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SERVICE SUPPORT DOCUMENTATION

MODEL 199

PRECISION DIGITAL THERMOMETER

Smead® MFG.CO. HASTINGS MN - LOS ANGELES - CHICAGO
LOGAN OH - McGREGOR TX - LOCUST GROVE GA

OMEGA ENGINEERING, INC.

MODEL 199

SERVICE DOCUMENTATION

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The Model 199 is a full performance, 3-1/2 digit, digital thermometer for thermocouple and RTD inputs. The circuitry is divided between the signal conditioning electronics and the main display board which contains the power supply, A/D converter and display.

1. Main Board Theory

A CMOS LSI A/D converter chip provides input resistance >1000 megohms with an input bias current less than 50 pA. The A/D converter is dual slope with autozero which holds gain drift to ±35 ppm/°C of reading and offset drift to ±1uV/°C over an operating temperature range of -10°C to +65°C. Power options available include +5Vdc ±5% @170mA, +8 to +28 Vdc @90mA, 110 Vac ±20% @1.6 watts and 220 Vac ±20% @1.6 watts.

Display and control signals include HOLD, BLANK, DISPLAY TEST, EOC (End of Conversion) and OVERLOAD.

Refer to Fig 1 (Functional Block Diagram) and Schematic for the circuit description that follows:

Input signals are filtered by a single pole filter consisting of R1 and C1. Since the A/D converter chip can tolerate 1mA current into or out of any of its terminals, R1 will protect the input up to ±300VDC. The filter time constant provides maximum filtering while still allowing a settling time to within 1 count in less than 1 complete conversion (400 msec). Reference signals are provided internally by a precision, temperature compensated reference Z3 or externally in ratio mode by pin A of J1. When the internal reference is used, the correct reference input voltage for the desired full scale reading ±1.999 volts or ±.1999 volts is provided by R4, R5 and R1 and trimmed to desired reading by R9.

The DPI's full scale reading of ±1999 counts occurs when the reference and input voltages are equal. When R4 and R5 are in parallel, R9 is adjusted for a full scale reading of 1999 for 2 volts signal input. If 200 mV full scale is desired, R5 of RN1 is removed by cutting the etch at E as indicated on the schematic and R9 is

adjusted for final calibration. Since the divider network in RN1 provides an input resistance of >10K ohms looking into ratio reference terminal (A of J1) the voltage provided by the internal reference may be easily overdriven for ratio operation.

The A/D converter chip contains all of the analog and digital components required for autozeroed dual slope A/D conversion but requires the following passive components to program the internal oscillator and integrator ramp. The oscillator frequency is controlled by R6 of RN3 which establishes a 40 kHz clock frequency. The unknown integration period is dependent on the clock frequency and is intentionally set at 100 msec to provide maximum normal mode rejection at 50 and 60 Hz. The integrator ramp is a function of R2 and R3 of RN1 and C3. For $\pm$2 volt full scale operation, only R3 is used. For 200 mV operation, R2 and R3 are paralleled by bridging pads at D. The integrator ramp in both cases is optimized for the maximum linear positive output swing. Considering low line operation 4.75 volts, component tolerances and a positive full-scale input, the ramp is limited to about +4.25 volts nominal.

Z1 provides a parallel by bit serial by digit BCD output. The output is scanned from MSD to LSD. Polarity information is encoded on the 2^2 bit and is valid during the MSD digit strobe. A high level on pin 22 turns on Q2 through R8 of RN3 which sinks current through R3 and R12 to light the plus sign on DS1. The BCD data is decoded by Z2 which drives the numerics of DS1 through DS4 synchronously with the digit strobes to provide the correct decimal display.

LED current is programmed by RN2 and the digit strobe lines of Z1 are buffered by Q3 through Q6.

Power required by the A/D converter chip is +5 and -5 volts. For all power options, -5 volts is supplied by a flyback circuit driven by the internal oscillator on Z1. The clock output of Z1 has a drive capability >2mA that swings between the + and - supply.

The clock output from pin 11 drives the base of Z1 through R7 of RN3. Q1 is used as a saturated switch which when conducting, stores energy in the field of L1. Since L1 is sinking current, when Q1 turns off the collapsing field of L1 causes a negative flyback voltage to be generated at its previously driven terminal. This negative voltage is clamped by zener diode CR1 to -5.1 volts. CR2 conducts only in the flyback mode of L1 preventing forward biasing of CR1 during Q1's conduction. The ripple is minimized by C4, and -5.1 volts is supplied to pin 12 of Z1.

For 110 Vac power, the primaries of T1 are connected in parallel by bridging H and J. 220 Vac operation is achieved by a series primary connection (bridging F). Secondary voltages are supplied to a full wave bridge rectifier assembly CR3. A cut is made at M and unfiltered DC is supplied to the collectors of the display multiplex transistors Q3 through Q6 from the center tap of T1 secondary (pins 6 & 7). The output of the full wave bridge is filtered by C7 and regulated by Z4 to +5 volts which supplies the DPI electronics.

For 8 to 28 Vdc operation, the unregulated D.C. input passes through CR4 which gives this power supply mode reverse polarity protection. The cathode of CR4 connects to C7 which filters the unregulated input to the 5 volt regulator. The output of the 5 Volt regulator supplies all of the 5 Volt D.C. power and total package dissipation is minimized by using high efficiency displays DS1 through DS4.

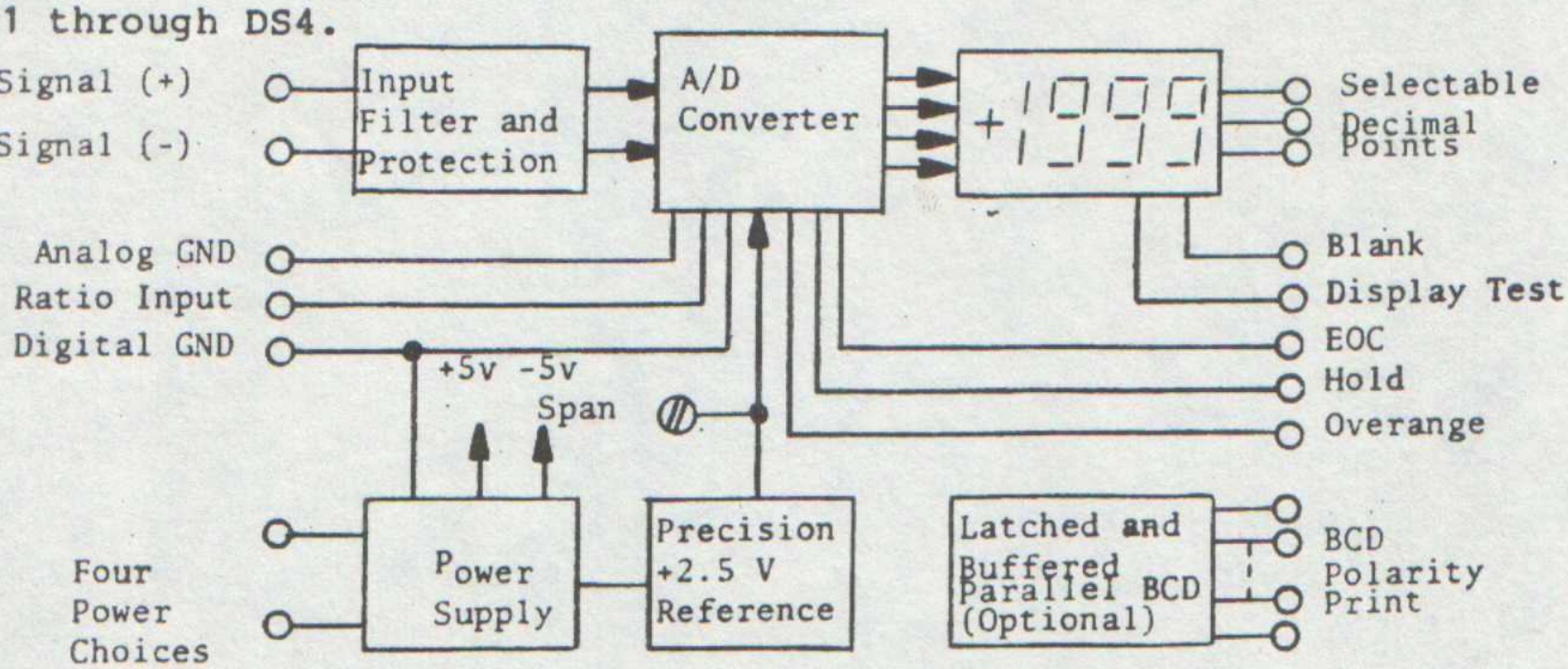


Figure 1

2. Signal Conditioner Theory

The signal conditioner is on a separate circuit board containing the plug-in software module. Figure 2 illustrates the circuit blocks therein:

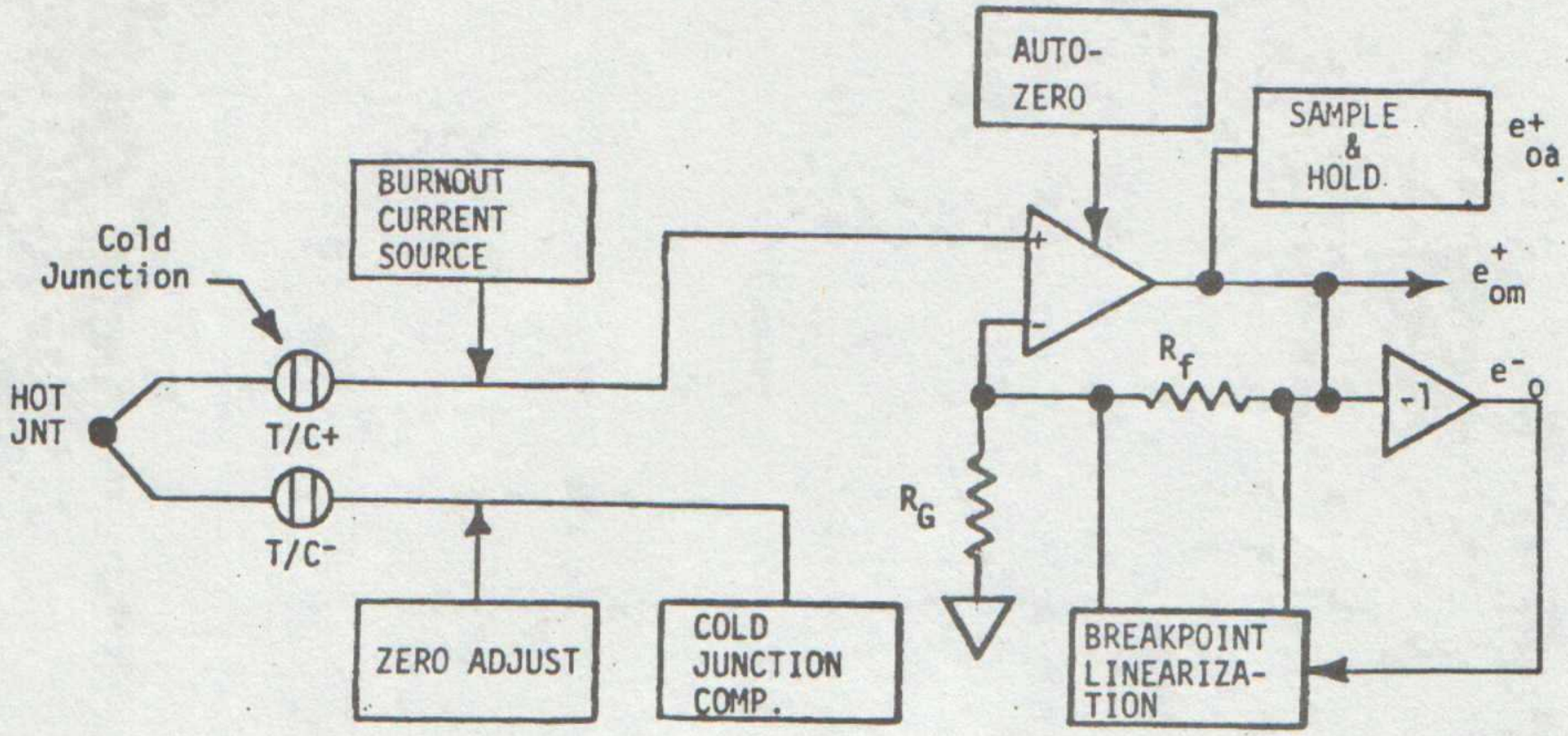


Figure 2 Signal Conditioning Block Diagram

Cold junction compensation and zero adjust modify the T/C-terminal voltage as required to zero the unit and provide reference junction conditions at the thermocouple input terminals. Autozero is synchronous with the autozero mode of the A-to-D converter due to timing signals from the A-to-D converter. Autozero removes offset and drift errors from the signal conditioning amplifier.

The gain of the signal conditioning amplifier is controlled by Rg and the breakpoint linearization circuits that shunts Rf.

The output temperature signal to the A-and-D converter, $e^{+}om$, is inverted as $e^{-}o$ to control negative temperature breakpoints. A sample-and-hold and a buffer provide the one millivolt per degree analog output, $e^{+}oa$.

3. Circuit Description

a. Reference Junction Compensation and Zero Adjustment

Q2 operates at the temperature of the T/C$^+$ terminal and supplies a -0.5VDC output that changes -2.2 millivolts per degree celsius. Zero adjustment is R39. R16 of the software module is in the range of 1 to 15 ohms depending on the thermocouple type. The zero and compensation voltages are attenuated by R36 and R23 and summed at R16 as required to modify the voltage at the T/C-terminal.

b. Burnout Detection

R33 provides a 0.06 microampere current to the T/C+ terminal, through the thermocouple, then to R16. An open input, or sensor burnout causes this current to charge C1 through R34 until a plus overrange blank display results.

c. Autozero Timing

End-of-Conversion, EOC, from the ADC resets counter Z3. Display Digit Scan pulses are buffered by Q3 and provided as a 500 hertz clock to Z3. Sixty-four clock pulses after EOC, (128 milliseconds), Z3-3 goes high. An additional 32 clock pulses later at 192 milliseconds Z3-4 goes high. Z4-4 is high for the first 128 milliseconds to provide a Ø0 signal that causes switches in Z5 to provide autozero operation, see description below. A low Ø0 signal causes the amplifier to output the linearized one millivolt per degree signal.

Z4-3 goes low at 192 milliseconds, removing collector signal power from Z3 via R50. The pin 3 and 4 outputs of Z3 are thus latched high until the next ADC sample initiates an EOC signal. Z4-11 is thus high, closing switch Z5-8 to charge sample and hold capacitor C4.

d. Autozero Operation

Capacitor C2 is the autozero capacitor. During autozero, time switches Z5-4 and Z5-11 are closed while switches Z5-1 and Z5-8 are open. Figure 3 illustrates the circuits in this mode where the Z8-1 amplifier output, through R17, forces a charge to exist on C2 which is the offset voltage correction to balance the amplifier. A + to - charge is shown on C2 as an example.

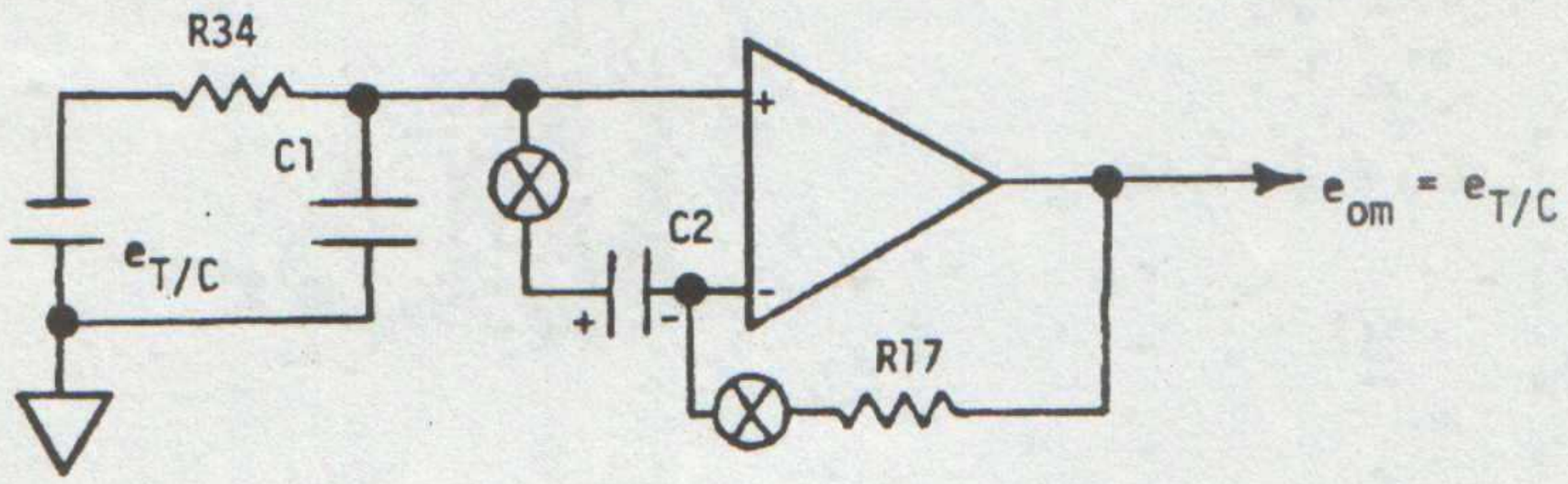


Figure 3 Autozero Mode, Ø0

e. Normal Gain Operation

The normal gain mode, Ø1 occurs when the autozero mode ends. Switches Z5-4 and Z5-11 are open and switch Z5-1 is closed. Figure 4 illustrates this mode of operation. C2 introduces the offset correction between the gain resistor node and the - amplifier input node (gate of FET Q1). R15 of the software module and R1 define the basic amplifier gain. Resistors R14 through R8 are sequentially switched in parallel with R18 to provide the required breakpoint gain.

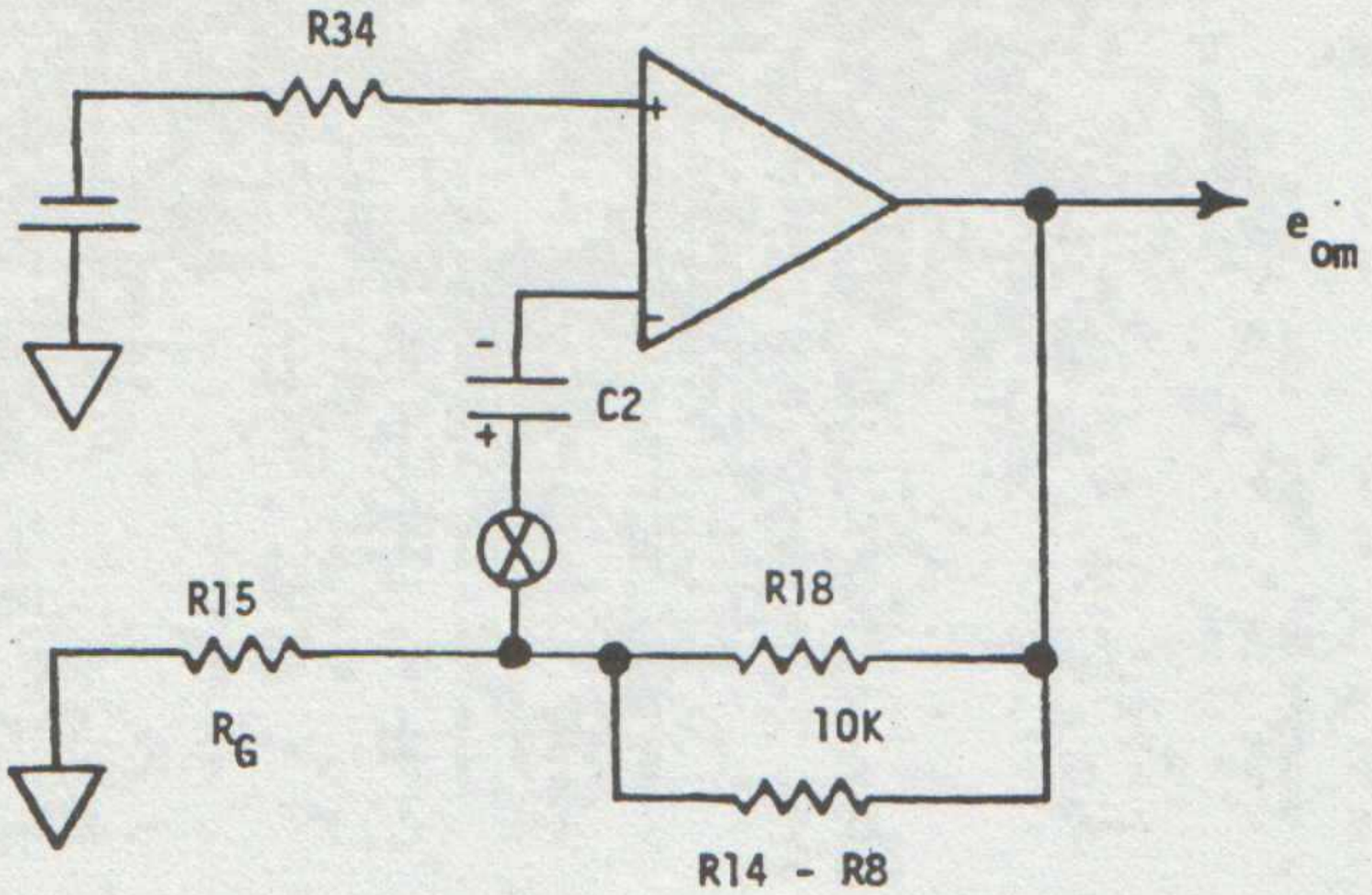


Figure 4 Normal Gain Operation

f. Breakpoint Gain Linearization

The one millivolt per degree output for the meter, e^{+}_{om}, is provided at Z8-1. R19 and R20 with amplifier Z8 provide a minus one millivolt per degree output, e^{-}_{om} at Z8-7. R1 through R7 are connected to e^{+}_{om} in the software module for positive temperature breakpoints and to e^{-}_{om} for negative temperature breakpoints.

R46, R45, R31 and Z2 provide an adjustable -3V reference for R24 through R30. R24 - R30 with R1 - R7 define the seven breakpoint voltages to the positive input modes of Z1 and Z2 (i.e. Z1 pin 12). If R1 were connected to e^{+}_{om}, the voltage divider effect of R1 and R24 will cause the Z1-5 input voltage to equal the thermocouple voltage at Z1-6 when the e^{+}_{om} output is at the desired millivolt temperature. Z1-7 will switch high causing diode CR4 to conduct and add shunt resistor R8 to be equivalently in parallel with R18. This reduces the amplifier gain above that breakpoint. If CR4 were connected in the opposite direction (Cathode to pin 13), R8 is connected below the breakpoint. Thus, the R8 shunt is removed above the breakpoint to increase the segment gain.

g. Analog Output (Sample and Hold)

The sample and hold circuit inhibits invalid autozero voltages from the analog output. Z4-11 goes high 192 milliseconds after EOC when the e^{+}om output settled to the output millivolt temperature. Switch Z5-8 is closed to store the millivolt temperature on C4 through the next autozero cycle. R40, R41 and R42 are used to zero the analog output.

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199 PART NO. CODE

Simply Specify Model 199 ---------- [ ] [ ] - [ ] - [ ]

For Thermocouple Type	Enter
Iron/Constantan	J
Chromel/Alumel	K
Chromel/Constantan	E
Platinum/Platinum 13% Rhodium	R
Platinum/Platinum 10% Rhodium	S
Copper/Constantan	T
Platinum 6% Rhodium/Platinum 30% Rhodium	B

For:	Enter
Readings in Degrees Fahrenheit	F
Readings in Degrees Celsius	C

For:	Enter
No Analog Output	X
With Analog Output	A

For:	Enter
No BCD Output	X
With BCD Output	D

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PSM CONVERSION KIT PART NO. CODE

Simply Specify Model 9---------- [ ] ---- [ ]

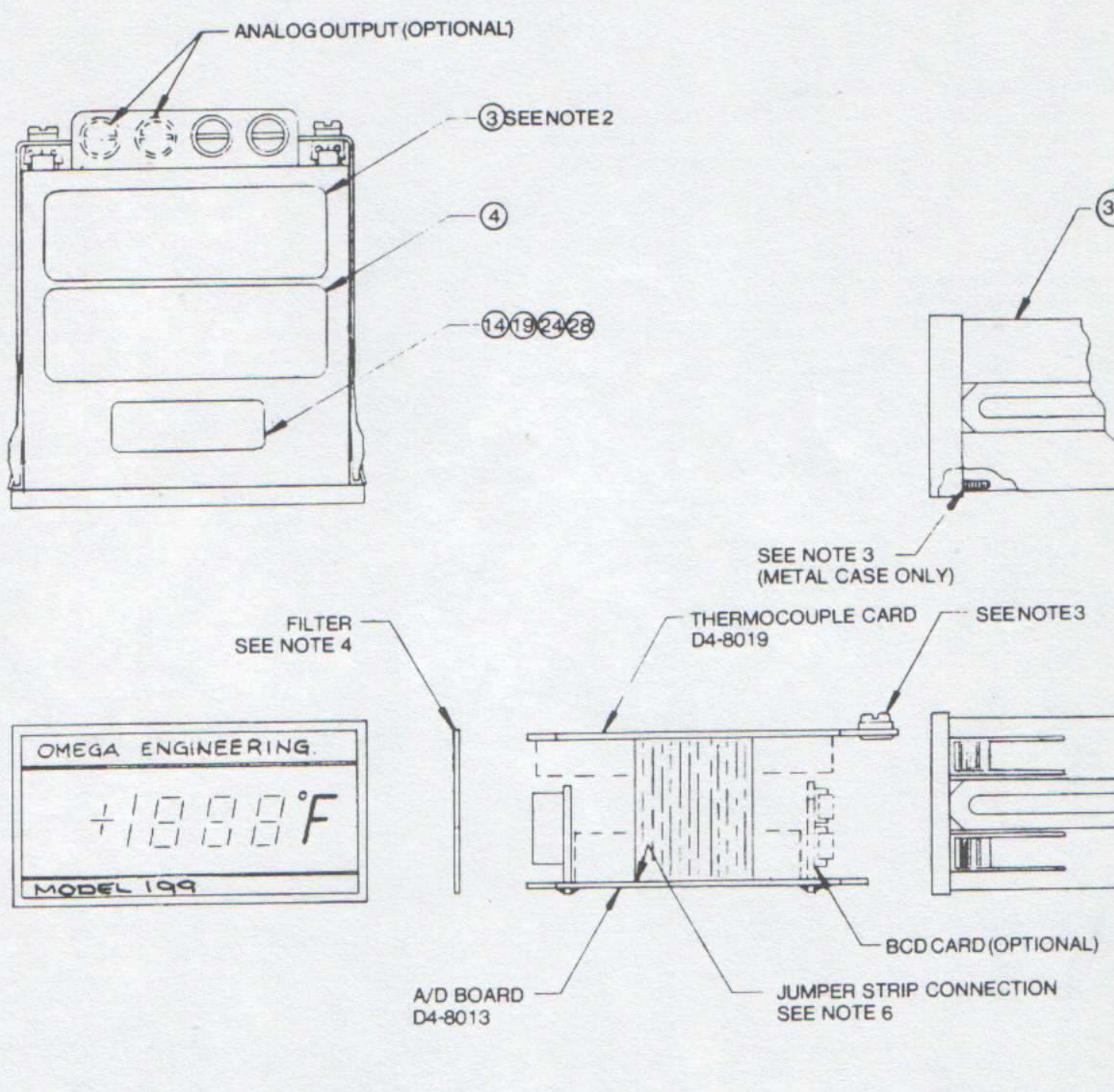
Enter

J, K, E, R, S, T, OR B

Enter

For °C or °F Readout---------- C or F

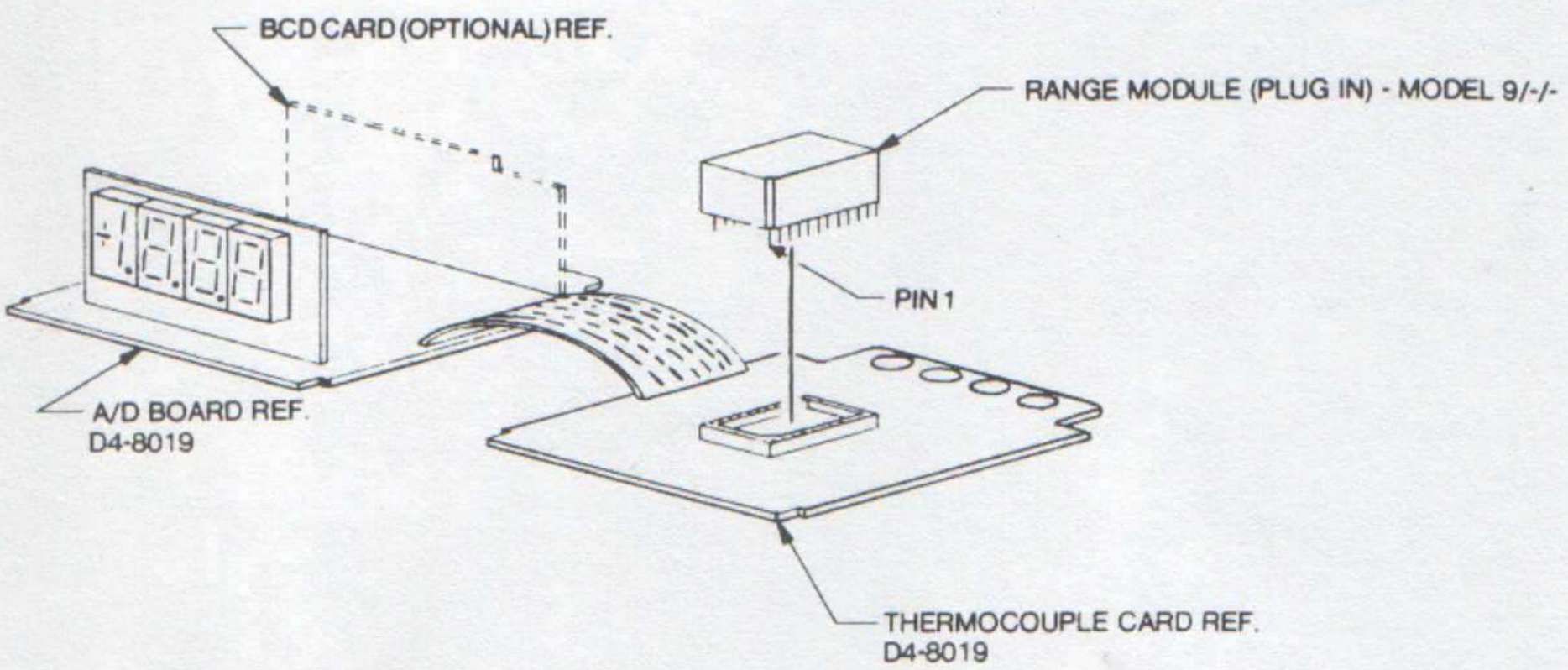
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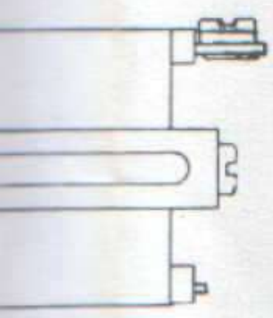


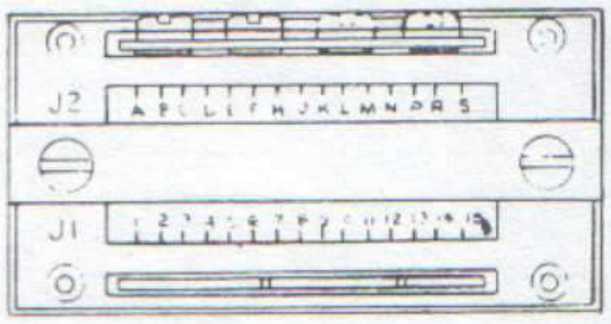
NOTES:

1. FOR SELECTION OF APPROPRIATE PARTS SEE PL10-2836.
2. TYPE IN MODEL NO., DATE CODE, AND SERIAL NO. BEFORE ADHERING LABEL TO CASE.
3. REMOVE SCREWS AND INSERT P.C. ASSEMBLY THEN REPLACE SCREWS.
4. FILTER SUPPLIED WITH RANGE MODULE.
5. FOR CHANGING PSM MODULE (9/-/-) SEE INSTRUCTION MANUAL #16-400007.
6. CONNECT JUMPER STRIP BY INSERTING LEADS THRU HOLES ON A/D BOARD AND HAND SOLDERING INTO PLACE. CLIP EXCESS LEADS OFF TO .030 INCHES ON WIRING SIDE OF BOARD.

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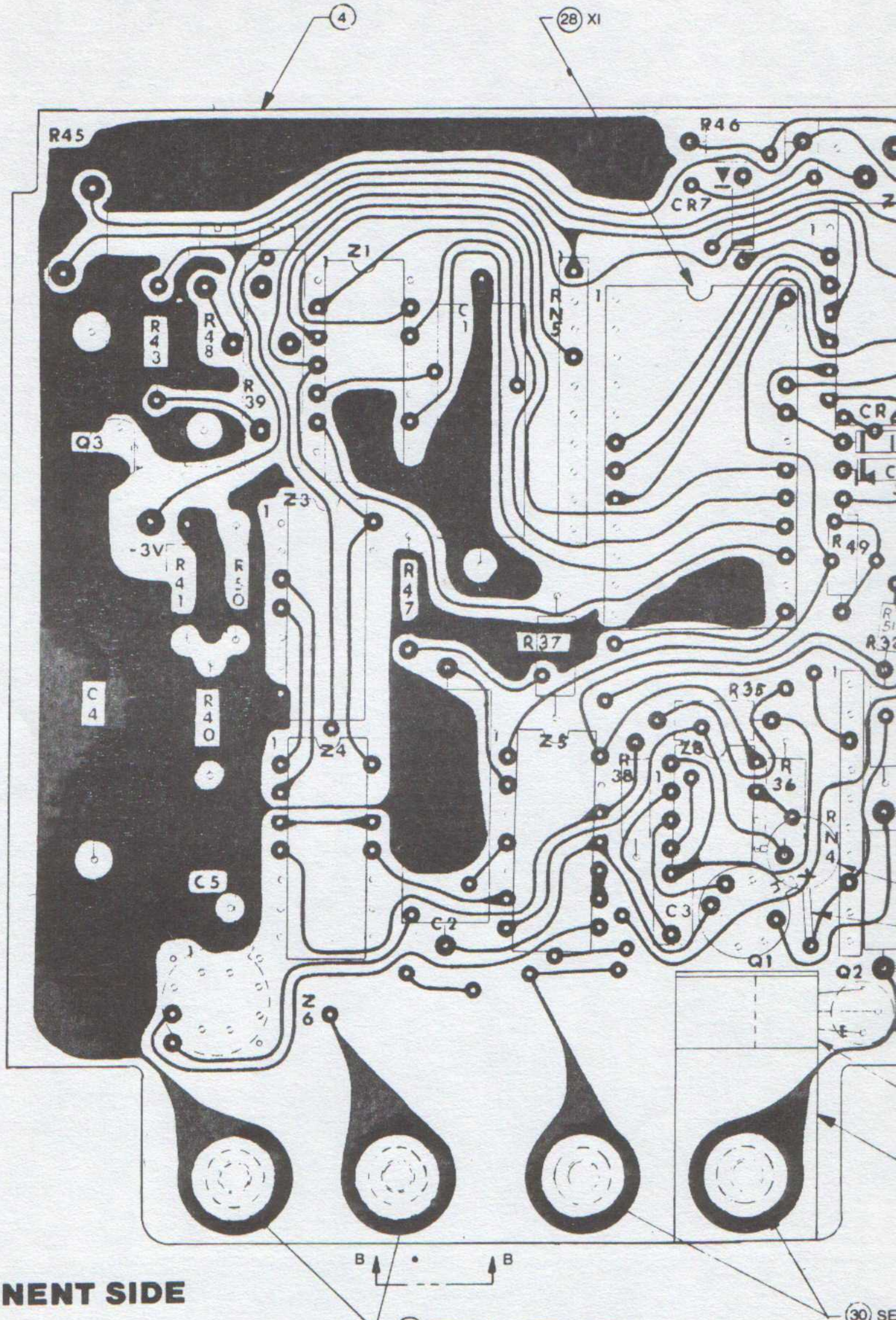






AIN ASSEMBLY
ERMOCOUPLE READOUT
MODEL 199
D7 - 2836

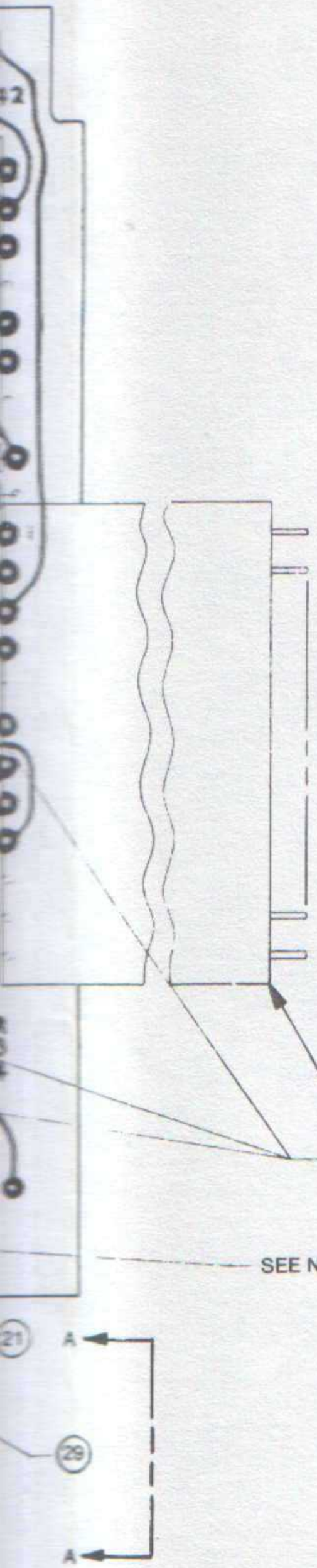
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COMPONENT SIDE

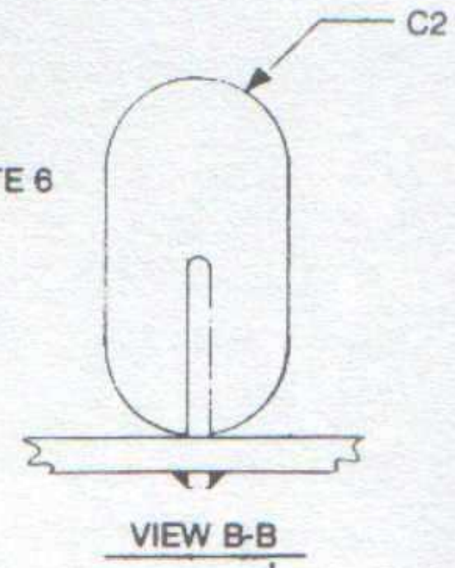
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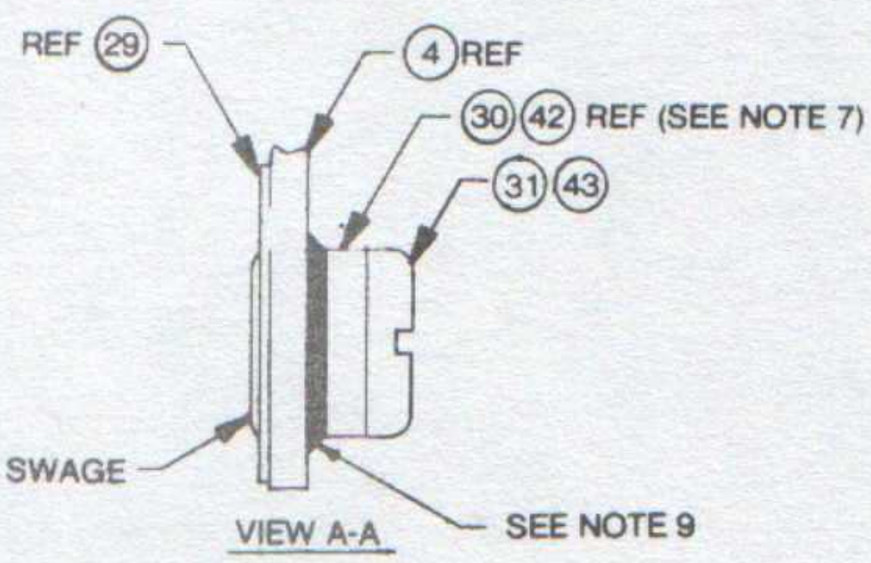


NOTE:

1. FOR PARTS LIST SEE PL10-8019.
2. FOR SCHEMATIC SEE D5-8019. (SHT 1)
3. CUT COMPONENT LEADS TO WITHIN .030 INCHES ON WIRING SIDE OF BOARD.
4. FOR 119/-/-/X/-/-, BRIDGE A. (SEE SHT 2)
5. FOR 199/-/-/A/-/-, BRIDGE B (SEE SHT 2) AND ADD DASHED COMPONENTS.
6. FOR 199/-/X,3/-/-/-/, ADD ITEMS 45, 46 AND 47 AND CUT ETCH WHERE SHOWN ON SHEET 2 (WIRING SIDE).
7. SOLDER MASK HOLES FOR ITEMS 21, 30 AND 42 AND INSTALL THESE ITEMS AFTER WAVE SOLDERING PROCESS USING SWAGING TOOLS C6-5081 & C6-5082.
8. CAPTURE HEAT SINK (ITEM 29) UNDER STANDOFFS AS SHOWN BELOW IN VIEW A-A. INSTALL BOTTOM EDGE OF Q2 FLUSH WITH EDGE OF ITEM 29.
9. AFTER SWAGING, SOLDER ITEMS 30 AND 42 SUCH THAT SOLDER NEATLY FILLETS AROUND COMPLETE CIRCUMFERENCE OF STANDOFFS.



VIEW B-B



VIEW A-A

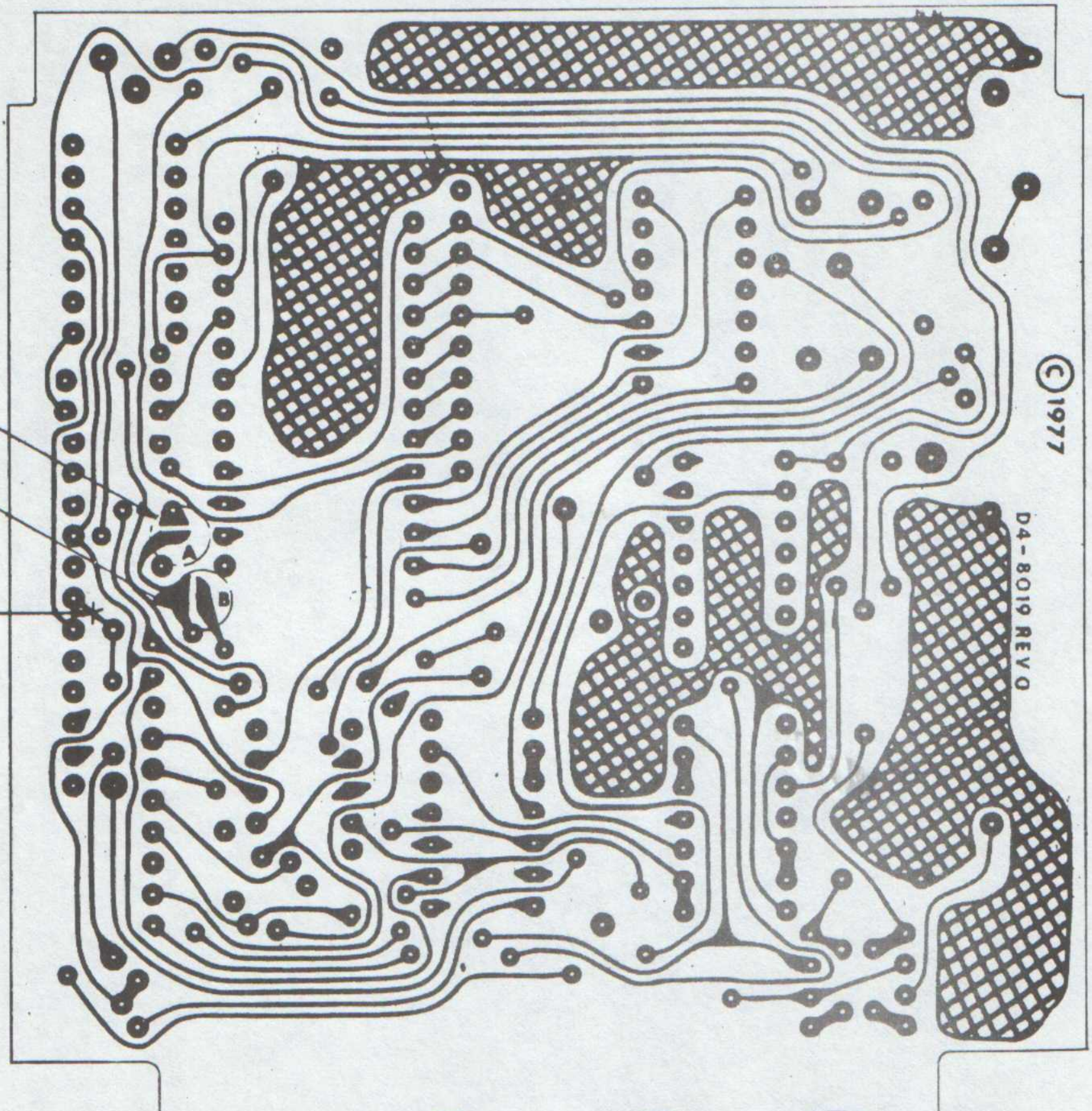
COMPONENT SIDE

ASSEMBLY
THERMOCOUPLE CARD
MODEL 199
D7 - 8019

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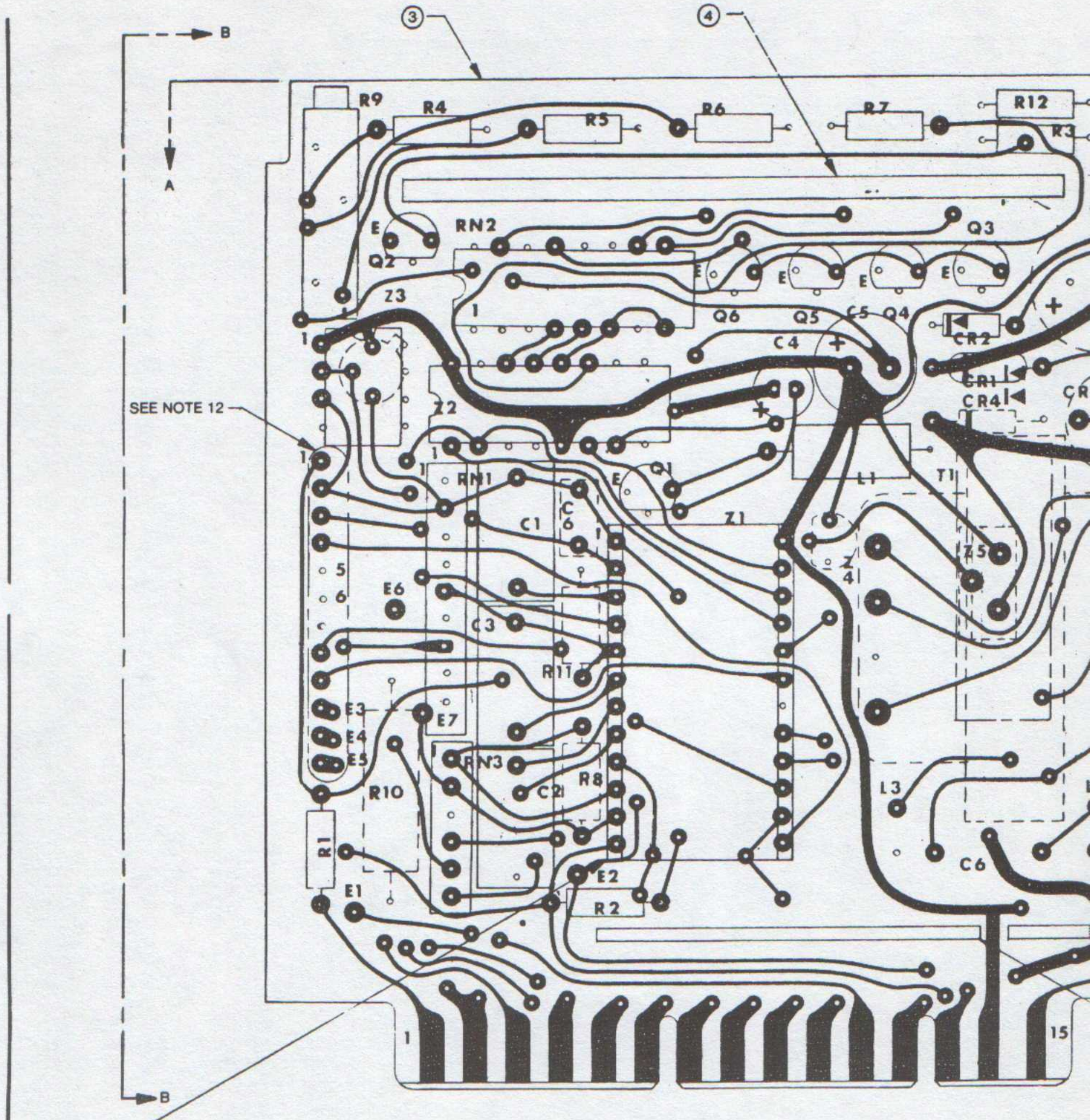




WIRING SIDE

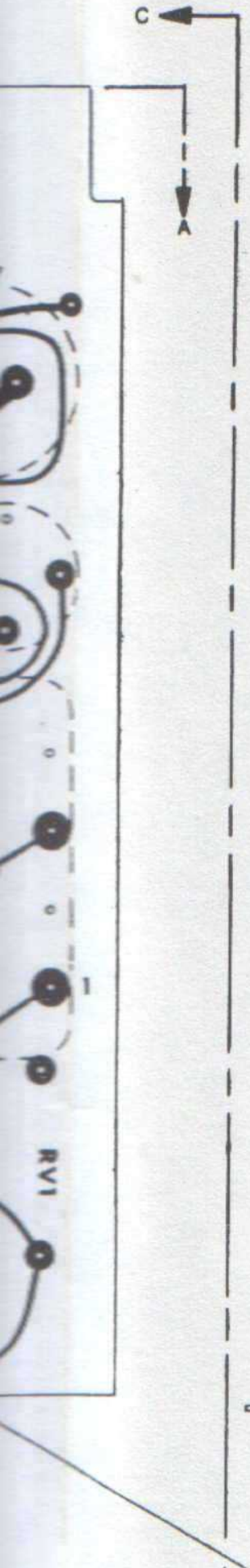
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THERMOCOUPLE CARD
MODEL 199
D7 - 8019

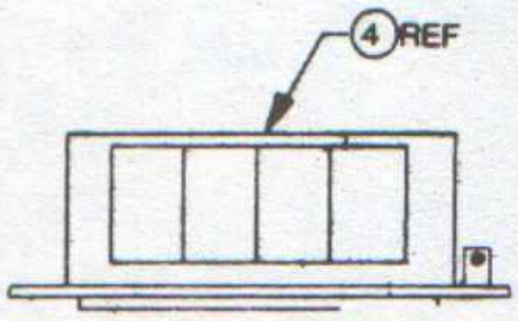
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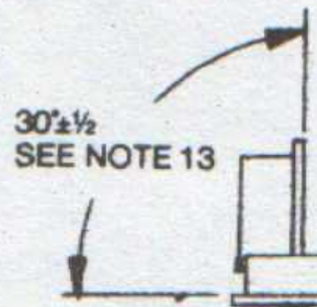
COMPONENT SIDE

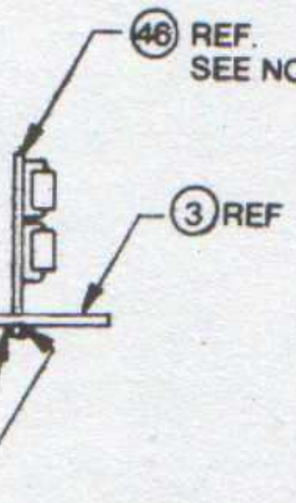
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VIEW A-A
1/1 SCALE

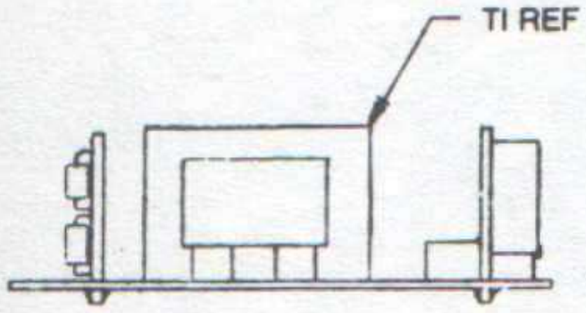




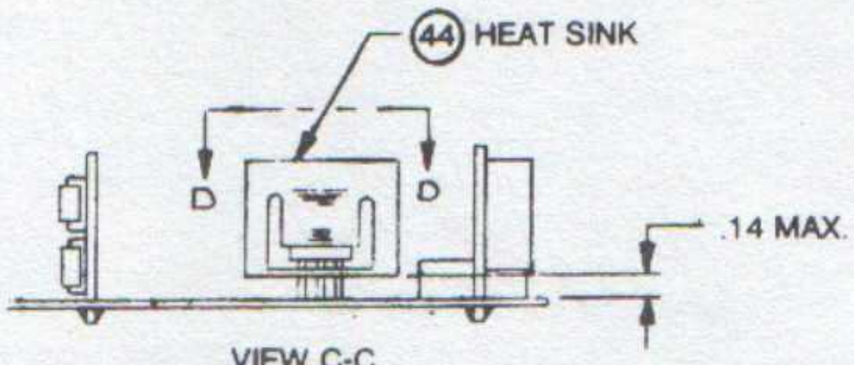
VIEW B-B
1/1 SCALE

NOTE:

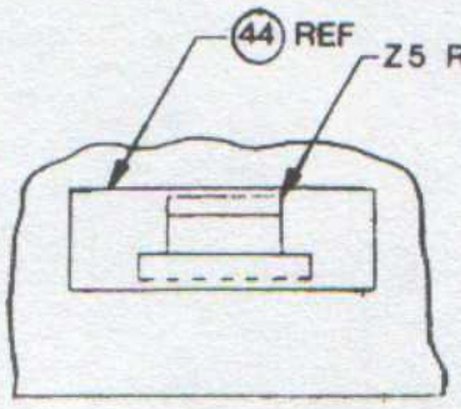
1. FOR PARTS LIST SEE PL10-8020.
2. FOR SCHEMATIC SEE D5-8019.(SHT.2)
3. CUT COMPONENT LEADS TO WITHIN .030 INCHES ON WIRING SIDE OF BOARD.
4. WORKMANSHIP PER SPEC. A2-1027.
5. FOR 199/-/-/-/D/-,INSTALL BCD CARD AND SOLDER, USING MATING FIXTURE C6-5057
6. FOR 199/-/-/-/-/5VDC, USE AS IS.
7. FOR 199/-/-/-/-/ 110 VAC, BRIDGE PADS J & H; CUT M. (SEE SHT. 2)
8. FOR 199/-/-/-/-/ 220 VAC, BRIDGE PAD F & CUT M. (SEE SHT 2)
9. FOR 199/-/-/-/-/ 8-28 VDC, SEE VIEW C-C.
10. ASSEMBLY Z5 (ITEM 38) WITH HEAT SINK (ITEM 44) AND INSERT PINS OF Z5 INTO P.C. CARD AS SHOWN.
11. ALL SOLDER BRIDGE GAPS MUST BE SOLDER BRIDGED ACROSS THE COMPLETE GAP.
12. PLUG ENCIRCLED HOLES BEFORE WAVE SOLDER OPERATION
13. USE MATING FIXTURE C6-5057.
14. DASHED COMPONENTS ARE OPTIONAL. SEE PARTS LIST.



VIEW C-C
199/-/1,2/-/-/-/-
LINE POWER
OPTION
1/1 SCALE



VIEW C-C
199/-/3/-/-/-/-
8 TO 28 VDC
1/1 SCALE



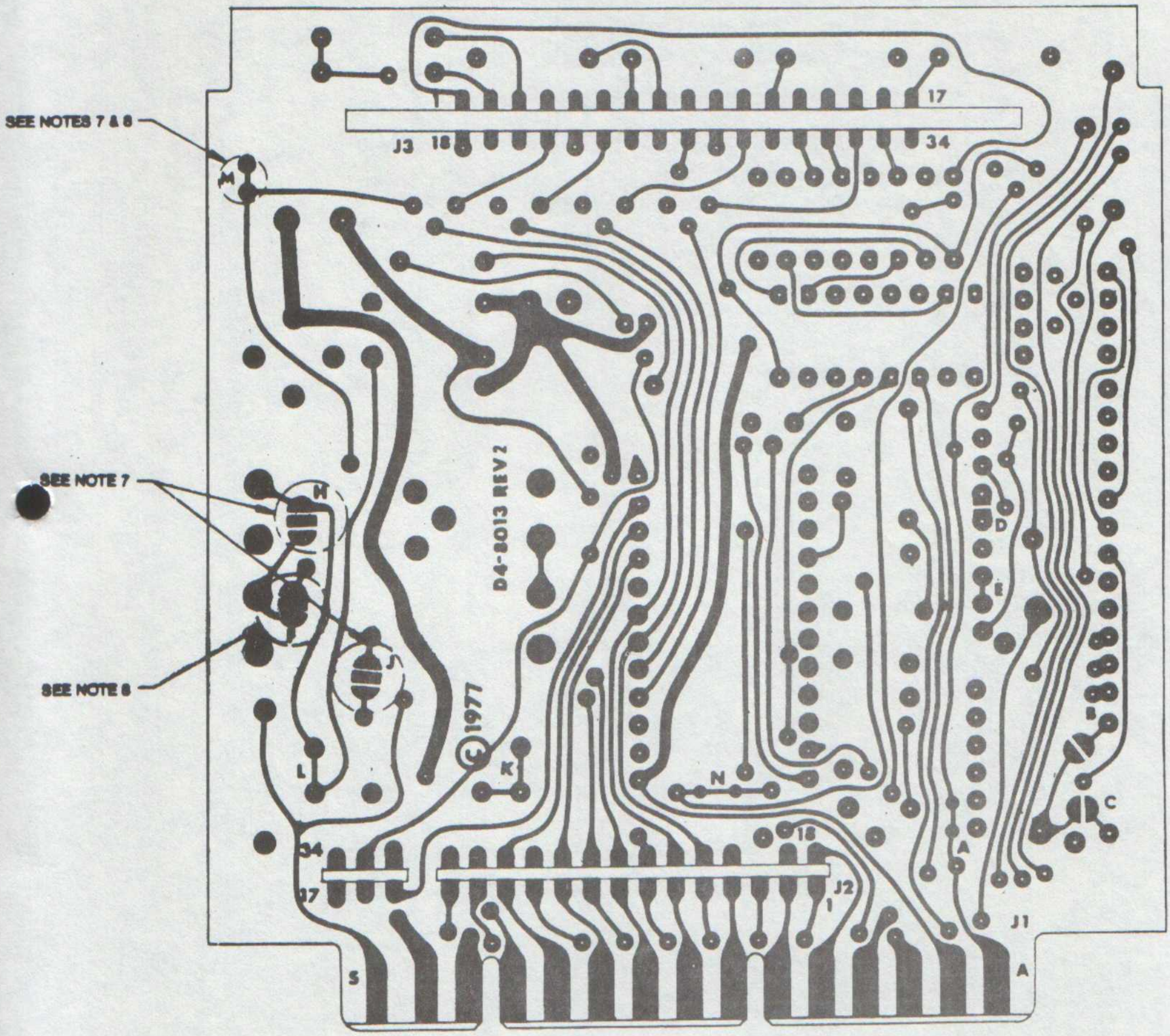
VIEW D-D
2/1 SCALE
SEE NOTE 10

ASSEMBLY
A/D BOARD
MODEL 199
D7 - 8020

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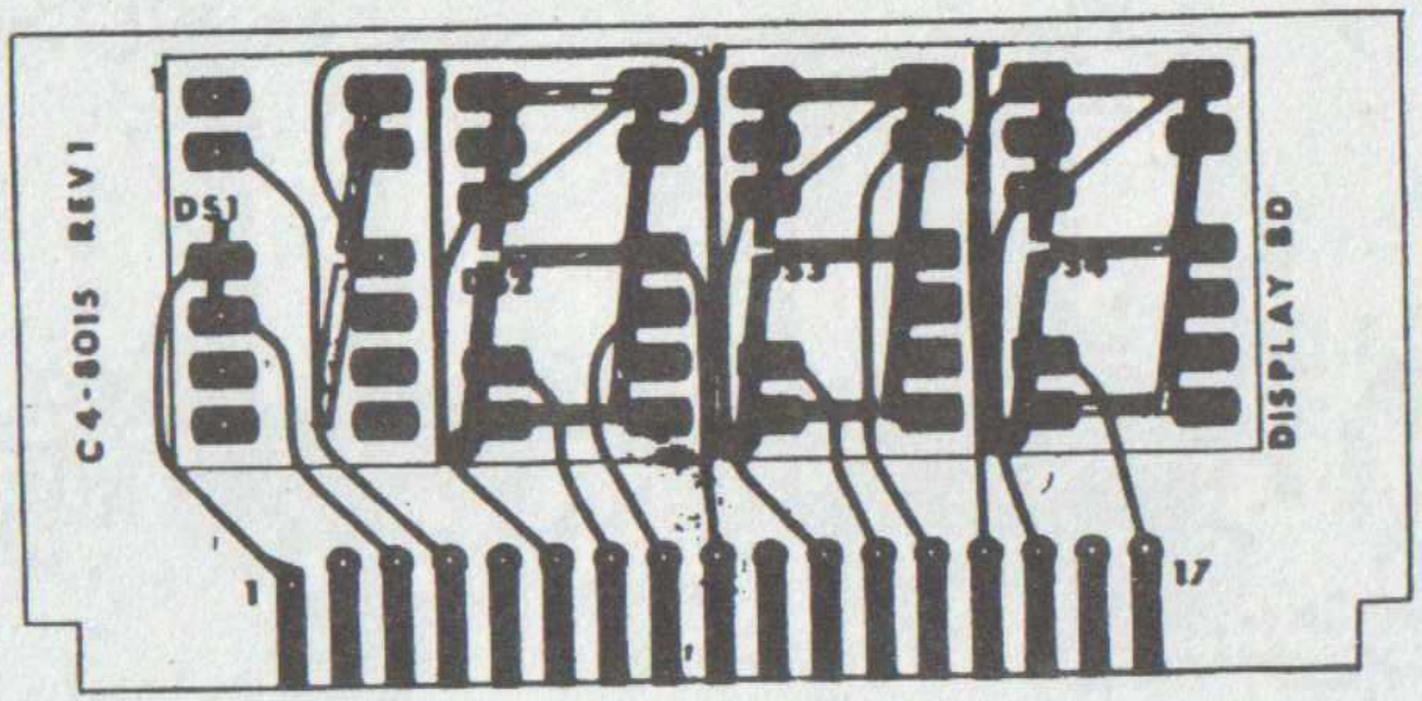


WIRING SIDE

ASSEMBLY
A/D BOARD
MODEL 199
D7 - 8020

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NOTES:
1. FOR PARTS LIST SEE PL10-8021
2. FOR SCHEMATIC SEE DS-8019
3. WORKMANSHIP PER SPEC. A2-1027
4. CUT COMPONENT LEADS TO WITHIN .030 INCHES ON WIRING SIDE OF BOARD.
5. MAXIMUM COMPONENT HEIGHT IS .32 INCHES.
6. WARNING: DO NOT VAPOR DEGREASE - CLEAN IN FREON ONLY.

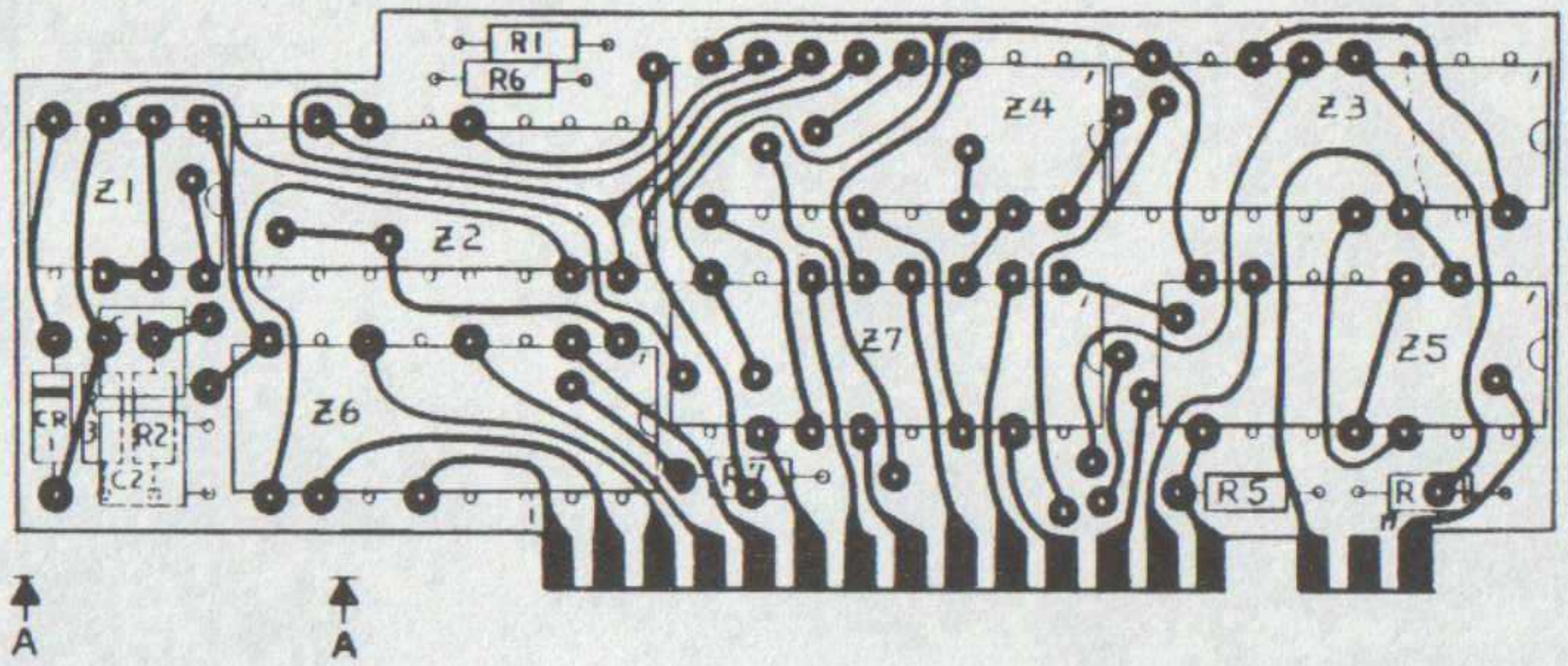
COMPONENT SIDE

ASSEMBLY DISPLAY BOARD MODEL 199 C7 - 8021

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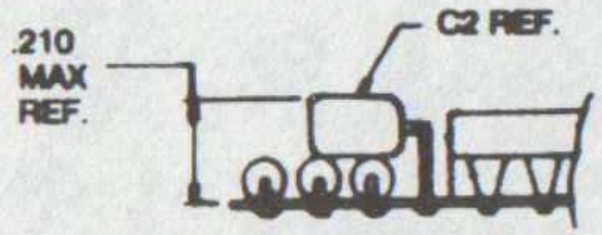
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NOTES:

1. FOR PARTS LIST SEE PL10-8016
2. FOR SCHEMATIC SEE C5-8016
3. WORKMANSHIP PER SPEC. A2-1027
4. CUT COMPONENT LEADS TO WITHIN .030 INCHES OF BOARD ON WIRING SIDE.
5. MAX. COMPONENT HEIGHT NOT TO EXCEED .210.

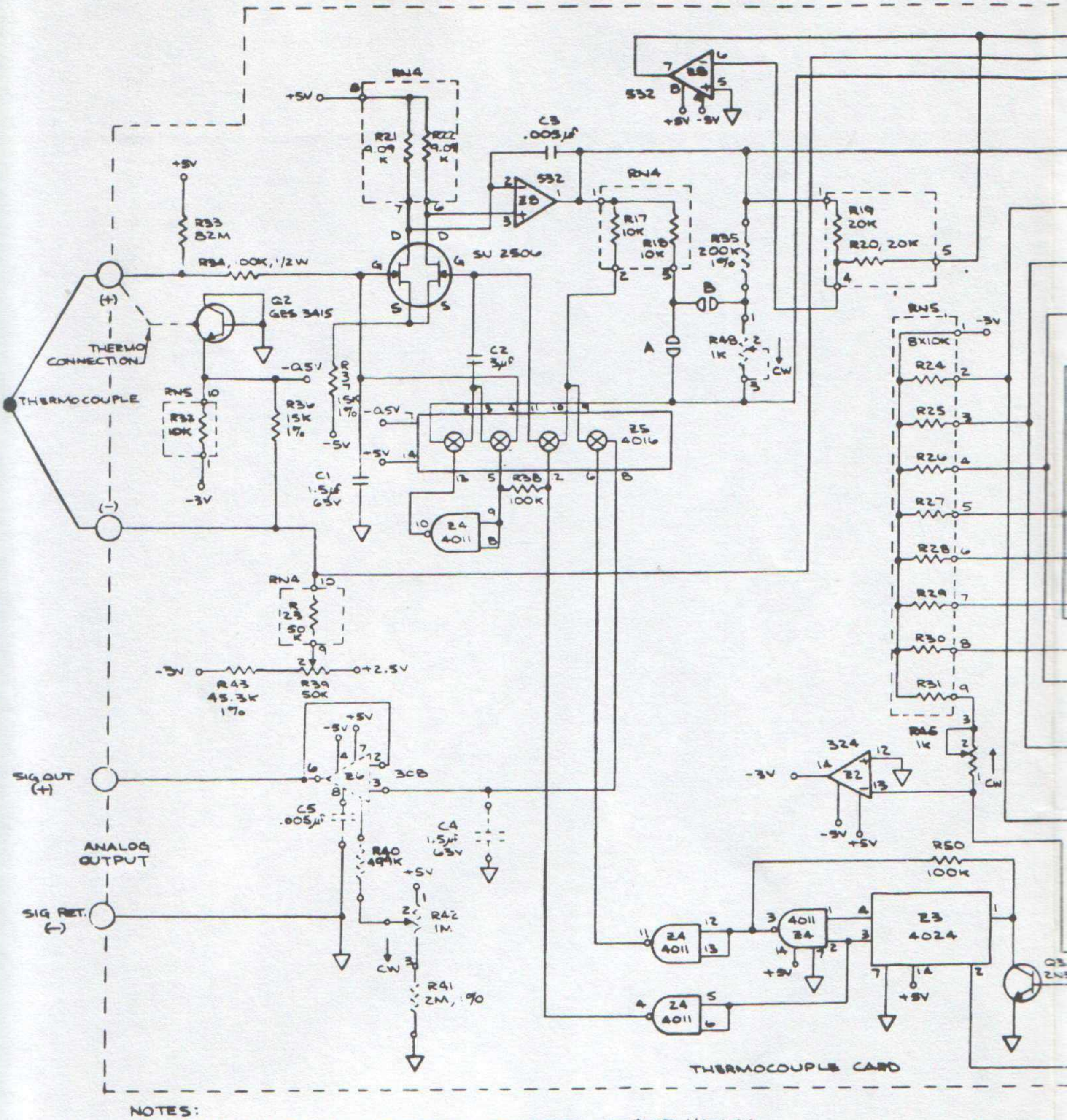


VIEW AA

COMPONENT SIDE

ASSEMBLY
BCD CARD
MODEL 199
C7 - 8016

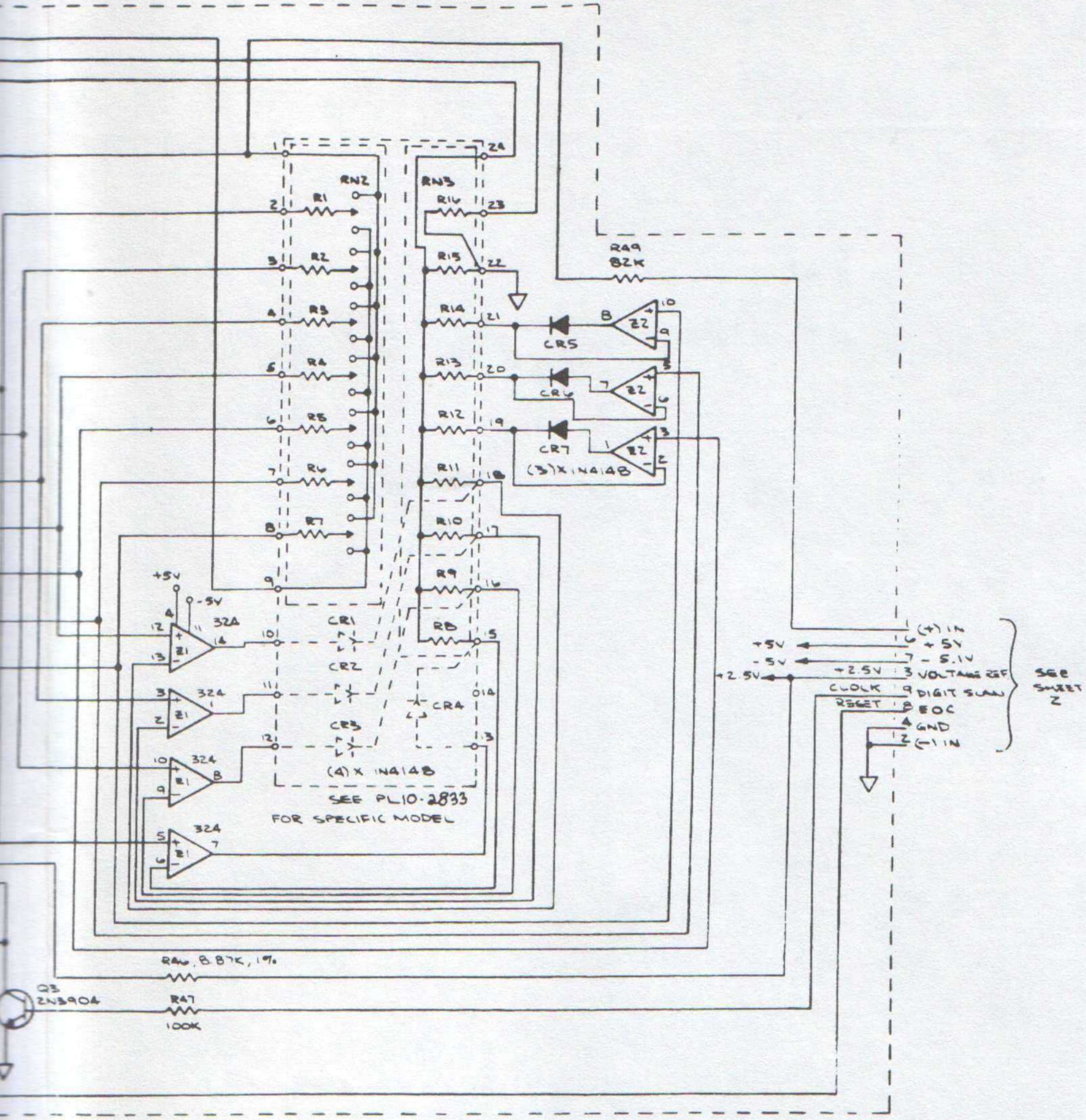
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NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE ±10%, 1/4W, CC
2. FOR THESE COMPONENTS SEE PL10-8020 (SEE SHEET 2).

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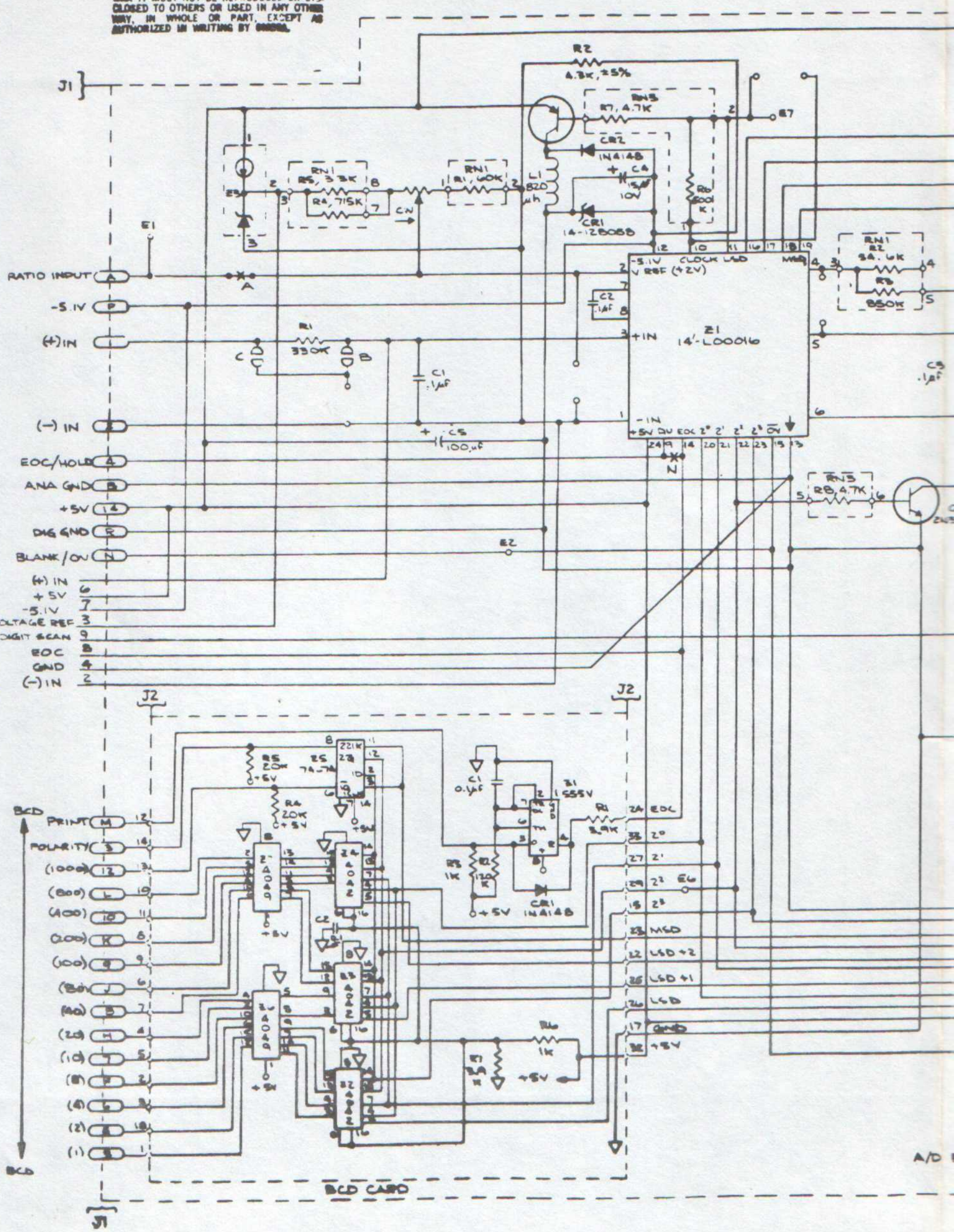
SCHEMATIC:
DIGITAL THERMOCOUPLE READOUT
MODEL 199

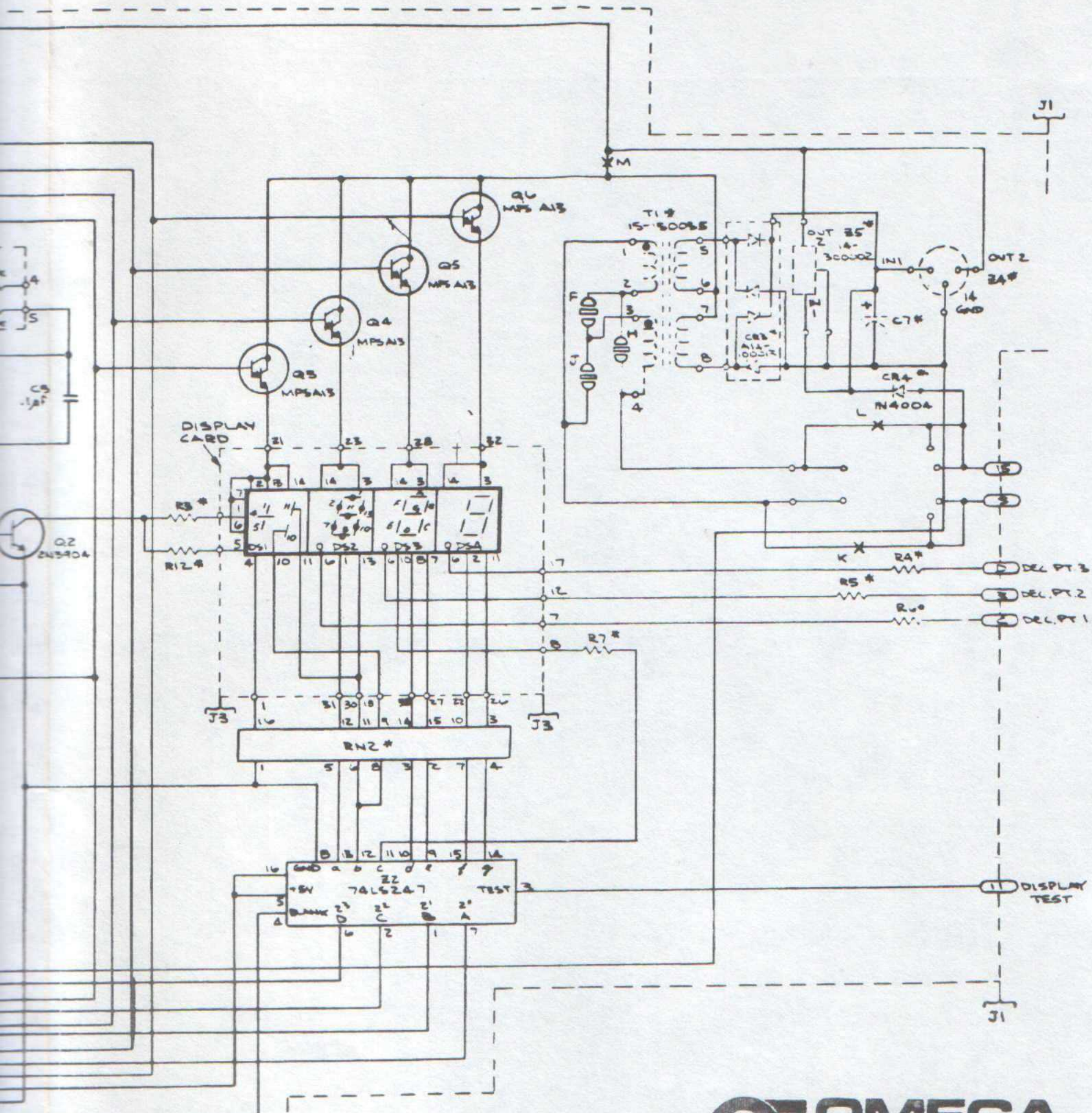
DS-8019

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SCHEMATIC :
DIGITAL THERMOCOUPLE READOUT
MODEL

05-3019

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