MIDLAND ROSS

Midland-Ross Corporation
Cambion Division

4/85

BIPOLAR TEMPERATURE CONTROLLER

CAMBION MODEL NUMBER
809-3011-01/02-00-00

(REVISION A)

SPECIFICATIONS

CONTROLLER SECTION

POWER OUTPUT:	3.5. VOLTS D.C., 6.5 AMPERES CONTINUOUS, 9 AMPERES INTERMITTANT
POWER REQUIREMENTS:	115/230 VAC $\pm$ 10%, 50/60 Hz, 110 WATTS MAX.
TEMPERATURE CONTROL RANGE:	0^{o}C to 50^{o}C NOMINAL
TEMPERATURE STABILITY:	$\pm$ 0.1^{o}C TYPICAL AT OPTIMUM INTERNAL GAIN SETTING: ACTUAL TEMPERATURE STABILITY IS DEPENDENT ON THE THERM SYSTEM AND MAY BE BETTER OR WORS THAN THE STATED SPECIFICATION.
TEMPERATURE RESOLUTION:	0.018^{o}C/DIV. TO 0.3^{o}C/DIV.
REPEATABILITY:	$\pm 0.05^{o}$C
INPUT SENSOR:	THERMISTOR (100K at 25^{o}C)
CONTROL MODE:	BIPOLAR PROPORTIONAL CONTROL

DIGITAL TEMPERATURE INDICATOR

TEMPERATURE RANGE:	-30^{o}C to $+50^{o}$C
RESOLUTION:	0.1^{o}C
DISPLAY:	3 1/2 DIGIT, 0.5" LED, AUTOMATIC POLARITY INDICATION
ACCURACY:	$\pm 0.3^{o}$C OR BETTER
SENSOR:	LINEAR THERMISTOR

GENERAL DATA

FRONT PANEL CONTROLS:	ON/OFF SWITCH WITH LIGHT, TEMPERATURE SETPOINT DIAL, SETPOINT DIAL LOCK.
INTERNAL CONTROLS:	AMPLIFIER GAIN CONTROL, TWO READOUT CALIBRATION TRIMPOTS
OPERATING AMBIENT TEMP.:	-10^{o}C to $+35^{o}$C

DIMENSIONS:		
	HEIGHT:	16.6 cm (6.5")
	WIDTH:	21.1 cm (8.3")
	DEPTH:	28.0 cm (11")
WEIGHT:		4.85 Kg (10.7 lbs)

BIPOLAR CONTROLLER OUTPUT LOAD COMPATIBILITY

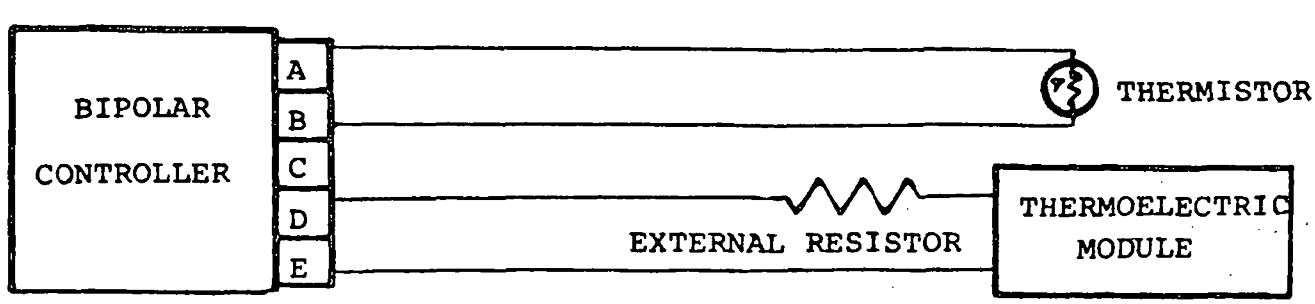
CAMBION MODELS: 809-1018-01-00-00
809-3010-01-00-00
809-3011-01/02-00-00

The Bipolar Controller models listed above have output characteristics designed to be compatible with thermoelectric modules or assemblies requiring approximately 3.5 volts DC at 9 amperes maximum intermittent duty and 6.5 amperes continuous duty. If these controllers are us to drive thermoelectric devices which require less than 3.5 volts DC, the maximum rated output current will be exceeded unless the current is limited by some external means. Consequently, when using lower voltage thermoelectric devices it will be necessary to connect a power resistor in series with the thermoelectric module(s) in order to maintain the current at a safe level.

Typical resistor values are shown in the table below. Where more than one module is indicated, all modules should be electrically connected in series.

THERMOELECTRIC DEVICE (P/N)	APPROXIMATE RESISTANCE VALUE (OHMS)	RESISTOR POWER RATING (WATTS)
(1) 801-1029-01-00-00	0.25	20
(2) 801-1029-01-00-00	0.15	12
(3) 801-1029-01-00-00	0.10	10
(1) 801-3959-01-00-00	0.20	16
(1) 801-3960-01-00-00	0.25	20
(2) 801-3960-01-00-00	0.20	16
(1) 801-3965-01-00-00	0.20	10
(1) 806-1006-01-00-00	0.20	16
(1) 806-7240-01-00-00	0.20	10

TYPICAL CONNECTION DIAGRAM



I GENERAL DESCRIPTION

The CAMBION Bipolar Controller is an automatic temperature controlling unit designed to be used in conjunction with various CAMBION thermoelectric modules, assemblies, and other devices. This instrument will precisely and accurately control the temperature of these devices either above or below existing ambient conditions in accordance with the stated specifications. Utilizing the thermodynamically reversible behavior of thermoelectric modules, the Bipolar Controller automatically compensates for any load or ambient fluctuations which would tend to affect the temperature stability of the system. A thermistor, critically located near the thermoelectric device, is used to sense its temperature and provide the necessary feedback signal to the controller.

A Digital Indicator, used in conjunction with a separate thermis sensor, enables the temperature of the thermoelectric device to be continuously monitored.

II INSTALLATION

A. Intital Inspection

The unit was carefully inspected both mechanically and electrically prior to shipment and should be in good physical and electrical condition upon receipt. To confirm this, the instrument should be inspected for physical damage in transit.

B. Power Requirements

Input power to the Bipolar Controller is 115 or 230 volts AC ±10%, 50/60 Hz, at 110 watts maximum. The voltage selector switch, located at the rear of the instrument, must be placed in the position corresponding to the AC line voltage being used.

C. Grounding Requirements

To protect operating personnel it is necessary that the cabinet of the Bipolar Controller be grounded. For this puspose the unit is equipped with a 3-prong AC line cord and, consequently it is recommended that a grounded AC receptacle is utilized. If a grounded receptacle is not used, an auxiliary chassis to ground connection should be provided.

D. Mounting

The Bipolar Controller is a self-contained unit suitable for bench or table-top operation, with all external connections being made at the rear of the cabinet. The instrument should not be located in a position which would result in the rear screen being obstructed, thus restricting cabinet ventillation.

E. Electrical Connections

1. The five pin connector at the rear of the unit contains the output load and control thermistor connections and should be wired as follows:

   Pin A -- Connect to one side of 100K Thermistor
   Pin B -- Connect to the other side of 100K Thermistor
   Pin C -- Not used
   Pin D -- Connect to negative (black lead) of thermoelectric device
   Pin E -- Connect to positive (red lead) of thermoelectric device

2. The second connector is a 3-wire phone jack used to connect the thermistor sensor for the Digital Temperature Indicator and is wired as follows:

   Sleeve -- Thermistor Green Wire
   Ring -- Thermistor Red Wire
   Tip -- Thermistor Brown or Black Wire

3. The thermistor sensors should be mounted to the thermoelectric device using one of the techniques listed below. In general, the thermistor should be placed as close as possible to the thermoelectric modules to ensure maximum sensitivity and accuracy.

   It should be noted that a number of CAMBION's thermoelectric assemblies are equipped with built-in thermistor sensors and, in this event, no special thermistor installation is required.

a. Optimum temperature control can be achieved by embedding a bead thermistor sensor (such as CAMBION P/N 740-0040-08 and 740-0158-01) into the body of the object to be controlled. To do this, drill a 0.10 inch (2.54 mm) diameter hole into the object, coat the thermistor bead with thermally conductive grease (such as CAMBION P/N 630-7208-01), and insert the thermistor into the hole.

   Some consideration, will, of course, have to be given to the possible existence of temperature gradients within the object or material, but such gradients can be minimized by selecting materials of adequate thickness and of relatively high thermal conductivity (such as copper, aluminum, etc.)

   Most of CAMBION's thermoelectric devices which are equipped with a built-in thermistor sensor, use the full or partial embedment thermistor mounting method. In these devices, the sensor is mounted in the optimum location for maximum accuracy.

b. A second possible thermistor mounting technique involves attaching the thermistor sensor to the surface of the TED or object to be controlled. This technique generally results in somewhat poorer temperature control than can be achieved by the embedment method, although satisfactory results can be frequently obtained if some care in mounting is taken. It is essential that good thermal contact be maintained between the thermistor and controlled surface. For this purpose, the thermistor should be coated with a thin layer of thermally conductive grease and attached to the surface by applying slight pressure. The sensor may be held in place with water resistance tape or by some other suitable method.

   Heat transfer between the ambient and top exposed portion of the sensor is a source of error which becomes increasingly important as the temperature difference between the ambient and controlled surface increases. To reduce this error, some type of foam insulation should be placed on top of the thermistor so as to cover the sensor and immediately surrounding surface area.

c. If the Bipolar Controller is to be used to control the temperature of a liquid in a bath, an immersible model of the same thermistor sensor suppoied with the Bipolar Controller should be submerged in the bath.

   In order to insure reasonable accuracy, (especially in large containers) the liquid should be circulated within the container, thus reducing the problem of temperature gradients.

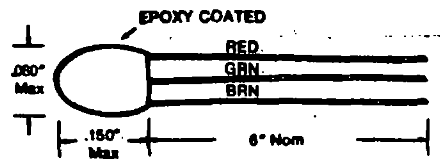
d. In each of the above cases, failure to obtain good thermal contact between the heat load and sensor will result in poor temperature control and/or oscillation.

4. When controlling the temperature of an object or specimen placed on top of a thermoelectric device, it is sometimes desirable to minimize temperature measurement error due to thermal gradients by measuring the temperature of the object or specimen itself rather than the surface plate of the thermoelectric device. To facilitate such measurements, an external thermistor probe may be plugged-in to the phone jack at the rear of the controller. Several types of probes are available from CAMBION as illustrated in Figure I.

FIGURE I - TEMPERATURE READOUT PROBES

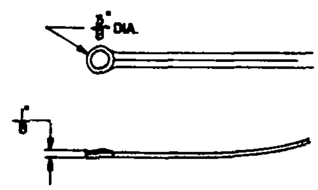
P/N 740-0158-01-00-00

General purpose bead thermistor; Non-immersible for embedment in solid objects.
Time Constant: 1.0 sec



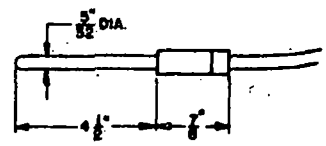
P/N 740-0259-01-00-00

Disc-type probe for flat-surface temperature measurement. Stainless steel cup, epoxy filled.
Time Constant: 1.1 sec



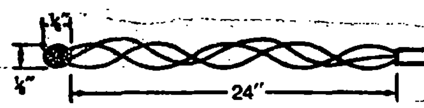
P/N 740-0263-01-00-00

Tubular-type stainless steel probe useful for liquid immersion or for oral or rectal temperature measurements.
Time Constant: 3.6 sec



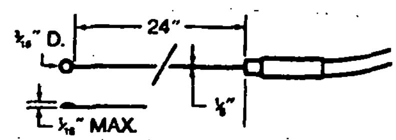
P/N 740-0572-01-00-00

General purpose bead-type probe. Non-immersible, epoxy tipped.
Time Constant: 0.6 sec



P/N 740-0610-01-00-00

Small disc-type probe for curvette, water bath, leaf, and other surfaces. Stainless steel disc, epoxy back, and 24" Teflon coated wires.
Time Constant: 0.3 sec



NOTE: All probes (except P/N 740-0158-01-00-00) feature a 10 foot long vinyl cable fitted with a 3-wire phone plug.

III OPERATING INSTRUCTIONS

A. Front Panel Controls

1. Power switch - pushbutton on/off main power switch for the unit. It is illuminated in the "on" position.
2. Temperature control setpoint - establishes setpoint temperature at which the thermoelectric device is to be maintained. Indicated on the front panel are arrows designating the direction in which to rotate the temperature set dial to enter either the heating or cooling mode.
3. Digital Indicator - Displays the temperature in degrees Celcius of the associated thermoelectric device.

B. Operation

1. Ensure that proper thermal protection (either fluid or air or heat sinking) is provided for the thermoelectric device prior to energizing the Bipolar Controller.

2. Important - Place the line voltage selector switch, located at the rear of the unit, in the position corresponding to the AC line voltage being used; either 115 or 230 volts. Improper positioning of this switch may result in damage to the unit.

3. Make all the required electrical connections as previously described.

4. Energize the Bipolar Controller by depressing the Power Switch on the front panel.

5. Achieving the desired temperature setpoint: Adjust the temperature setpoint dial until the desired temperature is indicated on the Digital Display. Always allow sufficient time for the temperature to stabilize after each adjustment.

6. Temperature set lock - This is the small black lever which protrudes from the silhouette of the temperature set dial. It may be used whenever the operator desires to lock in at one specific set point temperature (i.e., one desired dial setting). This is accomplished by setting the desired temperature and then pulling this black lever down as far as possible. When it is necessary to change the setpoint temperature again, the lever must be raised.

7. Internal gain control - A internal gain control has been provided to facilitate the selection of the optimum amplifier gain (between 18 and 100) for various thermoelectric devices. This control has been set at the factory for a gain of approximately 40 and this setting should provide the best operating point for the majority of TE assemblies.

Occasionally, a particular application may require the adjustment of this control for optimum performance. Generally, for applications where the mass of the surface plate and/or load is very small, a lower amplifier gain is best. In cases where the mass of the surface plate and/or load is relatively great, a higher gain is usually preferable. The operator may adjust this control (which is located on the printed circuit board) for the best performance of a particular thermoelectric assembly, but should keep the following in mind:

a. With a high gain, response to temperature changes is faster and the sensitivity of the controller is greater. However, exceeding the optimum setting will result in temperature oscillation and poor stability, especially at higher temperatures.

b. A low gain setting will result in slower response to temperature changes and lower overall sensitivity. Stability at higher temperatures will generally be somewhat improved.

It should be noted that when this controller is furnished together with a cooling assembly as part of a system, the internal gain control has been preset at the factory for the optimum operating characteristics throughout the overall temperature range. In this case, additional adjustment of the gain control should not be necessary.

C. DIGITAL OUTPUT (Model 809-3011-02 ONLY)

1. A BCD output is provided in the -02 model to facilitate the connection of a digital printer or other equipment. For optimum results, the interconnecting cable between the controller and external equipment should be kept as short as possible.

2. DIGITAL SPECIFICATIONS:

   a. LOGIC: DTL/TTL CMOS compatible; sinks 1.6ma at low level (0 to 0.5 volts) and sources 40 microamps at high level (+3.5 $\pm$ 1 volt)
   b. BCD DATA: 3 BCD digits (8-4-2-1) plus "1" over range; buffered parallel output, non-isolated, non-synchronous
   c. EXTERNAL BLANKING: Low level input on pin 23 blanks the three least significant digits.
   d. HOLD: Low level input on pin 24 retains last reading in display.
   e. END OF CONVERSION: Rising edge on pin 22 signals end of conversion.
   f. POLARITY: High logic level on pin 21 indicates that measurement is negative.

3. OUTPUT CONNECTIONS:

The BCD output is accessible through the twenty-four pin connector located at the rear of the cabinet. This connector is wired as follows:

PIN NO.	PARAMETER		PIN NO.	PARAMETER	
1	D1B1	(1)	13	D3B1	(100)
2	D1B2	(2)	14	D3B2	(200)
3	D1B4	(4)	15	D3B4	(400)
4	D1B8	(8)	16	D3B8	(800)
5	----		17	----	
6	D2B1	(10)	18	D4B1	(1000) over-range
7	D2B2	(20)	19	----	
8	D2B4	(40)	20	Digital Ground	
9	D2B8	(80)	21	Polarity Output	
10	----		22	End of Conversion	
11	----		23	Blanking Input	
12	----		24	Hold	

IV. THEORY OF OPERATION

A. The Peltier (thermoelectric) effect states that a temperature differential will be produced between the faces of a thermoelectric module when a current is passed through the module; and that temperature differential will be proportional to the amount of current through the module. Also, a change in the direction of the current flow through the module will result in a temperature differential which is opposite in direction to that of the first case. Thus, by varying the magnitude and direction of current flow through a thermoelectric module, it is possible to heat and cool both faces of that module. Because module temperature is a function on input current, the thermoelectric concept is ideally suited to temperature control applications.

B. The operation of the Bipolar Controller is basically, as follows: The thermistor sensor (a device whose resistance varies with temperature) and temperature set potentiometer form two legs of a Wheatstone Bridge circuit, the potentiometer establishing a reference input and the sensor functioning in the thermal feedback network. Any variation in resistance of either circuit element will produce an unbalanced bridge condition resulting in an output error signal (actuating signal) from the bridge. Consequently, the signal error is a result of the relationship between the potentiometer and thermistor resistances.

It can be seen that if the thermistor is sensing the temperature of the thermoelectric device being controlled, the thermistor's resistance will define the temperature of the TED. Any deviation in the TED temperature will result in a change of resistance of the thermistor, and thus produce an actuating signal. Since the reference input (potentiometer) can be varied, the setpoint temperature can also be varied.

C. The actuating signal described in the preceding paragraph is amplified by an operational amplifier and then sent to a Bipolar power amplifier. It is the current from this power amplifier that drives the thermoelectric module or assembly being controlled. The Bipolar Controller will, in effect, provide just enough current to the TED to maintain its temperature at the point established by the setpoint potentiometer, and at the same time, attempt to approach a balanced bridge condition.

V. MAINTENANCE AND REPAIR

A. General

The CAMBION Bipolar Controller is a self-contained solid state unit which should give long life and virtually maintenance free service. If the unit fails to operate properly, it may be either returned to CAMBION or repaired by a qualified technician, if desired. A Troubleshooting procedure is included to aid in locating any difficulty which might commonly be encountered. If the trouble can not be eliminated by following this procedure, write

Midland-Ross Corporation
Cambion Division
445 Concord Avenue, Cambridge, MA 02238
(617) 491-5400

B. Troubleshooting Procedure

1. Possible causes of temperature control failure:

   a. Thermistor sensor defective
   b. Thermoelectric module(s) defective
   c. No power to the Bipolar Controller
   d. The power supply voltages are not within the required limits.
   e. The amplifiers are not functioning properly.

2. Checking the thermistor sensor
   Turn the Bipolar Controller "off" and disconnect the 5-pin output load/sensor connector plug. Allow the thermoelectric device to stabilize at room temperature ($18^{O}C$ to $31^{O}C$) and measure the resistance between pins "A" and "B" of the male connector. If the measured value is outside of the range of 75,000 to 140,000 ohms, it is likely that the thermistor is defective.

3. Checking the thermoelectric load
   With the output load disconnected, measure the resistance between pins "D" and "E" of the same connector. The measured value should be within the range of approximately

0.2 to 0.5 ohms for most thermoelectric modules or assemblies used with this controller. If the resistance is appreciably outside of this range, it is likely that one or more of the thermoelectric modules is defective.

NOTE: In virtually all cases of thermoelectric failure, the module will exhibit a relatively large increase and, in many instances, approach an open circuit condition.

4. Checking for power failure

a. Connect the 5-pin connector from the thermoelectric device to the output receptacle at the rear of the cabinet, and plug in the AC line cord.

b. Note whether the power switch is "on" (illuminated) or "off" (not illuminated) prior to depressing the switch initially. If the switch is illuminated, proceed to Paragraph 5 "Circuit Test Procedure".

c. If the power switch is not illuminated, press the switch and note whether it now illuminates. If not, check both the fuse at the rear of the unit and the lamp in the "power" switch, and replace if either have blown out.

d. If the fuse has blown out, been replaced, and blown again, check for a short circuit. To do that, remove the Bipolar Controller cabinet by unfastening the four screws situated on the front corners and the two inside screws located in the bottom row at the rear. Push the chassis from the rear and pull out from the front. Examine the wiring to make sure that there are no obvious short circuits.

e. Remove the two power transistors from their socket and re-energize the controller. If the fuse does not blow out again with the power transistors out of the circuit, it is likely that one or both transistors has short-circuited and must be replaced. If the fuse does blow out with the power transistors removed, the most likely cause of the problem would be a defective bridge rectifier (A2).

3. Circuit Test Procedure - Controller Section

a. Equipment required
One 20,000 ohms/volt test meter (VOM)
One 100K $\pm$ 10%, 1/4 watt resistor

b. Disconnect the thermoelectric load and connect the 100K resistor between pins "A" and "B" of the 5-pin female output receptacle at the rear of the cahssis.

c. Turn the controller "on"

d. Measure the voltage across the terminals of filter capacitors C1 and C2. The voltage across each capacitor should be in the range of 6 to 12 volts DC. If appreciably outside this range, check transformer T1, bridge rectifier A2, and capacitors C1 and C2. Check to make sure that the 115/230 line voltage selector switch is placed in the proper position.

e. Measure the voltage from pin 7 of the integrated circuit AR1 to ground. This voltage should be 12 volts DC ±2 volts. If outside this range, check AR1, CR1, CR2, CR5, C3, C4 and R4.

f. Measure the voltage from pin 4 of AR1 to ground. This voltage should be -12 volts DC ±2 volts. If outside range, check AR1, CR3, CR4, CR6, C5, C6, and R3.

g. Turn the temperature setpoint dial on the front panel fully counterclockwise (maximum cooling). Measure the voltage from pin 3 of AR1 to ground. This voltage should be in the range of approximately -0.2 to -1.0 volts DC. If outside range, check resistors R1, R2, R7, R8, R9, and R11 and the integrated circuit AR1.

h. Measuring from the same point (pin 3 of AR1), turn the setpoint dial fully clockwise (maximum heating). The voltage should now be in the range of +0.2 to +1.0 volts DC. If outside range, check resistors R1, R2, R7, R8, R9, and R11 and the integrated circuit AR1.

i. With the setpoint dial fully clockwise, measure the voltage from pin 6 of AR1 to ground. The voltage should be in the range of approximately +6 to +12 volts. If outside range, AR1 is likely to be defective.

j. Measuring from the same point (pin 6 of AR1), turn the setpoint dial fully counterclockwise. The voltage should now be in the range of approximately -6 to -12 volts DC. If outside range, AR1 is likely to be defective.

k. With the setpoint dial fully counterclockwise, measure the voltage from pin "D" of output receptacle J1 to ground. This voltage should be within the range of approximately -6 to -12 volts DC. If the voltage is zero (0), it is likely that transistor Q2 (MJ4030) is defective. If the voltage is positive, it is likely that transistor Q1 (J 4033) has shortcircuited and requires replacement. In this event, also check transistor Q2 for a possible open-circuit condition (which is likely to occur when Q1 short-circuits).

1. Measuring from the same point (pin "D" of J1), turn the temperature setpoint dial fully clockwise. The voltage should now be in the range of approximately +6 to +12 volts DC. If the voltage is zero (0), it is likely that transistor Q1 is defective. If the voltage is negative, it is likely that transistor Q2 has shortcircuited and requires replacement. In this event, check transistor Q1 for a possible open circuit (which is likely to occur when Q2 short circuits).

4. Circuit Test Procedure - Readout Section

a. One possible source of difficulty with the temperature readout section is failure of the thermistor sensing element. The thermistor may be easily checked for catastrophic failure either by substituting another sensor known to be good, or, by measuring the sensor resistance.

To check the resistance of the thermistor sensor, remove the plug from the rear of the unit and allow the sensor to stabilize at normal room temperature. Measure the resistance across the plug, as follows:

Sleeve to tip,	6.8K	$\pm 20\%$
Sleeve to ring,	35 K	$\pm 20\%$

If the measured values are outside of tolerance, it is likely that the thermistor sensor is defective.

A thermistor sensor which is slightly out of tolerance will affect thermometer accuracy and presents a somewhat more difficult problem to diagnose. The best method of checking this possibility is by substituting a second thermistor probe known to be good and placing the two sensors in intimate thermal contact with one-another. If the reading with the known good sensor is the same as that with the original sensor, it is likely that the original sensor is working properly; if the reading differs significantly, it is likely that the original sensor is defective.

b. Remove the upper (beige colored) portion of the cabinet by first removing the two screws at the rear outside lower corners of the cabinet, and then pulling the upper cabinet body backward. This will expose the printed circuit board mounted on the back of the Digital Panel Meter.

c. Measure the voltage between pins 4 and 7 of the MC1456G OP-AMP mounted on this circuit board. If this voltage is outside a range of 20 to 28 volts DC, it is likely that a problem exists within the Digital Panel Meter. Also, check to make sure that the 115/230 volts AC line switch is in the proper position.

d. Measure the voltage between Pin 6 of the OP-AMP and ground. If this voltage is outside a range of 1.2 to 1.7 volts, it is likely that the MC1456G OP-AMP is defective.

e. If the instrument requires calibration, consult the calibration section of this manual for specific information.

f. If any other problem is encountered with the Readout Section, it is likely that the difficulty is within the Digital Panel Meter itself and the unit should be returned to CAMBION for repair.

VI. TEMPERATURE READOUT CALIBRATION

A. The Digital Temperature Readout will generally remain within calibration tolerances for a relatively long period of time, but when using the instrument in applications requiring optimum accuracy, it is frequently desirable to check the calibration every six months. For other less critical applications, a one year or greater calibration interval is usually sufficient.

There are two methods available for calibrating the DIGITAL READOUT, each having certain advantages over the other. The first method involves the use of externally connected precision resistors or decade boxes while the second requires the use of an additional well-calibrated temperature measuring device plus an adjustable-temperature reference. While the second method will sometimes result in slightly better accuracy when used with one specific thermistor sensor, the first method is usually preferred as it gives very satisfactory results while being both easier and much less time consuming to perform. Both methods are described for the information of service personnel.

B. RESISTANCE SUBSTITUTION METHOD

The RESISTANCE SUBSTITUTION METHOD of calibration is based upon the premise that at any given temperature the thermistor sensor will exhibit a highly predictable resistance value, and if a specific resistance value is connected to the input sensor jack, a temperature indication will be produced which corresponds to that resistance. When calibrating the temperature readout, two resistors will actually be needed for each calibration point due to the fact that a "dual" type of thermistor sensor is used. In order to achieve the specified accuracy, external resistance values should be correct to within $\pm 0.1\%$.

The absolute minimum number of calibration points for good accuracy is three although it is generally desirable to use five points to eliminate any possiblity of a non-linearity problem. The general calibration procedure involves setting the upper and lower range limits and then checking one or more points within the range to insure that they are within tolerance.

2. CALIBRATION PROCEDURE - (Resistance Substitution Method)

a. Turn the instrument on and allow it to warm-up for at least 30 minutes.

Connect the external resistances to a 3-wire "phone" plug and connect this plug to the mating jack at the rear of the cabinet (See Figure II).

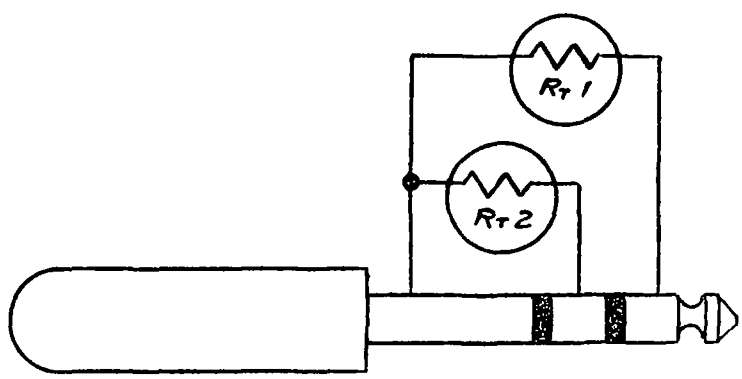


Figure II

b. The table shown in Figure III gives thermistor resistance values at various temperatures. Although the calibration procedure outlined herein is based upon five points for each range, data for additional points is shown for informational purposes.

Figure III

Resistance vs Temperature Data for Thermistor Sensor

Temperature - °C	Resistance - OHMS/T_1	Resistance - OHMS/T_2
-30.0°C*	106,200	481,000
-20.0°C	58,260	271,200
-15.0°C*	43,780	206,200
-10.0°C	33,200	158,000
0.0°C*	19,590	94,980
+10.0°C	11,940	58,750
+20.0°C	7,496	37,300
+30.0°C*	4,834	24,270
+40.0°C	3,196	16,150
+50.0°C*	2,162	10,970

* Indicates Standard Calibration Point

c. By means of the external resistance values, simulate each of the five standard calibration points (-30°C, -15°C, 0°C, +30°C, and +50°C) and observe the digital display. If the readings are within ±0.2°C of the standard calibration temperatures, the instrument is within its specified accuracy.

d. If the units is found to be calibrated satisfactorily, it is only necesasry to check the associated thermistor sensor for accuracy by placing it in a reference bath of known temperature. A stirred bath of ice and water provides a simple but accurate 0°C reference, and even most "non-immersible" thermistors may be briefly placed in such a bath without damage.

If there is more than a ±0.3°C difference between the reference temperature and the temperature indicated on the digital display, it is likely that the thermistor is out of tolerance.

If the instrument is found to be out of calibration, it will be necessary to re-calibrate the unit by adjusting the appropriate trimpots located on the internal printed circuit board.

e. Remove the top (beige-colored) portion of the cabinet by removing the two outside lower screws from the rear cabinet screen and then pulling the top cabinet section slightly back and up. On those units equipped with a 24-pin BCD output connector, be careful to avoid breaking the wires attached to the "inside" of this connector.

TEMPERATURE READOUT PRINTED WIRING BOARD

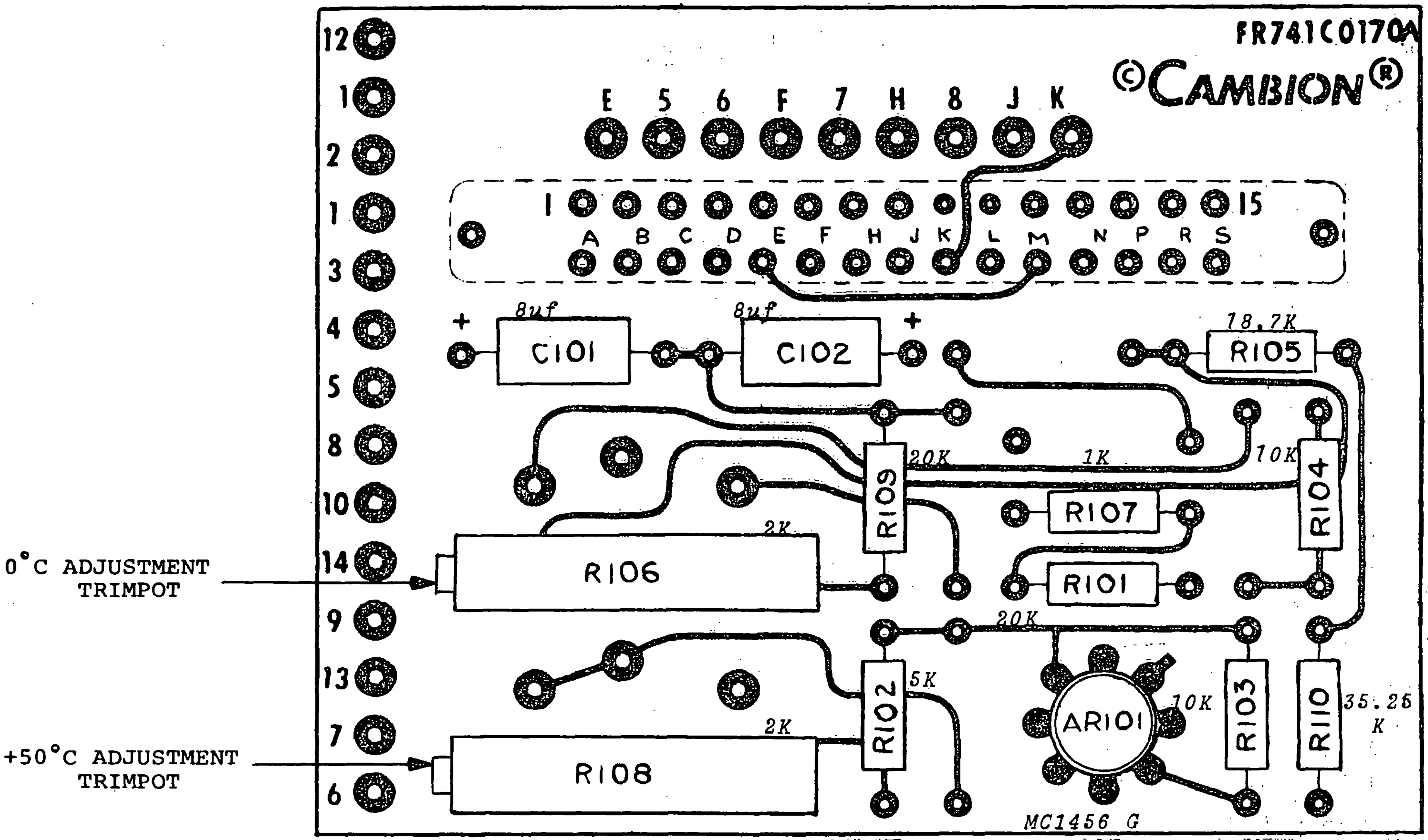


FIGURE IV

f. Locate the two calibration trimpots on the circuit board attached to the digital panel meter. The trimpot closest to the bottom edge of the PC board (R108) is used to set the upper range limit, while the second trimpot nearer the center of the board (R106) is used to set the zero point. (See Figure IV.)

g. Connect the appropriate external resistance values corresponding to a temperature of 0.0°C. Adjust trimpot R106 to obtain a reading of exactly 0.0 on the digital display.

h. Connect the appropriate external resistance values corresponding to a temperature of 50.0°C. Adjust trimpot R108 to obtain a reading of exactly 50.0 on the digital display.

i. Repeat steps g and h until correct readings are obtained at both points.

j. Using appropriate external resistance values as shown in Figure III, check other temperature points (-30.0°C, -15.0°C, and +30.0°C) to make sure they are within ±0.2°C of their correct values. Trim R106 and/or R108 if necessary to obtain ±0.2°C compliance of all points.

C. TEMPERATURE COMPARISON METHOD

1. The temperature comparison method of calibration involves checking the accuracy of the CAMBION digital readout against a second well calibrated temperature standard. If satisfactory results are to be obtained, the standard must be accurate to within ±0.05°C and the sensors of both the CAMBION temperature readout and the standard must be in intimate contact with one-another. For greatest accuracy, these sensors should be immersed in a well-stirred, adjustable temperature, oil bath.

Because of the difficulties normally encountered using this calibration method, a three-point procedure is usually desirable.

2. <u>CALIBRATION PROCEDURE</u>- (Temperature Comparison Method)

a. Open the cabinet as described in paragraph B-2-e above and locate the calibration trimpots as described in paragraph B-2-*f* and Figure IV.

b. Mount the sensors of the CAMBION digital thermometer and the standard thermometer in intimate contact and place these sensors in an adjustable temperature bath or other adjustable temperature medium or source.

c. Adjust the temperature reference source to 0.0°C as indicated by the standard thermometer. Set trimpot R106 to obtain a reading of exactly 0.0°C on the CAMBION digital display.

d. Adjust the temperature reference source to 50.0°C as indicated by the standard thermometer. Set trimpot R108 to obtain a reading of exactly 50.0°C on the CAMBION digital display.

e. Repeat steps c and d until correct readings are obtained at both points.

f. Adjust the temperature reference source to -30°C as indicated by the standard thermometer. The CAMBION readout should now indicate a temperature of -30°C $\pm$0.2°C. If not, resistors R106 and/or R108 will have to be trimmed to obtain the correct indication. After trimming, all three calibration points (+50°C, 0°C, and -30°C) will have to be checked to insure that they are within the $\pm$0.2°C tolerance.

VIII REPACKAGING FOR SHIPMENT

If it becomes necessary to return the instrument to CAMBION for repair, it is essential that the unit be adequately packaged in order to prevent damage in transit. To reduce the possibility of shipping damage, the following general procedure should be observed.

A. Wrap the instrument in paper or plastic material before placing in the shipping container.

B. Place no less than two inches of suitable packing material in the bottom of the container.

C. Place the instrument in the container, which should be of sufficient size to allow a minimum of two inches of packing material around all sides of the unit, including top.

D. Fill the container with packing material and seal with proper fastening material.

E. Mark the shpping container appropriately with such designations as "DELICATE INSTRUMENT", "FRAGILE", etc.

F. NOTE: Any unit being shipped to CAMBION for service or repair, should have a tag attached identifying the owner, and indicating the service or repair to be accomplished. Include the model and serial number of the instrument. Any correspondence should refer to the instrument by model and serial number.

FOR ADDITIONAL INFORMATION

Please contact MIDLAND-ROSS / CAMBION Division, 445 Concord Avenue, Cambridge, Massachusetts 02238; Telephone (617)491-5400.

LIST OF MATERIALS

-04 QTY	-03 QTY	-02 QTY	-01 QTY	ITEM NO.		PART NO.	DESCRIPTION
		1	1	A1	809		PRINTED WIRING ASSEMBLY
		1	1	A2	740	0126-01	BRIDGE RECTIFIER VT-200/T
		1	1	A3	809	0142-01	PRINTED WIRING ASSEMBLY
		1	1	A4	740	0463-01	DIGITAL DISPLAY (MODIFIED)
		1	-	A5	740	0464-01	BCD CIRCUIT CARD
		2	2	C1-2	560	0006-13-01	CAPACITOR, 9200 MFD, 15V
		1	1	C9	560	0010-02	CAPACITOR, 2 MFD, 600V
		1	1	DS1	740	0232-01	LAMP, MSC-J4
		1	1	F1	740	0063-22	FUSE, 1.5A SLO-BLO
		1	-	J2	740	0118-01	PC EDGE CONNECTOR
		1	-	J3	740	0387-01	CONNECTOR, 24-PIN FEMALE
		1	1	J4	740	0261-01	PHONE JACK, 3-WIRE
		1	1	J5	740	0238-02	CONNECTOR, 5-PIN FEMALE
		1	-	P3	740	0507-01	CONNECTOR, 24-PIN MALE
		1	1	Q1	740	0339-01	TRANSISTOR, MJ 4033
		1	1	Q2	740	0340-01	TRANSISTOR, MJ4030
		1	1	R11	740	0141-16	POT, 400K
		1	1	S1	740	0110-01	POWER SWITCH
		1	1	S2	740	0388-01	SLIDE SWITCH, 115/230
		1	1	T1	528	0024-01	TRANSFORMER, CTC 5-2
		1	1	W1	390	0083-01	AC LINE CORD
		1	1	XF1	740	0059-01	FUSEHOLDER
		1	1	1	809	0082-01	CHASSIS
		1	1	2	809	0083-01	FRONT PANEL, SILKSCREENED
		1	1	3	394	0086-01	HARNESS ASSEMBLY
		2	2	4	305	0018-07	SNAP BUSHING, 3/4" O.D.
		1	1	5	305	0015-04	STRAIN RELIEF BUSHING
		2	2	6	370	0030-02	TO-3 MICA INSULATOR
		2	2	7	300	0219-01	CAPACITOR CLAMP
		2	2	8	740	0337-01	HEATSINK
		2	2	9	740	0338-01	TO -3 TRANSISTOR SOCKET
		4	4	10	350	1299-01-07	STANDOFF
		1	1	11	740	0121-01	MULTIDIAL
		AR	AR	12	630	7208-01	THERMAL CREAM
		2	2	13	330	0067-03-07	SCREW, THREAD FORMING 4-40x1/4"
		4	2	14	330	1146-07-02	SCREW, 4-40 x 1/2" BH
		4	4	15	330	1146-03-02	SCREW, 4-40 x 1/4" BH
		10	10	16	330	1147-03-02	SCREW, 6-32 x 1/4" BH
		2	2	17	330	1147-06-02	SCREW, 6-32 x 7/16" BH
		4	4	18	330	1148-05-02	SCREW, 8-32 x 3/8" BH
		2	2	19	330	0065-07-02	SCREW, 6-32 x 1/2 OH PHILLIPS
		8	6	20	365	0030-02-02	LOCKWASHER, INT. TOOTH #4

CHASSIS ASSEMBLY 809-3011 BIPOLAR CONTROLLER	71279	LM 809-0081	10-26-78
	SCALE:	SHEET 1 OF 2	REV

-04 QTY	-03 QTY	-02 QTY	-01 QTY	ITEM NO.		PART NO.	DESCRIPTION
		4	4	21	310	0013-04-02	HEX NUT, #4-40
		18	18	22	365	0030-03-02	LOCKWASHER, INT. TOOTH #6
		14	14	23	310	0013-06-02	HEX NUT, #6-32
		4	4	24	365	0030-04-02	LOCKWASHER, INT. TOOTH #8
		4	4	25	310	0013-07-02	HEX NUT, #8-32
		4	4	26	330	0038-08-02	TAPPING SCREW, #6 x 5/8"

LIST OF MATERIALS

CHASSIS ASSEMBLY 809-3011
BIPOLAR CONTROLLER

71279 | LM809-0081 | 10-26-78

SCALE: | SHEET 2 OF 2 | REV

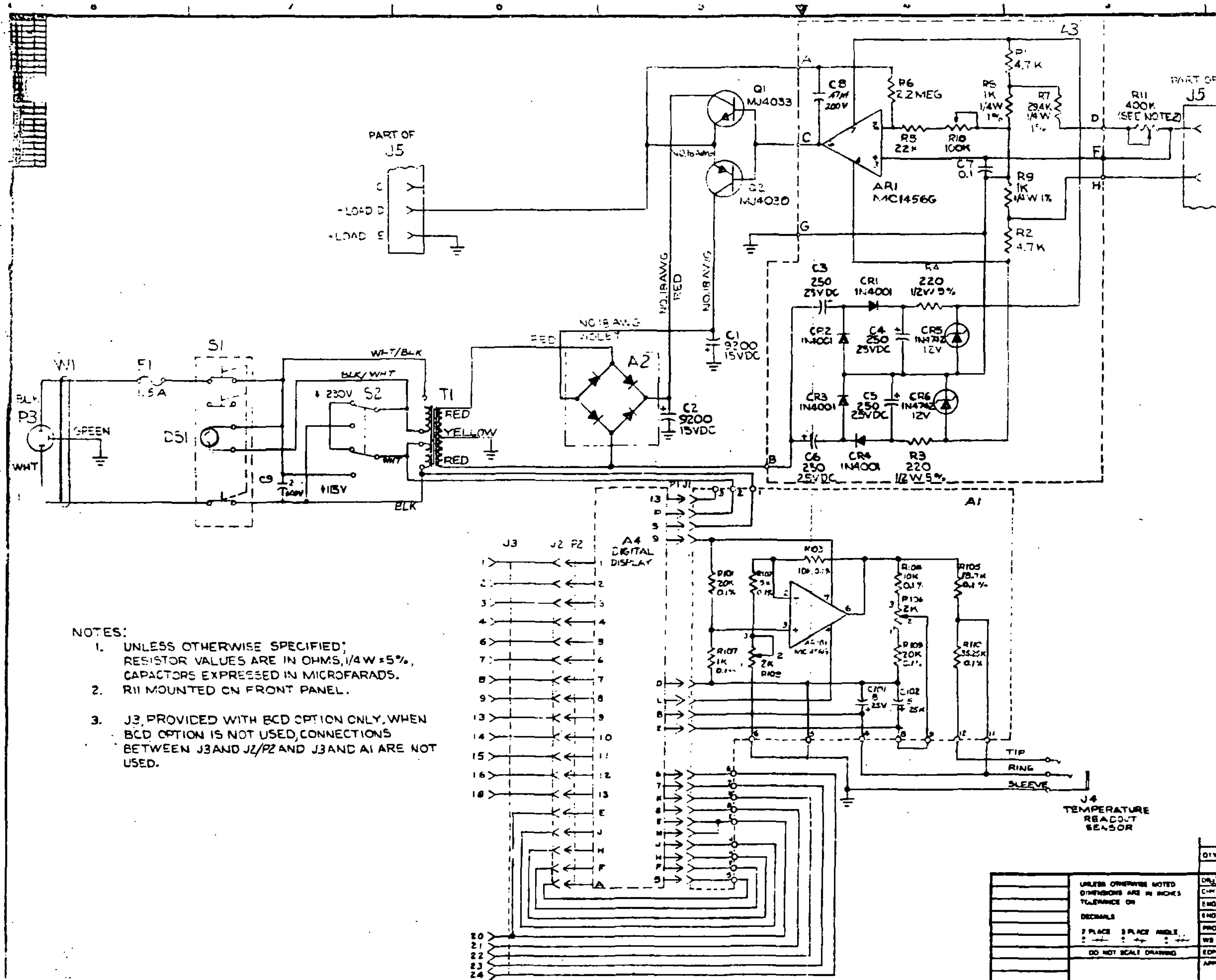
-04	-03	-02	-01	ITEM	LIST OF MATERIALS		
QTY	QTY	QTY	QTY	NO.		PART NO.	DESCRIPTION
			1	AR1	760	7020-01	OP-AMP, MOTOROLAMC14566
			4	C3-6	560	0039-01	CAPACITOR, 250 MFD, 25V
			1	C7	560	0005-21-03	CAPACITOR, 0.1 MFD 80V
			1	C8	560	0058-01	CAPACITOR, 0.47 MFD, 200V
			4	CR1-4	740	0359-01	DIODE, IN4001
			2	CR5-6	740	0342-01	ENTER DIODE IN4742
			2	R1-2	740	0012-35-01	RESISTOR, 4.7K, 1/4W, 5%
			2	R3-4	740	0036-11-01	RESISTOR, 220Ω, 1/2W, 5%
			1	R5	740	0012-51-01	RESISTOR, 22K, 1/4W, 5%
			1	R6	740	0012-81-01	RESISTOR, 2.2 MEG, 1/4W, 5%
			1	R7	740	0070-13-02	RESISTOR, 29.4K, 1/4W, 1%
			2	R8-9	740	0070-03-02	RESISTOR, 1K, 1/4W, 1%
			1	R10	740	0360-01	POTENTIOMETER, 100K
			1	1	809	0087-01	PRINTED WIRING BOARD
			1	2	740	0519-01	IC SOCKET, 8-PIN TO -5

A3 PRINTED WIRING ASSEMBLY	71279	LM 809-0142-01	10-25-78
809-3011 BIPOLAR CONTROLLER	SCALE:	SHEET OF	REV

LIST OF MATERIALS

-04 QTY	-03 QTY	-02 QTY	-01 QTY	ITEM NO.		PART NO.	DESCRIPTION
			1	AR101	760	7020-01	OP-AMP, MOTOROLA MC1456G
			1	C101	560	0044-07	CAPACITOR, 8 MFD
			1	C102	560	0044-07	CAPACITOR, 8 MFD
			1	J1	740	0371-01	PC CONNECTOR, CINCH
			1	R101	740	0448-09	RESISTOR, 20K, 0.13W,0.1%
			1	R102	740	0448-06	RESISTOR, 5K, 0.13W, 0.1%
			1	R103	740	0448-07	RESISTOR, 10K, 0.13W, 0.1%
			1	R104	740	0448-07	RESISTOR, 10K, 0.13W, 0.1%
			1	R105	740	0448-08	RESISTOR, 18.7K, 0.13W, 0.1%
			1	R106	740	0447-01	TRIMPOT, 2K
			1	R107	740	0448-02	RESISTOR, 1K, 0.13W, 0.1%
			1	R108	740	0447-01	TRIMPOT, 2K
			1	R109	740	0448-09	RESISTOR, 20K, 0.13W, 0.1%
			1	R110	740	0448-10	RESISTOR, 35.25K, 0.13W, 0.1%
			1	1	740	0519-01	IC SOCKET, 8-PIN
			1	2	811	0060-01	PRINTED CIRCUIT BOARD

A1 PRINTED WIRING ASSEMBLY 809-3011 Bipolar Controller	71279	LM	10-25-7
	SCALE:	SHEET OF	REV



NOTES:

1. UNLESS OTHERWISE SPECIFIED; RESISTOR VALUES ARE IN OHMS, 1/4 W ±5%, CAPACITORS EXPRESSED IN MICROFARADS.
2. R11 MOUNTED ON FRONT PANEL.
3. J3, PROVIDED WITH BCD OPTION ONLY. WHEN BCD OPTION IS NOT USED, CONNECTIONS BETWEEN J3 AND J2/P2 AND J3 AND A1 ARE NOT USED.

J3 FUNCTIONS	
PIN NO.	FUNCTION
1	D1B1 (1)
2	D1B2 (2)
3	D1B4 (4)
4	D1B8 (8)
5	—
6	D2B1 (10)
7	D2B2 (20)
8	D2B4 (40)
9	D2B8 (80)
10	—
11	—
12	—
13	D3B1 (100)
14	D3B2 (200)
15	D3B4 (400)
16	D3B8 (800)
17	—
18	D4B1 (1000)
19	—
20	DIGITAL GROUND
21	POLARITY OUTPUT
22	END OF CONVERSION
23	BLANKING INPUT
24	HOLD

QTY	PART NO.	DESCRIPTION	ITEM
LIST OF MATERIALS			

UNLESS OTHERWISE NOTED DIMENSIONS ARE IN INCHES TOLERANCE ON DECIMALS
2 PLACE ± 3 PLACE ± ANGLE ±
DO NOT SCALE DRAWING

DRN / CHK / ENG / ENG / PROD / WB / EDP / APPROVED / BY DIRECTION OF

NEXT ASSEMBLY: [illegible]

CAMBION® CAMBRIDGE THERMIONIC CORP CAMBRIDGE, MASS. 02138

SCHEMATIC DIAGRAM
DIGITAL BIPOLAR CONTROLLER

CODE IDENT NO.	SIZE	CLASS NO.	DRAWING NO.	REV
71279	D	509	0085	

809D0085

MIDLAND ROSS

Midland-Ross Corporation
Cambion Division

4/85

MICROSCOPE STAGE SUB-ASSEMBLY

CAMBION MODEL: 806-2019-01-00-00

General Description

The CAMBION model 806-2019-01 is a temperature controllable microscope stage sub-assembly which is adaptable to a number of various microscopes by modifying the existing stage platform. When used in conjunction with an appropriate controller, accurate temperature regulation of specimens may be obtained while maintaining excellent optical quality. The stage requires a flow of cooling water to remove waste heat from the internal thermoelectric components and ordinary tap water may be used for this purpose.

Specifications

Input Power:	9 amperes maximum at 3.5 volts DC nominal
Cooling Water Required:	500 milliliters per minute minimum at a maximum water temperature of approximately 20°C
Fluid Connections:	Accept 1/8" ID flexible tubing
Compatible Temperature Controllers:	1) For a temperature range of 0°C to +50°C, CAMBION model 809-3010-01-00-00 OR 809-3011-01-00-00 may be used; typical temperature stability is ±0.1°C 2) For a temperature range of -10°C to +65°C, use CAMBION model 809-3020-01-00-00 together with model 809-3048-01-00-00 Range Extender; typical temperature stability is ±0.1°C
Compatible Temperature Readout:	CAMBION model 811-7204-(01/02)-00-00 Digital Thermometer

Installation

1) Lower and/or raise the lens and condenser of the microscope to their limits of travel.

2) Remove the existing stage platform from the microscope and either
   a) make the required mechanical modifications to this platform to accept the 806-2019 temperature controlled stage and re-install on the microscope, or

b) install a previously modified platform with built-in temperature temperature controlled stage in place of the existing stage platform.

3) Orient the electrical cable and water fittings to facilitate maximum movement of the mechanical microscope components.

4) Using 1/8" ID tygon or rubber tubing, connect one of the barbed fluid fittings to a water source and the remaining fitting to a suitable drain.

5) Take the five-pin connector (male end) from the microscope stage and insert it into the proper receptacle at the rear of the Bipolar Controller unit. Fasten the connector by pushing it in towards the controller and rotating the metal collar around the male end in a clockwise direction until it snaps locked.

   Connect the 3-wire phone plug to the mating jack at the rear of the digital thermometer (or Bipolar Controller if the particular controller has a built-in temperature readout).

Operation

After making the required electrical and water connections, turn-on the water and adjust the flow rate to a minimum of 500 milliliters per minute.

CAUTION: Do not apply power to the stage without having a flow of water through the heat sink. Failure to observe this precaution may result in damage to the internal thermoelectric components.

Actual operation of the microscope stage is governed by the associated Bipolar Controller and the Controller's instruction manual should be consulted for specific operating information.

Maintenance and Repair

The 806-2019 microscope stage is a solid-state device which should provide reliable operation with virtually no maintenance.

Failure of the stage to operate properly may be due to one or more of the following:

1) Inadequate water flow - will result in poor overall performance. Check to insure that the minimum water flow requirement is met.

2) Excessive water temperature - will result in poor low temperature performance. Check to insure that the heat sink cooling water temperature does not exceed the recommended maximum of 20°C (68°F).

3) Thermoelectric module(s) defective - the thermoelectric modules may be checked by measuring the resistance between connector pins D and E. The measured resistance value should be within the range of approximately 0.2 to 0.4 ohms. If outside this range, it is likely that one or more of the thermoelectric modules is defective. In this event, it is recommended that the assembly be returned to CAMBION for repair.

4) Defective Control Thermistor -
Allow the assembly to stabilize at room temperature, and measure the resistance between pins A and B of the connector. The measured value should be within the range of 85,000 ohms and 140,000 ohms. If outside this range, it is likely that the 100K control thermistor is defective.

   If the control thermistor is found to be defective, it is recommended that the assembly be returned to CAMBION for repair.

5) Defective Readout Thermistor -
Allow the assembly to stabilize at room temperature and measure the resistance between the following points on the 3-wire phone plug.

   Sleeve (green wire) to tip (black wire): 6K $\pm$ 20%

   Sleeve (green wire) to ring (red wire): 30K $\pm$ 20%

   If the measured value is outside of tolerance it is likely that the readout thermistor is defective and the assembly should be returned to CAMBION for repair.

6) Several specialized techniques were utilized in the assembly of this unit and, consequently, it is recommended that the unit be returned to CAMBION if repair is required. If the user does desire to repair the assembly, CAMBION should be consulted before any work is attempted.

FOR ADDITIONAL INFORMATION

Please contact MIDLAND-ROSS / CAMBION Division, 445 Concord Avenue, Cambridge, Massachusetts 02238; Telephone (617) 491-5400.

CAMBION®

Midland-Ross Corporation
Cambion Division

7/86

OPERATION MANUAL FOR
CAMBION MODEL 809-3010-01
BIPOLAR CONTROLLER

MIDLAND ROSS

ELECTRICAL SPECIFICATIONS AND PHYSICAL CHARACTERISTICS OF CAMBION MODEL 809-3010-01 BIPOLAR CONTROLLER

POWER OUTPUT:	35 watts maximum, 6 amp continuous, 9 amp maximum capable of powering a thermoelectric module or assembly requiring approximately 3.5 to 4 volts D.C.
POWER REQUIREMENTS:	115 VAC ±10%, 50-60 Hz, 110 watts maximum
TEMPERATURE CONTROL RANGE:	0^{o}C to 50^{o}C Nominal
TEMPERATURE CALIBRATION:	1) Accurate tables (curves) of temperature vs. dial setting for a specific controller may be purchased from CAMBION. 2) Temperature setpoint dial may be calibrated by operator.
TEMPERATURE STABILITY:	±0.1^{o}C typical at optimum internal gain setting; actual temperature stability is dependent on the thermal system and may be better or worse than the stated specification.
TEMPERATURE RESOLUTION:	0.018^{o}C/div. to 0.3^{o}C/div.
REPEATABILITY:	±0.05^{o}C
INPUT SENSOR:	Thermistor (100K at 25^{o}C)
CONTROL MODE:	Bipolar Proportional Control
FRONT PANEL CONTROLS:	On/Off switch, temperature setpoint dial with indicator, setpoint dial lock.
INTERNAL CONTROL:	Factory set amplifier gain control.
AMBIENT TEMPERATURE:	5^{o}C to 35^{o}C (40^{o}F to 95^{o}F)
DIMENSIONS:	
Height:	16.6 cm (6.5")
Width:	16.0 cm (5.5")
Depth:	28.0 cm (11")
WEIGHT:	3.95 Kg (8.7 lbs.)

BIPOLAR CONTROLLER OUTPUT LOAD COMPATIBILITY

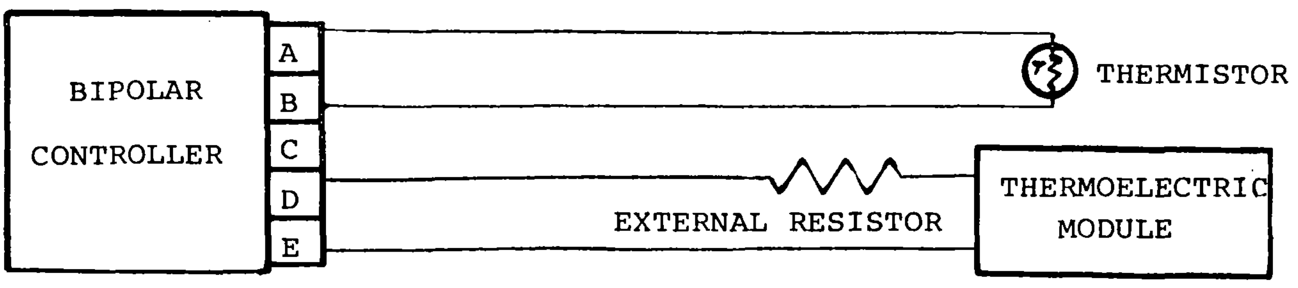
CAMBION MODELS: 809-1018-01-00-00
809-3010-01-00-00
809-3011-01/02-00-00

The Bipolar Controller models listed above have output characteristics designed to be compatible with thermoelectric modules or assemblies requiring approximately 3.5 volts DC at 9 amperes maximum intermittent duty and 6.5 amperes continuous duty. If these controllers are used to drive thermoelectric devices which require less than 3.5 volts DC, the maximum rated output current will be exceeded unless the current is limited by some external means. Consequently, when using lower voltage thermoelectric devices it will be necessary to connect a power resistor in series with the thermoelectric module(s) in order to maintain the current at a safe level.

Typical resistor values are shown in the table below. Where more than one module is indicated, all modules should be electrically connected in series.

THERMOELECTRIC DEVICE (P/N)	APPROXIMATE RESISTANCE VALUE (OHMS)	RESISTOR POWER RATING (WATTS)
(1) 801-1029-01-00-00	0.25	20
(2) 801-1029-01-00-00	0.15	12
(3) 801-1029-01-00-00	0.10	10
(1) 801-3959-01-00-00	0.20	16
(1) 801-3960-01-00-00	0.25	20
(2) 801-3960-01-00-00	0.20	16
(1) 801-3965-01-00-00	0.20	10
(1) 806-1006-01-00-00	0.20	16
(1) 806-7240-01-00-00	0.20	10

TYPICAL CONNECTION DIAGRAM



SECTION II: DESCRIPTION

The CAMBION Bipolar Controller is an automatic temperature controlling unit designed to be used in conjunction with various CAMBION thermoelectric modules, assemblies, and other devices. This instrument will precisely and accurately control the temperature of these devices either above or below existing ambient conditions in accordance with the stated specifications. Utilizing the thermodynamically reversible behavior of thermoelectric modules, the Bipolar Controller automatically compensates for any load or ambient fluctuations which would tend to affect the operating set-point temperature of the system. A thermistor, critically positioned near the thermoelectric device, is used to sense its temperature and provide the required feedback signal to the controller.

SECTION III: INSTALLATION

A. Initial Inspection

The unit was carefully inspected both mechanically and electrically prior to shipment and should be in good physical and electrical condition upon receipt. To confirm this, the instrument should be inspected for physical damage in transit.

B. Power Requirements

Input power requirements for the Bipolar Controller are stated in the specification section of this manual. Some instruments are equipped with a line voltage selector switch to permit operation from either a 115 or 230 volt power source. This switch, located on the rear apron of the controller, must be placed in the position conrresponding to the AC line voltage being used. The "115" position should be used for line voltages in the range of 105 to 125 volts, while the "230" position should be used for voltages in the range of 210 to 250 volts.

C. Grounding Requirements

To protect operating personnel from accidental shock, it is important that the chassis of the Bipolar Controller be grounded. The instrument is equipped with a 3-wire A.C. line cord and, consequently, it is recommended that a grounded A.C. receptacle be utilized. If a grounded receptacle is not available, an auxiliary chassis to ground connection should be provided.

D. Mounting

The Bipolar Controller is a self contained unit with all external connections being made at the rear of the instrument. The controller may be mounted in any position provided that the rear screen and/or fan inlet are not obstructed in a manner which would tend to restrict cabinet ventilation.

For instruments designed for rack mounting, adequate rack ventilation must be assured to prevent overheating of the Bipolar Controller.

E. Electrical Connections

The five-pin connector at the rear of the instrument contains the output load and control thermistor connections and is wired as follows :

PIN A -- Connect to one side of thermistor sensor

PIN B -- Connect to other side of thermistor sensor

PIN C -- Not used

PIN D -- Connect to negative (Black Wire) of thermoelectric device

PIN E -- Connect to positive (Red Wire) of thermoelectric device

NOTE: When connecting to the trermoelectric device, make sure that the device has electrical characteristics compatible with the controller output. Consult the section in this manual entitled BIPOLAR CONTROLLER OUTPUT LOAD COMPATIBILITY for further information.

F. Thermistor Sensor Installation

1. The thermistor sensor should be mounted to the thermoelectric device using one of the techniques listed below. In general, the thermistor should be placed as close as possible to the thermoelectric modules to insure maximum sensitivity, stability, and control accuracy.

   It should be noted that a number of CAMBION's thermoelectric assemblies are equipped with a built-in thermistor sensor and, in this event, no special thermistor installation is required.

2. Thermistor Mounting Techniques

   a. The preferred method for mounting thermistors which will result in optimum temperature control is that of embedding a bead thermistor sensor into the body of the object to be controlled. This may be accomplished by drilling a 0.10 inch (2,54mm) diameter hole into the object, liberally coating the thermistor bead with thermally conductive grease (or epoxy), and inserting the thermistor into the hole.

      Some consideration will have to be given to the possible existence of temperature gradients within the object or material, but such gradients can be minimized by selecting materials of adequate thickness and of relatively high thermal conductivity (such as copper, aluminum, etc.).

      Most of CAMBION's thermoelectric devices which are equipped with a built-in thermistor sensor use the full or partial embedment thermistor mounting technique. In these devices the sensor is mounted in the optimum location for maximum accuracy.

   b. An alternative method of thermistor installation involves attaching the thermistor sensor to the surface of the thermoelectric device or object to be controlled. This technique generally results in somewhat poorer temperature control than can be achieved by the embedment method, but satisfactory results can be frequently obtained if the thermistor is mounted carefully.

      When using this method, it is essential that good thermal contact be maintained between the thermistor and controlled surface. The thermistor bead should be liberally coated with thermally conductive grease, attached to the surface, and held firmly in place by means of water resistant tape or by some other suitable method. Thermally conductive epoxy may also be used for this purpose, and this will usually give somewhat better results than will the thermal grease.

Heat transfer between the ambient and top exposed portion of the sensor is a source of error which becomes increasingly important as the temperature difference between the ambient and controlled surface increases. To reduce this error, some type of foam insulation should be placed on top of the thermistor so as to cover the sensor and immediately surrounding surface area.

c. If the Bipolar Controller is to be used to control the temperature of a liquid in a bath, an immersible model of the same thermistor sensor supplied with the Bipolar Controller should be submerged in the bath liquid.

   In order to insure reasonable accuracy (especially in large containers), the liquid should be circulated within the container thus reducing the temperature gradient problem.

d. In each of the above thermistor installation methods, the principle consideration is to obtain optimum thermal contact between the heat load and sensor. Failure to achieve satisfactory contact will result in poor temperature control and/or oscillation.

SECTION IV: OPERATION

A. Front Panel Control

1. Power Switch - This red pushbutton switch is the main power-switch for the instrument. It is illuminated in the "ON" position.

2. Temperature Setpoint Dial - This 10-turn dial establishes the setpoint temperature at which the thermoelectric device is to be maintained. Clockwise rotation increases the setpoint temperature, while counter-clockwise rotation decreases the temperature.

B. Operating Instruction

1. Ensure that proper thermal protection (either fluid or air cooled heat-sinking) is provided for the thermoelectric device prior to energizing the Bipolar Controller.

2. IMPORTANT: For those instruments having a line voltage selector switch, place this switch in the position corresponding to the AC line voltage being used - either 115 or 230 volts. Improper positioning of this switch may result in damage to the Bipolar Controller.

3. Make and re-check all of the required electrical connections as previously described.

4. Energize the Bipolar Controller by depressing the power switch on the front panel.

5. The temperature setpoint dial may be adjusted to achieve the desired control temperature. This dial may be calibrated by the operator by use of an accurate temperature readout device. However, if the controller is used with several different thermoelectric assemblies or configurations, some difference in dial calibration may be noted for each assembly.

   If continuous temperature monitoring is desired, the sensor of a temperature readout device may be attached to the thermoelectric assembly using techniques similar to those described in the thermistor installation section of this manual. Some of CAMBION's thermoelectric assemblies are equipped with a built-in readout sensor which will directly interface with a standard CAMBION Digital Thermometer.

C. Temperature Set Lock

A small black lever protruding from the silhouettte of the Temperature setpoint dial may be used to lock the dial at one particular setting. The lock is engaged by pulling the lever down as far as possible, and disengaged by raising the lever.

D. Internal Gain Control

A gain control (located on the printed circuit board) has been provided to permit the selection of the optimum amplifier gain for various thermoelectric devices. This control, a single-turn potentiometer, has been set at the factory at a gain level which should provide the best operating point for the majority of T.E. assemblies.

Occasionally, a particular application may require that this control be adjusted in order to obtain optimum performance. Generally, for applications where the mass of the load (object to be controlled) is very small, a lower amplifier is best. In cases where the mass of the load is relatively large, a higher gain is usually desireable. The operator may adjust this control for the best performance of a particular thermoelectric assembly but should keep the following in mind:

1. With a high gain, response to temperature changes is faster and the sensitivity of the controller is greater, generally resulting in "tighter" temperature control. However, exceeding the optimum setting will lead to temperature oscillation and poor stability, especially at higher temperatures.

2. A low gain setting will result in slower response to temperature changes and lower overall sensitivity. Stability at higher temperatures will generally be somewhat improved.

   It should be noted that when this controller is furnished together with a cooling assembly as part of a system, the internal gain control has been preset at the factory for the optimum operating characteristics throughout the overall temperature range. In this case, additional adjustment of the gain control should not be necessary.

SECTION V: THEORY OF OPERATION

A. The thermoelectric or Peltier effect states that a temperature differential will be produced between the faces of a thermoelectric module when a current is passed through the module; and that temperature differential will be proportional to the amount of current through the module. Also, a change in the direction of the current flow through the module will result in a temperature differential which is opposite in direction to that of the first case. Thus, by varying the magnitude and direction of current flow through a thermoelectric module, it is possible to heat and cool both faces of the module. Because module temperature is a function of input current, the thermoelectric concept is ideally suited to temperature control applications.

B. The operation of the Bipolar Controller is basically as follows:

The thermistor sensor (a device whose resistance varies with temperature) and temperature set potentiometer form two legs of a Wheatstone Bridge circuit, the potentiometer establishing a reference input and the sensor functioning in the thermal feedback network. Any variation in resistance of either circuit element will produce an unbalanced bridge condition resulting in an output error signal (actuating signal) from the bridge. Consequently, the signal error is a result of the relationship between the potentiometer and thermistor resistances.

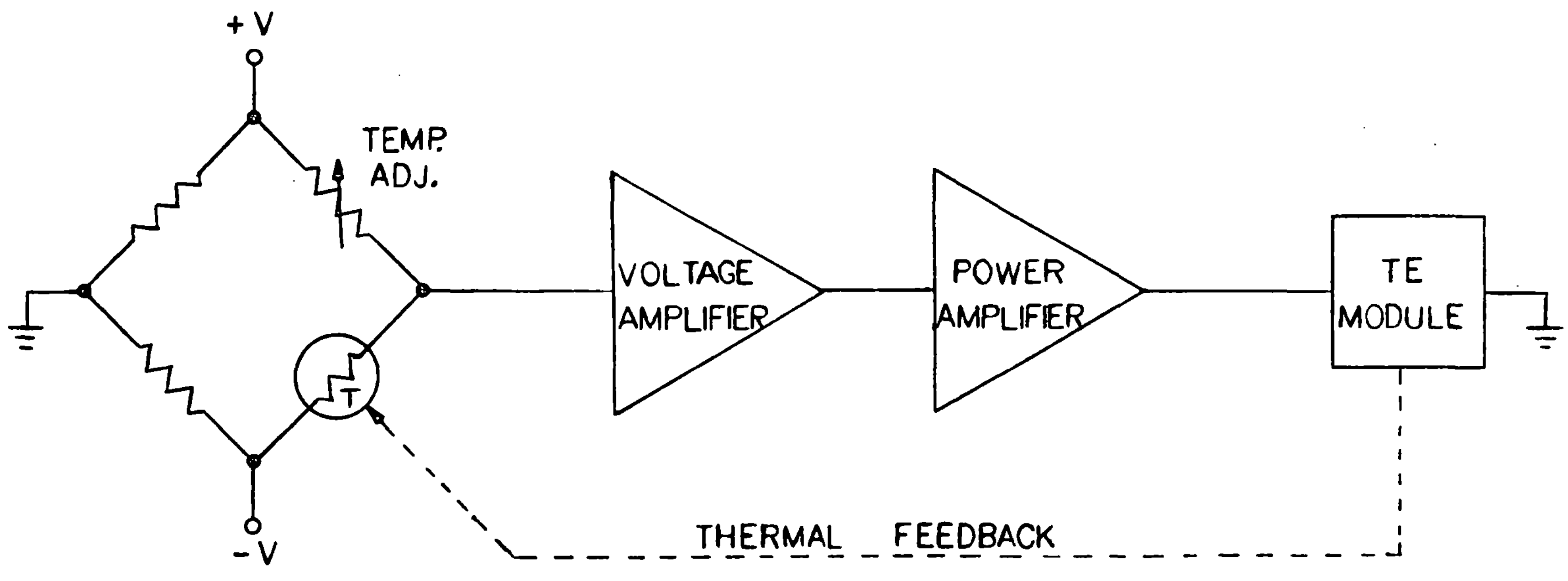
It can be seen that if the thermistor is sensing the temperature of the thermoelectric device (TED) being controlled, the thermistor's resistance will define the temperature of the TED. Any deviation in the TED temperature will result in a change of resistance of the thermistor, and thus produce an actuating signal. Since the reference input (Potentiometer) can be varied, the setpoint temperature can also be varied.

C. The actuating signal described in the preceding paragraph is amplified by an operational amplifier and then sent to a Bipolar power amplifier. It is the current from this power amplifier that drives the thermoelectric module or assembly being controlled. The Bipolar Controller will, in effect, provide just enough current to the TED to maintain its temperature at the point established by the setpoint potentiometer and, at the same time, attempt to approach a balanced bridge condition.

DWG NO.	SH	REV
A		

REVISIONS

REV	DESCRIPTION	DATE	APPROVED



QTY	PART NUMBER	DESCRIPTION	ITEM NO.
	LIST OF MATERIALS		

	DFTG	MIDLAND ROSS — Midland-Ross Corporation, Cambion Division, 445 Concord Avenue, Cambridge, MA. 02238
	CHKR	
	ENG JB	TITLE BIPOLAR CONTROLLER FUNCTIONAL DIAGRAM
	ENGRG	
	TOLERANCE STANDARDS — DECIMALS .XX ±. .XXX ±. ANGLES ± °	SIZE A — FSCM NO. 71279 — DWG NO. — REV
NEXT ASSEMBLY		SCALE: — NP # — SHEET OF

SECTION VI: MAINTENANCE AND REPAIR

A. General Information

The CAMBION Bipolar Controller is a self-contained solid state unit which should give long life and virtually maintenance free service. If the unit fails to operate properly it may either be returned to CAMBION or repaired by a qualified technician if desired. A trouble-shooting procedure is included to aid in locating any difficulty which might commonly be encountered. If the trouble can not be eliminated by following this procedure, write

Midland-Ross Corporation
Cambion Division
445 Concord Avenue, Cambridge, MA 02238
(617) 491-5400

B. Troubleshooting Procedure

1. Possible causes of temperature control failure:

   a. Thermistor sensor defective.
   b. Thermoelectric module (s) defective.
   c. No power to the Bipolar Controller.
   d. The power supply voltages are not within the required limits.
   e. The amplifiers are not functioning properly.

2. Checking the thermistor sensor:

   Turn the Bipolar Controller OFF and disconnect the output load sensor cable plug. Allow the thermoelectric device to stabilize at room temperature (18°C to 31°C) and measure the resistance between the appropriate pins of the male connector. If outside of the range stated below, it is likely that the thermistor is defective.

Measure Between Pins	Normal Resistance Range
A and B	75K to 140K OHMS

3. Checking the thermoelectric load:

   With the load disconnected, measure the resistance between the appropriate pins of the same connector. If the resistance is outside of the range shown below, it is likely that one or more of the thermoelectric modules is defective.

   Note: In virtually all cases of thermoelectric module failure, the module will exhibit a relatively large increase in resistance, in many cases approaching an open-circuit condition.

Measure Between Pins	Normal Resistance Range
D and E	0.2 to 0.4 OHMS

4. Checking for power failure:

   a) Connect the load/sensor plug from the thermoelectric device to the output receptacle at the rear of the controller and plug in the AC line cord.

   b) Depress the power switch to turn the unit ON. If the switch illuminates, proceed to Paragraph 5 "Circuit Test Procedure". If the switch does not illuminate, check both the fuse at the rear of the unit and the lamp in the POWER switch. Replace as necessary.

   c) If the fuse has blown out, been replaced, and blown again, check for a short-circuit. For instruments enclosed in a cabinet, the cabinet may be removed by unfastening the four screws located near the corners of the front panel plus the two inside screws located in the bottom row at the rear, and then pushing the chassis out towards the front. Examine the wiring to make sure there are no obvious short-circuits.

   d) Disconnect the red and violet leads from the four terminal barrier strip which interconnect with the heat sink assembly. Insert a new fuse into the instrument and turn the unit ON. If the fuse blows out again, it is likely that the bridge rectifier is defective. (Also check the power transformer and filter capacitors).

      If the fuse does <u>not</u> blow out again after the red and violet leads are removed, it is likely that one or more of the power transistors are defective. It is frequently necessary to replace all transistors at the same time since a short-circuit in one will usually damage the other (s).

5. Circuit Test Procedure:

   a) Equipment Required: One 20,000 Ohms/volt (minimum) test meter
One resistor: 100K, 5%, ¼ watt

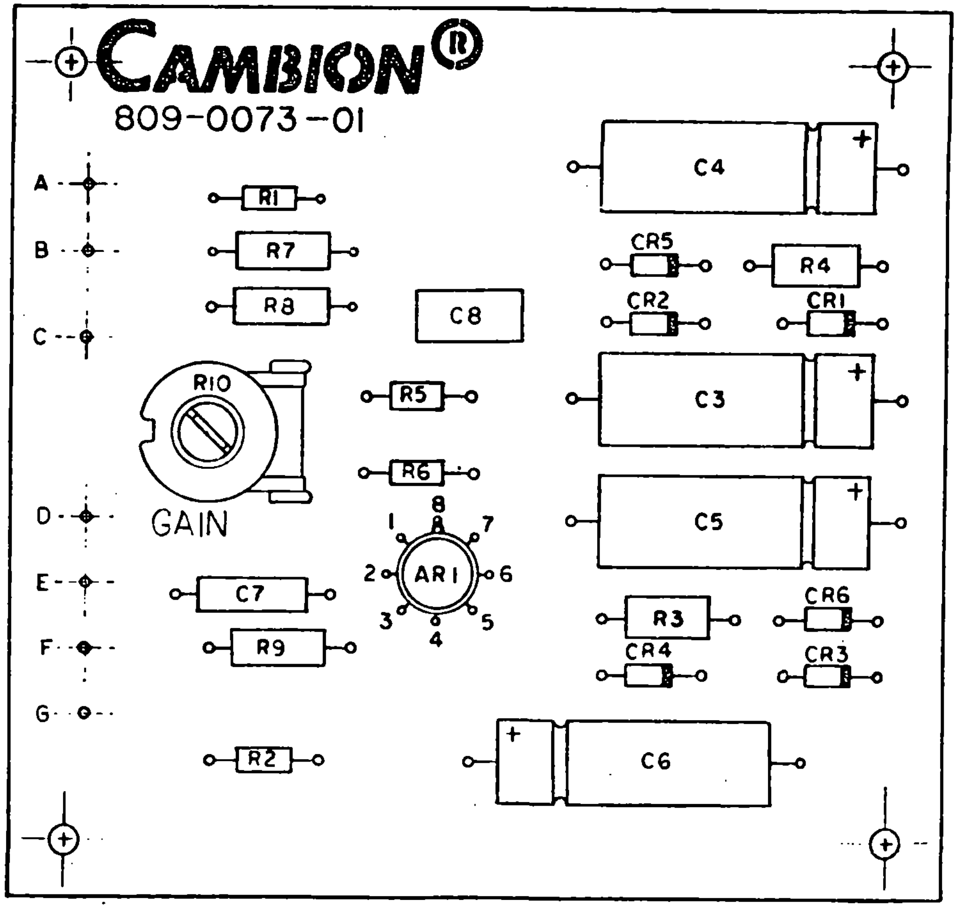
   b) Disconnect the thermoelectric load and connect the above resistor between female connector pins

   c) Turn the controller ON.

DWG NO.	SH	REV

REVISIONS

REV	DESCRIPTION	DATE	APPROVED



	DFTG
	CHKR
	ENG
	ENGRG
	TOLERANCE STANDARDS DECIMALS .XX ± . .XXX ± . ANGLES ± °
NEXT ASSEMBLY	

MIDLAND ROSS

Midland-Ross Corporation
Cambion Division
445 Concord Avenue, Cambridge, MA 02238

TITLE

CONTROL BOARD

SIZE	FSCM NO.	DWG NO.	REV
A	71279		
SCALE:	NP #	SHEET OF	

d) Measure the voltage across the terminals of the two large can-type filter capacitors. If the voltage is appreciably outside the range stated below, check the power transformer, bridge rectifier, and filter capacitors. On units equipped with a 115/230 line voltage selector Switch, check to make sure that the switch is placed in the proper position.

Normal Voltage Range: 6 to 12 Volts DC

e) Measure the voltage between Pins 4 and 7 of the integrated circuit which is located on the printed circuit board. If this voltage is outside of the range stated below, check the integrated circuit, the four 150 and/or 250 MFD filter capacitor, and the two Zener diodes along with their current limiting resistors.

Normal Voltage Range: 20 to 28 Volts DC

f) Turn the temperature setpoint dial on the front panel fully counterclockwise (maximum cooling) and measure the voltage from pin 3 of the integrated circuit to ground. If outside of the range stated below, check the integrated circuit and 10-turn temperature setpoint potentiometer.

Normal Voltage Range: -0.2 to -1.0 Volts DC

g) Measuring from the same point (Pin 3 to ground), turn the temperature setpoint dial fully clockwise (maximum heating). If this voltage is outside of the range stated below, check the integrated circuit and 10-turn temperature setpoint potentiometer.

Normal Voltage Range: +0.2 to +1.0 Volts DC

h) With the setpoint dial fully clockwise, measure the voltage from pin 6 of the integrated circuit to ground. If this voltage is outside of the range stated below, the integrated circuit is likely defective.

Normal Voltage Range: +6 to +12 Volts DC

i) Measuring from the same point (pin 6 to ground) turn the setpoint dial fully counterclockwise. If the voltage reading is outside of the range stated below, the integrated circuit is likely defective.

Nornal Voltage Range: -6 to -12 Volts DC

j) Some controllers have a buffer amplifier stage using complimentary 2N5401 and 2N5550 transistors. For units with this additional stage, complete steps <u>J</u> and <u>K</u> of this test procedure. For units which do not incorporate a buffer stage, skip to step <u>L</u>.

With the setpoint dial fully counterclockwise, measure the voltage from the 2N5401 and 2N5550 emitters to ground. If outside of the range stated below, it is likely that the 2N5401 transistor if defective.

Normal voltage range: NOT APPLICABLE

k) Measuring from the same point (2N5401/2N5550 emitters to ground), turn the setpoint dial fully clockwise. If the voltage is outside of the range stated below, it is likely that the 2N5550 transistor is defective.

Normal voltage range: NOT APPLICABLE

l) Turn the setpoint dial fully counterclockwise and measure the voltage from the common emitter point of the power transistors to ground. This voltage should be within the range of approximately -6 to -12 Volts DC

If the voltage is zero, it is likely that the NPN power transistor (s) is/are defective.

If the voltage is positive, it is likely that the NPN power transistor (s) is/are defective. In this event, also check the PNP transistor (s) for a possible open circuit condition.

m) Measuring from the same point, turn the temperature setpoint dial fully clockwise. The voltage should now be within the range of approximately +6 to +12 Volts DC

If the voltage is zero, it is likely that the NPN power transistor (s) is/are defective.

If the voltage is negative, it is likely that the PNP power transistor (s) is/are defective. In this event, also check the NPN transistor (s) for a possible open circuit condition.

n) In controllers which use parallel configurations of transistors in the power output stage, the failure of one transistor will frequently result in failure of the remaining transistors. Consequently, if a problem is traced to the power amplifier section, it is generally desireable to check, if not replace, all power transistors in that section.

If the procedure outlined above does not reveal the source of the difficulty the unit should be returned to CAMBION for repair.

SECTION VII: REPACKING FOR SHIPMENT

A. If it becomes necessary to return the instrument to CAMBION for repair or for any other reason, it is essential that the unit be adequately packaged in order to prevent damage in transit. To reduce the possibility of shipping damage, the following general procedure should be observed:

1. Wrap the instrument in paper or plastic material.

2. Place no less than two inches of suitable packing material in the bottom of the container.

3. Place the instrument in the container, which should be of sufficient size to allow a minimum of two inches of packing material around all sides of the unit, including the top.

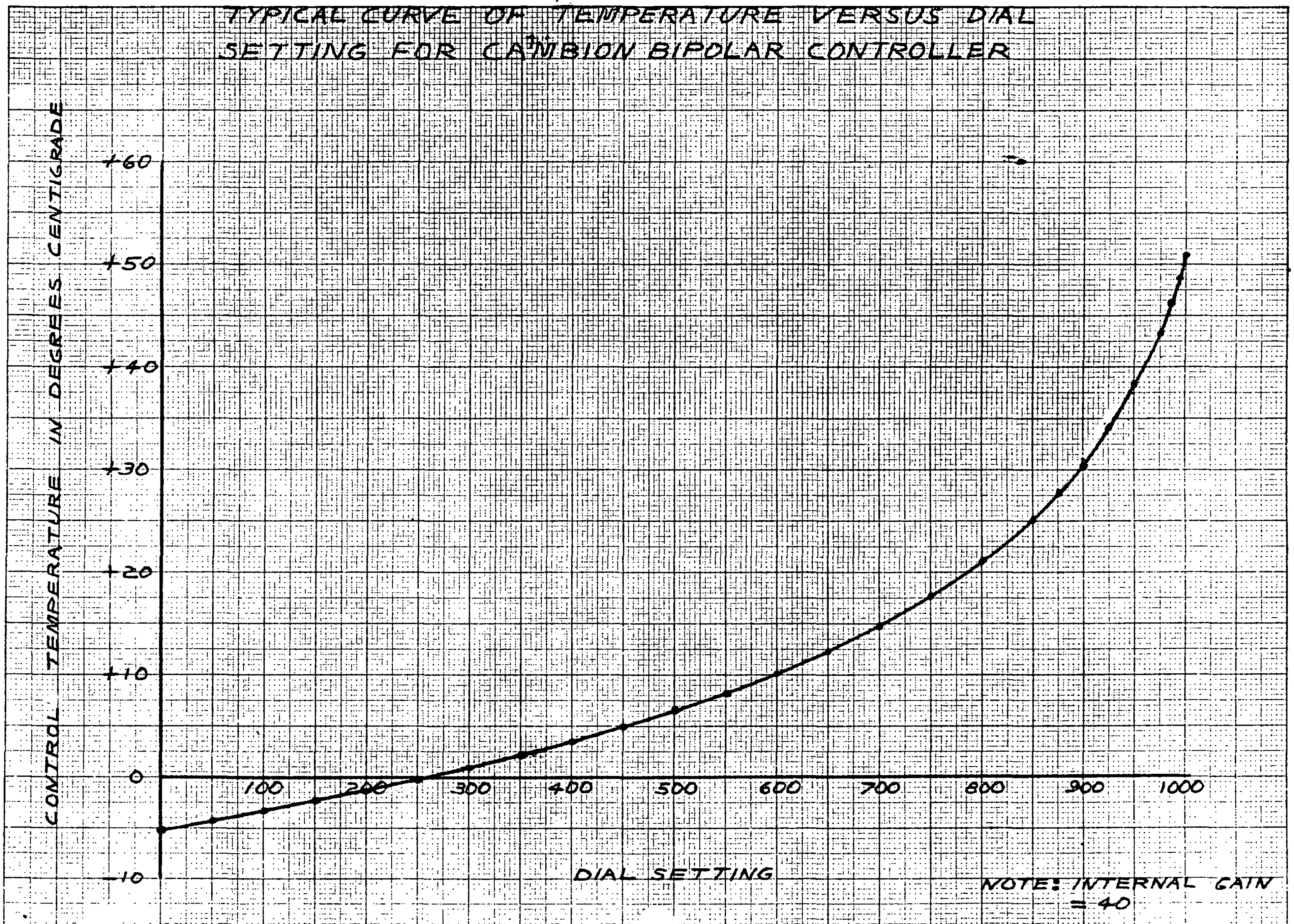
4. Fill the container with packing material and seal with proper fastening material.

5. Mark the shipping container appropriately with such designations as "DELICATE INSTRUMENT", "FRAGILE", etc.

B. Any unit being shipped to CAMBION for service or repair should have a tag attached identifying the owner plus the nature of the work to be performed. In addition, any information regarding the symptons or specific nature of the problem experienced should be included to aid service personnel. All correspondence about the instrument should include the model and serial numbers.

FOR ADDITIONAL INFORMATION

Please contact MIDLAND-ROSS / CAMBION Division, 445 Concord Avenue, Cambridge, Massachusetts 02238; Telephone (617) 491-5400


TYPICAL CURVE OF TEMPERATURE VERSUS DIAL
SETTING FOR CAMBION BIPOLAR CONTROLLER
CONTROL TEMPERATURE IN DEGREES CENTIGRADE
+60
+50
+40
+30
+20
+10
0
-10
100
200
300
400
500
600
700
800
900
1000
DIAL SETTING
NOTE: INTERNAL GAIN
= 40

-04 QTY	-03 QTY	-02 QTY	-01 QTY	ITEM NO.	LIST OF MATERIALS	PART NO.	DESCRIPTION
			1	A1	809	0073-01	Printed wiring assembly
			1	A2	740	0126-01	Bridge rectifier, VT-200T
			2	A3	740	0337-01	Heatsink
			2	C1/C2	560	0006-13-01	Capacitor, 9200 MFD, 15V
			1	DS1	740	0232-01	Lamp, MSC-J4
			1	J1	740	0238-02	Connector, 5-pin female
			2	J2	740	0338-03	Transistor socket
			1	Q1	740	0339-01	Transistor, MJ4030
			1	Q2	740	0340-01	Transistor, MJ4033
			1	R11	740	0141-16	Pot, 400K
			1	S1	740	0110-01	Power switch
			1	T1	528	0024-01	Transformer, CTC 5-2
			1	W1	390	0083-01	AC line cord
			1	1	809	0068-01	Chassis
			1	2	809	0070-01	Front panel
			1	3	740	0121-01	Multidial
			1	4	305	0015-01	Strain relief bushing
			2	5	305	0018-07	Snap bushing, 3/4" OD
			2	6	300	0219-01	Capacitor clamp
			6	7	150	0027-08	Crimp terminal
			4	8	350	1299-01-07	Standoff
			4	9	330	1146-05-02	Screw, 4-40 x 3/8" BH
			4	10	330	1147-05-02	Screw, 6-32 x 3/8" BH
			2	11	330	1147-06-02	Screw, 6-32 x 7/16" BH
			4	12	330	1148-05-02	Screw, 8-32 x 3/8" BH
			4	13	330	1149-05-02	Screw, 10-32 x 3/8" BH
			2	14	330	1147-08-02	Screw,6-32 x 5/8" BH
			2	15	330	0065-07-02	Screw, 6-32 x 1/2" Oval
			4	16	310	0013-04-02	Hex nut, #4-40
			12	17	310	0013-06-02	Hex nut, #6-32
			4	18	310	0013-07-02	Hex nut, #8-32
			4	19	365	0030-02-02	Lockwasher, int. tooth #4
			16	20	365	0030-03-02	Lockwasher, int. tooth #6
			4	21	365	0030-04-02	Lockwasher, int. tooth #8
			4	22	365	0030-05-02	Lockwasher, int. tooth #10
			AR	24	630	7208-01	Thermal cream
			1	25	740	0059-01	Fuseholder
			1	26	740	0063-22	Fuse, 1.5A Slo-Blo
			2	27	370	0030-02	Mica Insulator
			4	28	330	0038-08-02	Tapping screw, #6 x 5/8"
			1	29	394	0052-01	Harness assembly
			1	-	600	0054-01	Cabinet

Bipolar Controller 809-3010-01 Chassis Assembly	71279 SCALE:	LM 809-0074 SHEET OF	B REV

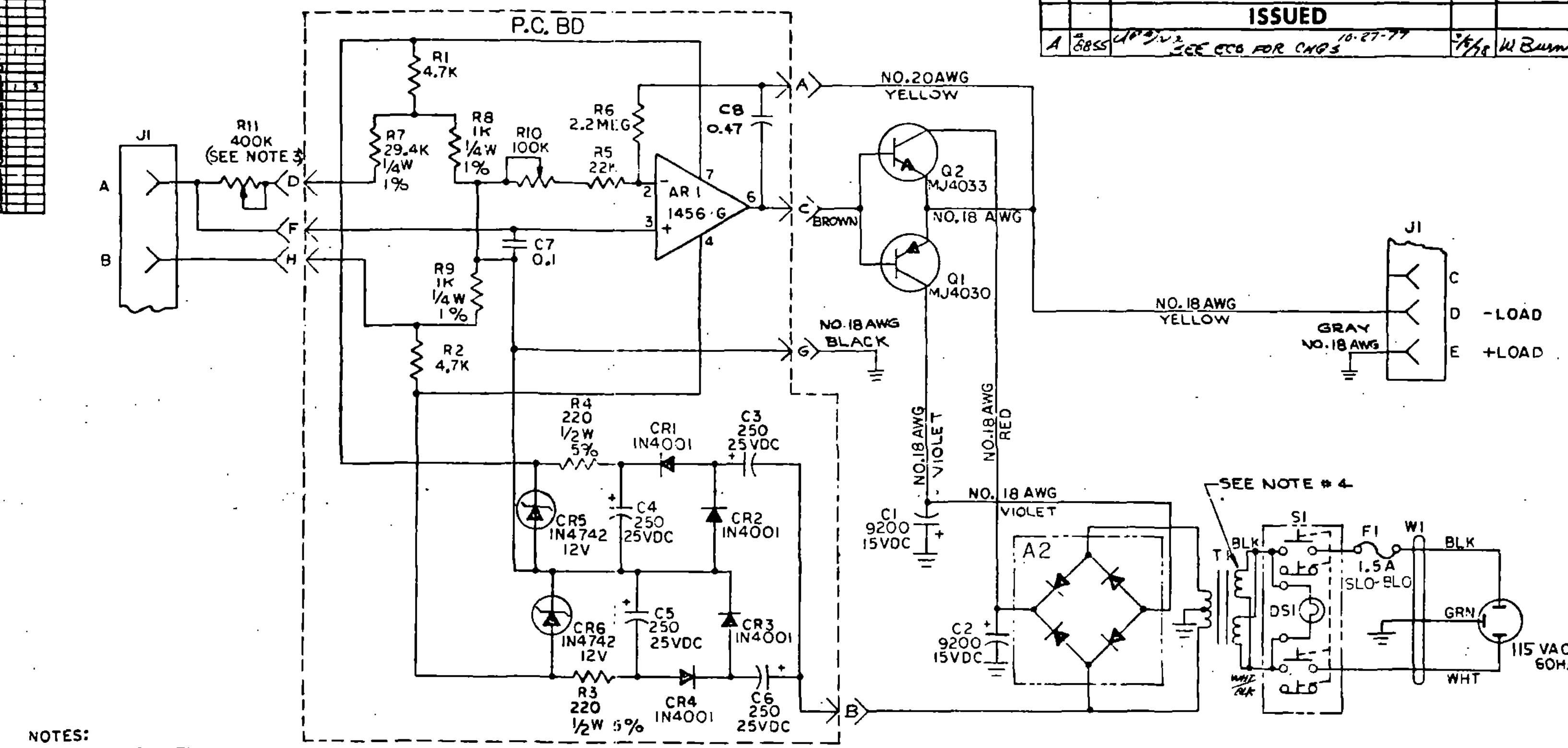
-04 QTY	-03 QTY	-02 QTY	-01 QTY	ITEM NO.	LIST OF MATERIALS	PART NO.	DESCRIPTION
			1	AR1	760	7020-01	Op-Amp, MC 1456G
			4	C3-6	560	0039-01	Capacitor, TVA-1208
			1	C7	560	0005-21-03	Capacitor, 0.1 MFD, 80V
			1	C8	560	0058-01	Capacitor, .47 MFD, 200V
			4	CR1-4	740	0359-01	Diode, IN4001
			2	CR5-6	740	0342-01	Zener Diode, IN4742
			2	R1-2	740	0012-35-01	Resistor, 4.7K, 1/4w, 5%
			2	R3-4	740	0036-11-01	Resistor, 220Ω, 1/4w, 5%
			1	R5	740	0012-51-01	Resistor, 22K, 1/4w, 5%
			1	R6	740	0012-81-01	Resistor, 2.2 meg, 1/4w, 5%
			1	R7	740	0070-13-02	Resistor, 29.4K, 1/4w, 1%
			2	R8-9	740	0070-03-02	Resistor, 1K, 1/4w, 1%
			1	R10	740	0360-01	Pot, 100K
			1	1	809	0087-01	Printed wiring board
			1	2	740	0519-01	IC Socket

Printed Wiring Assembly
809-3010-01
Bipolar Controller

71279 | LM 809-0073

SCALE: | SHEET OF | REV

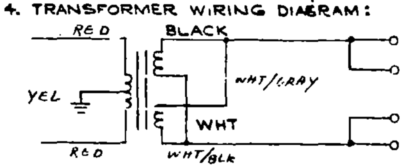
SYM	ECO	DESCRIPTION	DATE	APPROVED
		ISSUED		
A	8855	SEE ECO FOR CHGS 10-27-77		W Burns



NOTES:

UNLESS OTHERWISE INDICATED:

1. CONNECTING WIRE TO P.C. BD IS AWG NO.20
   ALL RESISTANCE VALUES ARE IN OHMS 1/4W ±5%
   CAPACITORS EXPRESSED IN MICROFARADS
2. SCHEMATIC PORTION WITHIN DOTTED LINE IS PRINTED CIRCUIT BOARD, OTHER PORTIONS CONNECTED TO P.C.BD FROM CHASSIS BY HARD WIRE CONNECTING POINT TO POINT AS REFERENCED BY CORRESPONDING LETTERS A-A, B-B ETC
3. R11 MOUNTED ON FRONT PANEL
4. TRANSFORMER WIRING DIAGRAM:



MAY 1978
APPROVED FOR MANUFACTURE
Q.T.B.

QTY	PART NO.	DESCRIPTION	ITEM
		LIST OF MATERIALS	

UNLESS OTHERWISE NOTED DIMENSIONS ARE IN INCHES TOLERANCE ON DECIMALS 2 PLACE 3 PLACE ANGLE

DO NOT SCALE DRAWING

DR 20FEB73
CHK
ENG
ENG
PROD
WS
EDP
APPROVED
BY DIRECTION OF

809C0073
NEXT ASSEMBLY

CAMBION® CAMBRIDGE THERMIONIC CORP. CAMBRIDGE, MASS. 02138

SCHEMATIC DIAGRAM
BIPOLAR CONTROLLER

809-3010-01

CODE IDENT NO.	SIZE	CLASS NO.	DRAWING NO.	REV
71279	C	809	0071	C

SCALE: —

809C0071