MODEL 128 D ACCUTROL

Temperature Controller

The Accutrol (Model 128D) Temperature Controller incorporates advanced integrated circuit design to provide dependability and long term controlled temperature stability. Performing the function (quality temperature control) while minimizing circuit complexity was the primary design criteria.

The instrument's controlled output is directly proportional to deviation from set point of the process temperature. Due to the split-second response of the instrument, the effect of process loading on oven temperature will, in many instances, be unnoticed, except by an increase in power being used.

The Accutrol features two control actions: proportional band and automatic reset. The integrated response of proportional band and automatic reset results in a floating instrument output. This floating proportional output affixes itself to a level determined by system requirements and process variables.

° ° ° FEATURES ° ° °

° Proportional Band ° Front panel adjustment, variable from 4°-40°C; field changeable to increase the band to 4°-80°C.

° Automatic Reset ° Nominal time is 2-1/2 minutes, expressed as minutes/reset; field changeable from one to six minutes.

° Automatic Reset Lockout ° Automatic elimination of reset action below the proportional band to prevent overshooting when inside the band.

° Digital Set Point ° Resolution to 1°C, settable to 1/4°C. The dial readout is electrically approximated to the non-linearity of the thermocouple, allowing closer dial-temperature correlation. A set point locking control minimizes accidental set point variation, and a knurled dial facilitates adjusting to the desired set point.

° Instrument Output ° A proportional dc output voltage from the controller is used to initiate turn-on of the power module. BTU systems use a Power Prop* module which develops a trigger from the controller dc output. This trigger fires the power thyristors in the Power Prop.

* Stepless Controls, trade name

° Deviation Meter ° Zero center meter calibrated at two degrees per division. Deviation is the difference between process temperature and set point.

° % Power Meter ° Displays the percentage of available power being used by the individual zone to maintain set point temperature.

° Power Lamp ° Indicates that ac input voltage is applied to the instrument.

° Oven ° Thermocouple reference junction and preamplifier are stabilized by a constant temperature oven maintaining temperature at 70°C.

° Range Selection ° The span of control is 1000°C. Span refers to the difference between the minimum temperature and maximum temperature of the normal range of control. Typical normal ranges include 200°-1200°C, 0°-1000°C, 250°-1250°C.

If instruments are required to control temperature below the minimum of the normal range, the span of control may be shifted downward to allow constant control from 0°C or from whatever value is desired. A front panel dual range switch is provided when this dual range function is utilized. Thus, constant temperature control is achieved throughout a range exceeding the basic 1000°C span of the instrument.

° Power Input ° Choice of 120, 208, or 240 volts ac, 50-60 Hz. Total power dissipation is approximately three watts.

° Dimensions ° Front panel, 4" W by 5-1/2"H; chassis, 3-1/2" W by 4-1/2"H by 8" D; cutout, 3-3/4" W by 4-3/4" H.

° ° ° SERVICEABILITY ° ° °

Major consideration has gone into making the Accutrol 128 D totally field serviceable with standard electronic test equipment and procedures. Single station modules allow minimum service down time and less interruption to the overall system during scheduled calibration maintenance required by government military specifications and critical commercial applications.

ACCUTROL 128 D

TEMPERATURE CONTROLLER

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1.0 INTRODUCTION

The Accutrol 128 D is a temperature controller designed to operate with thermocouple inputs. The instrument contains: thermocouple break protection (Fail-safe), cold junction compensation, proportioning band, automatic reset, automatic reset lockout, digital set point, deviation meter, load power indicator, and plug-in range card. All critical components are located in an electrical constant temperature oven to maintain high accuracy and long term stability.

2.0 CIRCUIT DESCRIPTION (Refer to figure 1)

AC line voltage is applied across the primary winding of power transformer T1. Connector pins 6 and 8 are used for 120 volts input; pins 8 and 9 for 208 volts, and pins 8 and 10 for 240 volt operation.

Voltage is induced into two 28 volt secondary windings of the transformer. One secondary feeds a bridge rectifier consisting of diodes D1, D2. D3, D4. The full wave rectified output passes through isolation diode D5 and is filtered by capacitor C1. This filtered dc (approximately 30 volts) is applied to a voltage dropping resistor R1. In series with R1 is Zener diode, Z1, which maintains the output at a constant twelve volts. This 12 volts is fed to proportional amplifier IC-2, pre-amplifier IC-1 and the various control circuitry.

The voltage induced in the other 28 volt secondary is half-wave rectified by diode D11 and filtered by capacitor C2. This voltage feeds voltage dropping resistor R2 and Zener diode Z2. The -12 volts developed by Z2 is fed to the amplifiers and control circuitry.

For any temperature range, the EMF input to the controller is a function of the temperature difference between the measuring and reference junctions of the thermocouple. The measuring junction is at the source where the temperature is being monitored and the reference junction is at the controller terminals to which the thermocouple extension wires are connected. The stability of the reference junction is maintained by a controlled oven, which is kept at a constant 70°C.

The oven temperature is monitored by a thermistor sensor (TH-1) near the heat dissipating resistors R11 and R12. The bias on transistor Q3 will be dependent on the voltage drop across the thermistor (proportional to temperature). Q3 will control conduction of Q4. As Q4 conducts, resistors R11 and R12 will dissipate power (joule heating) and oven temperature will rise. Inversely, when Q4 decreases conduction, power dissipation by R11 and R12 will decrease, thus oven temperature will be steadily maintained.

2.0 CIRCUIT DESCRIPTION (continued)

The thermocouple and thermocouple extension wires are used as an integral part of the thermocouple break (Fail-safe) circuit. Resistor R9 is selected to allow approximately 2 micro-amps to flow through the thermocouple. If the thermocouple opens, or if the thermocouple is not connected, this current path through R9 will be diverted from the thermocouple to the pre-amplifier IC-1 input. This increase in current will drive the pre-amplifier output to maximum and, in approximately 20 seconds, the controller output will be zero.

During normal operation, the EMF developed by the thermocouple as a function of temperature is applied to the positive input of pre-amplifier IC-1. The pre-amplifier input resistance is high (400k ohms typical) and loading effects on the thermocouple EMF are negligible.

There are two types of plug-in range cards. One type is for single range operation. The second type is for dual range, and provides for manual switching between two ranges, low and normal. When the dual range switch (if provided) on the front panel is in the up position, the normal range is selected. When the dual range switch is in the down position, the low range is selected. For the normal range, a "minimum temperature calibrate" potentiometer (P5) provides a variable voltage to the negative input of the pre-amplifier. It is adjusted so that when the thermocouple millivolt input corresponds to the lowest reading in the range of the instrument, the output of IC-1 is zero.

The pre-amplifier output (0-4 VDC) is fed to one side of the deviation meter, M1. The other side of the deviation meter connects directly to the set point potentiometer. The direction and amplitude of the current flow through the meter is dependent on the difference between the set point and pre-amplifier output.

The "maximum temperature calibrate" potentiometer (P2) provides a regulated voltage to the set point potentiometer (P1). The "maximum temperature calibrate" potentiometer is adjusted so that the deviation meter will read zero when the set point potentiometer is at its maximum setting, and a corresponding millivolt input is supplied to the pre-amplifier IC-1 (refer to temperature millivolt table). If the instrument is the dual range type, this pot is calibrated when in the normal range position.

For greater accuracy when operating in the low range, two calibrate potentiometers are provided:

a. Low range minimum temperature calibrate - adjusted for zero output from IC-1 when input temperature is at the minimum of the low range.

b. Low range maximum temperature calibrate - adjusted for maximum output of IC-1 when temperature input is at the maximum of the low range.

Resistor R4 is connected to the wiper arm of the set point potentiometer to compensate for thermocouple non-linearity. The specific thermocouple will determine the value of R4, as well as the polarity of the voltage connection to the other side of R4. Refer to chart for jumper connections and R4 values (section 4.5).

The difference between set point and thermocouple output is fed to the proportional amplifier IC-2. The offset trim potentiometer (P3) is adjusted so that the amplifier output is zero when the amplifier inputs at pins 3 and 2 are in a null condition. The trim is correctly adjusted if the deviation meter is zero when temperature control is established and maintained.

The output of proportional amplifier IC-2 is connected to the emitter of the reset lockout transistor (Q5). During initial startup, or whenever the temperature difference between the set point and thermocouple is greater than the proportional band (point where the amplifier saturates) of the amplifier, the output will be +12 volts. This voltage will forward bias the emitter-base junction of the reset lockout transistor and allow it to turn on. Automatic reset capacitor C5, connected to the collector of the reset lockout transistor, will be effectively short circuited during this period. Zener diode Z4 will limit the output to 6.2 volts.

Proportional band refers to the instrument output which varies from zero to five volts within the temperature span (adjustable) over which control action occurs.

Automatic reset provides the floating amplifier (IC-2) dc output with a correcting voltage for the difference between theoretical output (center of proportional band) and the actual control output required. Automatic reset also speeds recovery during process load variations on a time base selected to respond to these variations.

As the temperature difference decreases to within the proportional band (IC-2 just below saturation), the amplifier output will begin to decrease from the +12 volt level. When the output level decreases to less than 6.2 volts, the automatic reset lockout transistor will be reverse biased at the base-emitter (turned off), and capacitor C5 will tend to charge to the value of the amplifier output. Thus, as the temperature difference is decreasing within the proportional band, the voltage developed by the capacitor will be added to the output of the proportional amplifier.

When set point is reached, the deviation meter will be at zero and the remaining charge on the capacitor will be the voltage required to maintain the set point level.

The output of the pre-amplifier will be proportional to any deviation from set point. However, once the required output voltage to maintain temperature has been established, it is kept constant and the error between set point and process temperature will be reduced to zero by the automatic reset capacitor.

3.0 OPERATION

3.1 Proportional Band (Refer to figure 4).

Allow a minimum 15 minute warmup time. Set the proportional band potentiometer (P4) to midpoint. Refer to the odometer correction chart (Table I) and set the odometer to the desired temperature. If the instrument is dual range, the dual range switch on the front panel must be in the correct position for the temperature that is being selected. After the process temperature has reached the set point and stabilized, reduce the proportional band (P4 CCW) setting until the deviation meter begins to oscillate. Increase the proportional band until the oscillations cease. This is the optimum proportional band setting for the system.

To increase the range of the proportional band, resistor R31 (10K), across the proportional band pot, is removed. Band width range is factory set at 4°-40°C and under normal operation conditions need not be changed. If R31 is removed, the range will increase to 4°-80°C.

3.2 Automatic Reset

If the system oscillates when proportional band is maximum, the automatic reset resistor (R22) must be changed. Generally, oscillation will occur if automatic reset is too fast for the system. Consequently, automatic reset must be made slower to properly interface with the system.

Automatic Reset Values

R22 Value	Minutes per reset
50K	1
100K	2.5
150K	4
200K	5
240K	6

4.0 CALIBRATION and TESTING

Refer to figure 2 for locations of controls and components.

Bench Set-up (refer to figure 3.)

(1) D.C. millivolt source - simulates thermocouple millivolt output corresponding to a desired temperature.

(2) Ice Bath - used to immerse thermocouple to provide a cold reference junction.

(3) D.C. high impedance voltmeter - used to monitor the input millivolts without affecting the circuit.

(4) 1500 ohm load resistance simulates the impedance of the firing circuit.

(5) 0 - 10 VDC high impedance output voltmeter - monitors the instrument output voltage.

4.1 Temperature Calibration

The overall response of the controller is linear between zero and five volts output. To maintain repeatability and accuracy, the output test meter (5) must indicate between these values whenever an adjustment is made.

If the output test meter (5) is negative when a null condition exists, adjust the set point for negative deviation until a positive one or two volts is observed on the output test meter (5). Wait one minute until automatic reset increases the meter reading another volt. Readjust the set point for null on the deviation meter. Repeat as required, until the output is above zero when the deviation meter is at null.

NOTE: For accurate calibration it is essential that thermocouple connections be clean and tight. A connection which has an intolerable resistance will result in a millivolt drop across that connection and, effectively, the millivolt input to the controller will not correlate to the desired temperature.

The temperature span of the controller is 1000°C. Span refers to the difference between minimum and maximum temperature. Maximum and minimum will depend on the type thermocouple used. The controller may be the single range type or the dual range type. The dual range type is provided with a two position range select switch on the front panel (top right side).

Since it is necessary to calibrate the normal range first, the range switch should be set to the up position if a dual range type is being calibrated. Adjust the set point to the normal range minimum temperature calibrate point (refer to table I). Set the millivolt source to the equivalent temperature (refer to table II). Adjust the "minimum temperature calibrate" potentiometer (P5) to balance the deviation meter (refer to figure 2 for potentiometer location).

Adjust the set point to the normal range maximum temperature calibrate point (refer to table I). Set the millivolt source to the equivalent temperature (refer to table II). Adjust the "maximum temperature calibrate" potentiometer (P2) to balance the deviation meter (refer to figure 2 for potentiometer location). Recheck minimum and maximum adjustments and readjust as required until the deviation meter is zero at each calibrate temperature.

If the instrument is single range, the calibration is complete. If the instrument is dual range, the low range must also be calibrated. First, set the dual range switch to the down position. Adjust the set point to correspond to the minimum value indicated on the thermocouple chart. Set the millivolt source to the equivalent temperature. Adjust the "low range minimum temperature calibrate" potentiometer until deviation meter is zero.

Adjust the set point to correspond to the maximum low range temperature. Set the millivolt source to the equivalent temperature (refer to tables I and II). Adjust the "low range maximum temperature calibrate" potentiometer until deviation meter is zero.

Recheck maximum and minimum temperature and repeat the procedure as required, until the deviation meter is zero at each calibrate temperature.

4.2 Proportional Band Width Test

After the instrument has been calibrated, set the proportional band to minimum (CCW)and the set point to mid-range. Adjust the millivolt source until the dc output test meter reads zero. Readjust the set point until the output meter reads five volts. The set point difference should be 3 to 8 degrees from its original setting.

Adjust proportional band to maximum (CW). Readjust the millivolt source for zero output on the dc output test meter. Readjust set point until the meter reads 5 volts. The set point difference should be 35 to 60 degrees from its original setting. Since the automatic reset will affect the output meter, this check should be accomplished within one minute.

4.3 Automatic Reset Test

Set the proportional band to mid-scale. Adjust the millivolt supply so that the output meter is approximately 2 volts and does not change. Now change the millivolt input so that the output voltage increases one volt. Measure the time it takes for the automatic reset to increase the output another volt. The reset time should be approximately 2-1/2 minutes, depending on the fixed rate of the particular instrument (refer to section 3.2).

4.4 Constant Temperature Oven Test

Use bench setup described in figure 3. Allow 15 minute warm-up time. Adjust millivolt source and set point for null at any arbitrary temperature. Note that deviation meter is zero. Remove instrument power for approximately two minutes. Re-apply power and observe deviation meter to be positive, slowly decreasing to zero as the oven temperature stabilizes. If this does not occur, the oven is malfunctioning and should be repaired or replaced, as the situation requires.

4.5 % Power Meter Adjustment

The value of resistor R26 will depend on the input voltage being applied to the meter at pins 7 and 12 of the connector. If a unit is replaced in the field, R26 may be selected according to the following table:

Voltage Input: Half-wave RMS*	R26	Voltage Input: Full-wave RMS
12 - 110	10K	12 - 110
60 - 150	47K	60 - 150
110 - 190	100K	110 - 190
------	150K	175 - 250
-------	180K	200 - 300

* The RMS values of the full wave signal from which these half wave signals are derived are: 24-220, 120-300 and 220-380 volts respectively.

In some cases the maximum power capability of the heating system may be greater than the maximum power available at lower operating temperatures. This is in part due to the resistivity characteristics of the heating elements at different temperatures. The power meter is factory adjusted for full scale deflection which corresponds to total available power at the maximum specification temperature. If the instrument is used at an operating temperature lower than the specification temperature, a resultant error may develop in the power meter calibration. If this is the case, full scale re-calibration of the power meter may be desired. The following procedure will also apply to field replacements:

(1) Observe the deviation meter to be zero, indicating furnace is at set temperature.

(2) Adjust set point so that deviation meter reads full negative. At this point the available power is maximum.

(3) Adjust the "power meter" potentiometer for full scale deflection on power meter.

(4) Readjust the set point for the operating temperature.

4.6 Deviation Meter Zero Adjustment

When temperature control is being maintained, the deviation meter will indicate zero (null condition). If readjustment is required, the following bench procedure may be performed.

(1) The cover plate must be removed to gain access to the necessary points. Refer to figure 2 and figure 7. Locate points H and J. These correspond to input pins 2 and 3 of IC-2. With power off, install a temporary jumper wire between these two points. Locate points K and A. Connect the positive lead of a high impedance voltmeter to point K and the negative lead to point A. Set the voltmeter to 10 v., positive dc range. Apply power to instrument. Warmup time is not required. Observe that output voltmeter indicates a value within a range of +5 volts. Adjust P3 if necessary, to obtain this reading.

(2) Disconnect jumper wires and voltmeter. Reassemble the instrument and use as required.

The deviation meter may be balanced dynamically while the controller is operating and maintaining temperature:

(1) Raise the instrument out of the mounting panel. Lift off the side panel after removing the four metal retaining screws.

(2) Adjust the "deviation meter zero" potentiometer (P3) as required for zero null during control, i.e., if the deviation meter is balanced below zero null, the controller output must be increased, as observed by an increase in the power meter reading; if the deviation meter is balanced above the zero null point, the controller output must be decreased, as observed by a decrease in the power meter reading. Since the operating environment of the controller is a closed loop system, the effect of the adjustment will not be immediately apparent on the deviation meter. However, after the closed loop system re-stabilizes, the effect of the adjustment can be observed.

(3) Replace side panel and set the instrument back into its mounted position.

4.7 Plug-in Range Cards

Various types of range cards are supplied to accomodate specific ranges and to approximate the non-linearity of a specific thermocouple. The range card configuration chart on the next page indicates the components required for each individual range card type.

PLUG-IN RANGE CARD	R4	LOCATION ON CARD*	RW	R-10	R-32	R-34	R-35	P-8	P-9
TYPE W, DUAL RANGE 0-1000/800-1800°	2.4K	1	100 K	48 K	150 K	470	NOT USED	10 K	500
TYPE K, SINGLE RANGE 0-1000°	4.7K	1	NOT USED	20 K	NOT USED	NOT USED	300 K	NOT USED	NOT USED
TYPE K, SINGLE RANGE 200-1200°	4.7K	1	NOT USED	20 K	NOT USED	NOT USED	NOT USED	NOT USED	NOT USED
TYPE KPB, SINGLE RANGE 250-1250°	4.7K	1	NOT USED	20 K	NOT USED	NOT USED	NOT USED	NOT USED	NOT USED
TYPE S, SINGLE RANGE 325-1325°	10K	2	NOT USED	70 K	NOT USED	NOT USED	NOT USED	NOT USED	NOT USED
TYPE S, DUAL RANGE 0-600/600-1600°	10K	2	NOT USED	70 K	150 K	200	NOT USED	10 K	100
TYPE R, DUAL RANGE 0-600/600-1600°	10K	2	NOT USED	62 K	150 K	200	NOT USED	10 K	100
TYPE B, DUAL RANGE 0-1000/800-1800°	16K	2	NOT USED	75 K	150 K	200	NOT USED	10 K	100
TYPE E, SINGLE RANGE 0-1000°	22K	2	NOT USED	11.5 K	NOT USED	NOT USED	300 K	NOT USED	NOT USED

* LOCATIONS ARE SHOWN IN FIGURE 6.

NOTE:

RESISTOR LOCATION FOR R-33 WILL USE A SHORTING BUSS ON ALL RANGE CARDS.
ALL RESISTORS ARE 1/8 WATT.

RANGE CARD CONFIGURATION CHART

5.0 INSTALLATION

5.1 Removal

To replace an existing instrument:

a. Remove the four front panel retaining screws.

b. Lift unit from the instrumentation panel.

c. Instrumentation power need not be turned off; however, exercise caution whenever handling energized equipment. Remove the multi-pin connector plug, grounding wire, and the two thermocouple connections at the rear of the instrument.

5.2 Replacement

To insure proper operation of a newly installed instrument, it is essential that the following items be checked prior to installation:

a. Visually observe that no obvious damage has occurred in shipment.

b. The new instrument must be the correct type, as indicated by the part number on the chassis.

c. The power meter resistor (R26) and the automatic reset resistor (R22) must be the required values.

To install the instrument, reverse steps outlined in 5.1, above.

5.3 Initial Turn-on

The following adjustments may be required after turn-on:

a. Power meter adjustment (refer to 4.5)

b. Deviation meter adjustment (refer to 46)

6.0 MAINTENANCE

Periodic maintenance is not required. If the instrument fails under warranty, it should be returned immediately to the factory.

For troubleshooting malfunctioning units in the field, the bench setup described in figure 3 can be used effectively

6.1 Meter Maintenance

Due to the construction of the meters, the plastic meter case may build up a static charge under certain conditions. This will cause the meter needle to stick or be other wise erratic. To eliminate this condition, an anti-static compound should be applied directly to the meter face. If the meter continues to be erratic, it should be replaced.

6.2 Replacement Parts

When ordering replacement parts, all pertinent information should be included. This includes the controller part number, main card part number, range card part number, serial numbers where applicable and component circuit designation.

<u>Assembly Part Number Designation</u>

a. Complete Controller Assembly:

CN/ K 200- 1200 S 8181301

- 8181301 — BTU 7 DIGIT STOCK NO.
- S — DUAL OR SINGLE RANGE
- 200- 1200 — MINIMUM AND MAXIMUM RANGE
- K — THERMOCOUPLE TYPE

b. Range Card

CN/ K 200- 1200

- 200- 1200 — RANGE
- K — THERMOCOUPLE TYPE

c. Main Card

CN/ 200 - 1

6.3 **Parts List**

Designation	Description	Function
C1, C2, C3, C4	Cap. elect. 100 uf. 50 v.	Filter
C5	Cap. elect. 1000 uf. 15 v.	Auto reset
C6, C7	Cap., .33 uf. 100v.	Amplifier filter
C8, C9	Cap., .05 uf. 100 v.	Transient protection
C-10	Cap., 4700 uf., 3 v.	(Optional) meter filter
D1-thru D11	Diode, sil. 200 v. 750 ma.	Rectifier, IN2069
P1	Helipot, 10 turns, 500 ohms	Set point
P2	Trim, 500 ohms	Max. temp. cal.
P3	Trim pot, 10 k. ohms	Dev. meter zero
P4	Trim pot, 5 k. ohms	Proportional band
P5	Helitrim, 15 turns, 100 k.	Min. temp. cal.
P6	Helipot, 15 turns, 100 k.	% power meter adj.
P7		
P8	Trim 10 k. ohms	Low range max. temp.
P9	Trim 100 ohms	Low range min. temp.
IC-2, IC-1	Int. circuit, LM 709C	Operational amp.
Q3	PNP transistor, 25 v.	Oven control, 2N5354
Q4	NPN transistor, 50 v.	Oven control 2N4424
Q5	PNP transistor	Auto reset lockout, 2N5354
R1, R2	Res. 390 ohms, 10%, 2w.	
R3	Res. 220 ohms, 10%, 1/2 w.	
R4	Res. value dependent on T/C	Non-linearity comp.
R18	Res. 100 ohms, 1%, 1/8 w.	
R5	Res. 100 ohms, 1%, 1/8 w.	
R6, R7	Res. 200 ohms, 1%, 1/8 w.	
R8, R14, R16, R17-	Res. 4.7 k. ohms, 1%, 1/8 w.	
R9	Res. 3.3 meg., 10%, 1/4 w.	Thermocouple break
R10	Res. value dependent on T/C	Nominal 20 k. ohms
R11, R12	Res. 180 ohms, 10%, 1/2 w.	Heaters
R13, R19	Res. 10 k., 10%, 1/4 w.	
R15, R27	Res. 2.2 k. ohms, 10%, 1/4 w.	
R20	Res. 100 ohms, 10%, 1/4 w.	
R21, R23	Res. 470 ohms, 10%, 1/4 w.	
R22	Res. 100 k. ohms, 10%, 1/4 w.	Auto reset
R24	Res. 100 k. ohms, 10%, 1/4 w.	Offset balance
R25	Res. 180 ohms, 1%, 1/4 w.	Power meter shunt
R26 *	Res. 47 k. ohms, 10%, 1/2 w.	Power meter range
R27		
R34	Res. 200 ohms, 1%, 1/4 w.	
R29	Res. 24 k. ohms, 10%, 1/4 w	Power On lamp voltage div.

* Refer to section 4.6

6.3 PARTS LIST (continued)

Designation	Description	Function
R30	Res. 2.2 k. ohms, 10%, 1/4 w.	
R31	Res. 10 k. ohms, 10%, 1/4 w.	Proportional band range
R32	Res. 300 k. ohms, 10%, 1/4 w.	Dual range only
R33	Res. 4.7 k. ohms, 10%, 1/4 w.	Dual range only
R34	Res. 200 ohms, 1%, 1/4 w.	Dual range only
R35	Res. 300 ohms, 1%, 1/4 w.	Zero degree instruments only
R36	Res. 1 k. ohms, 10%, 1/4 w.	
SW-1	Switch , SPST	Dual range only
T-1	Power transformer	
TH-1	Thermistor, 10 k., 10%	
Z1, Z2	Zener diode, 12 v., 10%, 1w.	
Z3, Z4	Zener diode, 6.2 v., 10%, 1w	
M	Part no. 8313131	% power meter
DM	Part no. 8314541	Deviation meter

TABLE I CORRECTION TABLES FOR DIGITAL SET POINT

DESIRED TEMP. IN DEGREES CENTIGRADE	TYPE K CHROMEL ALUMEL 0^0-1000^0	TYPE K 200^0-1200^0	TYPE KPB 250^0-1250	TYPE S 325^0-1325^0	TYPE B 0^0-600^0 LOW RANGE	600^0-1600^0 HIGH RANGE	TYPE R 0^0-600^0 LOW RANGE	600^0-1600^0 HIGH RANGE	W5%RE/W26%RE 0^0-1000^0 LOW RANGE	800^0-1800^0 HIGH RANGE	PT6%RH/PT30%RH 0^0-1000 LOW RANGE	800^0-1800^0 HIGH RANGE
0							1000		800		1000	
100	100				▷1070		1066					
200	214*	220*			1169		▷1160		▷938		▷1025	
250	259		260*									
300	305	308	303		1270		1266					
400	400	402	389	408	1387		1370		1132		1130	
500	498	498	497	504	1487		1483					
600	598	600	600	596	▷▷1600	600	▷▷1600	612	1337		1310	
650			652									
700	699	700	704	700*		701		703				
750			754									
800	800	802	806	794		798		800	1569	807	1542	845
850			857									
900	898	902	908	897		897		896		901		
950												
1000	994**	1000	1006	997		998*		997*	▷▷1800	997	▷▷1800	1009
1050			1054									
1100		1102	1100	1102		1101		1100		1096		
1150			1154									
1200		1199**	1190	1202**		1205		1202		1199*		1198*
1250			1235**									
1300				1305		1308		1303		1303		
1400						1405**		1406**		1404		1397
1500						1503		1506		1504		
1600						1595		1597		1606**		1601**
1700										1702		
1800										1795		1796

* NORMAL RANGE " MIN. TEMP. CAL. " ▷ LOW RANGE " MIN. TEMP. CAL. "

** NORMAL RANGE " MAX. TEMP. CAL. " ▷▷ LOW RANGE " MAX. TEMP. CAL. "

TABLE II

Temperature Versus Millivolts

Thermocouple	Temperature Degrees Centigrade	Millivolt Output
K Chromel Alumel	0 200 1000 1200	0 8.13 41.31 48.89
KP B Platinel II	250 650 1050 1250	9.17 26.91 43.44 50.65
B Pt + 6% Rh / Pt + 30% Rh	0 100 700 800 1300 1350 1400 1800	.0 .033 2.431 3.158 7.866 8.418 8.979 13.616
W + 5% Re / W + 26% Re	200 800 1000 1800	2.988 14.374 18.120 30.922
R Pt/Pt + 13% Rh	200 600 1200 1600	1.465 5.563 13.193 18.727
S Pt/Pt + 10% Rh	100 600 1000 1400	.643 5.224 9.570 14.337
E CHROMEL/ CONSTANTAN	400 600 800 1000	28.95 45.10 61.08 76.45

NOTE : H, J, K, A, REFER TO CALIBRATION POINTS

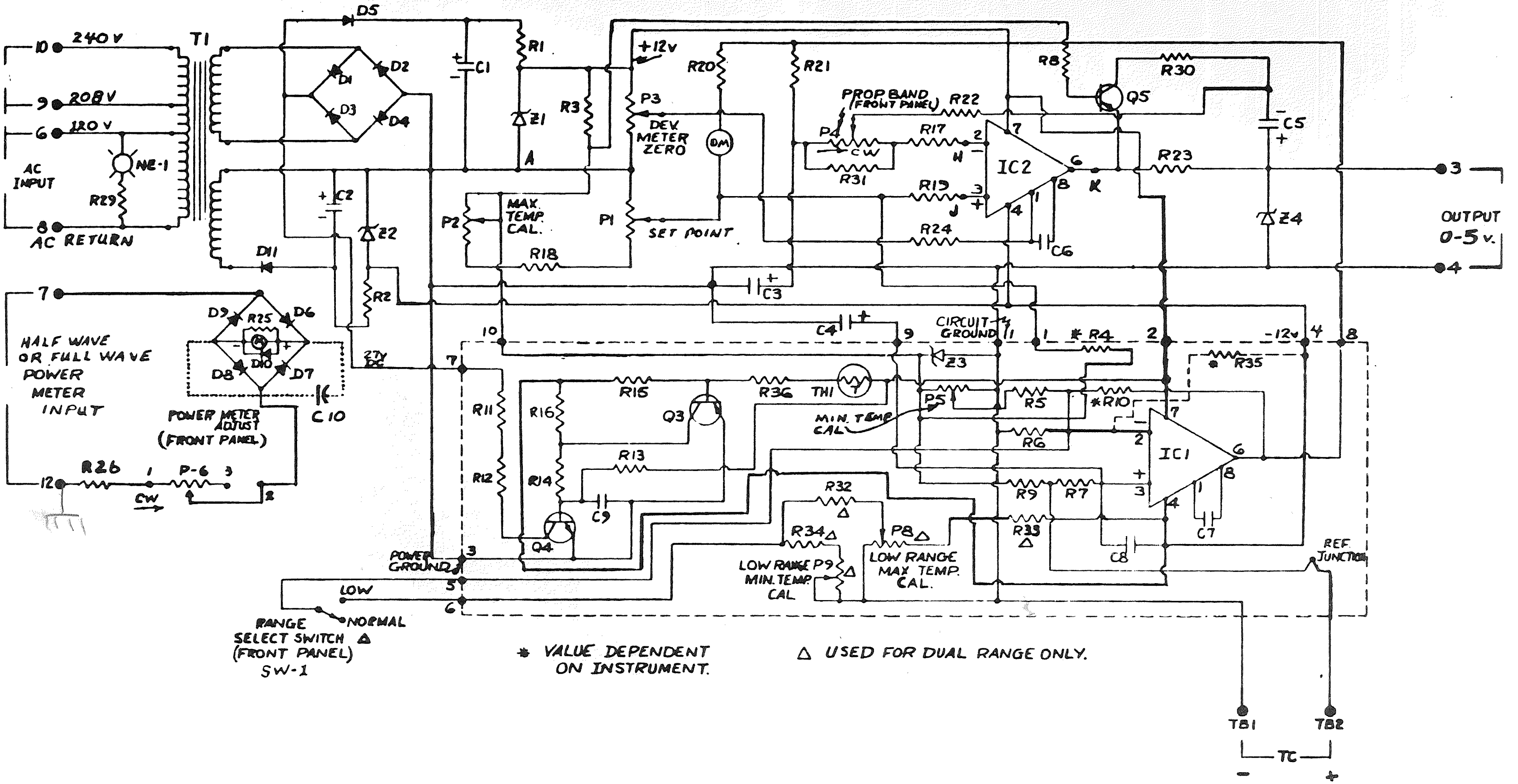
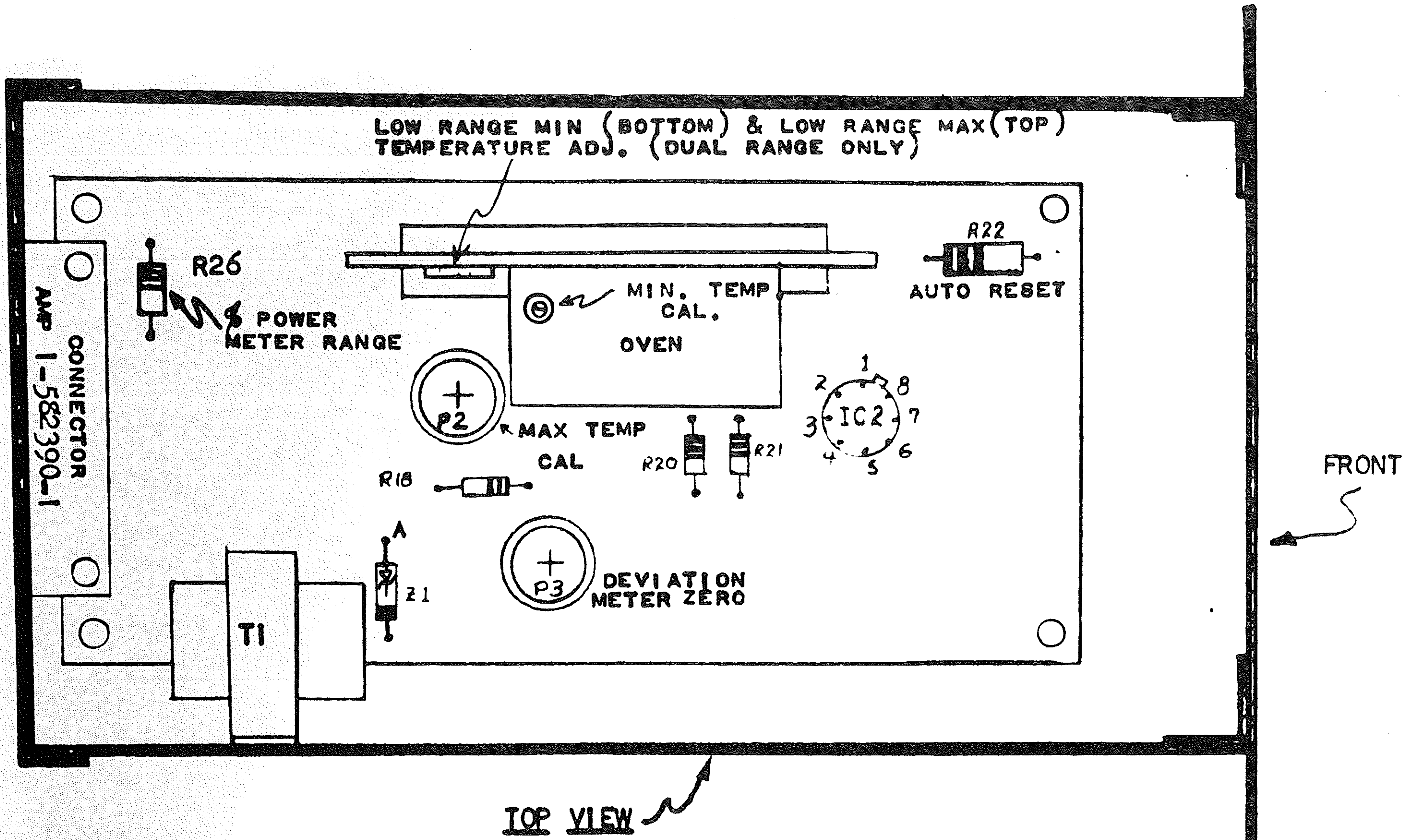
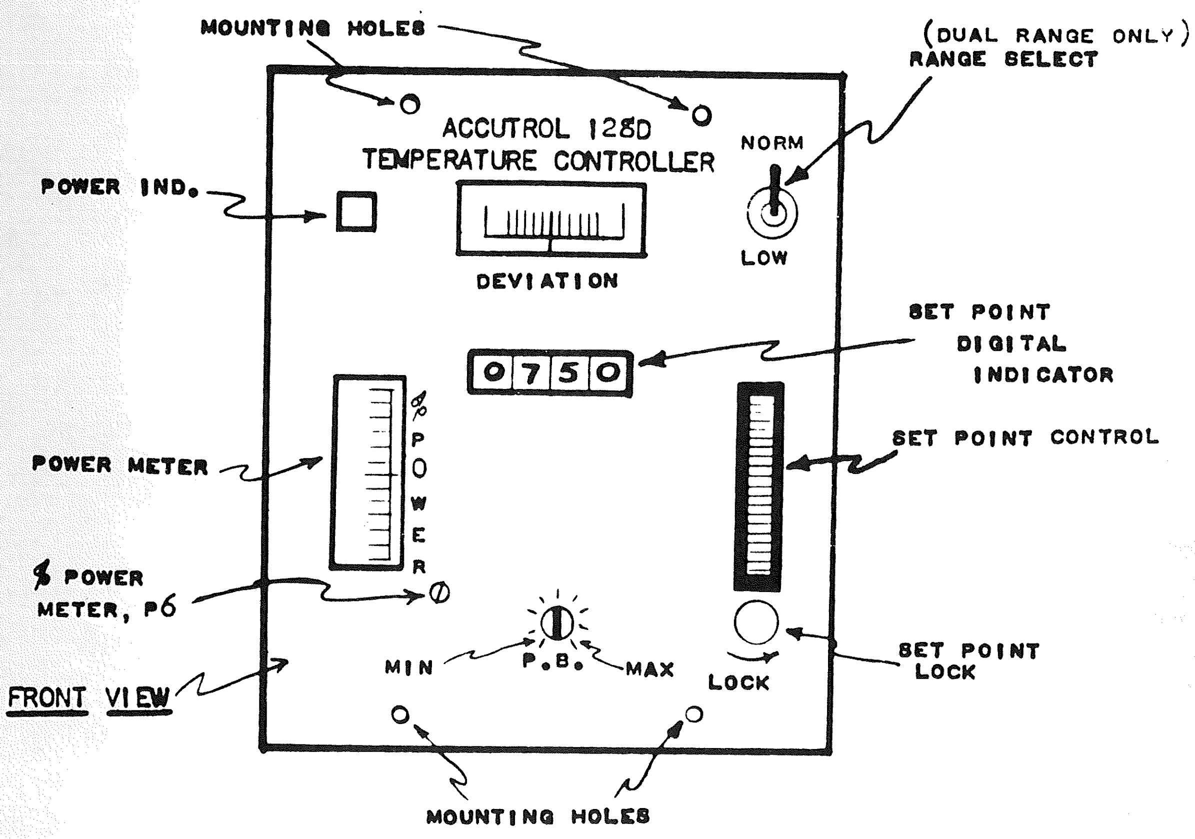


FIGURE 1.

ACCUTROL 128D TEMPERATURE CONTROLLER

REV. 2





REV 2

FIGURE 2

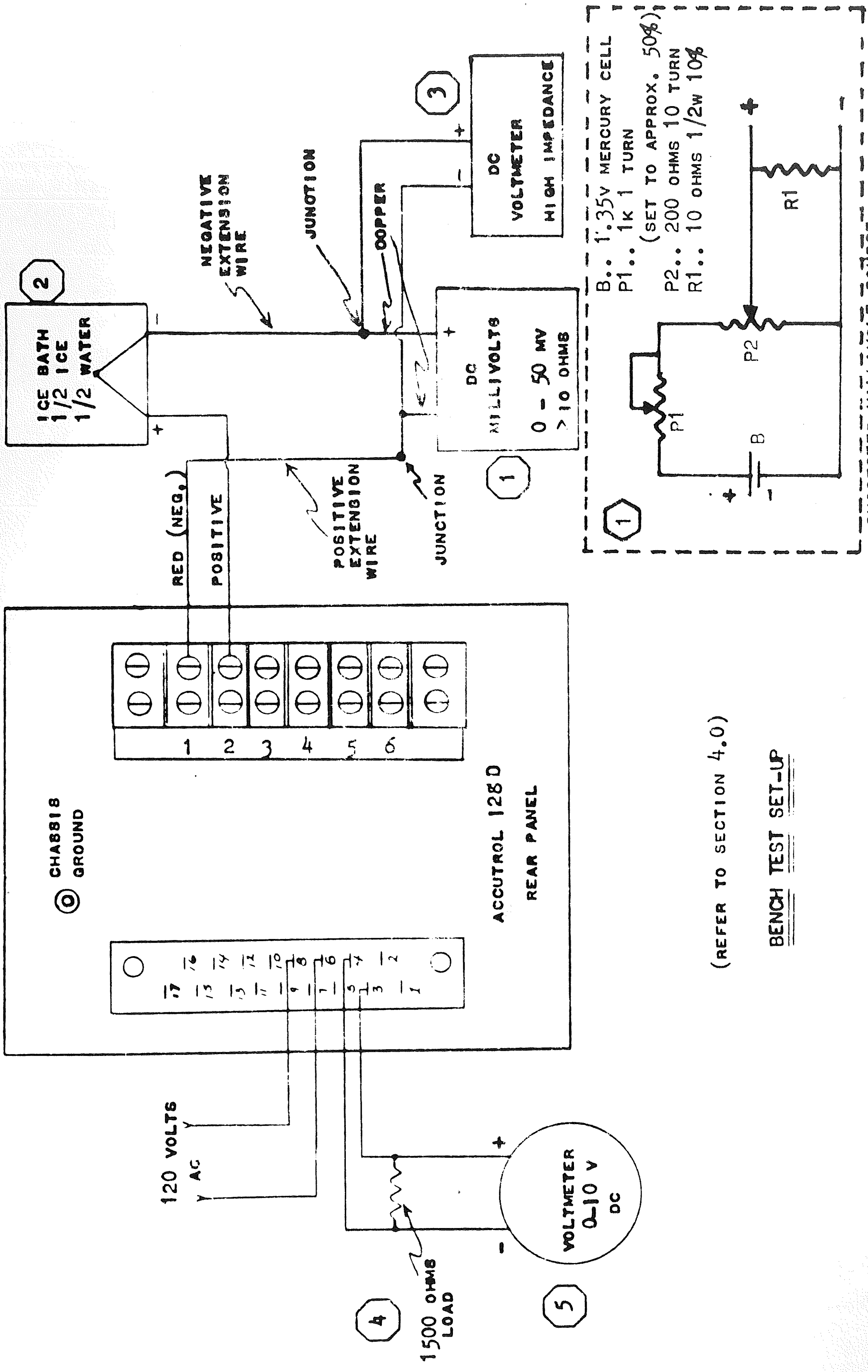
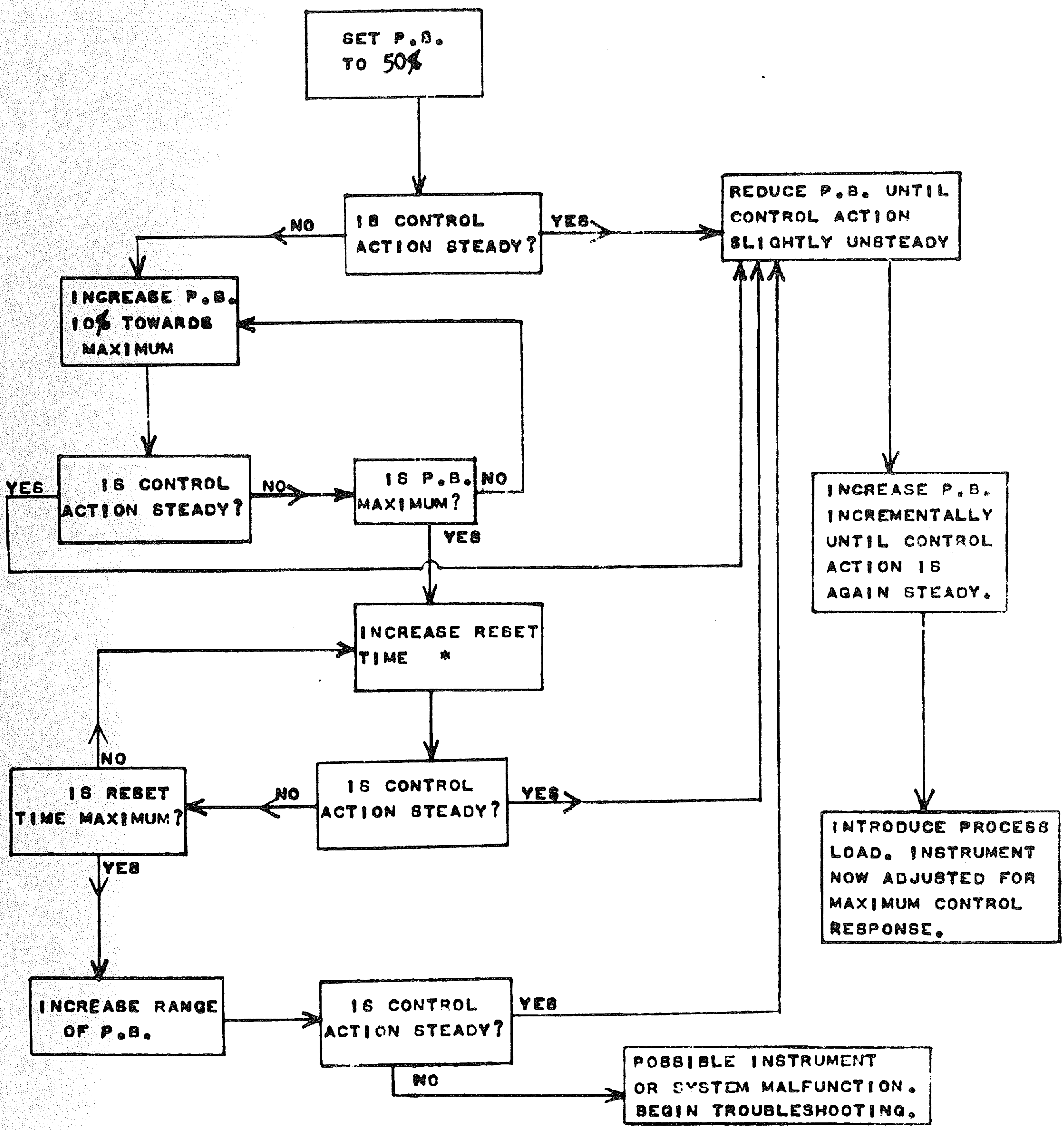

ICE BATH
1/2 ICE
1/2 WATER
NEGATIVE EXTENSION WIRE
JUNCTION
COPPER
DC VOLTMETER
HIGH IMPEDANCE
DC MILLIVOLTS
0 - 50 MV
> 10 OHMS
RED (NEG.)
POSITIVE
POSITIVE EXTENSION WIRE
JUNCTION
B.. 1.35V MERCURY CELL
P1.. 1K 1 TURN
(SET TO APPROX. 50%)
P2.. 200 OHMS 10 TURN
R1.. 10 OHMS 1/2W 10%
SUGGESTED MILLIVOLT SOURCE
CHASSIS GROUND
ACCUTROL 128 D
REAR PANEL
(REFER TO SECTION 4.0)
BENCH TEST SET-UP
120 VOLTS AC
1500 OHMS LOAD
VOLTMETER 0-10 V DC

FIGURE 3

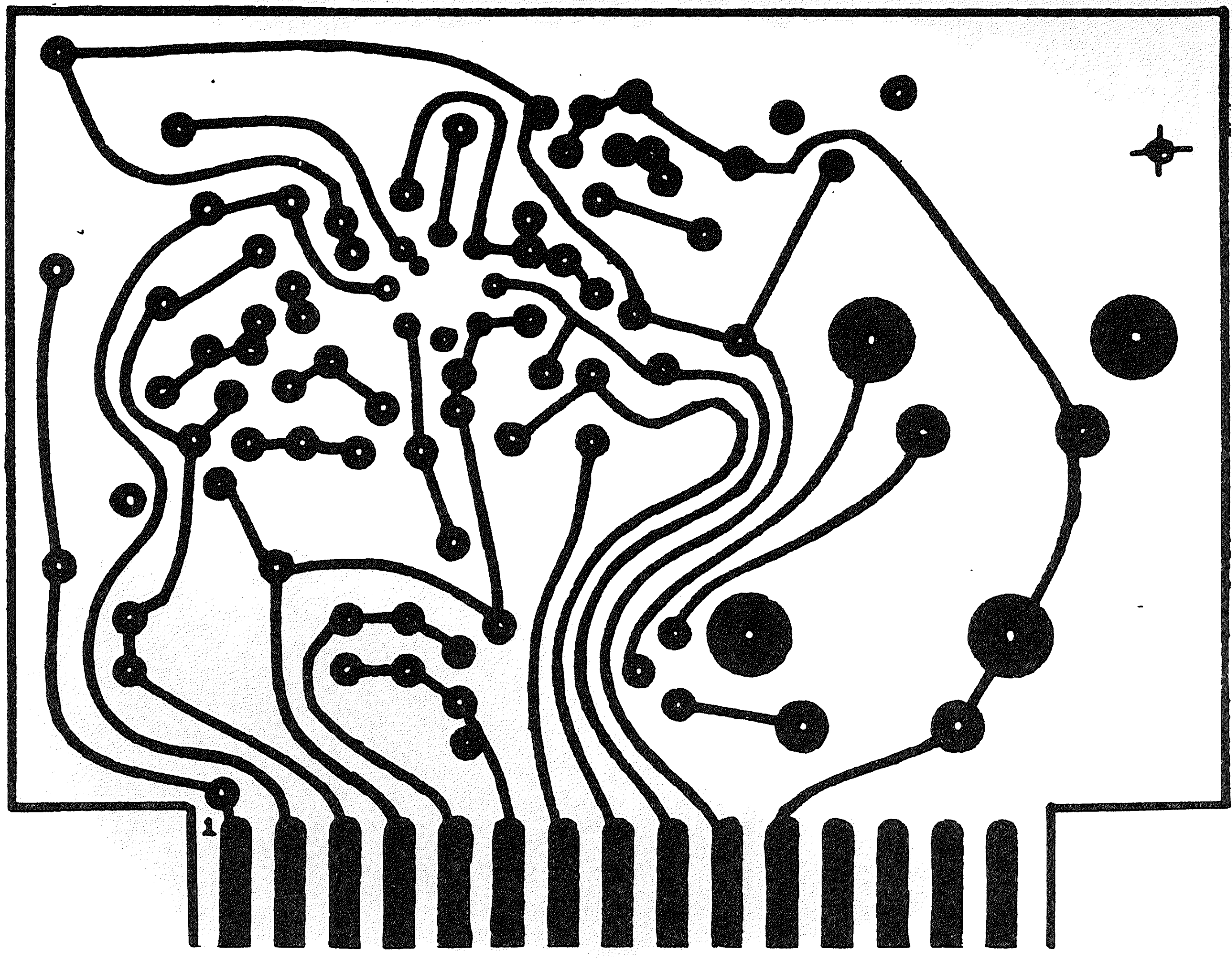
PROPORTIONAL BAND ADJUSTMENT



NOTE: FOR GREATER ACCURACY, A RECORDER WITH ONE PERCENT RESOLUTION MONITORING A THERMOCOUPLE IN AN ASSEMBLY COMMON TO THE CONTROLLER THERMOCOUPLE IS RECOMMENDED.

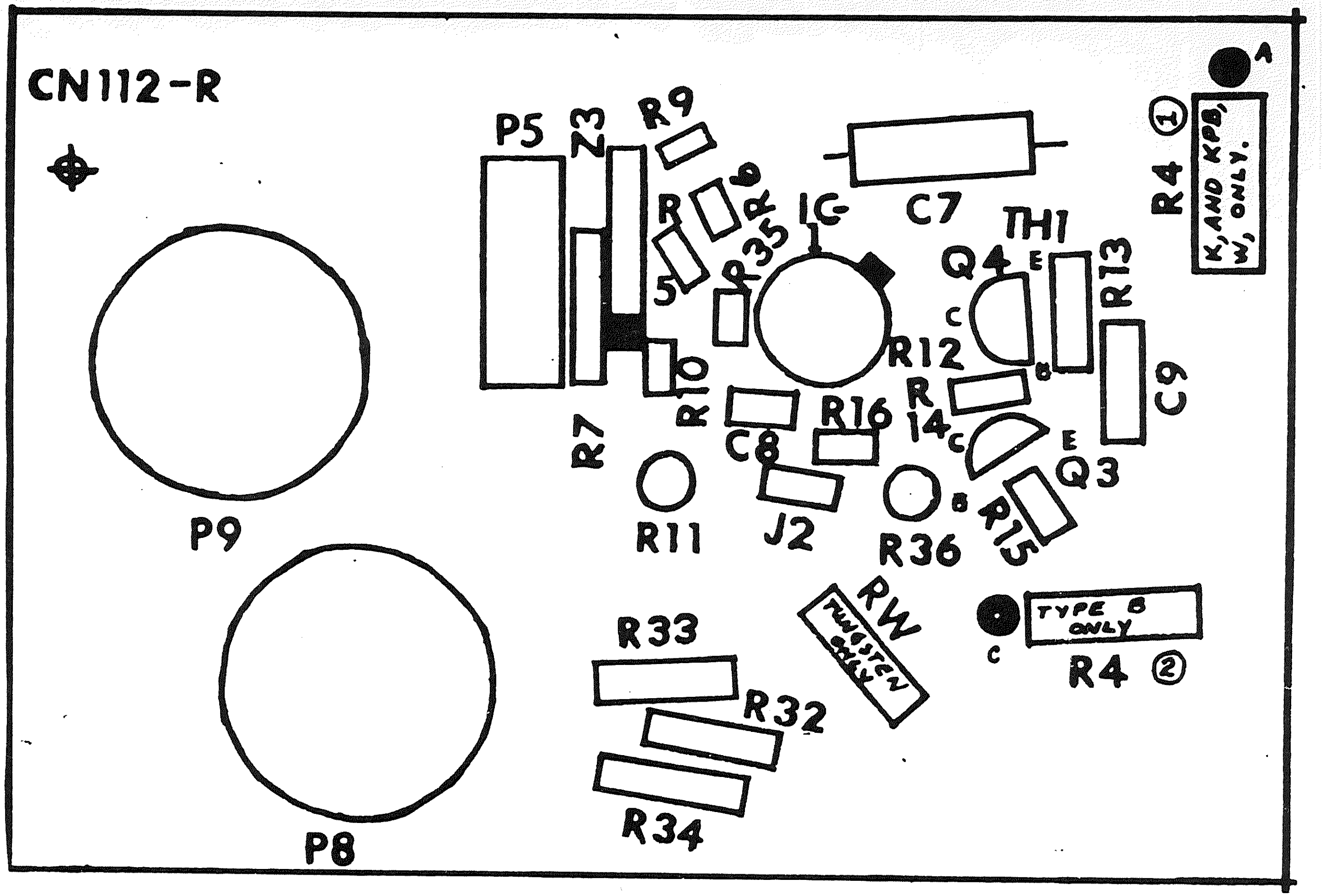
*REFER TO SECTION THREE FOR VALUES. AS THE RESET TIME INCREASES, THE PROPORTIONAL BAND RANGE NARROWS. IT MAY BE NECESSARY TO INCREASE THE PROPORTIONAL BAND WIDTH. REFER TO SECTION 3.1 PROPORTIONAL BAND.

FIGURE 4

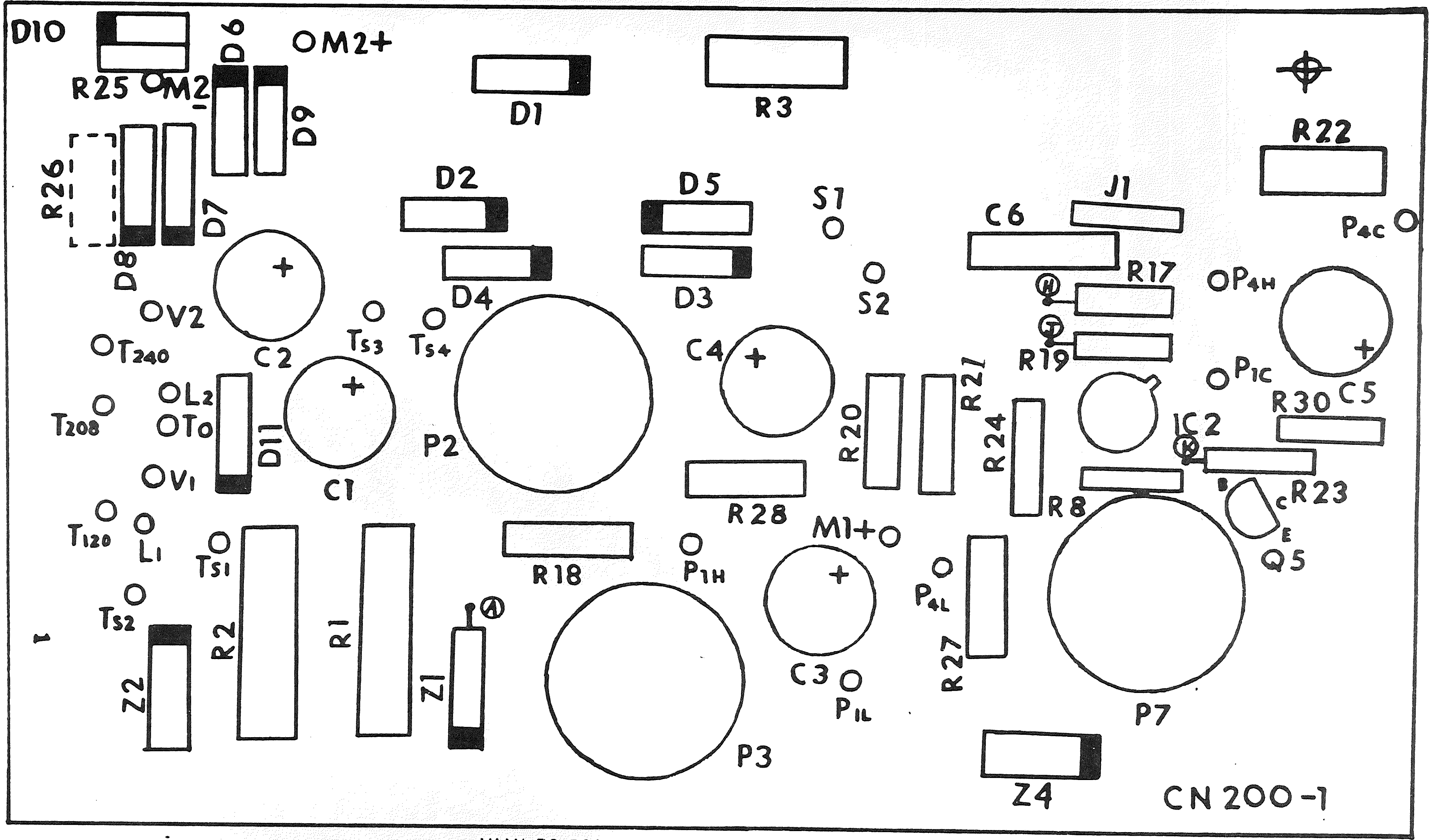


RANGE CARD, ETCHED SIDE

FIGURE 5



RANGE CARD, COMPONENT SIDE
FIGURE 6



MAIN PC BOARD COMPONENT SIDE

FIGURE 7