WJ-979
Thermo-Guard II

Instruction Manual

WATKINS-JOHNSON

TABLE OF CONTENTS

Section	Description
Section I	General Information
1.0	Description
Section II	Theory of Operation
2.1	Function
2.2	Circuit Description
2.3	Block Diagram
Section III	Installation
3.1	Wiring
3.2	Changing Number of Channels
Section IV	Operating Instructions
4.1	Description of Operating Switches and Setpoint Adjustment
4.2	Startup
Section V	Troubleshooting and Calibration
5.1	Calibration
5.2	Troubleshooting
Section VI	Parts List and Drawings
6.1	Parts List
6.2	Mother Board Assembly
6.3	Counter Board Assembly
6.4	Counter Board Schematic
6.5	Readout Board Assembly
6.6	Readout Board Schematic
6.7	Amplifier Board Assembly
6.8	Amplifier Board Schematic
6.9	Switching Board Assembly
6.10	Switching Board Schematic - Channel 1-8
6.11	Switching Board Schematic - Channel 9-15
6.12	Power Supply Board Assembly
6.13	Power Supply Board Schematic
6.14	Input Board Assembly
6.15	Input Board Schematic
6.16	WJ-979 Thermo-Guard Procurement Specification

SECTION I

GENERAL INFORMATION

1.0 Description

The Watkins-Johnson Company "Thermo-Guard" is specifically designed to provide low-cost overtemperature protection in multi-zoned furnaces, and in other applications where it is necessary to guard against excess temperatures at several points.

This protection is available up to 1700°C, depending upon the type of thermocouples used, and is achieved by automatically scanning and monitoring the outputs of up to fifteen thermocouples.

Indication of temperature is continuous over the total setpoint range with set-point adjustable over the same range. Scanning rate is approximately two seconds per channel and can be increased up to 60 seconds per channel by a simple resistor change. Thermocouple break protection is provided as a standard feature.

The zone being monitored is indicated on a solid state numerical display. Zone count can be programmed from 2 to 15 channels by changing jumpers in the counting circuit. When set-point is exceeded in any zone, the scanning stops to indicate the zone and a built-in relay is latched. A time delay of approximately one second prevents false actuation of the alarm circuit.

A set of single-pole double-throw contacts rated at 250V 5A non-inductive is provided for external circuits. Power requirement is 115V ac, 50/60 Hz, at approximately 10 watts.

SECTION II

THEORY OF OPERATION

2.1 Function (Refer to Block Diagram, Section 2.3)

The basic function of the Thermo-Guard is to sample up to 15 thermocouple outputs at a fixed rate and to provide overtemperature protection if any of the outputs exceed a predetermined setpoint. Thermocouples are individually switched in sequence into a precision amplifier. The output of the amplifier is then fed into a comparator and a digital voltmeter for temperature readout. As each thermocouple is scanned, a corresponding reference voltage is fed into the "plus" side of the comparator where it is compared with the thermocouple signal. Reference voltages are adjustable so that the setpoint may be changed for each channel. A switch is provided so that the reference can be connected to the digital voltmeter for readout. The output of the comparator is used to switch a double pole relay when the thermocouple signal exceeds the reference setpoint. A pulse generator sends pulses to a digital counter to provide scanning. The digital counter binary code is decoded for the channel readout. Another decoder changes the binary code to a 1 to 15 sequence for channel switching. The counter is disabled when an over-temperature condition occurs or when the "hold" switch is made. The alarm relay is of the latching type so that a reset switch must be depressed to resume normal operation.

2.2 Circuit Description

Consult the block diagram and the corresponding schematics to understand the following description. The following circuits are on individual plug-in circuit boards.

Amplifier (refer to Drawings 6.7, 6.8)

The thermocouple amplifier consists of IC No. 8 and IC No. 9. IC No. 8 is a precision temperature controlled instrument amplifier with very low drift. IC No. 9 is a 741 buffer to provide a single ended output. The thermocouple input is fed into the non-inverting input. The cold junction compensation, the zero-adjustment and the gain adjustment are summed into the inverting input across a 100 ohm summing resistor (R27). Amplifier gain and zero points are adjustable through pots P2 and P1, respectively.

The amplifier output is fed from the amplifier to 1/2 of IC No. 9 which is wired as a comparator and to a digital voltmeter for temperature readout. The comparator compares the amplifier output with the reference setpoint to determine the input status (i.e., overtemperature or normal). The comparator output is delayed through an RC circuit consisting of R36 and C17. Q4 and Q5 form a high impedance buffer to prevent loading on the delay circuit. The output of the buffer is fed into a Schmitt trigger and then to a bistable latch. Switch SW-2 resets the latch after conditions return to normal. The final alarm output is double pole relay 1CR which is driven by amplifier

Q6. A red light emitting diode is in parallel with 1CR to provide visual overtemperature indication.

Counter Circuit (refer to Drawings 6.3, 6.4)

The counter circuit consists of programmable counter IC6 and pulse generator IC7. The pulse generator feeds one pulse every two seconds (scan rate) into the binary counter. Pulse rate is governed by resistor R-21 and capacitor C12. The counter is programmed by sensing the binary outputs through nand gate IC5. The output of the nand gate resets the counter to 1 when the appropriate count is reached. The counter programming code is shown on the schematic diagram. The counter binary code is also fed into the channel switching boards and the channel readout board.

Readout Circuit (refer to Drawings 6.5, 6.6)

The readout circuit receives a four-bit binary code from the counter which is decoded to binary coded decimal by IC4. The binary decimal bits are fed to BCD to seven segment decoder IC3 which, in turn, drives a seven segment light emitting diode display for the "ones" place in the readout. Transistor Q3 is turned on for channels 10 through 15 to activate the "tens" light emitting diode readout.

Channel Switching Board (refer to Drawings 6.9, 6.10, 6.11)

Two circuit boards are incorporated for switching up to 15 thermocouple channels and the corresponding 15 reference supplies. When only 2 to 8 channels are required the second switching board is removed.

The switching board operates as follows: The binary code from the counter is fed into a decoder (IC 10 or 15) which sequentially switches its 15 outputs. The outputs drive buffer transistors for level changing into the gates of the CMOS IC switches (IC 11-14 and 16-19). Each CMOS IC contains four CMOS switches. Two switches switch thermocouple channels while the other two simultaneously switch the corresponding reference sources. The thermocouple switch outputs are tied together into the amplifier. The reference switch outputs are tied together into the comparator. Potentiometers P3 through P17 adjust the reference voltage for each channel.

Power Supply (refer to Drawings 6.12, 6.13)

The power supply circuit supplies various regulated voltages to different sections of the instrument. Starting at transformer 1T, 115 volts ac is reduced to two center tapped voltages by the secondary windings of 1T. Voltage at terminals 3 and 5 is rectified through bridge rectifier 1 RECT and filtered by capacitor C1 to give plus and minus 20 V dc unregulated. These two voltages feed power transistors Q1 and Q2 and voltage regulator IC 1 to provide plus and minus 15 volts regulated. These regulated voltages are further reduced through zener diodes D3 and D4 to plus and minus 7 volts dc. The plus and minus 7 volts is required for the CMOS switch power sources.

Voltage at terminals 6 and 8 of transformer 1T is rectified through diodes D1 and D2 and filtered by capacitor C3 to obtain approximately +8 volts dc unregulated. This voltage feeds voltage regulator IC 2 and filter capacitor C8 to obtain +5V dc for powering the "TTL" IC's used in various parts of the circuit.

Input Board (refer to Drawings 6.14, 6.15)

The input board is located on the rear of the instrument case and contains the terminal blocks for connecting up to fifteen thermocouples. A five pole terminal block provides the connections for 115V ac input power and the common, normally open, and normally open, and normally closed terminals of the control relay. Diodes D10 through D39 protect the input circuitry from excessive transients. Cold junction compensation is provided by voltage divider R91 and R92. R92 is a temperature sensitive silicon resistor with a positive temperature coefficient of .7% per degree centigrade. The center tap of the divider is fed to the summing point of the amplifier to provide correction for changes in temperature at the thermocouple cold junction.

Mother Board (refer to Drawing 6.2)

The mother board essentially provides a base for the various plug-in boards described above. Various other components are located on the mother board as shown on the drawing. The mother board slides into the rear of the instrument case for ease of servicing.

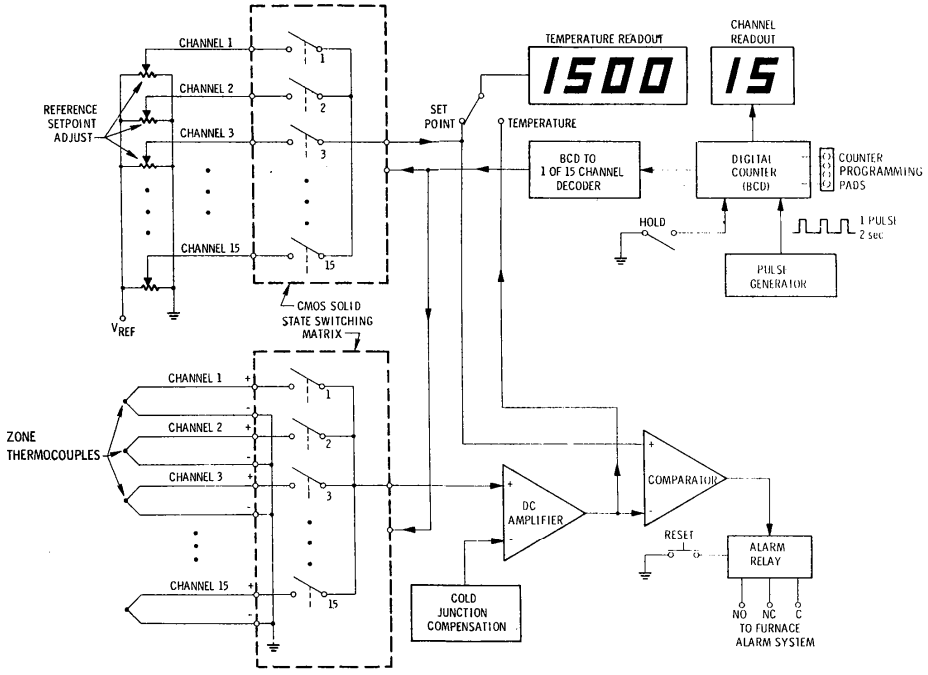

Figure 2.3. Block Diagram

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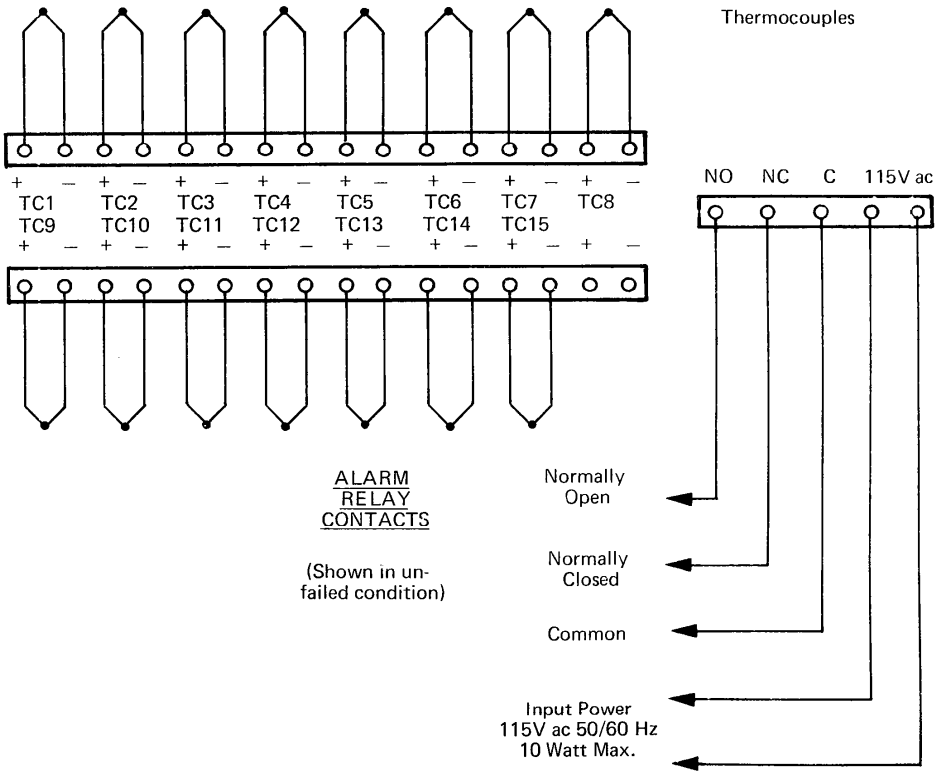
SECTION III

INSTALLATION

3.1 Wiring

Recommended wiring for the Thermo–Guard is shown below. Care should be taken to use the correct extension wire for the thermocouple connections.



3.2 Changing Number of Channels

The number of channels used on the Thermo-Guard can be changed in the field. If the instrument has eight (8) or less channels and it is desired to have more than eight, then another switching circuit board must be added. See Drawings 6.9, 6.10, 6.11. Otherwise, all that is necessary to increase or decrease the number of channels is to reprogram the counter circuit board (Drawing 6.3) and add or remove thermocouples.

Adding a Second Switching Board

(NOTE: When ordering a new switching board, specify Part No. 957190-2 and note that it is for Channels 8 through 15.)

Remove the instrument top cover. Slide the mother board back about one-half inch by removing the retaining screw on the input board and on the bottom of the mother board at the rear of the instrument. Plug the switching board into the second location as shown in Drawing 6.2. Remove the front rubber grommet to expose the reference adjustments for channels 8 through 15. Slide the mother board back in and replace holding screws. Reprogram the counter as described below and replace the top cover. Install thermocouples at rear of instrument to appropriate channels.

Reprogramming Counter Board (see Drawings 6.3, 6.4)

To reprogram the counter board, remove the top cover from the instrument. Next, remove the counter board from its connector by pulling vertically. (See Drawing 6.2 for the counter board location.) Refer to Drawing 6.4 and resolder the 8 pads on the rear of the board as shown on the schedule. Double check that open pads are really open or the counter IC will be destroyed.

SECTION IV

OPERATING INSTRUCTIONS

4.1 Description of Operating Switches and Setpoint Adjustment

The main operational switch for the Thermo-Guard is a 3-position switch located to the right of the reset push-button. The three positions are "Auto", "Hold" and "Setpoint". With the switch in "Auto" position, the instrument will automatically scan each zone at two seconds per channel. If an overtemperature condition occurs in a particular zone, the control relay will activate, the red lamp on the front panel will light and the scanning will stop on the faulty zone. When conditions return to normal, the instrument is reset with the "Reset" push-button.

When in the "Hold" function, the scan is stopped. This is useful for monitoring the temperature in a particular zone for a long period of time.

The "Setpoint" function is used for adjustment of the overtemperature setpoints. When in this mode, the scan is stopped and the temperature readout is switched to the reference temperature. Then the reference is adjusted to the desired setpoint with the corresponding potentiometer to the right of the front panel. For example, if the instrument was on Zone 2, then the Zone 2 potentiometer would be adjusted. By switching back to "Auto" and thus restarting the scan, any setpoint can be adjusted by waiting until the desired zone is displayed and then switching back to "Setpoint" for adjustment.

Thermo-Guards with eight channels or less have a plug in the setpoint adjustment slot for channels 9 through 15. These units can be increased to more than eight channels as described in Section III.

4.2 Startup

With the unit installed as in Section III and the mode switch on "Auto", apply control power. The unit will automatically start scanning from channel 1. If the setpoints have not been previously adjusted, switch to "Setpoint" before the scan leaves channel 1. Adjust all the setpoints as described in Paragraph 4.1 to the desired trip point temperatures. Be sure to allow a margin for overshoot during initial heat-up, if necessary. The instrument may be switched to hold if it is desired to monitor a particular zone during a product run. This is a particularly useful feature since the instrument gives a temperature readout accuracy to about $1^{o}C$.

SECTION V

TROUBLESHOOTING AND CALIBRATION

CAUTION: Troubleshooting and calibration should be performed only be qualified persons having the proper test instruments.

5.1 Calibration

Only two calibrations are necessary on the Thermo-Guard——the amplifier gain and the zero adjustment. Since the two adjustments interact slightly, they are always done together as follows:

1. Connect a millivolt potentiometer to channel 1 on the rear terminal block. Be sure when using the potentiometer that the ambient temperature of the cold junction is subtracted from the millivolt thermocouple chart value. (The thermocouple charts are usually referenced to $0^{o}C$.)

2. Locate the "gain" and "zero" adjustment potentiometers by removing the instrument top cover and by referring to Drawing 6.7.

3. Turn the instrument on and allow it to warm up for approximately 10 minutes. Be sure the mode switch is in the "Hold" position on channel 1.

4. Set the millivolt potentiometer for zero millivolts and adjust the "zero" to read ambient temperature.

5. Set the millivolt potentiometer to a value toward the end of the thermocouple range (say $1000^{o}C$ for Type K) and adjust the "gain" pot until the readout displays "1000".

6. Repeat Steps 4 and 5 until there is no change in readings going between steps.

7. Since all thermocouples are non-linear and the amplifier is linear, there shall be an error at temperatures other than the calibration points. In some cases it may be desirable to calibrate the upper temperature close to the operating temperature of the equipment to obtain good accuracy.

5.2 Troubleshooting

1. The Thermo-Guard is equipped with modular plug-in circuit boards which are broken down into the various functions in the circuit, such as power supply, amplifier, counter, etc. If it is possible to stock spare circuit boards for each of these sections, troubleshooting time and downtime can be greatly reduced by simply

plugging in a new circuit board in the suspect section. The old board can be returned to Watkins–Johnson Company for repair. If this is not possible, refer to Paragraph 2 below.

2. Before proceeding with troubleshooting, visually inspect the interior of the instrument for obvious defects. Make sure all plug-in cards and connectors are secure. If this fails to solve the problem, refer to the following troubleshooting guides.

TROUBLESHOOTING GUIDE

	Symptoms	Possible Cause	Check
1.	Unit does not scan - remains on one channel.	Counter board - oscillator.	Check for pulse at pin 3, IC 7 and/or replace IC 5, 6 and 21.
2.	Temperature readout erratic on all channels.	Digital voltmeter faulty.	See separate voltmeter manual.
		Amplifier faulty.	Replace IC 8 and/or IC 9 on amplifier card. Recalibrate unit.
		Low input voltage.	Check input voltage - minimum allowable is 100V ac.
		±15V power supply out.	Check for ±15V dc ±5%. Check IC 1, Q1, and Q2 on power supply board.
3.	Temperature readout drives hard upscale on only one channel.	Open thermocouple.	Replace thermocouple.
		Open CMOS switch on switching board.	Replace CMOS IC switch (IC 11-19).
		Faulty switching transistor	Replace IC 10, 15 and/or Q7 through 21 (depending on the channel).
4.	Temperature readout blank - rest of unit okay.	Faulty digital voltmeter.	Replace voltmeter or refer to voltmeter manual.
		115V ac connection for voltmeter disconnected.	Check 115V ac voltmeter wiring.
5.	Unit fails to alarm on overtemperature.	Comparator or latch on amplifier board.	Replace comparator (IC 9) and/or latch (IC 20). Also check Q4, 5 and 6 and relay 1CR.
6.	Unit will not reset when in fail status.	Latch circuit.	Replace IC 20 on amplifier board.
7.	Unit does not scan and temperature readout drives hard upscale.	+5V power supply.	Check for 5V dc ±5% on power supply circuit board.
8.	Unit alarms but red indicator fails to light.	Faulty red lamp.	Replace red lamp. (Note: This lamp is a light emitting diode and its polarity must be observed. The dotted lead is the cathode.)

SECTION VI

PARTS LIST AND DRAWINGS

OVERTEMPERATURE CONTROLLER WJ-979

PARTS LIST

Schematic Symbol	Part Number	Description
1 SUPR	082039	Transient Supressor, GE Type V130LA10A
1T	082050	Transformer, 117V ac Primary, 15.5 VCT & 32.0 VCT Secondary Microtran #PCT 6931
1RECT	082038	Bridge Rectif., 1 Amp, 100V, Motorola #MDA-920-3
C1, 2, 3	082009	Capacitor, Electrolytic, 1000MF, 25V, Sprague Type TVA-1211
C4, 5	082005	Capacitor, Disc, .001MF, 1000V, Centralab Type DD-102
C6, 7, 8	082008	Capacitor, Tantalum, 100MF, 35V, Sprague Type 150D-106X9035R2
C9, 26	082006	Capacitor, Electrolytic, 5MF, 15V, Sprague Type TE 1152
C12	082007	Capacitor, Electrolytic, 10 MF, 15V, Sprague Type TE 1155
C10, 11, 18-25	081267	Capacitor, Ceramic Disc, .01MF, 50V, Centralab Type CK-103
C14	081391	Capacitor, Ceramic Disc, .05MF, 100V, SRA TG550
C15, 13	081362	Capacitor, Ceramic Disc, .33MF, 100V, Erie Type 8131-100-651-334M
C16	081621	Capacitor, Ceramic Disc, .1MF, 50V, Erie Type 8131-100-651-104M
C17	081917	Capacitor, Electrolytic, 25 MF, 16V, Sprague Type TE1157.1
R1, 2	081801	Resistor, Carbon Comp. 47 ohm ±5%, 1/2W, Type RC-20
R5, 6, 38	081274	Resistor, Carbon Comp. 1K ohm ±5%, 1/2W, Type RC-20
R7-15	081270	Resistor, Carbon Comp. 1.5K ohm ±5%, 1/2W, Type RC-20

PARTS LIST (Continued)

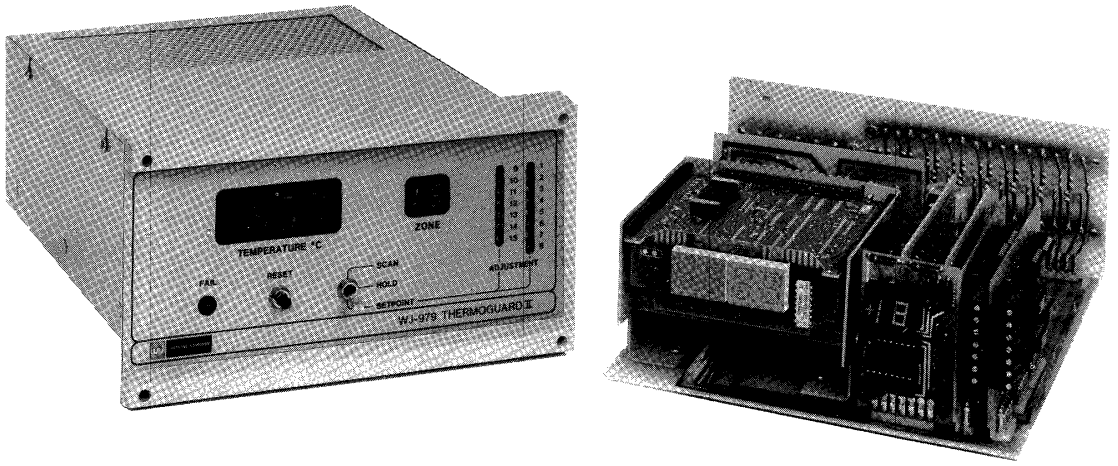
Schematic Symbol	Part Number	Description
R33	081994	Resistor, Carbon Comp. 10MEG ±5%, 1/2W, Type RC-20
R36	081864	Resistor, Carbon Comp. 100K ohm ±5%, 1/2W, Type RC-20
R20, 37, 39, 42	081748	Resistor, Carbon Comp. 2.2K ohm ±5%, 1/2W, Type RC-20
R43, 44	081296	Resistor, Carbon Comp. 10K ohm ±5%, 1/2W, Type RC-20
R21	082003	Resistor, Carbon Comp. 560K ohm ±5%, 1/2W, Type RC-20
R40	081997	Resistor, Carbon Comp. 27K ohm ±5%, 1/2W, Type RC-20
R41	081995	Resistor, Carbon Comp. 22MEG ±5%, 1/2W, Type RC-20
R95	082124	Resistor, Carbon Comp. 560 ohm ±5%, 1/2W, Type RC-20
R18	081296	Resistor, Carbon Comp. 10K ohm ±5%, 1/2W, Type RC-20
R28	081408	Resistor, Metal Film, 1MEG ±5%, 1/2W, Type RN-60
R16	081401	Resistor, Carbon Comp. 1K ohm ±5%, 1/4W, Type RC-07
R45-74	081993	Resistor, Carbon Comp. 4.7K ohm ±5%, 1/4W, Type RC-07
R75-90	081400	Resistor, Carbon Comp. 22K ohm ±5%, 1/4W, Type RC-07
R3, 4	081989	Resistor, Wire Wound, 1 ohm, ±5%, 1W, Dale Type RS-1A
R29, 30, 31	081734	Resistor, Metal Film, 1K ohm ±1%, 1/8W, Type RN-60
R26, 27	082000	Resistor, Metal Film, 100 ohm ±1%, 1/10W, Type RN-55

PARTS LIST (Continued)

Schematic Symbol	Part Number	Description
R25	081998	Resistor, Metal Film, 44.2K ohm ±1%, 1/10W, Type RN-55
R24	081604	Resistor, Metal Film, 18.4K ohm ±1%, 1/10W, Type RN-55
R32, 41	081579	Resistor, Metal Film, 10K ohm ±1%, 1/10W, Type RN-55
R34	081990	Resistor, Metal Film, 1.5K ohm ±1%, 1/10W, Type RN-55
R23	081812	Resistor, Metal Film, 68.1K ohm ±1%, 1/10W, Type RN-55
R93	081607	Resistor, Metal Film, 100K ohm ±1%, 1/10W, Type RN-55
R94	082002	Resistor, Metal Film, 402K ohm ±1%, 1/10W, Type RN-55
R97	081991	Resistor, Metal Film, 1.62K ohm ±1%, 1/10W, Type RN-55
R91, 96	081992	Resistor, Metal Film, 2.0K ohm ±1%, 1/10W, Type RN-55
R92	081988	Resistor, Temp. Sens. 1K ohm ±10% TI, Type TM1/4
D1, 2, 6-39	081419	Diode, 1A, 200V PN, Type IN4003
D3, 4	082037	Diode, Zener, 7.5V, 1W, Type IN4737A
Q1	082004	Transistor, Motorola Type MJE1093, PNP
Q2, 6	081715	Transistor, Motorola Type MJE1103, NPN
Q3, 4, 5	081277	Transistor, Motorola Type 2N4400, NPN
Q7-21	081275	Transistor, Motorola Type 2N4403, PNP
IC1	082020	Integrated Circuit, Volt. Reg., Mot. MC1468-G
IC2	082019	Integrated Circuit, +5 Reg., Mot. MC-7805CP
IC3	082013	Integrated Circuit, Decoder, Mot. MC-7447P

PARTS LIST (Continued)

Schematic Symbol	Part Number	Description
IC4	082014	Integrated Circuit, Decoder, National, Type DM-74185AN
IC5	082016	Integrated Circuit, Gate, Mot. MC-7420P
IC6	082011	Integrated Circuit, Binary Counter T.I. SN-74161
IC7	082018	Integrated Circuit, Timer, Signetics NE555V
IC8	081389	Integrated Circuit, Amplifier, Fairchild 727HC
IC9	082010	Integrated Circuit, Amplifier, Fairchild 747PC
IC10, 15	082012	Integrated Circuit, Decoder, Mot. MC-7445P
IC11-14, 16-19	081947	Integrated Circuit, CMOS Switch, Mot. MC-14016CP
IC20	082015	Integrated Circuit, Gate, Teledyne #333AJ
P1	082032	Potentiometer, 22T, 1K ohm, Bourns #3009P-1-102
P2-17	082031	Potentiometer, 10K ohm, Bourns #3009P-1-103
Readout (ones)	082053	LED Readout, 7 segment, Monsanto #MAN4610
Readout (tens)	082054	LED Readout, 2 segment, Monsanto #MAN4630
1 LED	082052	Light Emitting Diode, Monsanto #MV-5055
1CR	082036	Contact Relay 2 PDT, 12V Coil, Potter Brumfield #R10-E1-W2-185
SW1	082048	Switch, Toggle, SPDT, CK#7211-P3
SW2	081380	Switch, Momentary, SPDT, CK#P-8121
Heatsink	081693	Heatsink for Q1, Q2 & IC2, Thermal. 602 5B
R22		Jumper
IC21	082017	Integrated Circuit, Quad 2 input, Schmitt Gate Type DM74132N
R19	081746	Resistor, Carbon, 22K ohm ±5%, 1/2W, Type RC-20
Digital Voltmeter	082047	Digital Voltmeter, Weston #2461-0278384, 0-1.999 volt input range


TEMPERATURE °C
ZONE
FAIL
RESET
SCAN
HOLD
SETPOINT
ADJUSTMENT
WJ-979 THERMOGUARD II

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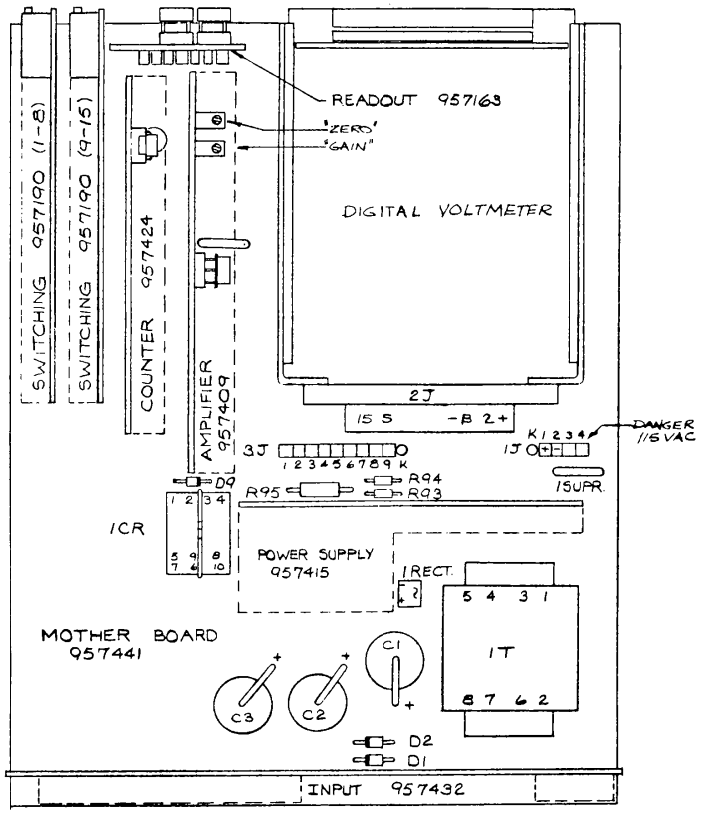
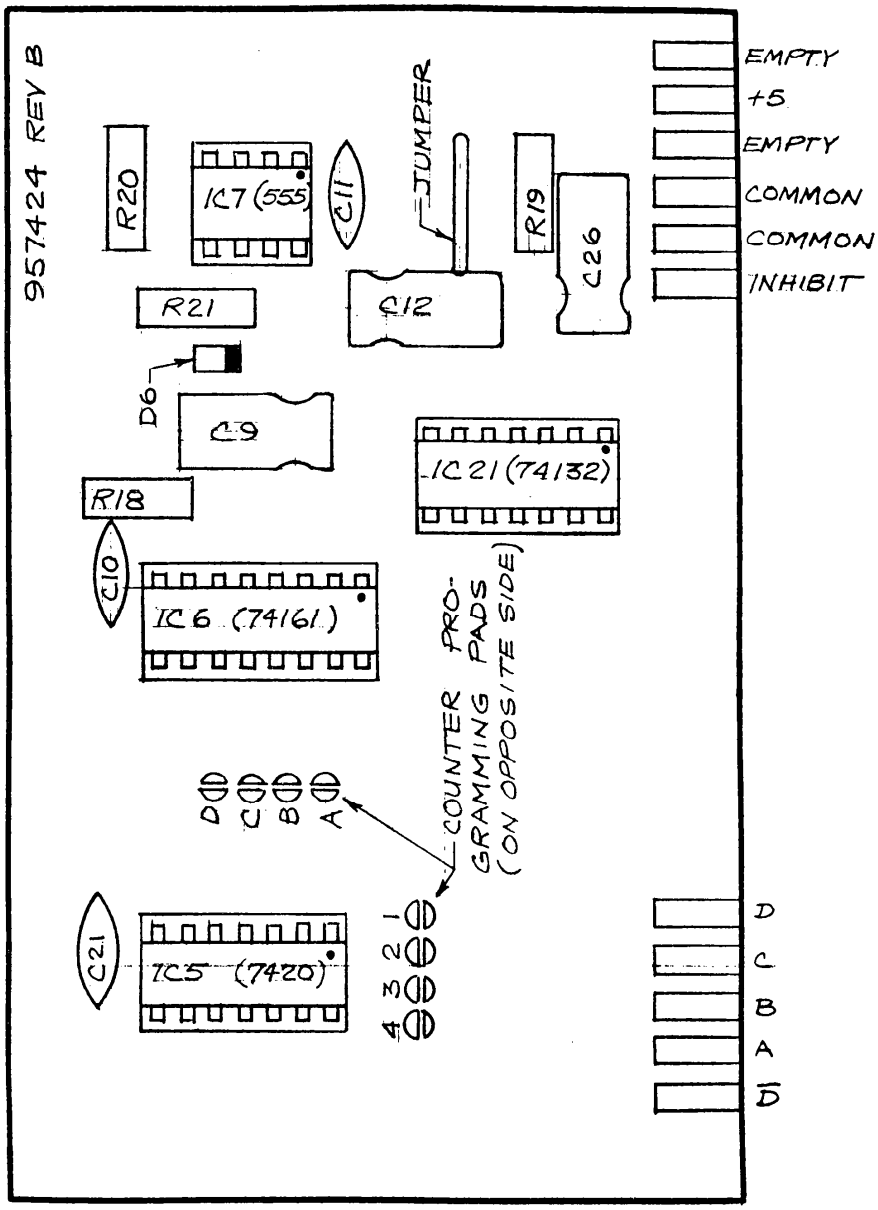


CONNECTOR PIN FUNCTIONS

CONNECTOR	NO.	FUNCTION	WIRE COLOR
1J	K	Connector Key	
	1	DC Power + VDC	RED
	2	DC Power – VDC	BRN
	3&4	AC Power 115 VAC	WHT BLK
2J	15 & S	Voltmeter 115 VAC	WHT BLK
	B	Voltmeter – VDC	BRN
	2	Voltmeter + VDC	RED
3J	1	Common	BRN
	2	Reset	RED
	3	Collector to "Fail" LED Cathode	ORG
	4	"Fail" LED Anode	YEL
	5	Reference Input (Pin 1 of SW-1)	GRN
	6	Common of SW-1 (Pin 2)	BLU
	7	TC Input (Pin 3 of SW-1)	VIO
	8	Common (Pin 5 of SW-1)	GRY
	9	NO of 1CR (Pin 4 of SW-1)	WHT
	K	Connector Key	

Figure 6.2. Mother Board Assembly (957441-2)



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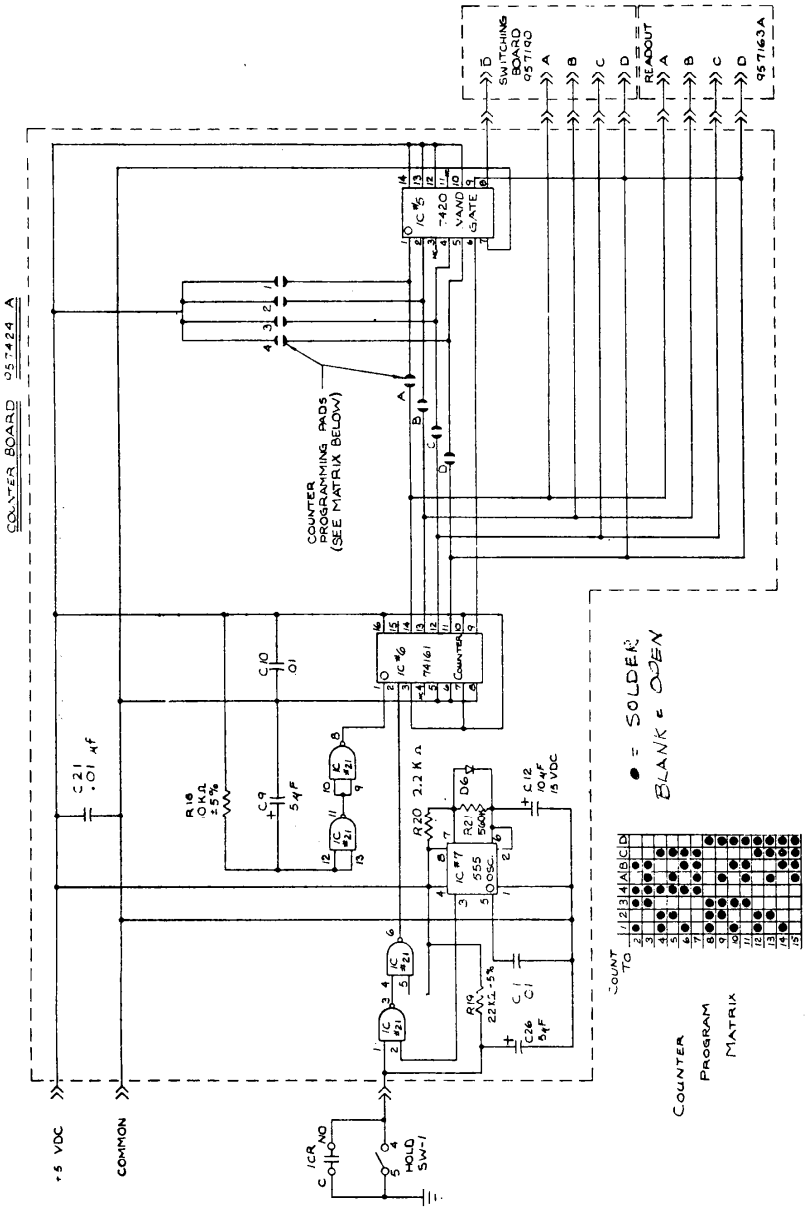

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Figure 6.4. Counter Board Schematic (957424-3)

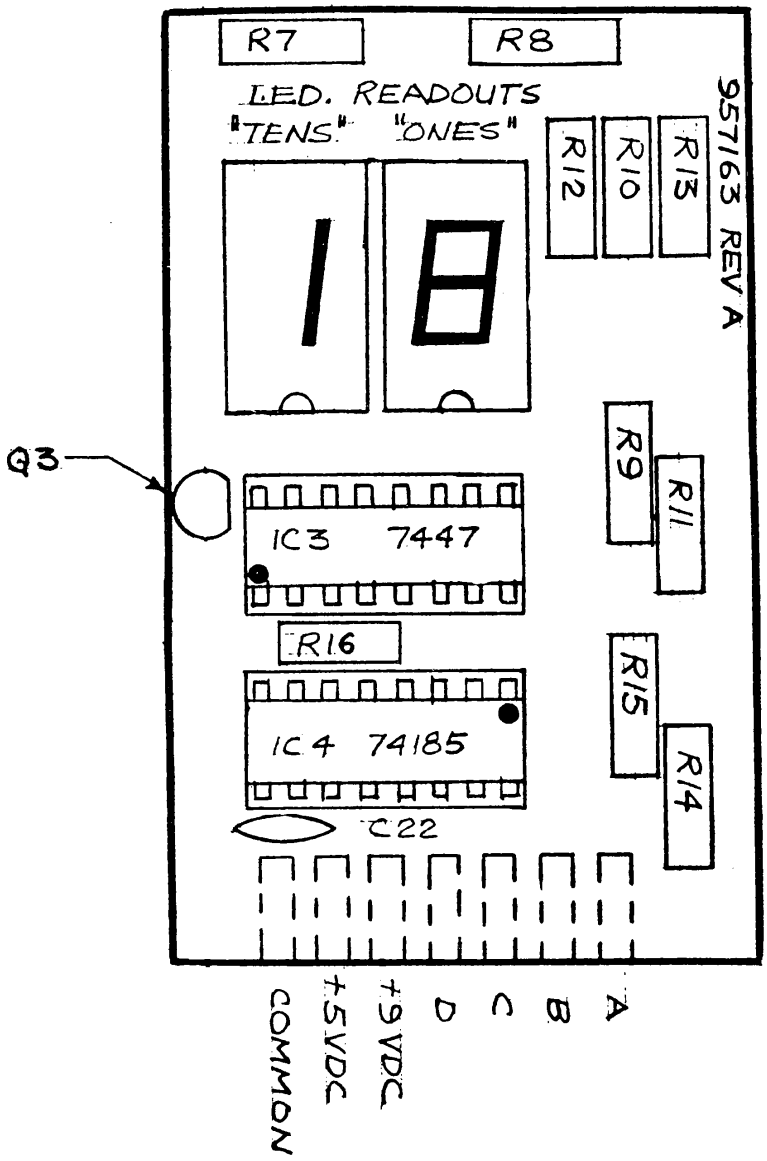

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Figure 6.5. Readout Board Assembly (957163-2)

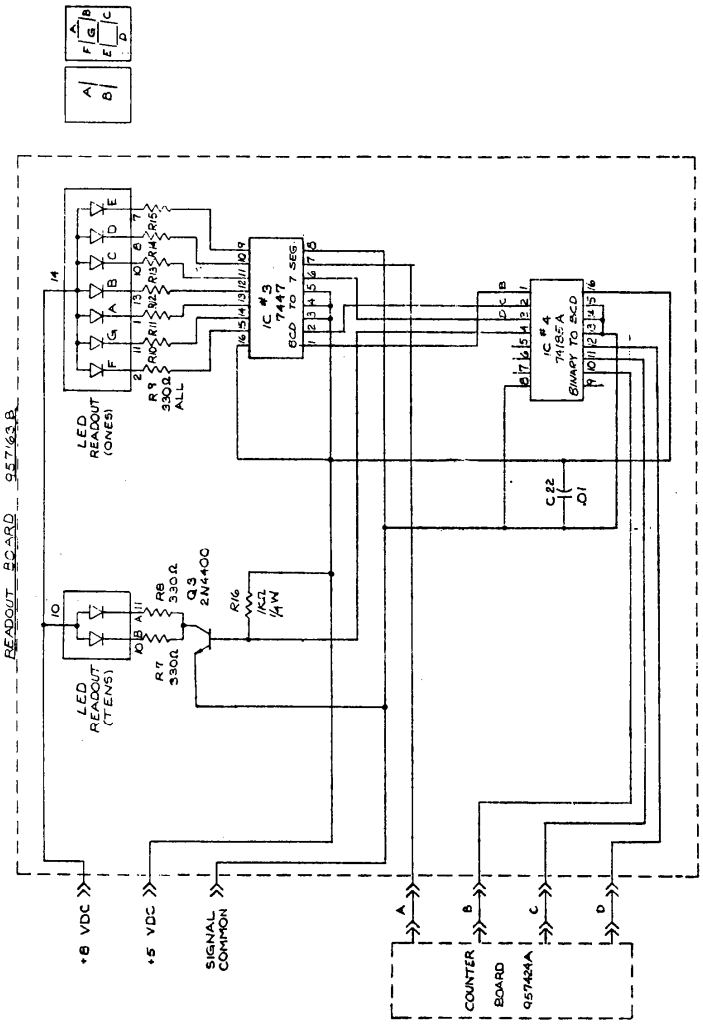

Figure 6.6. Readout Board Schematic (957163-3)

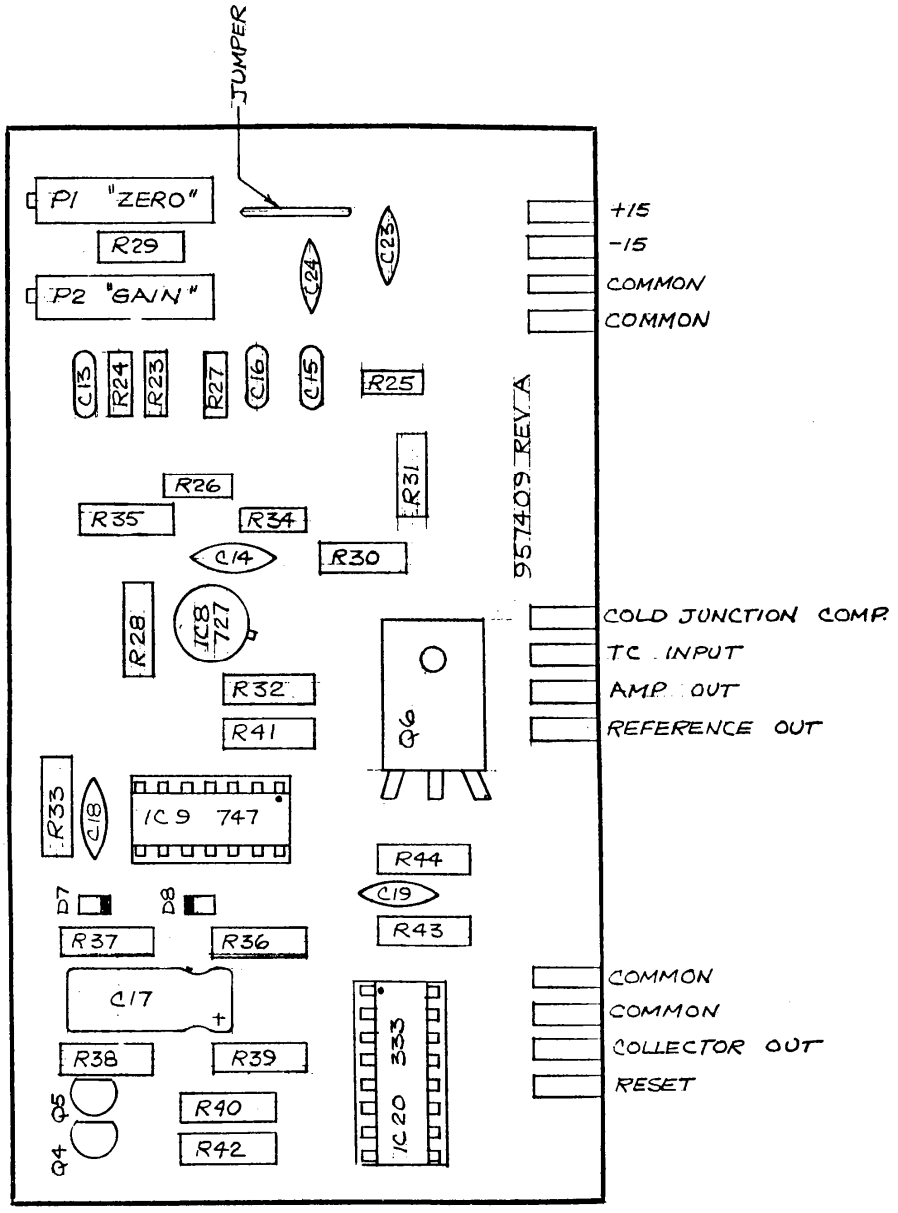

Figure 6.7. Amplifier Board Assembly (957409-2)

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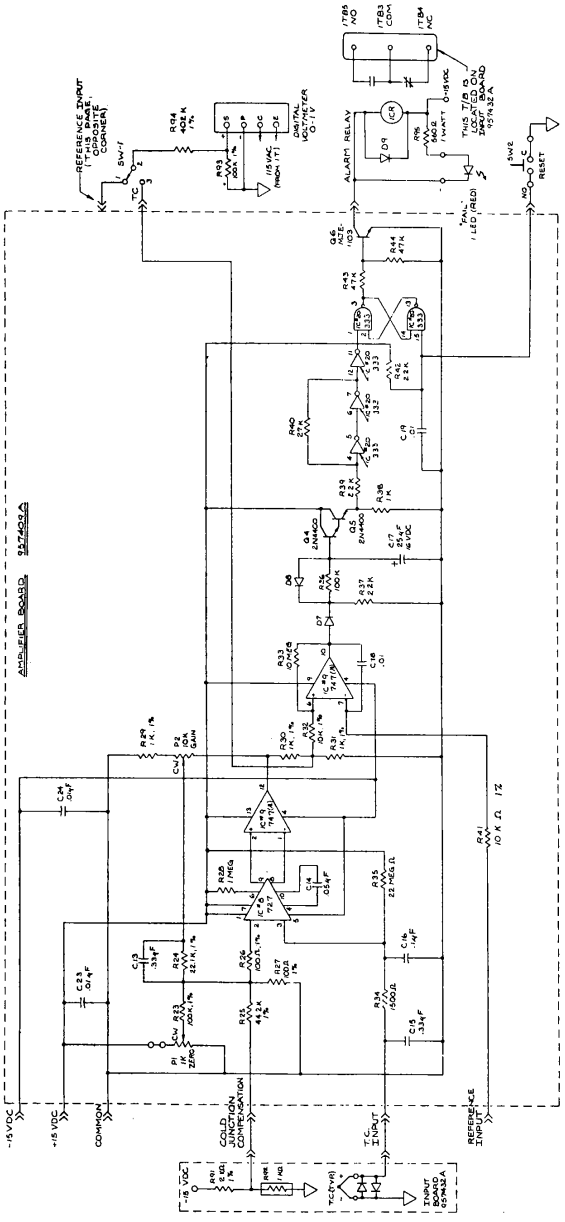

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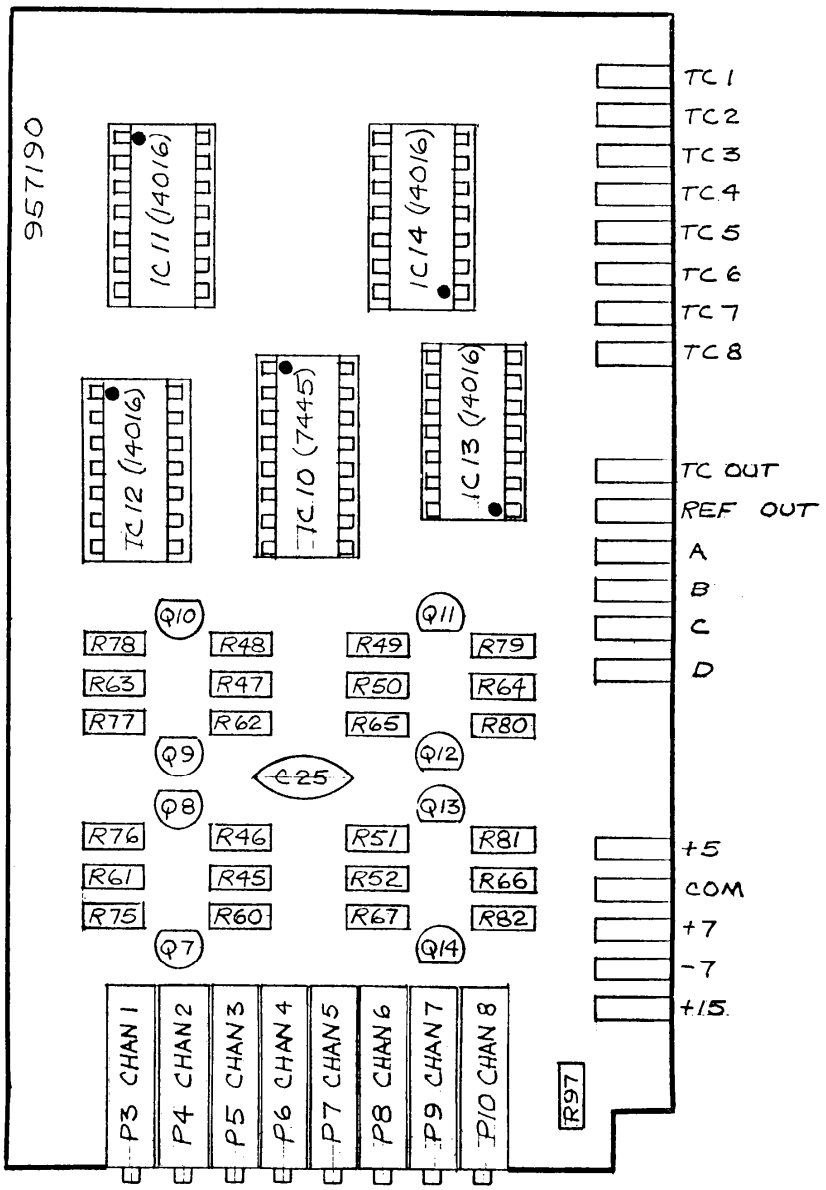
aa37697

Figure 6.8. Amplifier Board Schematic (957409-3)



957190-2
aa37703A

Figure 6.9. Switching Board Assembly (957190-2)

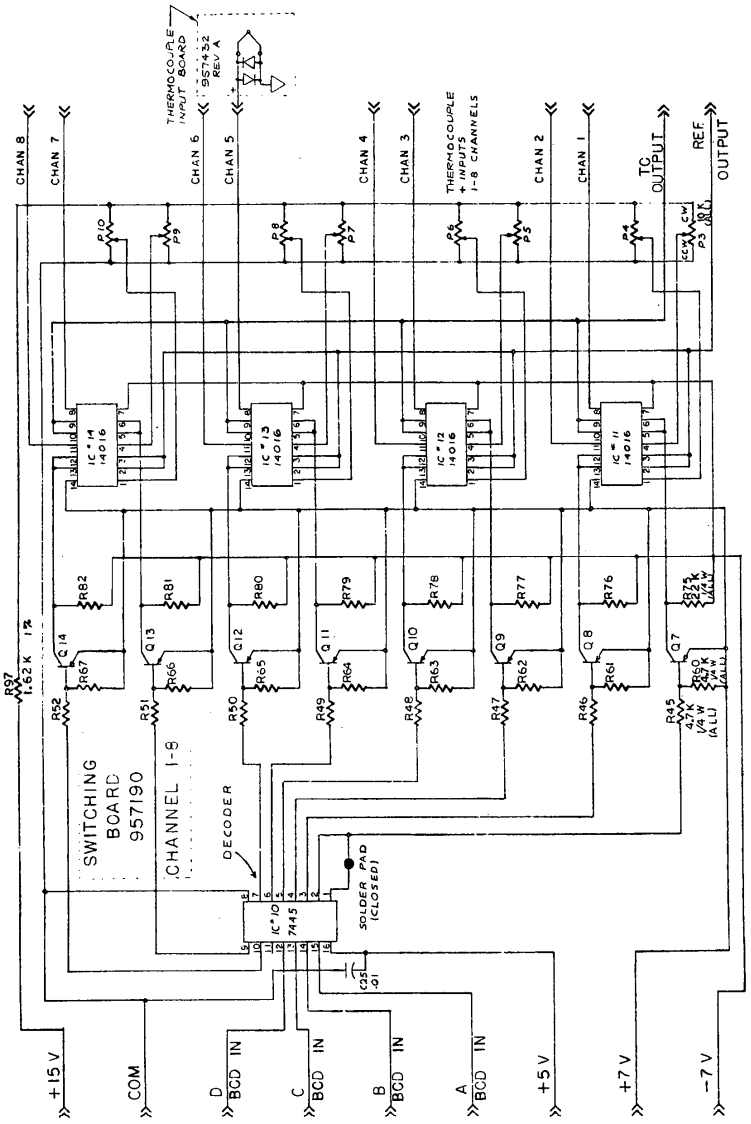


Figure 6.10. Switching Board Schematic, Channel 1-8 (957190-3)

957190-3
aa37690

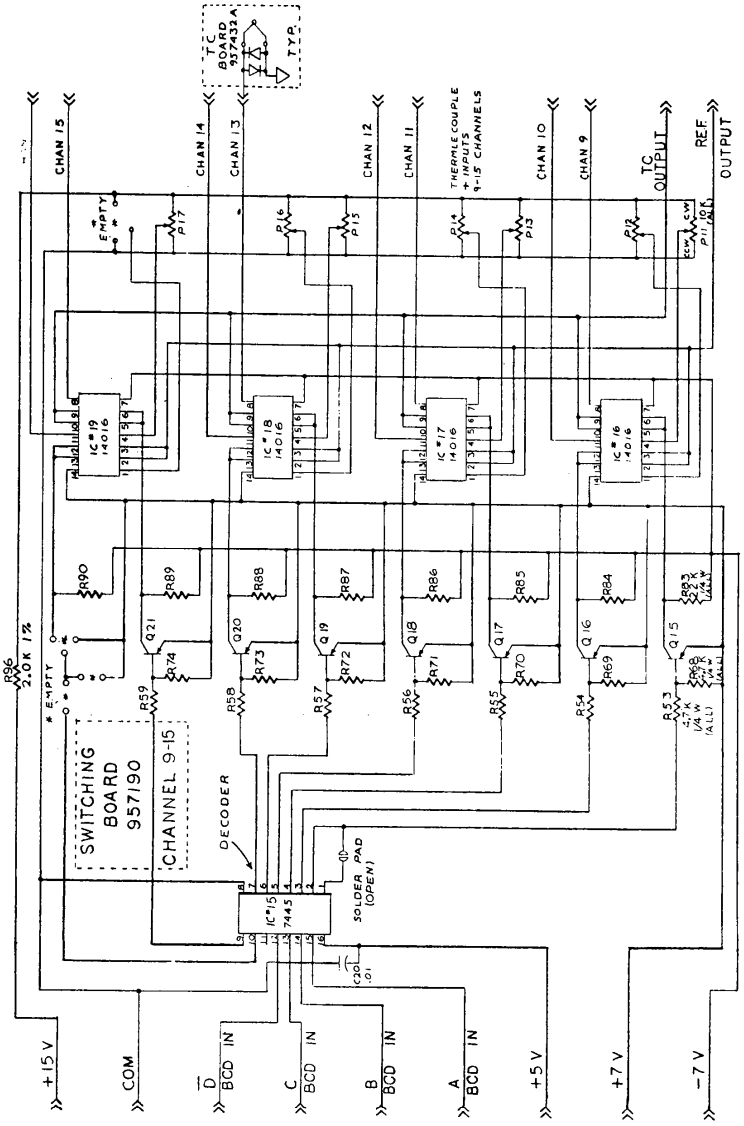


Figure 6.11. Switching Board Schematic, Channel 9-15 (957190-3)

957190-3
aa37691

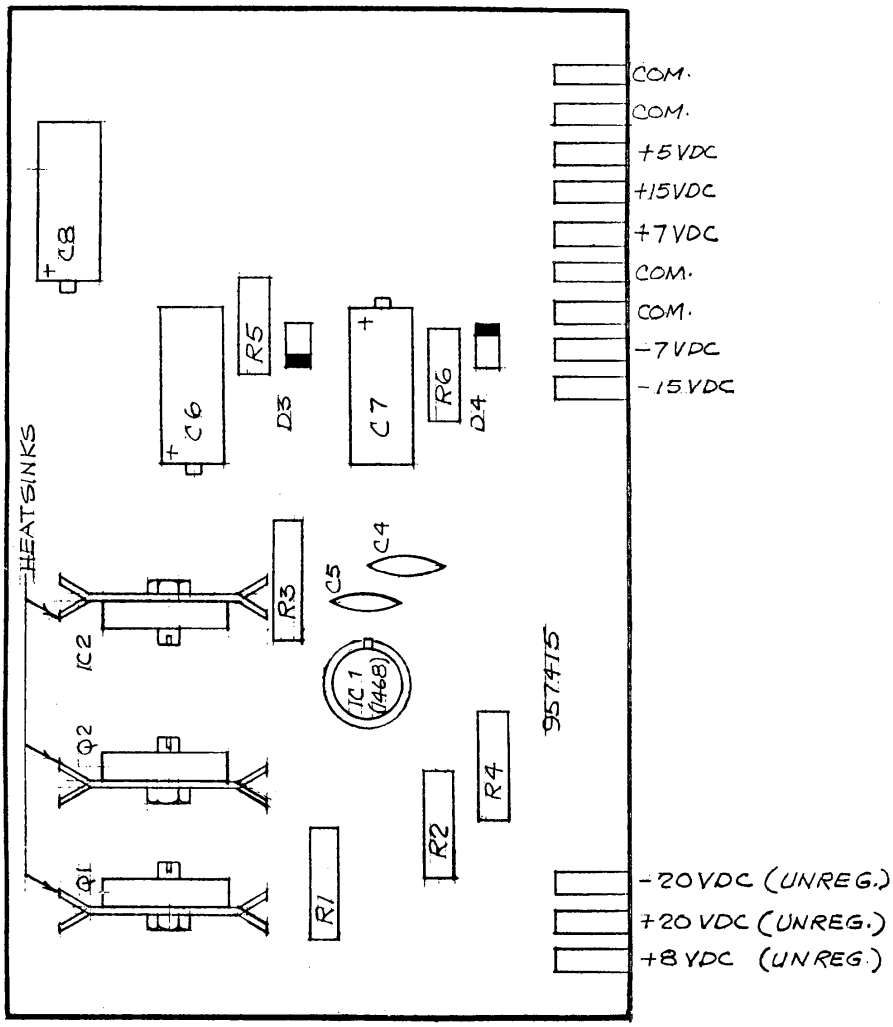


Figure 6.12. Power Supply Board Assembly (957415-2)

957415-2
aa37699

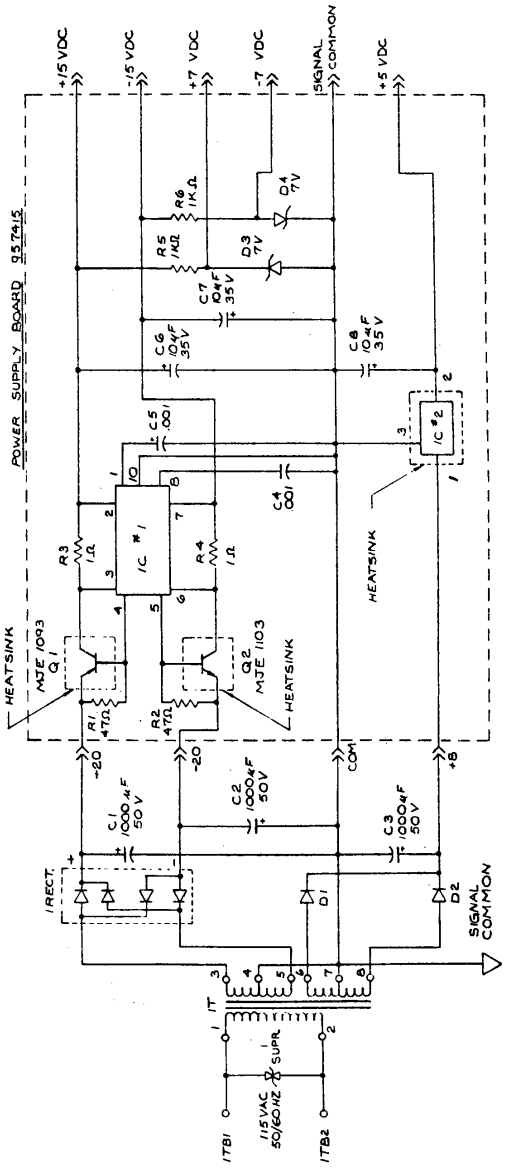


Figure 6.13. Power Supply Board Schematic (957415-3)

957415-3
aa37694

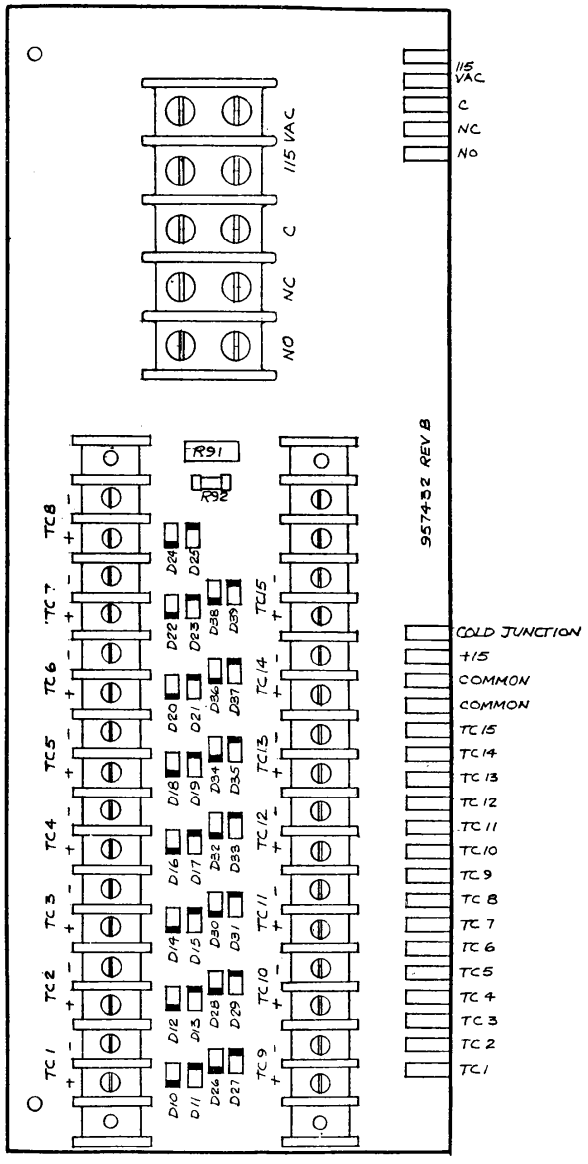


Figure 6.14. Input Board Assembly (957432-2)

957432-2
aa37698

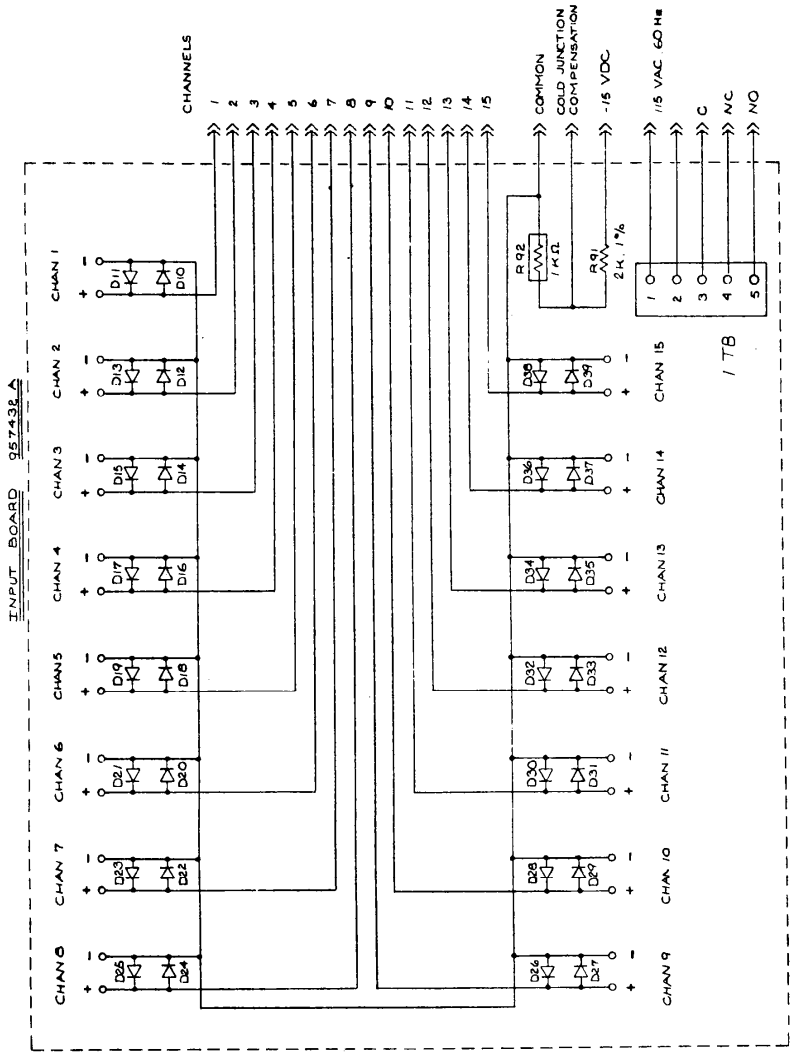


Figure 6.15. Input Board Schematic (957432-3)

957452-3
aa37692