TC292
Thrmocouple Amplifier

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REVISIONS PAGE

DATE	PAGE NO.	DESCRIPTION OF CHANGE	BY
3/20/81	4-4	R1 - Added Figure 4-1, TC292 Schematic, Page 4-4	RHC
10/13/81	1-1, 2-2, 2-4, 4-4	R2 - Change Cold Junction Compensation circuit to use silicon transistor as temperature sensitive component (was sensistor).	RHC

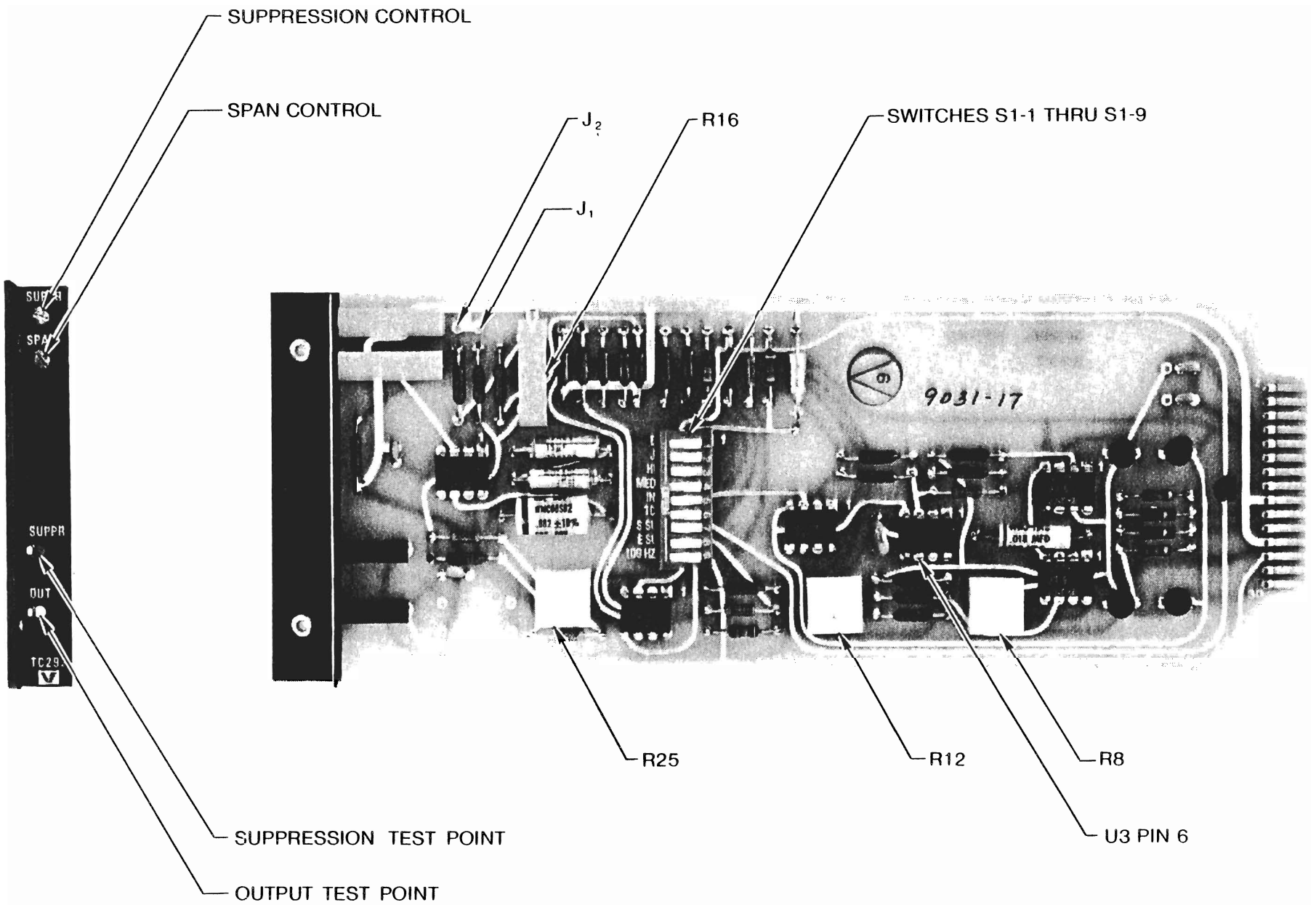

FIGURE 1.1 Model TC292 Thermocouple Amplifier

SECTION I
DESCRIPTION

1-0 INTRODUCTION

This technical manual contains installation, operation and maintenance instructions for a Model TC292 Thermocouple Amplifier Plug-in Module for the MC170 and MC170AD Modular Systems. This module is manufactured by Validyne Engineering Corporation, Northridge, California, 91324.

1-1 DESCRIPTION

The TC292 Thermocouple Amplifier is a plug-in module for the MC170 Multi-channel Modular Signal Conditioning System. It accepts inputs from Type E, J, K or T thermocouples, provides cold junction temperature compensation to a 32°F (0°C) reference, and amplifies the input signal to a 10 Vdc full scale output. It is basically a high gain DC amplifier with a high impedance differential input, adjustable gain from X100 to X1100, adjustable zero suppression and selectable frequency response. The cold junction compensation circuit can be switched out for TC292 use as a single-ended or differential input DC amplifier.

Internal switches provide selection of cold junction compensation for the type of thermocouple used, selection of three gain steps (X250, X500, X1000), and selection of 0-1 Hz or 0-100 Hz frequency response. Front panel controls provide vernier SPAN and zero SUPPRESSION adjustments along with test points for monitoring output and suppression levels.

Input and output connections are made via the terminals on the rear of the MC170 case, which supplies the TC292 operating power.

See Figure 1-1 for location of controls, adjustments and test points.

1-2 TECHNICAL CHARACTERISTICS

The technical characteristics for the TC292 are listed in Table 1-1.

Table 1.1 Technical Characteristics

Item	Characteristics
SPECIFICATIONS	
Input Signal Range:	±9.1mV FS to ±100mV FS for ±10 Vdc output.
Gain Switch Positions:	High (9.1mV to 25mV); Medium (18.2mV to 50mV); and Low (36.4mV to 100mV).
Gain Adjust ("SPAN") Potentiometer:	Continuous adjustment from 40% to 110% of selected gain step.
Gain Switch Accuracy:	±1% of full scale without readjustment.
Thermocouple Cold Junction Compensation:	Switch-selectable for types E, J, K and T; Reference temperature variation $\leq 5^{\circ}C$ over ambient temperature range of $25^{\circ}C \pm 25^{\circ}C$; junction temp taken as temp at connector end of TC292 board.
Zero Suppression:	To ±100% FS at all gain settings.
Input Characteristics:	
Safe Differential Voltage:	±20V
Differential Input Impedance:	≥1 Meg Ω in parallel with 0.018μF
Common Mode Voltage:	±10V
Common Mode Rejection Ratio:	≥105db at 60Hz, maximum gain.
Output Characteristics:	
Output:	0 to ±10Vdc, 0-2mA, short-circuit proof
Output Impedance:	<10 Ohms
Output Noise:	≤5mV rms at maximum gain and fast filtering.

Table 1.1 Technical Characteristics (Con't.)

Linearity:	0.05% FS output, referred to input; not linearized to thermocouple curves.
OPERATING CONTROLS	
Front panel Controls	
SPAN Control:	A screwdriver-operated potentiometer for vernier span adjustment.
Suppression ("SUPR") Control:	A screwdriver-operated potentiometer for vernier zero suppression or elevation.
Output ("OUT") Test Point:	A pin-jack for monitoring the DC signal output during setup and calibration.
Suppression ("SUPR") Test Point:	A pin-jack for monitoring the DC zero suppression voltage.
NOTE: The ground test point on the MC170 power supply provides ground return for TC292 test points.	
Internal Controls	
The following operating controls are located on the TC292 circuit board. For setting, the board must be removed from the MC170 case; removal can be done with power on with no damage or effect on other channels. See Figure 1.1 for control locations.	
Switch S1-1(E):	A SPST switch for selecting cold junction compensation for Type E thermocouple (S1-1 closed, S1-2 open).

Table 1.1 Technical Characteristics (Con't.)

Switch S1-2(J):	A SPST switch for selecting cold junction compensation for Type J thermocouple (S1-2 closed, S1-1 open).
Switches S1-1 and S1-2 both open for Type K or T thermocouples.	
Switch S1-3(HI):	A SPST switch for selecting high-gain (X1100) range (S1-4 open, S1-3 closed).
Switch S1-4(MED):	A SPST switch for selecting medium gain (X500) range (S1-4 closed, S1-3 open).
Switches S1-3 and S1-4 open for Low gain (X250) range.	
Switch S1-5(IN):	A SPST switch for selecting zero suppression IN or OUT (open for adjustable zero suppression, closed for no suppression).
Switch S1-6(TC):	A SPST switch for selecting cold junction compensation (TC) or none (open for compensation, closed for no compensation, and to use as a DC amplifier).
Switches S1-7, Sensor Slave (S SL); and S1-8, Excitation Slave (E SL):	Two SPST switches for selecting between internal cold junction compensation, or external compensation. See Section 2.4 for detailed instructions.
Switch S1-9(100Hz):	A SPST switch for selecting low or high frequency response (closed for 0-1 Hz response, open for 0-100 Hz response).

2.0 INSTALLATION

2.1 MC170 Module Case

The TC292 can be installed in any slot of the basic MC170 module case with wire-wrap terminals. If the case is the MC170T (with screw terminals), the TC292 must be inserted only in slots with terminals wired per Option A.

2.2 Input-Output Connections

The following is a tabulation of the electrical connections for the TC292 plug-in module; terminal numbers shown refer to the etched terminal pads on the printed circuit board. As external signal input and output connections are thru the MC170 module case, the manual for the specific module case type being used (e.g. MC170, MC170T, MC170AD, etc.) should be consulted for appropriate external wiring instructions.

Terminal No.	Function
7-8	+15 Vdc*
9-10	Power Ground*
11-12	-15 Vdc*
15-16	Temperature Compensation
17-18	Signal Ground*
19-20	+ Input
21-22	- Input
23-24	Signal Ground*
25-26	Output

*Items marked with asterisk are bussed to all channel positions.

The common thermocouple types are listed below along with the material polarities, which should be observed when making input connections.

Type E: Chromel + /Constantan - (Approx 34μV/°F)

Type J: Iron +/Constantan - (Approx. 29μV/°F)

Type K: Chromel +/Alumel - (Approx. 23μV/°F)

Type T: Copper +/Constantan - (Approx. 23μV/°F)

2-3. Setting Internal Switches:

For temperature measurement, the following factors must be known in order to set the internal switches on the TC292 circuit board.

a) Type of thermocouple - to select cold junction temperature compensation mode (S1-6), master/slave compensation (S1-7, S1-8), and type (S1-1, S1-2).

b) Gain desired - to set gain range for output desired (S1-3, S1-4).

c) Output frequency response - to select slow or fast response (S1-9).

d) Zero suppression - to select whether operative or not (S1-5).

Table 2-3 lists the switch positions for types E, J, K and T thermocouples. Also shown are the switch positions for copper wire connections to the MC170 terminals - e.g., wiring from a non-thermocouple signal source. In this case, no internal or external cold junction compensation is used.

Because of their location, these switches cannot be repositioned without pulling out the TC292 modules. This can be done with the case power on. If adjustments are to be made with the module operational, a Validyne P/N 8609 Module Extender Card should be used.

2-4 External Cold Junction Compensation:

The cold junction temperature compensation in the TC292 is achieved by using a silicon transistor (Q5) mounted near the connector end of the circuit board. This assumes that the temperature at this location will be essentially the same as that at the case terminals, where the thermocouple connections are made. In a normal indoor installation where the temperature is relatively stable, this arrangement reasonably reflects the temperature at the actual cold junctions.

Table 2.3 - Switch Positions

T/C Type	SWITCH POSITIONS (CLO - Closed; OPN - Open)					
	Cold Junction Comp	Gain Step			Filter	
		HI (X1000)	MED (X500)	LO (X250)	1 Hz	100 Hz
E	S1-1 CLO S1-2 OPN S1-7 CLO S1-8 CLO	S1-3 CLO S1-4 OPN	S1-4 CLO S1-3 OPN	S1-3 OPN S1-4 OPN	S1-9 CLO	S1-9 OPN
J	S1-2 CLO S1-1 OPN S1-7 CLO S1-8 CLO	S1-3 CLO S1-4 OPN	S1-4 CLO S1-3 OPN	S1-3 OPN S1-4 OPN	S1-9 CLO	S1-9 OPN
K	S1-1 OPN S1-2 OPN S1-7 CLO S1-8 CLO	S1-3 CLO S1-4 OPN	S1-4 CLO S1-3 OPN	S1-3 OPN S1-4 OPN	S1-9 CLO	S1-9 OPN
T	S1-1 OPN S1-2 OPN S1-7 CLO S1-8 CLO	S1-3 CLO S1-4 OPN	S1-4 CLO S1-3 OPN	S1-3 OPN S1-4 OPN	S1-9 CLO	S1-9 OPN
Copper	S1-1 OPN S1-2 OPN S1-6 CLO	S1-3 CLO S1-4 OPN	S1-4 CLO S1-3 OPN	S1-3 OPN S1-4 OPN	S1-9 CLO	S1-9 OPN

Other Switches: S1-5 OPN for adjustable zero suppression
S1-5 CLO for no suppression
S1-6 OPN for thermocouple input
S1-6 CLO for DC amplifier use (no cold junction compensation)
S1-7 CLO and S1-8 CLO to use internal TC292 cold junction temperature compensation; See Section 2.4.

2-4 External Cold Junction Compensation (Cont'd).

For installations where large and variable temperature gradients could exist within the MC170 case, the TC292 has provisions for moving the cold junction compensation device to an external position near the actual cold junction. Two internal switches, S1-7 and S1-8, have been incorporated into the TC292 for this purpose. Up to 24 TC292 modules can be slaved to one master TC292 cold junction network. If all transitions of thermocouple-to-copper take place in an isothermal location, then one remote cold junction compensation sensor can serve all the TC292 channels. This allows considerable cost savings by running copper in place of thermocouple material cables to the MC170 module case.

In the simpler case, the compensation sensor is located on or near the backplane of the module case where the transition from thermocouple leads to copper takes place. In this arrangement, the one sensor can be used for all TC292 plug-in's in the same module case.

In the more complex case, a location entirely remote from the module case and close to the termocouples may be selected which would minimize the run of thermocouple extension wire in favor of lower cost copper leads.

Accessory compensation sensor packages are available from Validyne for this purpose; it is suggested that the factory be contacted with the specifics of the intended application for recommendations as to the appropriate sensor.

2-4-1 Remote Compensation Sensor Wiring:

To use an external sensor, the following switch settings and electrical connections are used:

A. "Master" Plug-in Module - Switch S1-7 is open, S1-8 is closed. Sensor is connected between terminals 15-16, and Signal Ground, 17-18.

B. "Slave" Plug-in Module(s) - Switch S1-7 is open and S1-8 is open. Connect pin 15-16 of slave channel(s) to pin 15-16 of Master channel.

SECTION III
OPERATION

3.0 OPERATION

3.1 Zero and Span Calibration

3.1.1 Prior to system calibration with a thermocouple, perform the following steps:

(a) Place switches S1-1, S1-2, S1-7 and S1-8 into the proper positions for the type of thermocouple used. (See Table 2.3).

(b) Place switch S1-5 to the closed position (zero suppression OUT).

(c) Place switch S1-9 to either the slow (1 Hz) or fast (100 Hz) response position.

(d) Place switch S1-6 to the open position (TC input).

(e) Place switches S1-3 and S1-4 to the desired gain step.

> Example: A type J thermocouple is to be used to measure 32°-1000°F for an output voltage of 0-10 Vdc. Full scale input will be approximately 1000°F X 29μV/°F = 29mV. Required gain is $\frac{Eo}{Ein} = \frac{10V}{.029V} = 345$. Set switches S1-3 and S1-4 to Medium gain (X500) step (S1-3 open, S1-4 closed).

With the module in the MC170 case, the output can be monitored by a DC voltmeter connected to the output test point on the TC292 front panel and the GND test point on the MC170 power supply.

3.1.2 For system calibration, perform the following steps:

(a) With a screwdriver, turn the SPAN control on the front panel fully clockwise - i.e., maximum output voltage.

(b) Insert the thermocouple into an ice-bath (32°F). Output voltage should drop to 0.00 ±0.05 Vdc.

(c) Insert the thermocouple into boiling water (212°F at 14.7 PSIA atmospheric) and adjust the SPAN control for the desired output voltage at this temperature. Any other known temperature can similarly be used for this step.

(d) For optimum accuracy, the zero suppression control ("SUPR") can be used to eliminate any zero offset or to scale the output to some other zero reference than 32°F.

> Example: A type J thermocouple is to be used to provide 0-10 Vdc output from 0°-1000°F. In this case, since zero output is not to be at 32°F, set switch S1-5 to the OPEN position (suppression IN). With the thermocouple at 32°F, adjust Suppress control on front panel for an output of 0.32 Vdc. With the thermocouple at 212°F, adjust the SPAN for an output of 2.12 Vdc. The channel is now set up to read the temperature directly with an output scale factor of 1 Vdc/100°F.

System calibration can also be performed by using known input voltages taken from standard thermocouple output tables referenced to 32°F.

3.2 Zero Suppression

Zero Suppression is useful for expanding the output over part of a wide temperature range. For example, if the temperature range of interest is 400° to 500°F, the output can be suppressed to zero at 400°F and the gain increased to expand the output from 400°-500°F. The front panel SUPPRESS control on the TC292 provides up to ±100% zero suppression at any gain step, making it possible to suppress or elevate the zero. CCW adjustment suppresses zero, CW adjustment elevates zero. The suppression voltage, variable from 0 to ±10 Vdc, can be monitored at the front panel "SUPR" test jack.

For the zero SUPPRESS control to be active, switch S1-5 must be open; otherwise, this control will be inactive.

If only zero suppression is desired (no zero elevation) with better resolution of suppression control setting, circuit board pad J1 (on top left of circuit board just behind SUPPRESS control pot) can be jumpered to the resistor (R34) pad just below J1. For this, the resistor lead must be disconnected from its pad. (see Figure 1.1 for pad location).

If only zero elevation with better control resolution is desired, pad J2 can be jumpered to the resistor (R36) pad just below J2, with the resistor lead lifted from the pad.

3.3 As DC Amplifier

With switch S1-6 closed, the output of the cold junction compensation circuit is grounded, allowing the amplifier to be used as a variable-gain DC amplifier. In this situation, the positions of switches S1-1, S1-2, S1-7 and S1-8 will have no effect.

The gain switches S1-3 and S1-4, the filter switch S1-9, and the zero suppression switch S1-5 all remain operable with the amplifier in the DC mode.

SECTION IV
MAINTENANCE AND REPAIR

4.0 MAINTENANCE AND REPAIR

The TC292 is factory tested and burned-in before shipment. For periodic maintenance, only the adjustments given below should be made in order to assure proper operation. For access to the adjustments, an extender board, such as the Validyne P/N 8609 module extender card, is required. See Figure 1.1 for adjustment locations.

4.1 Zero Balance

4.1.1 Place Switches S1-1 through S1-9 into the following positions:

OPEN	CLOSED
S1-1	S1-3
S1-2	S1-5
S1-4	S1-6
S1-9	S1-7 & S1-8

4.1.2 Short Input Terminals - 19/20 to 21/22, and input to ground (pin 23/24). Connect DVM between U3 pin 6 and signal ground (terminal 23/24), and set to 100 mVDC range.

4.1.3 Adjust R8 for minimum reading on DVM.

4.1.4 With + and - inputs commoned, and DVM between U3 pin 6 and signal ground, alternately apply +10 Vdc and -10 Vdc between commoned inputs and ground; adjust R12 for minimum output.

4.1.5 Move positive lead of DVM to OUTPUT test point. Adjust R16 for 0.000 ±0.005 VDC reading.

4.2 Cold Junction Compensation

This check must be done at a known or measured ambient temperature at the TC292 board.

4.2.1 Place switches S1-1 through S1-9 into the following positions:

OPEN	CLOSED
S1-1	S1-3
S1-2	S1-5 & S1-6
S1-4	S1-7 & S1-8
	S1-9

4.2.2 Short input terminal 21/22 to circuit ground. Connect DVM to output test point and apply +10.00 ±0.01mVdc between input terminal 19/20 and circuit ground. Adjust SPAN control for 10.000 ±0.015 Vdc reading on DVM.

4.2.3 Types K and T:

Short input terminals - 19/20 to 21/22, open switch S1-6. Adjust R25 for a DVM reading at OUTPUT test point to reflect the ambient temperature at the TC292 board as follows:

70°F:	0.84 ±0.02VDC	76°F:	0.97 ±0.02VDC
71°F:	0.86 ±0.02VDC	77°F:	1.00 ±0.02VDC
72°F:	0.88 ±0.02VDC	78°F:	1.02 ±0.02VDC
73°F:	0.91 ±0.02VDC	79°F:	1.04 ±0.02VDC
74°F:	0.93 ±0.02VDC	80°F:	1.06 ±0.02VDC
75°F:	0.95 ±0.02VDC		

The above adjustment sets the cold junction configuration for Types K and T thermocouple.

4.2.4 Type J:

If a Type J thermocouple is to be used, check the "J" compensation by closing switch S1-2. The output should be as follows:

70°F:	1.08 ±.02VDC	73°F:	1.16 ±.02VDC
71°F:	1.11 ±.02VDC	74°F:	1.19 ±.02VDC
72°F:	1.13 ±.02VDC	75°F:	1.22 ±.02VDC

4.2.4 Type J (cont'd)

76°F:	1.25 ±0.02VDC	79°F:	1.34 ±0.02VDC
77°F:	1.28 ±0.02VDC	80°F:	1.36 ±0.02VDC
78°F:	1.31 ±0.02VDC		

4.2.5 Type E:

If a Type E thermocouple is to be used, check the "E" compensation by closing switch S1-1 (S1-2 open). The voltage at the output test point should be as follows:

70°F:	±1.26 ±0.02VDC	76°F:	±1.46 ±0.02VDC
71°F:	±1.29 ±0.02VDC	77°F:	±1.50 ±0.02VDC
72°F:	±1.33 ±0.02VDC	78°F:	±1.53 ±0.02VDC
73°F:	±1.36 ±0.02VDC	79°F:	±1.56 ±0.02VDC
74°F:	±1.39 ±0.02VDC	80°F:	±1.60 ±0.02VDC
75°F:	±1.43 ±0.02VDC		

4.3 Repair

Should circuit malfunction occur, Validyne recommends that the module be returned for prompt repair or replacement in accordance with the standard Validyne Warranty.

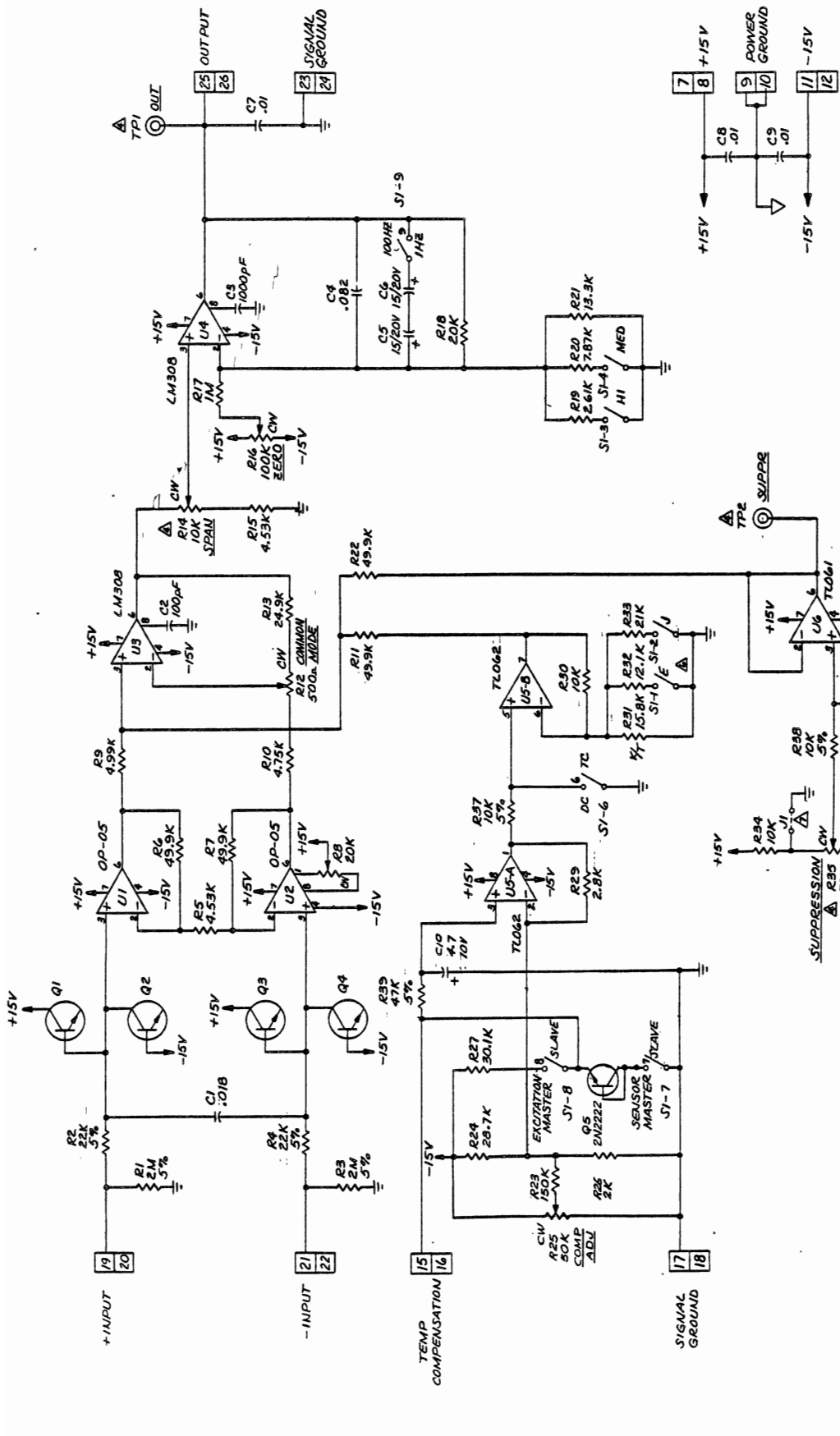

FIGURE 4-1. TC292 Schematic

NOTES: UNLESS OTHERWISE SPECIFIED.
1. CAPACITOR VALUES ARE IN MICROFARADS.
2. RESISTORS VALUES ARE IN OHMS ±1%, 1/8 WATT.
3. TRANSISTORS ARE 2N3859.
4. FRONT PANEL ACCESS COMPONENTS.
5. □ INDICATES CONTACTS ON CIRCUIT BOARD.
A LETTER DESIGNATES THERMOCOUPLE TYPE.
A OPTIONAL JUMPER.

WARRANTY

VALIDYNE ENGINEERING CORPORATION warrants equipment of its own manufacture to be free from defects in material and workmanship under normal conditions of use and service.

VALIDYNE will rework or replace any item found to be defective on as return to VALIDYNE within the time specified below:

1. Pressure Transducers and Pressure Transmitters (including transducers supplied as part of Digital Manometer Systems) within three (3) years of its original purchase.

2. Electronics products (Transducer Indicators, Carrier Demodulators, plug-in SignalCondioners, Module Cases, etc.) within one (1) year of its original purchase.

3. OEM Transducers within one (1) year of its original purchase.

Buyer is requested to secure authorization of VALIDYNE, and to describe defect prior to return of equipment under warranty. Shipment to VALIDYNE shall be at Buyer's expense, with return at VALIDYNE's expense. NON-VERIFIED problems or malfunctions, whether warranty or not, are subject to a $100.00 evaluation charge.

The warranty carries no liability, either expressed or implied, beyond our obligation to rework or replace, at VALIDYNE's option, the unit which carries the warranty to the original purchaser. Prices, specifications, and designs are subject to change without notice. This warranty is void if the product is subjected to misuse, accident, neglect, or improper application or operation.

Out of Warranty Rework

Units returned to VALIDYNE for rework which are out of warranty will be subject to the following conditions:

1. A description of the problem or malfunction shall accompany the unit returned for rework, or be communicated to VALIDYNE prior to shipment. Otherwise there will be a minimum evaluation and/or calibration charge of $100.00.

2. Unit will be reworked automatically if the charge is less than 65% of current list price, unless other specific instructions are received. Above 65% VALIDYNE will request authorization by Buyer.

3. If a quotation is required before proceeding with rework, unit should be accompanied by a document so stating, or communicated to VALIDYNE prior to shipment. A $100.00 evaluation charge will be invoiced for this service.

4. Shipping charges in both directions are the responsibility of the Buyer for all out of warranty returns.

Warranty on Rework

Warranty coverage on rework is 90 days on work done, or to the end of the original warranty period, whichever is longest.

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