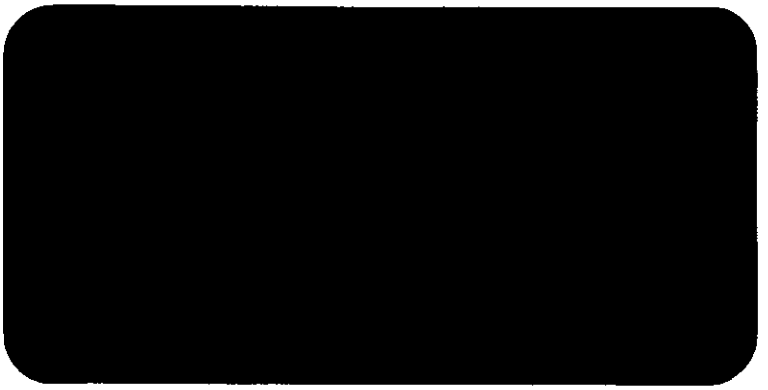

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MOBILE TIE[illegible] GLAZING HIGH DENSITY RADIANT HEATING SYSTEM MODEL 1023/8. PRELIMINARY MANUAL AND INSTRUCTION MANUAL (Research, Inc., Minneapolis, Minn.) 253 p

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RESEARCH INC
BOX 24064 MINNEAPOLIS, MINNESOTA USA 55424

PRELIMINARY

MANUAL

Model 102378

Mobile Tile Glazing High Density
Radiant Heating System
for
ROCKWELL INTERNATIONAL

May, 1979

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Section I

GENERAL INFORMATION

I-1 Introduction

This manual contains the general information, installation, operation, technical description, and maintenance information, including drawings and component manuals, for the Model 102378 Mobile Tile Glazing High Density Radiant Heating System. The following paragraphs describe physical and functional features, and overall specifications for the system.

I-2 Physical Features

The control console is housed in 3, interconnected metal rack cabinets, mounted on a mobile base assembly. Provision is made at the rear of the cabinets for input/output and power connections. Louvered vent panels and a blower assembly are provided to equalize the temperature throughout the cabinets. The system control console cabinets house the following equipment:

A. Cabinet #1

Water Circulation and Cooling System:
- Indicator Panel
- Water Reservoir
- Pump
- Heat Exchangers

B. Cabinet #2

- One, Research, Inc. Relay Panel
- One, Westronics Model M11E W/24 Recorder
- One, Research, Inc. Model FGE 5110 Data Trak Programmer
- Three, Research, Inc. Model 640U Process Controllers
- One, Research, Inc. RCP Panel

C. Cabinet #3

- Three, Research, Inc. Model 64600 Power Controllers
- One, Research, Inc. Meter Panel
- One, Research, Inc. Circuit Breaker Panel

I-3 Functional Features

A. General

The system consists of two basic assemblies: (1) control console, and (2) heater assembly. The following paragraphs contain a functional description of each basic assembly.

B. Control Console as shown on Figures 2 through 10

The control console consists of controls and instrumentation required for monitor and control of system operation. Thermocouples mounted at the load provide feedback signals to the Model 640U Process Controllers. These feedback signals are compared with a variable setpoint reference (provided by the Model 5110 Programmer) to provide control signals to the Model 64600 Power Controllers. The Power Controllers vary the 480 VAC input in proportion to the control signals supplied by the Model 640U Process Controllers.

The Westronics Model M1IE Recorder monitors and records the actual temperature via thermocouples mounted at the load.

Various panels (run control, meter, etc.) are provided on the system cabinets which contain the switches and indicators required to control and monitor system operation.

A self-contained water circulation and cooling system is provided to maintain an acceptable water temperature for continuous operation (up to 1 hour) of the heater assembly.

C. Heater Assembly

1-4. Overall Specifications

A. Control Console

Dimensions:

Height: ____ inches

Width: ____ inches

Depth: ____ inches

Operating Temperature: _____

Humidity: _____

Input Power: 480VAC, 60Hz, 3-Phase

B. HIGH DENSITY HEATER SPECIFICATIONS

1. Model Number----------5378
2. Shown on Figure numbers----------19 through 29
3. Drawing Number----------D54226, 12 sheets
4. Wiring Diagram----------Figure 33(dwg D54227)
5. Frontal Area----------17.60" x 17.60" = 309.76in^2
6. Emitter Opening area----------12" x 12" = 144in^2
7. Reflector----------Specular Aluminum Alloy 1100
8. Weight----------111 pounds
9. Emitter (lamp)----------General Electric Halogene Cycle Lamp # Q6MT3/CL/HT, 10 inch lighted length, rated 6 KW at 480 volts. Dissipates 2 KW at 240 volts
10. Number of Emitters (Lamps)----------18
11. Emitter (Lamp) Spacing----------.667 inches on centers
12. Emitter (Lamp) Circuit----------3 equal zones as shown on Figure 29 and 33 (dwg D54227)
13. Zones----------3 equal zones as shown on Figure 29
14. Input Voltage----------240 volts maximum
15. Power Dissipation Capability----------36 KW Total
    a. Zone 1----------12 KW
    b. Zone 2----------12 KW
    c. Zone 3----------12 KW
16. Radiant Efficiency----------70%
17. Radiant Heat Flux Density at Emitter Opening---190 Watts/in^2
18. Maximum Target Temperature----------2350° F.
19. Minimum Target Absorbency---------- α = .8
20. Cooling Water Required----------1.9 gallons/minute or more

B. HIGH DENSITY HEATER SPECIFICATIONS, continued

21. Water Circuit Diagram----------Figure 34 (dwg C54228)

22. Water Inlet Temperature----------110° F. or less

23. Water Connection----------at quick disconnects on front side of unit as shown on Figures 19, 21, and 22

24. Mounting Provision----------via 4 3/8-16 NC threaded holes on all 4 sides of unit as shown on Figures 22 and 24

25. Power Input Provision----------via 7 pin connector on front surface as shown on Figure 22

Section 2

INSTALLATION

2-1 General

The following paragraphs contain the procedures required for system cabinet and heater assembly placement, input/output connections, system power connection, thermocouple connections, and initial checkout. The system is supplied from the factory with all subassembly connections wired. The customer is required to install and connect all remote input and output cables and system operating power.

2-2 Cabinet Placement

The system is designed for installation in a standard control center environment. Consideration must be made to minimize all input/output signal and power line lengths. The system cabinet requires a minimum of 36 inches clearance on all sides of the cabinet.

2-3 Heater Assembly Placement

2-4 Control Console Connections

A. System Input Power

Connect customer supplied line cord to Research, Inc. connector J3.

B. Thermocouples (Type R, 0/2500°F)

1. Control Thermocouples

Connect the 3 control thermocouples to thermocouple jacks J1, J2, and J3 on the thermocouple jack panel (located on end of system cabinet #1). Reference Fig 8 and Fig 10 (Dwg D53739 sheet 2).

2. Recorder Thermocouples

Connect up to 9 recorder thermocouples to thermocouple jacks J1, J2, J3, J4, J5, J6, J7, J8 and J9 on the thermocouple jack panel labled Recorder.

2-5 Heater Assembly Connections

2-6 Initial Checkout

A. Control Console

After the equipment has been installed and connected, check the input/output connections, and all controls and indicators for proper connection.

B. Heater Assembly

Section 3

OPERATION

3-1 General

The following paragraphs describe the system controls and indicators, and overall system operating procedures. For detailed operation of individual equipment within the system refer to the component manuals contained in Section 8

3-2 System Controls and Indicators

A. General

The following tables list the name, type, and function of the system controls and indicators. Refer to component manuals contained in Section 8 for controls and indicators on individual equipment within the system.

B. Run Control Panel

Table 3-1 lists the name, type, and function of the controls and indicators on the Run Control Panel, which is located in system cabinet #2. Reference system schematic on Figure 16 (dwg D54141) and views on Figure 5 and Figure 17 (dwg B53745).

Table 3-1 Controls and Indicators - Run Control Panel

Name	Type	Function
POWER	White Indicator	Lights when 480 VAC power is applied to system.
RUN	Green Indicator	Lights when SEQUENCE START switch is pressed.
SEQUENCE START	Black Pushbutton Switch	Press to start glazing sequence.
STOP GLAZING	Red Pushbutton Switch	Press to stop glazing operation (removes all power from lamps).
EMERGENCY STOP	Red "Mushroom" Pushbutton Switch	Press to cut off power to heaters.

C. Meter Panel

Table 3-2 lists the name, type, and function of the controls and indicators on the Meter Panel, which is located in system cabinet #3. Reference system schematic on Figure 16 (dwg D54141) and Figures 6 and 15 (dwg C53741).

Table 3-2 Controls and Indicators - Meter Panel		
Name	Type	Function
AC AMPS	Current Meter	Monitors current output of phase (zone) A, B, or C.
AC VOLTS	Volt Meter	Monitors voltage output of phase (zone) A, B, or C.
AMMETER SELECT A/B/C	Rotary Switch 3-	Selects monitoring of phase (zone) A, B, or C.
PROX SENSOR OFF/ON	Selector Switch 2-Position	OFF-Disables heater proximity sensor. ON-Enables heater proximity sensor.
PROX SENSOR	Amber Indicator	Lights when PROX SENSOR OFF/ON switch is in ON position.
VOLTMETER SELECT A/B/C	Rotary Switch 3-	Selects monitoring of phase (zone) A, B, or C.
OVER TEMP	Red Indicator	Lights when thermocouple temperature limit is exceeded.
HEATER WATER FLOW	Red Indicator	Lights when there is no water flow to heaters.
HEATER AIR FLOW	Red Indicator	Lights when there is no air-flow to heaters (blower is off).
(Sonalert)	Audible Alarm	Audible alarm sounds when alarm condition exists.
ALARM ACK	Pushbutton Switch	Press to silence audible alarm.
RESET	Pushbutton Switch	Press to reset alarm circuitry after correcting alarm condition.
CONTROL POWER	Green Indicator	Indicates power applied to 120 VAC control circuits.
HEAT EXCHANGER	Green Indicator	Indicates power applied to heat exchangers in water cooling system.
HYDRAULIC PUMP	Green Indicator	Indicates power applied to hydraulic pump.

Table 3-2 Continued

Name	Type	Function
HEATER BLOWER	Green Indicator	Indicates power applied to heater blower system.
HEATER POWER	Green Indicator	Indicates power applied to quartz lamp heaters.

D. Circuit Breaker Panel

Table 3-3 lists the name, type, and function of the controls on the Circuit Breaker Panel, which is located in system cabinet #3. Reference system schematic on Figure 18 (dwg D54141) and Figure 6.

Table 3-3 Controls - Circuit Breaker Panel

Name	Type	Function
120 VAC CONTROL	Circuit Breaker 15 Amp	Cuts off all power to control circuits.
120 VAC HEAT EXCHANGER	Circuit Breaker 15 Amp	Cuts off all power to water cooling system.
120 VAC HYDRAULIC	Circuit Breaker 20 Amp	Cuts off all power to hydraulic motor receptacle.
HEATER BLOWER	Circuit Breaker 20 Amp	Cuts off all power to heater blower system.
HEATER POWER	Circuit Breaker 60 Amp with 120 VAC Shunt Trip	Cuts off all power to all quartz lamp heaters.

E. Indicator Panel - Water Circulation and Cooling System

Table 3-4 lists the name, type, and function of the indicators on the Indicator Panel for the water circulation and cooling system, which is located in system cabinet #1. Reference schematic on Figure 14 (dwg B54365) and Figure 4.

Table 3-4 Indicators - Indicator Panel, Water Circulation and Cooling System

Name	Type	Function
HEATER OUTLET TEMPERATURE	Temperature gage	Monitors water temperature from the heater unit
HEATER INLET TEMPERATURE	Temperature gage	Monitors water temperature to the heater unit
HEATER COOLING FLOW	Water Flow Indicator	Shows that water is flowing

3-3 Overall System Operating Procedures

The following procedures are used to operate the tile glazing system.

Step 1 - Ensure all installation procedures have been performed as described in Section 2.

Step 2 - Prepare all system equipment for operation as described in each component manual contained in Section 8.

Step 3 Prepare for turn on

Step 3.1 Attach protective cover with control and monitoring thermocouples to the tile area to be repaired.

Step 3.2 Connect type R zone control thermocouples to the control console at thermocouple jacks 1, 2, 3, labeled Control located at the side of cabinet #1.

Step 3.3 Connect type R monitor thermocouples to the control console at thermocouple jacks 1 through 9 labeled Recorder.

Step 3.4 Connect power to the console at the Power Input connector located at the lower side of cabinet #3 (45 KW, 480 volts AC, 3 phase, 60 Hz).

Step 4 Turn on system

Step 4.1 Close high voltage power entrance switch located at the top of cabinet #3 to apply power to the system. The white Power indicator located on cabinet #2 will light.

Step 4.2 Close system controls circuit breaker located on cabinet #3 to energize system control functions. The green control power indicator will light. The audio alarm will sound indicating that alarm conditions exist.

Step 4.3 Silence the audio alarm by pressing the Alarm Acknowledgement button located on cabinet #3.

Step 4.4 Close heat exchanger circuit breaker located on cabinets #3 to energize heat exchanger blowers and water pump. The green heat exchanger indicator will light. The red heater water flow indicator will go out indicating that water is flowing through the heater unit.

Step 4.5 Close hydraulic circuit breaker located on cabinet #3 to energize the hydraulic boom actuation system. The green hydraulic pump indicator will light.

Step 4.6 Close heater blower circuit breaker located on cabinet #3 to energize the air blower in the heater. The green heater blower indicator will light. The red heater air flow indicator will go out indicating that air is flowing through the heater unit.

Step 4.7 Press the alarm system reset button located on cabinet #3.

Step 5 · Verify that all lamps operate by observation at low power.

Step 5.1 Set-up system for "manual mode" by withdrawing the three 640U controllers located in cabinet #2 and setting the internal Auto/Manual switch to Manual, and setting the Manual Set knob to zero.

Step 5.2 Close heater power circuit breaker located on cabinet #3. The green Heater indicator will light, ~~by first setting~~ then push sequence ON button.

Step 5.3 Check lamps in zone 1 by setting voltmeter selection switch to phase A, then energize the lamps to about 45 volts via the Manual Set knob in the Zone 1 640U Controller. The six lamps in zone 1 will light for observation. After observation set the Manual Set knob for zone 1 to zero.

Step 5.4 Check lamps in zone 2 by setting voltmeter selection switch to phase B, then energize the lamps to about 45 volts via the Manual Set knob in the zone 2 640 U Controller. The six lamps in zone 2 will light for observation. After observation set the Manual Set knob for zone 2 to zero.

Step 5.5 Check lamps in zone 3 by setting voltmeter selection switch to phase C, then energize the lamps to about 45 volts via the Manual Set knob in the zone 3 640 U Controller. The six lamps in zone 3 will light for observation. After observation, set the Manual Set knob for zone 3 to zero.

Step 5.6 Set the Auto/Manual switches in the three 640 U Controllers to Auto and close controllers.

Step 5.7 Open heater power circuit breaker to de-energize heater lamp power circuit.

Step 6 Verify that the Data-Trak time vs. temperature programmer functions.

Step 6.1 Set Data-Trak Mode selector switch to off.

Step 6.2 Set Data-Trak Time Base to maximum drum speed.

Step 6.3 Set Data-Trak Mode selector switch to Run. The drum will rotate and the probe will follow the time vs. temperature curve.

Step 6.4 When Data-Trak probe reaches the end of cycle position, the drum will stop becaus of the end of cycle trip tab switch.

Step 6.5 Set the Data-Trak Mode Selector switch to Remote.

Step 6.6 Rotate the Data-Trak drum past the end of cycle trip tab switch to the starting position in the program.

Step 6.7 Set the Time Base selector switch to correct glazing cycle period.

Step 7 Verify that the 0 to 2500°F point printout temperature recorder located in cabinet #2 functions.

Step 7.1 Set recorder chart speed knob to desired chart speed.

Step 7.2 Set recorder thermocouple printout switches to print desired thermocouple temperatures.

Step 7.3 Set recorder High Limit alarm switch to desired temperature limit (i.e., 2350°F).

Step 7.4 Set recorder Power switch to On.

Step 7.5 Set recorder Chart switch to On and observe that desired thermocouple temperatures are clearly printed.

Step 7.6 Set recorder Chart switch to Off.

Step 7.7 Check recorder chart paper supply. There must be enough paper to record the following glazing cycle sequence.

Step 8 Position Heater unit

Step 8.1 Set the Prox-Sensor switch located on cabinet #3 to On. The yellow Prox-Sensor indicator will light.

Step 8.2 Extend the four spring loaded proximity probes on the heater unit 2 inches beyond its front face.

Step 8.3 Set the Proximity switch on the heater unit to Alarm.

Step 8.4 Position heater unit over the protective cover at the repair area via the hydraulic boom actuation system. When the heater is within 2 inches of the repair area surface, 1 or more of the 4 proximity probes at the corners of the heater unit will touch the work surface producing an audio signal at the heater unit.

Step 8.5 If desired, set the Proximity switch on the heater unit to Silence.

Step 9 Perform glazing cycle

Step 9.1 Set Deviation Trip switch located on cabinet #2 to Defeat to prevent a temperature deviation trip.

Step 9.2 Close Heater Power circuit breaker located on cabinet #3 to energize lamp load circuit. The green Heater Power indicator will light.

Step 9.3 Set recorder chart switch to On. Printing will start.

Step 9.4 Press Sequence Start button on cabinet #2 to start the automatic glazing cycle as programmed on the Data-Trak. The green Run indicator will light and the Data-Trak will start to program.

Step 9.5 Observe the automatic glazing cycle. When the Data-Trak probe reaches a temperature above that of the control thermocouples, the lamps in the heater unit will light as indicated by a null reading in the 640 U Controller deviation meters, by a voltage reading on the voltmeter, and by a current reading on the ammeter. The temperature recorder will display a temperature profile similar to that on the Data-Trak program. During the heating period, the lamp voltage and current will steadily increase assuming that the heating program is linear. When the holding period is reached, the power as determined by the voltmeter and ammeter will drop to a lower level to maintain steady state. When the cooling period is reached, the power required will continually drop to zero power where the tile heat losses are less than that of the Data-Trak program. However, the program will continue until the Data-Trak probe reaches the end of cycle position as programmed by the Data-Trak end of cycle trip tab switch. The green Run indicator on cabinet #2 will go out.

Step 10 Shut system off

Step 10.1 Open Heater Power circuit breaker. The green Heater Power indicator will go out.

Step 10.2 Set recorder Chart switch to off to discontinue spending chart paper.

Step 10.3 Remove heater unit from the repair region via the hydraulic boom actuation system.

Step 10.4 Allow heater unit to cool for at least 4 minutes before proceeding.

Step 10.5 Open control circuit breaker. The green Control Power indicator will go out.

Step 10.6 Open Heater Blower circuit breaker to discontinue heater unit air cooling. The green Heater Blower indicator will go out.

Step 10.7 Open Heat Exchanger circuit breaker to discontinue heater unit water cooling. The green Heat Exchanger indicator will go out.

Step 10.8 Open Hydraulic circuit breaker. The green Hydraulic Pump indicator will go out.

Step 10.9 Open High Voltage power entrance switch located at the top of the right cabinet to remove power to all portions of the system.

3-4 SYSTEM LIMITATIONS

The system has its limitations; therefore, the operator must exercise CAUTION to insure that the system is not operated beyond its limits. The following sections give some of the system limitations.

A. DO NOT operate radiant array with contaminated reflectors, quartz window, and lamps. If contaminated, (a) the radiant array efficiency will be reduced, (b) the reflector and lamps will overheat and fail. If these components are contaminated, they must be cleaned according to the procedures described in section 5.

B. DO NOT operate system without adequate cooling water flow. The system will self-destruct with insufficient cooling water.

C. DO NOT operate radiant array in a contaminating environment that may result from volatiles outgassing from the test article. These volatiles may condense on the quartz window and degrade its transmittance.

D. DO NOT operate heater with missing lamps. A missing lamp will disturb the cooling air flow circuit such that empty lamp sockets will rob existing lamps of cooling air.

E. DO NOT operate heater with a contaminated reflector or quartz window. If contaminated, the system efficiency will be reduced, causing more energy than necessary to be spent.

F. DO NOT operate heater where target surface absorbency is less than $\alpha = .8$ and where target surface temperature exceeds 2350° F.

G. DO NOT operate system with dirt, chips, trash, etc., inside the control console cabinets. Such foreign materials may cause a short circuit.

H. DO NOT operate the system when personnel are exposed to the radiant energy produced by the heater.

I. DO NOT operate the system with a known fault. Before operating, the cause of the fault must be determined and corrected.

Section 4

TECHNICAL DESCRIPTION

4-1 General

The following paragraphs contain the functional organization of the overall system and a description of each of its major assemblies. For detailed description of the internal operation of each assembly refer to the component manuals contained in Section 8.

4-2 Functional Organization

The system consists of the following major assemblies:

A. Control Console (Reference schematic on Figure 18 (dwg D54141))

1. System Controls and Indicators
2. Model 5110 Data Trak Programmer
3. Model M11E Recorder
4. Model 640U Process Controllers
5. Model 64600 Power Controllers
6. Water Circulation and Cooling System

B. Heater Assembly (Reference schematic on Figure 33 (dwg D54227))

1. The Radiant Chamber
2. The Air Cooling System
3. The Water Cooling Provision
4. The Proximity Sensor System
5. The Edge Reflector
6. The Interconnecting Cables

The following paragraphs describe the function of each major subsystem.

4-3 Control Console (Reference schematic on Figure 18 (dwg D54141))

A. System Controls and Indicators

Refer to Section 3 for detailed description of the system controls and indicators.

B. Model 5110 Data Trak Programmer

The Model 5110 Data Trak Programmer is a drum type, 3 potentiometer programmer, using an electro-static curve-following system and a 4-decade electronic time base. The Model 5110 setpoint output is applied to the Model 640U Process Controllers to provide a remote setpoint level. The Model 640U Process Controllers provide outputs proportional to the Model 5110 Data Trak setpoint and the thermocouple feedback signals. Automatic shut-off provisions are provided upon completion of a heating cycle. Refer to component manual for Model 5110 Data Trak Programmer contained in Section 8.

C. Model M11E Recorder

The Model M11E Recorder is provided to monitor and record actual temperature via system thermocouples. Inputs are ranged for 0 to 2500°F, type R thermocouples.

D. Model 640U Process Controllers

The Model 640U Process Controllers operate in either the local or remote mode. In the local mode, the local setpoint dials on front of the units are adjusted to provide the required output levels. In the remote mode, the setpoint levels are provided by the Model 5110 Data Trak Programmer. Thermocouples mounted at the customer's load provide feedback to the Model 640U Process Controllers to proportion the output levels according to the load requirements. This ensures the temperature at the load is maintained at the required level. Refer to component manual for Model 640U Process Controller contained in Section 3.

E. Model 64600 Power Controllers

The Model 64600 Power Controllers are solid state SCR power control units. The Power Controllers receive control signals from the Model 640U Process Controllers, which are applied to firing circuits in the Power Controllers. The firing circuits develop gating pulses which are applied to the power SCRs to control voltage flow in the output lines. Refer to component manual for Model 64600 Power Controller contained in Section 3.

F. Water Circulation and Cooling System

A self-contained water circulation and cooling system is provided in system cabinet #1 to maintain a water temperature acceptable for quartz heater continuous operation (up to 1 hour). The system includes an indicator panel, water reservoir, pump, heat exchangers, regulator valves, and flow switch. A sight flow indicator is provided to visually inspect water flow. Reference schematic on Figure 14 (dwg B54365) and Figure 34 (dwg C54228).

4-4 Heater Assembly (Reference schematic on Figure 33 (dwg D54227))

Table 4-1

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640
R T/C 0. TO 2500.0 DEG F
SETPOINT DIAL SETTING VS TEMPERATURE

DEG F...	0 ...	1 ...	2 ...	3 ...	4 ...	5 ...	6 ...	7 ...	8 ...	9
0:	0.0	0.2	0.3	0.5	0.7	0.8	1.0	1.2	1.3	1.5
10:	1.7	1.8	2.0	2.2	2.3	2.5	2.7	2.9	3.0	3.2
20:	3.4	3.5	3.7	3.9	4.0	4.2	4.4	4.5	4.7	4.9
30:	5.0	5.2	5.4	5.3	5.5	5.7	5.8	6.0	6.2	6.4
40:	6.6	6.8	7.0	7.2	7.4	7.5	7.7	7.9	8.1	8.3
50:	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3
60:	10.5	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.2
70:	12.4	12.6	12.8	13.0	13.3	13.5	13.7	13.9	14.1	14.3
80:	14.5	14.7	14.9	15.1	15.3	15.5	15.7	15.9	16.1	16.3
90:	16.5	16.8	17.0	17.2	17.4	17.6	17.8	18.0	18.2	18.4
100:	18.7	18.9	19.1	19.3	19.5	19.7	19.9	20.2	20.4	20.6
110:	20.8	21.0	21.2	21.5	21.7	21.9	22.1	22.3	22.6	22.8
120:	23.0	23.2	23.4	23.7	23.9	24.1	24.3	24.5	24.8	25.0
130:	25.2	25.4	25.7	25.9	26.1	26.3	26.6	26.8	27.0	27.3
140:	27.5	27.7	27.9	28.2	28.4	28.6	28.9	29.1	29.3	29.6
150:	29.8	30.0	30.2	30.5	30.7	30.9	31.2	31.4	31.6	31.9
160:	32.1	32.4	32.6	32.8	33.1	33.3	33.5	33.8	34.0	34.3
170:	34.5	34.7	35.0	35.2	35.4	35.7	35.9	36.2	36.4	36.7
180:	36.9	37.1	37.4	37.6	37.9	38.1	38.4	38.6	38.8	39.1
190:	39.3	39.6	39.8	40.1	40.3	40.6	40.8	41.1	41.3	41.6
200:	41.8	42.1	42.3	42.6	42.8	43.1	43.3	43.6	43.8	44.1
210:	44.3	44.6	44.8	45.1	45.3	45.6	45.8	46.1	46.3	46.6
220:	46.9	47.1	47.4	47.6	47.9	48.1	48.4	48.7	48.9	49.2
230:	49.4	49.7	50.0	50.2	50.5	50.7	51.0	51.3	51.5	51.8
240:	52.0	52.3	52.6	52.8	53.1	53.4	53.6	53.9	54.1	54.4
250:	54.7	54.9	55.2	55.5	55.7	56.0	56.3	56.5	56.8	57.1
260:	57.3	57.6	57.9	58.1	58.4	58.7	59.0	59.2	59.5	59.8
270:	60.0	60.3	60.6	60.9	61.1	61.4	61.7	61.9	62.2	62.5
280:	62.8	63.0	63.3	63.6	63.9	64.1	64.4	54.7	65.0	65.2
290:	65.5	65.8	66.1	66.4	66.6	66.9	67.2	67.5	67.7	68.0
300:	68.3	68.6	68.9	69.1	69.4	69.7	70.0	70.3	70.6	70.8
310:	71.1	71.4	71.7	72.0	72.2	72.5	72.8	73.1	73.4	73.7
320:	74.0	74.2	74.5	74.8	75.1	75.4	75.7	76.0	76.2	76.5
330:	76.8	77.1	77.4	77.7	78.0	78.3	78.6	78.8	79.1	79.4
340:	79.7	80.0	80.3	80.6	80.9	81.2	81.5	81.8	82.1	82.3
350:	82.6	82.9	83.2	83.5	83.8	84.1	84.4	84.7	85.0	85.3
360:	85.6	85.9	86.2	86.5	86.8	87.1	87.4	87.7	88.0	88.3
370:	88.6	88.9	89.2	89.5	89.8	90.1	90.3	90.6	91.0	91.3
380:	91.6	91.9	92.2	92.5	92.8	93.1	93.4	93.7	94.0	94.3
390:	94.6	94.9	95.2	95.5	95.8	96.1	96.4	96.7	97.0	97.3

Table 4-1 cont

RESEARCH INCORPORATED

640

R T/C 0. TO 2500.0 DEG F

SETPOINT DIAL SETTING VS TEMPERATURE

DEG F...	0	1	2	3	4	5	6	7	8	9
800:	235.1	235.5	235.9	236.2	236.6	237.0	237.4	237.7	238.1	238.5
810:	238.9	239.2	239.6	240.0	240.4	240.7	241.1	241.5	241.9	242.2
820:	242.6	243.0	243.4	243.7	244.1	244.5	244.9	245.2	245.6	246.0
830:	246.4	246.8	247.1	247.5	247.9	248.3	248.6	249.0	249.4	249.8
840:	250.2	250.5	250.9	251.3	251.7	252.1	252.4	252.8	253.2	253.6
850:	254.0	254.3	254.7	255.1	255.5	255.9	256.2	256.6	257.0	257.4
860:	257.8	258.1	258.5	258.9	259.3	259.7	260.0	260.4	260.8	261.2
870:	261.6	262.0	262.3	262.7	263.1	263.5	263.9	264.3	264.6	265.0
880:	265.4	265.8	266.2	266.6	266.9	267.3	267.7	268.1	268.5	268.9
890:	269.2	269.6	270.0	270.4	270.8	271.2	271.6	271.9	272.3	272.7
900:	273.1	273.5	273.9	274.3	274.6	275.0	275.4	275.8	276.2	276.6
910:	277.0	277.3	277.7	278.1	278.5	278.9	279.3	279.7	280.1	280.4
920:	280.8	281.2	281.6	282.0	282.4	282.8	283.2	283.5	283.9	284.3
930:	284.7	285.1	285.5	285.9	286.3	286.7	287.0	287.4	287.8	288.2
940:	288.6	289.0	289.4	289.8	290.2	290.6	290.9	291.3	291.7	292.1
950:	292.5	292.9	293.3	293.7	294.1	294.5	294.9	295.3	295.6	296.0
960:	296.4	296.8	297.2	297.6	298.0	298.4	298.8	299.2	299.6	300.0
970:	300.4	300.7	301.1	301.5	301.9	302.3	302.7	303.1	303.5	303.9
980:	304.3	304.7	305.1	305.5	305.9	306.3	306.7	307.1	307.5	307.8
990:	308.2	308.6	309.0	309.4	309.8	310.2	310.6	311.0	311.4	311.8
1000:	312.2	312.6	313.0	313.4	313.8	314.2	314.6	315.0	315.4	315.8
1010:	316.2	316.6	317.0	317.4	317.8	318.2	318.6	319.0	319.4	319.8
1020:	320.2	320.6	321.0	321.3	321.7	322.1	322.5	322.9	323.3	323.7
1030:	324.1	324.5	324.9	325.3	325.7	326.1	326.5	326.9	327.3	327.7
1040:	328.1	328.5	328.9	329.3	329.8	330.2	330.6	331.0	331.4	331.8
1050:	332.2	332.6	333.0	333.4	333.8	334.2	334.6	335.0	335.4	335.8
1060:	336.2	336.6	337.0	337.4	337.8	338.2	338.6	339.0	339.4	339.8
1070:	340.2	340.6	341.0	341.4	341.8	342.2	342.6	343.0	343.5	343.9
1080:	344.3	344.7	345.1	345.5	345.9	346.3	346.7	347.1	347.5	347.9
1090:	348.3	348.7	349.1	349.5	349.9	350.4	350.8	351.2	351.6	352.0
1100:	352.4	352.8	353.2	353.6	354.0	354.4	354.8	355.2	355.7	356.1
1110:	356.5	356.9	357.3	357.7	358.1	358.5	358.9	359.3	359.7	360.1
1120:	360.6	361.0	361.4	361.8	362.2	362.6	363.0	363.4	363.8	364.3
1130:	364.7	365.1	365.5	365.9	366.3	366.7	367.1	367.5	368.0	368.4
1140:	368.8	369.2	369.6	370.0	370.4	370.8	371.2	371.7	372.1	372.5
1150:	372.9	373.3	373.7	374.1	374.6	375.0	375.4	375.8	376.2	376.6
1160:	377.0	377.4	377.9	378.3	378.7	379.1	379.5	379.9	380.4	380.8
1170:	381.2	381.6	382.0	382.4	382.8	383.3	383.7	384.1	384.5	384.9
1180:	385.3	385.8	386.2	386.6	387.0	387.4	387.8	388.3	388.7	389.1
1190:	389.5	389.9	390.4	390.8	391.2	391.6	392.0	392.4	392.9	393.3

Table 4-1 cont

RESEARCH INCORPORATED
640
R T/C 0. TO 2500.0 DEG F
SETPOINT DIAL SETTING VS TEMPERATURE

DEG F...	0	1	2	3	4	5	6	7	8	9
1200:	393.7	394.1	394.5	395.0	395.4	395.8	396.2	396.6	397.1	397.5
1210:	397.9	398.3	398.7	399.2	399.6	400.0	400.4	400.8	401.3	401.7
1220:	402.1	402.5	402.9	403.4	403.8	404.2	404.6	405.1	405.5	405.9
1230:	406.3	406.8	407.2	407.6	408.0	408.4	408.9	409.3	409.7	410.1
1240:	410.6	411.0	411.4	411.8	412.3	412.7	413.1	413.5	414.0	414.4
1250:	414.8	415.2	415.7	416.1	416.5	416.9	417.4	417.8	418.2	418.6
1260:	419.1	419.5	419.9	420.4	420.8	421.2	421.6	422.1	422.5	422.9
1270:	423.3	423.8	424.2	424.6	425.1	425.5	425.9	426.3	426.8	427.2
1280:	427.6	428.1	428.5	428.9	429.4	429.8	430.2	430.6	431.1	431.5
1290:	431.9	432.4	432.8	433.2	433.7	434.1	434.5	435.0	435.4	435.8
1300:	436.3	436.7	437.1	437.6	438.0	438.4	438.8	439.3	439.7	440.1
1310:	440.6	441.0	441.5	441.9	442.3	442.8	443.2	443.6	444.1	444.5
1320:	444.9	445.4	445.8	446.2	446.7	447.1	447.5	448.0	448.4	448.9
1330:	449.3	449.7	450.2	450.6	451.0	451.5	451.9	452.3	452.8	453.2
1340:	453.7	454.1	454.5	455.0	455.4	455.9	456.3	456.7	457.2	457.6
1350:	458.1	458.5	458.9	459.4	459.8	460.3	460.7	461.1	461.6	462.0
1360:	462.5	462.9	463.3	463.8	464.2	464.7	465.1	465.6	466.0	466.4
1370:	466.9	467.3	467.8	468.2	468.7	469.1	469.5	470.0	470.4	470.9
1380:	471.3	471.8	472.3	472.7	473.2	473.6	474.0	474.5	474.9	475.3
1390:	475.8	476.2	476.6	477.1	477.5	478.0	478.4	478.8	479.3	479.7
1400:	480.1	480.6	481.0	481.4	481.9	482.3	482.7	483.2	483.6	484.1
1410:	484.5	484.9	485.4	485.8	486.2	486.7	487.1	487.5	488.0	488.4
1420:	488.9	489.3	489.7	490.2	490.6	491.1	491.5	491.9	492.4	492.8
1430:	493.3	493.7	494.1	494.6	495.0	495.4	495.9	496.3	496.8	497.2
1440:	497.7	498.1	498.5	499.0	499.4	499.9	500.3	500.7	501.2	501.6
1450:	502.1	502.5	502.9	503.4	503.8	504.3	504.7	505.2	505.6	506.0
1460:	506.5	506.9	507.4	507.8	508.3	508.7	509.1	509.6	510.0	510.5
1470:	510.9	511.4	511.8	512.3	512.7	513.1	513.6	514.0	514.5	514.9
1480:	515.4	515.8	516.3	516.7	517.2	517.6	518.0	518.5	518.9	519.4
1490:	519.8	520.3	520.7	521.2	521.6	522.1	522.5	523.0	523.4	523.9
1500:	524.3	524.8	525.2	525.7	526.1	526.5	527.0	527.4	527.9	528.3
1510:	528.8	529.2	529.7	530.1	530.6	531.0	531.5	531.9	532.4	532.8
1520:	533.3	533.7	534.2	534.6	535.1	535.5	536.0	536.4	536.9	537.3
1530:	537.8	538.2	538.7	539.1	539.6	540.1	540.5	541.0	541.4	541.9
1540:	542.3	542.8	543.2	543.7	544.1	544.6	545.0	545.5	545.9	546.4
1550:	546.8	547.3	547.7	548.2	548.7	549.1	549.6	550.0	550.5	550.9
1560:	551.4	551.8	552.3	552.7	553.2	553.7	554.1	554.6	555.0	555.5
1570:	555.9	556.4	556.8	557.3	557.8	558.2	558.7	559.1	559.6	560.0
1580:	560.5	560.9	561.4	561.9	562.3	562.8	563.2	563.7	564.1	564.6
1590:	565.1	565.5	566.0	566.4	566.9	567.4	567.8	568.3	568.7	569.2

Table 4-1 cont

RESEARCH INCORPORATED
640
R T/C 0. TO 2500.0 DEG F
SETPOINT DIAL SETTING VS TEMPERATURE

DEG F...	0	1	2	3	4	5	6	7	8	9
1600:	569.6	570.1	570.6	571.0	571.5	571.9	572.4	572.9	573.3	573.8
1610:	574.2	574.7	575.2	575.6	576.1	576.5	577.0	577.5	577.9	578.4
1620:	578.8	579.3	579.8	580.2	580.7	581.1	581.6	582.1	582.5	583.0
1630:	583.4	583.9	584.4	584.8	585.3	585.8	586.2	586.7	587.1	587.6
1640:	588.1	588.5	589.0	589.4	589.9	590.4	590.8	591.3	591.8	592.2
1650:	592.7	593.2	593.6	594.1	594.5	595.0	595.5	595.9	596.4	596.9
1660:	597.3	597.8	598.3	598.7	599.2	599.6	600.1	600.6	601.0	601.5
1670:	602.0	602.4	602.9	603.4	603.8	604.3	604.8	605.2	605.7	606.2
1680:	606.6	607.1	607.6	608.0	608.5	609.0	609.4	609.9	610.4	610.8
1690:	611.3	611.8	612.2	612.7	613.2	613.6	614.1	614.6	615.0	615.5
1700:	616.0	616.4	616.9	617.4	617.8	618.3	618.8	619.2	619.7	620.2
1710:	620.6	621.1	621.6	622.0	622.5	623.0	623.5	623.9	624.4	624.9
1720:	625.3	625.8	626.3	626.7	627.2	627.7	628.1	628.6	629.1	629.6
1730:	630.0	630.5	631.0	631.4	631.9	632.4	632.8	633.3	633.8	634.3
1740:	634.7	635.2	635.7	636.1	636.6	637.1	637.5	638.0	638.5	639.0
1750:	639.4	639.9	640.4	640.8	641.3	641.8	642.3	642.7	643.2	643.7
1760:	644.1	644.6	645.1	645.6	646.0	646.5	647.0	647.5	647.9	648.4
1770:	648.9	649.3	649.8	650.3	650.8	651.2	651.7	652.2	652.7	653.1
1780:	653.6	654.1	654.6	655.0	655.5	656.0	656.4	656.9	657.4	657.9
1790:	658.3	658.8	659.3	659.8	660.2	660.7	661.2	661.7	662.1	662.6
1800:	663.1	663.6	664.0	664.5	665.0	665.5	665.9	666.4	666.9	667.4
1810:	667.8	668.3	668.8	669.3	669.7	670.2	670.7	671.2	671.6	672.1
1820:	672.6	673.1	673.5	674.0	674.5	675.0	675.4	675.9	676.4	676.9
1830:	677.4	677.8	678.3	678.8	679.3	679.7	680.2	680.7	681.2	681.6
1840:	682.1	682.6	683.1	683.6	684.0	684.5	685.0	685.5	685.9	686.4
1850:	686.9	687.4	687.8	688.3	688.8	689.3	689.8	690.2	690.7	691.2
1860:	691.7	692.1	692.6	693.1	693.6	694.1	694.5	695.0	695.5	696.0
1870:	696.5	696.9	697.4	697.9	698.4	698.8	699.3	699.8	700.3	700.8
1880:	701.2	701.7	702.2	702.7	703.2	703.6	704.1	704.6	705.1	705.6
1890:	706.0	706.5	707.0	707.5	708.0	708.4	708.9	709.4	709.9	710.4
1900:	710.8	711.3	711.8	712.3	712.8	713.2	713.7	714.2	714.7	715.2
1910:	715.6	716.1	716.6	717.1	717.6	718.0	718.5	719.0	719.5	720.0
1920:	720.4	720.9	721.4	721.9	722.4	722.8	723.3	723.8	724.3	724.8
1930:	725.2	725.7	726.2	726.7	727.2	727.7	728.1	728.6	729.1	729.6
1940:	730.1	730.5	731.0	731.5	732.0	732.5	733.0	733.4	733.9	734.4
1950:	734.9	735.4	735.8	736.3	736.8	737.3	737.8	738.3	738.7	739.2
1960:	739.7	740.2	740.7	741.1	741.6	742.1	742.6	743.1	743.6	744.0
1970:	744.5	745.0	745.5	746.0	746.5	746.9	747.4	747.9	748.4	748.9
1980:	749.4	749.8	750.3	750.8	751.3	751.8	752.2	752.7	753.2	753.7
1990:	754.2	754.7	755.1	755.6	756.1	756.6	757.1	757.6	758.0	758.5

Table 4-1, cont

RESEARCH INCORPORATED

640

R T/C 0. TO 2500.0 DEG F

SETPOINT DIAL SETTING VS TEMPERATURE

DEG F...	Ø	1	2	3	4	5	6	7	8	9
2000:	759.0	759.5	760.0	760.5	760.9	761.4	761.9	762.4	762.9	763.4
2010:	763.8	764.3	764.8	765.3	765.8	766.3	766.8	767.2	767.7	768.2
2020:	768.7	769.2	769.7	770.1	770.6	771.1	771.6	772.1	772.6	773.0
2030:	773.5	774.0	774.5	775.0	775.5	775.9	776.4	776.9	777.4	777.9
2040:	778.4	778.9	779.3	779.8	780.3	780.8	781.3	781.8	782.2	782.7
2050:	783.2	783.7	784.2	784.7	785.1	785.6	786.1	786.6	787.1	787.6
2060:	788.1	788.5	789.0	789.5	790.0	790.5	791.0	791.4	791.9	792.4
2070:	792.9	793.4	793.9	794.4	794.8	795.3	795.8	796.3	796.8	797.3
2080:	797.7	798.2	798.7	799.2	799.7	800.2	800.7	801.1	801.6	802.1
2090:	802.6	803.1	803.6	804.0	804.5	805.0	805.5	806.0	806.5	807.0
2100:	807.4	807.9	808.4	808.9	809.4	809.9	810.4	810.8	811.3	811.8
2110:	812.3	812.8	813.3	813.7	814.2	814.7	815.2	815.7	816.2	816.7
2120:	817.1	817.6	818.1	818.6	819.1	819.6	820.1	820.5	821.0	821.5
2130:	822.0	822.5	823.0	823.4	823.9	824.4	824.9	825.4	825.9	826.4
2140:	826.8	827.3	827.8	828.3	828.8	829.3	829.8	830.2	830.7	831.2
2150:	831.7	832.2	832.7	833.1	833.6	834.1	834.6	835.1	835.6	836.1
2160:	836.5	837.0	837.5	838.0	838.5	839.0	839.5	839.9	840.4	840.9
2170:	841.4	841.9	842.4	842.8	843.3	843.8	844.3	844.8	845.3	845.8
2180:	846.2	846.7	847.2	847.7	848.2	848.7	849.2	849.6	850.1	850.6
2190:	851.1	851.6	852.1	852.5	853.0	853.5	854.0	854.5	855.0	855.5
2200:	855.9	856.4	856.9	857.4	857.9	858.4	858.8	859.3	859.8	860.3
2210:	860.8	861.3	861.8	862.2	862.7	863.2	863.7	864.2	864.7	865.1
2220:	865.6	866.1	866.6	867.1	867.6	868.0	868.5	869.0	869.5	870.0
2230:	870.5	871.0	871.4	871.9	872.4	872.9	873.4	873.9	874.3	874.8
2240:	875.3	875.8	876.3	876.8	877.2	877.7	878.2	878.7	879.2	879.7
2250:	880.1	880.6	881.1	881.6	882.1	882.6	883.1	883.5	884.0	884.5
2260:	885.0	885.5	886.0	886.4	886.9	887.4	887.9	888.4	888.9	889.3
2270:	889.8	890.3	890.8	891.3	891.8	892.2	892.7	893.2	893.7	894.2
2280:	894.7	895.1	895.6	896.1	896.6	897.1	897.5	898.0	898.5	899.0
2290:	899.5	900.0	900.4	900.9	901.4	901.9	902.4	902.9	903.3	903.8
2300:	904.3	904.8	905.3	905.8	906.2	906.7	907.2	907.7	908.2	908.6
2310:	909.1	909.6	910.1	910.6	911.1	911.5	912.0	912.5	913.0	913.5
2320:	914.0	914.4	914.9	915.4	915.9	916.4	916.8	917.3	917.8	918.3
2330:	918.8	919.3	919.7	920.2	920.7	921.2	921.7	922.1	922.6	923.1
2340:	923.6	924.1	924.5	925.0	925.5	926.0	926.5	927.0	927.4	927.9
2350:	928.4	928.9	929.4	929.8	930.3	930.8	931.3	931.8	932.2	932.7
2360:	933.2	933.7	934.2	934.6	935.1	935.6	936.1	936.6	937.0	937.5
2370:	938.0	938.5	939.0	939.4	939.9	940.4	940.9	941.4	941.8	942.3
2380:	942.8	943.3	943.8	944.2	944.7	945.2	945.7	946.2	946.6	947.1
2390:	947.6	948.1	948.6	949.0	949.5	950.0	950.5	950.9	951.4	951.9

Table 4-1 cont

RESEARCH INCORPORATED
640
R T/C 0. TO 2500.0 DEG F
SETPOINT DIAL SETTING VS TEMPERATURE

DEG F...	0	1	2	3	4	5	6	7	8	9
2400:	952.4	952.9	953.3	953.8	954.3	954.8	955.3	955.7	956.2	956.7
2410:	957.2	957.6	958.1	958.6	959.1	959.6	960.0	960.5	961.0	961.5
2420:	962.0	962.4	962.9	963.4	963.9	964.3	964.8	965.3	965.8	966.2
2430:	966.7	967.2	967.7	968.2	968.6	969.1	969.6	970.1	970.5	971.0
2440:	971.5	972.0	972.4	972.9	973.4	973.9	974.4	974.8	975.3	975.8
2450:	976.3	976.7	977.2	977.7	978.2	978.6	979.1	979.6	980.1	980.5
2460:	981.0	981.5	982.0	982.4	982.9	983.4	983.9	984.3	984.8	985.3
2470:	985.8	986.3	986.7	987.2	987.7	988.1	988.6	989.1	989.6	990.0
2480:	990.5	991.0	991.5	991.9	992.4	992.9	993.4	993.8	994.3	994.8
2490:	995.3	995.7	996.2	996.7	997.2	997.6	998.1	998.6	999.1	999.5
2500:	1000.									

Section 5

MAINTENANCE

5-1 General

The following paragraphs describe procedures for routine maintenance, troubleshooting and repair of the control portion of the system.

5-2 Routine Maintenance

The following procedures are required to insure optimum system performance and to prevent system malfunction.

WARNING

Shut off all power to system prior to performing following procedures.

1. Keep cabinets free of dust, dirt or other contaminants. Once a month (or more frequently if necessary) remove front and back access panels and vacuum cabinet interior. Use soft nozzle. Do NOT disturb wiring.
2. Inspect all switches and indicators on cabinet exterior to check for loose switches or broken indicator caps.
3. Ensure all indicator bulbs are functioning.
4. Check all high voltage and power connections for looseness, frayed insulation or broken wire.
5. Refer to component manuals contained in Section 8 for individual assemblies within this system. Perform routine maintenance as directed.

5-3 Troubleshooting

Troubleshooting the system consists of systematic isolation of malfunctioning components using the schematic D54141 for reference. Procedures for isolating a circuit malfunction are provided in the component manuals contained in Section 8. Table 5-1 provides basic procedures for failure isolation.

Table 5-1 Basic Troubleshooting Procedures

SYSTEM	PROBABLE CAUSE
1. White POWER ON indicator is off after circuit breaker is turned on.	a. Circuit breaker open. b. Fuse F1 or F2 is open. c. POWER ON indicator lamp burned out.
2. Green RUN indicator is off, RUN switch is pressed (POWER ON indicator is on).	a. Relay K1 inoperative. b. STOP switch is stuck open. c. RUN indicator lamp burned out.
3. POWER ON indicator on programmer or process controller is off.	See troubleshooting procedures in respective component manuals contained in Section 7.

5-4 Repair

Repair of the system is limited to circuit module replacement. Refer to component manuals contained in Section 8 for procedures.

5-5 LAMP REPLACEMENT

The radiant heat lamps are expendable and are subject to failure. In order to replace lamps, the technician must obtain access to the emitter side and lamp terminal cover side of the unit. The following procedure can be used to remove and install lamps.

Step 1. Position heater unit for access to the emitter side and lamp terminal cover sides of the heater.

Step 2. Open high voltage power entrance switch located at the top of cabinet #3 of the control console to remove all power to the system.

Step 3. Remove clear quartz window from emitter side of heater unit.

3.1 Remove three screws, item 7 on Figure 26 (Dwg D 54226, sheet 5) from window retainer bar, item 44 or 51.

3.2 Remove window retainer bar, item 44 or 51 on Figure 26.

3.3 Remove clear quartz window, item 27 on Figure 23 (dwg D 54226, sheet 2) by sliding it out of the retainer grooves in the right and left side reflectors, items 26 and 32 shown on Figure 23

CAUTION: Do not contaminate quartz window with bare hands. Use clean gloves to handle the quartz window

Step 4. Open the two lamp terminal access covers shown on Figures 23 and 24 to expose lamp lead terminals.

4.1 Remove the four top screws from each cover.

4.2 Loosen the four bottom screws from each cover.

4.3 Slide covers up until the four bottom screws engage the screw slots in the housing.

4.4 Tighten the four cover screws to hold the cover in its open position.

Step 5. Remove the defective lamp.

5.1 Disconnect each lamp lead from the bus bar screw as shown on Figure 23 (Dwg D 54226, sheet 2).

5.2 Squeeze the ears on the lamp mounting clip and push it with the disconnected lamp lead down into the lamp support ceramic tube.

5.3 Pull the lamp with its two lamp mounting clips out of the support tube from the reflector side.

Step 6. Install the new lamp # QMT3/CL/HT

6.1 Remove new lamp from carton. It is recommended that the lamp be handled by the metallic endseals and flexible leads rather than by the quartz lamp envelope, since quartz contamination due to body oils and etc., will degrade lamp envelope life.

6.2 Straighten flexible lamp leads to be perpendicular to filament axis.

6.3 Insert the ends of the flexible leamp leads together with the lamp mounting clips into the lamp support tube from the emitter side of the unit. The lamp mounting clip is secured when its open end latches over the inside end of the ceramic lamp support tube.

6.4 Connect flexible lamp leads to the terminal screw on the adjacent bus bar.

CAUTION: The lamp lead should not be in tension after tightening the lamp lead terminal screw.

Step 7. Close the two lamp terminal access covers by loosening the 4 screws, sliding the cover down; and tightening the 8 screws.

Step 8. Insert the clear quartz window

8.1 Slide the clear, clean quartz window into the groove shown on Figure 32 (Dwg B53846) into the window retainer grooves in the right and left side reflectors, items 26 and 32 shown on Figure 23.

CAUTION: Do not contaminate quartz window with bare hands. Use clean gloves to handle the quartz window.

8.2 Attach the window retainer bar, item 44 or 51 on Figure 26 with the three screws, item 7.

FIGURES
(Drawings, Photos, Graphs)

D54141	Wiring Diagram	FIG 16
D54225	System Assembly	FIG 1
D53739 (1 and 2)	Assembly, Subassembly & Parts List	FIG 9 & 10
B53745	Assembly - RCP Panel	FIG 17
C53741	Assembly - Meter Panel	FIG 15
C53743	Assembly - Circuit Breaker Panel	FIG 16
B54365	Piping Schematic - Cooling System	FIG 14

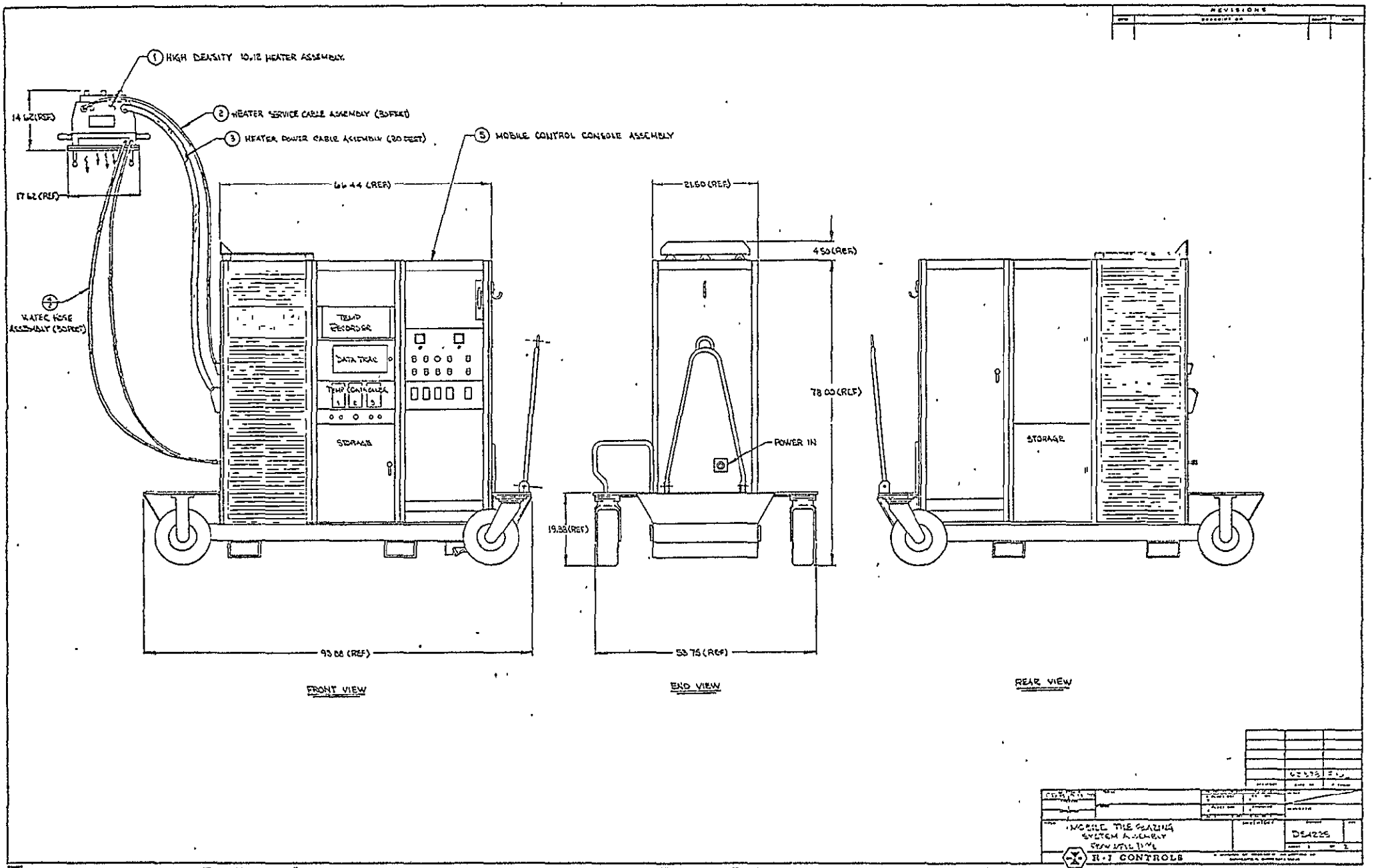


FIGURE 1 : MOBILE TILE GLAZING SYSTEM

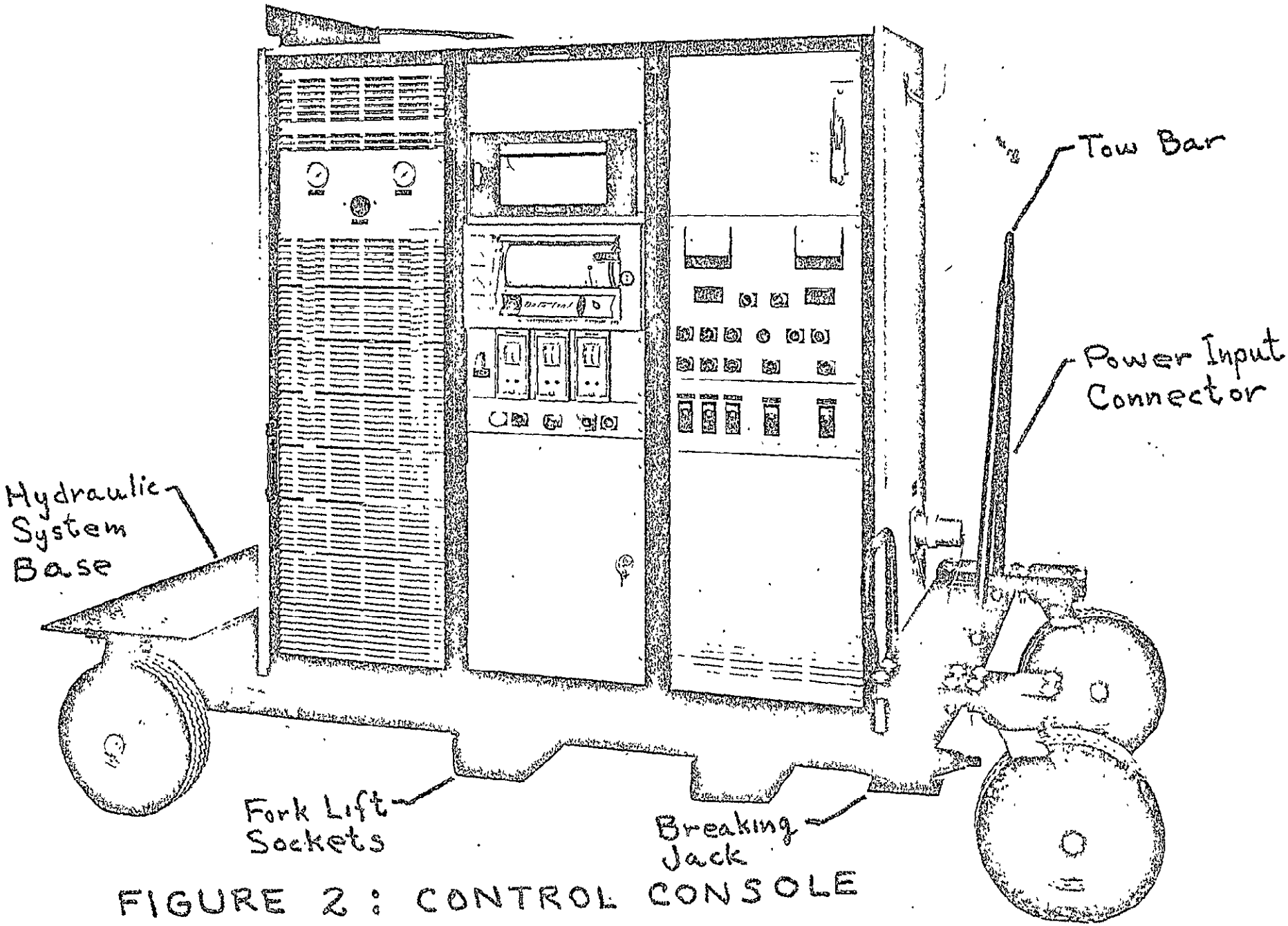


FIGURE 2 : CONTROL CONSOLE

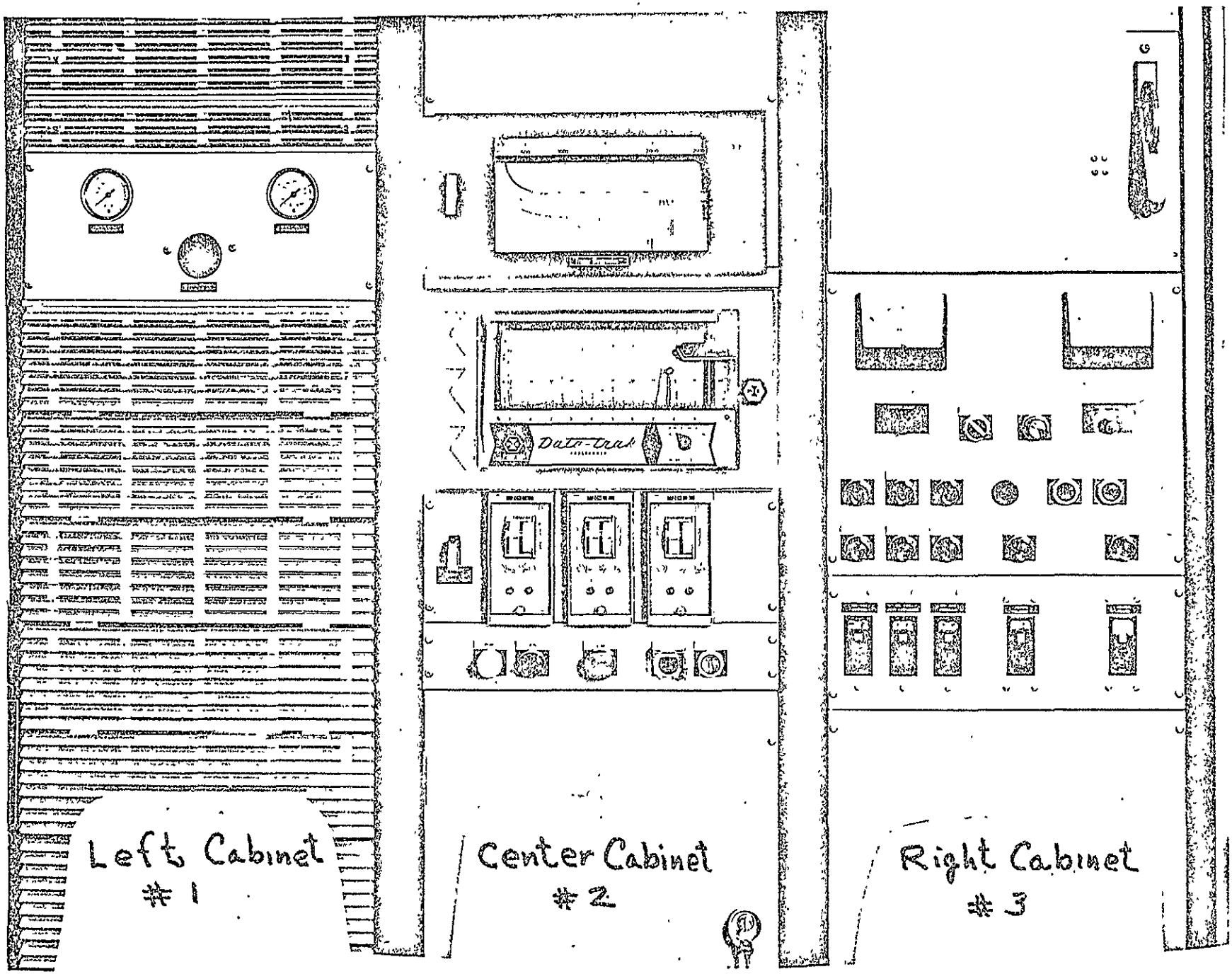


FIGURE 3 : CONTROL CONSOLE CONTROLS

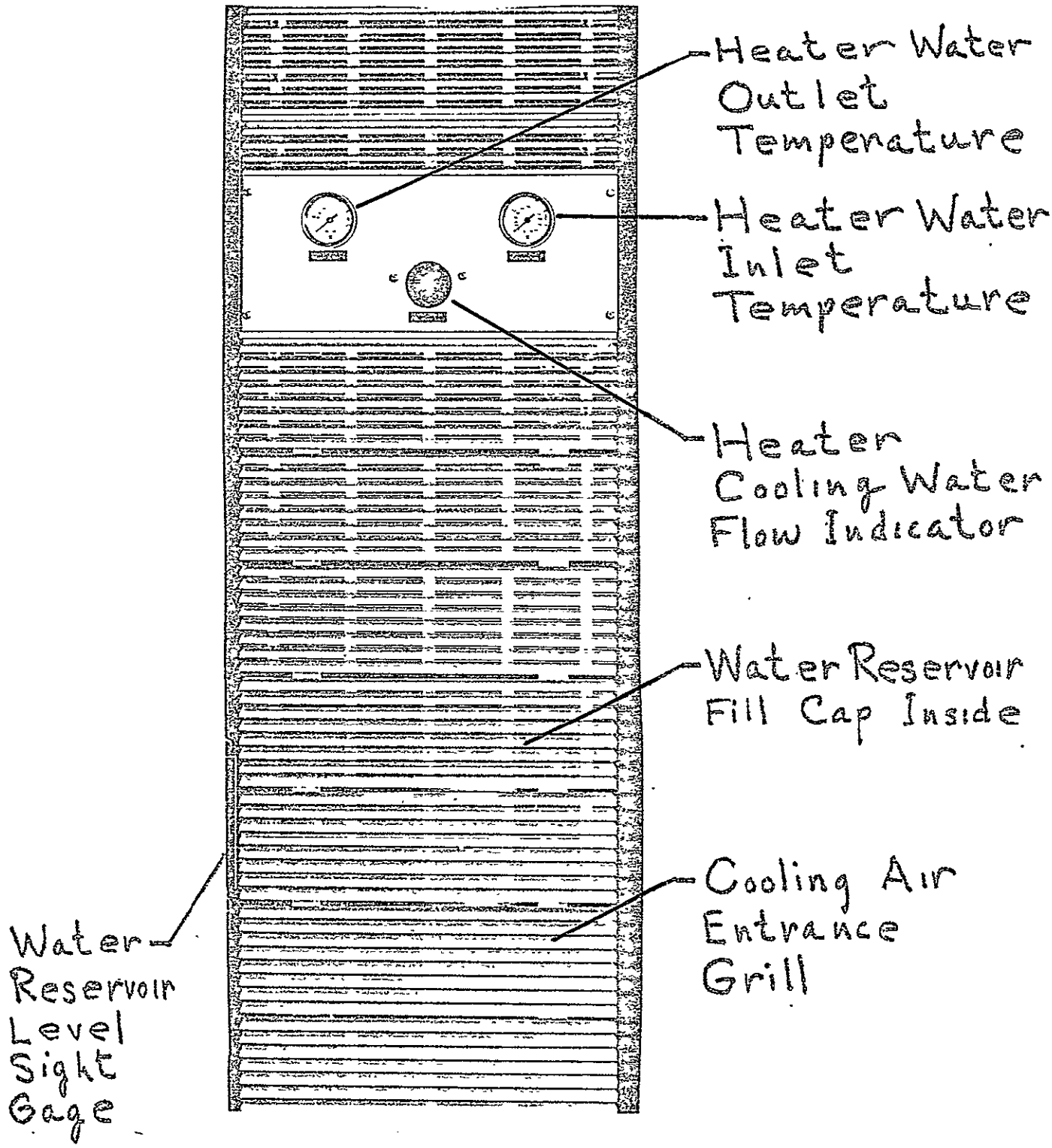


FIGURE 4: LEFT CABINET # 1 CONTROL PANEL

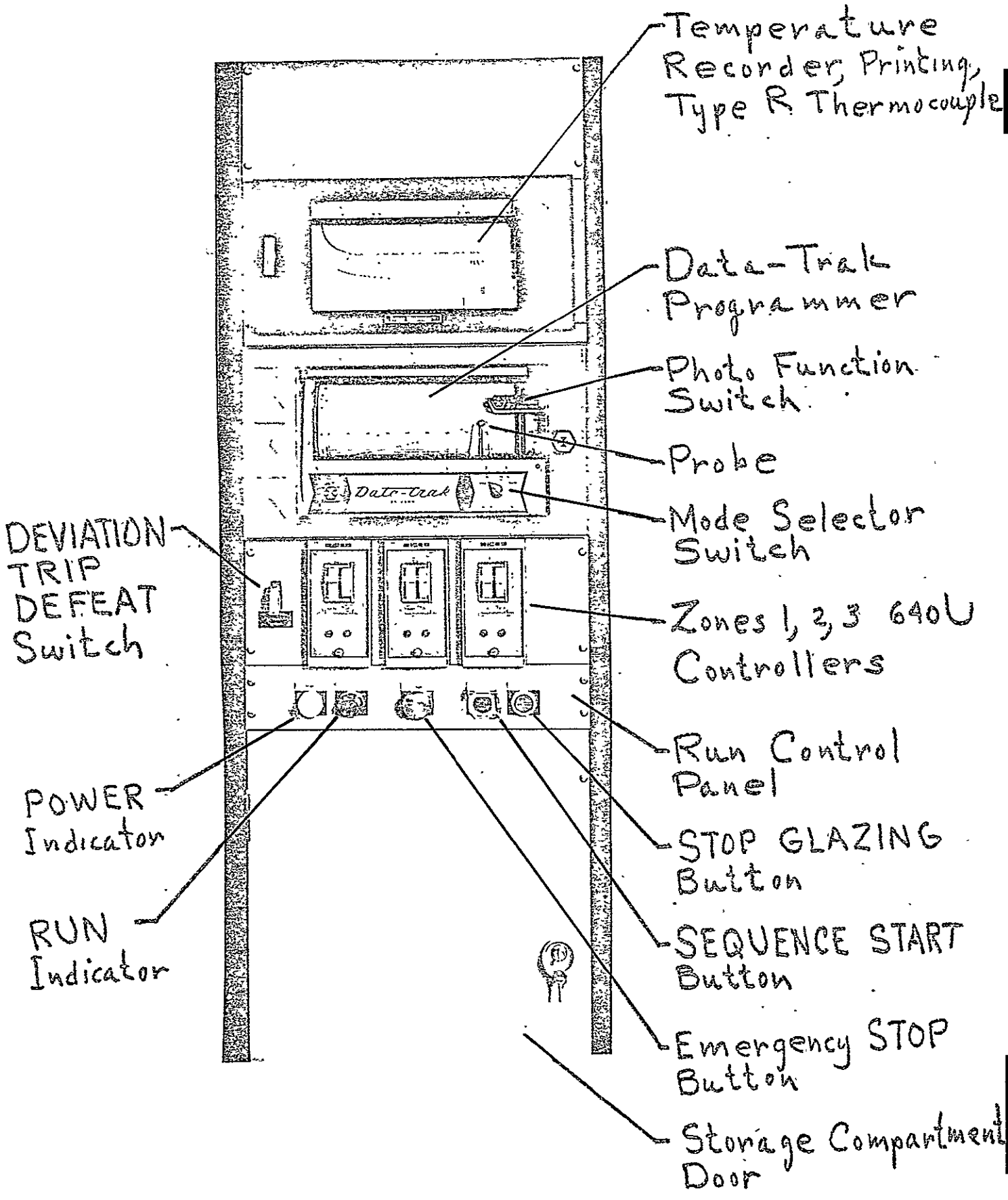


FIGURE 5: CENTER CABINET #2 CONTROL PANEL

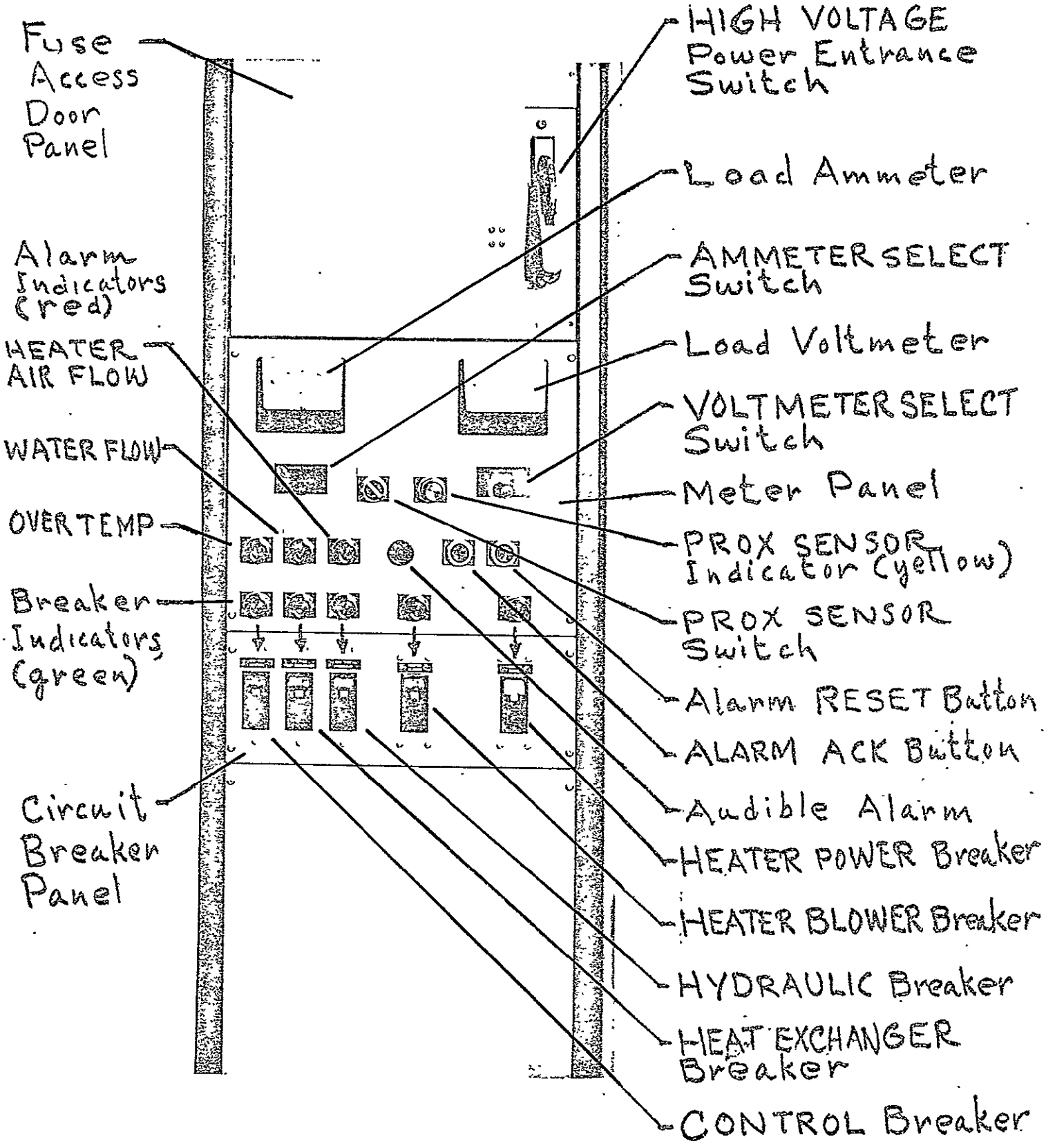


FIGURE 6: RIGHT CABINET#3 CONTROL PANEL

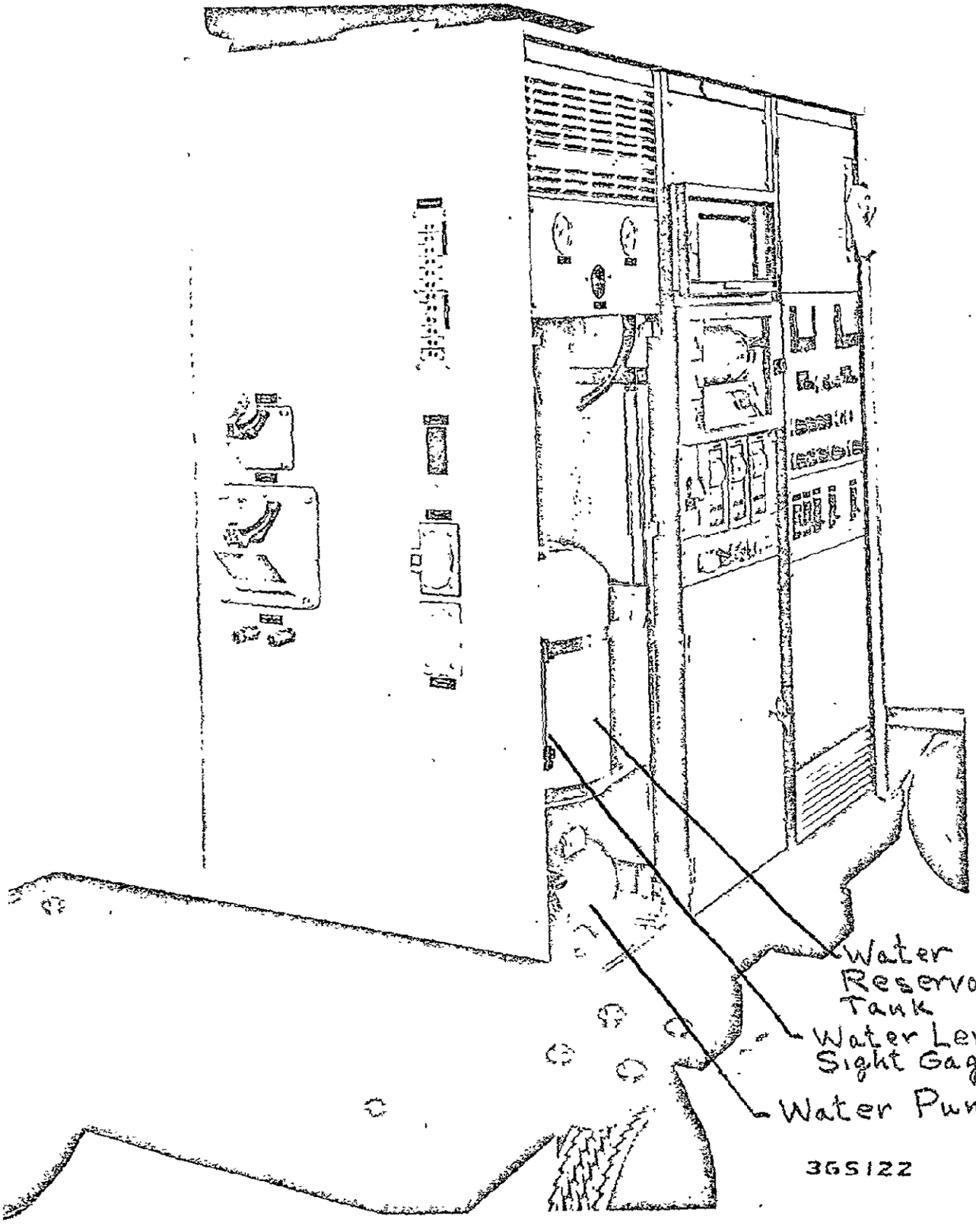


FIGURE 7.: CONTROL CONSOLE - LEFT SIDE VIEW.

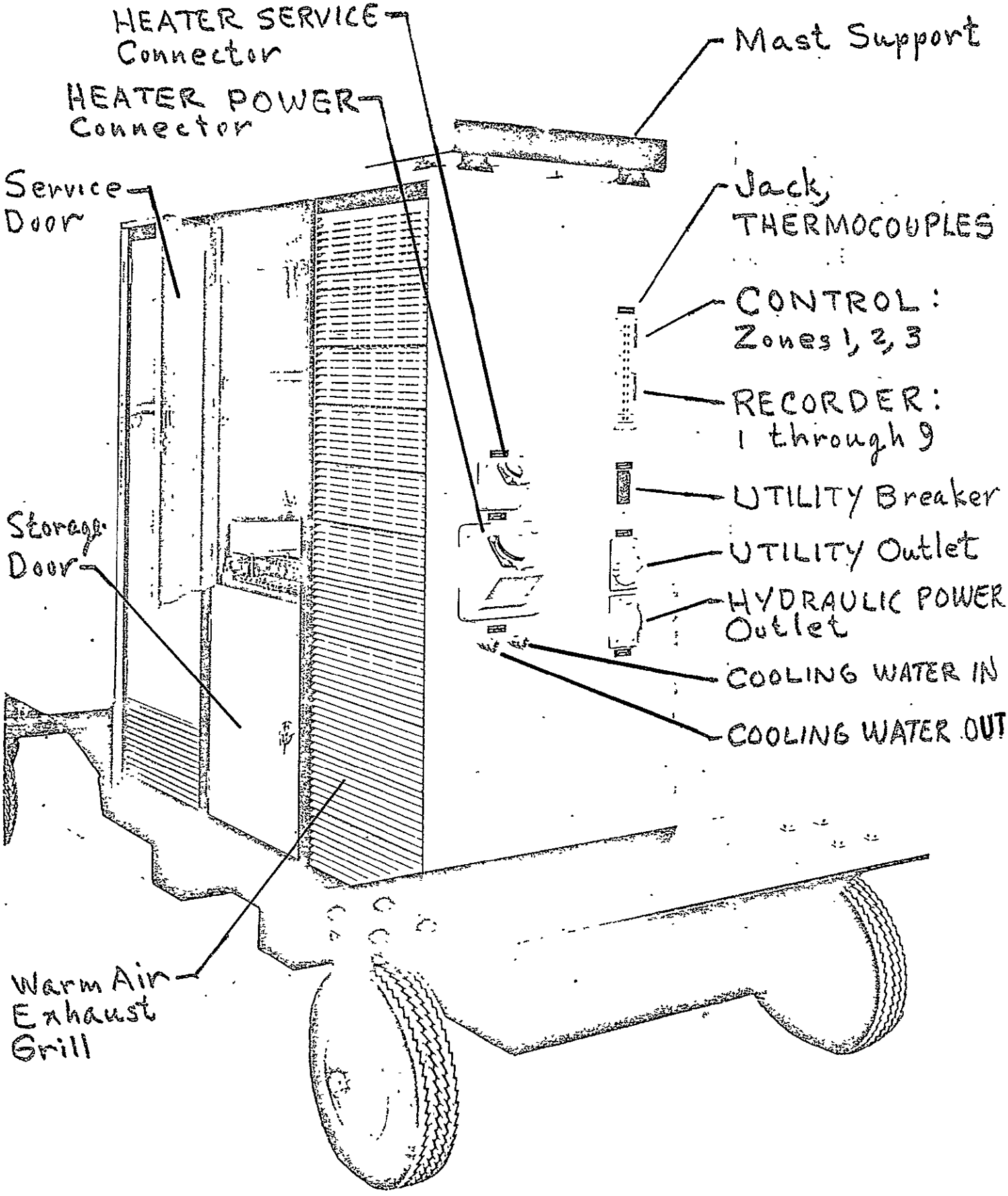
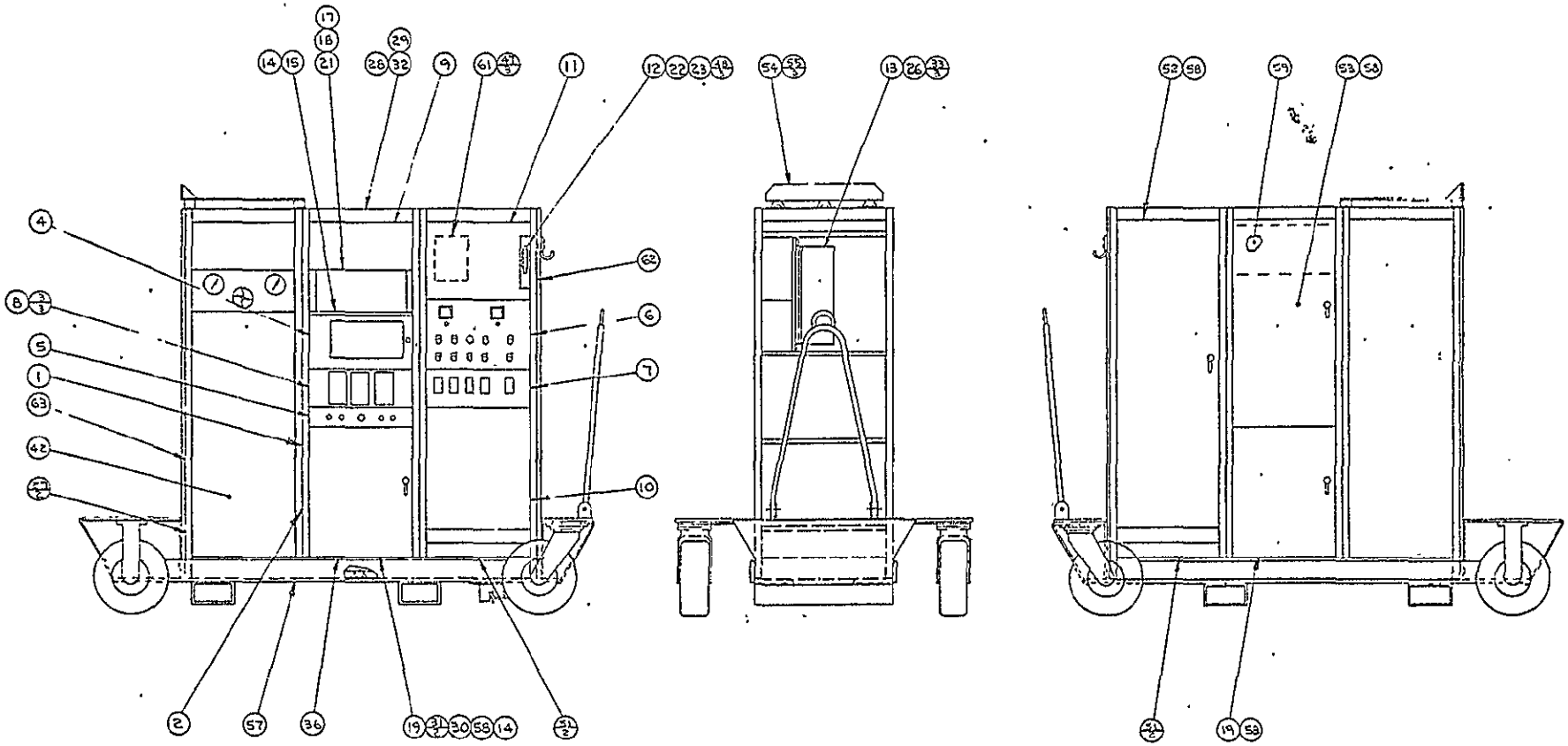


FIGURE 8: CONTROL CONSOLE - REAR VIEW

3GS124

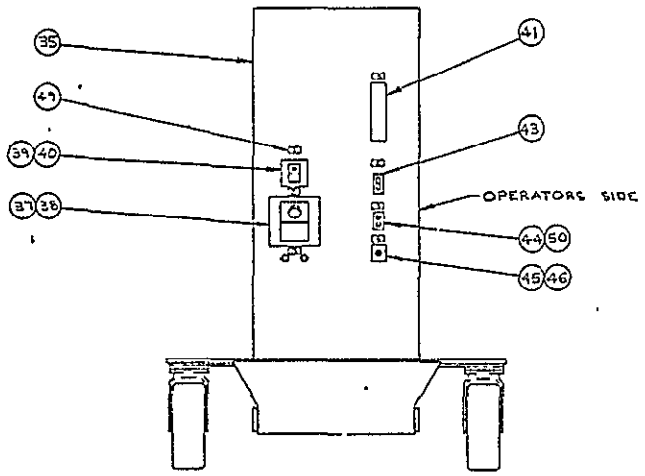


REVISIONS

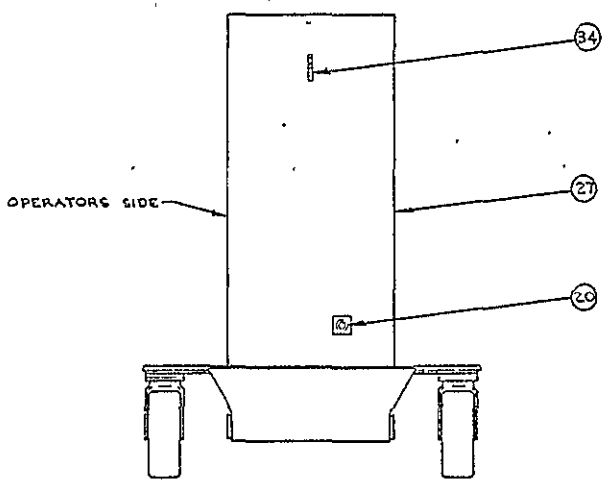
SYM	DESCRIPTION	DATE	APPD

CONTRACT	SEE P/L	SIZE	DWG NO.
			D553739
MOBILE CONTROL CONSOLE ASSEMBLY ROCKWELL INT'L.			
R-I CONTROLS			

FIGURE 9 : CONTROL CONSOLE - FRONT & REAR VIEWS



LEFT SIDE PANEL



RIGHT SIDE PANEL

REVISIONS

MOBILE CONTROL CONSOLE ASSEMBLY
ROCKWELL INT'L.
R·I CONTROLS
1/10
058739

FIGURE 10 : CONTROL CONSOLE - END VIEWS

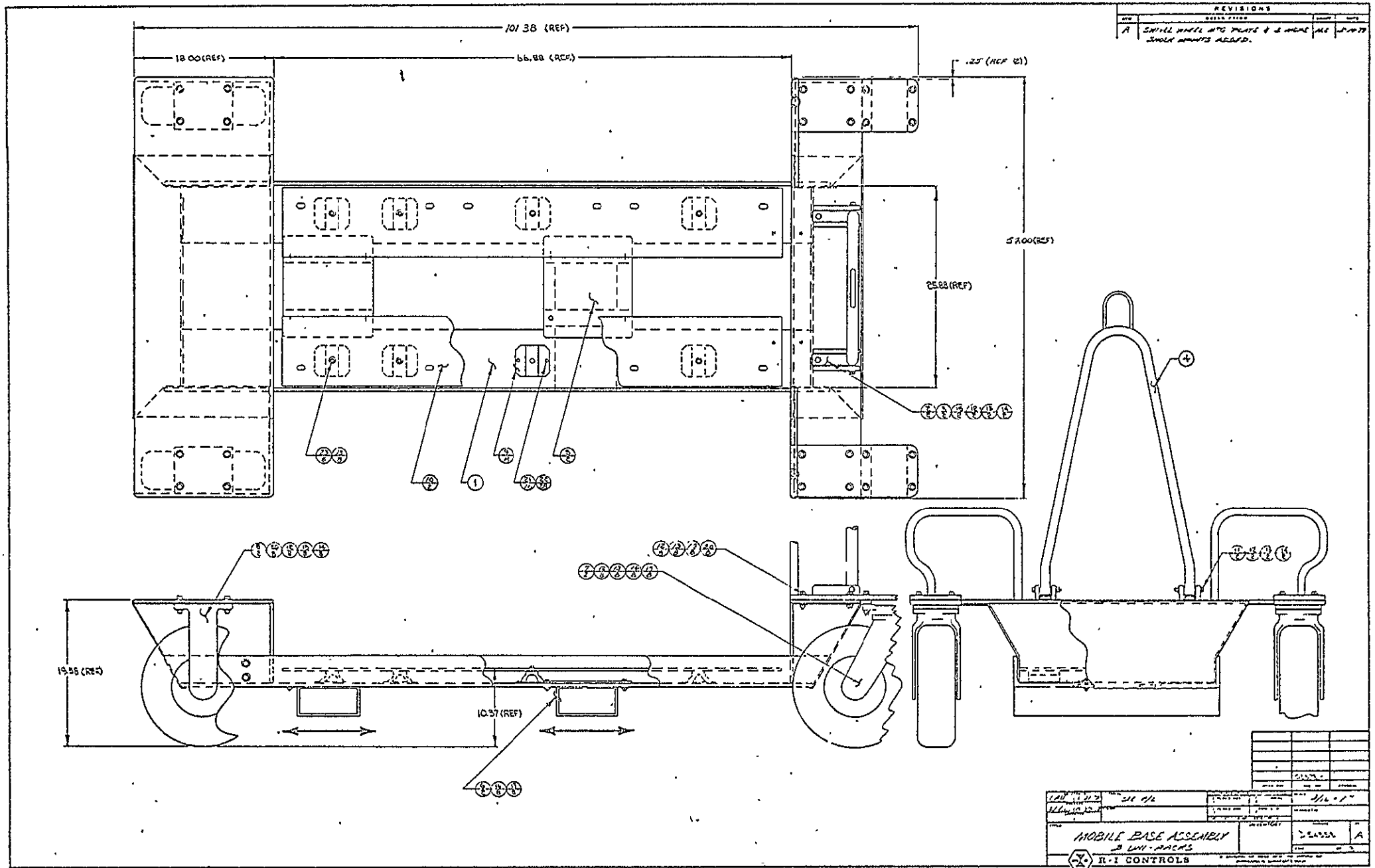


FIGURE 11 : CONTROL CONSOLE MOBILE BASE

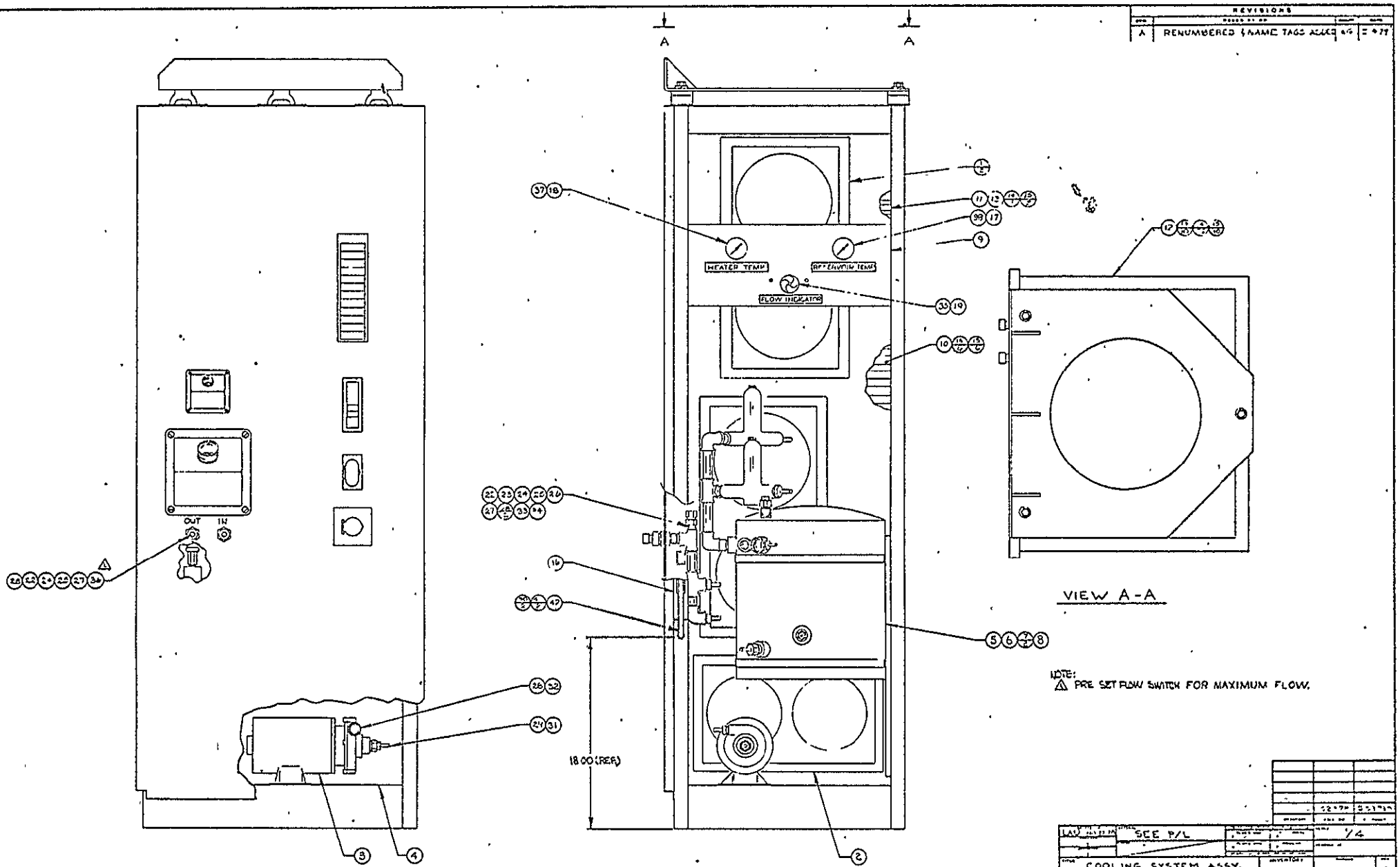
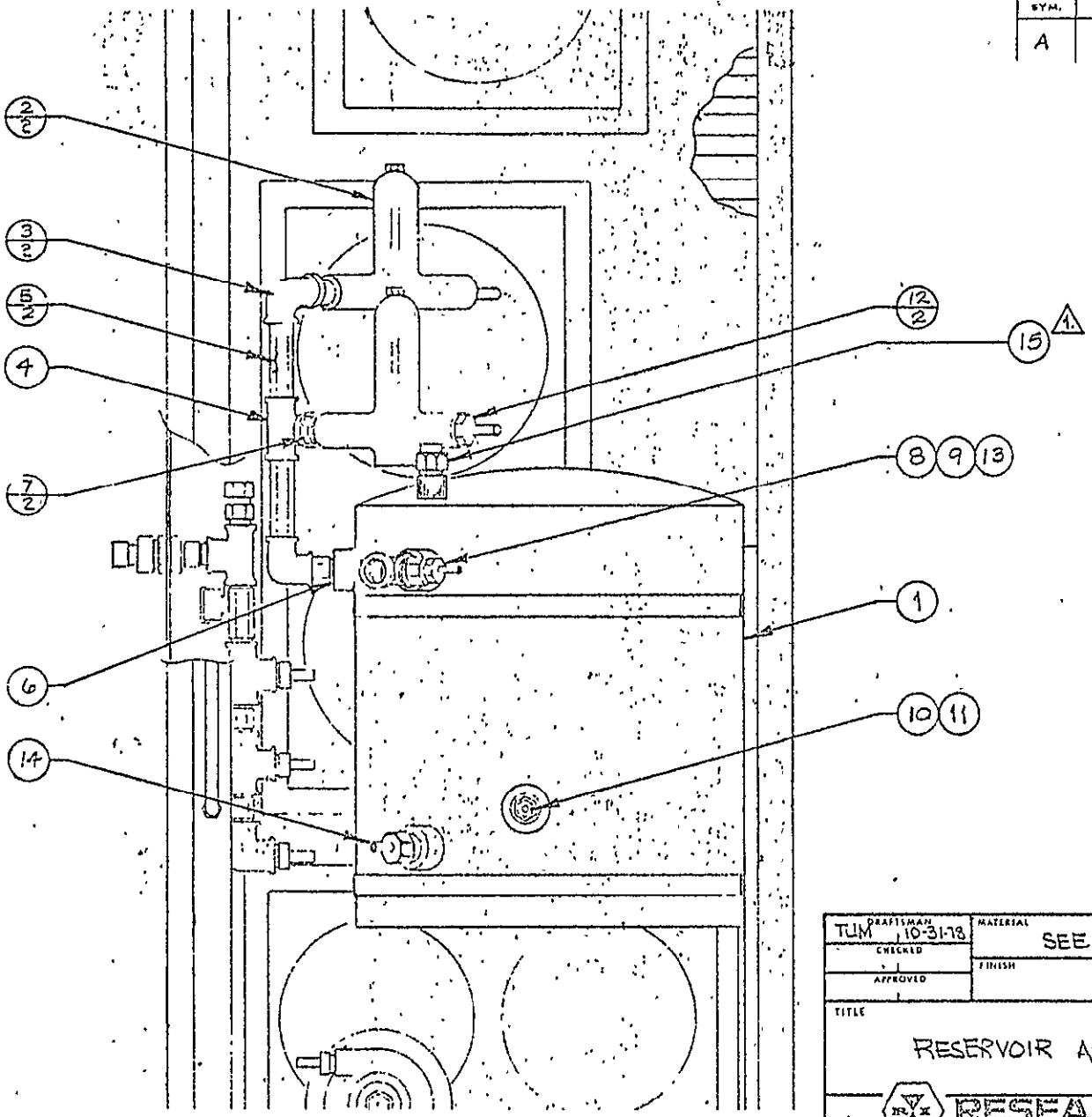


FIGURE 12 : COOLING SYSTEM CABINET



REVISIONS			
SYM.	DESCRIPTION	DRAFT	DATE
A	REPLUMBED.	WLM	5-3-79

NOTE:
1. PIPE PLUG : DRILL .125 DIA. THRU CENTER BEFORE INSTALLATION.

	102378-01	D54194
INVENTORY	USED ON	ASSEMBLY

DRAFTSMAN TUM 10-31-78	MATERIAL SEE P/L	TOLERANCE UNLESS OTHERWISE NOTED: 2 PLACE DEC ±	SCALE
CHECKED		FRACTL ±	
APPROVED	FINISH	3 PLACE ± ANGULAR	SCHEMATIC
		* REMOVE ALL BURRS AND SHARP EDGES	

TITLE		NUMBER	REV
RESERVOIR ASSEMBLY	INVENTORY	B54286	A
		SHEET 1 OF 2	

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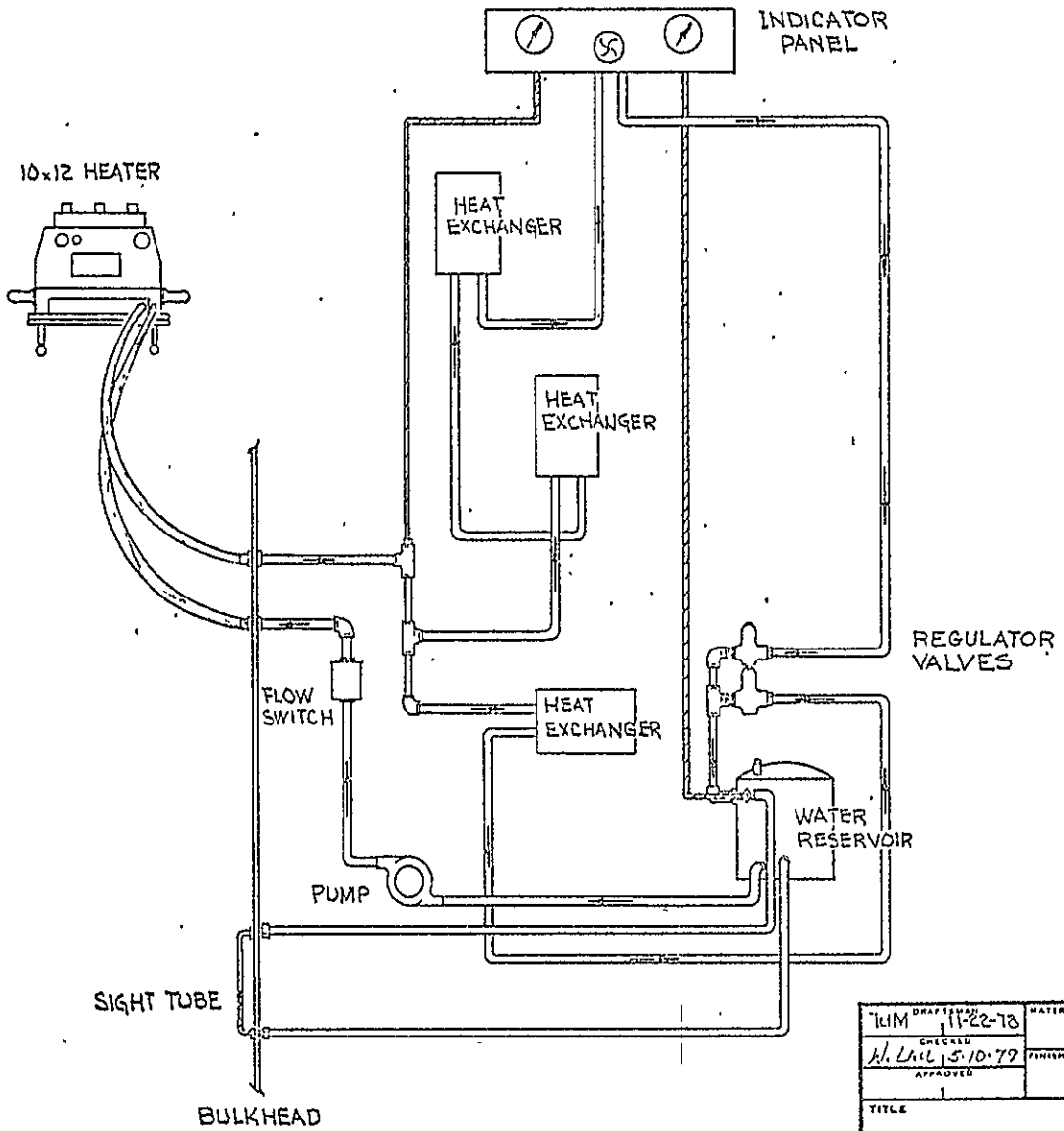
FIGURE 13 : WATER RESERVOIR



REVISIONS			
SYM	DESCRIPTION	DRAFT	DATE
A	RENUMBERED	N.L.	5-10-79

	102578-01	DE4194
INVENTORY	USED ON	ASSEMBLY

DRAFTSMAN TLM 11-22-78	MATERIAL	TOLERANCE UNLESS OTHERWISE SPECIFIED: 2 PLACE DEC ±	FRACTIONAL ±
CHECKED N. Lail 5-10-79	FINISH	3 PLACE DEC ±	ANGULAR ±
APPROVED		REMOVE ALL BURRS AND SHARP EDGES	

SCALE: NONE

SCHEMATIC

TITLE: PIPING SCHEMATIC / COOLING SYSTEM

INVENTORY

NUMBER: B 54365 REV: A

SHEET 1 OF 1

R·I CONTROLS
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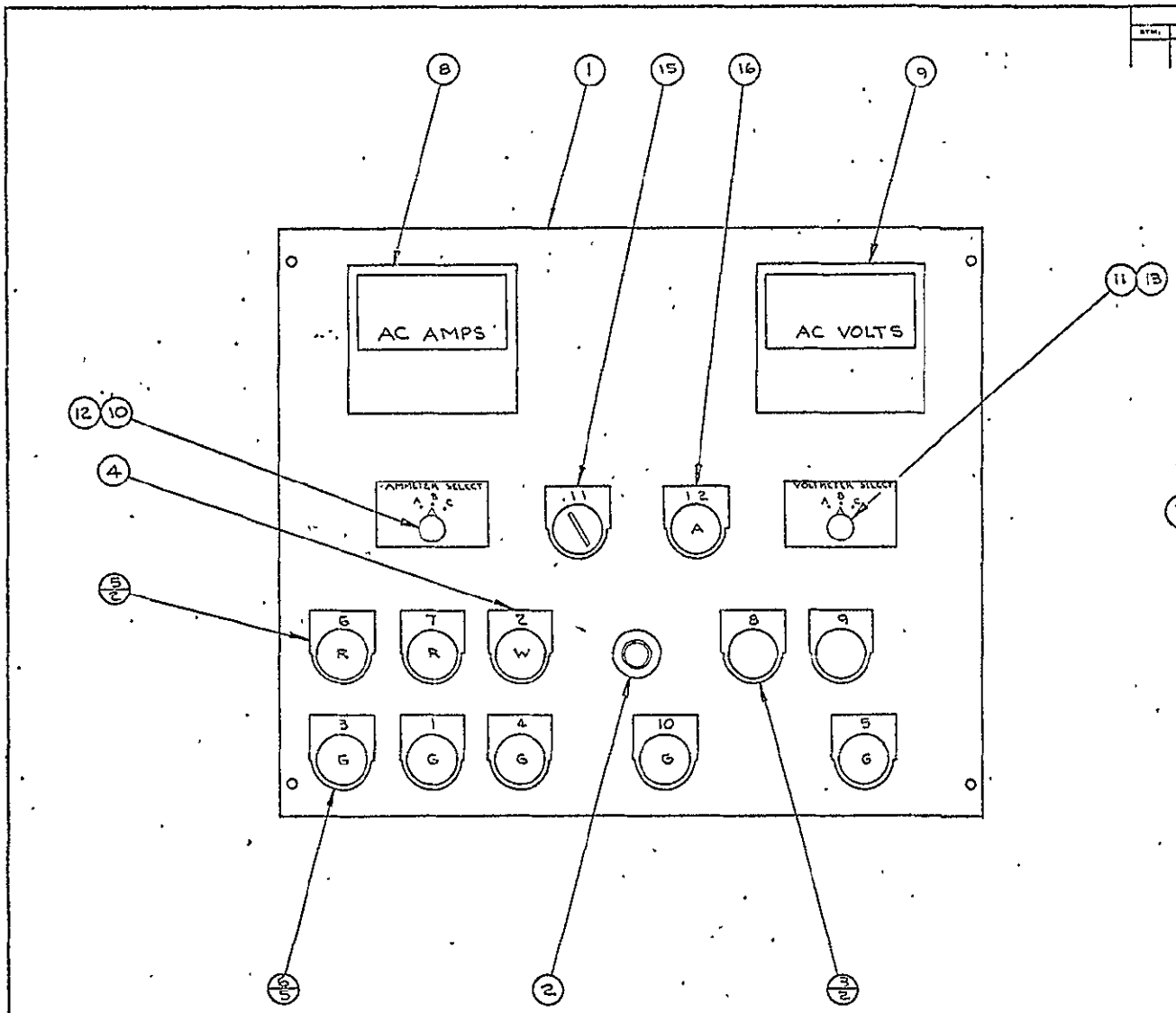
MINNEAPOLIS, MINNESOTA 55424

N26459

FIGURE 14 : WATER COOLING SYSTEM SCHEMATIC



REVISIONS

SYM.	DESCRIPTION	APPVD.	DATE

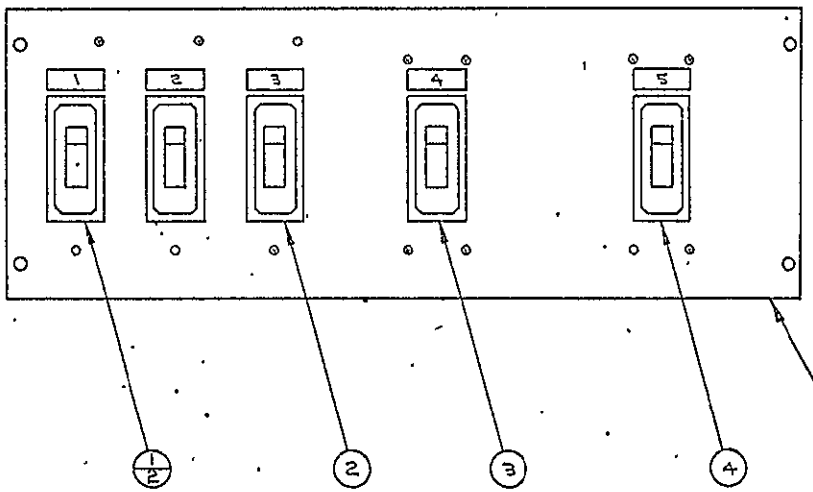
(7). LEGEND PLATES: B54190

1. HEAT EXCHANGER
2. HEATER AIR FLOW
3. CONTROL POWER
4. HYDRAULIC PUMP
5. HEATER POWER
6. OVER TEMP
7. HEATER WATER FLOW
8. ALARM ACKNOWLEDGE
9. RESET
10. HEATER BLOWER
11. PROXIMITY SENSOR ON/OFF
12. PROXIMITY SENSOR

CDH 10-2-79	SEE P/L		SCALE 1/2
			SCHEMATIC
TITLE: ASSY = METER PANEL		INVENTORY	NUMBER C53741
R·I CONTROLS			SHEET 1 OF 2

FIGURE 15 : METER PANEL

REVISIONS			
SYM.	DESCRIPTION	DRAFT	DATE



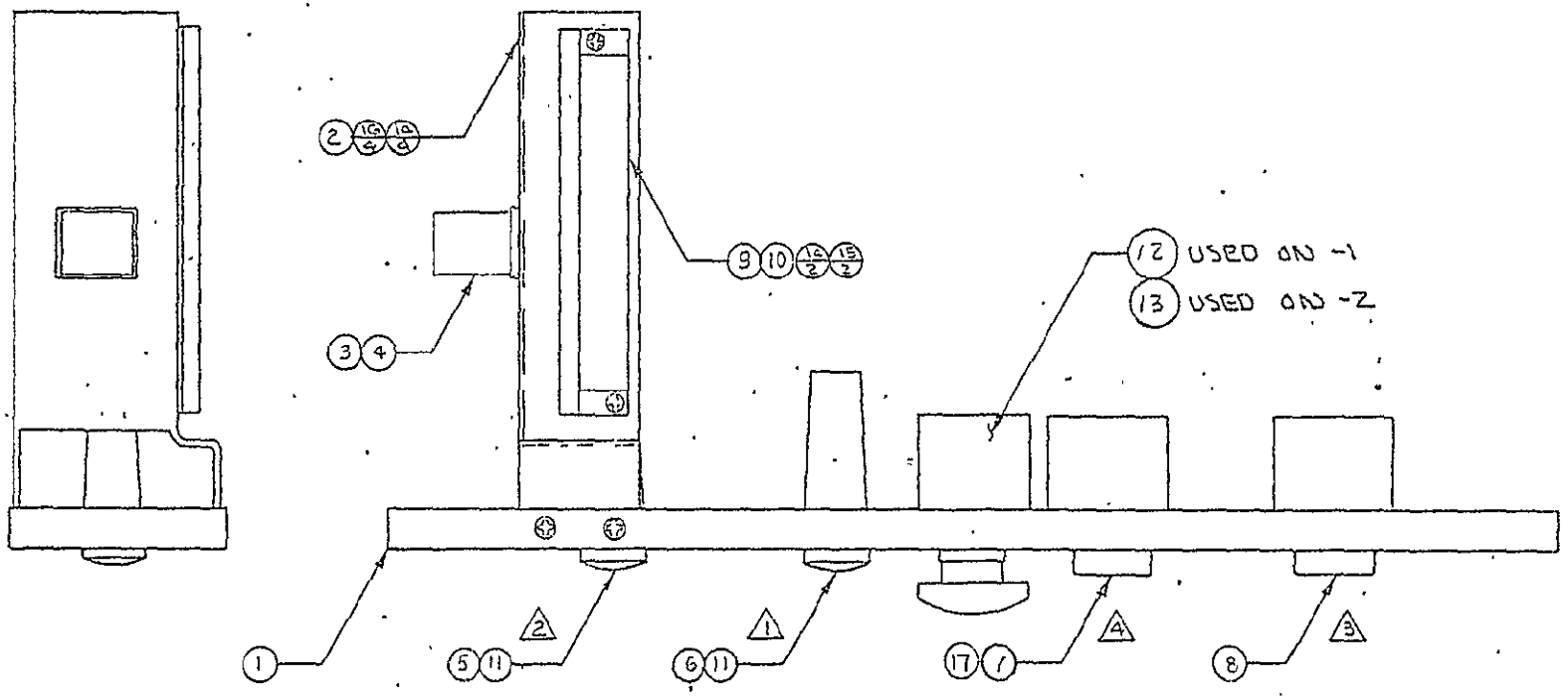
LEGEND PLATES :

1. 120 VAC CONTROL
2. 120 VAC HEAT EXCHANGER
3. 120 VAC HYDRAULIC
4. HEATER BLOWER
5. HEATER POWER

			10237-	D53743
		INVENTORY	USED ON	ASSEMBLY
CDL 9-72-A	SEE P/L		SCALE 1/2	
			SCHEMATIC	
		INVENTORY	NUMBER C53743	
ASSY. PANEL - CIRCUIT BREAKER				
R-I CONTROLS				

FIGURE 16 : CIRCUIT BREAKER PANEL

REVISIONS			
SYM.	DESCRIPTION	DRAFT.	DATE



NOTE:
LEGEND PLATE - B54192

1. RUN
2. POWER
3. STOP GLAZING
4. SEQUENCE START

PART NO.	DESCRIPTION	INVENTORY	USED ON	ASSEMBLY
B53745-2	CONTROL PANEL W/O E. STOP			
B53745-1	CONTROL PANEL W/E. STOP		102378	D53739

DRAFTSMAN / CHECKED / APPROVED
MATERIAL / FINISH
TOLERANCE UNLESS OTHERWISE SPECIFIED: 2 PLACE DEC ± .01 — FRACTIONAL ± 1/64 — 3 PLACE DEC ± .005 — ANGULAR ± 1/2°
REMOVE ALL BURRS AND SHARP EDGES
SCALE
SCHEMATIC

TITLE: ASSEMBLY - RCP PANEL
INVENTORY
NUMBER: B53745
REV
SHEET 1 OF 3

R·I CONTROLS
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MINNEAPOLIS, MINNESOTA 55424

FIGURE 17: RUN CONTROL PANEL

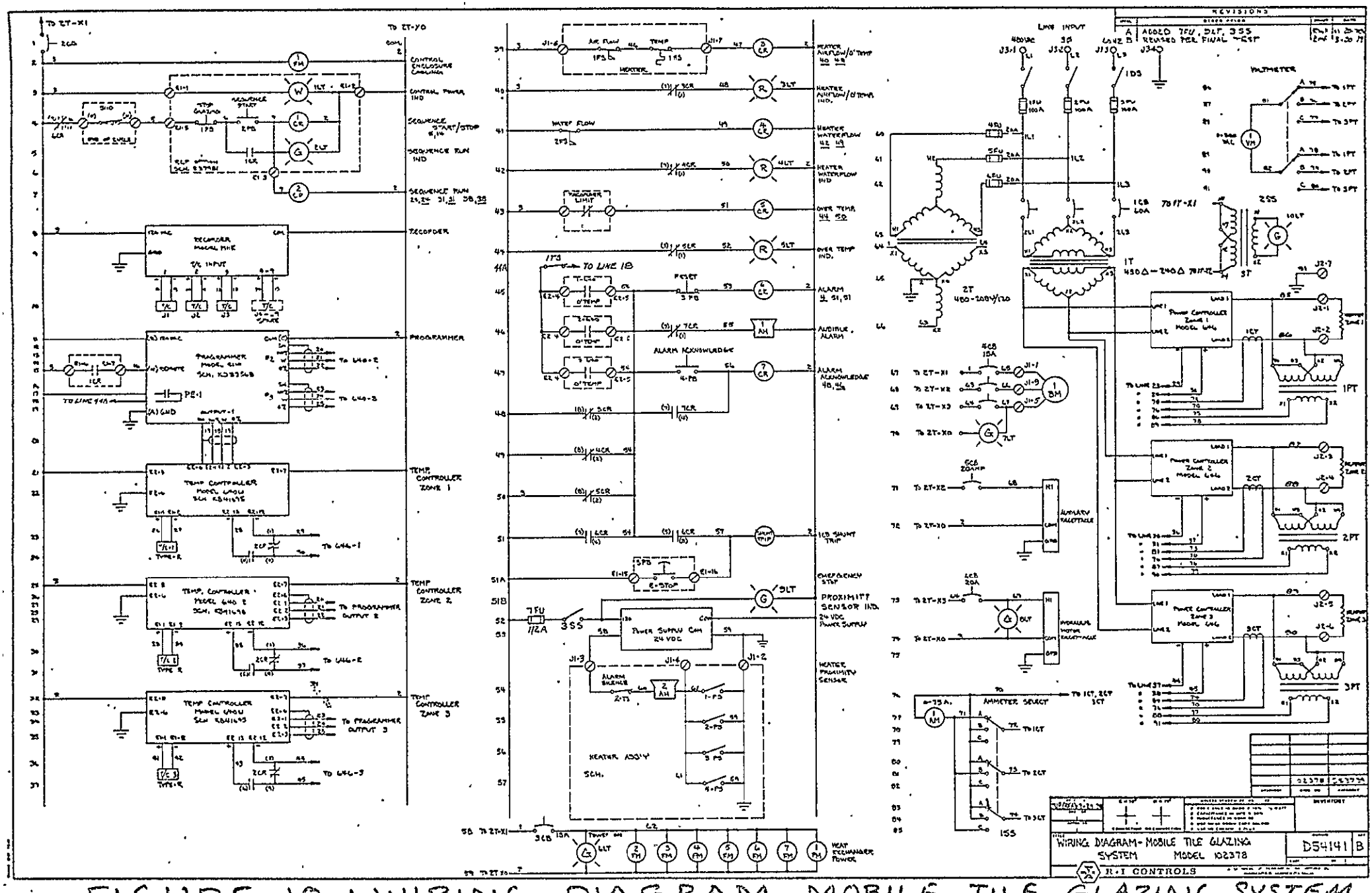


FIGURE 18 : WIRING DIAGRAM- MOBILE TILE GLAZING SYSTEM

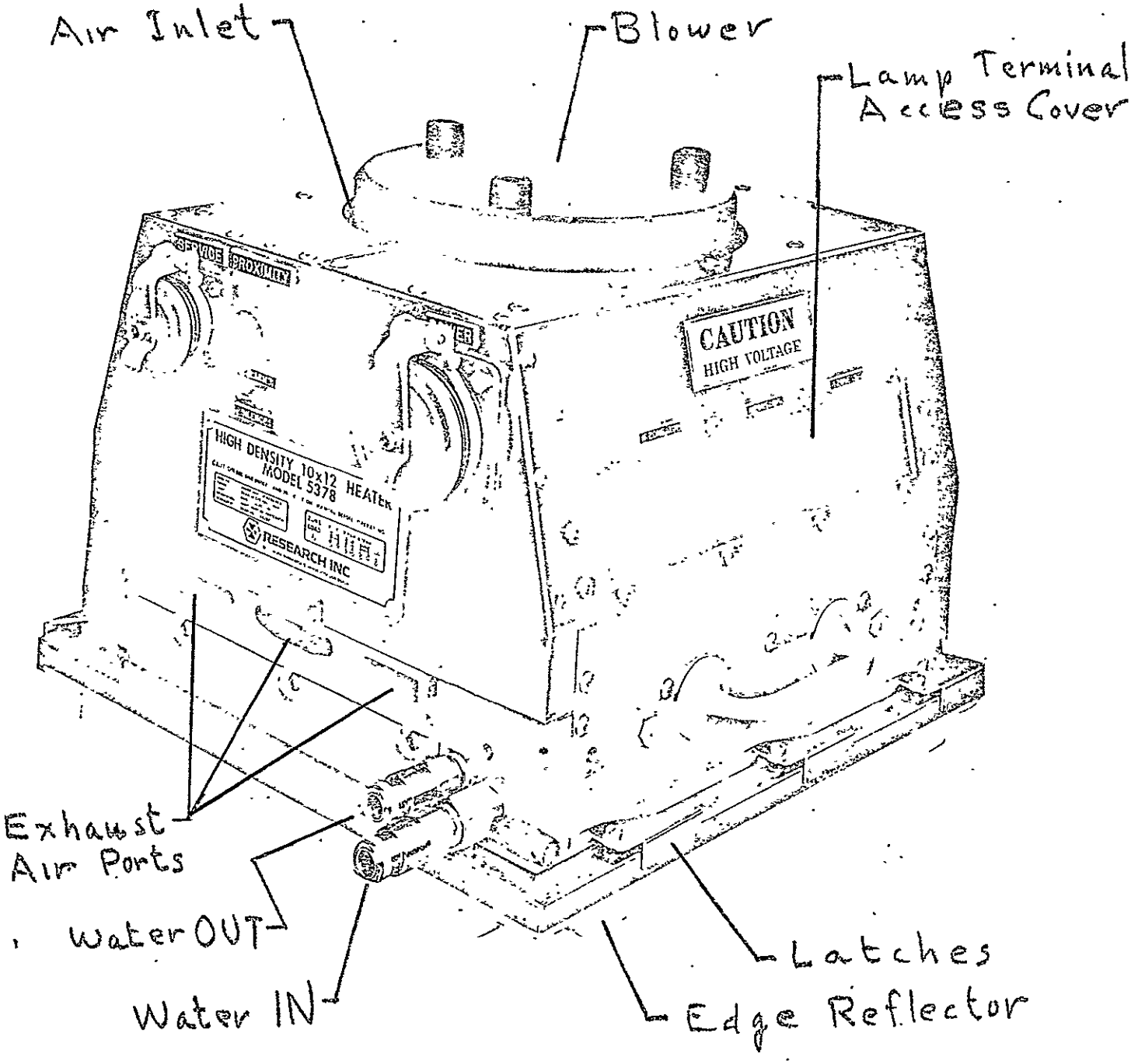


FIGURE 19: HIGH DENSITY 10X12 HEATER MODEL 5378

365126

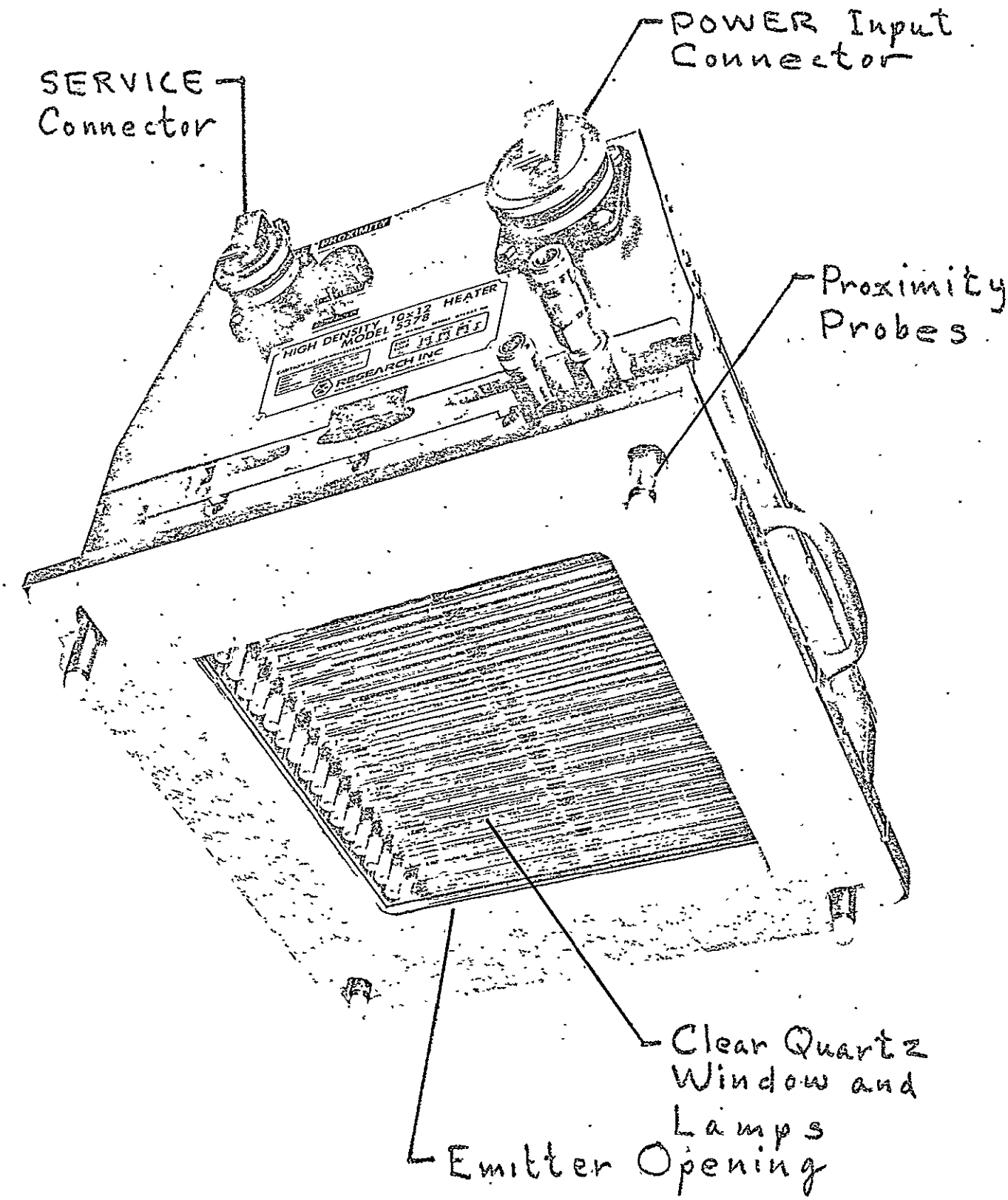


FIGURE 20: EMITTER OPENING VIEW OF HIGH DENSITY HEATER

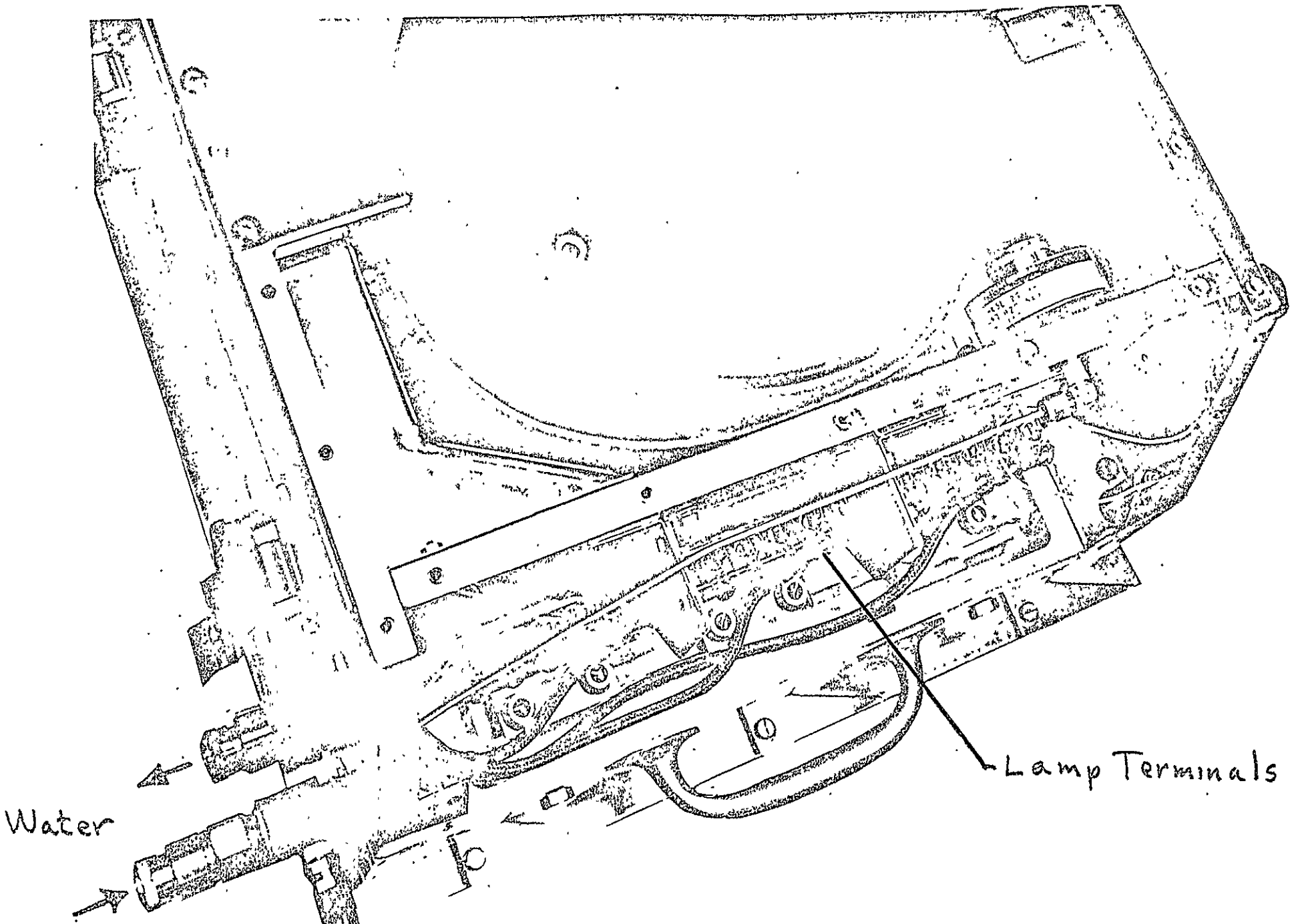


FIGURE 21 : DETAIL VIEW OF HIGH DENSITY HEATER

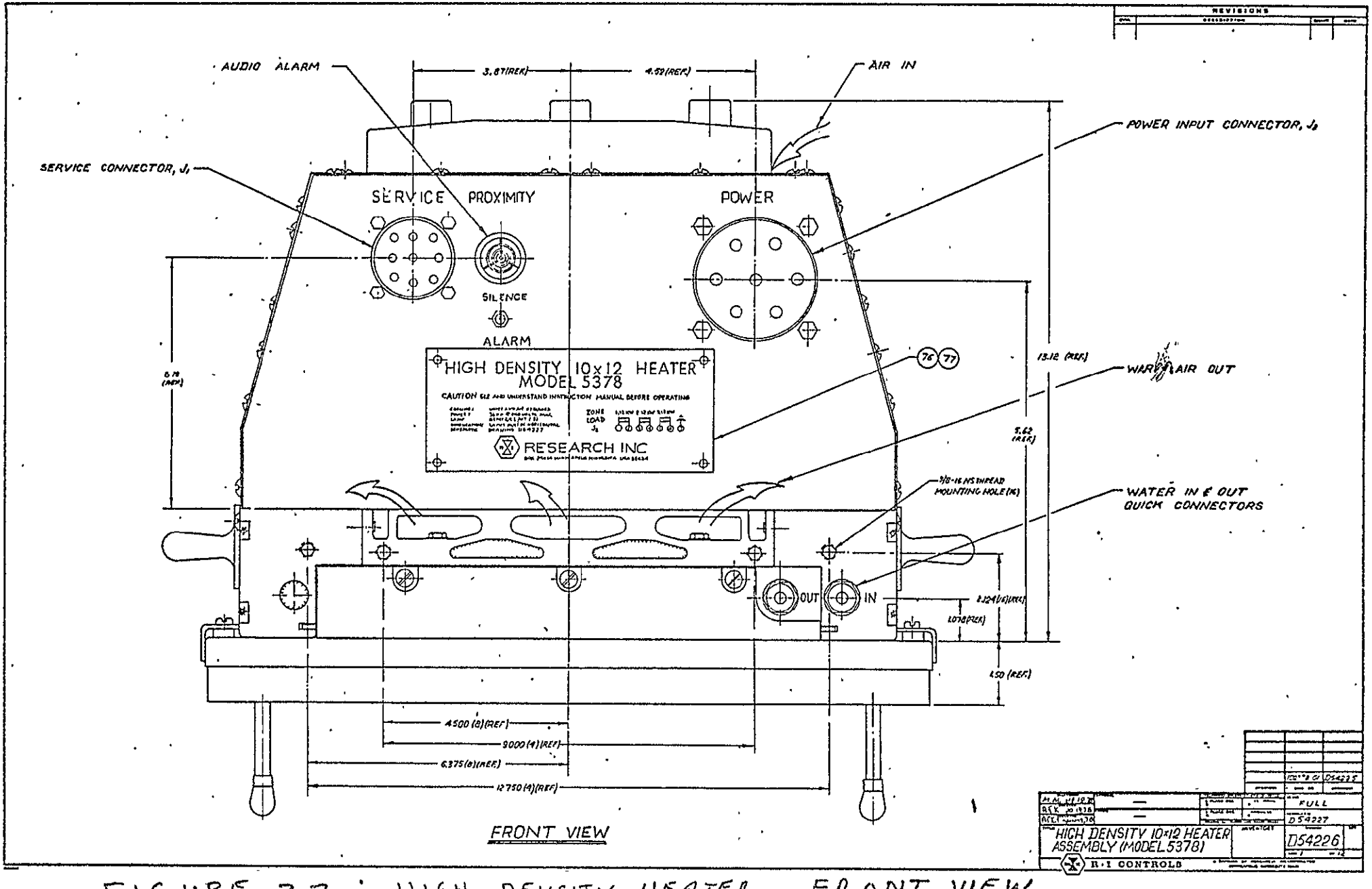


FIGURE 22 : HIGH DENSITY HEATER, FRONT VIEW

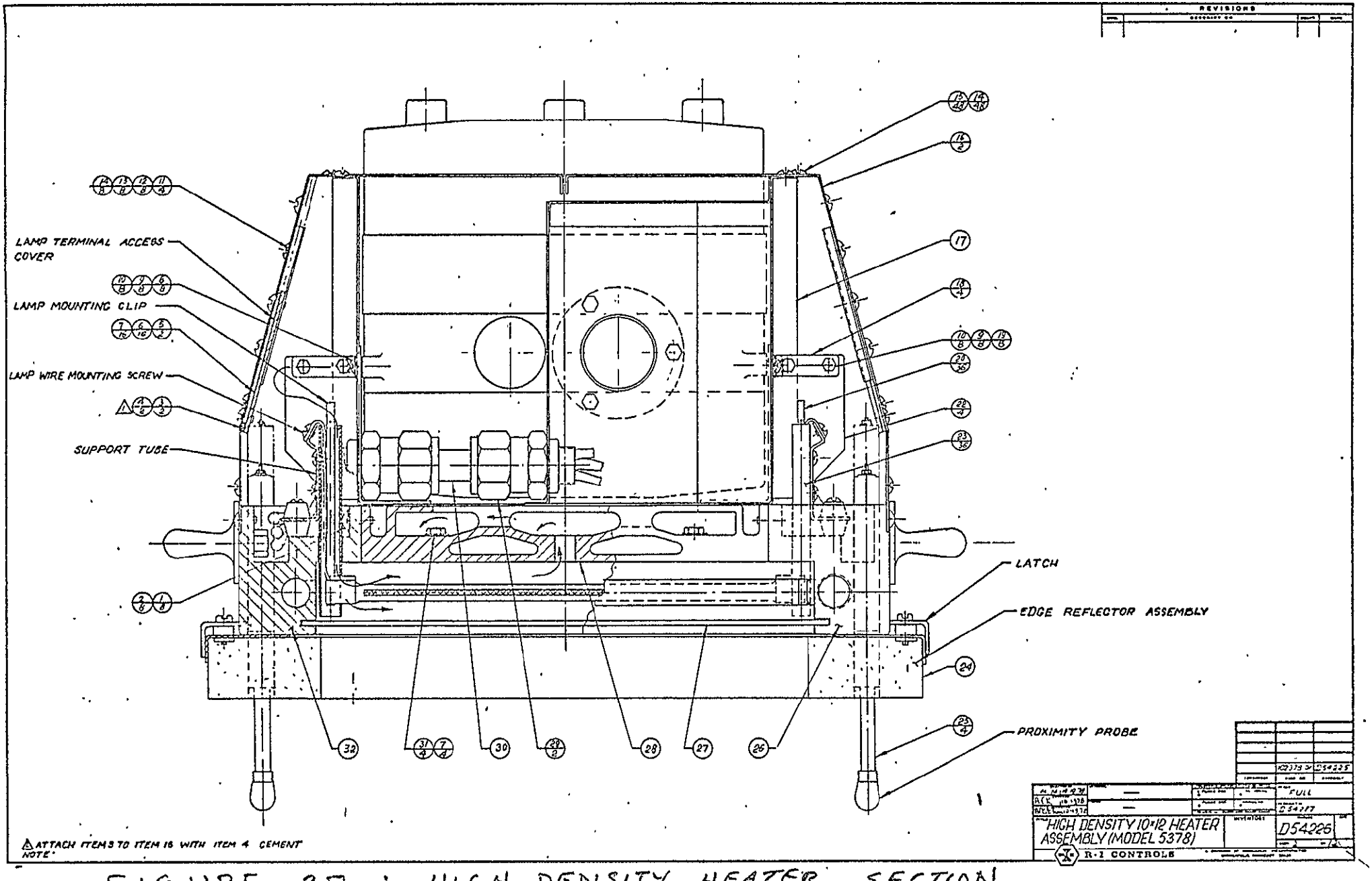
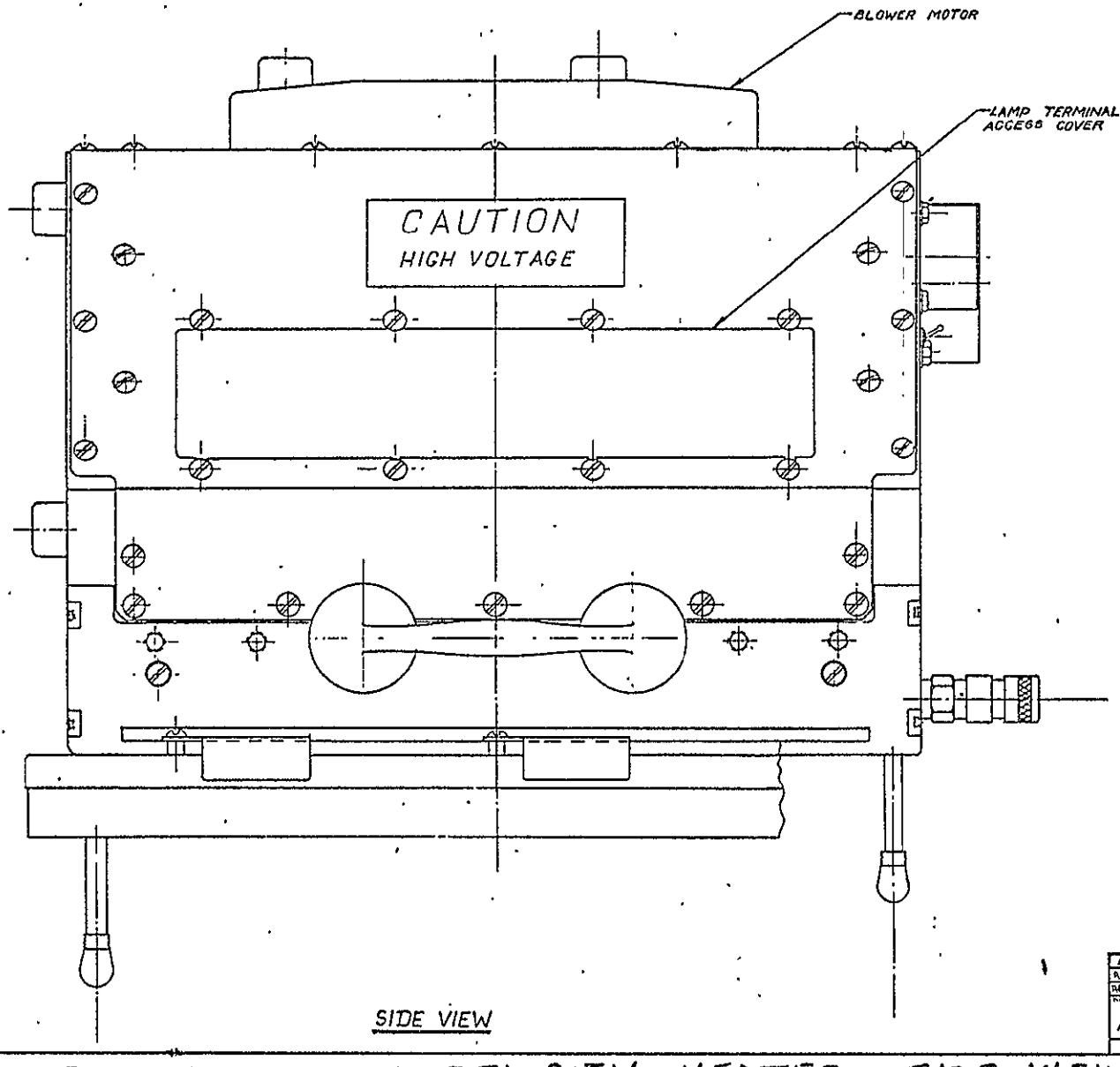


FIGURE 23 : HIGH DENSITY HEATER, SECTION



REVISIONS

HIGH DENSITY 10x12 HEATER ASSEMBLY (MODEL 5378)

D54226

R·I CONTROLS

FIGURE 24: HIGH DENSITY HEATER, SIDE VIEW

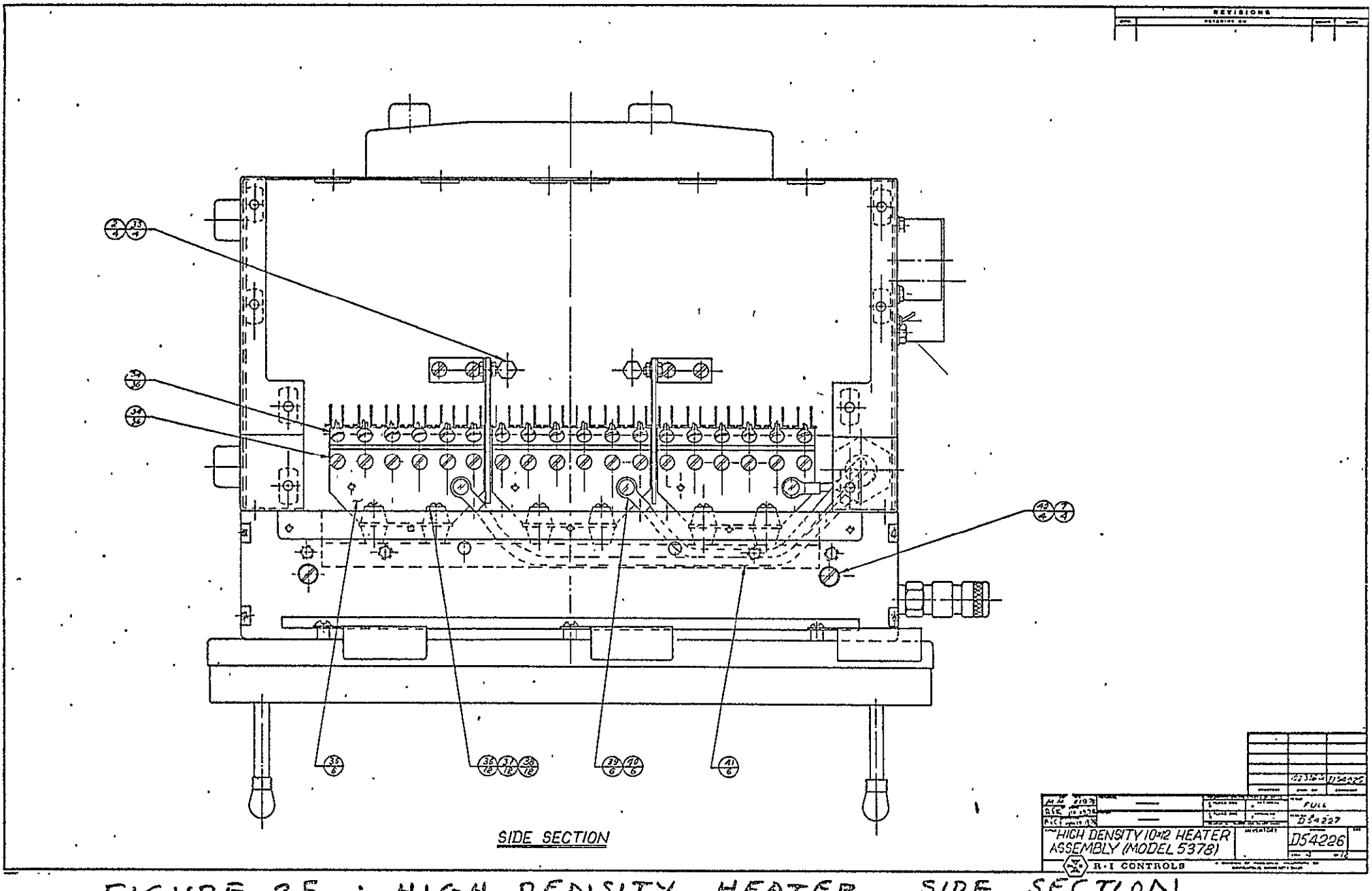
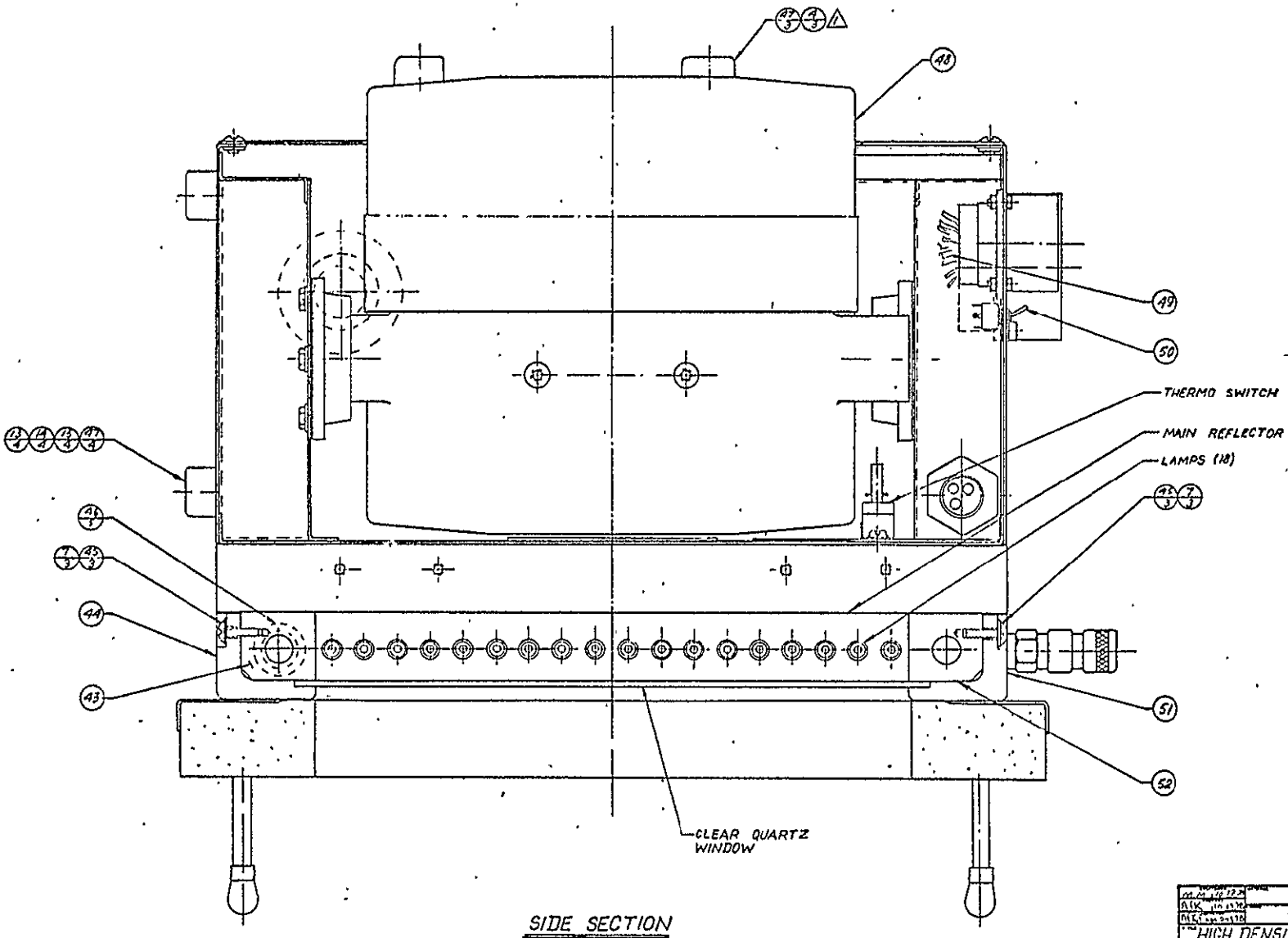


FIGURE 25 : HIGH DENSITY HEATER, SIDE SECTION



SIDE SECTION

△ CEMENT ITEM 47 TO ITEM 48 WITH ITEM 4 CEMENT.
NOTE.

HIGH DENSITY 10×12 HEATER ASSEMBLY (MODEL 5378)
R·I CONTROLS
D54226

FIGURE 26 : HIGH DENSITY HEATER, CENTER SIDE SECTION

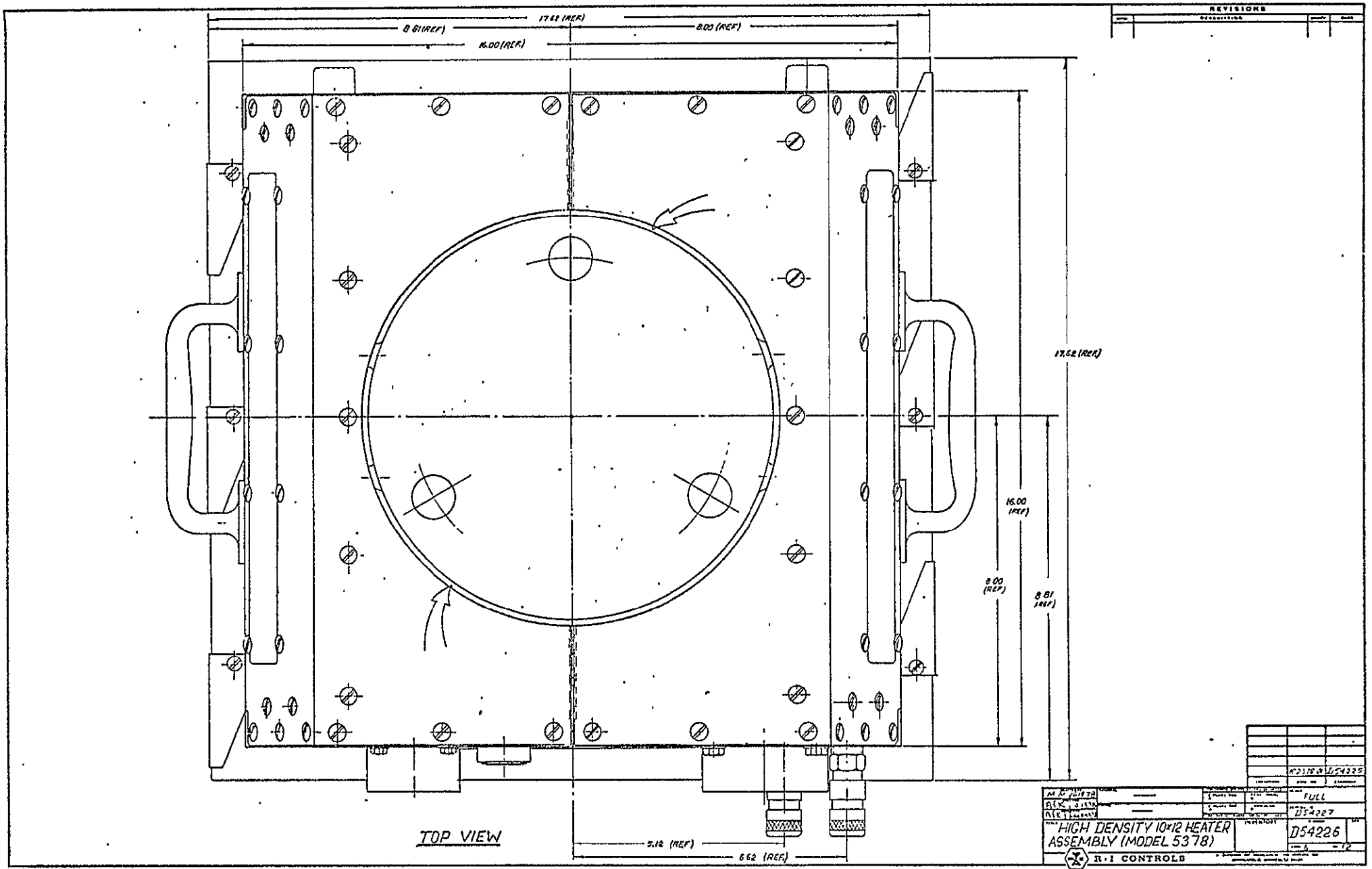


FIGURE 27 : HIGH DENSITY HEATER, TOP VIEW

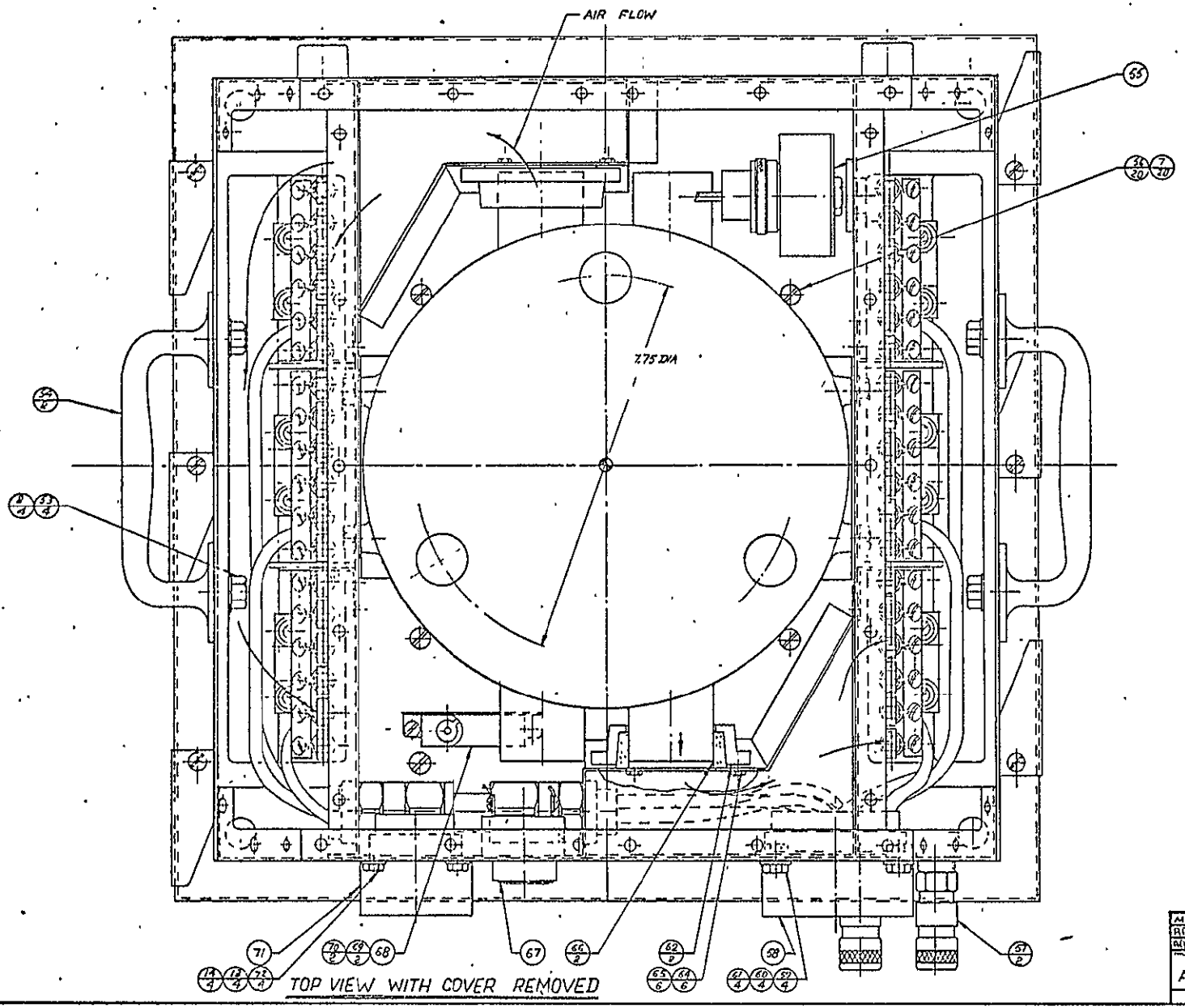


FIGURE 28: HIGH DENSITY HEATER, TOP VIEW WITH COVER REMOVED

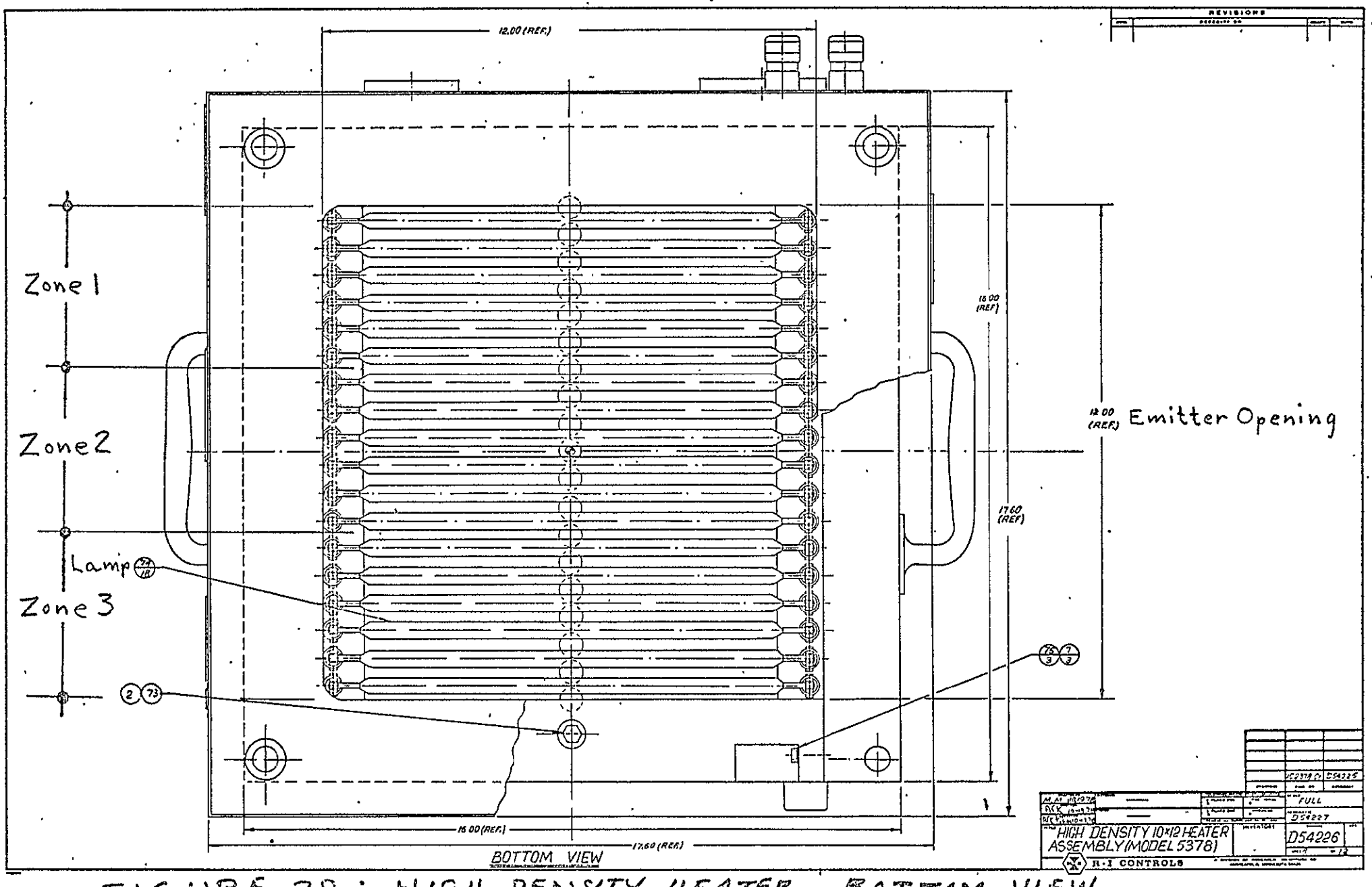


FIGURE 29 : HIGH DENSITY HEATER, BOTTOM VIEW

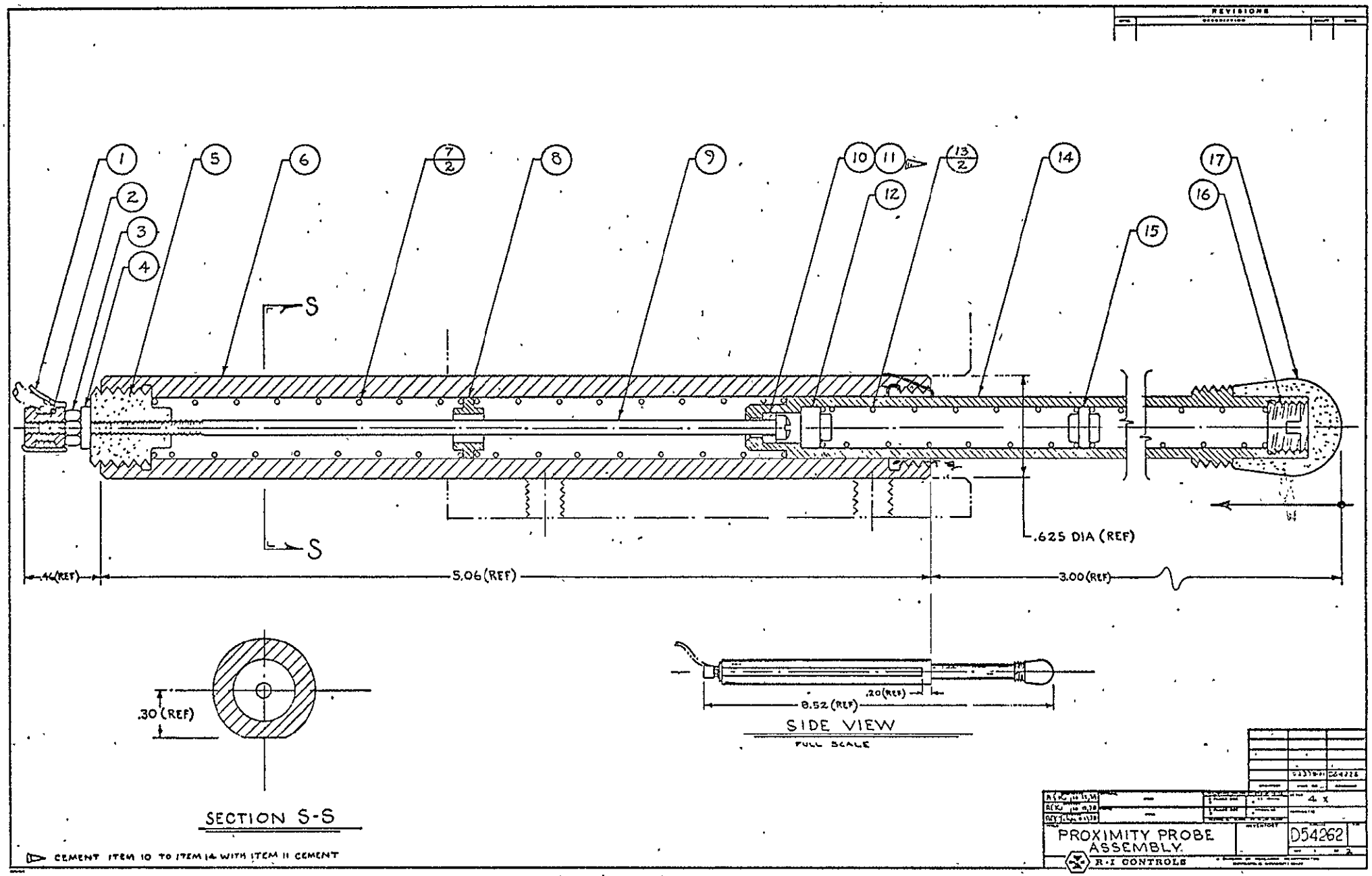


FIGURE 30 : PROXIMITY PROBE

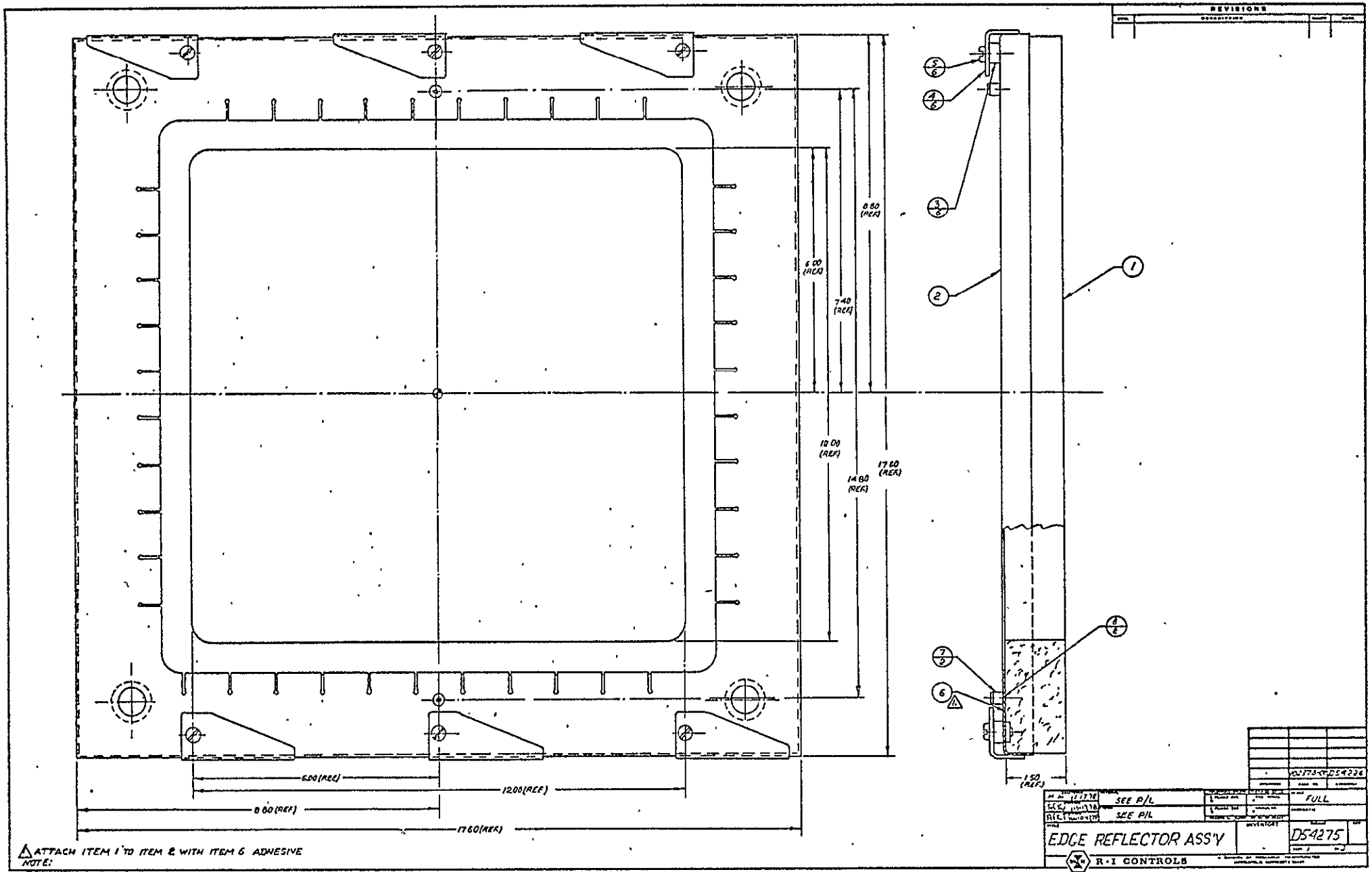
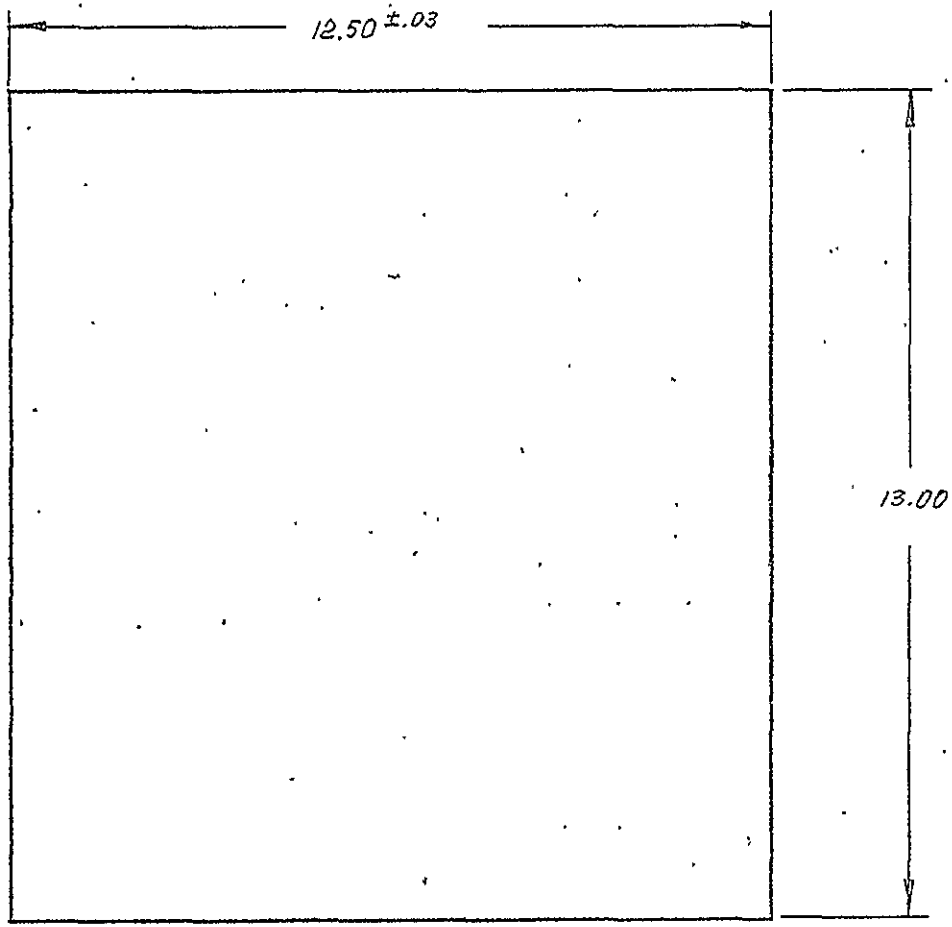
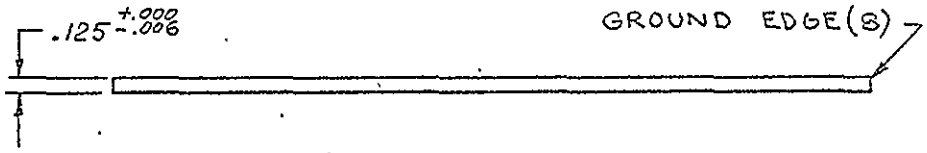


FIGURE 3.1 : EDGE REFLECTOR

REVISIONS			
SYM	DESCRIPTION	DRAFT	DATE
A	WINDOW WAS 13.00" □	M.M	3.15.79



1. MATERIAL: CLEAR FUSED QUARTZ PLATE
2. VENDOR: QUARTZ INTERNATIONAL CORP. 2999 SAN YSIDRO WAY, SANTA CLARA, CALIF 95051 (PHONE: 408 733 2100)



	102373-01	D54226
	INVENTORY	USED ON	ASSEMBLY

DRAFTSMAN M.M. 9.28.78	MATERIAL 1.	TOLERANCE UNLESS OTHERWISE NOTED ± PLACE DEC = FRACTIONAL =	SCALE HALF
CHECKED AFK 9-29-78	FINISH POLISH TOP & BOTTOM SURF	± PLACE DEC = ANGULAR ± 0°-5'	SCHEMATIC
APPROVED AFK 9-29-78	REMOVE ALL BURRS AND SHARP EDGES		
TITLE QUARTZ WINDOW		INVENTORY	NUMBER B53846 REV A
			SHEET 1 OF 1

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MINNEAPOLIS MINNESOTA 55424

FIGURE 32: QUARTZ WINDOW

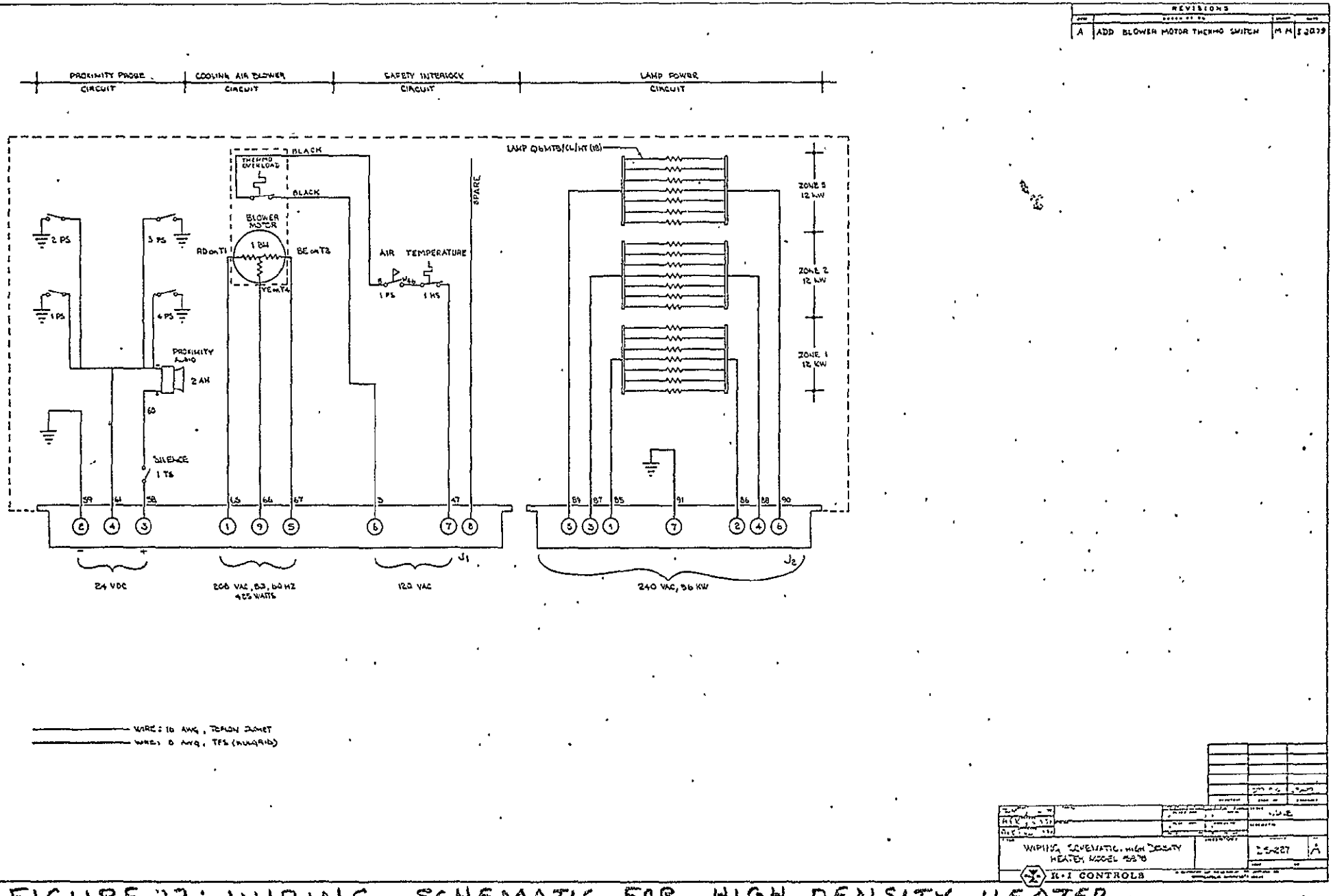

FIGURE 33: WIRING SCHEMATIC FOR HIGH DENSITY HEATER

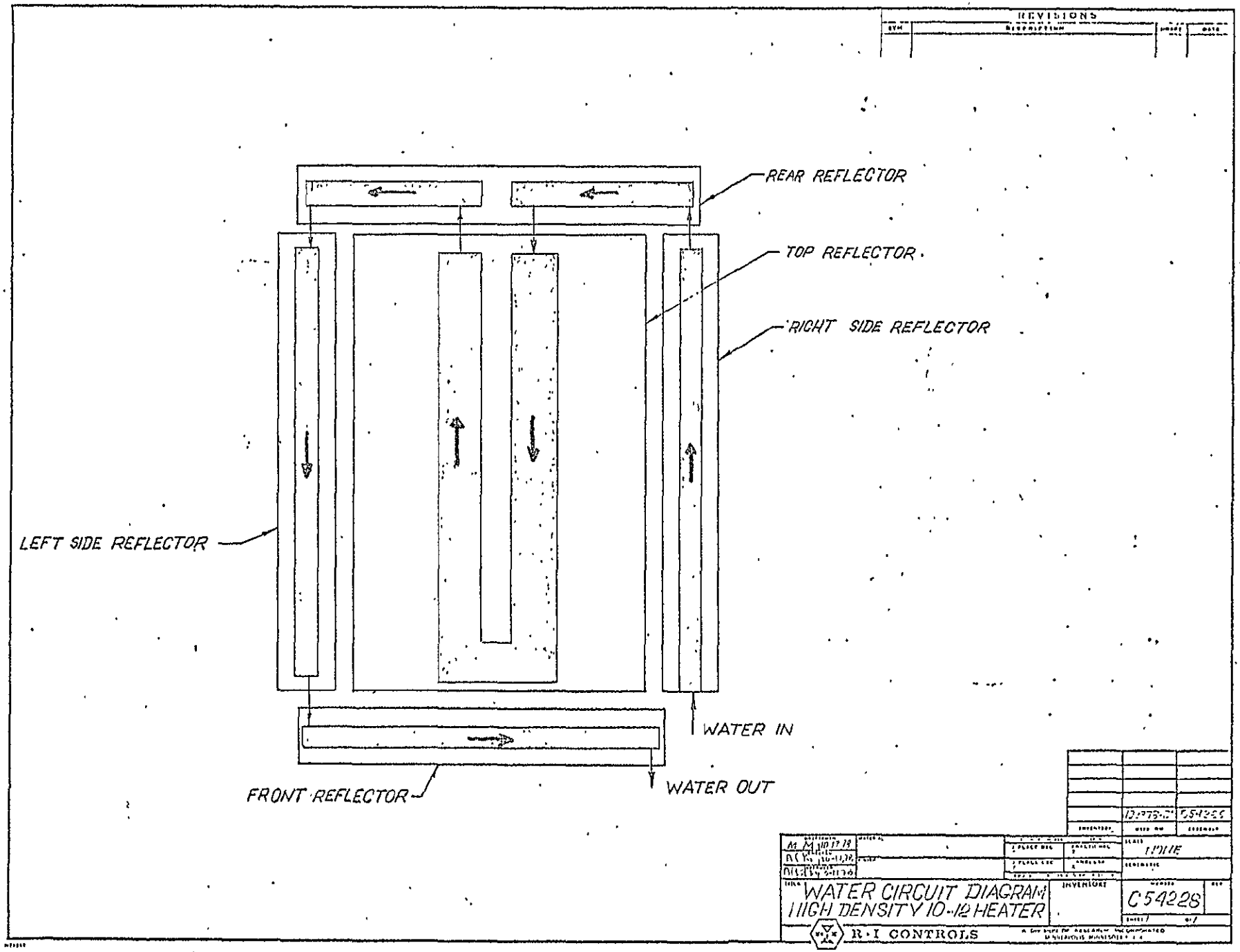

FIGURE 34: WATER CIRCUIT DIAGRAM OF HEATER

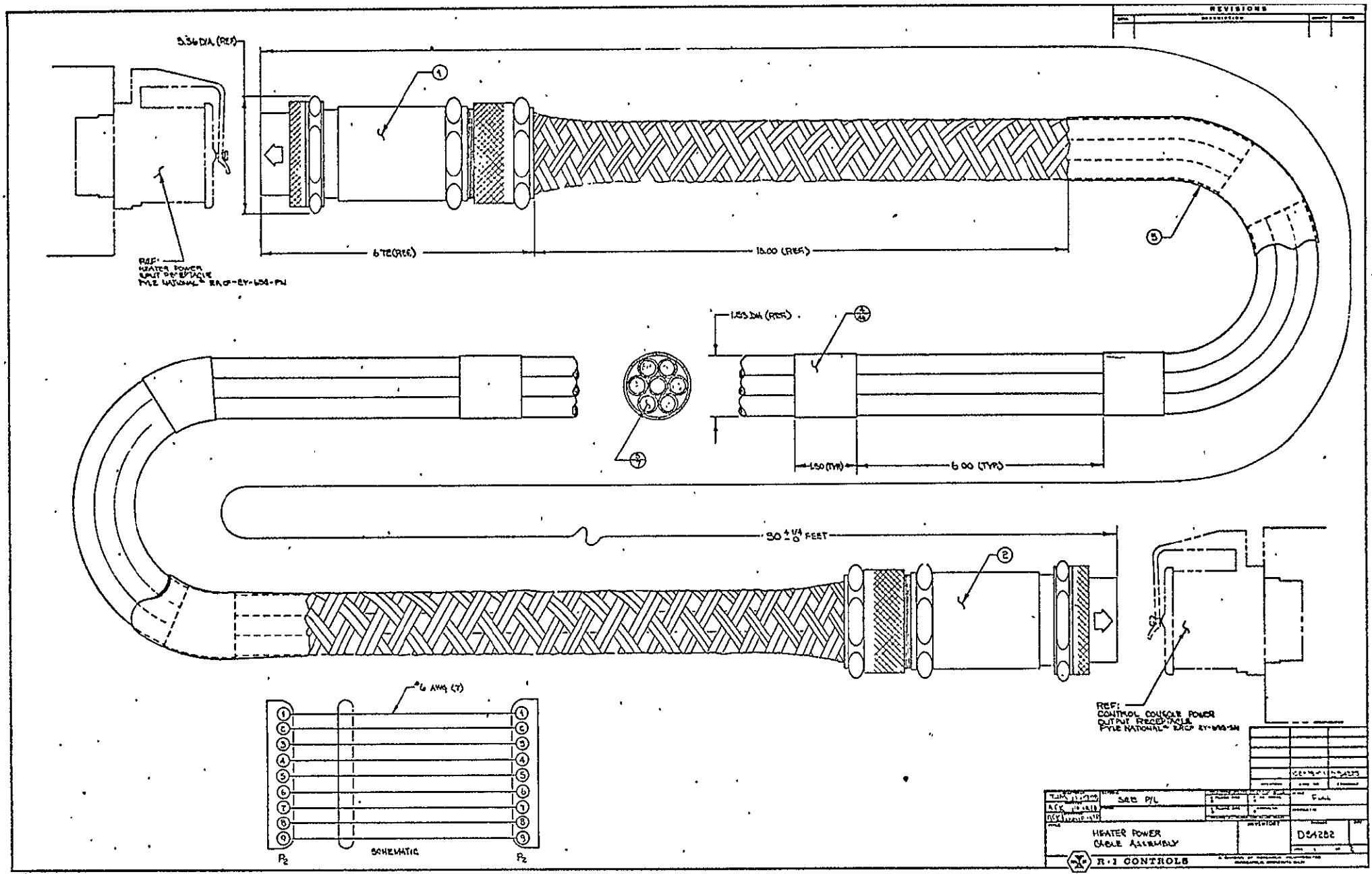

FIGURE 35 : HEATER POWER CABLE

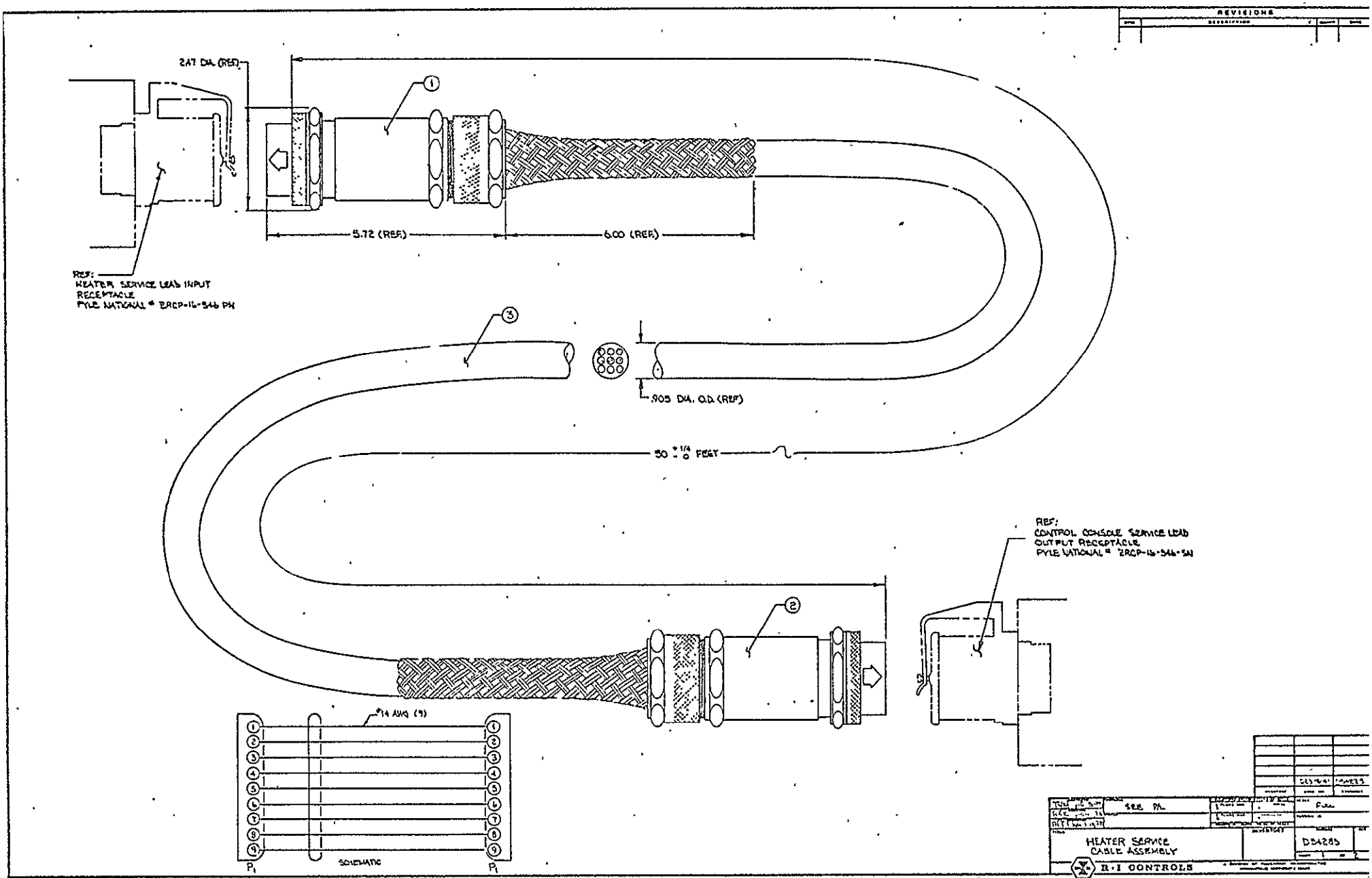

FIGURE 36 : HEATER SERVICE CABLE

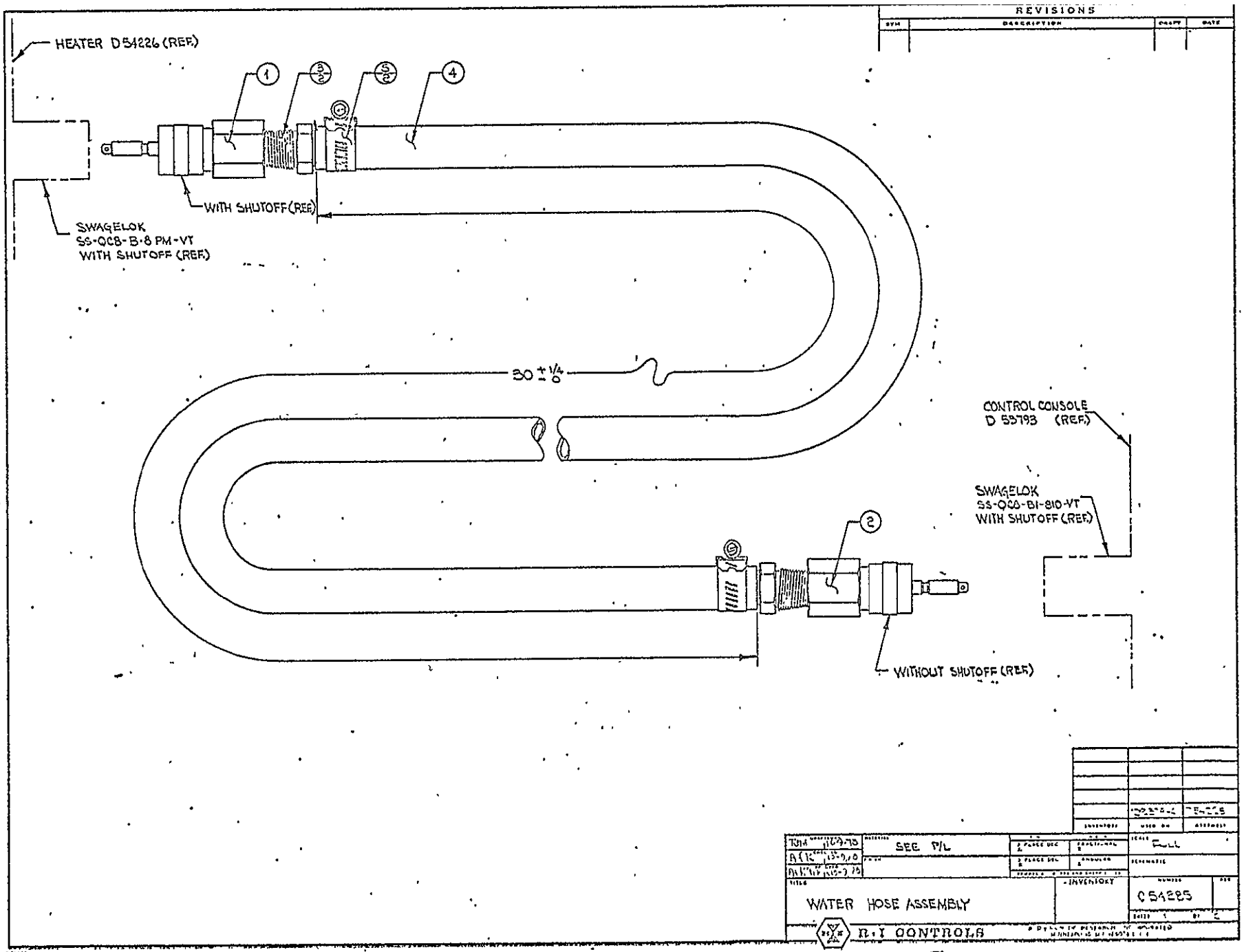

FIGURE 37 : WATER CONNECTION HOSE

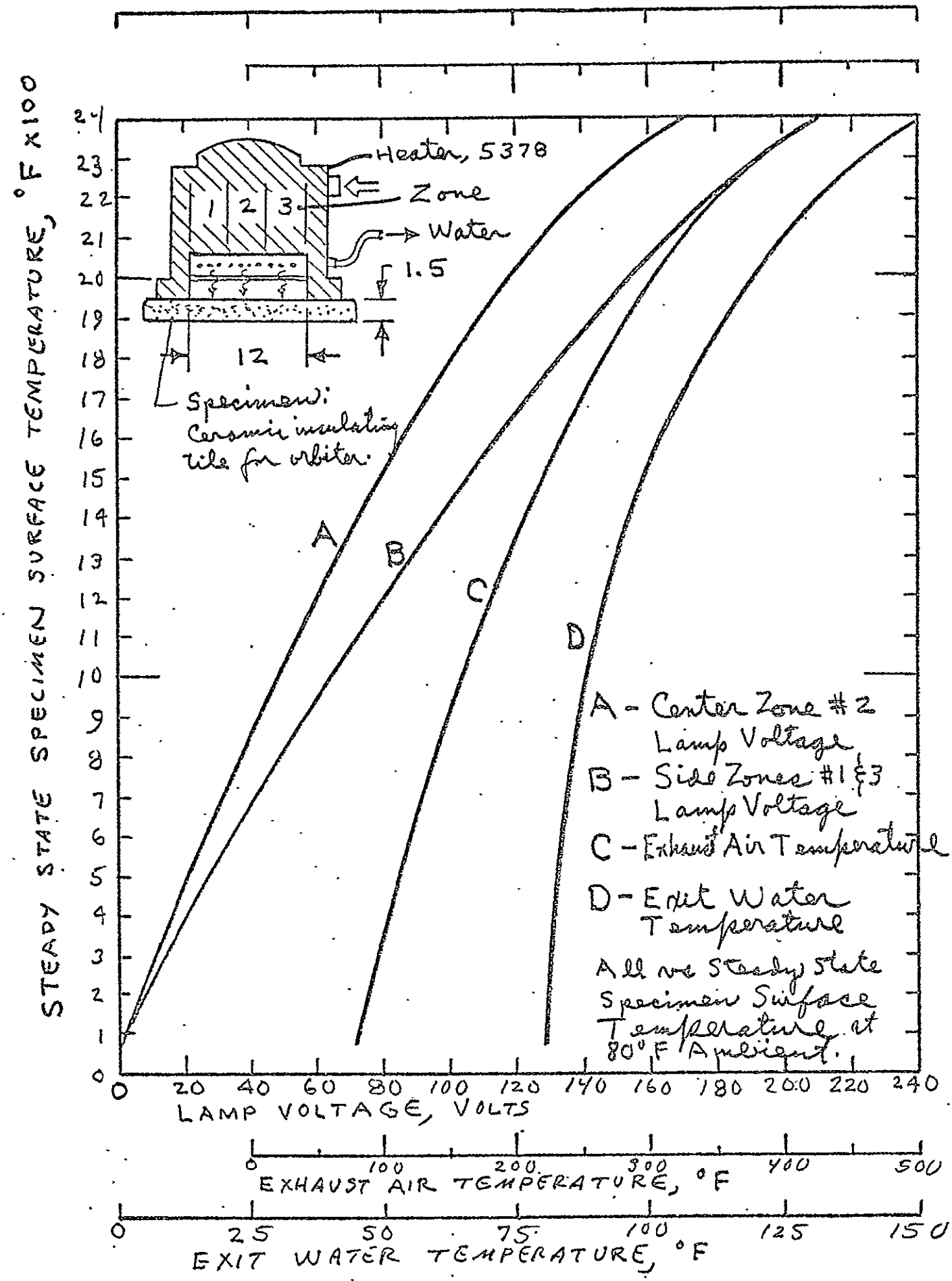

FIGURE 38: PERFORMANCE TEST DATA

Section 7

SYSTEM PARTS LIST

ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	J.O.	QTY.	P	PULL	DUE	STOCK	INVENTORY
21	RECORDER	WESTRONIC	M11E W/24	1							
20	RECEPTACLE	CROUSE HINDS	AR6642	1							
19	DOOR - 24.00 (Red Line)		KD22227-24	2							
18	FILLER BRACKET (Red Line)		B41595-2	1							
17	FILLER BRACKET (Red Line)		B41595-1	1							
16	SHELF UNIT		B17523	1							23B0134
15	SPACER SHELF (Red Line)		A19278	1							23B0221
14	RECORDER SHELF		B16130	2							23B0133
13	PANEL-MTG, 646		D53749	1							
12	BRKT-MTG, DISCONNECT SWITCH		C54169	1							
11	PANEL-SWITCH DISCONNECT 14.25		C54168	1							
10	PANEL-BLANK 22.75 (Red Line)		KB17510-22	1							
9	PANEL-BLANK 8.75 (Red Line)		KB17510-8	1							
8	PANEL-640 MTG. (Red Line)		KB41723	1							
7	ASSY-PANEL, CIRCUIT BREAKER		C53743	1							
6	ASSY-PANEL, METERS		C53741	1							
5	ASSY-RCP PANEL 3.50		B53745	1							
4	ASSY-MODEL FGE 5110		KD31112	1							
3	ASSY-MODEL 640.4		KA43060	3							
2	DIVIDER PLATE		C54310	1							
1	RACK-R4 (Red Line)		D54311-1	1							

DRAFTSMAN CDB | DATE | USED ON 102378

TITLE MOBILE CONTROL CONSOLE ASSEMBLY

INVENTORY NUMBER D53739 REV

RESEARCH INC MINNEAPOLIS MINNESOTA 55424

LIST OF MATERIALS

SHEET 3 OF 5

					J.O.		DUE
					QTY.		STOCK
42	COOLING SYSTEM ASSY	-	D54194	1			
41	T/C JACK PANEL	OMEGA	SJPI-12R	1			
*40	RECEPTACLE - 9 SOCKET	PYLE NAT'L	ZRCP-16-346 SN	1			
*39	STANDARD ADAPTER	"	ZP-2516-12	1			
*38	RECEPTACLE - 7 SOCKET	"	ZRCP-24-658 SN	1			
*37	STANDARD ADAPTER	PYLE NAT'L.	ZP-2524-12	1			
36	TRIM BAR, BOTTOM - TRIPLE RACK	(R/L)	B17506-3	1			23B0253
35	SIDE PANEL - LEFT, R4		D53748	1			
34	STEEL HOOK	AUSTIN HDWR.	164	1			
33	MODEL 646-P-240-100-CLA-SF 100		KD42578-3	3			3B1316
32	BLOWER	ROTRON	020188	1			
31	SIDE PANEL - CABINET		B54171	2			
30	FLOOR PANEL - CABINET		B54170	1			
29	FILTER SUPPORT		B42194	1			
28	FILTER PANEL		C54167	1			
27	SIDE PANEL - R4, RIGHT		D53747	1			
26	MOUNTING BRACKET - 646 PHASER		D44745	3			
25	TRANSFORMER 3Ø 480 V. TO 208/120 Y	SQ. D	15T2F	1			
24	TRANSFORMER 3Ø 480 Δ TO 240 Δ	SQ. D	45T6H	1			
23	FUSE BLOCK - ADAPTER KIT	A-B	1494F-C611	1			
22	DISCONNECT SWITCH	A-B	1494F-NF100	1			

ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	P	PULL	INVENTORY

DRAFTSMAN: CDB | USED ON: 102378 | TITLE: MOBILE CONTROL CONSOLE ASSEMBLY | INVENTORY | NUMBER: D53739 | REV

DATE

RESEARCH INC MINNEAPOLIS MINNESOTA 55424 — LIST OF MATERIALS — SHEET 4 OF 5

L26176

					J.O.		DUE
					QTY.		STOCK
63	RACK - R4 (Red Line)		D54311-3	1			
62	RACK - R4 (Red LINE)		D54311-2	1			
61	FUSE HOLDER - 600 V 30A 3 POLE	MARATHON	6F30A3S	1			
60	TRANSFORMER 480/240-120 50VA	RI	KA47366	3			7B0224
59	RELAY PANEL ASSY		B54191	1			
58	DOOR HANDLE W/Lock	NATIONAL	68-0340 -CHR292	4			23B0217
57	MOBILE BASE ASSY		D54358	1			
56							
55	SHOCK MOUNTS	BARRY	633A-130	3			
54	MAST SUPPORT BRACKET		C54188	1			
53	DOOR - PLAIN (Red Line) 37.25		D22228-37	1			
52	DOOR - PLAIN (Red Line) 52.50		D22228-52	1			
51	VENT PANEL - LOUVERED 4.37		KB17538	4			23B0123
50	PLATE - LIFT COVER, ALUM.	HUBBELL	5211	1			
49	NAME PLATE - LEFT SIDE PANEL		B54179	1			
48	FUSE 100 A 600 V	BUSS	FRS-100	3			
47	FUSE - 20A, 600V	BUSS	FRS-20	3			
46	LIFT COVER PLATE,	HUBBELL	74CM25	1			
45	RECEPTACLE, 20A.	HUBBELL	2310	1			
44	RECEPTACLE, DUPLEX 20 A.	HUBBELL	5362	1			
43	CIRCUIT BREAKER, 20 AMP	ITE	EE1-B020	1			

ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	P	PULL	INVENTORY

DRAFTSMAN	USED ON	TITLE	INVENTORY	NUMBER	REV
CDB	102378	MOBILE CONTROL CONSOLE ASSEMBLY		D53739	
DATE					

RESEARCH INC MINNEAPOLIS, MINNESOTA 55424 — LIST OF MATERIALS — SHEET 5 OF 5

L26176

					J.O.		DUE
					QTY.		STOCK
16	INDICATOR AMBER	A-B	800T-P16A	1			
15	SWITCH - SELECTOR	A-B	800T-H26	1			
14	KNOB		A42701	2			SA0284
13	NAMEPLATE - VOLTMETER SELECT		B50131-27	1			
12	NAMEPLATE - AMMETER SELECT		B50131-25	1			
11	ROTARY SWITCH, 3 POL NON-SHORTING	CENTRALAB	2507	1			
10	ROTARY SWITCH, 3 POL SHORTING	CENTRALAB	2506	1			
9	METER, 0-150 WITH 0-300 VAC Scale (MODEL 1359)	Simpson	10320	1			
8	METER, 0-5 AC Amps W/ 0-75 AC Amp Scale	SIMPSON	03300	1			
7	LEGEND PLATE	RI	B54190	1			
6	INDICATOR GREEN	A-B	800T-P16G	5			
5	" RED	"	800T-P16R	2			
4	INDICATOR WHITE	"	800T-P16W	1			
3	SWITCH	A-B	800T-A2A	2			
2	SONALERT	Mallory	SC110N	1			
1	PANEL - METER		C53742	1			

ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	P	PULL	INVENTORY

DRAFTSMAN	USED ON	TITLE	INVENTORY	NUMBER	REV
CDB	102378	ASSY- METER PANEL		C53741	
DATE 9-21-78					

RESEARCH INC MINNEAPOLIS, MINNESOTA 55424 — LIST OF MATERIALS — SHEET 2 OF 2

L26176

J.O.	DUE
QTY.	STOCK

ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	P	PULL	INVENTORY
6	NAME PLATES	RI	B54172	1			
5	PANEL - CIRCUIT BREAKER	RI	C53744	1			
4	CIRCUIT BREAKER 60 AMP W/ 120 VAC SHUNT TRIP	ITE	EF3-B060	1			
3	CIRCUIT BREAKER 20 AMP	ITE	EF3-B020	1			
2	〃 〃 20 AMP	〃	EE1-B020	1			
1	CIRCUIT BREAKER 15 AMP	ITE	EE1-B015	2			

DRAFTSMAN	USED ON	TITLE	INVENTORY	NUMBER	REV
CDB	102378	ASSY - PANEL, CIRCUIT BREAKER		C53743	
DATE 9-22-78					

RESEARCH INC MINNEAPOLIS, MINNESOTA 55424 — LIST OF MATERIALS — SHEET 2 OF 2

L26176

ITEM	DESCRIPTION	MFR.	PART NO.	QUANTITY 1	2	3	4	5	6	P	PULL	INVENTORY
										J.O.		DUE
										QTY.		STOCK
14	KEPNUT 6-32 NC			6	6							
13	SNAP HOLE PLUG 1¼	CINCH	91H		1							
12	SWITCH - PUSH BUTTON, RED WITH EMERG.- STOP NAMEPLATE	ALLEN BRADLEY	800TDGA	1								
11	LEGEND PLATE	〃	B 54192	1	1							
10	MARKER STRIP	JONES	MS16-190	1	1							
9	BARRIER STRIP	JONES	16-190	1	1							
8	SWITCH - RED	ALLEN BRADLEY	800TA6A	1	1							9A118
7	SWITCH - BLACK	ALLEN BRADLEY	800TA2A	1	1							9A117
6	INDICATOR - GREEN	〃	800T-P16G	1	1							
5	INDICATOR - WHITE	〃	800T-P16W	1	1							
4	RELAY SOCKET	P&B	9KH1	1	1							5A206
3	RELAY K1 120 VAC	P&B	KHP17A11	1	1							26A105
2	MOUNTING BRACKET	RI	B37984	1	1							
1	PANEL-RUN CONTROL	RI	B38911	1	1							

RUN CONTROL PANEL W/E STOP — 1
RUN CONTROL PANEL WO/E STOP — 2
3
4
5
6

DRAFTSMAN	USED ON	TITLE	INVENTORY	NUMBER	REV
CDB	102378	RUN CONTROL PANEL		B53745	
DATE 10-17-78					

R·I CONTROLS — A DIVISION OF RESEARCH, INCORPORATED, MINNEAPOLIS MINNESOTA 55424 — LIST OF MATERIALS — SHEET 2 OF 3

					J.O.	DUE
					QTY.	STOCK
17	LOCKING COVER	A-B	800T-N18	1		
16	SCREW - FLT. HD. 100° 6-32 NC x 3/8			6		
15	SCREW - TRUSS 6-32 NC x 1/2			6		
ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	P PULL	INVENTORY

DRAFTSMAN	USED ON	TITLE	INVENTORY	NUMBER	REV
DATE		RUN CONTROL PANEL		B53745	

R·I CONTROLS — A DIVISION OF RESEARCH, INCORPORATED, MINNEAPOLIS, MINNESOTA 55424

LIST OF MATERIALS

SHEET 3 OF 3

					J.O.		DUE
					QTY.		STOCK
21							
20	Piping schematic for cooling system	RI	B54365	.1			
19	Flow indicator name tag	RI	A56148-3	1			
18	Heater temp name tag	RI	A56148-1	1			
17	Reservoir temp name tag	RI	A56148-2	1			
16	Reservoir level gauge	RI	A56147	1			
15	Clip - vent panel	RI	KB17536-2	31			
14	Clip - vent panel	RI	KB17536-1	31			
13	Aluminum vent panel	RI	KB17539	11			23B0124
12	Aluminum vent panel	RI	KB17538	1			
11	Aluminum vent panel (red line) 3.00	RI	KB17538	1			
10	Vent panel weldment	RI	C54323	1			
9	Panel - indicator	RI	C54318	1			
8	Support angle - reservoir	RI	A49822	1			
7	Strap - reservoir restraint	RI	A54174	2			
6	Panel reservoir mtg	RI	C54173	1			
5	Reservoir assy	RI	B54286	1			
4	Floor panel - cabinet	RI	B54170	1			
3	Pump 3/4 HP teel close - coupled	Grainger	1P789	1			
2	Heat exchanger	Astrodyne	5430-BNZ	1			
1	Heat exchanger	Astrodyne	5360-BNZ	2			

ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	.P	PULL	INVENTORY

DRAFTSMAN: WL | USED ON | TITLE: COOLING SYSTEM ASSY | INVENTORY | NUMBER: D54194 | REV: A

DATE: 5/7/79

RESEARCH INC MINNEAPOLIS, MINNESOTA 55424 | LIST OF MATERIALS | SHEET 2 OF 4

L26176

					J.O.		DUE
					QTY.		STOCK
42	Sight tube: clear rigid 3/8 OD w/1-16" wall	Precision Punch	R-1	A/R			(20 inches)
41	Hose: pump input 3/4" ID	Imperial Eastman	U412	A/R			(4 ft)
40	Hose: cooling system 1/2" ID	"	U408	A/R			(100 ft)
39	Hose: sight gauge 3/8" ID	"	U406	A/R			(5 ft)
38	Temperature gage 0° - 150°F	Mueller	8544-153	1			Order
37	Temperature gage 60° - 260°F	"	8544-152	1			
36	Flow switch 0.5 to 20 GPM range	Harfiel	FS-10798-25363	1			
35	Flow indicator - visual, black color	"	FI-100	1			
34	Coupling - hex	MN Valve & Fittings	B-8-HCG	1			
33	Street tee	"	B-8-St	1			
32	Reducing bushing 3/4 to 1/2	"	B-12-RB-8	1			
31	Reducing bushing 1 to 3/4	"	B-16-RB-12	1			
30	Hose connector - female 3/8"	"	B-6-FHC-6S	2			
29	Male hose connector - serrated 3/4 to 3/4	"	B-12-MHC-12S	1			
28	Male hose connector - serrated 1/2 to 1/2	"	B-8-MHC-8S	4			
27	Tube - male pipe (conversion)	"	B-8-TA-1-8	2			
26	Nipple - hex	"	B-8-HN	1			
25	Nipple - hex long 2.00 inches	"	B-8-HLN-2.0	2			
24	Elbow	"	B-8-E	2			
23	Tee	"	B-8-T	1			
22	Quick connect bulkhead swaglok w/viton	"	SS-QC8-B1-810-VT	2			
ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	P	PULL	INVENTORY

DRAFTSMAN	USED ON	TITLE	INVENTORY	NUMBER	REV
WL		COOLING SYSTEM ASSY	-	D54194	A
DATE 5/7/79					

RESEARCH INC MINNEAPOLIS MINNESOTA 55424 — LIST OF MATERIALS — SHEET 3 OF 4

L26176

					J.O.		DUE
					QTY.		STOCK
45	Male elbow: parker - fast & tite	Quest Gng	P6ME6	2			
44	Hose clamps	Ideal	5016	2			
43	Hose clamps	Ideal	5008	30			

ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	P	PULL	INVENTORY

DRAFTSMAN	USED ON	TITLE	INVENTORY	NUMBER	REV
WL		COOLING SYSTEM ASSY		D54194	A
5/79					

RESEARCH INC MINNEAPOLIS, MINNESOTA 55424 — LIST OF MATERIALS — SHEET 4 OF 4

L26176

					J.O.		DUE
					QTY.		STOCK
5	MOBILE CONTROL CONSOLE ASSEMBLY	R.I.	D53739	1			
4	WATER HOSE ASSEMBLY	R.I.	C54285	2			
3	HEATER POWER CABLE ASSEMBLY	R.I.	D54282	1			
2	HEATER SERVICE CABLE ASSEMBLY	R.I.	D54283	1			
1	HIGH DENSITY 10 x 12 HEATER ASSEMBLY	R.I.	D54226	1			
ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	P	PULL	INVENTORY

DRAFTSMAN	USED ON	TITLE	INVENTORY	NUMBER	REV
9/18/78		MOBILE TILE GLAZING SYSTEM ASSEMBLY		D54225	

RESEARCH INC MINNEAPOLIS, MINNESOTA 55424 — LIST OF MATERIALS — SHEET 2 OF 2

L26176

						J.O.		DUE
						QTY.		STOCK
21								
20	CLIP, LAMP MOUNTING ASSEMBLY	2	R.I.	A 54245	36			
19	SCREW - HEX HD, #8-32 x 1/2, SST	2			8			2C0750
18	MOUNTING BRACKET	2	R.I.	A54258	4			
17	OUTTER CASE WELDMENT ASSEMBLY	2	R.I.	D54229	1			
16	COVER	2	R.I.	D54248	2			
15	SCREW - TRUSS HD, #10-32 x 3/4, SST	2			52			2C0223
14	WASHER - FLAT, #10	2			64			2C0130
13	NUT - HEX, #10-32, SST	2			12			2C0343
12	SCREW - TRUSS HD, #10-32 x 1/2, SST	2			12			2C0220
11	DOOR GUIDE	2	R.I.	A54260	4			
10	NUT - HEX, #8-32, SST	2			16			2C0336
9	WASHER - FLAT, #8, SST	2			16			2C0579
8	SCREW - TRUSS HD, #8-32 x 3/8, SST	2			8			2C0210
7	WASHER - SPLITLOCK, #10, SST	2			53			2C0183
6	SCREW - PAN HD, #10-32 x 3/8, SST	2			16			
5	ACCESS DOOR	2	R.I.	B 54249	2			
4	CEMENT - CONTACT (PERMABOND), DAB	2	PEARL CHEM. CO.	747	5			
3	RUBBER SEAL	2	R.I.	B54253	2			
2	WASHER - SPLITLOCK, 1/4	2			18			2C0186
1	SCREW - TRUSS HD, 1/4-20 x 3/4, SST	2			8			2C0232

ITEM	DESCRIPTION	SHEET	MFR.	PART NO.	QTY.	P	PULL	INVENTORY

DRAFTSMAN: M. M
DATE: 10.19.78
USED ON: 102378-01
TITLE: HIGH DENSITY 10x12 HEATER ASSEMBLY (MODEL 5378)
INVENTORY:
NUMBER: D54226
REV: A

R·I CONTROLS — A DIVISION OF RESEARCH, INCORPORATED, MINNEAPOLIS, MINNESOTA 55424

LIST OF MATERIALS

SHEET 9 OF 13

L26176

ITEM	DESCRIPTION	SHEET	MFR.	PART NO.	QTY.	P	PULL	INVENTORY
42	SCREW-TRUSS HD, #10-32×2½, SST	4			4			2C0456
41	WIRE 8 AWG, TFS, KULGRID, 3 FT LNG	4			6			
40	LUG - COMP, #8 WIRE, 1/4 STUD	4	BURNDY	YAV8C-L1	6			13C0136
39	SCREW- TRUSS HD, #10-32×1/4, SST	4			6			2C0219
38	SCREW- TRUSS HD, #6-32×1 1/8, SST	4			12			2C0359
37	CERAMIC BUSHING - FEMALE	4	AMERICAN LAWA	NS5W-4202	12			5A0171
36	CERAMIC BUSHING - MALE	4	AMERICAN LAWA	NS5W-4102	12			5A0169
35	BUS BAR ASS'Y	4	R.I.	B54296	6			
34	SCREW-TRUSS HD, #8-32×1/4, SST	4			72			2C0208
33	SCREW-HEX HD, 1/4-20×3/8, SST	4			4			
32	LEFT SIDE REFLECTOR WELDMENT ASS'Y	2	R.I.	D54241	1			2C0160
31	SCREW-HEX HD, #10-32×7/8	2			4			
30	TUBING, SST, 3/4 O.D., .049 WALL THICK., 5¼" LGTH	2			1			
29	CABLE SEALING GRIP; DBS SERIES DB	2	PYLE NATIONAL	3/4" SIZE	2			
28	TOP REFLECTOR WELDMENT ASSEMBLY	2	R.I.	D54238	1			
27	QUARTZ WINDOW	2	R.I.	B53846	1			
26	RIGHT SIDE REFLECTOR WELDMENT ASS'Y	2	R.I.	D54243	1	1		
25	PROXIMITY PROBE ASSEMBLY	2	R.I.	D54262	4			
24	EDGE REFLECTOR ASSEMBLY	2	R.I.	D54275	1			
23	SUPPORT TUBE	2	R.I.	A54257	36			
22	ZONE DIVIDER	2	R.I.	A54259	4			

J.O. | DUE | QTY. | STOCK

DRAFTSMAN: M. M.
DATE: 10.19.78
USED ON: 102378-01
TITLE: HIGH DENSITY 10×12 HEATER ASSEMBLY (MODEL 5378)
INVENTORY:
NUMBER: D54226
REV: A

R·I CONTROLS — A DIVISION OF RESEARCH, INCORPORATED, MINNEAPOLIS MINNESOTA 55424

LIST OF MATERIALS

SHEET 10 OF 13

L26176

						J.O.		DUE
						QTY.		STOCK
63	SCREW - HEX HD, 1/4-20x1, SST	7			1			2C0164
62	BUSHING - SEAL	7	R.I.	B54252	2			
61	NUT - HEX, 1/4-20, SST	7			4			2C0276
60	WASHER - FLAT, 1/4, SST	7			4			2C0692
59	SCREW - HEX HD, 1/4 - 20 x 7/8, SST	7			3			2C0693
58	SQUARE FLANGE PANEL MOUNT RECEPTACLE, 7#4 AWG PINS, WITH HINGED SPRING DOOR	7	PYLE NATIONAL	ZRCP-24-658 PN	1			
57	QUICK-CONNECT, MALE PIPE, SHUT OFF	7	SWAGELOK	SS-QC8-B-8PM-UT	2			
56	SCREW - TRUSS HD, #10-32 x 3/8, SST	7			20			2C0127
55	SENSITIVE CAPSOLE PRESSURE SWITCH	7	WHITMAN GENERAL	L110G-1-N-K4L	1			
54	HANDLE-PULL, SOLID CAST ALUM, OPP SIDE ATTACH	7	McMASTER CARR	1402A19	2			
53	SCREW - HEX HD, 1/4-20 x 3/4, SST	7			4			2C0163
52	FRONT REFLECTOR - WELDMENT ASS'Y	5	R.I.	C54244	1			
51	RETAINER BAR - FRONT	5	R.I.	C54250	1			
50	SWITCH - TOGGLE, SPOT	5	ALLIED CONTROLS	TS-3	1			9A0106
49	WIRE 16AWG, TEFLON JACKET	.5			10 FT			
48	HIGH PRESSURE BLOWER - SPIRAL DUPLEX, MODEL SL6A335, SERIES 927 Z7, 280/230V, 3PH, 50/60HZ	5	ROTRON INC	SL6A33F	1			
47	RUBBER FOOD	5			7			5C0101
46	O RING, .799 I.D., .103 SECTION, SILICONE COMP.	5	FEDERAL MOGUL CO.	AS568-117S59	5			
45	SCREW - TRUSS HD, #10-32 x 5/8, SST	5			6			2C0221
44	RETAINER BAR - REAR	5	R.I.	C54251	1			
43	REAR REFLECTOR	5	R.I.	D54247	1			

ITEM	DESCRIPTION	SHEET	MFR.	PART NO.	QTY.	P	PULL	INVENTORY

DRAFTSMAN	USED ON	TITLE	INVENTORY	NUMBER	REV
M. M	102378-81	HIGH DENSITY 10x12 HEATER ASSEMBLY (MODEL 5378)		D54226	A
DATE 10.19.78					

RESEARCH INC MINNEAPOLIS, MINNESOTA 55424 — LIST OF MATERIALS — SHEET 11 OF 13

ITEM	DESCRIPTION	SHEET	MFR.	PART NO.	QTY.	P	PULL	INVENTORY
84	PITOT TUBE	2	R.I.	B54223	1			
83	WASHER, FLAT, #6, SST							2C0176
82	NUT- HEX, #6-32, SST	4						2C0133
81	SCREW-TRUSS HD, #6-32 x 5/16, SST	4						2C0196
80	REFLECTOR SHIELD	1	R.I.	A54593				
79	INSULATION	1	R.I.	A54594				
78	CLIP	2	R.I.	A54595				
77	NAME PLATE	1	R.I.	B54255	1			
76	PLATE	1	R.I.	B54256	1			
75	SCREW - HEX SOCKET HD, #10-32x1/4, SST	8			3			
74	LAMP - TUBULAR QUARTZ	8	GE	Q6MT3/CL/HT	18			
73	SCREW - HEX HD, 1/4-20x1, SST	8			1			2C0164
72	SCREW-HEX HD, #10-32 x 5/8, SST	7			4			
71	SQUARE FLANGE PANEL MOUNT RECEPTACLE, 9 PINS, WITH HINGED SPRING DOOR	7	ZRCP-16-346 PN		1			
70	WASHER-LOCK- EXT TOOTH, #6	7			2			
69	SCREW-TRUSS HD, #6-32 x 5/16, SST	7			2			2C0196
68	SWITCH-THERMAL	7	FENWAL	30002-0	1			
67	AUDIBLE SIGNAL, MODEL SC 628	7	P.R. MALLORY & CO., INC		1			
66	SEAL RING	7	R.I.	A54261	2			
65	WASHER - SPLIT LOCK, #8	7			6			2C0179
64	SCREW - HEX HD, #8-32 x 5/16, SST	7			6			2C0209

J.O. | DUE | QTY. | STOCK

DRAFTSMAN: M. M. | DATE: 10/9/78 | USED ON: 102378.01

TITLE: HIGH DENSITY 10x12 HEATER ASSEMBLY (MODEL 5378)

INVENTORY

NUMBER: D54226 | REV: A

RESEARCH INC MINNEAPOLIS, MINNESOTA 55424

LIST OF MATERIALS

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						S.O.		DUE
						QTY.		STOCK
93	SCREW-FILISTER HD, 4-40x 3/16, SST	5			6			2C0273
92	CABLE CLAMP- NYLON	7	BURNDY	HP-5N	1			5C0131
91	RELIEF VALVE, 1/4 NPT, STAINLESS ST.	7	NUPRO	SS-4CPA2-150-DC	1			
90	ADAPTER	7	R.I.	A54222	1			
89	LABEL "ZONE 3"	3	R.I.	A53373-3	2			
88	LABEL "ZONE2"	3	R.I.	A53373-2	2			
87	LABEL "ZONE1"	3	R.I.	A53373-1	2			
86	WINDOW LOCATOR	5	R.I.	B54284	2			
85	ELBOW, 1/8 TUBE TO 1/8 NPT, STAINLESS ST.	2	SWAGE-LOK	SS-200-2-2	1			12A0530
ITEM	DESCRIPTION	SHEET	MFR.	PART NO.	QTY.	P	PULL	INVENTORY

DRAFTSMAN M.M.	USED ON 102378.01	TITLE HIGH DENSITY 10x12 HEATER ASSEMBLY (MODEL 5378)	INVENTORY	NUMBER D54226	REV A
DATE 10.19.78					
RESEARCH INC MINNEAPOLIS MINNESOTA 55424		LIST OF MATERIALS		SHEET 13	OF 13

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					J.O.		DUE
					QTY.		STOCK
17	PROBE TIP	RI	A54273	1			
16	PLUG	RI	A54272	1			
15	SPRING SPLICE - SMALL	RI	A54271	1			
14	PROBE STEM	RI	C54265	1			
13	SPRING-COMPRESSION, STAINLESS STEEL	ASSOCIATED SPRING	C0240-020 -2000 S	2			
12	CONTACT	RI	A54270	1			
11	CEMENT - CONTACT (PERMABOND), DAB	PEARL CHEM. CO	747	1			
10	STOP SLEEVE	RI	A54269	1			
9	LONG SCREW ELECTRODE	RI	C54264	1			
8	SPRING SPLICE - LARGE	RI	A54268	1			
7	SPRING-COMPRESSION, STAINLESS STEEL	ASSOCIATED SPRING	C0360-026 -2000 S	2			
6	CASE	RI	D54263	1			
5	INSULATOR CAP	RI	A54267	1			
4	WASHER-PLANE : #2			1			
3	NUT-HEX : #2-64 NF			1			
2	TERMINAL	RI	A54266	1			
1	SHRINK TUBE, .38 LONG	ALPHA WIRE CORP	FIT 105-1/4"	1			
ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	P	PULL	INVENTORY

DRAFTSMAN	USED ON	TITLE	INVENTORY	NUMBER	REV
BCK	102378-01	PROXIMITY PROBE ASSEMBLY		D54262	
DATE 10-12-78					

R·I CONTROLS — A DIVISION OF RESEARCH, INCORPORATED, MINNEAPOLIS, MINNESOTA 55424

LIST OF MATERIALS

SHEET 2 OF 2

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					J.O.		DUE
					QTY.		STOCK
10	WASHER - CONICAL SPRING, 1/4 ID			12			2C0766
9	WASHER-FLAT, #8 STAINLESS STEEL, WITH REAMED HOLE			6			2C0579
8	SCREW-FLAT HEAD; #6-32 NCX 1/4; STAINLESS STEEL			2			
7	INDEX PIN	RI	A54280	2			
6	ADHESIVE SEALANT-SILICONE RUBBER, RED, 4 oz.	GE	RTV 116	1			
5	SHOULDER SCREW - SLOTTED HD	PIC	4329	6			
4	LATCH	RI	A54279	6			
3	SPACER	RI	A54278	6			
2	FRAME	RI	C54277	1			
1	EDGE REFLECTOR	RI	C54276	1			
ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	P	PULL	INVENTORY

DRAFTSMAN: M. M | D54226 | USED ON: 102378-01 | DATE: 10-17-78

TITLE: EDGE REFLECTOR ASSEMBLY

INVENTORY

NUMBER: D54275 | REV: A

RESEARCH INC MINNEAPOLIS, MINNESOTA 55424

LIST OF MATERIALS

SHEET 2 OF 2

L26176

					I.O.		OVE
					QTY		STOCK
5	Shrink tube: 30 ft long	Alpha Wire Corp	FIT105 1½"	1			
4	Tape - friction			46			
3	Cable-motor lead-single #6 AWG-extra flexible 600V - 30 ft	Bronco	Bronco 66	7			
2	Straight plug-basket weave cable grip; 7#4 AWG pins	Pyle Nat'l	2PLK-2624-658-PN	1			
1	Straight plug-basket weave cable grip; 7#4 AWG sockets	"	2PLK-2624-658-SN	1			
ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	P	PULL	INVENTORY

DRAFTSMAN	USED ON	TITLE	INVENTORY	NUMBER	REV
TJM	D54225	HEATER POWER CABLE ASSEMBLY		D54282	
DATE 10/19/78					

RESEARCH INC MINNEAPOLIS, MINNESOTA 55424 — LIST OF MATERIALS — SHEET 2 OF 2

L26176

					J.O.		DUE
					QTY.		STOCK
3	Cable-portable control-9#14 AWG conductors - extra flex. 30 ft.	Bronco	Bronco 66	1			
2	Straight plug-basket weave cable grip; 9 pins	Pyle Nat'l	2PLK-1616 -346 PN	1			
1	Straight plug-basket weave cable grip; 9 sockets	"	2PLK-1616 -346 SN	1			
ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	P	PULL	INVENTORY

DRAFTSMAN	USED ON	TITLE	INVENTORY	NUMBER	REV
TJM	D54225	HEATER SERVICE CABLE ASSEMBLY		D54283	
DATE					

RESEARCH INC MINNEAPOLIS, MINNESOTA 55424 — LIST OF MATERIALS — SHEET 2 OF 2

L26176

													J.O.		DUE
													QTY.		STOCK
5	Clamps HOSE hex head slotted screw.		Ideal	50081	2										
4	Hose - low pressure 30 ft (1/2 ID x 3/4 OD)		Imperial Eastman	U-408	1										
3	Serrated male hose connector		Cajon	SS-8-MHC-85	2										
2	Single shutoff female pipe quick connect		Swagelok	SS-QC8-S-8PF	1										
1	Double shutoff female pipe quick connect		Swagelok	SS-QC8-D-8PF	1										
ITEM	DESCRIPTION		MFR.	PART NO.	1 2 3 4 5 6 QUANTITY								P	PULL	INVENTORY

DRAFTSMAN	USED ON	TITLE	INVENTORY	NUMBER	REV
T M.		WATER HOSE ASSEMBLY		054285	
DATE					

R·I CONTROLS — A DIVISION OF RESEARCH, INCORPORATED, MINNEAPOLIS MINNESOTA 55424

LIST OF MATERIALS

SHEET 2 OF 2

					J.O.		DUE
					QTY.		STOCK
15	Pipe plug	MN Valve & Fitting	B-12-P	1			
14	Male hose connector - serrated 3/4 to 3/4"	"	B-12-MHC-12S	1			
13	Male hose connector - serrated 3/8 to 3/8"	"	B-6-MHC-6S	1			
12	Male hose connector - serrated 1/2 to 1/2"	"	B-8-MHC-8S	2			
11	Male hose connector - serrated 1/2 to 3/8"	"	B-8-MHC-6S	1			
10	Reducing bushing 1 to 1/2"	"	B-16-RB-8	1			
9	Reducing bushing 3/4 to 3/8"	"	B-12-RB-6	1			
8	Stree tee	"	B-12-ST	1			
7	Nipple - hex	"	B-8-HN	2			
6	Nipple - hex reducing	"	B-12-HRN-8	1			
5	Nipple - hex long 4.00"	"	B-8-HLN-4.00	2			
4	Tee	"	B-8-T	1			
3	Elbow	"	B-8-E	2			
2	Flow meter/balancing valves, 1/2 NPT	McMaster Carr	9790N11	2			
1	Reservoir - modification	R.I.	B54287	1			

ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	P	PULL	INVENTORY

DRAFTSMAN	USED ON	TITLE	INVENTORY	NUMBER	REV
WL	102378-01	RESEARCH ASSY		B54286	A
DATE 5/3/79					

RESEARCH INC MINNEAPOLIS, MINNESOTA 55424 — LIST OF MATERIALS — SHEET 2 OF 2

L26176

					J.O. QTY.		DUE STOCK
21	Hex hd screw 3/8-16 x 3/4 lg			16			2C0762
20	Hex hd screw 1/2-13 x 2" lg			16			2C0709
19	Hex hd screw 1/2-13 x 3" lg			8			
18							
17	Washer 7/16			8			
16	Hex hd 7/16-14 x 1½" lg			8			
15	Hex hd screw 1/2-13 x 2" lg SST			2			2C0709
14	Nut hex 1/2-13 CAD			28			2C0299
13	Washer lock 1/2" CAD			36			2C0301
12	Washer flat 1/2" CAD			28			2C0257
11	Hex hd screw 1/2-13 x 3½" lg			2			
10	Mounting plate for Unirack to shocks	RI	C54359	2			
9	Shock mounts	Barry	633A-260	8			
8	Casters - rear (rigid)	Hamilton	R-7016	2			
7	Casters - front (swivel)	Hamilton	S-7016	2			
6	Fork lift guide weldment	RI	C54360	2			
5	Plate - fork lift guide	RI	B54363	2			
4	Tow bar	RI	D24131	1			
3	Spring leaf mount block	RI	A24130	2			
2	Spring leaf	RI	A24129	2			
1	Mobile base weldment	RI	D54350	1			

ITEM	DESCRIPTION	MFR.	PART NO.	QTY.	P	PULL	INVENTORY

DRAFTSMAN: WL | USED ON: 102378-01 | TITLE: MOBILE BASE ASSEMBLY | INVENTORY | NUMBER: D54358 | REV: A

DATE: 5/10/79

RESEARCH INC MINNEAPOLIS, MINNESOTA 55424 | LIST OF MATERIALS | SHEET 2 OF 3

L26176

Section 8

COMPONENT MANUALS
CONTROL CONSOLE

Model FGE 5110 Data Trak Programmer

Model 640U Process Controller

Model 64600 Power Controller

INSTRUCTION MANUAL

MODEL FGE 5110
DATA-TRAK
PROGRAMMER

January, 1978

RESEARCH INC
BOX 24064 MINNEAPOLIS, MINNESOTA USA 55424
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SECTION 3 - OPERATING CONTROLS AND INDICATORS

SECTION 4 - PREOPERATION SET UP PROCEDURES

SECTION 5 - STANDARD AND SPECIAL RUN CONTROL WIRING

SECTION 6 - MAINTENANCE AND ADJUSTMENTS

SECTION 7 - TROUBLESHOOTING

SECTION 8 - OPTIONAL FEATURES

SECTION 9 - SCHEMATICS

FIGURES

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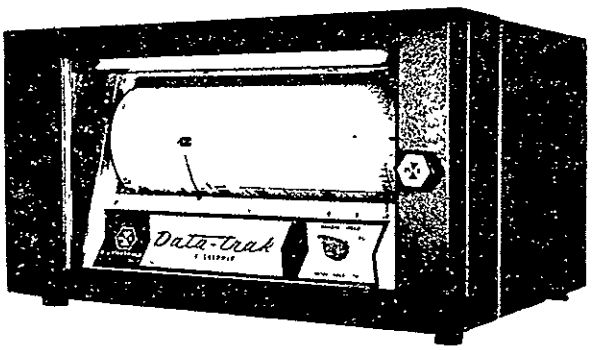


Figure 1-1 FGE 5110 DATA-TRAK Programmer

Section I

INTRODUCTION

I-1 Scope

This manual describes the Model FGE 5110 DATA-TRAK Programmer and provides information for its installation, operation and maintenance.

I-2 General Description of DATA-TRAK Operation

The DATA-TRAK Programmer is an electro-mechanical instrument designed to position the shaft of a rotary output device in accordance with variations in a preplotted program attached to a rotating drum. Several types of output devices may be used with the unit, including potentiometers, synchro-transmitters, differential transformers, etc., but because of its more frequent use, a potentiometer has been selected as a representative output device in the information presented in this manual.

To accomplish its function, the DATA-TRAK employs an electrostatic curve following system which provides the optimum in programming accuracy and reliability, while enabling the use of easily prepared programs.

A desired program curve is etched in the metallized surface of a special program chart with a sharp stylus. The stylus removes a fine line of metal from along the curve, dividing the surface of the chart into two electrically isolated conductive planes. The chart is then mounted on the outer surface of the program drum, which is subsequently installed in the DATA-TRAK.

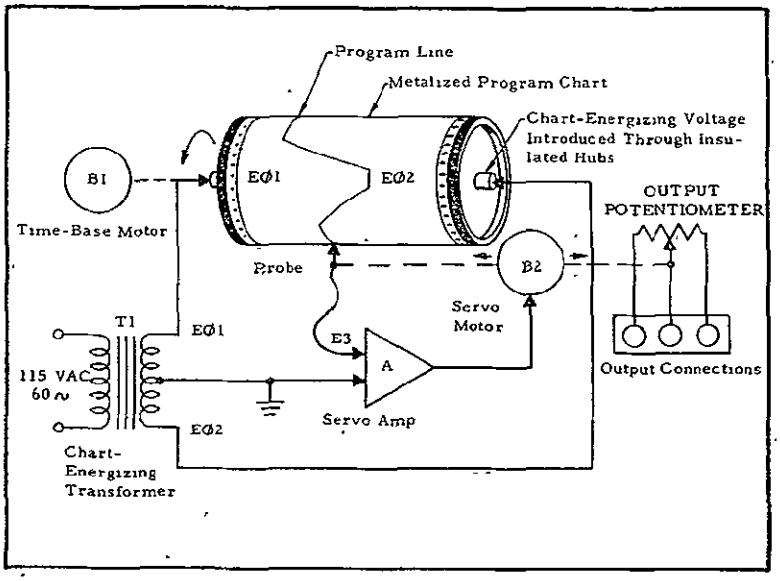


Figure I-2 DATA-TRAK - Simplified Functional Drawing

With the drum in position and the DATA-TRAK in operation, the two isolated planes on the surface of the chart are separately energized by oppositely phased AC voltages applied through the insulated hubs of the program drum. These voltages, designated E1 and E2 in Figure 1-2, establish an electrostatic voltage gradient across the gap on the chart created by the program curve. As the drum rotates the chart past the DATA-TRAK's curve following probe, the probe is driven by the servo system to continually seek the zero potential existing at the center of the program curve. The shaft of the output potentiometer is mechanically coupled to the probe through a system of pulleys. Therefore, as the probe is driven to follow the program curve, the position of the wiper on the potentiometer is varied accordingly.

The probe does not actually come in contact with the chart, but picks up a signal from the electrostatic field, which is used for positional reference. This "error" signal is designated E3 in Figure 1-2 and indicates by its phase and magnitude the direction and extent of probe displacement from the center of the curve.

When the probe tends to the right of the curve, the error signal reflects the phase of voltage E2, which, after amplifications, causes the servomotor to drive the probe to the left, back to the center of the curve. Conversely, when the probe tends to the left, the error signal reflects the phase of voltage E1, which causes the probe to be driven to the right, back to the center of the curve. The speed at which probe corrections are made is proportional to the magnitude of the error signal of either polarity, which, in turn, is proportional to the extent of probe deviation from the center of the curve. Minute deviations cause relatively slow correction rates, which are increased proportionally to maximum as probe deviations widen to equal approximately one percent of the program chart scale.

1-3 DATA-TRAK Specifications

The DATA-TRAK employs circuitry composed entirely of solid state components, thus providing the optimum in extended troublefree programming operation. A detailed schematic drawing of the instrument is located at the rear of this manual; the electrical and mechanical specifications are listed in the following table.

Table 1-1 Specifications and Characteristics

Input Power	0.5 ampere at 115 VAC, 60 Hz
Time Base	Adjustable from 3/4 inch per hour to 4 inches per second by gear and/or motor change. Other speeds available by special request.
Time Base Accuracy	1 percent of elapsed time
Metallized Chart Paper	Research #CMS51
Maximum Follow Rate	7 inches per second
Dead Band	0.01% of full scale
Repeatability	0.05% of full scale
Standard Output Potentiometers	
Type	3 Turn Spectrol or Helipot
Resistance	1000 ohms, ±1%
Linearity	0.2%
(Other resistances and linearities available.)	
Quantity	Provisions have been made for mounting up to four 3 gang output potentiometers in the DATA-TRAK.
Dimensions for rack mounting	10-1/2" high, 19" wide, 15" deep

Section 2

INSTALLATION

2-1 General

The DATA-TRAK may either be flush or face mounted in an instrument panel, or enclosed in an instrument case for portability (Figure 1-1). Information required for panel mounting the DATA-TRAK and for connecting external wiring to the unit for standard operation is provided under the following headings.

2-2 Panel Mounting the DATA-TRAK

Panel cut out dimensions and other pertinent information for either flush or face mounting the DATA-TRAK are provided in Figure 2-1.

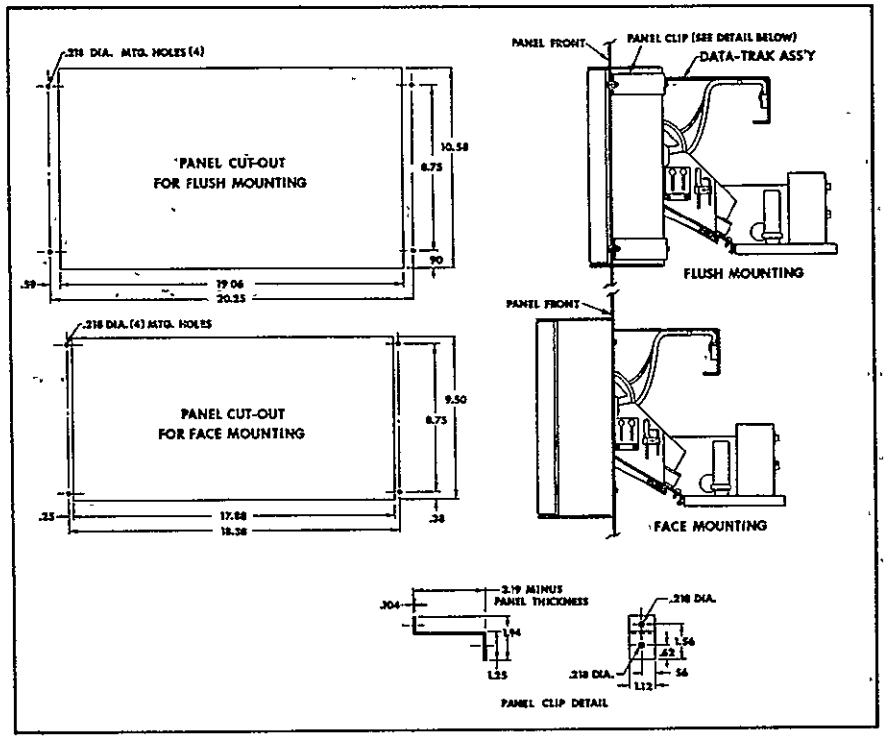
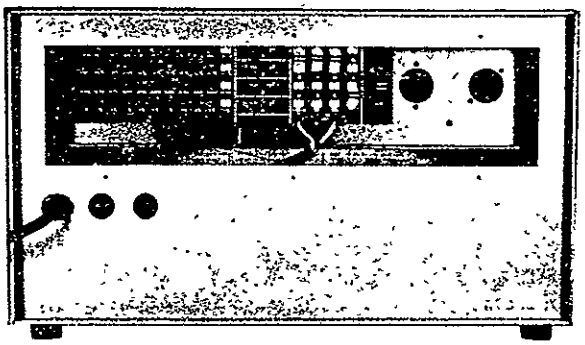


Figure 2-1 Panel Mounting the DATA-TRAK

2-3 DATA-TRAK External Wiring Connections

All external wiring connects to terminals on the entrance board, which is mounted on a flange located at the rear of the DATA-TRAK assembly (see Figure 2-2). These terminals are accessible from the rear by remains the rear access panel.



NOTE: Entrance board may be reversed for front access.

Figure 2-2 DATA-TRAK Entrance Board

Standard external wiring connections are described under the following headings; wiring for special run control functions is described in Section 5.

A. AC Input Connections

A 3 wire appliance cord is used to energize the DATA-TRAK with operating voltage. The wires of this cord connect to terminals of the entrance board as follows:

Standard	220 VAC 50Hz Option	
AC High	Terminal B	As indicated on entrance board
AC Common	Terminal C	
Ground	Terminal A	

B. Potentiometer Cable Connections

Wiring from up to twelve output potentiometers may be connected to the terminals of the entrance board. The numbering sequence of the output potentiometers and the system by which their terminals are wired to the entrance board are shown in Figure 2-3. (If more than one 3 gang potentiometer is used, the additional terminals required are wired in like manner.)

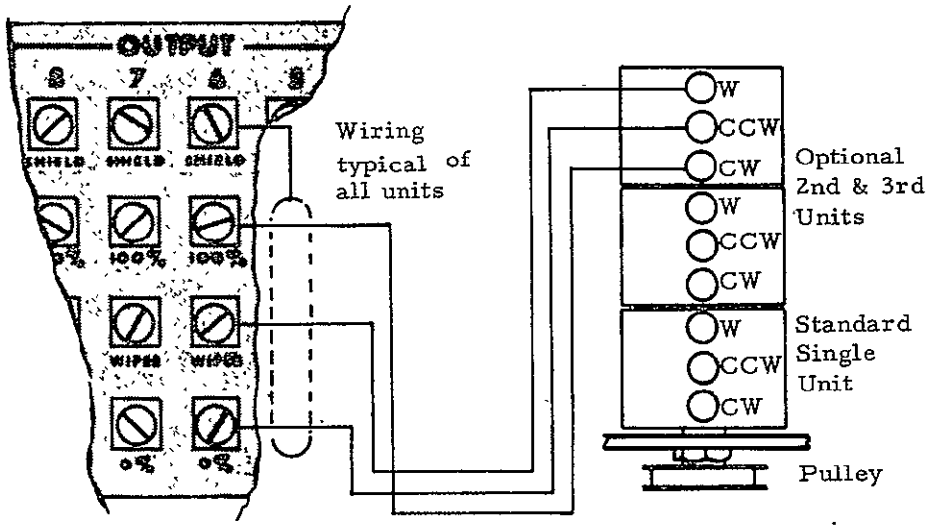


Figure 2-3 Potentiometer Cable Connections

C. Program Function Switches Connections (Optional)

Wiring from contacts of relays actuated at selected points in the program is terminated at terminals of the entrance board as shown in Figure 2-4. The manner in which external wiring is connected to these terminals to initiate or terminate selected external functions is left to the choice of the customer. This optional feature is fully described in Section 8.

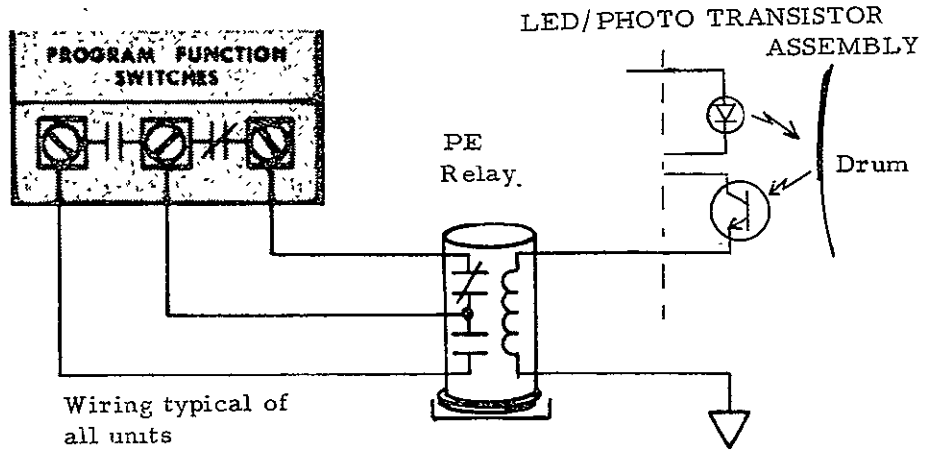


Figure 2-4 Program Event Switch Relay Wiring

Section 3

OPERATING CONTROLS AND INDICATORS

3-1 General

Operating controls and indicators for monitoring the status of the DATA-TRAK are listed and described under the following headings.

3-2 Mode Selector Switch

This 4 position rotary switch (S1 on the DATA-TRAK schematic drawing) is the only control mounted on the front panel of the DATA-TRAK. The function of the switch in each of its four positions is as follows:

1) OFF -De-energizes all circuits in the DATA-TRAK.

2) REMOTE -Energizes the servo circuits, but establishes drum rotation as a function of external run controls (see information in Section 5).

3) HOLD -With drum initially rotating under either remote or local control, switching to HOLD position de-energizes the AC drum motor and discharges a surge of DC current through its windings (see note below) to provide instantaneous braking. (The servo circuits remain energized during a HOLD interval.)

4) RUN -Energizes the drum drive motor to initiate a programming operation, or to restart from HOLD condition. Also applies power to a halfwave rectifier circuit which charges a capacitor with drum braking current in preparation for a HOLD initiation.

NOTE

Cramer time base motors do not require current braking, therefore, motor brake capacitor C5 (see schematic) is not installed in DATA-TRAK s using these units.

3-3 Gain Control

This 1 turn trim pot is mounted on the servo amplifier printed circuit board; it provides a means for adjusting the band of proportional control by increasing or decreasing the sensitivity of the amplifier (see information under Heading 4-10).

3-4 Drum Limit Switch

This microswitch is actuated at any arbitrary point within a drum revolution by appropriately attaching a trip tab to the scaled edge of the drum, as shown in Figure 4-3.

When actuated, the switch de-energizes the drum drive motor and applies DC braking current to its windings to terminate a programming operation. (The trip tab must be manually rotated past the switch by grasping the edges of the drum and turning it against the slip clutch before operation can be resumed.)

3-5 Auxiliary Switch

This microswitch is actuated at arbitrary points within a drum revolution by appropriately attaching one or more auxiliary trip tabs on the scaled edge of the drum, as shown in Figure 4-3. Wiring for its single pole double throw contacts is terminated at the entrance board, (see DATA-TRAK schematic) to facilitate external connection for such optional functions as:

1) Energizing or de-energizing external circuits at precise points in the program.

2) Stepping an external drum revolution counter during continuous rotation applications.

Refer to Section 5 for detailed external hookup information.

3-6 Percent of Run Indicator

A pointer is attached to the inner right hand frame, adjacent to the scaled edge of the program drum, and in line with the center of the program probe. As the drum rotates, a coarse percent of run time is indicated by the scale division directly opposite the stationary pointer.

3-7 Percent of Scale Indicator

A pointer attached to the probe carriage, in conjunction with the scale provided on the front panel of the DATA-TRAK, is used as a coarse indicator of probe position on the program chart. (Tapped holes have been provided at either end of the standard scale to enable installation of special scales.)

Section 4

PREOPERATION SET UP PROCEDURES

4-1 General

This section of the manual describes the procedures required to set up the DATA-TRAK for standard operations. Preparations for special applications are described in Section 5.

4-2 Program Preparation*

In the following information, it is assumed that the system to be programmed by the DATA-TRAK is capable of controlling variations in a selected parameter (load, pressure, temperature, etc.) over a range to be represented by from zero to 100 percent on the program chart; and further, that the variations are proportionally controlled in response to a signal which may be varied from minimum to maximum by the output potentiometer.

A. Program Sheet Layout

The program sheet (see Figure 4-1) is scaled to provide reference line for both "X" and "Y" coordinates. The "Y" axis is scaled from zero to 100 percent in 1/2% steps, representing the relative range of variability of a selected parameter.

The "X" axis has reference lines spaced at 1/4 inch intervals, representing divisions of time within a selected time base.

The time base of a program is arbitrarily determined by selection among various combinations of change gears to be used with a particular drum drive motor and gear train. This must be done before plotting a program curve to establish the relative value of the time divisions on the sheet.

For example, if it is desired to plot a program which is to run for four and one-half hours, each of the 54 time divisions on the chart will represent 5 minutes (270 minutes/54 time divisions).

With the time base known and assuming that the desired variations of the selected parameter have been established with respect to time, the program curve may be plotted directly on the program sheet as described under the following heading.

*For strip chart and programmable event switch program preparation, see information in Section 8.

B. Plotting the Program Curve

Place the program sheet on a smooth clean surface in a manner which positions the zero line of the "Y" axis vertically and toward the left hand of the viewer, as shown in Figure 4-1 A. In this position, the bottom edge of the chart is the program starting point and the top edge is the ending point.

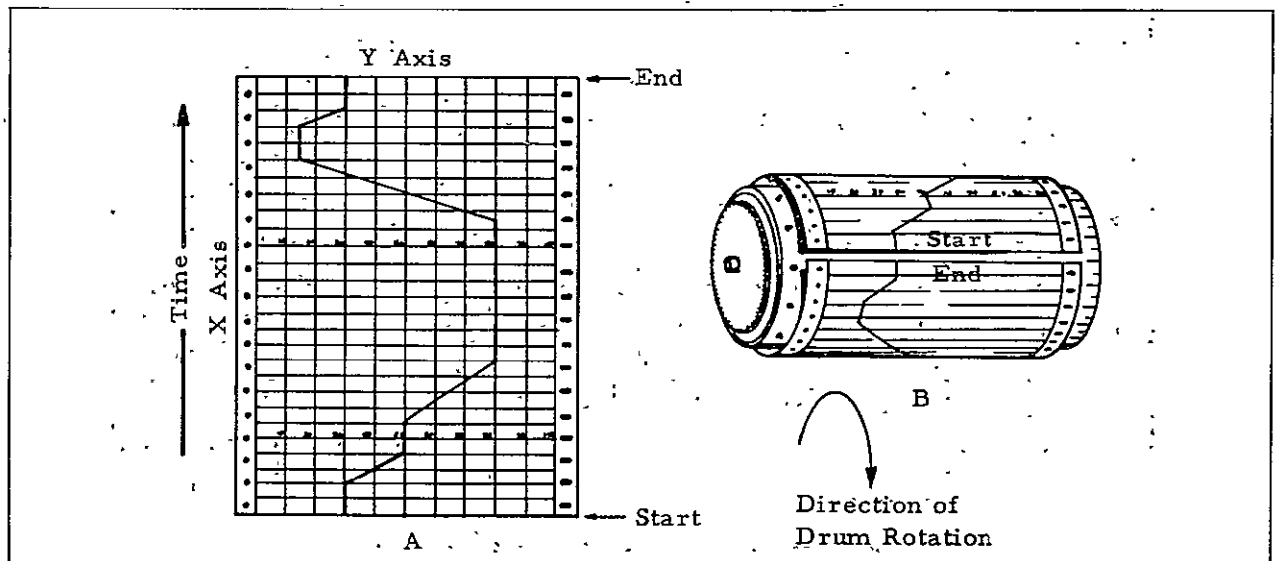


Figure 4-1 Program Chart Preparation

The program should be plotted in a manner which initiates and terminates the curve at identical levels on the "Y" axis of continuous rotation is anticipated (see Figure 4-1 B). The curve is drawn with the aid of standard drafting triangles, curves and a needlepoint stylus (part #PS53), progressing time wise from bottom to top of chart.

C. Checking the Program Curve

As previously stated, after a program curve has been etched on the chart, the metallized surfaces on either side of the curve should be electrically isolated from one another. This can usually be ascertained by visual inspection; flecks of metal that may not have been removed from the gap created by the program curve show up quite readily with the program held to a light source as the backing is translucent.

If desired, an ohmmeter may be used to check for the necessary infinite resistance between the two surfaces. However, due to the low conductivity of the carbon combined with the zinc-oxide coating, a careful visual inspection is recommended for all programs.

4-3 Change Gear Selection

Proper selection of change gears for a desired chart speed is accomplished with the aid of the chart in Table 4-1. The chart is divided into two sections by a relatively heavy vertical line; the right hand section lists speed ranges involving the high speed gear train and the left hand section lists those for the slow speed gear train. The double columns for each of the speed ranges (from I through XI on the bottom of the chart) are headed by a numbered box which designates the rpm of an associated motor. With the particular motor and gear train installed in the DATA-TRAK known, it is only necessary to go down the appropriate double column until the desired chart speed is found and then trace directly across the chart to the extreme left hand column, which lists the proper change gear combination for the selected speed. Chart speed is shown both in time-per-inch and in time-per-drum-revolution.

Table 4-1 Change Gear Selection Chart

FGE 5110 CHART SPEEDS

MOTOR SPEED (RPM)		1/8		1/4		1/2		1		2		4		10		60		4		10		60	
GEAR TRAIN		SLOW SPEED																HIGH SPEED					
CHANGE GEARS		INCH / DAY	DAYS / REV	INCH / DAY	DAYS / REV	INCH / DAY	DAYS / REV	INCH / HR	HRS / REV	INCH / HR	HRS / REV	INCH / HR	HRS / REV	INCH / HR	HRS / REV	INCH / MIN	MIN / REV	INCH / MIN	MIN / REV	INCH / MIN	MIN / REV	INCH / SEC	SECS / REV
LETTER PAIR	TEETH																						
C/H	16/64	1 1/8	12	2 1/4	6	4 1/2	3	3/8	36	3/4	18	1 1/2	9	3 3/4	3 6/10	3/8	36	1	13 1/2	2 1/2	5 4/10	1/4	54
A/B	15/50	1 7/20	10	2 7/10	5	5 2/5	2 1/2	9/20	30	9/10	15	1 8/10	7 1/2	4 1/2	3	9/20	30	1 1/6	11 1/4	3	4 1/2	3/10	45
J/N	24/72	1 1/2	9	3	4 1/2	6	2 1/4	1/2	27	1	13 1/2	2	6 3/4	5	2 7/10	1/2	27	1 1/3	10 1/8	3 1/3	4 1/20	1/3	40 1/2
K/M	32/64	2 1/4	6	4 1/2	3	9	1 1/2	3/4	18	1 1/2	9	3	4 1/2	7 1/2	1 8/10	3/4	18	2	6 3/4	5	2 7/10	1/2	27
D/G	30/50	2 7/10	5	5 2/5	2 1/2	10 4/5	1 1/4	27/30	15	1 8/10	7 1/2	3 3/5	3 3/4	9	1 1/2	9/10	15	2 2/5	5 5/8	5 5/8	2 2/5	5/9	22 1/2
E/F	32/48	3	4 1/2	6	2 1/4	12	1 1/8	1	13 1/2	2	6 3/4	4	3 3/8	10	1 7/20	1	13 1/2	2 2/3	5 1/16	6 2/3	2 1/40	2/3	20 1/4
L/L	48/48	4 1/2	3	9	1 1/2	18	3/4	1 1/2	9	3	4 1/2	6	2 1/4	15	9/10	1 1/2	9	4	3 3/8	10	1 7/20	1	13 1/2
F/E	48/32	6 3/4	2	13 1/2	1	27	1/2	2 1/4	6	4 1/2	3	9	1 1/2	22 1/2	6/10	2 1/4	6	6	2 1/4	15	9/10	1 1/2	9
G/D	50/30	7 1/2	1 4/5	15	9/10	30	9/20	2 1/2	5 2/5	5	2 7/10	10	1 7/20	25	27/50	2 1/2	5 4/10	6 2/3	2 1/40	16 2/3	81/100	1 2/3	8 1/10
M/K	64/32	9	1 1/2	18	3/4	36	3/8	3	4 1/2	6	2 1/4	12	1 1/8	30	9/20	3	4 1/2	8	1 11/16	20	27/40	2	6 3/4
N/J	72/24	13 1/2	1	27	1/2	54	1/4	4 1/2	3	9	1 1/2	18	3/4	45	3/10	4 1/2	3	12	1 1/8	30	9/20	3	4 1/2
B/A	50/15	15	9/10	30	9/20	60	9/40	5	2 7/10	10	1 7/20	20	27/40	50	27/100	5	2 7/10	13 1/3	1 1/80	33 1/3	81/200	3 1/3	4 1/20
H/C	64/16	18	3/4	36	3/8	72	3/16	6	2 1/4	12	1 1/8	24	9/16	60	9/40	6	2 1/4	16	27/32	40	27/81	4	3 3/8
SPEED RANGE		VIII		IX		X		XI		I		II		III		IV		V		VI		VII	

ORDERING INFORMATION CALL OUT MODEL FGE 5110-SS-60-CH (GEAR TRAIN) (GEAR SET) (DRUM MOTOR)

As indicated on the chart, each set of change gears (except LL) are used to provide two chart speeds with each of the motor/gear train combinations. This depends on their relative position in the drum drive assembly as described under the following heading.

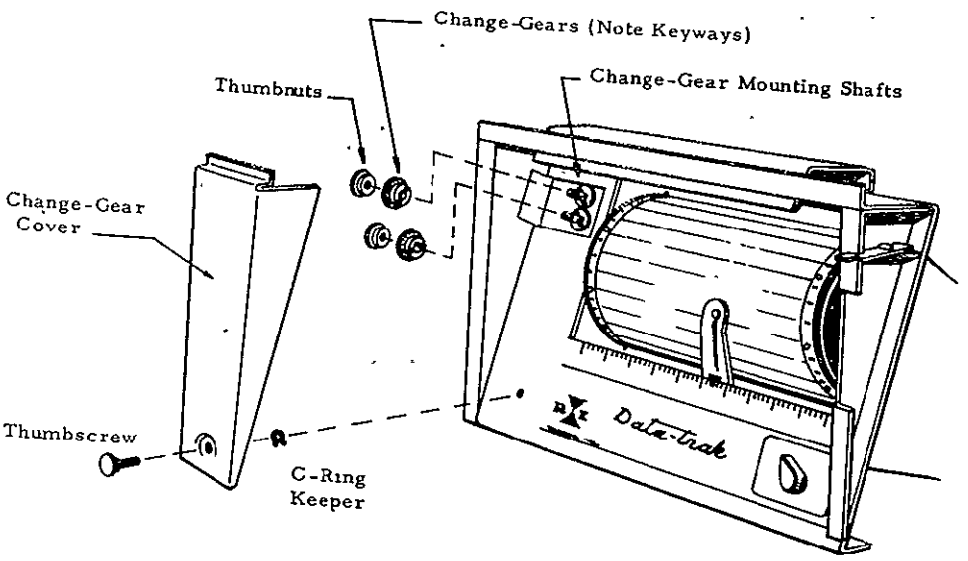


Figure 4-2 Change Gear Access and Mounting Positions

4-4 Installing Change Gears

The change gear mounting shafts are located under the removable cover on the face of the DATA-TRAK electromechanical assembly as shown in Figure 4-2.

The two mounting shafts are vertically aligned, therefore, to provide easy mounting reference, the combination of change gears letters for the various speed selections are also vertically aligned in the right hand column of Table 4-1. To illustrate, the gear represented by the upper letter in a combination must be mounted on the upper change gear shaft and the gear represented by the lower letter must be mounted on the lower shaft to obtain an indicated speed. (Mounting the smaller of the two gears of any combination on the upper shaft results in the slower of two possible speeds.)

After removing the thumbscrew which secures the cover to the face of the DATA-TRAK, installation of change gears is accomplished as follows:

1) Remove the knurled thumb nuts from each of the two shafts and slip off the change gears to be replaced.

2) Install the selected change gears on the upper and lower shafts as indicated for the desired speed.

3) Secure the gears to the shafts with the thumb nuts, ensuring that the teeth of the gears are meshed and that the keyed hubs on the shafts are properly engaged with the key ways on the backs of the gears.

4) Recover the assembly to complete the installation.

4-5 Detaching Program Drum

The program drum must be detached from the DATA-TRAK before the program chart can be properly attached to its outer surface; this is accomplished as follows:

1) Unlatch the DATA-TRAK door and swing the hinged electromechanical assembly out of the cabinet.

2) Grasp the left hand edge of the drum (as seen from the rear) with fingertips and pivot it free from its latching mechanism.

3) Holding both ends of the drum securely, free it from the assembly by lifting outward and to the left.

4-6 Mounting Chart on Program Drum

The starting point of the program (refer to Figure 4-1) can be aligned (approximately) with the zero percent of run indication on the scale inscribed

around one end of the drum. The chart must then be wrapped around the outer surface of the drum in a direction opposite to drum rotation, taking care to properly engage the drum sprockets with the holes in the edges of the chart. The elongated holes must be engaged with the sprockets on the scaled (right hand) end of the drum.

The chart has been accurately cut to a length of 13.5 inches and its opposite ends will meet squarely, forming a precise butt joint which must be taped together to secure the chart to the drum. (The tape does not interfere with probe signal pickup.)

After taping the chart to the drum, six chart energizing insert pins must be installed in the drum through the holes at the edges of the chart. There are three pins for each edge of the chart; two must be inserted, one on either side of the butt joint and the third must be inserted approximately half way around the circumference of the drum.

4-7 Attaching Trip Tabs to Program Drum

The Drum Limit and Auxiliary microswitches are positioned approximately 3.5 major drum scale divisions from the tip of the curve following probe, in the direction of drum rotation. Therefore, to properly stop with a selected point in the program curve directly under the probe, the Drum Limit trip tab must be attached to the drum in a position which leads the selected stopping point by 3.5 major scale divisions, as shown in Figure 4-3. The same is true for the Auxiliary trip tab, which must lead the point in the program where it is desired to initiate special external functions, such as described in Section 5.

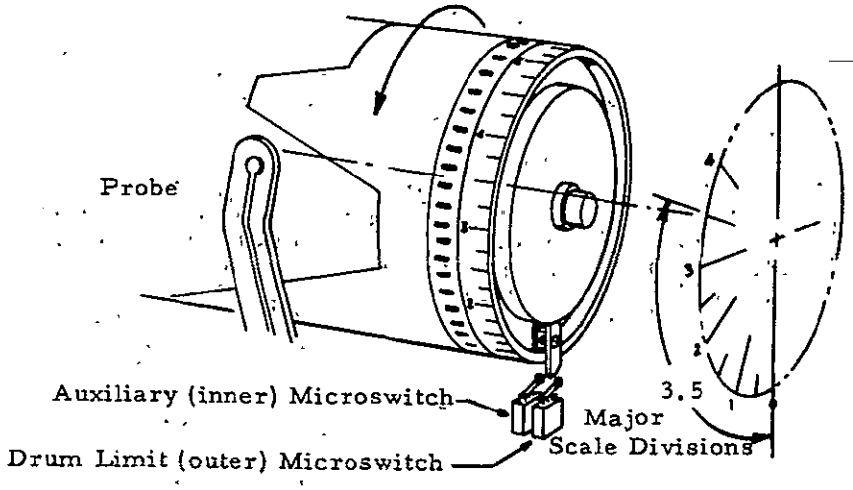


Figure 4-3 Attaching Trip Tabs on Drum

The trip tabs are inserted in the slot on the scaled end of the drum as shown in Figure 4-3; tightening the screw in the tab assembly provides a compression fit which locks the unit in place. The straight trip tab actuates the outer (drum limit) microswitch; the double angled tab actuates the inner (auxiliary) microswitch.

4-8 Installing Program Drum in DATA-TRAK

Lift the program drum from the work surface with fingertips, grasping it securely by the rim at either end. Engage the geared end of the drum in the DATA-TRAK first; then pivot the free end into position snapping it in place. Switch the DATA-TRAK assembly back into its housing, where it will automatically latch closed.

4-9 Initiating a Programming Operation

With the DATA-TRAK prepared for operation, switch the Mode Selector to HOLD position.

After the probe has been driven to the center of the program curve by the servo circuits, the Mode Selector may be switched to RUN. The programming operation will then run to completion, requiring no further operator intervention unless the conditions described under the following heading are noted.

4-10 Gain Control Adjustment

If, after drum rotation is initiated, the probe appears sluggish in following the program curve, or, if oscillation is apparent, maladjustment of the Gain control is indicated. The setting of the Gain control establishes the width of the band of proportional control. This control band may be defined as that distance the probe may deviate from the center of the program curve before maximum corrective torque is produced by the servomotor.

Since mechanical circuitry cannot respond as rapidly as its electronic counterpart, setting the Gain control too high will cause probe overshoot, which, if pronounced, will result in oscillation. Setting the control too low decreases overall system response, causing the probe to lag behind the curve during program intervals demanding rapid follow rates.

Proper setting of the Gain control matches the electronic response to the mechanical response of the system, resulting in smooth, precise curve following within the design limits of the instrument.

To adjust the response of the DATA-TRAK, swing out the electromechanical assembly from its housing. Then, with the unit in operation, turn the Gain adjusting trim pot clockwise until probe oscillation is noted; then turn the screw counterclockwise just enough to damp out the oscillations.

After this adjustment has been accomplished for an individual DATA-TRAK, the Gain control should require no further attention unless the mechanical load on the servo system is altered by either the addition of one or more potentiometers, or by slippage in the pulley-drive system. (See information under Heading 6-4 for drive cable retensioning procedures.)

NOTE

If oscillations cannot be induced by adjustment of the Gain trim pot, and hence, the response of the DATA-TRAK cannot be adjusted for optimum performance, improper spacing of the DATA-TRAK probe is indicated. Refer to Heading 6-8 for probe spacing procedure.

Section 5

STANDARD AND SPECIAL RUN CONTROL WIRING

5-1 General

To enable a variety of special run control applications, all control wiring is connected to the CONTROLS section of the entrance board where jumper wires may be added or removed and external wires connected as required for particular special functions.

Standard wiring of the terminals and two alternate wiring methods are shown in Figure 5-1 and described under the following headings.

5-2 Standard Wiring

For clarity, the terminals are not shown in their normal sequential order in Figure 5-1. Also, the internal DATA-TRAK wiring and components are shown but once since it is identical in each of the two additional examples.

It can be seen from the wiring illustrated in Example A, that the servo circuits are energized when the Mode Selector switch is in any position except OFF, but to energize the Drum Drive Motor, it is necessary that the Mode Selector be in RUN position and the Drum Limit switch be in normally closed condition. With the Drum Drive motor energized, power is also applied to the half wave rectifier circuit, where DC current is stored in capacitor C5* in preparation for dynamic braking of the motor at a subsequent stop. A stop may be initiated by either of the following means:

1) Manually switching the Mode Selector from RUN to HOLD. This action disrupts AC voltage to the motor and connects capacitor C5 into the circuit. The DC current stored in the capacitor during a RUN is discharged through the motor windings, causing it to instantly stop. (Note that the servo circuits remain energized during a HOLD.)

2) Actuation of the Drum Limit switch by a trip tab mounted on the program drum; this action causes results identical to those caused by manually switching the Mode Selector for RUN to HOLD. The significance of the Drum Limit switch is that a run may be automatically terminated by its actuation at an arbitrary point in the program thereby eliminating the necessity of operator intervertion. Normally, the trip tab is positioned on the drum to terminate operation after one complete program cycle.

External wiring of the Auxiliary switch, which is optional with the customer, is discussed under Heading 5-4.

*Capacitor C5 is not used with Cramer motors.

5-3 Remote Run Control Switch

Example B in Figure 5-1 illustrates the manner in which an external remote control switch may be connected to the DATA-TRAK. No changes in the standard wiring of the terminals are required for this application; just connect three wires from the external switch to the terminals as shown in the figure. The remote control switch will be enabled to initiate a RUN or HOLD only when the Mode Selector is switched to REMOTE; either drum motor AC energizing current or DC braking current will then be allowed to pass through the remote switch, through the REMOTE contacts of the Mode Selector and on through the Drum Limit switch to the drum drive motor.

The function of the Drum Limit switch in this application is identical to that described under Heading 5-2.

5-4 Remote Program - Cycle Control

For applications requiring continuous drum rotation for a predetermined number of program cycles, the run control circuits of the DATA-TRAK may be connected to an external predetermining counter as shown in Example C in Figure 5-1.

During operation, the program drum will continuously rotate until the counter has been stepped to zero from an arbitrary number set up in its register. At this time, a single pole double throw switch (or series of switches) will be actuated to de-energize the drum drive motor and discharge the DC braking current through its windings. The stepping of the counter is accomplished by means of the Auxiliary switch, which is actuated by its trip tab to energize the stepping coil of the counter once for each drum revolution.

5-5 Summary

The examples shown in Figure 5-1 are not intended to represent all possible external connections for special functions, but are merely presented as a basis for a clear understanding of the circuitry involved. A number of additional optional applications of the run control circuitry are listed below and on the following page.

1) A remote run control switch may be connected to the circuitry of Example C

exactly as shown in Example B. This will enable both remote run and program cycle control.

2) To enable unlimited, continuous drum revolution, no rewiring is required; simply remove the drum limit trip tab from the program drum.

3) Any timing device capable of operating a single pole double throw switch may be substituted for the predetermining counter shown in Example C, freeing the Auxiliary switch for other functions such as energizing or de-energizing various external circuits at precise points in the program.

4) If two Auxiliary switches are required for an operation in unlimited or predetermined program cycle applications, the Drum Limit switch may be used along with the standard Auxiliary switch for this purpose. Three jumpers must be removed from the entrance board (from "S" to "M", from "P" to "K" and from "L" to "R") as they are in Example C of Figure 5-1. External wiring may then be connected to terminals "M", "L" and "K" in a manner appropriate for the particular function desired. If this is done, a jumper must be installed between terminals "S" and "R" to enable the drum drive circuits.

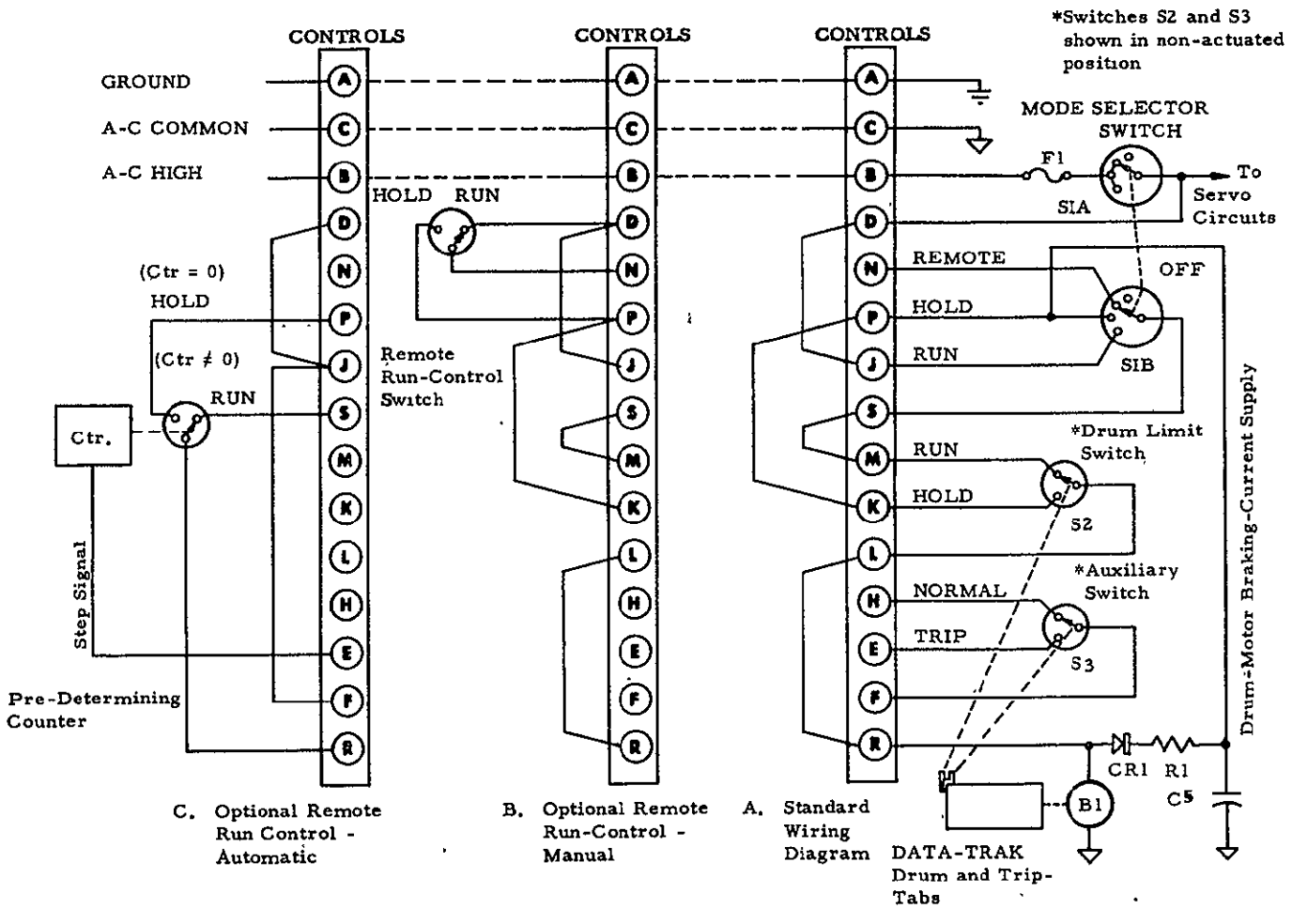


Figure 5-1 Model 5110 DATA-TRAK Standard/Special Run Control Wiring Diagram

Section 6

MAINTENANCE AND ADJUSTMENTS

6-1 General

Although minimum maintenance is required for the DATA-TRAK, it must be accomplished at regular intervals to ensure trouble free operation. The frequency at which the following procedures are to be performed will be determined by the environmental conditions under which the unit is operated.

6-2 Cleaning

The entire unit must be periodically vacuum cleaned to prevent accumulations of dust. (Since the door of the DATA-TRAK housing is equipped with a dust seal, keeping it closed as much as possible will minimize dust penetration.)

6-3 Lubrication

6-4 Gear Train

With the exception of the change gears, which require only to be kept free of dust, all gears in the gear train must be wiped clean and lightly regreased at regular intervals.

A. Bodine, Cramer and Globe motors are used with the DATA-TRAK for probe and drum drive. All motors are sealed units, requiring no additional lubrication.

6-5 Drive Cable Adjustments and Restringing Procedures

A. Tension Adjustment

Under normal conditions, the drive cable will remain serviceable indefinitely, requiring only retensioning from time to time if slippage is indicated by the necessity of frequent potentiometer alignment (see Heading 6-5). Retensioning is accomplished by loosening the lock screw on the tension adjust pulley (see Figure 6-1) and sliding the unit to left (as seen from rear of chassis) just enough to take up excessive slack and then relocking it in position.

B. Restringing the Drive Cable

If it becomes necessary to replace the drive cable refer to Figure 6-1 and proceed as follows:

1) Loosen the two set screws in the potentiometer pulley and remove the unit from the potentiometer shaft.

2) Insert one end of the new 90 inch* length of "cat gut" cable (Research part #PC5110-90) through the crossover holes in the pulley.

3) Draw the cable through the crossover holes in a manner which leaves a 30 inch length extending from the top crossover hole (nearest the pulley mounting collar).

4) Wrap the 30 inch length counterclockwise around the pulley one full turn then, holding the looped end in position with left thumb, wrap the opposite end clockwise around the pulley four full turns. The cable is now wound on the pulley as shown in Figure 6-1 B and may be secured in this position for the present, with a strip of masking tape. If more than one potentiometer pulley is used, each pulley will be wrapped in like manner.

5) Turn the shaft of the potentiometer fully counterclockwise then remount the pulley with crossover holes facing to the rear of the chassis (toward the viewer).

6) Loosen the cable fastening screws on the probe carriage and slide the unit to its zero position against the "C" ring stops on the carriage shaft and secure it in this position with a strip of masking tape.

7) Loosen the lock screw in the tension adjust pulley and slide the unit fully to the right (inward), leaving it unlocked for the present.

8) Loop the shortest end of the cable from the potentiometer pulley one half turn around the tension adjust pulley; then secure the end of the cable under the left hand cable fastening screw on the probe carriage as shown in Figure 6-1 C.

9) Loop the opposite end of the cable one full turn around the motor pulley and then a half turn around the idler pulley before securing it under the right hand cable fastening screw on the probe carriage as shown in Figure 6-1 C.

10) Cut off excess cable extending from the probe carriage and remove the tape from the potentiometer pulley and the probe carriage. If a small amount of slack exists in the pulley system, proper cable tension may be obtained by sliding the previously loosened tension adjust pulley outward, toward the left and locking it in position.

11) If the potentiometer shaft inadvertently shifted from its full counterclockwise position during the stringing procedure it may be reoriented with the probe zero position as described under the following Heading.

*See NOTE on following page.

NOTE

If a DATA-TRAK is equipped with more than a single 3 gang potentiometer, each additional pulley will require the length of the cable to be increased by 21-1/4 inches. When ordering replacement cable, specify complete length.

6-6 Potentiometer Alignment

To provide agreement between a desired program and the relative position of the wiper on the output potentiometer the potentiometer shaft must be at its counterclockwise limit when the probe is at zero position on the program chart.

Misalignment (or a faulty potentiometer) is indicated if an ohmmeter reading of more than 2.5 ohms is obtained between the wiper and the counterclockwise terminal of a standard 1000 ohms potentiometer when the probe is positioned at zero on the program chart.

CAUTION

Use only high impedance ohmmeter to check potentiometer resistance; low impedance meters can cause potentiometer burn-out.

Realignment is accomplished as follows:

1) Set the probe at zero position on the chart.

2) Loosen the set screws in the potentiometer pulley and holding the unit securely, rotate the potentiometer shaft fully counterclockwise with a screwdriver inserted in its slotted end; then resecure the pulley, taking care not to disturb the position of the shaft.

6-7 Removal of Gear Train and Time Base Motor Assembly

The gear train and time base motor assembly may be removed from the DATA-TRAK for replacement by first removing the change gears under the front cover and then loosening the three retaining screws pointed out in Figure 6-2.

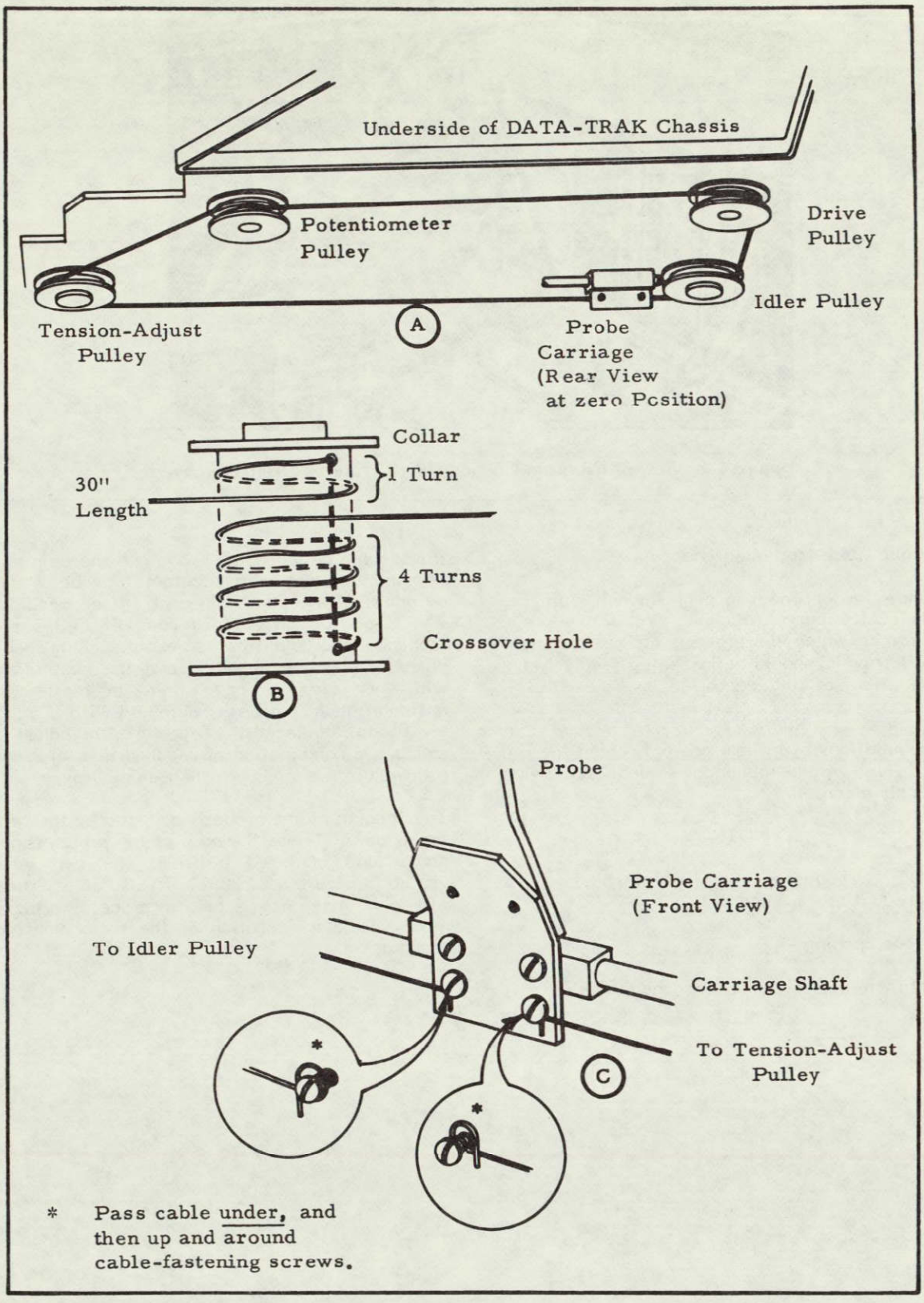


Figure 6-1 Drive Cable Wiring System

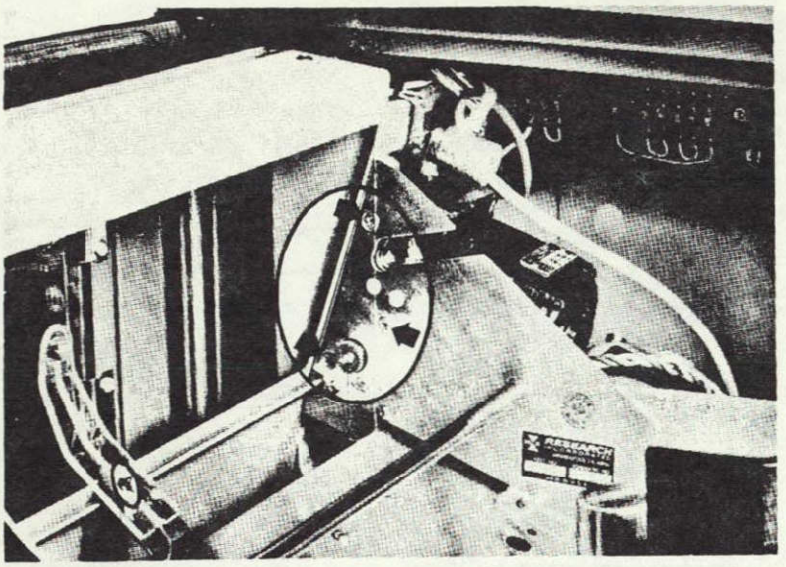


Figure 6-2 View of Program Carriage With Program Drum Removed

6-8 Probe Guide Rod Maintenance

To assure the optimum in performance from the DATA-TRAK s curve following probe, the probe guide rod to which the probe is affixed and upon which it travels, should be inspected regularly for accumulation of oil deposited by the OILITE bearing.

If accumulations of oil are present, clean the rod with a high grade cleaning solvent and wipe thoroughly clean.

NOTE

DO NOT use any form of petroleum product as a lubricant.

6-9 Probe Spacing

For optimum performance from the DATA-TRAK, the spacing between the probe and the drum must be such that optimum accuracy may be obtained by adjustment of the Gain control (see Heading 4-10). Due to differences inherent in the electronics of the amplifiers, an exact spacing specification cannot be obtained and the best spacing will vary from unit to unit. In most cases, optimum performance is obtained with a spacing of .04 to .06 inches. Therefore, to adjust the spacing, a combination of readjustment of spacing followed by Gain adjustment is necessary.

The spacing of the probe is adjusted by the teflon screw located near the base of the probe, slightly above and centered between the two screws visible in Figure 6-2 above. This screw is either a self-locking type or is held in place by a locking nut. Clockwise rotation of the screw decreases the spacing.

Section 7

TROUBLESHOOTING

7-1 General

The DATA-TRAK has been designed to provide the optimum in trouble free programming operation. The electronic circuitry is simple and straight forward and with the aid of the DATA-TRAK schematic diagram on which pertinent quiescent voltage levels are noted, little difficulty should be experienced in isolating any trouble that may develop. Some of the more common troubles are listed below: Waveforms, voltage and resistance readings follow:

TROUBLE	PROBABLE CAUSE	REMEDY OR CHECK
1. Drum does not rotate when switched to run.	a. Drum not properly seated (drive gears not engaged).	a. Reseat drum, ensuring proper meshing of gears.
	b. Change gears loose, or cocked on keys or drive shaft.	b. Ensure that teeth of gears are meshed and keyed hubs on shafts are properly engaged with keyways in backs of gears; then tighten thumb nuts securely.
	c. Drum limit switch is actuated by trip tab.	c. Manually rotate drum to position trip tab past drum limit switch.
2. Probe does not follow program curve.		
SYMPTOMS		
a. Probe remains stationary regardless of position on chart	a. Shorted program curve.	a. Check for short in curve as described under Heading 4-2 C; reetch faulty portion of curve.
b. Probe drifts in area to left (right) of program line	a. Left (right) hand chart energizing circuit shorted to ground.	b. Trace out left (right) hand chart energizing circuit and eliminate shorted condition.
c. Probe drives to and remains at left (right) edge	c. Left (right) hand chart energizing circuit open.	c. Ensure that chart energizing insert pins are installed in the left (right) edge of program drum and that they are making proper contact with the chart energizing hub clips.
d. Probe drifts erratically over entire surface of chart, irrespective of program line	d. Loss of energizing voltage to both sides of program chart.	d. Ensure that charge energizing insert pins have been installed in both edges of the program drum and are making proper contact with the metallized surface of the program chart.
3. Dead Probe	a. Shorted Program	a. Chart resistance (left to right) should be 1 megohm minimum. Redraw the curve if less.
	b. No AC power to the chart.	b. Check for 40 VAC present at the power supply, Transformer T1 secondary, current limiting resistors R2 and R3 and capacitor C4.
	c. Probe shorted.	c. Check the resistance between the shield and conductor of the microdot cable. Should be 10 megohm minimum. If less, replace cable.

SYMPTOMS	PROBABLE CAUSE	REMEDY OR CHECK
	d. Probe open.	d. Check the microdot cable for an open, replace if bad.
	e. Bad servo amplifier.	e. Check transistors. Replace the amplifier board if bad.
	f. Bad servomotor.	f. Check for open or short in the motor windings. Replace motor if bad.
	g. Bad power supply.	g. Check voltage levels of power supply.
4. Probe Erratic	a. Ungrounded probe head.	a. Resistance of the probe head to the cable connector shield should be less than 0.1 ohm. Replace if bad.
	b. Bad servo amplifier.	b. Check transistors. Replace the board if bad.
5. Probe Oscillates	a. Probe is too close to chart.	a. Check for a .030" to .050" gap. Readjust if necessary and reset the gain control.
	b. Gain on servo amplifier is too high.	b. Adjust the gain control for the best sensitivity without oscillations.
6. Probe drives to one end of the chart.	a. AC open to one side of the chart.	a. Check for proper voltages at the chart, current limiting resistors R2 and R3, or the power supply transformer T1.
	b. Shorted program.	b. Check the chart resistance left to right. Should be 1 megohm minimum. Redraw the curve if less.

7-2 Resistance and Voltage Checks

Reference schematic KD33568B for the following resistance measurements to ground. Equipment needed VOM (Triplett) or equivalent 20,000 ohms/volt meter.

A. Resistance Checks

For the following readings adjust the gain control for maximum (fully clockwise). Select the meter scale of X 1K ohms.

Minus Lead on Ground		Positive Lead on Ground	
Probe	Reading	Probe	Reading
Base Q1		Base Q1	40 K
Base Q3	3400	Base Q3	50 K
Q4	4000	Q4	20 K
Q5	15 K	Q5	12 K
Q6	6 K	Q6	35 K
Q7	20 K	Q7	7 K
Q8	1.2 K	Q8	1.2 K
Q9	1.2 K	Q9	1.2 K
P1A	Short	V1A	Short
L		L	9 K
X	200	X	200
Y	15 K	Y	17 K
Z	15 K	Z	15 K
Cathode CR1	4.2 K	Cathode CR1	3 K

B. Voltage Checks

From	To	
Junction CR12 & 13 (-)	Junction CR10 & 11 (+)	= 32 VDC
Cathode CR1 (+)	Ground (-)	= 15 VDC
Drum Feed D1	Ground	= 40 VDC
Drum Feed D2	Ground	= 40 VDC
Drum Feed D1	Drum Feed D2	= 85 VAC

The following measurements are to common at NULL.

LOCATION	READING
Base Q3	+1.2 VDC
Emitter Q3	0 VDC
Base Q4	+2.0 VDC
R14 to R17	+14.5 VDC to 15.5 VDC
Emitter Q4	+1.5 VDC
Collector Q5	0 VDC
Base Q5	+25.0 VDC
CR1	+15 VDC
C9	+20 to 25 VDC
Base Q6	+1 VDC
Base Q7	-1 VDC
Collector Q8	+16 VDC
Base Q8	+0.4 VDC
Base Q9	-0.4 VDC
Collector Q9	-16 VDC

The following illustrations reference the above component locations.

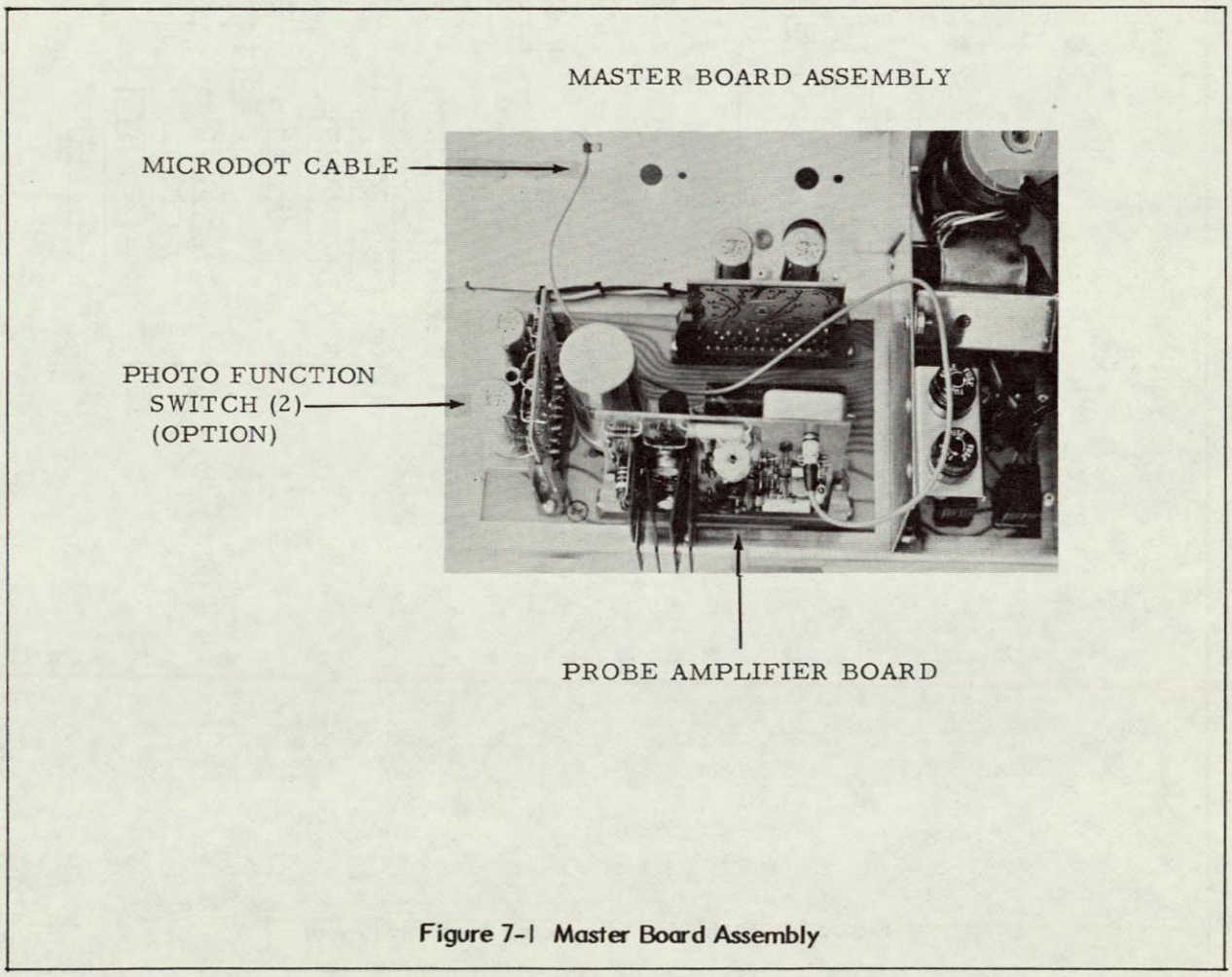


Figure 7-1 Master Board Assembly

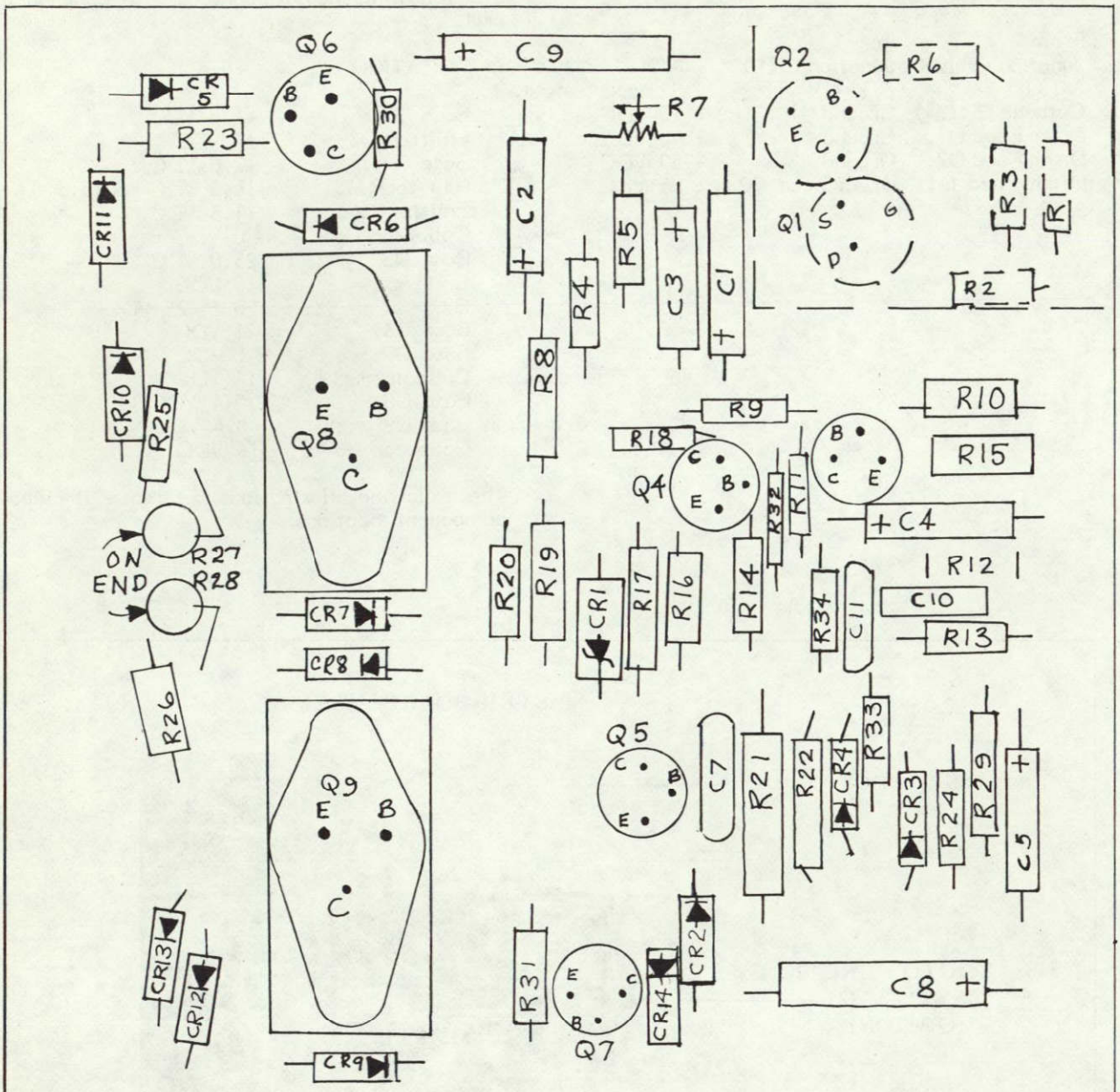
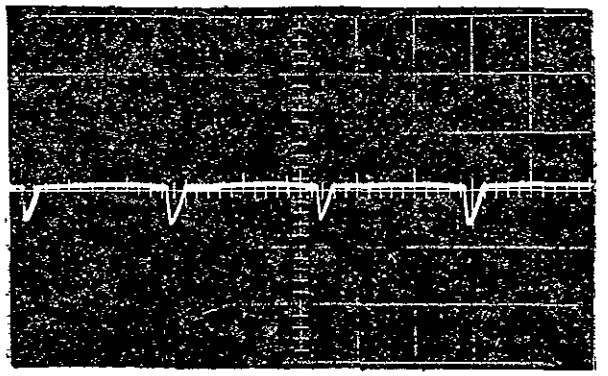


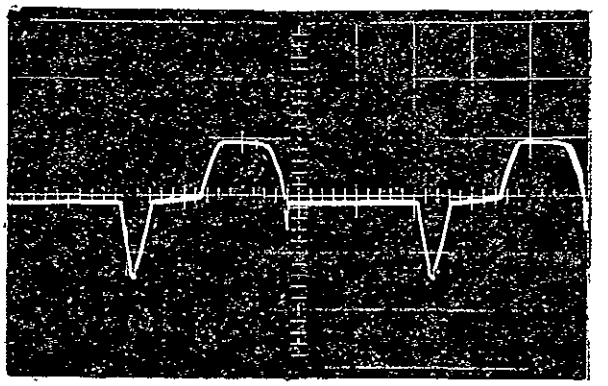
Figure 7-2 Probe Amplifier Board Assembly Layout

7-3 Waveforms

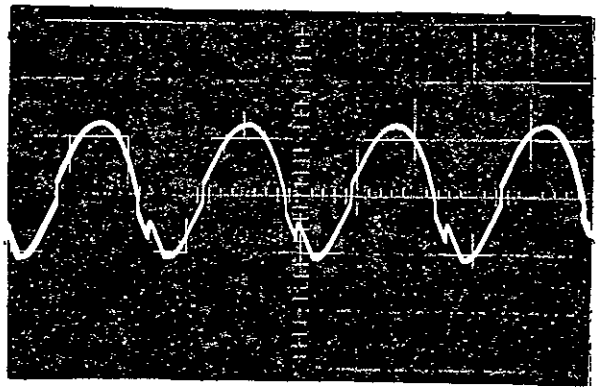
The following amplifier voltage waveforms were taken using a 5 millisecond per centimeter time base. Oscilloscope set up instructions are given below each waveform.



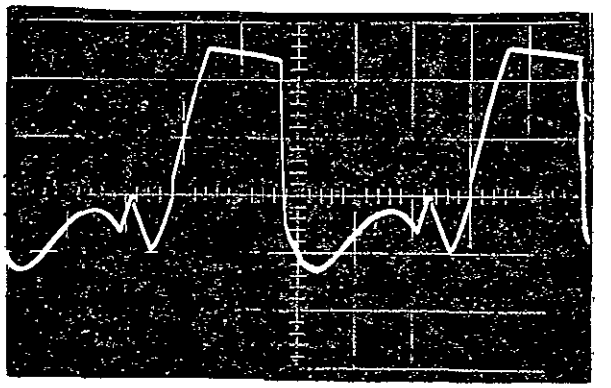
1 V/CM
Collector Q3 Null



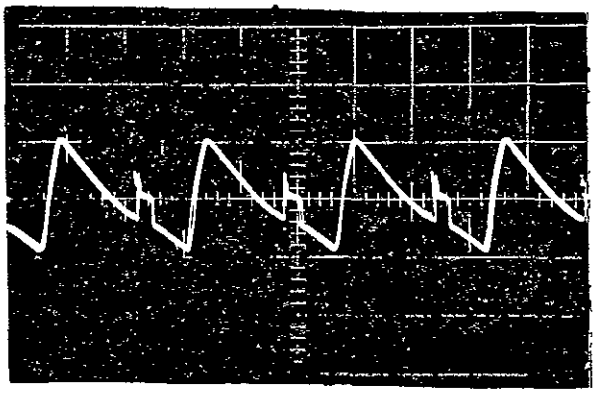
1V/CM
Collector Q3 Probe Offset



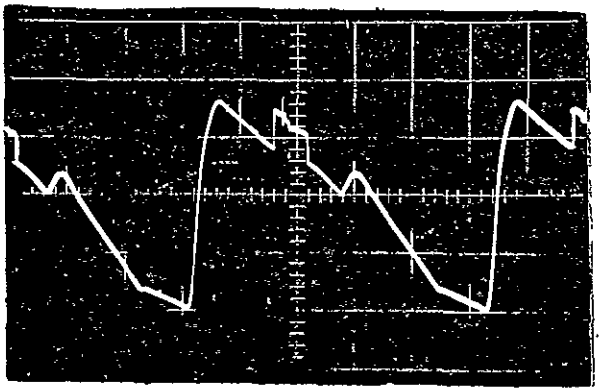
5 V/CM
Collector Q5 Null



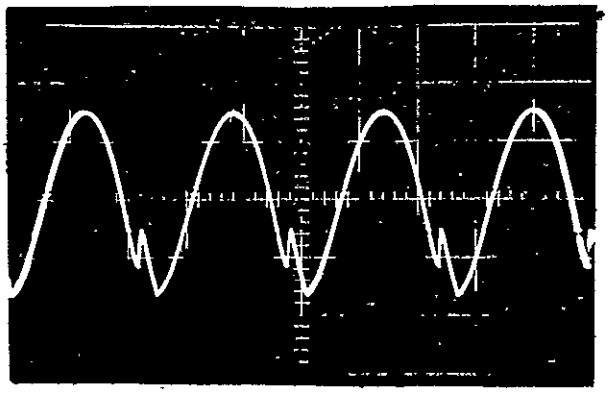
5 V/CM
Collector Q5 Probe Offset



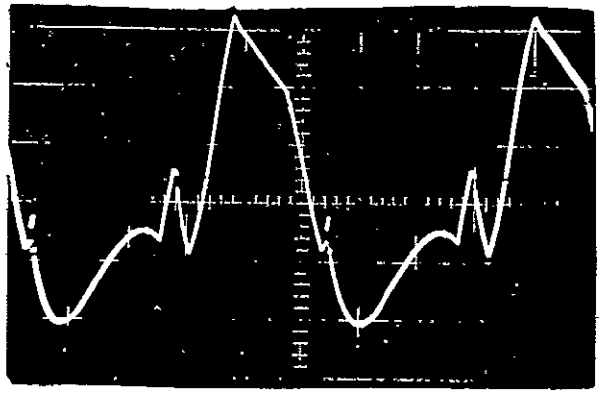
1 V/CM
Collector Q4 Null



1 V/CM
Collector Q4 Probe Offset



5 V/CM
Collector Q8 Null



5 V/CM
Collector Q8 Probe Offset

7-4 Motor Windings

Shown in the figures below are the various motor winding layouts and respective resistance (DC).

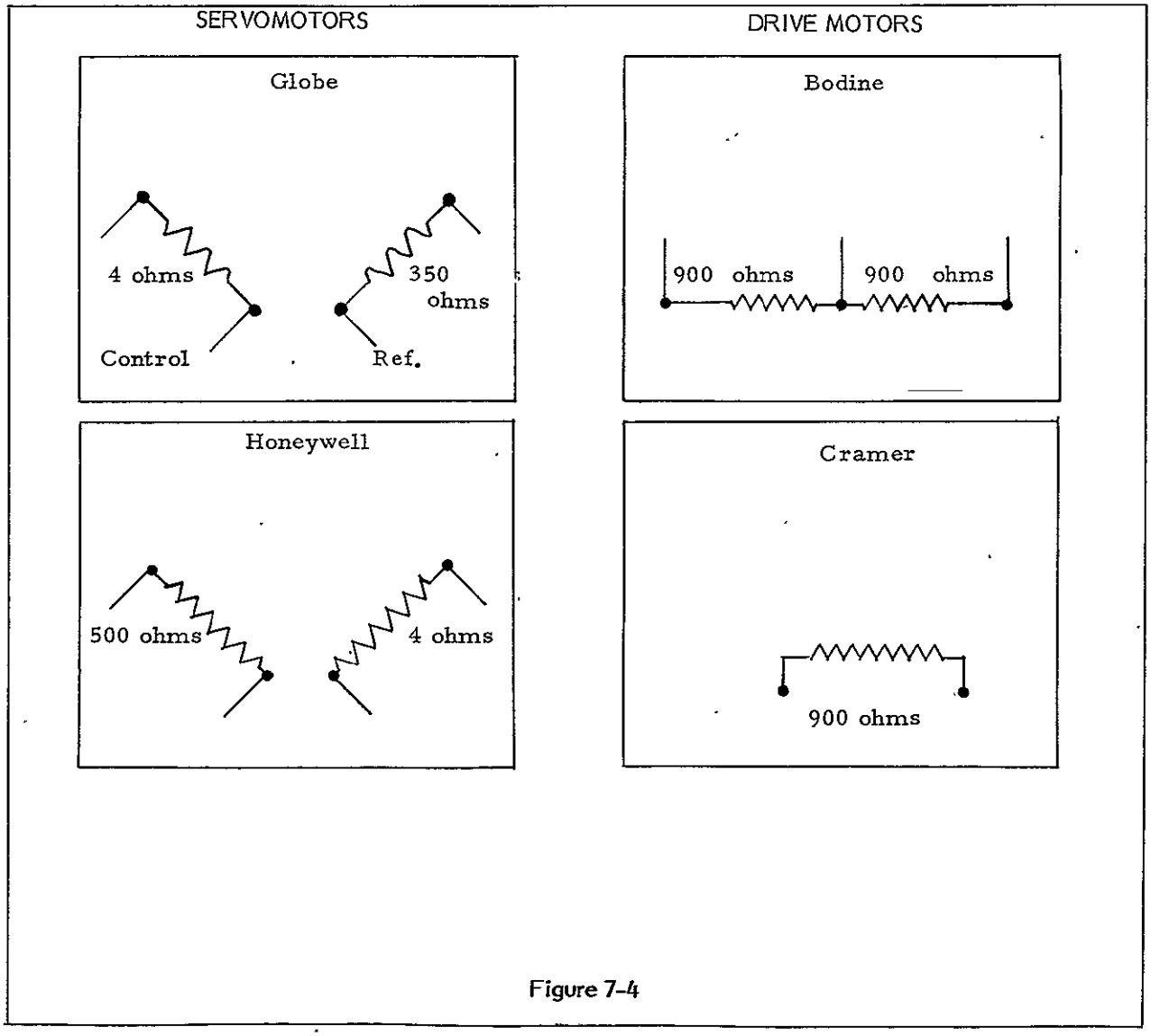


Figure 7-4

7-5 Optional Features Voltage and Resistance Checks

The following voltage and resistance checks are for the Photo Function Switch (PFS) option. Both sets of checks are to be made with the relays pulled out of the card.

Voltage Checks

These checks are to be made with the negative probe on common.

Location (+)	Reading
Junction CR9 & CR10	23 VDC
Junction CR6 & CR7	32 VDC
Junction CR5 & CR8	25 VDC
Junction CR3 & R1	20 VDC

Pull the PFS card out. Common is Pin A and S on the card.

Location	Reading (- to common)	Reading (+ to common)
B	30K	2K
C	20K	Infinity
D	30K	2K
E	Infinity	Infinity
F	Infinity	Infinity
H	Infinity	Infinity
J	20K	40K
L	NC	NC
M	Infinity	Infinity
N	Infinity	Infinity
P	Infinity	Infinity
R	20K	Infinity

Section 8

OPTIONAL FEATURES

NOTE

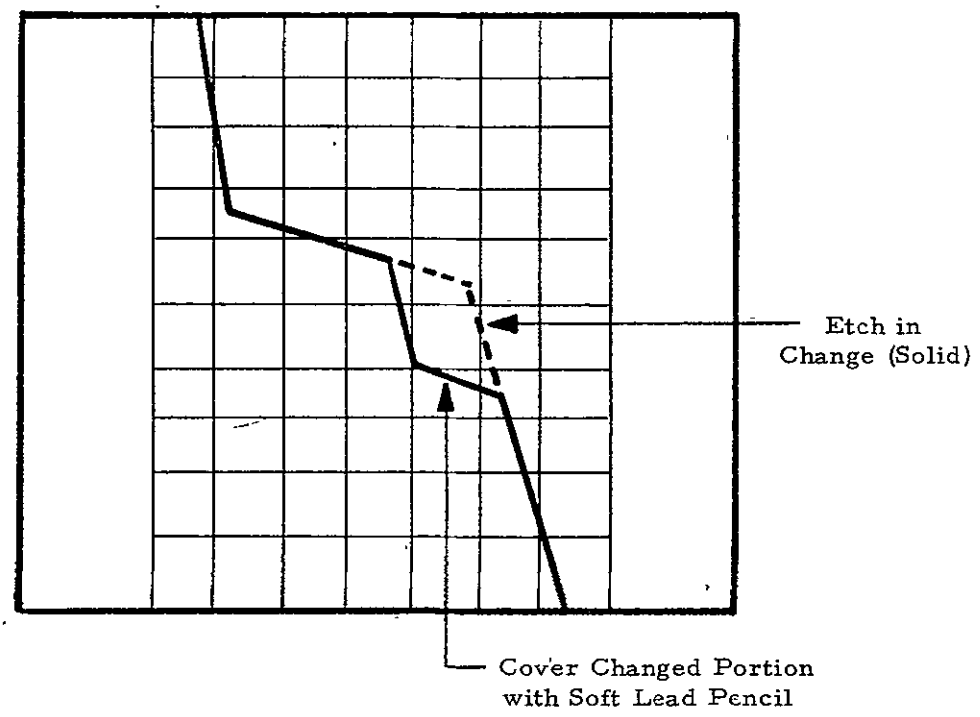
The following text and illustrations describe the optional features which may be installed on the instrument for which this instructional manual is provided.

5110
5300
5500

ADDENDUM FGE DATA-TRAKS

It is possible to make temporary change in an existing program without changing the chart. This can be done by using a soft lead pencil to cover the portion of the program to be changed and etch in the desired change. Reference the sketch below.

Once the program has been resolved, it is recommended that it be transferred to a new chart.



ALARM SWITCH OPTION

The AS51 option expands the DATA-TRAK s capabilities to allow the operator to program momentary contact transfer of a switch at a preselected level of programmed output. A notched cam and switch assembly is mounted on the DATA-TRAK s swing out assembly. This assembly is installed in the same fashion as the output device and the cams are pulley driven by the probe cable (see photo).

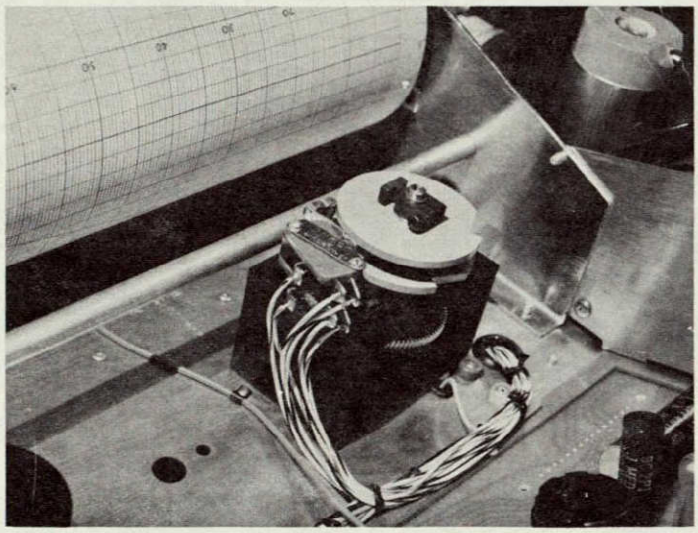


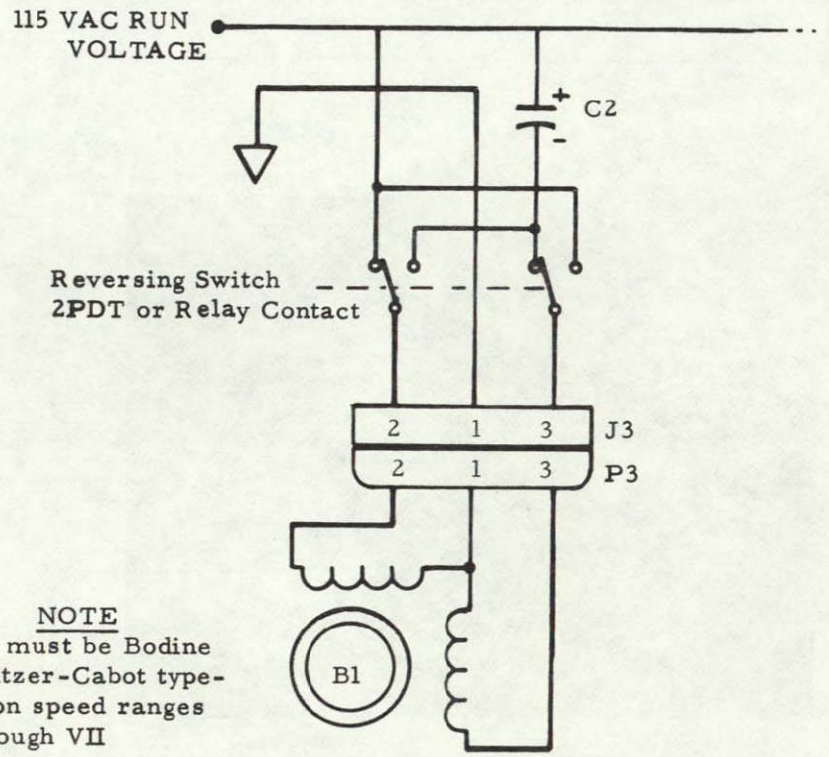
Figure 1 AS51-X Assembly Mounted

As the probe tracks back and forth to follow the program curve, the cams are rotated accordingly. As previously mentioned, the cams are notched and when the notch passes beneath the actuating arms of the switch the contacts of the switch transfer. The cam may be set (by loosening a set screw on the cam assembly and rotating the cam) to actuate the switch at any desired level of programmed output (probe position).

The contacts of the switches are wired to the terminals designated Limit Alarm Switch on the DATA-TRAK entrance board. Maximum current which may be passed through these contacts is 5 amperes at 115 VAC (2 amperes at 230 VAC). The switches are numbered from bottom to top as designated on the entrance board.

DRUM FORWARD/REVERSE SWITCH OPTION

The DATA-TRAK programmer may be equipped with a Drum Forward/Reverse switch to enable selection of either forward or reverse rotation of the program drum. If provided, the switch will be located directly to the left of the Mode Selector switch on the front panel of the DATA-TRAK; the manner in which its contacts are wired to reverse the phasing of the time base motor is illustrated below.



NOTE
Motor must be Bodine or Holtzer-Cabot type- Used on speed ranges III through VII

RPM Motors

P1----BLUE
P2----RED
P3----BLACK

5110 DATA-TRAK PRESET COUNTER (PSC) OPTION

The instrument for which this manual is provided may be equipped with a preset counter to enable the program drum to be automatically stopped after a predetermined number of revolutions.

To preset a desired number of drum revolutions, press the button next to the counter register and rotate the red plastic shield upward. Set up the desired number of revolutions on the setting register and close the red plastic shield.

When placed in operation, the DATA-TRAK drum will continue rotating until the accumulated count in the counter register is equal to the preset count in the setting register, at which time rotation of the drum will be automatically stopped.

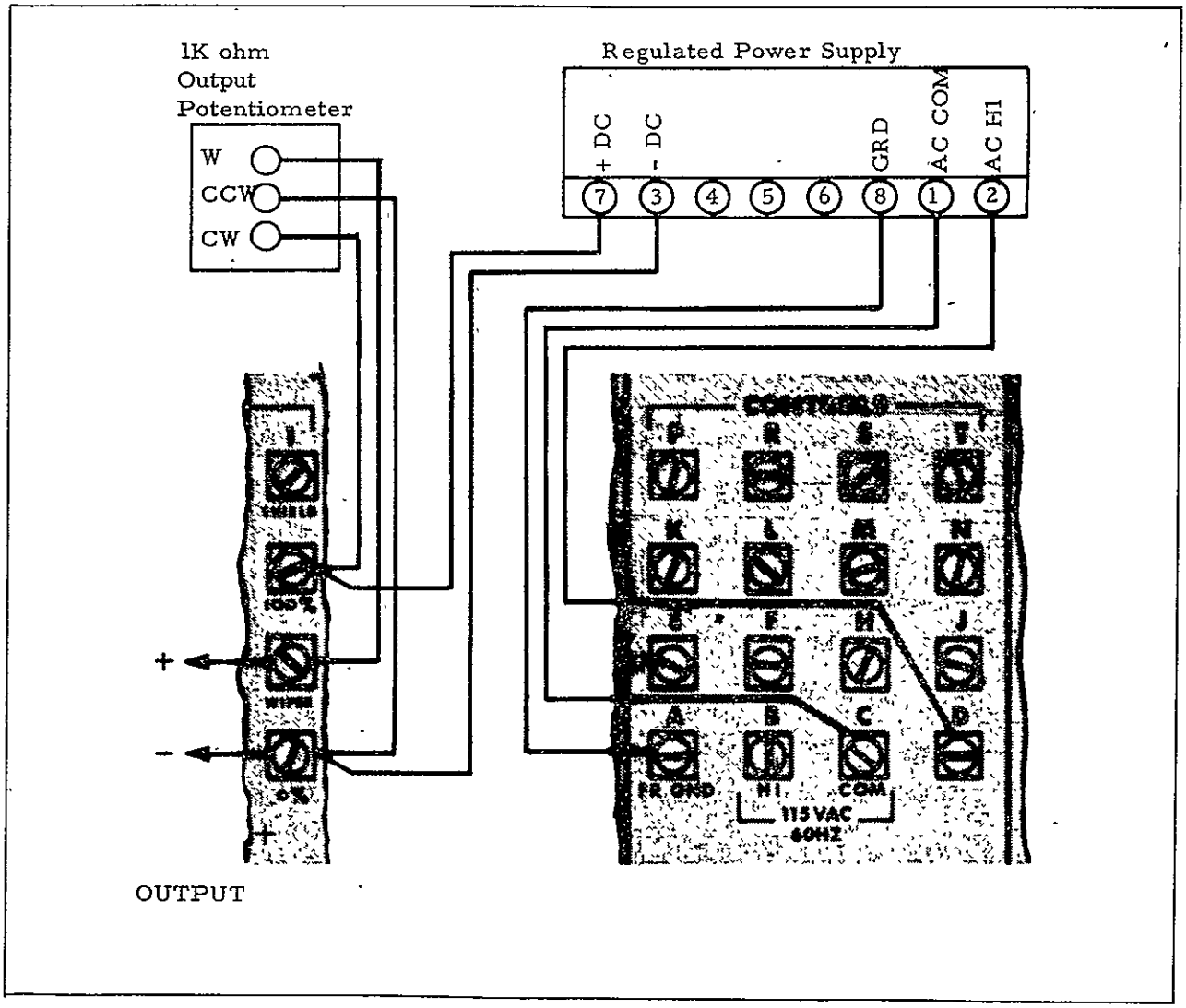
When equipped with the PSC, the DATA-TRAKs drum limit switch S2 is removed from the circuit. A jumper is installed between terminals "R" and "S" of the entrance board when the RDB option is provided.

To (effectively) remove the PSC from the circuit, dial in some arbitrary count and remove the S3 trip tab.

REGULATED POWER SUPPLY OPTION

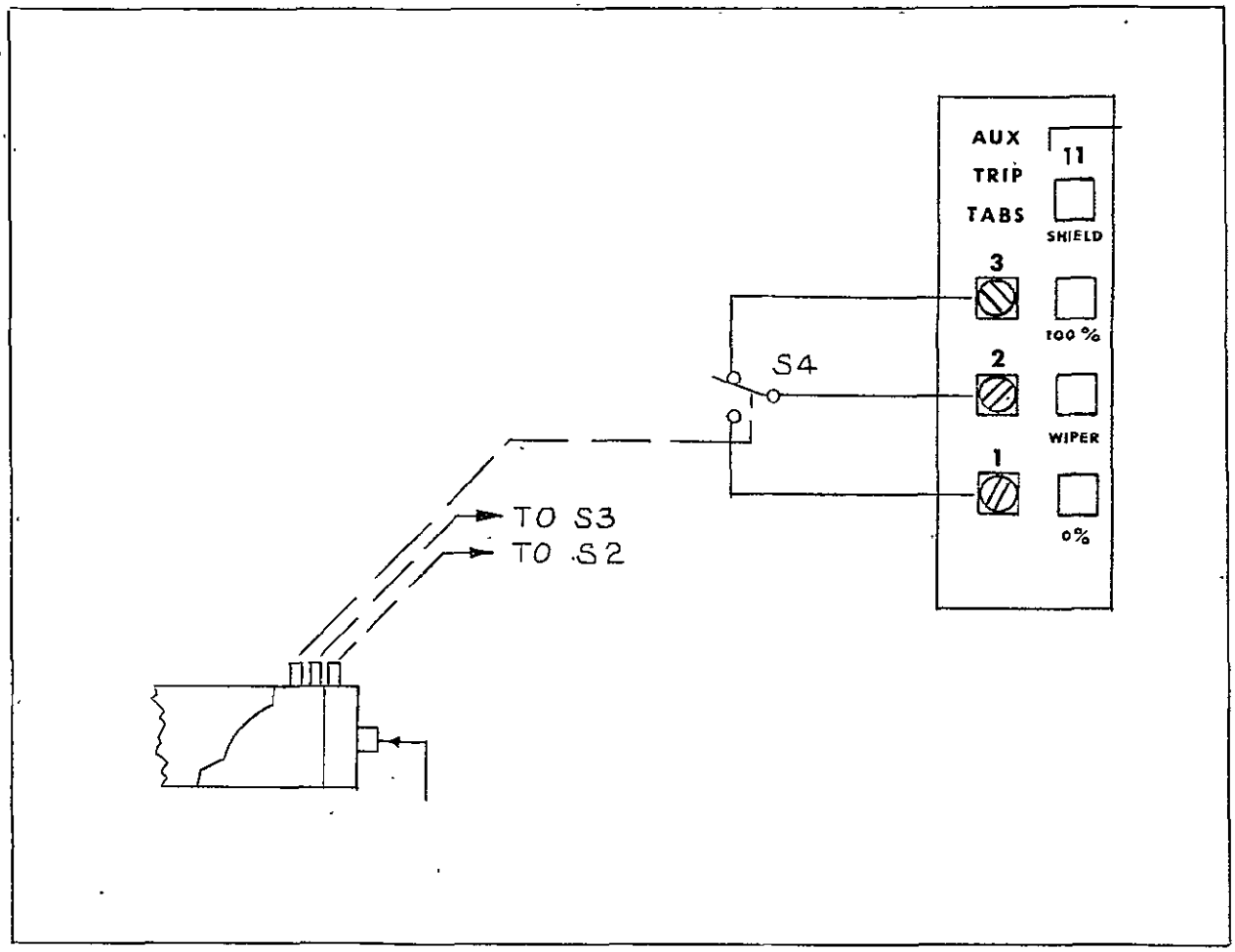
The DATA-TRAK may be equipped with an optional Regulated Power Supply output. This option provides a linear output voltage ranging from zero to +10 VDC (other ranges available). The output of the RPS is wired to the normal output connections of the DATA-TRAK; as shown below.

As the curve following probe of the DATA-TRAK tracks back and forth to follow the program, the wiper of the 1K output potentiometer is varied accordingly; delivering to the load from zero to 100% of the voltage applied to the output potentiometer.



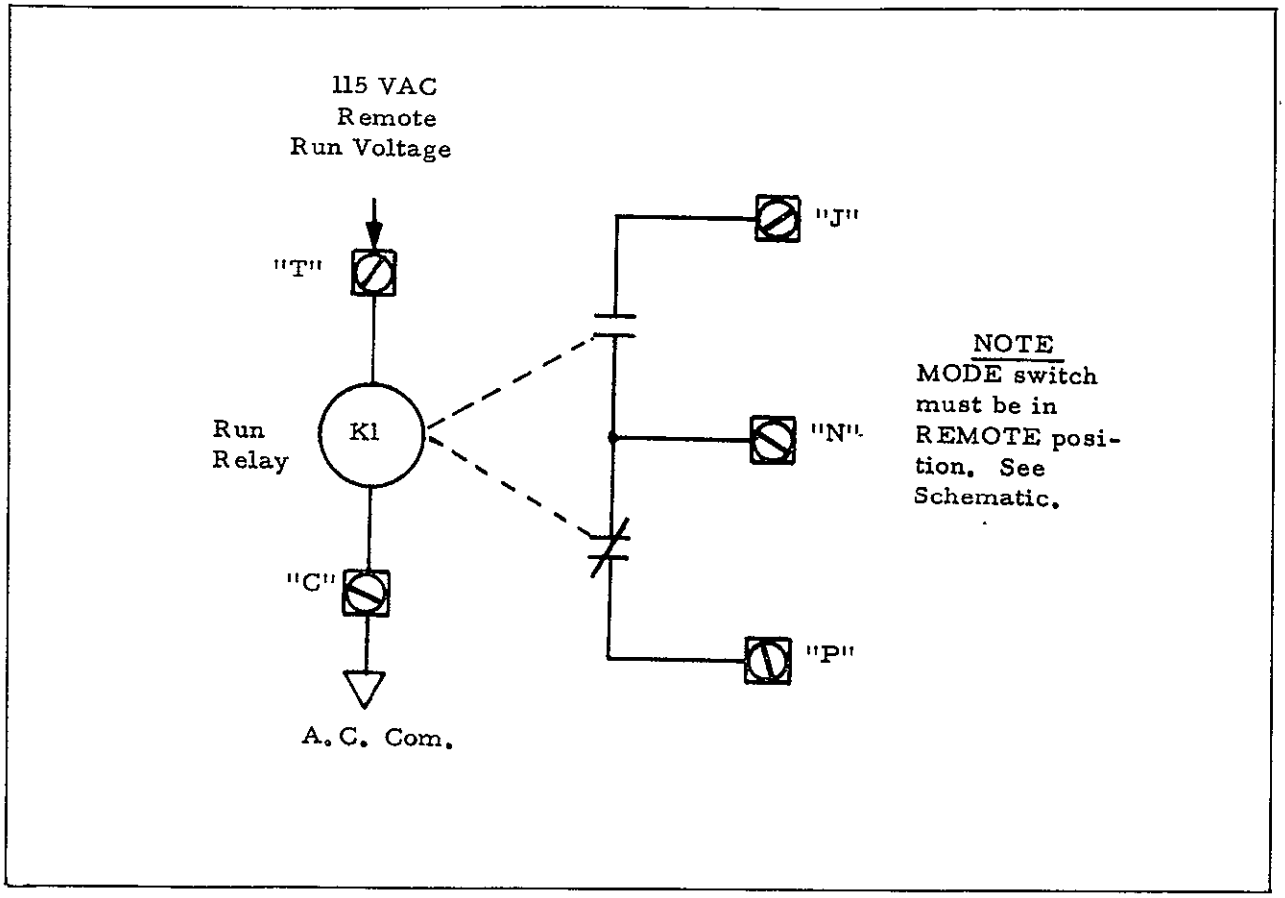
THIRD MICROSWITCH ADDITION

The DATA-TRAK Programmer may be equipped with a third auxiliary microswitch. The switch will be installed next to the two original microswitches and is actuated by a third trip tab.



REMOTE RUN CONTROL OPTION

The DATA-TRAK may (generally in system applications) be equipped with a remote run control relay. This option functions identically to the remote run control switch described under Heading 5-3 and illustrated by Example "B" in Figure 5-1. To operate under the control of the relay, the DATA-TRAK s Mode switch must be in the Remote position. Under these conditions, the DATA-TRAK will go into run when 115 VAC is applied to terminal "T" of the entrance board.

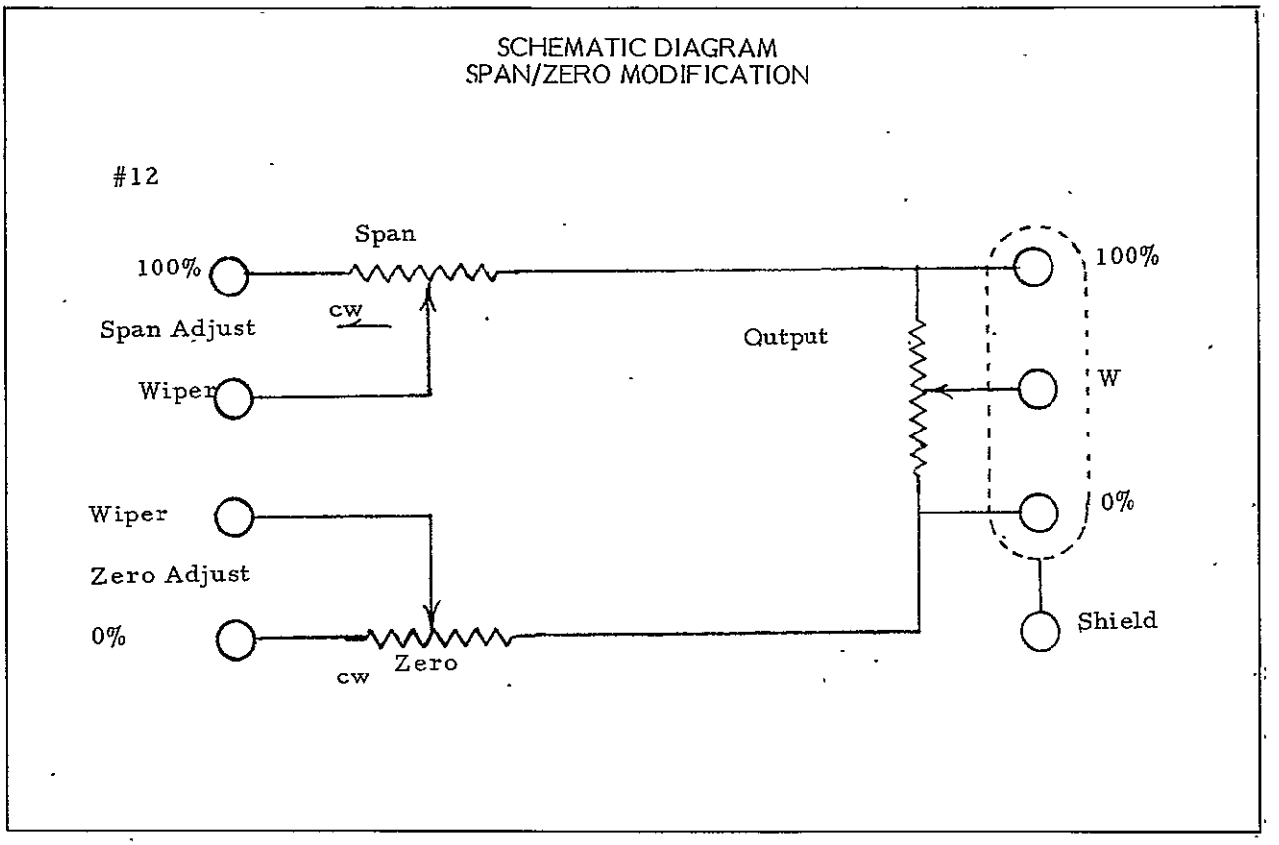


5110 DATA-TRAK SPAN/ZERO MODIFICATIONS

The instrument for which this instruction manual is provided may differ from standard with respect to the output potentiometer connections. The output potentiometer may be augmented by the addition of two trim pots designated Span and Zero. Refer to the schematic below for exact output potentiometer configuration and value.

The trim pots will be located behind the swing out chassis on a bracket near the top right side of the cabinet.

SCHEMATIC DIAGRAM
SPAN/ZERO MODIFICATION



POTENTIOMETER VALUES

R	R	R
Span	Output	Zero

TB5197 TIME BASE OPTION

The DATA-TRAK Programmer may be equipped with a special Model 5197 - time base. If designated 5197 in the model number, please disregard all information in the manual pertaining to the standard time base gear train and change gears.

The specific speed of the special time base, in inches/hour and hour/revolution, can be found on the tables below.

TIME BASE MODELS

MODEL NO.	PROGRAM SPEED	
	in./sec.	sec./rev.
5197-1	1-1/8	12
5197-2	DISCONTINUED	
5197-3	DISCONTINUED	
5197-4	3/10	45
5197-5	9/40	60
5197-6	3/16	72
5197-7	3/20	90
5197-8	9/80	120
5197-9	3/40	180
5197-10	3/64	288
5197-11	3/80	360
	in./min.	min./rev.
5197-12	1-1/2	9
5197-13	1-1/8	12
5197-14	9/10	15
5197-15	3/4	18
5197-16	6/10	22-1/2
5197-17	9/16	24
5197-18	9/20	30
5197-19	3/8	36
5197-20	3/10	45
5197-21	9/32	48

MODEL NO.	PROGRAM SPEED	
	in./hr.	hr./rev.
5197-22	13-1/2	1
5197-23	11-1/4	1-1/5
5197-24	9	1-1/2
5197-25	6-3/4	2
5197-26	5-5/8	2-2/5
5197-27	4-1/2	3
5197-28	3-3/8	4
5197-29	3	4-1/2
5197-30	2-13/16	4-8/10
5197-31	2-1/4	6
5197-32	1-1/2	9
5197-33	1-1/8	12
5197-34	3/4	18
5197-35	9/16	24
5197-36	3/8	36
5197-37	9/32	48
5197-38	1/4	54
	in./day	day/rev.
5197-39	4-1/2	3
5197-40	2-1/4	6
5197-41	1-1/2	9
5197-42	1-1/8	12

ADDENDUM FOR

4 Decade Electronic Time Base — Model 4ETB

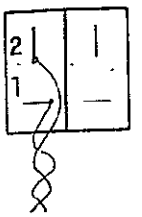
General Information

The Model 4ETB electronic time base is an easy to use, easily installed option for the Models 5110 and 5110-2P DATA-TRAK. It allows time base changes without substitution of new drive motor gears; at all settings it is accurate to one part in 3,600 or 0.028% of the program time span. Program time is set by means of four manually operated decimal entry switches; the standard unit allows durations ranging from 1 minute to 9,999 minutes in increments of 1 minute. The optional -4ETB 10M provides 10 minute increments giving a time range of 10 minutes to 99,990 minutes. Other options include: -FA (Fast Advance) providing remotely controlled selection of either normal switch selected time base or the alternate 1 minute fast advance of program drum. The -XD (External Driving source) allows the user to replace the 60 Hz power line reference source with his own timing pulses; the -XD option will accept standard TTL logic level signals (pulse amplitude +5 V) although higher levels are also usable.

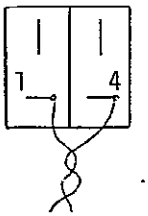
Installation

Mechanical installation is easily performed, using screws in the threaded ends of the three stand-offs attached to the frame of the 4ETB. Electrical connections involve insuring that 120 VAC power is applied to the time base. When the 4ETB is installed in a standard 5110, simply plug the connector from the time base into the mating jack, J3, located as the leftmost of the two jacks in the right corner of the master board. These jacks are accessable by opening the 5110 door and unlatching and swinging the main chassis out.

When the 4ETB is to be installed in a Model 5110-2P, the ETB plug P3 must be rewired. Refer to diagram below:



P3 (top view) for 5110



P3 (top view) for 5110-2P

Fast Advance Option Connections

The -FA option allows an externally supplied set of form C contacts to select between fast advance (1 minute program time) and the time base set on the manual entry switches. Refer to schematic D47171; in normal use the ETB is equipped with a jumper wire connecting the output of the divider chain to the stepper drive circuit. For the factory installed -FA option, this wire is removed and the three connection points are brought out to the rear panel of the 5110. Alternatively a front panel switch may be installed.

External Drive Option Connections

The -XD option permits external drive signals (pulse tachometer, etc.) to be used in place of the power line frequency reference. When factory installed, this option uses a jumper wire connecting the input of the timing chain and the output of signal conditioning circuitry. The input of the conditioning circuitry is in turn connected to terminals on the rear panel of the 5110. The driving source should provide positive going pulses of at least 5 volts amplitude (maximum input limit 100 volts) with pulse durations of 0.05 milliseconds. The maximum usable input frequency is limited to 10KHz and in general is limited to a frequency of 40 times the value on the decade switch settings.

Operation

To enter a time period: the program time (time for one complete revolution of the program drum) is equal

to the sum of the value of the four switches, where each switch represents the decimal number set on it times the multiplier printed next to it. For example, for switches reading from lowest to topmost, 5-4-4-0, the corresponding time is 5x1000 pus 4x100 plus 4x10 plus 0x1, or 5,440 minutes per revolution.

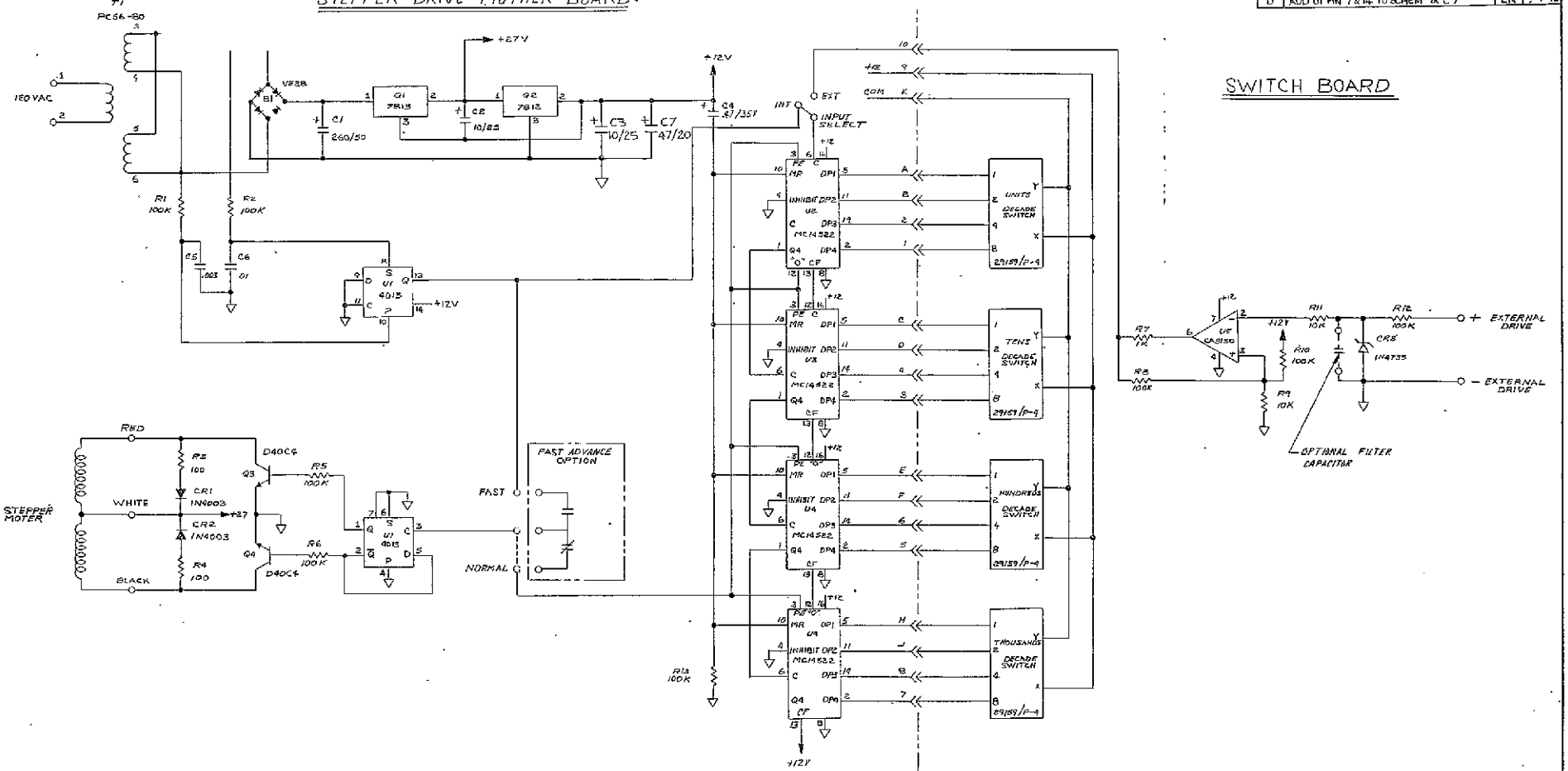
After entering a new time value, always set the 5110 Mode Switch to the Hold position for 5 seconds, which clears the previous setting from the time base. Normal operation may then be resumed.

Theory of Operation

The following description is applicable to both 60 Hz and 50 Hz units; the 50 Hz ETB has circuitry identical to the 60 Hz unit but is equipped with a different drive gear.

Operation is achieved by coupling a stepping motor to the program drum. For every 3,600 pulses to the stepping motor the drum revolves once. Timing is accomplished by electronically dividing the 60 cycle per second power line frequency and using the resulting pulses to step the motor. In one minute there are 60 seconds times 60 cycles per second or 3,600 cycles; the drum thus revolves exactly once per minute. If the line frequency is divided by two, there will be only 1,800 pulses per minute and so one complete revolution will occur in two minutes, and so on. Since the timing is based on the power line frequency which is maintained to high precision standards, the divided signal and hence the drum rotation is very accurate. The four program time switches determine the actual divisor used and so the time base is easily set for any of the 9,999 different time periods within its range. In addition, the -XD option allows any external frequency to be used as the master reference, giving a virtually unlimited range of speeds.

STEPPER DRIVE MOTHER BOARD



SWITCH BOARD

REVISIONS			
SYM	DESCRIPTION	DRAFT	DATE
A	C5 WAS .01/50V	DWM	2-13-74
B	C6 WAS .1 UF	DM	6-8-76
C	ADD INV #10	DS	7-23-76
D	ADD U1 PIN 7 & 14 TO SCHEM & C7	LN	9-1-76

381115	5110	047907
INVENTORY	USED ON	ASSEMBLY

INVENTORY 3D1716

SCHEMATIC - 4 DECADE ELECTRONIC TIME BASE

DRAWING KD47171 REV D

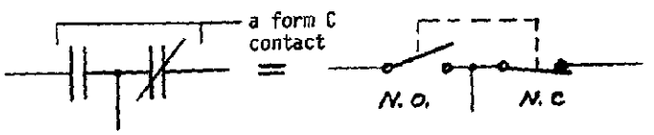
R-I CONTROLS
A DIVISION OF BERKSHIRE INDUSTRIES, INC.
MT. BELLEVUE, MINNESOTA 55424

ADDENDUM FOR
PROGRAMMABLE EVENT OPTION FOR THE 5110 DATA-TRAK

General

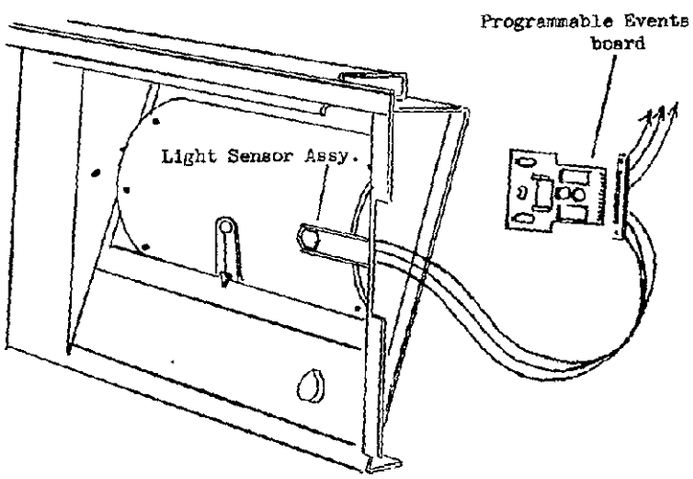
The Programmable Event (PE-) option for the 5110 DATA-TRAK Programmer allows the user to individually control up to four switch contact sets by means of optical (reflective tape strips) programming on a standard 5110 program chart. The PE-2 provides two independent form C contacts (see diagram below) while the PE-4 option allows four sets of form C contacts to be controlled. Electrical connections to the relays are made at the rear panel of the DATA-TRAK.

time
5-to
the
pow



PE Option - Switch Contacts: Form C

A PE-unit consists of a light sensor assembly containing phototransistors and infrared light emitting diodes (LEDs) plus one or two circuit boards containing power supply, detection and relay circuitry. See diagram below.

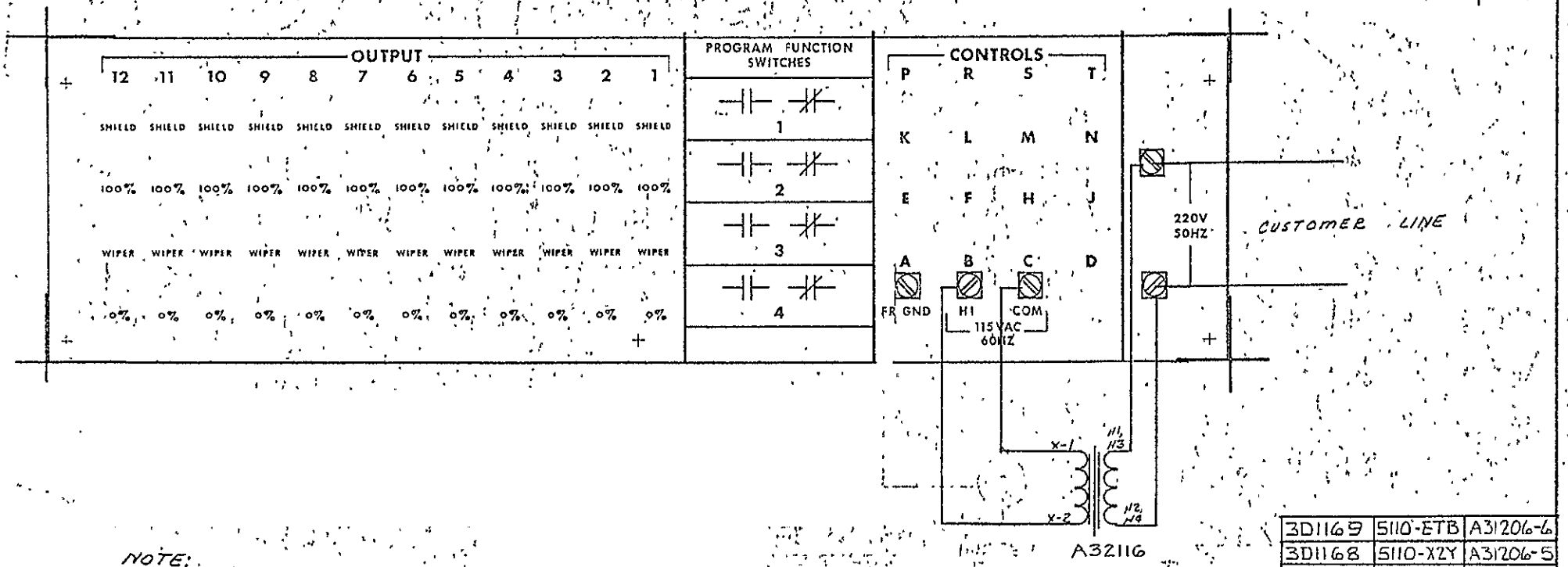


The PE circuitry features a design which significantly reduces the effects of ambient light and temperature on operation. This is accomplished by use of phototransistors and filter circuitry to detect pulsed light from the LEDs, reflected from the surface of aluminized tape strips laid down over black tape stripes applied to the surface of the program chart. For more information on circuitry, see the PE Theory of Operation.

Programming

(1) To prepare a chart for PE programming, a black background stripe must first be laid down to ensure contrast. Apply black tape (Research, Inc. part number 1A0158) to the full length of the drum

REVISIONS			
SYM	DESCRIPTION	DRAFT	DATE
C	REDRAWN	RL	10/23/67
D	REMOVED HUBBELL CONNECTOR-TYPE 5258 FROM 50 Hz OPTION	JBW	9-11-69
E	JUMPERS H1 TO H3 AND H2 TO H4 WERE H1 TO H2 AND H3 TO H4.	MARK	9-23-70



NOTE:
JUMPER - H1 TO H3
H2 TO H4

3D1169	5110-ETB	A31206-6
3D1168	5110-X2Y	A31206-5
3D1167	5110-TB48	A31206-4
3D1166	5110-XY	A31206-3
3D1165	5110-2P	A31206-2
3D0593	5110	A31206-1
INVENTORY	USED ON	SYSTEMS

FOR SILKSCREEN SEE B33550S
For SCHEMATIC SEE D33568 (3D0747)

DRAWN RL 10/23/67 | CHECKED | APPROVED | MATERIAL | TOLERANCE UNLESS OTHERWISE NOTED: 2 PLACE DEC ± | FRACTIONAL ± | 3 PLACE DEC ± | ANGULAR ± | REMOVE ALL BURRS AND SHARP EDGES | SCALE | SCHEMATIC

TITLE: ADDENDUM TO D33568 FGE 5110 DATA-TRAK For 50Hz OPERATION

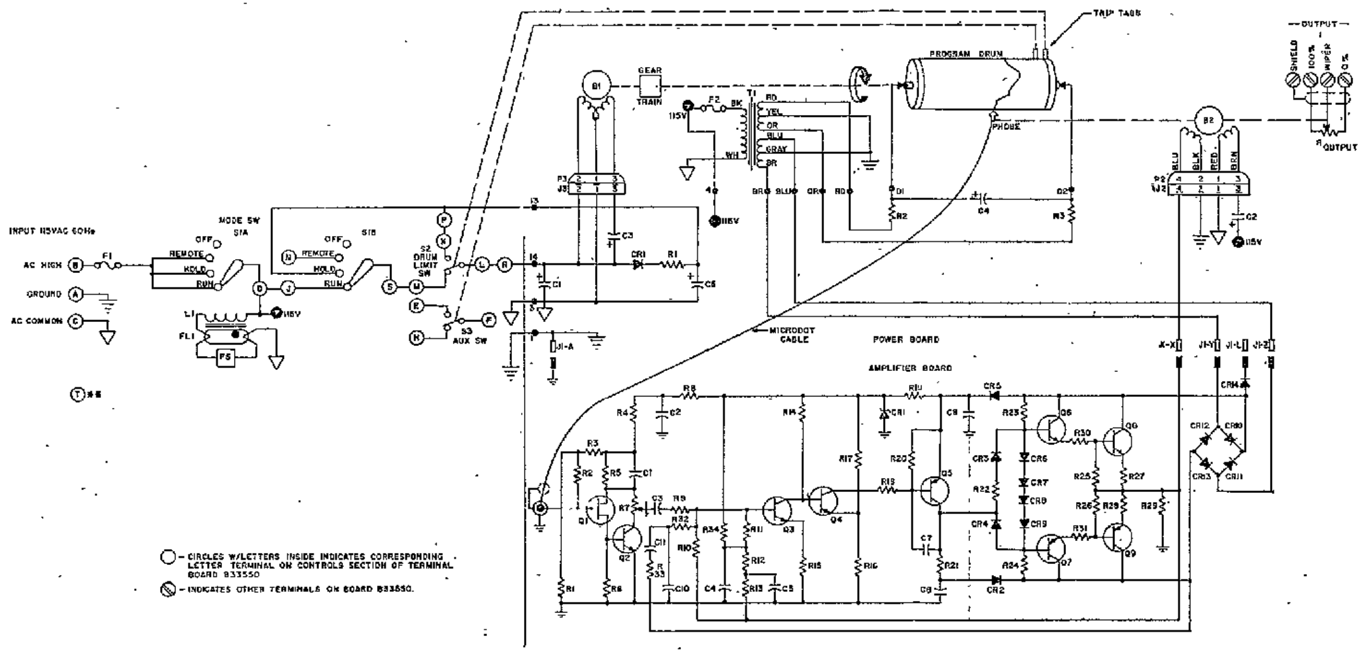
INVENTORY 3D0594 | NUMBER KB31207 | REV E | SHEET | OF

R·I CONTROLS

Section 9

SCHEMATICS

D33568 (1 & 2)	FGE5110 Data-Track
C34290	Probe Amplifier
C42433	Programmable Event Switches



○ – CIRCLES W/LETTERS INSIDE INDICATE CORRESPONDING LETTER TERMINAL ON CONTROLS SECTION OF TERMINAL BOARD B33550

⊘ – INDICATES OTHER TERMINALS ON BOARD B33550.

REVISIONS

REV	DESCRIPTION	DRAFT	DATE
A	R3 WAS 100K ON AMP PCB	RL	11/9/67
B	R2 & 3 ON POWER BOARD WERE 100K, ADDED R'OUTPUT NOTE F1 WAS ½ AMP SLO-BLO 3AG LITTLEFUSE	RL	12/8/67
C	ADDED C2 TO PPFS OPTION	BJ	5/1/69
D	[illegible]	[illegible]	8-19-70
E	PPFS CARD – ADDED R5, 6, 7, 8, C3, 4, 5 & 6 1N5357 WAS Z520B	RHP	5-20-71
F	R1 WAS 1/2W SHT 1 & 2	DS	6-2-72
G	SH 1 & 2 Q6 WAS 2N3643; Q5,7 WAS 2N[illegible]		
H	REDRAW SHT 2 [illegible] PWR BD.	DS	8-14-72
J	R27, 28 WERE 4.7 OHMS	[illegible]	8-31-74
K	CR10, 11, 12, 13 WERE D152	KB	9-20-74
L	REV. MASTER BD. AT P.E. CONNECTOR	[illegible]	1-19-76

FINAL, CASE, & CHASSIS ASSEMBLY

R OUTPUT – RESISTANCE & LINEARITY DETERMINED BY APPLICATION

FUSE F2 – SLO-BLO, 1/2 AMP, LITTLEFUSE, 3AG
TRANSFORMER, T1 – A32269
BALLAST, L1 – GE, 880435
STARTER, FS – GE, FS-5
FLUORESCENT TUBE, FL1 – STL, F8T5 CW
MOTOR, B1 – BODINE OR CRAMER, SYNCHRONOUS
MOTOR, B2 – GLOBE, 150 RPM
MICRODOT CABLE – 50-3804
SWITCH, S1 – A17689
S2,3 – MICROSWITCH, V3-601
FUSE F1, SLO-BLO, 3/4 AMP, LITTLEFUSE, 3AG

POWER BOARD ASSEMBLY D33544

CAPACITOR, C1 – 1 MFD, 200V
C2 – 1.5 MFD, 400V
C3 – 1 MFD, 600V
C4 – .01 MFD, 600V
* C5 – 40-40 MFD, 450V
DIODE, CR1 – D156
RESISTOR, R1 – 100Ω, 1W, 10%
R2,3 – 27KΩ, 1/2W, 10%

* NOT USED W/CRAMER MOTOR.
** USED W/REMOTE RUN RELAY OPTION.

AMPLIFIER BOARD ASSEMBLY D31504

POTENTIOMETER, R7 – 20KΩ, MTC24L1
TRANSISTOR, Q1 – U112
Q2,3,4 – 2N3565
Q5,7 – 2N4037
Q6 – 2N3053
Q8 – 2N3054
Q9 – 2N3741
ZENER DIODE, CR1 – 1D158
DIODE, CR2,3,4,5,6,7,8,9,14 / CR10,11,12,13 – 1N4003
CAPACITOR, C1,4,5 – 40 MFD, 10V
C2 – 22 MFD, 15V
C3 – 1.0 MFD, 35V
C7 – .001 MFD, 1KV
C8,9 – 75 MFD, 50V
C10,11 – .01 MFD, C. DISC
RESISTOR, R1,34 – 470KΩ, 1/4W, 10%
R2 – 100 MEGΩ, 1/4W, 10%
R3,6,32 – 100KΩ, 1/4W, 10%
R4 – 15KΩ, 1/4W, 10%
R5,11 – 27KΩ, 1/4W, 10%
R8 – 3.3KΩ, 1/2W, 10%
R9,23,24,3 – 33KΩ, 1/4W, 10%
R10,33 – 10 MEGΩ, 1/4W, 10%
R12,25,26 – 1KΩ, 1/4W, 10%
R13 – 22KΩ, 1/4W, 10%
R14 – 27KΩ, 1/4W, 10%
R15,30,31 – 100Ω, 1/4W, 10%
R16 – 470Ω, 1/4W, 10%
R17 – 4.7KΩ, 1/4W, 10%
R18,20 – 10KΩ, 1/4W, 10%
R19 – 1KΩ, 1/2W, 10%
R21 – 2.2KΩ, 1W, 10%
R27,28 – .47Ω, 1W, 10%
R29 – 220Ω, 1/2W, 10%
R22 – 2.2KΩ, 1/2W, 10%

WIRING CONNECTIONS – P3

RPM	CYCLES	MFG	PIN 1	PIN 2	PIN 3
4	60	BODINE	BLUE	RED.	BLACK
10	60	BODINE	BLUE	RED	BLACK
60	60	BODINE	BLUE	RED	BLACK
4	50	BODINE	BLUE	RED	BLACK
10	50	BODINE	BLUE	RED	BLACK
60	50	BODINE	BLUE	RED	BLACK
ALL	50-60	CRAMER	BLACK	BLACK	

NOTE:

3	6	9	12
2	5	8	11
1	4	7	10

WITH DOOR OPEN & CHASSIS SWUNG OUT, THE ORDER OF THE R OUTPUT POTENTIOMETERS IS ALWAYS – BOTTOM TO TOP & LEFT TO RIGHT

3D0107 | 5110 | D31112A

DRAFTSMAN: RL 6/29/67

UNLESS OTHERWISE INDICATED:
- RESISTANCE IN OHMS ± 10% ½ WATT
- CAPACITANCE IN MFD ± 20%
- INDUCTANCE IN HENRIES
- USE 60/40 ROSIN CORE SOLDER
- USE NO CORROSIVE FLUX

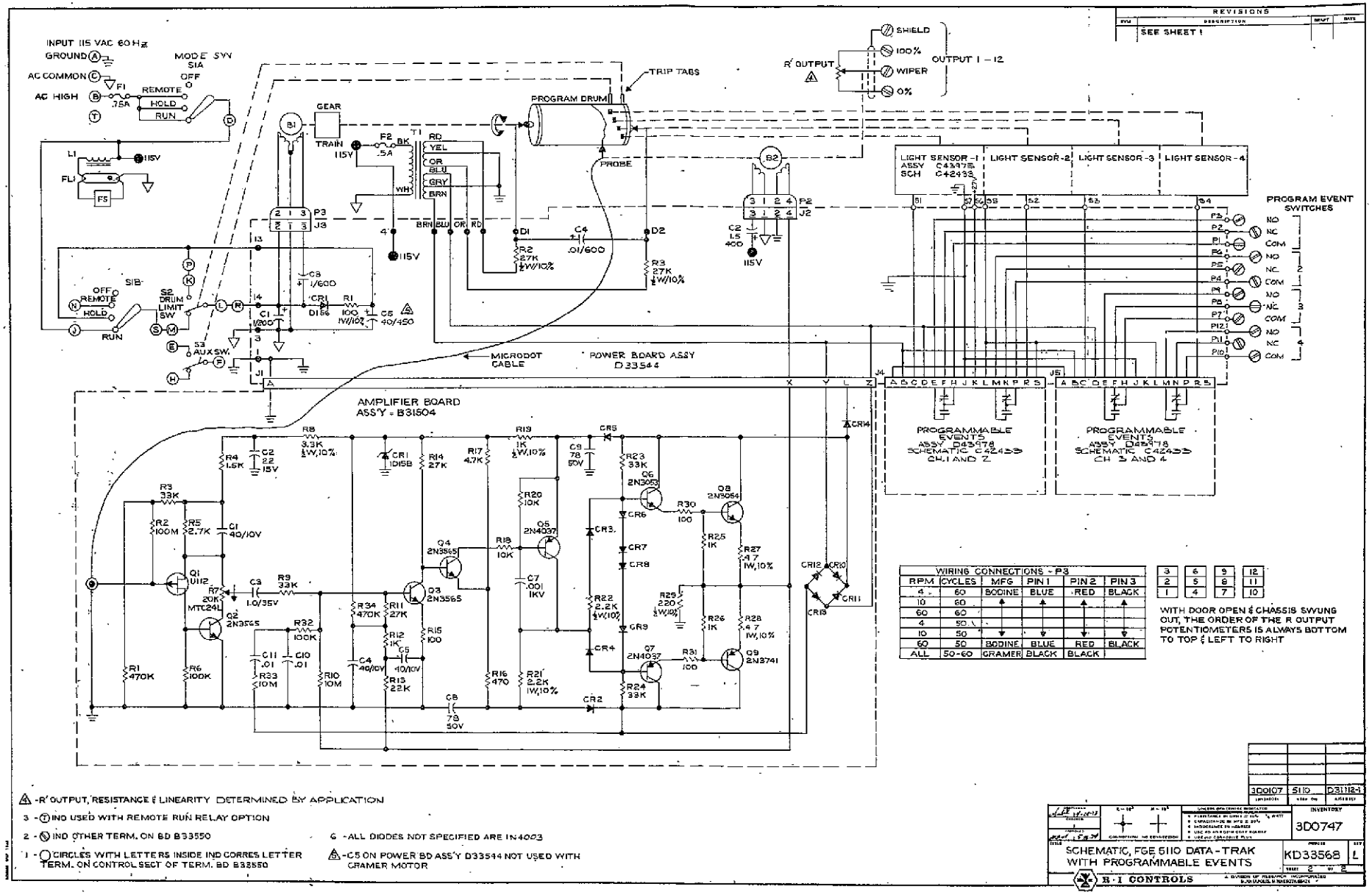
3D0747

TITLE: SCHEMATIC – FGE 5110 DATA-TRAK

KD33568 | REV L

SHEET 1 OF 2

RESEARCH INCORPORATED MINNEAPOLIS, MINNESOTA



WIRING CONNECTIONS - P3					
RPM	CYCLES	MFG	PIN 1	PIN 2	PIN 3
4	60	BODINE	BLUE	RED	BLACK
10	60				
60	60				
4	50				
10	50				
60	50	BODINE	BLUE	RED	BLACK
ALL	50-60	GRAMER	BLACK	BLACK	

3	6	9	12
2	5	8	11
1	4	7	10

WITH DOOR OPEN & CHASSIS SWUNG OUT, THE ORDER OF THE R OUTPUT POTENTIOMETERS IS ALWAYS BOTTOM TO TOP & LEFT TO RIGHT

REVISIONS

SEE SHEET 1

3 -Ⓣ IND USED WITH REMOTE RUN RELAY OPTION

2 -Ⓢ IND OTHER TERM. ON BD B33550

1 -○ CIRCLES WITH LETTERS INSIDE IND CORRES LETTER TERM. ON CONTROL SECT OF TERM. BD B33550

4 -ALL DIODES NOT SPECIFIED ARE IN4003

5 -C5 ON POWER BD ASS'Y D33544 NOT USED WITH CRAMER MOTOR

3D0107 | 5110 | D31121-1

INVENTORY 3D0747

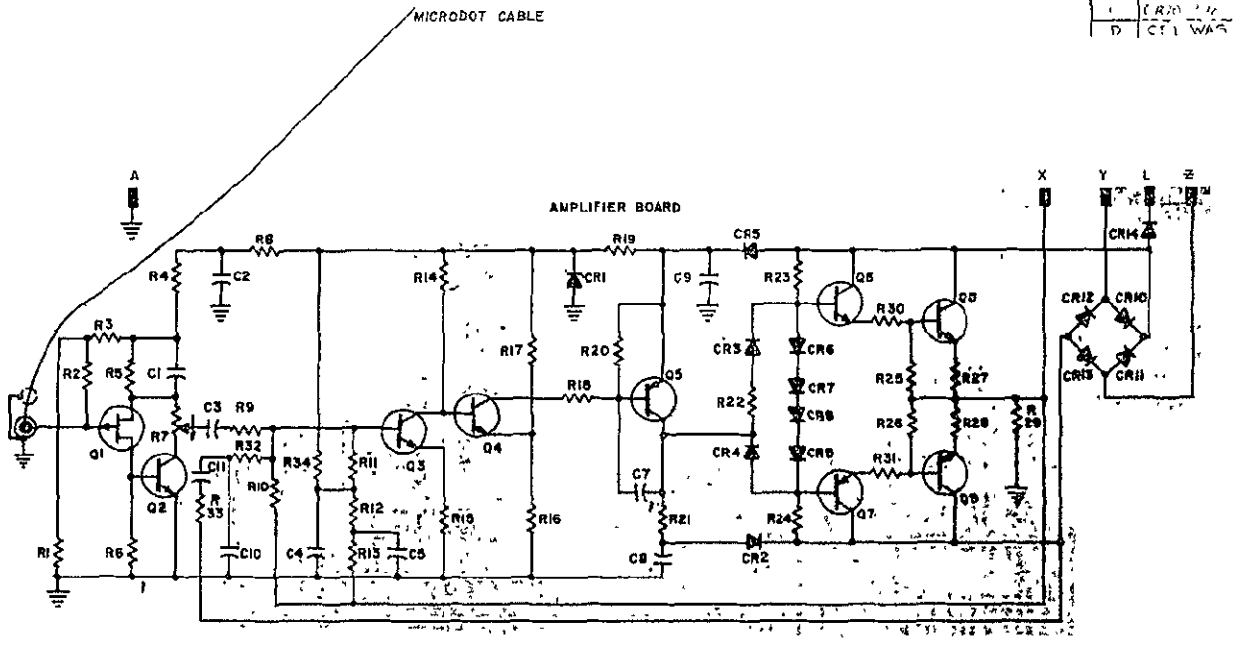
SCHEMATIC, FGE 5110 DATA-TRAK WITH PROGRAMMABLE EVENTS

KD33568 L

SHEET 2 OF 2

B-I CONTROLS

REVISIONS			
SYM	DESCRIPTION	DRAFT	DATE
A			
B	P2, P3 [illegible]	[illegible]	[illegible]
C	(R30 [illegible] WIRE LIST	MB	9-20-74
D	C51 WAS INCR[illegible]	LN	2-3-76



—AMPLIFIER BOARD ASSEMBLY—B31504—

POTENTIOMETER, R7 — 20K Ω, MTC24LI
TRANSISTOR, Q1 — U112
Q2,3,4 — 2N3565
Q5,7 — 2N4[illegible]
Q6 — 2N3[illegible]
Q8 — 2N3054
Q9 — 2N3741
ZENER DIODE, CR1 — IN4744A
DIODE, CR2,3,4,5,6,7,8,9,14 — IN4[illegible]
CR10,11,12,13 — IN4003
CAPACITOR, C1,4,5 — 40 MFD, 10V
C2 — 22 MFD, 15V
C3 — 10 MFD, 35V
C7 — 001 MFD, 1KV
C8,9 — 78 MFD, 50V
C10,11 — 01 MFD, CER DISC
RESISTOR, R1,34 — 470K Ω, 1/4W, 10%
R2 — 100 MEG Ω, 1/4W, 10%
R 6,32 — 100K Ω, 1/4W, 10%
R4 — 1.5K Ω, 1/4W, 10%
R5,11 — 27K Ω, 1/4W, 10%
R8 — 3.3K Ω, 1/2W, 10%
R9,23,24,3 — 33K Ω, 1/4W, 10%
R10,33 — 10 MEG Ω, 1/4W, 10%
R12,25,26 — 1K Ω, 1/4W, 10%
R13 — 22K Ω, 1/4W, 10%
R14 — 27K Ω, 1/4W, 10%
R15,30,31 — 100 Ω, 1/4W, 10%
R16 — 470 Ω, 1/4W, 10%
R17 — 4.7K Ω, 1/4W, 10%
R18,20 — 10K Ω, 1/4W, 10%
R19 — 1K Ω, 1/2W, 10%
R21 — 2.2K Ω, 1W, 10%
R27,28 — 4.7 Ω, 1W, 10%
R29 — 220 Ω, 1/2W, 10%
R22 — 2.2K Ω, 1/2W, 10%

3B0608	5110 X2Y	B31504
3B0608	5110-ZP	B31504
3[illegible]08	5110-TB48	B31504
3P[illegible]08	5110-XY	B31504
3B0608	5110	B31504
3B0608	5300	B31504
INVENTORY	USED ON	ASSEMBLY

DRAFTSMAN: RL 11/9/67
CHECKED
APPROVED

K = 10³ M = 10⁶

CONNECTION NO CONNECTION

UNLESS OTHERWISE INDICATED
- RESISTANCE IN OHMS ± 10% ¼ WATT
- CAPACITANCE IN MFD ± 20%
- INDUCTANCE IN MICROHENRIES
- USE 60/40 ROSIN CORE SOLDER
- USE NO CORROSIVE FLUX

INVENTORY 300758

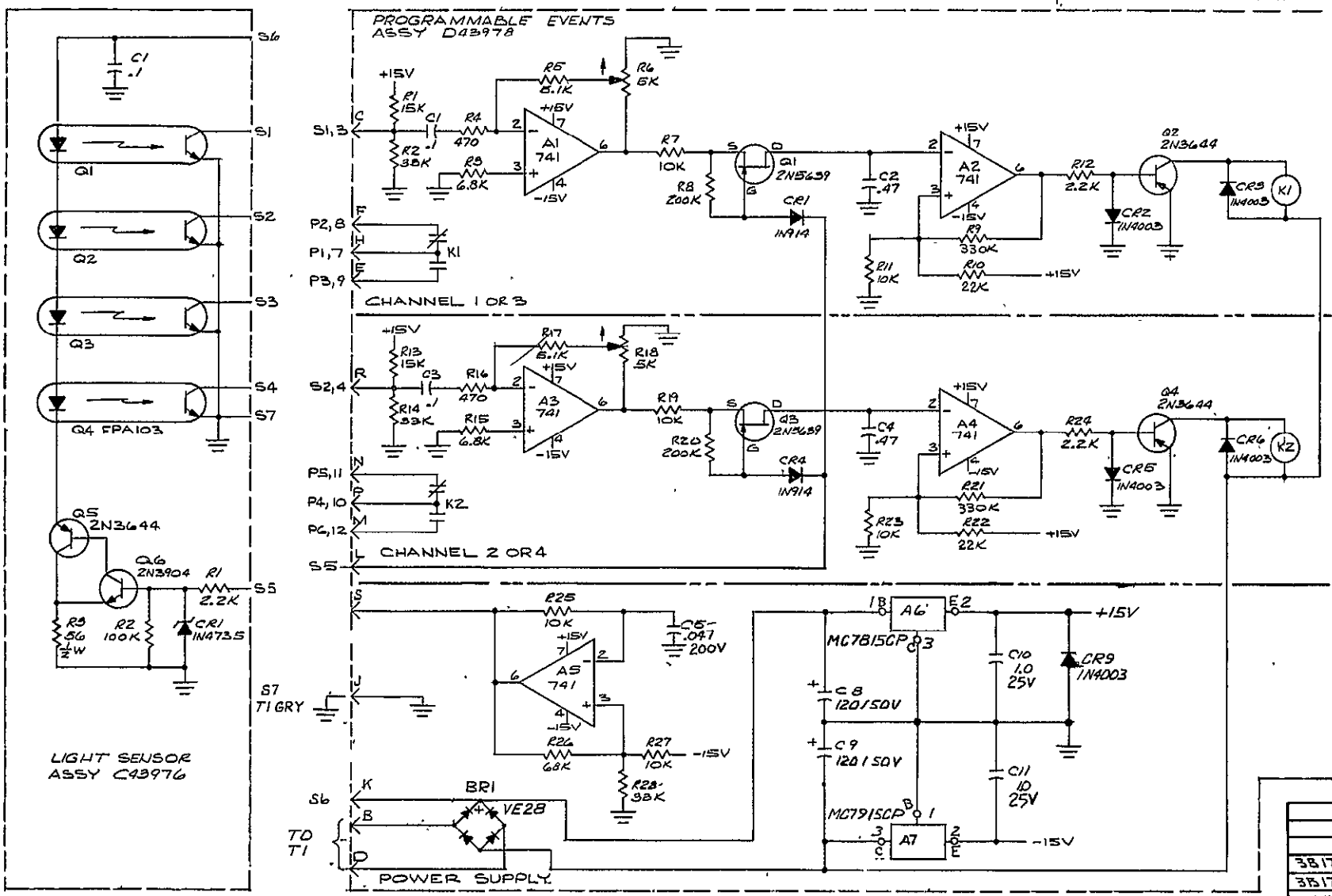
TITLE: SCHEMATIC-PROBE AMPLIFIER

NUMBER: KC34290 REV: D

SHEET OF

R·I CONTROLS — A DIVISION OF RESEARCH INCORPORATED, MINNEAPOLIS MINNESOTA 55424

REVISIONS			
SYM	DESCRIPTION	DRAFT	DATE
A	DELETE C6,C7,R29-32,CR7,8,Q5,6; ADD BR1,A6,7,CR9	DS	5-9-74
B	C10 & C11 WERE .1UF C5 WAS .05UF	D.S.	7-1-74
C	REV PWR SUPPLY	DS	1-14-76
D	C8 C9 WAS 100/35V.	SJ	6-8-77



381721	5110	C43978
381722	5110	C43976
INVENTORY	USED ON	ASSEMBLY

DRAFTSMAN: WILLKE 10-16-73
CHECKED:
APPROVED: 5-16-74

UNLESS OTHERWISE INDICATED
- RESISTANCE IN OHMS ± 5% ¼ WATT
- CAPACITANCE IN MFD ± 20%
- INDUCTANCE IN HENRIES
- USE 60/40 ROSIN CORE SOLDER
- USE NO CORROSIVE FLUX

K = 10^3 M = 10^6
CONNECTION NO CONNECTION

INVENTORY 301724

TITLE: SCHEMATIC, PROGRAMMABLE EVENT SWITCHES

NUMBER: KC42433 REV: D

SHEET 1 OF 1

R·I CONTROLS
A DIVISION OF RESEARCH INCORPORATED
MINNEAPOLIS, MINNESOTA 55424

RECOMMENDED SPARE PARTS LIST

Model FGE 5110 DATA-TRAK Programmer	KD33568	12/75
TITLE	NUMBER	REV

ITEM	DESCRIPTION	PART NO.	INVENTORY	QUANTITY 1	2	3	4	◆
1	Fuse-F2(½ Amp SLO-BLO)	Littlefuse 3 AG	17A0100			X		
2	Contact Pin Assembly (Note: 6 spares provided initially)	A26071	18A0134				X	
3	Drive Cable (Mylar-coated)	Squire Co.	10C0222	X				
4	Probe Assembly	B16344	3B0970	X				
5	Probe Amplifier Assembly	B31504	3B0608	X				
5a	Mounting Bracket	A25596	23B0171					
6	Aux. Switch Trip Tab	A18962	18A0125	X				
7	Drum Limit Switch Trip Tab	A18963	18A0126	X				
8	Output Potentiometer(Standard)	(100 ohms) 6B0100 (1000 ohms) 6B0101		X				
8a	Output Potentiometer(Non-Std.) -- NOTE: Specify valve, linearity tolerances, etc.		Consult Factory					
8b	Microswitch	(9A101 Switch (9A102 Actuator						
8c	Trim Potentiometer on PPFS	62P-200K	6B0184					
8d	Potentiometer Pulley	A20889	18A0129					
8e	Shunt Resistor 111.1 ± ½%	Precision, Inc.	14A0396					
9	Programmable Event Option	-PE2 -PE4						
9a	Lamp B1 - B4 (Cal Glo)	Brite Eye No. 62	11A0136		X			
9b	Light actuated SCR (Sensor) SCR1, SCR4	3P30	32A0125	X				

ORDERING INFORMATION

1) For ordering information and latest prices, contact your local representative or the RESEARCH, Incorporated factory in Minneapolis, Minnesota.

2) When ordering spare parts, please include references both to this parts list number and revision level, plus, the Model Number and Serial Number of the instrument for which these parts are being ordered.

TWX 910-576-2837	PHONE MINNEAPOLIS 612-941-3300	TELEX 029-5328

R·I CONTROLS
A DIVISION OF RESEARCH, INCORPORATED
BOX 24084 MINNEAPOLIS MINNESOTA USA 55424

RECOMMENDED SPARE PARTS LIST

Model FGE 5110 DATA-TRAK Programmer	KD33568	12/75
TITLE	NUMBER	REV

ITEM	DESCRIPTION	PART NO.	INVENTORY	QUANTITY 1	2	3	4	▼
9c	Globe Servo Motor	230A370	8B0122					
10	Capacitor, 40 mfd/450 v, elec.	FP238A Mallory	15A0247					
11	Fuse, F1 (3/4 Amp SLO-BLO)	Littlefuse 3AG	17A0157					
12	Power Board Assy.	D33544	3D0742					
13	Gear Box Assy., XY, X2Y	KC35157	3D0856					
14	PPFS-1 Card Assy.	B32573-1)						
14a	PPFS-2 Card Assy.	B32573-2)	Less					
14b	PPFS-3 Card Assy.	B32573-3)	Relays					
14c	PPFS-4 Card Assy.	B32573-4)						
14d	Relay for PPFS Card Assy.	P & B	26A0106					
15	Door Latch Assy.		12A0327 Latch/Lock) 19B0572 Knob)					
16	Transformer	A32269	7A0147					
17	Clutch Assy.		18A0901 Clutch) 18A0902 Clutch Face)					
			2C0353 Washer) 12A0368 Clutch Spring)					
18	Dual 1K-1K Potentiometer	Duncan	6B0213					

ORDERING INFORMATION

1) For ordering information and latest prices, contact your local representative or the RESEARCH, Incorporated factory in Minneapolis, Minnesota.

2) When ordering spare parts, please include references both to this parts list number and revision level, plus, the Model Number and Serial Number of the instrument for which these parts are being ordered.

TWX 910-576-2837	PHONE MINNEAPOLIS 612-941-3300	TELEX 029-5328

R·I CONTROLS
A DIVISION OF RESEARCH, INCORPORATED
BOX 24084 MINNEAPOLIS MINNESOTA USA 55424

INSTRUCTION MANUAL

640U Process Controller

August 1977

RESEARCH INC
BOX 24064 MINNEAPOLIS, MINNESOTA USA 55424
PHONE (612) 941-3300 • TWX 910-576-2837 • TELEX 29-0502

TABLE OF CONTENTS

SECTION 4 - NORMAL OPERATING PROCEDURES

SECTION 5 - CALIBRATION PROCEDURES

SECTION 6 - TROUBLESHOOTING CHART

SECTION 7 - SCHEMATICS

SECTION 1 - INTRODUCTION

1-1 Scope

This manual describes the 640U series of closed loop process controllers, and provides information for their installation, operation, calibration, and maintenance.

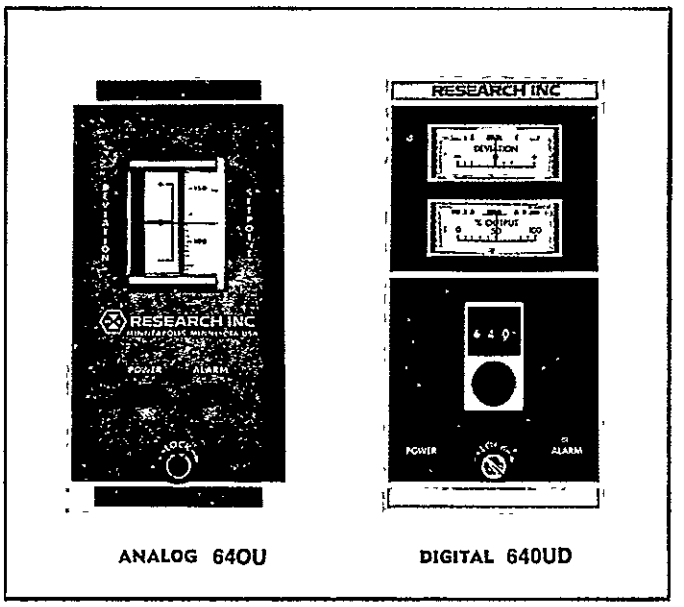


FIGURE 1-1 MODEL 640 (ANALOG SETTER LEFT) (DIGITAL SETTER RIGHT)

1-2 General Description

The 640U is a primary control instrument designed with completely solid state circuitry to provide the optimum in flexibility, accuracy, and extended troublefree operation. The only difference between the two basic main frames (shown in Figure 1-1) is the setpoint setter. All other electronics is identical.

The Model 640U can be used for controlling temperature, pressure, speed, force, position, or any process parameter that can be measured or controlled electrically.

The Model 640U provides AUTO (closed loop) 3 mode control with anti reset windup on process feedback as setpointed by local analog or digital dial set or remotely from 1000 potentiometer in programmer. Alternate MANUAL (open loop) operation by switch selection and Manual Control Dial provides output independent of process as manually set by operator. The 640U provides balanceless bumpless transfer upon return to AUTO Control Mode.

1-3 Functional Description

The 640U employs closed loop principles while controlling in either setpoint or programmer operating modes; open loop control is utilized in manual operating mode. Principles of closed loop control, and the manner in which closed loop control is accomplished is illustrated in Figure 1-2 and described under the following headings.

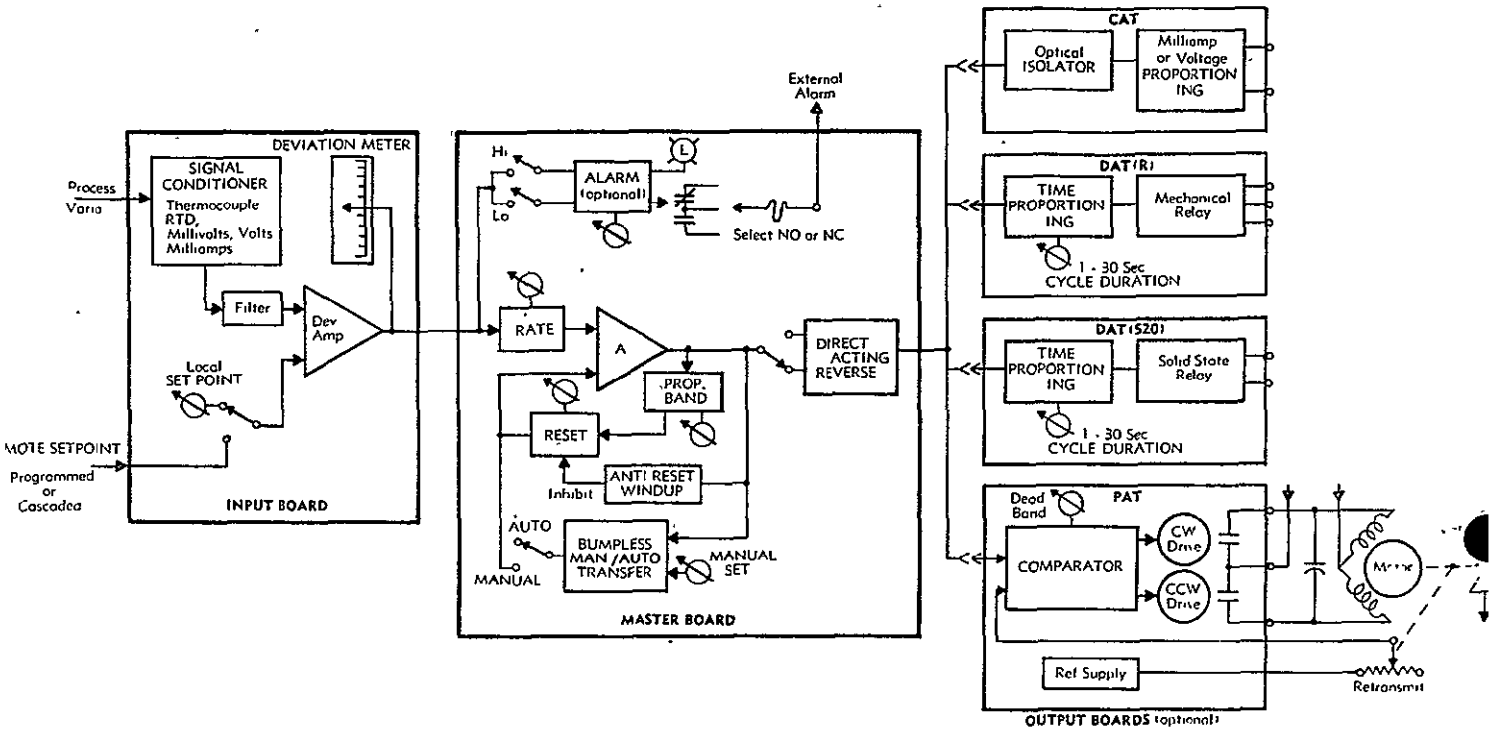


FIGURE 1-2 FUNCTIONAL BLOCK DIAGRAM

1-3-1 Setpoint Operating Mode

In setpoint operation, a sensor generates a feedback signal which represents the process level. This signal is compared with a setpoint command in the input board circuitry of the unit. With the process variable equal to the setpoint level, the command and feedback signals cancel each other and zero error voltage is applied to the master card amplifier circuits.

Any tendency of the process to vary below the setpoint command level causes a proportional decrease in feedback. The feedback no longer equals the command and an error voltage appears at the input of the master card amplifier circuits. The error voltage is amplified and applied to the output card which applies a proportional output to the final control elements. This then causes an increase in the process variable which brings the controller back to "null".

The extent to which the process may deviate below the command level before the unit applies maximum corrective signal to the final control elements is defined as the "proportional band" (i.e., the Proportional Band = $\frac{1}{\text{gain}}$). The width of the proportional band is adjustable by a proportional band control to provide stable system operation under various process conditions.

The controlled variable will usually settle out somewhat below the setpoint level with proportional control only. This inherent error (termed droop) may be cancelled out by manually resetting the SETPOINT dial to a higher setting such that the process variable will droop exactly to the desired level. "Reset" action, standard on the 640U, is accomplished by integrating out the droop or error signal. Reset lockout circuitry is provided to inhibit the Reset action until the process feedback enters the proportioning bavel width of the controller providing Anti-Reset Windup function.

A rate circuit is used to provide derivative action to the controller. It detects a rate-of-change and direction-of-change of error signal and adds a signal to either aid or oppose the controler output. The circuit anticipates the process variables' approach to the setpoint and reduces the controllers output to minimize overshoot.

1-3-2 Remote Programmer Operating Mode

In remote programmed mode, an external 1000 ohm pot or 0 - 15 VDC signal from DATA-TRAK or other remote setpointing device is substituted for the local setpoint. Operation in this mode is identical to setpoint operation except that, rather than being maintained at a static setpoint level, the command level is varied as a function of time, according to a pre-plotted program chart mounted in the programming device.

1-3-3 Manual Operating Mode

In the manual mode of operation, closed loop control is not utilized; the temperature command and feedback signals exercise no authority over the magnitude of the control signal, and the control signal becomes solely a function of the zero-to-maximum setting of the MANUAL control dial. A bumpless transfer feature is provided to provide a rate of change equal to the reset rate when a difference between manual and automatic is experienced when the controller is switched between operating modes. If the RESET control is in the OFF position the transfer will be at the maximum slew rate of the amplifier.

1-4 Physical Description

The main modular sub-assemblies to the 640U controller are called out in Figure 1-3 below and described under the headings which follow.

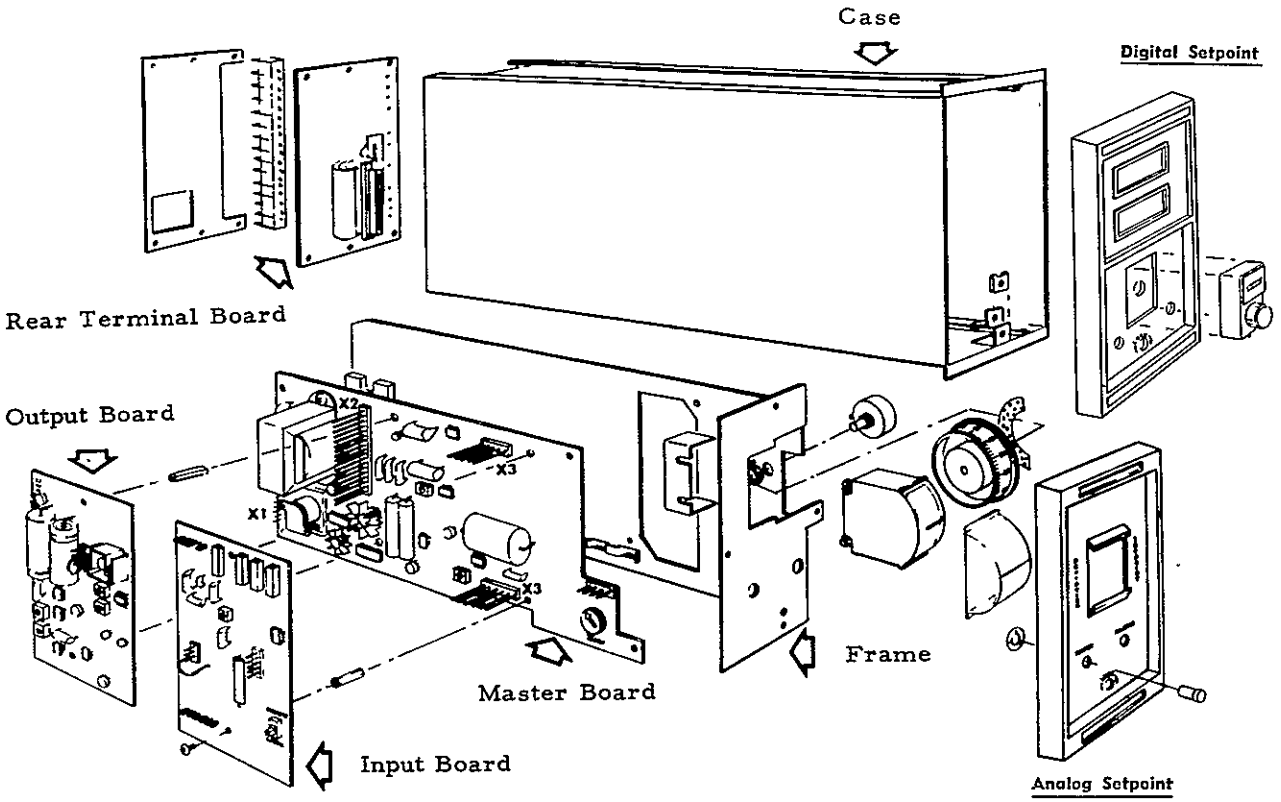


FIGURE 1-3 MAIN MODULAR SUB-ASSEMBLIES

1-4-1 640U Controller

The 640U consists of a case and slide-in-chassis. The case includes a rear terminal board and ribbon cable for connecting it to the plug-in chassis. With the 640U plug-in-unit installed all external wiring connections will terminate at the barrier strips at the back of the unit. The ribbon cable connector and chassis terminal board are keyed to prevent incorrect mating.

The unit measures approximately 7 inches high, 3.5 inches wide, and 14.5 inches deep (18 with DAT or PAT output). Exact dimensions are provided in Figure 2-1 as well as information pertinent to panel mounting the unit.

1-4-2 640U Chassis

The 640U chassis is a slide-in control module. It contains its own power supply. Plug-in input and output boards adapt it to the process to be controlled.

The electronics of the 640U are of completely solid state design utilizing integrated circuit, operational amplifiers as the main active components. These operational amplifiers allow straight DC coupling to amplify the error signal. A change in input of 1 uV will cause a measureable change in output.

Meters are provided to monitor the error signal (NULL) (standard) and control signal (OUTPUT) (optional DS only). The error signal is the difference between command SETPOINT dial (or remote programmer) and the feedback generated by the sensor (meter scale reflects ±15% input span of controller).

A selector switch on the master board provides the ability to readily change the control action from reverse to direct acting control function to fit the process needs at will.

An optional adjustable deviation alarm circuit is available to switch select a high, low or High/Low alarm from the preset level. The circuit includes and ALARM light and a relay with normally open or normally closed (jumper selected) contacts for remote control or indication.

1-4-2-1 Input Cards

The input card module is a plug-in unit. Each input board is a precision resistor, voltage divider network. Optional input boards accept thermocouple, millivoltage, RTD, voltage and current signals. In each range circuit, a command voltage (determined by the selected setting of the SETPOINT control or remote programmer potentiometer) is compared in a series opposition fashion with the feedback generated by the sensor. The differential between these two signals is the error signal applied to the amplifier circuits. The resistors in each range must be specially selected for the type of sensor to be employed.

A regulated reference voltage is applied to the range card from the reference voltage supply on master board. The range card precisely divides the reference voltage to establish the range of the SETPOINT potentiometer such that its zero and span voltages correspond to the curve of voltage generated by a particular sensor from the minimum to maximum levels of a specific range.

Automatic thermocouple cold junction temperature compensation is provided at the input terminals on the case for TC input controllers. A standard input card is referenced to 75° F if its temperature range is designated in °F; if its temperature range is designated in °C, it is referenced to 25° C. A-1 input boards are provided with a choice (jumper selectable) of upscale, downscale or no thermocouple break protection.

NOTE

The fail safe resistor will cause an undesirable offset in the potentiometric measuring circuits of the range card if the resistance value of the thermocouple circuit exceeds 100 ohms. Therefore, it must be removed if high resistance circuits are to be utilized with the 640U.

1-5 Output Cards

The Model 640U is designed to permit optional outputs. Each output card and rear case termination assembly interfaces the controller to the final control element. An explanation of the different output cards is described below.

1-5-1 Current Proportioning Output Card (CAT)

The CAT output card is used to interface the 640U to remote control elements driven by DC voltage or current. The CAT output board provides jumper selectable for 0 to 5 VDC (into 1K), 1 to 5 milliamperes (into 2K), 4 to 20 milliamperes (into 500 ohms), or 10 to 50 milliamperes (into 200 ohms). Each of the outputs is provided with current limiting to prevent instrument damage should the outputs be shorted while the instrument is in operation.

1-5-1-1 Bipolar CAT (+5 V) Output Card (Option - SP 1)

This version of the CAT output provides a bipolar proportioning voltage +5 to 0 to -5 volts into 2500 ohms on greater load for purposes of interface to processes that utilize dual final control media (i.e., heating/cooling, humidifying/dehumidifying, motoring/loosing torgues, etc.).

The +(5V to 0) represents reverse acting control on the underside of setpoint while overside of setpoint is a direct acting control signal reflected by -(0 to 5V) signal.

The CAT output card includes a photo-decoupler to provide complete input/output isolation. That is, there is no hard line path through the instrument from the sensor to the output, eliminating any possibility of ground loop problems.

1-5-2 Time Proportioning Output Card (DAT)

The DAT output card is used for direct control of heating loads. This output is offered in two current sizes: 5 ampere relay and 20 ampere solid state switch. Each device is timed proportioned on/off over a period adjustable from 1 to 30 seconds. For example, with a cycle time of 10 seconds and an output demand of 50% power, the swotch could be closed for 5 seconds and open for 5 seconds. With a 1 second cycle time, this same condition would produce ½ second on and ½ second off

1-5-3 Position Proportioning Output Card (PAT)

The position proportioning output card is used to provide open and close relay contacts to operate valves, dampers, and other motor positioned control devices. A retransmit slide wire on the control element (valves, damper, etc.) must be provided as feedback to the PAT output board. The relay contacts of the controller are rated at 5 amp for 120 VAC resistive loads. The output deadband is adjustable from .5 to 5%. The relays are deenergized for 50% of the deadband from when the relays were energized to prevent overshoot due to motor coasting.

1-6 Specifications

TABLE 1-1. CHARACTERISTICS AND SPECIFICATIONS

INPUTS (refer to bulletin D640 2 for complete listing of types and spans)	THERMOCOUPLE: Accepts directly any material, has internal cold junction compensation and burnout protection that is field selectable for upscale, downscale or none	
	RESISTANCE BULB THERMOMETERS: RTD inputs for 3 wire platinum or nickel wound elements accepted directly.	
	MILLIVOLT, VOLTAGE or CURRENT: Selected ranges available to accept industry standards from process transmitters.	
Input Impedances	THERMOCOUPLES: 100K ohms VOLTAGE or MILLIVOLTAGE: 100K ohms. CURRENTS: 2500/High end of span in ma	
Minimum Practical Spans	THERMOCOUPLES and MILLIVOLTS, at least 10mv change over process span. CURRENTS· at least 0.1ma change over process span RTD'S 60Ω minimum R, with ΔR the greater of 10Ω or 10% of minimum R.	
Maximum Zero Supression	50% of high end value.	
Common Mode	Better than 120 db.	
Normal Mode	Better than 40 db at 60Hz.	
SETPOINTS	Switch selectable local or remote setpoint all models	
Local Setpoint	Analog Models	Digital Models
Accuracy	Setpoint: ±½% of span at calibration points.	Setpoint: ±¼% of of span at null.
Setability	±0 3% of span on 5 inch calibrated scale	±0 05% of span ½ digit on 3 digit 10 turn dial
Remote Setpoint Standard Models	By 1000 ohm external potentiometer or +(0-15VDC).	
(optional) Cascade Models	Specify one input: 0-5 vdc into 20K ohm 1-5 vdc into 20K ohm 1-5 ma dc into 2,000 ohm 4-20 ma dc into 500 ohm 10-50 ma dc into 200 ohm	
DEVIATION METER	Analog Models Indicates Process value directly in engineering units	Digital Models Indicates deviation from Setpoint
SPAN	±15% span.	±15% span.
Accuracy	Indication. ±1% of span at null	Indication: ±1% of span at null.
DEVIATIONAL ALARM (optional)	Adjustable 1-10% input Span switch selectable Hi only, Lo only or Hi and Lo, panel light and external contact N O or N C (jumper selectable) indicator alarm state. Deadboard 1% of span	
NORMAL OPERATING CONDITIONS	Temperature: 40 to 120 F (4° to 49°C.) Influence on accuracy 02% of span/F° or 3 μV whichever is greater Line Voltage 120/220V —15% +10% influence on accuracy 05% of span/volt Humidity· 95% RH Maximum Influence on accuracy: Negligible	
DRIFT (control point)	Drift of control point is less than 0.1% of span or 30 μV, whichever is greater, over a 72-hour period (constant temperature and voltage)	
FREQUENCY RESPONSE	Down 20 db at 10Hz.	
STEP RESPONSE	100 milliseconds to achieve 63% of final ouput.	

CONTROL ACTION	Switch selectable to Direct or Reverse acting outputs.
CONTROL MODES (full 3 mode standard)	PROPORTIONING BANDWIDTH: Continuously variable from 1-50% of input span. RESET: (integral acton) Switch selectable in 9 steps (0 1-10 repeats/minute) plus (OFF) with Anti Reset windup occuring outside P B. RATE (derivative action) Continuously variable (0.1-5 minutes with separate on/off switch).
optional) Modified for medium fast loops (i e. speeds, torque, pressures, etc)	P B.: 10-500% span RESET: 2-200 repeats/minute RATE· 1.2-60 seconds
(optional) Modified fast loops. (i e power, voltage, currents, small volume pressure systems, etc)	P.B : 10-500% RESET 20-2,000 Repeats/minute RATE· 0 12-6 seconds
AUTO/MANUAL CONTROL	Manual open loop operation by AUTO/MANUAL Switch in secondary control panel, with adjacent manual potentiometer adjustment for process Balanceless Bumpless Transfer is inherent on return to AUTO mode so as to not bump and upset the process
OUTPUTS	CURRENT or VOLTAGE PROPORTIONING OUTPUT with short circuit protection
I/O Isolation	Controller input and output is isolated by photo coupler and may be operated floating or grounded with potential differences not to exceed 500VDC or 350VAC
CAT (1/5ma) CAT (4/20ma) CAT (10/50ma) CAT (0/5V)	All CAT' cards are field modifiable to: (1-5ma) into 2,000 ohms or less (4-20ma) into 500 ohms or less (10-50ma) into 200 ohms or less (0-5V) into 1,000 ohms or greater Field selectable by switch for Direct or Reverse acting
(optional) CAT (±5V)	BIPOLAR VOLTAGE PROPORTIONING CAT (±5V) into 2,500 ohms or greater
DAT (R) DAT (S20)	TIME PROPORTIONING with adjustable 1-30 second repeat time DAT(R) mechanical relay rated 120/240VAC at 5/2 5A resistive DAT(S20) solid state relay rated 120/240VAC at 20A resistive, providing zero crossing power control
PAT	POSITIONING PROPORTIONING for use with electric valve operators, provides dual contacts rated 120 VAC at 5Amperes for CW or CCW motor drive, accepts stem position retransmit potentiometer of any value 100-10K ohms. Deadband adjustable ½ - 5 % of proportional band setting
DIMENSIONS	Refer to sketch
WEIGHT	8 lbs . 13 lbs Shipping.
MOUNTING	Units may be mounted on 4 inch horizontal centers and 7½ inch vertical centers for high panel densities Hardware included for mounting to panels to ¼" thickness
CONNECTIONS	Barrier terminal strips on rear of case provide wiring terminations to process See photos of Rear Cases for details Internal ribbon cable and plug provide chassis access and disconnect for chassis removal
POWER controller only	120VAC, 50/60 Hz, 10VA | (optional) 240VAC, 50/60 Hz, 10VA

SECTION 2 - INSTALLATION

2-1 General

Installation of the instrument consists of connecting line and signal wiring as described under paragraph 2-3. To panel mount the unit proceed as outlined under the following paragraph. Before attempting installation, it is recommended that the operator read the balance of this manual to assure a full understanding of the operation and physical configuration of the unit.

2-2 Panel Mounting the 640U Controller

The instrument must be mounted in a 12-gauge, or heavier, panel to prevent distortion of the panel due to the weight of the instrument. Cut-out dimensions and other pertinent information for panel mounting are provided in Figure 2-1.

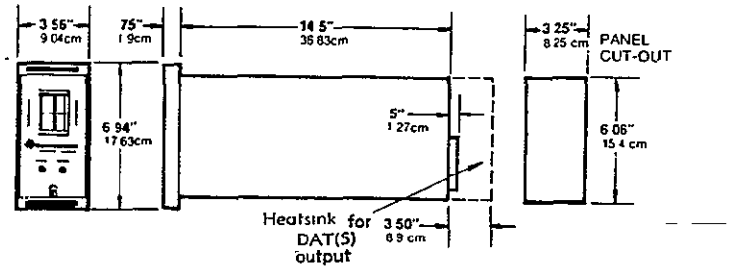


FIGURE 2-1 MOUNTING DIMENSIONS FOR THE 640

Panel mounting is most easily accomplished by first removing the electronics assembly from within the instrument case, and replacing it after the case has been secured to the panel. After removing the controller from its case, insert case through opening (rear end first) until the case flanges contact the mounting panel. Insert the four mounting clips (one at a time) through the holes in the case from the inside. Secure them with the 10 x 32 screws into the tapped mounting brackets of the case.

To remove the electronics assembly, loosen the captive thumb-screws on the front panel of the unit, and draw the chassis out until the stop is reached. Defeat the stop by depressing it and remove the chassis from the case. Unplug the connector cable by squeezing the connector, securing tabs and removing the connector.

2-3 Input/Output Wiring Connections

Connect all input/output wiring to the rear of the case, as shown in Figure 2-2. Check the label on the rear of the case for the correct supply voltage for Terminals 7 and 8 (120 or 220 VAC). Supply voltage for the DAT output option may be any voltage from 120 to a maximum of 240 VAC.

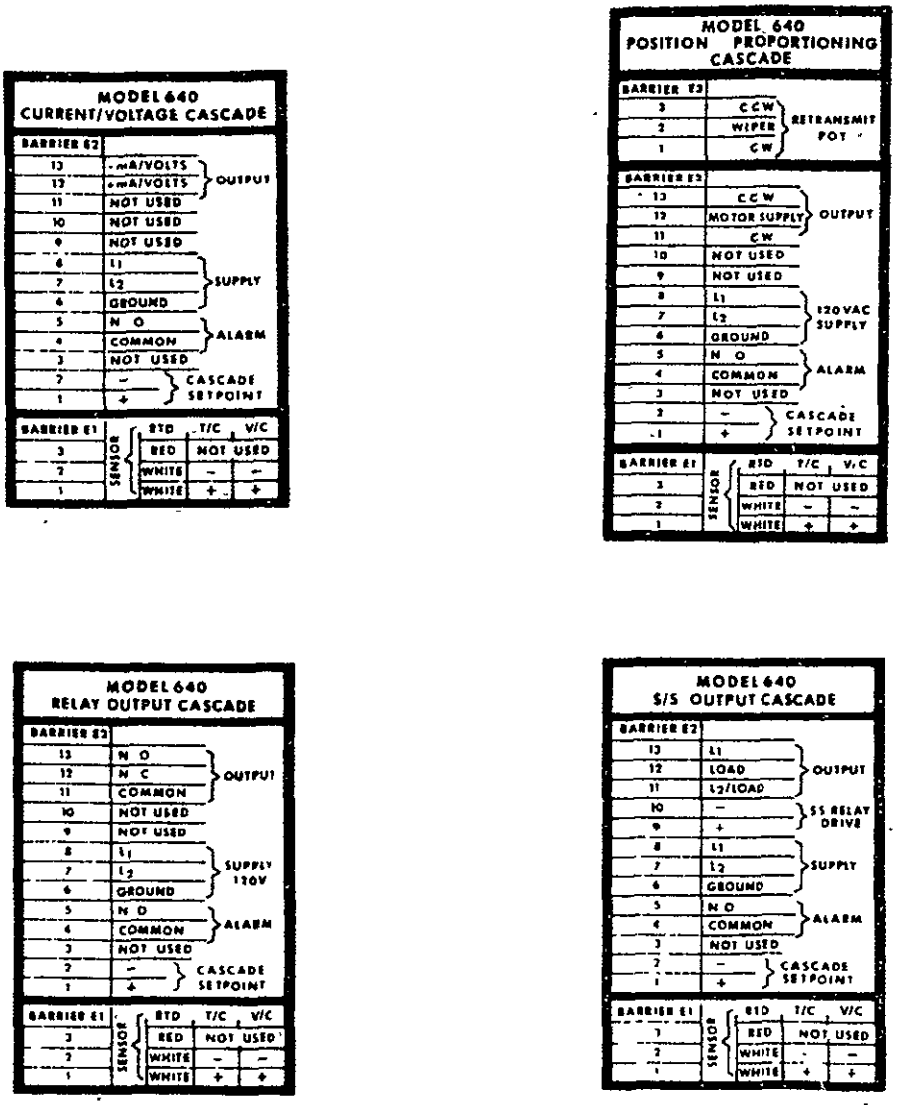


FIGURE 2-2 WIRING CONNECTIONS

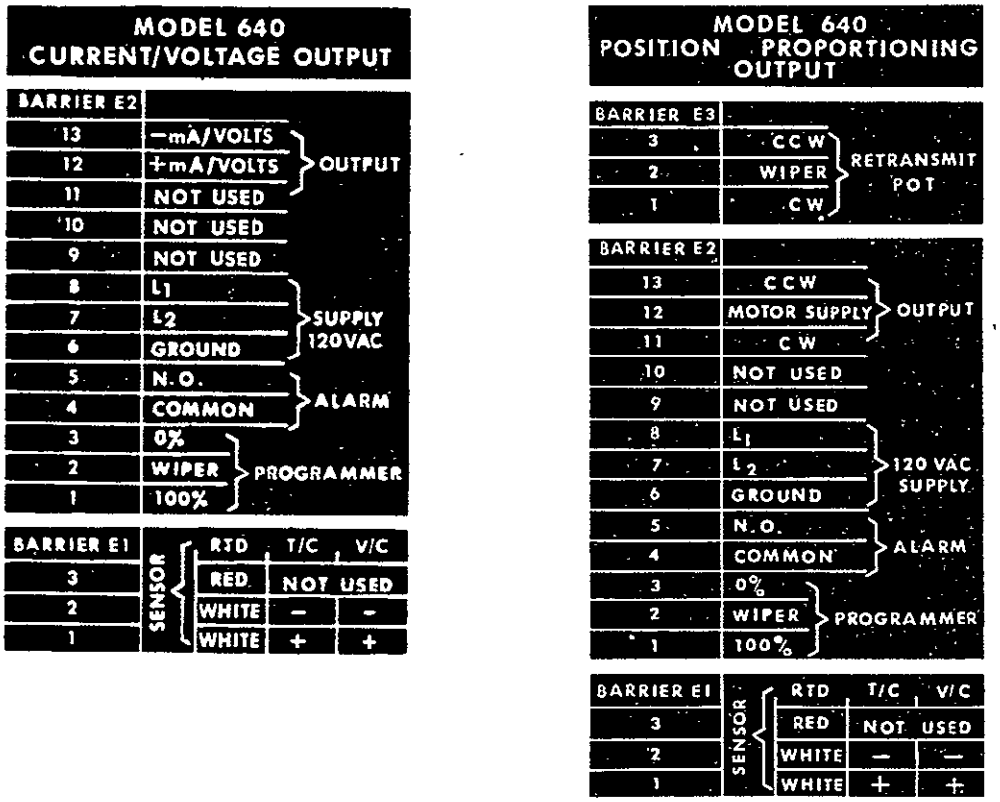


FIGURE 2-2A WIRING CONNECTIONS

2-4 Output Selection by Jumper Wire for CAT (Current or Voltage Output) Board

The selection of current or voltage output, and the establishment of current output range, is accomplished by installation of jumper wires on the CAT board. Refer to the tabulated description of necessary jumpers given on schematic diagram number KD41679. The jumpers are to be installed in the appropriate positions in the board, in the area between the word "OUTPUT" at the edge of the board, and the potentiometer P4 near the center of the board.

NOTE

These jumpers are normally installed at the factory.

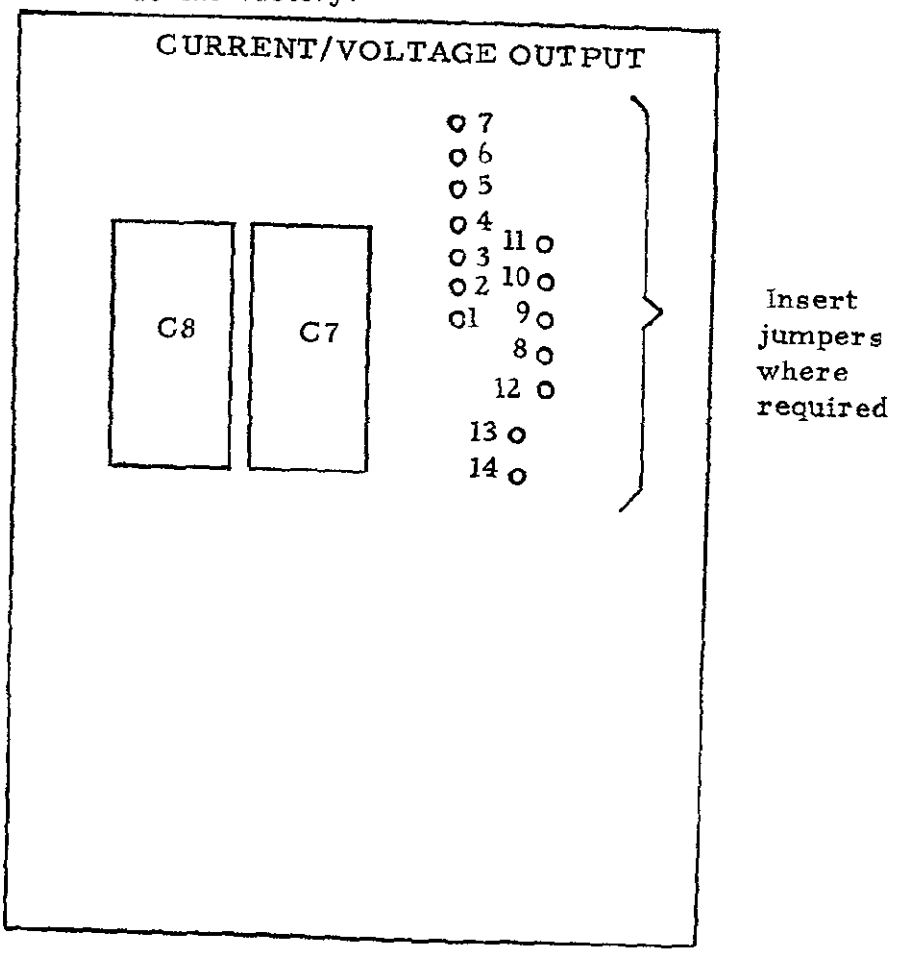


FIGURE 2-3 CAT BOARD JUMPER LOCATIONS

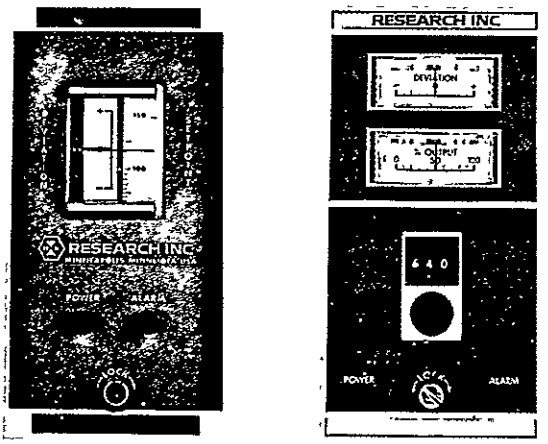
SECTION 3 - OPERATING CONTROLS AND INDICATORS

3-1 General

Operating controls and indicators for monitoring the status of the instrument are listed and described under the following heading, their physical locations are called out in Figures 3-1, 3-2, and 3-3.

3-2 Front Panel Controls and Indicators

The 640U front face provides access to the setpoint control. Deviation indication and output indication (optional on DS640 only) as well as "power on" and "alarm" lights comprise the instrument face.



ANALOG DIGITAL

FIGURE 3-1 640 FRONTS

3-2-1 POWER Indicator

This green indicator is lighted whenever line voltage is applied to the unit.

3-2-2 ALARM Indicator

Red indicator is lighted whenever an alarm condition exists.

3-2-3 SETPOINT Control

The 640U (analog) SETPOINT is a one turn dial providing direct setting of the process variable. The 5 inch scale is computer characterized to compensate for sensor nonlinearities.

The DS640U (digital) SETPOINT is a ten turn logging setter. Clockwise rotation of this dial (increasing dial settings) increases the command level requiring ever-increasing feedback. A digital printout is provided to correlate setpoint dial divisions to engineering units.

3-2-4 DEVIATION Indicator

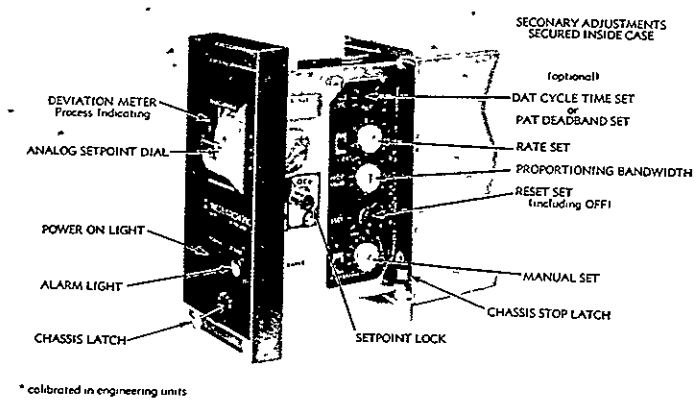
The DEVIATION indicator scale is calibrated to the setpoint dial on the analog 640U and 15% on the digital 640U. When the DEVIATION meter is centered at zero (null) on the scale, the feedback is equal to the command.

3-2-5 OUTPUT Indicator (optional)

The OUTPUT indicator is scaled 0 to 100%.

3-3 Standard Sub-Panel Controls

This group of controls and indicators is located behind the front panel of the 640U access to these controls is achieved by loosening the captive thumb screw on the front panel, and drawing the panel assembly forward to its stop.



)TE: PC Boards for both Analog and Digital
ntrollers are identical and interchangeable.

FIGURE 3-2 RIGHT SUB-PANEL CONTROLS

The individual controls in this group are utilized to set the 640U up for operation with a particular feedback signal and operating range, and to adjust the instrument for optimum controlled response.

3-3-1 Proportional Band

This control provides the means for adjusting the gain of the 640U proportional circuitry. The gain of the 640U is defined as the level to which feedback may deviate from command setpoint before maximum output signal is reached. The proportional band is adjustable from 1% to 50% of input span (optionally 10 - 500% of input span).

Clockwise rotation of the proportional band control increases the proportional band, reducing the instrument gain. The tighter the proportional band, the more responsive the controller will be to shifts in the level of feedback signal. For optimum controlling accuracy during operation, this control should be set for minimum proportional band consistent with system stability. If the gain of the 640U is set too high minor shifts in the feedback cause maximum corrective signal to be applied to the output load, causing unstable system operation.

3-3-2 Reset Control (integral)

The automatic reset circuit is standard to all 640U controllers and may be inhibited if not desired by the off position of the Reset adjustment. The Reset function is essentially an integrating amplifier that acts on the droop or error between setpoint and process feedback and adds an integrated term to the controller output bringing the process into setpoint.

The Reset adjustment controls the integration time of the reset circuit. The adjustment is a 10-position switch with Off in the fully counterclockwise position and approximately doubling reset times (from 1 to 10 repeats per minute) as the switch is rotated clockwise. That is, the first position would be Off, the second position would be .1 repeats per minute, the third position would be .2 repeats per minute, the fourth position .4 repeats per minute, the fifth position would be .6 repeats per minute, the sixth position would be 1 repeats per minute, etc. Hence, at the lower settings the reset signal will be added more slowly than at the higher settings.

The reset circuitry also includes an anti-reset windup or lockout circuit. The lockout circuit prevents reset from integrating when the control variable is outside of the proportional band. The reset circuit will begin to integrate again as soon as the error signal returns to within the limits of the porportional band.

The reset Off position on the selector switch is provided to eliminate reset from the circuit when initial system setup is being accomplished. This provides for optimum setting of the proportional band without the influence of reset in the control circuitry.

3-3-3 Rate Control (derivative)

Rate control is used to eliminate system overshoots. The rate signal is generated only when the error signal is changing in magnitude. When the error signal is constant, the rate signal is not generated. The rate control establishes the magnitude of the rate signal to be added to oppose changes in the control variable. The rate potentiometer is calibrated in a clockwise direction from .1 to 5 minutes. This correlates to the time in minutes that it would take the error signal to deviate from zero (setpoint) to the edge of the proportional band (or from the edge of the proportional band to zero) at a given rate of change.

Primarily, the rate circuit is a negative feedback which is designed to compensate for lags in control systems. That is, systems where immediate changes in input do not result in immediate changes in process variable. On slow responding systems where the lag is extensive, the higher rate control settings is applicable; on fast responding systems where lag is minimal, the lower rate control settings works better. On many fast responding systems, rate signal may not be necessary at all, and in fact, rate may be detrimental to system stability. The rate In/Out Switch is placed in the out position in these instances.

3-3-4 Cycle Time/Deadband Control

The cycle time control knob is provided on all 640U instruments with time proportioning (DAT) outputs. This adjustment determines the time frame for the time proportioning output. It is adjustable in a clockwise rotation from 1 to 30 seconds.

Cycle time adjustments are a function of loop response and customer preference. Fast responding systems require shorter cycle times, while slow responding systems can tolerate longer cycle times, and consequently, fewer operations of the load control device.

The cycle time adjusts the time frame for proportioning power to the load. For example, with a 50% output demand and a 10 second cycle time, the instrument would supply closed contacts for 5 seconds and open contacts for 5 seconds. If in this same instance the cycle times were 1 second, the contacts would be closed for 1/2 second and open for 1/2 second.

When used with a position proportioning (PAT) output card the deadband adjustment reduces the seek limit to prevent the driven motor from cycling continuously. The deadband is adjustable from .5 to 5% of controller output span.

3-3-5 Manual Output Control

All 640U instruments are provided with a standard Auto/Manual selector switch and manual output control potentiometer (refer to Figure 3-2). Manual control is provided to allow operation of the process open loop manual prior to automatic operation. This is desirable sometimes for calibrating final control elements such as valves and power control devices.

When the Auto/Manual switch is in the manual position, the output (regardless of the output board) is commanded between 0 and 100% as a function of rotation of the manual control.

A bumpless transfer circuit provides a rate of change equal to the reset rate when switching from the manual to automatic modes of operation. The reset rate is switched off the rate will equal the maximum slew rate of the amplifier.

3-3-6 Local/Remote (Programming) Switch

The Local/Remote switch is provided on all 640U input boards (see Figure 3-3). This switch selects either the front panel located setpoint or an externally provided 1,000 ohm potentiometer (such as a RESEARCH, INCORPORATED DATA-TRAK Programmer) or 15 VDC external supply.

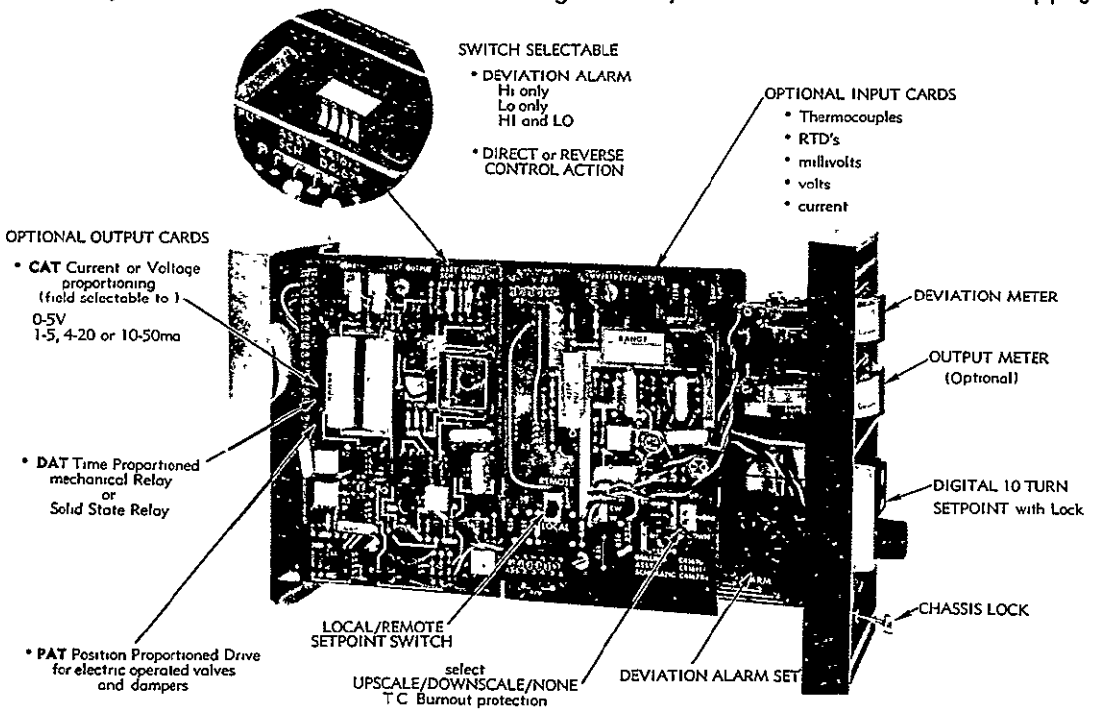


Figure 3-3 Bacpanel Controls

3-3-7 Cascade Control

A cascade control system differs from the basic single loop feedback system in that it employs two feedback controllers so arranged that the output of one controller, called the master or primary, is the setpoint of the other controller called the slave or secondary.

In single loop feedback systems, a load upset is allowed to travel all the way through the system before corrective action is taken. In cascade control systems, load upsets in the secondary portions of the process are handled by the secondary (or slave) controller. This allows the SECONDARY controllers' loop to be "tightened" with faster reset times and narrower proportional band settings, while the primary controller has a wider proportional band and slower reset, controlling the process with a more stable and uniform control.

3-3-8 Alarm Control (Optional)

The alarm control circuit provides a manual ALARM ajdust to select the deviation limits (above or below the setpoint) at which the ALARM indicator will light and the alarm relay will energize. The deviation limit is switch selectable (via the switch block on the master board) to select either the High, Low or High/Low alarm. With the high switch in the ON position the Alarm indicator will light when the setpoint high limit deviation limit has been exceeded. With the Low switch in the ON position the alarm indicator will come on and the relay energized when the low level deviation limit has been exceeded. With both the High and Low switches in the ON position the alarm indicator will light and the alarm relay will energize when either the high or low deviation limits have been exceeded.

3-3-9 (Direct) Forward/Reverse Control

The 640U is also equipped with forward and reverse switches. These switches (located on the switch block on the Master Board) are operated to enable the desired response to the setpoint control level. With the Forward switch in the On position the control output control signal will increase as the setpoint level is exceeded. With the Reverse switch in the On position the output control signal will decrease as the setpoint level is approached from underside. (See figure 3-

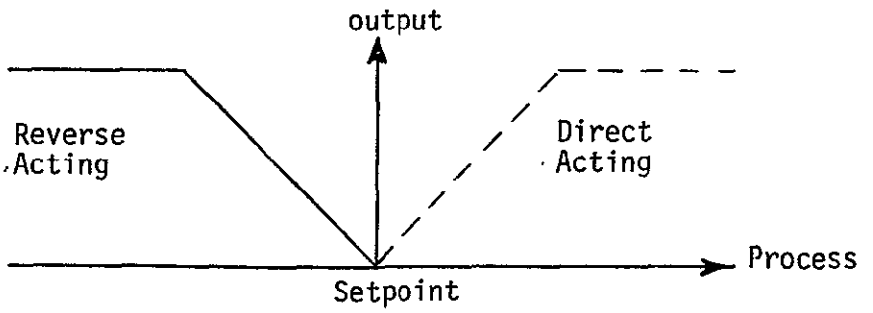


Figure 3-4 Forward/Reverse Control

SECTION 4 - NORMAL OPERATING PROCEDURES

4-1 General

This section of the manual provides information for placing the 640 in operation.

4-2 Pre-Operating Checkout

Prior to operation of the 640U, the following conditions should be insured:

1. All interconnections are proper and secure and correct input power is applied.
2. Continuity of the input checked.
3. Polarity of the input connections to the 640U double checked.
4. Thermocouple extension wire as (if a temperature application) isolated as far as possible from line and load wiring.
5. The FORWARD/REVERSE and ALARM switches are set to the desired position.
6. Burnout selected.

If the unit is used with a RESEARCH, INCORPORATED power controller, before placing the unit in operation, refer to the appropriate heading in the power controller instruction manual and select the proper operating mode for the firing circuit, depending upon the specific type of load to which the instrument is connected.

CAUTION:
Do this before applying line voltage to the unit.

4-3 Manual Operating Procedures

In manual operating mode, the value of the output is solely a function of the selected setting of the MANUAL control. In this mode the final control element can be operated between 0 and 100%.

The procedure for placing the unit in operation in manual mode is as follows:

1. Rotate MANUAL control fully counterclockwise.
2. Position AUTO/MAN switch to MANUAL.

3. Apply line voltage to the instrument.

4. Turn the MANUAL control fully clockwise. The final control element should smoothly vary, throughout the desired range.

NOTE

The MANUAL potentiometer is dead at the maximum CW and CCW positions.

4-4 Adjusting the Instrument to a Process

A closed loop process is initiated by rotating the SETPOINT dial to a setting corresponding to the desired process level.

After establishing the setpoint command level, the PROPORTIONAL BAND control must be adjusted for proper control operation. The rate and reset action are added to proportional control after the PROPORTIONAL BAND adjustment has been accomplished.

4-4-1 Adjusting the PROPORTIONAL BAND Control

The PROPORTIONAL BAND control setting establishes the level to which error signal magnitude deviates from null before full output is delivered. The PROPORTIONAL BAND control setting should be turned counter-clockwise (the proportional band tightened) until system oscillations occur in response to small shifts in command (setpoint) level. The PROPORTIONAL BAND control setting is then turned clockwise (proportional band widened) until oscillations cease. (See Figure 4-1.)

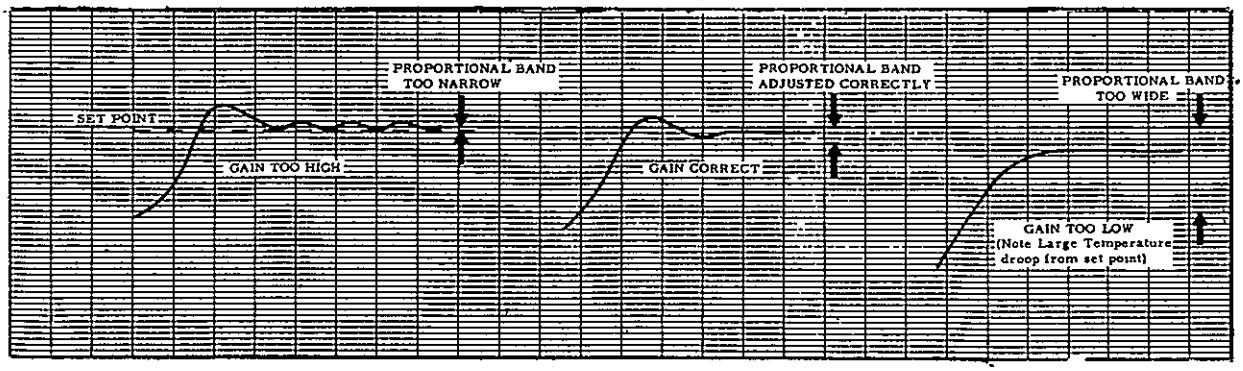


FIGURE 4-1 PROPORTIONAL BAND CONTROL ADJUSTMENTS

Once the DEVIATION Indicator has settled out after widening of the proportional band, signal is added to the proportional signal to bring the process exactly to setpoint (null). Refer to the information under the following paragraph for adjustment of the RESET control.

4-4-2 Adjusting the RESET Control

Reset signal is added to proportional control after the set-point has been selected and the PROPORTIONAL BAND control adjusted as outlined under the two preceding paragraphs.

To initially introduce reset action, turn the RESET control to the lowest (.1) setting (fully counterclockwise) so the reset signal is added at its slowest rise rate. It is not recommended that reset signal be added at the faster times (repeats per minute) until the operator has had some experience of the effect of reset signal rise rate on system stability. Generally, reset is added at the slower rates on the slower responding systems, on faster responding systems and specimens. Faster reset rise rates result in system oscillations and/or overshoot.

Most high response systems (such as those using radiant heating) do not normally require much reset, since the high response allows a band of proportional control of only a few degrees Fahrenheit. Slow response systems generally demand wider bands of proportional control to provide stable system operation. Wider bands proportionally increase droop, which must then be cancelled out by automatic reset action if accurate control is to be achieved (see Heading 3-3-2).

With the unit stabilized under proportional control as described under the preceding heading, start to add RESET. Observe the DEVIATION indicator for a decrease in the indicated droop error. Slowly, rotate the RESET control clockwise one increment and observe the DEVIATION indicator for reset action and indication of rise rate.

When the DEVIATION indicator nulls out at zero, increase the setting of the SETPOINT dial and again observe the DEVIATION indicator for reset action and any overshoot. If there is no overshoot and the process is responding too slowly, increase the setting of the RESET control clockwise another increment, and again shift the SETPOINT control to increase the command level. At some point, some overshoot and/or oscillation should be noted. The RESET control setting must then be decreased (turned counterclockwise to lower setting) until just a very small amount of overshoot and/or oscillation occurs with repeated shifts upward in command level. It may be necessary to widen the proportional band with the addition of reset signal. Figure 4-2 shows typical process versus time histories for three RESET control settings.

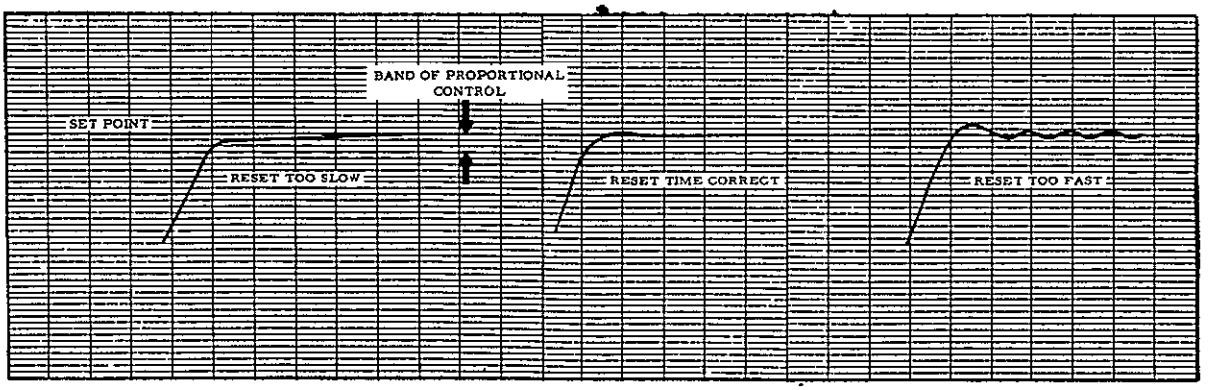


FIGURE 4-2 ADDING RESET ACTION TO PROPORTIONAL CONTROL

Reset action is automatically inhibited outside the proportional band of control by a special anti-reset circuit (in reset only instruments) and by the rate in 640's with rate to prevent an overshoot after a shift in command point greater than the width of the proportional band.

If a satisfactory setting of the RESET control cannot be achieved without unacceptable overshoot, or, if even without reset the system is subject to unacceptable overshoot, rate action may be required to stabilize the system. If rate action is required, place the RESET control fully counterclockwise and proceed as outlined under the following heading. When rate action is required, the sequence of control adjustment must be GAIN, RATE, RESET and then RATE again.

4-4-3 Adjusting the RATE Control

Rate action may be added to proportional control or proportional plus reset control to improve system responsiveness and to prevent overshoot. However, some systems can tolerate no rate action at all being inherently too responsive and/or unstable. On the other hand, some systems have satisfactory response without rate action, being stable enough and responsive enough to achieve setpoint without rate action. If rate action cannot be tolerated or is unnecessary, the RATE In/Out Switch should be left in the out position.

To introduce rate action, slowly rotate the RATE control clockwise up from its zero position while at a control point, until system oscillation occurs. Excessive rate action is characterized by system oscillations of a higher frequency than those produced by an excessively narrow proportional band. When system oscillations begin, reduce the setting of the RATE control until oscillations cease.

When the system has stabilized after oscillation, shift the setting of the SETPOINT control and observe the results on the DEVIATION meter. If the RATE control is too high, the DEVIATION indicator will indicate a "hunting" action characterized by a series of jerky movements of the pointer as it enters the null area. If rate action is not sufficient, the DEVIATION indicator will indicate overshoot by large deviations over setpoint. Figure 4-3 shows typical process versus time histories for three RATE control settings.

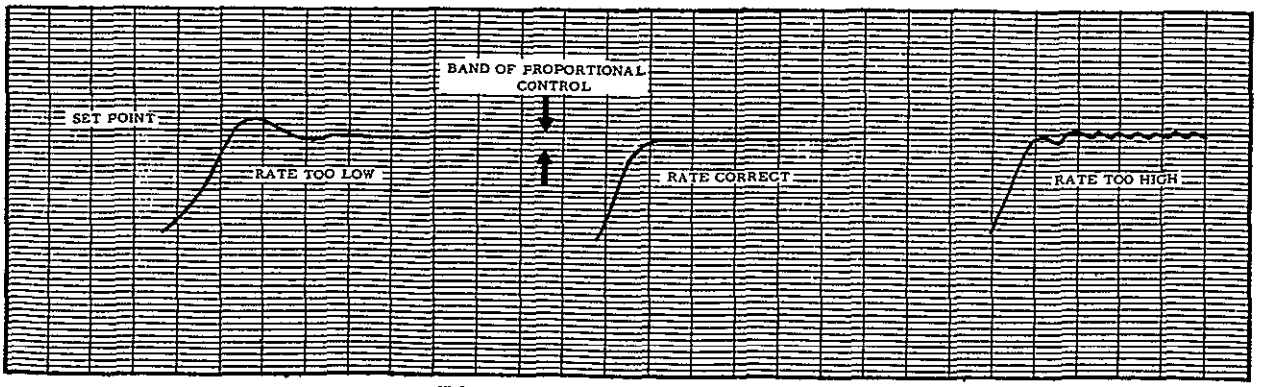


FIGURE 4-3 ADDING RATE ACTION TO PROPORTIONAL CONTROL

Rate action may be increased as long as overshoot decreases with small shifts in command (setpoint) level. When the best setting of the RATE control has been achieved refer to Heading 4-4-2, and if necessary, readjust the RESET control.

Occasionally, the amount of extraneous signal pickup in a system will not permit the use of rate action since this action greatly amplifies noise. This problem can usually be overcome by grounding the specimen and the controller, and by twisting the thermocouple leads and keeping them well away from the power wiring in temperature applications.

4-5 Programmer Operating Procedure

When an external programming device has been connected to the instrument as described in Section 2, the following procedure is used to adjust the unit for programmer operating mode:

1. Place the instrument in setpoint operating mode and adjust PROPORTIONAL BAND, RESET, and RATE controls as described in paragraph 4-4.

2. Place the LOCAL/REMOTE switch in PROGRAMMER mode, and initiate programming operation.

When establishing the settings of the PROPORTIONAL BAND, RESET, and RATE controls in setpoint, prior to programming (step 1), these settings are established at the high process variable level of the program.

4-6 Adjusting the ALARM Control

To set the optional ALARM control, turn it to the maximum clockwise position. Position the HIGH or LOW switches S1-1 and S1-2 to enable either a high level, low level or High/Low deviation detection as follows:

HIGH LEVEL	S1-1 ON, S1-2 OFF
LOW LEVEL	S1-1 OFF, S1-2 ON
HIGH/LOW	S1-1 and S1-2 ON
NO ALARM	S1-1 and S1-2 OFF

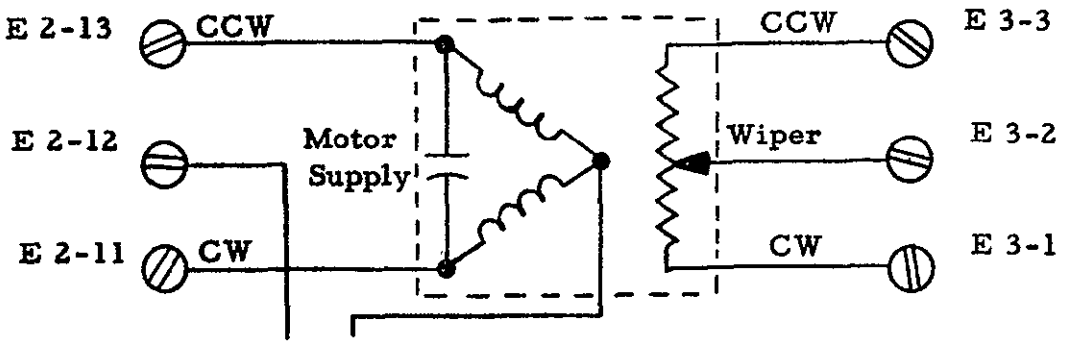
Keeping the process feedback level constant, either by disconnecting the output signal or removing the final control element, turn the Setpoint dial until the DEVIATION meter nulls. Noting the Setpoint level, increase (or decrease) the Setpoint dial to a setting equal to the desired deviation limit (maximum of 10% of span). Adjust the ALARM control counterclockwise until the ALARM light is lit. The Alarm contact is usually supplied normally open but may be changed to normally closed by removing the jumper from X1-8 to the terminal marked NO on the Master p.c. board and installing the jumper from X1-8 to the terminal marked NC.

Position Proportioning Output Instructions

The decal on the side of the 640U case shows the rear terminal board connections. The CW (clockwise) and CCW (counterclockwise) notation is referenced to the retransmit potentiometer only.

The output CW terminal is connected to the moter lead which causes the retransmit potentiometer to move towards the CW end. Conversly, the output CCW terminal is connected to the motor lead which causes the retransmit potentiometer to move toward the CCW end.

A typical motor operator is:



TYPICAL VALVE INTERFACE AND ADJUSTMENTS

(Note: Free the mechanical linkage between operator and valve as an initial condition.)

ON 640U 1) For initial checkout place the 640U in MANUAL mode with the switch on the master board. Turn the MANUAL potentiometer to mid-scale. Energize the 640U and the motor. The motor should run to mid-range. If the motor runs to one end or the other. reverse the E 3-3 and E 3-1 leads.

2) Adjust the CYCLE TIME potentiometer (which is the dead baud adjustment) so that the motor does not cycle continuously.

ON VALVE 3) Manually adjust the valve to closed position as per valve manufacturing instructions.

4) Set the motor operator retransmit pot to closed or "0" and of pot.

ON 640U 5) With controller on and in manual control mode with manual pot at "0", check to see that valve just closes and motor doesn't overtorque the valve into its seat.

6) Slowly rotate the manual pot towards the open end, watch the valve travel to insure the operator is not driving the valve into its fully open mechanical stop.

7) If it tends to overdrive:
Adjust the span pot on the 640U output card to reduce the operator stroke to that of the mechanical travel of the valve.

8) Recheck the zero or closed end of the stroke by repeating step three.

SECTION 5 - CALIBRATION PROCEDURES

5-1 GENERAL

This section contains the procedures for initial checkout, power supply tests, master board checks and adjustment and Input/Output calibration procedures.

NOTE

The following procedures require a voltmeter with 10 microvolt resolution, oscilloscope and a precision millivolt source or decade resistance box depending on the type of input board to be calibrated.

5-2 INITIAL CHECKOUT

Before placing the 640U in operation or prior to making calibration adjustments, perform the following procedures:

STEP 1. Check the operation of the setpoint controls. On the analog units check for correct centering on the setpoint dial. On the digital units check for 000 reading on the odometer scale when control is turned fully CCW.

STEP 2. Loosen the retaining screw and draw chassis out to its stop.

STEP 3. Visually inspect for broken or loose components.

STEP 4. Press the chassis stop to slide the chassis out to its maximum extension (do not disconnect ribbon cable) and repeat step 3.

STEP 5. Replace chassis in housing and tighten retaining screw.

STEP 6. Check the power connections at the rear of the 640U housing. Make sure the proper voltage is applied to the unit.

STEP 7. Energize the unit with input power. Observe if the green, POWER indicator is ON.

5-3 POWER SUPPLY CHECKOUT (Schematic KD47139)

To perform the following checks on the power supply loosen the retaining screw and extend the chassis to gain access to the test points.

STEP 1. Attach the ground lead of voltmeter to terminal X2-4.

STEP 2. Probe test point X2-3 for -15 +15M VDC, Adjust P7.

STEP 3. Probe test point X2-5 for +15 ±15M VDC, Adjust P8.

STEP 4. Probe test point X2-6 for +27 ±3 VDC.

5-3 MASTER BOARD CHECKOUT (Schematic D47139)

The following procedures are used to calibrate and adjust the master board.

5-3.1 Amplifier Board

STEP 1. With the 640U chassis extended carefully remove the input board to expose the master circuit board.

STEP 2. Set the following controls as listed below:

PROPORTIONAL BAND - fully CCW
RATE - OFF
RESET - OFF
AUTO/MANUAL-AUTO

STEP 3. Connect jumper between terminals X3-7 and X3-8.

STEP 4. Connect voltmeter between pin 6 of U1 (AD540) and X3-7.

STEP 5. Adjust NULL BALANCE pot P3 for 0 ±.01 volts.

STEP 6. Remove jumper from terminals X3-7 and X3-8 and replace input board.

5-3.2 Alarm Circuit

STEP 1. Connect voltmeter between X3-7 and X3-8.

STEP 2. Connect a millivolt source to terminals E1-1 and E1-2 at the input connector at rear of terminal board.

STEP 3. Set the following controls:
ALARM pot P1 - Maximum CW
HIGH/LOW alarm - On

STEP 4. Adjust millivolt input or setpoint control until ALARM indicator is On. The voltmeter should read -.80 to -.85 volts.

STEP 5. Adjust the millivolt input or SETPOINT control in the opposite direction from step 4 and observe that ALARM indicator is off. Continue to adjust the millivolt input (or SETPOINT control) until ALARM is just On. The voltmeter should read +.80 to +.85 volts.

NOTE

The difference between the reading obtained in step 4 should be less than .5 volts.

STEP 6. Position the low alarm (L) switch to OFF. Observe that the ALARM indicator is off. Adjust the millivolt input (or SETPOINT) for a positive deviation and observe that ALARM indicator is On.

STEP 7. Position the low alarm (L) switch to ON and the high alarm (H) switch to OFF. Adjust the millivolt source (or SETPOINT) for a negative deviation and observe that the ALARM indicator is On.

STEP 8. Position both high (H) and low (L) alarm switches to ON.

5-3.3 Forward/Reverse Switch

The following steps are used to check the operation of the forward/reverse acting feature:

STEP 1. Connect voltmeter to terminals X2-2 and X2-4.

STEP 2. Set the following controls switches to the position indicated:

PROP BAND - Maximum CW
RATE - Off
RESET - Off
AUTO/MAN - MAN
Forward/Reverse - OFF (Reverse acting mode)

STEP 3. Adjust MAN potentiometer CCW for +3 to +4 volt reading on voltmeter.

STEP 4. Adjust MAN potentiometer CW for -3 to -4 volt reading on voltmeter.

STEP 5. Set Forward/Reverse switches to ON (Forward acting mode).

STEP 6. Adjust MAN potentiometer P5 maximum CCW for a +3 to +4.5 volts reading.

STEP 7. Adjust MAN potentiometer P5 maximum CW for a -3 to -4.5 reading.

STEP 8. Readjust MAN potentiometer P5 for a +3 volt reading.

STEP 9. Reset Forward/Reverse switches to OFF (REVERSE acting mode and verify +3 $\pm$.3 volt reading on voltmeter.

5-3.4 Reset Check

The following procedures are used to check the operation of the reset circuits.

STEP 1. Conenct voltmeter to terminats X2-2 and X2-4.

STEP 2. Set the following controls to the position indicated.
RATE - Off (Max CCW)
RESET - Off (Max CCW)
AUTO/MANUAL - AUTO
FORWARD/REVERSE - OFF

STEP 3. Adjust millivolt input to +1 volt reading on voltmeter.

STEP 4. Quickly turn RESET control fully CW.

STEP 5. Observe voltmeter. Voltage should change from 1 volt to -3 volts in 12±2 seconds.

STEP 6. Set AUTO/MANUAL switch to MANUAL and adjust MANUAL control potentiometer for +1 volt reading on voltmeter.

STEP 7. Observe a bumpless transfer in the output to a -3 volt reading in a 12 ±2 second internal

5-3.5 Rate Check

The following procedures are used to check the operation of the rate circuit:

STEP 1. Set the following controls to the position indicated:
PROP BAND - Max CW
RATE - 5
RESET - Off
AUTO/MANUAL - AUTO

STEP 2. Connect voltmeter to X2-2 and X2-4.

STEP 3. Set RATE control to off.

STEP 4. Set AUTO/MANUAL to MANUAL- wait one second, then set AUTO/MANUAL to AUTO.

STEP 5. Adjust input voltage from millivolt source for +1 volt reading on voltmeter.

STEP 6. Set RATE switch to On. The output should jump to -5 to -7 volts and slowly decay to +.5 volts in 15 seconds (+10 to +5) seconds settling out at +1 volts.

5-3.6 Reset Lockout Check

STEP 1. Set the following controls to the position indicated:
PROP BAND - Max CW
RATE - Off
AUTO/MANUAL - AUTO
RESET - Max CW
FORWARD/REVERSE - REVERSE (both switches to off)

STEP 2. Connect a voltmeter between terminals X2-2 and X2-4.

STEP 3. Adjust millivolt input or SETPOINT control to 1 division of negative deviation.

STEP 4. The voltmeter should slowly read -3.75 to -4.25 then jump back to a -3 to -3.5 volt reading on the voltmeter.

STEP 5. Readjust SETPOINT for 1 division of positive deviation.

STEP 6. The voltmeter should slowly read +3.75 to +4.75 volts then jump back to a +3 to +3.5 volt reading on the voltmeter.

NOTE

The reset lockout check can also be performed by setting the AUTO/MANUAL switch to MANUAL, setting the MANUAL potentiometer to a + or - 3 volt reading and then switching to AUTO and observing a jump to 3 to 3.5 volt reading on the voltmeter.

5-3.7 Proportional Band Check

The following procedures are used to verify proper operation of the proportional band:

STEP 1. Set the following controls and switches to the position indicated:
RATE - Off
RESET - Off
AUTO/MANUAL - AUTO
PROP BAND - Max CW
FORWARD/REVERSE - REVERSE (both switches Off)

STEP 2. Connect voltmeter between terminals X2-2 and X2-4.

STEP 3. Position SETPOINT at center of span.

STEP 4. Adjust millivolt input for a +3 volt reading on meter.

STEP 5. Reposition SETPOINT to full scale and observe -2.5 to -3 volt reading on the voltmeter.

STEP 6. Rotate PROP BAND control max CCW.

STEP 7. Adjust SETPOINT for -3 volt reading at voltmeter.

STEP 8. Setpoint reading should be 1% of center of setpoint span used in step 3.

5-4 Input Cablibration (See schematic KC41678)

The following paragraphs list the procedures required to set up the input amplifier for operation:

5-4.1 Amplifier Balance

The following procedures are used to balance the input amplifier prior to connection to the remote thermocouple or sensor:

STEP 1. Set LOCAL/REMOTE switch to LOCAL position.

STEP 2. Turn SETPOINT control to minimum setting.

STEP 3. Rotate SPAN potentiometer fully CCW.

STEP 4. Set ZERO potentiometer for 0 volt output at wiper.

STEP 5. Insert jumper between wiper of ZERO potentiometer and X3-7.

STEP 6. Insert jumper across capacitor C7 (.47 ufd).

STEP 7. Insert jumper across capacitor C1 (18 ufd).

STEP 8. Measure voltage between terminals X3-8 and X3-7.

STEP 9. Adjust NULL balance potentiometer (P1) for an 0 volt ±.01 volt meter reading.

STEP 10. Remove jumpers from ZERO potentiometer and capacitors C-7 and C-1.

5-4.2 Thermocouple Input Calibration

The following procedures are used to calibrate the input amplifier for use with a thermocouple:

STEP 1. Measure temperature at location of thermocouple with thermometer.

STEP 2. Refer to reference chart for desired compensator millivoltage.

STEP 3. Use voltmeter to measure voltage between terminals E1-2 and E1-3 at rear of terminal board.

STEP 4. Adjust COMP potentiometer on input board for desirable voltage (±.01 millivolt).

STEP 5. Disconnect voltmeter.

STEP 6. Obtain minimum and maximum millivolt ranges from the reference table for the selected thermocouple for the 32°F (0°C) level.

STEP 7. Subtract offset millivoltage from Figure 5-1 from the maximum and minimum value obtained from Step 6 to establish the zero and full scale input values.

STEP 8. Connect a voltmeter between terminals X3-7 and X3-8.

STEP 9. Connect a millivolt source to the E2-1 (+) and E2-2 (-) input terminals.

STEP 10. Set the input level to the zero value obtained in step 7.

STEP 11. Set the SETPOINT control to the zero point.

STEP 12. Adjust the ZERO potentiometer (P4) for 0±.01 VDC.

STEP 13. Set the input millivolt level to the full scale value calculated in step 7.

STEP 14. Adjust the SETPOINT control to maximum.

STEP 15. Adjust the span potentiometer (P3) for 0±.01 volts between X3-7 and X3-8.

STEP 16. Repeat steps 10 through 15 until no further adjustment is required.

STEP 17. Set millivolt input to the full scale value calculated in step 7.

STEP 18. Set SETPOINT control to minimum.

STEP 19. Adjust GAIN potentiometer (P5) for 8±.01 volt reading on volt meter.

5-4.3 Millivolt Input Calibration

The following procedures are used for calibrating the input board for millivolt input levels:

STEP 1. Obtain correct compensation voltage from compensation chart.

STEP 2. Measure voltage between E1-2 and E1-3 on the rear terminal board.

STEP 3. Adjust COMP potentiomter (P2) for compensated reading on the voltmeter.

STEP 4. Disconnect and remove voltmeter.

STEP 5. Connect millivolt input supply to E1-1(+) and E1-2(-)

STEP 6. Connect voltmeter between terminals X3-7 and X3-8.

STEP 7. Adjust millivolt input source for zero value.

STEP 8. Adjust SETPOINT for zero value.

STEP 9. Adjust ZERO potentiometer (P4) for 0±.01VDC.

STEP 10. Adjust millivolt input source for full scale output.

STEP 11. Adjust SETPOINT to full scale value.

STEP 12. Adjust SPAN potentiometer (P3) for 0±0.1 volt reading on the voltmeter.

STEP 13. Repeat steps 7 through 12 until no further adjustment is required.

STEP 14. Adjust millivolt input source for full scale output.

STEP 15. Adjust SETPOINT to zero value.

STEP 16. Adjust GAIN potentiometer (P5) for a 8±.01 volt reading on the voltmeter.

5-4.4 Current/Voltage Input Calibration

The following procedures are used for calibration of the current/voltage input circuit.

STEP 1. Connect an adjustable range current or voltage input supply to E1-1(+) and E1-2(-).

STEP 2. Connect voltmeter between terminals X3-7 and X3-8.

STEP 3. Adjust input source for zero output (lower range limit).

STEP 4. Adjust SETPOINT to zero.

STEP 5. Adjust ZERO potentiometer (P4) for 90±0.01 volts on the voltmeter.

STEP 6. Readjust input supply for a full scale (upper range limit) reading on the voltmeter.

STEP 7. Adjust SETPOINT to full sale reading.

STEP 8. Adjust SPAN potentiometer (P3) for 0±.01 volt reading on the voltmeter.

STEP 9. Repeat steps 3 through 8 until no further adjustment of the ZERO or SPAN potentiometers are required.

STEP 10. Set input source to full scale (upper range limit) reading on the voltmeter.

STEP 11. Adjust SETPOINT to zero (minimum setpoint).

STEP 12. Adjust GAIN potentiometer (P5) for 8±0.01 volt reading on the voltmeter.

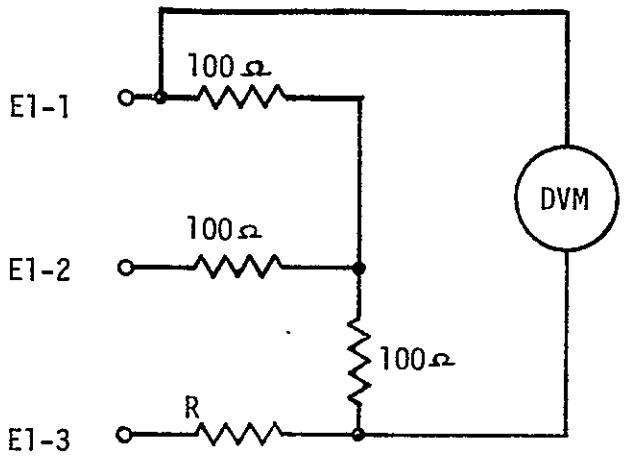
5-4.5 RTD Input Calibration

The following procedures are used for calibration of the RTD input circuit.

STEP 1. Connect the following circuit to the 640U terminal board.

NOTE

This procedure is used for leadwire compensation adjustment.



R = Mid-range Resistance of RTD ± 5%

STEP 2. Connect voltmeter as shown in preceding figure.

STEP 3. Adjust COMP potentiometer for an 0±.001 volt reading on the voltmeter.

STEP 4. Remove circuit installed in step 1.

STEP 5. Connect a decade resistance or other precision resistance source capable of resolving 0.1 ohm to the 640U terminal board between E1-1 and E1-3. Connect a third wire from E1-2 to terminal E1-1.

STEP 6. Connect a voltmeter between X3-7 and X3-8.

STEP 7. Set the decade box to the resistance corresponding to ZERO (minimum input) end of the range.

STEP 8. Adjust SETPOINT to zero (lower range limit).

STEP 9. Adjust the ZERO potentiometer (P4) for 0±0.1 volts.

STEP 10. Adjust decade box to full scale (maximum range limit) resistance.

STEP 11. Adjust SETPOINT to full scale (maximum range limit).

STEP 12. Adjust SPAN potentiometer (P-X) for 0±.01 volt reading.

STEP 13. Repeat steps 7 through 12 until no further adjustments of ZERO or SPAN are required.

STEP 14. Adjust decade box for full scale (maximum range limit) resistance.

STEP 15. Adjust SETPOINT to zero (minimum range limit).

STEP 16. Adjust GAIN potentiometer for 8±.01 volt reading.

5-4.6 Remote Setpoint Calibration

The following procedures are provided for 640U calibration when a remote setpoint potentiometer is used:

STEP 1. Connect Remote Setpoint potentiometer to E2-1 (CW), E2-2 (W) and E2-3 (CCW).

STEP 2. Set LOCAL/REMOTE switch to REMOTE.

STEP 3. Connect voltmeter to terminals X3-7 and X3-8.

STEP 4. Connect a millivolt input source to terminals E1-1 and E1-2.

STEP 5. Adjust input source for a zero (minimum range limit) input level.

STEP 6. Adjust Remote Setpoint potentiometer to zero (minimum range limit).

STEP 7. Adjust SPAN (P6) and ZERO (P7) potentiometers for 0±.01 volts

STEP 8. Adjust input level to full scale (maximum range limit).

STEP 9. Adjust Remote Setpoint to full scale (maximum range limit).

STEP 10. Adjust SPAN potentiometer (P7) to 0±.01 volts.

STEP 11. Repeat steps 5 through 10 until no further adjustment of the ZERO or SPAN potentiometer is required.

5-4.7 Deviation Meter Check

STEP 1. Turn off power to 640U and zero adjust the deviation meter movement.

STEP 2. Adjust SETPOINT to mid scale.

STEP 3. Connect input source to 640U.

STEP 4. Turn on power to 640U and adjust input source for a null reading on the deviation meter.

STEP 5. Adjust the SETPOINT as follows:

If an analog setter is used turn SETPOINT for + or - 10% of span the deviation meter should track SETPOINT within ± 1% for ±10% change in the setpoint.

If a digital setter is used turn the SETPOINT for + or - 15% of span. The deviation meter should track within ±2% of the setpoint.

5-5 Output Calibration Procedures

The following procedures are used to calibrate the output board.

5-5.1 Voltage/Current (CAT) Calibration (Schematic D141679)

The following procedures are used to calibrate the voltage/current (CAT) output board.

STEP 1. Connect an oscillorscope between the junction of R3 and R4 to X2-4 on the output board.

STEP 2. Adjust the SPAN potentiometer (P1) for 6 volt peak-to-peak triangular waveform.

STEP 3. Adjust the ZERO potentiometer (P2) for a 3 volt positive peak.

STEP 4. Repeat steps 2 and 3 until a positive ±.1 peak and a -3±.1 peak is obtained.

STEP 5. Connect volt (or current) meter to the output terminals E2-12(+) and E2-13(-).

STEP 6. Set AUTO/MANUAL switch to MANUAL and turn MANUAL potentiometer maximum CCW.

STEP 7. Adjust the ZERO potentiometer (P4) on the output board for zero (minimum output).

STEP 8. Adjust MANUAL potentiometer maximum CW.

STEP 9. Adjust SPAN potentiometer (P3) for full scale (maximum output).

STEP 10. Repeat steps 6 through 9 until no further adjustment of the ZERO and SPAN potentiometers is required.

5-5.2 Time Proportioning (DAT) Output Calibration (Schematic C41629)

The following procedures are performed for calibration of the time proportioning (DAT) output circuits.

STEP 1. Adjust CYCLE TIME (DAT) potentiometer.

STEP 2. Position AUTO/MANUAL switch to MANUAL.

STEP 3. Connect a voltmeter to terminals X2-2 and X2-4 (common) on the output board.

STEP 4. Connect an oscilloscope to terminals X2-8 and X2-1 (common).

STEP 5. Adjust MANUAL potentiometer (P5) on the master board for -3 volt on the voltmeter.

STEP 6. Adjust ZERO potentiometer (P3) on output board until output just remain low (less than 2 volts).

STEP 7. Adjust MANUAL potentiometer (P5) for a +3 volt reading on the voltmeter.

STEP 8. Adjust SPAN potentiometer (P2) on output board until output just remains high (greater than 24 volts).

STEP 9. Repeat steps 5 through 8 until no further adjustment is required.

STEP 10. Adjust MANUAL potentiometer (P-X) for 0$\pm$.1 volt reading.

STEP 11. Verify that output cycles with a period less than 1 second and a duty cycle of 50$\pm$10%.

STEP 12. Turn the CYCLE TIME potentiometer CW. Verify that the period increases to more than 30 seconds

STEP 13. If ON/OFF control is required move jumper on output board from terminal 1-2 to 1-3. Verify that output is on when X2-2 is less than -.1 volt and off when X2-2 is greater than +.1 volt.

5-5.3 Position Proportioning Output (PAT) Output Board Calibration (Schematic C46005)

The following procedures are used to adjust the position proportioning (PAT) output board for operation.

STEP 1. Set AUTO/MANUAL switch to MANUAL.

STEP 2. Adjust DEADBAND (PAT) control on master board maximum CCW.

STEP 3. Remove power from motor circuit..

STEP 4. Disconnect wiper lead from RETRANSMIT potentiometer (P-X) at terminal E3-2.

STEP 5. Install jumper between E3-2 and E3-3.

STEP 6. Connect voltmeter between terminals X2-2 and X2-1.

STEP 7. Adjust MANUAL (P-X) potentiometer on the master board for +3 +0.1 volt reading.

STEP 8. Adjust SPAN potentiometer (R3) on output board until both relays are deenergized.

STEP 9. Remove jumper between E3-2 and E3-3.

TYPICAL VALVE INTERFACE AND ADJUSTMENTS

1) Manually adjust valve to closed position as per valve manufacturing instructions.

2) Set motor operator retransmit pot to closed or "0" end of pot at manufacturers recommended valve and lock mechanical attachment to valve stem.

3) With controller on and in manual control mode with manual pot at "0" check to see that valve just closes and motor doesn't overtorque the valve into its seat.

4) Slowly rotate the manual pot towards the open end, watch the valve travel to insure the operator is not driving the valve into its fully open mechanical stop.

If it tends to overdrive:
5) Adjust the span pot on the 640U output card to reduce the operator stroke to that of the mechanical travel of the valve.

6) Recheck the zero or closed end of stroke by repeating step 3.

CALIBRATION THERMOCOUPLE TYPE	Temp. °F	69°	70°	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°	81°
		MILLIVOLTAGE												
J	Comp	12.9	12.9	12.9	13.0	13.0	13.0	13.0	13.1	13.1	13.1	13.2	13.2	13.2
	offset	1.048	1.076	1.105	1.134	1.162	1.191	1.220	1.248	1.277	1.306	1.335	1.363	1.392
K	Comp	10.2	10.2	10.3	10.3	10.3	10.3	10.4	10.4	10.4	10.4	10.4	10.5	10.5
	offset	.821	.843	.865	.888	.910	.933	.955	.978	1.000	1.023	1.045	1.068	1.090
R	Comp	1.67	1.68	1.68	1.68	1.69	1.69	1.69	1.70	1.70	1.70	1.71	1.71	1.71
	offset	.114	.118	.121	.124	.127	.131	.134	.137	.141	.144	.147	.150	.154
S	Comp	1.67	1.68	1.68	1.69	1.69	1.69	1.69	1.70	1.70	1.70	1.71	1.71	1.71
	offset	.116	.119	.123	.126	.129	.133	.136	.139	.142	.146	.149	.152	.156
T	Comp	10.1	10.1	10.2	10.2	10.2	10.2	10.3	10.3	10.3	10.3	10.3	10.4	10.4
	offset	.812	.834	.857	.879	.902	.924	.947	.969	.992	1.014	1.037	1.060	1.082
E	Comp	13.70	13.73	13.77	13.80	13.84	13.87	13.90	13.94	13.97	14.00	14.04	14.07	14.11
	offset	1.225	1.259	1.292	1.326	1.360	1.394	1.427	1.461	1.495	1.529	1.563	1.597	1.631
MV	Comp	—	—	—	—	—	10 mv	—	—	—	—	—	—	—
	offset	—	—	—	—	—	0 mv	—	—	—	—	—	—	—
W,B	Comp	—	—	—	—	—	10 mv	—	—	—	—	—	—	—
	offset	—	—	—	—	—	0 mv	—	—	—	—	—	—	—
W 3	Comp	2.59	2.60	2.60	2.61	2.61	2.62	2.62	2.63	2.63	2.64	2.64	2.65	2.65
	offset	.203	.209	.215	.221	.227	.233	.239	.244	.250	.256	.262	.268	.274
W 5	Comp	3.34	3.35	3.36	3.37	3.37	3.38	3.39	3.39	3.40	3.41	3.42	3.42	3.43
	offset	.243	.250	.258	.265	.272	.280	.287	.294	.302	.309	.316	.323	.331
Platinel II	Comp	7.74	7.75	7.77	7.79	7.81	7.82	7.84	7.86	7.88	7.89	7.91	7.93	7.95
	offset	.626	.643	.661	.678	.696	.713	.730	.748	.765	.783	.800	.818	.835

FIGURE 5-1 COMPENSATION AND OFFSET MILLIVOLTAGES

SECTION 6 - TROUBLESHOOTING CHART

This chart lists some symptoms and probable causes of malfunction.

SYMPTOM	PROBABLE CAUSE
No output (Manual or Auto Mode)	1. Incorrect rear terminal connections. 2. No AC power to instrument (is Power Light on?).
Power Light not lit (AC power to rear terminals)	1. Flex cable from case to master board not connected. 2. Defective Power Light.
Moving setpoint has no effect on output	1. AUTO/MAN switch is MAN. 2. REMOTE/LOCAL switch in REMOTE.
Moving setpoint has no effect on output (Deviation meter centered)	1. Open input sensor or sensor connected to wrong terminals (NONE burnout selected).
Deviation meter drives upscale	1. Open sensor (upscale burnout connected).
Deviation meter drives downscale	1. Open sensor (downscale burnout connected).

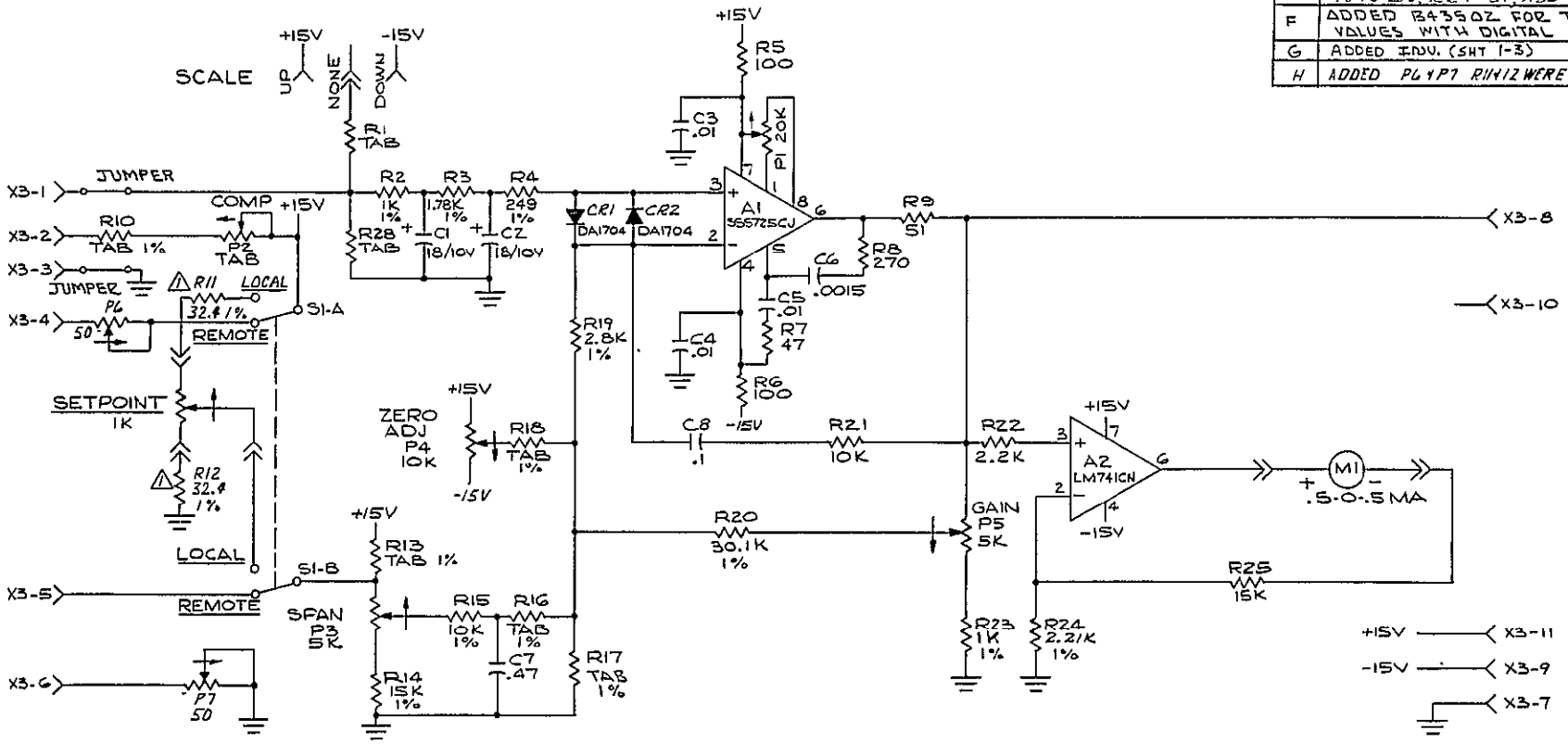
Section 7 - SCHEMATICS

DRAWING #	TITLE
KC41678 sheet 1	Standard Input Board
KC41678 sheet 2	Standard Input Board
KC41678 sheet 3	Standard Input Board
KC41679	Output Board - CAT
KC41689	Output Board - DAT
KB41695	Case and Terminals - CAT
KB41696	Case and Terminals - DAT (S20)
KB42023	Case and Terminals - DAT (R)
KC42663 sheet 1	Cascade Input Board
KC42663 sheet 2	Cascade Input Board
KC42663 sheet 3	Cascade Input Board
KB46002	Case and Terminals - PAT
KC46005	Output Board - PAT
KD47139	640U Master Board

HIGHEST REFERENCE DESIGNATIONS				
A2	C8	CR2	M1	P5
R33	S1			

REF. DESIGNATIONS NOT USED			
R26	R27	R29	R30
R31	R32	R33	

REVISIONS			
SYM	DESCRIPTION	DRAFT.	DATE
A	R17 WAS 200Ω 1%, R28 WAS R26 R20 WAS 37.4K, R23 WAS 1.37K	AKB	8-1-72
B	ALL INPUT SCHEMATICS MADE 1 DWG	DNH	9-14-72
C	R3 & 4 WERE 1K; R22 WAS 1.5K; C8 WAS .01	[illegible]	9-29-72
D	ADDED JUMPERS TO SHT 1.2.3	AKB	10-17-72
E	SH2, R4 WAS 249K; SH 3, ADD % TO R10, R29-31; ADD JUMPER R10	[illegible]	2-5-73
F	ADDED B43902 FOR TAB RESISTOR VALUES WITH DIGITAL SETTER	AKB	3-8-73
G	ADDED INDV. (SHT 1-3)	JAK	9-5-73
H	ADDED P6 & P7 R11 & 12 WERE TAB 1%	DS	10-15-75



2. FOR TAB RESISTOR VALUES SEE B42284/3D1210

⚠ USE JUMPER WITH ANALOG SETPOINT

3B1238	640 DS	C41611
3B1238	640	C41611
INVENTORY	USED ON	ASSEMBLY

DRAFTSMAN H.A. LOCKEN 3-29-72	K = 10^3	M = 10^6	UNLESS OTHERWISE INDICATED
CHECKED M. [illegible] 4-7-72	+ CONNECTION	+ NO CONNECTION	• RESISTANCE IN OHMS ± 5% ⅛ WATT
APPROVED M. [illegible] 4-14-72			• CAPACITANCE IN MFD ± 20%
			• INDUCTANCE IN HENRIES
			• USE 60/40 ROSIN CORE SOLDER
			• USE NO CORROSIVE FLUX

INVENTORY 3D1258

TITLE: SCHEMATIC, INPUT MODULE, T/C/MV

NUMBER: KC41678 REV P1

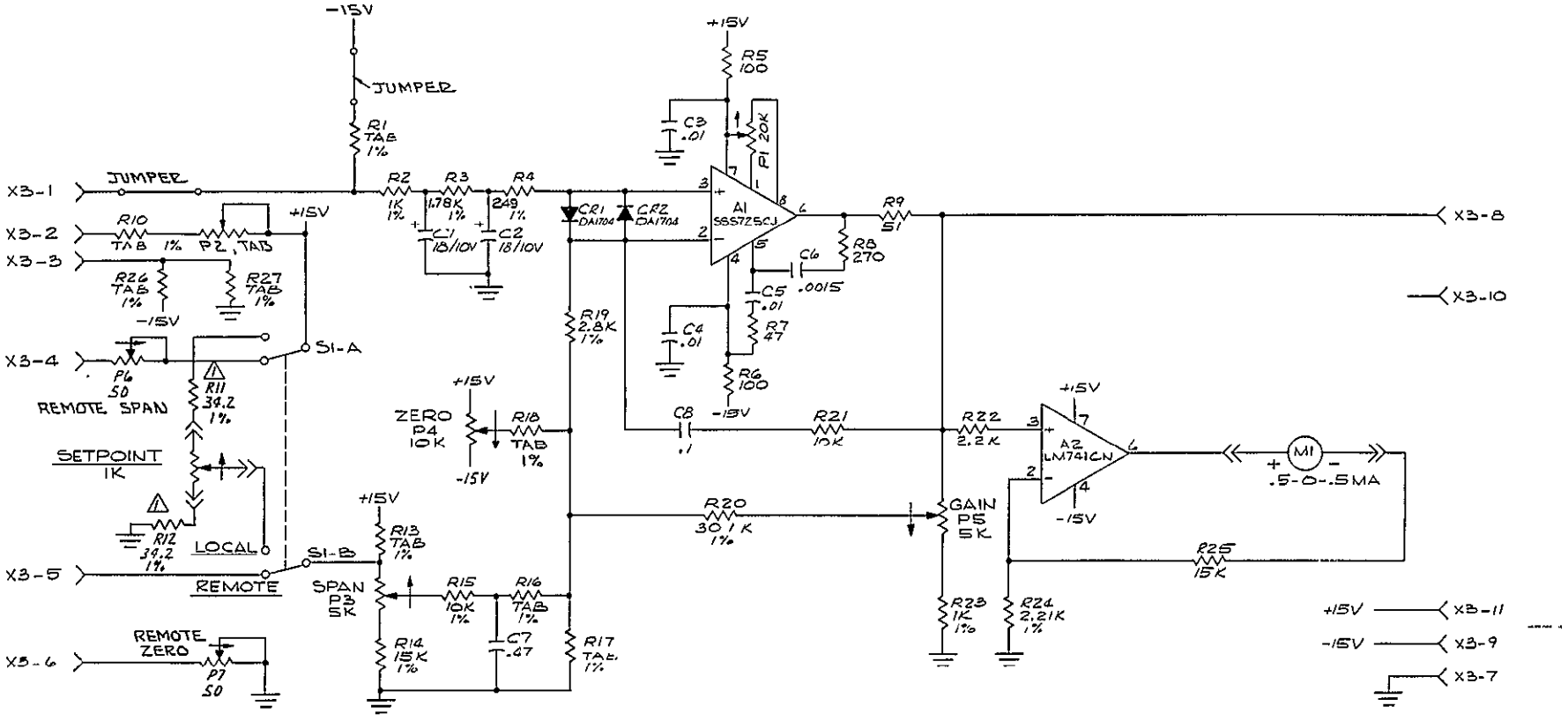
SHEET 1 OF 3

R·I CONTROLS — A DIVISION OF RESEARCH INCORPORATED, MINNEAPOLIS MINNESOTA 55424

HIGHEST REFERENCE DESIGNATIONS				
A2	C8	CR2	M1	P5
R33	S1			

REF DESIGNATIONS NOT USED			
R28	R29	R30	R31
R32	R35		

REVISIONS			
SYM	DESCRIPTION	DRAFT	DATE
	SEE SHEET 1		



3B1238	640 DS	C41611
3B1238	640	C41611
INVENTORY	USED ON	ASSEMBLY

DRAFTSMAN: Hassig 11-17-76
CHECKED:
APPROVED: Jenkins 8-8-77
SCALE:

K = 10^3 M = 10^6

CONNECTION NO CONNECTION

UNLESS OTHERWISE INDICATED
- RESISTANCE IN OHMS ± 5% ¼ WATT
- CAPACITANCE IN MFD ± 20%
- INDUCTANCE IN HENRIES
- USE 60/40 ROSIN CORE SOLDER
- USE NO CORROSIVE FLUX

INVENTORY 3D1258

SCHEMATIC, INPUT MODULE, RTD

NUMBER KC41678 REV H

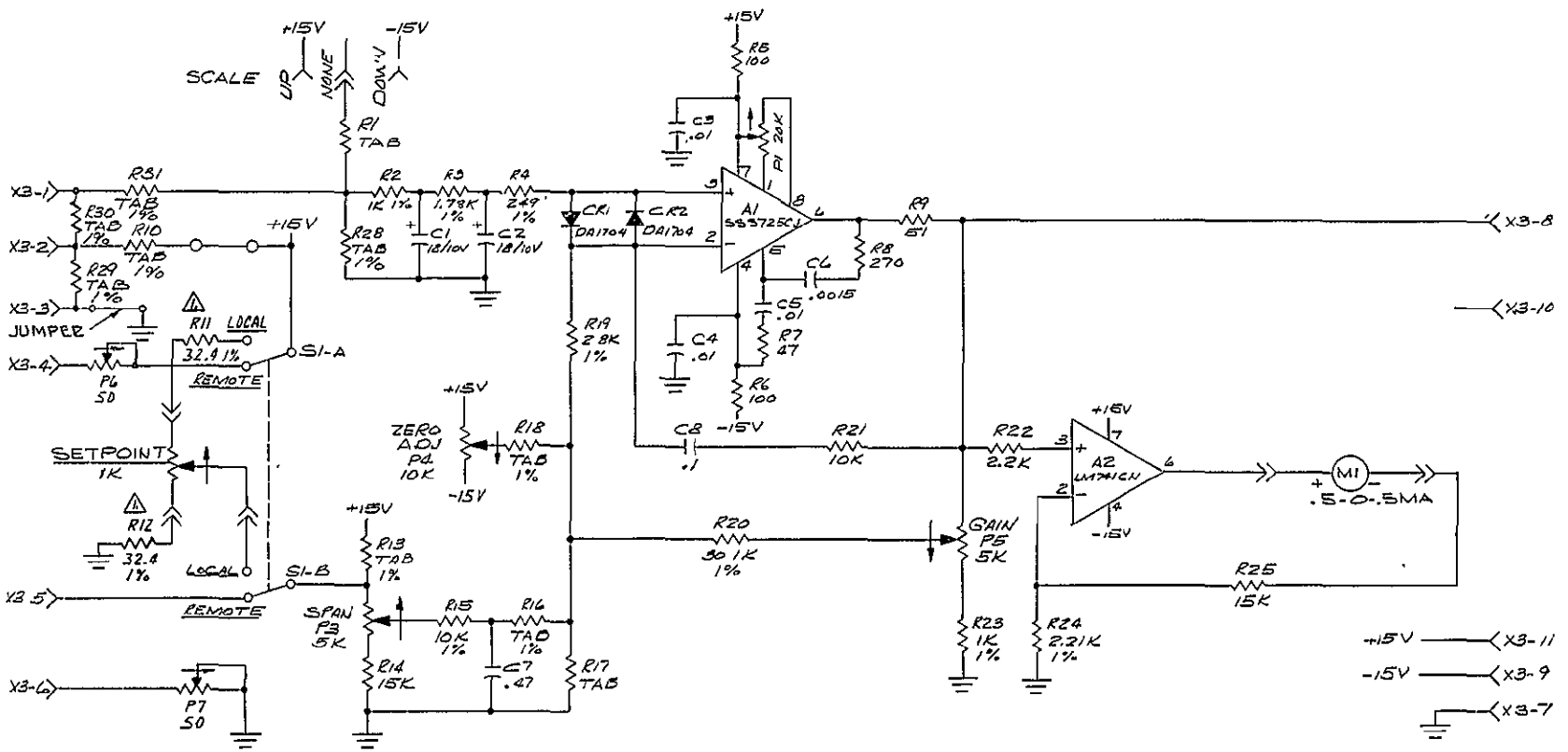
SHEET 2 OF 3

R·I CONTROLS
A DIVISION OF RESEARCH INCORPORATED
MINNEAPOLIS MINNESOTA 55424

HIGHEST REFERENCE DESIGNATIONS				
A2	C8	CR2	M1	P5
R33	S1			

REF DESIGNATIONS NOT USED				
R26	R27	P2	R32	R33

REVISIONS			
SYM	DESCRIPTION	DRAFT	DATE
	SEE SHEET 1		



381238	640 DS	C41611
381238	640	C41611
INVENTORY	USED ON	ASSEMBLY

DRAFTSMAN CHECKED	K = 10^3 M = 10^6	UNLESS OTHERWISE INDICATED
APPROVED	CONNECTION NO CONNECTION	• RESISTANCE IN OHMS ± 5% ⅛ WATT • CAPACITANCE IN MFD ± 20% • INDUCTANCE IN HENRIES • USE 60/40 ROSIN CORE SOLDER • USE NO CORROSIVE FLUX

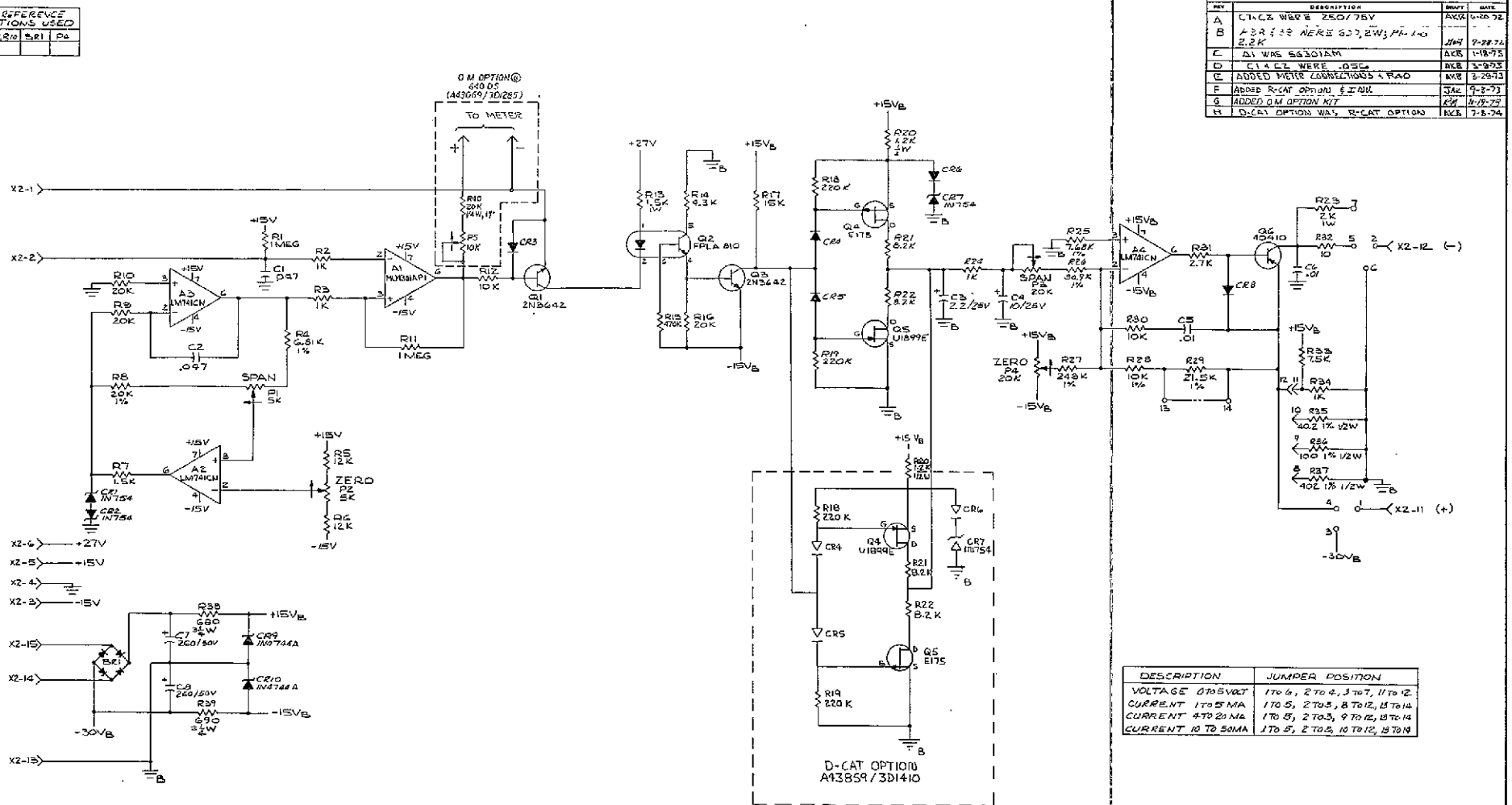
INVENTORY 3D1258

SCHEMATIC, INPUT MODULE - CURRENT/VOLTAGE

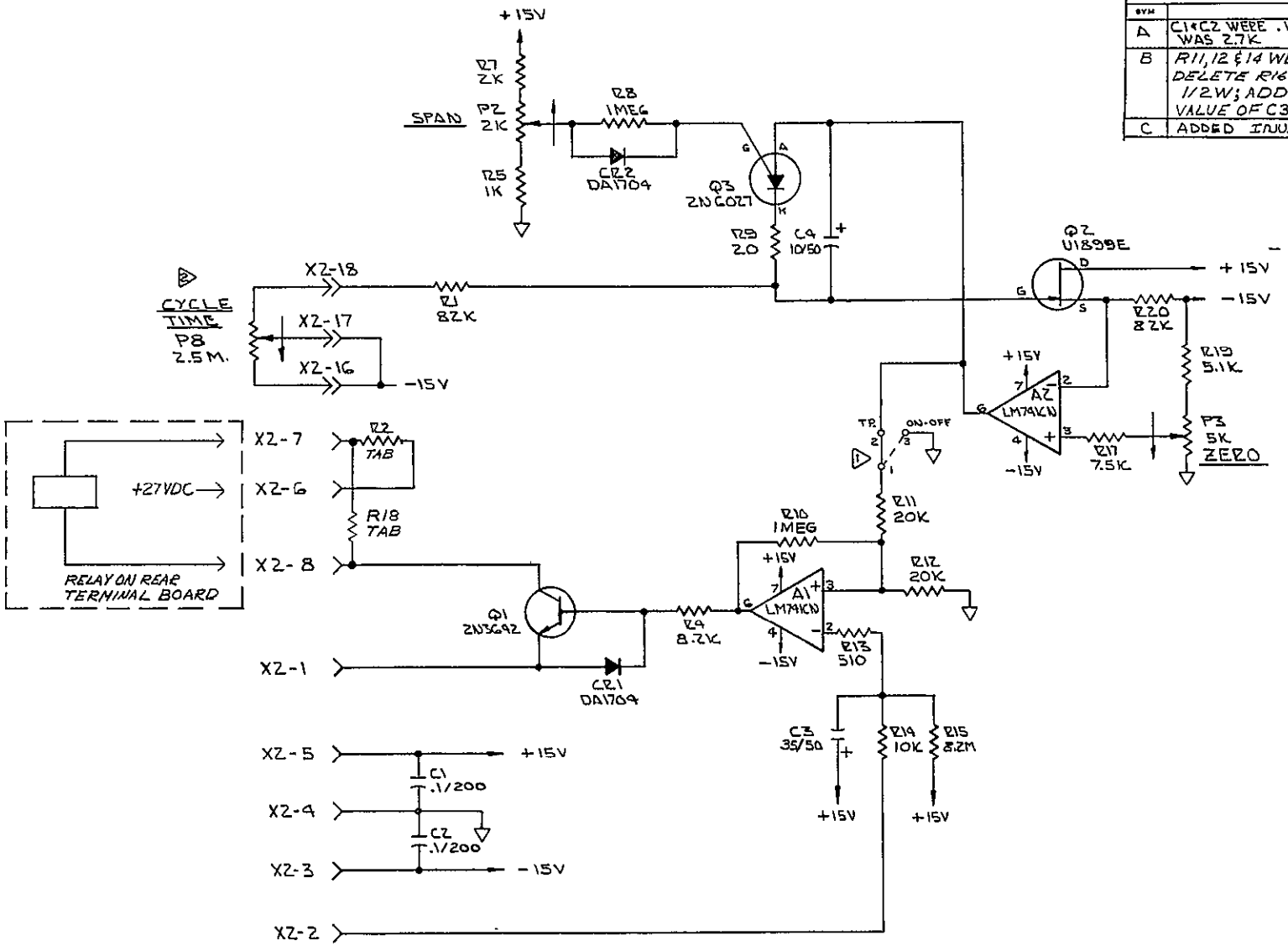
NUMBER KC41678 REV H

SHEET 3 OF 3

R·I CONTROLS — A DIVISION OF RESEARCH, INCORPORATED, MINNEAPOLIS MINNESOTA 55424


HIGHEST REFERENCE DESIGNATIONS USED
AA CB CR10 BR1 PA
Q6 R90
REVISIONS
REV DESCRIPTION DRAFT DATE
A C14,C2 WERE 250/75V AVB 6-20-72
B R32 & 33 WERE 637,2W; PR 1-0 2.2K JMH 9-28-72
C A1 WAS SG301AM AVB 1-18-73
D C14,C2 WERE .05C AVB 3-9-73
E ADDED METER CORRECTIONS & R40 AVB 3-29-73
F ADDED R-CAT OPTION & J-NW JAH 9-8-73
G ADDED O.M OPTION KIT KH 11-19-73
H D-CAT OPTION WAS, R-CAT OPTION AVB 7-8-74
O.M OPTION @ 640.05 (A43069/3D285)
TO METER
X2-1
X2-2
X2-3
X2-4
X2-5
X2-6
X2-11 (+)
X2-12 (-)
X2-13
X2-14
X2-15
+15V
-15V
+27V
-30VB
A1 MUX81A-P1
A2 LM741CH
A3 LM741CN
A4 LM741CH
Q1 2N3642
Q2 FPLA 810
Q3 2N3642
Q4 E175
Q5 U1899E
BR1
D-CAT OPTION A43859/3D1410
SPAN P3 20K
ZERO P4 20K
SPAN P1 5K
ZERO P2 5K
DESCRIPTION JUMPER POSITION
VOLTAGE 0 TO 5 VOLT 1 TO 6, 2 TO 4, 3 TO 7, 11 TO 12
CURRENT 1 TO 5 MA 1 TO 5, 2 TO 3, 8 TO 12, 13 TO 14
CURRENT 4 TO 20 MA 1 TO 5, 2 TO 3, 9 TO 12, 13 TO 14
CURRENT 10 TO 50 MA 1 TO 5, 2 TO 3, 10 TO 12, 13 TO 14
1- DIODES NOT SPECIFIED ARE GE DA1704
3D1285 640.05 A43069
3D1410 640 DS A43857
3D1410 -1 A43859
3B12.39 640 DS C40613
3D1239 640 C41613
MODEL 3DU 3D1240
SCHEMATIC, OUTPUT MODULE, CURRENT AND VOLTAGE
KD41679 H
RESEARCH INCORPORATED MINNEAPOLIS MINNESOTA

REVISIONS			
SYM	DESCRIPTION	DRAFT	DATE
A	C1 & C2 WERE .1/100, R13 WAS 2K, R19 WAS 2.7K	AKB	7-10-72
B	R11, 12 & 14 WERE 5.1K; R10 WAS 470K; DELETE R16, CR3, R3; R2 WAS 82, 1/2W; ADD R18; DELETE NOTE 2, 4, 5, 6; VALUE OF C3 WAS 10/50; DELETE C5	[illegible]	9-27-72
C	ADDED INV. NO. & NOT ▷	JMK	9-5-73



FOR SCH OF SOLID STATE RELAY TERMINAL BOARD — B91696 (3D1261)
FOR SCH. OF RELAY OUTPUT TERMINAL BOARD — B92023 (3D1259)

3B1265	640 DS	C41691
3B1265	640	C9691
INVENTORY	USED ON	ASSEMBLY

NOTES:

▷ FOR SOLID STATE RELAY R2 = 620Ω R18 = 1200Ω
FOR ELECTRO-MECHANICAL RELAY R2 = 62Ω R18 = OMIT

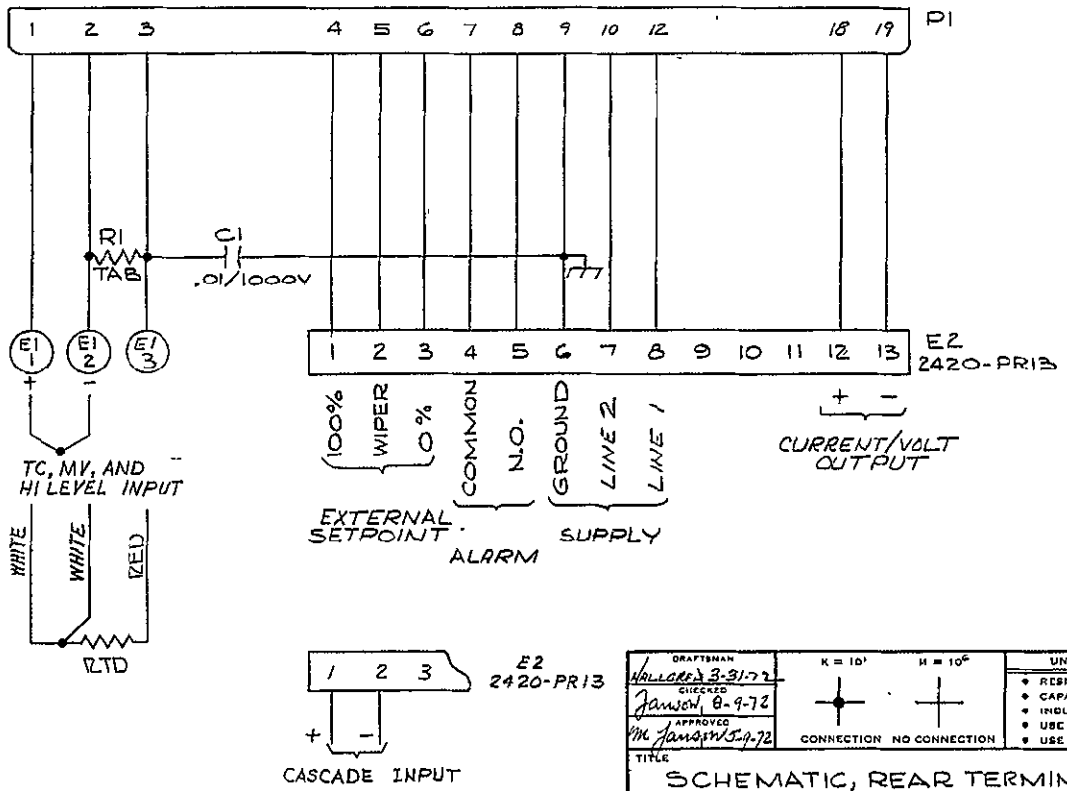
▷ CYCLE TIME POT. IS LOCATED ON MASTER BOARD D41609 SCH. D41607

▷ FOR USE AS ON/OFF CONTROLLER MOVE JUMPER ALTERNATE POSITION (PIN 1 TO 3).

DRAFTSMAN AKB 6-12-72	K = 10³ M = 10⁶	UNLESS OTHERWISE INDICATED: RESISTANCE IN OHMS ± 5% 1/4 WATT; CAPACITANCE IN MFD ± 20%; INDUCTANCE IN HENRIES; USE 60/40 ROSIN CORE SOLDER; USE NO CORROSIVE FLUX	INVENTORY 3D1267
CHECKED [illegible] 7-28-72	CONNECTION NO CONNECTION		
APPROVED [illegible] 8-10-72			
TITLE SCHEMATIC-TIME PROPORTIONING OR ON/OFF CONTROL OUTPUT BOARD		NUMBER KC91689	REV C
		SHEET 1 OF 1	

R·I CONTROLS — A DIVISION OF RESEARCH INCORPORATED MINNEAPOLIS MINNESOTA 55424

REVISIONS					
SYM	ZONE	DESCRIPTION	DRAFT	CHECK	DATE
A		ADDED RTD CIRCUIT & NOTE	AKR		8-1-72
B		L2 WAS COMMON L1 WAS 120 VAC	AKB		10-12-72
C		LINE 2 WAS L2(NEUTRAL); LINE 1 WAS L1(HOT)	DJH		11-1-72
D		ADDED INV.	JAK		9-5-73
E		CLARIFY THERMOCOUPLE INPUT	K.B.		11-27-74



1-FOR TAB. RESISTOR VALUES SEE ASSY C41623
OMIT R1 WHEN USED WITH A RTD INPUT

INVENTORY	USED ON	ASSEMBLY
3B1243	640 DS	C41623
3B1243	640	C41623

DRAFTSMAN: Wallgren 3-31-72
CHECKED: Janson, 8-9-72
APPROVED: M. Janson 8-9-72

K = 10^3 M = 10^6
CONNECTION NO CONNECTION

UNLESS OTHERWISE INDICATED
- RESISTANCE IN OHMS ± 10%, ½ WATT
- CAPACITANCE IN MFD ± 20%
- INDUCTANCE IN HENRIES
- USE 60/40 ROSIN CORE SOLDER
- USE NO CORROSIVE FLUX

[redacted]
INV. 3D1260

TITLE: SCHEMATIC, REAR TERMINAL BOARD CURRENT AND VOLTAGE OUTPUT

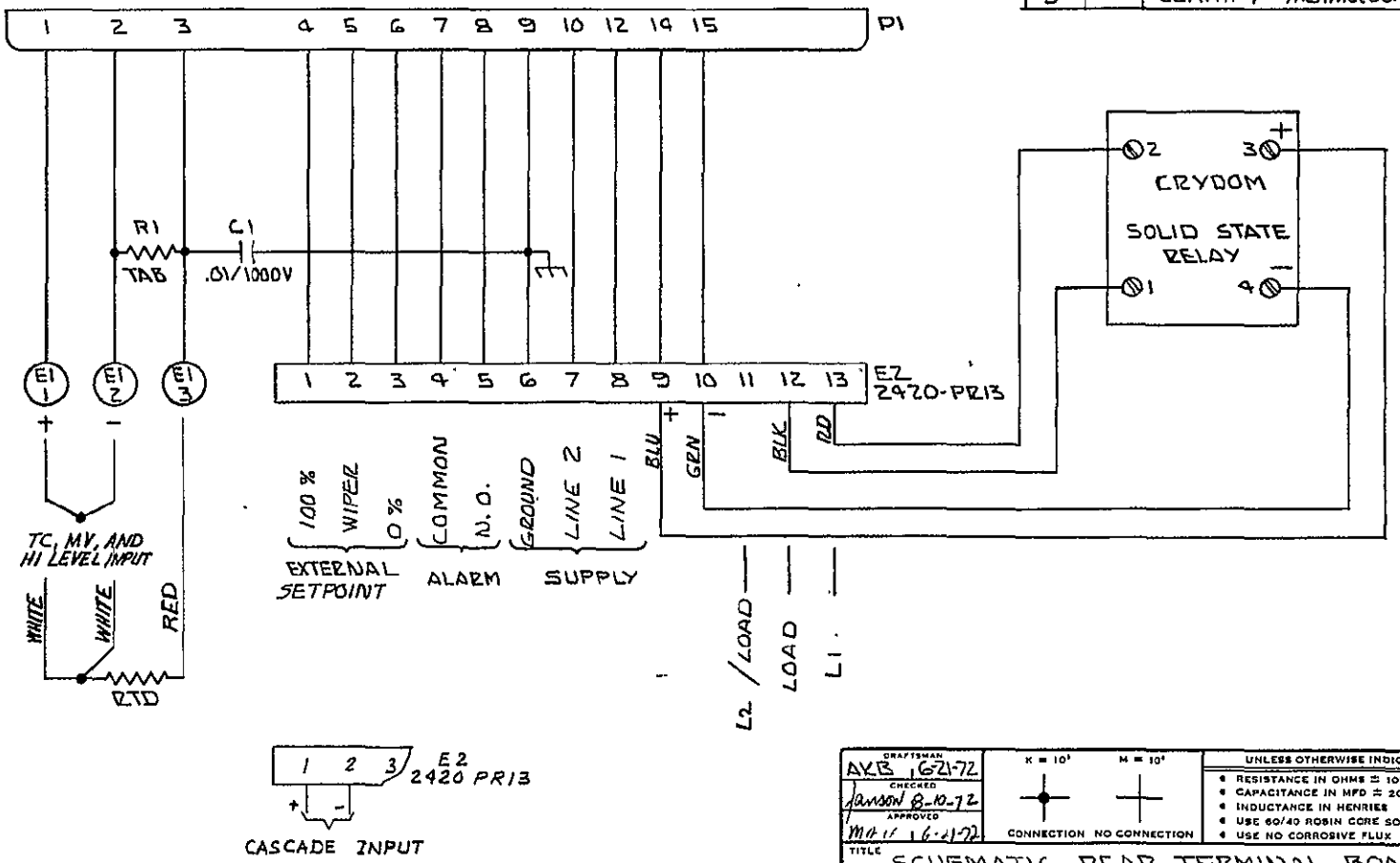
NUMBER: KB41695 REV: E

SHT 1 OF 1

CONTROLS DIVISION • RESEARCH, INCORPORATED • MINNEAPOLIS 24, MINNESOTA

MAY 05 1976

REVISIONS					
SYM	ZONE	DESCRIPTION	DRAFT	CHECK.	DATE
A		L2 WAS COMMON, L1 120 VAC L2/LOAD WAS LINE/LOAD & L1 WAS LINE/COM.	AKB		10-12-72
B		LINE 2 WAS L2 (NEUTRAL); LINE 1 WAS L1 (HOT)	DJM		11-1-72
C		ADDED INV. NO.	JAK		9-5-73
D		CLARIFY THERMOCOUPLE INPUT	K.B.		11-27-74



1. FOR TAB. RESISTOR VALUES SEE ASSY. C41698
   OMIT R1 FOR RTD INPUTS

3B1242	640 DS	C41698
3B1242	640	C41698
3B1249	640 DS	C42013-2
3B1248	640 DS	C42013-1
3B1249	640	C42013-2
3B1248	640	C42013-1
ASSEMBLY HISTORY	USED ON	ASSEMBLY

DRAFTSMAN AKB 6-21-72
CHECKED Jamson 8-10-72
APPROVED Mait 8-21-72

K = 10^3 M = 10^6

UNLESS OTHERWISE INDICATED
- RESISTANCE IN OHMS ± 10% ½ WATT
- CAPACITANCE IN MFD ± 20%
- INDUCTANCE IN HENRIES
- USE 60/40 ROSIN CORE SOLDER
- USE NO CORROSIVE FLUX

CONNECTION NO CONNECTION

[redacted]

INV. 3D12601

TITLE: SCHEMATIC REAR TERMINAL BOARD SOLID STATE RELAY OUTPUT

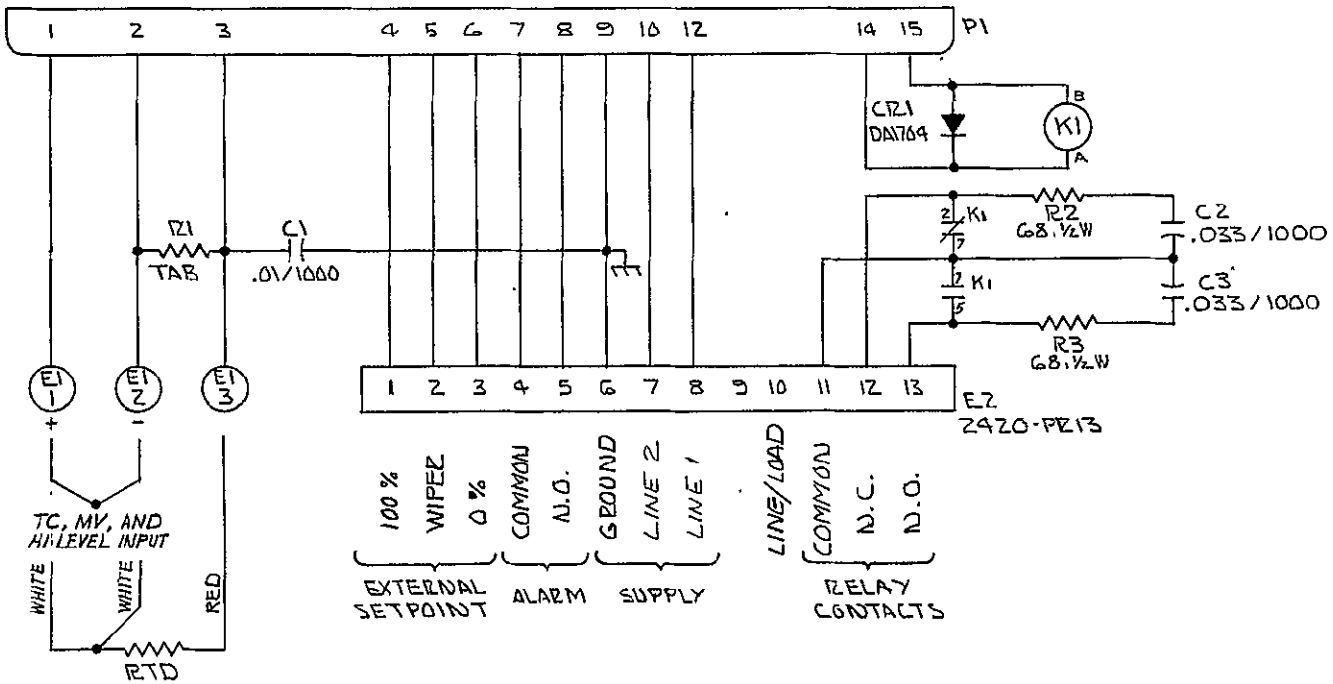
NUMBER KB41696G REV D

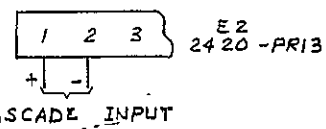
SHT 1 OF 1

CONTROLS DIVISION - RESEARCH, INCORPORATED • MINNEAPOLIS 24, MINNESOTA

MAY 05 1976

REVISIONS					
SYM	ZONE	DESCRIPTION	DRAFT	CHECK	DATE
A		REVERSED POLARITY OF CR1 C2 & C3 WERE .05/1000	AICB		8-7-72
B		L2 WAS COMMON, L1 120 VAC	AKB		10-12-72
C		LINE 2 WAS L2 (NEUTRAL); LINE 1 WAS L1 (HOT)	DJH		11-1-72
D		ADDED ±INV.	JAK		9-5-73
E	"	CLARIFY "THERMOCOUPLE INPUT	KB.		11-27-74





1. FOR TAB. RESISTOR R1 VALUES SEE ASSY C92025
   OMIT R1 WHEN USED WITH A RTD INPUT

3B1241	640 DS	C42025
3B1241	690	C92025
INVENTORY	USED ON	ASSEMBLY

DRAFTSMAN AKB 6-22-72
CHECKED
APPROVED Jamison 8-8-72
K = 10³ M = 10⁶
CONNECTION NO CONNECTION

UNLESS OTHERWISE INDICATED
- RESISTANCE IN OHMS ± 10% ½ WATT
- CAPACITANCE IN MFD ± 20%
- INDUCTANCE IN HENRIES
- USE 60/40 ROSIN CORE SOLDER
- USE NO CORROSIVE FLUX

INV. 3D1259

TITLE SCHEMATIC REAR TERMINAL BOARD TIME PROPORTIONING RELAY OUTPUT

NUMBER KB92023 REV E

SHT 1 OF 1

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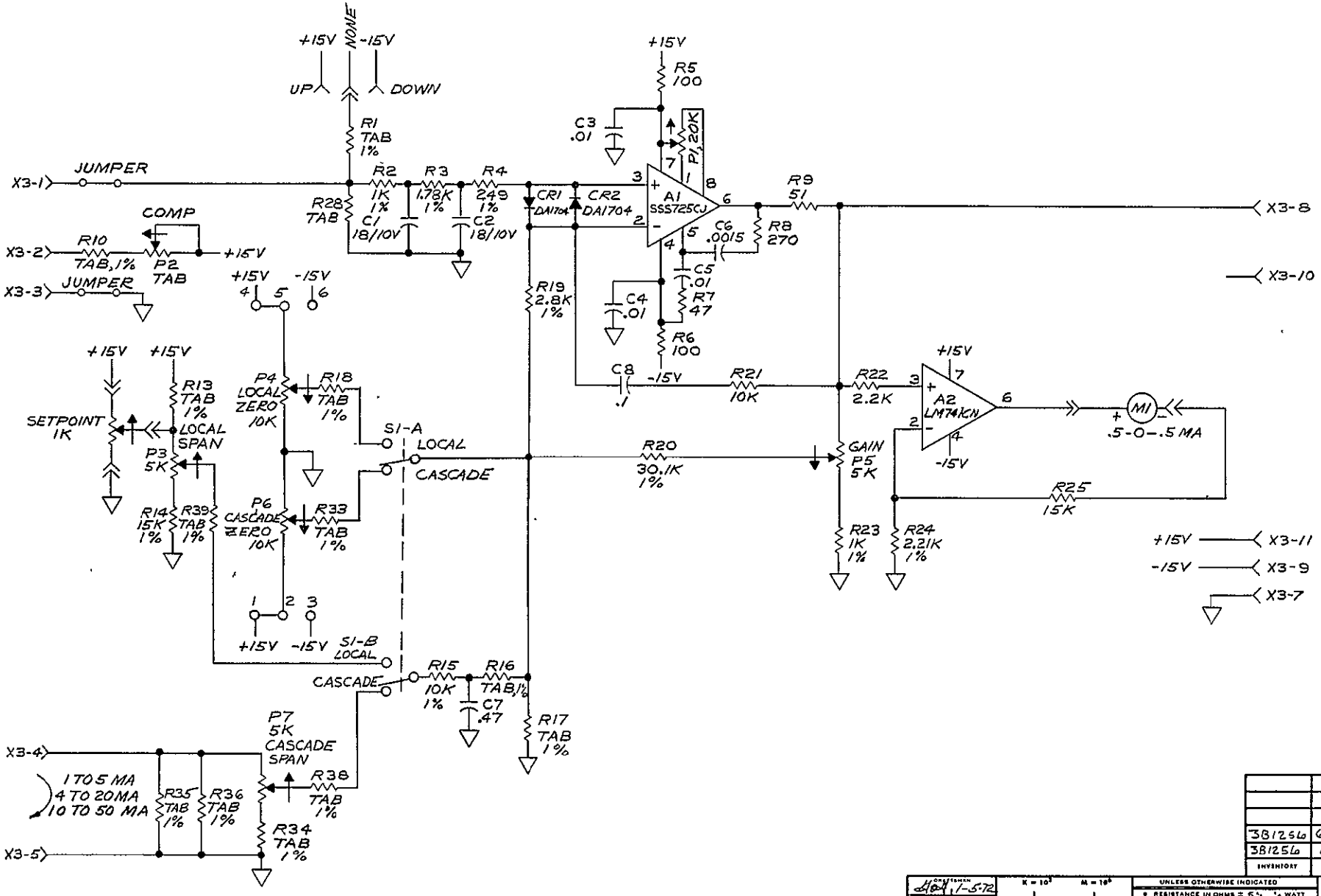
MAY 05 1976

HIGHEST REFERENCE DESIGNATIONS				
A2	C8	CR2	P7	R39

REF DESIGNATIONS NOT USED			
R11	R12	R26	R27
R28	R29	R31	R30
R32	R37		

REVISIONS			
SYM	DESCRIPTION	DRAFT	DATE
A	ADDED B43052 SELECT RESISTORS FOR DIGITAL SETTER	AKB	3-8 73
B	ADDED IMU NO 's (SHT 1,2,3)	JAK	9-3-73
C	+15V & NONE CONNECTIONS ARE NOT USED GHB	KB	2-4-75



1. FOR TAB RESISTOR VALUES SEE B42284 (SL 1310)

3812560	640DS	C42662
3812560	640	C42662
INVENTORY	USED ON	ASSEMBLY

DRAWN HBH 11-5-72
CHECKED JW 12-14-73
APPROVED WM J 2-14-73
STYLE

K = 10^3 M = 10^6
CONNECTION NO CONNECTION

UNLESS OTHERWISE INDICATED
- RESISTANCE IN OHMS ± 5% 1/4 WATT
- CAPACITANCE IN MFD ± 20%
- INDUCTANCE IN HENRIES
- USE 60/40 ROSIN CORE SOLDER
- USE NO CORROSIVE FLUX

INVENTORY 3D1257

SCHEMATIC, INPUT MODULE
T/C - MV CASCADE

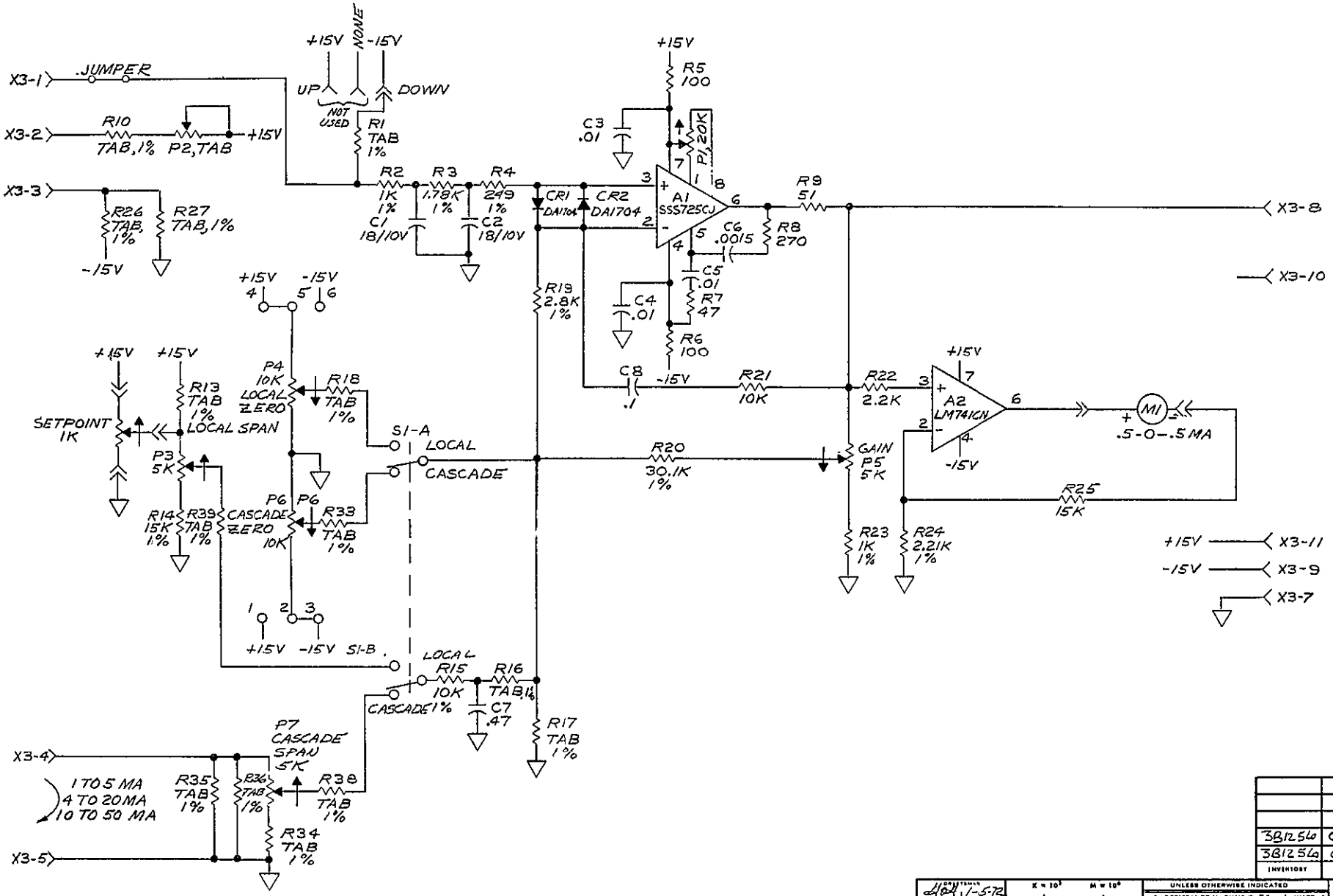
NUMBER KC42663 REV C
SHEET 1 OF 3

R·I CONTROLS
A DIVISION OF RESEARCH INCORPORATED
MINNEAPOLIS MINNESOTA 55424

HIGHEST REFERENCE DESIGNATIONS				
A2	C8	CR2	P7	R39

REF DESIGNATIONS NOT USED			
R11	R12	R28	R29
R30	R31	R32	R37

REVISIONS			
SYM	DESCRIPTION	DRAFT	DATE
	SEE SHT. 1		



3B12546	G40DS	C42662
3B12546	G40	C92662
INVENTORY	USED ON	ASSEMBLY

DRAWN HCH 1-5-72	K = 10^3	M = 10^6	UNLESS OTHERWISE INDICATED • RESISTANCE IN OHMS ± 5% ¼ WATT • CAPACITANCE IN MFD ± 20% • INDUCTANCE IN HENRIES • USE 60/40 ROSIN CORE SOLDER • USE NO CORROSIVE FLUX
CHECKED JW 12-14-73	CONNECTION	NO CONNECTION	
APPROVED 12-14-73			

INVENTORY 3D1257

TITLE SCHEMATIC, INPUT MODULE RTD - CASCADE

NUMBER C42663 REV. C

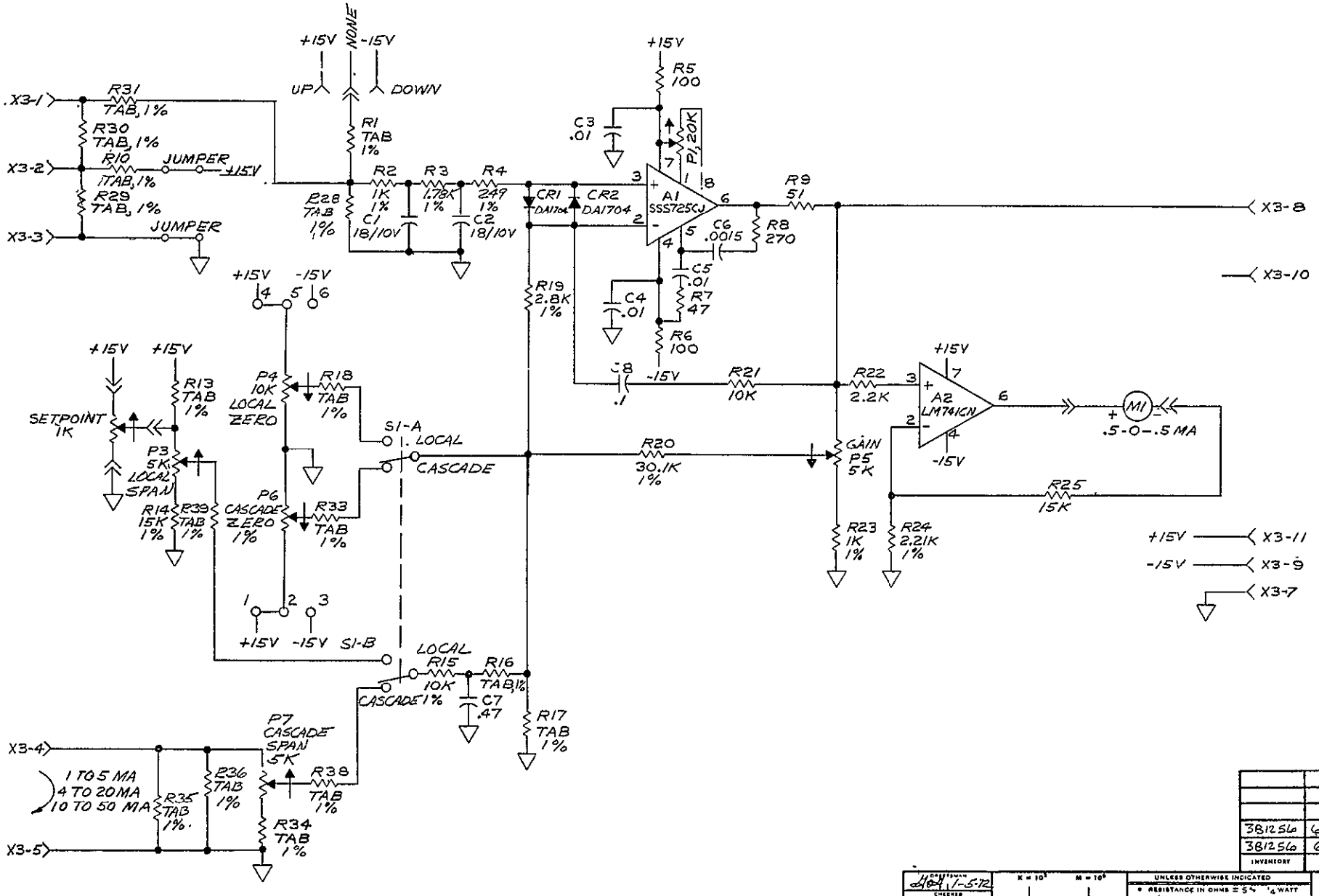
SHEET 2 OF 3

R·I CONTROLS — A DIVISION OF RESEARCH INCORPORATED MINNEAPOLIS MINNESOTA 55424

HIGHEST REFERENCE DESIGNATIONS				
A2	C8	C22	P7	R39

REF DESIGNATIONS NOT USED.			
R11	R12	R26	P2
R27	R28	R32	R37

REVISIONS			
SYM	DESCRIPTION	DRAFT	DATE
	SEE SHT 1		



3B1256	640DS	C42662
3B1256	640	C42662
INVENTORY	USED ON	ASSEMBLY

DRAWN A.B.H. 1-5-72
CHECKED J.W. 12-14-73
APPROVED M.M. 2-14-73

K = 10^3 M = 10^6

UNLESS OTHERWISE INDICATED
- RESISTANCE IN OHMS ± 5% 1/4 WATT
- CAPACITANCE IN MFD ± 20%
- INDUCTANCE IN HENRIES
- USE 60/40 ROSIN CORE SOLDER
- USE NO CORROSIVE FLUX

INVENTORY 3D1257

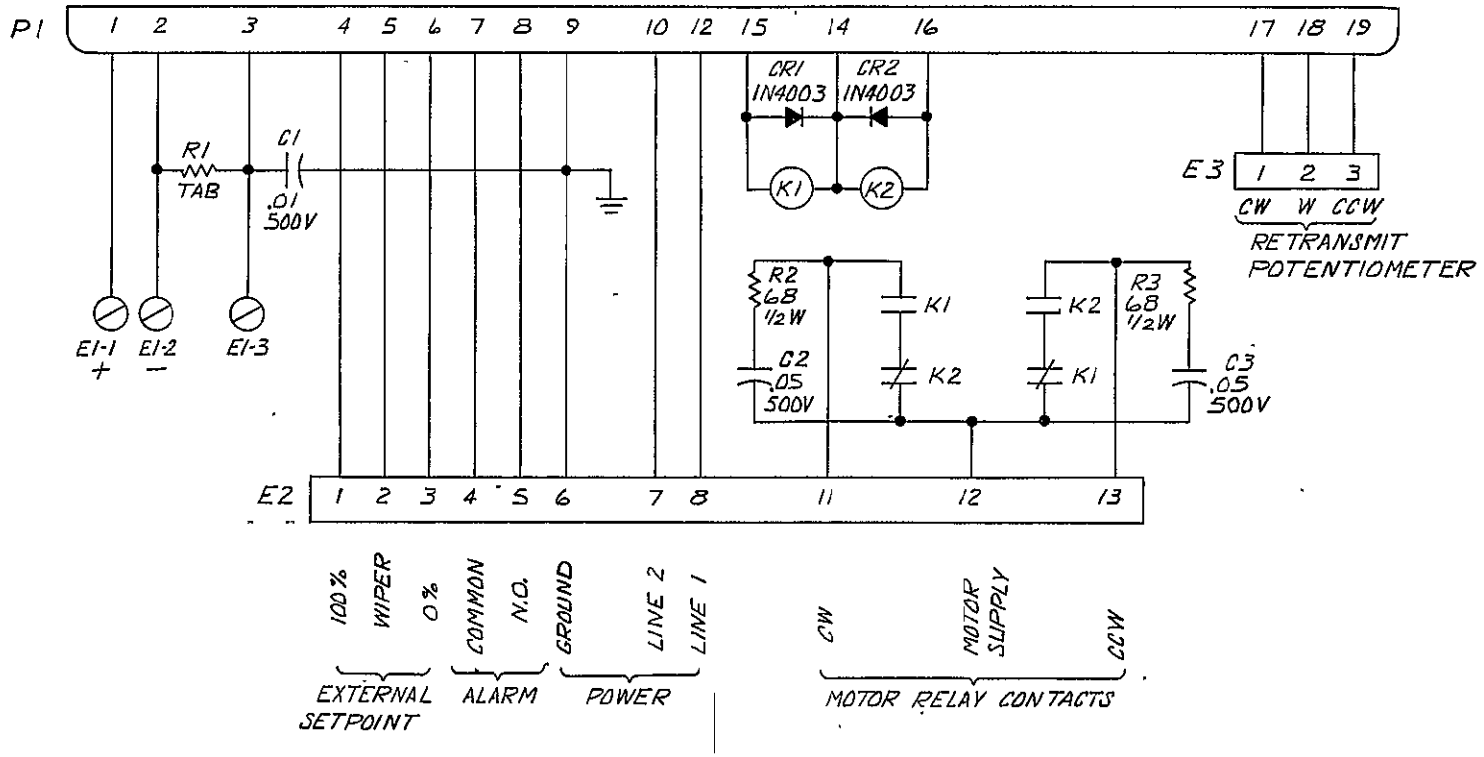
SCHEMATIC, INPUT MODULE
CURRENT VOLTAGE - CASCADE

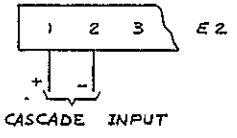
NUMBER K C42663 REV C

SHEET 3 OF 3

R·I CONTROLS
A DIVISION OF RESEARCH INCORPORATED
MINNEAPOLIS MINNESOTA 55426

REVISIONS					
SYM.	ZONE	DESCRIPTION	DRAFT	CHECK.	DATE
A		ADD (+,-) ON TERM E1-1 E1-2	DS		8-9-74
B		ADD INV NO	KB		10 31-74





3B1493	640DS	C46001
3B1493 INV. NO.	640 USED ON	C46004 ASSEMBLY

DS 7-16-74 DRAFTING
CHECKED
APPROVED

K = 10^3 M = 10^6
CONNECTION NO CONNECTION

UNLESS OTHERWISE INDICATED
- RESISTANCE IN OHMS ± 10% 1/8 WATT
- CAPACITANCE IN MFD ± 20%
- INDUCTANCE IN HENRIES
- USE 60/40 ROSIN CORE SOLDER
- USE NO CORROSIVE FLUX

MODEL 3D1494

TITLE: SCHEMATIC REAR TERMINAL BOARD (PAT)

NUMBER: KC46002 REV: B

INT OF

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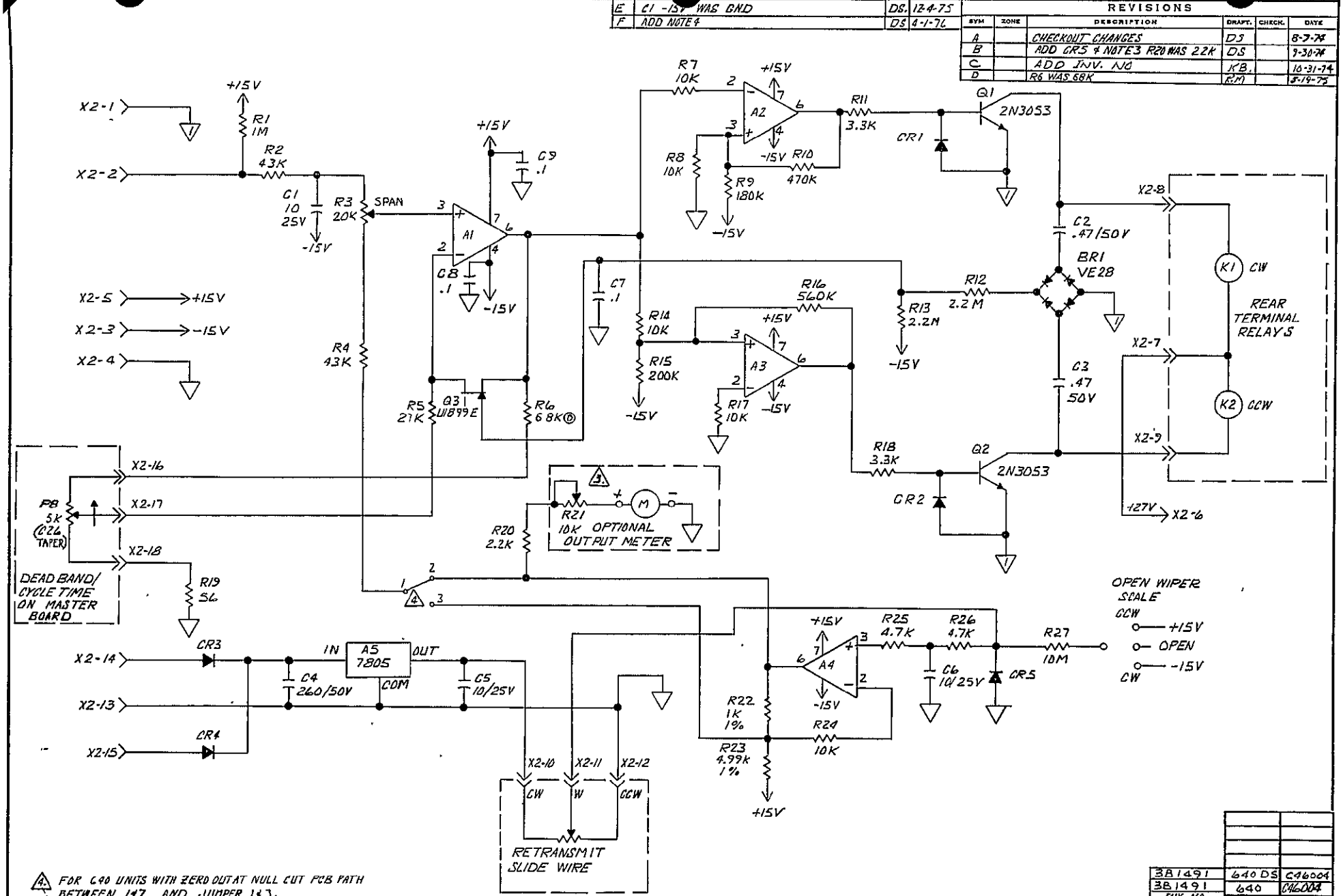
MAY 05 2016

E	C1 -15V WAS GND	DS.	12-4-75
F	ADD NOTE 4	DS	4-1-76

REVISIONS

SYM	ZONE	DESCRIPTION	DRAFT.	CHECK.	DATE
A		CHECKOUT CHANGES	DJ		8-7-74
B		ADD CR5 & NOTE 3 R20 WAS 22K	DS		9-30-74
C		ADD INV. NO	KB.		10-31-74
D		R6 WAS 68K	RM		5-19-75



4. FOR C40 UNITS WITH ZERO OUTAT NULL CUT PCB PATH BETWEEN 1#2 AND JUMPER 1#3.

3. OUTPUT METER OPTION A43869 (3D1285).

2. ALL ICS ARE 7410N UNLESS OTHERWISE SPECIFIED

1. ALL DIODES ARE IN4003 UNLESS OTHERWISE SPECIFIED

3B1491	640 DS	C46004	
3B1491	640	046004	
INV NO	USED ON	ASSEMBLY	

DS 7-18-74 DRAFTSMAN / CHECKED / APPROVED

K = 10^3 M = 10^6 CONNECTION NO CONNECTION

UNLESS OTHERWISE INDICATED
- RESISTANCE IN OHMS ± 5% ¼ WATT
- CAPACITANCE IN MFD ± 20%
- INDUCTANCE IN HENRIES
- USE 60/40 ROSIN CORE SOLDER
- USE NO CORROSIVE FLUX

MODEL 3D1492

TITLE: SCHEMATIC - POSITION PROPORTIONING OUTPUT CARD (PAT)

NUMBER KC46005 REV. F

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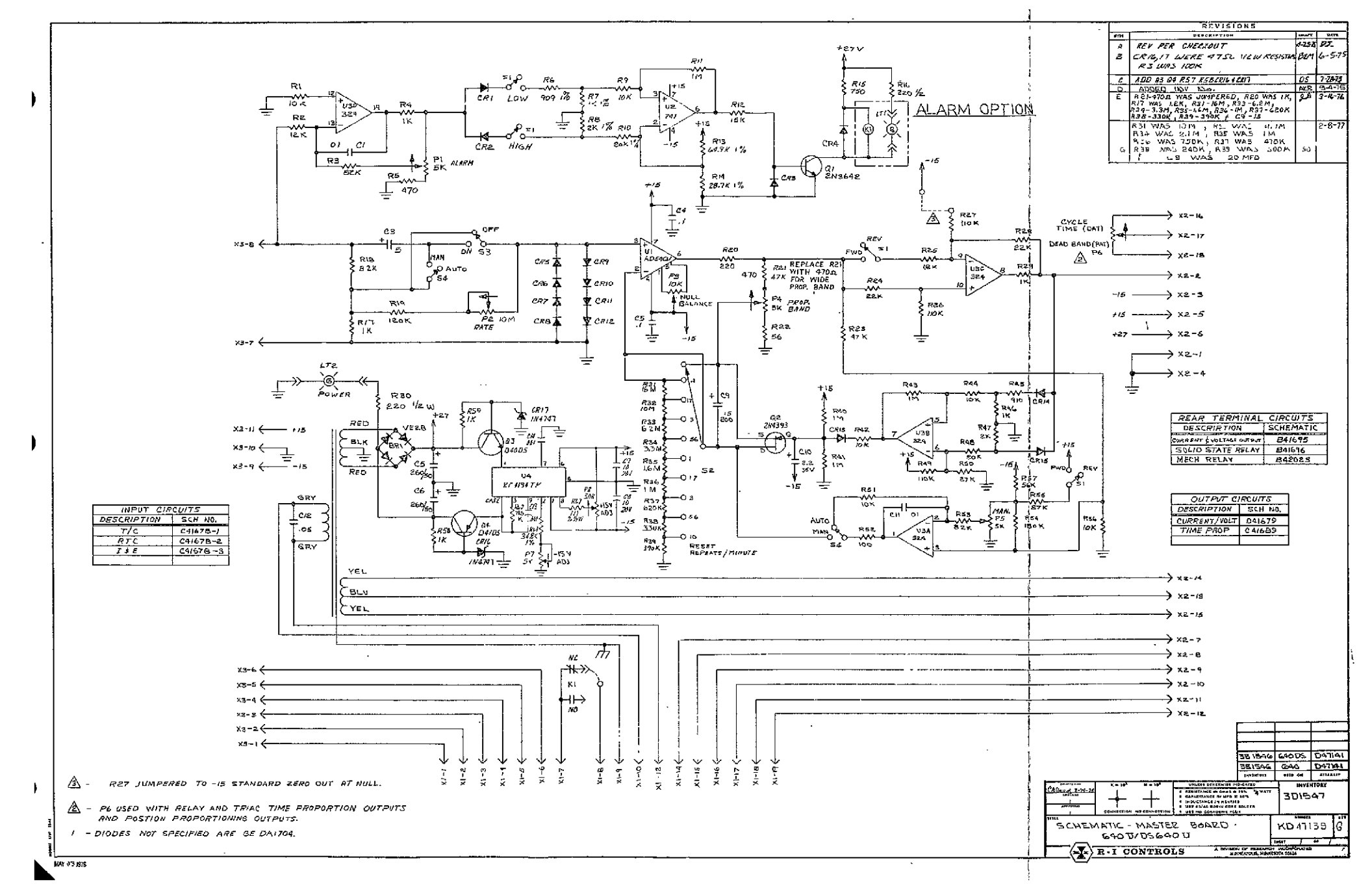
MAY 0 5 1976



REVISIONS			
SYM	DESCRIPTION	APPR	DATE
A	REV PER CHECKOUT	4-25A	3-3-
B	CR16,17 WERE 47Ω 1/2W RESISTOR R3 WAS 100K	DBM	6-5-75
C	ADD B3 D4 R57 RESERVED & CR17	DS	7-28-75
D	ADDED 10V Ref.	MR	9-4-75
E	R21-470Ω WAS JUMPERED, R20 WAS 1K, R17 WAS 1.6K, R31-16M, R33-6.2M, R34-3.3M, R35-1.6M, R36-1M, R37-620K R38-330K, R39-390K & C9-15	DB	3-14-76
G	R31 WAS 10M, R32 WAS 6.2M R34 WAS 2.2M, R35 WAS 1M R36 WAS 750K, R37 WAS 430K R38 WAS 240K, R39 WAS 300K C9 WAS 20 MFD	DB	2-8-77

REAR TERMINAL CIRCUITS	
DESCRIPTION	SCHEMATIC
CURRENT & VOLTAGE OUTPUT	B41695
SOLID STATE RELAY	B41696
MECH RELAY	B42025

OUTPUT CIRCUITS	
DESCRIPTION	SCH NO.
CURRENT/VOLT	D41679
TIME PROP	C41689

INPUT CIRCUITS	
DESCRIPTION	SCH NO.
T/C	C41678-1
RTC	C41678-2
I & E	C41678-3

⚠3 - R27 JUMPERED TO -15 STANDARD ZERO OUT AT NULL.

⚠2 - P6 USED WITH RELAY AND TRIAC TIME PROPORTION OUTPUTS AND POSTION PROPORTIONING OUTPUTS.

1 - DIODES NOT SPECIFIED ARE GE DA1704.

MAY 73 1976

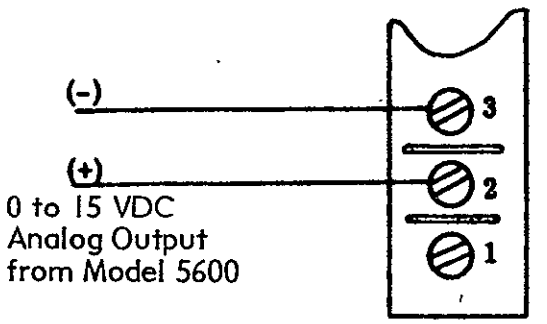
ADDENDUM
For
Model 640U/Model 5600
Interconnection

General Information

This addendum modifies the 640U Instruction Manual to incorporate the use of a 0-15 VDC signal from a program source and as the Model 5600 DATA-TRAK, as the remoted setpoint, in lieu of the usual 1000 Ω potentiometer setpoint device described in the manual paragraph.

Installation

The Analog output signal from the Model 5600 is connected to the Remote Setpoint terminals of the Model 640U as shown in the following figure.



Model 640U
Barrier Strip E_2

Operation

To initiate program control position the LOCAL/REMOTE switch on the Model 640U to the REMOTE position and provide the setpoint source by adjusting the 0-15 V input signal to the desired setpoint value. Where the controller input span zero point is the equivalent of 0 volts and 100% span point is 15 volts, intermediate set value as related to percent of span are to be determined by the look up tables provided with the control for the remote voltage set.

NOTE

These are different than the look up tables provided for Digital local setpoint or 1000 Ω remote potentiometer setpoint in that the latter include characterization for potentiometer loading error which drop out when voltage setpointing is used.

Examples:

1. For remote voltage setpointing.

2. For potentiometer setpointing.

The 0-15 volt remoted inputs are typical zero/span values that agree with the local setpoint zero and span values. In reality they are slightly different and the actual zero trim and span trim of the 0-15 volt outputs should be adjusted on the Model 5600 to make the remote setpoint coincident with the local setpoint to prevent upset on the deviation

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"T" T.C. -88 TO 191 DEG C

FOR: 624, 625, 630 LOCAL OR REMOTE SET POINT BY POTENTIOMETER
USE AS: DIRECT DIAL SET OR % OF SET SPAN VS TEMPERATURE

FOR: 639, 640 AS REMOTE CASCADE SET BY VOLTAGE OR CURRENT
USE AS: % OF SET SPAN VS TEMPERATURE

DEG C...	0	1	2	3	4	5	6	7	8	9
-80:	20.4	17.8	15.2	12.7	10.1	7.6	5.0	2.5	0.	
-70:	46.8	44.1	41.4	38.8	36.1	33.5	30.8	28.2	25.6	23.0
-60:	74.1	71.3	68.6	65.8	63.1	60.3	57.6	54.9	52.2	49.5
-50:	102.4	99.5	96.7	93.8	91.0	88.1	85.3	82.5	79.7	76.9
-40:	131.5	128.6	125.6	122.7	119.8	116.9	113.9	111.0	108.1	105.3
-30:	161.5	158.5	155.4	152.4	149.4	146.4	143.4	140.4	137.5	134.5
-20:	192.2	189.1	186.0	182.9	179.8	176.8	173.7	170.6	167.6	164.5
-10:	223.6	220.4	217.3	214.1	211.0	207.8	204.7	201.6	198.4	195.3
-0:	256.0	252.3	249.1	245.9	242.7	239.5	236.3	233.1	229.9	226.7
0:	256.0	259.0	262.2	265.5	268.8	272.1	275.4	278.8	282.1	285.4
10:	288.8	292.1	295.5	298.8	302.2	305.6	309.0	312.4	315.8	319.2
20:	322.6	326.0	329.4	332.8	336.3	339.7	343.2	346.7	350.1	353.6
30:	357.1	360.6	364.1	367.6	371.1	374.6	378.1	381.7	385.2	388.7
40:	392.3	395.8	399.4	403.0	406.6	410.2	413.7	417.3	420.9	424.6
50:	428.2	431.8	435.4	439.1	442.7	446.4	450.0	453.7	457.4	461.1
60:	464.7	468.4	472.1	475.8	479.6	483.3	487.0	490.7	494.5	498.2
70:	502.0	505.7	509.5	513.3	517.0	520.8	524.6	528.4	532.2	536.0
80:	539.8	543.7	547.5	551.3	555.2	559.0	562.9	566.7	570.6	574.5
90:	578.3	582.2	586.1	590.0	593.9	597.8	601.8	605.7	609.6	613.5
100:	617.5	621.4	625.4	629.3	633.3	637.3	641.2	645.2	649.2	653.2
110:	657.2	661.2	665.2	669.3	673.3	677.3	681.3	685.4	689.4	693.5
120:	697.6	701.6	705.7	709.8	713.8	717.9	722.0	726.1	730.2	734.4
130:	738.5	742.6	746.7	750.9	755.0	759.1	763.3	767.5	771.6	775.8
140:	780.0	784.1	788.3	792.5	796.7	800.9	805.1	809.3	813.6	817.8
150:	822.0	826.2	830.5	834.7	839.0	843.2	847.5	851.8	856.0	860.3
160:	864.6	868.9	873.2	877.5	881.8	886.1	890.4	894.7	899.1	903.4
170:	907.7	912.1	916.4	920.8	925.1	929.5	933.9	938.2	942.6	947.0
180:	951.4	955.8	960.2	964.6	969.0	973.4	977.8	982.3	986.7	991.1
190:	995.6	1000.								

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"T" T.C. -88 TO 191 DEG C

FOR: 639, 640 LOCAL OR REMOTE SET POINT BY POTENTIOMETER
USE AS: DIRECT DIAL SET OR % OF SET SPAN VS TEMPERATURE

DEG C...	0	1	2	3	4	5	6	7	8	9
-80:	19.4	16.9	14.5	12.0	9.6	7.2	4.8	2.4	0.0	
-70:	44.6	42.1	39.5	36.9	34.4	31.9	29.4	26.8	24.4	21.9
-60:	71.0	68.3	65.6	63.0	60.3	57.7	55.1	52.4	49.8	47.2
-50:	98.5	95.7	92.9	90.1	87.4	84.6	81.9	79.1	76.4	73.7
-40:	127.0	124.1	121.2	118.3	115.5	112.6	109.8	106.9	104.1	101.3
-30:	156.5	153.5	150.5	147.6	144.6	141.6	138.7	135.8	132.8	129.9
-20:	187.0	183.9	180.8	177.8	174.7	171.7	168.6	165.6	162.6	159.5
-10:	218.3	215.2	212.0	208.9	205.7	202.6	199.4	196.3	193.2	190.1
-0:	250.9	247.1	243.9	240.7	237.5	234.3	231.1	227.9	224.7	221.5
0:	250.9	253.9	257.2	260.5	263.8	267.2	270.5	273.9	277.2	280.6
10:	284.0	287.4	290.8	294.2	297.6	301.0	304.5	307.9	311.4	314.8
20:	318.3	321.8	325.3	328.7	332.3	335.8	339.3	342.8	346.4	349.9
30:	353.5	357.0	360.6	364.2	367.8	371.3	374.9	378.6	382.2	385.8
40:	389.4	393.1	396.7	400.4	404.1	407.7	411.4	415.1	418.8	422.5
50:	426.2	430.0	433.7	437.4	441.2	444.9	448.7	452.4	456.2	460.0
60:	463.8	467.6	471.4	475.2	479.0	482.8	486.6	490.5	494.3	498.2
70:	502.0	505.9	509.8	513.6	517.5	521.4	525.3	529.2	533.1	537.0
80:	540.9	544.9	548.8	552.7	556.7	560.6	564.6	568.5	572.5	576.5
90:	580.5	584.5	588.4	592.4	596.4	600.4	604.5	608.5	612.5	616.5
100:	620.6	624.6	628.6	632.7	636.7	640.8	644.8	648.9	653.0	657.0
110:	661.1	665.2	669.3	673.4	677.5	681.6	685.7	689.8	693.9	698.0
120:	702.1	706.3	710.4	714.5	718.7	722.8	726.9	731.1	735.2	739.4
130:	743.5	747.7	751.8	756.0	760.2	764.3	768.5	772.7	776.8	781.0
140:	785.2	789.4	793.6	797.8	802.0	806.1	810.3	814.5	818.7	822.9
150:	827.1	831.3	835.5	839.7	843.9	848.2	852.4	856.6	860.8	865.0
160:	869.2	873.4	877.6	881.9	886.1	890.3	894.5	898.7	903.0	907.2
170:	911.4	915.6	919.8	924.1	928.3	932.5	936.7	940.9	945.2	949.4
180:	953.6	957.8	962.1	966.3	970.5	974.7	978.9	983.1	987.4	991.6
190:	995.8	1000.								

INSTRUCTION MANUAL

Model 64600

Phaser Power Controller

NOTE

This manual also contains correct information for Model 646 (old model number). Disregard new model number (above) if your unit has old model number designations.

October 1978

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IM6460000

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SECTION 5 - MAINTENANCE

SECTION 6 - TROUBLESHOOTING

SECTION 7 - CIRCUIT DIAGRAMS AND RECOMMENDED SPARE PARTS LIST

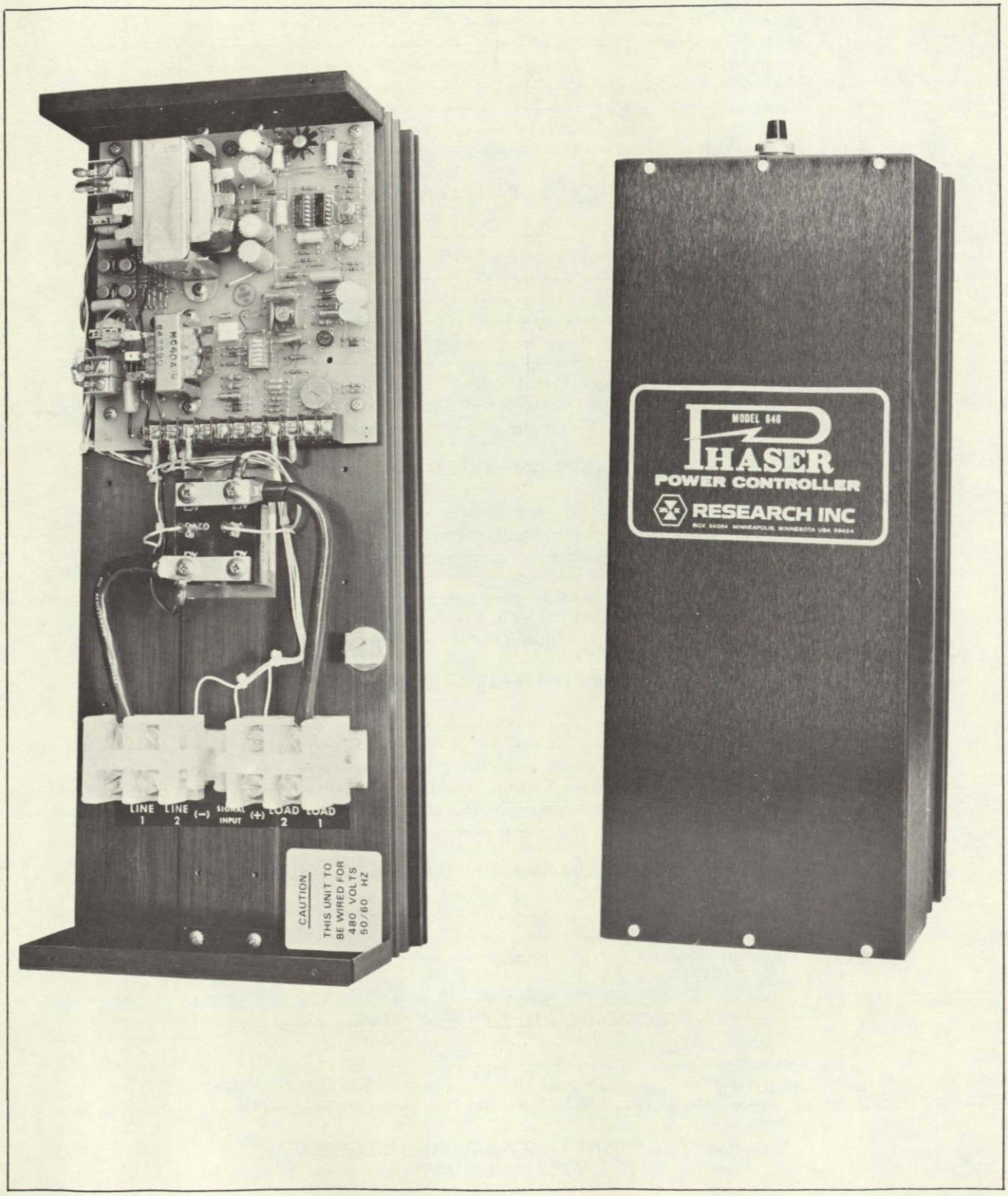


Figure 1-1 64600 Phaser Power Controller

Section I

INTRODUCTION

1-1 Scope

This manual provides installation, operation and maintenance instructions for the Model 64600 Phaser Single Power Controller and its options. A general knowledge of electronics is required for installation and set up.

1-2 General Description

The Model 64600 Phaser is a single phase power controller using SCRs (silicon controlled rectifiers) in a grounded heatsink design for safety and ease of installation. It is controlled by either a voltage or current input or an optional manual-adjust potentiometer. For units equipped with phase-angle firing circuits, the R.M.S. output voltage is linearly proportional to the input signal; distributed zero-crossover models provide an average voltage output (Vavg) which is linearly proportional to input. Both the phase angle firing and the distributed zero-crossover firing boards will accept either voltage or current input control signals; the phase angle board features output signal conditioning enabling the 64600 to power resistive, transformer-coupled, or incandescent lamp loads. Options include CLA (adjustable current limiting) for phase angle firing only, a Dv/Dt network for operation with transformer-coupled loads, and a subcycle fuse for load protection against short circuits.

1-3 Specifications

Input Control Signal:	Switch selectable adaptation to any of the following: 0 to 5 volts DC across 5200 ohms 1 to 5 ma into 1200 ohms 4 to 20 ma into 320 ohms 10 to 50 ma into 120 ohms
Power Line Voltages:	240 volt models: 120, 208, or 240 volts customer selectable by taps on transformer. 480 volt models: 120, 280, 240 or 480 volts customer selectable. (The Model 64600 will operate with line voltages within ±10% of nominal.) All units supplied adjusted for 50 Hz or 60 Hz operation as required.
Output Current:	0 to 50 amps for 50 amp units; 0 to 100 amps for 100 amp units.
Output Voltage:	Phase angle units: RMS output voltage is linearly proportional to control signal. Distributed zero-crossover units: Average voltage output is linearly proportional to control signal.
Load Characteristics:	The Phase Angle Firing Circuit is capable of driving resistive, transformer-coupled or incandescent lamp loads. The Distributed Zero Crossover Firing Circuit can drive resistive loads and, in specific applications, incandescent loads. Neither circuit is intended to power solenoid-type loads.
Line/Load Regulation:	±0.5% for ±10% change in line voltage
Ambient Temperature:	No derating necessary between 0° and 50°C (32° to 122°F)
Cooling Method:	Convection cooled by vertical heatsink
Size:	18" H x 7" W x 6" D (45.7 cm. H x 17.8 cm. W x 15.2 cm. D)
Weight:	15 pounds, 3 ounces (6.89 kg.)

1-4 Functional Description

A complete 64600 Phaser consists of a mainframe containing SCRs and an integral heatsink, plus a gate circuit (firing circuit) of either the phase angle or noise-eliminating distributed zero-cross-over type, plus options as desired.

1-4-1 Mainframe

The mainframe contains input and output terminals, power control elements, wiring, heatsink and space for mounting firing circuit board and options. It must be mounted vertically for proper cooling; see installation section.

1-4-2 Gate Circuit (Firing Circuit)

Either type of gate circuit provides the Phaser with ability to deliver an output voltage which is linearly proportional within 0.5% to the input control signal. The phase angle firing circuit causes the power control elements to deliver phase-angle controlled voltages to the load; the distributed-zero crossover board causes the power control to turn on only at zero-crossing points on the line voltage; this eliminates switching noise by gating full cycles of power to the load, spaced apart appropriately so as to give a linear relationship between control signal and output average voltage. Both gate circuits can be adjusted to accept either current or voltage inputs; in the voltage input mode a potentiometer may be used for manual output control.

1-4-3 Options Description

The options include:

1. MANUAL POTENTIOMETER (customer supplied): Manual output control is provided by a 5 K potentiometer on the input to the firing circuit. The potentiometer is connected to terminals 5 (ccw), 6 (wiper) and 7 (cw) on the firing circuit. Refer to Schematic KC47715, Model 64600 Wiring Diagram in Section 7.

2. CLA (Current Limit Adjust): By means of an added current sensing transformer around the load lead, plus a toroidal transformer added to the firing circuit, maximum limit of current through the load can be set by a potentiometer.

   NOTE

   CLA is available only for phase-angle-firing units.

3. Dv/Dt Network: When operating the 64600 into transformer coupled loads, a resistor-capacitor network must be placed across the power control elements to ensure proper operation.

4. Sub-cycle Fuse: For load protection against short circuits, the sub-cycle fuse provides fast clearing, typically 2 milliseconds with a x10 overcurrent. For long time-period overloads, such as a 60 amp overcurrent on a 50 amp unit, use the CLA option.

Section 2

INSTALLATION

2-1 Preliminary

The entire contents of this manual should be read before installation of the unit to ensure proper operation.

2-2 Environmental Considerations

The ambient temperature of the controller must not exceed 122°F (50°C) or damage to the unit may result. Avoid installation close to sources of heat.

2-3 Mounting the 64600

Since the Model 64600 has a grounded heatsink, insulated from the power line, it may be attached to any type of surface including metal beams, posts, etc. It must be mounted vertically for proper cooling, with a minimum of 3 inches of free air space above and below the unit.

The unit is mounted by passing suitable bolts through the support surface and tightening them into 1/4-20 nuts slid into slots located in the heatsink for this purpose. For mounting on a concrete wall or similar surface, attach angle brackets to the wall with appropriate fasteners and attach the unit to the brackets with bolts and nuts as above. The unit with cover, weighs approximately 15 pounds (6.8 kg).

2-4 Electrical Connections

2-4-1 Preliminary Instructions

Refer to Figure 2 Model 64600 Firing Circuit and Schematic KC47715 contained in Section 7.

2-4-2 Load Connections

Connect the load to terminals marked LOAD 1 and LOAD 2 on the phenolic terminal block near the top of the unit.

NOTE

Units equipped with the distributed zero crossover firing circuit can only be used with RESISTIVE LOADS.

2-4-3 Control Signal Connections

Connect the control signal input to the terminals marked INPUT SIGNAL on the phenolic terminal block.

NOTE

The control signal leads should be twisted pair wires, run them in a conduit separate from the high voltage power wiring.

2-4-4 Control Signal Settings - Phase Angle Firing Circuit

To set up the 64600 for the type of control signal to be used, locate the small block of 6 switches on the firing circuit board. Refer to Figure 1 FIRING CIRCUIT BOARD. The ON setting of a switch activates the desired function.

Input Signal Conditioning

Set only one of the switches shown in Table 2-4 for the required input signal range.

NOTE

The remaining 3 switches must be set to the OFF position.

Load Signal Conditioning

The switches marked "R" (Ramp) and "L" (Lamp) determine the type of load signal conditioning.

1. For RESISTIVE LOADS: Set both R and L to the OFF position. This places the unit in the FAST mode.

NOTE

DO NOT use this mode if the CLA option is installed as damage to the unit will result.

2. For TRANSFORMER-COUPLED LOADS: Set switch R to the ON position and switch L to the OFF position. This initiates a 300 ms ramp action.

3. For INCANDESCENT LOADS: Set switch R to the OFF position and switch L to the ON position. This initiates a 4 second ramp action.

Table 2-4 Input Signal Conditioning

LABEL	FUNCTION
10-50	10 to 50 ma into 120 ohm impedance
4-20	4 to 20 ma into 320 ohm impedance
1-5	-1 to 5 ma into 1220 ohm impedance
0-5	0 to 5 volts into 5200 ohm impedance

2-4-5 Control Signal Settings - Distributed Zero Crossover Circuit

Two types of Input Signal Conditioning selection devices may be encountered: One type has a block of pins and a jumper wire and the other type has a block of 4 miniature switches.

Input Signal Conditioning

To set up the 64600 for the required input signal range, locate the selection device near the C+ terminal on the firing circuit board. Refer to Table 2-4 for further information.

1. Jumper selection: Place the jumper wire on the pin corresponding to the required input range.

OR

2. Switch selection: Set the required switch ON for the required input range.

NOTE

The remaining switches must be OFF.

Remote Trip (Optional user installation)

If a remote trip relay or switch is to be used, remove jumper from remote trip terminals on firing circuit and install connection to remote relay terminals or switch contacts.

2-4-6 Power Line Connections

1. Connect the terminal marked GND to a good electrical ground.

2. Verify that the taps of transfers T1 and T2 are correctly set to match the power line voltage.

CAUTION

Do not select an operating voltage higher than the maximum voltage rating given on the 64600 nameplate.

3. Verify that any options used in this unit have been installed correctly before continuing.

4. Connect the low/neutral side of the power line to terminal marked LINE 1 and the high side of the power line to the terminal marked LINE 2.

Section 3

OPERATION AND OPERATING ADJUSTMENTS

3-1 General

Once installed and interconnected in accordance with the instructions in Section 2, the 64600 may be energized and placed in operation. The information under the following headings describes the three most commonly used methods of operating the unit: (1) Manual Control Mode; (2) Control Signal Mode; and (3) Manual and Control Signal Mode.

NOTE

Prior to energizing the 64600, the operating mode of the firing circuit must be selected to correspond to the load (see Section 2-4-4).

3-2 Modes of Operation

3-2-1 Manual Mode

In this mode, the setting of the control potentiometer controls the output. Properly installed, the full counterclockwise setting of the wiper provides minimum output and the full clockwise provides the maximum output.

1. Any input leads to terminals C- and C+ must be disconnected.
2. Input Signal Conditioning Settings
   (A) Phase Angle Firing Circuit: The 10-50, 4-20 and 1-5 switches must be OFF and the 0-5 switch set to ON.
   (B) Distributed Zero Crossover Firing Circuit: Place the jumper wire on pin labeled 0-5 V.

3-2-2 Control Signal Mode

With the Manual potentiometer at zero (full ccw), the ouput of the 64600 is proportional to the control signal applied to the C- and C+ terminals of the firing circuit.

3-2-3 Manual Control Signal Mode

In this mode the output is derived from the control signal applied to the C- and C+ terminals with the Manual potentiometer setting establishing the point at which the control signal takes effect.

3-3 Adjusting the SPAN Control

The SPAN control affects the maximum output value of the 64600. To adjust the SPAN control:

1. Connect the load and energize the 64600.
2. Set control signal input (or optional Manual potentiometer) for full output to the load.
3. Adjust the SPAN control counterclockwise until the load voltage begins to drop, then turn clockwise until maximum load voltage is obtained.

3-4 CLA (Current Limiting) Adjustment

The Current Limiter Adjust Control is adjusted as follows:

1. Ensure that the signal conditioning switch is set for either Ramp (R) or Lamp (L) mode.
2. Set the % CURRENT adjust fully counterclockwise.
3. Monitoring the output of the 64600 with a true RMS reading ammeter, set the Manual potentiometer fully clockwise or set the control signal input to provide full output.
4. Rotate the % CURRENT clockwise to the maximum level desired.

The circuitry will now limit load current to the value indicated on the ammeter. Current limit levels greater than 50 or 100 amps can be set up to a maximum of 120%. For 50 amp units, current limiting can be set from nearly 0 to 60 amps (0-120%). For 100 amp units, current limiting can be set from nearly 0 to 120 amps (0-120%).

Section 4

OPERATING PRINCIPLES

4-1 General

The basic function of the power controller is to electronically switch the AC line to a load for discrete intervals within each cycle of the line voltage.

The switching function is synchronized to the line frequency in a manner which establishes the R.M.S. value of the AC voltage appearing across a load as a proportional function of the magnitude of a DC control signal. An increasing DC control signal proportionally increases the R.M.S. load voltage from zero to its maximum value, by causing the line to be switched to the load at progressively earlier instants in time within each successive voltage cycle.

4-1-1 SCR Characteristics

An SCR (Silicon Controlled Rectifier) is a solid state device consisting of three elements: a cathode, an anode, and a gate. To enable an SCR to switch from a non-conducting to a conducting state, two conditions must be satisfied: (a) the anode on the SCR must be at a positive potential with respect to the cathode, and (b) the gate must be at a positive potential with respect to the cathode.

With the SCR connected to an AC line in series with a load, condition (a) will be satisfied during one-half of each cycle of the AC line voltage; condition (b) will be satisfied only if at some point during the proper half-cycle, the potential at the gate of the SCR is driven positive to enable the SCR to conduct during this period of proper line-voltage polarization. Once fired, the SCR will continue to conduct (regardless of the gate potential) until the anode-to-cathode potential drops below the level necessary to maintain conduction (when the half-cycle nears completion).

4-1-2 Power Controller Operating Principles

The power controller utilizes two SCRs connected in inverse parallel to enable full wave AC voltage to be applied to a load. The inverse-parallel connection enables the SCRs to alternately conduct during oppositely polarized halves of the AC voltage cycle; that is, while conduction of the other SCR is enabled, and will occur if its gate is energized during this period.

4-2 Operation of Phase Angle Firing Circuit

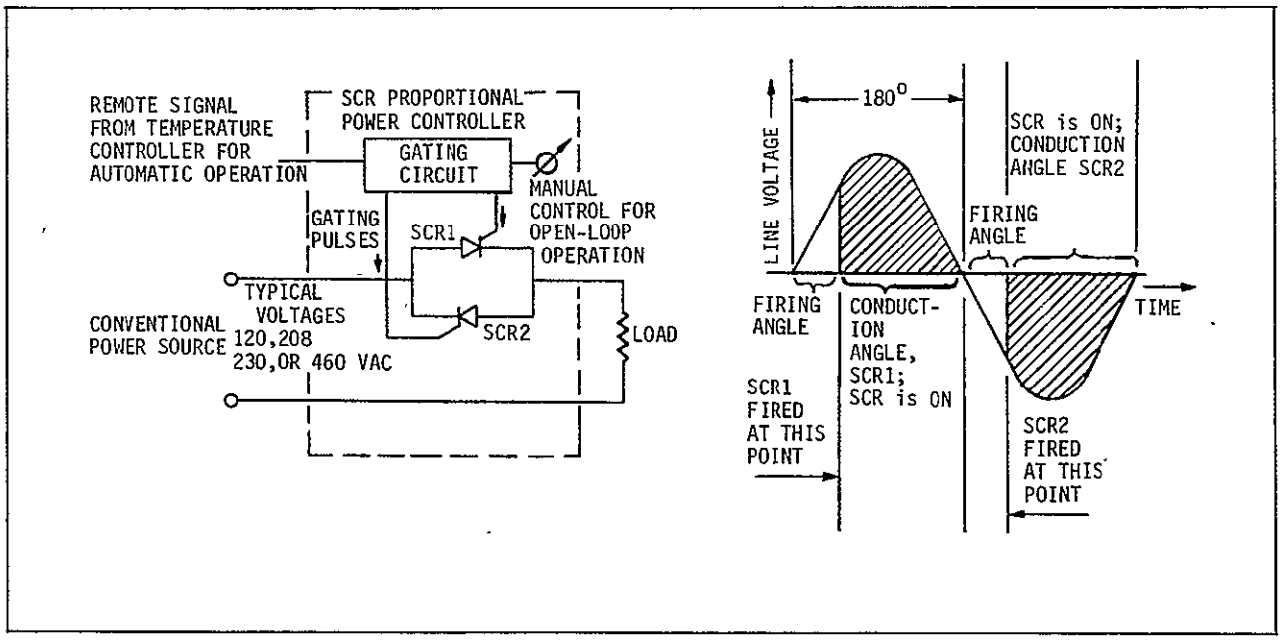


Figure 4-2 Block Diagram and Firing Angle Illustration

The method in which the firing circuit generates the necessary waveforms to gate the SCR is described in the following text. It is recommended that the Solid State Firing Circuit schematic (found in Section 7) be used for reference while following the discussion.

Switch S1A, B, C, and D select the desired input signal. If S1A is closed the input impedance is 5.2 K ohm and the firing circuit responds to a 0-5 VDC signal. Resistor R4 supplies a 5% zero suppression to assure shut off with zero control signal. If only S1B is closed, the input impedance drops to 1,200 ohms and the firing circuit responds to a 1-5 milliampere control signal. If only S1C is closed, the input impedance drops to 320 ohms and the firing circuit responds to a control signal of 4-20 milliamperes. If only S1D is closed the input impedance is only 120 ohms and the firing circuit responds to a control signal of 10-50 milliamperes. Resistor R3 provides the necessary 20% zero suppression for all the current input ranges.

Capacitors C1, C2 and C3 in conjunction with Amplifier #1 provide signal conditioning capabilities. C3 is always in the circuit limiting the amplifier step response to approximately 30 milliseconds. Depressing S1F includes C2 in the feedback loop, limiting the Amp. #1 step response to approximately 300 milliseconds. With this response time, sufficient delay is present to prevent stray pickup from producing a DC component in the load and to prevent DC saturation of a transformer. When S1E is closed, C1 is included in the feedback loop. Response to a step input is slowed to approximately 3 seconds, allowing use with most incandescent or tungsten loads without nuisance clearing of sub-cycle fuses.

The output Amp. #1 is applied to the input of Amp. #2, through R10 and R11, where it is summed with a sawtooth ramp voltage from across capacitor C16. Gate A5 outputs (pin 6 and 8) are driven "low" twice each cycle when transistors Q1 and Q2 are both "off". When the gate output goes "low", C16 is discharged through CR6 down to approximately +1.0 volts. When the gates are "high", CR6 is reversed biased, allowing C16 to charge through R23. R24 isolates C16 from Amp #2 to prevent loading. Amp. #2 output is the sum of the control signal input and a sawtooth voltage (representing time) and inverted in polarity. Amp. #3 is connected as a level detector whose output is plus, whenever the signal from Amp. #2 exceeds the bias level set by R13 and R14. Transistors Q1 and Q2 produce a signal, synchronized to the power line, but of opposite phase. These signals are used to determine which SCR is to be gated and to reset the sawtooth ramp across C16 through A5 gates.

The A6 gates combine the time duration information generated by Amp. #2 with the gating information from A5 gates to control transistors Q8 and Q9.

Capacitor C24 provides an inhibit signal to the A6 gates during initial application of power to prevent spurious triggering. Diode CR5 insures the rapid discharge of C24 upon removal of line voltage.

The G1/K1 and G2/K2 SCR driver circuits are identical so only the G1/K1 circuit will be discussed. of Q4 of Q4, Q5, and T3, from oscillating. The gating signal from A6 drives Q8 towards cutoff, allowing the oscillator to start. Feedback from T3 winding 4-5 is applied to the base of Q5 through diode CR17. Q5 is held in saturation until T3 saturates effectively, removing Q5 base drive through T3's low DC resistance. As the flux field starts to collapse, the polarity across T3 winding 4-5 reverses, supplying base drive to Q4, through CR19, causing Q4 to rapidly saturate. The voltage drop across CR19 assures Q5 is completely cutoff. The voltage at T3 secondary windings 6-7-8 is rectified by high speed diodes CR15 and CR16 and filtered by capacitor C25. R41 limits the maximum short circuit current to a safe value while R49 provides a low gate impedance to the SCR for best dv/dt rating. Clamp diodes CR18 and CR20 are low forward drop devices to insure cutoff when Q8 saturates. R43 unbalances the multi-vibrator, insuring rapid starts.

As the SCRs fire, load voltage is sensed by T2. The load voltage is scaled and isolated by T2's secondary. This voltage is rectified by CR8/CR9 and fed to wave shape circuitry R30, R29, R28, and C18 where the DC pulses are shaped to equal R.M.S. value. The output of the wave shaper is stored in C17 through isolation diode CR7. The DC voltage from C17 is fed through R25/R26 back to Amp. #1 input. This DC is of opposite polarity to the input command, and cancels the input command at Amp. #1 input; therefore, Amp. #1 output will drive until the output voltage equals the input command giving a null at Amp. #1 input. Any change in line voltage will be felt by the feedback loop, causing Amp. #1 to drive to a new balance point. This circuit provides load voltage regulation. The span control, R26, varies the feedback, allowing exact calibration of the input span.

T1 has a multi-tapped primary, allowing operation on any standard line voltage. The secondary is subdivided with the 9-10-11 portion supplying 12 volts DC at 500 milliamps to the gate drive circuitry. The 8-10-12 portion through the bridge BR1 supplies plus and minus 20 volts with respect to circuit common. A4 is an integrated circuit voltage regulator whose plus and minus 15 volt output supplies power for the rest of the circuit. This regulator assures excellent isolation from line voltage and/or temperature affects on the operation of the circuit.

The current limiter senses the load current through T5, converts this to a DC level through the rectifier, BR2, and wave shaping circuitry to generate a DC voltage across C20 proportional to the R.M.S. load current. The circuit common reference level of C20 is set by R38, current limit set. R38 establishes a negative level which, when exceeded by the C20 R.M.S. current voltage, causes Q3 to conduct. As Q3 conducts its collector becomes less positive, forward biasing CR10. CR10 is connected to the high impedance summing point of Amp. #1's output. By limiting the maximum voltage via Q3's conduction, a predetermined current level cannot be exceeded by any input command, even if the command is beyond the normal signal range.

4-3 Operation of Distributed Zero-Crossover Firing Circuit

T1 steps down the applied line voltage, through the appropriate primary tap, to approximately 36 VAC center tapped. T1 also supplies the necessary line isolation. CR1 and CR2 form a full-wave rectifier developing approximately 12 volts across filter cap C1. This high current supply is used to supply the high frequency output inverters only. The entire T1 secondary feeds a bridge rectifier, BR1, which forms a double full wave rectifier with respect to circuit common, generating a plus and minus 24 volts across C2 and C3 respectively. The raw DC is regulated through Q1 for the +15 volt supply and through Q2 for the -15 volt supply. Terminal 8 of T1 also feeds R12 and R5 with an 18 volt nominal AC voltage.

R5 and C4 plus R6 and C5 filter the AC from T1, removing any line spikes or noise. This signal is then used to synchronize the A1 oscillator to the line. The square wave output of A1 is used to synchronize the outputs, insuring synchronization with the applied line voltage.

With no control signal applied, negative bias on the inverting input of A2 results in a positive output. A positive input to the inverting input of A3 results in a negative output. When A3 output is low, or off, A4 pin 8 goes high, driving pin 13 of A5 high. A1 output, a positive going square wave, toggles A4 pin 11, in synchronization with the applied line. When A5 pin 12 and 13 are high, A5 pin 11 is low, causing A5 pin 8 to be high. As one half of A5 is connected as a flip-flop, pin 8 being high causes pin 6 to be low. A5 pin 6 being low holds A4 pin 6 high preventing any output.

A4 and A5 are high level (15 volt) digital logic devices. Each device contains four identical "NAND" gates. For the NAND function, the output is "high" whenever either or both of the inputs are "low". When both inputs are "high" the output goes "low".

The input control signal is applied through R28 to the input of A2 that is operating as an integrator. Current inputs are developed into a 5 volt span by R25, R26, and R27. A positive control signal applied to the input of A2 causes the output (pin 6) to go negative. As A2 pin 6 passes -.25 volts, A3 toggles positive, driving A4 pins 9 and 10 high, causing A4 pin 8 to go low. A4 pin 8 going low causes A5 pin 11 to go high, which will allow the flip-flop to toggle at the proper time. A3 pin 8 going low causes A5 pin 11 to go high, which will allow the flip-flop to toggle at the proper time. A3 pin 6 also drives A5 pin 1. When A5 pin 1 is high and the synchronization from A1 is low, it causes A4 pin 11 to go high. This puts a high signal on pins 1 and 2 of A5, causing pin 3 to go low. When A5 pin 3 goes low, it drives A5 pin 4 low causing A5 pin 6 to go high, or "set". The flip-flop A5 pin 6 drives A4 pin 5. With A4 pin 5 high when A4 pin 4 goes high, (the synchronization signal was previously set low in out description and now is going high), A4 pin 6 now goes low, turning on Q4 and coupling through C9, back biasing diode CR10, turning off Q5 via R36. This event occuring means the control signal is requesting power (A3 output high) and the line is just crossing zero (A1 output going high). Therefore, the time to fire the SCR is now.

As Q5 turns off, the forward bias is removed from Q6 and Q7, turning them off. This allows the saturating multi-vibrator formed by Q8-19 and T2 to oscillate. Fast start-up of the multi-vibrator is assured via R41 which insures a positive unbalance during initial turn on. R55 limits the base current to a safe value. CR12 and CR13 provide the return path from Q9 and Q8 base drive respectively. The high frequency square wave (approximately 20 K Hz) is coupled to the 6-7-8 center tapped secondary of T2. (T2 is designed for low primary to secondary capacitance, less than 20 pF) where CR14 and CR15, fast recovery diodes, rectify the square wave to supply a DC gate drive for the SCR. R42 and R57 limit the maximum current, while C12 provides filtering. R43 provides a low impedance DC leakage path for the SCR.

After a time set by R35-C9 (typically 4 milliseconds), CR10 is forward biased, supplying positive base drive to Q5, which in turn saturates Q6 and Q7 damping the multi-vibrator off. R39-R40 insure sharing of base current by Q6 and Q7. The purpose for gating the SCR for less than 8 milliseconds (1/2 cycle) is to conserve power, but at the same time insure the SCR has "hard" (over driven) gate drive during turn on for any practical load condition.

When Q4 is turned on by A4 pin 6 going low, CR6 is reversed biased allowing Q3 to conduct. The timing is such that when Q3 is on, T1 terminal 8 is negative, Q3 conducts, pulling A2's input negative. This is opposite the input signal polarity, resulting in A2's output going high if the control signal was

at a low level. Since the negative signal is supplied by T1, it is proportional to line voltage, making the feedback line voltage proportional. As a result, a decrease in line voltage decreases the feedback, making the output "on" for a proportionally longer period.

Returning to A4 pin 6, which was low with A1 pin 6 being high, as line voltage returns to zero, A1 pin 6 now goes low, causing A4 pin 6 to go high. A4 pin 6 is inverted at A4 pin 3, so as pin 6 goes high, pin 3 goes low. Pin 3 is coupled through C14 to CR16. As pin 3 goes low, CR16 is reverse biased allowing R48 to cut off Q11. The balance of the circuit operates as previously described for Q6-Q7-Q8 and Q9, resulting in a DC gate signal at the G2-K2 terminals. The SCRs are fired, SCR1 first then SCR2, as a pair is necessary to hold A2's output near the -.25 volt level. Because of the integrator action of A2, the long term output will be proportional to the input level. That is, a 50.5% level is achieved by 10 pairs of on then off cycles, then 2 on cycles followed by an off, and the pattern repeating. Any level from approximately 1 cycle out of 120 through 120 cycles out of 120 can be commanded via the input control signal in this matter.

Q10 serves as a shutdown clamp during initial power application. Q10 is turned on until C13 is charged almost to 12 volts through R44. Clamping off the output during power application prevents any spurious output which might occur because of differences in B+ and B- rise rates, competent balances, etc. The remote trip option permits use of relay contacts or a remote switch to provide instantaneous shutdown of power by removing +12 volts from Q10 operation.

4-4 Current Limiter Operation

The optional current-limiting circuit provides the means for limiting load current to any value between 5% and 120% of rated capacity. In this circuit, load current is sensed by a current transformer and is fed back to the limiter-circuit which converts it to a DC signal representing true R.M.S. load current. This signal then operates in a manner to inhibit the command signal whenever load current tends to exceed the preselected level. This action is illustrated by Figure 4-4 where the preselected level is 100% on a high resistance-ratio load (such as an incandescent lamp) which is transformer coupled.

Since the limiter has a finite response time, it cannot be used as a high speed protective device like a fuse nor is it fast enough to prevent damaging inrush currents when lamp-type loads are driven unless a "soft-start" circuit providing a gradual turn-on is used.

NOTE

DO NOT operate the unit in FAST mode (L or R OFF) with this option as damage to the unit will result.

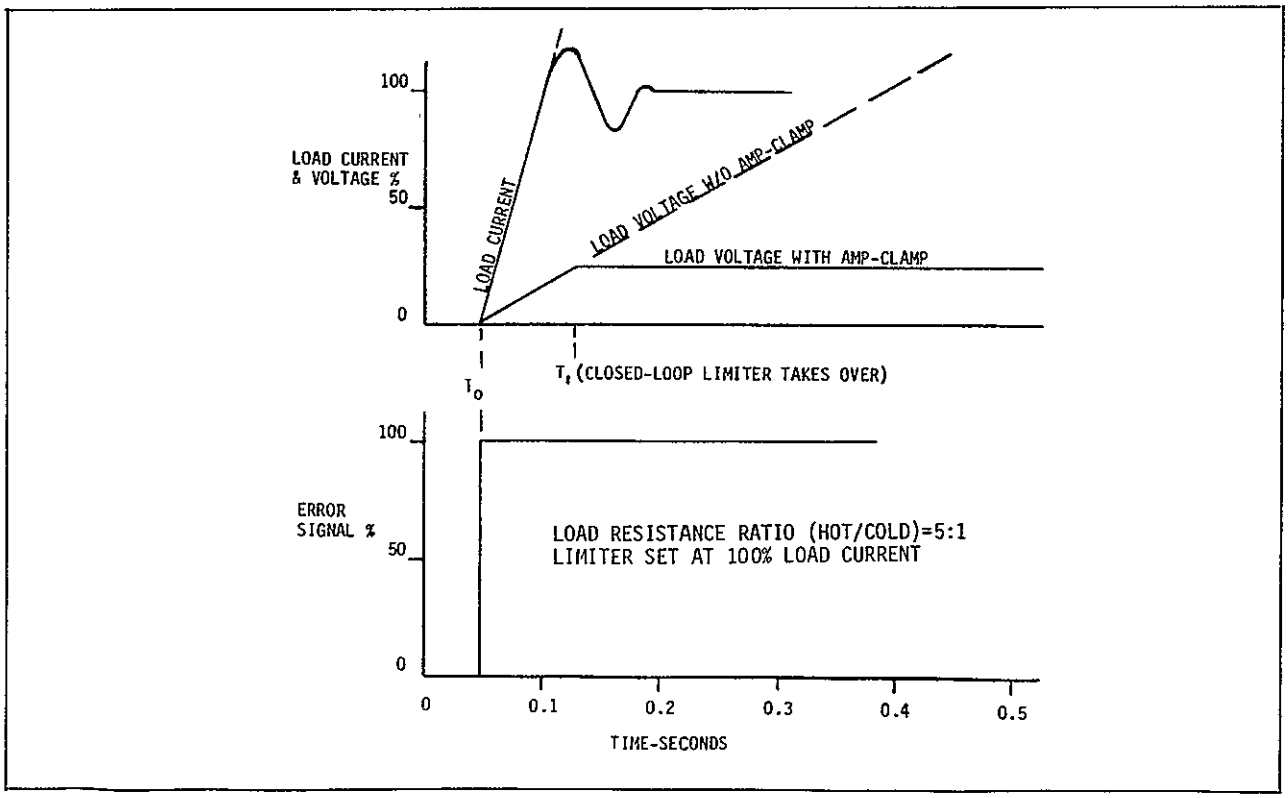


Figure 4-4 Current Limiter Action

Section 5

MAINTENANCE

5-1 General

Maintenance on the PHASER will consist primarily of keeping the unit free of dust or other contaminants. The heatsinks should be blown free of dust as determined by environmental conditions around the unit.

5-2 Changing Fuses

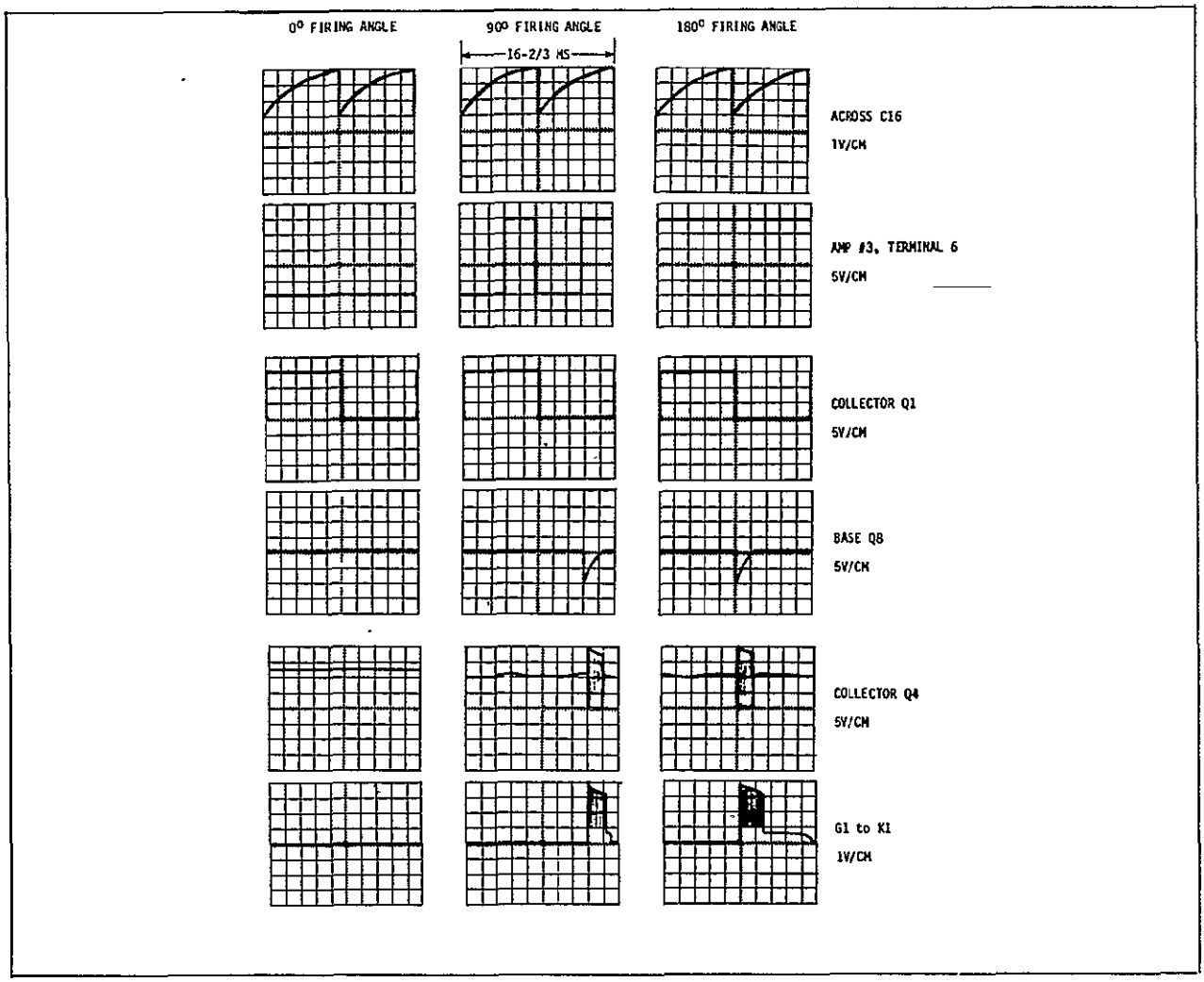
The SCRs in the 64600 are protected with special fuses to match their time-current rating. Under no circumstances should these fuses be replaced with any other type than those installed on the unit. Refer to the Recommended Spare Parts List in Section 6 for the appropriate type and rating.

5-3 Replacing Power Control Element

Should replacement be necessary, proceed as outlined below:

1. De-energize the 64600 (disconnect from line as safety precaution).
2. Remove the leads from the Power Control Element.
3. Remove the defective Power Control Element which is held in place by 2 philips-head screws.
4. Install new element using any commercially available heat conducting compound between the element and the heatsink.
5. Connect the leads to the new element.
6. Reconnect the line voltage wiring.

5-4 Firing Circuit Waveforms



Section 6

TROUBLESHOOTING

6-1 General

The following is intended as a guide for rapidly localizing common failures in malfunctioning 64600 Phasers.

1. Correct wiring to and from unit.
2. Broken wires.
3. Loose or broken connections.
4. Presence of correct input voltage levels.
5. Proper load voltage and current labels. Refer to Section 5 for replacement procedures and the Recommended Spare Parts List in Section 7 for replacement information.

6-2 Constant Full Power Output

1. DISCONNECT INPUT POWER FROM UNIT and check resistance from AC1 to AC2 terminals of the Power Control Element. A meter reading of 0 ohms indicates a shorted Power Control Element and the unit should be replaced.
2. If the Power Control Element is not shorted, the problem is in the firing circuit board. Consult the factory for further information.

6-3 No Power Output

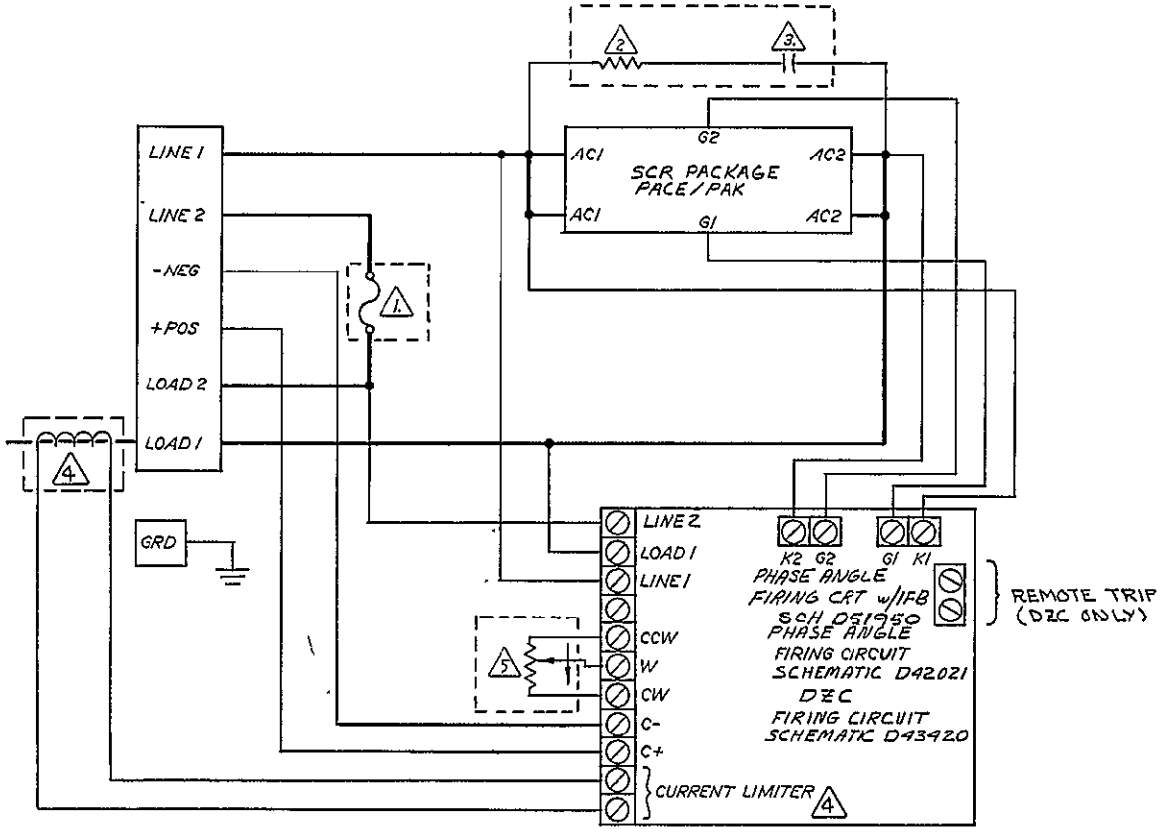
1. DISCONNECT INPUT POWER FROM UNIT and check for 0 ohms resistance across the optional fuse. Replace fuse if required.
2. If the fuse is good the problem is in the firing circuit board. Consult the factory for further information.

Section 7

CIRCUIT DIAGRAMS AND RECOMMENDED SPARE PARTS LIST

KC47715	Schematic, 646 Power Controller
KD42021	Schematic, Phase Angle Firing Circuit
KD51950	Schematic, Phase Angle Firing Circuit with Current Feedback (IFB)
KD43420	Schematic, Distributed Zero Crossover Firing Circuit
D44869	Schematic, Distributed Zero Crossover Firing Circuit with Current Feedback (IFB)

REVISIONS			
SYM	DESCRIPTION	DRAFT.	DATE
A	REVERSED LINE 1 & LOAD 1	AKB	1-16-76



5 OPTIONAL MANUAL POT. 5KΩ

4 OPTIONAL CURRENT LIMITER & CURRENT FEEDBACK (USED WITH PHASE ANGLE FIRING CKT ONLY)

3. OPTIONAL CAPACITOR: .5MFD/1000V. FOR DVDT

2 OPTIONAL RESISTOR: 25Ω 50W WITH 50A UNIT. FOR DVDT
10Ω 50W WITH 100A UNIT. FOR DVDT

1. OPTIONAL FUSE: USE JUMPER B42593-2 WHEN FUSE IS NOT USED

3B1316	646	D42578-4
3B1315	646	D42578-3
3B1314	646	D42578-2
3B1314	646	D42578-1
INVENTORY	USED ON	ASSEMBLY

DRAFTSMAN R.M. 7-18-75	MATERIAL	TOLERANCE UNLESS OTHERWISE NOTED: 2 PLACE DEC ± / FRACTIONAL ±	SCALE
CHECKED			
APPROVED	FINISH	3 PLACE DEC ± / ANGULAR ±	SCHEMATIC
		REMOVE ALL BURRS AND SHARP EDGES	

TITLE: SCHEMATIC- 646 PWR CONT.

INVENTORY: 3D1545

NUMBER: KC477/5

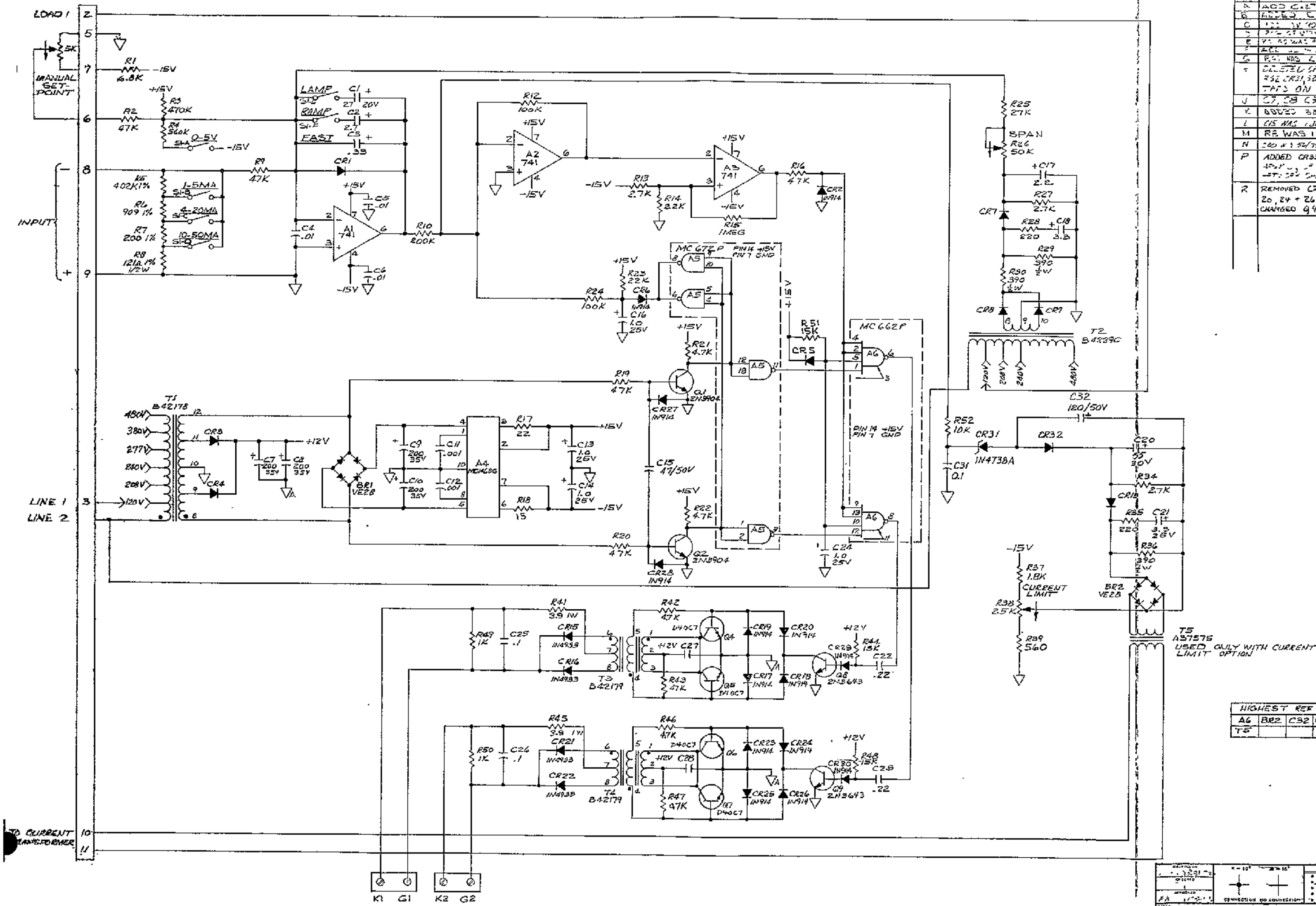
REV: A

SHEET 1 OF 1

R·I CONTROLS — A DIVISION OF RESEARCH INCORPORATED, MINNEAPOLIS MINNESOTA 55424

L26176

	REVISIONS		
LTR	DESCRIPTION	[illegible]	[illegible]
A	ADD C27, 28 [illegible]	[illegible]	[illegible]
B	ADDED C31	AKB	2-25-[illegible]
C	[illegible]	[illegible]	3-[illegible]
D	[illegible]	KNF	6-[illegible]
E	[illegible] WAS [illegible] R27 WAS 47K ADDED C23, [illegible]	R-F	6-25-[illegible]
F	[illegible]	[illegible]	7-[illegible]
G	R41 WAS [illegible] R15 WAS 22, R45 WAS 1K	AYE	3-8-7[illegible]
H	DELETED [illegible] 4, R3-3340, [illegible] ADDED R52 CR31, 32, C32 [illegible] 277V & 380V TAPS ON T1 & T2, [illegible] WAS [illegible]K	[illegible]	[illegible]
J	C7, C8 C9, C10 WAS 25V	KB	[illegible]
K	ADDED 380V & 277V TAPS TO T1	ALB	2-25-[illegible]
L	C15 WAS [illegible] DELETE NOTE 2	DS	[illegible]
M	R8 WAS 12Ω	LN	9-3-[illegible]
N	[illegible] 52/35V, C32 WAS 100/35V	[illegible]	7-20-[illegible]
P	ADDED CR33, 34; CR17, 19 SWITCHED [illegible] CHANGED	NDS	4-[illegible]
R	REMOVED CR 33, 34, CHANGED CR 18, 19 20, 24 + 26 TO 1N914, REMOVED C 29, 3[illegible] CHANGED Q4, 5, 6 + 7 TO D40C7	MP	7-25-78



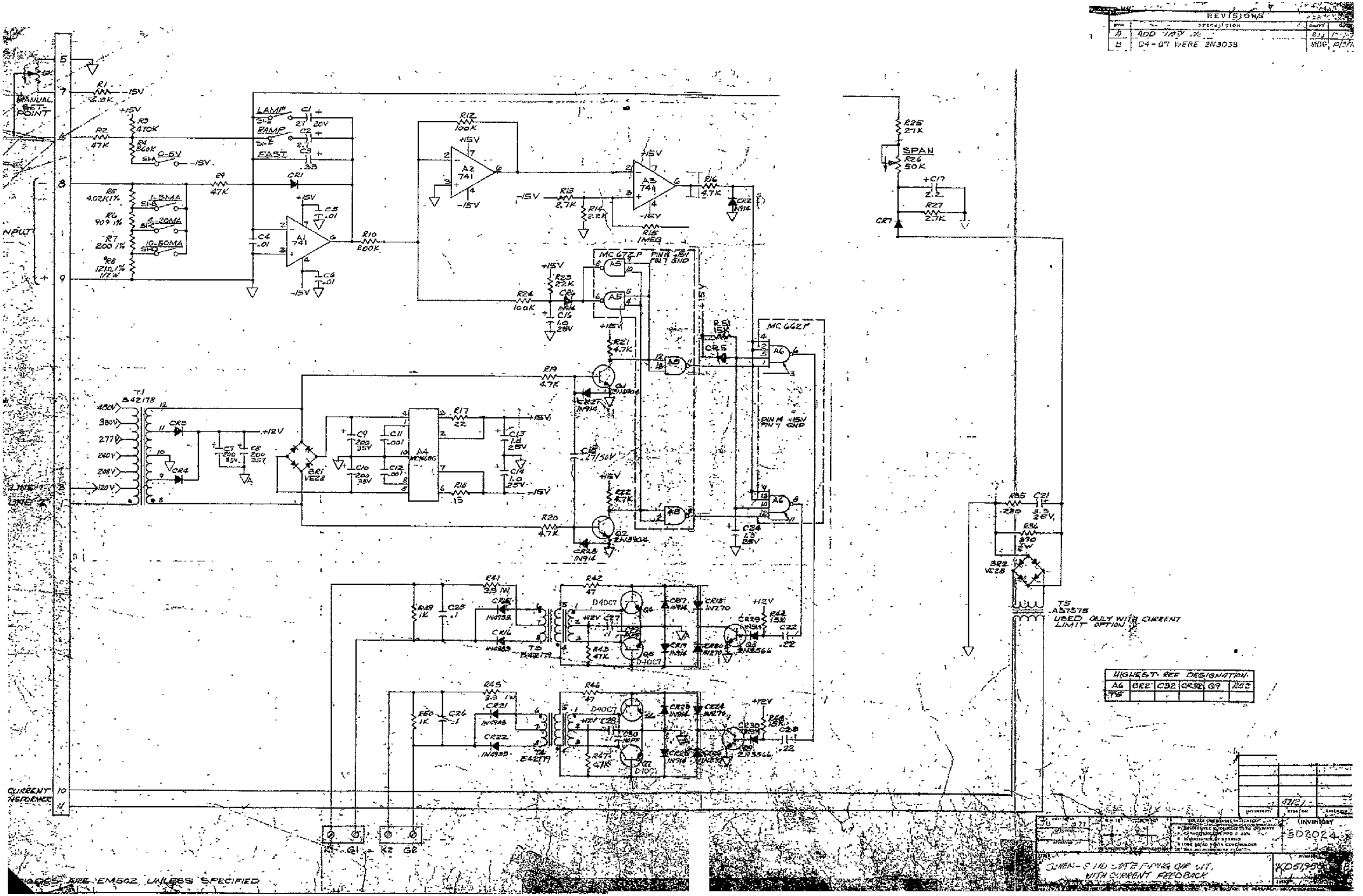
HIGHEST REF DESIGNATION					
A6	BR2	C32	CR34	Q9	R52
T5					

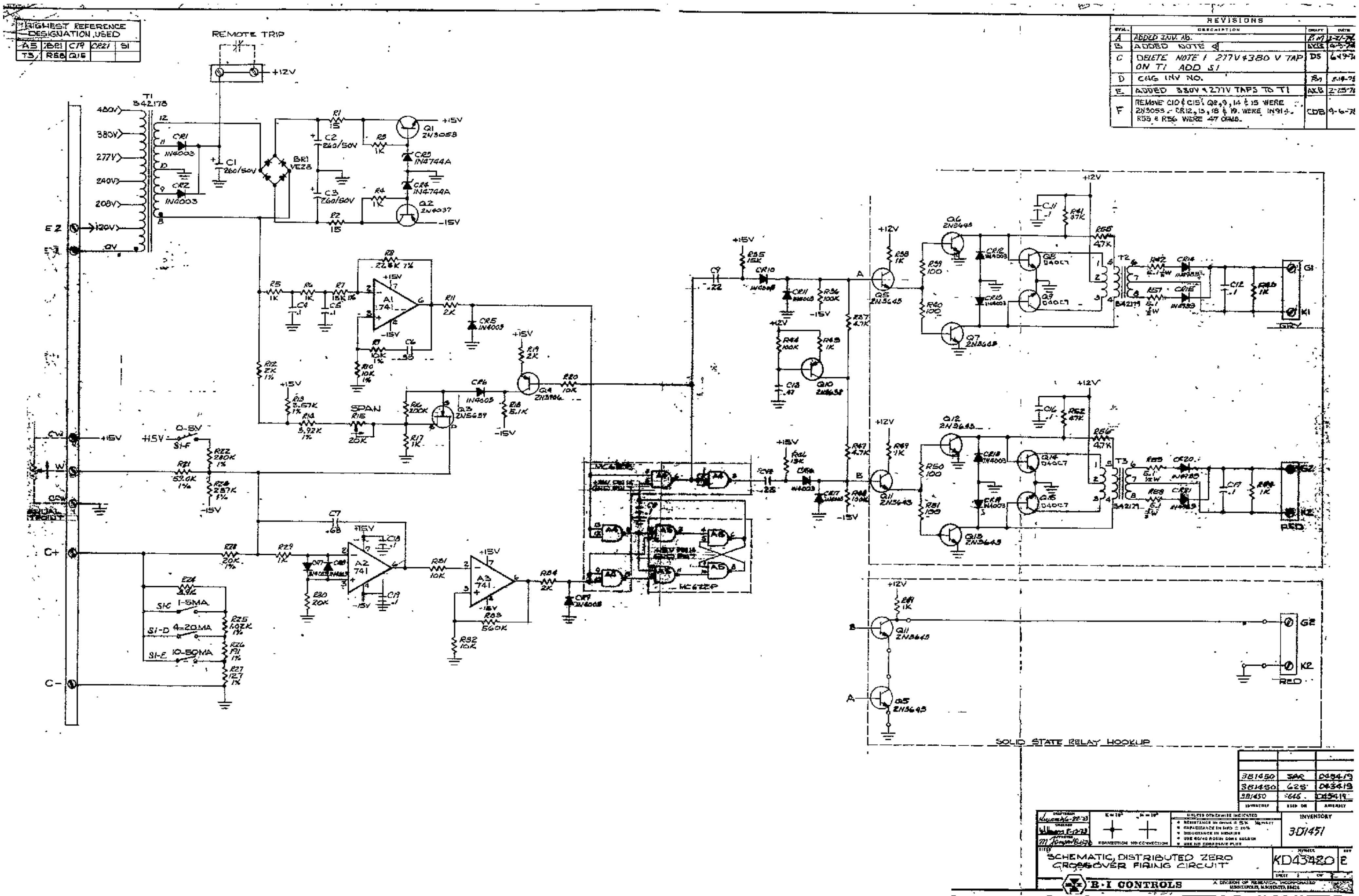
3D1199	646	[illegible]
3D1199	625	[illegible]
3D1199	SPR	[illegible]

SCHEMATIC, SOLID STATE FIRING CIRCUIT

KD42021 R

R-I CONTROLS


REVISIONS
A ADD
B Q4-Q7 WERE 2N3038
MANUAL SET-POINT
R1 -15V
R2 47K
+15V
R3 470K
R4 560K
0-5V
-15V
LAMP
RAMP
FAST
C1 27 20V
C2 27
C3 .33
CR1
R9 47K
R5 402K 1%
R6 909 1%
R7 200 1%
R8 121 0.1% 1/2W
1-5MA
4-20MA
10-50MA
INPUT
C4 .01
A1 741
C5 .01
C6 .01
R10 200K
R12 100K
A2 741
+15V
-15V
R13 2.7K
R14 2.2K
A3 741
R15 1MEG
R16 4.7K
CR2 1N914
MC672P
PIN 14 +15V
PIN 7 GND
A5
R24 100K
R23 22K
CR6 1N914
C16 1.0 25V
R21 4.7K
A6
MC662P
R51 15K
CR5
R19 4.7K
Q1 2N3906
CR27 1N914
T1 B42178
480V
380V
277V
240V
208V
120V
CR3
CR4
+12V
C7 200 35V
C8 200 35V
BR1 VE28
C9 200 35V
C10 200 35V
C11 .001
C12 .001
A4 MC1468G
R17 22
R18 15
C13 1.0 25V
C14 1.0 25V
-15V
C15 .47/50V
R22 4.7K
R20 4.7K
Q2 2N3904
CR28 1N914
C24 1.0 25V
R25 27K
SPAN
R26 50K
C17 2.2
R27 2.7K
CR7
R35 220
C21 3.3 25V
R36 390 1W
BR2 VE28
T5 A37575
USED ONLY WITH CURRENT LIMIT OPTION.
R41 3.9 1W
R42 47
R49 1K
C25 .1
CR15 1N4933
CR16 1N4933
T3 B42179
D40C7
Q4
Q5
C27 .1
R43 47K
CR17 1N914
CR18 1N270
CR19 1N914
CR20 1N270
C29
R44 15K
Q8 2N3566
C22 .22
+12V
R45 3.9 1W
R46 47
R50 1K
C26 .1
CR21 1N4933
CR22 1N4933
T4 B42179
D40C7
C28
C30
R47 47K
Q7 D40C7
CR23 1N914
CR24 1N270
CR25 1N914
R48 15K
Q9 2N3566
C23 .22
HIGHEST REF DESIGNATION
A6 BR2 C32 CR32 Q9 R52
T5
CURRENT TRANSFORMER
K1 G1 K2 G2
DIODES ARE EM502 UNLESS SPECIFIED
SOLID STATE FIRING CIRCUIT WITH CURRENT FEEDBACK
5D2024
KD51959



REVISIONS			
SYM.	DESCRIPTION	DRAFT	DATE
A	ADDED INV. NO.		
B	ADDED NOTE 4		
C	DELETE NOTE 1 277V & 380 V TAP ON T1 ADD S1	DS	
D	CHG INV NO.		
E	ADDED 380V & 277V TAPS TO T1	AKB	
F	REMOVE C10 & C15. Q8, 9, 14 & 15 WERE 2N3055 - CR12, 13, 18 & 19 WERE IN914. R55 & R56 WERE 47 OHMS.	CDB	9-6-78

381450	SAR	043419
381450	625	043419
381450	646	043419
INVENTORY	USED ON	ASSEMBLY

UNLESS OTHERWISE INDICATED
- RESISTANCE IN OHMS ± 5% ¼ WATT
- CAPACITANCE IN MFD ± 20%
- INDUCTANCE IN HENRIES
- USE 60/40 ROSIN CORE SOLDER
- USE NO CORROSIVE FLUX

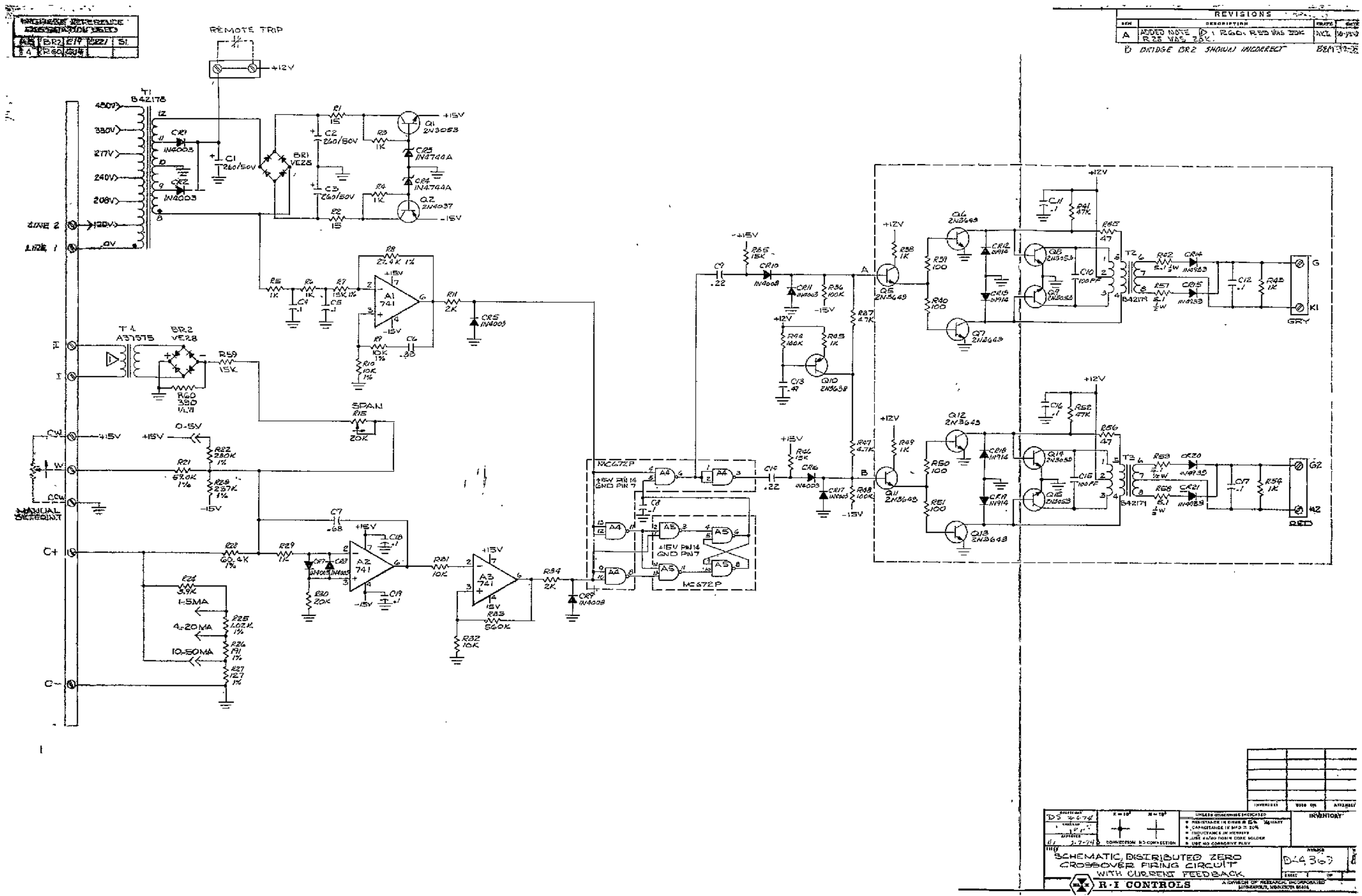
CONNECTION NO CONNECTION

INVENTORY 301451

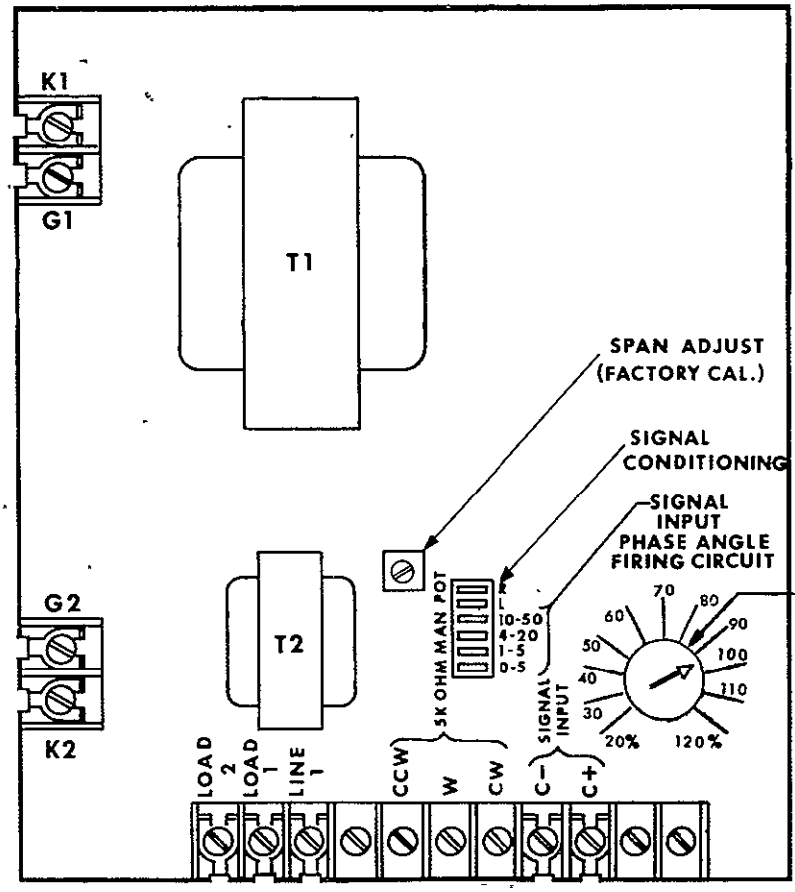
TITLE: SCHEMATIC, DISTRIBUTED ZERO CROSSOVER FIRING CIRCUIT

NUMBER KD43420 E

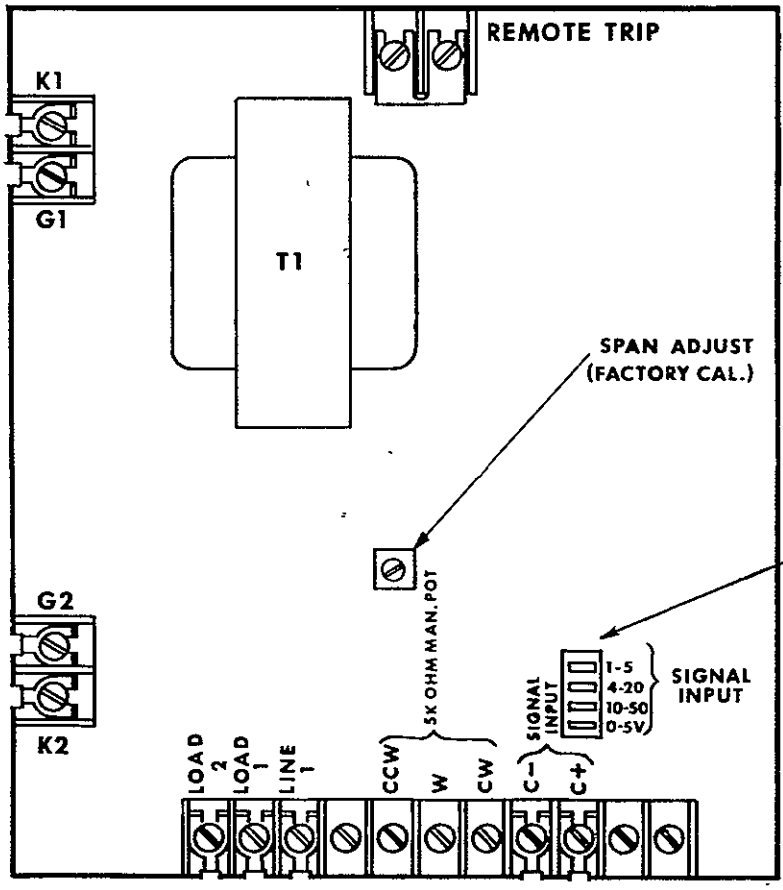
R·I CONTROLS
A DIVISION OF RESEARCH, INCORPORATED MINNEAPOLIS, MINNESOTA



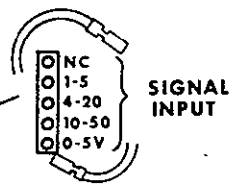
REVISIONS
A ADDED NOTE 1, R60, R59 WAS 25K, R28 WAS 20K.
B BRIDGE BR2 SHOWN INCORRECT
REMOTE TRIP
+12V
T1 B42178
480V
380V
277V
240V
208V
120V
0V
LINE 2
LINE 1
CR1 1N4003
CR2 1N4003
C1 260/50V
BR1 VE28
R1 15
R2 15
C2 260/50V
C3 260/50V
R3 1K
R4 1K
Q1 2N3053
Q2 2N4037
CR3 1N4744A
CR4 1N4744A
+15V
-15V
R5 1K
R6 1K
R7 15K 1%
C4 .1
C5 .1
R8 27.4K 1%
A1 741
R9 10K 1%
R10 10K 1%
C6 .33
R11 2K
CR5 1N4003
T4 A37575
BR2 VE28
R59 15K
R60 390 1/4W
SPAN
R15 20K
CW
W
CCW
MANUAL SETPOINT
0-5V
R22 280K 1%
R21 57.0K 1%
R23 237K 1%
C+
C-
R28 60.4K 1%
R29 1K
C7 .68
A2 741
CR7 1N4003
CR8 1N4003
R30 20K
C18 .1
C19 .1
R31 10K
A3 741
R33 560K
R32 10K
R34 2K
CR9 1N4003
R24 3.9K
1-5MA
4-20MA
10-50MA
R25 1.02K 1%
R26 191 1%
R27 127 1%
MC672P
+15V PIN 14 GND PIN 7
A4
A5
C8 .1
C9 .22
C14 .22
R55 15K
R46 15K
CR10 1N4003
CR11 1N4003
CR16 1N4003
CR17 1N4003
R36 100K
R48 100K
R37 4.7K
R47 4.7K
R44 100K
R45 1K
Q10 2N3638
C13 .47
A
B
Q5 2N3643
Q11 2N3643
R38 1K
R49 1K
R39 100
R40 100
R50 100
R51 100
Q6 2N3643
Q7 2N3643
Q12 2N3643
Q13 2N3643
CR12 1N914
CR13 1N914
CR18 1N914
CR19 1N914
Q8 2N3053
Q9 2N3053
Q14 2N3053
Q15 2N3053
C10 100PF
C15 100PF
C11 .1
C16 .1
R41 47K
R52 47K
R55 47
R56 47
T2 B42171
T3 B42171
R42 5.1 1/2W
R57 5.1 1/2W
R53 5.1 1/2W
R58 5.1 1/2W
CR14 1N4933
CR15 1N4933
CR20 1N4933
CR21 1N4933
C12 .1
C17 .1
R43 1K
R54 1K
G
K1
GRY
G2
K2
RED
UNLESS OTHERWISE INDICATED
RESISTANCE IN OHMS ± 5% 1/4 WATT
CAPACITANCE IN MFD ± 20%
INDUCTANCE IN HENRIES
USE 60/40 ROSIN CORE SOLDER
USE NO CORROSIVE FLUX
CONNECTION
NO CONNECTION
INVENTORY
SCHEMATIC, DISTRIBUTED ZERO CROSSOVER FIRING CIRCUIT WITH CURRENT FEEDBACK
R·I CONTROLS



PHASE ANGLE FIRING CIRCUIT
SCHEMATIC KD 42021



DZC FIRING CIRCUIT
SCHEMATIC KD 43420



NOTE: EITHER JUMPER OR SWITCHES MAY BE SUPPLIED

RECOMMENDED SPARE PARTS LIST

MODEL 646 PHASER	- - -	6/75
TITLE	NUMBER	REV

ITEM	DESCRIPTION	PART NO.	INVENTORY	QUANTITY 1	2	3	4	▼
1.	Firing Circuit Ass'y - Phase Angle	KD 42021	3D1199	X				
2.	Firing Circuit Ass'y - DZC	KD 43420	3B1450	X				
3.	SCR Pac 240v/50A	P242	32B0221	X				
4.	SCR Pac 480v/50A	P245	32B0220	X				
5.	SCR Pac 240v/100A	P342	32B0194	X				
6.	SCR Pac 480v/100A	P345	32B0195	X				
7.	Sub-cycle Fuse 120-480v/50A	A050FA060XA	17B179	X				
8.	Sub-cycle Fuse 120-480v/100A	A050FC125A	17B180	X				
	NOTE: All of the above parts are not							
	required for each controller -							
	Select only those parts used in							
	this unit.							

ORDERING INFORMATION

1) For ordering information and latest prices, contact your local representative or the RESEARCH, Incorporated factory in Minneapolis, Minnesota.

2) When ordering spare parts, please include references both to this parts list number and revision level, plus, the Model Number and Serial Number of the instrument for which these parts are being ordered.

TWX 910-576-2837	PHONE MINNEAPOLIS 612-941-3300	TELEX 029-5328

R·I CONTROLS
A DIVISION OF RESEARCH, INCORPORATED
BOX 24064 MINNEAPOLIS MINNESOTA USA 55424

Section 9

COMPONENT DATA SHEETS

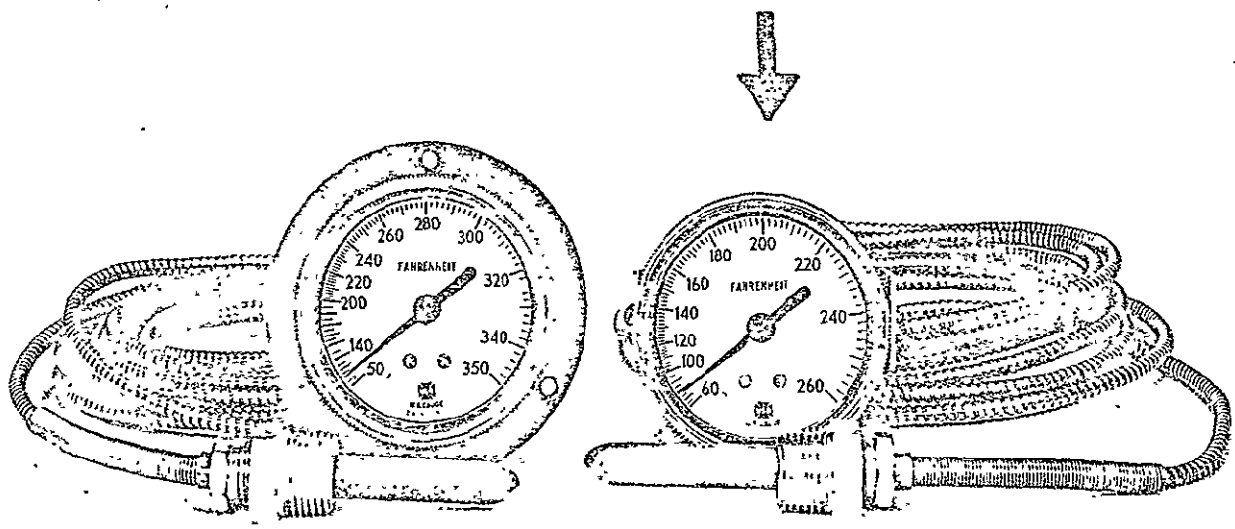
AMETEK

MUELLER SALES CORP.
2420 Nevada Ave. No.
GOLDEN VALLEY, MINN. 55427
612 544-8888 TLX 29-0301

REMOTE READING EQUIPMENT THERMOMETERS

BULLETIN: 72-6A

Vapor Actuated Remote Reading Equipment Thermometers



GENERAL

The 2″, 2½″ and 3½″ series 8000 vapor actuated, remote reading thermometers are low cost panel mounted instruments that are readily adaptable to a wide variety of applications.

The temperature at the bulb is indicated by measuring the vapor pressure of the filling medium which increases with temperature. The vapor pressure-temperature relationship is not linear, so that the low temperature portion of the scale is compressed with respect to the high temperature portion of the scale. Therefore, for best readability and accuracy, the range should be selected so that the working temperature is indicated in the upper half of the scale.

An advantage of vapor actuated thermometers is that no temperature compensation at the indicating head or the capillary is necessary. Regardless of the ambient temperature surrounding the head or capillary, the thermometer will indicate the temperature at the bulb.

APPLICATIONS

Frozen Food Display Cabinets
Diesel & Gasoline Engines
Temperature Operated Valves
Milk Coolers
Cooking Vats
Ovens
Refrigerators
Dishwashers
Water Chillers
Incubators
Film Developers
Air Ducts

SPECIFICATIONS

DIAL: Steel—white background—black letters
POINTER: Aluminum—black finish—adjustable
BOURDON TUBE: Non-ferrous
MOVEMENT: Glasstuf®, glass filled nylon
CASE: Drawn steel—black finish
RING AND WINDOW: One piece polycarbonate, threaded
CAPILLARY: Brass armored—10 feet standard
CONNECTION: ½″ NPT, brass union

RANGES

STOCK RANGES	OPTIONAL RANGES
−20°F. to 120°F.	−40°F. to 65°F.
60°F. to 260°F.	0°F. to 100°F.
50°F. to 350°F.	0°F. to 150°F.
200°F. to 450°F.	20°F. to 220°F.
	30°F. to 240°F.

ORDER INFORMATION

To identify the combinations available in this line, a seven-digit code number is used. The first four numbers, as a group, serve to identify the thermometer head (Table 1). The second group, the final three digits, indicates the specifications for the thermal system (Table 2).

Standard models are indicated by bold type in Tables 1 and 2. For example, Figure 8514-152 and 8544-152 specify thermometers available from finished stock. In cases where the components are not covered by the identifying digit numbers shown, substitute letter X and state what it represents when ordering.

TABLE 1—CASE AND RING

SIZE	STEM AND DOORS	CASE	MATERIAL	3RD DIGIT	RING WINDOW	4TH DIGIT
FRONT	85	FRT. FLANGE	—STEEL—BLACK	1	POLYCARBONATE, THREADED	4
		U-CLAMP	—STEEL—BLACK	4	POLYCARBONATE, THREADED, WEATHERTIGHT	5

TABLE 2—THERMAL SYSTEM

MATERIAL CAPILLARY TUBE	5TH DIGIT	CAPILLARY PROTECTION	6TH DIGIT	CONNECTION TYPE	7TH DIGIT
COPPER	1	NO PROTECTION	1	PLAIN BULB	1
STAINLESS STEEL 300 SERIES	2	PROTECTION HEAD END*	2	UNION CONN.—½ NPT—BRASS	2
COPPER—HEAVY DUTY	3	PROTECTED BOTH ENDS*	3	UNION CONN —¾ NPT—BRASS	3
STAINLESS STEEL—HEAVY DUTY	4	ARMORED—BRASS FLEXIBLE	5	UNION CONN.—½ NPT—ST. STL. 347	4
		ARMORED—ST. STL. FLEXIBLE	6	UNION CONN.—¾ NPT—ST. STL. 347	5
		POLYPROPYLENE**	7	SEPARABLE SOCKET—½ NPT—BRASS	6
				SEPARABLE SOCKET—¾ NPT—BRASS	7
				SEP. SOCKET—½ NPT—ST. STL. 347	8
				SEP. SOCKET—¾ NPT—ST. STL. 347	9

**Available with copper capillary only.

*Protection of capillary employs use of stainless steel spiral spring reinforcing

DIMENSIONS

8544 U-Clamp

DIAL SIZE	A	G	N	P	Q	S	T	U
2	2 25	2.28	1.09	2.12	.24	.81	1.62	1 00
2½	2 80	2 81	1.09	2.59	.30	.81	2.20	1 00
3½	3 88	3.94	1.09	3 70	.32	.81	3 25	1.00

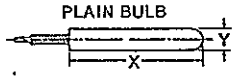
8514 Front Flanged

DIAL SIZE	A	G	H	J	N	P	Q
2	2 25	2 81	.156	2 562	1.09	2 12	24
2½	2 80	3 53	.156	3.125	1.09	2.59	30
3½	3 88	4 84	.219	4 250	1 09	3 70	.32

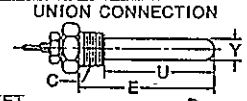
TABLE 2

BULB CONNECTIONS	C	E	U	X	Y
PLAIN BULB COPPER				2.75	.44
PLAIN BULB ST. STL.				2 77	.44
UNION CONNECTION BRASS	½ or ¾ NPT	2 70	2.14		44
UNION CONNECTION STAINLESS STEEL	½ or ¾ NPT	2 66	1.97		.44
SEPARABLE SOCKET BRASS	½ or ¾ NPT	2.90	2.34		.44
SEPARABLE SOCKET STAINLESS STEEL	½ or ¾ NPT	2.87	2.31		.44

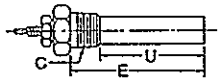
PLAIN BULB



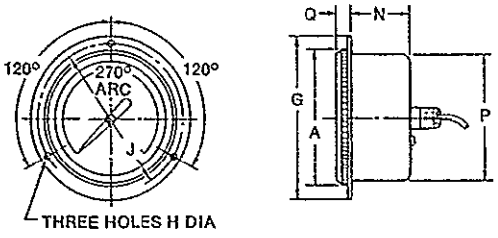
UNION CONNECTION



SEPARABLE SOCKET

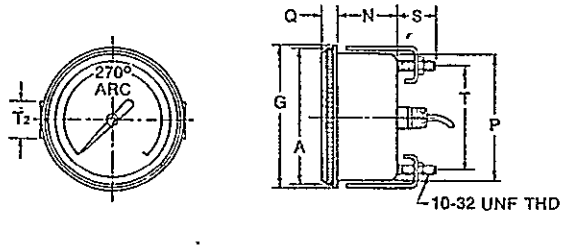


8514



FOR BULB DIMENSIONS SEE AU-3360-C

8544



FOR BULB DIMENSIONS SEE AU-3360-C

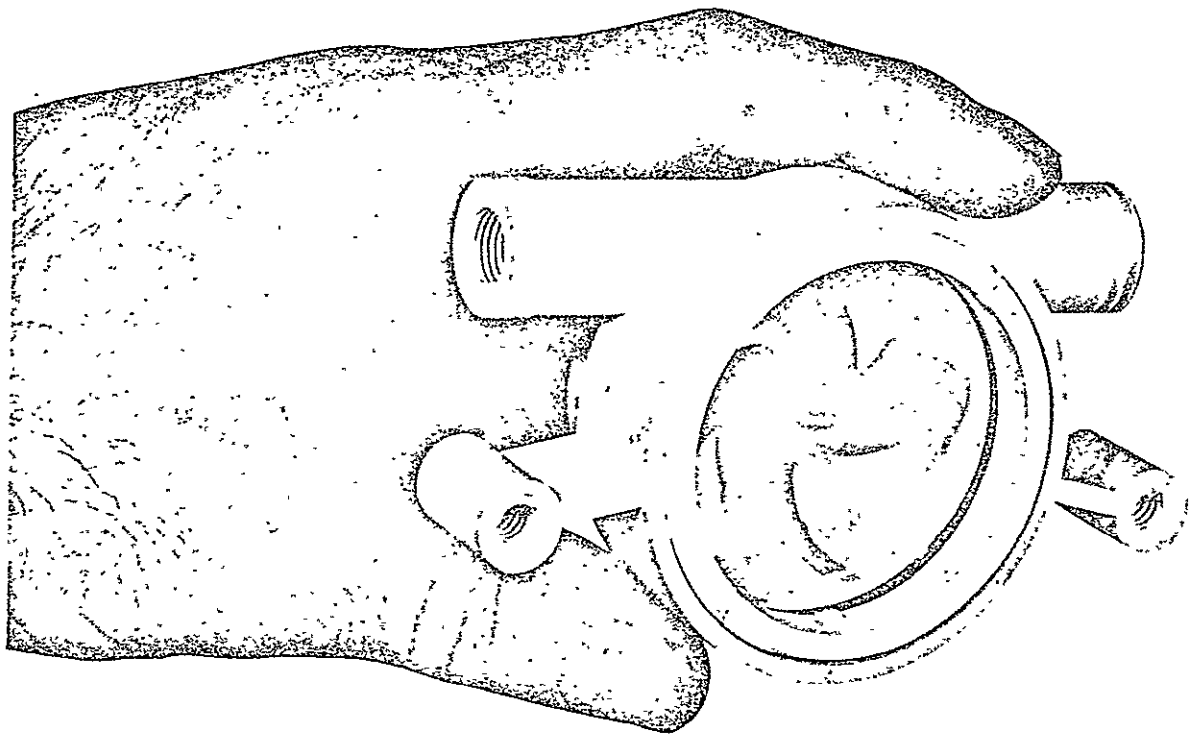
AMETEK

U.S. GAUGE DIVISION • SELLERSVILLE, PENNSYLVANIA 18960

Printed in U.S.A.

BARKSDALE FI-100 FLOW INDICATOR

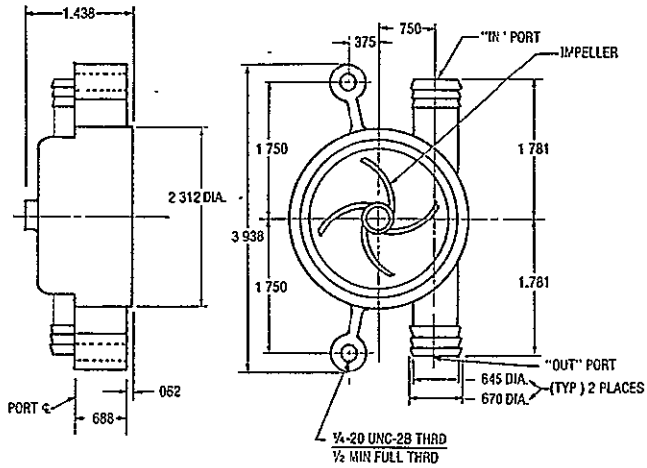
THE HARTFORD COMPANY
6104 Excelsior Boulevard
Minneapolis, Minn. 55416
Tel. (612) 929-1631



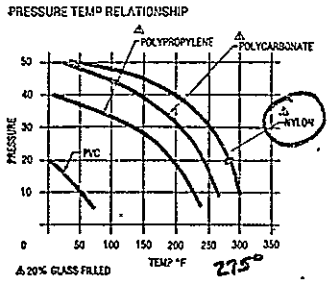
Visual Indicator For Air or Liquids

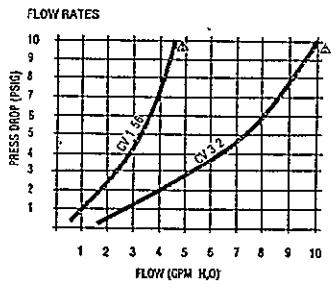
The FI-100 Flow Indicator provides an instantaneous reading of liquid or air flow conditions. The brightly colored spinner is visible from a considerable distance as it rotates in its housing, cast of your choice of PVC, Polypropylene, Polycarbonate, or Nylon.

Cost engineered for O.E.M. applications, the FI-100 is designed to function in working pressures of 0 to 50 psi, depending on the selection of housing material (see Pressure Temperature Relationship chart, right). Standard fittings for ⅛" NPT pipe and ½" I.D. flexible tubing are provided for quick, easy, leak resistant connection into existing lines.



SPECIFICATIONS
Overall dimensions: 3 15/16" X 2 5/16" X 1 7/16"
Media: Air or Liquids
Working Pressure: 20 psi (see chart)
Pressure Drop: See chart
Fluid Temperature Range: 0°F to 300°F
Standard Material: PVC, Polypropylene, Polycarbonate, Nylon
Porting: ⅛" NPT or Male nipple (½" I.D. tubing)





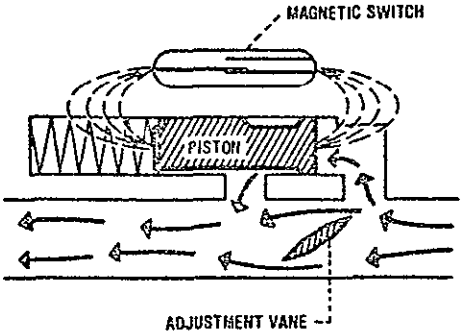
⚠ STD MIN FLOW DIA-5/16 DIA (⅛ NPT PORTING)
⚠ MAX FLOW DIA-7/16 DIA OPTIONAL (½ I.D. TUBE PORTING)

DELAVAL

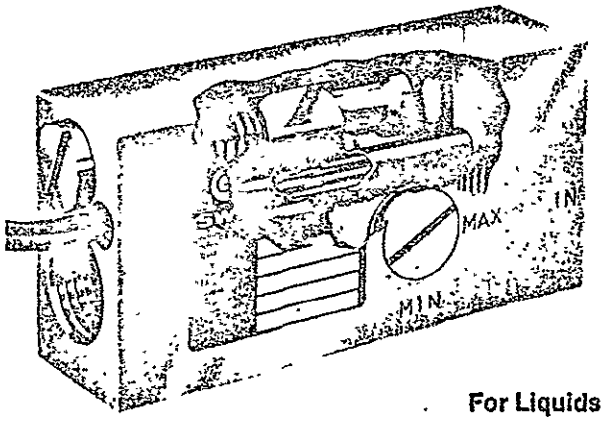
DELAVAL TURBINE INC., BARKSDALE CONTROLS DIVISION, 5125 Alcoa Avenue, Los Angeles, California 90058

DELAVAL TURBINE INC.
GEMS SENSORS DIVISION
Farmington, Connecticut 06032

GEMS SERIES FS-10798 ADJUSTABLE FLOW SWITCHES



Flow diagram with switch shown actuated.



For Liquids or Gases

FUNCTION

The Gems FS-10798 Flow Switch is an externally adjustable flow rate detector of extreme sensitivity and dependability . . . for use in liquids or gases. A screwdriver adjusted, vane-type, by-pass valve provides an infinite number of actuation set points over broad standard ranges, and adjustments may be made during operation at line pressures to 1000 PSIG. Repeatability of the FS-10798 is precise at any detection setting . . . and line pressure drop is minimized.

TYPICAL APPLICATIONS

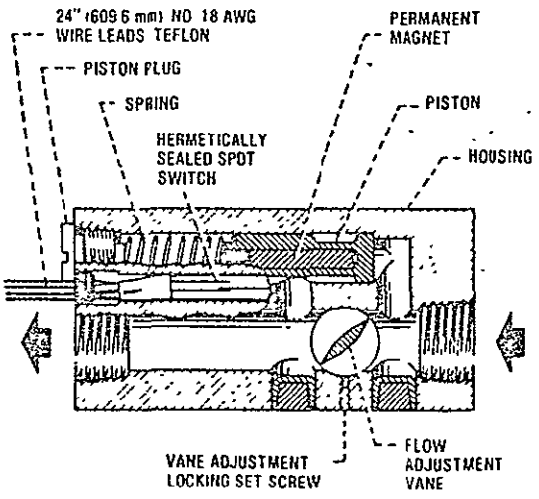
- **In electronic apparatus cooling systems . . .** for instant, automatic shutdown before system can be damaged by coolant flow fail-off.
- **On machine tools . . .** to protect expensive tools from coolant flow failure.
- **In chemical process systems . . .** where loss of, or too much flow would ruin the product.
- **For bearing protection in all industries . . .** to prevent production shut-downs from loss of lubricant.
- **As a simple, adjustable, auxiliary alarm for rotameters** in existing systems, test stands or process controls.
- **In gas flow applications** with any compatible gas requiring a precise set point for alarm or control of process.

OPERATING PRINCIPLE

Pressure differential, caused by flow around the adjusting vane, displaces a spring-biased, permanent-magnet-equipped piston which actuates a hermetically sealed, SPDT, magnetic switch within the unit. This switch operates a remote alarm or indicator; or may, through accessory relays, initiate automatic control of the system. Spring return of the piston is positive on decreasing flow . . . adjustment is set-screw-locked for tamper-free operation after field calibration.

CONSTRUCTION

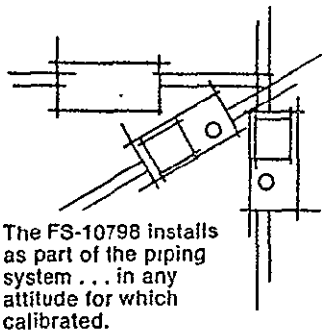
Rugged simplicity of design . . . and the use of high-quality, corrosion-resistant materials . . . insure the reliability of the FS-10798 over long, continuous service life. Units are of brass with Polysulfone pistons for water or brass pistons for oil, or of all-stainless-steel. The single moving part — the piston — has ample clearance to maintain a flushing action, which prevents foreign particle build-up.



FS-10798 Flow Switch cutaway.

INSTALLATION AND MAINTENANCE

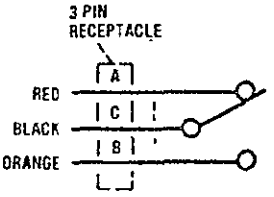
Standard pipe fitting procedures are used to install the FS-10798, with care taken to keep thread sealing compound out of the unit. While operation is reliable in any mounted attitude, the installed position of units calibrated at the factory must be specified for guaranteed set point accuracy. 50 micron filtration is suggested. However, if any foreign particle accumulation should occur, removing the piston plug, spring and piston assembly permits easy access to the chamber for cleaning. Units damaged in any way should be factory-serviced.



The FS-10798 installs as part of the piping system . . . in any attitude for which calibrated.

WIRING DIAGRAM

Switch at no-flow



Units are standard with three electrical connection alternatives:

- 24" (609.6mm) lead wires and strain relief.
- 24" (609.6mm) lead wires and ½" NPT conduit connector.
- 3-pin electrical receptacle.

SPECIFICATIONS

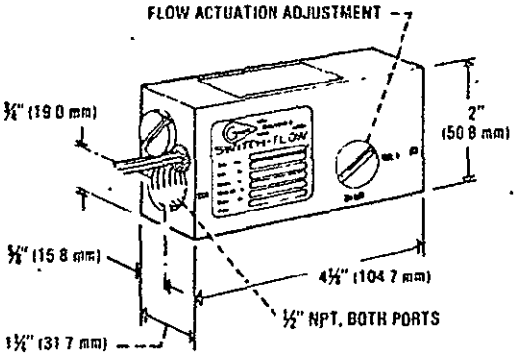
Materials of Construction:

Housing	Brass or 316 SS
Piston in Brass Housing	Polysulfone for water Brass for oil
Piston in 316 SS Housing	316 SS
Spring: All Units	316 SS
"O" Ring Seals	Viton
Liquid Flow Adjustment Range—Water	0 5 to 20 GPM
Pressure Ratings' Operating	1000 PSIG
Proof	2500 PSIG
Burst	5000 PSIG
Operating Temperature: with SS Piston	−20°F to +300°F
with Polysulfone Piston	−20°F to +225°F
Repeatability	1% Max. Daviation
Set Point Differential	15% Max.
Set Point Accuracy-Constant Temp	
Factory-set Standard	±10% Max
Customer-set	To Test Stand Accuracy
Temperature Effect on Set Point In:	
Water	Slight Change
Gas	Slight Change
Oil	Varies with Viscosity
Gas Flow Adjustment Ranges*— dependent on operating line pressures.	
For 5 PSIG Line	3 to 100 SCFM, Approx.
For 100 PSIG Line	8 to 475 SCFM, Approx.
Switch	SPDT, 20 W

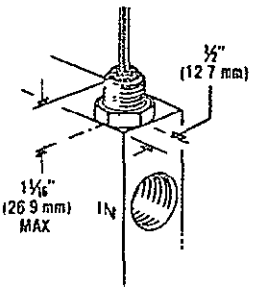
For switch data and electrical ratings, see page 15

*For special gas flow installations, consult the factory for complete "pressure vs flow" curves

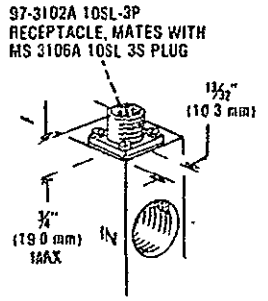
DIMENSIONAL DATA



FS-10798 with wire leads and strain relief.



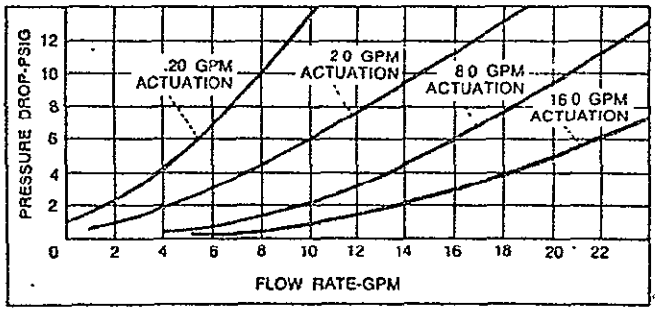
FS-10798 with ½" NPT conduit connector.



FS-10798 with 3-pin receptacle.

PRESSURE DROP CURVES

Test liquid-water at 70°F, all units horizontally mounted. Data will vary slightly for vertically mounted units.



ORDERING DATA

When ordering Gems FS-10798 Flow Switches, please specify the correct parts list (P/L) numbers for the actuation adjustment ranges and materials required from the table below.

Flow Adjustment Range	Material	Parts List (P/L) Nos. With Lead Wires	With ½" Conduit Connect.	With 3-pin Receptacle
0 5-20 0. GPM (Water)	Brass	25357	25363	25369
	316 SS	25358	25364	25370
Gases—See Specifications	Brass	25359	25365	25371
	316 SS	25360	25366	25372

For flow adjustment ranges below 0 5 GPM, consult factory for other standard model units.

OPERATING INSTRUCTIONS & PARTS LIST

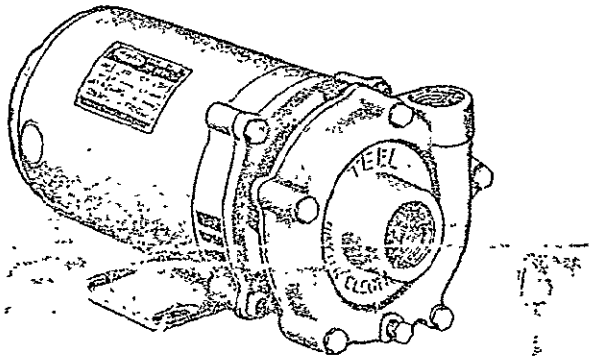
CLOSE-COUPLED CENTRIFUGAL PUMPS (Bronze)

MODELS 1P787 THRU 1P793

FORM 5S1164

DAYTON ELECTRIC MANUFACTURING CO. CHICAGO 60648

0374/068/5M 2



Description

Teel Centrifugal Pumps use an open type, curved vane impeller centrally located and rotating in an efficiently designed volute housing. The medium to be pumped enters the eye of the impeller and is picked up by the vanes. It is then accelerated to a high velocity by rotation of the impeller and discharged by centrifugal force into the volute and out the discharge. This simplicity of operation affords operation under a wide variety of conditions. Centrifugal pumps when properly installed and maintained will operate trouble-free over long periods of time.

Quiet, continuous, high volume flow are features of your Teel Pump. The complete absence of contacting parts assures long life. The Close-Coupled Pump and Motor Unit operates at 3450 RPM to give maximum design efficiency. Maximum horsepower is required with a wide open discharge line. Increasing the pressure head (discharge restriction) decreases the power required.

Specifications

Model	Dayton Motor HP	Type	60 Hz. Volts	Inlet	Outlet	High	Wide	Long
1P787	1/3	Split Phase	115	¾"	½"	6"	6½"	12½"
1P788	1/2	Capacitor	115/230	1	¾	6¼	6¾	12½
1P789	3/4	Capacitor	115/208-230	1	¾	6¼	6¾	13¼
1P790	1	Capacitor	115/208-230	1¼	1	8½	6¾	14
1P791	1½	Capacitor	115/208-230	1¼	1	6¼	6¾	14
1P792	3/4	3-Phase	208-220/440	1	¾	6½	6¾	13¼
1P793	1½	3-Phase	208-220/440	1¼	1	6½	6¾	14

Performance

Model	PUMP HEAD IN FEET 5'	10'	15'	20'	30'	40'	50'	60'	70'
1P787	29	26	25	23	17	12	2	—	—
1P788	43	37	32	28	20	2	—	—	—
1P789	83	78	75	68	57	47	22	1	—
1P790	89	86	83	76	67	54	37	16	—
1P791	95	94	92	88	77	66	52	32	—
1P792	83	78	75	68	57	47	22	1	—
1P793	95	94	92	88	77	66	52	32	—

Safety

When wiring motor, follow all local electrical and safety codes, as well as the National Electrical Code (NEC) and the Occupational Safety and Health Act (OSHA).

Motor must be securely and adequately grounded. This can be accomplished by wiring with a grounded, metal-clad raceway system, by using a separate ground wire connected to the bare metal of the motor frame, or other suitable means.

Always disconnect power source before working on or near a motor or its connected load. If the power disconnect point is out-of-sight, lock it in the open position and tag to prevent unexpected application of power.

Be careful when touching the exterior of an operating motor — it may be hot enough to be painful or cause injury. With modern motors this condition is normal if operated at rated load and voltage — modern motors are built to operate at higher temperatures.

Do not insert any object into motor.

Thermal Protection

Motor is equipped with an automatic reset thermal protector, and may restart unexpectedly when motor and protector cools after tripping. Protector tripping is an indication of motor overloading as a result of operating the pump at low heads (low discharge restriction), excessively high or low voltage, inadequate wiring, incorrect motor connection, or a defective motor or pump.

Installation

Improper installation may cause poor pump efficiency, increase power consumption and decrease operating life. Position your pump as close as possible to the source of liquid. Keep the suction line as short and direct as possible. Plan and install the suction line so that air pockets cannot form in it. Use a minimum of elbows and fittings and use a length of straight pipe at least 6" long for the entrance into the pump suction. Never use pipe smaller than the pump port sizes and preferably use the next larger size. A suitable strainer should be installed in the suction line. The net area of the strainer must be at least four (4) times that of the suction pipe.

Location

Locate pump close to and below the liquid level supply so that there will always be a positive supply of fluid at the pump inlet. If necessity demands that the pump be located above the liquid level, a positive sealing foot valve or check valve must be installed in the suction line below the liquid level.

Open, dripproof motors are designed to be used in clean, dry location with access to an adequate supply of cooling air. Ambient temperature around the motor should not exceed 104°F (40°C). For outdoor installations, motor must be protected by a cover that does not block air flow to and around the motor. For hazardous locations (explosive atmosphere), an explosion-proof motor may be required; consult your local governmental inspection agency for guidance.

Suction

Proper suction is the most important part of your pump installation. Most centrifugal pump problems can be traced to improper suction conditions. Flooded suction conditions have been outlined above. On a suction lift installation, install a foot valve at least 3 feet below the liquid level. Make sure there are no air leaks in this line. Suction lifts of more than 15 feet should be avoided.

Power

Voltage, frequency and phase of power supply must be that shown on the motor nameplate. On three phase systems, voltage on all three lines must be balanced. Unbalance greater than a 2 volt variation line-to-line can result in reduced torque, increased heating and noise, and premature motor failure. Low voltage can reduce performance and cause overheating.

Motor current may exceed rated value because of overloading or high voltage. Voltage 5% or more above rated will cause both no load and full load current to increase, frequently above nameplate value.

Wiring

All wiring and electrical connections must comply with the National Electrical Code (NEC) and local electrical codes. In particular, refer to Article 430, "Motors, Motor Circuits and Controllers," of the NEC.

Use of a motor starter, either manual or magentic, incorporating thermal protection, is advisable and may be required by local electrical codes. Follow motor starter manufacturer's recommendations on thermal overload relay heater selection. Do not oversize heaters. On three phase systems, three heaters must be used.

Wherever possible, each motor should be powered from a separate branch circuit of adequate capacity to keep voltage drop, during starting and running, to a minimum. Increase wire size where the motor is located a distance from the power source.

Where extension cords are used, they should be as short as possible, for minimum voltage drop. Long or inadequately sized cords, especially on hard starting loads, can cause motor failure. Always use grounding-type (3 conductor) extension cords in conjunction with a properly connected, grounding-type receptacle.

MINIMUM WIRE SIZES FOR WIRING AND EXTENSION CORDS

MOTOR	25 FT.		50 Ft.		100 Ft.		150 Ft.		200 Ft.	
HP	115V	230V	115V	230V	115V	230V	115V	230V	115V	230V
1/3	14	18*	12	18*	10	16*	8	14	6	12
1/2	14	16*	12	16*	8	14	6	12	6	12
3/4	12	16*	10	16*	8	14	6	12	4	10
1	12	16*	10	14	6	12	4	10	4	10
1½	10	14	8	14	6	12	4	10	2	8

*(Use only #14 AWG or larger wire for permanent installations)

To connect motor for proper voltage, refer to the **connection diagram located on the nameplate or inside the terminal box.** On three phase motors, interchange any two line leads to reverse rotation. On centrifugal pump applications involving a three phase motor with threaded shaft, motor rotation must be counterclockwise as viewed facing shaft end.

Operation

Priming

Your centrifugal pump must be satisfactorily primed before it will pump. Satisfactory priming requires that all air must be removed from the pump and suction lines and that these areas be completely filled with liquid. This must be accomplished with the pump at a standstill. A priming cup installed in the discharge line just above the pump is recommended.

Maintenance

Routine:

Pump should be drained if subjected to freezing temperatures. A drain plug is provided on the pump casing.

Clean the suction line strainer at regular intervals.

Properly selected and installed electric motors are capable of operating for years with minimal maintenance. Periodically clean dirt accumulations from open-type motors, especially in and around vent openings, preferably by vacuuming (avoids imbedding dirt in windings).

Pump motor is provided with sealed ball bearings. Normal relubrication of the bearings is not required.

Periodically check that electrical connections are tight.

Mechanical Seal

All Teel pumps are furnished with a precision mechanical seal. This seal is installed and checked at the factory and should require no adjustment at the time of the installation of the pump. Running the pump without water will result in rapid seal failure.

Maintenance (Cont.)

After the pump has been in service for a long period of time, or if the pump has seen severe service on abrasive materials, it may be necessary to replace this seal (the seal may leak). Leakage can be detected by a dripping or flow of liquid from the area around the motor shaft.

The following instructions cover the removal and replacement of the mechanical seal:

CAUTION: The precision lapped faces on the mechanical seal are easily damaged. Handle your replacement seal carefully and read these instructions before attempting to replace the seal.

Removal of Old Seal

1. Disassemble the centrifugal housing (Ref. 8) from the pump by removing five (5) hex head capscrews (Ref. 11).
2. Unscrew the impeller (Ref. 7). A screwdriver slot is provided in the rear end of the motor shaft. (Remove bearing cap for access). To hold the shaft from turning, insert a large screwdriver blade into the slot. Thread is standard right hand. Turn the impeller counterclockwise to remove.
3. Grasp the ceramic seal seat (Ref. 5) and slip from the motor shaft.
4. Remove the pump body (Ref. 3) from the motor by removing four (4) hex head capscrews (Ref. 4).
5. Remove the spring seal (Ref. 5) by pushing from the direction of the pump body mounting flange (Ref. 3). Care must be exercised with pusher so as not to damage the seal cavity area.

Installation of Replacement Seal

1. Clean the centrifugal body seal cavity before inserting a new seal.
2. Using a clean cloth wipe the shaft and make sure that it is perfectly clean.

   If removed, slide the rubber shaft slinger washer (Ref. 2) on the shaft until it is located about ⅛" from the face of the motor bearing hub.
3. Carefully wipe the surface of the ceramic seat with a clean cloth.
4. Wet the rubber portion of the ceramic seat with a light coating of oil, bore only.
5. Press the brass cap, bellows, and spring squarely into the cavity in the casing cover. Do not distort the brass cap. Press uniformly around its flange.
6. After the seal is in place, insure that it is clean and has not been scratched or cracked.
7. Mount the centrifugal body (Ref. 3) on the motor mounting face. Carefully guide motor shaft through seal.
8. Apply a light coating of oil on the motor shaft. Slide the seal seat onto the shaft (with the sealing face first). Use a ⅝" I.D. tube, or ½" drive socket to aid in pushing the rubber portion on to the shaft.

HOW TO ORDER REPLACEMENT PARTS

Please provide following information:

- Model Number
- Serial Number (if any)
- Part Description and Number as shown in Parts List.

Address order to:

Dayton Electric Mfg. Co.

CUSTOMER SERVICE DEPT.

5959 W. Howard St.

Chicago, Illinois 60648

LIMITED WARRANTY

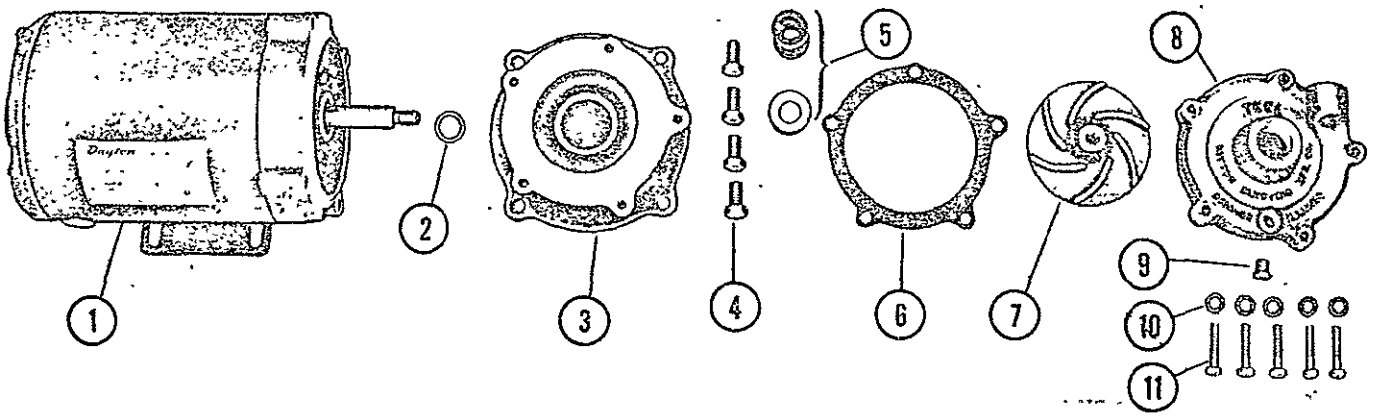
Teel Centrifugal Pumps are warranted against defects in workmanship or materials, under normal use (rental excluded) for one year from date of purchase.

Liability in all events is limited to the purchase price paid and liability under the aforesaid warranty is limited to replacing or repairing any part or parts which are defective in material or workmanship and returned to our Factory or Authorized Service Station, shipping cost prepaid No warranty, expressed or implied, other than the aforesaid is made or authorized by Dayton Electric Mfg. Co

PROMPT DISPOSITION will be made if item proves to be defective, within warranty Before returning any item, write or call Dayton Electric Mfg Co or dealer from whom product was purchased, giving date and number of original invoice, and describe nature of defect. If damage was incurred during transit to you, file claim with carrier.

DAYTON ELECTRIC MFG CO., 5959 W. HOWARD STREET, CHICAGO, ILLINOIS 60648

Replacement Parts List



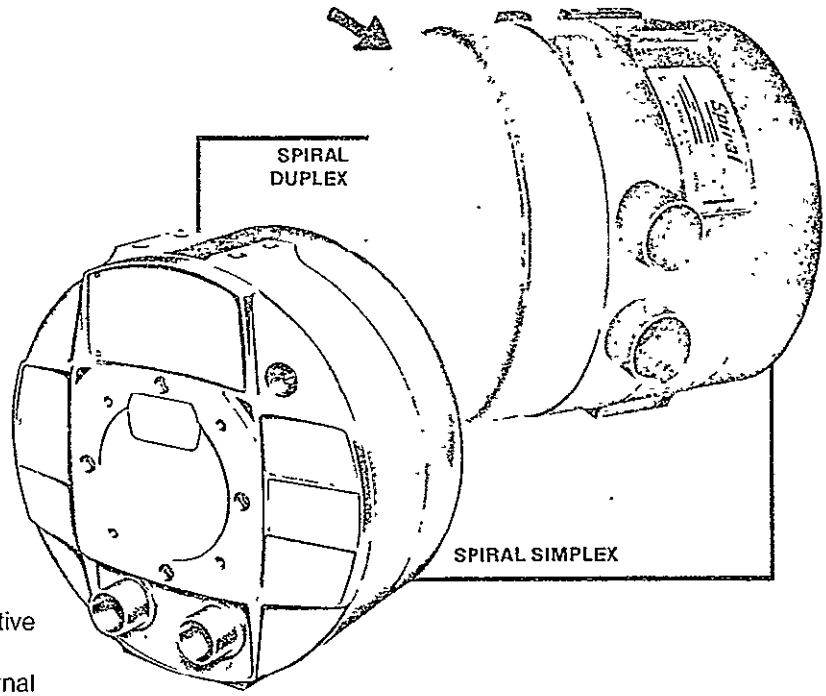
Ref. No.	Description	Qty. Req'd.	Part Number for Model 1P787	1P788	1P789	1P790	1P791	1P792	1P793
1	Motor	1	6K492	6K497	6K507	6K511	6K516	3N088	3N090
2	Slinger	1	6150	6150	6150	6150	6150	6150	6150
3	Centrifugal Body	1	11614	11584	11584	11584	11584	11584	11584
4	Hex Bolt	4	(*a)	(*a)	(*a)	(*a)	(*a)	(*a)	(*a)
5	Seal and Seat Ass'y.	1	11625	11625	11625	11625	11625	11625	11625
6	Gasket	1	11616	11618	11618	11618	11618	11618	11618
7	Impeller	1	11605	11748	11592	11755	11590	11592	11590
8	Centrifugal Housing	1	11537	11617	11617	11536	11536	11617	11536
9	Drain Plug	1	(*b)	(*b)	(*b)	(*b)	(*b)	(*b)	(*b)
10	Lockwasher	5	(*c)	(*d)	(*d)	(*d)	(*d)	(*d)	(*d)
11	Hex Bolt	5	(*e)	(*f)	(*f)	(*g)	(*g)	(*f)	(*g)

* These parts are available locally.
(a) 3/8-16 x 3/4" Long Hex Head Bolt.
(b) 1/8" Pipe Plug.
(c) 1/4" Light Lockwasher.
(d) 5/16" Light Lockwasher.
(e) 1/4-20 x 1-1/4" Long Hex Head Bolt.
(f) 5/16-18 x 1-1/4" Long Hex Head Bolt
(g) 5/16-18 x 1-3/4" Long Hex Head Bolt.

ROTRON® INCORPORATED

Spiral® Simplex and Duplex

HIGH PRESSURE BLOWERS



FEATURES

- ☐ High pressures or vacuums—to 30 or 50 inches H_2O
- ☐ Oil free air flow—no possible contamination
- ☐ 115 or 230 vac • 1 or 3 phase • 50/60 Hz
- ☐ Precision extra-wide ball bearings
- ☐ Long, maintenance-free life

APPLICATION

The Spiral *Simplex* produces high positive or negative air pressures at low air volume.

The Spiral *Duplex* produces high pressures by internal ducting of the airflow from the two impellers in Model SL4. Model SL5 extends the airflow range. Model SL6 provides an economical source of two independent high pressure air streams.

Both the Simplex and Duplex blowers achieve their high performance without the use of sliding vanes or seals as in positive displacement pumps. Contacting surfaces are confined to the precision extra-wide ball bearings. Life expectancy is enhanced by the low speed motors as well as the absence of brushes and commutators. Because brushes and commutators are eliminated, the Spiral Simplex and Duplex blowers will not generate troublesome RF noise. This fact makes the Spirals especially attractive for those applications where spark-generated interference is bothersome.

The Spiral Simplex has been successfully put to use in the computer industry as

- ☐ a vacuum source for computer tape slack control columns
- ☐ a pressure source for tape air bearings
- ☐ a differential pressure source in card handling equipment and paper sorting machines

The Simplex has been applied in general industry as a pressure/vacuum source for cleaning debris from benches or machine tools.

The Spiral Duplex has been successfully applied in a wide variety of applications, including.

- ☐ magnetic tape control and capstan motor cooling in one package (MSL6).
- ☐ document and card handling equipment
- ☐ paper tape and card reading equipment
- ☐ laser head cooling
- ☐ power supply for fluid amplifiers
- ☐ printed circuit motor cooling
- ☐ gas sampling and purification
- ☐ air bearings for tape and film
- ☐ dryers for plastic pellets
- ☐ micro wave cavity cooling

The Spiral Simplex and Duplex will operate reliably in ambients up to +55°C.

APPLICATION NOTES

Aerodynamic heating of the air passing through the blower can result in excessive motor temperature at low flows

Simplex– below flows of 5 cfm for periods of more than five minutes per hour of operation, it is recommended that the optional accessory trimmer valve be used

Duplex– below flows of 10 cfm for periods of more than five minutes per hour of operation, it is recommended that the optional accessory trimmer valve be used.

The trimmer valve will permit flow of enough air through the blower to maintain safe motor temperatures. When started up, the Simplex and Duplex blowers will produce somewhat higher pressures. However, the pressure will decrease to the stabilized values given in the performance curves when operating temperature is reached

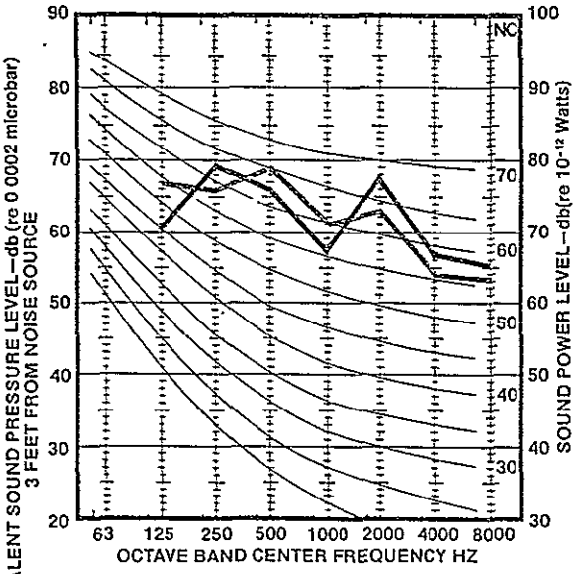
CONSTRUCTION

Simplex and Duplex

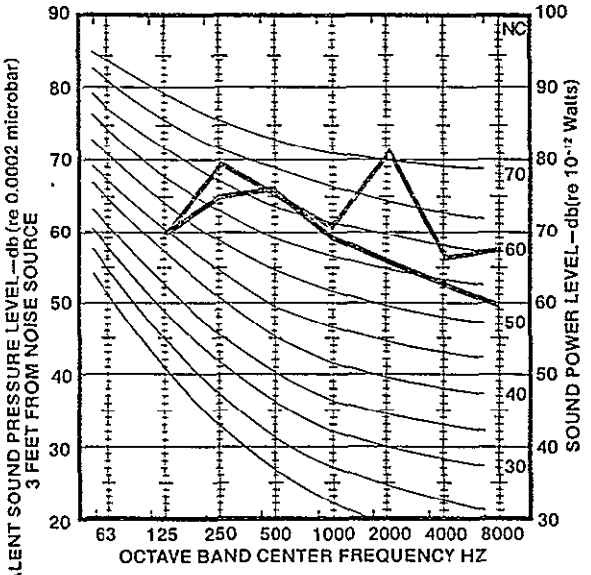
- ☐ Motors are single phase permanent-split capacitor or three phase induction motors
- ☐ Motor housing, End bells, Air impellers } high strength die cast aluminum
- ☐ NEMA Class F insulation
- ☐ Precision alloy steel, extra-wide ball bearings lubricated for long, maintenance-free life
- ☐ Stainless steel motor shafts
- ☐ Blower covers are cold rolled steel
- ☐ External finishes are satin blue enamel

ACOUSTICS

Acoustical data was obtained in Rotron's reverberant room sound test facility, permitting accurate determination of sound power level (PWL) referenced to 10^{-12} watts. For easy comparison with other published data, the left hand ordinate of the graph shows the calculated sound pressure level (SPL) at a distance of three feet from the Simplex and Duplex blowers The SPL figures may be correlated with the NC contours drawn to determine the NC rating The NC rating of the Simplex and Duplex blowers will be found suitable for laboratories, computer rooms and similar applications



UNIT TYPE	LEGEND	FLOW (cfm)	SPEED (rpm)	PSIL (db)
SL4	———	35 CFM	3390	63.8
SL5	———	55 CFM	3200	64 5

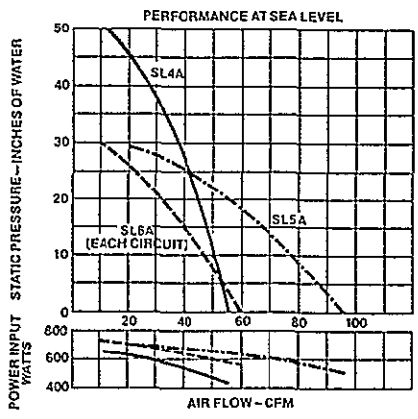


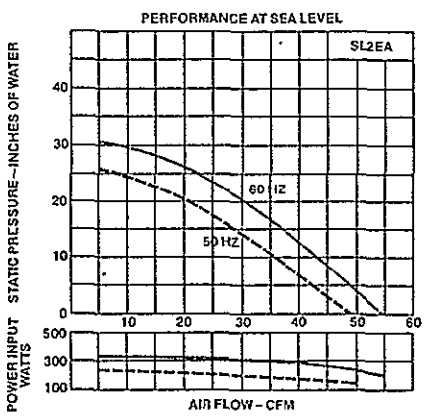
UNIT TYPE	LEGEND	FLOW (cfm)	SPEED (rpm)	PSIL (db)
SL2	———	30	3320	60.3
SL6	———	30 EACH CIRCUIT	3340	65 5

③

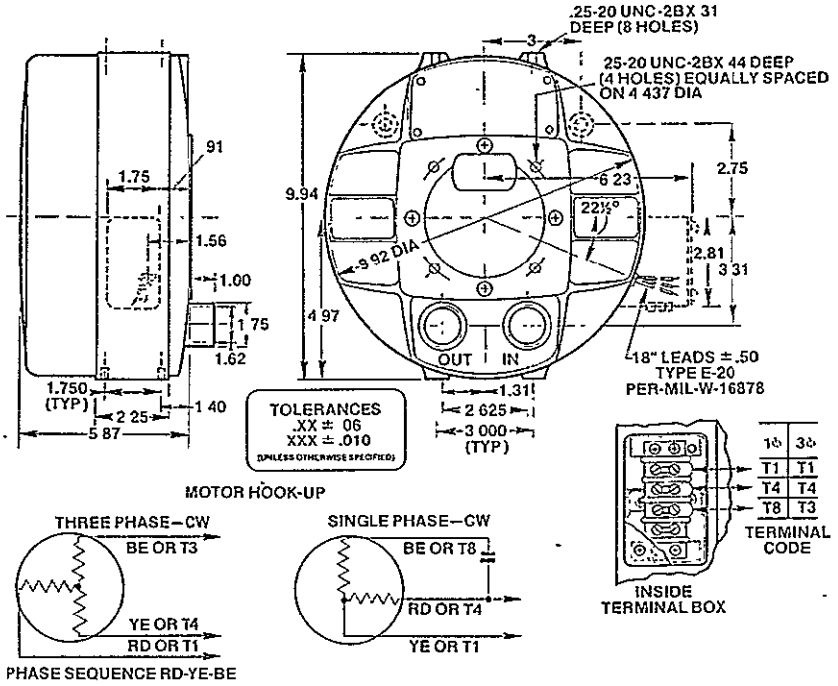
SPECIFICATIONS

Model No	Series	Part No	Volts	Ph	Hz	Cap Mfd	F/D Watts	F/D Amps	Locked Rotor Amps	CFM	Weight
Simplex											
SL2EA2F	876Z7	021571	115	1	50/60	25	240	2.20	7.5	55	21 9
SL2EA52F	1013Z7	027232	208-230	1	50/60	10	300	1 60	3 6	55	21 9
SL2EA33F	891W7	024863	208-230	3	50/60	—	210	0 80	4 9	55	21 9
Duplex											
SL4A2F	943Z7	023096	115	1	50/60	50	500	5 0	13.0	55	36
SL4A52F	949Z7	027233	230	1	50/60	25	400	2 5	6 5	55	36
SL4A33F	927W7	023508	208-230	3	50/60	—	400	1 3	8 0	55	36
SL5A2F	943Z7	020933	115	1	50/60	50	500	5.0	13 0	100	36
SL5A52F	949Z7	027234	230	1	50/60	25	500	2 63	6.5	100	36
SL5A33F	927Z7	020757	230	3	50/60	—	500	1.9	8 0	100	36
SL6A2F	943Z7	027235	115	1	50/60	50	525	5.5	13 0	55	36
SL6A52F	949Z7	027236	230	1	50/60	25	425	2 6	6 5	55	36
SL6A33F	927Z7	022121	208-230	3	50/60	—	425	1 7	8 0	55	36

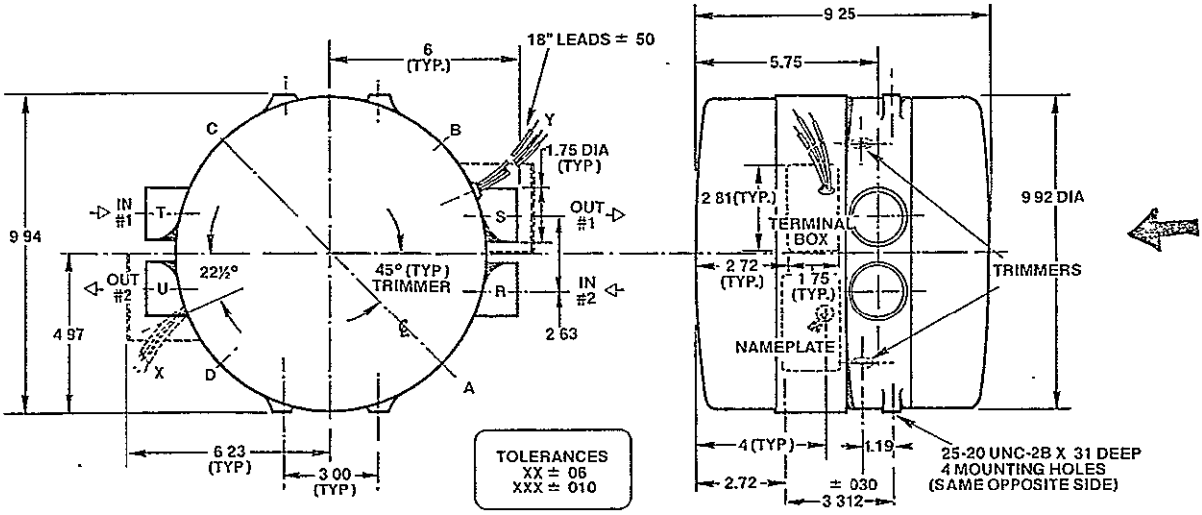




SPIRAL SIMPLEX



SPIRAL DUPLEX



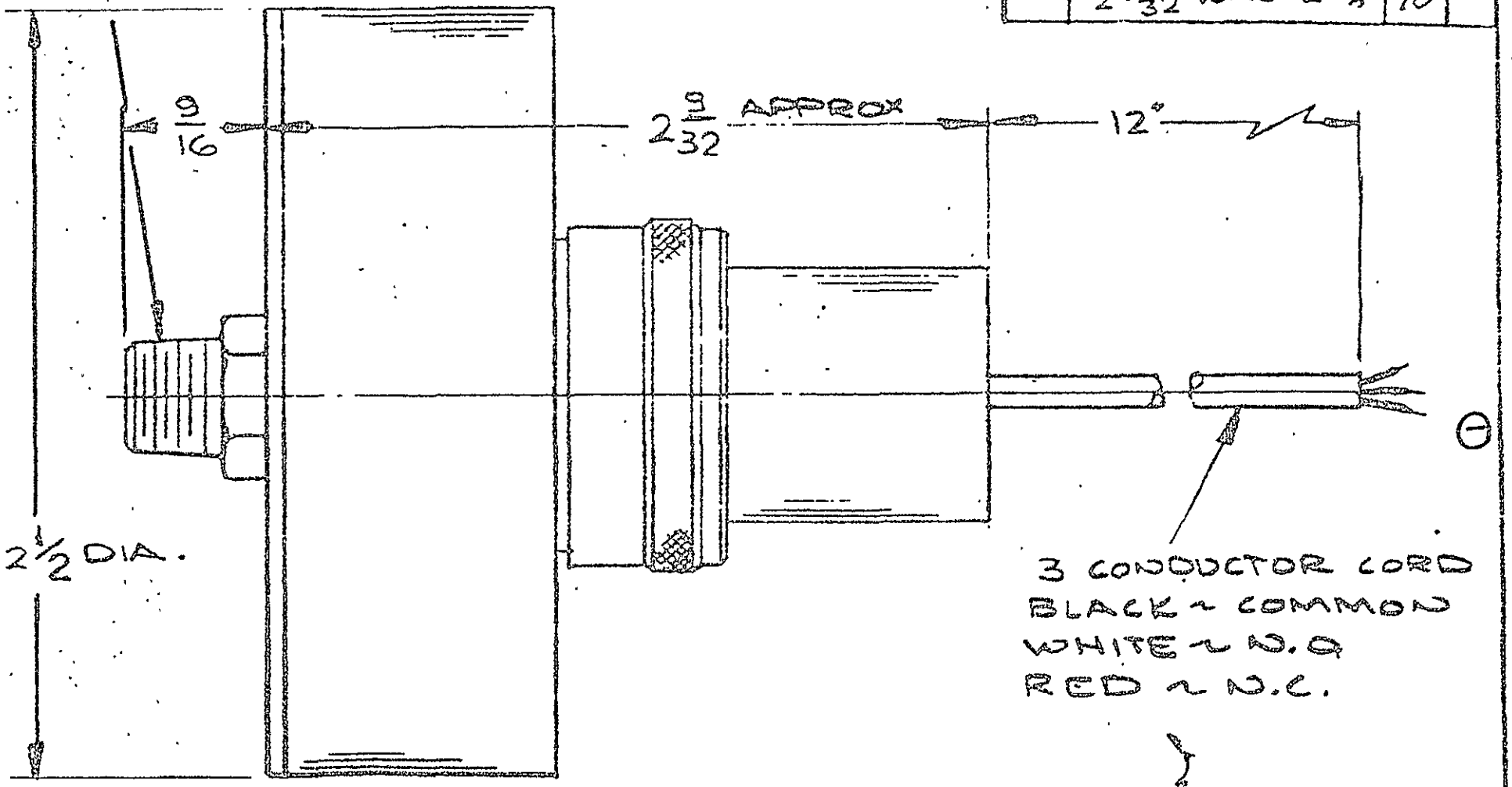
ROTRON INCORPORATED

ROTRON INC.

Woodstock, N.Y 12498 □ 914 • 679-2401 □ TWX 510-247-9033

Pacific Div., Burbank, Cal. 91506, 213•849-7871 • Rotron B V, Breda, Netherlands Tel: 79311, Telex 844-54074

A	2½ WAS 2 5/8 9/16 WAS ½ 2 9/32 WAS 2 3/8	3 17 78	D



SEE REVERSE SIDE FOR SPECIFICATIONS

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
REMOVE ALL BURRS, BREAK SHARP EDGES .003 - .015
UNMACHINED SURFACES NO FINISH SPECIFIED (MILL)
FRACTIONS ± .031
DECIMALS .X ± .030
.XX ± .010
.XXX ± .005
ANGLES ± 1°

WHITMAN GENERAL CORPORATION
TERRYVILLE, CONN.

MATERIAL	SCALE 2X1	DRWN. LARSON APVD.

TITLE SEALED SENSITIVE SPECIAL PRESSURE SWITCH

DATE	DWG. NO.	REV.
4-26-77	L110 SERIES	A

(2)

L110 SERIES

SPECIFICATION SHEET

PRESSURE ELEMENT

CAPSULE
NISPAN C OR 17-7PH

PRESSURE CONNECTION

1/8-27 NPT MALE
303 STAINLESS STEEL

OPERATING MEDIA

COMPATIBLE WITH 300 SERIES STAINLESS STEEL AND PRESSURE ELEMENT.

HOUSING MATERIAL

ALUMINUM
CLEAR ANODIZE

ELECTRICAL RATING

3, 5, OR 7 AMP @ 125V AC
3 TO 7 AMP RESISTIVE @ 28V DC
2 TO 4 AMP INDUCTIVE @ 28V DC
U.L. & C.S.A. LISTED

ELECTRICAL INTERFACE

T, TS, TSO, TB, L
(L is shown)

TEMPERATURE RANGE

-65°F TO +225°F

ADJUSTABLE RANGE

DASH NO.	DECREASING MIN. H2O	DECREASING MIN. PSI	DECREASING MAX. H2O	DECREASING MAX. PSI	INCREASING MIN. H2O	INCREASING MIN. PSI	INCREASING MAX. H2O	INCREASING MAX. PSI	SET POINT ACCURACY	PROOF PRESSURE
⇨ 1	.416	.02	50	1.8	2.8	0.1	50	1.8	±0.05 PSI	7.5 PSI
2	50.0	1.8	100	3.6	50.0	1.8	100	3.6	±0.05 PSI	7.5 PSI
3	2.8	0.1	250	9.0	28.0	0.7	250	9.0	±0.25 PSI	32.0 PSI
* 4	250.0	9.0	500	18.0	250.0	9.0	500	18.0	±0.25 PSI	32.0 PSI

* A "-4A" switch may be used for vacuum service from .2"Hg to 18"Hg ±.5"Hg set point tolerance.

* A "-4B" switch may be used for vacuum service from 12"Hg to 30"Hg ±.5"Hg set point tolerance.

Mobile Tile Glazing High Density Radiant Heating System Model 1023/8. Preliminary Manual and Instruction Manual

Research, Inc.
Minneapolis, MN

Prepared for

National Aeronautics and Space Administration
Washington, DC

May 79

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