OPERATING AND INSTRUCTION MANUAL FOR MODEL DRC-5

GENERAL INFORMATION

1.1 INTRODUCTION

This manual provides the necessary information to install, operate, and maintain the Model DRC-5 Digital Thermometer.

1.2 DESCRIPTION

The DRC-5 Digital Thermometer is a completely self-contained temperature indicator with an integral reference junction that automatically displays the temperature of an attached Chromel-Gold-Iron thermocouple.

The unit contains adequate controls and gated BCD output to make it useful in a variety of system applications.

1.3 INPUT/OUTPUT CONNECTIONS

The following is a list of input/output connections for the DRC-5 Digital Thermometer.

CONNECTOR P2

PIN NO.	FUNCTION	PIN NO.	FUNCTION
1	+10 V	A	BCD 40
2	BCD .8	B	BCD 20
3	BCD .1	C	BCD 800
4	BCD .4	D	BCD 100
5	BCD .2	E	BCD 400
6	BCD 8	F	BCD 200
7	BCD 1	H	ERROR
8	BCD 4	J	BCD 1000
9	BCD 2	K	BCD 2000
10	BCD 80	L	Positive Polarity
11	BCD 10	M	Measurement Enable (IN)
12	Transfer Enable (IN)	P	Read Rate (IN)
13	BCD Inhibited (OUT)	R	Read Rate (IN)
14	BCD Enable	S	Digital Ground

CONNECTOR P3

PIN NO.	FUNCTION		PIN NO.	FUNCTION
A	Common	Power Input 50-400 Hz	1	Same as Pin A
B	High		2	Same as Pin B
C	Low		3	Same as Pin C
D	Guard		4	Same as Pin D
E	Calibrate Voltage		5	Same as Pin E
F	6V return	Reference Junction	6	Same as Pin F
H	6V	Excitation	7	Same as Pin H
J	Lo Input and	Analog Ground	8	Analog Signal Output
K	Hi Input		9	Same as Pin K
L	Guard		10	Same as Pin L

1.4 SPECIFICATIONS

1.4.1 Electrical Specifications:

The following specification applies over a temperature range of 0°C to 45°C.

Maximum Full Scale	±38000 counts
Polarity Selection	Full automatic
Resolution	0.1° on any range or function
Repeatability	±1 count for 30 minutes at constant temperature
Linearization	Fully digital linearization with up to 63 straight line segments
Zero Stability	±0.2uV/°C ± 1/2uV/week
Long-Term Stability	±0.02%R for 90 days ±0.03%R for 6 months
Input Resistance	100 megohms minimum
Differential Overdrive	Up to 140V RMS causes no damage

Warmup Time	Rated accuracy ±1 count within 5 minutes after power is applied; rated accuracy after 20 minutes
Input Power	Dual-primary; 115V/230V ±10% selection by jumper 50 to 400Hz, 20 watts
Common-Mode Rejection, DC to 60Hz	
Common-Mode Rejection Ratio to Digital Ground	140 db with 300V isolation
Common-Mode Rejection Ratio to Power Ground	140 db with 300V isolation
Normal-Mode Noise Rejection	Rejection ratio of 100 db at 60Hz and a settling time of 2 seconds
Settling Time	After a full-scale step input, to within .01% FS
Read Rates	
Internal Control Mode	From 1 per 10 sec to 6 per sec available, programmable by external resistor
External Control Mode	0 to 6 readings per second
BCD Outputs	Buffered, gated, isolated, IC compatible
Display	0.6" high numerals, glow discharge type, with circular-polarized view screen

1.4.2 Mechanical Specification:

Dimensions	2.4" H x 5.0" W x 9.3" D See Drawing 02482 for details
Weight	6 pounds

1.4.3 Operating Environment:

Temperature	$0^{o}C$ to $45^{o}C$ ($-30^{o}C$ to $+85^{o}C$ non-operating)
Relative Humidity	0 to 90%, non-condensing. Humidity-sealed boards available on request

1.4.4 Temperature Specification:

Thermocouple Material	Chromel versus Gold-.07 Atomic % Iron
Calibrated Range	1.0 to 325.0 K
Conformity*, Degrees	0.2 K (10280 K)
Maximum Digitizing Error, 8 hrs. at $25^{o}C$	0.9 K
Maximum Digitizing Error, $15-35^{o}C$ 90 days	1.1 K

*Conforms to NBS Standard tables, not included in digitizing error.

OPERATING INSTRUCTIONS

2.1 WIRING

All wiring to the Model DRC-5 is accomplished from the rear of the unit. (See Drawing A-052-000). All power and control wiring is accomplished via edge card connections.

2.1.1 Power Wiring:

The standard unit operates from 115V ±10%, 50-400 Hertz power source. Operation on 230V is available as an option. The unit should be connected to the power source by a three conductor cable. Two conductors provide the power to the meter and the third provides for safe grounding of the case. The third conductor should connect to earth ground at the power end of the cable and to the top printed circuit board connector (J3) at the thermometer end of the cable.

2.1.2 Thermocouple Wiring:

The thermocouple input wires are attached directly to the Reference Junction which contains thermocouple compensating alloy terminal lugs to minimize thermal error voltages. Drawing A-052-000 provides the correct connection polarity required for proper operation.

2.2 EXTERNAL CONTROL SIGNALS

The following paragraphs describe the external controls and their functions.

2.2.1 Measurement Enable:

This control commands the meter to begin to take a reading. It may be a DC level or a pulse of minimum amplitude of +3 volts and minimum duration of 5 u sec. The meter will take readings as long as this command is held high (or open). It will inhibit readings if it is held low.

2.2.2 Read Rate:

This control provides a means of setting the internal read rate from approximately 6 per second to once per 10 seconds using a programming resistor.

By shorting pins R and P on connector J2, the meter will operate at a maximum rate of approximately 6 readings per second. This rate may be decreased by inserting a resistance between these two pins. The required resistance R in megohms may be determined from the formula

$R = \frac{1}{\text{reading rate}} - 0.133$ where the desired reading rate is between the values of 0.1 and 6 readings/second. When operating in an external control mode, the pins should be shorted to provide a maximum read rate of 6/sec.

2.2.3 BCD Enable:

This control enables the BCD outputs. When this line is held high (or open), the output will assume the value stored in the output registers.

If the line is held low, all outputs will go to their high state. This provides the system capability of bussing together the BCD outputs of several instruments.

2.2.4 Transfer Enable:

This input controls the transfer of data from the counters to the storage registers and display. As long as this command is high (or open), the storage registers and display will automatically be updated at the completion of each conversion. If this command is held low, the last reading in storage will be held even though the meter is making new conversions.

2.2.5 Conversion Complete:

This output is high whenever the meter is not making a conversion and the transfer of data to storage is complete. The positive-going edge is useful as a print command.

2.2.6 BCD Inhibited:

This output is high whenever the gated BCD outputs are inhibited (all outputs in their high state).

2.2.7 Calibration Voltage:

This output provides a millivolt level analog signal derived from the internal reference to provide a near full scale calibration. See section labeled calibration procedures.

2.3 MODES OF OPERATION

The DRC-5 may be operated in either a fully automatic mode where readings are taken at a fixed rate or operated under external control.

2.3.1 Automatic Mode:

To operate the meter in an automatic mode:

1. Connect the power wiring (Paragraph 2.1.1)
2. Select the proper read rate program resistor (Paragraph 2.2.2)
3. Connect the thermocouple observing proper polarity (Paragraph 2.1.2)

The meter will take readings at the selected rate, display the temperature directly and provide the BCD equivalent output of the displayed value.

2.3.2 External Control Mode:

There are many variations possible for external control of the Model DRC-5. Some typical examples are outlined here to demonstrate the various uses of the control functions. It is assumed the power wiring and thermocouple have been properly terminated (Paragraph 2.1).

2.3.2.1 Single Reading on Command:

To cause the meter to take a single reading at intervals determined by an external source:

1. Short pins R and P on connector J2 (Read Rate Paragraph 2.2.2).

2. Apply a positive pulse to pin M on connector J2 (Measurement Enable) with a minimum width of 5 usec and a maximum width of 33 msec. (Paragraph 2.2.1)

The meter will take one reading for each pulse but no more than one reading every 133 milliseconds. The BCD outputs and display will be updated at the end of each conversion.

2.3.2.2 Asynchronous Use of Gated BCD Outputs - Multiple Meters:

The gated BCD outputs are used when two or more meters are connected to a single output device such as a printer. To enable the user to randomly select the meter to be connected to the output busses:

1. Short pins R and P on connector J2 (Read Rate Paragraph 2.2.2).

2. Connect pin 13, J2 (BCD Inhibited) to pin 12, J2 (Transfer Enable).

3. Apply a high level to pin 14, J2 (BCD Enable) of the selected meter to connect its BCD outputs to the common busses. In this configuration the meter is continuously making conversions and updating the buffered storage register and display at the end of each conversion. However, with pin 14 low, all the BCD outputs are held high. When the BCD Enable input is made high, the BCD outputs will assume their last stored values. The BCD Inhibited output line will go low and inhibit, via the Transfer Enable, further change of data in the storage register. By returning the BCD Enable to ground, the Transfer Enable line goes high and the storage register will be updated at the completion of the next conversion.

NOTE: Connection of a resistor selected to rate determined by Paragraph 2.2.2 or a jumper wire between pins R and P must be made for the instrument to operate.

THEORY OF OPERATION

3.0 GENERAL

The Model DRC-5 Digital Thermometer with integral reference junction accepts the millivolt output of a thermocouple and provides a digital display of the equivalent temperature. Since the voltage generated by a thermocouple is a non-linear function of temperature, the analog-to-digital converter circuit in the Model DRC-5 is made non-linear to match the thermocouple curve. The curve is approximated by a number of straight line segments. Up to 63 segments per curve are used to reduce the conformity error to less than the standard thermocouple error.

A digital linearization technique is used incorporating a Binary Frequency Generator (BFG) controlled by a Read-Only Memory (ROM). The output of the BFG serves as the clock source for the modified analog-to-digital converter. The 8 bit binary coded frequency input to the BFG is derived from the parallel outputs of the ROM. The output of the BFG is a frequency, $fo \cdot N/256$, where N is an integer from 1 to 255.

The ROM is addressed by a 6 Bit segment counter.

The segment counter is advanced at equal intervals of degrees derived from the temperature display counter. A jumper plug provides several choices of segment length to best match a particular thermocouple curve.

The segments corresponding to positive temperatures occur during the first part of the ROM and the segments corresponding to negative temperatures, if any, occur during the last part of the ROM. If the voltage from the thermocouple represents a negative temperature, the segment counter is preset to the beginning segment for negative readings. Since the desired beginning segment number may vary for different thermocouples, it is made selectable by a jumper plug.

An integral reference junction provides the interface between the thermocouple and input amplifier. The input circuit contains a chopper stabilized, fixed gain, potentiometric amplifier and has multiple pole filtering for high noise rejection. The modified A-D converter is truly bipolar and will read the average value of the input signal to provide further rejection of noise.

Basic reference voltages are derived from carefully selected, aged, low temperature coefficient zener diodes to insure maximum long term accuracy.

The analog conversion circuitry is transformer coupled to the digital system to provide high level DC and AC common mode isolation.

CALIBRATION PROCEDURE

The Model DRC-5 requires infrequent calibration but, when necessary, the following easy procedure may be used.

4.1 CALIBRATION WITHOUT REFERENCE JUNCTION

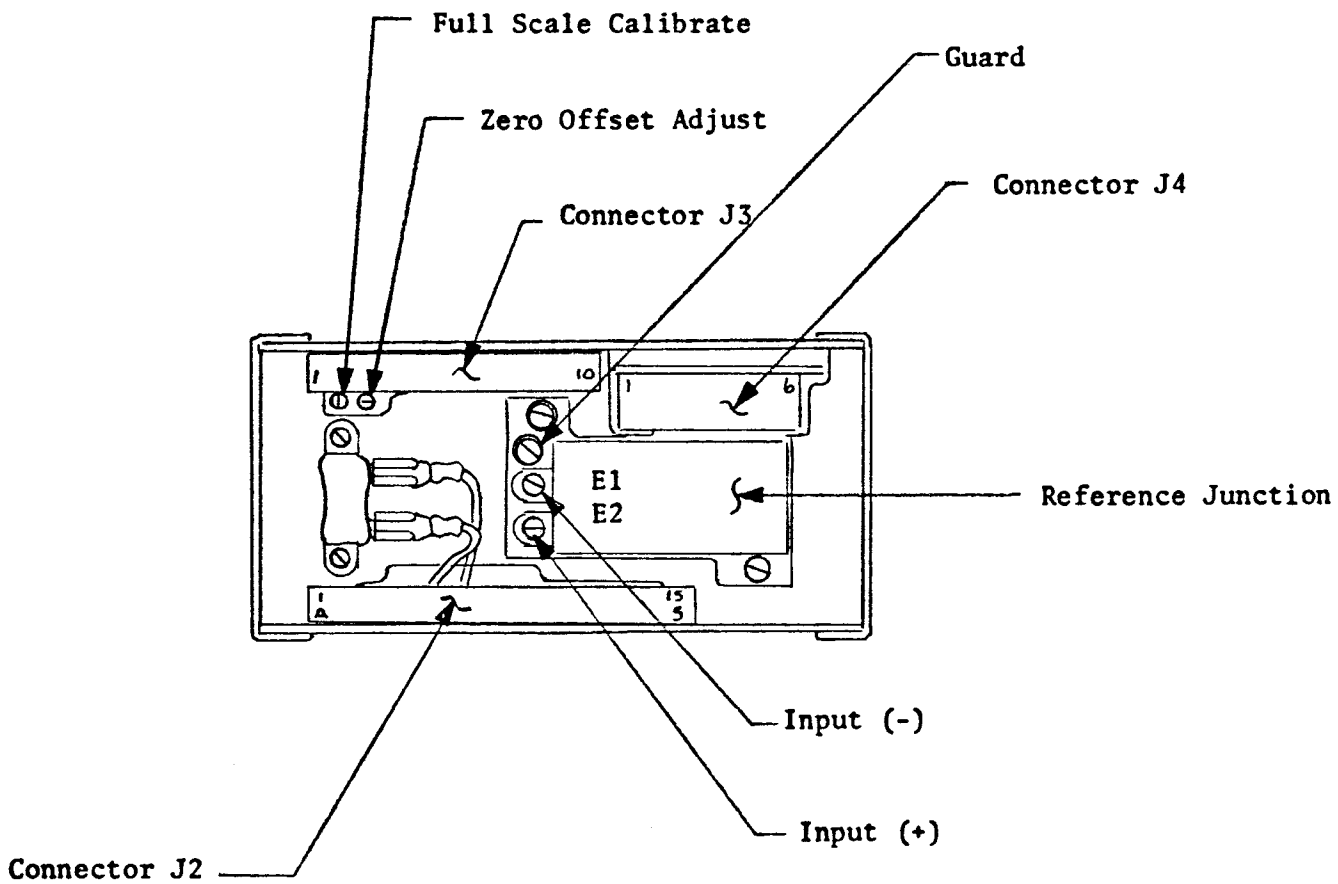
The Model DRC-5 has a built-in reference voltage which greatly facilitates calibration of the meter. No external voltage source is required.

For full scale calibration, short together pins J, K, and L on connector J3 and adjust the full scale pot for a reading of 273.1 K. (See Drawing A-052-000).

For zero calibration, connect pin E to pin K and pin J to pin L on J3. Adjust the zero offset pot for a reading of +0000.0 K.

4.2 CALIBRATION WITH REFERENCE JUNCTION

First calibrate the meter with the reference junction removed as described in Paragraph 4.1. After completing the calibration, replace the reference junction and attach the thermocouple as shown in Drawing A-052-000. Place the thermocouple in a suitable ice point reference and adjust Reference Junction zero for proper reading of 273.1 K.



NOTE: E1 - Gold/.07 Atomic & Iron
E2 - Chromel

LAKE SHORE CRYOTRONICS, INC.
Eden, New York 14057

SCALE:	APPROVED BY:	DRAWN BY JRB
DATE: 4/1/75		REVISED

CONNECTIONS LOCATOR FOR MODEL DRC-5

DRAWING NUMBER
A-052-000

LAKE SHORE CRYOTRONICS, INC.

9631 SANDROCK ROAD, EDEN, NEW YORK 14057

Telex 91-396 Cryotron EDNE 716-992-3411

Chromel(P) Versus Gold-.07 Atomic Percent Iron Thermocouple

The Lake Shore Cryotronics Model DRC-5 Digital Thermometer utilizes high purity thermometric material of Chromel vs. Gold/.07% Fe as the sensing element. Definable thermoelectric characteristics illustrating the usefulness of this thermocouple were reported in July 1968[1] with corrections to the table, for voltage values above 20 K, occurring in June 1972[2] due to the IPTS-68 temperature scale correction.

The usefulness of this thermocouple as the only practical 'cryogenic thermocouple' as well as handling and installation precautions are presented in a paper by Dr. Ralph Rosenbaum.[3]

The thermocouple wire is available in two sizes of 0.005" and 0.010" diameter with an outside protective sheath of TFE teflon.

Typical Thermal EMF Response for
Chromel P Vs. Gold/0.07 At % Fe
(Referenced to 0°C)

Temp. (K)	EMF (-mV)	Temp. (K)	EMF (-mV)
273.16	0.00000	50.0	4.51607
260.0	0.29219	40.0	4.68186
240.0	0.73271	30.0	4.84668
220.0	1.16916	25.0	4.92998
200.0	1.60007	20.0	5.01435
180.0	2.02417	15.0	5.09923
160.0	2.44040	10.0	5.18212
140.0	2.84737	8.0	5.21348
120.0	3.24361	6.0	5.24293
100.0	3.62706	4.0	5.26956
77.34	4.03635	2.0	5.29225
70.0	4.17320	0.0	5.30952
60.0	4.34678		

REFERENCES:

1) National Bureau of Standards Report 9712
2) L. Sparks and B. Powell, J. Research of the National Bureau of Standards, 76A, No. 3 (May/June 1972)
3) R. Rosenbaum, "Some Properties of Gold-Iron Thermocouple Wire", Rev. Sci. Inst., 39, No. 6 (June 1968)