower displays. The full status display sequences with the set value; Program run, Hold, or OoFF; and with the time remaining for the ramp S1rA or the soak S1So segments.

1rt Ramp Time in Hours & Minutes: Select **0.00** to **99.59** (HH.MM).

1St Soak Time in Hours & Minutes: Select **0.00** to **99.59** (HH.MM).

PEnd End of Soak action: Select **Hold** or **OoFF**.
- **Hold** Stay at the Present Set Pt.
- **OoFF** Turn Off SP1 and SP2 Outputs at the End of the Soak.

InPC Input Correction: Select **±500 °F (±260 °C)** or **±1000** counts. This feature allows the input value to be changed to agree with an external reference or to compensate for sensor error. When setting values having one or more decimal points, the lowest negative value allowed is -199.9, -19.99, or -1.999. **Note:** InPC is reset to zero when the input type is changed, or when decimal position is changed in T/C or RTD ranges. Changing decimal position in current or voltage ranges will not reset InPC.

FILt Digital Filter: Select **OFF, 1** to **99**. In some cases the time constant of the sensor, or noise could cause the display to jump enough to be unreadable. A setting of 2 is usually sufficient to provide enough filtering for most cases, (2 represents approximately a 1 second time constant). When the 0.1 degree resolution is selected this should be increased to 4. If this value is set too high, controllability will suffer.

LPbr Loop Break Protection: Select **OFF, 1** to **9999** seconds. If, during operation, the output is minimum (0%) or maximum (100%), and the input moves less than 5°F (3°C) or 5 counts over the time set for LPbr, the **LOOP bAd** message will appear. This condition can also be routed to an Alarm Condition if alarms are present and turned On (see ALbr in the secure menu). The loop break error can be reset by pressing the **ENTER** key when at the LPbr menu item. The **INDEX & ENTER** keys may also be used.

POL *Process Output Low (936): Select -450°F, -260°C, or -1999 counts to 50 degrees or counts less than* ***POH****.*

POH *Process Output High (936): Select from 50 degrees or counts greater than* ***POL*** *to +9990°F, +5530°C, or 9990 counts. A voltage output is scalable from 0 to 10 VDC that represents the Process Variable. To properly scale the output, the values for* ***POL*** *and* ***POH*** *must be calculated. The simplest example is an output of 0 to 10 VDC from 0 to 200°. In this example* ***POL****=0 and* ***POH****=200. To Calculate POL and POH for other ranges use the following:*

K *= (Highest desired temperature - Lowest desired temperature) /*
(Maximum desired voltage - Minimum desired voltage)

POH *= ((10 - Maximum desired voltage) * K) + Highest desired temperature*

POL *= ((Minimum desired voltage - 0) * K) - Lowest desired temperature*

LOrE *Local / Remote Status (992): Select LOC or rE. When LOC is selected, the host computer is advised not to send remote commands. When rE is selected, CFLt=2, and nAt is set > 0, if the control is not accessed by the host computer in the time set in nAt, the control will revert to the CFSP*

CFSP *Communications Fail Set Point (992): Set to desired value.*

Addr *Control Address (992): Set from 1 to FF. This number (hexadecimal, base 16) must match the address number used by the host computer. Viewed only in this menu.*

SECURE MENU
Hold **UP ARROW & ENTER** for 5 Seconds. Press **INDEX** to change the lower display. Press **UP ARROW** or **DOWN ARROW** to change the value in the upper display.

SECr Security Code: See the Security Level Selection and the Password Table in this manual, in order to enter the correct password.

InP Input Type: Select one of the following. The Inputs are based on four different groups; Thermocouples, RTD's, Current, and Voltage. If changing from one of these groups, the DIP switch on the A/D circuit board will have to be changed to match that particular group. Refer to the Input wiring section for the proper switch settings.

- **J-IC** Type "J" Thermocouple, Iron/Constantan (NIST)
- **CA** Type "K" Thermocouple Chromel/Alumel
- **E-** Type "E" Thermocouple Chromel/Constantan
- **t-** Type "T" Thermocouple Copper/Constantan
- **L-** Type "L" Thermocouple Iron/Constantan (DIN)
- **n-** Type "N" Thermocouple Nicrosil/Nisil
- **r-13** Type "R" Thermocouple Pt 13%Rh/Pt
- **S-10** Type "S" Thermocouple Pt 10%Rh/Pt
- **b-** Type "B" Thermocouple Pt 6%Rh/Pt 30%Rh
- **C-** Type "C" Thermocouple W 5%Re/W 26%Re
- **P392** 100 ohm Platinum (NIST 0.00392 Ω/Ω/°C), Love Cal. 104.
- **n120** 120 ohm Nickel, Love Cal. 105.
- **P385** 100 ohm Platinum (DIN 0.00385 Ω/Ω/°C), Love Cal. 106.
- **Curr** DC Current Input 0.0 to 20.0 or 4.0 to 20.0 milliamperes.
- **VoLt** DC Voltage Input 0.0 to 5.0 or 1.0 to 5.0 volts.
- **- - - -** Reserved

OSUP Zero Suppression: Select **On** or **OFF**. Only with Current and Voltage Input types.

- **OFF** The input range will start at 0 (zero) input.
- **On** The input range will start at 4.00 mA or 1.00 V.

Unit F, C or None

- **F** °F descriptor is On and temperature inputs will be displayed in actual degrees Fahrenheit.
- **C** °C descriptor is On and temperature inputs will be displayed in actual degrees Celsius.
- **nonE** °F and °C descriptors will be Off. This is only available with Current and Voltage Inputs.

dPt Decimal Point Positioning: Select **0**, **0.0**, **0.00**, or **0.000**. On temperature type inputs this will only effect the Process Value, SP1, SP2, ALLo, ALHI, and InPC. For Current and Voltage Inputs all Menu Items related to the Input will be affected.

- **0** No decimal Point is selected. This is available for all Input Types.
- **0.0** One decimal place is available for Type J, K, E, T, L, RTD's, Current and Voltage Inputs.
- **0.00** Two decimal places is only available for Current and Voltage Inputs.
- **0.000** Three decimal places is only available for Current and Voltage Inputs.

InPt Input Fault Timer: Select **OFF**, **0.1** to **540.0** minutes. Whenever an Input is out of range, shorted, or open the timer will start. When the time has elapsed, the controller will revert to a safe condition (Outputs Off, Flashing Displays). If OFF is selected, the Input Fault Timer will not be recognized (time = infinite).

SEnC Sensor Rate of Change: Select **OFF, 1** to **4000** °F, °C, or counts per 1 second period. This value is usually set to be slightly greater than the fastest process response expected during a 1 second period, but measured for at least 2 seconds. If the process is faster than this setting, the SEnC bAd error message will appear. The outputs will then be turned off. This function can be used to detect a runaway condition, or speed up detection of an open thermocouple. Use the **INDEX & ENTER** keys to reset.

SCAL Scale Low: Select **100** to **9999** counts below **SCAH.** The total span between **SCAL** and **SCAH** must be within 11998 counts. Maximum setting range is -1999 to +9999 counts. For Current and Voltage inputs, this will set the low range end. Viewable only for Thermocouples and RTD's.

SCAH Scale High: Select **100** to **9999** counts above **SCAL.** The total span between **SCAL** and **SCAH** must be within 11998 counts. Maximum setting range is -1999 to +9999 counts. For Current and Voltage inputs, this will set the high range end. Viewable only for Thermocouples and RTD's.

SPL Set Point Low: Select from **SCAL** value to **SPH** value. This will set the minimum SP1,SP2, ALLo, ALHi, SP1d, and SP2d values that can be entered. If any of the values are less than the SPL value, a check message will appear and the value will not be accepted.

SPH Set Point High: Select from **SCAH** value to **SPL** value. This will set the maximum SP1, SP2, ALLo, ALHi, SP1d, and SP2d values that can be entered. If any of the values are greater than the SPH value, a check message will appear and the value will not be accepted.

SP1o Set Point 1 Output Terminal Assignment: Select **OutA** or **Outb.**
NOTE: Reassigning the output terminals does not change the Hardware type assigned to those terminals. For single set point models, SP1o is locked to OUTA.
- **OutA** Set Pt. 1 output will be directed to terminals 7 & 8 and Set Pt. 2 output to terminals 9 & 10.
- **Outb** Set Pt. 1 output will be directed to terminals 9 & 10 and Set Pt. 2 output to terminals 7 & 8.

S#Ot Set Point Output Type: Select **CY, OnOF, PUL,** or **Ft.** Fixed for Curr and Volt, the Hardware Configuration has selected this.
- **CY** Cycle Rate, Adjustable Time Proportioning.
  - **CY#** Cycle Rate Time: Select **2** to **80** sec.
- **OnOF** On/Off Output.
  - **SP#d** Set Point Differential in 1 degree or count steps from 2 degrees or counts to full scale, but limited by SPL and SPH.
- **PUL** Pulse Time Proportioning.
  - **PUL#** Pulse Width Value: Select **1** to **7.**
- **Ft** Fast Time Proportioning: Fixed at 1 sec. Time Base.
- **Volt** Proportional Voltage, 0 to10 V.
- **Curr** Proportional Current, 0 to 20 mA.

S#St Set Point State: Select **dIr** or **rE.**
- **dIr** Direct Action. As the input increases the output will increase. Most commonly used in cooling processes.
- **rE** Reverse Action. As the input increases the output will decrease. Most commonly used in heating processes.

S#OL Set Point Output Low Limit: Select **0** to **90%** but less than **S#OH.** This item limits the lowest output value. This is useful for adding a bias to the process when needed. When a current or voltage output is used, the standard output value is 0 to 20mA or 0 to 10V. If 4 to 20 mA or 2 to 10 V is required, the S#OL value should be set for 20% to raise the lowest output.

S#OH Set Point Output High Limit: Select **10** to **102%** but greater than **S#OL.** This item allows setting the maximum output limit. This is useful with processes that are over powered.

S#LP Set Point Lamp: Select **O on** or **OoFF.**
O on Lamp ON when Output is ON.
OoFF Lamp OFF when Output is ON.

S2t Set Point 2 type: Select Abs or dE.
AbS Absolute SP2. SP2 is independent of SP1, and may be set anywhere between the limits of SPL and SPH.
dE Deviation SP2. SP2 is set as a deviation from SP1, and allows SP2 to retain its relationship with SP1 when SP1 is changed (tracking SP2).

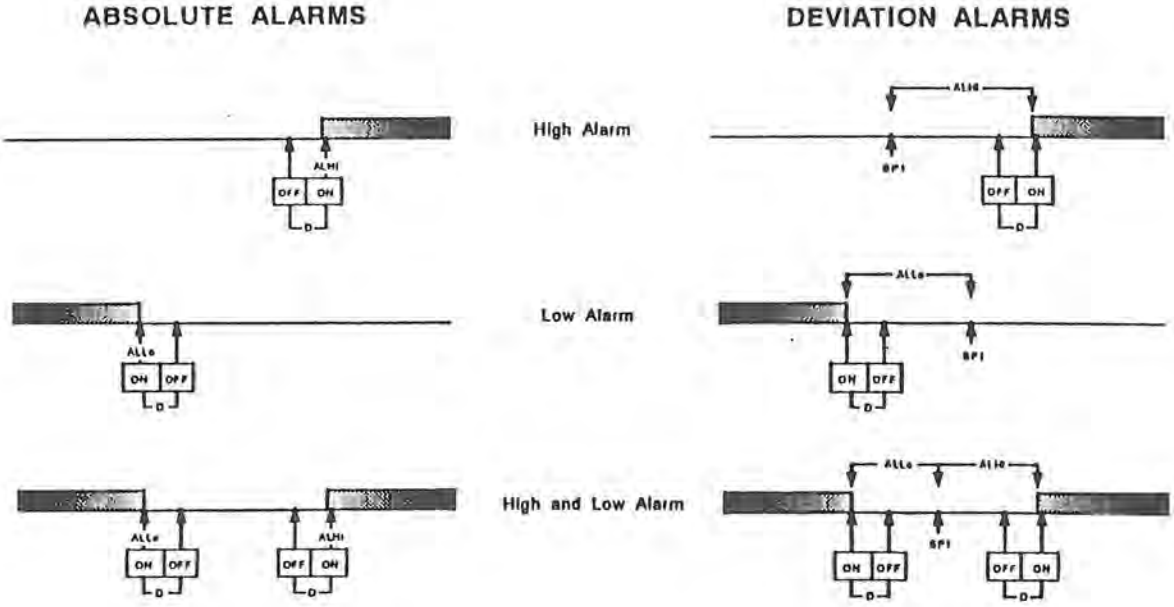
ALARM TYPE AND ACTION (If present)

Caution: In any critical application where failure could cause expensive product loss or endanger personal safety, a redundant limit controller is recommended.

When setting an alarm value for an absolute alarm (ALt = AbS), simply set the value at which the alarm is to occur.

When setting the alarm value for a deviation alarm (ALt = dE), set the difference in value from the Set Value (SV) desired. For example if a low alarm is required to be 5 degrees below the SV, then set ALLo to -5. If a high alarm is required 20 degrees above the SV, then set ALHi to +20. If SP1 is changed, the alarm will continue to hold the same relationship as originally set.

The following diagram shows the action and reset functions for both absolute and deviation alarms.



When "Alarm Power Interrupt" ALPI is programmed ON and "Alarm Reset" is programmed for Hold, the alarm will automatically reset upon a power failure and subsequent restoration if no alarm condition is present.

If "Alarm Inhibit" ALIH is selected ON, an alarm condition is suspended upon power up until the process value passes through the alarm set point once. Alarm Inhibit can be restored as if a power up took place by pressing together the **INDEX** and **ENTER** keys for 5 seconds.

Warning: Resetting a high alarm inhibit will not allow an alarm to occur if the Process Value does not first drop below the high alarm setting. Do not use the Alarm Inhibit feature if a hazard is created by this action. Be sure to test all combinations of high and low alarm inhibit actions before placing control into operation.

The following Secure menu items apply only to the alarm.

AL Alarms: Select **OFF, Lo, HI,** or **HILo.**
- **OFF** Alarms are turned OFF. No Alarm menu items appear in the Secondary and Secure menus.
- **Lo** Low Alarm Only. ALLo appears in the Secondary Menu.
- **HI** High Alarm Only. ALHI appears in the Secondary Menu.
- **HILo** High and Low Alarms. Both share the same Alarm Relay output.

ALt Alarm Type: Select **AbS** or **dE**
- **AbS** Absolute Alarm that may be set anywhere within the values of SPL and SPH and is independent of SP1.
- **dE** Deviation Alarm that may be set as an offset from SP1. As SP1 is changed the Alarm Point will track with SP1.

ALrE Alarm Reset: Select **OnOF** or **Hold.**
- **OnOF** Automatic Reset.
- **Hold** Manual Reset. Acknowledge by simultaneously pressing the **INDEX & DOWN ARROW** keys for 5 sec.

ALPI Alarm Power Interrupt: Select **On** or **OFF.**
- **On** Alarm Power Interrupt is ON.
- **OFF** Alarm Power Interrupt is OFF.

ALIH Alarm Inhibit: Select **On** or **OFF.**
- **On** Alarm Inhibit is ON. Alarm action is suspended until the process value first enters a non-alarm condition.
- **OFF** Alarm Inhibit is OFF.

ALSt Alarm Output State: Select **CLOS** or **OPEn.**
- **CLOS** Closes Contacts at Alarm Set Point.
- **OPEn** Opens Contacts at Alarm Set Point.

ALLP Alarm Lamp: Select **O on** or **OoFF.**
- **O on** Alarm Lamp is ON when alarm contact is closed.
- **OoFF** Alarm Lamp is OFF when alarm contact is closed.

ALbr Alarm Loop Break: Select **On** or **OFF.**
- **On** Loop Break Condition will cause an Alarm Condition.
- **OFF** Loop Break will not affect the Alarm Condition.

The following Secure menu items apply only to Options. They may not appear in your control.

SPSA *Set Point Select Action (948): Select **rE** or **Int.***
- ***rE*** *Remote (external) selection of active set point value.*
- ***Int*** *Internal selective of active set point value.*

Addr *Control Address (992): Set from 1 to FF. This number (hexadecimal, base 16) must match the address number used by the host computer.*

bAUd *Communications baud rate (992): Select 300, 1200, 2400, 4800, 9600, 19.2, 28.8, or 57.6. This number must match the baud rate used by the host computer. The data format is 8 bits, 1 stop bit, No parity.*

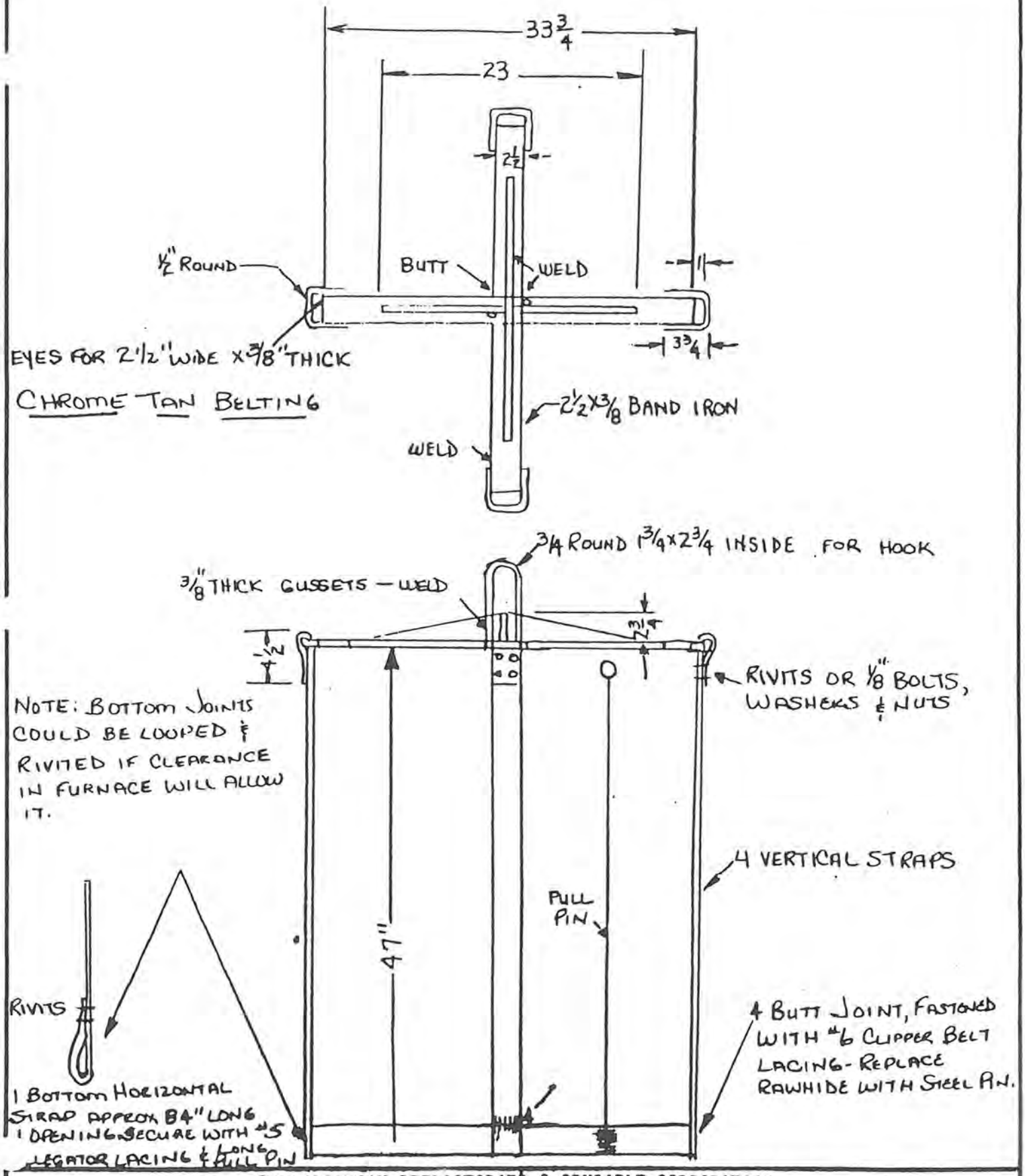
nAt *No Activity Timer (992): Select OFF to 99. If a number is set, the control will expect access by the host computer. If no access is detected within that time, the control will indicate an error, **CHEC LorE** and go to the set point indicated by **CFLt.***

CFLt *Communication Fault Mode (992): Select 1 or 2. 1 = On Communication fault use local Set Point. 2 = On Communications fault use **CFSP.***

DIAGNOSTIC ERROR MESSAGES

DISPLAY	MEANING	SP1, SP2, and ALARM OUTPUTS	ACTION REQUIRED
UFL or OFL	Underflow or Overflow: Process value has exceeded input range ends set by SCAL or SCAH.	Set point outputs active Alarms active	Input signals may normally go above or below range ends. If not, check input and correct.
bAd InP OPEn InP	**UFL** or **OFL** will sequence to display one of these messages if the **InPt** is set for a time value. For RTD, CURRENT, or VOLTAGE inputs; input error has occurred. For THERMOCOUPLE inputs thermocouple is open.	Set point outputs inactive Alarms active	To reset use the **INDEX & ENTER** keys. When **InPt** (input fault timer) has been set for a time, the outputs will be turned off after the set time. Setting the time to OFF causes the outputs to remain active, however **UFL** or **OFL** will still be displayed. Correct or replace sensor. To reset use the **INDEX & ENTER** keys.
LOOP bAd	The sensor may be defective, heater fuse open, heater open or the final power output device is bad.	Set point outputs inactive Alarms active	Correct or replace sensor, or any element in the control loop that may have failed. To reset use the **INDEX & ENTER** keys, or press the **ENTER** key while in the **LPBr** menu item.
SEnC bAd	Sensor rate of change exceeded the programmed limits set for **SEnC**.	Set point outputs inactive Alarms active	Check the cause. The value setting may be too slow for the process, or the sensor is intermittent. To reset use the **INDEX & ENTER** keys.
#### ArEA	Area appears if the controller's ambient temperature nears specification ends, -5°C (+23°F) or +50°C (+122°F).	Set point outputs active Alarms active	Correct the ambient temperature conditions. Ventilate the area of the cabinet or check for clogged air filters.
(blank) ArEA	Area appears if the controller's ambient temperature exceeds specification ends, -10°C (+14°F) or +55°C (+131°F).	Set point outputs inactive Alarms active	Correct the ambient temperature conditions. Ventilate the area of the cabinet or check for clogged air filters. To reset use the **INDEX & ENTER** keys.
CHEC CAL	Check calibration appears as an alternating message if the instrument calibration nears tolerance edges.	Set point outputs active Alarms active	Remove the instrument for service and / or recalibration. To reset use the **INDEX & ENTER** keys.
	Check calibration appears as a flashing message if the instrument calibration exceeds specification.	Set point outputs inactive Alarms active	

DISPLAY	MEANING	SP1, SP2 AND ALARM OUTPUTS	ACTION REQUIRED
No displays lighted	Both displays are blank. Instrument may not be getting power, or the supply voltage is too low.	Set points inactive Alarms inactive	Check that the power supply is on, or that the external fuses are good.
FAIL tESt	Fail test appears upon power up if the internal diagnostics detect a failure. This message may occur during operation if a failure is detected. Displays flash.	Set points inactive Alarms inactive	Press the **INDEX** key to display the following messages: **FACt dFLt**: Memory may be corrupted. Press the **ENTER** key and the **DOWN ARROW** key to start the factory default proceedure. Re-check controller programming. **bAd A-d**: The A/D board is bad, return to factory. **rEt FACt**: Can not recover from error, return to factory for service.
CHEC SCAL or **CHEC SCAH**	The difference between scale low and scale high is programmed for more than 11,998 or less than 100 counts during programming of the voltage or current ranges.	Set points inactive Alarms inactive	Program parameter within the allowed count range.
CHEC SP1, CHEC #SP1, CHEC SP1d, CHEC SP2, CHEC SP2d, CHEC ALLo, CHEC ALHI, or **CHEC CFSP**	One or more of these messages will appear upon power up if any of these set points or differentials are set outside of the **SPL** or **SPH** values, or the range ends (**SCAL** or **SCAH**).	Set points inactive Alarms inactive	Check that each of the set points are within **SPL**, **SPH** range, or reprogram SPL and / or SPH values to be at or beyond the set points values found in error. Do not exceed the range ends (**SCAL** or **SCAH**).
CHEC SPL or **CHEC SPH**	This message appears at power up if **SPL** or **SPH** values are programmed above or below the range ends (**SCAL** or **SCAH**). This message also appears if one or more set points are set above or below **SPL** or **SPH** during normal programming.	Set points inactive Alarms inactive	Correct the **SPL** or **SPH** values by programming new values. **CAUTION:** The old values are retained when these messages appear during set point programming.
CHEC POL or **CHEC POH**	This message appears if the POL or POH values are incorrectly programmed.	Set points active Alarms active	Correct the POL or POH by programming new values.



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