User's Manual

Model DRC-84C

Digital Cryogenic Thermometer/Controller

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LakeShore®

Lake Shore Cryotronics, Inc.
575 McCorkle Blvd.
Westerville, Ohio 43082-8888 USA

E-Mail Addresses:
sales@lakeshore.com
service@lakeshore.com

Visit Our Website:
www.lakeshore.com

Fax: (614) 891-1392
Telephone: (614) 891-2243

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Specifications, DRC-84C Temperature Controller

Input:

Temperature Range: 1.4 to 330K with standard silicon diode DRC Sensor (to 380K with other silicon Sensors). 30 to 800K with platinum sensor. Silicon diodes cannot be exposed to temperatures above their useful range.

Sensors (order separately): Silicon Diode: DT-500-DRC, DT-500CU-DRC-36 or any calibrated DT-500 Series Diode (with DRC-Precision Option). See below for proper response curve. Platinum RTD: PT-101, PT-102, PT-103, or any other 100-ohm, 0.00385/°C sensor. See response curve details below.

Sensor Input: Two section input (silicon-diode and platinum RTD). Front-panel switch selects either section. Each section accommodates two sensors with 4-terminal input for each sensor. Front-panel switches enable independent selection of either sensor within each section as display and/or control sensor. Display/control sensors cannot be mixed between silicon and platinum sections.

Sensor Excitation: Current source. 10 microamperes for each sensor in silicon-diode section, 0.5 milliampere (±0.005%) for each sensor in platinum RTD section.

Sensor Response Curves: Silicon Diode Section: Domestic US units require Sensor Curve "D". Export units require Sensor Curve "E". Sensor curves subject to change, refer to manual for proper curve when reordering Sensors. Curves to match existing Sensors available on special request. See also DRC-Precision Option. Platinum RTD Section: Standard response curve is based on 0.1% interchangeability at 0°C and temperature coefficient (0-100°C) of 0.00385/°C. Refer to Lake Shore PT-100 Technical Data for details. Special calibrations are available and may be incorporated into the 84C via the DRC-Precision Option.

Input Resistance: Greater than 1000 megohms. Maximum Sensor Power Dissipation: Silicon-diode: 25μW at 4.2K. Platinum: 25μW below 80K increasing to 100μW at 273K.

Temperature Readout:

Display: 4 digit, 1.1 cm (0.43") LED shows temperature directly in Kelvin or Celsius as selected by front-panel switch. Display Sensor can be selected independent of Control Sensor within each section.

Resolution: 0.1K or 0.1°C. "Scale Expand" increases resolution to 0.01K for temperatures below 30K and 0.05K for 30-100K (no increase in accuracy).

Accuracy (20-25°C ambient): Silicon-diode: ±0.5K at 4K and 77K, ±1.0K at 300K with standard sensor. Accuracy with Lake Shore calibrated Sensor and DRC-Precision ±0.1K or better depending on calibration range. Platinum RTD: Conforms to DIN 43760 tolerances ±0.1K. See Lake Shore PT-100 Technical Data for details. Calibrated Sensor and DRC-Precision improves accuracy to ±0.01K depending on range.

Temperature Control:

Set-Point: Digital thumbwheel selection directly in Kelvin, (+) Celsius, or (-) Celsius as determined by front-panel switch. Remotely settable in Kelvin with BCD or IEEE-488 Option.

Set-Point Resolution: 0.1K or 0.1°C.

Typical Controllability: 0.1K or better in a properly designed system.

Control Mode: Proportional (gain) and integral (reset). Set via front panel or remotely with BCD or IEEE-488 option.

Heater Output: HI: 0-25 watts (1A max, 25V max). LO: 0-10 watts nominal (1A max or 12V max). Isolated output. 25-ohm heater is recommended.

Control Sensor: Selected by front-panel pushbutton independent of Display Sensor within either section.

General:

Monitor Output: Buffered output of 1X Display Sensor voltage (silicon) and 5X Display Sensor voltage (platinum). Additional outputs listed below as options.

Dimensions, Weight: 432mm wide x 102mm high x 330mm deep (17 in x 4 in x 13 in). Style L, full-rack package. Net weight 8.4 kg (18.5 lbs).

Power: 90-110, 105-125, or 210-250VAC, 50 or 60Hz, 75 watts.

Accessories Supplied: Mating connectors for sensor inputs and monitors, instruction manual.

Options and Accessories Available:

Model DRC8-BCD. Parallel BCD interface, TTL compatible. Allows remote control of set-point, gain, reset, and provides BCD output of temperature in Kelvin and Sensor selected (either from front-panel or optional SW-10A).

Model DRC8-IEEE. 488 interface. Allows remote control of set-point, gain, reset and provides digital output of temperature in Kelvin and Sensor selected (either from front-panel or optional SW-10A).

Model DRC8-L/A. Analog output proportional to Kelvin temperature for use with recorders, or other readouts. 10mV/K at <10 ohm output resistance.

Model KT-LA. Analog output identical to DRC8-L/A except for use when unit is also equipped with DRC8-BCD.

Model KT-BCD. Parallel BCD interface identical to DRC8-BCD except for use when unit is also equipped with DRC8-L/A.

Model SW-10A. 10-Sensor Selector Switch for use with DRC Thermometer or Controller. Pushbutton selection of any one of up to 10 sensors. Connects to Sensor "B" position. Sensor selected is also identified via digital interfaces. Dimensions: 216mm wide x 102mm high x 330mm deep (8½ in x 4 in x 13 in). Style L half-rack package.

Model RM-3F. Rack ears with handles to mount style L full-rack instrument package in standard 3½" rack space.

Model RM-3H. Rack mounting hardware to mount either one of two Style L half-rack unit(s) in standard 3½" rack space.

DRC-Precision Option: Custom-programmed read-only-memory for DRC instruments which improves specified accuracy to ±0.1K or better over a given calibration range. Any DT-500 Series Silicon Diode Sensor or PT-100 Series Platinum RTD can be utilized. Requires that an appropriate calibration be purchased for the Sensor. Specify Sensor input position (A or B or 1-10 on SW-10A) to assure proper location of calibration within PROM.
First calibration stored.
Subsequent Calibrations stored in same PROM.

Model DT-500-DRC. Silicon Diode Temperature Sensor (1.5mm diameter x 4.1mm long). Specify response curve.

Model DT-500CU-DRC-36. Silicon Diode Temperature Sensor (8mm diameter x 3.3mm thick with mounting hole). Specify response curve.

Model PT-101. Platinum RTD (3.1mm diameter x 30.5 mm long).

Model PT-102. Platinum RTD (2.0mm diameter x 20.3mm long).

Model PT-103. Platinum RTD (1.8mm diameter x 12.1mm long).

Specifications subject to change.

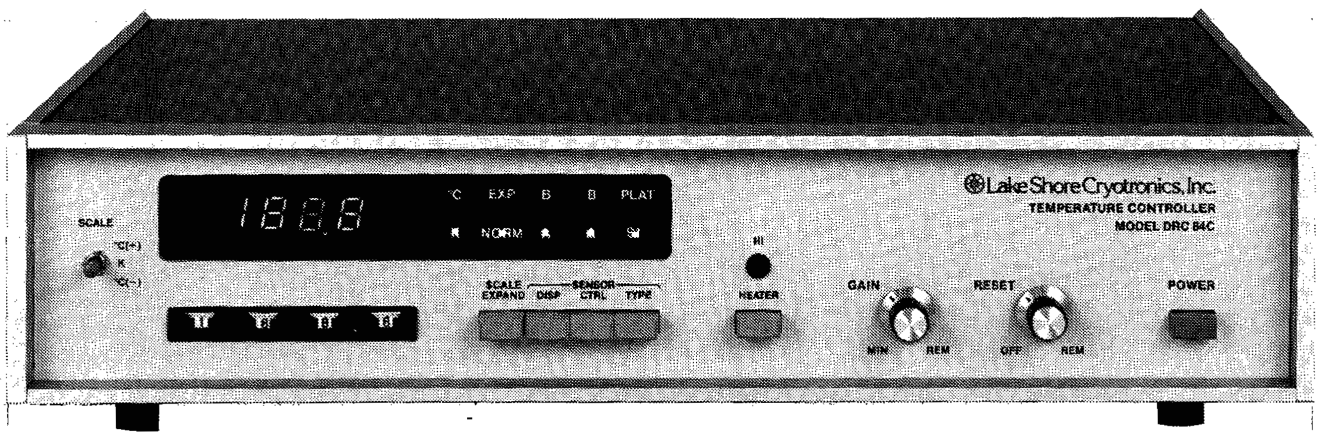


FIGURE 1.1 Model DRC-84C Digital Cryogenic Thermometer/Controller

SECTION I

General Information

1.1 Introduction

The following is a description of the DRC-84C Cryogenic Digital Thermometer/Controller. The DRC-80 Series of instruments is designed to be used with the Model DT-500-DRC and DT-500CU-DRC-36 silicon diode sensors manufactured by Lake Shore Cryotronics, Inc.

Several different diode sensor curves are designed for use with this instrument. When ordering replacement sensors, care must be taken to assure that the correct sensor curve is specified. Multiple curves are needed so that Lake Shore can assure the customer that replacement sensors will be available at any time in the future. For details, please see Section 1.4.

This controller will also use the PT-101, 102, 103 Series of platinum resistance thermometers which are available from Lake Shore Cryotronics, Inc. The data sheet for these sensors is included in the back of this manual.

1.2 Description

The DRC-80 Series is comprised of completely self-contained units providing direct digital readout in Kelvin temperature units and, for the controllers, temperature control by direct analog comparison between the sensor voltage and an analog equivalent of the digital temperature set point.

The Lake Shore DRC-84C utilizes two temperature sensor technologies to achieve its wide range: Silicon diodes for the low range (1.4-330K), and platinum RTD's for higher temperatures (30-800K). Each sensor type has its own input section which contains appropriate sensor excitation sources, signal conditioning, and switching. A microprocessor in the 84C determines the temperature based on the input section activated, the sensor signal, and the sensor-response curve stored in internal memory. Additionally, the microprocessor generates a voltage equivalent to the control set-point temperature for the sensor in use. Comparison of that voltage with the actual sensor voltage produces the error signal which is the basis of the 84C's analog control.

Each input section of the DRC-84C features dual-sensor input which enables two sensors to be used concurrently. Either sensor can be selected to be the control sensor and/or the temperature display sensor (both sensors must be of the same type - silicon diodes or platinum RTD's). Thus control can be centered at one point in a system and temperature monitored elsewhere. This permits, for instance, maintenance of temperature at a particular cold stage and simultaneous measurement of sample temperature. Selection of input section as well as display and control sensor is made via front-panel push-buttons.

A 4-digit display clearly and unambiguously shows the temperature directly in Kelvin or Celsius with 0.1 degree resolution. At low temperatures (under 30K) a SCALE EXPAND mode increases resolution to 0.01K for monitoring trends and other relative temperature measurements. Absolute accuracy at low temperatures is ±0.5K in either mode.

The silicon-diode input section of the DRC-84C is designed to use proven Lake Shore DT-500 Series DRC-curve silicon-diode Sensors, which provide measurement accuracy to ±0.5K at low temperatures. Accuracy can be increased to better than ±0.1K through use of an individually calibrated sensor and the DRC-Precision option to store the calibration. Any DT-500 Sensor can be utilized in the latter case.

Lake Shore PT-100 Series 100-ohm Platinum RTD's are the ideal Sensors for the platinum section. The standard response curve is based on 0.1% interchangeability at $0^{\circ}C$ and a temperature coefficient (0 to $100^{\circ}C$) of $0.00835/^{\circ}C$. The curve conforms to DIN standard 43760 and is published in the Lake Shore PT-100 Technical Data sheet. Custom calibrations are available and can be incorporated into the 84C via the DRC-Precision option.

Since silicon-diode sensors can be damaged by exposure to temperatures above 380K (DT-500DRC Sensors should not be used above 330K to prevent deterioration of their epoxy seals), precautions are recommended in designing systems for operation at higher temperatures. The preferred approach is to have diode sensors installed only when the system is operated below room temperature. Special software limits and error codes are generated if the instrument is set to control a point above or below the silicon diode or platinum sensor temperature limits (see Section 3.13 - Table of Error Conditions).

Control temperature is easily selected and read directly in Kelvin or Celsius on front-panel digital thumbwheel switches and an adjoining scale-select switch. The switches provide quick and constant display of the set point with a resolution of 0.1K or $^{\circ}C$. Temperature controllability is a function of system design; and performance is often better than 0.1 degree.

Both the gain and reset are variable, and can be set from the front panel to enable the Controller to be precisely tuned to match the system response over any temperature region. Ample gain and reset have been designed in to assure fast response, low offset error, and high stability.

Two heater output levels are selectable on the DRC-84C. Th HI mode provides up to 25 watts of heater power while the LO mode limits output power to a nominal 10 watts.

Five options are available with the DRC-80 Series of instruments. One option is an analog signal which is proportional to temperature (DRC8-L/A). This option has a sensitivity of 10 mV/K.

A second option is a ten-position switch (SW-10A) for multiple sensor readout. This switch is a separate half-rack box which plugs into the Sensor "B" position of the DRC-84C. The sensor selected is also identified via digital interface of the DRC-84C, if present.

Another option is a custom cut PROM (DRC-Precision Option) which corresponds to the calibration curve of the customer's DT-500 Series sensor. A combination of a calibration and custom cut PROM will increase display accuracy to nearly ±.1 Kelvin over the calibrated range. Please note that any sensor may be used with this option, i.e., the customer is not restricted to the DRC Series sensors.

There are two programming options available; each will control the set-point, the gain and reset as well as output the displayed temperature and sensor selected from the SW-10A. The DRC8-BCD-I/O is in a parallel BCD format while the DRC8-IEEE is in the popular IEEE-488 format.

The DRC-80 Series is designed around a 3870 microprocessor and associated support circuits. The DRC curve is stored in a PROM which can handle up to 32 break points per curve. The data consists of a table of temperature and voltage associated with each break point. These straight line segments can generate the DRC curve to an accuracy of better than 0.1 Kelvin over the entire temperature range (4.0 - 400K). The DRC diodes match this curve to ±0.5K at Helium and Nitrogen temperatures and to ±1.0K at room temperature.

1.3 Major Assemblies Supplied

The DRC-84C includes as standard equipment, in addition to the digital thermometer-controller, the following:

A. Operating and Servicing Manual

B. Four five Pin Plugs for Temperature Sensor Cables

C. One seven Pin Plug for Monitor of Sensor Output Voltage and the DRC8-L/A option

Model DT-500 Series silicon diodes or platinum thermometers are not supplied as part of the DRC-84C instrument.

Complete Specifications, Accessory Equipment and Customs Options are listed in the front of the Manual.

1.4 Ordering of Replacement or Additional Sensors

Two different sensor configurations are available for use with the Model DRC-80 Series instruments. These are the DT-500-DRC and the DT-500CU-DRC-36 sensors. Their description is included elsewhere in this manual. All sensor configurations are available if the diode is calibrated and a special PROM is cut.

More than one curve presently exists which can be used with the DRC-80 Series instruments. If additional sensors are ordered for use with your instrument, you must be certain to order the correct curve so that your instrument will have its stated accuracy. The proper curve may be determined in one of the following ways:

A. Specify the sensor serial number that is currently being used with the instrument (serial number is found on the end of the plastic box in which the sensor was received).

B. Specify the serial number of your instrument. Our records will indicate with which sensor the instrument is compatible.

C. Remove the top of your instrument and observe the indicator on the curve PROM.

D. The fourth way is to measure the diode voltage at 4.2K and give this value to Lake Shore Cryotronics, Inc. when re-ordering sensors.

Lake Shore PT-100-ohm Platinum RTD's are available for the platinum section. These thermometers have a 0.1% interchangeability at $0^{\circ}C$ and a temperature coefficient (0 to $100^{\circ}C$) of $0.00385/^{\circ}C$.

SECTION II

Installation

2.1 Introduction

This section contains information and instructions necessary for the installation and shipping of the model DRC-84C Cryogenic Temperature Indicator and Controller. Included are initial inspection instructions, power and grounding requirements, installation information and instructions for repackaging for shipment.

2.2 Initial Inspection

This instrument was electrically and mechanically inspected prior to shipment. It should be free from mechanical damages, and in perfect working order upon receipt. To confirm this, the instrument should be inspected visually for obvious damage upon receipt and tested electrically by use to detect any concealed damage. Be sure to inventory all components supplied before discarding any shipping materials. If there is damage to the instrument in transit, be sure to file appropriate claims with the carrier, and/or insurance company. Please advise the company of such filings. In case of parts' shortages, please advise the company. The standard Lake Shore Cryotronics warranty is given on the title page.

2.3 Power Requirements

Before connecting the power cable to line voltage, insure that the instrument is of the proper line voltage and fused accordingly. The line voltage and fuse are shown on the rear panel of the instrument.

The line voltage can be changed by switching line voltage selector switch (S2 - Figure 6.5 DRC-84C Component Layout) located on the main printed circuit board of the unit.

Nominal permissible line voltage fluctuation is ±10% at 50 to 60 Hz.

2.4 Grounding Requirements

To protect operating personnel, the National Electrical Manufacturer's Association (NEMA) recommends, and some local codes require, instrument panels and cabinets to be grounded. This instrument is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument.

2.5 Installation

The DRC-84C Thermometer/Controller is all solid state and does not generate significant heat. It may therefore be rack mounted in close proximity to other equipment in dead air spaces. The heat from such adjacent equipment should not subject the controller to an ambient temperature in excess of

$50^{o}C$ ($122^{o}F$). As with any precision instrument, it should not be subjected to the shock and vibrations which usually accompany high vacuum pumping systems.

The recommended cable diagrams for the sensor diode and heater element (in the case of the DRC-84C controllers) are shown in Figure 2.1 (a) and (b). The use of a four wire diode or resistor connections is highly recommended to avoid introducing lead IR drops which will occur if the alternate two lead sensor cable connection is used. For example, for a two lead connection with diodes, every 25 ohms of cable resistance corresponds to a .1K error above 30 Kelvin. The alternate wiring scheme shown in Figure 2.1 (c) may be used for the diode in less critical applications where lead resistance can be kept small. Because of the low resistance of platinum resistance thermometers, the four lead cable connections must be used to obtain system accuracy. The indicated shielding connections are the recommended standard practice to avoid ground loops. Figure 2.1 (d) shows the monitor connections for the analog output of sensor voltage (0-2.5V for diodes, 0-3.0V for platinum, Pin A) and optional linear analog output of temperature (0-8V, Pin C). In the case of the platinum resistor, the buffered output voltage is -20 times the actual sensor voltage. For example, if the input voltage from the platinum sensor is 0.0100V, then the buffered output voltage would be -0.2000V.

2.6 Repackaging for Shipment

Before returning an instrument to the factory, should repair be necessary, please discuss the malfunction with a factory representative. He may be able to suggest several field tests which will preclude returning a satisfactory instrument to the factory when the malfunction is elsewhere. If it is indicated that the fault is in the instrument after these tests, the representative will provide shipping and labeling instructions for returning it.

When returning an instrument, please attach a tag securely to the instrument itself (not on the shipping carton) clearly stating:

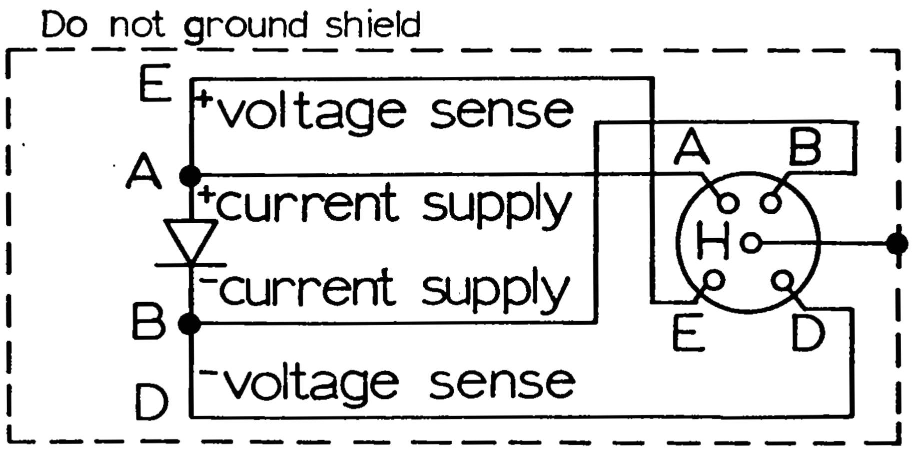
A. Owner and Address

B. Instrument Model and Serial Number

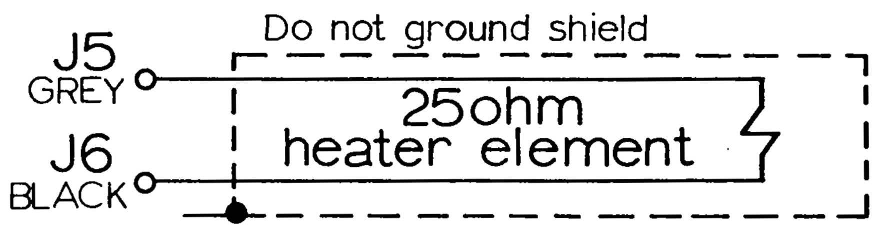
C. Malfunction Symptoms

D. Description of External Connections and Cryostats

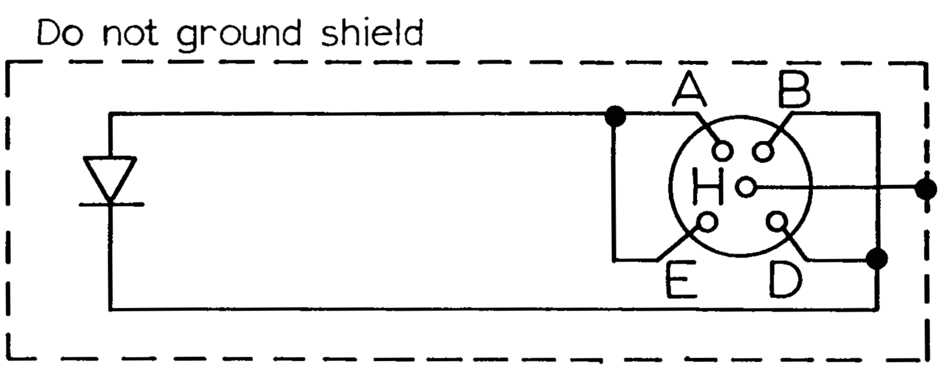
If the original carton is available, repack the instrument in a plastic bag, place in carton using original spacers to protect protruding controls, and close carton. Seal lid with paper or nylon tape. Affix mailing labels and "FRAGILE" warnings.



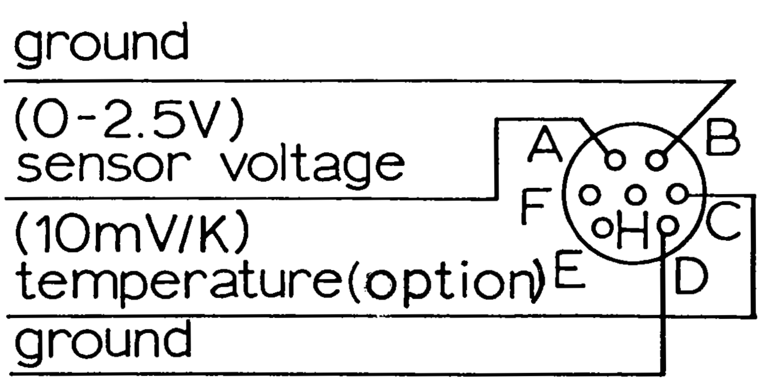
(A) RECOMMENDED SENSOR CABLE



(B) RECOMMENDED HEATER CABLE



(C) ALTERNATE SENSOR CABLE



(D) MONITOR OUTPUT

FIGURE 2.1 Sensor, Cable, and Monitor Connections

SECTION III

Operating Instructions

3.1 Introduction

This section contains a description of the operating controls and their adjustment under normal operating conditions, and typical controller applications. These instructions are based upon the instrument having been installed as outlined in Section II. The diode polarity as shown in Figure 2.1 (a), in particular, must be correct. For the DRC-84C instrument, a 25 ohm heating element is assumed attached to the "Heater" terminals as shown in Figure 2.1 (b).

3.2 Controls, Indicators, Connectors

The operating controls, indicators and connectors on the DRC-84C instrument's front and rear panels are shown in Figures 3.1, and 3.2. The numbers with leaders to various controls in the figures are keyed to the entries in Table 3.1.

Table 3.1 - Entry Number Correlation

NO. KEY	NAME	FUNCTION
1	POWER	A.C. line switch (ON/OFF) (Display serves as indicator light).
2	NO LABEL	Digital set point. Has 0.1 K resolution.
3	Gain	Variable gain allows adjustment of overall controller gain over 100 to 1 range. Maximum gain is full clockwise prior to detent position labeled REM which transfers gain control to remote BCD or IEEE option when present. The potentiometer is logarithmic so that x10 gain is approximately one-half of full rotation.
4	Reset	Adjusts reset time constant of integrator. Effectively determines time constant of integrator between 25 and 1 seconds, minimum and maximum, respectively. Note that reset control can be transferred to either the BCD or IEEE options if one of them is present.
5	NO LABEL	Digital temperature display located behind filter panel. LED indicators also indicate scale expand, which sensor is selected for display, which sensor is selected for control and type of sensor.

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6	Scale Expand	With button out, the display reads to 0.1K at all temperatures; with button in detent position, temperature reads to 0.01K below 30K, 0.05K between 30K and 100K, and to 0.1K above 100K. Scale expand is indicated on display panel.
7	Sensor Display	With button out, sensor A temperature is displayed; with button in detent position, sensor B is read and displayed. Sensor being read is also indicated on display panel.
8	Sensor Control	With button out, sensor A is control sensor; with button in detent position, sensor B is the control sensor. Control sensor is also indicated on display panel.
9	Type	With button out, the silicon diode inputs are selectable; with button in detent position, the platinum sensor inputs are selected.
10	Heater Power	With button out, heater power maximum is 10 watts (LO); in detent position, full heater power is available (25 watts).
11	HI	Hi power LED indicator.
12	Scale	Selects either the Celsius or Kelvin scale for both the display and the set-point.
13	NO LABEL	A.C. line cord.
14	Fuse	A.C. line fuse.
15	Diode Sensor Inputs	Diode Sensor A and B input lead terminals (Pin A, I+, Pin E, V+, Pin B, I-, Pin D, V-, Pin H, Shield).
16	Platinum Sensor Inputs	Same connections as for diode sensors.
17	Monitor	Analog output of sensor voltage (0-2.5V, pin A) and optional linear analog output of temperature (0-4V, pin C). Pin B is ground for sensor voltage, Pin D is ground for linear analog output.

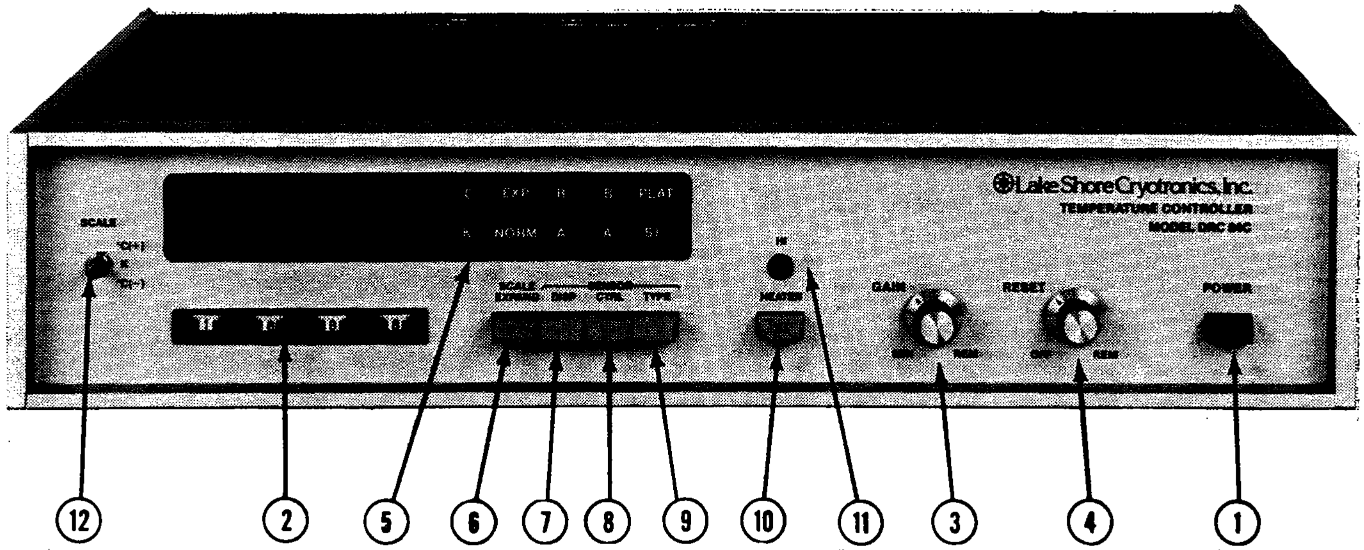

FIGURE 3.1 DRC-84C Front Panel

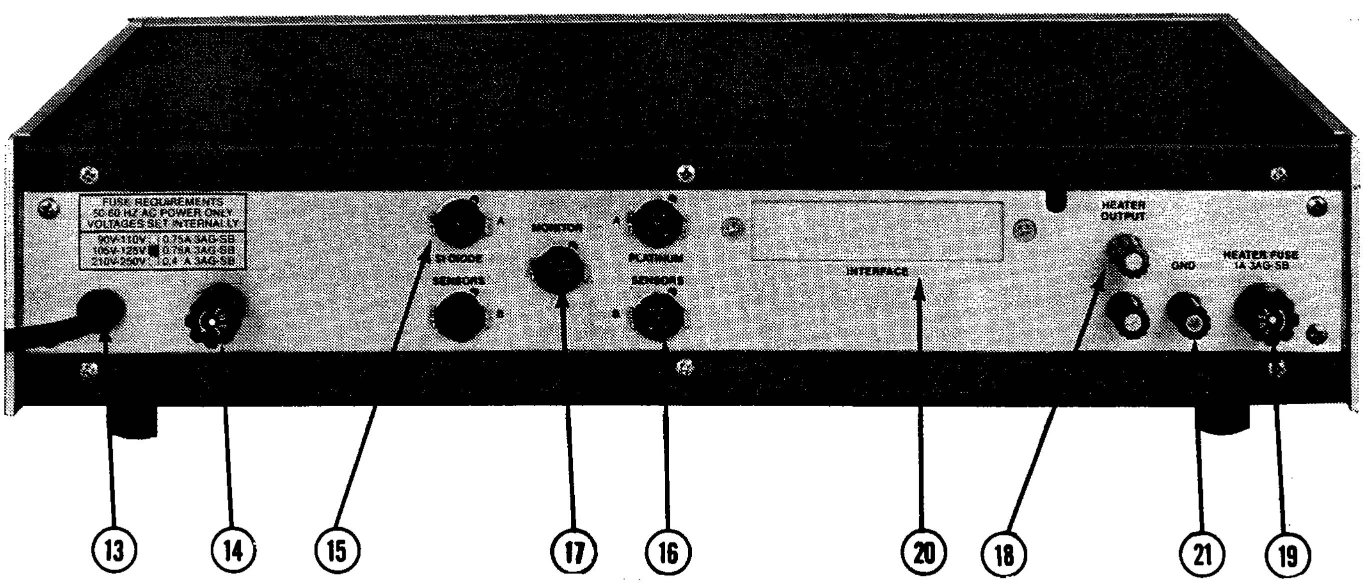

FIGURE 3.2 DRC-84C Back Panel

18	Heater	Heater element terminals (25 ohm heater required for 25 watts of power).
19	Fuse	Output power fuse (1.0 ASB specified).
20	Interface	BCD input of set point, gain and reset output of temperature. Also IEEE interface port.
21	GND	Instrument or case ground

3.3 Temperature Readout

The sensor(s) and heater should be installed following the suggestions listed in the "Installation and Application Notes for Cryogenic Sensors" brochure in Section VIII.

Connect the sensor(s) to the instrument following the diagram in Figure 2.1.

Depress the power switch and observe that the display shows the proper temperature relative to the sample temperature.

If the diode or lead wires are shorted or if the diode is connected backwards, the display will read (----) and flash 428.0. In the case of an open current or voltage lead, the display will slowly drift higher in temperature from the last voltage reading taken by the A/D converter.

The sensor and readout display for diodes should follow Table 3.4 which illustrates typical values expected of the standard DT-500-DRC or DT-500CU-DRC-36sensors for your appropriate curve.

The DIN standard curve for the platinum sensors is given in Table 3.7.

If the instrument or sensor does not agree with values listed in the table, within the accuracy of the system, consult sections on installation and/or section on troubleshooting to determine the cause and cure of the malfunction. If an error code is displayed, refer to Section 3.13 for possible corrections.

3.4 Analog Control

The digital set point of temperature is converted to an analog set point of voltage which is then compared to the sensor voltage by summing two respective currents of opposite sign.

To familiarize yourself with the DRC-84C control section, set the instrument so that you are reading and controlling with the same sensor. Turn the reset (integral) control section off. Establish a set point temperature several degrees above the display temperature. Gradually turn the gain clockwise from a minimum position. Note that as the gain is increased, the offset between the display temperature and the set point will be decreased. The gain potentiometer is logarithmic with rotation and covers a 100 to 1 range so that the gain at mid-rotation is ten times the minimum gain.

With most systems, an oscillation in temperature will occur at some clockwise rotation. Further clockwise rotation will cause a wild oscillation in temperature. The gain should then be backed off until a stable control temperature occurs. Note that an offset between display temperature and set point will still be present.

Finally, turn on the reset control. With the addition of reset, the temperature error between setpoint and control temperature should reduce to zero. The rate at which this reduces to zero is determined again by a clockwise rotation with the shortest time constant occurring at full clockwise rotation.

Note that the system can become unstable again with too much reset added. Slight variations in the gain and/or reset should give stable temperature control.

The HI-LO power switch also changes the loop gain with the HI position increasing the gain by a factor of approximately two. It may be necessary when changing from LO to HI power setting to reduce the gain slightly to compensate for the increased overall loop gain.

3.5 Analog Output of Temperature

The analog output of temperature takes the display temperature and converts it to an analog signal which has a sensitivity of 10 mV/K under normal operation. The analog output voltage is located on the monitor connector (Key $_{17}$ of Figure 3.2). See Section 3.10 for installation notes on DRC-8-L/A.

3.6 Standard DT-500-DRC and DT-500CU-DRC-36 Curves

The standard DT-500-DRC and DT-500CU-DRC-36 curve is explained in Section 3.3. The Tables include a list of PROM sensor voltages and breakpoints used in the linearization of the DRC curve to arrive at the correct temperature readout.

3.7 The 10-Sensor Selector Switch

The 10-Sensor Selector Switch includes an umbilical which ties to the DRC-84C main printed circuit board (via a 16-pin ribbon cable header which plugs into internal socket JC (see Figure 6.5, DRC-84C Component Layout) and a cable to connect the selected sensor leads to the DRC-84C (Sensor Plug B is either Key $_{15}$ or Key $_{16}$ of Figure 3.2).

The SW-10A is supplied with an 18" cable which is shielded and has male 5-pin amphenol connectors at each end. This cable connects between

J11 of the SW-10A and one of the B sensor plugs of the DRC-84C. Sensors are connected to the SW-10A via printed circuit edge J10. A 36-pin edge card connector and hood has been supplied with the SW-10A. Connectors to this edge J10 are given in Table 3.5.

3.8 Remote Parallel BCD Input/Output Option

The BCD option consists of a 16 bit parallel output of temperature along with a scale expand bit to indicate decimal point, a 15 bit parallel input of set point in Kelvin degrees or Celsius (depending on switch position), a 4 bit parallel input of gain setting, a 4 bit parallel input of reset setting, and a 4 bit output of switch position from the SW-10A.

Table 3.6 can be used for input and output line coding.

The BCD in and out is handled through connector J4 (denoted on back panel as INTERFACE), a 50 pin connector on the rear panel of the instrument. Two internal jumper wires are placed on the printed circuit board in front of internal connector JE. Cutting these jumpers allows the user to enable the remote set point by setting Pin 38, J4 high (see Table 3.6). If the option was installed prior to shipment, these jumpers have already been cut. Options that are field installed need to have their jumpers cut by the user.

Data latches internal to the instrument provide a 1-2-4-8 code using positive logic with standard TTL levels of 0.4 volts or less for low (logic 0) and 2.4 volts or higher for the high (or 1) state under full load conditions. The drivers are sufficient to drive two standard loads, 3.2mA, in the low state.

Set point is input to the instrument via a remote set point enable pin (externally generated, pin 38). With no connection made to the external enable pin, the option selects the internal (front panel) set point. When the unit is receiving a set point externally, the front panel set point switches are disabled.

The sensor temperature output is externally gated through the use of an internally generated data valid pulse.

Input of gain value and reset can be seen in the following tables (highs are denoted as "1" and lows are denoted as "0").

Table 3.2

Relative Gain for BCD Option

GAIN

Pin 48	Pin 46	Pin 44	Pin 42	Relative Gain*
0	0	0	0	Min.
0	0	0	1	2.
0	0	1	0	2.5
0	0	1	1	3.25
0	1	0	0	3.85
0	1	0	1	4.8
0	1	1	0	5.2
0	1	1	1	6.1
1	0	0	0	13.3
1	0	0	1	14.2
1	0	1	0	14.5
1	0	1	1	15.4
1	1	0	0	15.8
1	1	0	1	16.65
1	1	1	0	17.2
1	1	1	1	Max.

*The gain of the basic instrument is 10 to 1000 with the front panel potentiometer covering a 100:1 span. The relative gain is the gain factor above which the base instrument has incorporated. These relative gains can be multiplied by about 10 to get overall gain.

These values were determined to make use of the range of gain most used and the fact that the circuit is based on a negative logarithmic variation of the front panel potentiometer.

This table can be shifted up or down in terms of overall gain if the customer needs to, but should not be necessary.

The reset amplifier readings take on roughly the same sort of plot as the gain with minimum reset value with all lines low and maximum reset value with all lines high.

Table 3.3

Reset Time Constants for BCD Option

RESET:

Pin 47	Pin 45	Pin 43	Pin 41	(sec)
0	0	0	0	Off (Open)
0	0	0	1	28
0	0	1	0	21
0	0	1	1	19
0	1	0	0	16
0	1	0	1	14
0	1	1	0	12
0	1	1	1	10
1	0	0	0	9
1	0	0	1	8
1	0	1	0	7
1	0	1	1	6
1	1	0	0	5
1	1	0	1	4
1	1	1	0	3
1	1	1	1	Min.

Table 3.4

DT-500DRC (D) Voltage-Temperature Characteristic

BP#	TEMP (K)	PROM VOLTAGE
	1.4	2.5984
	1.5	2.5958
	1.6	2.5932
	1.7	2.5906
	1.8	2.5880
	1.9	2.5854
30	2.0	2.5828
	2.2	2.5735
	2.4	2.5643
	2.6	2.5551
	2.8	2.5458
29	3.0	2.5366
	3.2	2.5226
	3.4	2.5086
	3.6	2.4946
	3.8	2.4807
	4.0	2.4667
	4.2	2.4527
	4.4	2.4387
	4.6	2.4247
	4.8	2.4108
	5.0	2.3968
	5.5	2.3618
	6.0	2.3269
	6.5	2.2919
	7.0	2.2570
	7.5	2.2220
	8.0	2.1871
	8.5	2.1521
28	9.0	2.1172
	9.5	2.0909
	10.0	2.0646
	11.0	2.0119
	12.0	1.9592
27	13.0	1.9066
	14.0	1.8338
26	15.0	1.7610
	16.0	1.6984
25	17.0	1.6359
	18.0	1.5646

DT-500DRC (D) Voltage-Temperature Characteristic

BP#	TEMP (K)	PROM VOLTAGE
	19.0	1.4932
	20.0	1.4219
24	21.0	1.3505
	22.0	1.3006
23	23.0	1.2507
	24.0	1.2114
22	25.0	1.1720
21	26.0	1.1486
20	27.0	1.1308
19	28.0	1.1190
18	29.0	1.1116
17	30.0	1.1058
16	32.0	1.0970
15	34.0	1.0902
	36.0	1.0850
	38.0	1.0798
14	40.0	1.0746
	45.0	1.0633
	50.0	1.0520
13	55.0	1.0407
	60.0	1.0287
	65.0	1.0166
12	70.0	1.0046
	75.0	0.99172
	80.0	0.97890
	85.0	0.96609
11	90.0	0.95327
	95.0	0.93987
	100.0	0.92647
	105.0	0.91307
	110.0	0.89966
	115.0	0.88626
	120.0	0.87286
	125.0	0.85946
10	130.0	0.84606
	135.0	0.83228
	140.0	0.81850
	145.0	0.80472
	150.0	0.79094
	155.0	0.77716

DT-500DRC (D) Voltage-Temperature Characteristic

BP#	TEMP (K)	PROM VOLTAGE
	160.0	0.76338
	165.0	0.74961
9	170.0	0.73582
	175.0	0.72170
	180.0	0.70757
	185.0	0.69344
	190.0	0.67931
	195.0	0.66518
	200.0	0.65105
	205.0	0.63693
	210.0	0.62280
	215.0	0.60867
8	220.0	0.59455
	225.0	0.58080
	230.0	0.56707
	235.0	0.55334
7	240.0	0.53960
	245.0	0.52649
	250.0	0.51337
	255.0	0.50026
	260.0	0.48714
6	265.0	0.47403
	270.0	0.46057
	275.0	0.44711
	280.0	0.43365
5	285.0	0.42019
	290.0	0.40613
	295.0	0.39208
	300.0	0.37802
4	305.0	0.36397
	310.0	0.34940
	315.0	0.33482
	320.0	0.32025
	325.0	0.30568
	330.0	0.29111
	335.0	0.27654
	340.0	0.26197
3	345.0	0.24739
	350.0	0.23325
	355.0	0.21911
	360.0	0.20497
2	365.0	0.19083
	370.0	0.17774
	375.0	0.16464
1	380.0	0.15155

Table 3.5

SW-10A CONNECTOR DETAIL

Function	Sensor	Edge Connector Contact
Shield	All	1
I-	All	2
V+	1	A
V-	1	B
I+	1	3
V+	2	C
V-	2	D
I+	2	4
V+	3	E
V-	3	F
I+	3	5
V+	4	H
V-	4	J
I+	4	6
V+	5	K
V-	5	L
I+	5	7
V+	6	M
V-	6	N
I+	6	8
V+	7	P
V-	7	R
I+	7	9
V+	8	S
V-	8	T
I+	8	10
V+	9	U
V-	9	V
I+	9	11
V+	10	17
V-	10	18
I+	10	12

Table 3.6

BCD TEMPERATURE OUTPUT - MODEL DRC-SERIES
REMOTE I/O

•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49

BCD TEMPERATURE OUTPUT		BCD TEMPERATURE SET POINT INPUT	
PIN		PIN	
1	800	2	.1
3	400	4	.2
5	200	6	.4
7	100	8	.8
9	80	10	1
11	40	12	2
13	20	14	4
15	10	16	8
17	8	18	10
19	4	20	20
21	2	22	40
23	1	24	80
25	.8	26	100
27	.4	28	200
29	.2	30	SW-BO
31	.1	32	SW-B1

BCD TEMPERATURE OUTPUT		BCD TEMPERATURE SET POINT INPUT	
PIN		PIN	
33	Data Valid	34	Ground
35	Trend Bit 1 - .01 0 - .1	36	SW-B2
37	SW-B3	38	Remote Control 0 - Internal 1 - External
39	Not used	40	+5V
41	BO - Reset	42	BO - Gain
43	B1 - Reset	44	B1 - Gain
45	B2 - Reset	46	B2 - Gain
47	B3 - Reset	48	B3 - Gain
49	400 IN	50	Not used

Table 3.7

DIN Standard Curve for Platinum Sensors

BP#	TEMP (K)	RES (OHMS)
28	30.0	3.82000
27	32.0	4.23481
	34.0	4.68000
26	36.0	5.14601
	38.0	5.65000
25	40.0	6.17000
24	42.0	6.72621
	44.0	7.31000
23	46.0	7.90899
	48.0	8.57000
	50.0	9.24000
22	52.0	9.92364
	54.0	10.66000
	56.0	11.41000
21	58.0	12.17995
	60.0	12.99000
20	65.0	15.01541
	70.0	17.11000
19	75.0	19.22302
	80.0	21.36000
18	85.0	23.52499
	90.0	25.67000
	95.0	27.82000
	100.0	29.95000
17	105.0	32.08087
	110.0	34.16000
	115.0	36.25000
	120.0	38.34000
	125.0	40.42000
	130.0	42.49000
	135.0	44.57000
16	140.0	46.64758
	145.0	48.69000
	150.0	50.75000
	155.0	52.80000
	160.0	54.84000
	165.0	56.88000
	170.0	58.92000
15	175.0	60.96840
	180.0	62.98000

DIN Standard Curve for Platinum Sensors

BP#	TEMP (K)	RES (OHMS)
	185.0	65.00000
	190.0	67.01000
	195.0	69.02000
	200.0	71.03000
	205.0	73.03000
14	210.0	75.04385
	215.0	77.02000
	220.0	79.00000
	225.0	80.98000
	230.0	82.96000
	235.0	84.94000
	240.0	86.92000
	245.0	88.90000
	250.0	90.88000
	255.0	92.86000
	260.0	94.83000
	265.0	96.80000
13	270.0	98.78433
	275.0	100.72000
	280.0	102.67000
	285.0	104.62000
	290.0	106.57000
	295.0	108.51000
	300.0	110.45000
	305.0	112.39000
	310.0	114.32000
12	315.0	116.27003
	320.0	118.19000
	325.0	120.11000
	330.0	122.03000
	335.0	123.95000
	340.0	125.86000
	345.0	127.78000
	350.0	129.69000
11	355.0	131.61563
	360.0	133.50000
	365.0	135.40000
	370.0	137.31000
	375.0	139.20000
	380.0	141.09000

DIN Standard Curve for Platinum Sensors

BP#	TEMP (K)	RES (OHMS)
	385.0	142.98000
	390.0	144.87000
	395.0	146.76000
10	400.0	148.65215
	405.0	150.51000
	410.0	152.39000
	415.0	154.26000
	420.0	156.14000
	425.0	158.01000
	430.0	159.87000
	435.0	161.73000
	440.0	163.59000
9	445.0	165.46573
	450.0	167.30000
	455.0	169.15000
	460.0	171.00000
	465.0	172.84000
	470.0	174.68000
	475.0	176.52000
	480.0	178.36000
	485.0	180.19000
8	490.0	182.03545
	495.0	183.85000
	500.0	185.67000
	505.0	187.49000
	510.0	189.32000
	515.0	191.13000
	520.0	192.94000
	525.0	194.75000
	530.0	196.56000
7	535.0	198.38649
	540.0	200.17000
	545.0	201.96000
	550.0	203.75000
	555.0	205.54000
	560.0	207.33000
	565.0	209.12000
	570.0	210.91000
	575.0	212.69000
	580.0	214.46000

DIN Standard Curve for Platinum Sensors

BP#	TEMP (K)	RES (OHMS)
6	585.0	216.25553
	590.0	218.01000
	595.0	219.78000
	600.0	221.55000
	605.0	223.31000
	610.0	225.07000
	615.0	226.83000
	620.0	228.59000
	625.0	230.34000
5	630.0	232.10593
	635.0	233.84000
	640.0	235.57000
	645.0	237.31000
	650.0	239.06000
	655.0	240.79000
	660.0	242.52000
	665.0	244.25000
	670.0	245.97000
4	675.0	247.71350
	680.0	249.42000
	685.0	251.14000
	690.0	252.85000
	695.0	254.56000
	700.0	256.27000
	705.0	257.97000
	710.0	259.68000
3	715.0	261.39092
	720.0	263.07000
	725.0	264.77000
	730.0	266.46000
	735.0	268.14000
	740.0	269.83000
	745.0	271.51000
	750.0	273.19000
	755.0	274.87000
2	760.0	276.56633
	765.0	278.22000
	770.0	279.88000
	775.0	281.55000
	780.0	283.21000
	785.0	284.87000
	790.0	286.53000
	795.0	288.18000
1	800.0	289.83000

3.9 IEEE Interface Option

The IEEE interface option available for the DRC instruments fully complies with the IEEE standard 488-1978 and incorporates the functional, electrical and mechanical specifications of the standard.

3.9.1 General IEEE Specifications and Operation

The following discussion covers the general operation of the IEEE-488 interface. For a more detailed description of signal level and interaction, refer to the IEEE Std. 488-1978 publication "IEEE Standard Digital Interface for Programmable Instrumentation".

All instruments on the interface bus must be able to perform the interface functions of TALKER, LISTENER, or CONTROLLER. A TALKER transmits data onto the bus to other devices. A LISTENER receives data from other devices through the bus. Some devices perform both functions. The CONTROLLER designates to the devices on the bus which function to perform.

The IEEE works on a party line basis with all devices on the bus connected in parallel. All the active circuitry of the bus is contained within the individual devices with the cable connecting all the devices in parallel to allow the transfer of data between all devices on the bus.

There are 16 signal lines contained on the bus:

A) 8 Data Lines
B) 3 Byte Transfer Control Lines
C) 5 General Interface Management Lines

The data lines consist of 8 signal lines that carry data in a bit parallel, byte serial format. These lines carry universal commands, addresses, program data, measurement data, and status to all the devices on the bus. The controller designates the functions of the units on the bus by setting the ATN line low (true) and sending talk or listen addresses on the DATA lines. When the ATN line is low, all devices listen to the DATA lines. When the ATN line goes high (false), then the devices addressed to send or receive data perform their functions while all others ignore the DATA lines.

Transfer of the information on the data lines is accomplished through the use of three signal lines: DAV (Data Valid), NRFD (Not Ready For Data), and NDAC (Not Data Accepted). These signals operate in an interlocking handshake mode. The two signal lines, NRFD, and NDAC are each connected in a logical AND to all devices connected to the bus. The DAV is sent by the talker and received by listeners while the NRFD and NDAC are sent by listeners back to the talker.

The General Interface Management Lines manage the bus and control the orderly flow of commands on the bus. The IFC (Interface Clear) message basically clears the interface to a known state appropriate to the device being addressed. SRQ (Service Request) is used by a device to indicate the need for attention or service and to request an interruption of data flow. REN (Remote Enable) is used to select between two sources of device data (an an example: front panel or rear panel controls on a measurement device). EOI (End or Identify) indicates the end of a multiple byte transfer sequence, or along with the ATN line, executes a polling sequence.

3.9.2 Specific Operation of the DRC8-IEEE Interface

The DRC8-IEEE allows for the remote control of set-point, gain and reset. It also provides a digital output of temperature in Kelvin, the present values of set-point, gain and reset, as well as the status of the front panel switches and Remote/Local status.

Address and function selection are made via a switch package located on the rear panel of the DRC instrument (see Figure 3.3 DRC8-IEEE panel layout). Positions 4-8 of the switch are the address switches for the interface with 4 being the most significant bit and 8 being the least significant bit. As an example: with switches 5, 6, and 7 ON, and switches 4 and 8 OFF, the address selected is 14 (or E base 16). Position 3 of the switch package is the TALKER select with position 2 being the LISTENER select. Both functions are selected with both switches OFF (or up), while either can be deselected by turning the appropriate switch ON (or down).

Switch position 1 is used to select the order in which the output delimiters are put onto the IEEE bus. The following table gives the delimiter orientation versus switch position:

Switch 1 Position	Delimiter Order (Delm 1)(Delm 2)
Up (OFF)	(LF) (CR)
Down (ON)	(CR) (LF)

The use of this switch allows the DRC8-IEEE to interface to controllers which accept both forms of delimiters to terminate input strings. NOTE: the address switches are updated on power up only. The address and delimiter orientation is read only when the instrument is turned on. Any change in the address switch while the instrument is on will be ignored.

The DRC8-IEEE transmits and receives all characters in ASCII. The cable connector meets IEEE-488, 1978 standards and is polarized for proper cable insertion. The following table shows cable connector contact wiring for the IEEE-488 bus:

Contact	Signal Line	Contact	Signal Line
1	DIO1	13	DIO5
2	DIO2	14	DIO6
3	DIO3	15	DIO7
4	DIO4	16	DIO8
5	EOI(24)	17	REN(24)
6	DAV	18	Gnd(6)
7	NRFD	19	Gnd(7)
8	NDAC	20	Gnd(8)
9	IFC	21	Gnd(9)
10	SRQ	22	Gnd(10)
11	ATN	23	Gnd(11)
12	SHIELD	24	Gnd(LOGIC)

Note: Gnd (n) refers to the signal ground return of the referenced contact. EOI and REN return on contact 24.

When addressed as a TALKER, the interface outputs gain and reset settings, front panel settings (including Remote/Local status), set point and display temperature in the form of five string variables. After each one of the variables is output, delimiters DELM1 and DELM2 are transmitted. After the fifth variable, the last delimiter has the EOI line set for end.

NOTE: In programming for an input from the DRC8-IEEE interface five string variables must be used (or read into the computer) or the interface will hang up, waiting to output all of the data. In outputting data to an array, the array must have enough elements to allow the input of all five variables from the DRC8-IEEE interface (in this case the number of elements is 27). Since there are five sets of delimiters output, and most computers use these delimiters to terminate string variables, the need for five string variables arises. An example of a transmission is as follows:

FUNCTION	FORMAT FOR DATA	FORMAT LIMITS (X)
Gain	X(DELM1)(DELM2)	0-9, A-F
Reset	X(DELM1)(DELM2)	0-9, A-F
Front Panel	XXX(DELM1)(DELM2)	0-9, A-F
Set Point	XXX.X(DELM1)(DELM2)	numerics only
Temperature	XXXX.XX(DELM1)(DELM2)	numerics only

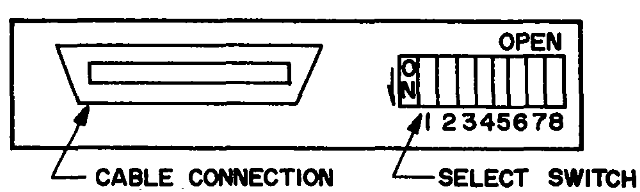

Figure 3.3 DRC-84C-IEEE Panel Layout

The front panel variable has as its first character a remote/local status indicator. If the first character is a 0, then the instrument will respond to front panel set point controls. If the character is a 1, then the unit will respond to a set point from the IEEE interface.

The next two front panel characters are output in a packed format with individual bits representing a piece of data. The front panel indicators are denoted as follows:

Bit	8	7	6	5	4	3	2	1

a)	Bits 1-4	SW-10A Display Sensor switch positions with bit 1 being the Least Significant Bit, and bit 4 being the Most Significant Bit.		
b)	Bit 5	Type	0 1	Button Out (Si) Button In (Plat)
c)	Bit 6	Control Sensor	0 1	Button Out (A) Button In (B)
d)	Bit 7	Display Sensor	0 1	Button Out (A) Button In (B)
e)	Bit 8	Scale EXPAND Mode	0 1	Button Out (normal) Button In (Expanded Scale)*

*NOTE: The expanded scale bit is set only if the button is in and the display temperature is below 100.0°K.

A chart which shows the pushbutton information and corresponding output character is shown below. (This is data represented by the second character of the Panel information variable, or bits 5-8 above).

Output Character	Bit Representation	Expanded Scale	Display Sensor	Control Sensor	Type
0	0000	no	A	A	Si
1	0001	no	A	A	Plat
2	0010	no	A	B	Si
3	0011	no	A	B	Plat
4	0100	no	B	A	Si
5	0101	no	B	A	Plat
6	0110	no	B	B	Si
7	0111	no	B	B	Plat
8	1000	yes	A	A	Si
9	1001	yes	A	A	Plat
A	1010	yes	A	B	Si
B	1011	yes	A	B	Plat
C	1100	yes	B	A	Si
D	1101	yes	B	A	Plat
E	1110	yes	B	B	Si
F	1111	yes	B	B	Plat

The SW-10A switch position is represented by the characters 1-9, and A. The 1-9 stands for positions 1 thru 9, the A stands for position 10. The switch position information is only present for the B display sensor. When the A position is selected as display sensor, the position is returned as zero. (When there is no position present for the B display sensor, the switch position is returned as zero. An example of the panel information for a DRC instrument that is in remote (accepts set point commands from the IEEE), is in the expanded scale mode, has B as display sensor, A as control sensor, and has an SW-10A position of 2, would look like 1C2.

When the instrument is in display A mode, the external switch position is ignored and the switch position character is set to zero.

An example of a transmission for an instrument which has: switch 1 of the IEEE address switch up at power on, a gain setting of 5, a reset setting of C, scale expand button in, A as display sensor, B as control sensor, no SW-10A input, set point of 130.0°K, and a display of 24.06°K, is in remote control (IEEE), and has Si as type would look like this:

5(LF)(CR)C(LF)(CR)1A0(LF)(CR)130.0(LF)(CR)0024.06(LF)(CR)
EOI SET ON FINAL (CR)

When there is a display error message, this message is transmitted over the bus in the temperature variable. The following table gives the display error and the corresponding error code output from the IEEE:

Display Sensor	Interface Equivalent
LO 1	E100.00
HI 1	E200.00
HI 2	E300.00
LO 2	E400.00

When addressed as a LISTENER, the interface must receive a code (function) and code settings to set parameters. The codes and commands along with formats are:

CODE	FUNCTION	FORMAT FOR DATA	FORMAT LIMITS (X)
A	Set Point	Variable forms of XXX.X	only numerics accepted
B	Gain	X	0-9, A-F
C	Reset	X	0-9, A-G
D	Flag Toggle	--	--

The A command allows for considerable flexibility. If the A command is received, but not followed by any numerics, the set point is set to zero. The internal program is structured so that the last three numerics before the decimal point are accepted and the first numeric after the decimal point. All other ASCII characters are ignored except for B, C, and D. The following examples should illustrate the flexibility of the input. (This format makes the allowance for the implied sign before any numeric variable output in basic programming.)

INPUT	SET POINT
A	000.0
A9	009.0
A8009.6	009.6
A130	130.0
A1Z2EF3Y.9Z	123.9
A1239	239.0
A50.5	050.5

The B and C commands each require 1 character following the command. The gain and reset values can be seen in Section 3.8.

The D code command is used to change from front panel controls to IEEE control or vice versa. The D code acts as a flag toggle, in that, if the unit is under front panel control and the D command is sent to the DRC instrument, then it will respond to changes only from the interface. If the D command is sent again, the instrument returns to front panel control. Therefore, on odd times for the D command being sent the unit is in remote control, and on even times the unit is in front panel control.

As an example, a controller sends the ASCII sequence,

A130.0B9C5D

A	is the set point code
130.0	five characters to represent the set point (130.0°K)
B	is the gain code
9	is the setting for resistors (1001)
C	is the reset code
5	is the setting for resistors (0101)
D	is the flag to convert controller operation (if no other D has been sent through, this one switches control from front panel to IEEE).

The interface looks for one of two input terminators. The DRC8-IEEE will return to normal operation when the EOI command is accepted on input. The DRC8-IEEE will also look for an input delimiter depending on the position of switch 1 of the address switch. The following table shows the input delimiter selection.

Switch 1 Position	Input Delimiter
UP (OFF)	(CR)
DOWN (ON)	(LF)

The DC (Device Clear) command on the IEEE bus will clear the flag and return control of the set point to the front panel.

3.9.3 Sample Programming

This section contains some sample programming for the DRC8-IEEE option.

3.9.3.1 Commodore Pet/CBM 2001

Set the address switch to 6 by putting address switches 6 and 7 down; 8, 5 and 4 up. Make sure switches 2 and 3 are up (off) to allow the DRC8-IEEE to both talk and listen. Set switch 1 up (off) to select (LF)(CR) as the delimiter orientation. NOTE: The address switch is updated only on power up. Connect the CBM IEEE cable to the DRC8-IEEE interface. Turn on the PET and enter the program below, including line numbers, by pressing the return key after every line. After entering the program, type RUN and press the return key. The display will read "ENTER ". To set the set point to 130.0, the remote gain value to 5, the remote reset value to A, and toggle the flag to external control type in A130B5CAD and press return. The display will then return those values just set in and return for a new input.

```
 10 INPUT"ENTER           ";A$
 20 OPEN1,6
 30 PRINT#1,A$CHR$(13)
 40 CLOSE1
 50 OPEN2,6
 60 INPUT#2,G$,R$,P$,S$,T$
 70 CLOSE2
 80 PRINT
 90 PRINT
100 PRINT"GAIN            ";G$
110 PRINT"RESET           ";R$
120 PRINT"PANEL           ";P$
130 PRINT"SET POINT       ";S$
140 PRINT"TEMPERATURE     ";T$
150 GOTO10
```

3.9.3.2 HP-85

Set the address switch to 6 by putting address switches 6 and 7 down; 8, 5 and 4 up. Make sure switches 2 and 3 are up (off) to allow the DRC8-IEEE to both talk and listen. Set switch 1 down (on) to select (CR)(LF) as the delimiter orientation. NOTE: The address switch is updated only on power up. Connect the DRC8-IEEE to the IEEE interface of the HP-85. Turn on the unit and enter the program below, including line numbers, by pressing the END LINE key after every line. Press the RUN key. The display will read "ENTER ". To set the set point to 130.0, the remote gain value to 5, the remote reset value to A, and toggle the flag to external control, type in A130B5CAD and press the END LINE key. The display will then return those values just set in and return for a new input.

```
 10 DISP"ENTER              "@INPUTA$
 20 OUTPUT706;A$
 30 ENTER706;G$,R$,P$, S$,T$
 40 PRINT
 50 PRINT
 60 PRINT"GAIN              ";G$
 70 PRINT"RESET             ";R$
 80 PRINT"PANEL             ";P$
 90 PRINT"SET POINT         ";S$
100 PRINT"TEMPERATURE       ";T$
110 GOTO10
```

3.9.3.3. HP-9845B

Set the address switch to 6 by putting address switches 6 and 7 down; 8, 5 and 4 up. Make sure switches 2 and 3 are up (off) to allow the DRC8-IEEE to both talk and listen. Set switch 1 down (on) to select (CR)(LF) as the delimiter orientation. NOTE: The address switch is updated only on power up. Connect the DRC8-IEEE to the 98034A IEEE interface of the 9845B. Turn on the unit and enter the program below, including line numbers, by pressing the STORE key after each line is entered. Press the RUN key. The display will read "ENTER ". To set the set point to 130.0, the remote gain value to 5, the remote reset value to A and toggle the flag to external control, type in A130B5CAD and press the CONT key. The display will then return those values just set in and return for a new input.

```
 10 DIMG$[5],R$[5],P$[5],S$[10],T$[10],A$[20]
 20 INPUT"ENTER             ";A$
 30 OUTPUT706;A$
 40 ENTER706;G$,R$,P$,S$,T$
 50 PRINT
 60 PRINT
 70 PRINT"GAIN              ";G$
 80 PRINT"RESET             ";R$
 90 PRINT"PANEL             ";P$
100 PRINT"SETPOINT          ";S$
110 PRINT"TEMPERATURE       ";T$
120 GOTO20
```

3.9.3.4 HP-9825A

Set the address switch to 6 by putting address switches 6 and 7 down; 8, 5 and 4 up. Make sure switches 2 and 3 are up (off) to allow the DRC8-IEEE to both talk and listen. Set switch 1 down (on) to select (CR)(LF) as the delimiter orientation. NOTE: The address switch is updated only on power up. Connect the DRC8-IEEE to the 98034A IEEE interface of the 9825A. Turn on the unit and enter the program below by pressing the STORE key after each line is typed. Press the RUN key. The display will read

"ENTER ". To set the set point to 130.0, the remote gain value to 5, the remote reset value to A and toggle the flag to external control, type A130B5CAD and press the CONT key. The printer will read the values just set in and return for a new input.

```
0 dimG$[5],R$[5],P$[5],S$[10],T$[10],A$[20].
1 ent"ENTER    ",A$
2 wrt706,A$
3 red706,G$,R$,P$,S$,T$
4 prtG$
5 prtR$
6 prtP$
7 prtS$
8 prtT$
9 gto1
```

3.9.3.5 HP-9835A

Set the address switch to 6 by putting address switches 6 and 7 down; 8, 5 and 4 up. Make sure switches 2 and 3 are up (off) to allow the DRC8-IEEE to both talk and listen. Set switch 1 down (on) to select (CR) (LF) as the delimiter orientation. NOTE: The address switch is updated only on power up. Connect the DRC8-IEEE to the 98034A interface of the HP-35A. Turn on the unit and enter the program below by pressing the STORE key after each line is typed. Press the RUN key. The display will read "ENTER ". To set the set point to 130.0, the remote gain value to 5, the remote reset value to A and toggle the flag to external control, type A130B5CAD and press the CONT key. The display will read the values just set in and return for a new input.

```
 10 INPUT"ENTER           ";A$
 20 OUTPUT706;A$
 30 ENTER706;G$,R$,P$,S$,T$
 40 PRINT
 50 PRINT
 60 PRINT"GAIN            ";G$
 70 PRINT"RESET           ";R$
 80 PRINT"PANEL           ";P$
 90 PRINT"SETPOINT        ";S$
100 PRINT"TEMPERATURE     ";T$
110 GOTO10
```

3.10 Installation of DRC BCD/L-A Option Board

The installation of the DRC BCD/L-A option board can be done as follows:

1) Remove instrument cover.

2) Insert the BCD/L-A option board into instrument JE connector (the instrument has its edge card connector configured such that the option board can only be inserted in one way).

3) Take 50 pin ribbon connector, with mounting plate attached, and secure it in Interface opening, J4 (after any existing plate is removed). Place 14 pin header connector into board connector JF (noting Pin 1 to Pin 1 alignment).

Note: Ribbon cable and 14 pin header are only present for BCD option.

4) If set point is to be controlled externally, main circuit board jumpers JMP1 and JMP2 must be cut.

5) Connect black (or green) and white wires of BCD/L-A board to 7 pin rear panel connector J3. White goes to pin C and black (or green) goes to pin D.

6) Replace instrument cover.

3.11 Installation of DRC IEEE Option Board

The installation of the DRC IEEE option board can be done as follows:

1) Remove instrument cover.

2) Remove blank plate covering J4 connector on rear panel.

3) Install 14 pin header into connector JF. Install 24 pin header into JD'. Note pin 1 to pin 1 correlation. (See Figure 6.5 - DRC-84C Component Layout for connector locations).

4) Place option board in J4 opening and secure in place with screws provided.

5) Replace instrument cover.

3.12 Rack Mounting the DRC-84C

The DRC-84C can be rack mounted with an RM-3F rack mounting kit. A typical full rack mount unit can be seen in Figure 3.4.

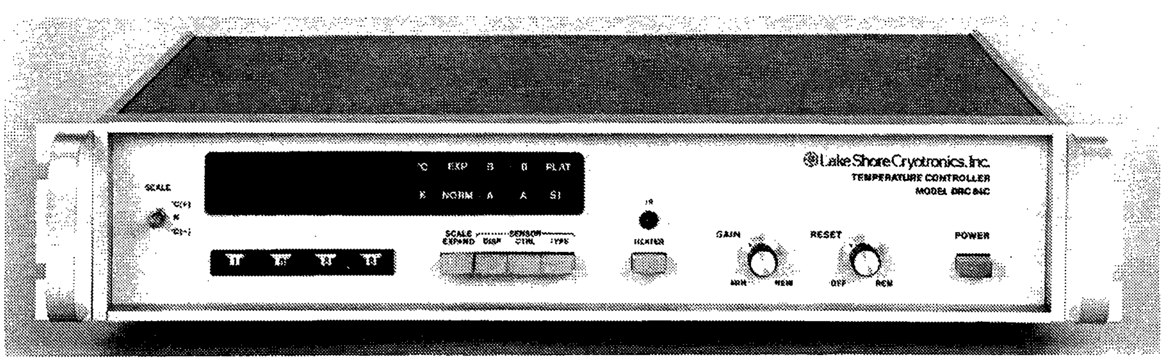

FIGURE 3.4 Typical Rack Mounted Unit

3.13 Error Conditions

The following error conditions can occur with the DRC-84C:

Display	Condition
LO 1	The display temperature calculated for the platinum sensor is below 20.0°K. Since the temperature in this range would be inaccurate, the error code has been added. This code will also be displayed if an input is selected that does not have a platinum sensor in it.
LO 2	The set point input is below 20.0°K for the platinum sensor. This is an inaccurate region of the platinum curve. The instrument will continue to look for a set point above 20.0°K and will not update the temperature information until this is done.
HI 1	The set point is above 399.9°K for the silicon diode. The instrument will continue to look for a set point within the upper limit of the sensor.
HI 2	The set point is above 799.9°K for the platinum sensor. The instrument will continue to look for a set point within the upper limit of the sensor.

SECTION IV

Theory of Operation

4.1 Introduction

The DRC-84C Thermometer/Controller is in actuality two instruments, a digital thermometer and an analog controller. A general description of the instrument is given in Section 4.2 with a detailed description in the following sections.

4.2 General Description

Refer to the DRC-84C Block Diagram (Figure 4.1) for the following discussion. Two precision 10 microampere constant current sources are used to excite the diode thermometers (Models DT-500-DRC, DT-500CU-DRC-36 or any DT-500 series sensor with a precision option). Front panel push-buttons select which sensor is to be displayed and/or controlled.

Two precision 0.5 milliamperes constant current sources are used to excite the platinum resistance thermometers (Models PT-101, 102, and 103). Two ultra-stable amplifiers multiply the voltage signal by a factor of 20 so that 100 ohms is seen as a 1.0000 volt signal. Front panel push-buttons select the type of sensor (diode or platinum) as well as which sensor is to be displayed and/or controlled.

The display sensor voltage is fed to an Analog-to-Digital converter pair (A/D), where it is converted to a digital voltage signal proportional to the sensor voltage. The multiplexed BCD outputs from the A/D are sampled and verified by the microprocessor. The microprocessor executes a program which takes the sampled sensor voltage and, using break point voltage and temperature information stored in a tabulator array, calculates the associated Kelvin temperature to better than 0.01 Kelvin. The microprocessor then outputs the temperature information to the display board. The decoder/driver decodes this temperature data, latches the information and drives the display digits.

The sensor display voltage is also available as a buffered output through the monitor plug on the rear of the instrument.

The control section of the instrument is essentially independent of the display or thermometer section. To control at a particular temperature, the thumbwheel switches on the front of the instrument are set for the desired temperature. This information is then input into the microprocessor, and, by using the same breakpoint-temperature information, a digital set point voltage is calculated. This voltage is output through data latches to a 16 bit D/A converter where an analog voltage corresponding to the set point temperature is generated.

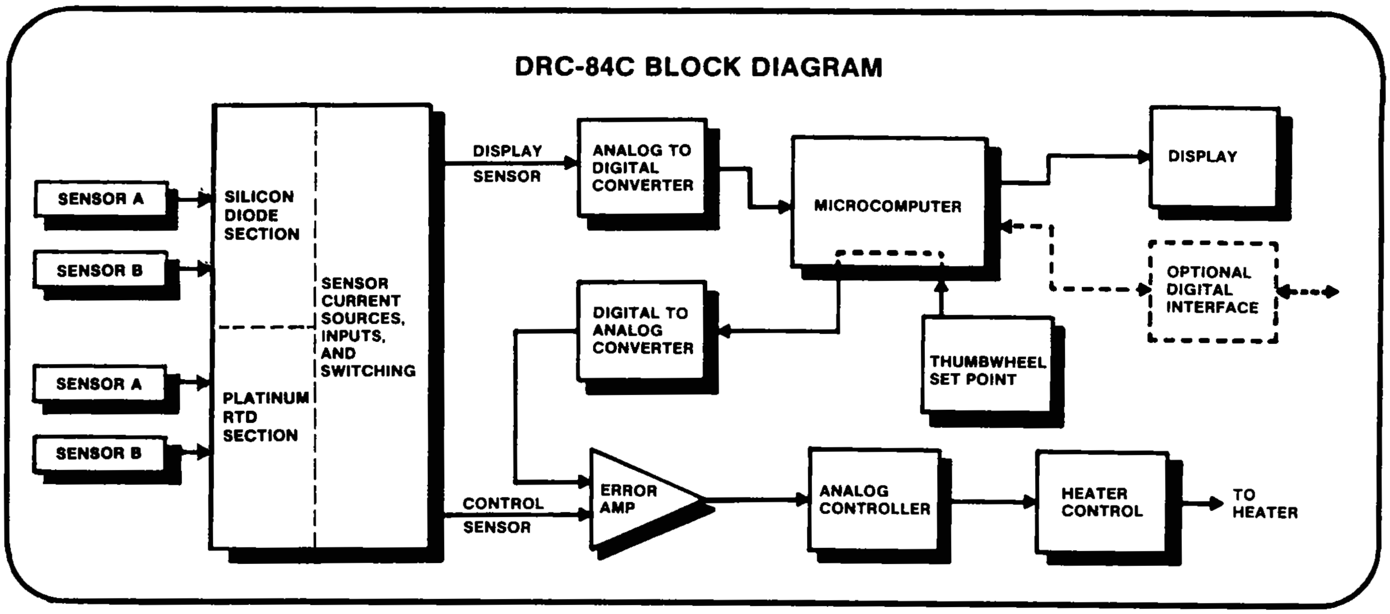

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FIGURE 4.1 DRC-84C Block Diagram

The control sensor voltage is input buffered and fed to an error amplifier along with the opposite sign set point voltage. The error amplifier generates a signal proportional to the gain setting. With the addition of reset (integral), output power is controlled and applied to the system through a twenty-five watt heater.

The microprocessor also controls the BCD and IEEE options. These options remotely control the set point, gain and reset as well as indicating the display temperature.

4.3 Detailed Description

A detailed description of the operation of the DRC instrument is outlined in the following sections. The Figures required for each section will be denoted in that section.

4.3.1 Power Supplies

Please refer to Figure 6.1 (Schematic #1) for the following discussion. There are eight different power supplies incorporated in the DRC-series instruments. The main power transformer, TX1, has split primaries for 115 or 230 volt AC operation. The slide switch, S2, selects the proper line voltage.

The first secondary is output through leads 1 and 3. This secondary is rectified by CR1 and a floating 15 volt supply is obtained through C1, C6, and the positive 15 volt regulator U1. This supply is used to power the constant current sources for diodes in the case of the DRC-80C and both diodes and platinum sensors in the case of the DRC-84C.

The second secondary, through leads 2, 4, and 6, is full wave bridge rectified by CR2-5. A +15 volt supply is generated by C2, C7 and a positive 15 volt regulator U2. The negative 15 volt supply is generated by C3, C8 and voltage regulator U3. Both these supplies are used in the A/D and D/A converters as well as the analog section. Regulators U6 and U7 with capacitors C10, C47, C48, and C11 generate plus and minus 8 volts for the low voltage, low offset operational amplifiers used in the analog section.

The third secondary is through leads 8, 10, and 12 and is full wave rectified by CR6-7. The five volt supply that is used by the TTL IC's is formed by C4, C9, and a 5 volt positive voltage regulator U4. A 5 volt half wave supply for the LED display is provided by CR8, C5 and the 5 volt positive regulator U5. The reason for splitting the 5 volt supplies is to avoid the LED display from loading down the main 5 volt supply.

The eighth supply is used in the output power section and will be covered there.

4.3.2 Precision Current Sources and Input Switching

Please refer to Figure 6.2 (Current Sources, Input Connections, Switching Schematic #2) for the following discussion.

An explanation of the constant current sources will be limited to the Sensor A source of the silicon diode since the four current source circuits are exactly the same with the exception of resistor values between the platinum and diode sources to achieve the two different values of current.

A precision reference voltage is generated by an internal temperature stabilized precision voltage reference (U12). Resistors R11 and trimpot R12 vary this voltage to match the voltage generated by feedback resistor R13. Resistor R13 has been selected to generate 4.99V (by an adjustment of the reference voltage to equal this feedback voltage). Op amp U15 drives an FET (U16) to generate a current flow through Pins A and B of the sensor connector.

The voltages generated by the sensors are fed to front panel push button switches S7, S8 and S9. Selector switch S7 selects the type of sensor selected, platinum or silicon. S10 then routes the appropriate voltage and type information to switches S8 and S9. Switch S9 selects which sensor, A or B, will be the display sensor. This switch takes the appropriate sensor voltage and feeds it to the A/D converter as well as informing the microprocessor of its position. Switch S8 selects which switch is the control sensor. This switch takes the voltage and feeds it to an input buffer amplifier to be used as the control voltage. This switch also identifies its position to the microprocessor.

Switch S10 identifies whether or not the scale expand is in use.

Switch S6 selects the power setting and will be explained in detail in the power amplifier section (Section 4.3.5).

Buffer Amplifier U19 gives a buffered output of the display sensor which is available at the monitor plug. This amplifier can have an offset voltage as high as 0.5 mV. This is adjusted to zero with trim potentiometer, R20.

4.3.3 A/D Converter and Microprocessor Hardware

Please refer to Figure 6.3 (DRC-84C Schematic #3) for the following discussion.

The Analog-to-Digital converter consists of a precision 4½ digit IC pair (8052A/7103A, U31 and U32) that produces a multiplexed BCD output that is accurate to ±1 count over the entire 40,000 count range. The 7103A (U31) runs on a 50K Hz clock cycle generated by U33. This clock frequency allows for one reading every .8 seconds (since one clock pulse is required to make one count; 50,000 pulses per second would allow for

1.2 readings per second). The digital signal is output in a bit-parallel byte serial form. The A/D converter output is multiplexed by U27 and U28 and input by the microprocessor.

In addition to the A/D information, the microprocessor inputs the front panel control information, external switch position, set point and optional inputs (BCD or IEEE), and outputs display information and set point voltage.

The microprocessor unit (MPU) used in the DRC-84C is a 38P70 which utilizes a piggy-back memory architecture. A 3870µp was originally a mask-only part with the user tied to one program form when the part was fabricated. The piggy-back variation of the part allows for variable memory space (between 8K and 64K of PROM) to be placed on top of the µp. This allows all lines that were used for addresses and data to be used for input/output.

The microprocessor unit has an internal RAM scratchpad memory used for programming. The unit derives its internal clock from resistor R23 (and C18, if needed). The MPU has four (4) 8-bit bi-directional ports used for communication to and from the processor. Two of these ports, Ports 0 and 5, are used for internal control of the instrument (A/D input, BCD temperature output, set point voltage output, etc.). The remaining two ports, Ports 1 and 4, are used for option access (IEEE-488).

The CPU uses one of its I/O ports to control Tri-State 8-line to 4-line multiplexers (74LS257) controlled by a decoder/demultiplexer (74139) to input the information needed. The second of the 2 ports handles the input of data and manipulation of display data.

The CPU outputs the set point information through one of its I/O ports as well.

The DRC-84C software is discussed in detail in Section 4.3.4.

4.3.4 Software

Refer to Figure 4.2 as an aid in the following discussion. The flow chart gives the major steps of the program. When the instrument is turned on, the program does a power on reset and starts the program at the beginning. At this point, the program initializes internal registers to be used in the program. The program first checks for an A/D converter overrange and then inputs multiplexed A/D information when the A/D tells it there is fresh data ready (the program loops until the A/D information is ready). The program then verifies that there are no illegal characters that were input and stores the reading. After the first cycle, a calculation is done with each A/D reading.

The program then inputs display sensor information. There is one standard curve for the instrument and there are a maximum of <u>twelve</u> additional curves for each type of sensor. There can be a calibrated curve for Sensor A, B and ten different switch positions generated by the SW-10A. The program determines the type of sensor input and what curve to use for that sensor.

Once the curve is determined, the proper Voltage-Temperature Break Point is determined. The program finds the correct break point for temperature determination by checking each break point voltage to see if it is lower than the input voltage. As the break point is found, the temperature is calculated using the following equation:

$$T = (V_{BP} - V_{AD}) * \frac{dT}{dV} + T_{BP}$$

where:

T is temperature in K

V_{BP} is break point voltage

V_{AD} is input voltage

$\frac{dT}{dV}$ is slope between successive break points

T_{BP} is break point temperature

After the correct temperature has been calculated, the program looks to see if the instrument is in the scale expand mode. In this mode, the front panel display converts to a resolution of .01K from .1K when below 100°K.

If there is no LO 1 error condition (in the case of the platinum sensor) the temperature is output in a bit-parallel, digit-serial form and is latched into the display board.

Once the temperature has been output, the program looks to the set point. The program determines if there is an option present and if there will be a set point input from that option. If no option is present, the program reads the front panel thumbwheel switches. If an option is present, the front panel switches are ignored and the set point is read from the remote source.

The program then determines whether the LO 2, HI 1, or HI 2 errors have occurred. If so, the program continues and outputs the appropriate error to the display and loops back to input another set point until the error is corrected. The program then calculates the break point voltage in much the same way it calculates the temperature. The program determines which is the control sensor and its appropriate curve. It then calculates the set point voltage using the following equation:

$$V_{SP} = (T_{BP} - T_{SP}) * \frac{dV}{dT} + V_{BP}$$

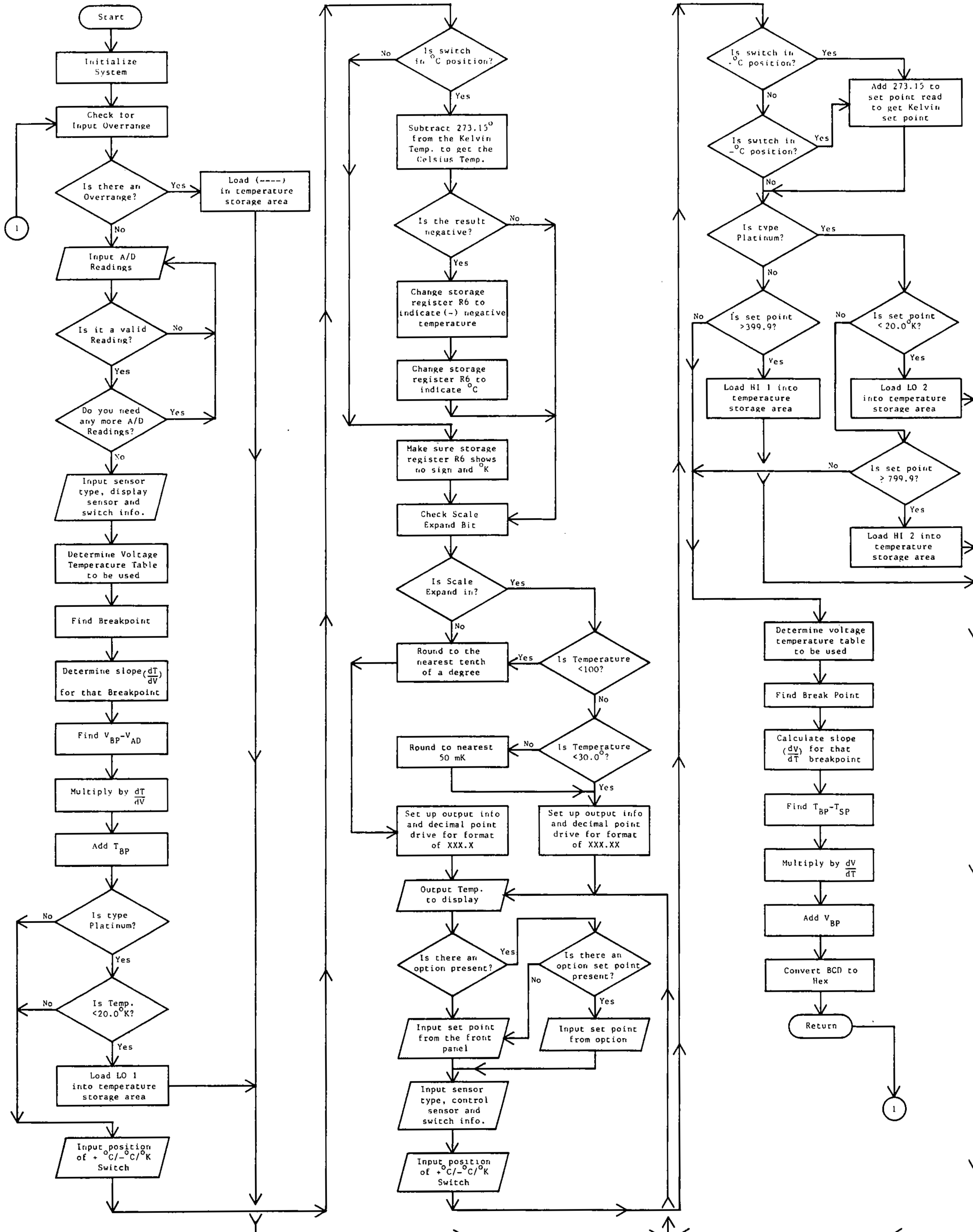

FIGURE 4.2 DRC-84C Software Flow Diagram

where:

V_{SP} is set point voltage in volts

T_{BP} is break point temperature

T_{SP} is set point temperature

$\frac{dV}{dT}$ is slope between successive break points

V_{BP} is break point voltage

At this point, the program converts the BCD voltage to hexadecimal (base 16) and outputs it to the D/A converter in complementary form.

The program then loops back to begin the cycle over again.

4.3.5 Analog Control and Set Point

Refer to Figure 6.4 (Schematic #4) for the following discussion. The digital set point voltage information is output in digit serial, bit parallel form. The data is then latched by four quad latches, U34 through U37, using a data valid signal from U24. The data latched into the quad latches is in a complementary hexadecimal form. This data is converted by a D/A converter for a negative analog voltage (silicon) or positive (platinum) set point. The set point is then compared to the opposite polarity sensor voltage by amplifier U40 and its associated circuitry. If the two signals are not equal in magnitude, this error signal is amplified with the amplification controlled by the gain control potentiometer on the front panel.

In order to understand the analog control circuitry, three different cases should be discussed (The examples will be covered for the diode. The examples can be applied to the platinum sensor, keeping in mind the platinum sensor has the opposite temperature coefficient of the diode.). It should be remembered that, in the case of the diode sensor, voltage decreases with increasing temperature, i.e., the diode is a negative temperature coefficient sensor.

For the first case, assume that the sample temperature is less than the decimal set point temperature. Therefore, the sensor voltage is greater than the set point voltage and the error signal is positive resulting in the inverting gain amplifier output being negative. Since the output amplifier is also an inverting amplifier, power is applied to the load. The amount of power is dependent on the magnitude of the error signal, the gain setting and also the magnitude of the integral signal.

If the combination of the gain and error signal are such that the output of the gain amplifier is more negative than two volts, the output amplification will result in full power being delivered to the load. For this condition, an integral time is not required and is eliminated by using the comparator U42. The output gain is inverted resulting in a positive signal. If this signal is greater than two volts, the output of the comparator approaches the negative supply voltage and CR11 is forward biased. This in turn causes CR13 to become forward biased so that the integrator is effectively removed from the circuit. However, when the output of the gain amplifier is between zero and a minus two volts, the comparator output approaches the positive supply voltage resulting in CR11 being shut off and R59 and R60 having no effect since pin 2 of amplifier U43 is a virtual ground. The integrator will then integrate with a time constant which is proportional to the setting of the potentiometer R62 and the magnitude of the amplifier error signal. The output of the gain amplifier is summed with the output of the integrator to drive the heater circuit. When the error signal goes to zero, the integrator supplies a constant signal which keeps the output power constant and, therefore, the temperature constant.

For positive error signals, i.e., the sensor temperature greater than the set point temperature, the output power is kept on by the charge stored on the integrator. If the error signal stays positive, this charge drops off the integrator which gradually reduces the output power towards zero. The output of the integrator would go positive towards the supply voltage except that the diode CR13 shorts this output at about +0.4 volts.

The available power to the heater is generated by a power supply that consists of transformer TX2, full wave bridge rectifier (CR15-18) and a capacitor (C45). This transformer has its input voltage (115-230) selected by S2. A split secondary is used for HI/LO power selection. The low end of the secondary (Pin 1 of JN) is carried on to the diode full wave bridge. One of the other two points of the secondary is selected by S6, the HI/LO power selector on the front panel. This switch either picks a portion of the secondary voltage (LO power mode) or the entire secondary (HI power mode). The voltage selected is then rectified by the diode bridge and filtered by its capacitor and the power transistor and load. This voltage is applied to power transistor U45. The amount of voltage applied to the load (J5 to J6) is then dependent on its loop gain of the controller, the voltage stored on the integrator and the magnitude of the error signal.

4.3.6 Digital Display Board

Please refer to Figure 6.6 (Display Board Schematic) and Figure 6.7 (Display Board Component Layout) as an aid in the following discussion.

The display board receives its data in a bit-parallel/digit-serial form. The information is latched into the display decoder/driver U101 which drives the display digits DS1-4.

Control of the decimal point is carried out by the BCD/decimal decoder/driver, U102. This driver receives its information directly from the microprocessor. Front panel pushbutton information is displayed by pilot light LED's, DS5-12, and are explained by information contained on the display glass.

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SECTION V

Calibration and Troubleshooting

5.1 Introduction

This section contains the instructions for calibrating and troubleshooting the DRC-84C instrument.

5.1 Test Equipment

A high input impedance digital voltmeter and oscilloscope, a 25 ohm, 25 watt resistor to simulate a heater element, and a precision resistor connected to simulate the diode wired according to Figure 2.1 (c) are normally sufficient to test and calibrate the DRC-84C instrument.

5.3 General Remarks

On installation, one of the major problems is an improperly connected temperature sensing diode. It is advised that other portions of the cryogenic system be tested before the instrument is troubleshooted. Some checks that could be made are:

1) Open or shorted sensor or heater leads (especially in an area of frequent disassembly).

2) Leakage paths between heater and sensor leads that induce electrical feedback in addition to thermal feedback.

If the malfunction points toward the instrument, more detailed tests should be made.

5.4 Instrument Calibration

The DRC-84C has been factory calibrated. If a recalibration is needed, the following procedure should be followed. Please refer to the component layout for the DRC-84C, Figure 6.5 for the following discussion:

5.4.1 Current Sources

a) Current Source - Diode Sensor A

A precision resistor of not less than .01% tolerance should be connected across pins A and B (Figure 2.1) of the diode A Sensor socket. A high input impedance voltmeter connected across the precision resistor should measure a voltage equal to 10 micro amperes times the value of the resistor. For example, a 100K ohm ±.01% resistor should read 1.0000 volts within 100 μvolts. If recalibration is needed, the voltage across the 100K resistor can be adjusted by varying resistor R12.

b) Current Source - Diode Sensor B

The above procedure can be followed with the diode B Sensor socket. R9 should be varied for this adjustment.

c) Current Source - Platinum Sensor A

A 100 ohm precision resistor of not less than 0.1% tolerance should be connected across pins A and B (Figure 2.1) of the platinum A Sensor socket. A high input impedance voltmeter connected across the precision resistor should measure a voltage equal to 0.5 milli-amperes times the value of the resistor. For example, a 100 ohm ±0.1% resistor should read 50 millivolts within 5 μvolts. If recalibration is needed, the voltage across the 100 ohm resistor can be adjusted by varying resistor R3.

d) Current Source - Platinum Sensor B

The above procedure can be followed with the platinum B Sensor socket. R5 should be varied for this adjustment.

5.4.2 A/D Converter

To adjust the A/D converter, a voltage needs to be applied across pins E and D (Figure 2.1) of the display sensor connector for the diode-A. A variable 200K resistor hooked up as in Fig. 2.1 (a), or precision voltage source in place of the diode are ideal ways to generate this voltage. If a resistor is used, it should be varied until one of the breakpoint voltages, indicated in the Voltage-Temperature Characteristic Table is generated (A high impedance voltmeter must be used for this adjustment). After an appropriate voltage is obtained, the display should be calibrated by adjusting trimpot R38 until the display reads the correct temperature. If a precision voltage source is used, a breakpoint voltage should be dialed in and the display should be calibrated as above. A breakpoint temperature above 40K should be used since the voltage sensitivity with temperature is lower at the higher temperatures (2.5 mV/$^{\circ}$K) than for temperatures below 30K.

5.4.3 D/A Converter

a) D/A Verify

Pins 1 through 16 of U38 have parallel data present representing the set point voltage generated by the set point switches. The data is in complimentary hexadecimal form. As an example, a decimal-hex table is given in Table 5.1:

<u>Table 5.1</u>

Decimal	Hexadecimal	Complimentary Hexadecimal
0	0	F
1	1	E
2	2	D
3	3	C
4	4	B
5	5	A
6	6	9
7	7	8
8	8	7
9	9	6
10	A	5
11	B	4
12	C	3
13	D	2
14	E	1
15	F	0

The following table (Table 5.2) gives a set of data for pins 1-16 for the two standard curves D and E as well as for the D/N standard curve for the platinum input.

<u>Table 5.2</u>

Curve D

T (Set Point)	Data (Pin 1-4, 5-8, 9-12, 13-16)			
004.0	1011	1111	0010	0100
022.0	1010	0001	0100	1001
130.0	1001	0101	1010	1000
300.0	1000	1001	1010	1100

Curve E

T (Set Point)	Data			
004.0	1100	0000	1110	1100
022.0	1010	0010	0011	0010
130.0	1001	0101	1010	0000
300.0	1000	1001	1010	0000

DIN Standard Curve

T(Set Point)	Data (Pin 1-4, 5-8, 9-12, 13-16)			
077.0	0111	1010	1101	1100
130.0	0111	0101	0001	1111
300.0	0110	0011	1011	1011

The previous sets of data were given for the purpose of data verification. If the data does not match, refer to Section 6.5 to find the problem.

b) D/A Calibrate

The calibratioin of the D/A converter is an iterative process using a span and offset potentiometer to get a calibrated reading.

The reading can be calibrated in one of two methods:

(1) Method 1 - Use of the Voltmeter

With the voltmeter connected between ground and TP#1, a negative voltage (for diodes) should be present that corresponds to the set point temperature from the front panel thumbwheel switches. As an example, Curve D is used to calibrate the instrument for a D-curve sensor; the curve the instrument has can be noted from the sticker on PROM U20. The curve is denoted in parenthesis (*).

A temperature is dialed in to give a fairly low voltage reading, for example 330.0K. The voltage read on the voltmeter should be -.29111 V. Trimpot R41 is varied until this reading is obtained. Then a temperature point is selected to give a higher voltage reading, for example, 21.0K. The voltage read on the voltmeter should be -1.3505 V. Trimpot R42 is varied until this reading is obtained. This process should be repeated until no further trim adjustments are needed.

(2) Method 2 - Use of Display

The DRC-84C incorporates a method by which the D/A converter can be tied to the input sensor voltage line. With no sensor in either rear panel connector, TP1 and TP2 should be tied together. This links the D/A output with the A/D converter input.

The same iterative process should be used as in Method (1) with the exception that the display should read the setpoint setting.

Note: This method should be used in the diode type only. The linearity of the converter is the same for diodes and platinum. If this method is used for the platinum type, the high stability instrumentation amplifiers of the platinum input may be damaged.

Note: An A/D that is in calibration is vital to the accuracy of this method of calibration.

5.4.4 Output Buffer

With a constant voltage fed into the instrument, as in the A/D converter calibration, place the voltmeter between Pins A and B of 7 pin rear panel connector J3. This voltage should be equal to the input voltage. R20 is varied to obtain the proper buffered signal.

5.4.5 DRC L/A Option (if present)

The output of the DRC L/A option outputs 10mV/K relative to display temperature. In other words, 100.0 ^{o}K on the display corresponds to a 1.0000V output between Pins C and D of monitor connector J3. To recalibrate the option, two adjustments need to be made. With a low temperature on the display (e.g., 22.0 ^{o}K), adjust the offset adjustment potentiometer R89 (see Figure 6.9 - DRC-80C BCD/L-A Option Component Layout) until the output corresponds to 10 mV/K. Then take the display to a higher temperature (e.g., 300 ^{o}K). Adjustment of gain potentiometer R88 will bring the output to 10 mV/K. The procedure may need one more iteration, that is, go to the low temperature on the display, adjust the offset, then go to high temperature display and adjust the gain again.

5.5 Instrument Tests

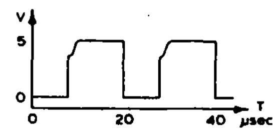
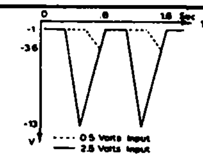
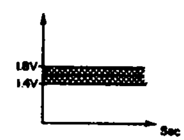
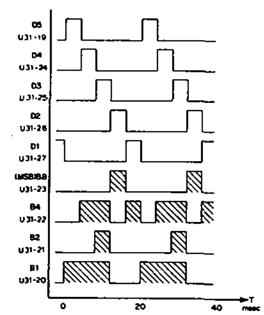
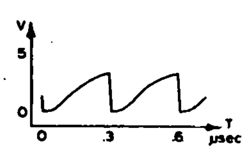
The first check to be made would be to check the input line fuse. The type of fuse and line voltage are shown on the rear panel of the instrument. If the input line voltage and sensor input voltage have been checked, the following sequence should be followed:

1) Check all the power supplies for proper operation. Power supply lines are indicated in Figure 6.5 (Component Layout).

2) Check for the waveforms at the following pins and refer to Table 5.3 for waveforms.

Table 5.3

DRC-84C Signals

Signal	Function	Wave Form
a) Pin 12 of U31 or Pin 3 of U32	Clock signal of A/D converter. The frequency should be about 50K Hz. If not present, replace U32. Also check R34, R35 and C26.	
b) Pin 14 of U32	Integrated signal of A/D to determine the count period. The period should be about .35 seconds. If not present, check U31 and U32.	
c) Pin 7 of U31	This is a D.C. level that is the reference voltage for the integrator. The value should be between 1.4 and 1.8 volts. If not present, check U32. Also check resistance string R36-39 for proper value and operation.	
d) A/D Output of U31	The digit drives (Pins 19, 24, 25, 26, and 27) are positive going pulses and last for 200 clock pulses. The scan sequence is D5 (MSD), D4, D3, D2, and D1 (LSD). The BCD pins (pins 20-23) are positive going signals that go on simultaneously with the digit device. If not present, and signals a), b), and c) are correct, replace U31.	
e) Pin 2 of U40	This is the μP clock signal. This is generated by an external RC network with the help of the main processor. If not present, check R23, C18, and U20 for proper operation.	

Signals from this point on are of a D.C. nature. A general explanation of the D.C. levels is given in the following Table 5.4:

Table 5.4

Signal	Function
1) Input buffer U39	This op-amp circuit is used to buffer the incoming control sensor voltage so that there will be no current load on the sensor. Resistor R33 varies the output. If the voltage at pin 6 cannot be varied until it equals pin 3, U44 may be bad.
2) Summing amplifier U40	This unit uses current summing to obtain an error signal. With the voltages TP#1 and TP#5 equal and opposite, the output of U40 should be nulled (approx. 0 volts). If this is not present, U40 may be bad.
3) Integrating amplifier U43	If, with an error signal, the integrator does not integrate (increase output voltage at TP#4 with time), check U41, U42, and U43.
4) Output power amplifier U44	If there are problems with the output circuit, U44 and U45 should be checked for proper operation. If they appear to operate properly, check the supply voltage present at the collector of U45. In the low power state, it should be about 15.7 volts and 35 volts in the hi power state. If this voltage is not present, check diode bridge CR15-18, switch S2 and C45 for proper operation. TX2 may also need to be replaced.

Signal paths should also be checked. If signals are present at source components and not at destination components, a printed circuit problem requiring a repair of the printed circuit foil may be required. Continuity checks between points will turn up any unwanted open circuits in signal paths.

If the signals at the component pins outlined in Table 5.3 and 5.4 are present, and a problem still exists, a factory representative should be contacted.

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SECTION VI

DRC-84C
REPLACEABLE PARTS LIST

6.1 Main Board Components

CAPACITORS

CIRCUIT DESIGNATION	VALUE	RATING	TYPE
C1	470 µf	35V	E. Al.
C2	470 µf	35V	E. Al.
C3	470 µf	35V	E. Al.
C4	2700 µf	25V	E. Al.
C5	470 µf	35V	E. Al.
C6	.1 µf	100V	Poly.
C7	.1 µf	100V	Poly.
C8	.1 µf	100V	Poly.
C9	.1 µf	100V	Poly.
C10	.1 µf	100V	Poly.
C11	.68 µf	100V	Poly.
C12	.0015 µf	100V	Mylar
C13	150 pf	500V	Mica D.
C14	.0015 µf	100V	Mylar
C15	150 pf	500V	Mica D.
C16	.0015 µf	100V	Mylar
C17	150 pf	500V	Mica D.
C18	Not used		
C19	.68 µf	100V	Poly.
C20	.33 µf	100V	Mylar
C21	.68 µf	100V	Poly.
C22	.68 µf	100V	Poly.
C23	.68 µf	100V	Mylar
C24	.68 µf	100V	Poly.
C25	.33 µf	100V	Mylar
C26	330 pf	500V	Mica D.
C27	330 pf	500V	Mica D.
C28	1.5 µf	25V	Tan.
C29	.1 µf	100V	Poly.
C29A	.68 µf	100V	Poly.
C30	.68 µf	100V	Poly.
C31	.68 µf	100V	Poly.
C32	.033 µf	100V	Mylar
C33	.033 µf	100V	Mylar
C34	.033 µf	100V	Mylar
C35	.033 µf	100V	Mylar
C36	.033 µf	100V	Mylar
C37	Not used		
C38	.033 µf	100V	Mylar
C39	.033 µf	100V	Mylar
C40	.033 µf	100V	Mylar

CAPACITORS

CIRCUIT DESIGNATION	VALUE	RATING	TYPE
C41	.033 μf	100V	Mylar
C42	.033 μf	10V	Mylar
C43	.033 μf	100V	Mylar
C44	.68 μf	100V	Mylar
C45	2400 μf	50V	E. Al.
C46	.68 μf	100V	Poly.
C47	.68 μf	100V	Poly.
C48	.68 μf	100V	Poly.

CONNECTORS

CIRCUIT DESIG.	DESCRIPTION	MFR. and PART NO.
J1	5 Pin Socket (Sensor A)	Amphenol 126-218 (mates with 126-217)
J2	5 Pin Socket (Sensor B)	Amphenol 126-218 (mates with 126-217)
J3	7 Pin Socket (Monitor)	Amphenol 126-193 (mates with 126-195)
J4	BCD/IEEE In-Out (Interface)	Lake Shore Cryotronics, Inc.
J5	Grey Binding Post (Heater V+ Out)	E.F. Johnson 111-0113-001
J6	Black Binding Post (Heater V- Out)	E.F. Johnson 111-0103-001
J7	Black Binding Post (Heater GND)	E.F. Johnson 111-0103-001
JA	10 Contact PC Mount (Display Board)	AMP MODII 3-86018-5 (mates to JG)
JB	10 Contact PC Mount (Display Board)	AMP MODII 3-86018-5 (mates to JH)
JC	16 Pin IC Socket (SW-10 Input of switch position)	Cambion 703-5316-01-04-12
JD'	24 Pin IC Socket (IEEE Interface Connection)	Cambion 703-5324-01-04-12
JE	24 Contact Edge Card (BCD/L-A Option)	TRW 50-24B-10
JF	14 Pin IC Socket (Gain-Reset Option Input)	Cambion 703-5314-01-04-12
JG	10 Contact PC Mount (To Display Board)	AMP 87228-5 (mates to JA)

CONNECTORS

CIRCUIT DESIGNATION	DESCRIPTION	MFR. and PART NO.
JH	10 Contact PC Mount (To Display Board)	AMP 87228-5 (mate to JB)
JL	16 Contact PC Mount (Power Transformer)	AMP 350214-1 (mates to 1-480 438-0)
JM	3 Contact Transistor (Mounts on U45))	Molex-10-17-2032
JN	8 Contact PC Mount (Heater Output Transformer)	AMP 350212-1 (mates to 1-480 285-0)

DIODES

CIRCUIT DESIG.	TYPE	MFR. and PART NO.
CR1	Silicon	IN4006
CR2	Silicon	IN4006
CR3	Silicon	IN4006
CR4	Silicon	IN4006
CR5	Silicon	IN4006
CR6	Silicon	MR501
CR7	Silicon	MR501
CR8	Silicon	MR501
CR9	Silicon	IN743
CR10	Silicon	IN743
CR11	Not Used	
CR12	Silicon	IN4148
CR13	Silicon	IN459
CR14	Silicon	IN459
CR15	Silicon	MR501
CR16	Silicon	MR501
CR17	Silicon	MR501
CR18	Silicon	MR501
DS1	7 Segment LED (Least Significant Digit)	Hewlett-Packard 5082-7651
DS2	7 Segment LED (2nd Significant Digit)	Hewlett-Packard 5082-7651
DS3	7 Segment LED (3rd Significant Digit)	Hewlett-Packard 5082-7651
DS4	7 Segment LED (Most Significant Digit)	Hewlett-Packard 5082-7651
DS5	Pilot Light LED (Scale Expand Indicator)	Hewlett-Packard 5082-4494

DIODES

CIRCUIT DESIG.	TYPE	MFR. and PART NO.
DS6	Pilot Light LED (Scale Normal Indicator)	Hewlett-Packard 5082-4494
DS7	Pilot Light LED (B Display Indicator)	Hewlett-Packard 5082-4494
DS8	Pilot Light LED (A Display Indicator)	Hewlett-Packard 5082-4494
DS9	Pilot Light Indicator (B Control Indicator)	Hewlett-Packard 5082-4494
DS10	Pilot Light Indicator (A Control Indicator)	Hewlett-Packard 5082-4494
DS11	Pilot Light Indicator (Hi Power Indicator)	Hewlett-Packard 5082-4494
DS12	Pilot Light Indicator (Low Power Indicator)	Hewlett-Packard 5082-4494
DS13	Pilot Light Indicator	Hewlett-Packard 8052-7656
DS14	Pilot Light Indicator	Hewlett-Packard 5082-4494
DS15	Pilot Light Indicator	Hewlett-Packard 8052-4494

INTEGRATED CIRCUITS

CIRCUIT DESIG.	DESCRIPTION	PART NO.
U1	15V Positive Voltage Regulator	7815
U2	15V Positive Voltage Regulator	7815
U3	15V Negative Voltage Regulator	7915
U4	5V Positive Voltage Regulator	7805
U5	5V Positive Voltage Regulator	7805
U6	8V Positive Voltage Regulator	78L08
U7	8V Negative Voltage Regulator	79M08
U8	Operational Amplifier	LM308
U9	F.E.T.	3N163
U10	Operational Amplifier	LM308
U11	F.E.T.	3N163
U12	Temp. Stabilized Voltage Reference(Current Sources)	LM399H
U13	Operational Amplifier (Current B)	LM308N
U14	F.E.T. (Sensor B Current Driver)	3N163

INTEGRATED CIRCUITS

CIRCUIT DESIG.	DESCRIPTION	PART NO.
U15	Operational Amplifier (Current A)	LM308N
U16	F.E.T. (Sensor A Current Driver)	3N163
U17	Operational Amplifier	AD522
U18	Operational Amplifier	AD522
U19	Operational Amplifier (Output Buffer)	OP07EJ
U20	Microprocessor Unit (with piggy-back PROM)	38P70 Plus PROM (2716 or 2532)
U21	Decoder/Multiplexer	74LS139
U22	Decoder/Multiplexer	74LS139
U23	Hex Inverters	7404
U24	Hex Inverters	7404
U25	Tri-State Quad 2-data Selectors/Multiplexers	74LS257
U26	Tri-State Quad 2-data Selectors/Multiplexers	74LS257
U27	Tri-State Quad 2-data Selectors/Multiplexers	74LS257
U28	Tri-State Quad 2-data Selectors/Multiplexers	74LS257
U29	Tri-State Quad 2-data Selectors/Multiplexers	74LS257
U30	Decoder/Multiplexer	74LS139
U31	A/D Converter Building Block	7103A
U32	A/D Converter Building Block	8052A
U33	Timer Circuit	NE555N
U34	Quad Latch	4042
U35	Quad Latch	4042
U36	Quad Latch	4042
U37	Quad Latch	4042
U38	16-Bit D/A Converter	HP16-BGC
U39	Operational Amplifier (Input Buffer)	ICL-7650
U40	Operational Amplifier (Summing Amplifier)	ICL-7650
U41	Operational Amplifier	ICL-7650
U42	Operational Amplifier	ICL-7650
U43	Operational Amplifier (Integrating Amplifier)	ICL-7650
U44	Operational Amplifier (Output Driver)	MC1436CU
U45	8-Ampere Darlington Power Transistor	2N6044

MISCELLANEOUS

CIRCUIT DESIG. or FIG. NO.	DESCRIPTION	MFR. & PART NO.
F1	Main Fuse 3 AG, Slow Blow 90V-125V:3/4A 210V-250V:4/10A Fuseholder	 Bussmann MDL 3/4 Bussmann MDL 4/10 Littlefuse 342004A
F2	Heater Fuse 3AG, Slow Blow 1A Fuseholder	 Bussmann MDL 1 Littlefuse 342004A
TX1	Power Transformer	LSCI supplied TX 696-107
TX2	Heater Transformer	TX 696-106 LSCI supplied
	Power Cord:115V:	Belden 17236
	CEE Color Coded:230V	Belden 17740C
	Strain Relief	H.H. Smith 939
	Heat Sink for U4	Aavid 5772B

RESISTORS

CIRCUIT DESIG.	VALUE	RATING	TYPE
R1	3.74K	1% $\frac{1}{4}$W	Mt.F.
R2	20K	1% $\frac{1}{4}$W	Mt.F.
R3	5K Trimpot		Bournes 3059Y-1-502
R4	20K	1% $\frac{1}{4}$W	Mt.F.
R5	5K Trimpot		Bournes 3059Y-1-502
R6	12K	1% $\frac{1}{4}$W	Mt.F.
R7	12K	1% $\frac{1}{4}$W	Mt.F.
R8	10K	1% $\frac{1}{4}$	Mt.F.
R9	5K Trimpot	Sensor B, I Source Adjust)	Bournes 30594-1-502
R10	499K	1% $\frac{1}{4}$W	Mt.F.
R11	10K	1% $\frac{1}{4}$W	Mt.F.
R12	5K Trimpot	(Sensor A, I Source Adjust)	Bournes 30594-1-502
R13	499K	1% $\frac{1}{4}$W	Mt.F.

RESISTORS

CIRCUIT DESIG.	VALUE	RATING	TYPE
R14	100K Trimpot	1% ¼W	Mt.F.
R15	10K Trimpot		Bournes 3059Y-1-104
R16	16.2K	1% ¼W	Mt.F.
R17	100K Trimpot		Bournes 3059Y-1-104
R18	10K Trimpot		Bournes 3059Y-1-103
R19	16.2K	1% ¼W	Mt.F.
R20	20K Trimpot	(Output Buffer Adjust)	Bournes 30594-1-203
R21	10 ohm	1% ¼W	Mt.F.
R22	4.75K	1% ¼W	Mt.F.
R23	4.42K	1% ¼W	Mt.F.
R24	4.75K	1% ¼W	Mt.F.
R25	4.75K	1% ¼W	Mt.F.
R26	4.7K	Resistor Network	Bournes 8-2-472
R27	4.7K	Resistor Network	Bournes 8-2-472
R28	4.7K	Resistor Network	Bournes 8-2-472
R29	4.7K	Resistor Network	Bournes 8-2-472
R30	121K	1% ¼W	Mt.F.
R31	301K	1% ¼W	Mt.F.
R32	36.5K	1% ¼W	Mt.F.
R33	121K	1% ¼W	Mt.F.
R34	10K	1% ¼W	Mt.F.
R35	33.2K	1% ¼W	Mt.F.
R36	107 ohm		
R37	196 ohm		
R38	5K(A/D Adjust)		Bournes 30594-1-502
R39	1.18K	1% ¼W	Mt.F.
R40	511K	1% ¼W	Mt.F.
R41	50K Trimpot(D/A Span Adjust)		Bournes 30594-1-503
R42	50K Trimpot(D/A Zero Adjust)		Bournes 30594-1-503
R43	2.2 M-ohm	1% ¼W	Mt.F.
R44	100K	1% ¼W	Mt.F.
R45	100K	.01% ¼W	Vishay B8111 S102C
R46	100K	.01% ¼W	Vishay B8111 S102C
R47	33.2K	1% ¼W	Mt.F.
R48	71.5K	1% ¼W	Mt.F.
R49	10K	1% ¼W	Mt.F.
R50	100K	1% ¼W	Mt.F.
R51	10K	1% ¼W	Mt.F.
R52	10 ohm	1% ¼W	Mt.F.
R53	10K Potentiometer(Integral to Gain Switch)		
R54	20K	1% ¼W	Mt.F.
R55	2K	1% ¼W	Mt.F.

RESISTORS

CIRCUIT DESIG.	VALUE	RATING	TYPE
R56	1K	1% ¼W	Mt.F.
R57	14.7K	1% ¼W	Mt.F.
R58	1.96 M-ohm	1% ¼W	Mt.F.
R59	332K	1% ¼W	Mt.F.
R60	10K	1% ¼W	Mt.F.
R61	100 ohm	1% ¼W	Mt.F.
R62	100K Potentiometer(Integral to Reset Switch)		
R63	7.87K	1% ¼W	Mt.F.
R64	1.96 M-ohm	1% ¼W	Mt.F.
R65	200K	1% ¼W	Mt.F.
R66	200K	1% ¼W	Mt.F.
R67	374K	1% ¼W	Mt.F.
R68	.47 ohm	5% 1W	Mt.F.
R69	4.75K	1% ¼W	Mt.F.
R70	4.75K	1% ¼W	Mt.F.
R71	10K	1% ¼W	Mt.F.
R72	1K	1% ¼W	Mt.F.
R73	10K	1% ¼W	Mt.F.
R74	1K	1% ¼W	Mt.F.
R75	976K	1% ¼W	Mt.F.
R76	976K	1% ¼W	Mt.F.

SWITCHES

CIRCUIT DESIG.	DESCRIPTION	MFR. & PART NO.
S1	ON/OFF Switch	Centralab P10074
S2	115/230 Line Switch	Switchcraft C46206LFR
S3	Reset ON Switch	Allen Bradley 21M562
S4	Reset Remote Switch	Allen Bradley 21M563
S5	Gain Remote Switch	Allen Bradley 21M563
S6	Hi-Low Heater Output Select	Centralab PO25026
S8	Control Sensor Select	Centralab PO25025
S9	Display Sensor Select	Centralab PO25025
S10	Trend Sensor Select	Centralab PO25025
S11	Trend Sensor Select	Centralab PO25025

6.2 DRC-84C BCD-L/A and IEEE Components List

CAPACITORS

CIRCUIT DESIGNATION	VALUE	RATING	TYPE
C56	.033 µf	100V	Mylar
C57	.68 µf	100V	Poly.
C58	.68 µf	100V	Poly.
C59	.68 µf	100V	Poly.
C200	.1 µf	100V	Poly.
C201	.1 µf	100V	Poly.
C202	.1 µf	100V	Poly.
C203	.1 µf	100V	Poly.
C204	.1 µf	100V	Poly.
C205	.1 µf	100V	Poly.
C206	.1 µf	100V	Poly.
C207	.1 µf	100V	Poly.
C208	18 µf	500V	Mica. D.
C210	.1 µf	100V	Poly.
C211	.1 µf	100V	Poly.

CONNECTORS

CIRCUIT DESIGNATION	DESCRIPTION	MFR. and PART NO.
J4 (BCD option)	50 pin Connector	T&B Ansley 609-5016 (Mates with T&B Ansley 609-5030)
J4 (IEEE option)	24 pin Connector	AMP 552791-1 (Mates with IEEE cable connector)
JD (IEEE option - S/N 4136 or lower)	16 pin IC Socket (IEEE Interface Connection)	Cambion 703-5316-01-04-12
JD' (IEEE option - S/N 4137 or higher)	24 pin IC Socket (IEEE Interface Connection)	Cambion 703-5324-01-04-12
JF	14 pin IC Socket (Gain-Reset Control)	Cambion 703-5314-01-04-12

DIODES

CIRCUIT DESIGNATION	TYPE	MFR. and PART NO.
CR200	Silicon	IN4148

INTEGRATED CIRCUITS

CIRCUIT DESIGNATION	DESCRIPTION	PART NO.
U51	Quadruple D-type flip flops with clear	74LS175
U52	"	74LS175
U53	"	74LS175
U54	"	74LS175
U55	4 normally open SPST JFET Analog Switches	LF13202
U56	Dual Retriggerable Monostable Multivibrator	74123
U57	Dual SPST (MOS Analog Switches	HI1-5043-5
U58	4 normally open SPST JFET Analog Switches	LF13202
U59	Tri-State Quad 2-data Selectors/Multiplexers	74LS257
U60	Tri-State Quad 2-data Selectors/Multiplexers	74LS257
U61	Operational Amplifier	OP07EJ
U62	16 Bit D/A Converter	HP16-DGC
U63	Dual 4-input Positive NAND Gates	7420
U200	Peripheral Input/Output Circuit (P10)	MK3871
U201	General Purpose Interface Adapter	MC68488
U202	Hex Inverting Buffer	CD4049
U203	Tri State Octal Buffers	DM81LS95N
U204	Tri State Octal Buffers	DM81LS95N
U205	Quad 2-Input NOR Gate	74LS02
U206	Quadruple D-type flip flops with clear	74LS175
U207	"	74LS175
U208	4 normally open SPST JFET Analog Switches	LF13202
U209	"	LF13202
U210	Bidirectional Instrumentation Bus Transceiver	MC3448A

INTEGRATED CIRCUITS

CIRCUIT DESIGNATION	DESCRIPTION	PART NO.
U211	Bidirectional Instrumentation Bus Transceiver	MC3448A
U212	"	MC3448A
U213	"	MC3448A
U214	Timer Circuit	NE555N
U215	Quad AND-OR Select Gates	CD4019BCN

RESISTORS

CIRCUIT DESIGNATION	VALUE	RATING	TYPE
R72	2.05K	1% ¼W	Mt.F.
R73	100K	1% ¼W	Mt.F.
R74	57.6K	1% ¼W	Mt.F.
R75	19.6K	1% ¼W	Mt.F.
R76	1.96M	1% ¼W	Mt.F.
R77	1.0K	1% ¼W	Mt.F.
R78	1.0K	1% ¼W	Mt.F.
R79	1.0K	1% ¼W	Mt.F.
R80	1.0K	1% ¼W	Mt.F.
R81	2.0M	1% ¼W	Mt.F.
R82	3.09K	1% ¼W	Mt.F.
R83	6.65K	1% ¼W	Mt.F.
R84	562 ohm	1% ¼W	Mt.F.
R85	9.76K	1% ¼W	Mt.F.
R86	2.0M	1% ¼W	Mt.F.
R87	511K	1% ¼W	Mt.F.
R88	50K trimpot	(L/A Gain Adjust)	Bournes 3006P-1-503
R89	50K trimpot	(L/A Offset Adjust)	Bournes 3006P-1-503
R200	4.7K	1% ¼W	Mt.F.
R201	10 ohm	1% ¼W	Mt.F.
R202	2.05K	1% ¼W	Mt.F.
R203	19.6K	1% ¼W	Mt.F.
R204	57.6K	1% ¼W	Mt.F.
R205	100K	1% ¼W	Mt.F.
R206	562 ohm	1% ¼W	Mt.F.
R207	3.09K	1% ¼W	Mt.F.
R208	6.65K	1% ¼W	Mt.F.
R209	9.76K	1% ¼W	Mt.F.
R210	4.75K	1% ¼W	Mt.F.
R211-218	(2) 4 Resistor Networks		Bournes 8018-08-2-472
R219	10K	1% ¼W	Mt.F.
R220	33.2K	1% ¼W	Mt.F.

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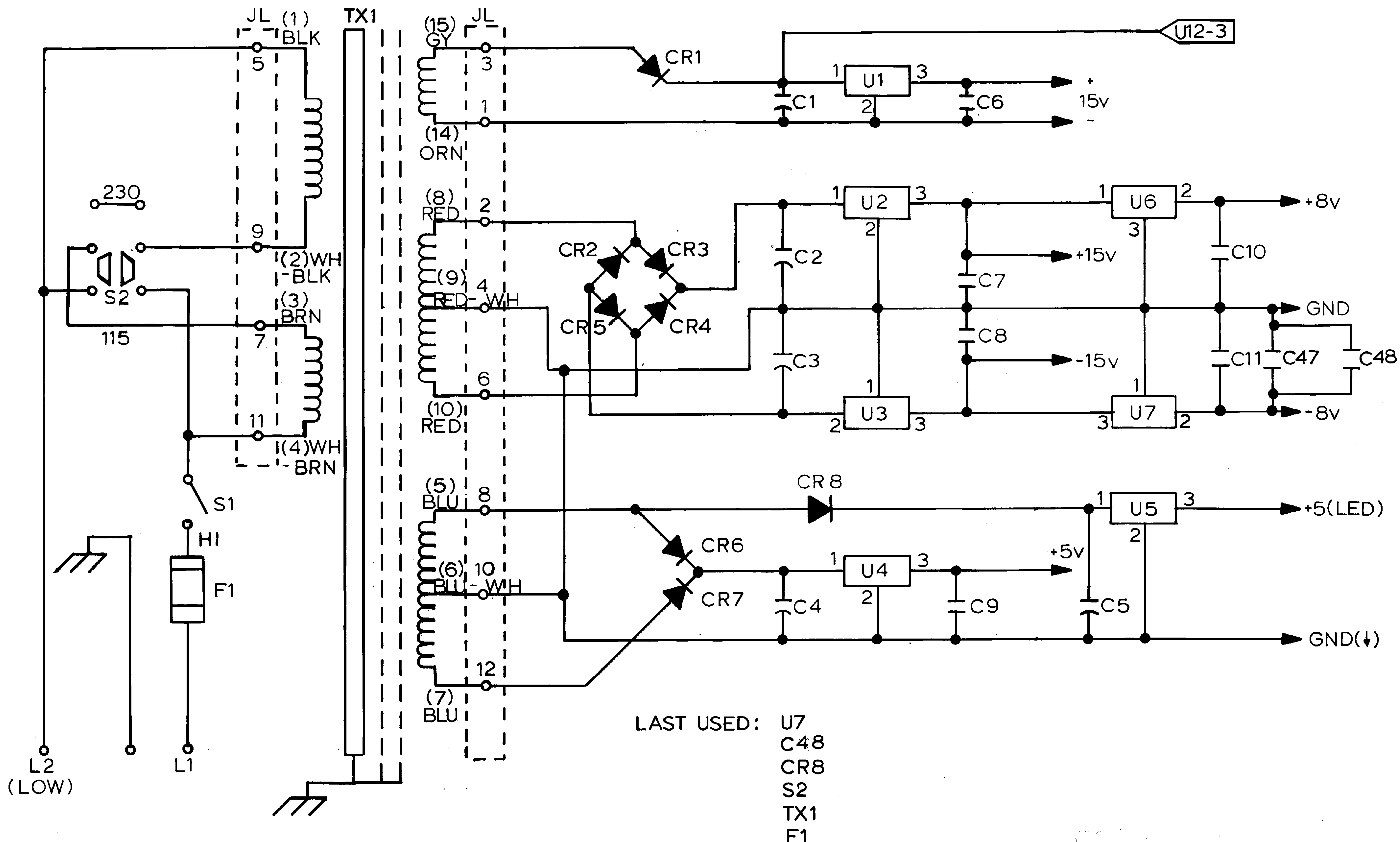

FIGURE 6.1 DRC-84C Power Supply

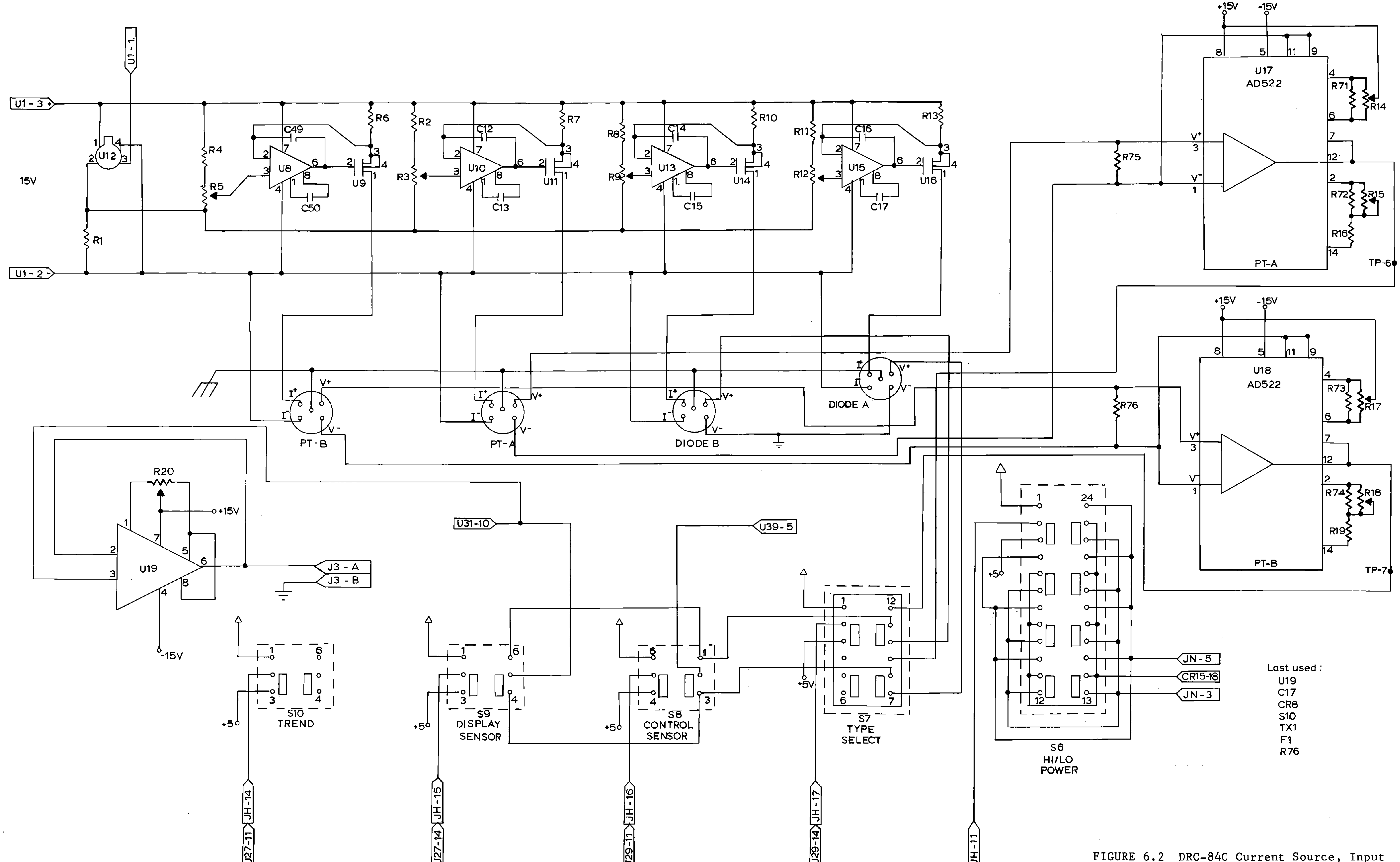

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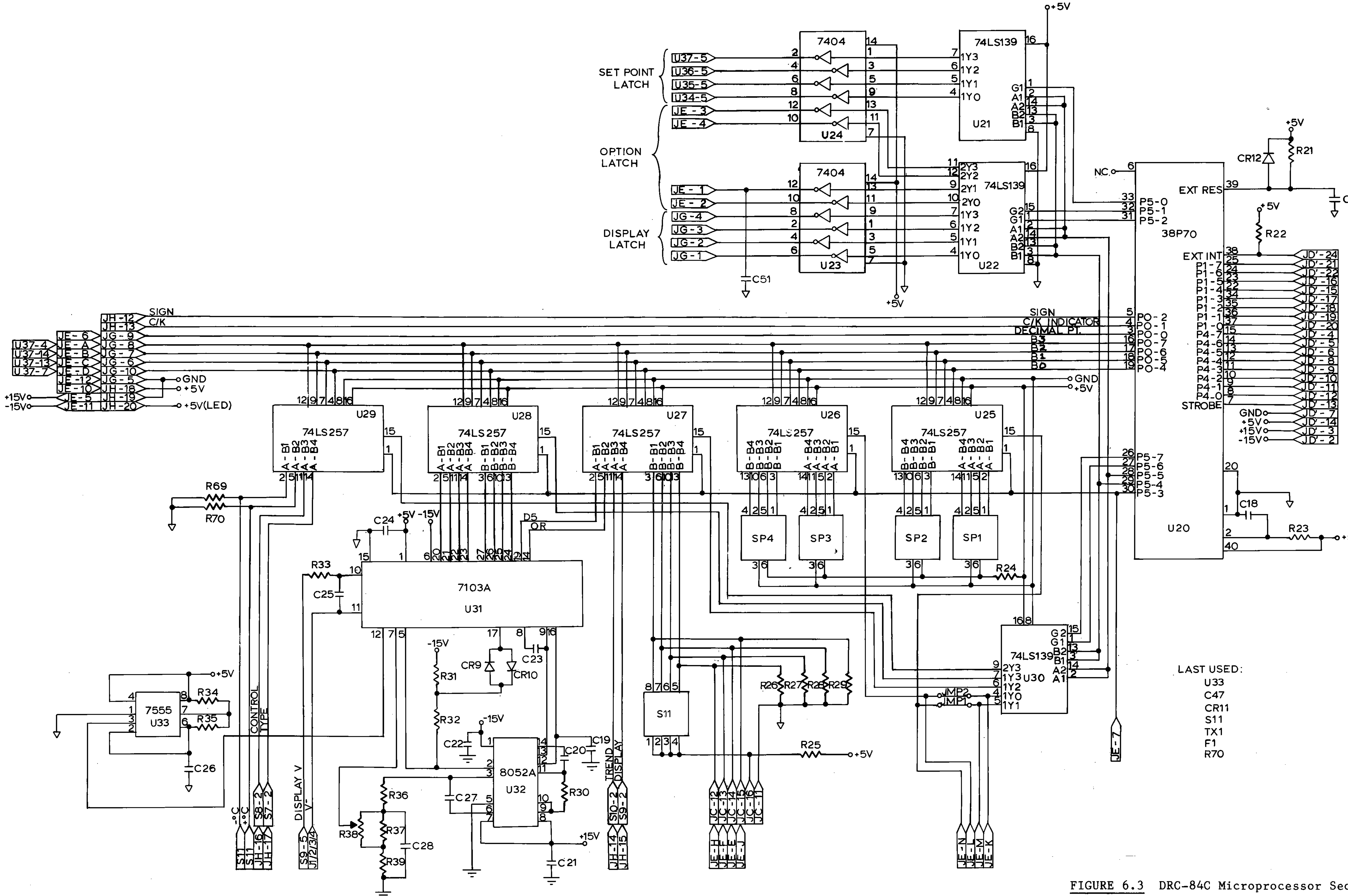
FIGURE 6.2 DRC-84C Current Source, Input Connections, Switching



LAST USED:
U33
C47
CR11
S11
TX1
F1
R70

FIGURE 6.3 DRC-84C Microprocessor Section

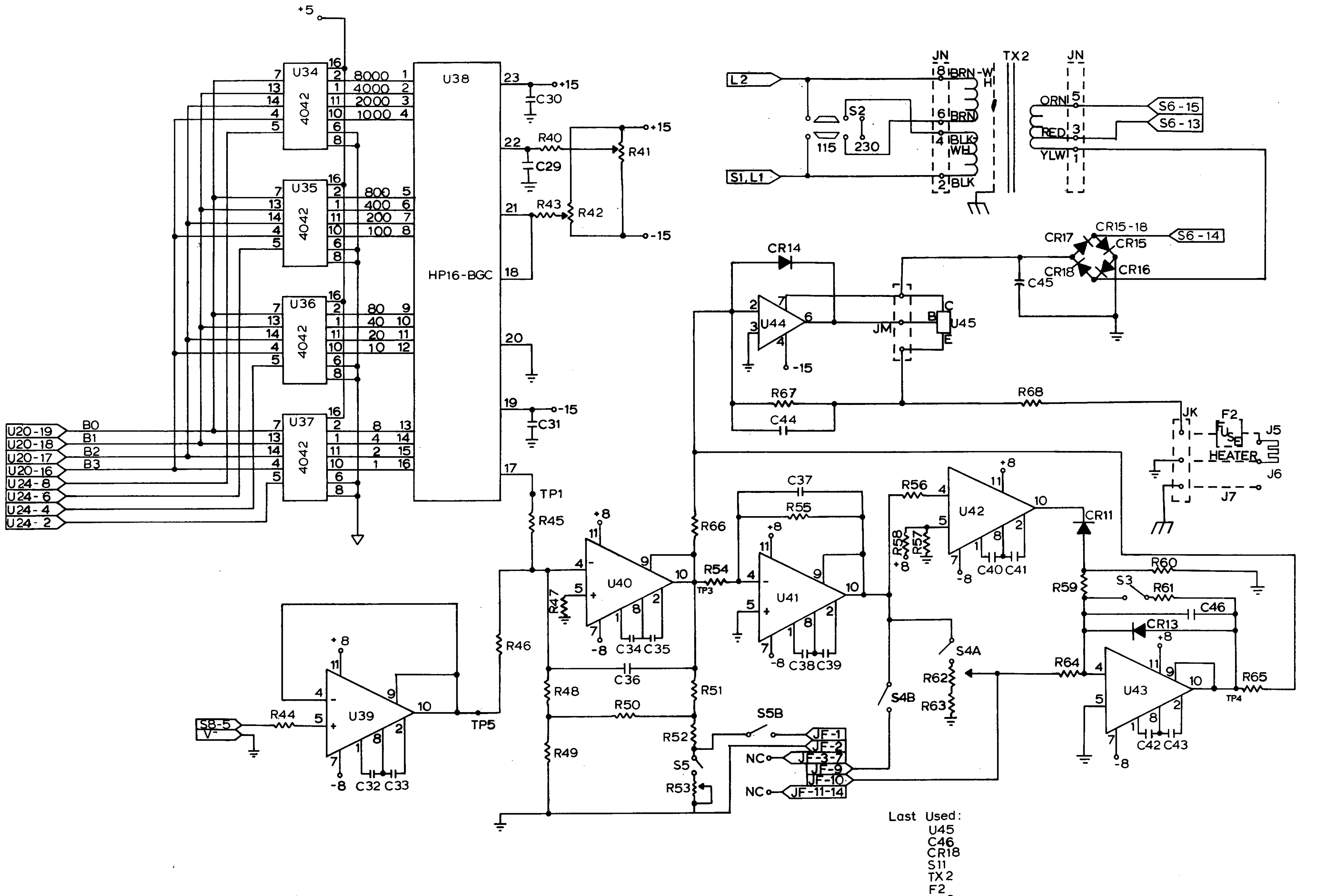


FIGURE 6.4 DRC-84C Analog Output Section

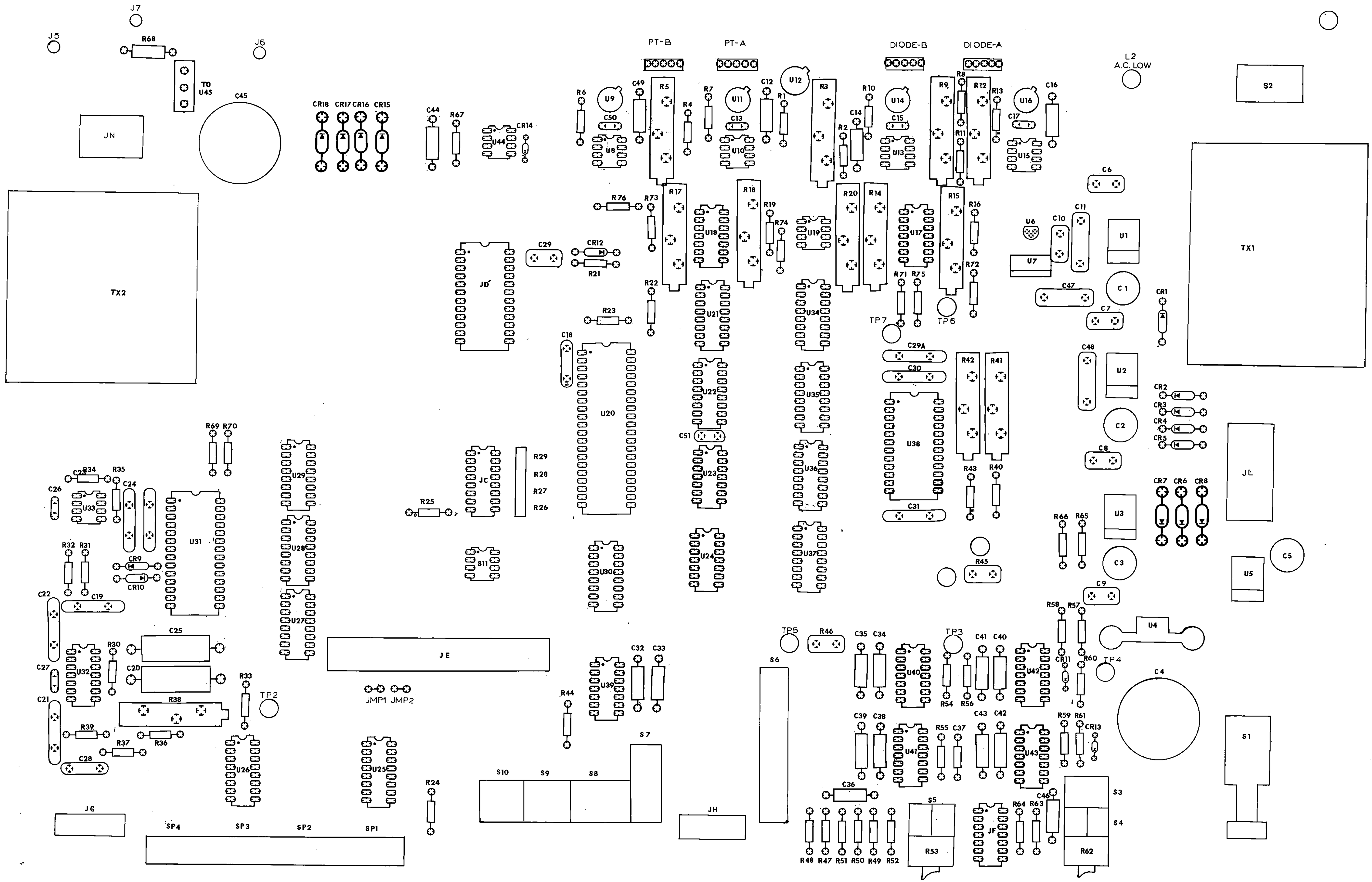
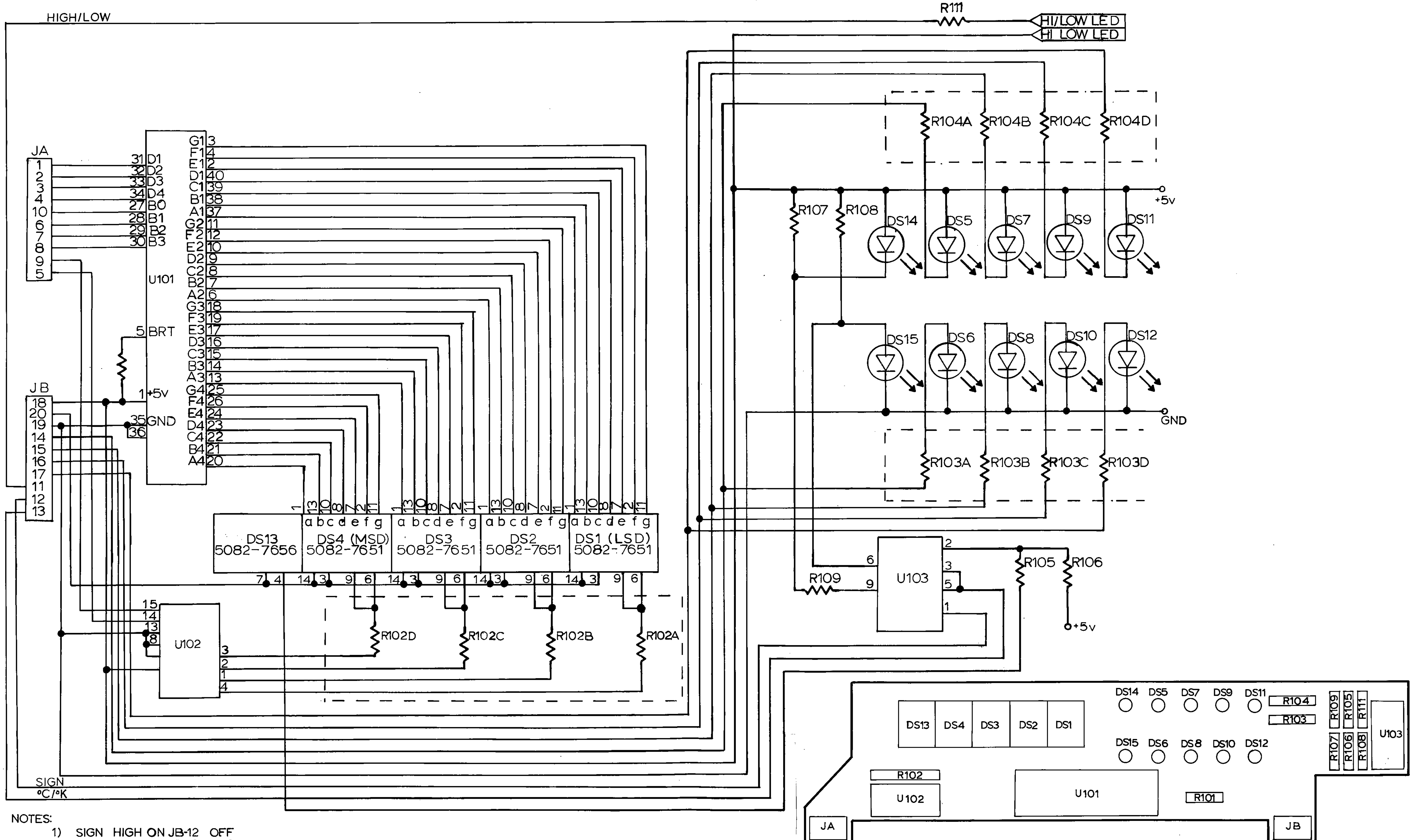


FIGURE 6.5 DRC-84C Component Layout



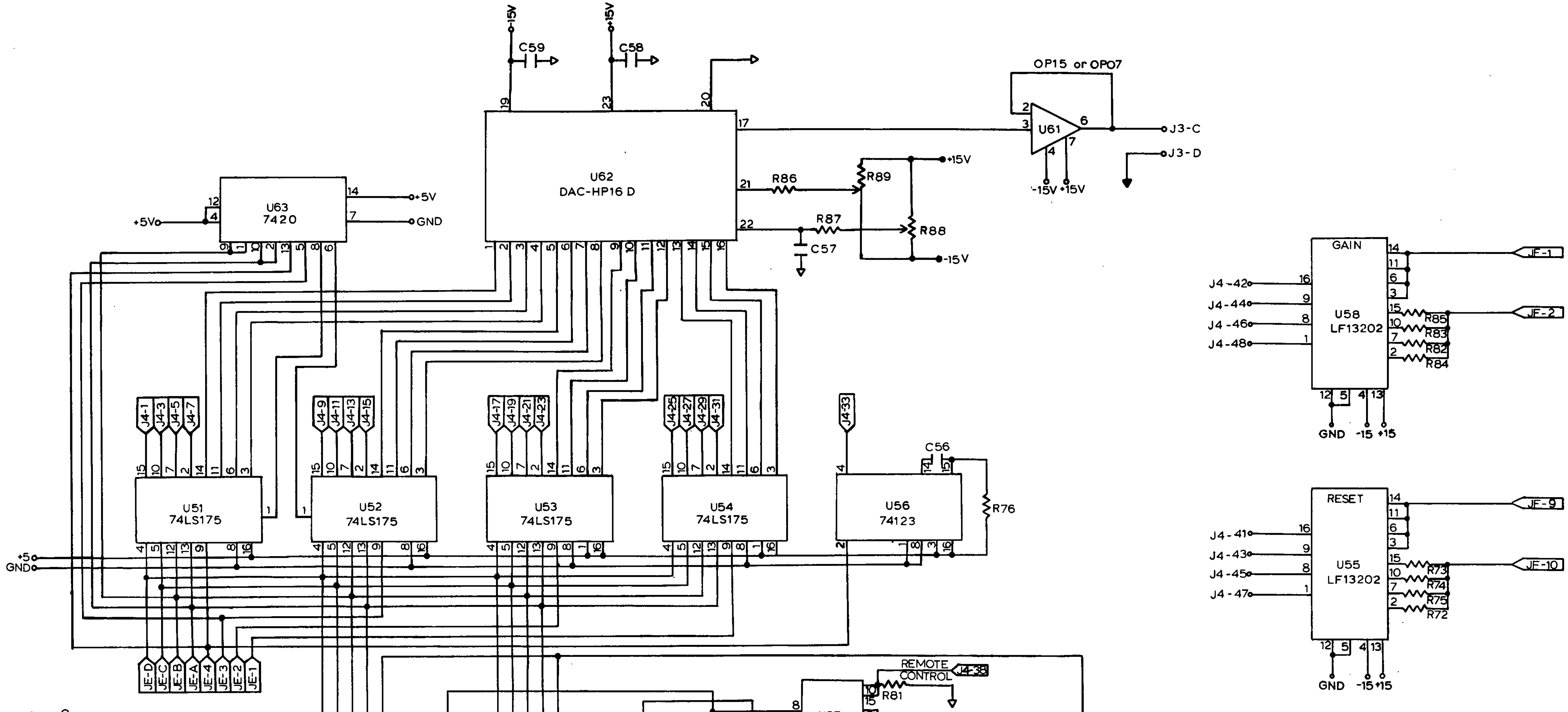
NOTES:

1) SIGN HIGH ON JB-12 OFF
LOW ON JB-12 NEG. ON

2) °C/°K HIGH ON JB-13 °K
LOW ON JB-1 °C

FIGURE 6.7 DRC-84C Display Board Component Layout

FIGURE 6.6 DRC-84C Display Board Schematic



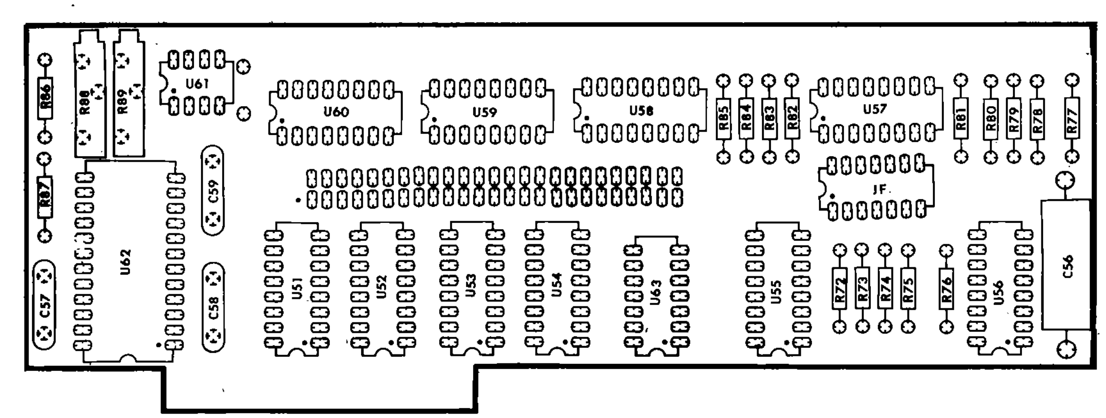
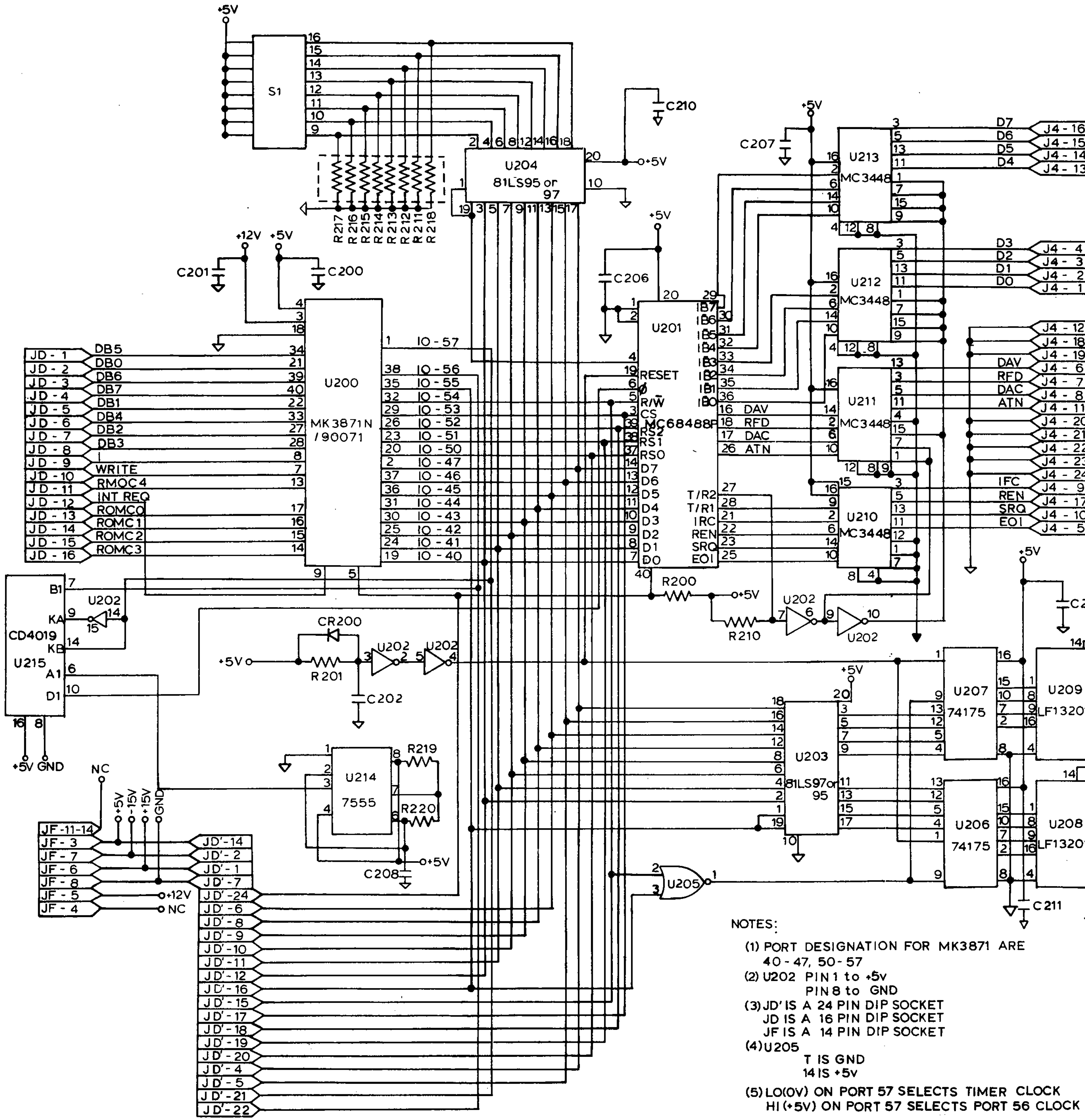


FIGURE 6.9 DRC-84C BCD/L-A Component Layout

FIGURE 6.8 DRC-84C BCD/L-A Option



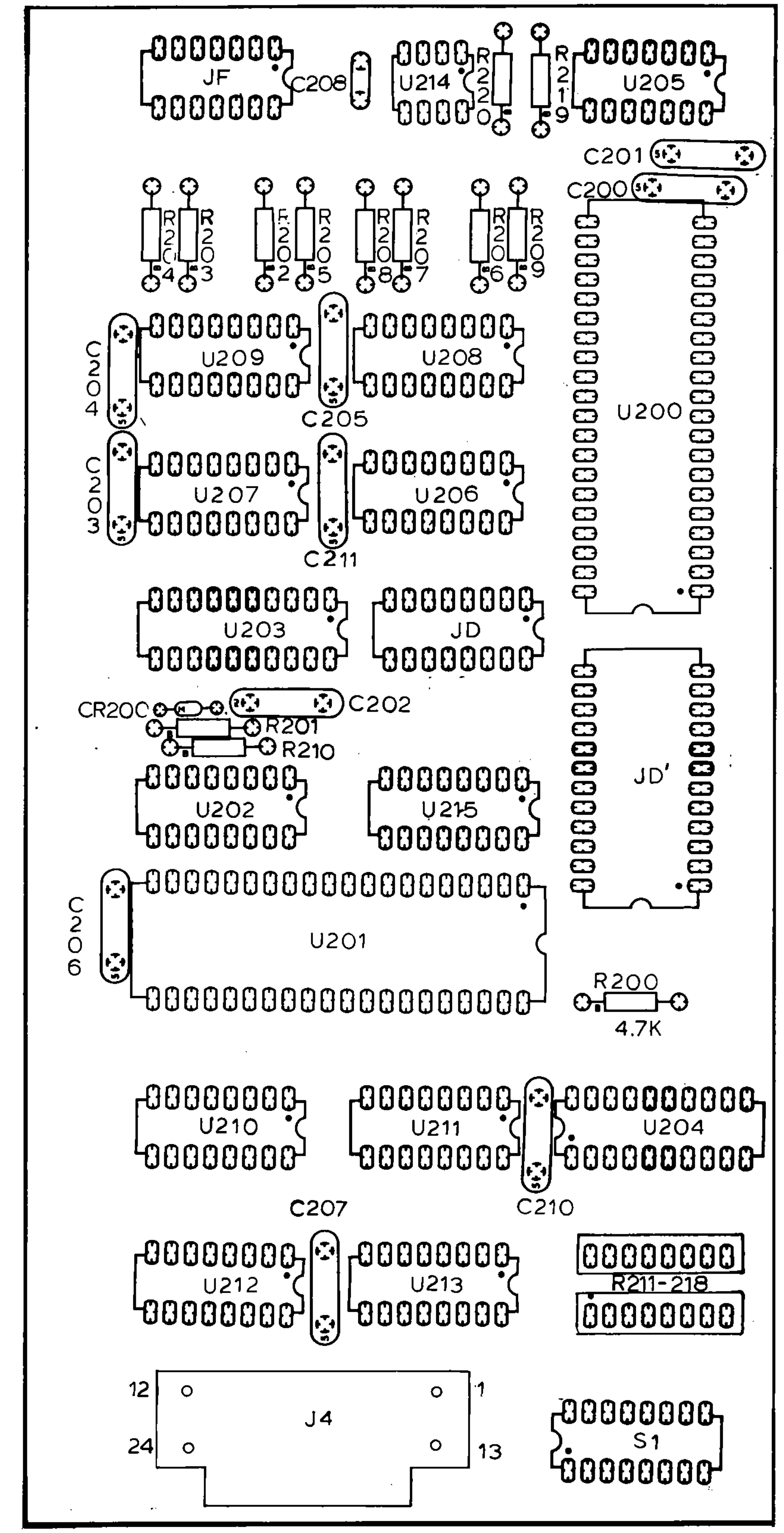


FIGURE 6.11 DRC-84C IEEE Option Component Layout

FIGURE 6.10 DRC-84C IEEE Option