Model 9650
Cryogenic Temperature Indicator/Controller Manual

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INSTRUCTION MANUAL
for
9650 MICROPROCESSOR-BASED
DIGITAL TEMPERATURE
INDICATORS/CONTROLLERS

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SECTION I

GENERAL DESCRIPTION

1-1 INTRODUCTION

The 9650 Microprocessor-based Digital Temperature Indicator/Controller has been designed to interface with cryogenic refrigeration systems. The controller measures temperature using a calibrated temperature sensor mounted in the system, and controls power to a heater within the refrigeration system to maintain process temperature at a predetermined setpoint value. System data are presented to the operator as a sixteen-character reading on a front panel liquid crystal alphanumeric readout.

The proper power output to the heater for a given set of process conditions, is determined via an equation involving Proportional, Integral and Derivative terms. These terms can be changed by the operator at any time, by means of front panel controls.

An analog output feature is also provided enabling the 9650 to output a voltage (0 - 10 volts) that corresponds to a user definable temperature range.

In addition to its function as a temperature indicator, the sixteen-character alphanumeric readout permits the operator to monitor all principal indicator/controller operational parameters at any point in time without affecting system operation. Provisions are made whereby the operator can also change these parameters once they are accessed and displayed.

Data entry, including sensor calibration data, programmable setpoint and proportional, integral and derivative terms is made via a 3 X 4 membrane keypad mounted on the front panel. E^2PROMS provide nonvolatile memory capability. In addition there are three function switches on the front panel which allow the operator to activate each of three different modes of operation -- "Stop" mode, "Manual" mode and "Run" mode.

1-2 INDICATORS AND CONTROLS

A sixteen-character LCD alphanumeric readout, three function switches and a 3 X 4 membrane keypad are furnished on the front panel of the controller. These enable the operator to:

a) Input a number of operational parameters into nonvolatile memory,

b) Display any one of these parameters at any time without affecting the control process,

c) Select the desired control mode.

The operational parameters input and displayed via the front panel function switches include:

a) A temperature setpoint

b) Four terms (proportional, integral, derivative, rate) used in the power output control equation.

c) Multiple sensor calibration voltages, for each of two (2) temperature sensors

d) A calibration reference voltage

e) 100 temperature versus time Run mode program point pairs (Point 0 is the first point!)

f) Three terms (zero, span and Sn) used to set the temperature high and low limits for the analog output voltage, and

g) A remote address (for selection of IEEE-488 or RS-232C)

The temperature setpoint is the temperature that the 9650 will attempt to maintain in the system when in the "manual" control mode (see Section 1-3).

The four terms used in the heater output equation are input to define the relative amount of heater power to be applied to or removed from the heater for a given temperature deviation from the setpoint.

Calibration inputs match the controller to the temperature characteristics of the particular sensor employed. These need be entered only after initial installation of the sensor or after a replacement sensor has been installed.

The calibration reference voltage input is used as a scale factor in computing accurate voltage. This is set at the factory and should not be changed. In the unlikely event that this number is lost from permanent storage, it should be reset to the original value.

The temperature versus time program point inputs enable the 9650 to "ramp" to a series of temperatures in a specific time period (see 1-3 below).

The three terms used for the analog output voltage are input to enable the operator to configure the 9650 to output a voltage of 0 - 10 volts over a set range. (The Zero specifies the beginning point of the range, the Span specifies the width of the range and the Sensor value specifies which sensor data to use for calculating the voltage).

1-3 MODES OF OPERATION

Three modes of operation are available and are selectable by means of the front panel function switches. These are termed "Stop", "Manual" and "Run".
When placed into the "Stop" mode of operation (by pressing the "Stop" function switch or by powering up), the 9650 indicator/controller assumes a standby condition and the heater power output voltage from the controller circuit is set to zero.

If the temperature drops below the setpoint **OR** if the temperature is below the setpoint when the "Manual" mode is in effect, the controller will output power to the heater as determined by the power output control equation. The operator can change the temperature setpoint value at any time. He can also monitor all instrument operating parameters without affecting control of the process medium.

When in the "Run" mode, the 9650 operates through a previously-inserted set point temperature-versus-time program. This mode is intended for those applications where a detailed analysis of process characteristics under varying set point temperature conditions is desired.

Essentially, the program comprises a collection of continuous set point temperature-versus-time ramp functions. For any given program, the 9650 indicator/controller can store up to 100 individual set points with up to 999.9 minute intervals between points. In addition, when the Run mode is initiated by pressing the front panel function switch, a program may be started at any of the 100 points. The following sequential events will occur upon initiation of the "Run" mode.

1) The indicator/controller will establish the "starting" set point value at that temperature reading currently being displayed.

2) The set point will be increased (or decreased) toward the first program temperature point using the first time point as the time necessary to reach that point.

3) Immediately upon reaching point #1, the indicator/controller will begin adjusting the set point display value toward the second set point value.

4) Operation will continue in this fashion until the last point in the program is reached (defined by a zero temperature value). At that time the 9650 will switch to the 3 "Manual" mode and maintain the current set point value.

1-4 HEATER POWER PROTECTION CIRCUIT

The heater power supply incorporates internal short circuit protection to ground, in the event that the heater coil is inadvertently shorted as well as short circuit protection to the 50 volt supply in the event that the power transistor fails.

Internal circuitry monitors the heater output voltage and load current. Detection of a short circuit condition activates a dual stage integrator that is configured to discriminate between a catastrophic condition and spurious noise by verifying the presence of the short over a specific period of time. After verification a relay that is in series with the output opens, disconnecting power at the heater terminals. The bar graph then switches from percent heater power to a ramping display indicating that power has been removed.

1-5 QUICKSTART OF THE 9650

This section is provided solely to give the user some idea of the 9650's performance as quickly as possible. After following the procedures below, the operations section may be consulted to understand the 9650's full capabilities.

1) Apply A/C power (110/220) to the 9650
2) After the 9650 startup messages are displayed, perform the following:
   a) Activate the (DIAG) key to display "Diagnostics No:0".
   b) Activate the <edit> key to position the cursor to the digit after the colon.
   c) Activate the "9" key and press enter to edit the max heater voltage.
   d) Activate the numeric keys to select a desirable maximum voltage. (Many applications prefer 30, the 9650's maximum allowable voltage.)
   e) When satisfied with this entry pres (enter) to accept.
3) Connect a voltmeter to the heater output connector on the 9650.
4) Activate the <DIAG> key to display "Diagnostic No:0"
5) Activate the <edit> key to position the cursor to the digit after the colon.
6) Activate the "3" key then the <enter> key to display "Htr output 0.0". The voltmeter should also be displaying 0 voltage.
7) Activating any key will now change the 0.0 on the display to 7.5; the voltmeter should display a comparable value. Continue activating any key and checking the voltmeter in this manner until "30.0" appears on the display. This will then verify that the heater output on the 9650 is functioning properly.
8) Activating any key at this point will restore the normal 9650 temperature display.
9) All input/output connections between the controller and the external refrigerator system are made via rear panel connectors. Refer to drawing number B040-343 for details and connect the 9650 to the external refrigerator system.

10) Activate the <SET> key to display "Txxx.xx S000.0".

11) Activate the <edit> key to position the cursor to the first digit after the "S" (for temperature setpoint).

12) Activate the "1" key; then the <enter> key to accept a setpoint value of 100.0.

13) Activate the <HTR> key to display "Txxx.xx H00.0".

14) Activate the <MAN> front panel function switch. The 9650 will now attempt to control the temperature of the external refrigerator system at 100.0K.

15) Experiment with changing the setpoint value as done previously in steps 10-13.

16) Refer to the Operations section of the manual to gain a full understanding of all of the 9650's capabilities.

SPECIFICATIONS - Model 9650-1 (Silicon Diode)

Sensors (dual channel)	Silicon Diode, standard SII Model Si-410
Controller - Electrical	
Temperature Range:	1.5 to 450K
Sensor Excitation:	Constant current - 10 microamperes
Operating Voltage Range:	90-125/180-250 VAC, 50/60 Hz (switchable)
Display:	1) Sixteen-character liquid crystal 2) Bar graph heater indication
Operator Controls:	Embossed Tactile Membrane switches
Data Storage:	E²PROM: Standard stored data is for Model SI-410 Silicon Diode Sensor. Other data can be stored
Resolution:	±0.01K
Accuracy:	±0.1K(1.5 to 35K) ±0.5K(35 to 450K)
Controllability:	±0.1K(1.5 to 35K) ±0.2K(35 to 450K)
Repeatability:	±0.1K
Set Point:	±0.1K
Analog Output:	0 to 450 Kelvin (.1K resolution) 0 to 10 volts
Heater Output:	60 watts max (30VDC @ 2A). @ 100/200 VAC min
Remote Interface: desired	GPIB (IEEE-488) or RS-232C as
Program Control:	100 points (multi-program capability)
Control Sensor: sensor.	Programmable by operator to either
Controller - Mechanical ½ DIN Package	
Dimensions:	5.25"H x 8.00"W x 9.00"D

SPECIFICATIONS-Model 9650-2 (Platinum R.T.D.)

Sensors (dual channel)	Platinum R.T.D. 200 OHMS standard. Other values are optional
Controller - Electrical	
Temperature Range:	50 to 600K
Sensor Excitation:	Constant current - 1.0 milliamp
Operating Voltage Range:	90-125/180-250 VAC, 50/60 Hz (switchable)
Display:	1) Sixteen-character liquid crystal 2) Bar graph heater indication
Operator Controls:	Embossed Tactile Membrane switches
Data Storage:	E^2PROM: Calibration parameters and variables stored in non-volatile memory
Resolution:	0.01K
Accuracy:	±0.1K(50 to 600K) Based on standard table inputs
Controllability:	±0.2K(50 to 600K)
Repeatability:	±0.1K
Set Point:	±0.1K
Analog Output:	0 to 600 Kelvin (.1K resolution) (User Configurable) 0 to 10 volts
Heater Output:	60 watts max (30VDC @ 2A). @ 100/200 VAC min
Remote Interface:	GPIB (IEEE-488) or RS-232C as desired
Program Control:	100 points(multi-program capability)
Control Sensor:	Programmable by operator to either sensor.
Controller - Mechanical ½ DIN Package	
Dimensions:	5.25"H x 8.00"W x 9.00"D

SPECIFICATIONS-Model 9650-3 (Germanium Resistance Thermometer)

Sensors (dual channel)	Germanium, calibrated SII Model N1V
Controller - Electrical	
Temperature Range:	1.5 to 100K
Sensor Excitation:	Constant voltage - 10 millivolts
Operating Voltage Range:	90-125/180-250 VAC, 50/60 Hz (switchable)
Display:	1) Sixteen-character liquid crystal 2) Bar graph heater indication
Operator Controls:	Embossed Tactile Membrane switches
Data Storage:	E^2PROM: For configuration and program points.
Resolution:	±0.001K (1.5 to 60K) ±0.002K (60 to 100K)
Accuracy:	±0.07K (1.5 to 60K) ±0.1K (60 to 100K)
Controllability:	±0.01K (1.5 to 60K) ±0.05K (60 to 100K)
Repeatability:	±0.05K
Set Point:	±0.05K
Analog Output:	0 to 100 Kelvin (.1K resolution) 0 to10volts
Heater Output:	60 watts max (30VDC @ 2A). @ 100/200 VAC min
Remote Interface:	GPIB (IEEE-488) or RS-232C as desired
Program Control:	100 points (multi-program capability)
Control Sensor:	Programmable by operator to either sensor.
Controller - Mechanical ½ DIN Package	
Dimensions:	5.25"H x 8.00"W x 9.00"D

SPECIFICATIONS - Model 9650-5 (Chromel vs Gold Theromocouple)

Sensors (dual channel)	Standard SII Model CG07F
Controller - Electrical	
Temperature Range:	4.2 to 550K
Operating Voltage Range:	90-125/180-250 VAC, 50/60 Hz (switchable)
Display:	1) Sixteen-character liquid crystal 2) Bar graph heater indication
Operator Controls:	Embossed Tactile Membrane switches
Data Storage:	E^2PROM: For configuration, sensor calibration, and program points.
Resolution:	±0.01K
Accuracy:	±0.3K(matched to standard curve)
Controllability:	±0.2K
Repeatability:	±0.2K
Set Point:	±0.1K
Analog Output:	0 to 600 Kelvin (.1K resolution) 0 to 10 volts
Heater Output:	60 watts max (30VDC @ 2A). @ 100/200 VAC min
Remote Interface:	GPIB (IEEE-488) or RS-232C as desired
Program Control:	100 points (multi-program capability)
Control Sensor:	Programmable by operator to either sensor.
Controller - Mechanical ½ DIN Package	
Dimensions:	5.25"H x 8.00"W x 9.00"D

SPECIFICATIONS - Model 9650-6 (Gallium Arsenide)

Sensors (dual channel)	Gallium Arsenide, calibrated SII Model GA-300NN
Controller - Electrical	
Temperature Range:	1.5 to 450K
Sensor Excitation:	Constant current - 10 microamperes
Operating Voltage Range:	90-125/180-250 VAC, 50/60 Hz (switchable)
Display:	1) Sixteen-character liquid crystal 2) Bar graph heater indication
Operator Controls:	Embossed Tactile Membrane switches
Data Storage:	E^2PROM: For configuration, sensor calibration, and program points.
Resolution:	±0.01K (1.5 to 35K) ±0.01K (35 to 450K)
Accuracy:	±0.1K(1.5 to 35K) ±0.5K(35 to 450K)
Controllability:	±0.1K(1.5 to 35K) ±0.2K(35 to 450K)
Repeatability:	±0.1K
Set Point:	±0.1K
Analog Output:	0 to 450 Kelvin (.1K resolution) 0 to 10 volts
Heater Output:	60 watts max (30VDC @ 2A). @ 100/200 VAC min
Remote Interface:	GPIB (IEEE-488) or RS-232C as desired
Program Control:	100 points (multi-program capability)
Control Sensor:	Programmable by operator to either sensor.
Controller - Mechanical ½ DIN Package	
Dimensions:	5.25"H x 8.00"W x 9.00"D

SPECIFICATIONS - Model 9650-7 (Ruthenium Oxide)

Sensors (dual channel)	SII Model RO-104 (100K ohms)
Controller - Electrical	
Temperature Range:	1.5 to 273K
Sensor Excitation:	Constant current - 10 microampers
Operating Voltage Range:	90-125/180-250 VAC, 50/60 Hz (switchable)
Display:	1) Sixteen-character liquid crystal 2) Bar graph heater indication
Operator Controls:	Embossed Tactile Membrane switches
Data Storage:	E^2PROM: For configuration, sensor calibration, and program points
Resolution:	0.01K (1.5 to 20K) 0.01K to 0.03K (20 to 80K) 0.03K to 0.33K (80 to 273K)
Accuracy:	±0.05K (1.5 to 20K) ±0.05K to ±0.15K (20 to 80K) ±0.15K to ± 5.0% (80 to 273K)
Controllability:	±0.1K (1.5 to 20K) ±0.10K to ±0.30K (20 to 80K) (Not Recommended Above 80K)
Repeatability:	±0.1K
Set Point:	±0.1K
Analog Output:	0 to 450 Kelvin (.1K resolution) 0 to 10 volts
Heater Output:	60 watts max (30VDC @ 2A). @ 100/200 VAC min
Remote Interface:	GPIB (IEEE-488) or RS-232C as desired
Program Control:	100 points (muli-program capability)
Control Sensor:	Programmable by operator to either sensor.
Controller - Mechanical	
Dimensions:	5.25"H x 8.00"W x 9.00"D

NOTE: Due to the relatively high resistance of the Model RO-104 Sensor, accuracy can be affected by high resistance shorts. Be sure to clean all solder connections for best performance.

SPECIFICATIONS - Model 9650-7 (Ruthenium Oxide)

Sensors (dual channel)	SII Model RO-105 (100K ohms)
Controller - Electrical	
Temperature Range:	2.0 to 273K
Sensor Excitation:	Constant current - 10 microampers
Operating Voltage Range:	90-125/180-250 VAC, 50/60 Hz (switchable)
Display:	1) Sixteen-character liquid crystal 2) Bar graph heater indication
Sensor Fault:	Open 000 Shorted 555
Operator Controls:	Embossed Tactile Membrane switches
Data Storage:	E^2PROM: For configuration, sensor calibration, and program points
Resolution:	0.01K (1.5 to 20K) 0.01K to 0.03K (20 to 80K) 0.03K to 0.15K (80 to 273K)
Accuracy:	±0.05K (1.5 to 20K) ±0.05K to ±0.15K (20 to 80K) ±0.15K to ± 2.2% (80 to 273K)
Controllability:	±0.1K (1.5 to 20K) ±0.10K to ±0.30K (20 to 80K) (Not Recommended Above 80K)
Repeatability:	±0.1K
Set Point:	±0.1K
Analog Output:	0 to 450 Kelvin (.1K resolution) 0 to 10 volts
Heater Output:	60 watts max (30VDC @ 2A). @ 100/200 VAC min
Remote Interface:	GPIB (IEEE-488) or RS-232C as desired
Program Control:	100 points (muli-program capability)
Control Sensor:	Programmable by operator to either sensor.
Controller - Mechanical	
Dimensions:	5.25"H x 8.00"W x 9.00"D

NOTE: Due to the relatively high resistance of the Model RO-105 Sensor, accuracy can be affected by high resistance shorts. Be sure to clean all solder connections for best performance.

SECTION II

OPERATION

2-1 INTRODUCTION

Successful operation of the 9650 Temperature Indicator/Controller involves the following basic steps:

1) Properly connecting the 9650 to the external refrigerator system.

2) Powering-up the controller.

3) Entering the proper controller setup data (temperature setpoint, Proportional-Integral-Derivative values, sensor calibration data, etc.) via the front panel keypad.

4) Selecting the desired mode of operation.

5) Monitoring the control process via the front panel liquid crystal display (temperature, heater power and set point as desired).

2-2 CONNECTING THE 9650 TO THE EXTERNAL REFRIGERATOR SYSTEM

All input/output connections between the controller and the external refrigerator system are made via rear panel connectors. Drawing B040-343 in Section 3 details the required connections.

2-3 POWERING-UP THE 9650

The front panel of the 9650 Temperature Controller contains a POWER ON/OFF function switch, an alphanumeric readout, three function switches and a 3 X 4 membrane keypad. After properly making the I/O connections, place the power switch in its "on" position.

Upon initial power-up, the controller will display the "Scientific Instruments" product name and current value for maximum heater voltage output. the controller will then assume a standby condition, with the standard temperature display and "Stop" mode in effect.

Normally, the readout will display the temperature as shown below. However, when the operator is reviewing or changing controller data, the readout is employed to display instrument operating parameters.

T123.45 t123.45

2-4 ENTERING 9650 SETUP DATA

Reviewing and/or changing sensor calibration data, temperature setpoint, PID values, the temperature vs. time program points, analog output range values and remote address value is accomplished via the 3 X 4 membrane keypad.

In general, changing any of the above parameters involves the following sequential steps.

1) Display the desired parameter by pressing its corresponding key on the keypad.
2) Press the <edit> key to change the parameter.
3) The cursor will appear on the first digit of the first field to edit.
4) Press the numeric keys to edit the parameter as desired.
5) Press the <edit> key to advance to the next field.
6) Continue steps 4 and 5 until satisfied with all parameter settings. (Note: If the <edit> key is pressed while in the last field of the display the cursor will "wrap around" to the first field).
7) Press the <enter> key to accept and save the desired settings. For clarification, several examples follow:

2-4.1 Programming the Temperature Setpoint

```
T123.45  S123.45
```

1) Activate the <SET> key to display the temperature/setpoint values.
2) Activate the <edit> key to move the cursor to the setpoint field and to the first digit of that field.
3) Activate the numeric keys to change the setpoint parameter noting that the cursor increments automatically as each key is pressed. When the last digit of the field is reached the cursor wraps around to the beginning of the field.
4) After all digits have been changed to the desired setpoint value, activate the <enter> key to accept and save the new setpoint value. Activating the Manual" mode will now cause the controller to attempt to bring the process medium to the new setpoint and maintain it at that temperature.

2-4.2 Programming the PID Terms

P50 I10 D10 R09

1) Activate the <PID> key to display the PID parameters.

2) Activate the <edit> key to move the cursor to the Proportional term field and to the first digit of that field.

3) Activate the numeric keys as desired to change the proportional term.

4) Activate the <edit> key to advance to the next field (the integral term).

5) Repeat steps 3 and 4 until all terms have been changed to the desired values.

6) Press <enter> to accept and save the displayed values.

NOTE: The "R" parameter on the PID display signifies "RATE" and is used only in the Run mode. It is defined as the maximum rate at which temperature can change in degrees Kelvin per minute. While calculating the new setpoint, if the 9650 determines that it will exceed the "R" parameter, the "R" parameter is substituted in the calculations to insure that the maximum rate of temperature change does not exceed this value.

2-4.3 Programming the Sensor Calibration Data

1) Only whole numbers are displayed in this EDIT routine.

2) When shipped, default values from our standard curve data record are installed unless a calibrated sensor is purchased. In this case, the actual calibration data points are installed.

2-4.3.1 Silicon Diode -Ruthenium Oxide- Platinum RTD

00 2K 1.8610

1) Activate the <CAL> key to bring up the calibration point display.

2) Activate the <edit> key to move the cursor to the first field and the first digit of that field.

3) Activate the numeric keys to select the desired calibration point number as shown below.

4) Activate the <edit> key to select the desired point and move the cursor to the first digit of the next field (the calibration voltage).

5) Activate the numeric keys to change the calibration voltage value, from the sensor calibration data sheet or standard data record.

6) After all digits have been changed to the desired value, activate the <edit> key to save the new value and "wrap around" to the first field.

7) Repeat steps 3 through 6 until all calibration data have been changed as desired.

8) Activate the <enter> key to accept and save the changes.

Silicon Diode Sensors
Ruthenium Oxide (100K Ω)

Channel 1		Channel 2	
00	2.00K	13	2.00K
01	4.00K	14	4.00K
02	6.00K	15	6.00K
03	8.00K	16	8.00K
04	10.00K	17	10.00K
05	18.00K	18	18.00K
06	25.00K	19	25.00K
07	40.00K	20	40.00K
08	50.00K	21	50.00K
09	60.00K	22	60.00K
10	80.00K	23	80.00K
11	270.00K	24	270.00K
12	450.00K	25	450.00K

Platinum

Channel 1		Channel 2	
00	77.38K	13	77.38K
01	273.15K	14	273.15K
02	373.15K	15	373.15K

2-4.3.2 Gallium Arsenide Diode

43 77K 1.2345

1) Programming the calibration data is performed using the same procedure as for other sensors except the user is prompted to select sensor '1' or sensor 2' when editing the Cal points. Once selected, the Cal points are numbered from 00 thru 62 as shown below:

00	1.5K	21	22.0K	42	70.0K
01	2.0K	22	23.0K	43	77.0K
02	3.0K	23	24.0K	44	80.0K
03	4.0K	24	25.0K	45	90.0K
04	5.0K	25	26.0K	46	100.0K
05	6.0K	26	27.0K	47	125.0K
06	7.0K	27	28.0K	48	150.0K
07	8.0K	28	29.0K	49	175.0K
08	9.0K	29	30.0K	50	200.0K
09	10.0K	30	31.0K	51	225.0K
10	11.0K	31	32.0K	52	250.0K
11	12.0K	32	33.0K	53	270.0K
12	13.0K	33	34.0K	54	273.0K
13	14.0K	34	35.0K	55	275.0K
14	15.0K	35	36.0K	56	300.0K
15	16.0K	36	37.0K	57	325.0K
16	17.0K	37	38.0K	58	350.0K
17	18.0K	38	39.0K	59	375.0K
18	19.0K	39	40.0K	60	400.0K
19	20.0K	40	50.0K	61	425.0K
20	21.0K	41	60.0K	62	450.0K

2-4.3.3 Germanium Resistance Thermometer

1) Programming the calibration data providing a specific E-Prom for each particular sensor. Sixty-three (63) data points are incorporated to provide the specified accuracy. These points are not accessible to the user for editing. A completecalibrated data table accompanies each sensor.

2-4.3.4 Chromel/Gold Thermocouple

As previously explained, stressing the thermocouple wires can cause the output voltage to deviate from the NBS values. By reading the voltage values at a known temperature, the voltages at other temperatures can be corrected for a specific thermocouple. To accomplish this correction, proceed as follows:

1) Select the diagnostic (6,7) DIAG-Edit-6 (CH1)7(CH2)-Enter

2) Place the thermocouple in one of the calibration liquids (Helium, Nitrogen and Ice Bath) and allow the display to stabilize.

3) Record the displayed value on the right side of bezel for that point. Record as many of the points as desired. It is not necessary to obtain all of the points, especially if the unit will not be operated in the affected temperature range. For example, if primary operation is in the range between 77K and 273K, it is not necessary to obtain a calibration point as 4.2K. However, if the unit is operated in the range between 4.2K and 77.38K, the temperature display may exhibit decreasing accuracy as the 4.2K point is approached if the 4.2K point is not obtained.

4) Exit the diagnostic function by pressing any key and enter calibrate function Cal-Edit-00-07 (Calibration datapoints **CH-1**: 00-4K, 01-77K, 02-273K, 03-450K.
   CH-2: 04-4K, 05-77K, 06-273K, 07-450K. Use the Edit key to go through the needed calibration points, then when this is accomplished, press Enter.

5) The unit is now calibrated for the thermocouple being used. If a different thermocouple is connected, the calibration procedure should be repeated. If it is desired to return the unit to read the NBS table values, enter the NBS values supplied on the calibration sheet for the proper points. Each unit has a uniquely calibrated reference junction diode. The data for this diode is factory calibrated and should not be changed. This data is recorded on the "Instrumentation Data Record" and can be displayed as follows: Cal-Edit-08 (voltage-boiling water, 373K), then Edit-09 (voltage-ice-273K), press Enter to exit.

Thermocouple Calibration Points **Reference Diode**

Channel 1		Channel 2		Channel 1	
00	4.21K	04	4.21K	08	373.15K
01	77.38K	05	77.38K	09	273.15K
02	273.15K	06	273.15K		
03	450.00K	07	450.00K		

6) It is not possible to immerse the thermocouple in the calibration liquids and you have a calibrated thermocouple, you may calculate calibration values for the unit by using the formula on page D-2 of manual (V = (T/C voltage/2) + 0.1). If ice was used as a reference to obtain calibration values for your thermocouple, proceed as the following example for the 77.38K point:

$$\frac{\text{Cal Pt}}{4218} - \frac{\text{N.B.S. Ice Point}}{5309.3} = -\tilde{1}091.3$$

$$V = (1.0913/2) + 0.1 = .6457$$

This is the value to be entered into M9650 Cal Point 01.

2-4.4 Programming a Temperature/Time Program

00 T123.4 M000.5

1) Activate the <PROG> key to bring up the temperature vs. time display.

2) Activate the <edit> key to move the cursor to the first field and the first digit of that field.

3) Activate the numeric keys to select the desired program point number as desired. (**NOTE:** on power up the default value will be zero, otherwise the program point last edited will be displayed.)

4) Activate the <edit> key to select the desired point and move the cursor to the first digit of the next field (the program point temperature value).

5) Activate the numeric keys to change the program point temperature value.

6) After all digits have been changed to the desired value, activate the <edit> key to save the new value and move the cursor to the first digit of the next field (the program time point).

7) Activate the numeric keys to change the program point time value.

8) After all digits have been changed to the desired value, activate the <edit> key to save the new value and cause the cursor to wrap around to the first field (program point).

9) Repeat steps 3 through 8 until all desired program points have been changed.

NOTE: A maximum number of 100 program points may be entered (0 - 99). A program point with a temperature value of 000.0 defines the end of a program.

10) Activate the <enter> key to accept and save all changes.

2-4.5 Programming the Analog Output Range Values

Zr100 Sp020 Sn1

1) Activate the <ANA> key to bring up the analog output display.

2) Activate the <edit> key to move the cursor to the first field and the first digit of that field.

3) Activate the numeric keys to change the Zero point temperature value. (**NOTE:** the Zero point defines the temperature range starting value -- minimum entry = 0; maximum entry = 650.)

4) Activate the <edit> key to save the desired zero value and move the cursor to the first digit of the next field (the Span temperature value).

5) Activate the numeric keys to change the Span point temperature value. (**NOTE:** The Span point defines the width of the temperature range -- minimum entry = 1; maximum entry = 650.)

6) Activate the <edit> key to save the desired span value and move the cursor to the first digit of the next field (the analog sensor number).

7) Activate the numeric keys to change the analog sensor number to the desired sensor. (**NOTE:** this value should be entered as 1 or 2 for best results. Any value other than 1 will be interpreted by the 9650 as a 2.)

8) After all digits have been changed to the desired value, activate the <edit> key to save the new value and cause the cursor to wrap around to the first field (Zero point).

9) Activate the <enter> key to accept and save all changes.

2-4.6 Programming the Remote Address Value

GPIB Address= 15

1) Activate the <REM> key to bring up the remote address display.

2) Activate the <edit> key to move the cursor to the numeric field and the first digit of that field.

3) Activate the numeric keys to change the GPIB address to the desired address on the GPIB bus.

NOTE: This value must be less than 32 to enable the 9650 to function for IEEE-488. Any value over 32 disables the IEEE-488 function and configures the 9650 to function for RS232C.)

4) Activate the <enter> key to accept and save all changes.

NOTE: Whenever this configuration change occurs, the 9650 must be powered down and back up to function properly in either IEEE-488 or RS232C transmission mode.

2-4.7 Programming the Control Sensor

```
T123.45  t123.45
```

1) Activate the TEMP key to bring up the normal temperature display.

2) Activate the edit key to change the control sensor. The message CONTROL SENSOR will appear with the current control sensor number in the last digit on display.

3) Enter either a 1 or 2 using the numeric keys. Any number may be entered, but any number entered other than 1 will be treated in the program as sensor 2. To avoid confusion, only use the number 1 for sensor 1 and 2 for sensor 2.

4) Activate the enter key to accept and save the selection.

NOTE: When sensor 2 is selected as the control sensor, an arrow points to the"t" identifier. When sensor 1 is selected as control sensor, the display appears normally without the arrow.

2-5 SELECTING THE DESIRED MODE OF OPERATION

STOP MAN RUN

These three modes are explained fully in section 1-3. Pressing any one of these switches will activate that particular mode. Below are several important notations to consider when selecting a mode:

1) These three keys are ignored by the 9650 if the operator is in the process of editing **ANY** of the system parameters.

2) When selecting the PROG mode, the operator is prompted with **"Start Prog at: 00"**. The operator must enter a two digit number (0-99) which the 9650 will use as the starting point to begin a program. This feature enables the 9650 to begin a program from anywhere in its memory. This effectively permits an operator to keep many commonly used programs stored in memory to be activated on command.

3) A program is terminated when the 9650 reads a program point with a temperature of 000.0 and is accompanied by three high-pitched sounds.

4) If the Run mode is initiated at a starting point where the first temperature point is 000.0, the 9650 will display an error message - "No program - abort" accompanied by three **short,** high-pitched sounds.

2-6 MONITORING THE CONTROL PROCESS

The display can be caused to alternate between displaying temperature of the process medium, temperature and heater output, AND temperature and current setpoint (of particular interest when in the "Run mode") by activating the <TMP>, <HTR> and <SET> keys respectively.

NOTE: If the sensor is open, the 9650 will display 0.0 heater output and will automatically shut off the heater. (This feature is not available on the 9650-5.)

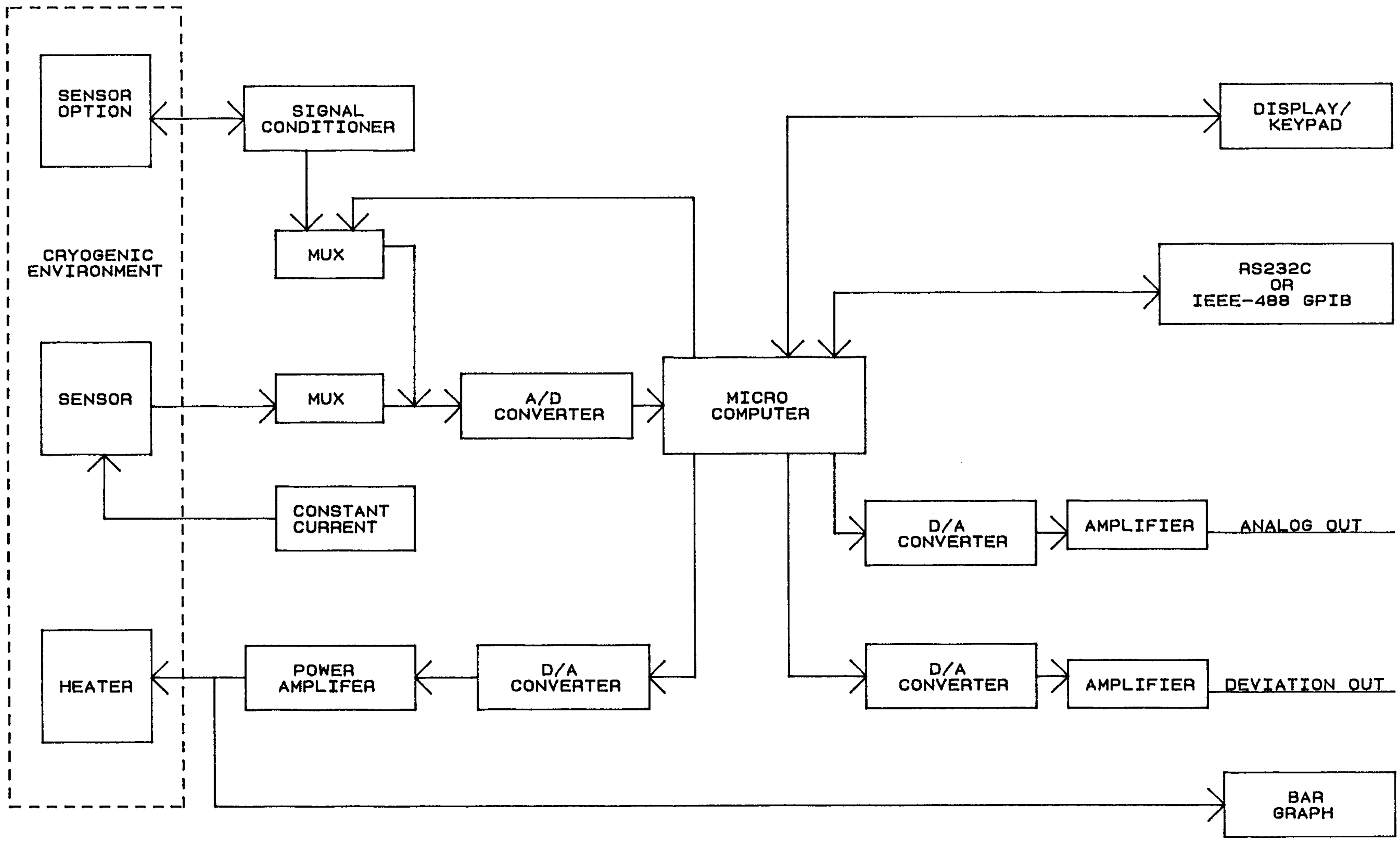
SECTION III

PICTORIALS

P/C ASSEMBLIES

SCHEMATICS

Note: All drawings are latest revision

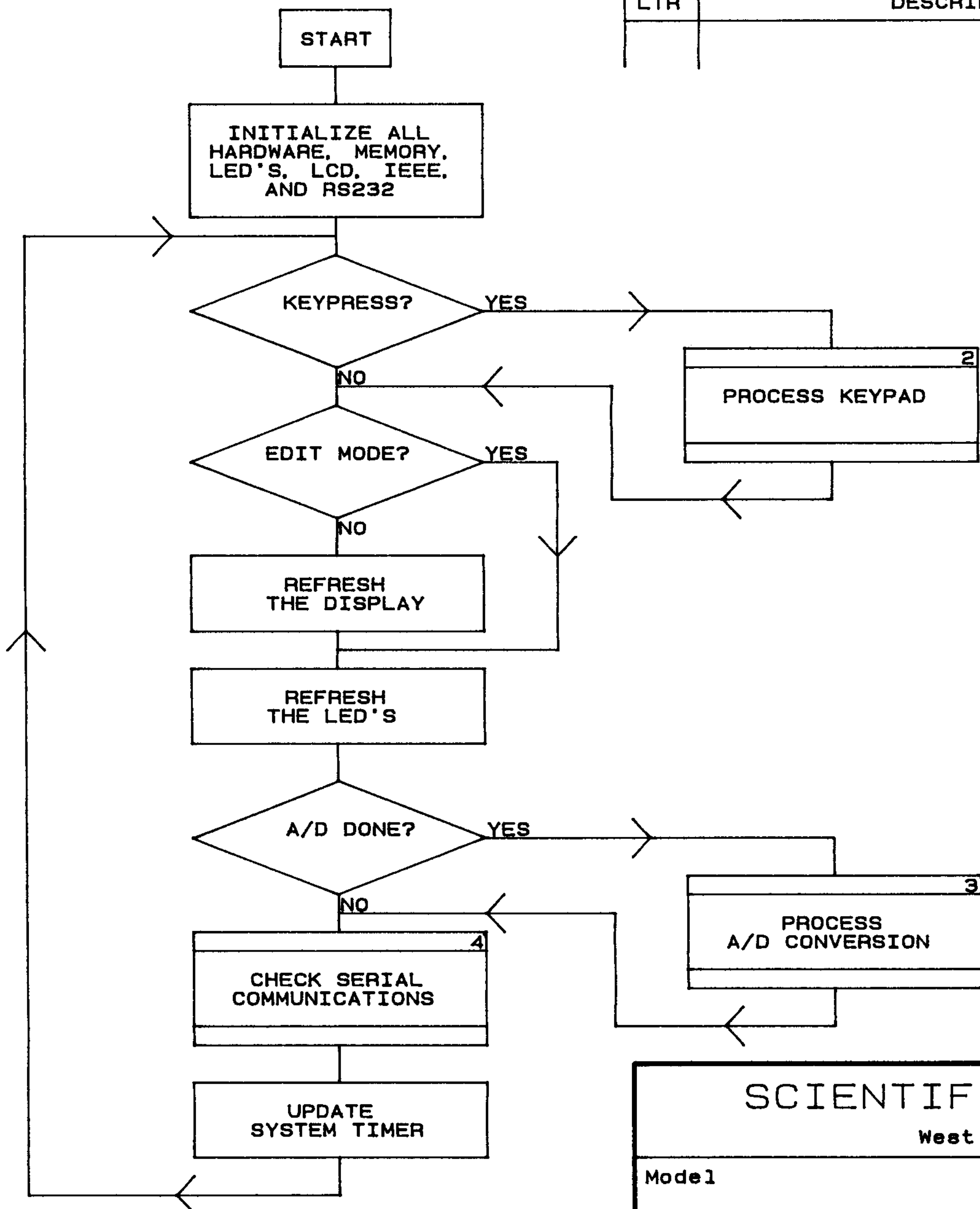


SCIENTIFIC INSTRUMENTS, INC. West Palm Beach, Florida 33407						
Model		Product INST	Scale N/A	Finish		
				Dwn. W.W.J.	10/26/88	
Title BLOCK DIAGRAM				Ckd. M.LEE	10/26/88	
				Apd.		
.0 ± .030 .00 ± .015 .000 ± .005	FSCM No. 53547	Size A	Dwg. No. 030-037	Rev. 0	Sheet 1 of 1	

MAINLINE

1

REVISION			
LTR	DESCRIPTION	DATE	APPROVED



SCIENTIFIC INSTRUMENTS, INC.

West Palm Beach, Florida 33407

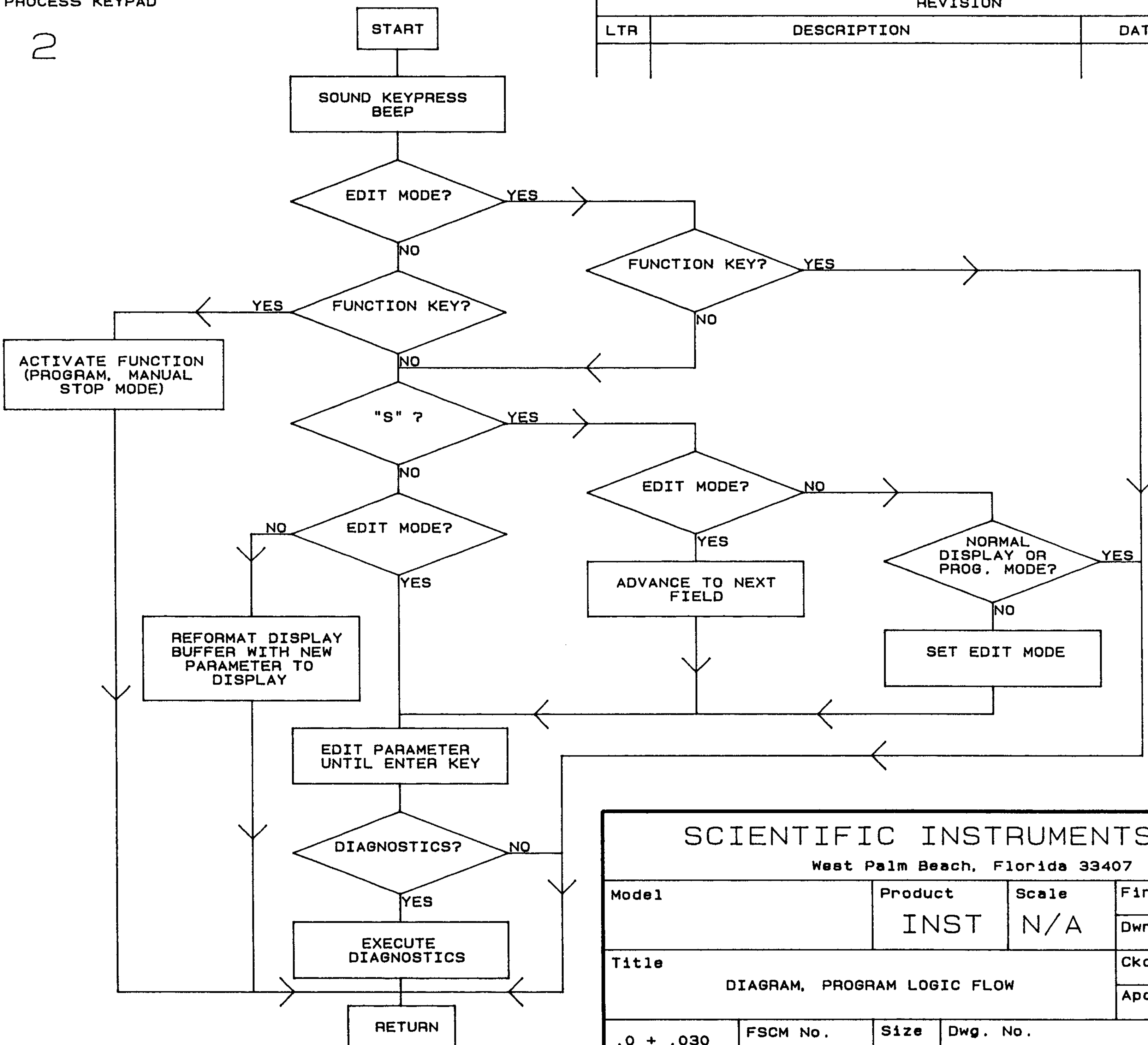
Model	Product	Scale	Finish	
	INST	N/A	Dwn. W.W.J.	10/13/88
Title: DIAGRAM, PROGRAM LOGIC FLOW			Ckd. J.ROUSE	10/14/88
			Apd.	

	FSCM No.	Size	Dwg. No.	Rev.	Sheet
.0 ± .030 .00 ± .015 .000 ± .005	53547	A	031-004	0	1 of 4

PROCESS KEYPAD

2

REVISION			
LTR	DESCRIPTION	DATE	APPROVED



SCIENTIFIC INSTRUMENTS, INC.

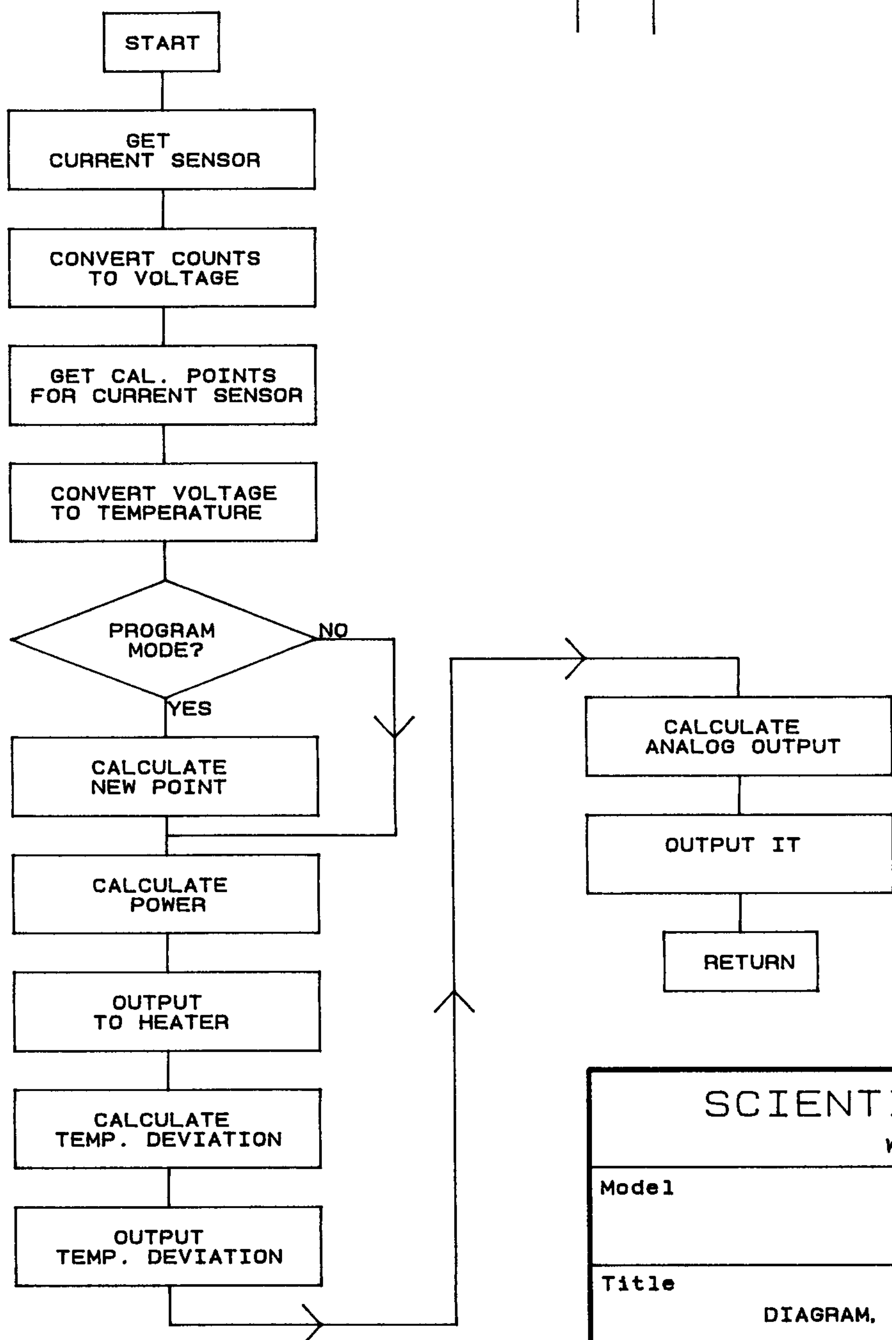
West Palm Beach, Florida 33407

Model	Product INST	Scale N/A	Finish	
			Dwn. W.W.J.	10/13/88
Title DIAGRAM, PROGRAM LOGIC FLOW			Ckd. J.ROUSE	10/14/88
			Apd.	
.0 ± .030 .00 ± .015 .000 ± .005	FSCM No. 53547	Size A	Dwg. No. 031-004	Rev. / Sheet 2 of 4

PROCESS A/D CONVERSION

3

REVISION			
LTR	DESCRIPTION	DATE	APPROVED



SCIENTIFIC INSTRUMENTS, INC.

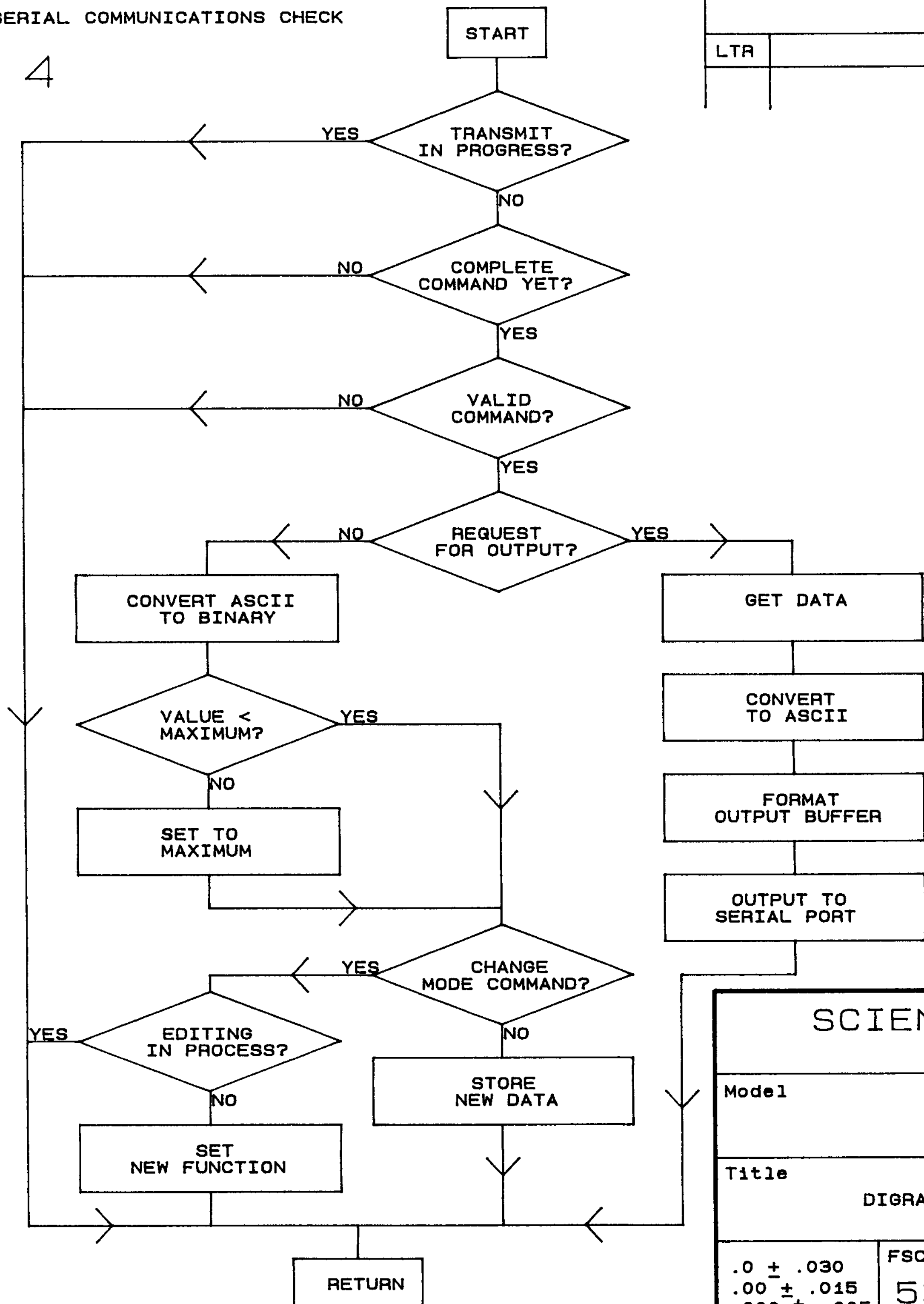
West Palm Beach, Florida 33407

Model	Product	Scale	Finish	
	INST	N/A	Dwn. W.W.J.	10/13/88
Title: DIAGRAM, PROGRAM LOGIC FLOW			Ckd. J.ROUSE	10/14/88
			Apd.	

.0 ± .030 .00 ± .015 .000 ± .005	FSCM No.	Size	Dwg. No.	Rev.	Sheet
	53547	A	031-004	0	3 of 4

SERIAL COMMUNICATIONS CHECK

4



REVISION			
LTR	DESCRIPTION	DATE	APPROVED

SCIENTIFIC INSTRUMENTS, INC.

West Palm Beach, Florida 33407

Model	Product INST	Scale N/A	Finish	
			Dwn. W.W.J.	10/13/88
Title DIGRAM, PROGRAM LOGIC FLOW			Ckd. J.ROUSE	10/14/88
			Apd.	

.0 ± .030 .00 ± .015 .000 ± .005	FSCM No. 53547	Size A	Dwg. No. 031-004	Rev. 0	Sheet 4 of 4

The thermocouple compensation connections are made inside the connector housing located on the rear panel which is in close proximity to the calibrated reference diode.

This construction feature provides an excellent thermal lock between the reference junction and the reference diode. The reference diode is a precision silicon diode temperature sensor which is used to measure the absolute temperature of the reference junction. The actual compensation is performed in software which produces high and repeatable accuracy.

If a chromel vs gold thermocouple is purchased with a Model 9650-5 instrument, the 2-pin mating plug is connected to the thermocouple at the factory. However, for those applications where the user furnishes his own chromel vs. gold thermocouple, a 2-pin mating plug is shipped with the instrument. To connect this plug to the chromel and gold wires, proceed as follows:

a) Remove the screws which secure the cover to the connector body.

b) Remove the screws which secure the two contacts to the connector body.

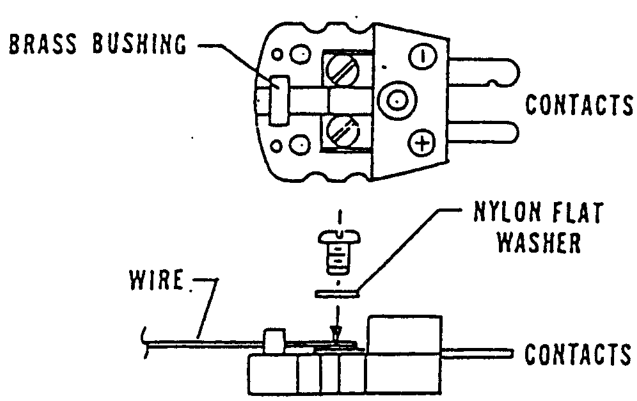
c) Route the thermocouple wires through the hole in the brass bushing.

d) Using a nylon flat washer and a screw, mount the chromel wire of the thermocouple to that contact which is labeled "+". Make certain that the lead wire is <u>between</u> the washer and the contact, as illustrated.

e) Mount the gold wire to the "-" contact in the same manner.

f) Insert the bushing into the recess in the connector body.

g) Replace the connector cover and secure it with the screws.



SCIENTIFIC INSTRUMENTS, INC. W.PALM BEACH FLORIDA 33407	MATERIAL:			DWN. CU 2/09/95
	MODEL: 9650-5	PRODUCT:		ENG. CMG 2/09/95
	TITLE: THERMOCOUPLE CONNECTOR PREPARATION			Q.C.
FSCM 53547	DWG. NO. A 040-389		REV.	PAGE 1 OF 1

Customer:________________ P.O. NO.:________________

Model No.: 9650 Serial No.:__________ Job No.:__________

Sensor Type: Silicon ____ Gallium ____ Platinum ____ Germanium ____

Thermocouple ____ Ruthenium Oxide ____

CALIBRATION DATA

Ref. Junct. # ____ Cal. Pt. 08-373K= ______ /Cal. Pt. 09-273K= ______

Parameter	Sensor No. 1	Sensor No. 2
Serial Number		
Reference Voltage	1.2500	1.2500
Calibration Points		
TEMP 2		
TEMP 4		
TEMP 6		
TEMP 8		
TEMP 10		
TEMP 18		
TEMP 25		
TEMP 40		
TEMP 50		
TEMP 60		
TEMP 80		
TEMP 270		
TEMP 450		
TEMP 4.21		
TEMP 77.35		
TEMP 273.15		
TEMP 373.15		

Note: 1. See attached calibration table "Gallium Arsenide Thermometer" (GA-300NN) for sensor calibration data points.
2. See attached Cal Table "Germanium" for data points stored in E-PROM.

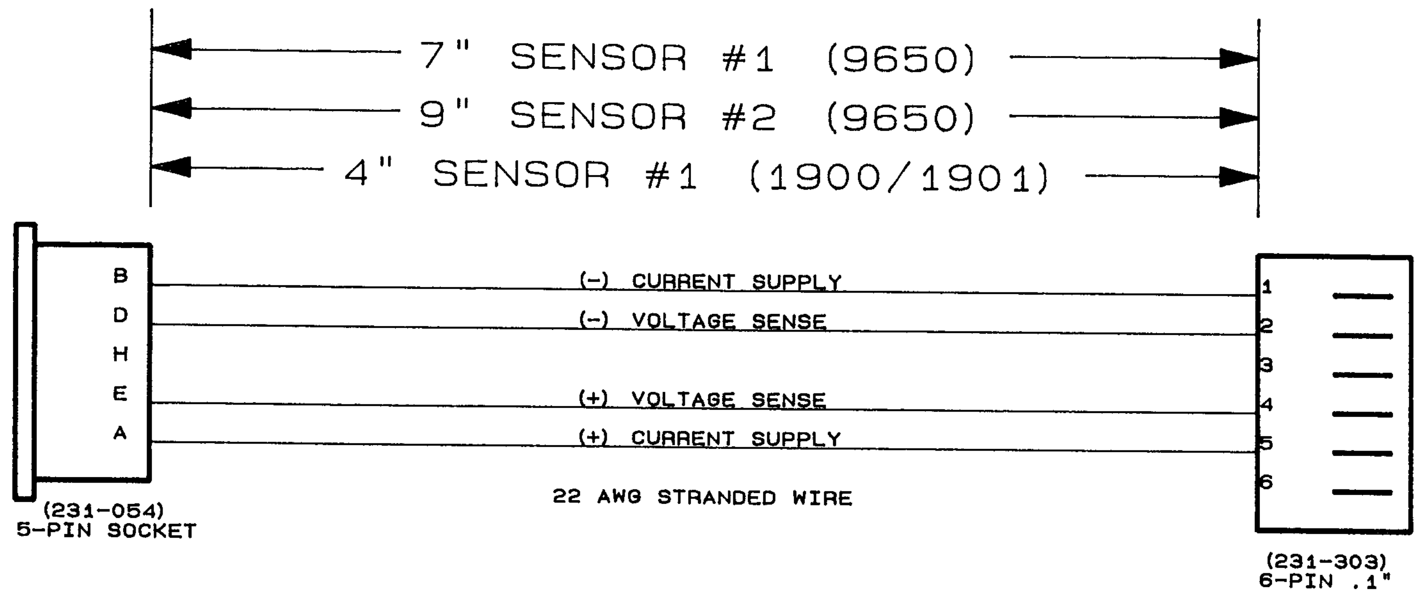
TEMPERATURE DISPLAY DATA		
MEDIA	SENSOR 1	SENSOR 2
WATER 100°C		
ICE 0°C		
NITROGEN		
HELIUM		

AS SHIPPED PARAMETERS			
AC POWER	VAC	RATE	10
SENSOR INPUT		PROP	20
EPROM VERSION		INT	10
IEEE ADDRESS	15	DER	10
RS232 ADDRESS	33	ANALOG	

Data Entered By:________________ Date ________

SCIENTIFIC INSTRUMENTS, INC. WEST PALM BEACH, FL	MATERIAL		SCALE	Dwn. DM Apd. Cmb.	12/10/90 12/10/90	
	Tolerance .00 ± .015 .000± .005 Fract± 1/32 Ang. ± 2°	TITLE INSTRUMENTATION DATA RECORD				
		FSCM NO. 53547	SIZE A	DWG. NO. 0 5 4 - 1 5 8	REV G	SHEET 1 OF 1

REVISION			
LTR	DESCRIPTION	DATE	APPROVED
A	ADDED (1900/1901) ASS'Y. LENGTH	03/22/91	

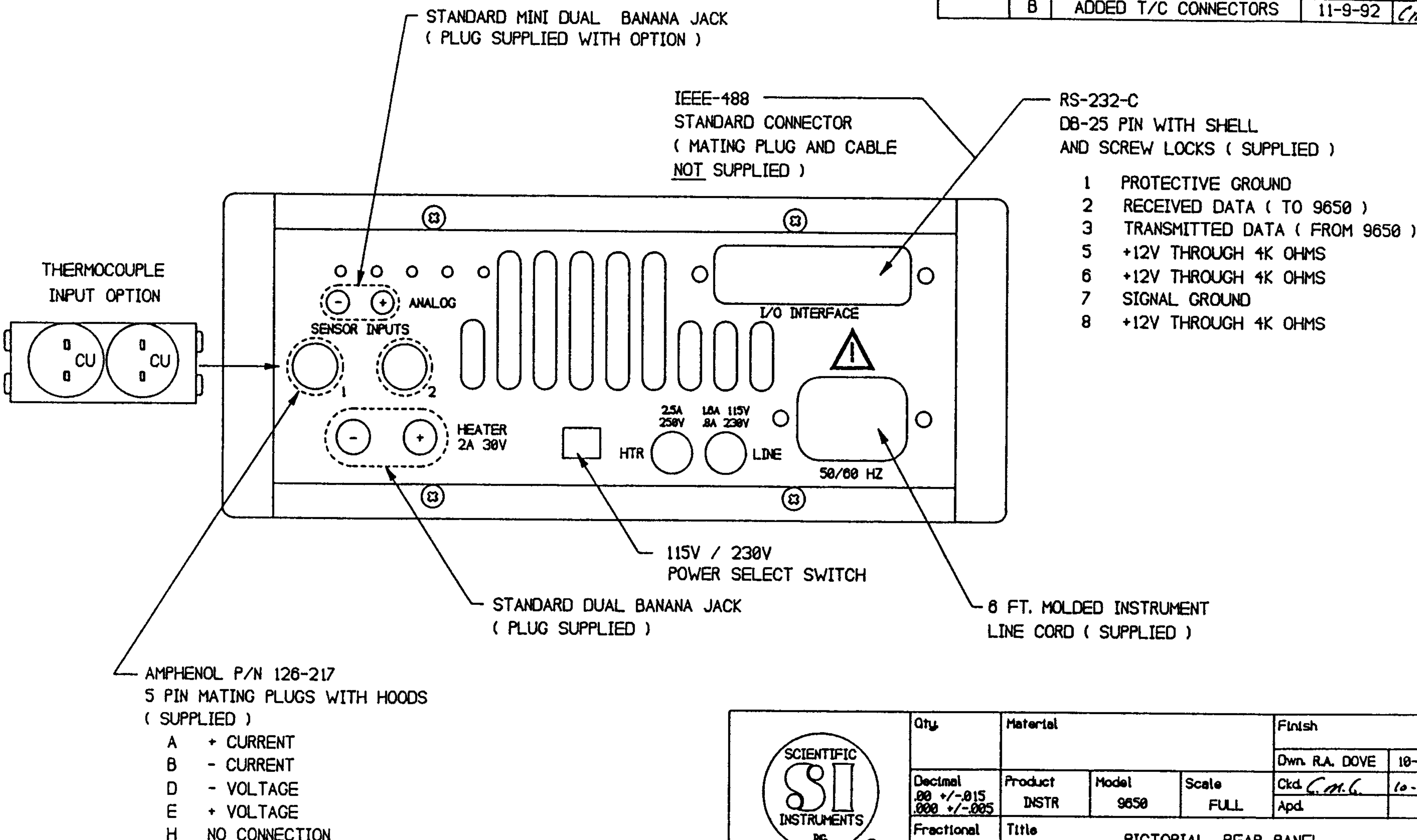


NOTE:

1. 6-PIN CONNECTOR (231-303) TO BE INSTALLED AFTER INSTALLATION INTO REAR PANEL.

SCIENTIFIC INSTRUMENTS, INC. West Palm Beach, Florida 33407					
Model: 9650	Product: INST	Scale: N/A	Finish		
			Dwn. W.W.J.	10/26/89	
Title: CABLE ASS'Y., SENSOR #1 AND #2			Ckd.		
			Apd.		
.0 ± .030 .00 ± .015 .000 ± .005	FSCM No. 53547	Size A	Dwg. No. 162-195	Rev. A	Sheet 1 of 1

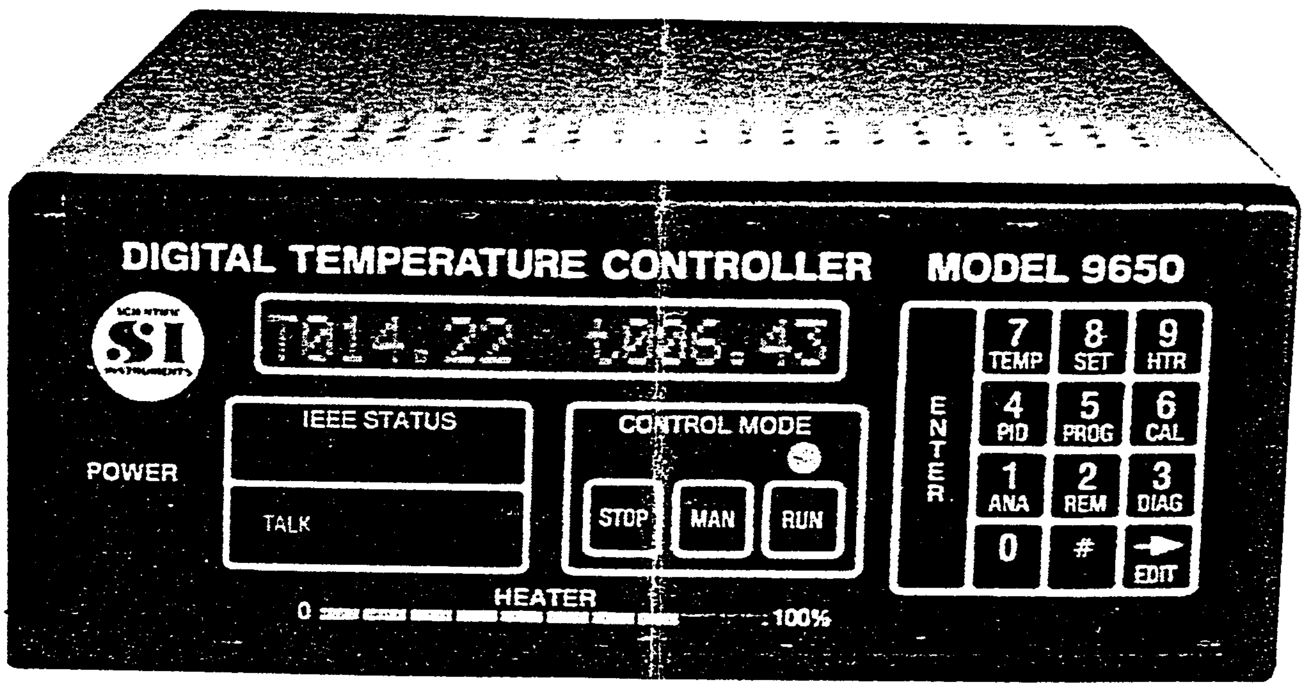
Change No	LTR	Description	Date	Approved
	A	ADDED T/C OPTION	10-31-91	C.M.C.
	B	ADDED T/C CONNECTORS	11-9-92	CMC.



SCIENTIFIC INSTRUMENTS INC. ®
West Palm Beach
Florida 33407

Qty.	Material			Finish	
				Dwn. R.A. DOVE	10-3-90
Decimal .00 +/-.015 .000 +/-.005	Product INSTR	Model 9650	Scale FULL	Ckd. C.M.C.	10-3-90
				Apd.	
Fractional +/- 1/32	Title PICTORIAL, REAR PANEL				
Angular +/- 2 Deg.	FSCM No. 53547	Size B	Dwg. No. 040-343	Rev. B	Sheet 1 OF 1

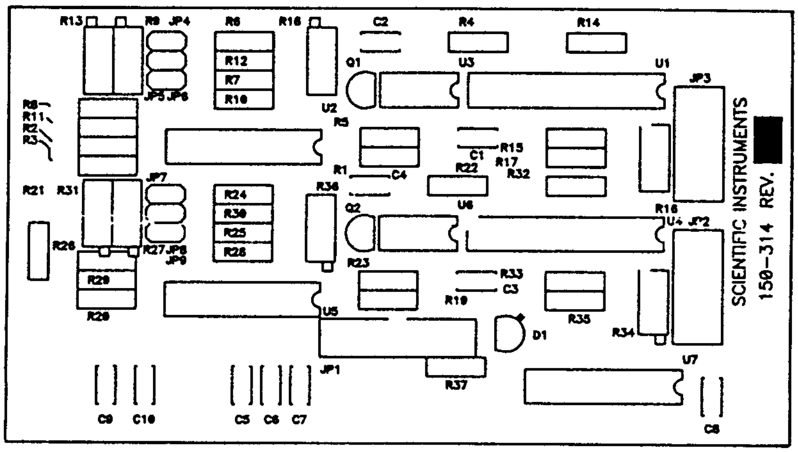
ECO NO.	LTR	Description	Date	Approved



SCIENTIFIC SI INSTRUMENTS INC. West Palm Beach Florida 33407	Material		Finish	Scale	Dwn. R.A. DOVE	1-7-92
					Apd.	
	Tolerance Decimal .00 +/-.015 .000 +/-.005 Frac. +/- 1/32 Ang. +/- 2 Deg.	Title: PICTORIAL, FRONT PANEL				
		FSCM NO. 53547	Size B	Dwg. No. 040-355	Rev.	Sheet 1 OF 1

VERSION

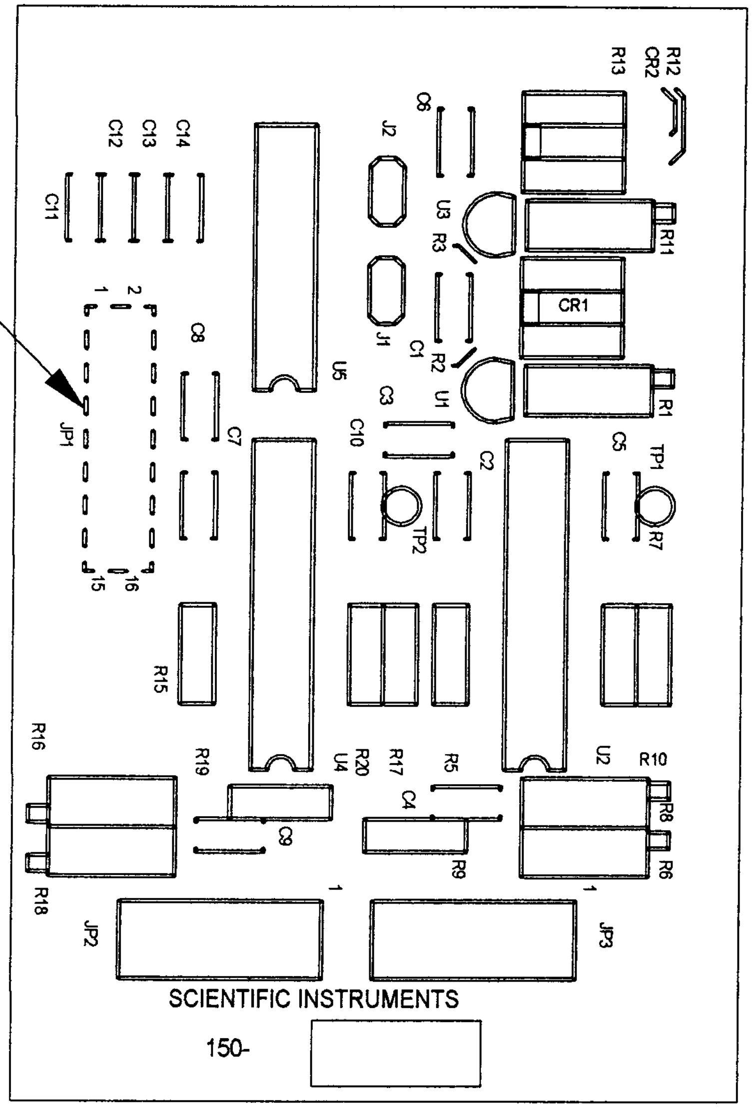
Change NO.	LTR	Description	Date	Approved



SCIENTIFIC SI INSTRUMENTS INC. ®	Qty.	Material M/F 145-160		Finish	
				Dwn. R.A. DOVE	4-26-91
	Decimal .00 +/-.015 .000 +/-.005	Product 1NSTR	Model 9650-3	Scale FULL	Ckd. PRJ	4-29-91
				Apd. C.M.G.	4-29-91
	Fractional +/- 1/32	Title ASSEMBLY, P.C.B., GERMANIUM OPTION			
West Palm Beach Florida 33407	Angular +/- 2 Deg.	FSCM No. 53547	Size A	Dwg. No. 150-314	Rev.	Sheet 1 OF 1

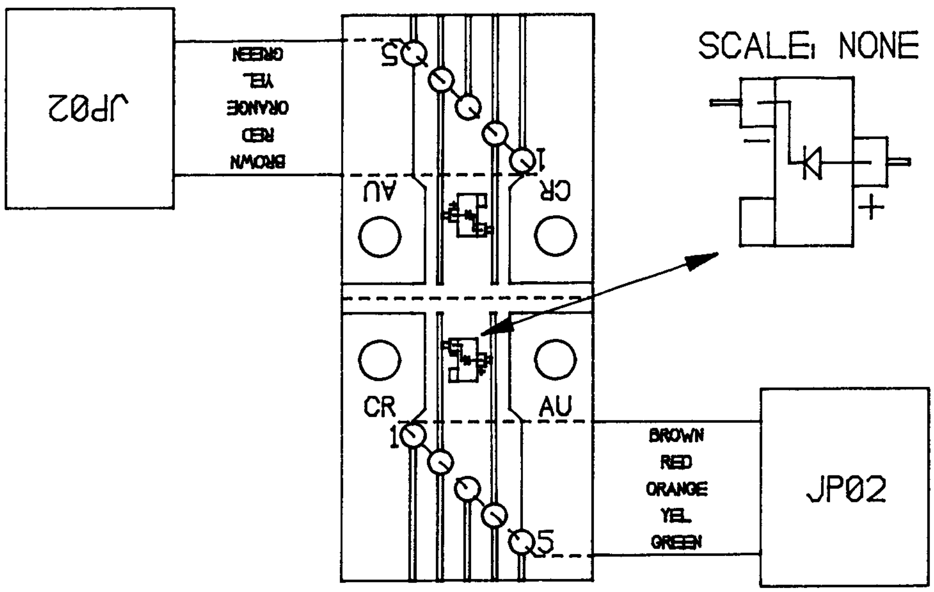
RFEA NO.	LTR	Description	Rev. By	Date	Appr.	Date
N/A	A	INCREASE SIZE 2X	SM	12-4-97	CMG.	12/4/97

MOUNTED TO CIRCUIT SIDE



SCIENTIFIC SI INSTRUMENTS INC. ® West Palm Beach Florida 33407	Material: M/F 145-163	Finish: 32	Scale: NONE	Dwn. R.A. DOVE 4-7-92; Appr. J. RAWLINS 4-7-92	
Tolerance: .00 +/-.030; .000 +/-.010; Frac. +/- 1/16; Ang. +/- 1/2 Deg.; Corners +/- .010	Title: ASSEMBLY, THERMOCOUPLE OPTION P.C.B.				
	FSCM NO. 53547	Size A	Dwg. No. 150-322	Rev. A	Sheet 1 OF 1

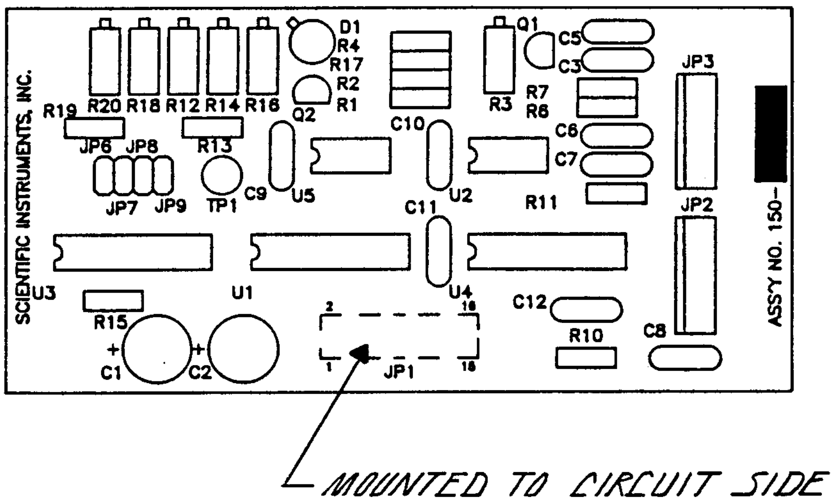
Change NO.	LTR	Description	Date	Approved



SCIENTIFIC SI INSTRUMENTS INC. ®	Qty.	Material		Finish	
				Dwn. R.A. DOVE	10-25-91
	Decimal .00 +/-.015 .000 +/-.005	Product INSTR	Model 9650-5	Scale 2X	Ckd. [illegible]	10-31-91
				Apd.	
	Fractional +/- 1/32	Title ASSEMBLY, REFERENCE JUNCTION P.C.B.			
West Palm Beach Florida 33407	Angular +/- 2 Deg.	FSCM No. 53547	Size A	Dwg. No. 150-323	Rev.	Sheet 1 OF 1

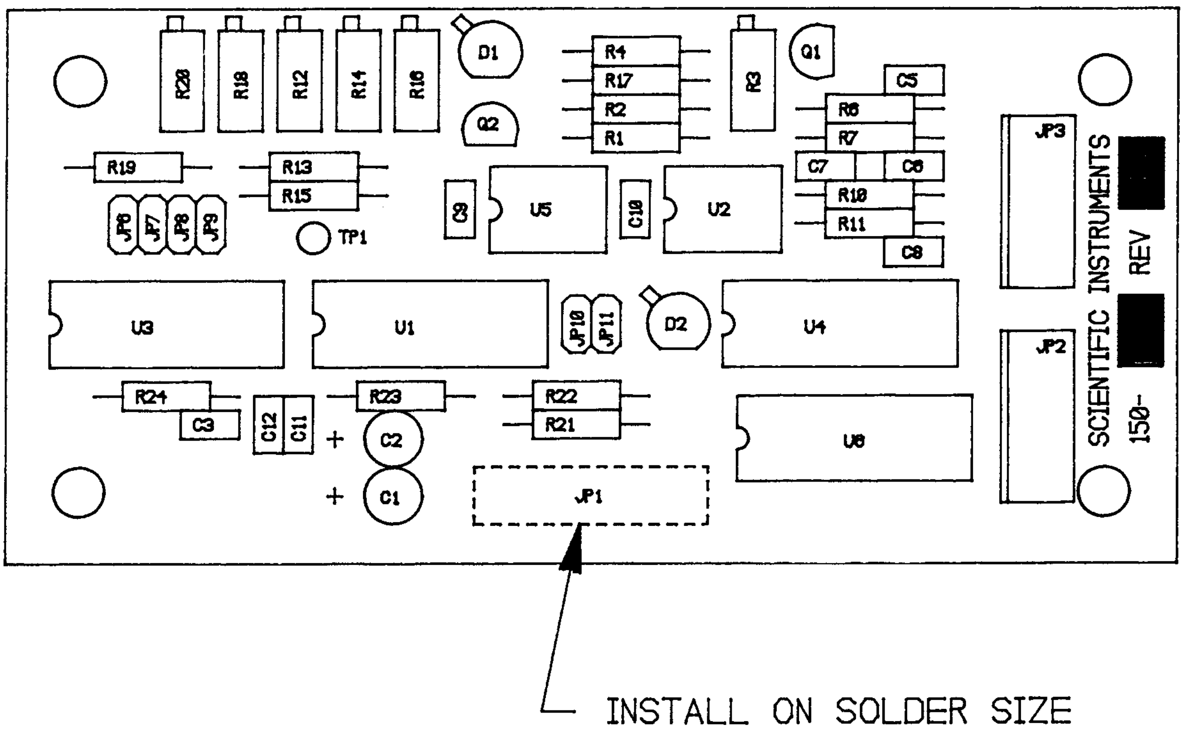
2.6 VERSION

REVISIONS				
CHANGE NO.	LTR	DESCRIPTION	DATE	APPROVED



SCIENTIFIC SI INSTRUMENTS INC West Palm Beach, Florida 33407	Qty.	Material M/F 145-154			Finish Dwn. R.A.DOVE 8-7-90
	Decimal .00 ± .015 .000 ± .005	Product INSTR.	Model 9650/LTC60	Scale FULL	Ckd C.M.G. 8-7-90 Apd.
	Fractional ± 1/32	Title ASSEMBLY P.C.. GALLIUM ARSENIDE / PLATINUM SENSOR OPTION			
	Angular ± 2°	FSCM No. 53547	Size A-	Dwg. No. 151-002- Rev.	Sheet 1 of 1

ECO NO.	LTR	Description	Date	Approved



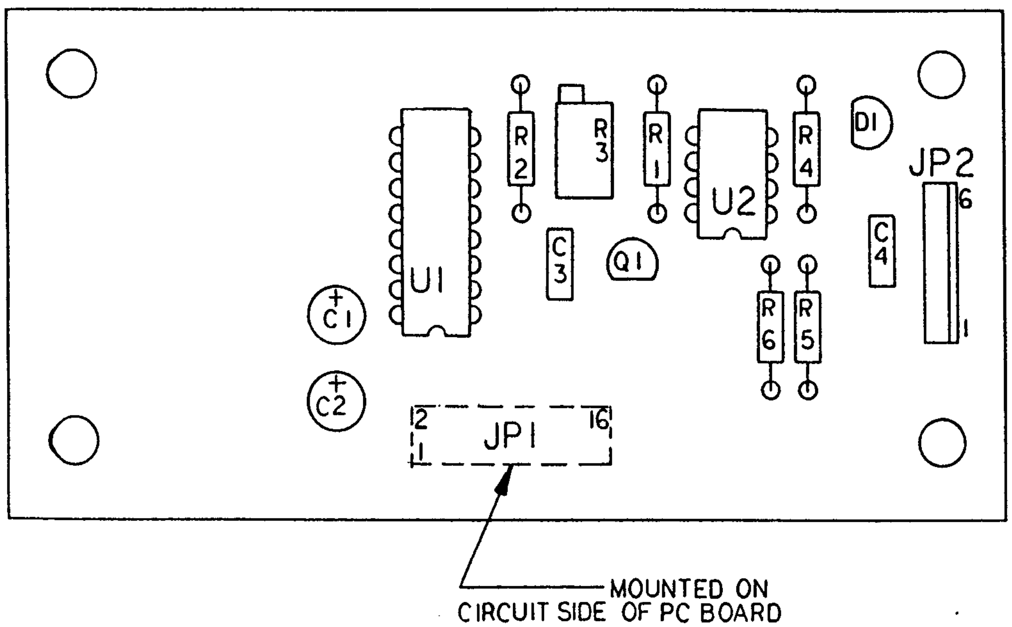
INSTALL ON SOLDER SIZE

SCIENTIFIC SI INSTRUMENTS INC. ® West Palm Beach Florida 33407	Material M/F 145-168	Finish	Scale	Dwn. R.A. DOVE 11-3-92 Apd. C.M.G. 11/3/92
	Tolerance Decimal .00 +/-.015 .000 +/-.005 Frac. +/- 1/32 Ang. +/- 2 Deg.	Title ASSEMBLY, P/C RU02 OPTION BOARD		
		FSCM NO. 53547	Size A	Dwg. No. 151-007 / Rev. / Sheet 1 OF 1

FCAD 2.7 VER. (DISK # 1)

REVISIONS

CHANGE NO	LTR	DESCRIPTION	DATE	APPROVED



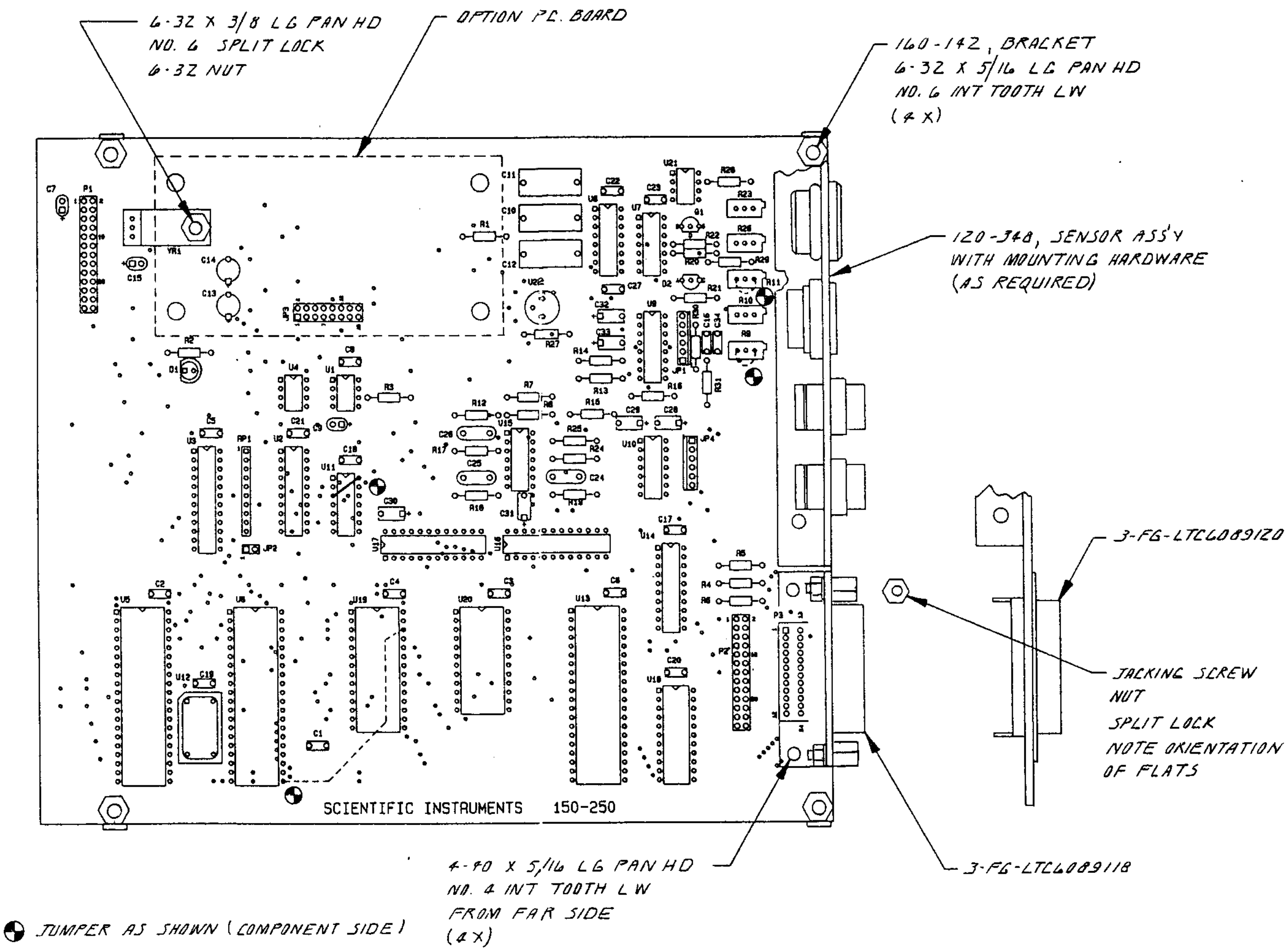
SCIENTIFIC SI INSTRUMENTS INC

West Palm Beach, Florida 33407

Qty. —	Material —			Finish —	
				Dwn. DJE	22 OCT 88
Decimal .00 ± .015 .000 ± .005	Product	Model	Scale 2-1	Ckd. R.A. DAVE	21 OCT 88
				Apd C. M. G.	26 OCT 88
Fractional ± 1/32	Title ASS'Y, P/C 2ND SENSOR				
Angular ± 2°	FSCM No. 53547	Size B-	Dwg. No. 150-276	Rev. 0	Sheet 1 of 1

BRUNING 40 21 66619

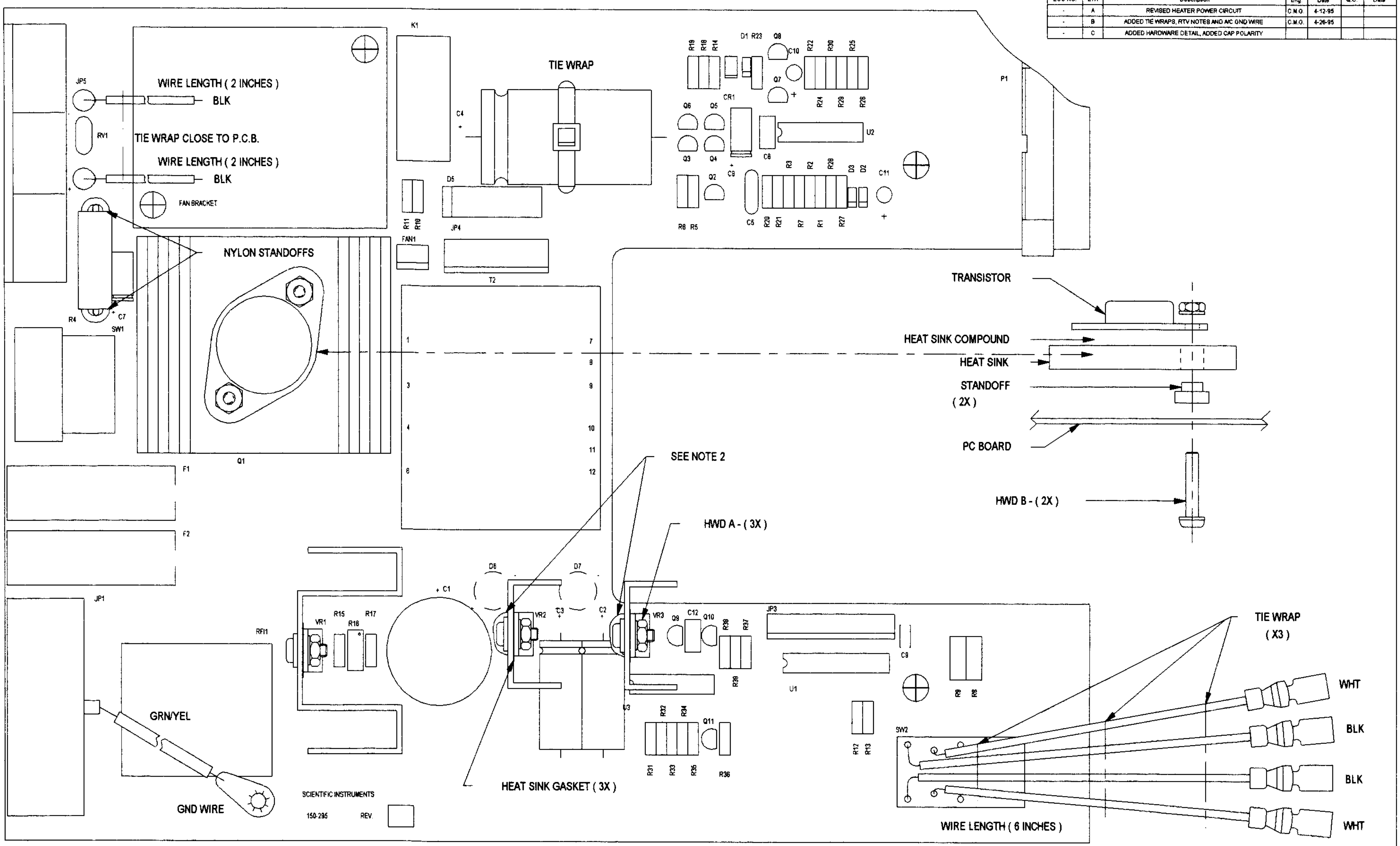
REVISION			
LTR	DESCRIPTION	DATE	APPROVED
A	ADDED JUMPERS & 2ND SENSOR OPTION	15 MAR 89	C.M.G.
B	ADDED JUMPER U8-21 TO U19-26	17 AUG 90	
C	ADDED HARDWARE	5 MAR 97	C.M.G.



JUMPER AS SHOWN (COMPONENT SIDE)

SCIENTIFIC INSTRUMENTS, INC. West Palm Beach, Florida 33407					
Model	Product: INST	Scale: N/A	Finish		
			Dwn. I.B.H.	02/28/89	
Title: ASS'Y.. P/C PROCESSOR			Ckd. M. LEE	02/28/89	
			Apd. C.M.G.	02/28/89	
.0 ± .030 .00 ± .015 .000 ± .005	FSCM No. 53547	Size C	Dwg. No. 150-250	Rev. C	Sheet 1 of 1

ECO NO.	LTR	Description	Eng	Date	Q.C.	Date
-	A	REVISED HEATER POWER CIRCUIT	C.M.O.	4-12-95		
-	B	ADDED TIE WRAPS, RTV NOTES AND A/C GND WIRE	C.M.O.	4-26-95		
-	C	ADDED HARDWARE DETAIL, ADDED CAP POLARITY				



NOTES:

1. C2 AND C3 TO BE SECURED WITH RTV ADHESIVE (3145 OR EQUIV.).

2. VR2 AND VR3 PINS TO BE SECURED WITH RTV ADHESIVE (3145 OR EQUIV.)

HARDWARE	
SYM	DESCRIPTION
A	4-40 X 3/8 PAN HD
B	6-32 X 3/4 PAN HD

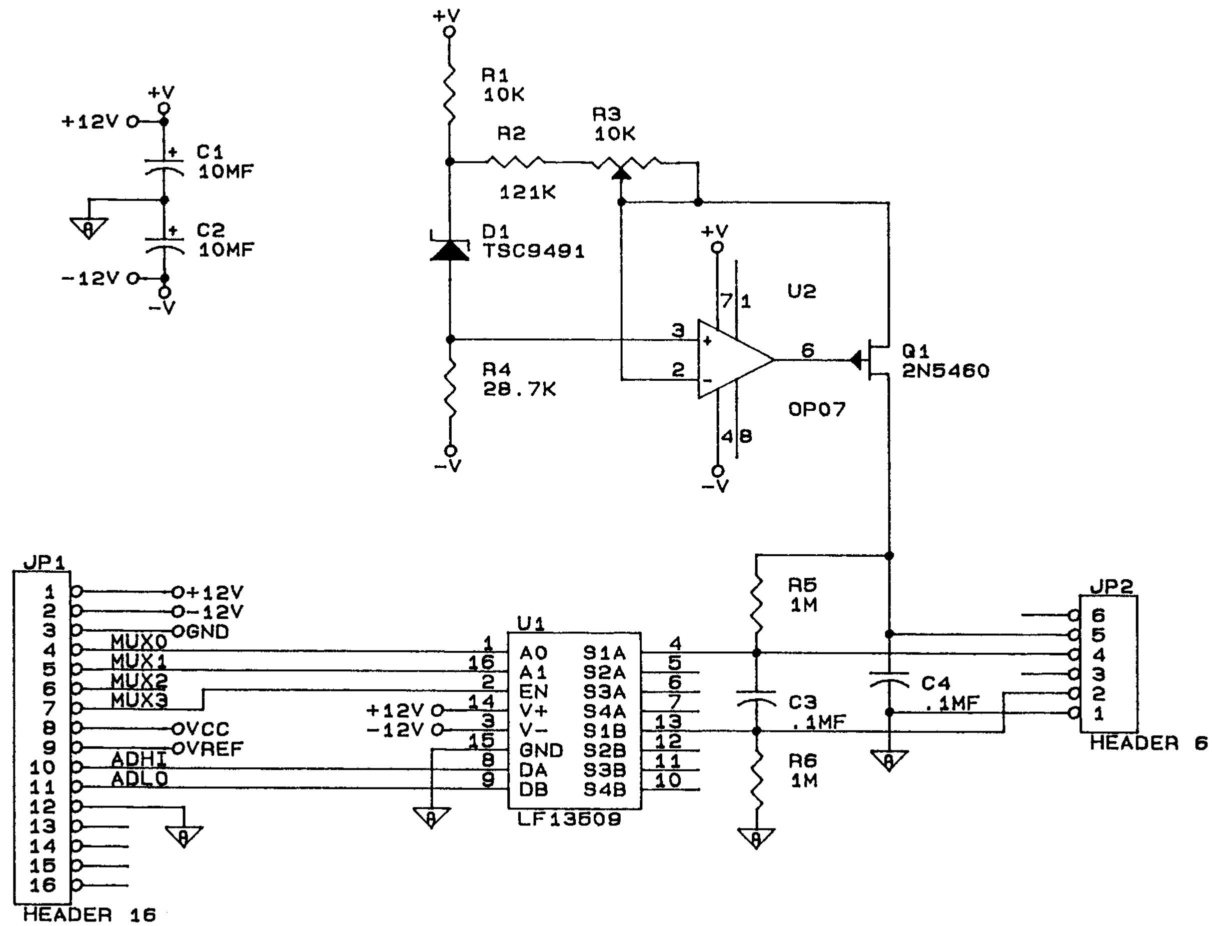
Material | Finish | Scale | Dwn. S.M. 2-16-95 | Eng. C.M.O. 2-16-95 | Q.C.

Tolerance: .00 +/- .030; .000 +/- .010; Frac. +/- 1/16; Ang. +/- 1/2 Deg.; Corners +/- .010

Title: ASSY P/C POWER SUPPLY

FSCM NO 53547 | Size D | Dwg. No 151-001 | Rev C | Sheet 1 OF 1

REVISION			
REV.	DESCRIPTION	ENG. DATE	Q.C. DATE
A	REDRAWN. (R2 WAS 115K)	JPS 11/7/96	

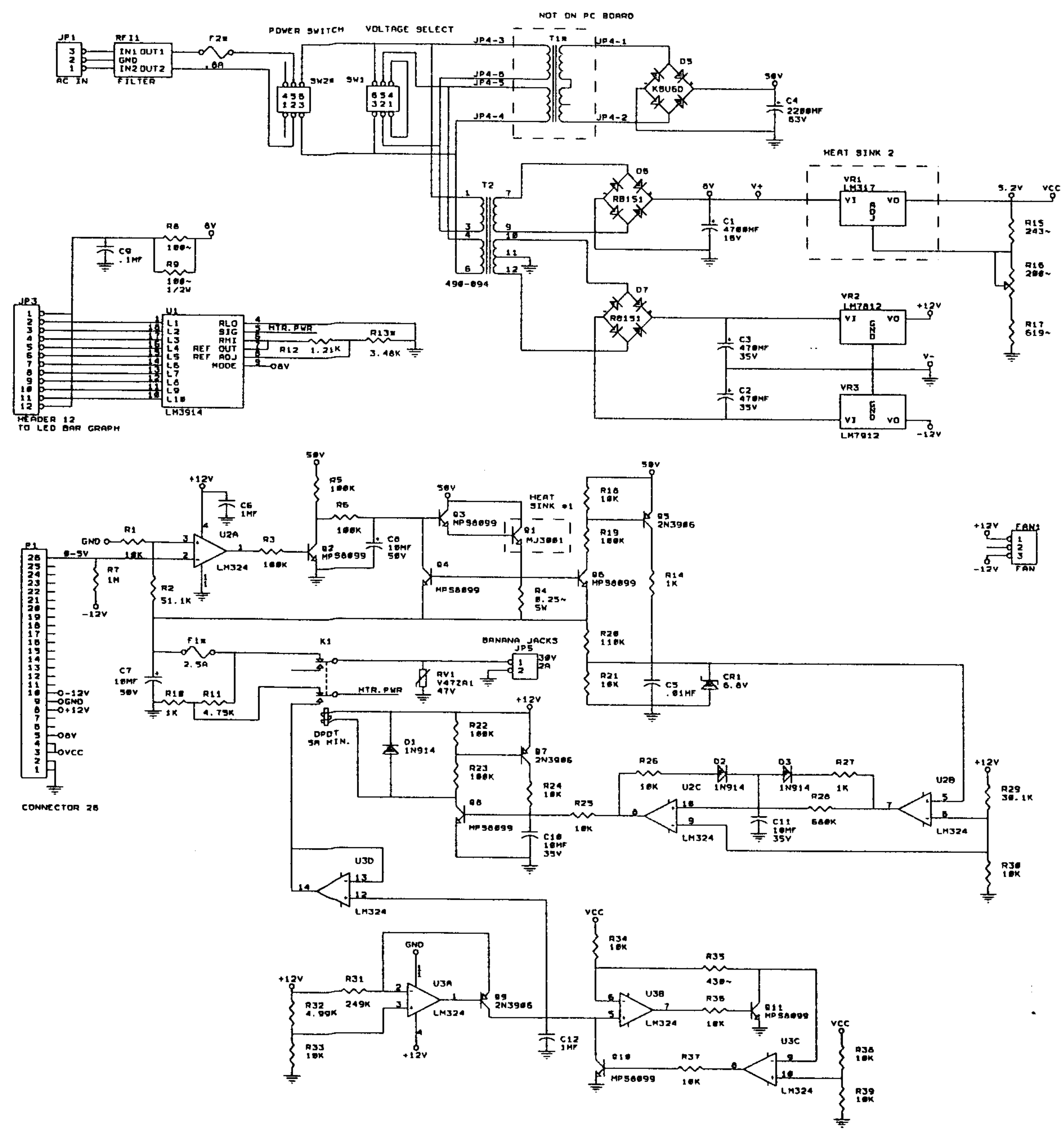


SCIENTIFIC INSTRUMENTS, INC. 4400 WEST TIFFANY DR. WEST PALM BEACH, FL. 33407		DWN. M. LEE	10/07/88
MODEL LTC60	PRODUCT INST	ENG. W.W.J.	10/07/88
		Q.C.	

TITLE SCH., SECOND SENSOR BOARD

DIM. NOM. RES. OHMS CAP. MF	FSCM NO. 53547	SIZE A	DWG. NO. 060-242	REV. A	SHEET 1 OF 1

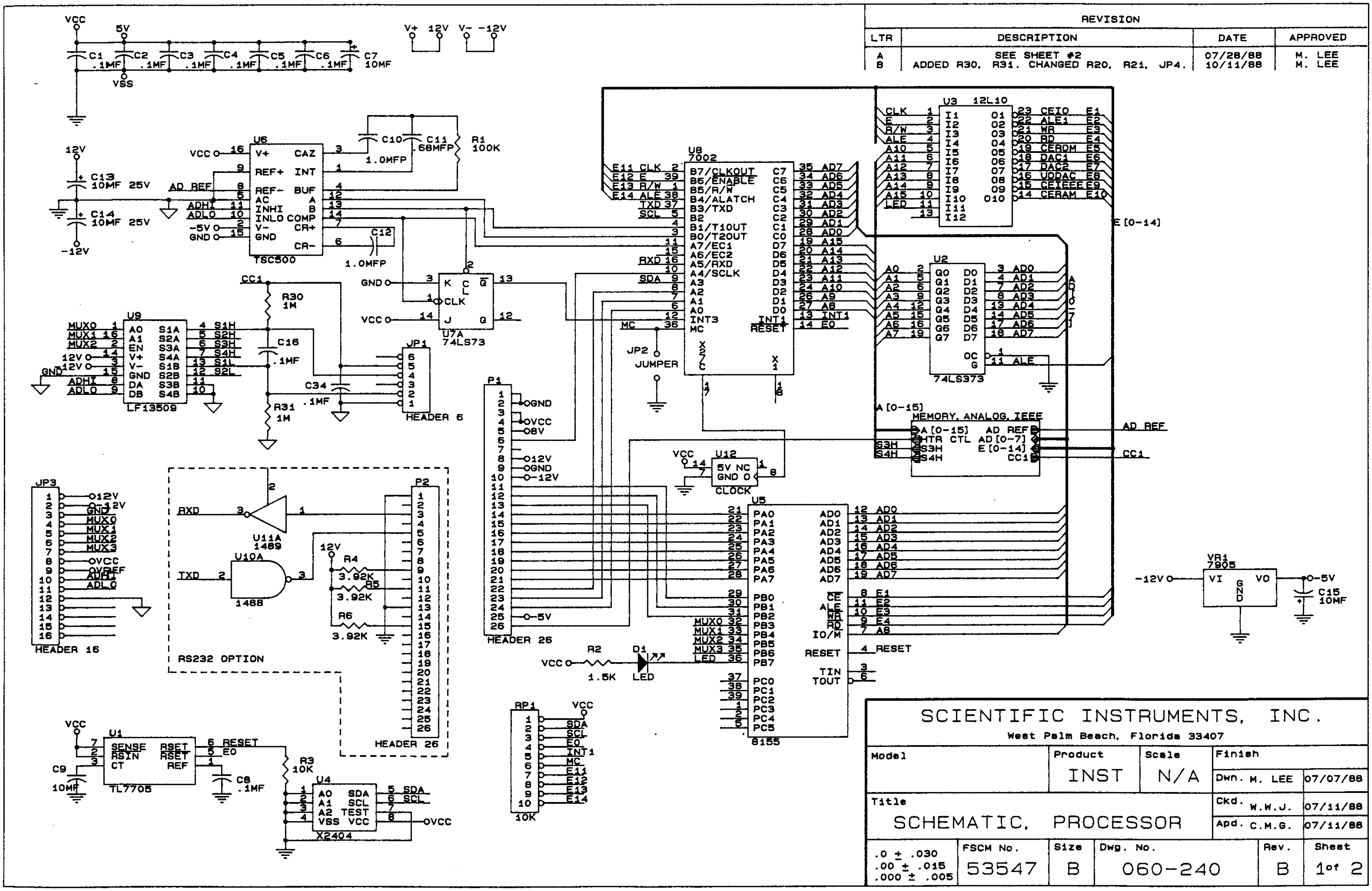
REV.	DESCRIPTION	ENG. DATE	Q.C. DATE
A	MODIFIED 5V SUPPLY	07/27/88	
B	D5 WAS A KBC502	02/01/89	
C	JP5 WAS CALLED JP2	06/09/89	
D	ADDED * NOTE	09/08/89	
E	REVISED AND REDRAWN		



NOTE:
*-REFER TO BOM FOR CORRECT VALUE.

SCIENTIFIC INSTRUMENTS, INC. 4400 WEST TIFFANY DR. WEST PALM BEACH, FL. 33407	DWN. W.W.J.	02/14/95	
MODEL	PRODUCT INST	Q.C.	
TITLE	SCH., POWER SUPPLY		
SIZE C	DWG. NO. 060-238	REV. E	SHEET 1 of 1

REVISION			
LTR	DESCRIPTION	DATE	APPROVED
A	SEE SHEET #2	07/28/88	M. LEE
B	ADDED R30, R31. CHANGED R20, R21, JP4.	10/11/88	M. LEE

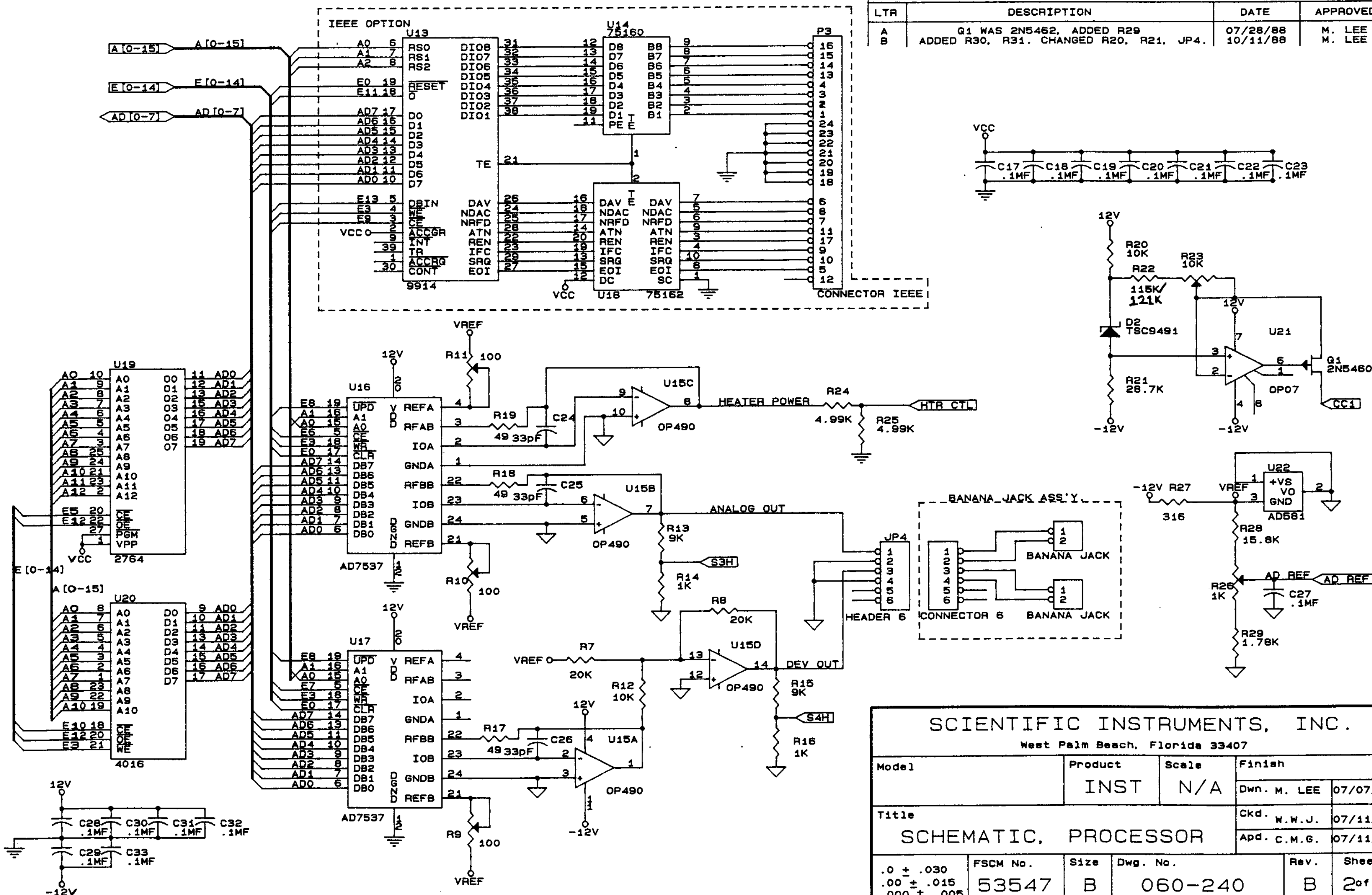


SCIENTIFIC INSTRUMENTS, INC.
West Palm Beach, Florida 33407

Model	Product	Scale	Finish	
	INST	N/A	Dwn. M. LEE	07/07/88
Title: SCHEMATIC, PROCESSOR			Ckd. W.W.J.	07/11/88
			Apd. C.M.G.	07/11/88

Tolerances	FSCM No.	Size	Dwg. No.	Rev.	Sheet
.0 ± .030 .00 ± .015 .000 ± .005	53547	B	060-240	B	1 of 2

LTR	DESCRIPTION	DATE	APPROVED
A	Q1 WAS 2N5462, ADDED R29	07/28/88	M. LEE
B	ADDED R30, R31. CHANGED R20, R21, JP4.	10/11/88	M. LEE

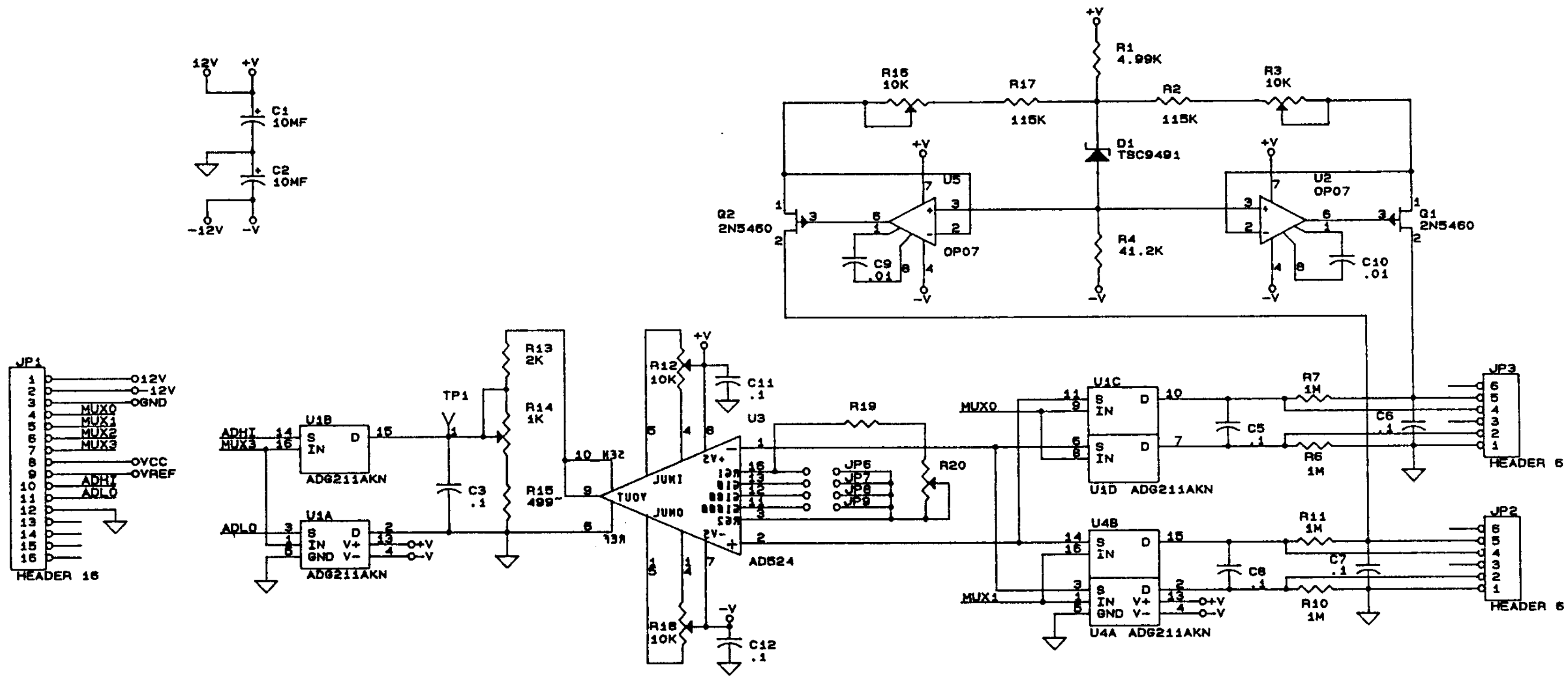


SCIENTIFIC INSTRUMENTS, INC.
West Palm Beach, Florida 33407

Model	Product	Scale	Finish	
	INST	N/A	Dwn. M. LEE	07/07/88
Title: SCHEMATIC, PROCESSOR			Ckd. W.W.J.	07/11/88
			Apd. C.M.G.	07/11/88

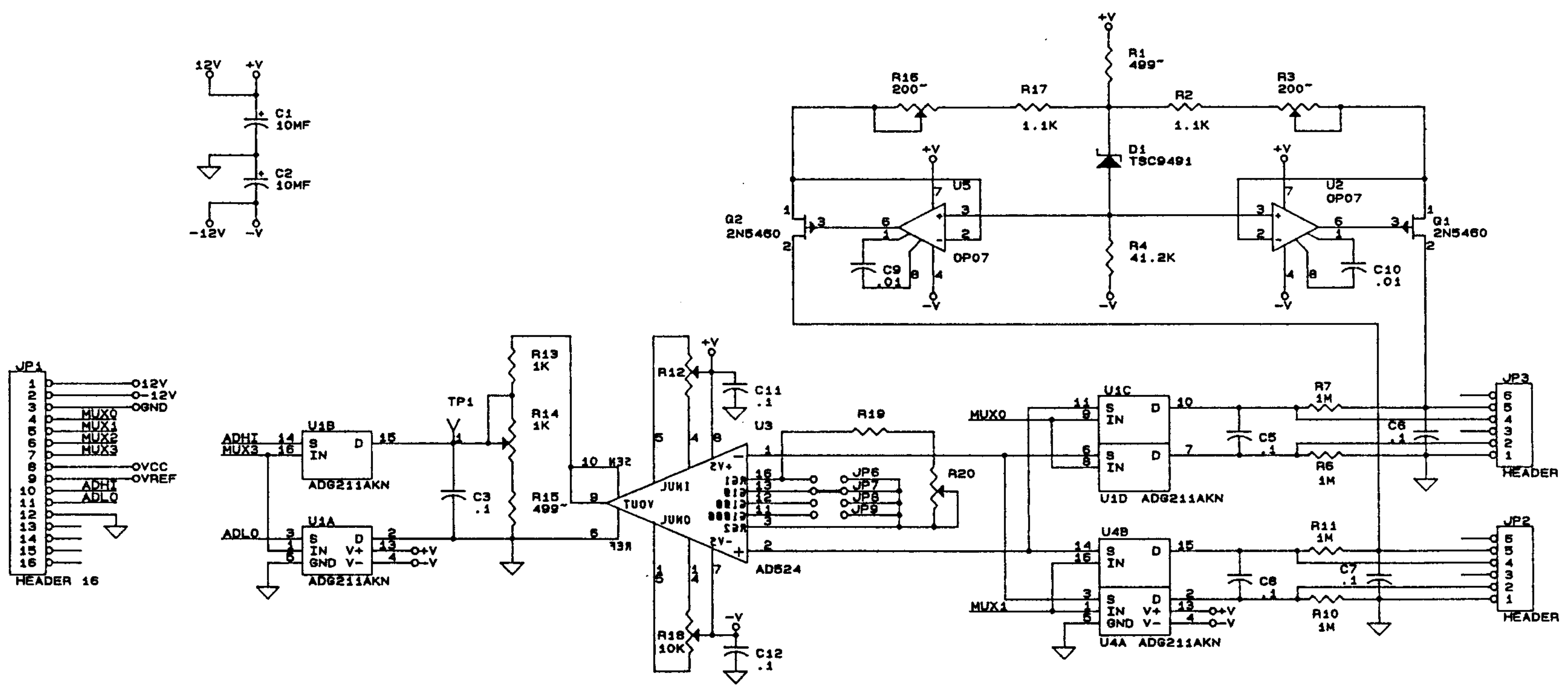
Tolerances	FSCM No.	Size	Dwg. No.	Rev.	Sheet
.0 ± .030 .00 ± .015 .000 ± .005	53547	B	060-240	B	2 of 2

REVISION			
LTR	DESCRIPTION	DATE	APPROVED
A	R18 WIPER WAS TIED TO +V	12/12/91	

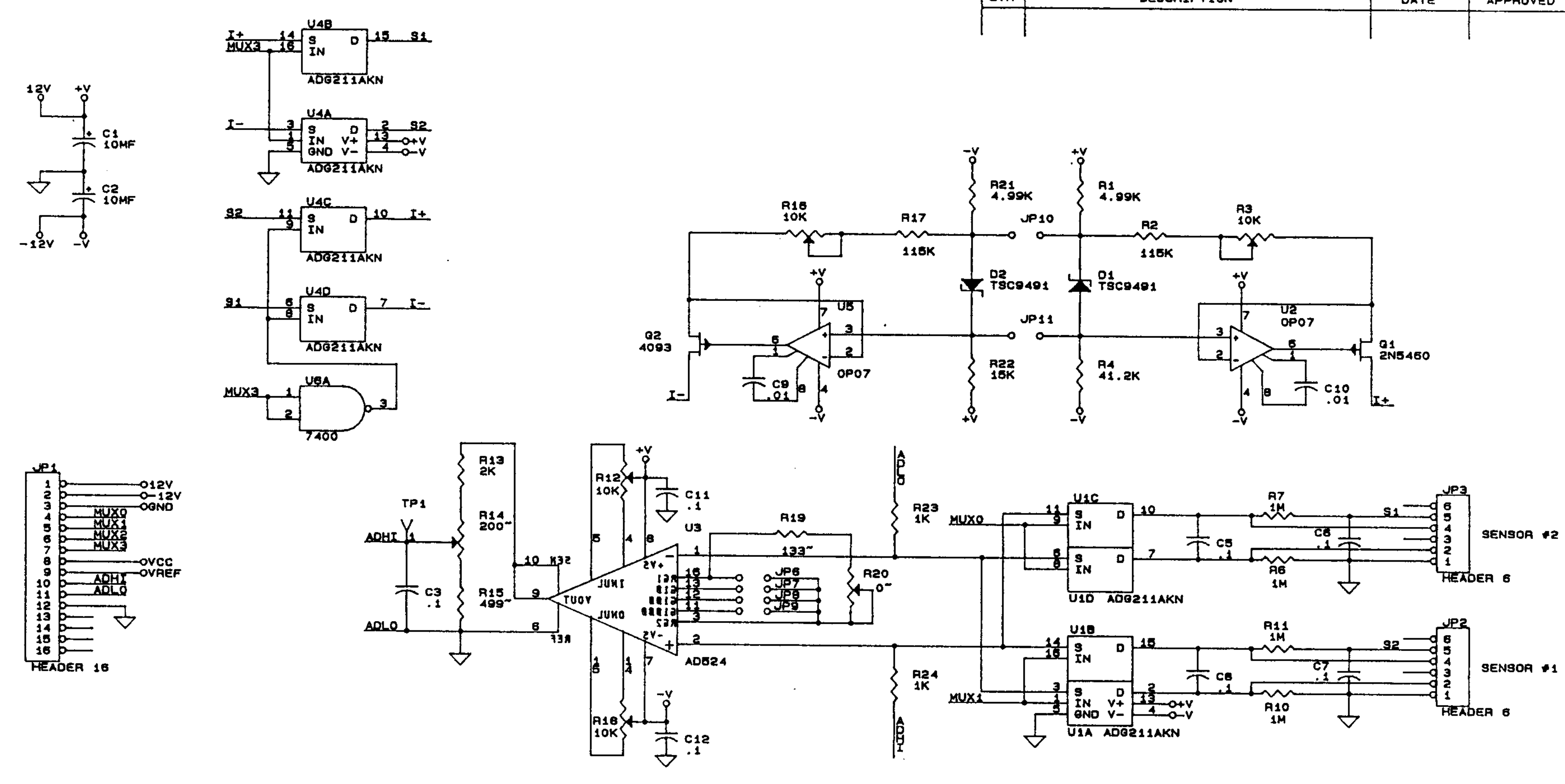


SCIENTIFIC INSTRUMENTS, INC. West Palm Beach, Florida 33407						
Model	Product INST	Scale N/A	Finish			
			Dwn. M.LEE	11/28/90		
Title SCH., DUAL GALLIUM SENSOR OPTION BOARD			Ckd.			
			Apd.			
.0 ± .030 .00 ± .015 .000 ± .005	FSCM No. 53547	Size B	Dwg. No. 060-261	Rev. A	Sheet 1 of 1	

REVISION			
LTR	DESCRIPTION	DATE	APPROVED
A	R18 WIPER WAS TIED TO +V	12/12/91	



SCIENTIFIC INSTRUMENTS, INC. West Palm Beach, Florida 33407					
Model	Product INST	Scale N/A	Finish		
			Dwn. M.LEE	11/28/90	
Title SCH., DUAL PLATINUM SENSOR OPTION BOARD			Ckd.		
			Apd.		
.0 ± .030 .00 ± .015 .000 ± .005	FSCM No. 53547	Size B	Dwg. No. 060-268	Rev. A	Sheet 1 of 1



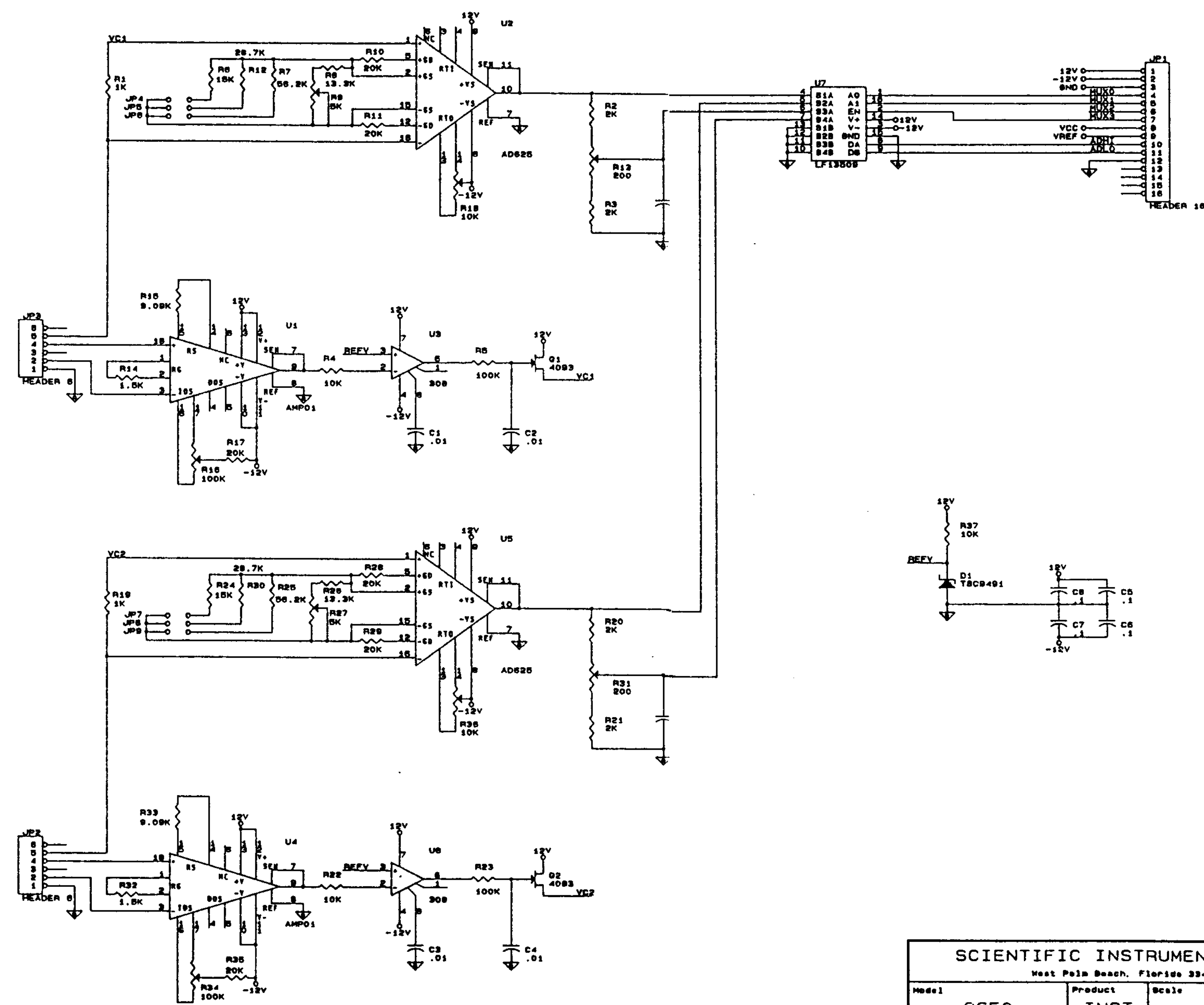
REVISION			
LTR	DESCRIPTION	DATE	APPROVED

SCIENTIFIC INSTRUMENTS, INC.
West Palm Beach, Florida 33407

Model	Product	Scale	Finish		
	INST	N/A	Dwn.	W.W.J.	10/15/92
Title			Ckd.		
SCH., RuO2 OPTION BOARD			Apd.		

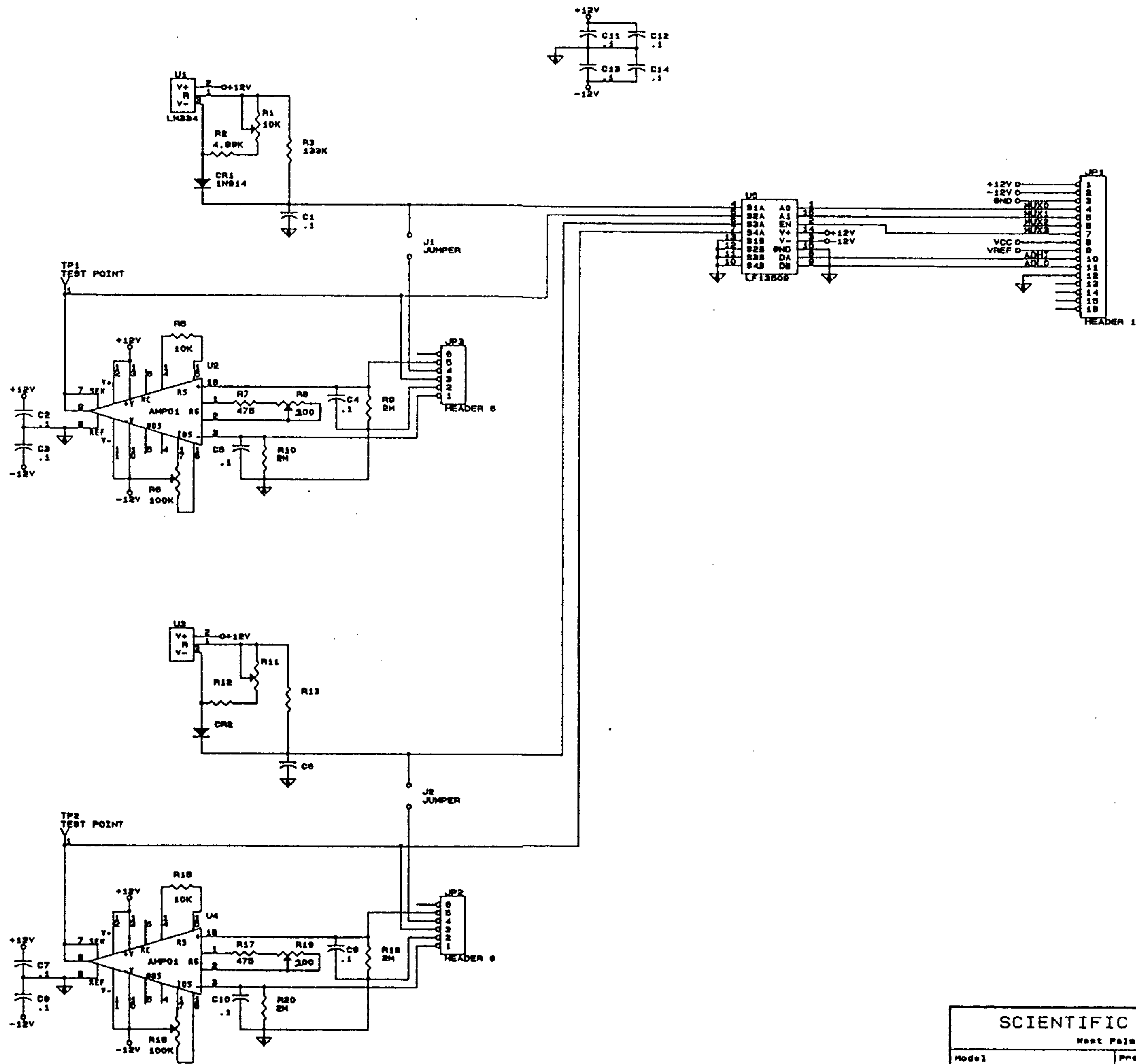
.0 ± .030 / .00 ± .015 / .000 ± .005	FSCM No.	Size	Dwg. No.	Rev.	Sheet
	53547	B	060-278		1 of 1

REVISION			
LTR	DESCRIPTION	DATE	APPROVED



SCIENTIFIC INSTRUMENTS, INC. West Palm Beach, Florida 33407					
Model: 9650	Product: INST	Scale: –	Finish		
			Dwn.	M.L.	03/26/91
Title: SCH. GERMANIUM OPTION			Ckd.		
			Apd.		
.0 ± .030 / .00 ± .015 / .000 ± .005	FSCM No. 53547	Size C	Dwg. No. 060-271	Rev. –	Sheet 1 of 1

REVISION			
LTR	DESCRIPTION	DATE	APPROVED



SCIENTIFIC INSTRUMENTS, INC.
West Palm Beach, Florida 33407

Model	Product	Scale	Finish	
9650	INST		Dwn. W.H.J.	11/18/91
Title: ASS'Y., THERMOCOUPLE OPTION BOARD			Ckd. JHC	16 NOV 91
			Apd. C.M.G.	11/16/91
.0 ± .030 .00 ± .015 .000 ± .005	FSCM No. 53547	Size C	Dwg. No. 060-272	Rev. — Sheet 1 of 1

APPENDIX A

EXPLANATION OF THE 9650 TEMPERATURE CONTROLLER PID CONTROL FEATURE

CONTROLLING TEMPERATURE

The 9650 controls the temperature of a sample block by applying electrical power to a heater on the block. The effect is to balance the cooling obtained from a refrigerator or from a heat leak to a surrounding lower temperature bath. The maximum available output is 30 volts at 2 amp DC, so the resistance of the heater should be no less than 15 ohms. However, better performance is achieved when the heater is selected to use the full voltage range of the instrument. That is, the user should determine how much power is required to provide a convenient warming rate to the highest temperature to be used, and choose a heater resistance that will give this amount of power at 30 volts $(R=(30)^2/W)$.

The function of a temperature controller is to adjust the output to the heater in such a way as to change its temperature T to a setpoint S. Therefore, the temperature sensor should be physically located close to the heater so that it can quickly sense the effect of the applied power. In a real system, however, some time is required for the heat to diffuse through the sample block. For this reason, it is desirable to control not the present temperature, but the temperature at some future time. The 9650 utilizes a derivative term in its control equation to estimate this anticipated temperature:

$$P = PROP * (S - (T + 0.4 * DER * dT/dt)).$$

Where:

DER is the derivative time constant setting, which is in units of the instrument's measurement time (0.4 second), and PROP is the proportional gain settings which determines the instrument's sensitivity to temperature errors.

Ideally, the gain should be as high as possible, but the thermal lags in a real system place a limit on the allowable gain for stable control. If the gain is too high, too much heat will be applied before the temperature change can be detected, resulting in repeated overshoots of the setpoint (oscillation). Because of this limitation, the above equation can only achieve stable control at a temperature below the setpoint, since a certain amount of offset would be needed to generate the steady power required to maintain the temperature. The 9650 overcomes this problem with an integral term in its output equation:

$$HTR = 0.094\ V/K * (P + f (P/INT)\ dT)$$

(If INT is 0, the integral term is set to 0). This integral term can maintain an output level based on the amount of heat needed to reach the setpoint temperature, so that no continuing error is required. When the temperature reaches the setpoint, P is zero and the value of the integral does not change. INT is the integral time constant setting (in seconds) which determines how quickly the integral term responds to an offset. Note that P is allowed to be either positive or negative, so that the integral may both increase and decrease, thus providing good control near the setpoint. The heater output must be positive, however, since the 9650 cannot supply cooling. For this reason, the integral is also limited to the range of the output to provide fast recovery when the temperature has been outside the control band, such as often occurs when the setpoint is changed.

The preceding explanation should be sufficient to calculate the optimum values of the control parameters, provided the user has enough information on the thermal characteristics of his system. In practice, however, it is easier to determine these values empirically. The settings generally are not very critical, so a small change usually will not yield a noticeable affect on the control behavior. The following procedure should help in finding a good starting point:

1) Turn on the 9650, and allow the system to reach its lowest temperature.

2) Set PROP to 50, and disable the INT and DER by setting them both to 00.

3) Select a setpoint in the middle of the normal operating range, and activate the heater.

4) Allow the system to reach a stable condition just below the setpoint. If the temperature continues to oscillate, decrease the PROP setting until the oscillations are small. If there are no oscillations, increase the PROP setting until a slight oscillation begins.

5) Start with an INT setting equal to the period of oscillation in seconds. Decrease the INT setting until the oscillations increase slightly.

6) Set the DER value to half the oscillation period in seconds. This may reduce the oscillations so that the PROP may be increased slightly.

The 9650 should now be set up for satisfactory control. The user should next observe its behavior when the setpoint is changed, and adjust the control parameters to achieve the desired response. A higher PROP will provide better compensation for temperature fluctuations and drift; a higher DER will reduce the overshoot on a setpoint change; a lower INT will provide faster settling to the setpoint. Going too far with any of these adjustments, however, can cause oscillation.

In principle, the larger heat capacities and cooling powers of real systems at higher temperatures mean that the optimum control settings would vary with temperature. However, since the control equation determines the output voltage, and the output power is proportional to the square of the voltage, a given temperature change will result in a larger power change at higher temperatures. This tends to counteract the changes in thermal characteristics, so that settings can often be found which give satisfactory control over the entire temperature range.

APPENDIX B

RS232C OPERATION OF THE 9650

The 9650 may be operated remotely through an RS232C interface. Commands are sent to and information is received from the instrument in the form of ASCII character strings. It is assumed that the user is familiar with how to send and receive these strings from his computer.

The RS232C interface uses a standard DB-25 connector on the rear panel. Setting the GPIB address to 33 enables operation of the RS232C interface. (See 2-4.6 step 5 for an important note.) The 9650 uses a **baud rate of 1200, eight data bits, one stop bit, and no parity**. The pinouts of the DB-25 connector are:

1 Protective Ground
2 Received Data (to 9650)
3 Transmitted Data (from 9650)
5 +12V through 4 Kohms
6 +12V through 4 Kohms
7 Signal Ground
8 +12V through 4 kohms

Temperature setpoint, the three PID parameters (proportional, integral and derivative), the sensor calibration voltages and all other system data may be input to the 9650 by means of specific command strings consisting of alphanumeric characters arranged in a prescribed order. Basically, the format is either "Znnn<cr>" OR "Z<cr>" where Z represents a command character, "nnn" represents a numeric string and <cr> represents an ASCII carriage return character (decimal value 13). Generally, a command with "nnn" is used to **input** data **to** the 9650 and a command without "nnn" is used to **get** data **from** the 9650. The structure of each command string necessary to implement the desired function is detailed in Table 2-1 (starting on page 2-6). Any command string received by the 9650 that deviates from this arrangement will be discarded.

NOTE: When **inputting data to** the 9650 (as in "S1234<cr>" and not "S<cr>" which **gets data from** the 9650) from a host computer, there **MUST** be a short delay (0.2 seconds) between successive commands to allow time for internal processing before transmitting the next command. For example, in inputting the calibration voltages via host computer, there must be at least a 0.2-second delay between successive voltages.

IMPORTANT

NOTE: The 9650 ignores all decimal points and right justifies the data it receives: trailing zeros "0" are important for proper data format.

Examples: To enter setpoint of 80.0K (setpoint entered in tenths.)

Input	**Processed as**	
S80<cr>	8.0	incorrect
S80.0<cr>	80.0	correct
S800<cr>	80.0	correct
S080<cr>	8.0	incorrect
S0800<cr>	80.0	correct
S080.0<cr>	80.0	correct
S80.00<cr>	800.0	incorrect

More examples:

Command - "S1234<cr>" will cause the 9650 to accept a temperature setpoint **input**of 123.4 Kelvin.

Command - "P50<cr>" will cause the 9650 to accept a proportional term value **input** of 50.

Command - "S<cr>" will cause the 9650 to **transmit** the previously entered temperature setpoint value.

Command - D<cr>" will cause the 9650 to **transmit** the previously entered Derivative term value.

NOTE: Calibration voltage commands and Program temperature/time commands use a special format. The format of these two commands is "Cxxnnn<cr>" for inputting data and "Cxx<cr>" for getting data. This is the same as the other commands except for the 'xx' which is a two digit number defining the point to be input or retrieved. Two examples follow:

Command - "C0010110<cr>" will cause the 9650 to accept a calibration voltage of 1.0110 for the first calibration voltage point.

Command - "C00<cr>" will cause the 9650 to **transmit** the previously entered calibration voltage for the first calibration voltage point.

TABLE 2-1 RS232C COMMAND STRUCTURE

INPUT:

FUNCTION	COMMAND	REMARKS
Input Temperature Setpoint	"Snnnn<cr>"	Units 0.1K
Input Proportional Term	"Pnn<cr>"	
Input Integral Term	"Inn<cr>"	
Input Derivative Term	"Dnn<cr>"	
Input Rate Term	"Rnn<cr>"	
Input Analog Zero Term	"Znnn<cr>"	Units 1K
Input Analog Span Term	"Ynnn<cr>"	Units 1K
Input Analog Sensor Number	"sn<cr>" Note: Small s	1 - Sensor 1 2 - Sensor 2
Input Mode (Stop, Man, Run)	"Mn<cr>"	1 - Stop 2 - Manual 3 - Run
Input Program Temp. Point	"Axxnnnn<cr>"	Units 0.1K
Input Program Time Point	"Bxxnnnn<cr>"	Units 0.1 Min.
Input Sensor Calibration	"Cxxnnnnn<cr>" Note: Small "c" for channel 2 (-6 Only)	Type Point Format 1 - All 1.2345 V 2 - All 123.45 Ω 3 - N/A 5 - 0-7 1.2345mV 8,9 1.2345 V 6 - All 1.2345 V 7 - All 123.45KΩ
Input Reference Voltage	"Vnnnn<cr>"	Factory Set 1.2500 V **Do Not Change**

TABLE 2-1 RS232C COMMAND STRUCTURE

GET:

FUNCTION	COMMAND
Get Temperature Setpoint	"S<cr>"
Get Proportional Term	"P<cr>"
Get Integral Term	"I<cr>"
Get Derivative Term	"D<cr>"
Get Rate Term	"R<cr>"
Get Analog Zero Term	"Z<cr>"
Get Analog Span Term	"Y<cr>"
Get Analog Sensor Number	"s<cr>" Note: Small s
Get Mode (Stop, Man, Run)	"M<cr>"
Get Program Temp. Point	"Axx<cr>"
Get Program Time Point	"Bxx<cr>"
Get Sensor Calibration	"Cxx<cr>" Note: Small c for channel 2 (GA300 Only)
Get Reference Voltage	"V<cr>"
Get Heater Output	"H<cr>"
Get Temperature of Sensor 1	"T<cr>"
Get Temperature of Sensor 2	"t<cr>" Note: Small t

"n" = numeric digit
<cr> = carriage return

APPENDIX C

IEEE-488 OPERATION OF THE 9650

The 9650 may be operated remotely through an IEEE-488 (GPIB). Commands are sent to and information is received from the instrument in the form of ASCII character strings. It is assumed that the user is familiar with how to send and receive these strings from his computer.

The GPIB interface uses a standard IEEE-488 connector on the rear panel. The Talk, Listen, and Remote status lights on the front panel monitor the address status of the instrument. The GPIB address is selected through the REMote key as described in Sec. 2.4-6. Valid addresses are 0 through 30, but no two devices on the bus may have the same address. (See 2-4.6 step 5 for an important note.)

Temperature setpoint, the three PID parameters (proportional, integral and derivative), the sensor calibration voltages and all other system data may be input to the 9650 by means of specific command strings consisting of alphanumeric characters arranged in a prescribed order. Basically, the format is either "Znnn<cr>" OR "Z<cr>" where Z represents a command character, "nnn" represents a numeric string and <cr> represents an ASCII carriage return character (decimal value 13). Generally, a command with "nnn" is used to **input** data **to** the 9650 and a command without "nnn" is used to **get** data **from** the 9650. The structure of each command string necessary to implement the desired function is detailed in Table 2-1 (starting on page 2-6). Any command string received by the 9650 that deviates from this arrangement will be discarded.

NOTE: When **inputting data to** the 9650 (as in "S1234<cr>" and not "S<cr>" which **gets data from** the 9650) from a host computer, there **MUST** be a short delay (0.2 seconds) between successive commands to allow time for internal processing before transmitting the next command. For example, in inputting the calibration voltages via host computer, there must be at least a 0.2-second delay between successive voltages.

IMPORTANT

NOTE: The 9650 ignores all decimal points and right justificates the data it receives: trailing zeros "0" are important for proper data format.

Examples: To enter setpoint of 80.0K (setpoint entered in tenths.)

Input	Processed as
S80<cr>	8.0 incorrect
S80.0<cr>	80.0 correct
S800<cr>	80.0 correct
S080<cr>	8.0 incorrect
S0800<cr>	80.0 correct
S080.0<cr>	80.0 correct
S80.00<cr>	800.0 incorrect

More examples:

Command - "S1234<cr>" will cause the 9650 to accept a temperature setpoint **input** of 123.4 Kelvin.

Command - "P50<cr>" will cause the 9650 to accept a proportional term value **input** of 50.

Command - "S<cr>" will cause the 9650 to **transmit** the previously entered temperature setpoint value.

Command - D<cr>" will cause the 9650 to **transmit** the previously entered Derivative term value.

NOTE: Calibration voltage commands and Program temperature/time commands use a special format. The format of these two commands is "Cxxnnn<cr>" for inputting data and "Cxx<cr>" for getting data. This is the same as the other commands except for the 'xx' which is a two digit number defining the point to be input or retrieved. Two examples follow:

Command - "C0010110<cr>" will cause the 9650 to accept a calibration voltage of 1.0110 for the first calibration voltage point.

Command - "C00<cr>" will cause the 9650 to **transmit** the previously entered calibration voltage for the first calibration voltage point.

TABLE 2-1 IEEE-488 COMMAND STRUCTURE

INPUT:

FUNCTION	COMMAND	REMARKS
Input Temperature Setpoint	"Snnnn<cr>"	Units 0.1K
Input Proportional Term	"Pnn<cr>"	
Input Integral Term	"Inn<cr>"	
Input Derivative Term	"Dnn<cr>"	
Input Rate Term	"Rnn<cr>"	
Input Analog Zero Term	"Znnn<cr>"	Units 1K
Input Analog Span Term	"Ynnn<cr>"	Units 1K
Input Analog Sensor Number	"sn<cr>" Note: Small s	1 - Sensor 1 2 - Sensor 2
Input Mode (Stop, Man, Run)	"Mn<cr>"	1 - Stop 2 - Manual 3 - Run
Input Program Temp. Point	"Axxnnnn<cr>"	Units 0.1K
Input Program Time Point	"Bxxnnnn<cr>"	Units 0.1 Min.
Input Sensor Calibration	"Cxxnnnnn<cr>" Note: Small "c" for channel 2 (-6 Only)	Type Point Format 1 - All 1.2345 V 2 - All 123.45 Ω 3 - N/A 5 - 0-7 1.2345mV 8,9 1.2345 V 6 - All 1.2345 V 7 - All 123.45KΩ
Input Reference Voltage	"Vnnnn<cr>"	Factory Set 1.2500 V **Do Not Change**

TABLE 2-1 RS232C COMMAND STRUCTURE

GET:

FUNCTION	COMMAND
Get Temperature Setpoint	"S<cr>"
Get Proportional Term	"P<cr>"
Get Integral Term	"I<cr>"
Get Derivative Term	"D<cr>"
Get Rate Term	"R<cr>"
Get Analog Zero Term	"Z<cr>"
Get Analog Span Term	"Y<cr>"
Get Analog Sensor Number	"s<cr>" Note: Small s
Get Mode (Stop, Man, Run)	"M<cr>"
Get Program Temp. Point	"Axx<cr>"
Get Program Time Point	"Bxx<cr>"
Get Sensor Calibration	"Cxx<cr>" Note: Small c for channel 2 (GA300 Only)
Get Reference Voltage	"V<cr>"
Get Heater Output	"H<cr>"
Get Temperature of Sensor 1	"T<cr>"
Get Temperature of Sensor 2	"t<cr>" Note: Small t

"n" = numeric digit
<cr> = carriage return

APPENDIX D

9650
DIAGNOSTICS

The 9650 has ten diagnostic software features built-in. To use the 9650 diagnostics:

1) Activate the <DIAG> key to access the diagnostic display.
2) Activate the <edit> key to position the cursor in the numeric field.
3) Activate the numeric key corresponding to the diagnostic desired (see table below).
4) Press <enter> to accept and activate this diagnostic.

The table below contains a listing of the ten built-in software diagnostics.

DIAG.	Description
0	Displays the **Revision Number** of the current software and temperature sensor type.
1	Displays the **Reference Voltage** (set at the factory and should **NOT** be changed, although a written copy of this number should be kept, in the unlikely event it ever becomes necessary to re-enter it). If for some reason it becomes necessary to change this number, it may be edited and changed in the same way all other system parameters are changed.
2	Performs a **Display and Front Panel LED check**. When first selected, the message "Display & LED Ck" will appear on the display. The six LED's will be turned on one at a time in the following sequence: **STOP-MAN-RUN-REM-LIST-TALK** The message "Press each key" will then appear followed by a clear screen. At this time, the operator should press each key once. As it is pressed, the corresponding character will appear on the screen. The numbers 0-9 correspond directly. The other keys will display the following characters: **STOP-X, MAN-M, RUN-P, EDIT-S, #-D, & ENTER-E** The ENTER key should be pressed last, exiting this diagnostic function and return to the normal display.
3	Performs **Heater Power Output** check. When this diagnostic is first accessed, "Htr output 0.0" will be displayed and output to the heater circuit will be zero. By pressing any key the "0.0" on the display will be changed to "7.5" and output to the heater will be 7.5 volts. Continuously pressing any key in this manner will cycle through the full range of values - 0.0, 7.5, 15.0, 22.5, and 30.0 volts. After "30.0" is displayed, pressing any key will exit this diagnostic and return to the normal display. Output to the heater circuit can thus be easily monitored by attaching a voltmeter and comparing the voltmeter with the displayed value.

4 Performs the **Analog Output** check. As with the heater output diagnostic check, pressing any key cycles through a range of values. "Ana Output "0.0" is displayed on entry and the full cycle of values is: 0.0, 2.5, 5.0, 7.5, and 10.0 volts. Again, the output may be monitored with a voltmeter attached to the analog output circuitry.

5 **Thermocouple option only**: Displays the temperature and the voltage of the diode located on the reference junction pcb assembly. This temperature is used as the reference junction temperature.

6 Performs the **A/D Converter** check on sensor channel #1 ("Tnnn.nn Vn.nnnn") for diodes or ("Tnnn.nn Rnnn.nn") for resistive elements (not available for germanium option). The values are displayed on entry and continuously updated every A/D conversion. By attaching a known fixed resistance to the sensor leads (as with a decade box) the A/D can be monitored for a functionality check.

NOTE: **Thermocouple option**: Displays sensor input voltage and calculated voltage. The first parameter is the input voltage (in mV) into the 9650. The second parameter is the sample thermocouple voltage referenced to 0K and scaled for input as a calibration point. The calculated voltage of the sample thermocouple scaled in the form:

$$V = (\text{TC voltage}/2) + 0.1$$

The units of the second parameter are the same as needed for the calibration points, so this function can be used to read those values directly.

7 Same as diagnostic #6 except **sensor channel #2** is monitored.

8 Performs a self-check **Rom Test** of its internal read only memory contained on the processor board. A "Rom test OK" or "Rom failure" message will be displayed depending on the results of the test. If the failure message is displayed the unit should be returned to the factory for repair.

Diagnostic 8 continues performing a self-check **Ram Test** of its internal random access memory. As with the Rom test, a "Ram test OK", or "Ram failure" message will be displayed. Again, if the failure message is displayed the unit should be returned to the factory for repair.

9 Displays the **Max Heater Voltage** output value last entered and the edit mode is invoked. The numeric keys may then be activated to change this value as desired. Pressing (enter) will accept the currently displayed value and exit diagnostics, returning to the normal display. This newly entered value will remain as is until changed by a further subsequent editing operation.