2186-00

OPERATOR'S MANUAL

Digi-Sense®
Temperature Controllers

J Thermocouple Models	K Thermocouple Models
2186-00 (115V)	2186-10 (115V)
2186-05 (230V)	2186-15 (230 V)

Cole Parmer Instrument Co.
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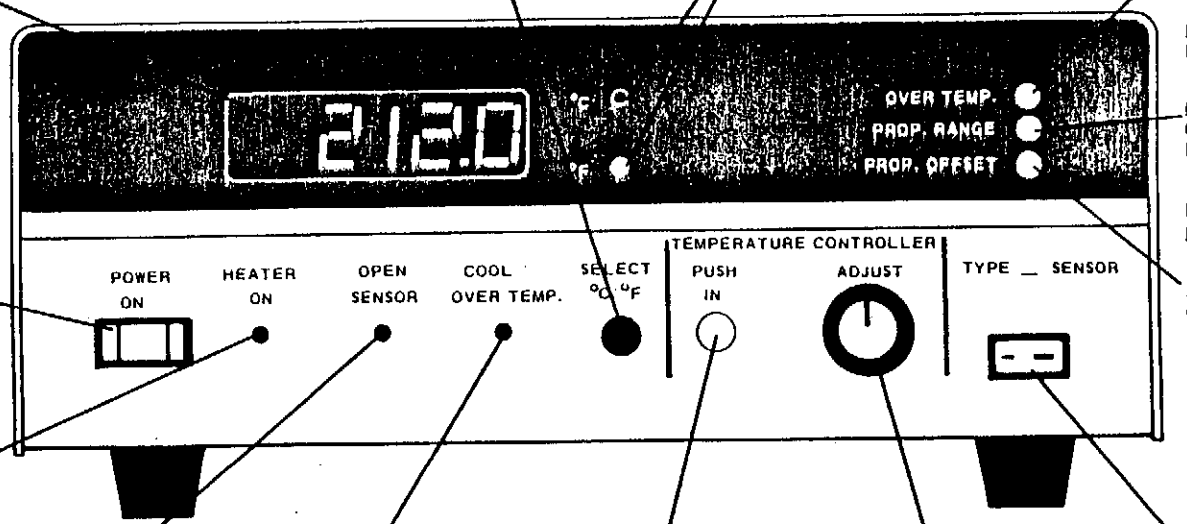
Edition 1289



SELECT °C/°F Press pushbutton to select C or F temperature scale.

°C/°F ANNUNCIATORS Indicate Celsius or Fahrenheit temperature scale being used.

DIGITAL DISPLAY continuously reads actual temperature (to 0.1°) at thermocouple 4½ digit LEDS, ½" high (14mm).

POWER ON ON/OFF instrument power rocker-switch. This switch controls load and instrument power.

HEATER ON Indicates power is being applied to load.

OPEN SENSOR Indicates disconnected thermocouple (accompanied) by audible alarm.)

COOL/OVER TEMP. Indicates cooling action or if an Over-Temperature condition exists.

PUSH-IN Display Mode Switch. Press to read programmed Setpoint. (Display normally shows actual temperature at sensor). Also used for setpoint and Over-Temperature adjustments.

ADJUST Dual Coarse/Fine concentric Setpoint controls. Single turn for Coarse (0 to 100%), and Fine (4%), achieves better than 0.1° settability.

MINI-CONNECTOR
Black for type "J"
Yellow for type "K"

TRIM CONTROLS:

OVER TEMPERATURE
Adjusts Over Temperature value up to 50° above setpoint.

50°

Increase OVER-TEMPERATURE Range.

PROPORTIONAL RANGE
Classic bandwidth control. Adjusts from 0 to ± 40°C.

Increase accuracy and decrease proportional range.

PROPORTIONAL OFFSET
Classic control brings actual and setpoint temperature into agreement. Variable over 100% of proportional band setting.

Increase Resultant Actual Temperature Relative to Setpoint.

Fail-Safe Design

An over-temperature circuit shuts down the system if the sensor temperature exceeds an adjustable alarm point (up to 50°) above the setpoint. Also, an alarm is sounded if the sensed temperature exceeds the range of the controller.

In addition to normal fusing, power to the load is automatically disabled if the input sensor is disconnected or broken. An audible alarm warns if power is delivered in the absence of proper control action, due to failure of the solid state power output device. If this occurs, turn off the power switch. This will protect the load from overheating.

Finally, an integral heat sink, on the rear panel reduces temperature errors due to internal thermal gradients.

CAUTION
READ THIS MATERIAL AND THE REMAINDER OF THESE INSTRUCTIONS CAREFULLY BEFORE OPERATING THE EQUIPMENT.

This Temperature Controller is intended to be used in a variety of experimental, process laboratory and engineering applications involving the controlled delivery of significant amounts of AC (Alternating Current) electrical energy, current, and power for powering heating mantles, heating tapes and general purpose heaters. When properly used and applied, this controller will perform dependably for thousands of hours. We give the following suggested practices to ensure safe and reliable installation and success:

1) Avoid applications where spillage, soaking, immersing, or excess liquid come in contact with the controller and its power outlet socket.

2) Avoid any temperature, humidity, or electrical environment outside of the recommended ranges given in this manual.

3) **Always understand the temperature limitations of the equipment that is being controlled.** This controller has the provision for an adjustable (up to 50 degrees Celsius) upper temperature limit above the set point. In addition, an absolute worst case upper limit of 120 and 650 degree Celsius (corresponding to the Thermistor and RTD modes, respectively) will automatically shut down the controller, in the event of a "run away" process.

For a further improvement in system safety, you may want to provide a secondary protection device such as a fuse or circuit breaker to the electrical load being controlled. It is possible, for example, that the temperature controller may be inadvertently programmed to deliver "100%" Power (about 15 amperes) where only "20%" (about 2 amperes) would represent a safe continuous rating. In this example, the application of excess power to a heating mantle could result in excess temperatures which could result in an unsafe condition due to fire hazard, an unexpected or premature chemical reaction, or a whole host of other problems.

If a secondary protection device is not possible, you may use the controller's rear panel output fuse but with a lower than 15 ampere rating. Before you change fuses and/or substitute another fuse rating, however, make sure that the controller power is removed by unplugging the unit from the power source!

4) **Remove the unit from the power source and load when not in use or if there has been a system failure of any type.** We recommend the use of a suitable switched electrical utility box such as the Cole-Parmer Instrument Company 1574 Series.

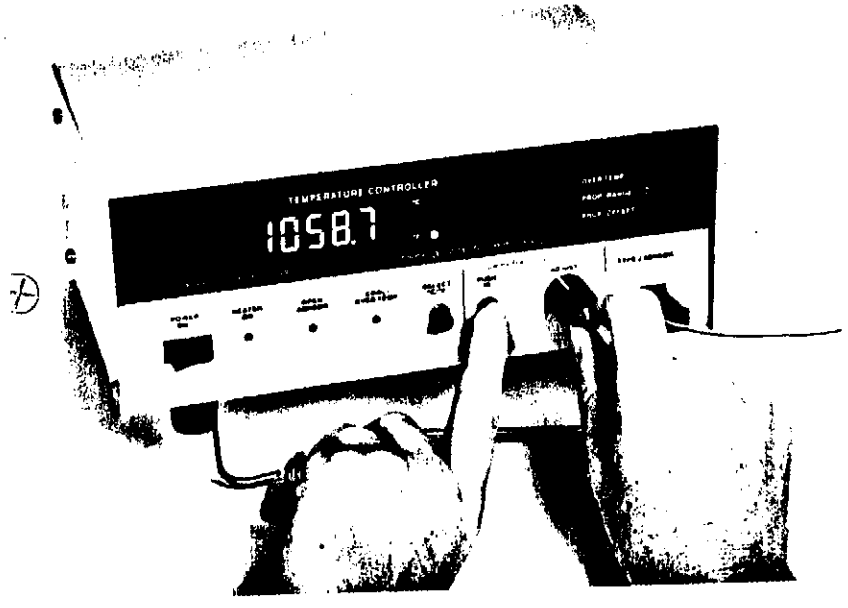
5) If you are uncertain as to the meaning of these cautionary statements or are otherwise uncertain as to the limits of safe application, consult your dealer for technical advise before proceeding.

6) This controller is not intended to be used with induction heating systems using an RF (Radio Frequency) source, fluorescent lighting or with other electrical arc discharge devices.

CONTENTS

B

TEMPERATURE CONTROLLER



This research grade proportional controller has alarm capabilities for reliable operation in critical heating and cooling applications. Teamed-up with a Type J or K thermocouple, the controller detects the slightest deviation from a setpoint temperature and "proportions" the corrective action to the size of the temperature change.

In effect, the controller continuously reduces or increases the heating or cooling input to maintain a process temperature at a precise setpoint. Proportional band control eliminates the wide variations from setpoint common with conventional full on/off controllers. A manual offset control fine-tunes the system for load changes and other variables.

A 4½ digit display reads either C° or F° to tenths of a degree. Typical J thermocouple accuracy is .4°C (mid-range). Repeatability of setpoint and control can be as low as 0.1°C.

INTRODUCTION

The instructions in this manual are task-oriented for easy reference. You can go directly to a particular section and quickly find the answers. The step-by-step operating instructions, with examples, are easy to follow. Also, for quick reference, all the front panel display and control functions are summarized inside the foldout sheet. The rear panel controls and connectors are defined in the Setup Procedures section.

Application Data

This Temperature Controller is ideal for use in pilot process laboratories requiring proportional heating, including cooling control capabilities, if required. It's designed for processes which undergo frequent work temperature changes which must be quickly brought to a setpoint temperature. Control applications range from simple hot plates to mid-sized reaction or fermentation vessels, plus distillation process equipment.

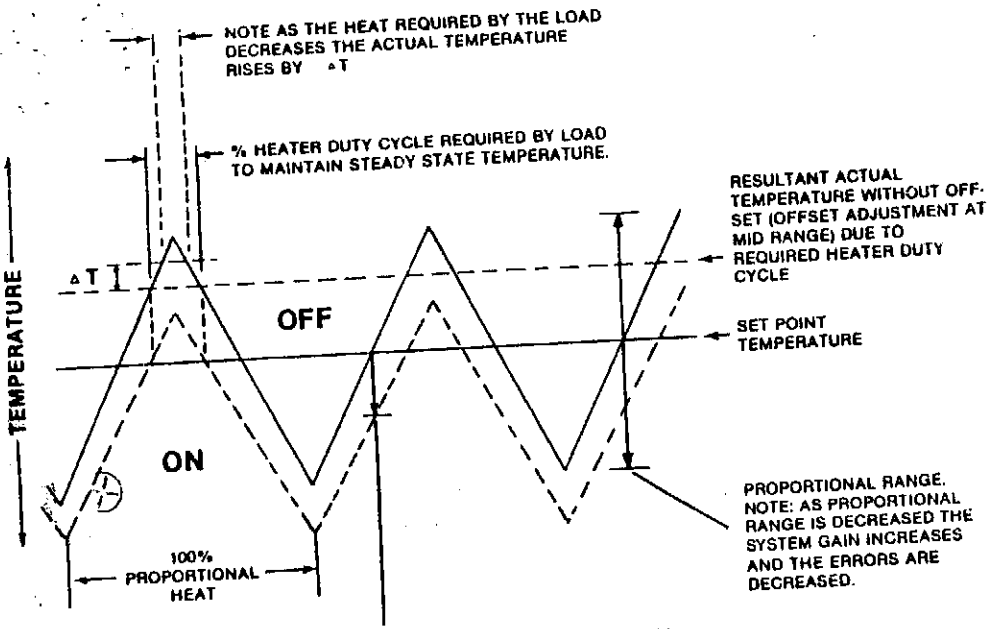
A separate output is provided on the back panel for controlling cooling equipment, such as water pumps, fans, and refrigeration systems. A common application would be maintaining an exothermic processes at a regulated temperature.

Basics of Feedback/Proportional Control

The Temperature Controller operates with type J or K thermocouples to comprise an automatic feedback system. The thermocouple sensor, mounted at the heat source, continuously detects temperature changes. It converts this information into corresponding voltage signals which are fed to the controller where comparisons are made with the selected setpoint. The controller then "tailors" a correction signal based on the difference and feeds it to the controlled device, such as a heater, to regulate its power output to the process. Thus, with proportional control action, there is a continuous and direct relation between the output and input.

When a disturbance, such as an increase in the flow rate, results in a load change, the controller will adjust the heater output power to compensate for the change. The temperature shift required to achieve this change in output is a function of the inverse of the proportional range. Steady state errors can be eliminated by use of the proportional offset control.

4



The graph summarizes the relationship between proportional and offset control. The shaded areas show how heat delivered to load is changed (proportionally) in response to temperature measurements.

The Proportional Range (from 0° to ± 40°C) is adjusted to meet individual application needs. A PROPORTIONAL RANGE control is provided to decrease the range, thus increasing system accuracy. Or, it can be used to increase the proportional range, but will decrease accuracy. Thus, trade-offs may be required.

The shaded areas in the graph represent the proportion of heater output required to maintain the setpoint temperature. The heater will settle into a duty cycle somewhere between 0 to 100%, as determined by the load and sensed by the temperature information supplied to the controller by the thermocouple. The result is a "proportioning" action which greatly minimizes over and undershoot and maintains a constant temperature.

SETUP PROCEDURES

The Temperature Controller is furnished ready to use as soon as you install the following equipment:

(1) Plug In Heater

☐ Use the receptacle provided on the rear panel for connecting the heater load.

NOTE: The following pages show diagrams of rear panel connections for 115V and 230V Temperature Controllers

(2) Plug In Thermocouple

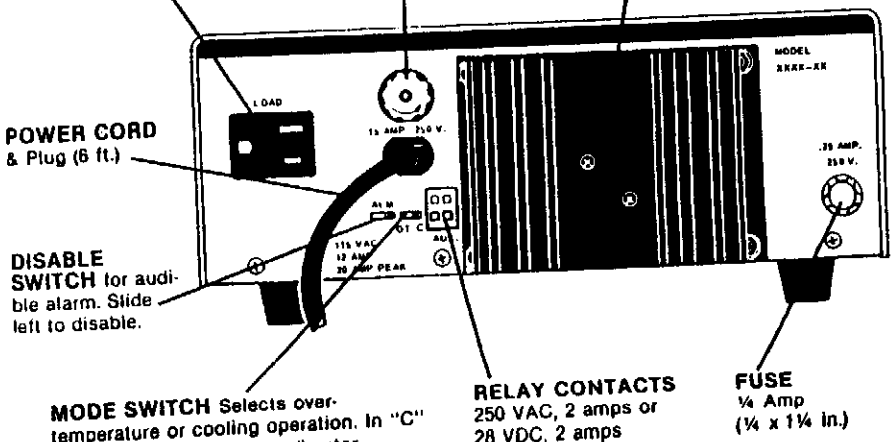
☐ Use the miniconnector located on the front panel. Be sure to insert the proper J or K thermocouple. (For guidance in thermocouple selection, see Specifications Section.

☐ Mount the sensor end of the thermocouple at the heating or cooling source to be measured.

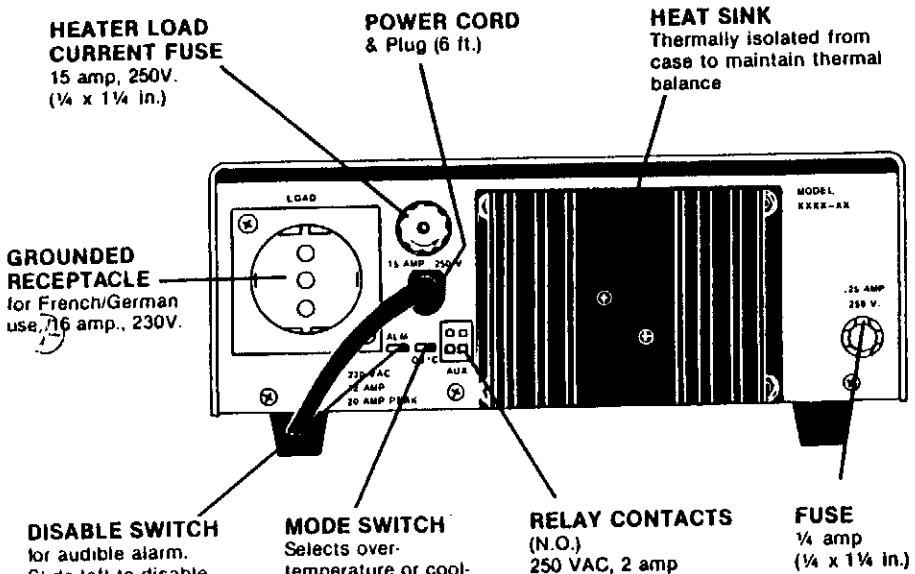
(3) Plug In Power Line

☐ Plug controller into proper power line source.

REAR PANEL
115V Version



REAR PANEL
230 V Version



OPERATING PROCEDURES

After the controller has been properly set up, it should be ready to adjust temperature setpoint and trim adjustments for your application. The objective in any application is to adjust the controller so that it will maintain the actual process temperature at the selected setpoint temperature.

The following instructions are for heating applications. For combination heating/cooling applications, see separate instructions at the end of this section.

A. Operating Procedures for HEATING Applications

(1) Turn Power On

☐ Press the POWER ON rockerswitch.

NOTE: If you have not yet installed the thermocouple, an audible alarm will sound, and the OPEN SENSOR LED will blink.

(2) Select Operating Mode

A MODE SWITCH, designated "OT/C" (Over Temperature/Cooling) is located on the rear panel. This switch selects either Over-Temperature alarm actuation or cooler control.

☐ For a heating application, be sure the MODE SWITCH is in the left (O/T) position.

(3) Select Temperature Scale

The controller defaults to the Celsius scale when power is turned on. Note the LED annunciator.

☐ If you wish to use the Fahrenheit scale, press the SELECT °C/°F push-button. The °F LED Annunciator will come ON (and the °C LED will go OFF).

(4) Adjust The SETPOINT Value

With the system properly installed, the digital display will be showing the actual temperature at the controlled process. To enter the setpoint:

☐ Press the blue PUSH-IN button while simultaneously adjusting the TEMPERATURE ADJUST concentric Coarse/Fine knobs. Watch the display.

Example: A simple, quick way is to turn the Fine knob fully CCW (counter-clockwise). Then turn the Coarse knob to about 10° below the desired setpoint. Then turn the Fine knob CW (clockwise) to adjust the setpoint. Thus, if you wish to enter a setpoint of 550°C:

☐ Turn the Fine control to maximum CCW. Then turn the Coarse control until you read about 540°C. Finally, turn the Fine control CW until you read 550°C.

NOTE: The fine control range is about 23 (33)°C for the J (K) thermocouple controller.

After you enter a setpoint, you can verify it at any time by simply pressing the PUSH-IN button. It will appear in the display.

(5) Adjust the OVER-TEMPERATURE Value

The OVER TEMP. trim control interrupts the heater output if the measured temperature should exceed an adjustable

6

range between 2° and 50° above the selected setpoint temperature.

Select the value of the Over-Temperature setpoint by the maximum temperature allowable for the process. Here's the procedure:

☐ Press the blue PUSH-IN button while simultaneously adjusting TEMPERATURE ADJUST concentric Coarse/Fine controls and watching the display. Adjust the setpoint below the actual temperature by the amount of Over-Temperature required above the setpoint.

☐ If the COOL/OVER TEMP. light is OFF, slowly turn the OVER TEMP. screw CCW until it just comes ON.

☐ If the COOL/OVER TEMP. light is ON, slowly turn the OVER TEMP. screw CW until the light goes OFF — then CCW again until it just comes ON.

NOTE: If the actual temperature at the process changes quickly during this setup sequence, disconnect the heater (and cooler, if used).

Example OVER-TEMPERATURE Setting:

The measured (actual) temperature is 30.6°C. The Over-Temperature alarm point is to be 15.0°C above the setpoint.

☐ To set the Over-Temperature, first adjust the setpoint for 15.0°C below the present actual measured temperature. Thus, 30.6 − 15.0 = 15.6°C, and 15.6°C will be the temporary setpoint

☐ Assuming the (COOL/) OVER TEMP. light is ON, turn the OVER TEMP. adjustment screw CW until the light goes OFF. Then turn it CCW until the light just comes ON.

The setting can be checked by raising the setpoint until the OVER TEMP. light goes OFF, then by lowering it until light comes ON. Read the setpoint temperature and subtract it from the actual temperature when the blue PUSH-IN switch is released. This is the temperature above setpoint at which the alarm will sound.

IMPORTANT: Don't forget to reset the setpoint value for the proper operation.

How to Test OVER TEMPERATURE Setting

In some applications, it may be desirable or necessary to test for the OVER TEMP. setting after the setpoint value is adjusted and the system is stable.

After the system has stablized, press the blue PUSH-IN button to display the setpoint value. Then rotate the setpoint controls. CCW until the COOL/OVER TEMP. light comes ON. The difference between the actual temperature and the setpoint temperature is the temperature above the normal setpoint temperature that the alarm condition will activate.

To change the setting, turn the OVER TEMP. screw for the amount of change required — about 3°C per turn (or 5°F per turn). Retest as required.

(6) Adjust Proportional Offset Value

The PROP. OFFSET trim control compensates for the amount of heat required to maintain the selected setpoint. It provides a fine-tuning function to compensate for the steady state (HEATER ON) duty cycle.

NOTE: The actual Offset Temperature per revolution of the PROP. OFFSET adjusting screw is a function of the PROP. RANGE adjustment. It will be zero when the PROP. RANGE control is fully CW, and will have maximum effect when the PROP. RANGE Control is fully CCW.

☐ Check the digital display. When the system reaches a steady state temperature, press the PUSH-IN button and read the setpoint. Compare it with the actual temperature.

☐ If the actual temperature is high, turn the PROP. OFFSET screw CCW; if the actual temperature is low, turn it CW. Check the display and allow the system to reach a steady state condition. (1 turn = about 6% heater capacity or about 5°C when the PROP. RANGE control is fully CCW).

☐ If the actual temperature is still too high or too low, repeat the preceding step.

(7) Adjust The Proportional Range Value

The PROP. RANGE control allows the controller to regulate power to the process heater. The width of the proportional range (0 to ± 40°C) is adjustable.

☐ Slowly turn the PROP. RANGE screw CW to narrow the band — and increase the accuracy of the output temperature.

☐ Stop the adjustment when the proper response is achieved. Excessive CW adjustment may cause oscillation and large

overshooting for a step change in the temperature setting. At the other extreme, excessive CCW adjustment will cause a sluggish response and less than optimum regulation of the temperature under varying load conditions.

(8) How To Respond to System Alarms

Protective circuits automatically activate audible and visual alarms to alert you when or if an operating failure occurs:

(a) The OPEN SENSOR LED on front panel will come ON if the thermocouple connection has a discontinuity.
☐ Check the connections.

(b) An Over Temperature condition alarm warns you if the process temperature exceeds your preset OVER TEMP. value (up to 50°) over the setpoint.

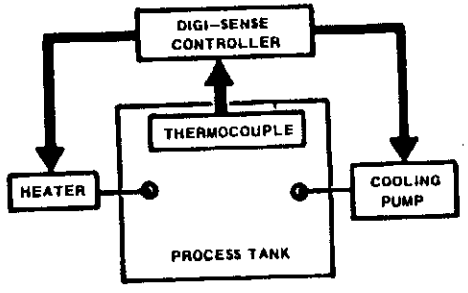
☐ Change the OVER TEMP. setting. Also check the process for a runaway condition, or a heater or cooler failure.

(c) A Fail-Safe Temperature Range alarm will sound if the level is exceeded (650°C for Type J Controllers; 875°C for Type K Controllers).

☐ Turn system OFF. Check Over-Temperature condition. Allow system to cool off. Operate manual cooling, if required.

B. Operating Procedures for HEATING/COOLING Applications

The Temperature Controller can also be used to regulate processes that become self-heating, but require a cooling function to maintain control. Typical cooling devices include water pumps and fans. The following diagram summarizes the flow of information/control commands:



To operate the controller in the heating/cooling mode, follow these steps:

(1) Adjust Mode Switch

☐ Slide the OT/C switch (rear panel) to the "C" (right) position. (This will disable the audible OVER TEMP. alarm).

(2) Connect Controller to Cooling Device

Two output connections (designated "AUX") are provided on the rear panel to control a cooling device.

CAUTION: Be sure power is OFF on the AUX power source when connecting to the AUX connector.

☐ Slide a small pick or screwdriver into the top slot(s) and pry upward slightly. This will force open the bottom slot(s) to accept a stripped wire. Use caution to avoid shorts. Connect cooling device through its external power source to the AUX connector (which is internally connected to a relay contact).

NOTE: Select a cooling rate that will reduce the temperature during a steady state condition. Then, the heater will turn ON proportionally to keep the load at the setpoint.

(3) Connect Thermocouple to Controller

The mini-connector is located on the front panel.

(4) Apply Power & Adjust Controls

☐ Apply power to Controller.

☐ Adjust the system in the same manner as described on preceding pages for HEATING applications — except, instead of paragraph A.(5), simply set the OVER TEMP. screw fully CCW. This will allow the cooling device to turn ON about 1° over the setpoint and OFF about 1° below the setpoint. In effect, use the OVER TEMP. control to operate the cooling function.

☐ Connect heater to the controller's output connector.

Until the process reaches the setpoint temperature, only the heater will operate. Then, when the temperature rises to the OVER TEMP. level (due to process reaction), cooling will begin and continue until the sensed temperature drops about 2° below the OVER TEMP. "ON" temperature. The cooling function will cycle ON and OFF until the reaction has stopped. If the temperature stabilizes above the setpoint, adjust the proportional offset CCW. If the temperature stabilizes below the setpoint, or if the cooling cycles on and off, adjust the proportional offset CW.

SPECIFICATIONS

Controller Model	Load Receptacle	Setpoint Range		Thermo-couple Type	Fail-Safe Temp. Range
		Coarse + Fine	Fine		
2186-00	115V, 15 amp (Std. USA)	0 to 600° C.	0 to 22° C.	J (Black)	650°C
2186-05	230V, 16 amp (Europe)				
2186-10	115V, 15 amp (Std. USA)	0 to 850°C	0 to 32°C	K (Yellow)	875°C
2186-15	230V, 16 amp (Europe)				

Power Consumption
Less than 15 VA, plus controlled load power.
Frequency: 49 to 61 Hz.

Input Voltage	Input Voltage Range	Instrument Fuse	Load Fuse
115 Volt	90 to 130 V_{RMS}	.25 amp	15 amp
230 Volt	200 to 260 V_{RMS}	.25 amp	15 amp

Solid State Output
20 amps peak power, 15 amps continuous at 25°C ambient. No relay contacts to erode, and no need for "booster" output devices to drive loads to 1800 watts (115V models) or 3500 watts (230V models).

NOTE: At higher temperatures, the controller will derate to 12 amps continuous.

Displays
4½ digit, ½ in. high (14mm) LED readout shows setpoint and actual load temperature to a resolution of 0.1 degree. Illuminated indicators show:

Main power ON
Open sensor
Over-temperature
Heater ON
Degrees °C or °F

NOTE: The "Heater ON" light will "blink" proportionally to the amount of heater power used.

Alarms
Audible alarms supplement illuminated displays for over-temperature, over-range, and open sensor, plus warning of failure in heater output power device.

Adjustable Resolution
Within 0.1° control.

Auxiliary Output Connection
Cooling output for peripheral water pumps, fans, etc., available from an isolated 230 VAC (28 VDC), 2 ampere isolated relay contact (normally open.) Connections via quick-connect strip.

Environmental Specifications
Operating Temperature: 0 to 50°C.
Relative Humidity: to 90%, non-condensing.

Service Requirements
Two rear panel fuses. No other user serviceable parts employed.

Thermal Balanced Design
Circuit errors due to internal thermal gradients are minimized via heat sink mounted on rear panel to absorb full power without heating chassis.

Dimensions
9½ W x 4¼ H x 8 in. D. (24.1 W x 10.8 H x 20.3 cm).
Weight, approx. 5 lbs. (2.3 kg).

Construction
Heavy aluminum chassis and cover. Front panel is of polycarbonate with transparent red plastic over digital display window. Tilt bale permits raising front 2 in. (50mm).

Warranty
Refer to Warranty Card furnished with instrument.

Thermocouple Specifications
Careful sensor selection is based on required sensitivity, accuracy and repeatability. The thermocouple input is an ANSI standard color-coded miniconnector on front panel. Cold junction compensation is provided over ambient temperature range of 0 to 50°C.

The following table shows calibration when controller is used with Type J or K thermocouples, including typical thermocouple nonlinearities.

Calibration Accuracy & Range

Thermocouple Type	Sensed Temperature (°C)	Accuracy at 23°C (ambient)	Accuracy (1) (2) at 23 ± 5°C amb. or 8 amp load
J	0°	+6°	+6°
	25°	+4°	+4°
	50°	+3°	+3°
	100°	+1°	+1°
	160-500°	± 0.4°	± 0.4°, ± .2% reading
	560°	+2°	+3°
	600°	+4°	+5°
K	0-325°	± 1°	± 2°
	325-450°	+5°	+6°
	450-600°	+12°	+15°
	600-850°	+18°	+20°

NOTES: (1) Calibration error with load change: an additional load of 7 amps (15 amps total) produces additional typical error of .5°C.

(2) Repeatability is better than ± .2°C under conditions of constant ambient temperature and load.