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INSTRUCTION MANUAL

MODEL DRC-3

CRYOGENIC DIGITAL THERMOMETER

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SECTION I

CHARACTERISTICS

1.1 INTRODUCTION

The Model DRC-3 Cryogenic Thermometer provides direct readout of temperatures from 2 to 100 kelvin. It provides a Nixie+ readout with a 0.1 K resolution and an accuracy of ±0.2K. A gallium arsenide diode is used as the sensing element. This sensor is small, stable, and is practically unaffected by strong magnetic fields, so that the instrument can be used in virtually all cryogenic applications including those involving superconducting magnets. For determining temperatures exceeding the range covered by direct readout, a sensor-voltage display mode provides a readout translatable by use of a calibration chart to temperatures in the 1-400 kelvin range.

The direct readout feature can be matched to the characteristics of any gallium arsenide sensing element for which the appropriate calibration table is available. A plug-in circuit board is aligned to the sensor calibration either at the factory or by the operator, depending on the history of the specific sensor. Extra plug-in boards can be obtained from the factory so that the instrument can be used with sensors installed in different pieces of equipment.

The unit is packaged in an attractive freestanding cabinet, which may be rack or panel mounted using a special adaptor kit.

1.2 SPECIFICATIONS**

TEMPERATURE RANGE

2-100 kelvins, ±0.2K. For availability of plug-in boards providing wider range, check with the factory.

INPUT CONNECTIONS

Front panel BNC connector. Up to 25 ohms lead resistance is acceptable.

READOUT

(1) 3½ digit Nixie+ display. Numerals are 9/16" high.

(2) Rear panel recorder output. +10 V full scale.

(3) On special order, the digital output from the meter can be made available from the rear panel.

+Nixie is a trademark of Burroughs Corporation.
**Specifications subject to change without notice.

SENSOR

See specification sheet in Appendix.

POWER REQUIREMENTS

105-125 V or 210-250 V, 50-60 Hz, 10 watts.

WEIGHT

7 pounds (3.2 kg).

DIMENSIONS

8½" W x 3½" H x 11" D (23 cm W x 6.4 cm H x 28 cm D).

MOUNTING

Freestanding, or in rack if special adaptor kit is used.

SECTION II

INITIAL CHECKS

2.1 INTRODUCTION

The following procedure is provided to facilitate initial performance checking of the DRC-3. In general, the procedure should be performed after inspecting the instrument for shipping damage (any noted to be reported to the carrier and to Lake Shore Cryotronics, Inc., but before using it experimentally. Should any difficulty be encountered in carrying out these checks, contact the factory or one of its representatives, a list of whom appears at the end of this manual.

This procedure can also be used as a quick check for proper operation after the instrument has been through a period of obscure history, and as an aid in determining the symptoms while troubleshooting.

2.2 EQUIPMENT NEEDED

(1) Calibration Card corresponding to the sensor for which the plug-in board has been calibrated.

(2) A short length of coax cable for connecting between the rear and front panel BNC connectors.

(3) Resistor in the range of 50 kΩ to 120 kΩ whose value is known to within 0.1%.

(4) For highest precision, a voltmeter capable of measuring up to 1.5 volts to ±0.0001 volt is desirable. Use it, connected via a BNC TEE fitting, to measure the input voltage during steps 6 through 9 below.

2.3 PROCEDURE

(1) Make sure that the number showing in the window of the rear-panel slide switch corresponds to the line voltage to be used (115/230V, 50/60 Hz). Then energize the instrument and allow a fifteen minute warmup period.

(2) Set the front panel function switch to A ZERO. Adjust the A ZERO trim-potentiometer on the front panel for .000 on the digital panel meter.

(3) Set the function switch to B ZERO. Adjust the B ZERO trim-potentiometer for .000 on the digital meter.

(4) Set the function switch in CAL. Adjust the 1.500 CAL. trim-potentiometer on the front panel for 1.500 on the digital meter.

(5) Connect the cable between the front and back panel BNC jacks.

(6) Set the function switch to E_D. Then set the range switch and potentiometer on the back panel so that the digital meter indicates exactly the first voltage given on the sensor's calibration card.

(7) Set the function switch to TEMP. The meter indication should be the same as the temperature given on the card corresponding to the voltage set in step (6).

(8) Switch back to E_D, and set the next voltage given on the card. Then switch back to TEMP. The meter indication should be the same as the corresponding temperature given on the card.

(9) Continue setting voltages and checking meter indications against corresponding temperatures for all points on the card. None of the temperature indications should be off more than 0.2 K.

(10) Disconnect the cable from the front and back BNC jacks, and connect the precision resistor to the front panel Probe jack. (Connect between the center conductor and the outer shell of the jack. Do not use chassis ground.)

(11) Set the function switch to E_D. The digital panel meter should indicate 10^{-5} x R volts (R is resistance of precision resistor), with an accuracy of 1%. For example, if R were 100 kΩ, the panel meter would indicate 1.000 V ±0.01 V. (This step checks the accuracy of the 10 uA sensor supply current.)

This completes the initial checks. If the instrument performed as described, one can be reasonably sure that it is operating properly.

SECTION III

OPERATING INSTRUCTIONS

3.1 INSTALLATION

The DRC-3 can be free standing or rack mounted. If free standing, it can rest on four plastic feet, or the front can be tilted upward using the swing-out stand for better viewing of the panel meter. For rack mounting, two mounting kits are available, one for mounting a single unit in a standard 19" relay rack, and the other for mounting two units side by side. Instructions accompany the kits. Factory part numbers for the kits are:

Single mounting: Panel, rack mounting, part number 1415-0553-08.

Double (side by side) mounting:

Coupling, rear, part number 1415-0555-14
Coupling, front, part number 2517-0217-19
Screw, coupling, part number 2517-0218-18

Flanges are required for both types of rack mounting. Most units are shipped with flanges, but if a unit to be mounted does not have them, order part number 1402-0008-20 (two for each type of mounting).

Before operating the DRC-3, be sure that the sensor is properly installed and connected, and an aligned circuit board is in place (SectionV).

3.2 OPERATION

(1) Zero and Meter-Calibrate Adjustments

Before a reading or a set of readings is taken, the A and B zeros should be adjusted and the digital panel meter should be calibrated. These three adjustments are made by placing the function switch in the appropriate position and adjusting the corresponding trim-potentiometer on the front panel. In the CAL. position, the CAL. trim-potentiometer is adjusted for +1.500 on the meter. Then the function switch is placed in the A ZERO position and the A ZERO trim-potentiometer is adjusted for .000 on the meter. After A ZERO is adjusted the function switch is placed in the B ZERO position and the B ZERO trim-potentiometer is adjusted for .000 on the meter. The A ZERO adjustment should be made before the B ZERO adjustment, because, in order for the B adjustment to be valid, the A adjustment must be accurate. The +1.500 adjustment can be made at any time.

(2) Reading the Temperature

With the function switch set to TEMP. (and if the preceding adjustments are accurate), the digital panel meter indicates the temperature directly in kelvin. On standard models the range is 2 K to 100 K and the accuracy is ±0.2 K.

With the function switch in the E_D position, the meter indicates the voltage on the sensor diode. This position is used if the temperature lies outside the range of direct readout. In the E_D position, temperatures over the range of 1 K to 400 K can be determined if the calibration chart for this range is on hand. (The sensor current is 10 uA, 0.1% accurate and 0.1% stable.)

(3) Chart Recorder

A chart recorder can be connected to the rear panel Recorder terminals. The output resistance is 1 kΩ. The recorder sensitivity must be adjusted for accurate full-scale deflection, using the Thermometer's digital panel meter indication as the reference. To simulate a sensor output for setting the recorder scale, connect the rear panel BNC jack to the front panel Probe BNC jack, using a short cable, and adjust the rear panel range switch and potentiometer for the required full-scale reading on the meter. Then set the recorder sensitivity for a corresponding deflection at the recorder. Approximate ranges of voltages at the Recorder terminals are 0 to +10 V corresponding to 100 K to 0 K when the function switch is in the TEMP. position, and 5 x the sensor voltage (and meter indication) when the function switch is in the E_D position. In the latter case, the voltage range is typically +8 V to +3.5 V corresponding to 1.6 V to 0.7 V sensor voltage (and meter indication) over the 0 K to 100 K temperature range.

(4) Power Supply Voltage Adjustment

The power supply voltage must be accurate to achieve accurate temperature indications. The pin jack and trim-potentiometer on the back panel are used in setting this voltage. First, allow the instrument to warm up for fifteen minutes. Then, using an external DVM of suitable accuracy, set the pin-jack voltage to 1.5000 V, ±0.1 mV. (Connect the voltmeter ground to the Recorder ground terminal, not to chassis ground. Chassis and signal grounds are isolated from each other.) This adjustment should not have to be made very often, perhaps once a year.

Alignment of the plug-in board to the sensor calibration and other adjustments are described in Section V. Section V also discusses sensor installation.

CAUTION: When installing and connecting the sensor, the anode and cathode leads can be identified with an ohmmeter. See Lake Shore Cryotronics, Inc. Instruction Sheet "Installation and Application Notes for Cryogenic Sensors."

SECTION IV

CIRCUIT DESCRIPTION

4.1 INTRODUCTION

The voltage on the temperature sensing element at constant current is not a linear function of temperature. Therefore, to obtain an accurate direct readout, a curve-fitting function generator circuit is included in the feedback loop of an amplifier, making the gain of the amplifier a function of input voltage. In all positions of the function switch except TEMP, the amplifier is operated as a linear amplifier, with the sensor voltage, a test voltage, or ground applied to the input as appropriate to the switch setting.

For stability of the break points of the function generator, the temperature of the plug-in board is held constant by a regulator circuit which controls the heat dissipation of resistors mounted on the board.

The accuracy and stability requirements of the temperature measuring functions necessitate that the dc supply voltage be very stable. To achieve this stability, regulated power-supply dircuits are employed.

4.2 SCHEMATIC DISCUSSIONS

A. Sensor Current Source

Refer to the upper left-hand corner of the main schematic on page VIII-6. Q200 provides constant current to the sensor diode (probe). CR200 and CR201 temperature compensate the forward-biased emitter junction of Q200. R200 is used to set the sensor current (10 uA). The voltage developed across the sensor as a function of temperature is applied to the input amplifier via the TEMP. and E_D positions of the B section of the front-panel function switch, S200.

B. Dc Amplifiers

There are several dc amplifiers. The input amplifier is composed of Q201 through Q206, and is operated as a straightforward operational amplifier having a gain of x5. A second dc amplifier is built up around integrated-circuit operational amplifier U201. The curve-fitting function generator and several other amplifiers are in the feedback circuit of this second amplifier, as will be described shortly.

Q201A and Q201B amplify the voltages at their gates. Q202 provides constant current to the common source point, insuring that Q201A & B amplify differentially. The differential outputs of Q201A & B are amplified by common-emitter pair Q203 and Q204. Q205 inverts the output of Q203 to help Q204 in driving Q206. Q206 is the emitter-follower output transistor of the first dc amplifier. Common mode signals applied to Q201A and Q201B cancel at the base of Q206. Differential input signals are amplified and added at the base of Q206. Feedback is applied to the gate of Q201B via R210. A fundmental principle of operational amplifiers in this configuration is that the output voltage assumes whatever value is required to make the feedback voltage equal the input voltage. This is by virtue of very high loop gain and degenerative feedback. Therefore, as determined by voltage divider R209 and R210, the gain of this operational amplifier is x5 (ratio of (R209 + R210) :R209).

U201 is the second stage operational amplifier. Its output voltage is applied to the digital panel meter and Recorder terminals. In the Z_A, Z_B, CAL., and E_D positions of the function switch, feedback from the output to the summing junction (pin 2 of U201), is via R218 or R217. With the function switch in any of these four positions, the amplifier operates as a linear operational amplifier. The output voltage becomes whatever value is required to make the current through the feedback resistor exactly equal the current through the input resistor, R220, so that the summing input voltage is maintained equal to the voltage at the reference input, pin 3. Gain is thus determined by the ratio of the feedback and input resistors. In the E_D and CAL. positions, gain is unity. In the A and B ZERO positions, the gain is much higher, x20, so that the zeros can be set with high resolution.

In the Z_A switch position, the input of the second stage is grounded so that R219 can be adjusted to compensate any input offsets that U201 may have. In the Z_B position, the input to the first stage is grounded so that R206 can be adjusted to balance Q201A & B, zeroing the first stage. In the CAL. position, both stages of amplification are active and 1.500 V is applied to the input. The scale factor can be adjusted in this position with R239 of the attenuator at the input of the digital meter. In the E_D position, the digital panel meter indicates directly the sensor voltage, which can be converted to temperature by using a calibration chart.

C. Curve-Fitting Function Generator

With the function switch in the Temp. position, the function generator is inserted into the feedback loop of U201 so that the gain is a non-linear function of the sensor voltage, as required to provide direct temperature readout. The components in this feedback path are amplifier U202 and Q207 through Q210, amplifier U203 and Q211 through Q214, amplifiers U204, U205, and U206, and the function generator board, whose schematic is on page VIII-7.

The output of U201, besides being applied to the digital meter and Recorder terminals, is applied to the feedback loop beginning with U202 and U203. U202 and U203 are operational amplifiers, the output driver circuits of which are Q207 through Q210 and Q211 through Q214. The output of U202 is applied to the base of Q207. Q207 emitter-couples this voltage to the emitter of Q208. The output from the collector of Q207 is inverted by Q209 so that Q209 helps Q208 in driving emitter-follower output transistor Q210. The ratio of feedback to input resistors, R227:R225, is 3:1, determining the gain of the operational amplifier to be x3. The output circuit for U203 operates in the same manner as the U202 output circuit, except corresponding transistors are of the opposite type and are returned to the opposite supply voltage. However, the outputs of the two amplifiers change in the same direction. The U203 circuit output differs from the U202 circuit output in that the U203 circuit output is offset +30 V as a result of current supplied to the summing junction via R229.

The two amplifier outputs, one offset +30 V, are applied to the divider network R309-R310, R312-R313, R315-R316, etc., on the function generator board. As the sensor temperature changes from 2 K to 100 K, the sensor voltage changes from approximately +1.6 V to 0.7 V, and the two amplifier outputs applied to the divider network change approximately 30 V in the negative-going direction. The ratios of the pairs of resistors of the divider network are in progressive sequence such that the diodes connected to their junctions turn on in succession, beginning with CR301 and ending with CR320. The progression of diode turn-on is matched to the sensor characteristics (uniform for this type of sensor), the turn-on break points being closer together where the curvature of voltage vs. temperature is high, and spaced further apart where the curvature is low.

Current is provided to the summing junctions of U204 and U205 (on main schematic) via the trim-potentiometers to which the forward-biased diodes are connected. U206 differentially amplifies the outputs of U204 and U205. The output of U206 is applied back to the summing junction of U201 via R302 (on the function generator board), thereby completing the feedback loop of U201.

The gain of U201 is a function of the gain of the degenerative feedback path to its summing point. The U201 output voltage assumes whatever value is required to make its summing point voltage equal the reference input voltage at pin 3. Therefore, the gain is a function of the difference voltages applied to U206. At each break-point, the gain is altered as a function of the setting of the trim-potentiometer corresponding to that breakpoint. As a diode turns on, the amount of feedback is changed by an amount and direction corresponding to the amount and direction of offset from the center of the potentiometer.

A negative voltage is applied to the reference inputs, pin 3 of U204 and U205, by R304 on the function generator board. Because the individual feedback loops of U204 and U205 keep their summing point voltages equal to their reference input voltages, the voltage at which the function generator diodes become forward biased and the amount of current through the corresponding trim-potentiometers are controlled by R304, i. e., R304 shifts the whole curve-fitting function on the temperature axis.

CR300 on the function generator board is the board-temperature sensor, part of the temperature regulator circuit. However, in being connected to one end of R304 (& R305), it serves a dual function of temperature compensating the forward diode drops of the breakpoint diodes. (The voltage of a forward biased silicon diode is approximately 0.6 V and varies with temperature.)

R308, the #1 trim-potentiometer of the function generator, is an independent linear feedback path for U201. It is used to adjust the median slope of the temperature vs. sensor voltage curve.

R301 provides an offset current to the summing input of U201, so that the output of U201 is zero for zero temperature.

D. Temperature Regulator

Q215 through Q219, CR300, and R369 through R391 comprise the regulator circuit that maintains the temperature of the diodes on the function generator board constant. CR300 is the sensor, and is mounted on the board along with the break-point diodes. The temperature variable 0.6 V forward-bias voltage of the diode is applied to the base of Q216. Q216 through Q219 differentially amplify the diode voltage and the voltage at the base of Q217 obtained from R264, heating R369 through R391. Thermal coupling from the heating resistors to the sensor diode completes a degenerative feedback loop to the amplifier input. Therefore, the temperature is maintained constant at the level that keeps the sensor voltage equal to the R264 reference voltage.

E. Power Supply

Refer to the Power Supply schematic on page VIII-10. Notice that the chassis and power/signal grounds are isolated from each other to prevent ground loops. The power transformer reduces the ac line voltage so that when rectified by CR100 through CR103 ±24 V is produced. This unregulated ±24 V is used by some of the driver amplifier stages. For operating the other circuitry, these voltages are reduced by the regulators to ±15 V.

The regulators are composed of pass transistors Q102 and Q105 incorporated in operational amplifier feedback loops. U100 and U101 are IC operational amplifiers which drive Q101 and Q104, which in turn drive the pass transistors. Because of the opposite polarities of the regulated voltages, the +15 V regulator uses NPN transistors and the -15 V regulator uses PNP transistors. Otherwise, both regulators operate the same way, although the references are different. The -15 V regulator uses a Zener diode (CR104) for reference, and the +15 V regulator uses the -15 V regulated output as a reference. The high-gain degenerative feedback loops maintain the output voltages at the levels that keep the pin 2 and pin 3 inputs of the individual operational amplifiers equal. Because the pin 3 inputs are referenced, regulation is achieved. Q100 and Q103 are diode-connected transistors that temperature compensate the emitter junctions of Q101 and Q104, respectively. In order to bias the pass transistors, it is necessary that the collector resistors of Q101 and Q104 be returned to voltages higher than the emitter voltages of the pass transistors. Since this voltage is unregulated, C101 and C107 serve to decouple some of the ripple.

The regulated +15 V is attenuated by R125 through R130 for use as an adjustable calibration voltage, available at the rear panel BNC connector. R109 and R110 attenuate the +15 V to 1.5 V, available at the rear panel pin jack for adjusting the +15 V supply (R121). This 1.5 V is also provided to the input amplifier via S200B-3(R) when the front-panel function switch is in the 1.500 CAL. position.

SECTION VIII

SCHEMATICS AND PHOTOGRAPHS

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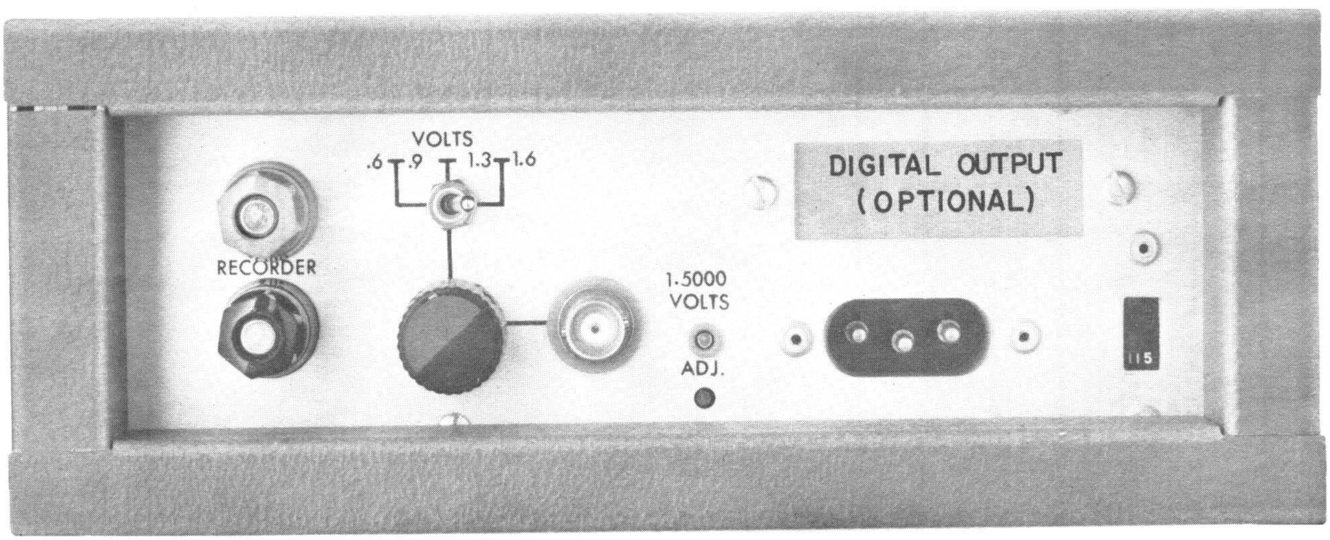
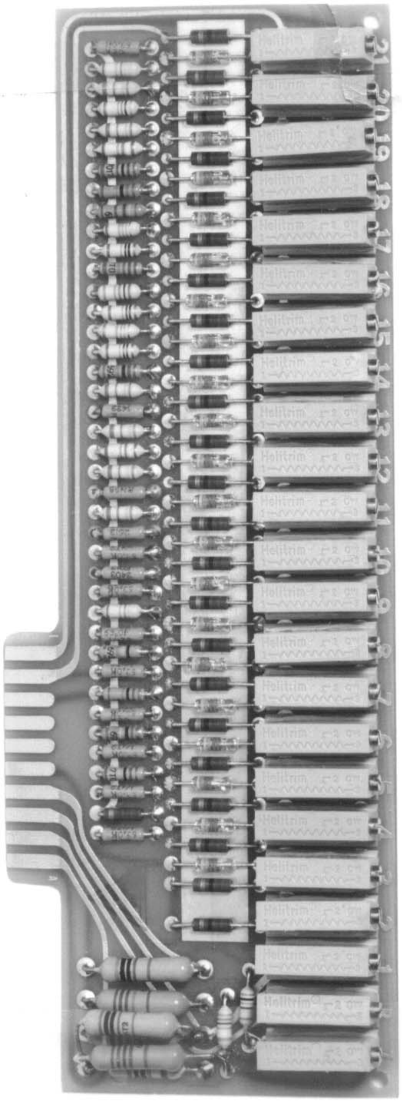
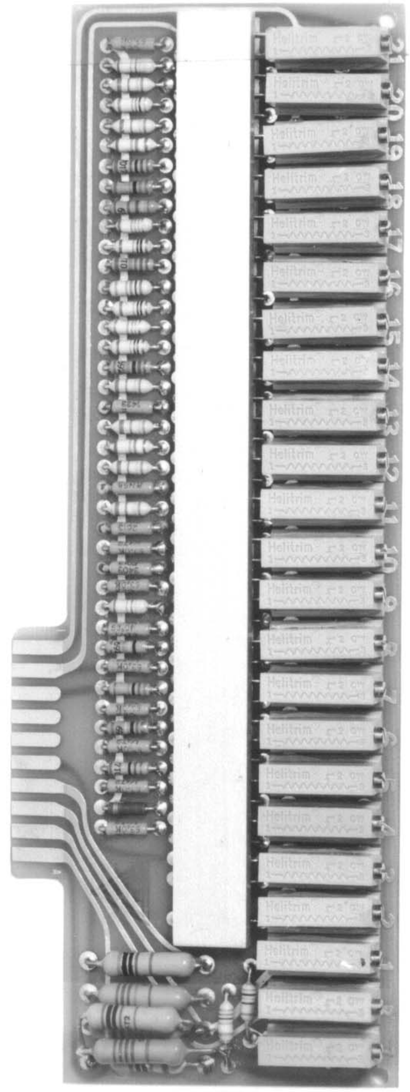


Figure VIII-I, Rear Panel, Model DRC-3



Thermal Bar removed to show diodes and heating resistors.



Thermal Bar in place.

Figure VIII-2. Plug-In Board TGL-2-100

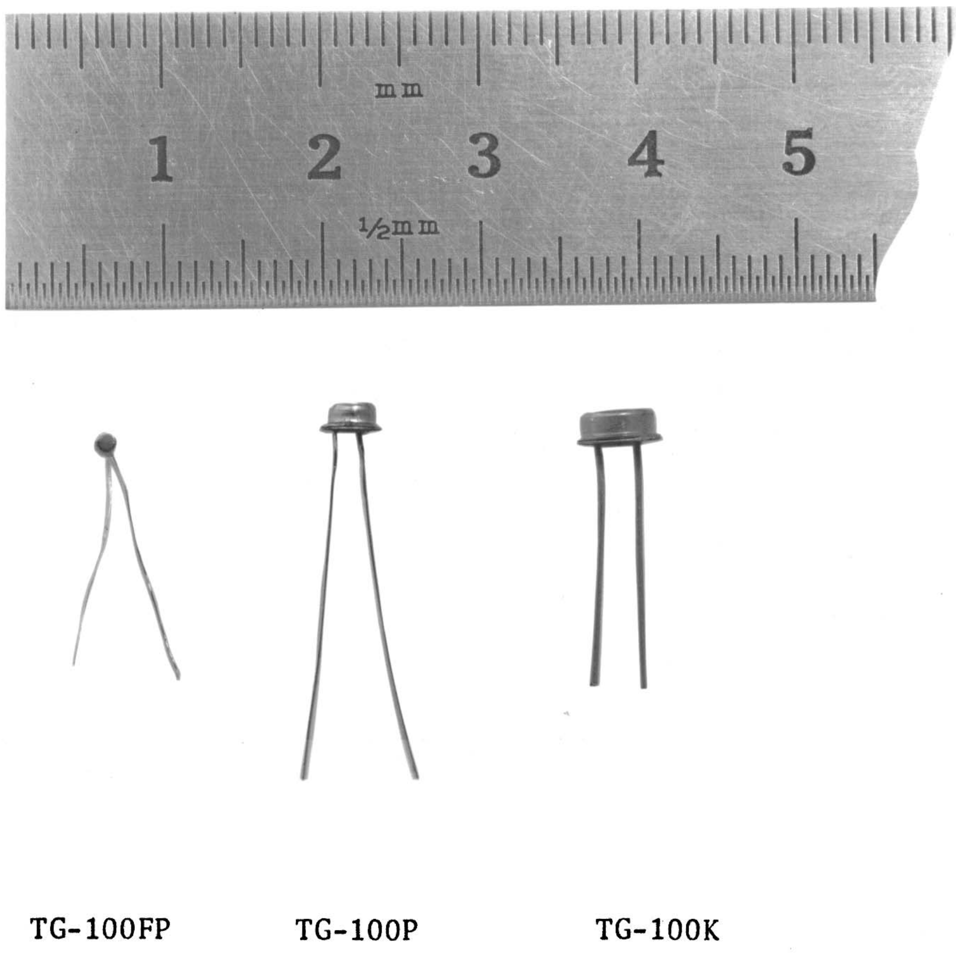


Figure VIII-3. Sensors

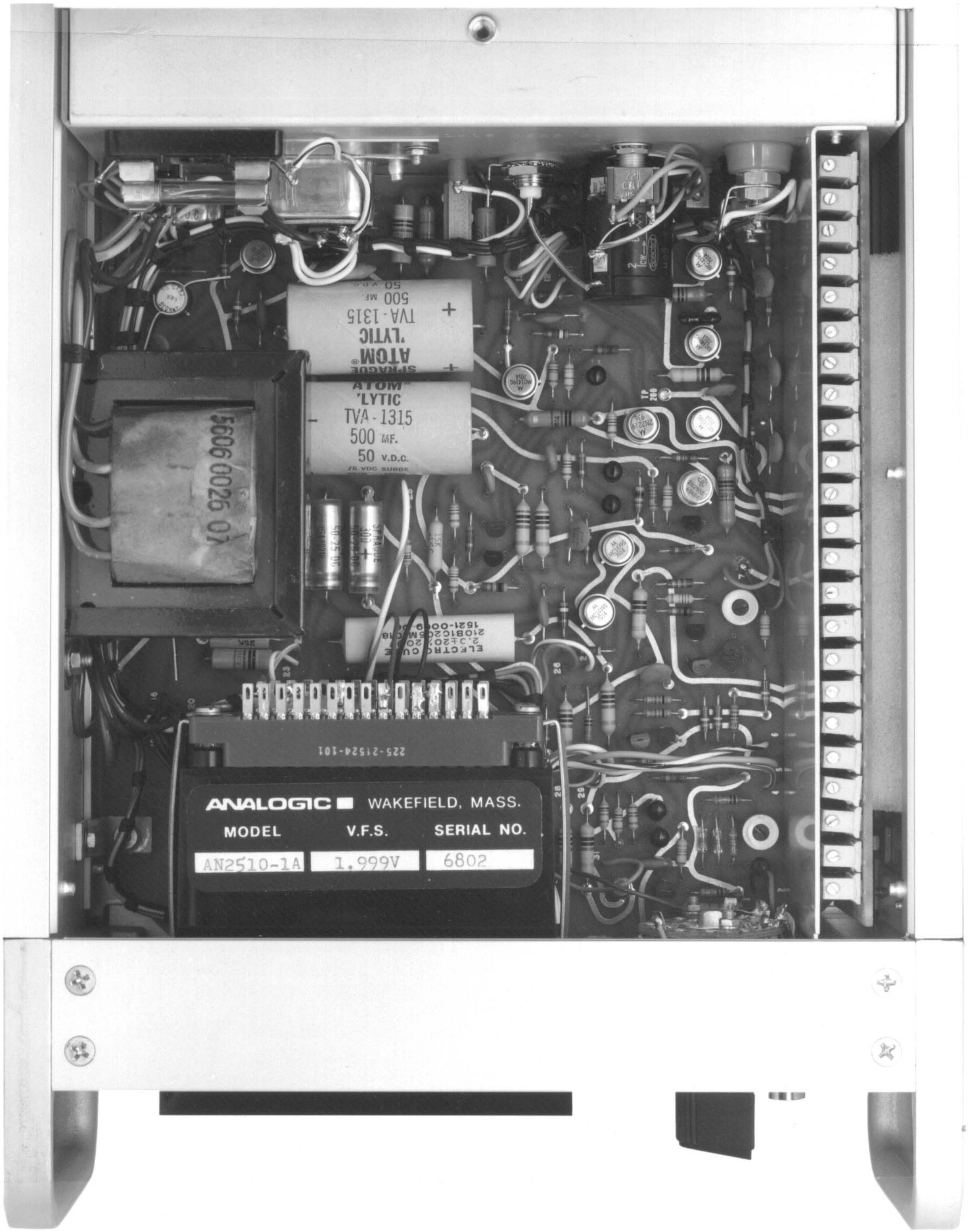


Figure VIII-4. Inside Photograph

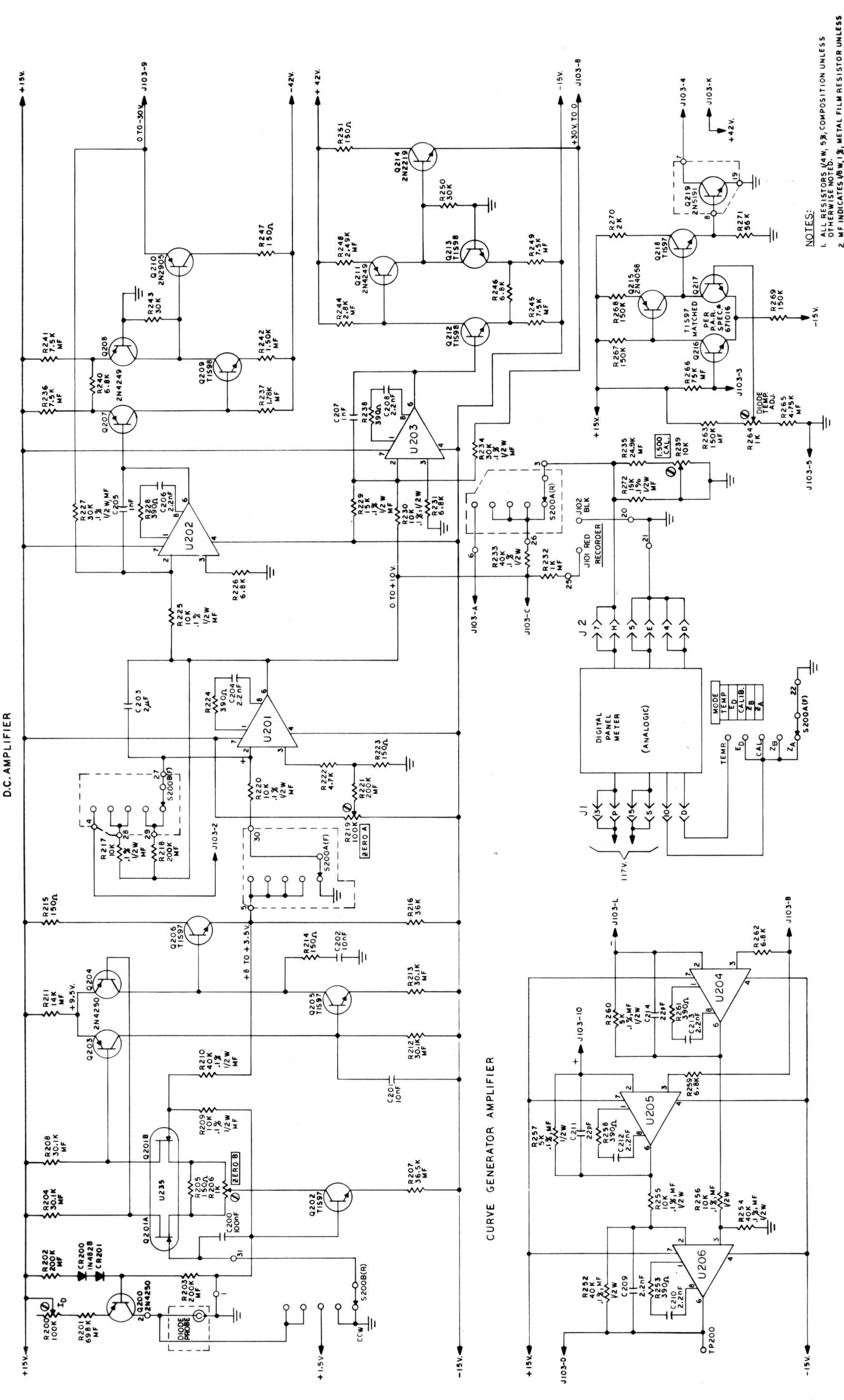


Figure VIII-5. Model DRC-3 Schematic

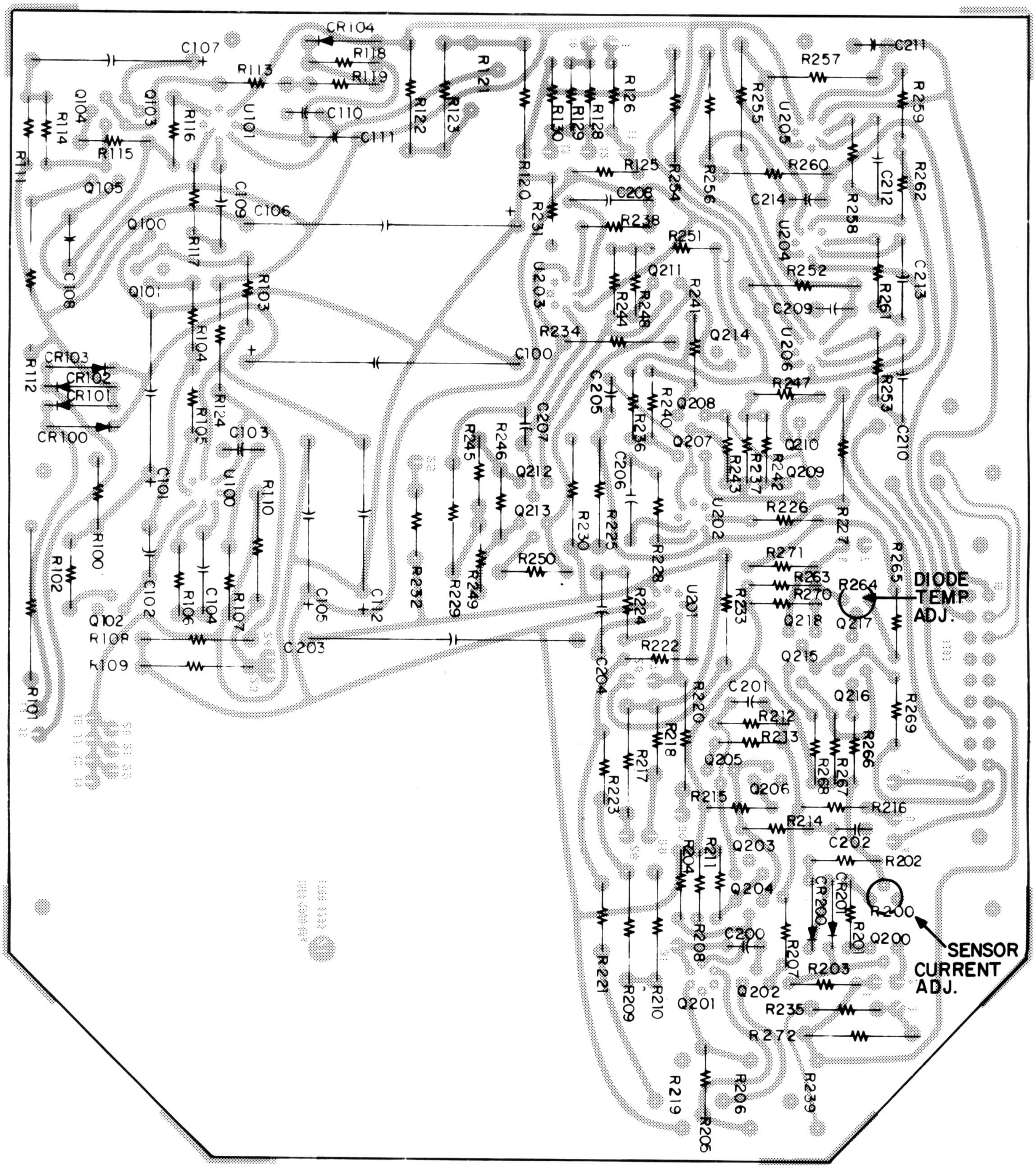


Figure VIII-6. Main Board Symbolization

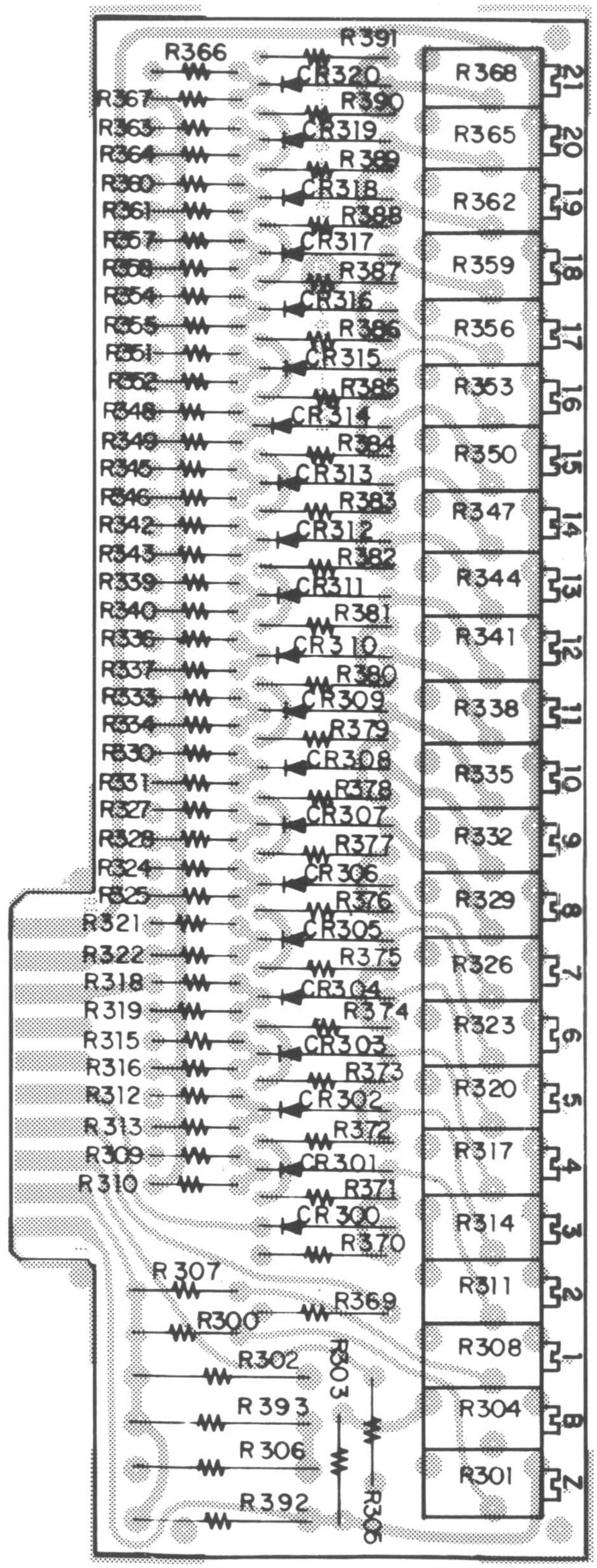
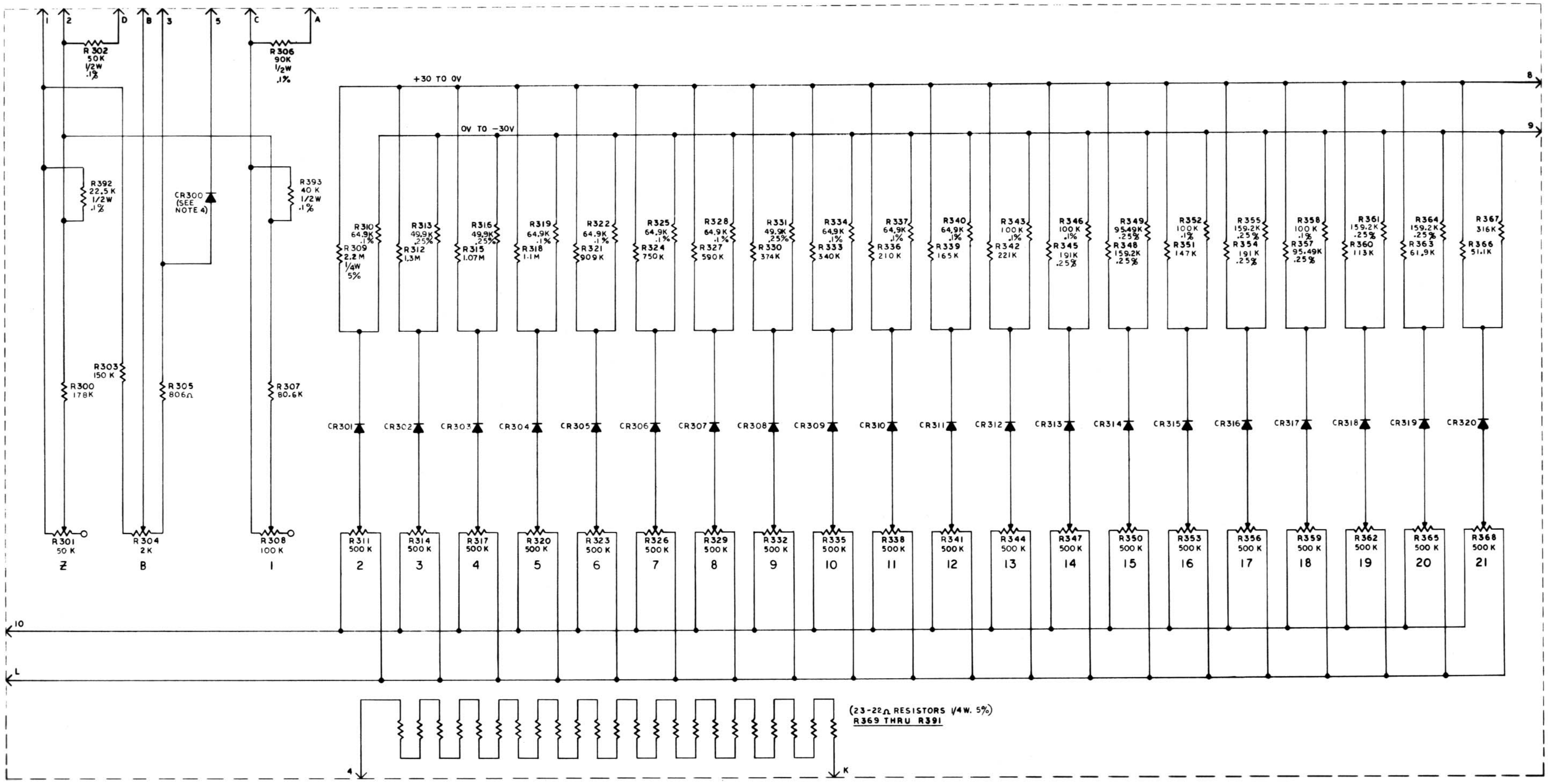


Figure VIII-7. TGL-2-100 Symbolization Master



FUNCTION GENERATOR BOARD

NOTES:

1 - ALL RESISTORS 1/8W, 1%, METAL FILM, UNLESS OTHERWISE NOTED.

2 - ALL 1/4W, 5% RESISTORS ARE CARBON COMPOSITION.

3 - DIODES CR301 THRU CR320 ARE IN482B AND ARE MATCHED PER P.A.R. SPEC.#700311.

4 DIODE CR300 SELECTED PER P.A.R. SPEC.#701106

Figure VIII-8. TGL-2-100 Schematic

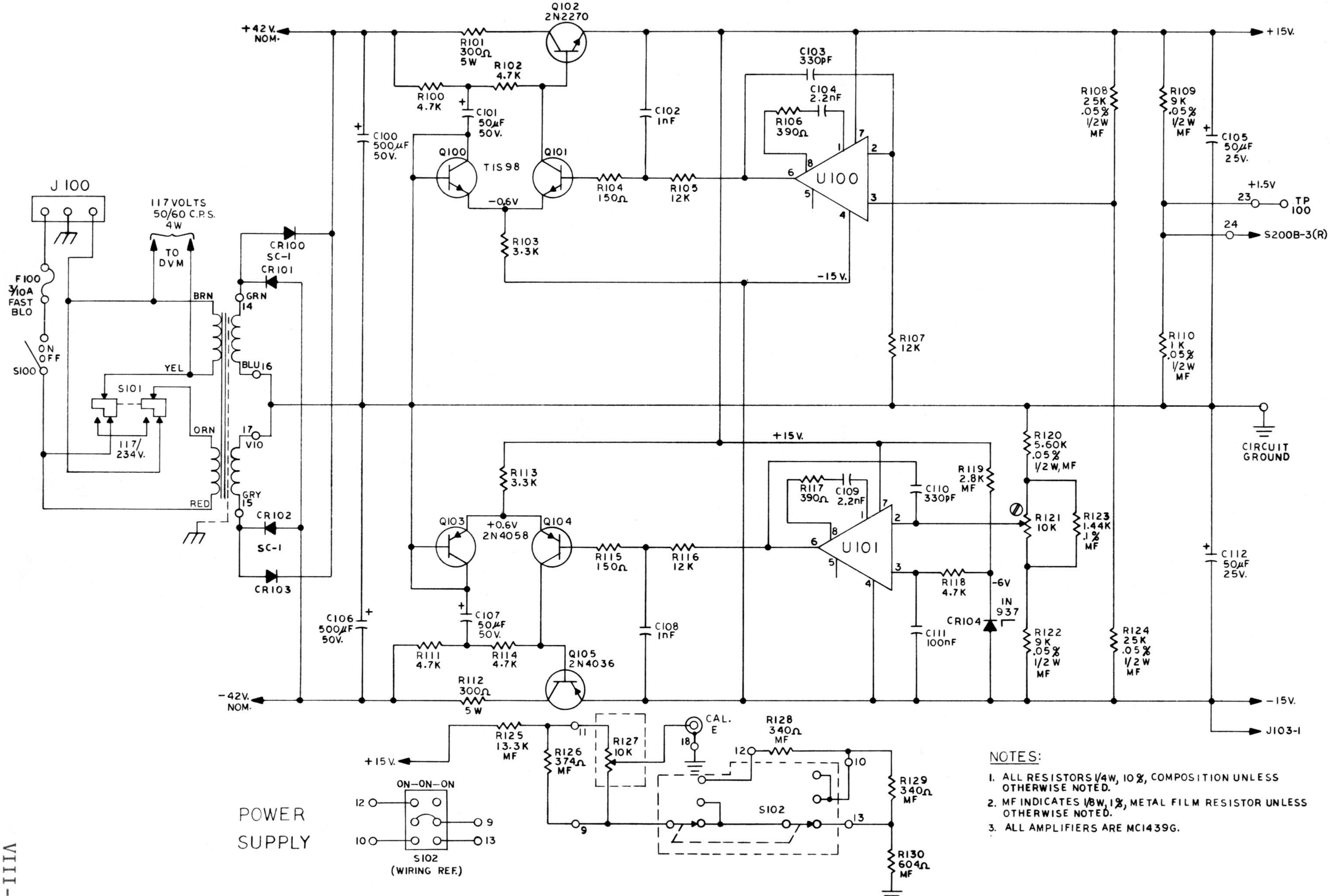


Figure VIII-9. Power Supply Schematic

SECTION XI

APPENDIX

ADDENDUM, 10/71
MODEL DRC-3 MANUAL

The following procedure replaces the procedure to be found under 'D' on page V-4 of the instruction manual.

ALIGNING THE PLUG-IN BOARD

INTRODUCTION

Before the plug-in board can be aligned to a given sensor, it is necessary to have the calibration table for that sensor. Each table is divided into three sections, with each section providing a series of calibration temperatures and calibration voltages for a single range. The ranges correspond to the two variations of the Model DRC-3 currently available as follows: Model DRC-3 - 2 K to 100 K, Model DRC-3A - 4 K to 300 K. In other words, the necessary data is furnished to calibrate to a sensor for use with any Model DRC.

Three different 'reference' tables follow this addendum, one for each temperature range. These tables list the plug-in board trim-potentiometer to be adjusted and the calibration temperature corresponding to each adjustment. The corresponding calibration voltage is blank, indicating that these are general tables and that the data for a specific sensor must be entered. Operators are strongly advised to transfer the required data from the calibration tables supplied with the sensor to these reference tables to facilitate making the calibration. If more than one sensor is involved, it will prove convenient to make copies of these tables so that the data for all the sensors can be transferred.

The only item of external equipment required for the calibration is a digital voltmeter able to make voltage measurements with an accuracy of ±0.1 mV. In the course of the calibration, a cable interconnects the rear-panel variable voltage source to the front-panel Probe Input jack. By connecting a BNC Tee connector to this Probe Input jack and connecting one input of the Tee to the external voltmeter and the other input of the Tee to the rear-panel connector, provision is easily made for making the required measurements.

The following procedure contains references to both the Model DRC-3 digital display and to the display of the external digital voltmeter. To make it clear which one is being referred to, the external voltmeter indication will be referred to as the DVM display, while the Model DRC-3 indication will simply be referred to as the panel meter display.

PROCEDURE

(1) Verify that the adjustments outlined in paragraphs 'A', 'B', and 'C' of subsection 5.3 are correct.

(2) Set the front-panel function switch to A ZERO. Then adjust the corresponding trim-potentiometer for a panel meter display of .000.

(3) Set the function switch to B ZERO and adjust the corresponding trim-potentiometer for a panel meter display of .000.

(4) Set the function switch to CAL and adjust the 1.500 CAL trim-potentiometer for a panel meter display of 1.500.

(5) Remove the Model DRC-3 cover. Then adjust all the plug-in board trim-potentiometers to the center of the range WITH THE EXCEPTION OF THE 'B' TRIM-POTENTIOMETER WHICH SHOULD NOT BE DISTURBED.

(6) If necessary, adjust the 'B' trim-potentiometer by means of the following procedure. NOTE: Ordinarily, one should never have to change the setting of this potentiometer, which is set and sealed at the factory. This is done whether the board is shipped aligned to a specific sensor or not. The 'B' potentiometer setting is good for all sensors. Probably the only circumstances under which it might be necessary to change the setting of this adjustment would be where the adjustment has been disturbed accidentally or where one of the board components associated with the adjustment has failed and been replaced. In any case, should it ever prove necessary to readjust the 'B' trim-potentiometer, the following procedure can be used.

   (a) With the instrument power off, remove the plug-in board. Then, using the symbolization diagram on page VIII-8, identify resistor R302. Unsolder and lift one end of this resistor so that the circuit is broken. Return the plug-in board to its socket and turn on the power.

   (b) Adjust trim-potentiometer '2' fully counterclockwise (this is the fourth adjustment from the end, the sequence being Z, B, 1, 2, ----). NOTE: To be absolutely sure of the proper identity of these adjustments, refer to the diagrams on page VIII-8.

   (c) Interconnect the rear-panel connector and the front-panel PROBE INPUT jack with a short length of cable.

   (d) Set the selector switch to TEMP and adjust the rear-panel ten-turn control for a panel meter display of 00.0 K. Set the range switch associated with the control to whatever position is required to get the desired indication.

   (e) Monitor the voltage at TP200 with the external DVM. This test point is a gold terminal mounted on the main printed circuit board about two-thirds of the way toward the back and a couple of inches to the left of the plug-in board. An identifying label is printed on the board itself so there should be no difficulty in identifying the test point. Note and record the test point voltage.

   (f) The objective in making the 'B' adjustment is to achieve that adjustment which, when the ten turn control at the rear panel is adjusted for a 20 mV change in the test point voltage, will result in a particular indicated temperature on the panel meter display. The desired display indication varies according to the type of Model DRC-3 as follows.

Model DRC-3	Indicated Temperature
DRC-3	2.9 K
DRC-3A	5.5 K

If the 'B' setting is wrong, when the 20 mV change is made, the display will indicate a temperature other than as indicated above. It may be necessary to go back and forth a few times to get the correct setting. Each time the adjustment is changed, check the effect by: (1) readjusting the ten-turn control for 00.0 K, (2) noting and recording the voltage at TP200, (3) adjusting the ten-turn control for a 20 mV change in the TP200 voltage, and (4) noting the resulting panel meter temperature indication.

(g) After completing the adjustment, turn off the power, remove the plug-in board, and resolder resistor R302. Then return the plug-in board to its socket and turn the power back on.

(7) Set the 'Z' and '1' trim-potentiometer adjustments as follows.

(a) Connect the external DVM to the Probe Input using a BNC 'Tee" as explained in the introduction.

(b) Set the ten-turn control so that the DVM displays the 'Z' calibration voltage as given in the reference table. Then adjust the 'Z' trim-potentiometer so that the panel meter display indicates the 'Z' calibration temperature as given in the table.

(c) Set the ten-turn control so that the external DVM displays the '1' calibration voltage. Then adjust the '1' trim-potentiometer so that the panel meter display indicates the '1' calibration temperature.

(d) Repeat steps b and c until no further improvement can be made in these two adjustments.

(8) Adjust in sequence (2, 3, 4, ------ 21) the remaining 21 trim-potentiometers. For each, proceed as follows.

(a) Set the ten-turn control so that the external DVM indicates the calibration voltage which the table indicates as corresponding to the trim-potentiometer to be adjusted.

(b) Adjust the appropriate trim-potentiometer to obtain the corresponding calibration temperature indication on the panel meter display.

These adjustments do not interact, making it a matter of only a few minutes to complete the alignment. When the procedure is completed, it is generally advisable to go back through the entire procedure again 'just to be sure'. Ordinarily, no readjusting will prove necessary on the second time through.

REFERENCE CALIBRATION TABLE FOR MODEL DRC-3 (2 K to 100 K)

Trim-potentiometer	Calibration Temperature	Calibration Voltage
Z	2.0 K	______
B*		
1	2.7 K	______
2	3.4 K	______
3	4.2 K	______
4	5.3 K	______
5	6.3 K	______
6	7.6 K	______
7	9.5 K	______
8	11.4 K	______
9	15.5 K	______
10	23.1 K	______
11	27.7 K	______
12	30.7 K	______
13	33.9 K	______
14	37.0 K	______
15	40.0 K	______
16	45.0 K	______
17	50.0 K	______
18	57.0 K	______
19	70.0 K	______
20	84.0 K	______
21	100.0 K	______

*Factory sealed adjustment.

REFERENCE CALIBRATION TABLE FOR MODEL DRC-3A (4 K to 300 K)

Trim-potentiometer	Calibration Temperature	Calibration Voltage
Z	4.2 K	________
B*		
1	5.5 K	________
2	8.0 K	________
3	11.5 K	________
4	16.8 K	________
5	21.5 K	________
6	26.0 K	________
7	30.0 K	________
8	34.0 K	________
9	39.6 K	________
10	46.5 K	________
11	51.0 K	________
12	64.0 K	________
13	80.0 K	________
14	96.0 K	________
15	130.0 K	________
16	166.0 K	________
17	194.0 K	________
18	225.0 K	________
19	248.0 K	________
20	277.0 K	________
21	300.0 K	________

*Factory sealed adjustment.

If R310 is **49.9 K**

Trimpot #	Calibration Temp.
Z	2.0 K
1	2.0 K
2	3.0 K
3	4.2 K
4	5.7 K
5	7.5 K
6	10.0 K
7	12.3 K
8	16.0 K
9	19.2 K
10	24.0 K

Trimpot #	Calibration Temp.
11	30.0 K
12	36.0 K
13	41.8 K
14	47.6 K
15	53.6 K
16	60.0 K
17	66.7 K
18	73.8 K
19	80.9 K
20	88.1 K
21	100.0 K

If R310 is **64.9 K**

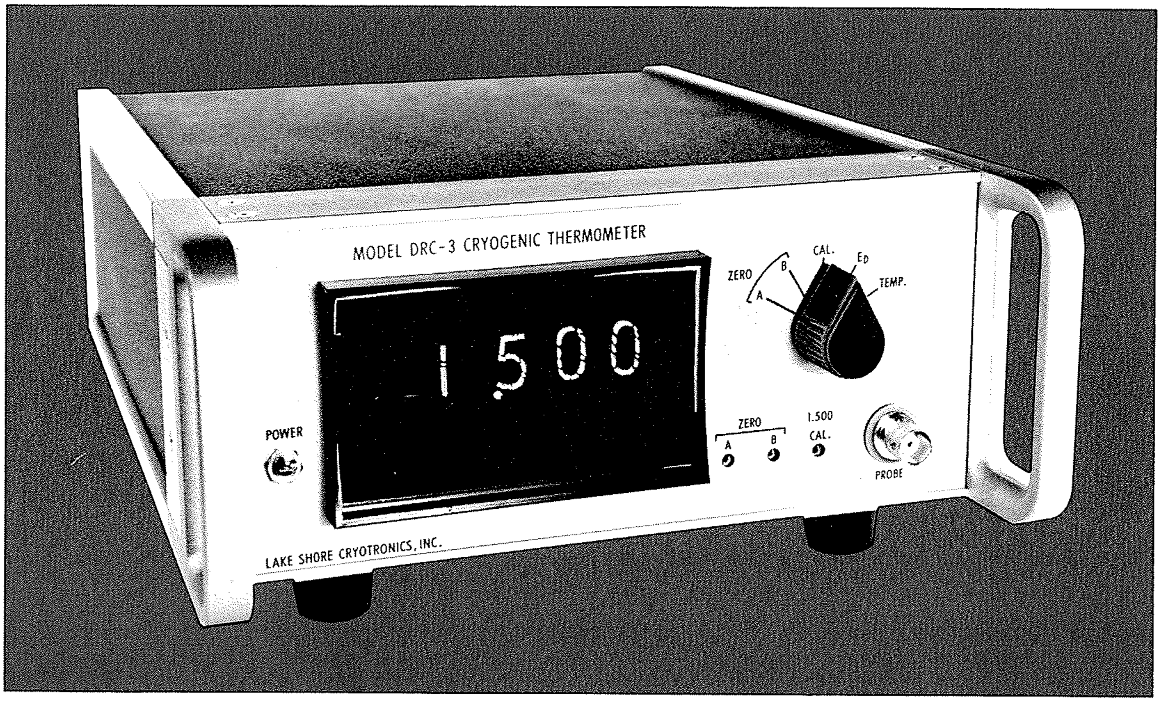
Trimpot #	Calibration Temp.
Z	2.0 K
1	2.7 K
2	3.4 K
3	4.2 K
4	5.3 K
5	6.3 K
6	7.6 K
7	9.5 K
8	11.4 K
9	15.5 K
10	23.1 K

Trimpot #	Calibration Temp.
11	27.7 K
12	30.7 K
13	33.9 K
14	37.0 K
15	40.0 K
16	45.0 K
17	50.0 K
18	57.0 K
19	70.0 K
20	84.0 K
21	100.0 K

MODEL DRC-3

DIGITAL CRYOGENIC THERMOMETER

1.5 to 400 K



The DRC-3 Digital Cryogenic Thermometer is the first single sensor, full range direct readout instrument for the range of 1.5 to 400 K. Direct digital readout to 0.1 K is provided from 2 to 100 K with an accuracy of ± 0.2 K. Readout over the range from 100 to 400 K at a somewhat reduced accuracy is obtained by readout of the sensor voltage which can be chart converted to the temperature being measured. (This capability is provided over the full useful range of below 1.5 to 400 K.)

Developed for use with the TG-100 Gallium Arsenide Diode Cryogenic Sensor, the DRC-3 Cryogenic Thermometer utilizes a plug-in adjustable calibration board. This calibration board, model TGL-2-100, can be aligned with any appropriately calibrated TG-100, should it be desired to change sensors at any time.

Alternately, extra calibration boards may be utilized so that each may be adjusted to match the characteristics of one of a number of sensors. In this manner, by interchanging these calibration boards or by utilizing a switching device and multiple board, the DRC-3 can conveniently be used with multiple TG-100 sensors.

An optional BCD output provides direct connection of the instrument to data processing equipment.

As a result of the relatively high output of the gallium arsenide sensor over the entire temperature range of the instrument, the effects of stray thermal voltages, electromagnetic interference and line losses are minimized. In addition, these sensors offer small size, rugged reliability, low temperature accuracy, and higher sensitivity than sensors of previously available materials.

SPECIFICATIONS

Temperature Range: Digital Mode: 2 to 100 K with resolution of 0.1 K
Voltage Readout Mode: 1.5 to 400 K with resolution of 1 mV

Temperature Readout Accuracy: Digital Mode: ± 0.2 K
Voltage Readout Mode: below 2 K, ± 0.2 K
above 100 K, ± 0.5 K

Sensor Input: Front Panel BNC connector, with 25 ohms maximum lead resistance acceptable.

Sensor Current: 10 uA

Readout: 3-1/2 digit Nixie* display with 9/16" high numerals
*A registered trademark of the Burroughs Corporation.

Sensor Specifications: See Lake Shore Cryotronics, Inc. brochure, "TG-100 Cryogenic Sensor"

Sensor Calibrations: The TG-100 Sensor and Sensor Calibration must be ordered separately. Three ranges are available: 1.5 to 100 K, 1.5 to 300 K, and 1.5 to 400 K. Specific calibration data are required to match the TGL-2-100 calibration board. (see current price list)

Calibration Board: The TGL-2-100 calibration board must be ordered separately and is not included with the basic DRC-3 instrument. A specially identified sensor calibration is required for use with the TGL-2-100 calibration board. (see current price list)

Sensor Grounding: the DRC-3 instruction manual gives specific instructions relative to care in grounding of sensor leads, sensor, and the DRC-3.

Maximum Energy Available in Sensor Circuit: 75 microwatts. This extremely low energy level minimizes the possibility of explosion of hydrogen vapor should a sensor lead break.

Optional BCD Output: Appropriate circuitry and a rear panel connector can be provided.

Voltage Input: 115 V, 220 V, 50-60 Hz, single phase.

Power Consumption: 10 VA

Weight: 7 pounds (3.2 kG)

Dimensions: 8½" wide x 3½" high x 11" deep (23 cm W. x 6.4 cm H. x 28 cm D.)

Mounting: Freestanding

APPLICATION NOTES:

1. For optimum usage of the DRC-3 Cryogenic Thermometer instrument system, it is necessary to temper (heat-sink) the leads of the TG-100 sensor in the immediate temperature environment. A minimum of 7" of lead tempering is recommended.
2. Calibrations are provided to the same accuracy specifications for all Lake Shore Cryotronics sensor calibrations. These calibrations are at an accuracy of 0.1 mV and generally exceed the requirement for the DRC-3.
3. Any TG-100 sensor can be mated to the TGL-2-100 calibration board. Returning the DRC-3, the TG-100, and the TGL-2-100 to the factory is not necessary.
4. Twenty specific calibration points are required to match the TG-100 to the TGL-2-100 calibration board.
5. Installation instructions for the TG-100 Cryogenic Sensor are provided with the DRC-3 manual.

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