4400 West Tiffany Drive, West Palm Beach, FL, USA
(561) 881-8500 (561) 881-8556 Fax

Instruction Manual for 9620 Dual Channel Temperature Indicator/Controller

www.scientificinstruments.com

info@scientificinstruments.com

INSTRUCTION MANUAL
for
SERIES 9620 MICROPROCESSOR-BASED
DUAL CHANNEL DIGITAL TEMPERATURE
INDICATOR/CONTROLLER

RECORD OF REVISIONS				
REV.	DATE	DESCRIPTION	AFFECTED PAGES	AUTHOR. BY
A	08 Mar 90	Revised Section III Internal Components	All	CMG
B	14 Jun 90	Added IEEE Interface	1-3, 2-4 2-5, 2-6 3-1	CMG
C	25 Sep 90	Remove "ref voltage" from RS-232	2-4	CMG

SCIENTIFIC INSTRUMENTS, INC.
MANUAL # A090-180
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SECTION I

GENERAL DESCRIPTION

1-1 INTRODUCTION

The Model 9620 Microprocessor-based Digital Temperature Indicator/Controller has been designed to interface with cryogenic refrigeration systems. The two channels (channel 1 controls & channel 2 indicates) measures and displays process temperature via a remote calibrated silicon diode temperature sensors, and controls power to a heater within the refrigeration system to maintain process temperature at a pre-determined setpoint value. Process temperature is presented to the operator as a four-digit reading on a front panel eight-character 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.

In addition to its function as a temperature indicator, the eight-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 three pushbutton switches mounted on the front panel. EPROMS provide nonvolatile memory capability.

1-2 INDICATORS AND CONTROLS

An eight-character LCD alphanumeric readout and three pushbutton switches 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) activate/deactivate the control feature.

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

a) a temperature setpoint,

b) three terms (Proportional, Integral, Derivative) used in the power output control equation,

c) two calibration offset values and,

d) a calibration reference voltage

The temperature setpoint is the temperature that the Model 9620 will attempt to maintain in the system when in the "control mode" (see section 1-3). The three 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.

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.

1-3 MODES OF OPERATION

Two modes of operation are available and are selectable by means of the front panel <return> pushbutton. These are termed "Control On" and "Control Off". The <return> pushbutton may be pressed while displaying temperature (T nnn.n) or heater output while displaying temperature (T nnn.n) or heater output (H nn.n) to toggle between these two modes.

If the temperature drops below the setpoint while in the "Control On" mode OR if the temperature is below the setpoint OR when the "Control On" mode is initiated, the controller will output power to the heater as determined by the power output control equation. (When in "Control Off" mode the controller will be out putting zero power to the heater.)

The operator can change the temperature setpoint value at any time. He can also monitor all instrument operating parameters (including the current amount of power being applied to the heater) without affecting control of the process medium.

The calibration values allow a single temperature offset to be applied to each sensor. This offset value can be used to calibrate a particular sensor in a specific temperature range to increase the accuracy of the displayed temperature.

1-4 SPECIFICATIONS

1-4.1	Sensors	Silicon Diode, Scientific Instruments, Inc. Model Si-410
1-4.2	Controller - Electrical	
	Temperature Range:	1.5 to 450K
	Number of Channels:	2 (1 control sensor and 1 monitor sensor).
	Sensor Excitation:	Constant current - 10 microamperes
	Input Power:	110/220VAC, 50/60 Hz (switchable)
	Display:	eight character liquid crystal
	Data Entry:	Three (3) pushbuttons, front panel mounted for sensor data
	Data Storage:	E^2PROM
	Resolution:	0.1K
	Accuracy:	±0.5K(1.5 to 25K); ±1.0(>25 to 300K); ±2.5K(>300 to 450K)
	Controllability:	±0.2K(1.5 to 25K); ±0.4(25 to 450K)
	Repeatability:	±0.2K
	Heater Output:	25 Watts max, DC supply (0-25 VDC 1 amp)
	Interface:	RS232C or IEEE-488
1-4.3	Controller - Mechanical	¼ DIN Package
	DIN chassis unit:	5.25"H x 4.25"W x 9.00"D

SECTION II

OPERATION

2-1 INTRODUCTION

Successful operation of the Model 9620 Temperature Indicator/Controller involves the following basic steps:

1) Properly connecting the Model 9620 to the external refrigerator system.

2) Powering-up the controller.

3) Entering the proper controller setup data (temperature setpoint, Proportional-Integral-Derivative values and sensor calibration data) via the front panel pushbutton switches or RS232C (see Section 2.4 & Figure 2-2).

4) Selecting "Control On" or "Control Off" mode as desired.

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

2-2 CONNECTING THE MODEL 9620 TO THE EXTERNAL REFRIGERATOR SYSTEM

All input/output connections between the controller and the external refrigerator system are made via rear panel connectors. Figure 2-3 details the required connections.

2-3 POWERING-UP THE MODEL 9620

The front panel of the Model 9620 Temperature Controller contains a POWER ON/OFF switch, an alphanumeric readout and three pushbutton switches. After properly making the I/O connections, place the power switch in its "on" position.

Normally, the readout will display the temperature as shown in Figure 2-1 below. However, when the operator is reviewing or changing controller data, the readout is employed to display instrument operating parameters.

T 1 123.4

FIGURE 2-1

Upon initial power-up, the controller will assume a standby condition, with the standard temperature display and "Control Off" mode in effect. "Control On" mode may be selected as desired, by pressing the pushbutton <return> switch.

2-4 ENTERING MODEL 9620 SETUP DATA

Reviewing and/or changing sensor calibration data, temperature setpoint and PID values is accomplished via three front panel switches (or via the RS232C link - see Section 2-7).

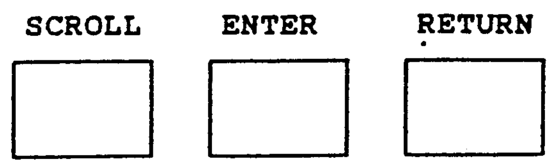


Figure 2-2 depicts, in pictorial form, how the instrument responds to activation of the three front panel switches. For clarification, several examples of switch sequencing follow:

2-4.1 Programming the Temperature setpoint

1) Activate the <enter> switch to increment to the setpoint parameter.

2) Activate the <enter> switch to move the cursor to the setpoint field and to the digit of interest in that field.

3) Activate the <scroll> switch to change the digit of interest.

4) After all digits have been changed to the desired setpoint value, activate the <return> switch. The new setpoint value is saved and if in "control mode", the controller will attempt to bring the mode" process medium to the new setpoint and maintain it at that temperature.

2-4.2 Programming the Proportional term

1) Activate the <enter> switch to increment to the setpoint parameter.

2) Activate the <scroll> switch to increment to the Proportional term.

3) Activate the <enter> switch to move the cursor to the Proportional term field and to the digit of interest in that field.

4) Activate the <scroll> switch to change the digit of interest.

5) After all digits have been changed to the desired value, activate the <return> switch. The new value is saved, and a corresponding change should be observed in the output to the heater.

NOTE: Programming the Integral and Derivative terms is accomplished similarly. The difference is in step #2 -- the number of times the <scroll> needs to be pressed to display the desired parameter.

2-4.3 Programming the Sensor Calibration Data

1) Activate the <enter> switch to increment to the setpoint parameter.

2) Activate the <scroll> switch to increment to either "CAL1" or "CAL2".

3) Activate the <enter> switch to change the calibrate value.

4) Activate the <scroll> switch to set the desired sign off the offset.

5) Activate the <enter> switch to move the cursor to the desired digit.

6) After the desired value is set, activate the <return> switch to save the new value.

2-5 SELECTING THE MODE

The two modes of operation -- "Control On" and "Control Off" are discussed in Section 1-3. It should be emphasized that those modes can be selected ONLY while displaying temperature or heater output.

2-6 MONITORING THE CONTROL PROCESS

The display can be caused to alternate between displaying the control sensor temperature, the monitor sensor temperature, or the heater output, by pressing the <scroll> pushbutton when either of these parameters is presently being displayed.

NOTE: If the sensor is open, the Model 9620 will display 000.0 as temperature, heater output will automatically be shut off.

2-7 REMOTE INTERFACE CAPABILITIES

The Model 9620 may be equipped with either RS232C or GIPB (IEEE-488) interface option but not both at the same time. This section details the unique feature of each plus the software protocol which is the same for both.

2-7.1 RS232C OPERATION OF THE MODEL 9620

As detailed in the RS232C interface communication link is made via pins: (1) GND, (2) TRANSMIT OUT, and (3) RECEIVE IN of the rear panel RS232 connector. Note that the Model 9620 operates at a baud rate of 1200, with eight bit character length, no parity and one stop bit. Thus, any communications equipment in the link must be set to match the Model 9620.

Temperature setpoint, the three PID terms (proportional, integral and derivative) are all input to the Model 9620 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 a carriage return. Generally, a command with "nnn" is used to input data to the Model 9620 and a command without "nnn" is used to get data from the Model 9620. (One exception to this, however, is the "X" command which is used to toggle between "Control On" and "Control Off" mode and is neither an "input" command nor a "get" command. Its format is like the "get" command but it neither inputs nor gets data.) 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 Model 9620 that deviates from this arrangement will be discarded.

NOTE: When inputting data to the Model 9620 "S1234<cr>" and not "S<cr>" which gets data from the Model 9620) from 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.

2-7.2 GIPB OPERATION OF THE MODEL 9620

The IEEE-488 General Purpose Interface Bus (GPIB) option is offered as an alternative method of interfacing the Model 9620 to a host computer or data acquisition system. It is assumed that the user is familiar with the general operation of the bus in his own system. This information should be provided in the documentation for the bus controller.

The Model 9620 is normally shipped set to a bus address of 24. Since no two devices on the bus may have the same address, it may be necessary for the user to change this setting. The following procedure explains how this can be accomplished:

1) Unplug the instrument power cord, and disconnect all wiring and cables from the rear panel.

2) Remove the instrument from the equipment racks or panel into which it is mounted.

3) Lay the instrument on its right side on the workbench.

4) Remove the four screws which secure the front panel to the instrument case.

5) Carefully move the front panel forward until the display board clears the case, then move it to the left side.

6) Locate the DIP switches on the middle board to the right of the ribbon cable connector. The GPIB address is selected by the first five switches from the left. The switches may be moved with a small screw driver. The last three switches must be left in the down position.

7) The address is specified in a normal binary manner (hexidecimal) with "down" being zero and "up" being one. It is shipped from the factor with setting of 24.
   * Switch 1 is LSB, switch 5 is MSB.

8) Carefully replace the front panel, and the four screws, re-install the instrument, and re-connect the cabling.

After the bus address has been selected, the instrument may be connected to the bus with a standard GPIB cable and powered up. Be sure that the cable is securely attached.

Data can either be sent or read from the Model 9620. To send data to the instrument, a string is sent according to the format indicated in table 2-1. Note that the normal format is an identifier character followed by a number and <CR>. The command will be processed once the <CR> is received.

For data to be sent to the host, two steps must be taken. First, a single letter command must be sent to the controller indicating the data that is described. For example, to receive the temperature of channel 1, a "T" followed by a <CR> must be sent to the unit. Then the Model 9620 should be placed in the talker mode. After this, any time a data transfer is initiated, the temperature will be sent according to the format in table 2-1. No other command need be sent if only that parameter is desired. If a second parameter is desired, however, then the identifier of that parameter should be sent and the same procedure followed.

Note that when editing data from the front panel, the GPIB interface is not operative. This should not be a problem, since normally the instrument is either operated from the remote interface or from the front panel but not both at the same time.

2-7.3 SOFTWARE PROTOCOL

I M P O R T A N T

The Model 9620 processes (and displays) the temperature setpoint in tenths (0.0), thus all input data must be structured to take this into account. The following table is included for clarification:

	Input Value	Processed as
Temp. Setpoints:	12	1.2
	12.3	12.3
	123	12.3
	1230	123.0
	1.230	123.0

For clarification of data entry, several examples follow:

Command - "S1234<cr>" will cause the Model 9620 to accept a temperature setpoint input of 123.4 Kelvin.

Command - "P50<cr>" will cause the Model 9620 to accept a proportional term value input of 50.

Command - "S<cr>" will cause the Model 9620 to transmit the previously entered temperature setpoint value.

TABLE 2-1 RS232C COMMAND STRUCTURE

I N P U T:

FUNCTION	COMMAND
Input temperature setpoint	"Snnn<cr>"
Input Proportional term	"Pnn<cr>"
Input Integral Term	"Inn<cr>"
Input Derivative term	"Dnn<cr>"

G E T:

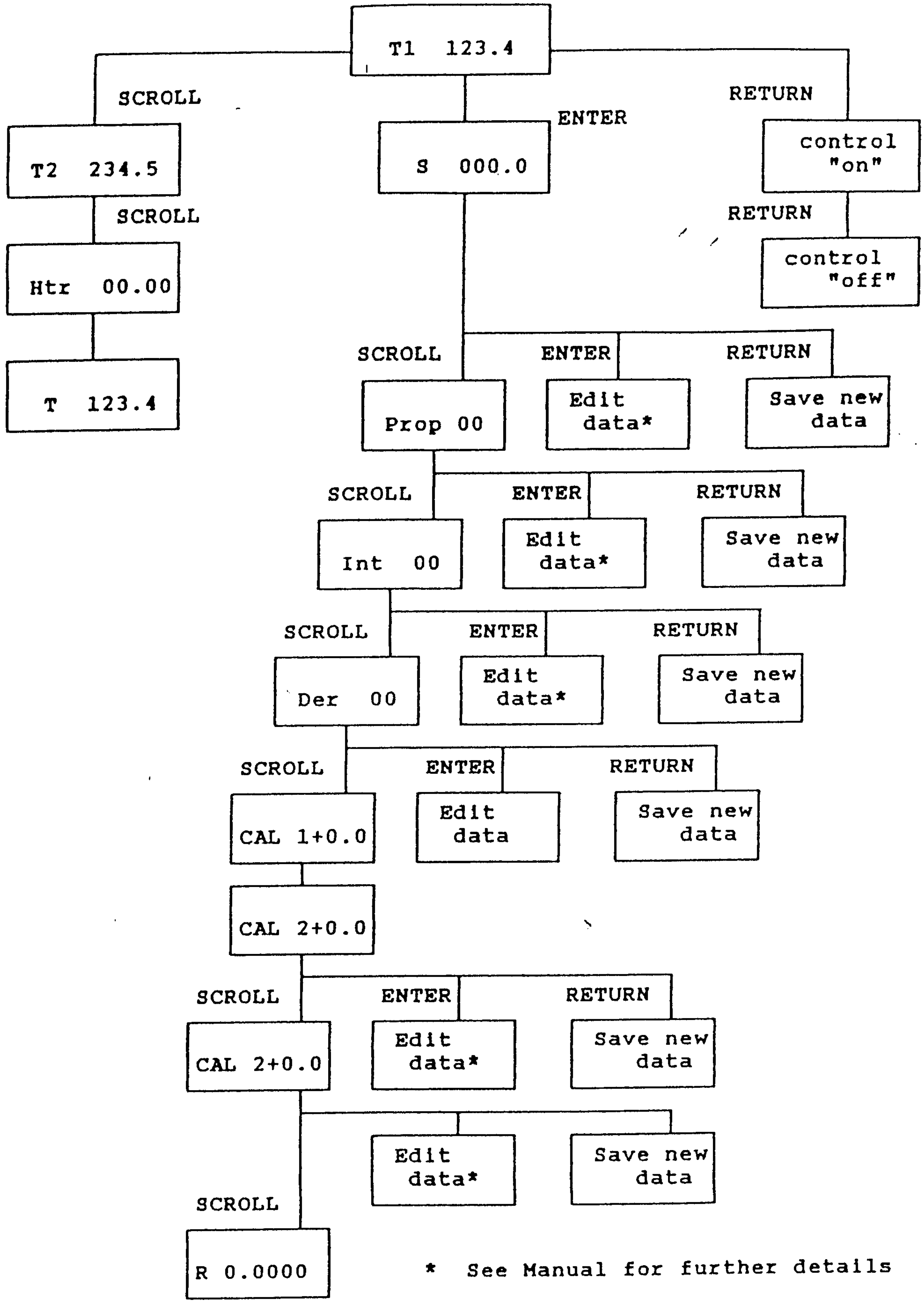
FUNCTION	COMMAND
Get Temperature setpoint	"S<cr>"
Get Proportional term	"P<cr>"
Get Integral Term	"I<cr>"
Get Derivative term	"D<cr>"

	Get Heater output	"H<cr>"
	Get Temperature T1	"T<cr>"
	Get Temperature T2	"t<cr>"
SPECIAL:	Toggle control mode	"X<cr>"

"nnn" = numeric string

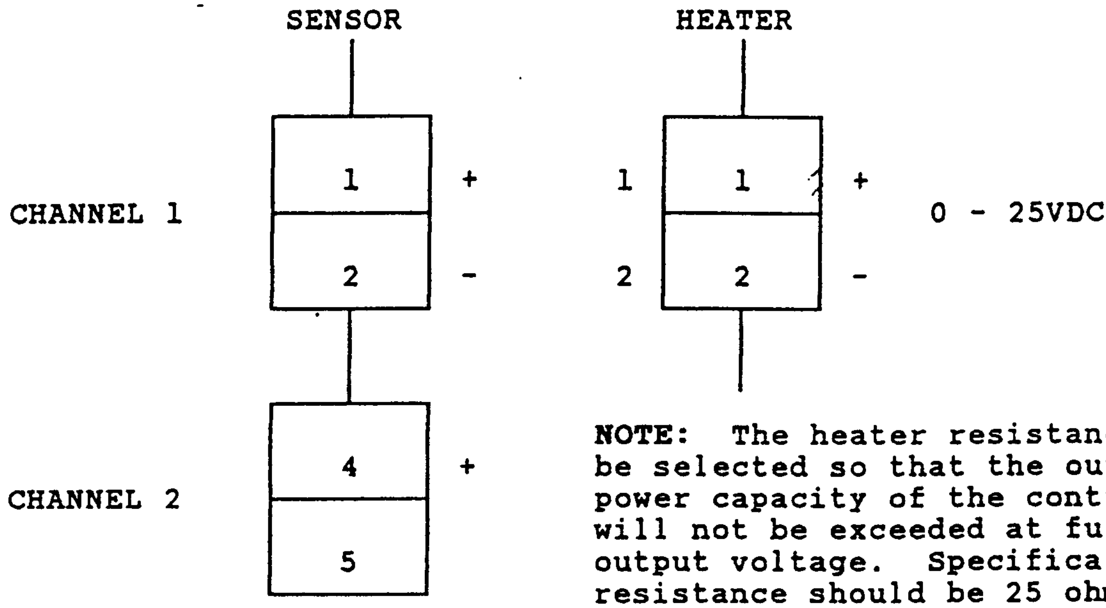
<cr> = carriage return

DISPLAY AT POWER UP



* See Manual for further details

FIGURE 2-2



NOTE: The heater resistance must be selected so that the output power capacity of the controller will not be exceeded at full output voltage. Specifically, the resistance should be 25 ohms or greater to limit the power to 25 watts or less.

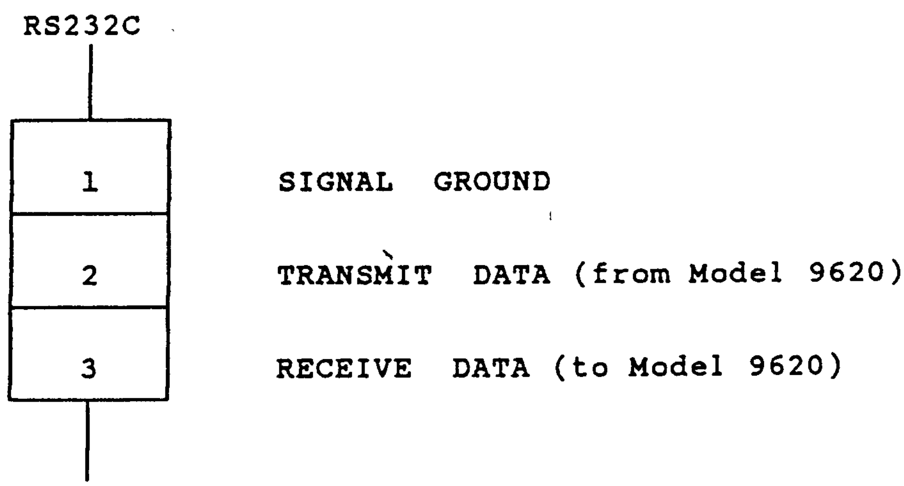


FIGURE 2-3

REAR PANEL CONNECTIONS

SECTION III

INTERNAL COMPONENTS

3-1 INDEX

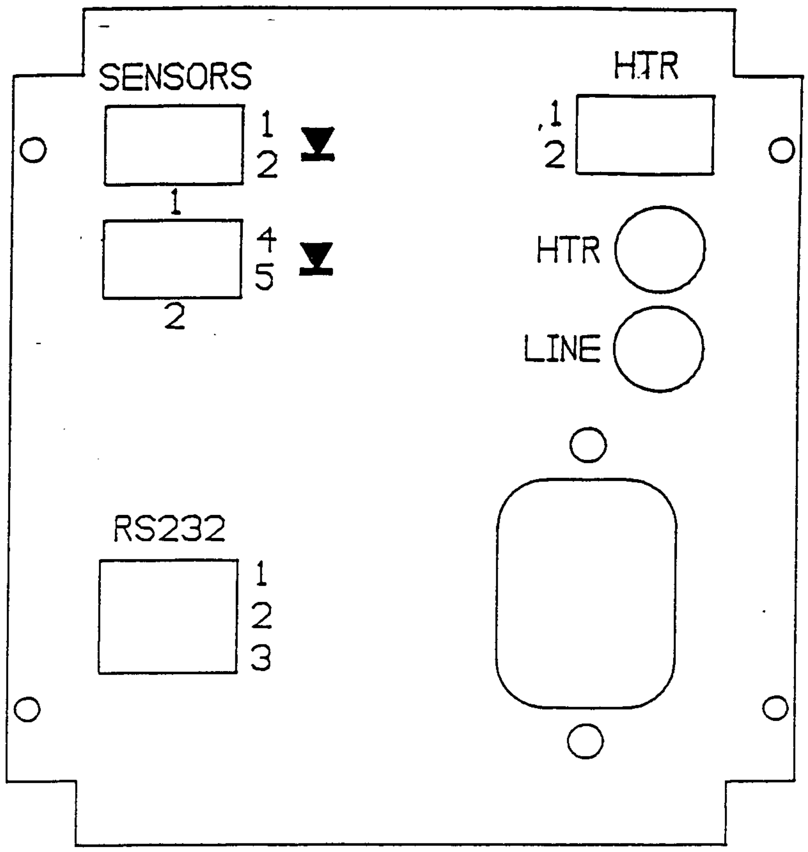
P/C ASSEMBLIES:

PICTORIAL, REAR PANEL CONNECTIONS (RS232)	A040-335
PICTORIAL, REAR PANEL CONNECTIONS (IEEE)	A040-336
DISPLAY P/C ASSEMBLY (reduced)	C150-215A
IEEE-488 OPTION P/C ASSEMBLY (reduced)	C150-218C
POWER SUPPLY P/C ASSEMBLY (reduced)	C150-235B
PROCESSOR P/C ASSEMBLY (reduced)	C151-000D

SCHEMATICS:

SCHEMATICS, DISPLAY P/C BOARD	A060-248A
SCHEMATICS, POWER SUPPLY	B060-228A
SCHEMATICS, PROCESSOR P/C BOARD (reduced)	C060-212G
SCHEMATICS, IEEE-488 P/C BOARD (reduced)	C060-214A

Change No	LTR	Description	Date	Approved

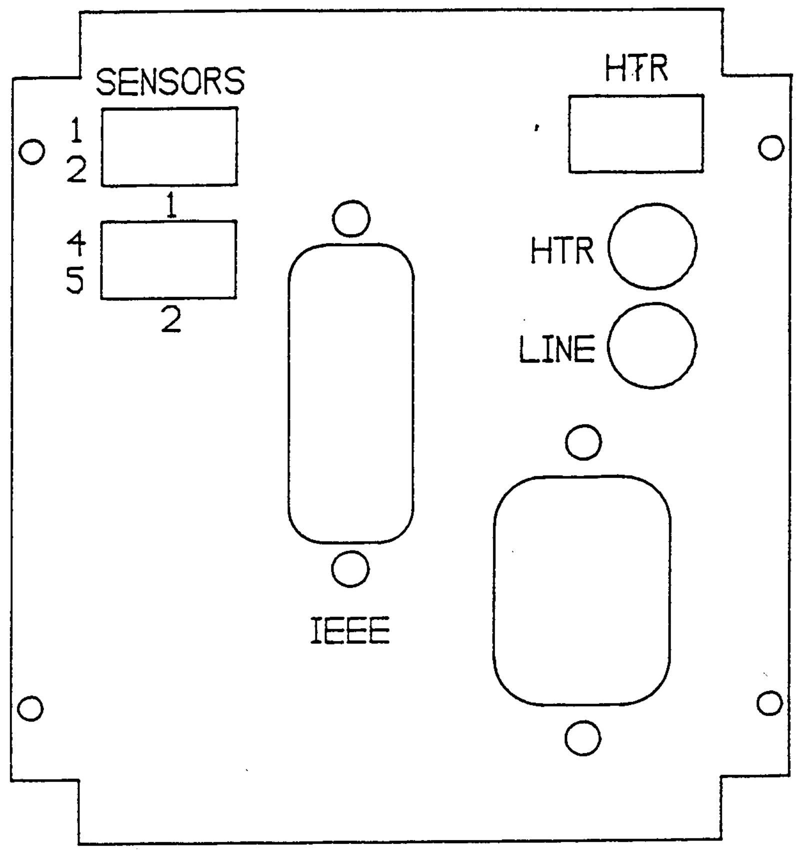


NOTE:

THE HEATER RESISTANCE MUST BE SELECTED SO THAT THE OUTPUT POWER CAPACITY OF THE CONTROLLER WILL NOT BE EXCEEDED AT FULL OUTPUT VOLTAGE. SPECIFICALLY, THE RESISTANCE SHOULD BE 25 OHMS OR GREATER TO LIMIT THE POWER TO 25 WATTS OR LESS.

SCIENTIFIC SI INSTRUMENTS INC.®	Qty.	Material			Finish	
					Dwn. R.A. DOVE	5-14-90
	Decimal .00 +/-.015 .000 +/-.005	Product INSTR	Model 9600	Scale FULL	Ckd.	
					Apd.	
	Fractional +/- 1/32	Title PICTORIAL, REAR PANEL CONNECTIONS (RS232)				
West Palm Beach Florida 33407	Angular +/- 2 Deg.	FSCM No. 53547	Size A	Dwg. No. 040-335	Rev.	Sheet 1 OF 1

Change No	LTR	Description	Date	Approved



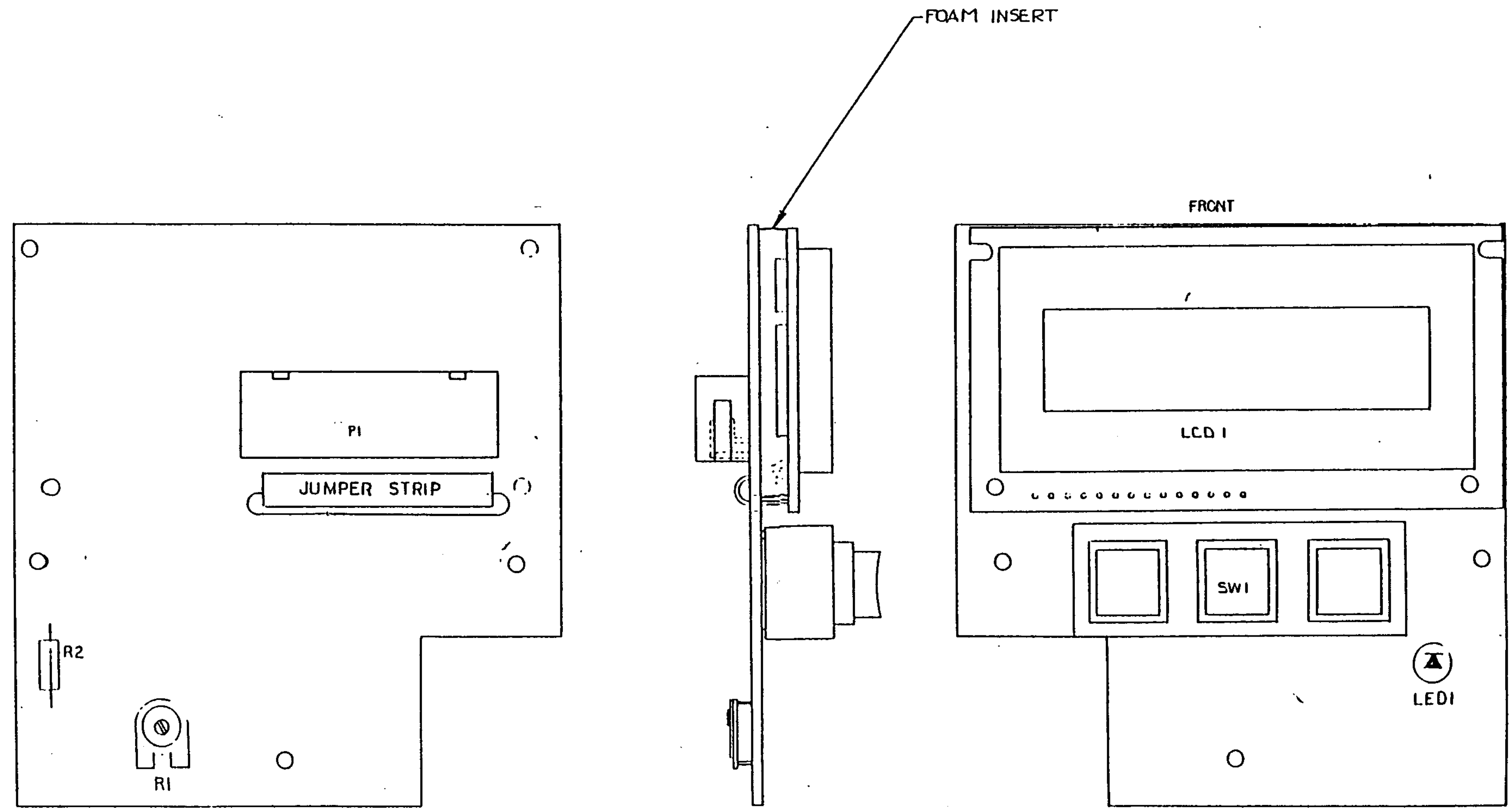
NOTE:

THE HEATER RESISTANCE MUST BE SELECTED SO THAT THE OUTPUT POWER CAPACITY OF THE CONTROLLER WILL NOT BE EXCEEDED AT FULL OUTPUT VOLTAGE. SPECIFICALLY, THE RESISTANCE SHOULD BE 25 OHMS OR GREATER TO LIMIT THE POWER TO 25 WATTS OR LESS.

SCIENTIFIC SI INSTRUMENTS INC. ®	Qty.	Material			Finish
					Dwn. R.A. DOVE — 5-14-90
	Decimal .00 +/-.015 .000 +/-.005	Product INSTR	Model 9620	Scale FULL	Ckd.
					Apd.
	Fractional +/- 1/32	Title PICTORIAL, REAR PANEL CONNECTIONS (IEEE)			
West Palm Beach Florida 33407	Angular +/- 2 Deg.	FSCM No. 53547	Size A	Dwg. No. 040-336 — Rev.	Sheet 1 OF 1

REVISIONS

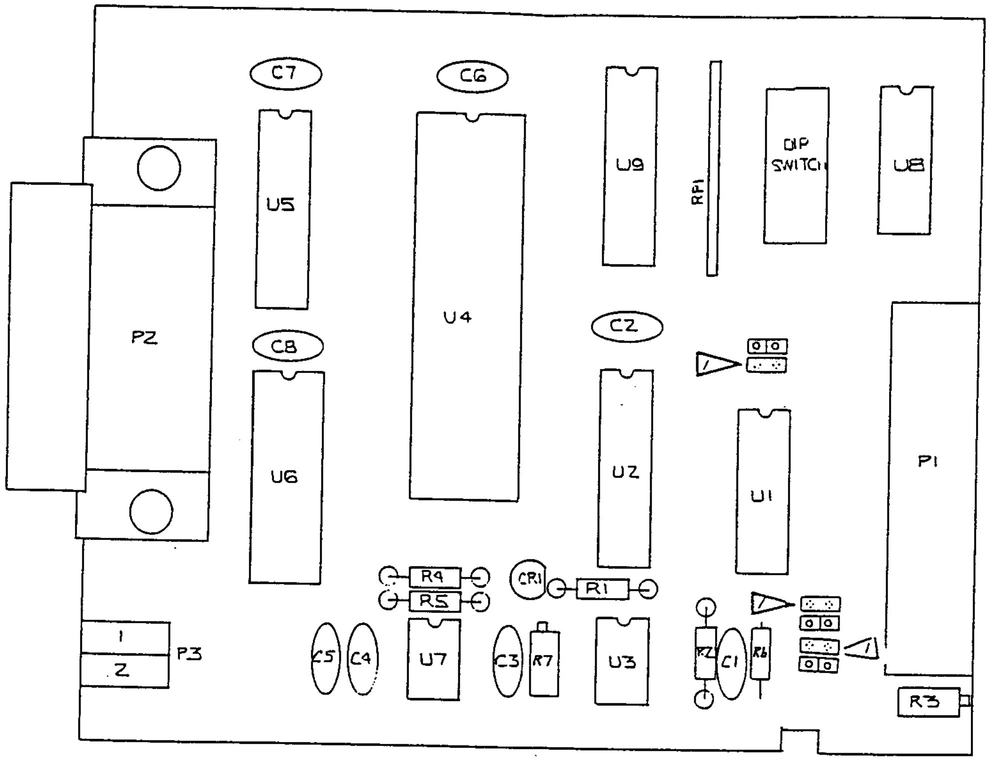
CHANGE NO.	LTR	DESCRIPTION	DATE	APPROVED
	A	DELETE HARDWARE; ADDED FOAM DELETE SHEET 2	9 DEC '88	

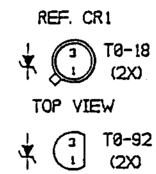


SCIENTIFIC INSTRUMENTS INC West Palm Beach, Florida 33407	Qty. 1	Material			Finish
					Dwn RWS 3/19/86
	Decimal .00 ± .015 .000 ± .005	Product	Model	Scale 2X	Ckd.
					Apd CMG
	Fractional ± 1/32	Title DISPLAY ASSEMBLY - DISPLAY BOARD			
	Angular ± 2°	FSCM No. 53547	Size C-	Dwg. No. 150-215	Rev A / Sheet 1 of 1

REVISIONS

CHANGE NO	LTR	DESCRIPTION	DATE	APPROVED
	A	ADDED 15V CIRCUIT	16 NOV. 87	M.L.
	B	ROTATED CR1 180°	19 MAR. 92	C.M.G.
	C	MOVED BOTTOM 2 JUMPERS	13 JUL. 92	C.G.





NOTES:

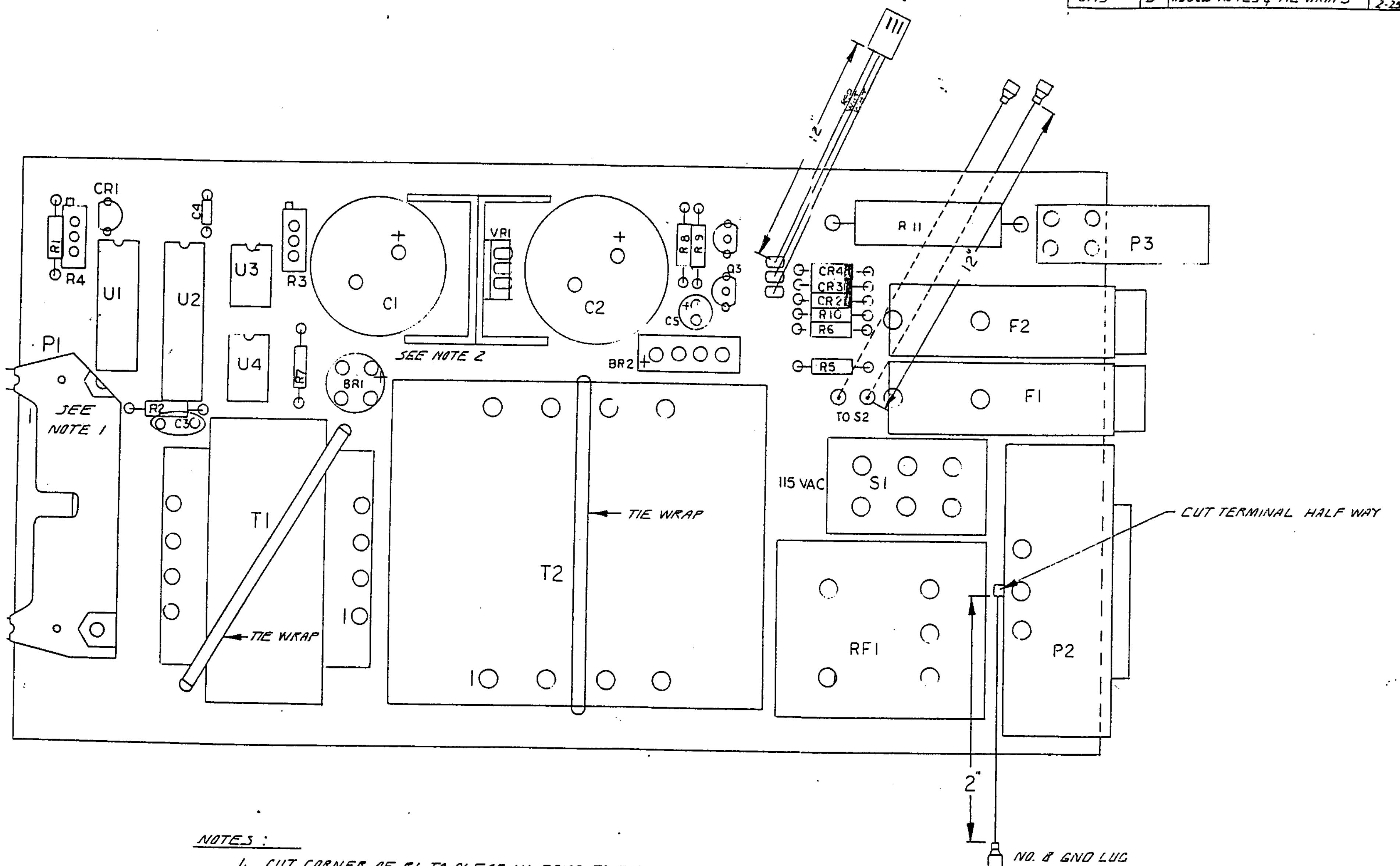
1. JUMPERS ARE SHOWN IN 5 VOLT CONFIGURATION. (TYP 3 PLCS) OPPOSITE PINS ARE FOR 15 VOLT CONFIGURATION. (TYP 3 PLCS)

SCIENTIFIC INSTRUMENTS INC. West Palm Beach, Florida 33407	Qty.	Material			Finish
	Decimal .00 ± .015 .000 ± .005	Product	Model 9300	Scale 2X	Dwn. SNIADACH 6-20-86
					Ckd. 2-23-91
					Apd.
	Fractional ± 1/32	Title ASS'Y - IEEE OPTION BOARD			
	Angular ± 2°	FSCM No. 53547	Size C	Dwg. No. 150-218	Rev. C / Sheet 1 of 1

Size	Dwg. No.	Rev.	Sheet
C-	150-218	B	1 of 1

BRUNING 40 21 66619

CHANGE NO	LTR	DESCRIPTION	DATE	APPROVED
	A	DELETED C6, C7, C8, C9, R12, R13, CR5 & Q1. CR1 ROTATED 180° ADDED WIRES & TERMINALS	7 DEC 86	
0175	B	ADDED NOTES & TIE WRAPS	R. DOVE 2-25-97	CMG 3/4/97



NOTES :

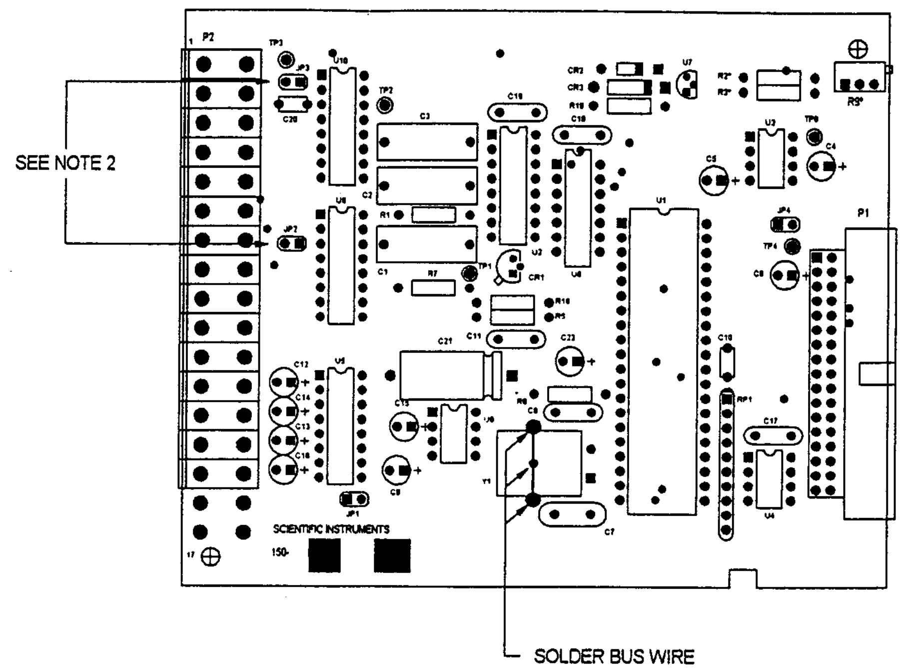
1. CUT CORNER OF P1 TO CLEAR U1 PRIOR TO INSTALLING.
2. INSTALL C1 PRIOR TO VR1 AND C2 (FOR EASE OF ASSEMBLY).

SCIENTIFIC SI INSTRUMENTS INC

Qty.	Material			Finish	
				Dwn.	DJE
Decimal .00 ± .015 .000 ± .005	Product	Model 9600	Scale 2-1	Ckd. R. A. DOVE	7 AUG 87
				Apd. C.M.G	7 AUG 87
Fractional ± 1/32	Title ASSEMBLY, POWER SUPPLY BD.				
Angular	FSCM No. 53547	Size C	Dwg. No. 50-235	Rev. B	Sheet 1 of 1

Size C- Dwg. No. 150-235 Rev. A Sheet 1 of 1

RFEA NO.	LTR	Description	Eng.	Date
-	A	ADDED NOTE 2	C.M.G.	3-7-90
0130	B	REDESIGNED	C.M.G.	3-25-95
0187	C	CLARIFIED JUMPER DESIGNATION	C.M.G.	11-27-96
0210	D	REMOVED 2 CONNECTORS, ADDED CAP POLARITY		



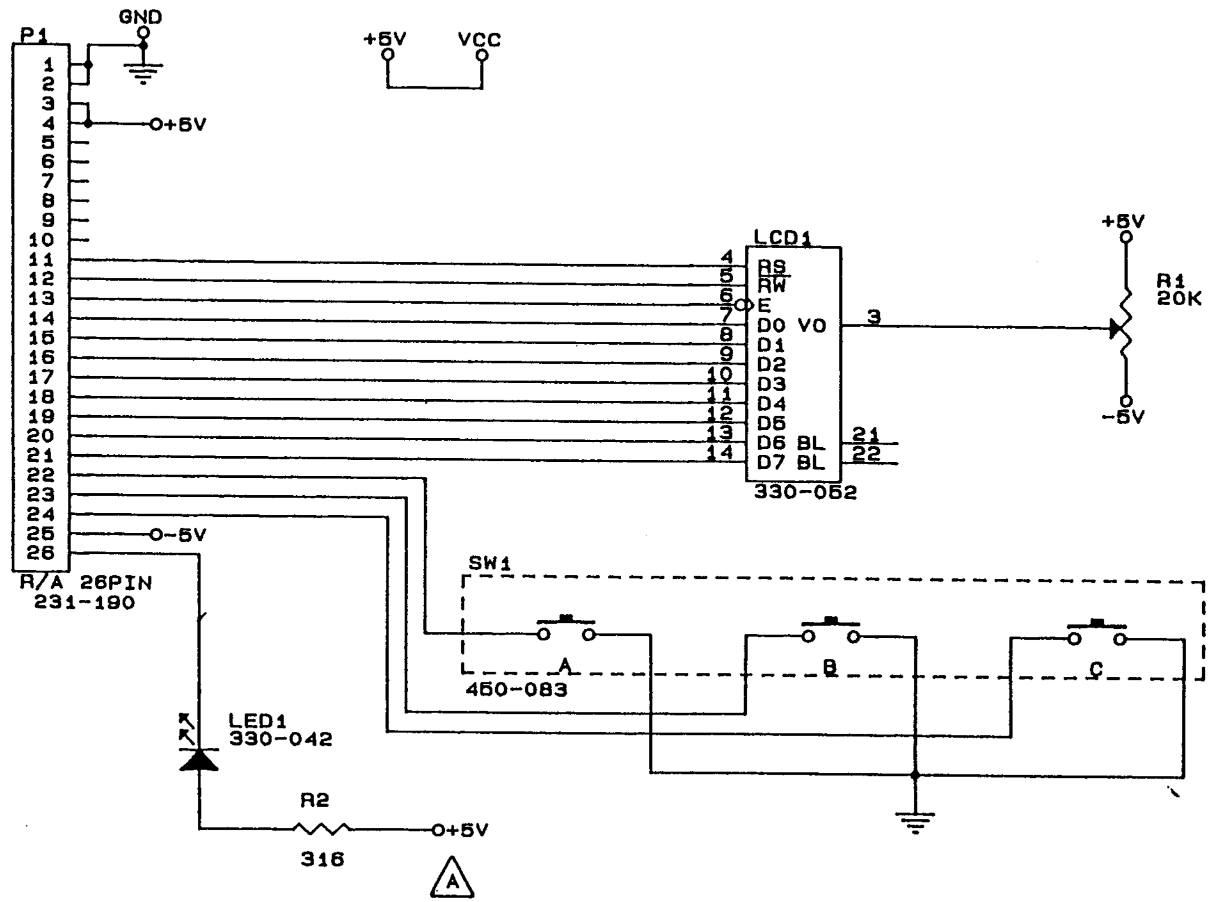
NOTES:

1. REMOVE JUMPER JP1 UPON INSTALLATION OF RS232 OPTION.

2. INSTALL JUMPERS JP2 AND JP3 FOR MODEL 9600 ONLY IN LIEU OF U9 AND U10.

SCIENTIFIC INSTRUMENTS inc. West Palm Beach Florida 33407	Material: M/F 145-117	Finish: 32 √	Scale: 1.5X	Dwn. R.A. DOVE / Eng. C.M.G. / Q.C. P.R.Z.	2-27-96 / 2-27-96 / 2-27-96
	Tolerance: .00 +/-.030, .000 +/-.010, Frac. +/- 1/16, Ang. +/- 1/2 Deg., Corners +/- .010	Title: ASSEMBLY, P/C, PROCESSOR 9300/9600			
		FSCM NO. 53547	Size - C	Dwg. No. 151-000	Rev. D / Sheet 1 OF 1

REVISION			
LTR	DESCRIPTION	DATE	APPROVED
A	WAS GND	01/13/89	M. LEE



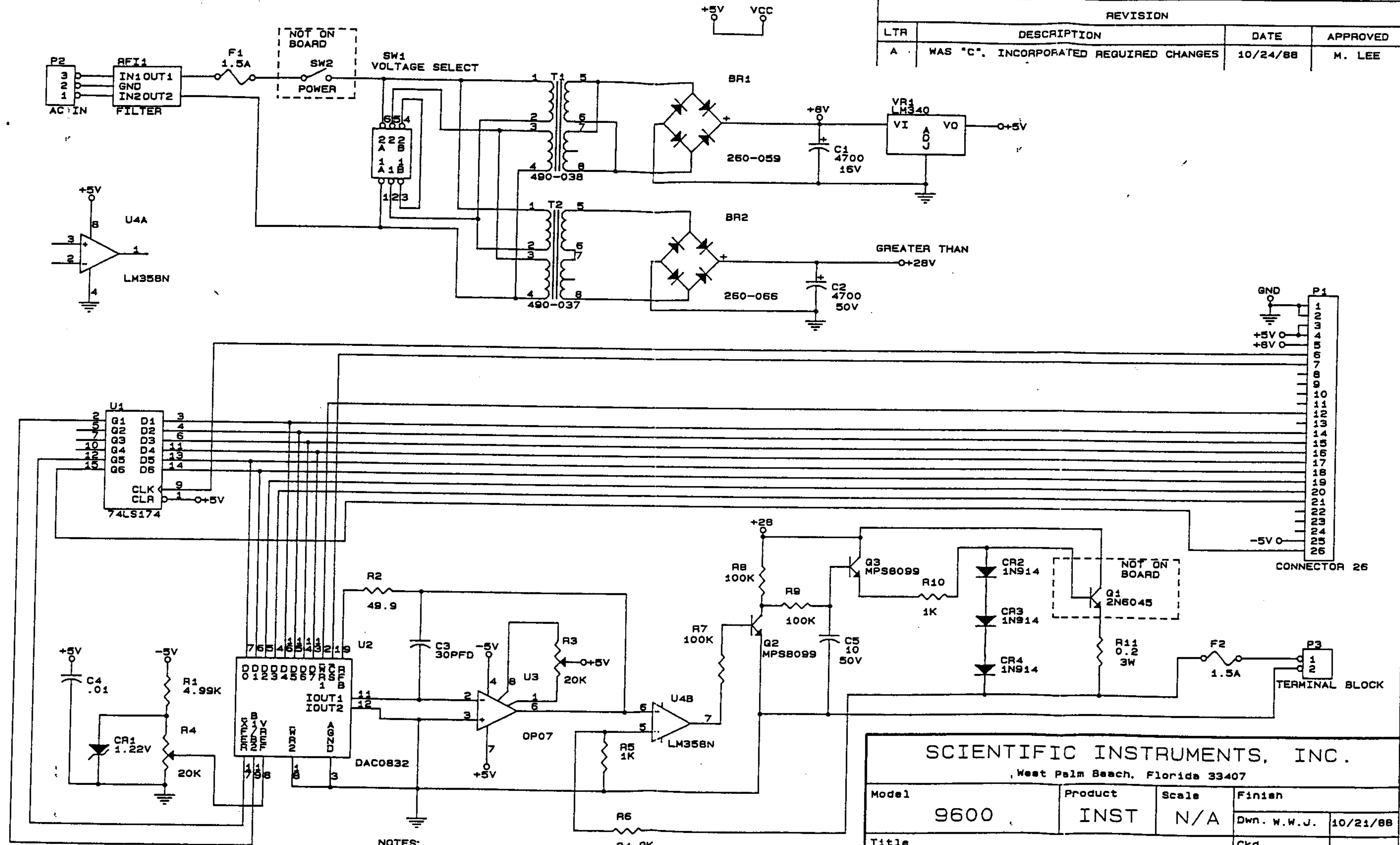
SCIENTIFIC INSTRUMENTS, INC.

West Palm Beach, Florida 33407

Model	Product	Scale	Finish	
9600	INST	N/A	Dwn. W.W.J.	11/22/88
Title: SCHEMATIC, DISPLAY P/C BOARD			Ckd. M. LEE	11/22/88
			Apd.	

	FSCM No.	Size	Dwg. No.	Rev.	Sheet
.0 ± .030 .00 ± .015 .000 ± .005	53547	A	060-248	A	1 of 1

REVISION			
LTR	DESCRIPTION	DATE	APPROVED
A	WAS "C". INCORPORATED REQUIRED CHANGES	10/24/88	M. LEE



NOTES:

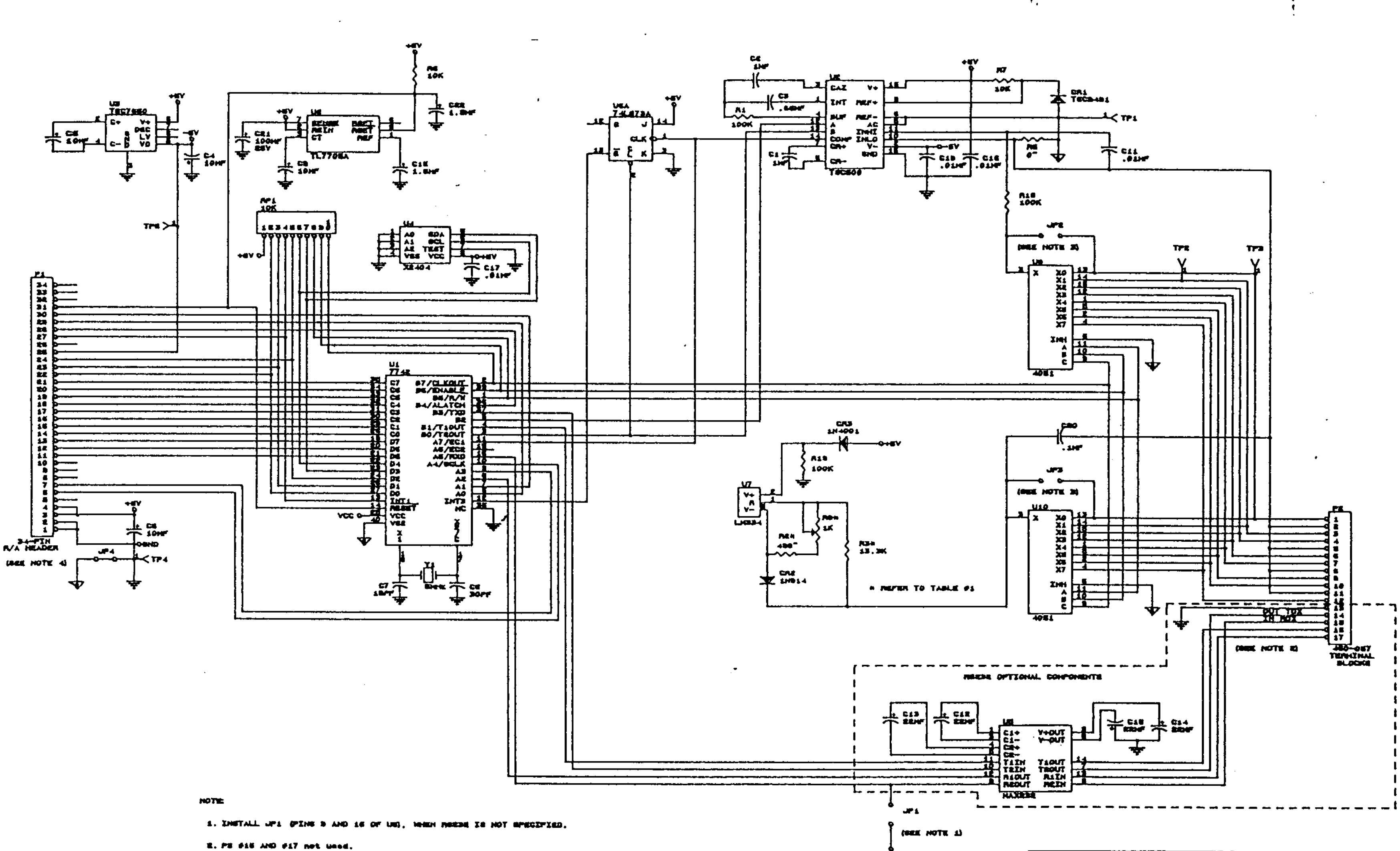
1. UNLESS NOTED OTHERWISE:

RESISTOR VALUES ARE IN OHMS
CAPACITOR VALUES ARE IN MFD'S

SCIENTIFIC INSTRUMENTS, INC.
West Palm Beach, Florida 33407

Model	Product	Scale	Finish	
9600	INST	N/A	Dwn. W.W.J.	10/21/88
Title: SCHEMATIC, POWER SUPPLY			Ckd. M. LEE	10/24/88
			Apd.	

Tolerances	FSCM No.	Size	Dwg. No.	Rev.	Sheet
.0 ± .030 .00 ± .015 .000 ± .005	53547	B	060-228	A	1 of 1



CONSTANT CURRENT
TABLE #1

	10uA	100uA
R2	4.3K	499
R3	133K	13.3K
R5	10K	1K

REVISION

LTR	DESCRIPTION	DATE	APPROVED
A	ENG. CHANGES	[illegible]	
B	C6 AND C7 WERE 10PFD	[illegible]	
C	ENG. CHANGES	[illegible]	
D	ADDED C20	[illegible]	
E	ADDED CR3, R18, JP2 AND JP3	[illegible]	H. LEE
F	R6 WAS 1K	[illegible]	
G	CHANGED C18, ADDED C21, C22 AND TABLE		

NOTE:

1. INSTALL JP1 (PINS 9 AND 16 OF U8), WHEN RS232 IS NOT SPECIFIED.
2. P2 #16 AND #17 not used.
3. INSTALL JUMPERS (JP2 + JP3) IN U9 AND U10'S ABSENCE.
4. IN THE 9600 CONFIGURATION (P1) IS REPLACED
   WITH A 26-PIN R/A HEADER USING POSITIONS 1 - 26.

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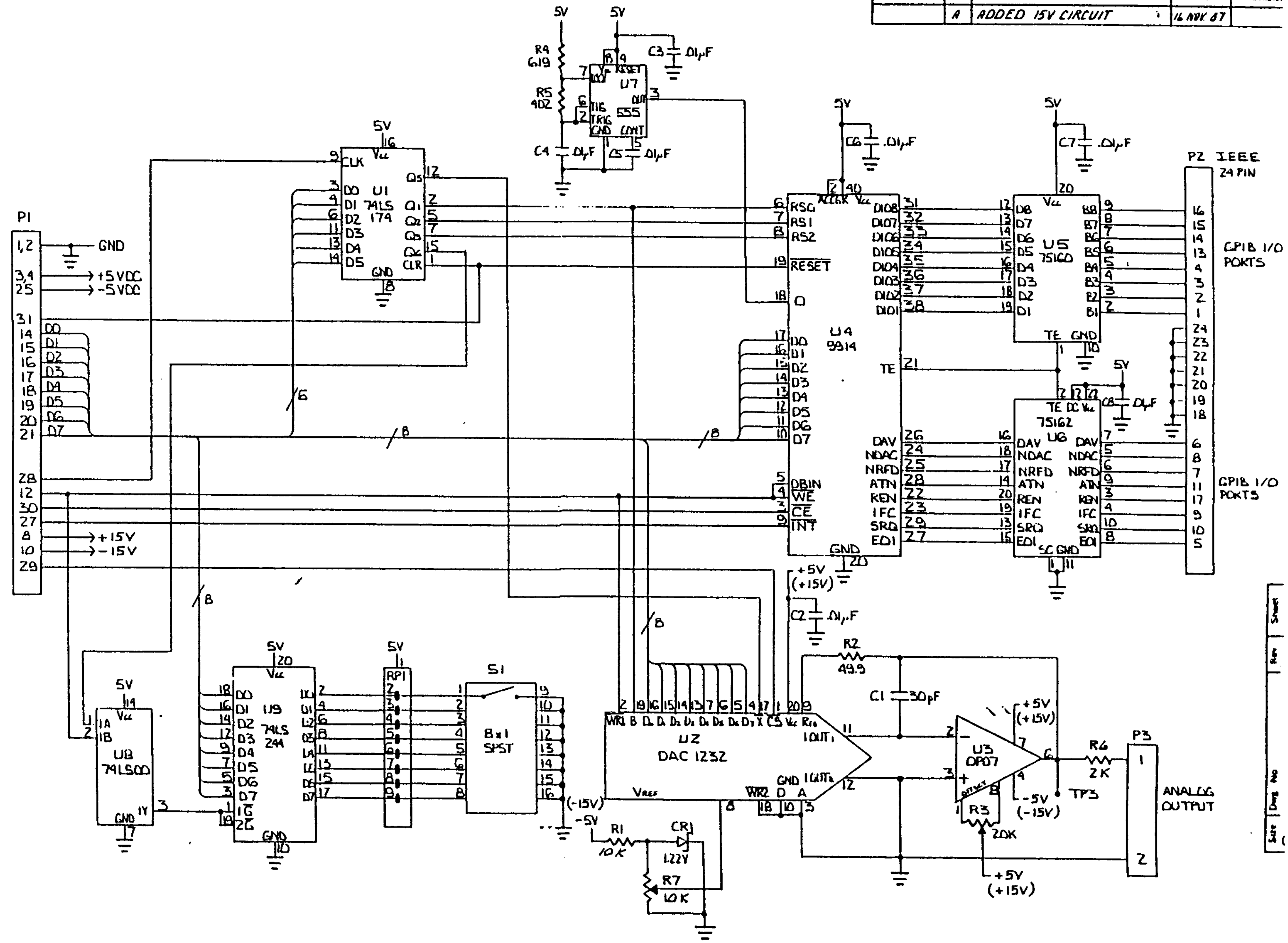
Model	Product	Scale	Finish	
9300/9600	INST	N/A	Dwn. W.H.J.	10/26/88
Title: SCHEMATIC, PROCESSOR BOARD			Chkd. H.LEE	10/31/88
			Apd.	
.0 ± .030 .00 ± .015 .000 ± .005	PSCH No. 53547	Size C	Dwg. No. 060-212	Rev. G, Sheet 1 of 1

CHANGE NO	LTR	DESCRIPTION	DATE	APPROVED
	A	ADDED 15V CIRCUIT	16 NOV 87	



Qty.	Material			Finish	
Decimal .00 ± .015 .000 ± .005	Product	Model 9300	Scale —	Dwn. SNIADACH	6-18
				Chd	
				Apd	
Fractional ± 1/32	Title SCHEMATIC-IEEE OPTION BOARD				
Angular ± 2°	FSCM No 53547	Size C	Dwg No 060-214	Rev A	Sheet 1 of

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APPENDIX A

EXPLANATION OF THE MODEL 9620 TEMPERATURE CONTROLLER PID CONTROL FEATURE

CONTROLLING TEMPERATURE

The Model 9620 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 25 volts at 1 amp DC, so the resistance of the heater should be no less than 25 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 25 volts ($R=(25)^2/W$).

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 Model 9620 utilizes a derivative term in its control equation to estimate this anticipated temperature:

$$P = PROP * \left(S - \left(T + 0.4 * DER * \frac{dT}{dt} \right) \right).$$

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 Model 9620 overcomes this problem with an integral term in its output equation:

$$HTR = 0.078\ V/K * \left(P + \int^{P} INT\ dT \right).$$

(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 present 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 Model 9620 cannot supply cooling. For this reason, the intégral 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 effect on the control behavior. The following procedure should help in finding a good starting point:

1) Turn on the Model 9620, 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 Model 9620 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.

Model 9620
Analog Output Option

This option furnishes an analog representation of process temperature, as measured via that sensor assigned to the first channel (i.e., channel "T1"). The analog output is a linearized step function voltage, with a scale factor of 1 millivolt per degree K over the range of 0 to 409.6K. Maximum drive current is 2 milliamperes.

Analog output connections are made via two rear panel screw terminals as indicated below at the "+" and "-" points.