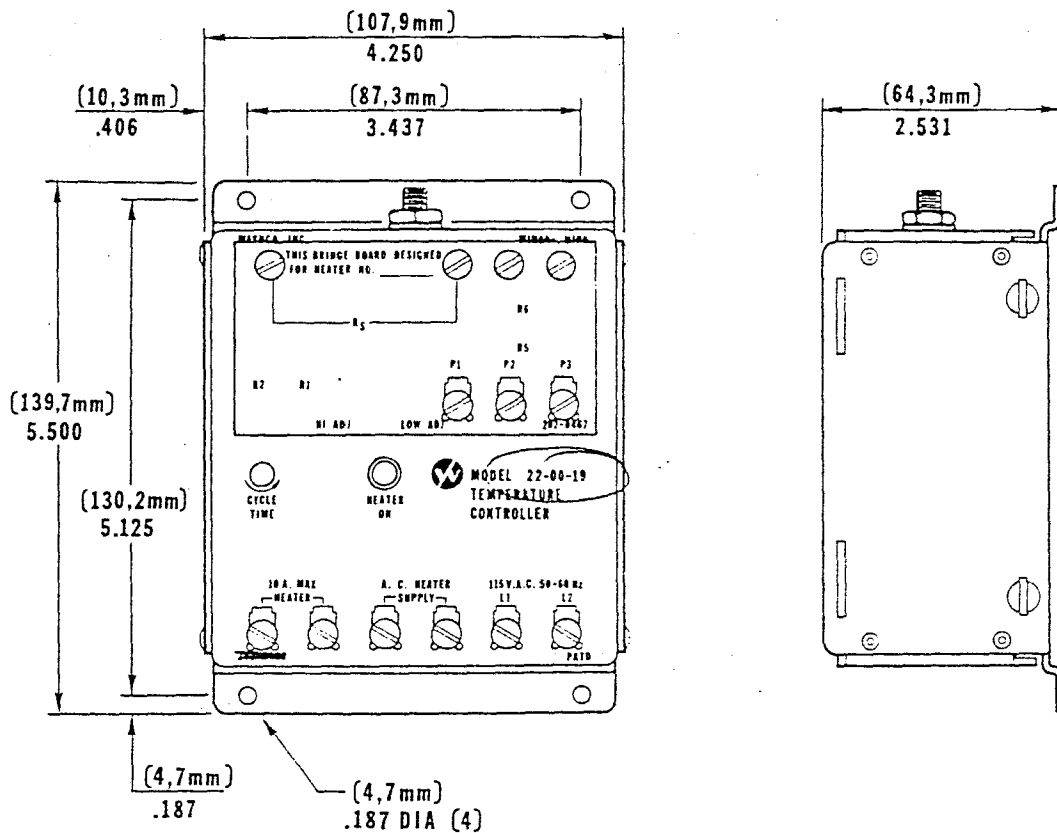




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TEMPERATURE CONTROLLER



SPECIFICATIONS:

CONTROLLER SUPPLY VOLTAGE: 115 volts \pm 10%, 50/60 Hz., 4 V.A. maximum
230 volts \pm 10%, 50/60 Hz., also available.

CONTROLLER OUTPUT: Isolated zero cross-over solid state switch rated at 10 amps maximum, 0.5 amps minimum.

HEATER SUPPLY VOLTAGE: This will vary depending upon application. Power bridge must be designed for the application. The supply voltage for the heater can be the same as is used for the controller. However, the heater can be operated from a separate source from 24 to 230 volts A.C., 50/60 Hz.

HEATER TEMPERATURE RESISTANCE CHARACTERISTICS: The proper heater material and selection depends upon the application. Consult factory for information.





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SPECIFICATIONS:

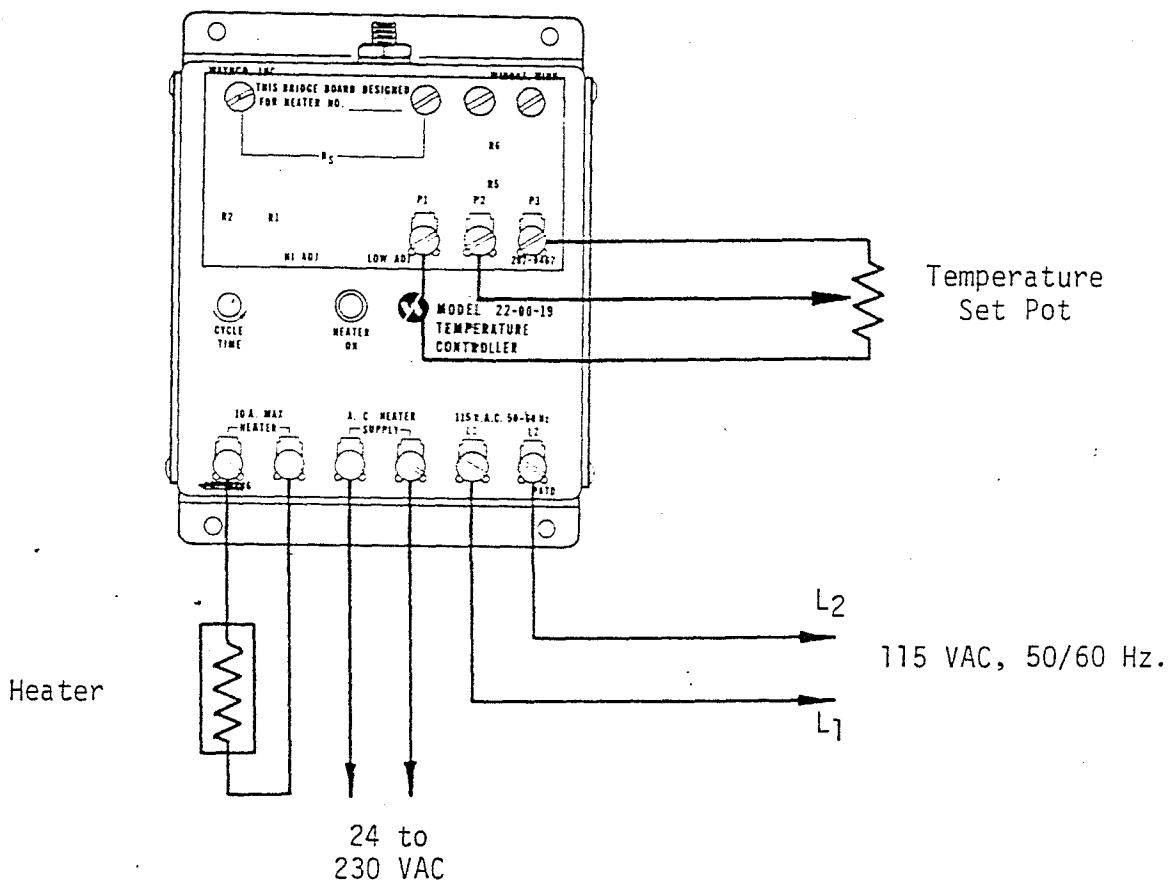
SET POINT RANGE: Set point is adjustable by a remote connected potentiometer. The range of adjustments are selected for the application. Heaters are available for operation up to 2000°F.

CYCLE TIME: The sampling rate is adjustable over a range of 1 to 5 seconds minimum.

OPERATING AMBIENT TEMPERATURE: 50°F to 125°F.

LED INDICATOR: A red LED indicator lamp on the terminal board indicates the operational status of the controller. The LED is on when the controller is applying power to the heater.

EXTERNAL WIRING DIAGRAM:





APPLICATION OF HEAT-SENSE CONTROL

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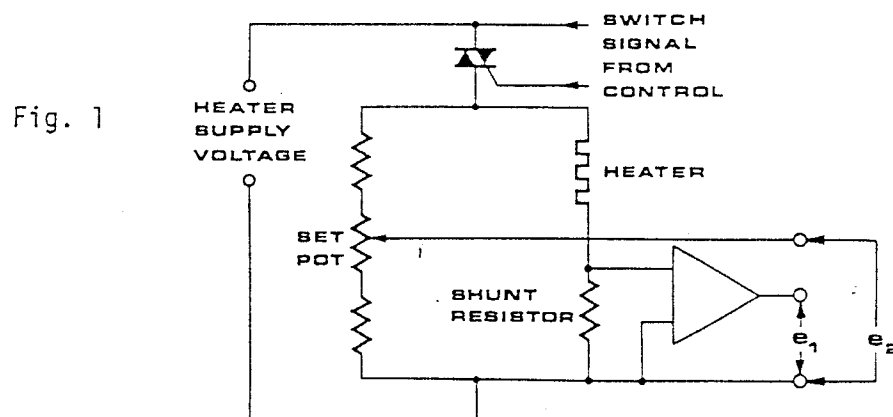
²²⁰⁰⁻⁰⁰¹⁹⁻⁰⁰⁰¹
The Model 22-00-19 heat-sense temperature controller utilizes the principle of change in resistance of the heater with temperature to provide the feedback signal to the controller to maintain a constant temperature of the heater. In other words, the resistance heater supplies the thermal requirements of the system as well as the feedback signal for control. The response time is essentially instantaneous since the heater cannot change temperature without a corresponding change in resistance.

In a conventional temperature control system the feedback signal is obtained by means of a separate sensor such as a thermocouple, thermistor, RTD, etc. Normally, the heater used in a conventional system maintains a relatively constant resistance over a wide range of temperatures. The response time in a conventional system depends upon the thermal time constant between the heater and sensor.

Both systems have obvious advantages. The choice depends upon the control application. In some applications superior results can be obtained by a combination of both systems. There are other types available to suit various applications. This bulletin covers only one type of heat-sense controller. The key to successful application of the heat-sense technique is to satisfy the thermal requirements of the system before choosing a particular heat-sense control or designing the power bridge.

A temperature control system utilizing the heat-sense principle consists of a resistance heater, power bridge, electronic controller package and solid state power relay or switch.

Since the heater supplies the thermal requirements as well as the feedback signal, a power bridge is required. Fig. 1 illustrates the basic heat-sense power bridge.



The heater and shunt resistor form one arm of the bridge and the set pot and associated resistors form the opposite arm of the bridge. The voltage (e_1)





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developed by the heater current through the shunt resistor is amplified by a factor of 10 and balanced against the voltage (e_2) on the wiper of the set pot.

The complete control system is shown in Fig. 2. The additional bridge components provide for calibration adjustment and limit power dissipation. On the Model 22-00-19 the power bridge is mounted on the controller terminal board so that the control system may be readily modified to suit a particular heater or series of heaters within the power capabilities of the output switch. Fig. 3 illustrates the power bridge board and the various components.

Fig. 2

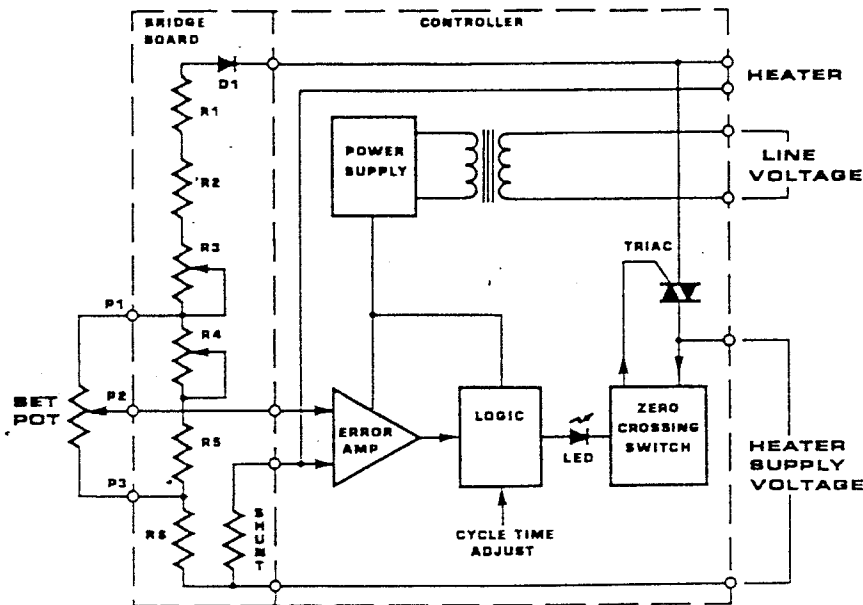
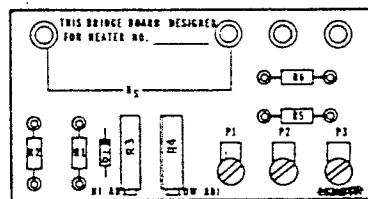


Fig. 3



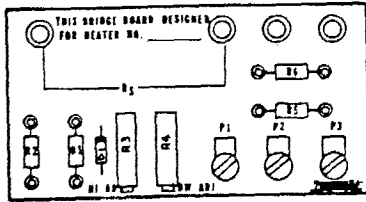
Blank bridge boards as well as individual components are available to suit a particular application. Following is the procedure for determining the correct bridge component values:





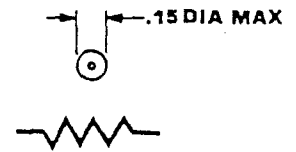
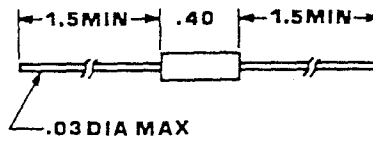
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BRIDGE BOARD ASS'Y.



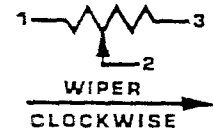
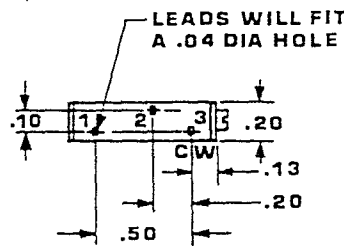
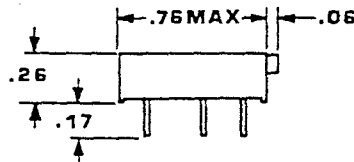
The following is a list of discrete components needed to make up this Bridge Board Assembly. Use as listed or equivalent.

RESISTORS: Qty: 1 ea. R₁, R₂, R₅, R₆
 Waynco P/N: 803-017 ± 1%, 1/2W
 Manufacturer: IRC (T0-60)
 Standard 1% resistance values available.



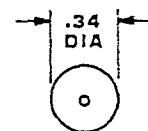
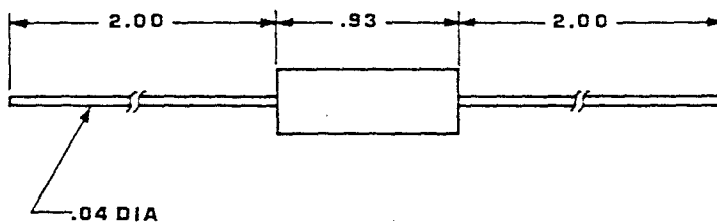
SCHEMATIC SYMBOL

TRIM POTS: Qty: 1 ea. R₃, R₄
 Waynco P/N: 005-032 15 turn
 Manufacturer: Bourns (3006P)
 Standard resistance values needed:
 1K, 2K, 5K, 10K, 20K ohm



SCHEMATIC SYMBOL

SHUNT RESISTOR: Qty: 1 ea.
 Waynco P/N: 803-025 ± 1%, 5W
 Manufacturer: Dale (LVR-5)
 Resistance values needed:
 .025, .05, .10, .25, .50 ohms



SCHEMATIC SYMBOL



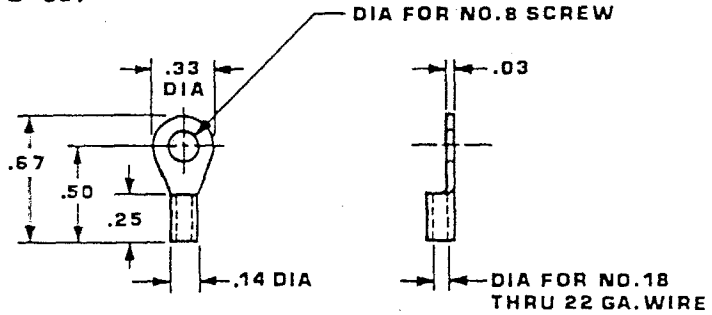


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TERMINALS FOR SHUNT RESISTOR: Qty. 2 ea.

~~Waynco~~ ^{WAYNCO} P/N: 0817-0100-0000

Manufacturer: VACO (11208)

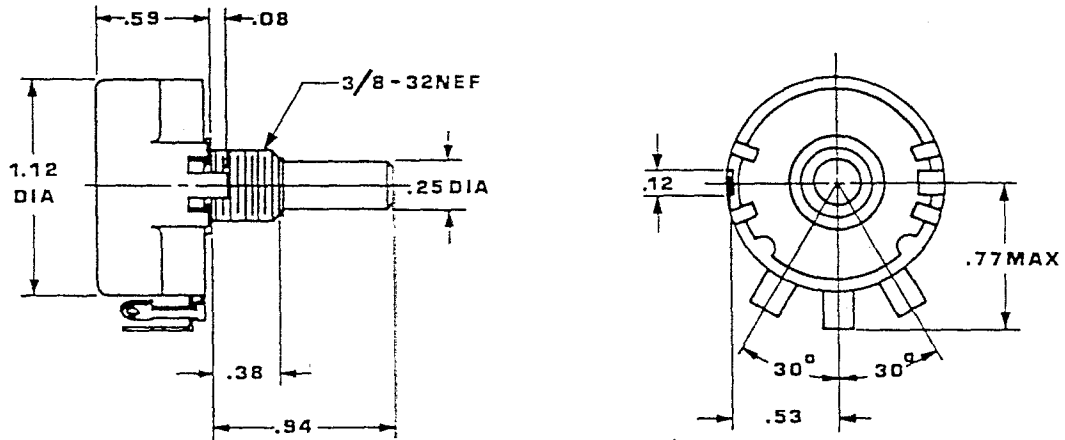


REMOTE SET POT: Qty. 1 ea.

~~Waynco~~ ^{WAYNCO} P/N: 0005-012-0000

Manufacturer: Clarostat (Series 43 H.T.)

Standard resistance values: 25, 100, 200, 250, 500, 1K ohms



SCHEMATIC SYMBOL





DESIGN PROCEDURE FOR POWER BRIDGE

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1. The value of the following parameters must be determined prior to design of the bridge circuit.

- a) Line Voltage, E_L
- b) Resistance of the heater at room temperature, $R_H @ 72^\circ F$
- c) Resistance of the heater at the low end of the temperature range, R_{HL}
- d) Resistance of the heater at the high end of the temperature range, R_{HH}

2. The maximum value of the shunt resistor R_S MAX. is now calculated. Its value should be the maximum allowable by the following two constraints:

- a) The maximum power dissipation rating of the shunt resistor, P_S MAX.
- b) The maximum input voltage of the temperature control, 0.6 volts.

$$R_S \text{ MAX. } \frac{\leq P_S \text{ MAX.}}{(I_H @ 72^\circ F)^2} \quad \text{and} \quad R_S \text{ MAX. } \frac{\leq 0.6 \text{ VOLTS}}{I_H @ 72^\circ F}, \quad \text{where} \quad \frac{I_H @ 72^\circ F = E_L}{R_H @ 72^\circ F}$$

The value of the shunt resistor is now selected.

3. The current through the heater at the low (I_{HL}) and high (I_{HH}) end of the temperature range is now calculated.

$$I_{HL} = \frac{E_L}{R_{HL}} \qquad I_{HH} = \frac{E_L}{R_{HH}}$$

4. The voltage across the shunt resistor at the low (E_{SL}) and high (E_{SH}) end of the temperature range can now be calculated.

$$E_{SL} = I_{HL} R_S, \qquad E_{SH} = I_{HH} R_S$$

The change in the voltage across the shunt resistor, ΔE_S , is needed to determine the value of the set pot.

$$\Delta E_S = E_{SL} - E_{SH}$$

5. The total power dissipated by the resistors in the bridge circuit should be limited to approximately 0.6 watts to avoid changes in the resistance due to the temperature coefficient of the resistors. Therefore for operation on 120V line, the bridge current should be approximately 0.010 amps and on 240V line .005 amps. The currents for other line voltages can be calculated from the equation:

$$I = \frac{1.2}{E_L} \quad \text{NOTE! Power Dissipation} = \frac{\text{RMS (Power)}}{2}, \quad \text{since bridge circuit is half wave.}$$





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6. The approximate value of the set pot can now be calculated from:

$$R_p = \frac{10 \Delta E_s}{I}$$

The closest standard value pot is chosen, R_{pS} . The current through the pot, I_{RP} , is calculated using the selected standard pot value with the equation:

$$I_{RP} = \frac{10 \Delta E_s}{R_{pS}}$$

7. To provide for calibration of the set pot at the low end of the temperature range, R_4 and R_5 are connected in parallel with the set pot. These resistors provide +20% calibration adjustment. The value of R_5 is determined by:

$$R_5 = \frac{10 \Delta E_s}{.2 I_{RP}}$$

R_4 is selected to have a minimum value 20 times R_{pS} .

8. The value of R_6 is now determined from the equation:

$$R_6 = \frac{10 E_{SH}}{I_{RP} + .2 (I_{RP})}$$

9. The total resistance of the bridge circuit is determined next.

$$R_{TOTAL} = \frac{E_L}{I_{RP} + .2 (I_{RP})}$$

From R_{TOTAL} , the values of R_1 , R_2 and R_3 can be calculated.

$$R_1 + R_2 + R_3 = R_{TOTAL} - R_p - R_6$$

For + 20% adjustment at the high temperature end of the temperature range, R_3 should be made $.4 (R_{TOTAL} - R_p - R_6)$ and $R_1 + R_2 = R_{TOTAL} - R_p - R_6 - \frac{R_3}{2}$

R_1 and R_2 are made equal in value to divide the power dissipation.

$$\text{Therefore, } R_1 = \frac{R_{TOTAL} - R_p - R_6 - \frac{R_3}{2}}{2} = R_2.$$

The calculation of the bridge resistors is now complete.





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DESIGN EXAMPLE

1. a) Line Voltage, $E_L = 240\text{VAC}$
- b) $R_H @ 72^\circ\text{F} = 20\text{ ohms}$
- c) $R_{HL} = 27\text{ ohms}$
- d) $R_{HH} = 55\text{ ohms}$
2. $I_H @ 72^\circ\text{F} = \frac{240\text{VAC}}{20\text{ ohms}} = 12\text{ amperes}$

$P_S \text{ MAX.} = 5\text{ watts}$

$R_S \text{ MAX.} \leq \frac{5\text{ watts}}{(12\text{ amps})^2} < .034\text{ ohms}$

$R_S \text{ MAX.} \leq \frac{0.6\text{ volts}}{12\text{ amps}} \leq .050\text{ ohms}$

A shunt resistor of .025 ohms, 5 watts is selected.

3. $I_{HL} = \frac{240\text{ volts}}{27\text{ ohms}} = 8.88\text{ amps}$ $I_{HH} = \frac{240\text{ volts}}{55\text{ ohms}} = 4.36\text{ amps}$

4. $E_{SL} = (8.88\text{ amp}) (.025\text{ ohms}) = .222\text{ volts}$
 $E_{SH} = (4.36\text{ amps}) (.025\text{ ohms}) = .109\text{ volts}$
 $\Delta E_S = .222\text{ volts} - .109\text{ volts} = .113\text{ volts}$

5. $I = \frac{1.2}{E_L} = \frac{1.2}{240} = .005\text{ amps}$

6. $R_p = \frac{(10)(.113)}{.005} = 226\text{ ohms}$

The closest standard value pot is 250 ohms.

$I_{RP} = \frac{(10)(.113)}{250} = .00452\text{ amps.}$

7. $R_4 = \frac{(10)(.113)}{(.2)(.00452)} = 1250\text{ ohms}$ $R_5 = (20)(250) = 5\text{K ohms}$

8. $R_6 = \frac{(10)(.109)}{(.00452) + (.2)(.00452)} = 200\text{ ohms}$





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$$9. R_{TOTAL} = \frac{240}{(.00452) + (.2) (.00452)} = 44,247 \text{ ohms}$$

$$R1 + R2 + R3 = 44,247 - 250 - 200 = 43,797$$

$$R3 = (.4) (43,797) = 17,519 \text{ closest pot value is 25K ohms.}$$

$$R1 + R2 = 43,797 - \frac{25,000}{2} = 31,297$$

$$R1 = \frac{31,297}{2} = 15,648 = R2$$

R1, R2 = 15.4K ohms.





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SYSTEM CALIBRATION PROCEDURE

The system may be calibrated by utilizing a temperature sensor such as a thermistor, thermocouple, etc. attached to the heater surface in combination with a suitable temperature indicator.

Following is the recommended procedure:

1. Make all connections to the temperature control system. CAUTION: Check all connections for mechanical and electrical integrity. Never energize the system with the shunt disconnected as the controller may be permanently damaged.
2. Turn the temperature set pot, low temperature adjust and high temperature adjust to their minimum temperature settings (counter clockwise). Turn the cycle time adjust to its maximum counter clockwise direction. Supply power to the controller only.
3. With the heater supply voltage disconnected and the cycle time pot maximum counter clockwise, the LED should remain off. Slowly turn the cycle time pot in a clockwise direction until the LED turns on. The LED should remain on. Connect the heater supply voltage. The LED will begin to cycle on-off when the heater reaches temperature. This will be the minimum temperature at which the heater can be operated.
4. Turn the temperature set pot to its maximum temperature setting.
5. Adjust the high temperature pot to obtain the desired maximum temperature of the surface to be controlled as indicated by the temperature monitor.
6. Turn the temperature set pot to its minimum temperature setting.
7. Adjust the low temperature pot to obtain the desired minimum temperature of the surface to be controlled as indicated by the temperature monitor.
8. Repeat steps 4 through 7. Re-adjust the high and low temperature pots if necessary.
9. Turn the set pot to the desired operating temperature.
10. Decrease the cycle time if the temperature is fluctuating to obtain minimum change in temperature. NOTE: Decreasing the cycle time will increase the minimum obtainable temperature.





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TROUBLE ANALYSIS AND SERVICE CHART

<u>SYMPTOM</u>	<u>CAUSE</u>	<u>REMEDY</u>
Over Heats	Shorted Solid State Switch	Connect jumper wire across shunt resistor. If power turns off, switch okay. If not, replace control.
Over Heats	Controller Indicator Light OFF	If solid state switch from above test okay, replace controller.
Over Heats	Controller Indicator Light ON.	Check inter-connecting wire to terminals. If connections per connection diagram and system continues to over heat, replace controller.
Power On Heater But Not Heat	Heater Open	Replace Heater. Also check wiring and all connections.
Pulses ON-OFF But Temp. Below Set Point	Improper Calibration	Repeat Calibration Procedure.
Pulses ON-OFF But Temp. Below Set Point	High Resistance connection in heater circuit.	Check heater resistance and all connections.
Pulses ON-OFF But Temp. Below Set Point	Bridge Board not screwed down tightly.	Tighten all screws on Bridge Board
Pulses ON-OFF Temp. Below Set Point	Set Pot. leads P ₁ and P ₃ reversed.	Check wiring of remote Set Pot.





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TROUBLE ANALYSIS AND SERVICE CHART

<u>SYMPTOM</u>	<u>CAUSE</u>	<u>REMEDY</u>
Pulse ON-OFF Temp. Below Set Point.	Bad Controller	Replace Controller.
Unit does not pulse Heater Power. In- dicator light on, controller is off.	Improper adjustment, cycle rate adj.	Turn Clockwise until indicator light comes on. If unable to attain this condition, replace controller.
Unit does not pulse Heater Power and Indicator Light On.	Improper wiring. Indicates broken lead or open circuit in Heater Supply or Heater.	Check wiring. If wiring okay, replace controller.

