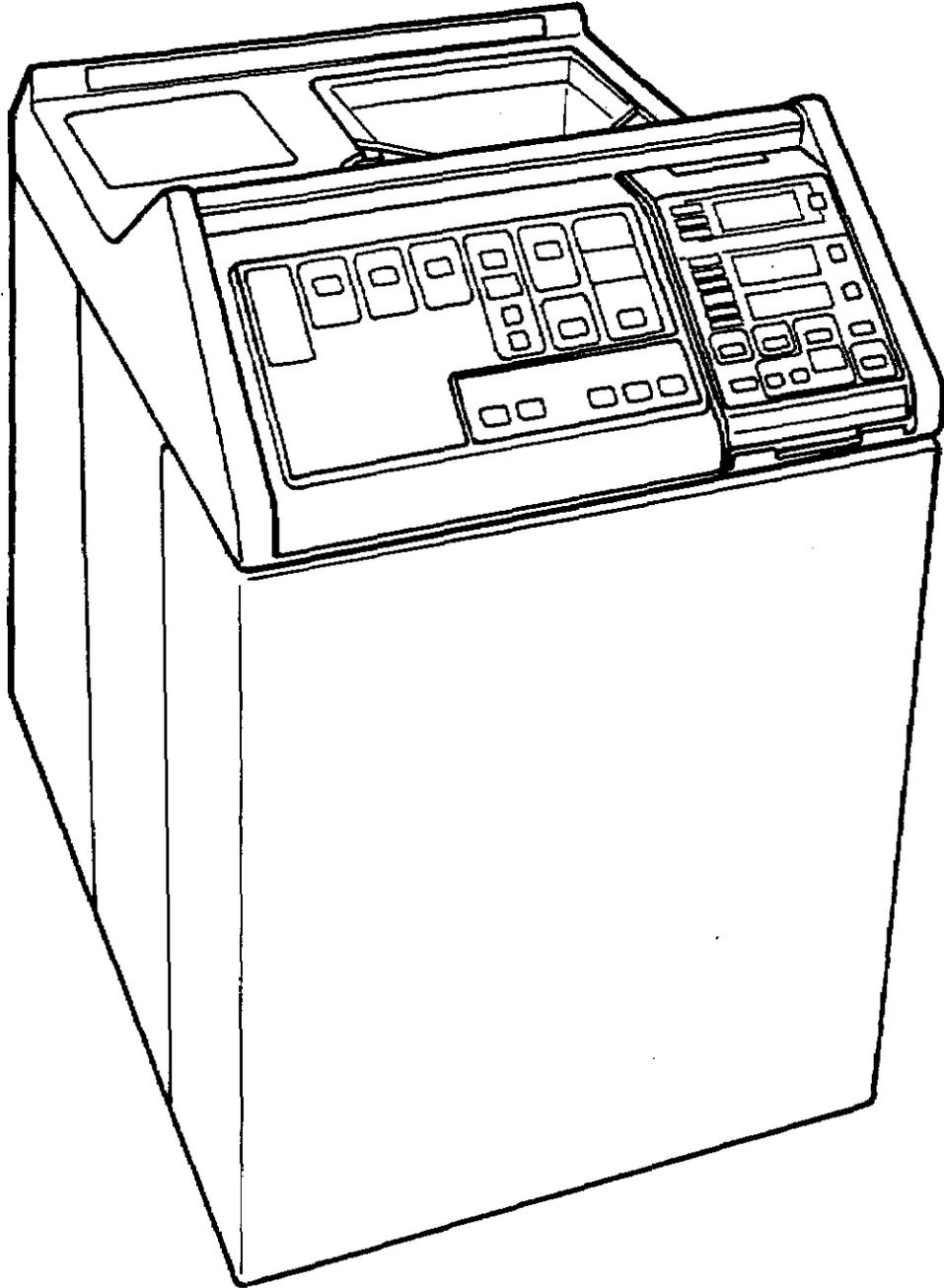


Field Service Handbook

Sarns™ TCM II



34-9998-2780-0 R/A

Sarns
3M Health Care
6200 Jackson Road
Ann Arbor, Michigan 48103

The 3M logo, consisting of the letters "3M" in a bold, stylized font.

How To Use This Manual

This manual provides technical information about the Sarns™ TCM II. It is intended for only those trained to service Sarns equipment. The information in this manual is specific to this device and should not be used for any other equipment.

Part Number 98-0702-0629-1 115V/60 Hz with Cardioplegia, Catalog No. 4415

Part Number 98-0702-0627-5 220V/50 Hz with Cardioplegia, Catalog No. 4416

Repairs may be made only by persons specifically trained and certified by Sarns to work on the TCM II.

Fully test the TCM II after each servicing.

Warnings:

Before servicing the system, disconnect the TCM II from the wall power source.

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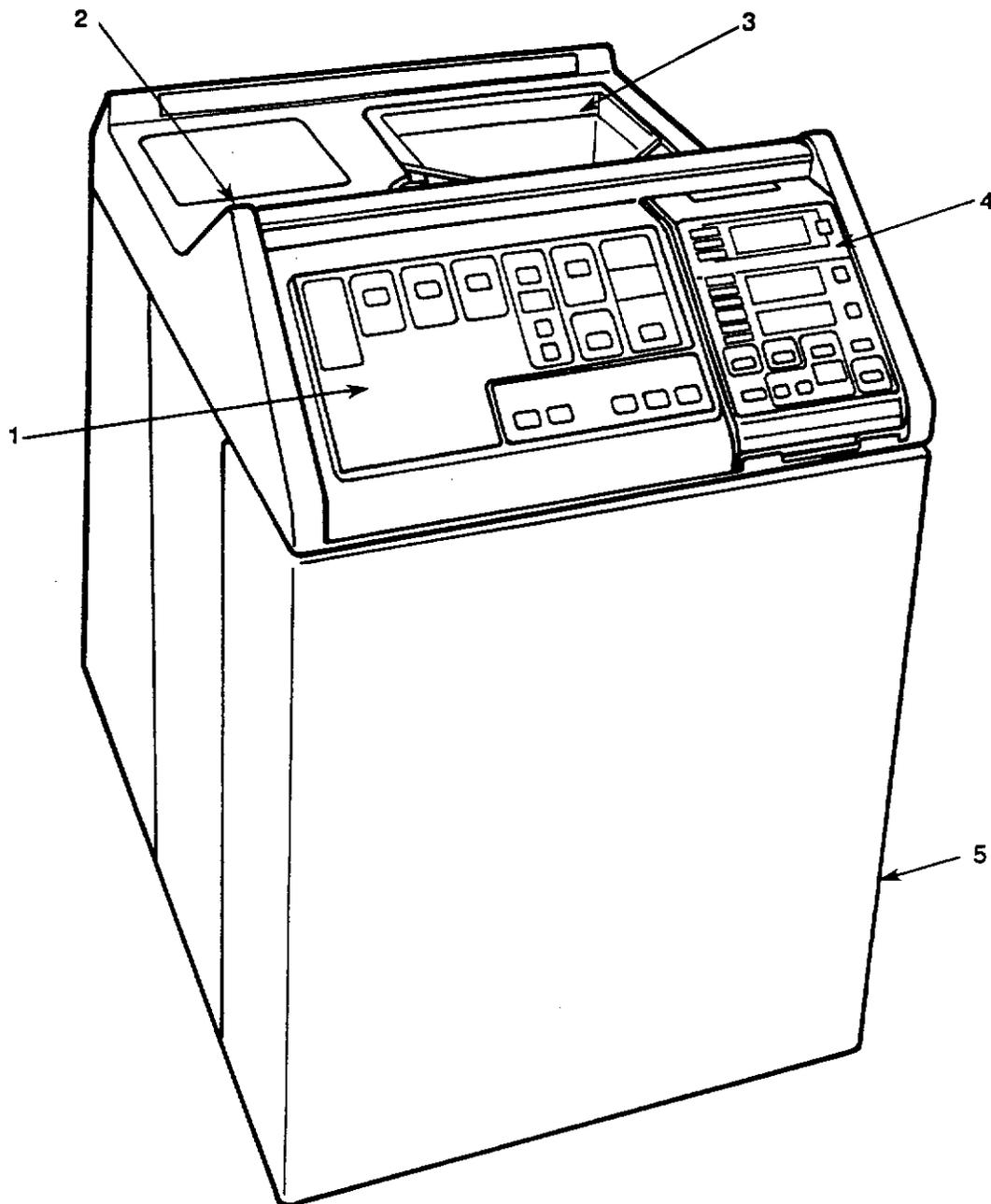
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1.1 Product Features



- | | |
|---------------------------|-----------------------------------|
| 1. Main Control Panel | 4. Remote Module |
| 2. Large Tank (not shown) | 5. Circuit Breakers and Run Timer |
| 3. Small Tank | |

Figure 1-1. Product Features

1.1 Product Features

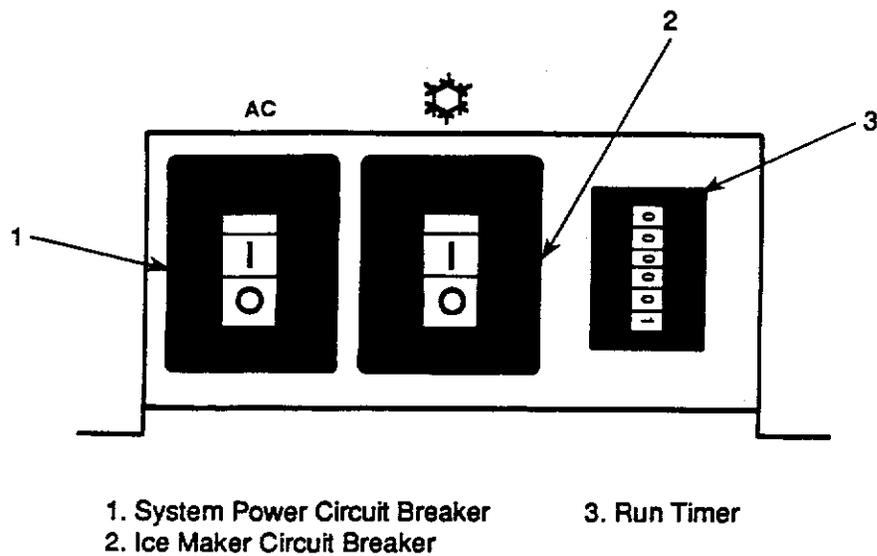
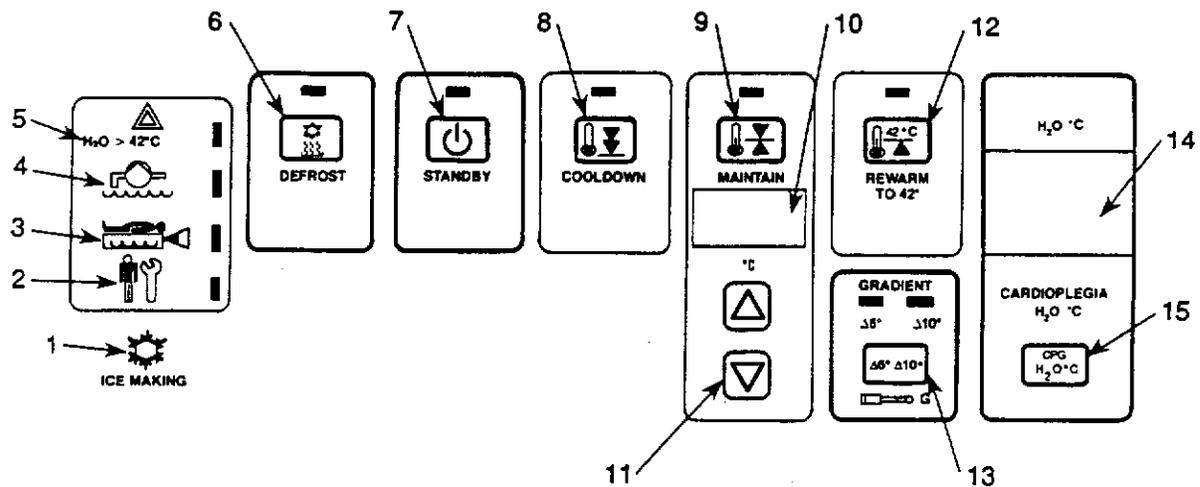


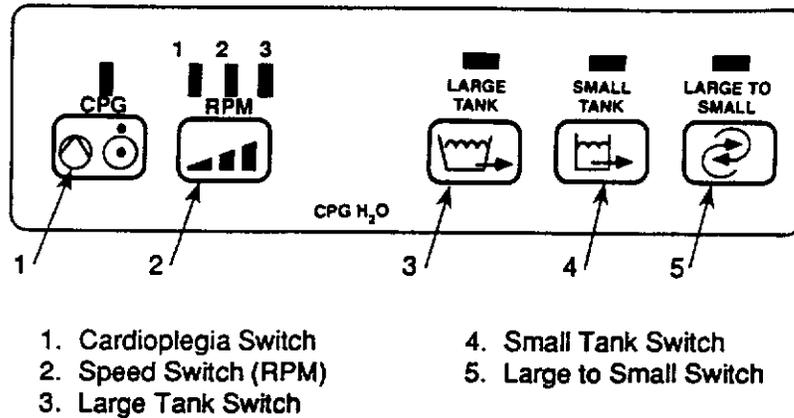
Figure 1-2. Side Panel



- | | | |
|-----------------------------------|----------------------------------|---------------------------------|
| 1. Ice Making Indicator | 6. Defrost (Mode) Switch | 11. Maintain Temperature Switch |
| 2. Service Indicator | 7. Standby (Mode) Switch | 12. Rewarm (Mode) Switch |
| 3. Low Flow to Blanket Light | 8. Cooldown (Mode) Switch | 13. Gradient Switch |
| 4. Pump Not Primed Light | 9. Maintain (Mode) Switch | 14. Water Temperature Display |
| 5. H ₂ O > 42 °C Light | 10. Maintain Temperature Display | 15. Cardioplegia Water Switch |

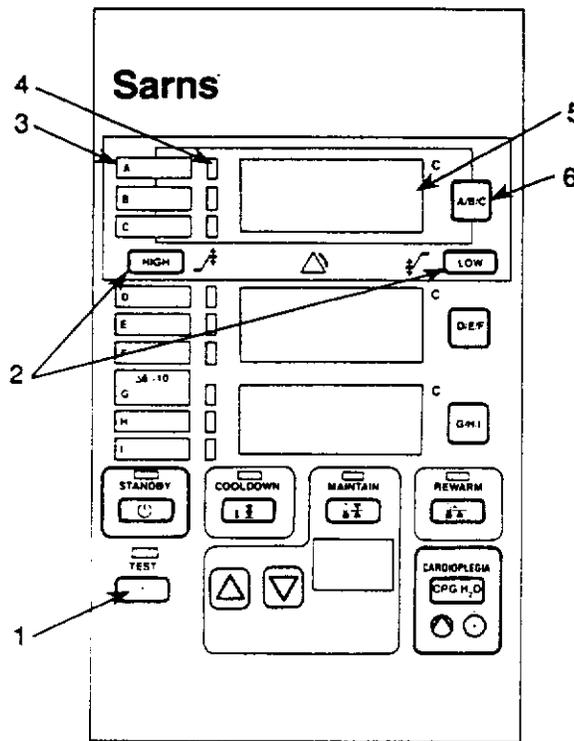
Figure 1-3. Main Control Panel

1.1 Product Features



- 1. Cardioplegia Switch
- 2. Speed Switch (RPM)
- 3. Large Tank Switch
- 4. Small Tank Switch
- 5. Large to Small Switch

Figure 1-4. Cardioplegia Panel



- 1. Test Switch
- 2. High and Low Alarm Switches
- 3. Probe Labels
- 4. Probe Light
- 5. Temperature Display
- 6. Probe Display Switch

Figure 1-5. Temperature Display Module Panel

1.2 Accessories

1.2.1 Accessory Kit (P/N 78-8067-4125-8)

The accessory kit includes the following items:

1. ARTERIAL HEAT EXCHANGER SUPPLY, P/N 16040010, 3M I.D. 78-8066-7416-0

Description	Size	Qty.	Sarns P/N	3M I.D. No.
Water Fitting	1/2 in. (12,7 mm)	2	16052010	78-8066-7421-0
Barbed Connector	1/2 in. (12,7 mm)	2	25324011	26-1008-4365-0
Hose Clamps		9	25325020	26-1008-4380-9
Drainage Line Assy Tubing	1/2 in. (12,7 mm) ID x 10 ft. (3,04 m)	1	30108113	26-1008-4429-4
Nylon Tee	1/2 in. (12,7 mm)	1	25612022	26-1008-4367-6
Ball Valve	1/2 in. (12,7 mm)	1	14191010	78-8066-7165-3

2. BLANKET SUPPLY, P/N 16042010, 3M I.D. 78-8066-7418-6

Description	Size	Qty.	Sarns P/N	3M I.D. No.
Water Fitting for Out	1/4 in. (6,4 mm)	1	16053010	78-8066-7420-2
Water Fitting for In	1/4 in. (6,4 mm)	1	16131010	78-8066-7437-6
Barbed Connector	1/4 in. (6,4 mm)	2	25321029	26-1008-1827-2
Hose Clamps		5	25325020	26-1008-4380-9

3. CARDIOPLEGIA WATER SUPPLY, P/N 16041010, 3M I.D. 78-8066-7417-8

Description	Size	Qty.	Sarns P/N	3M I.D. No.
Water Fitting	3/8 in. (9,5 mm)	2	16051010	78-8066-7420-2
Barbed Connector	3/8 in. (9,5 mm)	2	25324010	26-1008-1828-0
Hose Clamps		9	25325020	26-1008-4380-9
Drainage Line Assy Tubing	3/8 in. (9,5 mm) ID x 10 ft. (3,04 m)	1	30106093	26-1008-4427-8
Nylon Tee	3/8 in. (9,5 mm)	1	25612021	26-1008-0549-3
Ball Valve	3/8 in. (9,5 mm)	1	16048010	78-8066-7419-4

4. WATER SUPPLY CLEANING LOOP, P/N 16465101, 3M I.D. 78-8066-7522-5

5. CARDIOPLEGIA SUPPLY CLEANING LOOP, P/N 16465201, 3M I.D. 78-8066-7523-3

1.2.2 Temperature Display Module (P/N 15746)

1.2.3 Temperature Probe Module (P/N 15745)

1.2.4 Temperature Probes

Any YSI (Yellow Springs Instrument) 400 Series Probe or Sarns equivalent probe.

1.3 Functional Description

MAIN UNIT

The main unit, which supplies water for both a blood heat exchanger and a blanket, has five modes of operation. The standby mode allows any air trapped in the internal plumbing to rise up and out. In cooldown mode (see figure 1-6) the pump draws water through the ice water tank only for maximum cooling. In rewarm mode (see figure 1-7) the pump draws water past the heaters only for maximum warming to 42 °C. In maintain mode (see figures 1-8, 1-9 and 1-10) the operator selects a water temperature; water is drawn either past the heaters or from the ice water tank to attain and maintain the selected temperature. In defrost mode (see figure 1-11) the pump draws water past the heater and recirculates it through the large tank. To prevent accidentally defrosting the unit, defrost mode must be entered from standby mode. In all five modes the outlet water temperature appears on the digital display.

The ice maker can build at least 19 pounds (8,6 kg) of ice in 3 hours or it can produce an entirely new supply of 50 pounds (22,7 kg) in 8 hours. The defrost mode will turn off the compressor, defrost until the water temperature reaches 20 °C, and reactivate the compressor to build a new ice supply which is evenly distributed around the cold plate.

CARDIOPLEGIA WATER SUPPLY

The TCM II will provide water for a cardioplegia heat exchanger. Three pump speeds allow variation of the cooling rate of the cardioplegia by changing the water flow rate. Three water supply modes are available to accommodate different heat exchangers and demands. A large tank mode (see figure 1-12) pumps water from the large tank to external outlets for use with pressurized-water heat exchangers. A small tank mode (see figure 1-13) pumps water from the small tank to external outlets for use with pressurized-water heat exchangers; this allows independent cardioplegia cooling. A large to small tank mode (see figure 1-14) recirculates water from the large to the small tank and back for use with drop-in heat exchangers.

TEMPERATURE DISPLAY MODULE

The temperature display module may be used to monitor the temperature of the patient or extracorporeal circuit. Temperature probes are connected to a temperature probe module, which is installed in the rear of the TCM II. One temperature probe module will translate information from the three probes for display on the three digital displays. Up to nine temperature readings are available with the use of three temperature probe modules and nine temperature probes. Probe display switches are used to select which information will be displayed. Lights, next to alphabetically marked labels, indicate which probe has been selected. These labels have an erasable writing surface for marking the probe location in the patient or extracorporeal circuit.

1.3 Functional Description

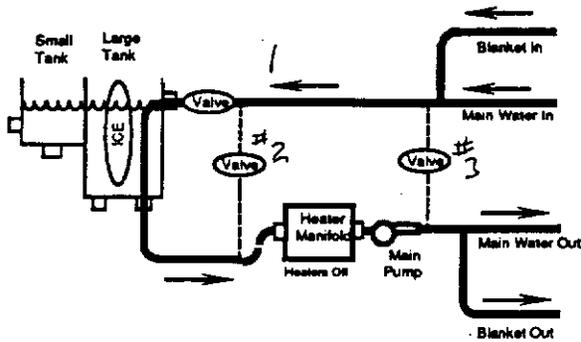


Figure 1-6. Cooldown Mode

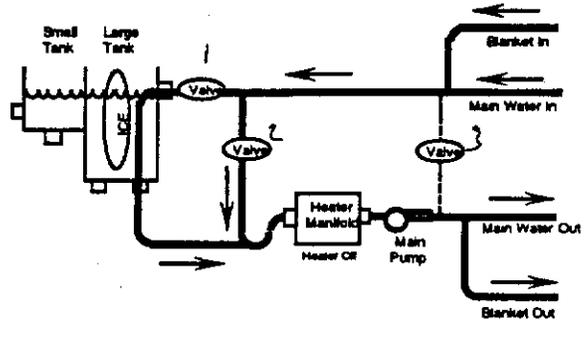


Figure 1-9. Maintain Mode
(Set Temperature slightly Less than Water Temperature)

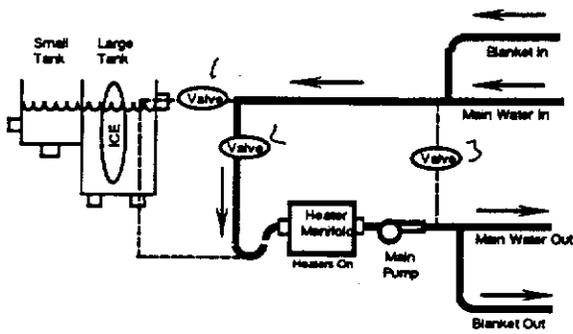


Figure 1-7. Rewarm Mode

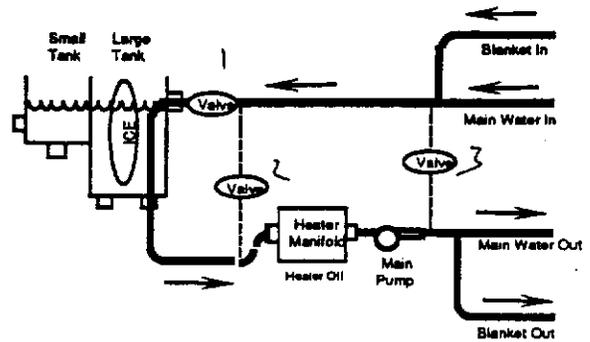


Figure 1-10. Maintain Mode (Set Temperature Much Less than Water Temperature)

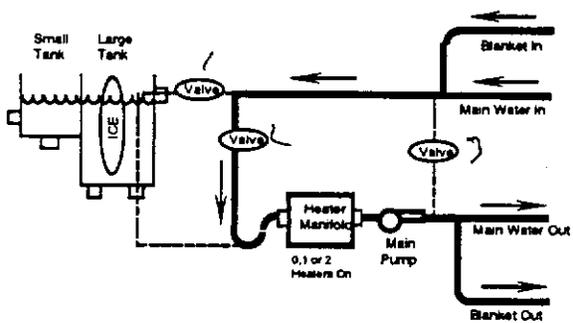


Figure 1-8. Maintain Mode
(Set Temperature Greater than or Equal to Water Temperature)

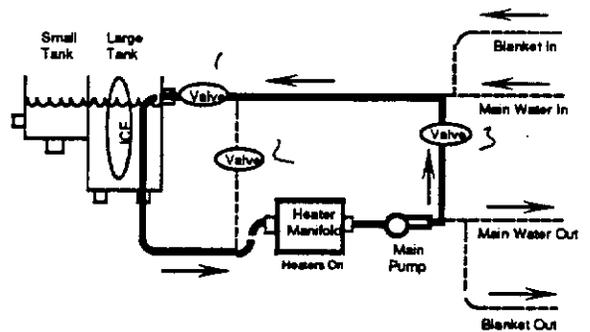


Figure 1-11. Defrost Mode

1.3 Functional Description

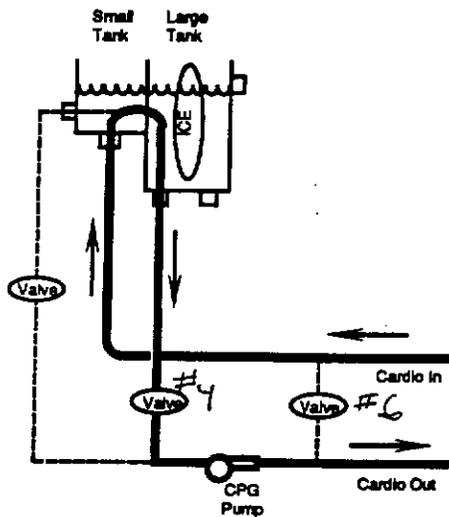


Figure 1-12. Large Tank CPG

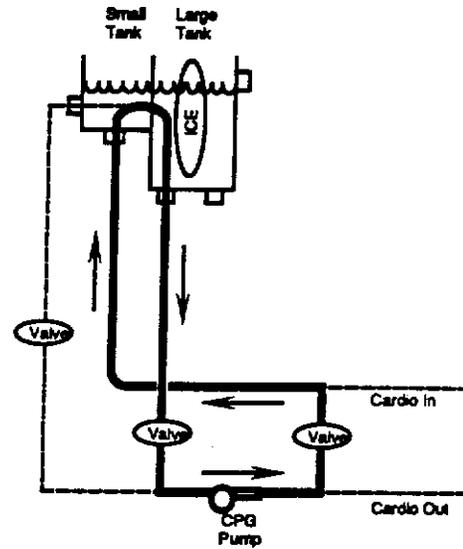


Figure 1-14. Large to Small CPG

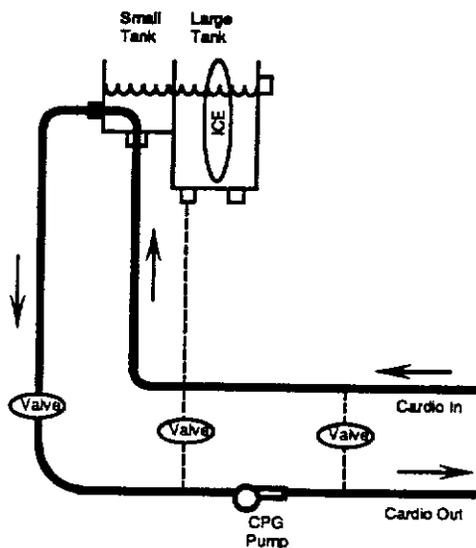


Figure 1-13. Small Tank CPG

Gradient rewarming frees the operator from constant monitoring and setting of temperatures. When probe G is measuring the venous blood temperature, gradient rewarming may be used to limit the warming rate of water to 6 °C or 10 °C above the temperature of the venous blood. Selecting a gradient while in rewarm mode allows microprocessors to maintain the correct differential between venous blood temperature and water temperature while heating the water to 42 °C. Selecting a gradient while in maintain mode allows the operator to select the maximum water temperature. Microprocessors will maintain the correct temperature differential until the desired maximum temperature is reached.

The temperature display module remote control function duplicates the main unit cooling, warming, and maintain controls and the cardioplegia pump On/Off switch. The module may be mounted on a vertical pole up to 7.5 feet (2,3 meters) from the main unit; the remote controls allow convenient operation of the main unit while monitoring temperatures.

1.4 Theory of Operation

For an arterial heat exchanger or blanket supply, water is drawn by the pump: 1) from a cold water reservoir for maximum cooling, 2) in a closed path past electric heaters for maximum warming, or 3) in a path with either cold reservoir water added or heat added to attain and maintain a set temperature. Microprocessors translate and compare thermistor probe measurements to the selected temperature; then they operate the correct valves and electric heaters to adjust the water temperature. The microprocessors also translate the probe measurements for digital displays. When a gradient relative to the venous blood temperature is used for rewarming, microprocessors measure the difference between venous blood temperature and water temperature and control the TCM II valves and heaters to maintain the correct differential.

The TCM II is designed to provide protection against excessively high temperatures. The maximum temperature available for operator selection is limited to 42 °C. The software compares the primary and redundant temperature probes in the heaters to verify temperature accuracy. The software will give an alarm and shut off the heaters if the temperature reaches 42.5 °C. In the event of software failure a completely separate monitoring system with an emergency circuit will shut off the heaters at 43.0 °C.

The ice maker is a compressor type refrigeration system which uses Dichlorodifluoromethane (R-12) for the refrigerant gas. The water freezes onto a cold plate located in the large tank. A sensor, near the cold plate, turns off the compressor when approximately 50 pounds of ice has collected.

For cardioplegia water supply, water is 1) drawn by a pump from a water reservoir, supplied to an external port, and returned; or 2) drawn from the large water reservoir, supplied to a small water reservoir, and returned to the large reservoir. The pump operates at three speeds to change the water flow rate. The mode and speed selections are activated by the cardioplegia switch.

For patient temperature monitoring, a thermistor, at the tip of each telethermometer probe, senses external temperature. When there is a shift in the external temperature, the electrical resistance of the thermistor changes accordingly. This resistance change is measured by the temperature probe modules, and transmitted for display.

The remote controls function in the same manner as their counterparts on the main unit. Choosing a mode on the remote panel causes the appropriate information to be sent to the main unit. The main unit acknowledges receiving the information by returning the information to the remote unit and illuminating the correct remote light. The display of the light on the remote unit indicates the change has been received on the main panel.

1.5 General Specifications

ELECTRICAL SPECIFICATIONS

Part Numbers:	98-0702-0629-1	98-0702-0627-5
Voltage:	108 to 122 V~ (115 V nominal)	210 to 250 V~ (220 to 240 V nominal)
Frequency:	60 Hz	50 Hz
Amperage:	16 A	12 A
Current Leakage:	100 microamps maximum for 115 V 500 microamps maximum for 220 V	
Ground Resistance:	0.1 Ohm maximum	

DIMENSIONS

MAIN UNIT

Height:	34.5 in. (87,6 cm)
Width:	20 in. (50,8 cm)
Depth:	29.5 in. (74,9 cm)
Weight:	294 lbs. (133,4 kg) with the tanks empty 386 lbs. (175,1 kg) with the tanks full

	LARGE TANK	SMALL TANK
Length:	18.5 in. (47,0 cm)	9.5 in. (24,1 cm)
Width:	8.7 in. (22,1 cm)	5.5 in. (14,0 cm)
Depth:	21.5 in. (54,6 cm)	9.3 in. (23,6 cm)
Capacity: Water	9 gal. (34 L)	1.2 gal. (4,5 L)
Capacity: Crushed Ice	40 lbs. (18,1 kg)	7.5 lbs. (3,4 kg)

	TEMPERATURE DISPLAY UNIT	TEMPERATURE PROBE MODULES
Height:	8-3/4 in. (22,2 cm)	9 in. (22,9 cm)
Width:	5-1/2 in. (14,0 cm)	5-3/4 in. (14,6 cm)
Depth:	2-1/2 in. (6,4 cm)	2-1/2 in. (6,4 cm)

1.5 General Specifications

PERFORMANCE

Water Outlet Temperature

Arterial Heat Exchange and Blanket: 0 to 42 °C
Cardioplegia: Ice Water Only
Heaters: 1 each - 700 watt, 850 watt, 115V units
2 each - 1000 watt, 220V units

Maximum Flow Performance (1/8 hp Pump)

Arterial Heat Exchanger* Outlet Port:
5.5 gal/min (21.0 L/min) at zero head
13.5 psi (700 mmHg) maximum pressure

Blanket Supply* Outlet Port:
0.8 gal/min (3.0 L/min) at zero head
11.8 psi (610 mmHG) maximum pressure

Cardioplegia Water Supply port:
2.1 gal/min (7.8 L/min)
7.5 psi (388.9 mmHg) maximum pressure

Ice Supply

If the large tank is filled to the maximum level with 25 °C water, the ice maker can provide a maximum of 50 lbs (22,7 kg) in 8 hours.

If the large tank is filled to the maximum level with 3 °C water, the ice maker can provide a maximum of 33.5 lbs (15,1 kg) in 3 hours.

Temperature Probe Module Operating Range: 0 to 50°C

Remote Temperature Sensing and Display Accuracy: ± 0.3 °C

Venous Differential Mode:

6 °C gradient = rewarm water temperature is held to a maximum of 6 °C more than the incoming venous blood temperature

10 °C gradient = rewarm water temperature is held to a maximum of 10 °C more than the incoming venous blood temperature

* Note: Performance will be different with both a heat exchanger and a blanket being supplied at the same time.

1.6 Performance Specifications

Note: This performance information was selected from the TCM II System Performance Specification.

1.6.1 Main Display Board and Cardioplegia Display Board

FUNCTIONAL DESCRIPTION

These boards are located in the TCM main unit. They contain a number of LED displays and indicators, and the drive circuitry for those displays. The cardioplegia display board contains the displays for the cardioplegia water supply. The purpose of these boards is to hold all the LED displays and indicators of the main control panel and to drive them according to signals from the computer; they also channel signals from the membrane switches on the control panel back to the computer.

PHYSICAL DESCRIPTION

Main Display - The main display board is a 10.59" (26.9 cm) by 3.5" (8.9 cm), odd-shaped, double-sided board, with four mounting holes for #8 screws. It has four connectors. The board features a pair of large seven-segment red LED displays, a pair of smaller seven-segment yellow LED displays, and thirteen rectangular single-LED indicators, four red and nine green. It also contains a number of logics devices and other components. Components must be low-profile because this is a display board, and in fact, three of the connectors (P29, J31 and J32) are mounted on the non-component side of the board for this reason.

Cardioplegia Display - The cardioplegia display board is a 5.35" (13.6 cm) by 1.45" (3.7 cm), double-sided board, with two mounting holes for #6 screws. It has two connectors, which are mounted on the non-component side. This board also contains seven rectangular green LEDs and a DIP resistor array.

ELECTRICAL DESCRIPTION

The main display board uses the +5 volt supply from the main board. The board has LED displays and indicators, TTL logic, and CMOS logic devices. The cardioplegia display board has no components requiring a power supply.

INTERFACE DESCRIPTION

Main Display - P29 is a 34-pin connector for an IDC ribbon cable which goes to the main board; P30 accepts the flat cable from the main membrane switch panel; J31 connects this board to the cardioplegia display board (described below) through a short 16-pin ribbon cable; J32 is similar to J31, but is presently not used.

Cardioplegia Display - J33 connects this board to the main display board (described above) through a short 16-pin ribbon cable; P34 accepts the flat cable from the cardioplegia membrane switch panel.

1.6 Performance Specifications

1.6.1 Main Display Board and Cardioplegia Display Board (Continued)

THEORY OF OPERATION

Main Display - This board receives an output data bus from the A/D-timer board via the main board, which is derived from the expansion output data bus of the main computer board. It also receives four output lines from, and sends four input lines to the computer via the main board. Finally, it receives a strobe line from the A/D-timer board. The output data bus is latched by two types of latches: IC2 through IC5 are BCN-to-seven-segment latch/decoder/driver, which drive the four LED digit displays on the board, while IC6 through IC10 are octal latches, which drive the single-LED indicators and the column-strobes of the membrane switch panels. IC1 decodes three output lines (upon strobe and chip-select) to eight lines, which are used as strobes for the various latches just mentioned.

IC8 drives the column-select lines of the membrane switch panels as follows: four on the main panel, two on the cardioplegia panel, and two on the "future expansion" panel. No more than one of these lines should be driven at any one time. If a key is being pressed in the presently selected column, then the column-select signal will appear on the row line of that key, which is channeled via the display board back to the computer.

J31 connects through a short ribbon cable to J33 on the cardio display board. That board is simply an extension of the main display board, with its own LEDs and membrane panel, but depending on the main display board for its drivers. J32 is capable of supporting another option board electrically identical to the cardio display board, but there is no provision for mounting such a board.

Cardio Display - The cardioplegia display board is merely an extension of the main display board. It contains additional single-LEDs, a resistor array to limit LED current, and two connectors: J33 accepts a short ribbon cable from the main display board and P34 accepts the flat cable from the cardioplegia membrane switch panel. The devices that drive and select the LEDs and membrane switches are actually on the main display board.

CALIBRATION SPECIFICATIONS

These boards require no calibration except possibly of displays and LEDs before assembly to ensure good matching of color and intensity.

1.6 Performance Specifications

1.6.2 TCM Cardioplegia Relay Board

FUNCTIONAL DESCRIPTION

The Cardioplegia Relay Board is located in the TCM main unit. Its purpose is to drive the three cardioplegia valves and the cardioplegia water pump according to signals it receives from the main computer. The valves are either On or Off, whereas the pump may be Off or operating at Low, Medium, or High speed.

PHYSICAL DESCRIPTION

The Cardioplegia Relay Board is a 10.5 in. (26.7 cm) by 3.8 in. (9.6 cm) with six mounting holes for #6 screws. There are five connectors on the board. The board also has four replaceable fuses.

ELECTRICAL DESCRIPTION

The Cardioplegia Relay Board uses two DC supply voltages, +10 VDC from the main board and +12 VDC generated on the relay board. The +10 VDC is fused at 0.1 amp (F1). The +12 volt supply transformer primary is fused at 0.1 amp (F2), and the secondary at 0.1 amp (F3). The board also gets several AC voltages from the multi-tapped secondary of the main power transformer. The highest of these voltages is nominally 115 VAC at a line voltage of either 115 VAC or 230 VAC, depending on line voltage option. The other two taps of the secondary are nominally 70 VAC and 55 VAC. A 2.5 amp fuse, (F4), protects all three secondary taps through the AC common return circuit.

INTERFACE DESCRIPTION

The Cardioplegia Relay board has five connectors:

P44, an 8 pin MTA header, brings in driving signals from the computer.

<u>Pin</u>	<u>Signal Description</u>	<u>Voltage</u>
1	not used	
2	not used	+24 VDC
3	pump speed select	signal return
4	pump speed select	signal return
5	power	+10 VDC
6	CARDIO RECIRC select	signal return
7	CARDIO SMALL select	signal return
8	CARDIO LARGE select	signal return

P45, a 9 pin Mate and Lock header, connects to the main power transformer.

<u>Pin</u>	<u>Signal Description</u>	<u>Voltage</u>
4	AC voltage	55 VAC
7	AC voltage	70 VAC
8	AC voltage	115 VAC
9	AC neutral	0 VAC

P46, a 4 pin Mate and Lock header, goes to the cardioplegia water pump.

<u>Pin</u>	<u>Signal Description</u>	<u>Voltage</u>
3	AC neutral	0 VAC
4	Selected pump voltage	0, 55, 70 or 115 VAC

1.6 Performance Specifications

1.6.2 TCM Cardioplegia Relay Board (Continued)

P47, a 6 pin Mate and Lock header, goes to the three cardioplegia solenoid valves.

<u>Pin</u>	<u>Signal Description</u>	<u>Voltage</u>
1	CARDIO LARGE (V4)	0, 115 VAC
2	CARDIO SMALL (V5)	0, 115 VAC
3	CARDIO RECIRC (V6)	0, 115 VAC
4	CARDIO LARGE (V4)	AC neutral
5	CARDIO SMALL (V5)	AC neutral
6	CARDIO RECIRC (V6)	AC neutral

TP, a 6 pin MTA header, not connected to TCM, brings out test points from Cardioplegia Relay Board.

<u>Pin</u>	<u>Signal Description</u>	<u>Voltage</u>
1	digital power	+12 VDC
2	digital ground	0 VDC
3	decoder enable	0, 12 VDC
4	high pump speed	active high
5	medium pump speed	active high
6	low pump speed	active high

THEORY OF OPERATION

Solid-state relays K1-K3 drive CARDIO LARGE (V4), CARDIO SMALL (V5), and CARDIO RECIRC (V6) valves, respectively. Each solid-state relay has a resistor/capacitor snubber and varistor for protection.

Two signal lines from Darlington transistors on the main board, which are driven by the computer, are optocoupled by optoisolators U1-U2 to decoder U3. When the output of U1 or U2 changes, a 100ms pulse is generated by monostables U4-U5. This disables decoder U3, thus, turning off relays K4 -K6, triacs Q1-Q3, and disconnecting voltage from cardioplegia pump. After this 100ms delay, U3 is enabled and the selected output (high) is buffered through Darlington U7, turning on selected solid-state relay and triac to connect selected voltage to pump. Each solid-state relay and triac is protected by a snubber. There is one varistor across the transformer and another across the motor for further protection.

CALIBRATION AND CONFIGURATION

The Cardioplegia Relay Board does not require any calibration.

SERVICE

Field Service Diagnostics

When this board is powered up, voltage readings and signals may be verified using connectors listed in the interface section above.

PREVENTIVE MAINTENANCE GUIDE

None required

1.6 Performance Specifications

1.6.3 Main Board

FUNCTIONAL DESCRIPTION

The main board is the principal and largest PC board in the TCM II system; it is located in the main unit. The board serves as a mother board for several cards, contains components of the power supplies and drivers, and acts as a terminus for many cables.

PHYSICAL DESCRIPTION

This is a double-sided, extra thick (3/32 in.—2.38 mm), rectangular board, measuring 16.0 in. (40.6 cm) by 5.0 in. (12.7 cm). The board mounts with six #6 screws and has 25 connectors, five fuses, and other components, but most prominent on the board is a card cage, which makes this a motherboard, among other things. The card cage accepts three 4.5 in. (11.4 cm) by 6.5 in. (16.5 cm) boards.

The connectors include the following types: 0.100 in. and 0.156 in. MTAs, Mate 'n' Locks, IDC ribbon cable, 56-pin edge connectors (pins on 0.125 in. by 0.250 in. centers), and formed pins.

ELECTRICAL DESCRIPTION

The board receives AC line voltage through connector P25. Fuse F6 is on the AC line and protects the primary of the main power transformer. The board contains the components (other than the transformer) for the unregulated ± 24 volt supplies, including their fuses, F2 and F3, respectively. The board also contains some of the components of the regulated +5 volt supply, including its fuse F1; this supply is derived from the unregulated +10 volt supply, which is located entirely off the board, and has its own off-board fuse. The connections for both the +10V unregulated and +5V regulated (via off-board 7805 regulator) supplies are made through P19. The board maintains separate analog and digital commons (ACOM and DCOM, respectively), which are joined at only one place on the board.

The board also receives a 115 VAC supply (even on a 230 V unit) from the transformer, which is used to power the three main water valves. This 115 VAC supply is protected by fuse F11 on the board. The transformer connects to the board through both P24 and P23, with 24V secondary S3 entering through P23 and high voltage primaries as well as 115V secondary S1 entering through P24. Connector P26 accepts either a 115 V or 230 V line voltage jumper plug, which determines whether the dual-primary transformer is wired for the 115 VAC or 220/240 VAC line voltage ranges.

There are two test points on the board, labeled TP1 and TP2, which may be used if diagnostic software is installed on the computer card.

INTERFACE DESCRIPTION

The card cage has three slots for 4.5 in. (11.4 cm) by 6.5 in. (16.5 cm) cards with 56-pin edge connectors. The cage is designed to accept three specific cards: a single-board computer (the PLS-858 from Pro-Log Corporation), the A/D-timer card, and the communications card. The backplane connections of the main board are supplemented by a short ribbon cable between the computer and A/D-timer cards. The communications card has a ribbon connector which does not go to the main board.

1.6 Performance Specifications

1.6.3 Main Board (Continued)

THEORY OF OPERATION

Power Supplies - The main board accepts AC line voltage and provides the following voltages: 115 VAC, +24 VDC unregulated, -24 VDC unregulated, +10 VDC unregulated, +6.5 VDC, +5 VDC. All of these are derived from secondaries of the main transformer, which is off-board. A number of other power supply components are located off the board, usually because they either are too large or require mounting on the heatsink. Connector P26 accepts a jumper plug which configures the transformer for either 115 VAC or 220/240 VAC.

Card Cage and Nature of Computer Bus - The card cage has three slots for 4.5 in. (11.4 cm) by 6.5 in. (16.5 cm) cards with 56-pin edge connectors. This is the same physical format as an STD standard card, but these are not compatible with the STD bus. In fact, the backplane is not configured as a bus at all, and each card must be inserted only in its designated slot. The card cage is designed to accept three specific cards: a single-board computer (the PLS-858 from Pro-Log Corporation) through J16, the A/D-timer card through J17, and the communications card through J18. The computer card uses the edge connector for I/O ports rather than for the processor bus, which is not directly accessible. The A/D-timer card serves several functions, including data acquisition, interrupt timing, safety, and synthesizing the bi-directional data bus (which the computer lacks). The communications card contains three UARTs (Universal Asynchronous Receiver-Transmitters), which allow serial communication to remote devices. The backplane connections of the main board are supplemented by a short ribbon cable between the computer and A/D-timer cards.

SOD (Serial Output Data) Test Point - Two test points on the main board are labeled TP1 and TP2. TP1 goes to the SOD output of the 8085 processor on the computer card. TP2 goes to digital common ground (DCOM). The SOD output is not actually used by the system, but could serve as a diagnostic signal if a SIM instruction were included at a strategic place in the software. A short timing pulse would then appear at TP1 (referred to TP2) which could be used to synchronize an oscilloscope or be read as a period by a counter-timer.

Darlington Drivers with Watchdog Feature - Some of the output lines from the computer card go to IC2 and IC4, which are tri-state inverting buffers. They in turn drive IC1 and IC3, which are arrays of seven Darlington transistor drivers optimized for TTL-level inputs. The Darlington drivers drive such things as: the solid-state relays that operate the solenoid valves and heaters, the electromechanical relays that operate the water pumps and compressor, and the warning buzzer. Some of the relays are located on the main board and others are elsewhere. The buzzer is mounted on the card cage and connects to P9. The tri-state inputs of IC2 and IC4 are driven by the NMI* (non-maskable interrupt) signal from the watchdog circuit on the A/D-timer card; this causes all the Darlington drivers (except those driving the compressor and buzzer) to turn off until the software is able to recover from the watchdog error condition. Watchdog signal NMI goes from the A/D-timer card to the computer NMI Interrupt pin to attempt a non-maskable interrupt which cold-starts the computer.

Valve Drivers - Solid-state relays K3-K5 drive the three main water valves (through connector P14) with 115 VAC, on command from the computer. Additional solid-state relays are located on the cardio relay board to drive the cardioplegia water valves, but these relays too are driven by the Darlington drivers on the main board.

Water Pump and Hour Meter - Relay K2 drives the main water pump (through connector P21) with AC line voltage, on command from the computer. This same voltage also goes through P20 to the hour meter, which measures total elapsed time that the main water pump has run.

1.6 Performance Specifications

1.6.3 Main Board (Continued)

Flow Switches - The sensors for main water pressure and blanket water flow are excited by pull-up resistors R11 and R10, respectively, and feed to two of the computer input lines. The connection to the main and blanket flow switches are made through P5 and P6 respectively.

Water Temperature Probes - The dual (main and backup) water temperature probe, and the single (cardio) water temperature probe connect to the main board through P1/P2 and P3, respectively, and are channeled to the A/D-timer card.

Thermostat Circuit - The safety thermostat connects to the main board through P7 and is excited by +5 VDC through the voltage divider consisting of R15, R16 and R21/Q1. This signal goes to an input of the computer and also turns on transistor Q1 as long as the thermostat remains open. Q1 drives an off-board solid-state relay which is in series with both heaters in the heater manifold. Therefore, if the thermostat temperature limit is exceeded, then the power to the heaters will be interrupted, even if the computer malfunctions or the other solid-state relays are shorted. The computer is able to monitor the state of the thermostat so that it can display an "overtemperature" warning, even if the temperature acquisition circuits malfunction. P12 interfaces the heater solid state relays to the main board.

ICE MAKING light - Formed pin connectors P27 and P28 provide power to the ICE MAKING light which appears on the front display panel.

Buzzer - One of the Darlingtons drives the warning buzzer (mounted on the card cage) on command from the computer.

Interface to Main Display - The main board communicates with the main display and cardioplegia display boards through P15. It provides +5 VDC to those boards, as well as four input lines and four output lines from the computer, and an outgoing data bus with strobe from the A/D-timer card.

Remote Panel - The main board communicates with the temperature display module (Remote Panel) through P8. It provides a +6.5 VDC supply, as well as one incoming and one outgoing communication port, coming from the communications card. These ports are opto-isolated current-loops. The communications card talks to the computer via the bi-directional data bus, plus address and decoder signals, which are buffered on the A/D-Timer card from the computer's expansion bus. This expansion bus does not pass through the main board, but rather is carried by a short 50-conductor ribbon cable from the computer card to the A/D-timer card. The communications card also has serial communications ports for the three optional temperature probe modules and for a presently undefined and unsupported external computer. These ports do not pass through the main board, but rather use a 34-pin ribbon cable which connects to the communications card directly.

Drive for Cardio Relay Board - The main board connects to the cardioplegia relay board through P13, providing +24 VDC, +10 VDC, and drive signals for relays. The drive signals ultimately control the three cardio water valves and the speed of the cardio water pump.

Interface with Compressor Delay Board - The main board connects to the compressor delay board through P22. It does not supply power since the compressor delay board has its own separate supply. The board does provide an enabling signal (powered by the compressor delay board's own +12 VDC supply) through relay K2, which is driven by the computer.

CALIBRATION SPECIFICATION

This board does not require any calibration.

1.6 Performance Specifications

1.6.4 Compressor Delay Board

FUNCTIONAL DESCRIPTION

The Compressor Delay Board provides the Ice Making function; it is located in the TCM II main unit. The purpose of the board is to control power to the compressor, and to ensure that the compressor is not damaged by being started while the refrigerant pressure is high. This function is achieved by delaying the start-up by a fixed time interval. The board has its own power supply, which is fed from the Compressor Circuit Breaker (not the System Circuit Breaker) and so is independent of the other electronics in the system.

For each assembly (115 and 230 V) voltage selection is made through a jumper plug which is interchangeable to accommodate these two possible mains voltages.

PHYSICAL DESCRIPTION

The compressor delay board is a 4.5 in. (11.4 cm) by 4.5 in. (11.4 cm) square double-sided board, with four mounting holes in the corners for #6 screws. There are five connectors on the board. Other noteworthy components on the board include a replaceable fuse (F9), and a PC-mounted transformer.

ELECTRICAL DESCRIPTION

The board uses a single +12 VDC supply, which is on the board. The AC line voltage is brought onto the board for switching to the compressor as well as for the DC supply. The board requires an AC line voltage: 115VAC for the 115 V version; 220 or 240 VAC for the 230 V version. Fuses F9 and F14 protect the line from shorts on the board or in the K5 relay coil, but not in the high-current compressor circuit. Fuse F13 in transformer T1 secondary protects the transformer. The differences between the 115 V and 230 V version include the jumper plug J26 and the electromechanical relay, not located on the board.

INTERFACE DESCRIPTION

There are five connectors on the board: P26 provides line voltage selectability (either 115 or 230 V) with insertion of the proper jumper plug; P48 brings in the enabling signal from the computer and control panel; P63 brings in the AC line from the compressor circuit breaker; P64 connects to the relay which is mounted next to the board, and P66 goes to the compressor. A sixth connector, P65 does not reside on the board, but provides the interface with the ice bank sensor through an interruption in the wiring harness which connects P64 to the double pole relay K5.

1.6 Performance Specifications

1.6.4 Compressor Delay Board (Continued)

THEORY OF OPERATION

AC line voltage (115 or 230 V) from the compressor circuit breaker enters the board through P63 and is used as follows:

1. The voltage is stepped down by transformer T1, rectified by full-wave bridge DB1, filtered, and regulated to +12 volts by IC4 for use by circuitry on the board.
2. The voltage from the output of solid state relay K1 is applied to the coil of AC relay K5 through the ice bank sensor.
3. The voltage then passes through the contacts of K5 via P64 and to the compressor via P66.

All but the last branch, which carries the compressor current, pass through fuse F9 or fuse F14.

A computer-controlled relay on the main board connects to this board through P48. When this relay closes the circuit, the input of IC1A goes high, making the output of IC1B go high and triggering one-shot IC2A, which triggers programmable timer IC3. The timer output goes high after the time-out interval, which is determined by the setting of DIP switch array SA1, as well as by R3 and C4. When the timer output goes high, and if the output of IC1B is still high, then the output of IC1D goes high, turning on transistor Q1. Transistor Q1 then turns on solid-state relay K1, which turns on relay K5, which then connects both sides of the line to the compressor. However, the ice-bank sensor switch may interrupt the path from the solid state relay K1 to relay K5 coil, thus turning the compressor off, if ice making is complete.

Transistor Q1 is connected to the "Ice-Making" light on the front panel through P48 thereby indicating when Q1 is on and the compressor is empowered to make ice.

CALIBRATION SPECIFICATIONS

The board is designed to provide a minimum 4 minute delay between arrival of a computer enable signal and delivery of power to the compressor. This is accomplished by setting all four switches on DIP switch array SA1 to the closed position. With four switches closed, a nominal 255 second delay is provided.

Board Level Calibrations - Make these adjustments by performing the corresponding procedure in the TCM II Check and Calibration Procedure, part number 16506000 or 78-8067-0231-8.

1.6 Performance Specifications

1.6.5 TCM II System Product Performance Specification

1.6.5.1 Product Description

PHYSICAL DESCRIPTION

The cabinet is constructed of finished structural foam, stainless steel, and aluminum with a baked enamel finish. Six outer side panels are fixed to a steel inner frame which provides support and stability. The top is made of structural foam with EMI protective inner finish.

The main unit houses the rotomolded ice reservoir, the heaters, the control computer and other major electronic components, the plumbing circuitry, the ice maker and the blanket supply.

The cardioplegia water supply mounts in the main unit and consists of the pump, plumbing, and circuitry that controls delivery of water to cardioplegia heat exchangers.

The temperature display module mounts in a pocket on the main unit or elsewhere in the operating room (up to 7.5' away from the main unit). In order to use the display module, one to three temperature probe modules must be installed in the main unit.

HYDRAULIC DESCRIPTION

Water pumps (2) used are 1/8 hp. Heaters (2) are 700 and 850 watt for 115V unit and 1000 watt each for the 220V unit.

COMPATIBILITY WITH OTHER EQUIPMENT

Heat Exchangers. The TCM II is designed for use with all heat exchangers that will withstand 11 psi (568 mmHg) pressure and temperatures of 0-42 °C.

Thermal Blankets. The TCM II is designed for use with thermal blankets that will withstand pressures of 10 psi (517 mmHg) and temperatures of 0-42 °C.

Cardioplegia Heat Exchangers. TCM II is designed for use with "drop-in" heat exchangers which fit into the small tank along with the necessary ice, and with water manifold heat exchangers that will withstand pressures of up to 11 psi (568 mmHg).

Temperature Probes. The TCM II is designed for use with (Yellow Springs Instruments) YSI Series 400 temperature probes.

1.6 Performance Specifications

1.6.5.2 Product Performance Statements

PRESSURE PERFORMANCE

Pressure performance figures below are applicable when the TCM II is connected to only that specific piece of external equipment, i.e., blanket performance is applicable with only a blanket connected to the unit. As the blanket and heat exchanger draw from a common water supply and the ports are internally connected, different pressure performance figures will result when the TCM II is connected to both an oxygenator and a blanket or when extensive lengths of tubing are connected.

To obtain the pressure performance, the TCM II was tested by connecting a set of in and out ports with a 4 feet (1,3 m) loop of tubing. A flow rate meter was inserted into this loop of tubing to obtain the flow rate with no restrictions. A pressure meter tapped into the tubing at a point close to the out port to obtain the maximum pressure.

The TCM II was operated in rewarm mode to test the blanket and heat exchanger pressure performance; it was operated in external small tank mode with the pump at high speed to determine the cardioplegia pressure performance.

	FLOW RATE (no restriction)	PRESSURE (maximum)
Water Out Port		
Heat Exchanger	5.5 gal/min 21.0 L/Min	15.0 psi (700 mmHg)
Blanket Supply	0.8 gal/min 3.3 L/Min	11.8 psi (610 mmHg)
Cardioplegia Supply	2.1 gal/min 5.1 L/Min	7.5 psi (386 mmHg)

TEMPERATURE PERFORMANCE

Temperature performance figures represent nominal design figures.

1. Temperature Limits

Heating

Maximum heaters (2) output	1550 watts @ 115V 2000 watts @ 220V
Maximum water temperature	42 °C
Temperature gradient control	6 or 10 °C
Defrost cycle maximum temperature	20 °C

Cooling using an Ice Maker

Power requirement	1200 watts
Ice making capability starting with 25 °C water:	
50 lbs (22.7 kg) in 8 hours	
19 lbs (8.6 kg) in 3 hours	

Water temperature selection range:	0-42 °C
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1.6 Performance Specifications

1.6.5.2 Product Performance Statements

TEMPERATURE PERFORMANCE (Continued)

2. Temperature Control

General. A redundant (2) thermistor system signals "system failure" if a significant discrepancy between thermistors (>5.1 °C) is sensed. Plus an overtemperature thermostat cuts off power to the heaters if water temperature reaches 43 °C.

Maintain Mode. The main computer controls the temperature of the output water according to the maintain temperature which has been set by the operator; a setting range of 0 to 42 °C is available.

Rewarm mode. The main computer limits the maximum rewarm temperature of the output water to 42.2 °C or to 6 °C or 10 °C (venous blood) — (water) temperature gradient.

Cooling mode. Water is supplied at the temperature of the water in the ice reservoir.

3. Temperature Monitoring

Output water temperature is monitored and is displayed on the front panel in a range of 0 to 50 °C.

Patient or extracorporeal circuit temperature sensing and display accuracy is ± 0.3 °C. The temperature probe modules allow a sensing range of 0 to 50 °C.

1.6.5.3 Operating Systems

HYDRAULIC SYSTEM

The hydraulic system includes the plumbing, valves, Hansen fittings, tanks, pump, manifold, and two heaters (see Hydraulic Block Diagram, part number 16095001, for details). The cardioplegia water supply adds a second pump, additional plumbing, valves, and use of the smaller tank. The hydraulic system also includes:

- Flow switch, on the blanket outlet line, to detect low flow for the blanket.
- Pressure switch, on the heat exchanger outlet line, to sense inadequate water pressure in the main plumbing in order to protect the pump.
- Thermistor T1, in the manifold, to monitor water output temperature and to monitor manifold water temperature.
- Thermistor T2, in the manifold, to serve as a check on T1.
- Thermistor T3, on the Cardioplegia output line, to measure cardioplegia water output temperature.
- Thermistor OT1 switch, in the manifold, set to activate at 43 °C.

1.6 Performance Specifications

1.6.5.3 Operating Systems (Continued)

ICE MAKER SYSTEM

The ice maker system includes a compressor, ice thickness sensor, cold plate, refrigerant plumbing, refrigerant plumbing switch, filter dryer in the refrigerant line, and its own circuitry (see Compressor Block Diagram, and Paragraph 1.6.4, Compressor Delay Performance Specification, Section 5 for details).

ELECTRONIC SYSTEM

The electronic system includes the circuit breakers, the PC boards, and the software. It is the communication center for the unit. The operator inputs information through the external controls and displays. The microprocessors on the PC boards receive the input and control the internal systems according to the software program.

1. Power

- 115 or 220 VAC unit has two circuit breakers: one for ice making and one for the main TCM.
- The AC power for the main TCM supplies energy for the heaters, the cardioplegia subsystem the pumps, and the transformers; the transformer supplies 115 VAC power to solenoid valves and other voltages to the DC power supplies for the PC boards.

2. PC Boards

The TCM II system may have up to a total of 14 PC boards; these are listed below with their basic purpose; for further details see the specific PC board specification.

- The main board is a mother board for the main unit; it is a central terminus for cables and holds fuses; it also contains some driver electronics and some power supply components.
- The A/D-timer board expands the computer I/O ports; it receives the thermistor input which measures internal water temperature and converts this input for computer use; it contains the watchdog circuitry; it also contains the interrupt timer for the main computer.
- The main display board contains displays for the main unit and connects the panel switches to the computer.
- The main computer board performs most of the logic for the main unit; it communicates, processes information and directs functions. It also communicates to the user via the panel controls and displays.
- The compressor delay board gives protection for the compressor by controlling power to the compressor used in the ice making system.
- The cardioplegia display board extends the functions of the main board.
- The cardioplegia relay board contains relays for cardioplegia valves and pump speeds.

1.6 Performance Specifications

1.6.5.3 Operating Systems (Continued)

2. PC Boards (Continued)

- The remote mother board electronically interconnects all parts of the temperature display module.
- The remote display board contains displays and related electronics for the temperature display module.
- The remote computer board performs most of the logic for the temperature display module. This remote computer stores information from the main microprocessor; it determines which probe information is selected for display and which digital display to use; it relays remote control information to the main unit microprocessor; it controls the alarm limit functions; it tests the functioning of the temperature probe module.
- The temperature probe module board has a microprocessor which analyzes and determines the probe temperature and sends the information to the TCM II main computer. This board is electrically isolated for patient safety.
- The communications board is located in the main unit; it assists the main computer in communicating with the temperature probe modules and the temperature display module.

3. Software

There are three different software programs in the complete system: one in the main computer in the TCM II, one in the remote computer in the temperature display module, and one in each temperature probe module. See the PC board selection above or refer to the component specifications for details.

1.6.5.4 Controls

MAIN UNIT

System Circuit Breaker Switch (CBS) ON: The main computer conducts a 6 second initialization which turns all LEDs on and off and displays software version on the maintain and water temperature displays. Next, the main computer conducts an internal prime of approximately 1 minute duration with all valves open so that water fills the plumbing and the internal air is released. The valves remain open and the pumps and heaters may not be turned on from the panel during this period. Finally, the main computer allows full panel selection. Note: The system CBS must remain off for about 2 seconds to repeat this startup procedure completely or the temperature display module may not initialize properly. The default startup setting is maintain 25 °C

Standby Mode: The main computer displays the water temperature sensed by thermistor T1. It does not activate heaters or pump.

Cooldown Mode: The main computer opens valve 1 to allow water from the large reservoir to flow to the pump, activates the pump to circulate water through plumbing, and displays the water temperature sensed by thermistor T1.

1.6 Performance Specifications

1.6.5.4 Controls (Continued)

Rewarm Mode: The main computer opens valve 2 to bypass the large reservoir and direct water through the heater manifold, activates the pump to circulate warm water through the plumbing, and displays water temperature as sensed by thermistor T1. The target temperature for rewarm is 42 °C or the value determined by the gradient selection. Using the water temperature as sensed by thermistor T1, the main computer turns off one heater when the water temperature is approximately 0.8 °C below the target temperature, and turns off the second heater if the water temperature is approximately 0.4 °C below the target temperature. It cycles the heaters on and off to maintain water temperature equal to the target temperature.

Maintain Mode: The main computer compares the output water temperature as sensed by thermistor T1 to the maintain temperature set by the operator. The computer also displays the output water temperature and controls valves 1 and 2 and heaters 1 and 2 as follows to maintain the set temperature.

CONDITION	VALVE 1	VALVE 2	HEATER 1	HEATER 2
$(T_{\text{water}} - T_{\text{set}}) > 7.8 \text{ }^{\circ}\text{C}$	Open	Closed	Off	Off
$0.8 \text{ }^{\circ}\text{C} < (T_{\text{water}} - T_{\text{set}}) < 7.8 \text{ }^{\circ}\text{C}$	Open	Open	Off	Off
$-0.4 \text{ }^{\circ}\text{C} < (T_{\text{water}} - T_{\text{set}}) < 0.8 \text{ }^{\circ}\text{C}$	Closed	Open	Off	Off
$-2.0 \text{ }^{\circ}\text{C} < (T_{\text{water}} - T_{\text{set}}) < -0.4 \text{ }^{\circ}\text{C}$	Closed	Open	Off	On
$(T_{\text{water}} - T_{\text{set}}) < -2.0 \text{ }^{\circ}\text{C}$	Closed	Open	On	On

Gradient Selection: The main computer monitors the information from the temperature probe module microprocessor and compares venous blood temperature (measured by probe G) to the water output temperature as sensed by thermistor T1; it limits the water temperature to no more than 6 °C or 10 °C (according to gradient selected) above the venous blood temperature reading and controls the valves and the heaters accordingly. Gradient selection requires installation of a temperature display module and at least one temperature probe module, with temperature probe G monitoring the patient's venous blood temperature. It is active in both maintain and rewarm modes. It is disabled if no probe is connected in position G.

Defrost Mode: The main computer switches on both heaters, shuts off the ice maker, starts the pump, and opens valves 1 and 3 to circulate warm water through main reservoir; then, after a one minute delay, it shuts off the pump and heaters when the water temperature reaches 20 °C (sensed by thermistor T1), reverts to standby mode, and starts the compressor if the ice maker controls are On; it continuously displays the water temperature as sensed by thermistor T1.

1.6 Performance Specifications

1.6.5.4 Controls (Continued)

Ice Making Circuit Breaker On:

- The compressor starts and the ICE MAKING indicator lights. The cold plate in the main reservoir builds an ice bank. An ice bank sensor shuts the compressor off when the ice bank is full.
- If the system CBS is On, the compressor will run only if the compressor CBS is On and no more than one heater is operating. The main computer operates relays to shut off the ice maker when both heaters are on in order to limit the current draw of the TCM II: use of the CPG pump will not be affected. The ice maker is also disabled in standby mode if this mode was entered due to an error condition. When turning on the compressor CBS, a compressor delay prevents restart of the compressor for 4 to 6 minutes (see Compressor Delay Performance Specification, Paragraph 1.6.4).

Water Output Temperature Display: The main computer digitizes and displays the thermistor probe output signals; thermistor 1 monitors the main output water temperature and thermistor 3 measures the cardioplegia water output temperature.

Maintain Set Switches: The main computer relays 25 to the display until this number is changed by the set switches. The setting reverts to 25 whenever startup is repeated.

CARDIOPLEGIA WATER SUPPLY

Pump On-Off: The main computer activates the cardioplegia pump and opens valves according to the external or internal mode selection.

Pump Speeds: The main computer illuminates the RPM high, medium, or low lights according to the switch position.

External-Internal Modes: The main computer illuminates the appropriate CPG light for the mode selected.

Large Tank External: With the pump On, the main computer opens valve 4 to allow water from the large tank to be pumped to the cardioplegia water outlet port; water returns to the small tank and overflows into the large tank.

Small Tank External: With the pump On, the main computer opens valve 5 to allow water from the small reservoir to be pumped to the cardioplegia outlet port; water returns to the small tank.

Large to Small Tank Internal: With the pump On, the main computer opens valves 4 and 6 to allow water to recirculate from the large tank to the small tank; the water returns to the large tank by overflow.

1.6 Performance Specifications

1.6.5.4 Controls (Continued)

TEMPERATURE DISPLAY MODULE

Probe Displays: The remote computer receives probe information in the form of binary coded decimal signals from the main computer. This information is translated into logic signals appropriate for LED number displays and indicators. Each display is updated and powered many times per second. The probe display switch directs the remote computer as to which probe information to display; the remote computer illuminates the appropriate probe LED.

Remote Controls: The remote computer sends selected information to the main computer which illuminates the corresponding LED on the main panel and directs the proper mode function; the main computer returns the information to the remote computer which in turn lights the corresponding remote LED.

Test Switch: The remote computer, via the main computer, requests a set resistance for the probe input. If the temperature probe module is functioning correctly, the appropriate display will show 25 ± 0.4 ; the top display pertains to the first temperature probe module, the middle display pertains to the second module, and the bottom display pertains to the third module. If the corresponding module is not connected, the display will be blank.

High and Low Alarm Limits: The alarm switches are used to display and establish high and low values in the remote computer for probes A, B, and C. If the alarm limit value is exceeded, the remote computer triggers the probe LED to flash and a buzzer to sound. The flashrate is faster if the particular probe is also being displayed. The default alarm limits on startup are 42 °C and 0 °C.

1.6.5.5 Safety Features

INTERNAL SYSTEM SAFETY FEATURES (NO EXTERNAL INDICATORS)

Startup: Startup is a two part process: (1) A 3 second initialization which turns all LEDs on and then off to verify their function, followed by a 3 second display of the software version and then the display of specific startup conditions; (2) An internal priming procedure lasting approximately 1 minute during which all valves are open and the pumps and heaters remain off. Panel selections relating to the valves, pumps, and heaters are inactive during startup. Startup ends with the unit in a standby mode with the COOLDOWN light flashing to indicate modes are completely available but that external priming is still required.

System Monitor Circuitry: System monitor circuitry ensures that the main computer operates properly. It consists of a watchdog circuit which includes a timer that must be reset by the main computer at specified intervals. If the timer is not reset when specified, due to the main computer getting caught in a loop or otherwise failing, the system monitor circuitry shuts off the pump and heaters and forces the computer to repeat the startup routine; the software will attempt to repeat the watchdog test, the priming procedure, and the display of startup conditions.

Compressor Delay Circuitry: Compressor delay circuitry protects the ice making compressor by preventing early restarting. There is a 4 to 6 minute restart delay which prevents the motor from overload by allowing pressures in the system to equalize (see Compressor Delay Performance Specification, Paragraph 1.6.4). The compressor is disabled by the main software when more than one heater is on to prevent excessive current draw.

1.6 Performance Specifications

1.6.5.5 Safety Features (Continued)

Communications Errors: The computer software screens all data transmissions and rejects any that do not conform to data format requirements. This prevents electrical interference which could alter command signals or generate false command signals.

Overtemperature Protection: A separate thermostat OT1 switches off the heaters if the output water temperature is over 42.5 °C. Also, a selection range of only 0 to 42 is available.

SAFETY FEATURES WITH PANEL WARNING INDICATORS

Low Flow To Blanket: Within 15 seconds of the flow switch detecting a flow of less than 1 ± 0.1 L/Min on the blanket inlet, the main computer illuminates the warning indicator light. This warning is not active when the unit is in standby mode, during the startup procedure, or in defrost mode.

Pump Not Primed: Within 5 seconds of the pressure switch sensing inadequate water pressure in the main plumbing, the main computer illuminates the warning indicator light, sounds an alarm, stops the pump, and goes into standby mode. This warning is not active when the unit is in standby mode or during the startup procedure. The audible alarm will sound for 2 seconds at 60 second intervals until cooldown, maintain, rewarm or defrost mode is selected by the user.

Service Indicator: The main computer compares the inputs from thermistor T1 and the redundant thermistor T2; if the inputs from T1 and T2 differ by > 5.1 °C when in a mode other than cooldown, it illuminates the warning indicator light and sounds an alarm. Service indicator is also activated if the internal reference temperature does not read within specs (26.5 to 29.4 °C).

Over 42 °C: If thermistor T1 or T2 senses 43 °C or if the thermostat OT1 senses 43 °C, the main computer illuminates the warning indicator light, sounds an alarm, and shuts off the heaters.

Note: With a minimal load, such as only a blanket attached, the unit could go to 43 °C; to operate correctly with only a minimal load, the unit may be set in maintain mode at 40 °C until additional equipment is attached.

TEMPERATURE DISPLAY MODULE SAFETY FEATURES

Watchdog Circuitry: Each display is powered serially many times per second. If the displays are powered continuously they will burn out. The watchdog circuit detects if the displays are being powered improperly and turns off the displays and lights on the temperature display module.

Startup Routine: The remote computer does a 3 second initialization which completes shortly before the main computer finishes its initialization. Correct startup conditions appear on the temperature display module but all valves will remain open and the pumps and heaters will remain off for approximately 1 minute while the main unit is completing the internal priming procedure.

Error Information on Probe Displays: The remote computer causes the display to go blank if there is a bad temperature probe module or no module installed. The remote computer directs the display of "--" if the temperature a probe senses is below -0.4 °C or if no probe is attached; it directs the display to show 99.9 if the temperature a probes senses is over 50 °C.

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2.1 Required Tools, Test Equipment, Supplies

The following items are required to service the TCM II:

Item No.	Sarns P/N	3M I.D.	Description
1	16040010	78-8066-7416-0	Heat Exchanger Accessories Kit
2	16041010	78-8066-7417-8	Cardioplegia Water Supply Accessories Kit
3	16042010	78-8066-7418-2	Blanket Water Supply Accessories Kit
4	13771534	78-8067-7417-8	10 Degree Probe
5		78-8066-9341-8	25 Degree Probe
6		78-8066-9340-0	47 Degree Probe
7	13771529	78-8067-2906-3	TCM Zero Degree Fixture
8	13771530	78-8067-2907-1	TCM Forty Degree Fixture
9	13771531	78-8067-2908-9	TCM Overtemp Jumper
10	13771532	78-8067-2909-7	TCM 5-pin Test Connector
11		78-8066-6136-5	TCM Inspection Form
12		78-8066-8426-8	Inspection Label

2.2 Abbreviation Key

ART	Arterial
BKT	Blanket
CPG	Cardioplegia
LED	Light Emitting Diode
NMI	Non-Maskable Interrupt

2.3 Emergency Maintenance Procedure

Note: When following this procedure, reference the Preventive Maintenance Procedure in this manual and fill out the Inspection Report Form.

1. Complete the Preliminary Inspection.
2. Complete the Check and Calibration (if malfunction does not hinder) note any additional problems.
3. Repair all problems.
4. Repeat the Check and Calibration again.
5. Complete the Final Inspection.

2.4 Preventive Maintenance Procedure

Note: When following this procedure, fill out the Inspection Report Form.

2.4.1 Preliminary Inspection

1. Record the system part number, serial number, and run time.
2. Inspect the system visually for damage, modifications, cracked control panels, abnormal wear, cleanliness, etc. Record findings. Advise customer to follow proper procedure if unit needs cleaning, descaling or decontamination.
3. Check the line voltage. It should be 108 to 122V~ or 210 to 250V~.
4. Connect the leakage box and start the system. Record the leakage current in normal and reverse. Electrical specifications should be as follows:
 - 100 microamperes maximum for 115 V units
 - 500 microamperes maximum for 220 V units
 - Ground impedance of 0.1 ohm maximum.
5. Inspect the power cord strain relief. Check the power cord for damage, loose ends, or cord held too tight in strain relief.
6. Remove the front and rear panels.

2.4.2 System Check and Calibration

1. Follow the Check and Calibration Procedure.
2. Record all the information on the Inspection Report.

2.4 Preventive Maintenance Procedure

2.4.3 Final Inspection

1. Replace the front and back panels; check that the unit functions properly.
2. Inspect the system visually.
3. Check the leakage current in normal and reverse.
4. Record whether the system needs additional service; if so, define in the comments section.
5. Install the inspection label.
6. List any parts installed on the Inspection Form.

2.5 Check and Calibration Procedure

2.5.1 Preliminary Steps

On the lower right side of the TCM, above the System Power and Ice Maker switches:

- Record part number.
- Record serial number.
- Record run hours.

If TCM has a Remote Temperature Display Module, look on the right side of the module:

- Record the Module part number.
- Record the Module serial number.

2.5.2 Prepare the System

Be aware of the following:

- Unless otherwise specified, the various voltages listed throughout this procedure are based on a nominal line voltage to the unit.
- Whenever a check condition is not met, refer to the appropriate heater, pump and valve sections located in Section 4 Troubleshooting.

Before conducting any checks or calibrations, prepare the system as follows:

2.5 Check and Calibration Procedure

2.5.2.1 Set-up

1. Connect all water loops.

Note: Include a ball-type valve and drainage line in the following cardioplegia and arterial water circuits. Connecting loops of more than 2 ft. in length may affect the rewarm time specified on the following pages.

- Position the unit near a sink or floor drain.
 - Locate In and Out ports at the bottom of the rear of the TCM.
 - Connect 2 ft. (0,6 m) tubing to In port labeled ART H20.
 - Connect the other end of the same tube to the ART H20 Out port.
 - Connect 2 ft. (0,6 m) tubing to In port labeled CPG H20.
 - Connect other end of same tube to CPG H20 Out port.
 - Connect 2 ft. (0,6 m) tubing to In port labeled BKT H20.
 - Connect other end of same tubing to BKT H20 Out port.
2. Add water, filling both tanks to the maximum level indicated.
 3. Check that ground impedance is less than 0.1 ohm.
 4. Check the leakage current.

2.5.2.2 Verify Power Supply

Note: For AC reference point, use Pin 2 of P50 or P51 connected to heaters. The DC common is the negative (-) lead of the large blue capacitor, located above the heat sink assembly midway up the right front side of the unit .

1. Turn System Power and the Ice Maker OFF.
2. Remove the front panel.
 - Locate two screws on right side of TCM that connect front panel to TCM and remove.
 - Locate two screws on left side of TCM that connect front panel to TCM and remove.
 - Gently lift and remove the front panel.
 - Place front panel away from the TCM.
3. Remove the rear panel.
 - Locate two screws at top of the rear panel and remove.
 - Locate and remove two screws at bottom of the rear panel.
 - Half-way down on both sides of the rear panel, locate and disconnect latches connecting rear panel to side panels.
 - Place panel away from the TCM.

2.5 Check and Calibration Procedure

2.5.2.2 Verify Power Supply (Continued)

4. Remove the side panels.
 - Locate and remove three screws connecting right side panel to the TCM.
 - Locate and remove three screws connecting left side panel to the TCM.
 - Place both side panels away from the TCM.
5. Turn System Power ON and verify the following voltage readings on each side of the fuse. If the correct voltage is not read at each end, replace the fuse and re-check the voltage.

<u>Fuse Nominal Voltage</u>			
<u>Fuse</u>	<u>Location</u>	<u>Fuse Rating</u>	<u>Nominal Voltage</u>
F1	Main Board	6.25 A slo-blo	4.8 to 5.2 VDC
F2	Main Board	1 A	26 to 31 VDC for 115 VAC, or 23 to 29 VDC for 220 VAC
F3	Main Board	100 mA slo-blo	-26 to -31 VDC for 115 VAC, or -23 to -29 for 220 VAC
F4	Not used		
F5	Not used		
F6	Main Board	7 A slo-blo, 115 V 5 A slo-blo, 220 V	115 VAC 220 VAC
F7	Not Used		
F8	Not used		
F9	Compressor Delay Board	100 mA	115 VAC or 220 VAC
F10	Midway up the front of machine, left of the blue capacitor	6.25 A slo-blo	7 to 11 VDC
F11	Main Board	1 A	115 VAC
F13	Compressor Delay Board	100 mA slo-blo	10 to 15 VAC
F14	Compressor Delay Board	100 mA slo-blo	115 VAC or 220 VAC
F1	Cardioplegia Relay Board	100 mA slo-blo	7 to 11 VDC

6. Check for +12 VDC across test points TP1 and TP2 on the cardioplegia relay board.
7. Check for the following readings at P45 on the cardioplegia relay board: 115 VAC across pins 8 and 9; 70 VAC across pins 7 and 9; and 55 VAC across pins 4 and 9.
8. Turn system circuit breaker off. Remove fuses F2, F3 and F4 on the cardioplegia relay board and check for continuity respectively. Replace fuse if faulty.

F2	Cardioplegia Relay Board	100 mA slo-blo
F3	Cardioplegia Relay Board	100 mA slo-blo
F4	Cardioplegia Relay Board	2.5 A

2.5 Check and Calibration Procedure

2.5.2.3 Verify Startup Conditions

1. Turn System Power ON.
2. Self test lasts approximately 6 seconds. Verify the following:
 - All front panel lights illuminate.
 - All displays show "88."
 - The audio alert sounds.
 - Displays and lights extinguish briefly.
 - Software version 2.0.0 is displayed as "02" on the MAINTAIN display, and "00" on the H₂O °C display.
 - STANDBY light begins flashing.
 - All valves energize, signaled by audible click.
3. Internal Prime lasts approximately 60 seconds. Afterward, verify the following:
 - STANDBY light stops flashing, but remains illuminated.
 - COOLDOWN light flashes (until next mode is selected).
 - The MAINTAIN display shows "25".
 - H₂O °C display shows manifold water temperature.

Note: With temperature display module installed, remote control lights respond like their counterpart on the main control panel. For temperature, the A, D and G lights illuminate. With no probes installed, the temperature displays show "- -".

4. Prime External Loops.
 - Press COOLDOWN switch. Leave system in cooldown mode until all air bubbles are purged from external tubing.
5. Press STANDBY.

2.5.2.4 Check Maintain Mode

The maintain mode begins warming water or adding cold water to attain and maintain an operator-selected temperature.

Note: When the MAINTAIN switch is pressed, one or two heaters may turn on, or water may flow over the cold plate to maintain the selected temperature.

1. Press and hold the MAINTAIN DOWN arrow to observe MAINTAIN display decrease in 1 °C increments from 25 °C until stopping at 00 °C.
2. Press and hold the MAINTAIN UP arrow to observe MAINTAIN display increase in 1 °C increments to 25 °C.

2.5 Check and Calibration Procedure

2.5.2.4 Check Maintain Mode (Continued)

3. Press MAINTAIN. Observe:
 - The MAINTAIN light illuminates.
 - The main pump starts.
 - Valve 2 energizes. (Valve 1 may energize if water temperature exceeds set maintain temperature.)
 - The water temperature increases or decreases in 1 °C increments to 25 ± 1 °C and maintains that temperature.
 - Wait one minute for water temperature to stabilize.
4. Press STANDBY; the STANDBY light illuminates. Main pump stops.
5. Press MAINTAIN UP arrow until MAINTAIN display shows 30 °C.
6. Simultaneously Press MAINTAIN and start external timer. Observe:
 - MAINTAIN light illuminates.
 - Main pump starts.
7. Record the time it takes for water temperature to reach 30 °C. It should take 3 minutes or less. If it takes longer than 3 minutes to maintain 30 °C and there is evidence of cold water trickling over the cold plate, Valve 1 may be malfunctioning.
8. Press STANDBY.
9. Press and hold MAINTAIN UP arrow until MAINTAIN display shows 42 °C.
10. Press MAINTAIN. Observe:
 - Water temperature increases to and maintains 42 ± 1 °C.
11. Press STANDBY; STANDBY light illuminates.
12. Press MAINTAIN DOWN arrow until MAINTAIN display shows 25 °C.
13. Press MAINTAIN. Observe:
 - Water flows at high rate over cold plate until water temperature is 32 °C (with adequate ice supply).
 - Water flow then decreases by one-half until 25 °C is reached.

Note: Water temperature may overshoot 5-7 °C. Before proceeding, allow water temperature to stabilize at 25 °C.

14. Press STANDBY; STANDBY light illuminates. Main pump stops.

2.5 Check and Calibration Procedure

2.5.2.5 Check Cooldown Mode

Note: Cooldown mode opens the valves to circulate cold water from the large tank through the main hose circuitry and blanket circuitry if appropriate.

1. Check that there is an adequate supply of ice for this procedure.
2. Check that water temperature is 25 °C. If is not, press MAINTAIN UP or DOWN arrow to 25 °C and press MAINTAIN switch. Wait until temperature stabilizes at 25 °C.
3. Press COOLDOWN switch. Observe:
 - COOLDOWN light illuminates.
 - Heaters go off.
 - Water flows full-force over the cold plate.
 - Water temperature decreases to below 10 °C in less than 20 seconds.
4. Press STANDBY.

Note: If the water temperature takes longer than 1 minute to decrease below 10 °C, check that ice supply is adequate. Verify that main pump has started. Verify that Valve 1 only is energized.

2.5.2.6 Check Rewarm Mode

Rewarm mode activates the heaters to warm water at maximum speed up to 42 °C.

1. Press REWARM switch. Observe:
 - REWARM light illuminates.
 - Pump starts.
 - Both heaters come on.
 - Heater #1 turns off immediately after water temperature passes 41 °C.
 - Valve 2 only energizes.
 - Water temperature should increase 10 °C in 3 minutes or less.
 - H2O°C display shows 42 °C and maintains 41 to 42 °C.
 - Heater #2 cycles on and off to maintain 41 to 42 °C.

2.5 Check and Calibration Procedure

2.5.2.7 Check Pump Not Primed Alarm

The Pump Not Primed symbol illuminates to warn that outlet pressure has dropped because the main pump has lost its prime and shut off. This alarm does not apply to the cardioplegia pump.

1. Make sure system power is OFF.
2. Disconnect P21 from the main board.
3. Turn system power ON. Allow startup procedure to finish.
4. Press COOLDOWN switch. Observe:
 - Within 5 to 10 seconds, the unit will simultaneously beep, illuminate the Pump Not Primed symbol, and automatically change to standby mode.
5. Turn system power OFF.
6. Reconnect P21.

Note: If alarm does not function properly, refer to Section 4 Troubleshooting.

2.5.2.8 Check H20 > 42 °C Alarm and Thermostat

The H20 > 42 °C alarm light illuminates to warn that the water temperature is at or above 42.5 °C. When this occurs, the alarm sounds and the heaters automatically turn off.

1. Turn system power and ice maker switches OFF.
2. Locate main board.
 - Remove P12 from J12 on main board.
 - Install P/J 12 over-temperature fixture between J12 and P12 cable harness.

Note: The above procedure will allow the temperature to increase above what the software allows; the software is bypassed in order to check the thermostat.

3. Turn system power ON.

2.5 Check and Calibration Procedure

2.5.2.8 Check H2O > 42 °C Alarm and Thermostat (Continued)

4. Press REWARM. Observe:
 - Water temperature continues to increase through 42 °C, but not exceed 4 °C. (This may take some time depending on the original water temperature.)
 - The audio alert sounds.
 - The H2O > 42 °C light illuminates.

Note: If the water temperature exceeds 44 °C, check to make sure there are no kinks in the external water lines, and that the thermostat is properly connected.

5. Turn system power OFF.
6. Remove P/J 12 over-temperature fixture and reconnect P12 with J12.

2.5.2.9 Check the Compressor

Note: The ice maker switch starts and stops the compressor. However, when returning from OFF to ON position, there will be a delay of up to 6 minutes before the compressor starts again.

1. Make sure system power and ice maker switches are OFF.
2. Simultaneously turn ice maker switch ON and start an external timer. Observe:
 - The green ICE MAKING lamp (located on the left side of the main panel) illuminates within 6 minutes.

Note: With a substantial amount of ice already present in the large tank, compressor might not start, but green ICE MAKING lamp will illuminate.

3. Make sure fan runs quietly. Listen for excessive rattling. (A dirty unit or mechanical failure can prevent the fan from functioning properly.)

Note: The compressor will often rattle when system power is turned ON.

2.5 Check and Calibration Procedure

2.5.2.9 Check the Compressor

4. Turn the ice maker switch OFF.

Note: Clean the condenser coils at least once every 3 months. Unplug the system from its wall power supply. Remove the back and left rear panel. Use a soft brush or vacuum to remove lint from coils. Replace the panels and plug system back into wall power.

Caution: Remove any lint from the refrigeration coils to prevent damage to the ice maker. When cleaning coils, beware of sharp edges.

2.5.2.10 Check the Service Alarm.

The service indicator illuminates to warn that the water temperature is not changing as expected, that the 2 internal temperature probes are not in agreement, or that there are problems within the A/D board.

1. Make sure system power and ice maker are OFF.
2. Locate connectors P1 and P2 on the main board.
3. Remove either connector P1 or P2 from the main board.
4. Turn system power ON. Observe:
 - Audio alert sounds for 3 seconds.
 - Service Alarm/System Malfunction LED lights.
5. Reconnect P1 or P2. Service alarm/service indicator light extinguishes.
6. Press STANDBY.

2.5 Check and Calibration Procedure

2.5.2.11 Check the Cardioplegia Water Supply

Note: The large tank mode and the small tank mode are both dependent on an external closed loop for water flow. The large to small tank mode is not dependent on an external closed loop.

1. Press the CPG (cardioplegia) pump switch. Observe:
 - The CPG light illuminates and the pump starts.
 - Valves 4 and 6 energize.
 - The #3 light above the RPM switch is illuminated, indicating that water flows full force from the small tank to the large tank.
2. Vary the pump speeds and check the flow rate changes accordingly.
 - Press the RPM switch once. The #1 (low speed) light illuminates and water flows from the small tank into the large tank at a greatly reduced rate.
 - Press the RPM switch again. The #2 (medium speed) light illuminates. The water flow rate increases.
 - Press the RPM switch again. The #3 light illuminates. The water flow rate increases to an even greater speed.
3. Press the LARGE TANK switch. Observe:
 - The LARGE TANK light illuminates.
 - Valve 4 only energizes.
 - Water continues flowing from the small tank into the large tank, and through the CPG ports.
4. Using a clamp or hands, momentarily restrict the water flowing through the external loop leading to the CPG ports. Observe:
 - Water stops flowing from the small tank into the large tank.
5. Place an external thermometer into the small tank.
6. Press and hold the CPG H₂O°C water display switch. Observe:
 - The temperature in the small tank is the same as the CPG water display ± 1 °C.
7. Press CPG pump switch. The CPG pump light extinguishes and the pump stops.

2.5.2.12 Check the Low Flow to Blanket Alarm.

The low flow to blanket light warns that water flow for the blanket is low.

1. Verify that the blanket hose or closed loop is connected to the blanket ports.
2. Press COOLDOWN.
3. Remove one (1) side of the blanket loop from its port. Observe:
 - The low flow to blanket light illuminates.
4. Reconnect the dislodged side of the blanket loop. Observe:
 - The low flow to blanket light extinguishes.
5. Press STANDBY.

2.5 Check and Calibration Procedure

2.5.2.13 Check Defrost Mode.

Defrost mode turns the compressor off and the heaters on. It circulates warm water throughout the large tank until the water temperature reaches 20 °C.

Note: Standby mode must be selected before defrost can be initiated.

1. If not in standby mode, press STANDBY. Observe:
 - The STANDBY light illuminates.
2. Press DEFROST. Observe:
 - The DEFROST light illuminates.
 - The heaters and main pump turn on until the water temperature reaches 20 °C.
 - Water runs full force over the cold plate.
 - Valves 1 and 3 only energize.
3. Press STANDBY.

Notes: If the water temperature display shows 20 °C or above, the system will automatically revert to standby mode. After the water temperature reaches 20 °C, the ice maker (if turned on) will start.

As it may take 2-3 hours to reach 20 °C in defrost mode if previous steps followed in sequence, during which time existing ice will melt, simply confirming that the defrost mode is operational may suffice.

If TCM does not have the optional remote temperature module, proceed to Step 2.5.2.20 Calibrating the Main System.

2.5 Check and Calibration Procedure

2.5.2.14 Check the Remote Temperature Display Module.

1. Set a high limit on channel A.
2. Press the black ABC switch until channel A light illuminates.
3. Press and quickly release the HIGH switch. Observe:
 - The top display shows 42 °C.
4. Press and hold the HIGH switch until the display shows 24 °C.
5. Set a low limit on channel A.
6. Press and quickly release the LOW switch. Observe:
 - The top display shows 00.0 °C.
7. Press and hold the LOW switch until the display shows 05 °C.
8. Verify that each alarm limit will display properly without changing the setting.
9. Press the ABC switch until the channel A light illuminates.
10. Press and quickly release the HIGH switch. Observe:
 - The top display shows 24 °C for approximately 3 seconds.
11. Press and quickly release the LOW switch. Observe:
 - The top display shows 05.0 °C for approximately 3 seconds.
12. Verify that alarms function properly.
13. Insert a 47° probe for the temperature probe module into channel A on the first module. Observe:
 - The audio alert sounds for approximately 3 seconds.

Notes: If more than one temperature probe module is installed, repeat the above steps for each module.

If the alarm limits for two probes are exceeded, both probe lights will flash. If one of these probes is also selected for display, its light will flash at a higher rate.

14. Verify the temperature display accuracy.

2.5 Check and Calibration Procedure

2.5.2.14 Check the Remote Temperature Display Module. (Continued)

15. Insert a 25 ° probe for temperature probe modules into channel A. Observe:
 - The channel A light illuminates.
 - The display shows 25 °C ± 0.2 degrees. If not, refer to Step 2.5.2.21. Calibrate the Temperature Display Module (Remote Controls).
16. Replace the 25° probe with a 47° probe. Observe:
 - The display should show 47 °C ± 0.2 degrees. If not, refer to Step 2.5.2.21. Calibrate the Temperature Display Module (Remote Controls).
17. Repeat steps 1 through 16 for each temperature probe installed.

2.5.2.15 Check the Cooldown Mode. (Remote Controls)

1. Press the COOLDOWN switch (remote). Observe:
 - Remote COOLDOWN light illuminates.
 - Cooldown mode begins.
2. Press STANDBY (remote).

2.5.2.16 Check the Maintain Mode. (Remote Controls)

1. Press MAINTAIN up or down arrow until display shows 25 °C.
2. Press MAINTAIN switch (remote). Observe:
 - Remote MAINTAIN light illuminates.
 - Water temperature displayed increases/decreases toward temperature displayed on MAINTAIN °C display on panel.
 - Water temperature display stabilizes at 25 °C.
3. Press STANDBY (remote).

2.5.2.17 Check the Rewarm Mode. (Remote Controls)

1. Press the REWARM switch (remote). Observe:
 - Remote REWARM light illuminates.
 - Water temperature display indicates water temperature is increasing.
2. Press STANDBY (remote).

2.5 Check and Calibration Procedure

2.5.2.18 Check the Cardioplegia Water Supply (Remote Controls)

1. Press the CPG H2O°C switch (remote). Observe:
 - Main panel pump light illuminates and the pump starts.
 - The pump speed and mode selections remain the same.
2. Press the CPG H2O°C switch (remote) again. Observe:
 - Main panel pump light extinguishes and the pump stops.

2.5.2.19 Check the Gradient Maintain Mode and the Gradient Rewarm Mode.

1. Insert a 25° probe for gradient temperature into channel G on the temperature module. Observe:
 - Channel G on the display should read 25 °C ± 0.2 degrees.
 - Display will stay the same throughout this test.
2. Press the remote MAINTAIN up arrow until reaching 40 °C.
3. Press the GRADIENT switch on the main panel one time. Observe:
 - The GRADIENT 6° light illuminates.
4. Press remote MAINTAIN switch. Observe:
 - The water temperature display increases to 31 °C (25 plus 6) and holds.
5. Press the GRADIENT switch again. Observe:
 - The GRADIENT 6° light extinguishes.
 - The GRADIENT 10° illuminates.
 - Water temperature increases to 35 °C.
6. Press the GRADIENT switch again. Observe:
 - The GRADIENT 10° light extinguishes.
 - Note increasing temperature.
7. Repeat Steps 1 through 6 to this point, but select rewarm mode instead of maintain.
8. Remove the 25 °C probe.
9. Press STANDBY.

2.5.2.20 Calibrate the Main System.

Note: Proper static precautions should be observed.

1. Turn the system power and ice maker switches OFF.
2. Locate the card cage (upper right side on front of the unit).
3. Unplug ribbon cable on the A/D Board (center board in the card cage).
4. Remove the main computer board (front board in the card cage).

2.5 Check and Calibration Procedure

2.5.2.20 Calibrate the Main System. (Continued)

5. Remove the communications board (back board in the card cage).
6. Install the 5-Pin-Connector to the A/D board. (The red wire should be up and on pin 5.)
7. Connect a voltmeter to the A/D board.
8. Connect the common lead of the meter to the black wire.
9. Connect the positive lead of the voltmeter to the blue wire.
10. Turn the system power ON.
11. Use a nonconductive screwdriver or equivalent to adjust R18 Ref Cal (bottom pot) to show 2.500 ± 0.001 VDC.
12. Disconnect meter from the blue wire (reference).
13. Connect meter to red wire on the test fixture.
14. Disconnect J3.
15. Install a 0° A/D fixture to connector P3 on the main board.
16. Turn R23 zero (middle pot) clockwise until a positive reading is indicated on the voltmeter.
17. Adjust R23 for 0.005 ± 0.005 VDC.
18. Disconnect the 0° A/D fixture from connector P3.
19. Install the 40° A/D fixture to connector P3.
20. Adjust R29 gain (top pot) to show 4.000 ± 0.002 VDC.
21. Remove the 40° A/D fixture from connector P3.
22. Insert connector J1 (main temperature sensor) into connector P3. Observe:
 - The voltmeter should indicate the manifold temperature (1 volt = 10°C)
23. Record voltmeter reading.
24. Disconnect connector J1.
25. Insert connector J1 into P1 position.
26. Insert connector J2 (back-up temperature sensor) into connector P3 position. Observe:
 - The voltmeter should show the same as in Step 23, ± 0.015 volts.
 - If readings do not agree, replace the dual temperature sensor and repeat Steps 11 through 26.

2.5 Check and Calibration Procedure

2.5.2.20 Calibrate the Main System. (Continued)

27. Remove connector J2.
28. Insert connector J2 into connector P2 position.
29. Insert connector J3 (cardioplegia temperature sensor) into connector P3 position. Observe:
 - The voltmeter indicates the cardioplegia water temperature (1 volt = 10 °C).
30. Short the purple wires of the 5-Pin Connector. Observe:
 - The voltmeter shows 2.82 ± 0.02 V. If not, repeat the A/D calibration (Steps 11 through 26).
31. Turn the system power OFF.

Note: If the A/D board fails this calibration, replace it and repeat the calibration.

32. Remove the 5-pin connector fixture.
33. Install the main computer board and communications board and associated connectors.

2.5.2.21 Calibrate the Temperature Display Module (Remote Controls)

1. Turn system power OFF.
2. Remove the rear panel.
3. Turn system power ON.
4. Press and hold the TEST switch while the following calibrations are completed.
5. Adjust R2 for each temperature module until the associated display shows 25.0 ± 0.1 °C.
6. Turn the system power OFF.

2.5.2.22 Clean Filters and Screens

1. Turn system power ON.
2. Press DEFROST and completely defrost the TCM.
3. Drain the TCM.
4. Remove the two screens from the bottom of the large tank and the two screens from the bottom of the small tank.
5. Clean or, if necessary, replace the screens.

2.5 Check and Calibration Procedure

2.5.2.22 Clean Filters and Screens (Continued)

6. Remove front and rear panels.
7. Remove filter caps from inlet.
8. Remove and clean screens and caps.
9. Reinstall the clean screen and cap.
10. Leave the TCM empty and store properly, or refill with water and turn the ice maker ON.

2.5.2.23 Re-attach front, rear and side panels.

2.6 Recommended Spare Parts

Item No.	Sarns P/N	3M I.D. No.	Description
1	16067010	78-8066-7427-7	Blanket Flow Switch Assembly
2	15796010	78-8066-9604-9	Cardioplegia Temperature Sensor
3	15791010	78-8066-6527-9	Dual Temperature Sensor Assembly
4	23420607	26-1008-2360-3	Fuse 6.25A (Slo Blo 3AG, 250V)
5	25511077	26-1006-6643-2	Ice Sensor
6	25010040	26-1006-6646-5	Impeller Magnet
7	N/A	78-8066-8309-6	Membrane Switch Cardioplegia
8	N/A	78-8066-8307-0	Membrane Switch Main
9	N/A	78-8066-8308-8	Membrane Switch Remote Module
10	15726010	78-8066-6256-1	PC Assembly A/D Timer
11	N/A	78-8067-1533-6	PC Assembly Cardioplegia Relay
12	N/A	78-8066-7957-3	PC Assembly Main Computer Card
13	23699008	26-1008-1799-3	Pressure Switch
14	25010039	26-1006-6649-9	Pump Housing
15	N/A	26-1010-1288-3	Solenoid Valve NC 1/2" FPT 115V
16	N/A	26-1010-1287-5	Solenoid Valve NC 3/4" FPT 115V
17	23510150	26-1008-1696-1	Solid State Relay (280VAC, 25A)
18	16001001	78-8066-7411-1	Tank Filter

115 V Units Only

Item No.	Sarns P/N	3M I.D. No.	Description
1	N/A	26-1009-6735-0	18A System Circuit Breaker
2	N/A	26-1009-6736-8	15A Compressor Circuit Breaker
3	N/A	78-8067-3890-8	Compressor Delay Assembly 115V

220-240 V Units Only

Item No.	Sarns P/N	3M I.D. No.	Description
1	N/A	26-1010-0858-4	13A System Circuit Breaker
2	N/A	26-1010-0859-2	6.5A Compressor Circuit Breaker
3	N/A	78-8067-1523-7	Compressor Delay Assembly 230V

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Note: Perform a complete system inspection after completing any procedure which requires any disassembly of the unit.

3.1 Preparation for Disassembly

- Turn system power OFF and disconnect power cord from power source.
- Drain TCM.

Notes: It is necessary to defrost TCM before draining. Follow Defrost procedure in TCM Operator's Manual. Allow up to three hours for TCM to complete defrost mode.

Up to 11 gallons of water must be disposed. A suitable reservoir must be available before the TCM is drained. Always replace TCM water supply with clean water.

3.2 Remove Panels

3.2.1 Front Panel

The front panel is secured with four screws, two located on each side of the TCM where the front panel wraps around the unit. To remove the panel, first remove the four screws, then pull the panel down and away from the TCM.

To attach the front panel, slide the top of the panel up and under the top panel, then seat the bottom of the front panel on the base of the chassis. Attach the four screws.

3.2.2 Rear Panel

The rear panel is attached with six screws. To remove the rear panel, first remove the two screws at the bottom of the panel, located directly above the cardioplegia and blanket supply ports. Next remove two screws at the top of the panel. Free the panel by loosening the two screws halfway down and on either side of the panel. Slide panel down and away from TCM.

Reattach the rear panel by sliding it up and under the top panel and attaching screws.

3.2 Remove Panels

3.2.3 Side Panels (2)

The side panels are on both sides toward the rear of the machine where they are connected to the rear panel. To remove a side panel, first remove the rear panel in order to remove a screw located inside the top rear corner of the side panel. If the TCM is equipped with a temperature control module, it will have to be removed to access this screw when removing the right side panel. Remove the two screws on the face of the panel. A third screw, located around the back of the TCM near the bottom, overlaps the side and rear panels. Loosen the third screw to completely free the side panel being removed.

3.2.4 Bottom Panel

Note: If bottom panel must be removed during a disassembly procedure, remove it before removing other panels.

The bottom panel is connected to the TCM by eight screws. To remove the bottom panel, tip the TCM on its right side, resting it on a soft, non-abrasive surface. Remove the eight screws. Any maintenance to be performed on the bottom assembly should be done before tipping the TCM upright.

3.2.5 Top Panel (Disassembly)

Removal of the top panel in a field service environment is necessary only in rare cases, such as when replacing the compressor. Technicians should ensure that an adequate supply of silicone sealant is available before performing this procedure.

Caution: Use proper static precautions when handling printed circuit boards or integrated circuit chips.

1. Set aside tank covers to large and small tanks. Remove remote module (or blank cover) and front, rear and side panels.
2. Unplug P8, P15, P27, and P28 from main board. Remove wire duct cover.
3. Disconnect ribbon cable from communication board in card cage.
4. Remove two screws from remote module compartment.
5. Remove nut securing ground wires for front panel LED and remote module.
6. Remove nut securing three temperature probe module ground wires at center of rear assembly base.
7. Remove two nuts securing top panel to bracket in upper right portion of rear assembly.
8. Disconnect P40 and any ribbon cables to temperature probe modules. Remove four screws securing board housing to rear of top panel. Slide each board and housing down and away from the TCM.
9. Break the seal securing the top panel to the unit by lifting one corner of the top panel until it lifts away from the TCM.
10. Reassemble in reverse order of disassembly with the following exception:
 - Scrape silicone sealant from channel on underside of top panel. Fill channel with a liberal amount of silicone sealant (about two 10.3-ounce tubes) using a caulk gun. Align channel with rim along top of large and small tanks and set top panel firmly into place. Examine inside of large and small tanks and remove any excess silicone sealant.

3.3 Main Computer Card, A/D Timer Board and Communication Board (See figure 3-1.)

Caution: Use proper static precautions when handling printed circuit boards or integrated circuit chips.

1. Prepare system per Procedure 3.1, and remove front panel.
2. Remove any ribbon cable attached to the board to be replaced. Pull back the top of the white tab connecting board to the card cage and carefully pull board out.
3. Slide new card(s) into appropriate slot in card cage. Ensure that it is seated properly and secure with tabs.
4. Reattach front panel.

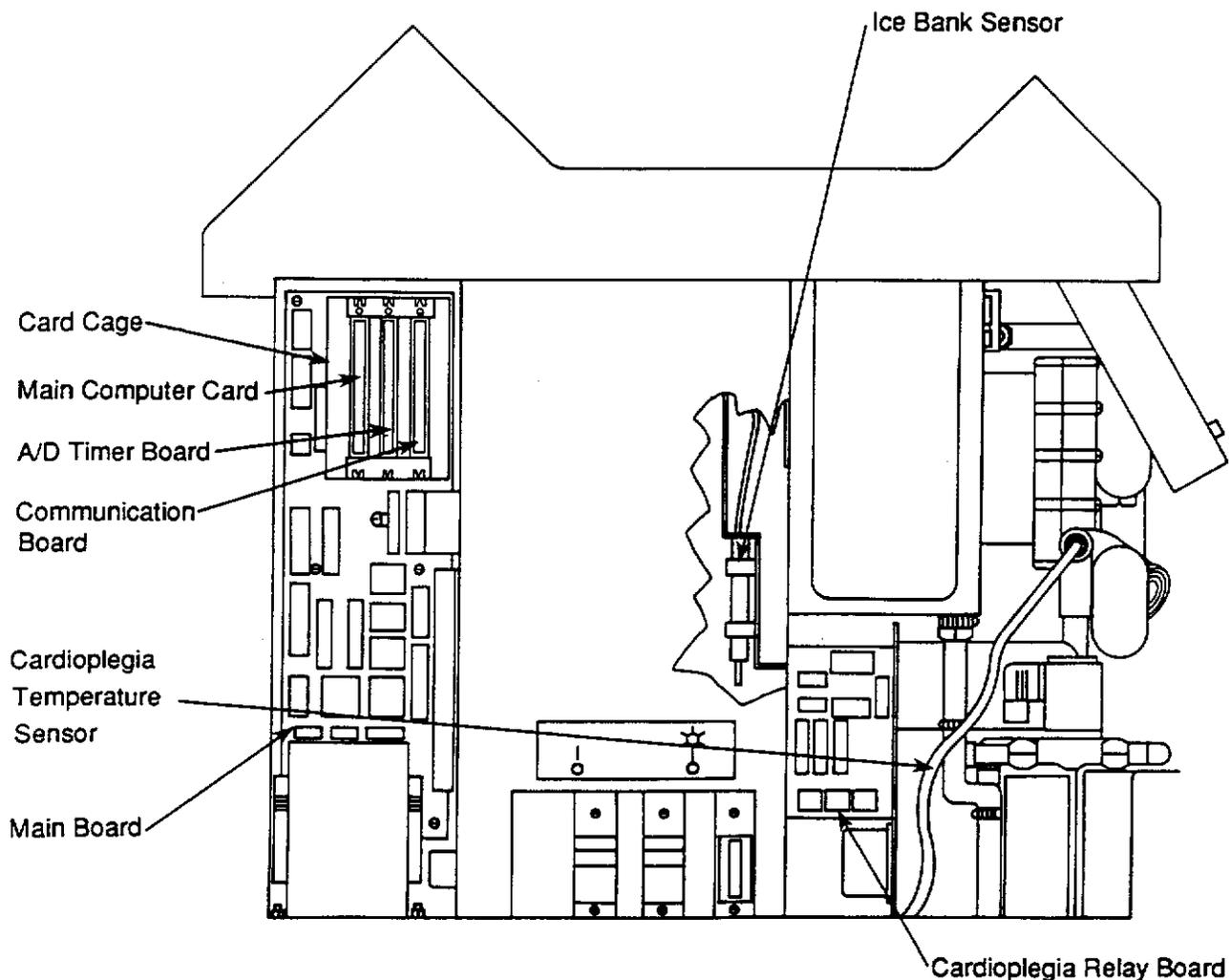


Figure 3-1. Printed Circuit Boards

3.4 Main Board (See figure 3-1.)

Caution: Use proper static precautions when handling printed circuit boards or integrated circuit chips.

1. Prepare system per Procedure 3.1, and remove front panel.
2. Disconnect 50-pin ribbon cable (P15) and all plugs except P26.
3. Remove printed circuit boards from the card cage per Procedure 3.3, Main Computer Card, A/D Timer Board and Communication Board.
4. Remove six screws attaching board to the chassis (See Figure 3-1.). Holding the board in one hand and gripping the card cage in the other, carefully slide assembly from the TCM.
5. Disconnect P26 from old board and immediately connect to the new board.
6. Secure new board to chassis with six screws.
7. Connect 50-pin ribbon cable (P15) and all remaining plugs to corresponding pins.
8. Install printed circuit boards. Ensure that each is seated properly and secure with tabs.
9. Reattach front panel.

3.5 Heater Assembly (See figure 3-2.)

Notes: This procedure requires the removal of one or more sections of heater hose. It may be easier to cut hose sections and replace with new hose of the same size. If so, ensure that enough of the appropriate size hose is available before starting procedure.

The gasket between the manifold and manifold faceplate must be removed to perform this procedure. A replacement gasket should be available before performing this procedure.

1. Prepare system per Procedure 3.1, and remove front panel.
2. Loosen three hose clamps and remove pipe section.
3. Disconnect P50, P51, and P52 from the main board.
4. Disconnect P1 and P2 from the main board.

3.5 Heater Assembly (See figure 3-2.)

5. Loosen hose clamps and remove two hoses connected to elbow fixtures attached to the faceplate.
6. Remove four bolts securing faceplate to the manifold and pry faceplate free. Remove gasket seal.
7. Remove the heater(s) to be replaced using appropriate sized socket wrench.
8. Apply thread seal tape to new heater(s) and install.
9. Apply silicone sealant to faceplate and new gasket seal and reattach faceplate to the manifold. Secure with four bolts removed in Step 6.
10. Connect P1 and P2.
11. Connect P50, P51, and P52.
12. Reinstall pipe assembly removed in Step 2. Replace any heater hose cut and discarded earlier in this procedure.
13. Reattach front panel.

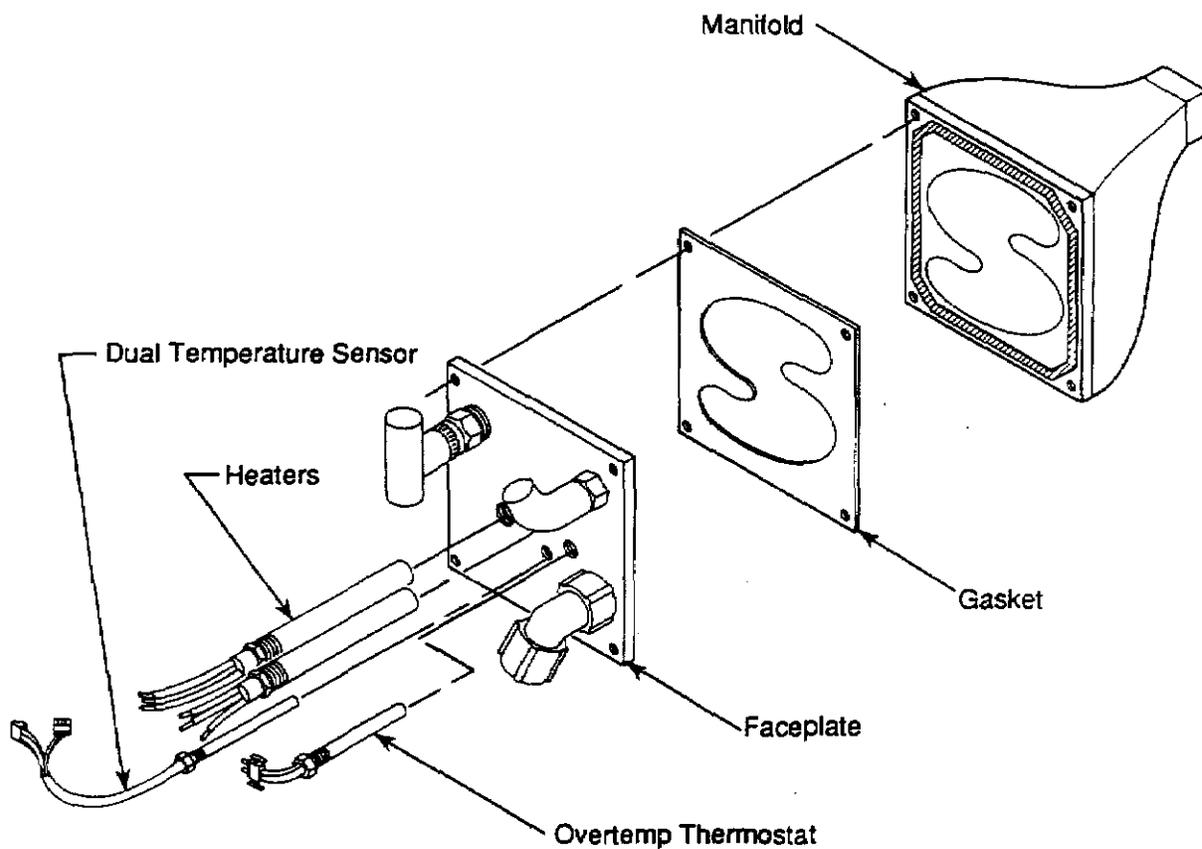


Figure 3-2. Heater Assembly

3.6 Overtemp Thermostat (See figure 3-2.)

1. Prepare system per Procedure 3.1, and remove front panel. Locate overtemp thermostat.
2. Disconnect P52 at the overtemp thermostat.
3. Remove the overtemp thermostat using a 5/8-inch deep-well socket wrench.

Note: It may be easier to cut away the portion of P52 that is attached to the overtemp thermostat to ensure better access for the deep-well socket wrench.

4. Apply several wraps of thread seal tape on the threads of the new thermostat and install. Secure with deep-well socket wrench.
5. Reattach front panel.

3.7 Dual Temperature Sensor (See figure 3-2.)

1. Prepare system per Procedure 3.1, and remove front panel. Locate dual temperature sensor.
2. Disconnect P1 and P2.
3. Cut any tie wraps necessary to free temperature sensor cable.
4. Cut the cable close to the sensor and discard cable.
5. Use 7/16-inch socket wrench to remove sensor from heating chamber.
6. Apply thread seal tape to new sensor and install using a 7/16-inch open-end wrench.
7. Route cable from the new sensor along proper course and connect the new P1 and P2 to the main board.
8. Reassemble in reverse order of disassembly with the following exceptions:
 - Replace any tie wraps previously cut.
 - Calibrate the A/D timer board as described in Section 2, Calibrate Main System.

3.8 System Power and Ice Maker Circuit Breakers and Run Timer (See figure 1-2.)

1. Prepare system per Procedure 3.1.
2. Remove two screws securing circuit breakers and run timer assembly to lower right side of the TCM.
3. Use a short screwdriver to remove two screws from bottom panel under the breakers.
4. Pull circuit breaker assemblies out. At this point, the assembly will be connected to the TCM only by circuit breaker wiring scheme.
5. On the outside of the assembly, remove two screws above and below the breaker to be replaced and pull breaker free.

Note: Mark or tag wiring to ensure proper installation.

6. Remove all wires to the circuit breaker that is to be replaced.
7. Install new breaker. Secure with two screws removed in Step 5.
8. Attach wires to the new breaker in the appropriate position.
9. Insert assembly with new breaker and secure using screws removed in Step 2.

3.9 Compressor Assembly (See figure 3-3.)

Note: It is recommended that Step 8 and Step 9 of this procedure be performed by two people to ensure safety and avoid damage to the new component. Both should be capable of lifting 30-35 lbs.

1. Perform Procedure 3.1, Preparation for Disassembly.
2. Remove bottom panel.

Note: Three bolts secure the compressor to the bottom of the chassis. Two bolts come up through the bottom of the chassis and are visible 12 inches from the back of the unit on the left and right sides of the compressor plate. The third bolt goes down through the compressor plate, through the bottom of the chassis, and is located in the front left area of the plate, approximately three inches from the back of the unit.

3. Remove two bolts entering the compressor through the bottom of the chassis. An extension may be needed to reach these bolts. It may be easier to remove some sections of pipe and hose to gain better access to the bolts. Return TCM to an upright position.
4. Remove front, rear, and both side panels.
5. Remove top panel per Procedure 3.2.5.

3.9 Compressor Assembly (See figure 3-3.)

6. Disconnect P64, P65, and P66 from the compressor delay board. Remove two screws to free the relay on the right side of the compressor delay board housing.
7. Remove the remaining bolt securing compressor to the bottom panel.
8. Slide the compressor out of the rear of the TCM: One person should control the compressor while the other balances the cold plate. When the base plate of the compressor is above and past the metal lip along the bottom of the unit, lift compressor and cold plate up and out of the TCM.

Note: When installing the new compressor and cold plate, one person should balance the cold plate to avoid causing any kinks in the capillary tubes.

9. Install new compressor and cold plate. From above the TCM, one person should lower the cold plate into the large tank while the other simultaneously grips the compressor from the bottom and lowers it onto the base in the rear of the unit.
10. Secure compressor base plate to bottom of TCM with bolt removed in Step 7.
11. Reattach P64, P65, and P66.
12. Reattach front, rear and side panels per steps described in Procedure 3.2.
13. Apply silicone sealant to slot through which capillary tube passes into the large tank and allow to dry.
14. Turn TCM on its right side. Insert two bolts removed in Step 3 and reattach bottom panel. Return TCM to an upright position.
15. Reset top panel per Procedure 3.2.5.

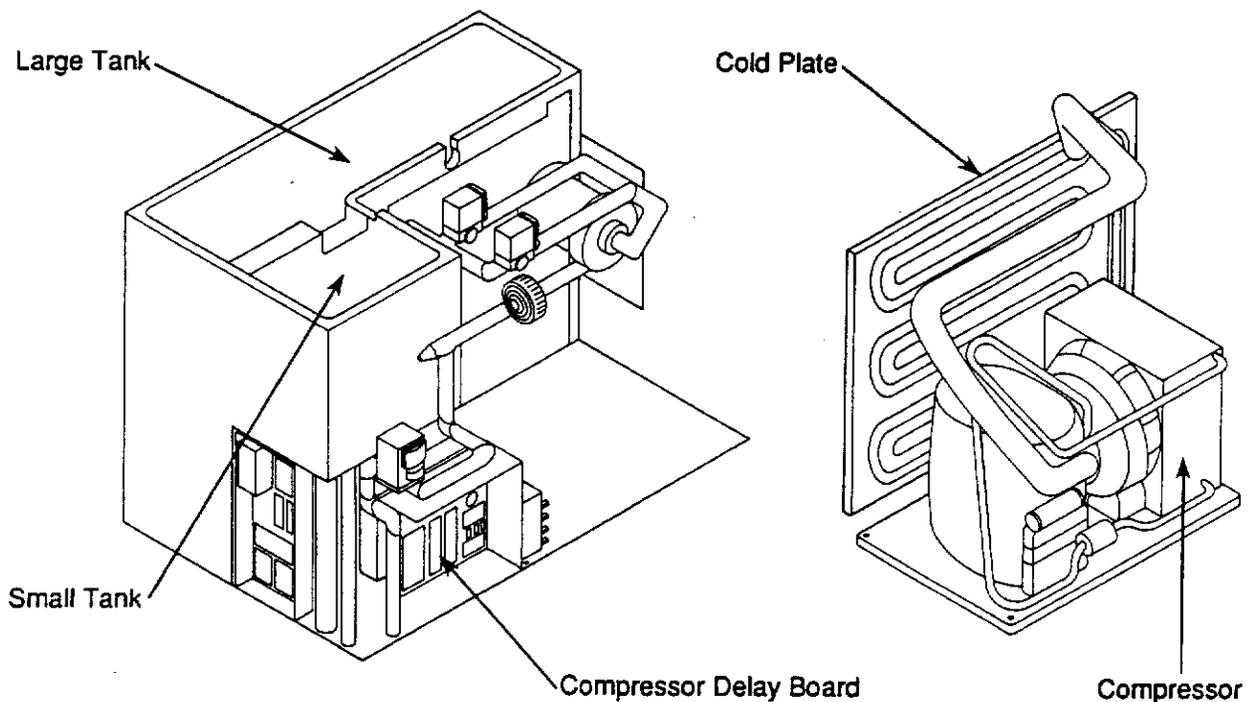


Figure 3-3. Compressor Assembly

3.10 Cardioplegia Temperature Sensor (See figure 3-1.)

1. Prepare system per Procedure 3.1. Remove front, rear and the right side panels. Locate cardioplegia temperature sensor in rear section of TCM.
2. Remove circuit breaker assembly from its housing per Procedure 3.8 to expose cardioplegia sensor wiring route.
3. Disconnect P3 from the main board and cut all tie wraps necessary to free the cable. Remove cable from the chassis.
4. Remove cardioplegia temperature sensor using long nose pliers.
5. Route new cardioplegia sensor cable starting at the connector for P3.

Note: In a field service environment, it may be easier to route the new cable through the hole behind the transformer, through the chamber housing the circuit breakers, and up through the hole toward the rear of the large tank.

6. Install new cardioplegia temperature sensor. Place several wraps of thread seal tape on the threads of the new sensor before installation.
7. Reattach front, rear, and side panels.
8. Reinstall circuit breaker assembly and secure with two screws.

3.11 Main Pump Assembly (See figure 3-4.)

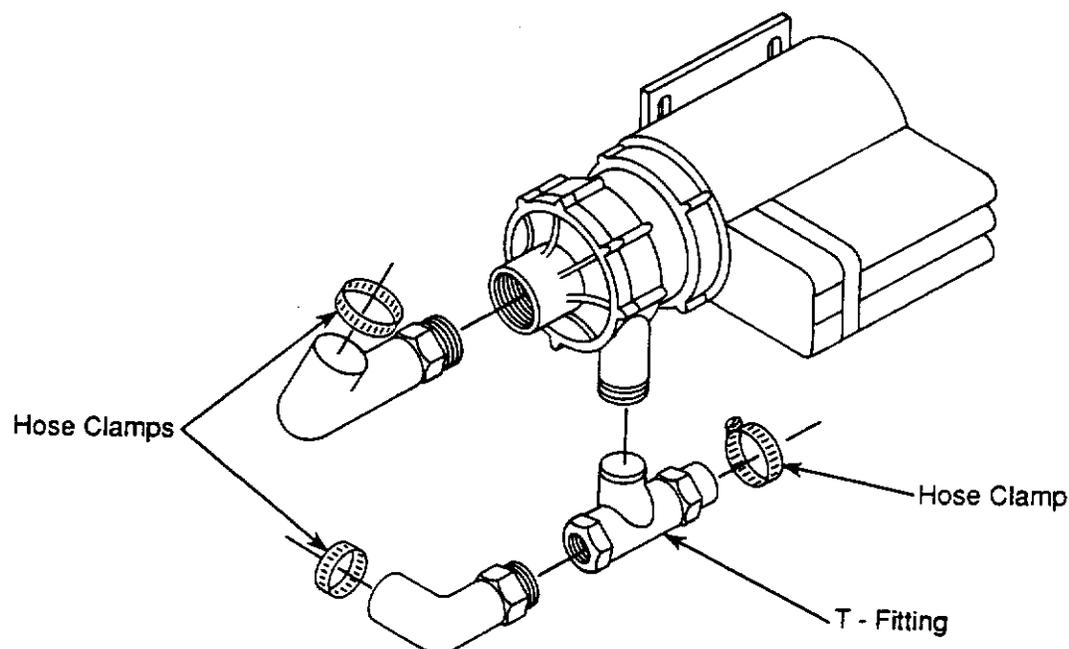
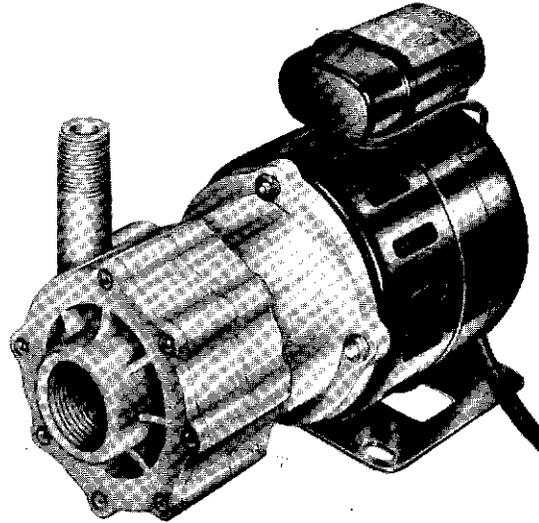


Figure 3-4. Main Pump Assembly

MARCH

INSTRUCTIONS AND REPAIR PARTS

FOR MODEL AC-5C-MD PUMP



MODEL
AC-5C-MD
ASS'Y. NO. 150-026-01

PUMP CONSTRUCTION & SERVICING

March "Orbital" Magnetic Drive Pumps eliminate the conventional shaft seals found in most pumps. This means that there is no rotating seal to wear and allow the liquid being pumped to leak out. The pumping action may eventually fail, however the liquid can never leak out. The Model AC-5C-MD has an open air fan cooled, moisture protected motor, allowing the pumps to be run continuously.

All pumps can be serviced with the use of a screwdriver. The only moving part in the pump, other than the motor, is the impeller-magnet assembly. This assembly rotates on a stationary spindle and up against a thrust washer. These are the only parts that can wear, and may need to be replaced. See the Repair Parts List for replacement parts.

ELECTRICAL CONNECTIONS AND RUNNING DRY

All models are standard in 115 volt, 50/60 cycle, 1 phase, A.C. The motors are thermal overload protected, and the motor and overload combinations are U.L. and C.S.A. listed. All cord sets are U.L. approved 18/3 wire, SJO or SJT cords. The AC style pumps have 3 foot long cords with no plug attached.

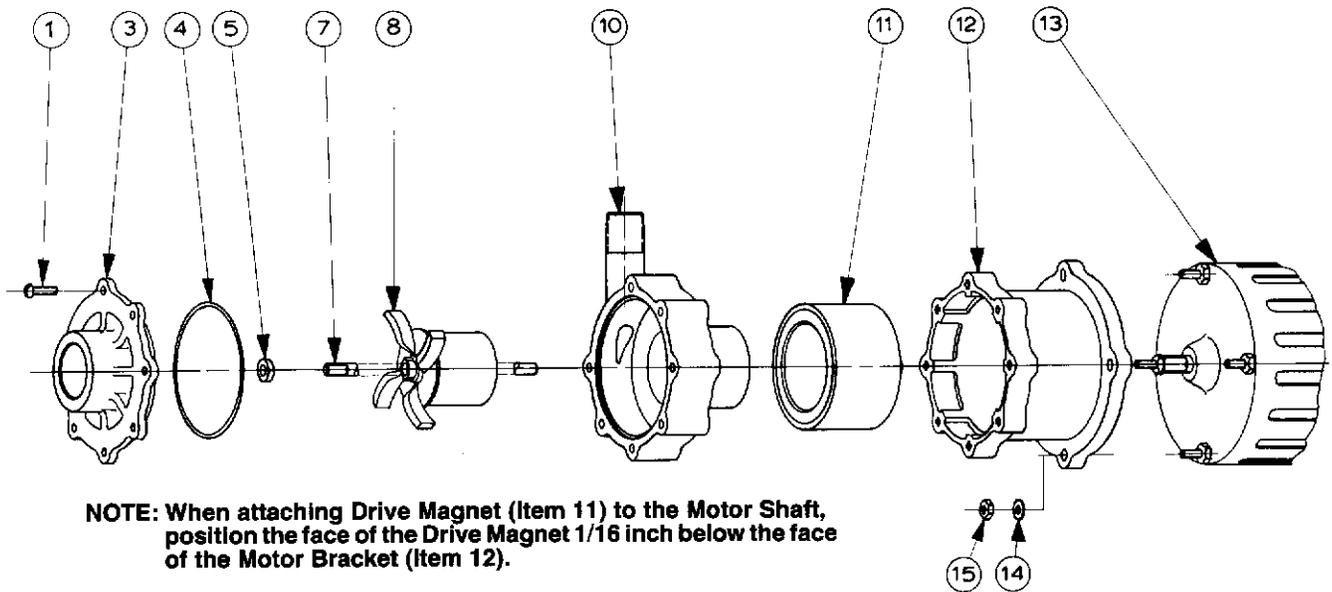
We rely on the liquid being pumped to lubricate the impeller-magnet assembly spinning on the stationary spindle. The pump is not to run dry as the plastic may "freeze" onto the spindle. Bronze, Teflon, and Carbon bushings are available if needed for dry running. Contact the factory for special applications.

PUMP MATERIALS

All screws are type 18-8 stainless.
All "O" ring gaskets are Buna-N rubber.
All stationary spindles are ceramic.
All wetted plastic parts are Glass Filled Polypropylene Plastic. Motor Bracket on AC-5 is Glass Filled Polypropylene.
The thrust washer is ceramic.
Other materials are available, contact the factory for other than standard parts.

RATINGS AND SPECIFICATIONS

MODEL NO.	CONNECTORS		ELECTRICAL			G.P.M. AT LISTED HEAD						PSI GAGE	DIMENSIONS			PACK WT.
	INLET	OUTLET	HP	WATTS	AMPS	1 FT.	3 FT.	6 FT.	12 FT.	18 FT.	24 FT.		HT.	WD.	LG.	
AC-5C-MD	1" FPT	1/2" MPT 13/16 O.D.	1/8	227	2.2	18	16.3	15	12.5	9.5	4.2	11.2	6-3/16"	4-1/2"	9-1/8"	14 LBS.



MODEL AC-5C-MD REPAIR PARTS LIST

ITEM	PART NUMBER	DESCRIPTION	QTY. REQ'D.
1	150-021-10	#8 x 1 $\frac{3}{4}$ Long Screws	7
3	150-032-10	Cover	1
4	135-007-10	"O" Ring, Buna-N	1
4A	135-023-10	"O" Ring, Viton	1
5	130-028-10	Ceramic Thrust Washer	1
7	130-024-10	Spindle	1
8	150-030-01	Impeller-Magnet Ass'y.	1
8A	150-030-02	Impeller-Magnet Ass'y. with Stainless Cover	1
8B	150-030-03	Impeller-Magnet Ass'y. with Bronze Bushing	1
8C	150-030-04	Impeller-Magnet Ass'y. with Cover and Bushing	1
10	150-031-10	Pump Housing	1
11	150-081-01	Drive Magnet Ass'y.	1
12	150-070-10	Motor Bracket	1
13	150-027-10	Motor, 115 Volt	1
14	802-006-10	Bracket Washer	4
15	625-024-10	Bracket Nuts	4

LIMITED WARRANTY

This pump is guaranteed against defective workmanship or material for a period of one year from date of manufacture. Warranty may be extended up to one year from date of purchase if the enclosed warranty card is filled out completely and returned at date of installation. All pumps not warranty registered at March will be limited to one year from date of manufacture. Warranty void if pump is connected to wrong voltage or if otherwise abused. All pumps must be shipped to March freight prepaid. Warranty pumps will be either repaired or replaced, at our option. See Warranty Card F4109, which is packed with each pump.

MARCH MANUFACTURING COMPANY

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3.11 Main Pump Assembly (See figure 3-4.)

Note: This procedure requires the removal of one or more sections of heater hose. It may be easier to cut hose sections and replace with new hose of the same size. If so, ensure that enough of the appropriate size hose is available before starting procedure.

1. Prepare system per Procedure 3.1, and remove front panel. Locate main pump assembly.
2. Remove pipe section by loosening hose clamps. (See figure 3-4.)
3. Disconnect P50 and P51.
4. Remove hose connecting manifold faceplate and impeller housing.
5. Free brass T-fitting below impeller housing: Loosen hose clamps connecting plastic piping to heater hose on each side of the T-fitting so that T-fitting assembly can be removed with the motor later in this procedure. (See figure 3-4.)
6. Remove seven screws from impeller housing and pull housing away from motor.
7. Disconnect P21 from the main board, remove four nuts securing the motor isolation plate to the chassis, and remove motor with P21 attached to it.
8. Remove motor from isolation plate and secure replacement motor to plate.
9. Balance motor with one hand while threading P21 wiring through port leading to main board. Secure motor and isolation plate to chassis with four bolts and connect P21 to main board.
10. Reattach front panel.

3.12 Impeller Blade (See figure 3-5.)

Notes: This procedure requires the removal of one or more sections of heater hose. It may be easier to cut hose sections and replace with new hose of the same size. If so, ensure that enough of the appropriate size hose is available before starting procedure.

This procedure was written specifically for removing the impeller blade located in the main pump assembly, but may be used to remove impeller blade from the cardioplegia pump assembly with the following changes:

1. In steps 1 and 5, substitute the rear panel for the front panel.
2. Refer to Procedure 3.19 to remove the cardioplegia pump assembly.

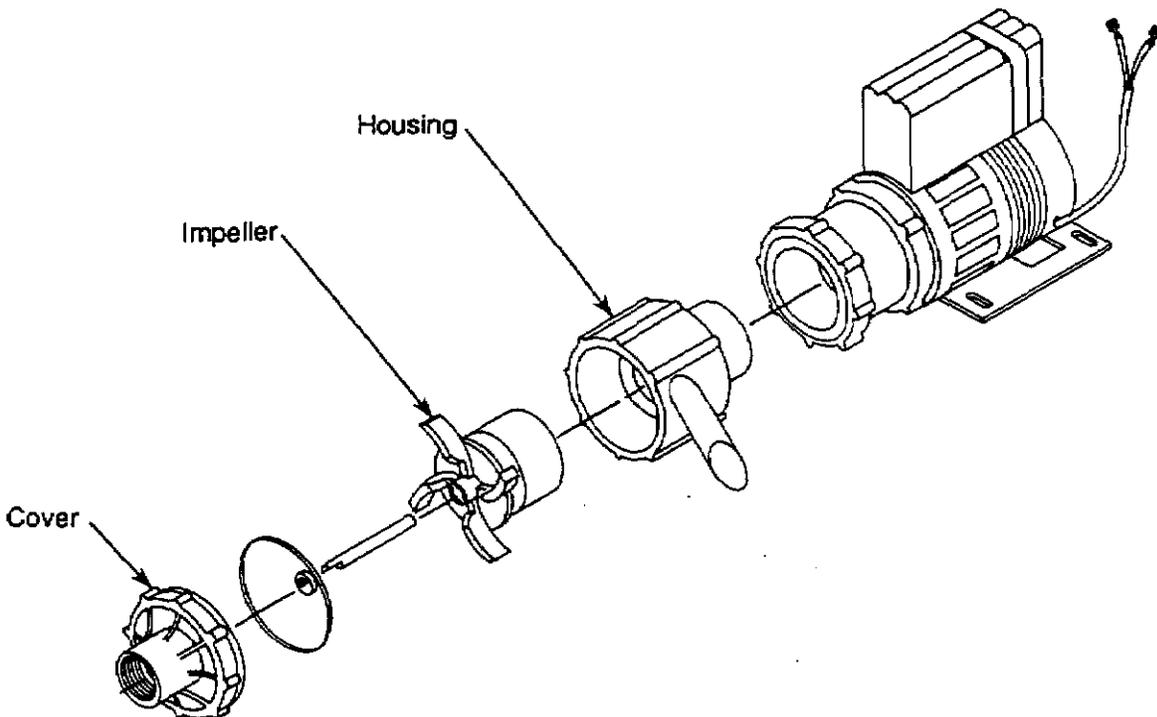


Figure 3-5. Impeller Blade

1. Prepare system per Procedure 3.1, and remove front panel. Perform steps 1 through 6 of Procedure 3.11.
2. Remove impeller blade from the housing. (See figure 3-5.)
3. Insert new impeller and reattach cover to impeller housing. Secure with seven screws.
4. Reset heater hose removed in Step 2. Secure with hose clamps. Replace any heater hose cut or discarded earlier in this procedure.
5. Reattach front panel.

3.13 Main Display Board (See figure 3-6.)

Caution: Use proper static precautions when handling printed circuit boards and integrated circuit chips.

1. Prepare system per Procedure 3.1, and remove front panel.
2. Remove ^{all 4} ~~two~~ nuts connecting the control panel to the top panel.
3. Grip the lower part of the control panel and pull it away from the TCM until the top of the panel snaps free.
4. Turn the control panel over to reveal the main display board and disconnect ribbon cables.
5. Remove four screws securing the main display board and remove the board.
6. Install the new main display board. Secure with four screws.
7. Reconnect ribbon cables to new main display board and reassemble in reverse order of disassembly with the following exception:
 - Before securing nuts removed in Step 2, open the clamps and slide the top of the control panel into place. Secure by closing the clamps.

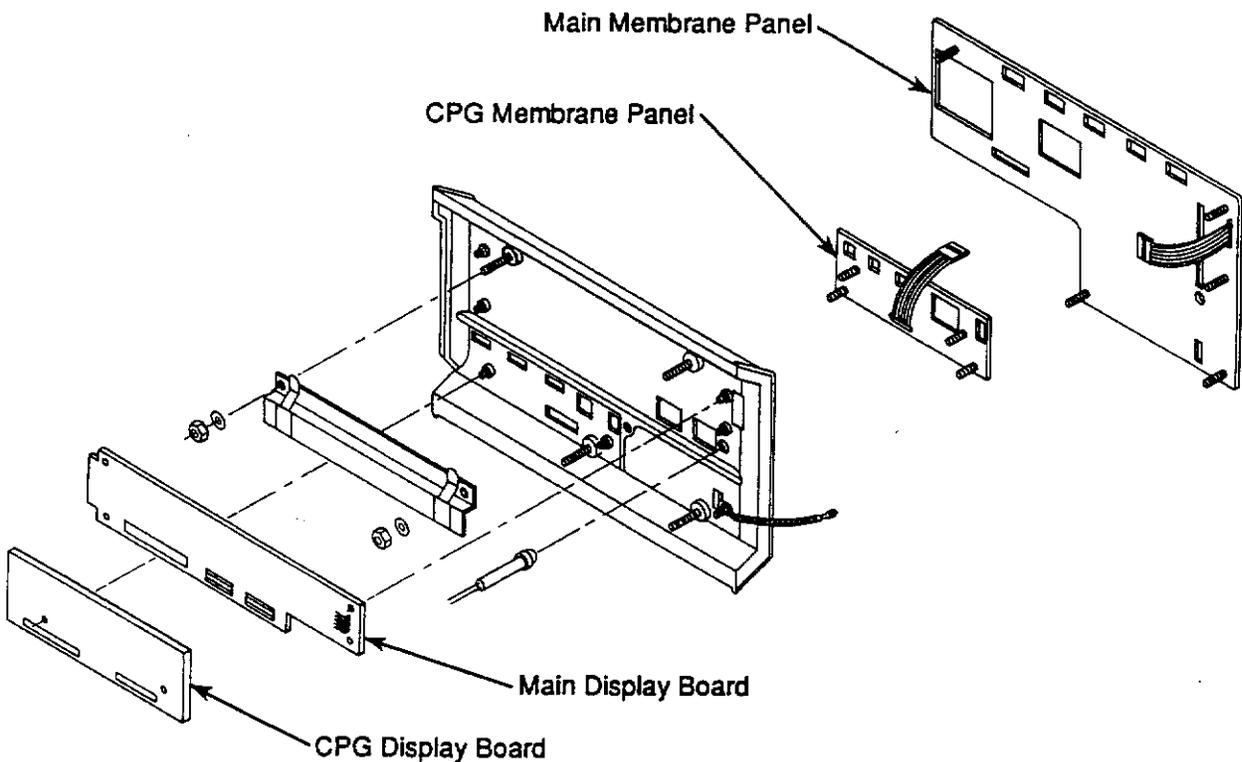


Figure 3-6. Main Display

3.14 Cardioplegia (CPG) Display Board (See figure 3-6.)

Caution: Use proper static precautions when handling printed circuit boards or integrated circuit chips.

1. Prepare system per Procedure 3.1, and remove front panel.
2. Remove two nuts connecting the control panel to the top panel.
3. Grip the lower part of the control panel and pull it away from the TCM until the top of the panel snaps free.
4. Turn the control panel over to reveal the cardioplegia display board and disconnect ribbon cables.
5. Remove four screws securing the cardioplegia display board and remove the board.
6. Install the new cardioplegia display board. Secure with four screws.
7. Reconnect ribbon cables to new cardioplegia display board and reassemble in reverse order of disassembly with the following exception:
 - Before securing nuts removed in Step 2, open the clamps and slide the top of the control panel into place. Secure by closing the clamps.

3.15 Main Membrane Panel/Cardioplegia Membrane Panel (See figure 3-6.)

Caution: Use proper static precautions when handling printed circuit boards and integrated circuit chips.

1. Prepare system per Procedure 3.1, and remove front panel. Locate appropriate membrane panel in figure on previous page.
2. Remove two nuts connecting the control panel to the top panel.
3. Grip the lower part of the control panel and pull it away from the TCM until the top of the panel snaps free.
4. Turn the control panel over to reveal the corresponding display board and disconnect ribbon cables.
5. Remove screws securing the corresponding display board and remove the board.
6. Lift one corner of the membrane panel and peel panel off. It may be necessary to pry a corner of the panel up with the tip of a screwdriver in order to ensure a firm grip.
 - Another way to lift the panel is to push the membrane panel screws back through the front panel until the membrane panel is free of the front panel.
7. Reconnect ribbon cables to new display board and reassemble in reverse order of disassembly with the following exception:
 - Before securing nuts removed in Step 2, open the clamps and slide the top of the control panel into place. Secure by closing the clamps.

3.16 Compressor Delay Board (See figure 3-3.)

Caution: Use proper static precautions when handling printed circuit boards or integrated circuit chips.

1. Prepare system per Procedure 3.1, and remove rear and right side panels.
2. Disconnect P26, P48, P63, P64 and P66 from the compressor delay board, located in lower left section of the rear assembly.
3. Remove four screws securing the board and pull it from its housing.
4. Install new board and secure with four screws. Reconnect P26, P48, P63, P64, and P66.
5. Reattach rear and right side panels.

3.17 Ice Bank Sensor (See figure 3-1.)

1. Prepare system per Procedure 3.1, remove rear and right side panels. Remove covers from large tank.
2. Disconnect P65 near compressor delay board and pull yellow and blue wires out of the compressor delay board housing.
3. Remove the old ice bank sensor: Cut the capillary tube above the ice bank sensor and remove the sensor from the large tank.
4. Remove two screws securing ice bank sensor bracket and remove bracket. Be careful not to allow keps nuts to fall into rear assembly.
5. Remove the gray ice bank sensor control box mounted on the back side of the compressor delay board. Pry cover off the old control box. Loosen two screws securing the box and pull it out the side of the TCM, pulling with it the capillary tube from the large tank.
6. Transfer yellow and blue wires to P65 into the new control box: Loosen screws securing yellow and blue wires to the sensor. Remove the black O-ring wire protector from the top of the old box. Punch out round depression on top of the new control box and install the black O-ring hole protector removed from the old box. Run yellow and blue wires through the hole and secure to the control box with two screws.
7. Free enough of the capillary tube from the new sensor to travel through the rear panel assembly, through the hole into the large tank. Grip the capillary tube and steer the sensor through the rear assembly toward and through access hole to large tank, allowing new ice bank sensor to hang free inside the large tank.

Note: Be careful not to kink the copper capillary tube when installing the new sensor.

3.17 Ice Bank Sensor (See figure 3-1.)

8. Install the new control box. Secure with two screws. Attach cover to control box.
9. Reattach bracket removed in Step 4. Secure with two screws. Set new ice bank sensor in bracket.
10. Reconnect P65.
11. Reattach panels.

3.18 Cardioplegia (CPG) Relay Board (See figure 3-1.)

Caution: Use proper static precautions when handling printed circuit boards or integrated circuit chips.

1. Prepare system per Procedure 3.1, remove rear and right side panel.
2. Disconnect P44, P45, P46, and P47.
3. Remove four screws securing board to the chassis and remove board from housing.
4. Install new board and secure with four screws.
5. Reconnect P44, P45, P46, and P47.
6. Reattach rear and right side panels.

3.19 Cardioplegia (CPG) Pump Assembly (See figure 3-7.)

Notes: This procedure requires the removal of one or more sections of heater hose. It may be easier to cut hose sections and replace with new hose of the same size. If so, ensure that enough of the appropriate size hose is available before starting procedure.

If replacing only the impeller blade, refer to Procedure 3.12.

1. Prepare system per Procedure 3.1, remove rear and both side panels.
2. Loosen designated hose clamps.
3. Disconnect P46 on the cardioplegia relay board. Clear P46 cable from cardioplegia relay board housing by passing it through the O-ring on the side of the housing.
4. Disconnect wires at valves 4 and 5.
5. Remove the motor assembly: Remove four nuts securing motor mount bracket to the chassis using nut driver and appropriate length extensions. Pull the cardioplegia pump assembly out of the rear of the TCM. P46 cable should be attached to the old motor.
8. Slide the motor bracket with valves attached out of the the unit.
9. Remove four bolts securing the motor.
10. Reassemble in reverse order of disassembly.

3.19 Cardioplegia (CPG) Pump Assembly (See figure 3-7.)

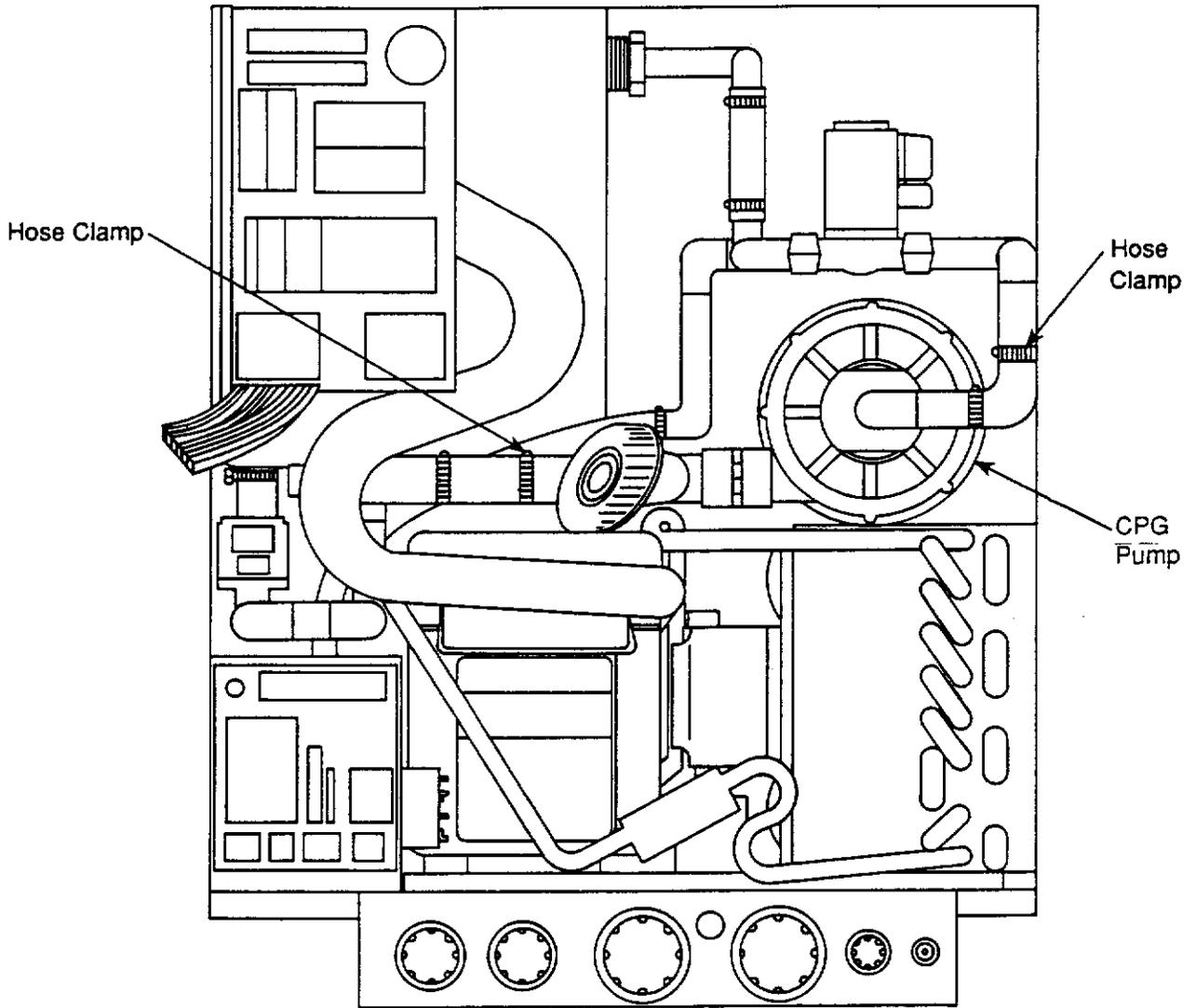


Figure 3-7. Rear View

3.20 Replace Low Flow to Blanket Switch (See figure 3-8.)

Note: This procedure requires the removal of one or more sections of heater hose. It may be easier to cut hose sections and replace with new hose of the same size. If so, ensure that enough of the appropriate size hose is available before starting procedure.

1. Prepare system per Procedure 3.1, and remove bottom panel.
2. Disconnect P67.
3. Loosen two hose clamps at points where switch connects to heater hose and pull switch free.
4. Replace any heater hose cut and discarded earlier in this procedure.
5. Install new switch: Insert open ends of switch into appropriate heater hose and secure by tightening hose clamps.
6. Reconnect P67.
7. Reattach bottom panel.

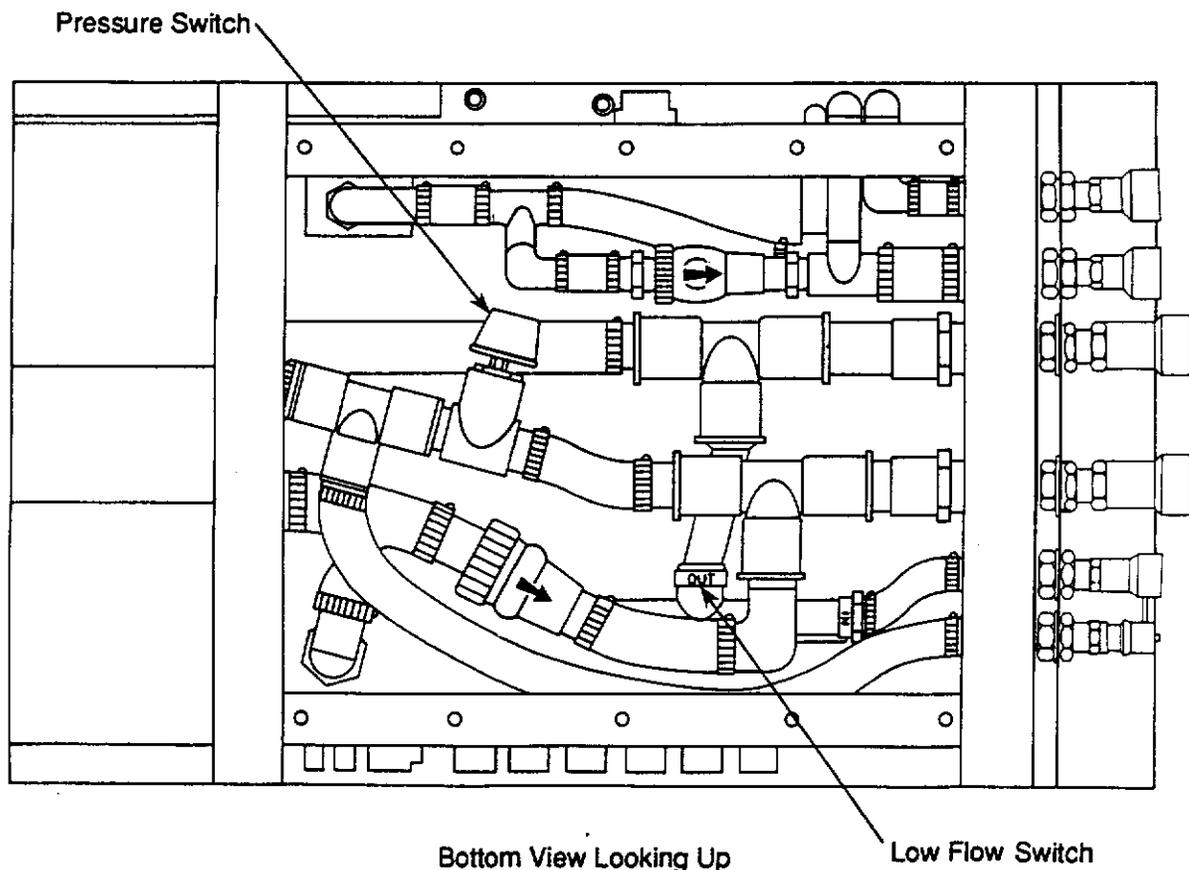


Figure 3-8. Low Flow and Pressure Switches

3.21 Pressure Switch (See figure 3-8.)

1. Prepare system per Procedure 3.1, and remove bottom panel.
2. Loosen appropriate hose clamps and remove large section of heater hose from arterial water IN line.
3. Remove two wires at top of the pressure switch using the appropriate size screwdriver.
4. Use appropriate size wrench to grip and unscrew old pressure switch.
5. Apply several wraps of thread seal tape to threads of new switch and install. Tighten and secure with appropriate size wrench.
6. Reattach wires removed in Step 3.
7. Reattach bottom panel.

3.22 Solid State Relays (See figure 3-9.)

1. Prepare system per Procedure 3.1, and remove rear and left side panels.
2. Locate faulty relay and disconnect four wires.
3. Remove two screws securing relay to the chassis and remove it.
4. Apply liberal amount of a thermal joint compound to new relay and install, securing with two screws. Reconnect four wires removed in Step 2.
5. Reattach rear and left side panels.

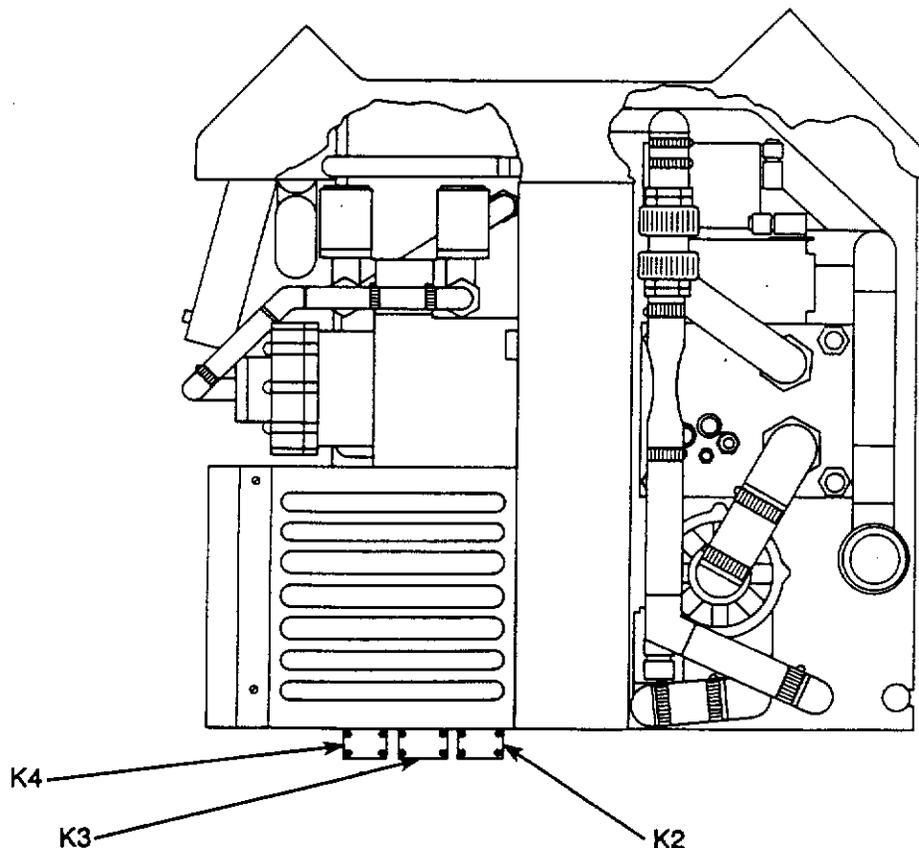
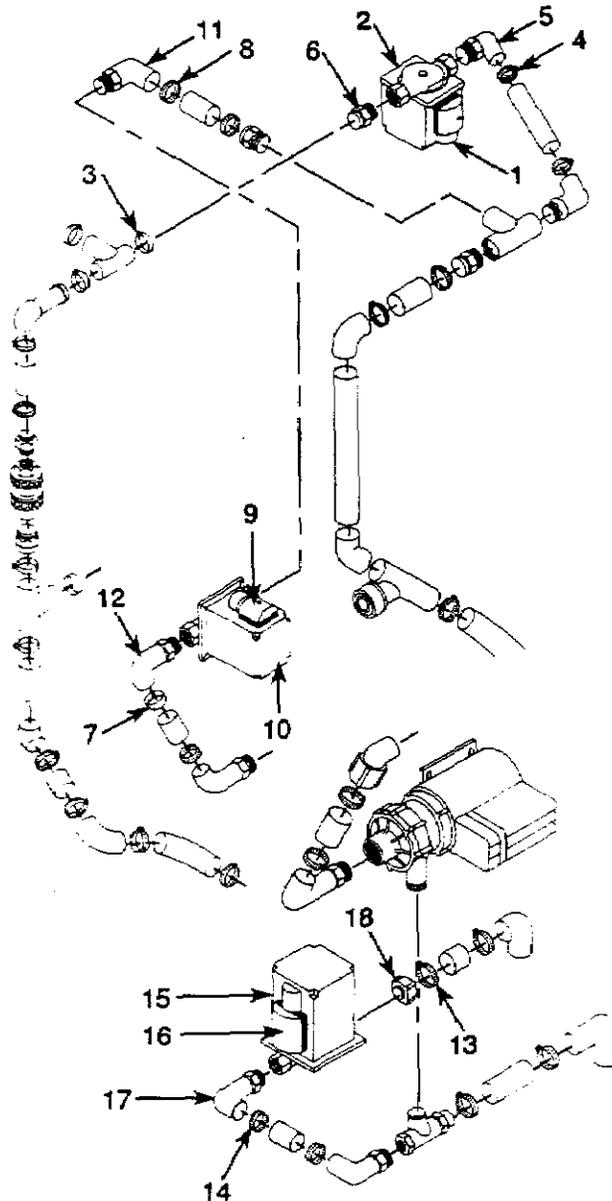


Figure 3-9. Solid State Relays

3.23 Valves

Notes: Water may be present in valves despite draining procedure described in Procedure 3.1.

Always observe direction of water flow indicated by an arrow on each valve and install new valve accordingly.



- | | | | |
|---------------|---------------|----------------|-------------|
| 1. Plug | 6. Fitting | 11. Fitting | 16. Plug |
| 2. Valve 1 | 7. Hose Clamp | 12. Fitting | 17. Fitting |
| 3. Hose Clamp | 8. Hose Clamp | 13. Hose Clamp | 18. Fitting |
| 4. Hose Clamp | 9. Plug | 14. Hose Clamp | |
| 5. Fitting | 10. Valve 2 | 15. Valve 3 | |

Figure 3-10. Valves #1, 2 and 3

3.23 Valves

3.23.1 Valve #1 (3/4") (See figure 3-10.)

1. Prepare system per Procedure 3.1, and remove front panel.
2. Remove control panel per Procedure 3.13.
3. Remove plug (1) from valve 1 (2) using appropriate size screwdriver.
4. Remove two bolts and washers connecting valve bracket to the chassis.

Note: It may be easier to cut the heater hose in order to free the pipe and valve, and replace it with a new section of heater hose the same size during reassembly.

5. Loosen hose clamps (3 and 4). Remove valve 1 (2) from chassis.
6. Remove valve bracket from valve 1 (2) by removing screws and washers.
7. Remove fittings (5 and 6) from valve 1 (2).
8. Clean residue from fittings (5 and 6) and apply pipe sealant to threads.
9. Install fittings (5 and 6) to new valve 1 (2).
10. Attach valve 1 (2) to valve bracket by using screws, washers and keps nuts. Replace any hoses cut during disassembly.
11. Position new valve 1 (2) in chassis.
12. Secure valve bracket to chassis with bolts and washers and tighten hose clamps (3 and 4).
13. Install plug (1) to valve 1 (2).
14. Install control panel and front panel.

3.23.2 Valve #2 (3/4") (See figure 3-10.)

1. Prepare system per Procedure 3.1, and remove front panel.
2. Remove control panel per Procedure 3.13.
3. Remove plug (9) from valve 2 (10) using appropriate size screwdriver.
4. Remove two bolts and washers connecting valve bracket to the chassis.

Note: It may be easier to cut the heater hose in order to free the pipe and valve, and replace it with a new section of heater hose the same size during reassembly.

3.23 Valves

3.23.2 Valve #2 (3/4") (See figure 3-10.)(Continued)

5. Loosen hose clamps (7 and 8). Remove valve 2 (10) from chassis.
6. Remove valve bracket from valve 2 (10) by removing screws and washers.
7. Remove fittings (11 and 12) from valve 2 (10).
8. Clean residue from fittings (11 and 12) and apply pipe sealant to threads.
9. Install fittings (11 and 12) to new valve 2 (10).
10. Attach valve 2 (10) to valve bracket by using screws, washers and keps nuts. Replace any hoses cut during disassembly.
11. Position new valve 2 (10) in chassis.
12. Secure valve bracket to chassis with bolts and washers and tighten hose clamps (7 and 8).
13. Install plug (9) to valve 2 (10).
14. Install control panel and front panel.

3.23.3 Valve #3 (1/2") (See figure 3-10.)

1. Prepare system per Procedure 3.1, and remove front panel.
2. Remove plug (16) from valve 3 (15) using appropriate size screwdriver.
3. Remove two bolts and washers connecting valve bracket to the chassis.

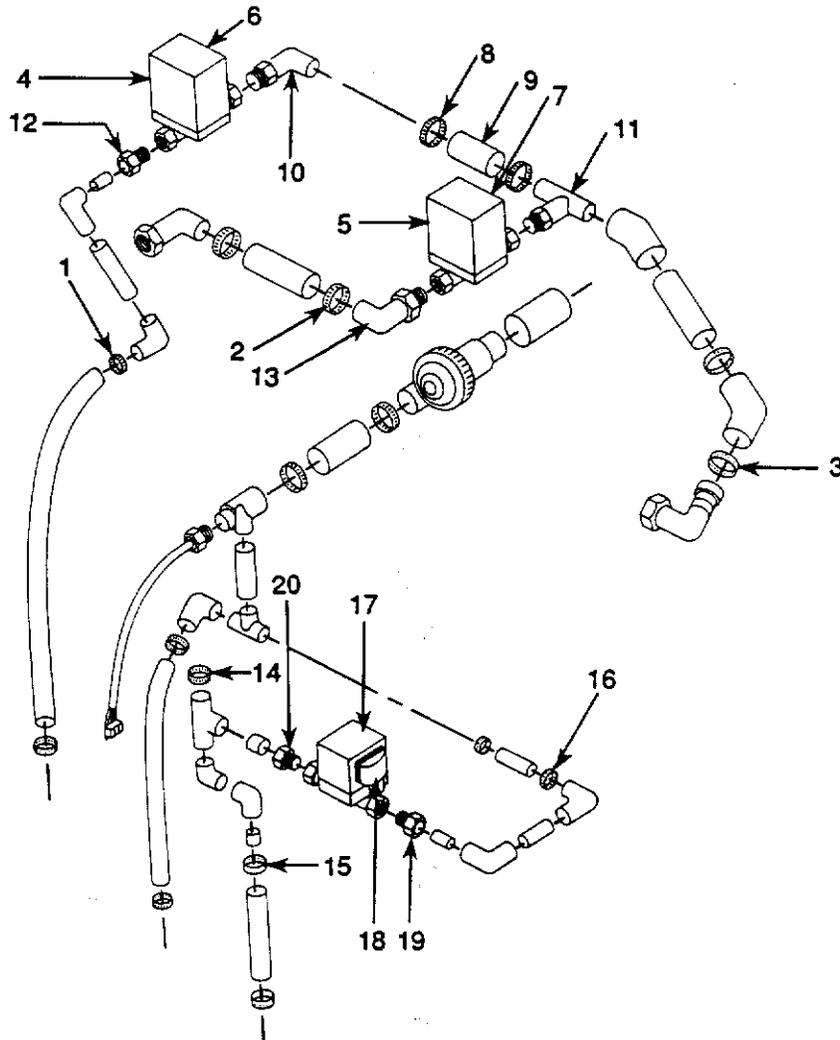
Note: It may be easier to cut the heater hose in order to free the pipe and valve, and replace it with a new section of heater hose the same size during reassembly.

4. Loosen hose clamps (13 and 14). Remove valve 3 (15) from chassis.
5. Remove valve bracket from valve 3 (15) by removing screws and washers.
6. Remove fittings (17 and 18) from valve 3 (15).
7. Clean residue from fittings (17 and 18) and apply pipe sealant to threads.
8. Install fittings (17 and 18) to new valve 3 (15).
9. Attach valve 3 (15) to valve bracket by using screws, washers and keps nuts. Replace any hoses cut during disassembly.
10. Position new valve 3 (15) in chassis.
11. Secure valve bracket to chassis with bolts and washers and tighten hose clamps (13 and 14).
12. Install plug (16) to valve 3 (15).

3.23 Valves

3.23.4 Valve #4 and #5 (1/2") (See figure 3-11.)

Note: References to "valve assembly" during this procedure refer to Valves 4 and 5. Either valve may be replaced individually, but due to their proximity to one another it is suggested that during disassembly steps, both be removed as part of a single assembly. Replace valves individually when assembly is removed from the chassis.



- | | | |
|---------------------|----------------|----------------|
| 1. Hose Clamp | 8. Hose Clamp | 15. Hose Clamp |
| 2. Hose Clamp | 9. Hose | 16. Hose Clamp |
| 3. Hose Clamp | 10. Fitting | 17. Valve 6 |
| 4. Valve 4 | 11. Fitting | 18. Plug |
| 5. Valve 5 | 12. Fitting | 19. Fitting |
| 6. Plug (not shown) | 13. Fitting | 20. Fitting |
| 7. Plug (not shown) | 14. Hose Clamp | |

Figure 3-11 Valves # 4, 5 and 6

3.23 Valves

3.23.4 Valve #4 and #5 (1/2") (See figure 3-11.)

1. Prepare system per Procedure 3.1, and remove rear and left side panels.
2. Remove plugs (6 and 7) from valves 4 and 5 (4 and 5) using appropriate size screwdriver.
3. Remove bolts and washers connecting valve brackets to the chassis.

Note: It may be easier to cut the heater hose in order to free the pipe and valve, and replace it with a new section of heater hose the same size during reassembly.

4. Loosen hose clamps (1, 2 and 3). Remove valves 4 and 5 (4 and 5) from chassis.
5. Separate valves 4 and 5 (4 and 5) by loosening hose clamps (2 and 8).
6. Remove valve brackets from valve 4 and 5 (4 and 5) by removing screws and washers.
7. Remove fittings (10, 11, 12 and 13) from valves 4 and 5 (4 and 5).
8. Clean residue from fittings (10, 11, 12 and 13) and apply pipe sealant to threads.
9. Install fittings (10, 11, 12 and 13) to new valves 4 and 5 (4 and 5).
10. Attach valves 4 and 5 (4 and 5) to valve brackets by using screws, washers and keps nuts. Replace any hoses cut during disassembly
11. Attach valves 4 and 5 (4 and 5) by connecting hose (9) and fitting (10) and tighten hose clamp (8).
12. Position new valves 4 and 5 (4 and 5) in chassis.
13. Secure valve brackets to chassis with bolts and washers. Tighten hose clamps (1 and 2).
14. Install plugs (6 and 7) to valves 4 and 5 (4 and 5).
15. Install rear and left side panels.

3.23 Valves

3.23.5 Valve #6 (1/2") (See figure 3-11.)

1. Prepare system per Procedure 3.1, and remove rear and right side panels.
2. Remove plug (18) from valve 6 (17) using appropriate size screwdriver.
3. Remove two bolts and washers connecting valve bracket to the chassis.

Note: It may be easier to cut the heater hose in order to free the pipe and valve, and replace it with a new section of heater hose the same size during reassembly.

4. Loosen hose clamps (15 and 16). Remove valve 6 (17) from chassis.
5. Remove valve bracket from valve 6 (17) by removing screws and washers.
6. Remove fittings (19 and 20) from valve 6 (17).
7. Clean residue from fittings (19 and 20) and apply pipe sealant to threads.
8. Install fittings (19 and 20) to new valve 6 (17).
9. Attach valve 6 (17) to valve bracket by using screws, washers and keps nuts. Replace any hoses cut during disassembly.
10. Position new valve 6 (17) in chassis.
11. Secure valve bracket to chassis with bolts and washers and tighten hose clamps (15 and 16).
12. Install plug (18) to valve 6 (17).
13. Install rear and right side panels.

3.24 Temperature Display Module (See figure 3-12.)

Caution: Use proper static precautions when handling printed circuit boards or integrated circuit chips.

1. Turn system power OFF and disconnect power cord.
2. Remove remote module from its housing and disconnect module cable from TCM chassis.
3. Rest the module face down and remove two screws at the bottom of the rear panel.
4. Loosen two screws at the top of the module rear panel and tilt the panel up. Disconnect P57, P58, and P59 from the remote motherboard to completely free the panel.
5. Remove the module computer card by removing the screw in the upper right corner and sliding the card out and away from the mother PC assembly.
6. Remove the display PC assembly by removing four screws, each located in one corner of the board. Slip the blade end of a screwdriver under the bottom of the mother PC assembly, to which the display assembly is attached, and pry it free. Pull firmly on both boards until the seal breaks and both boards are free of the module housing.
7. Reassemble in reverse order of disassembly.

3.25 Temperature Display Module Membrane Panel (See figure 3-12.)

1. Perform Steps 1 through 6 of Procedure 3.24.
2. Lift one corner of the membrane panel and peel panel off. It may be necessary to pry a corner of the panel up with the tip of a screwdriver in order to ensure a firm grip.
 - Another way to separate the panel is to push parts of the membrane panel exposed by removal of the remote display PC assembly: Exposed are the back of the probe LED's (red) and the back of maintain temperature display (yellow).
3. Reconnect ribbon cable to the display board and reassemble in reverse order of disassembly.

3.25 Temperature Display Module Membrane Panel (See figure 3-12.)

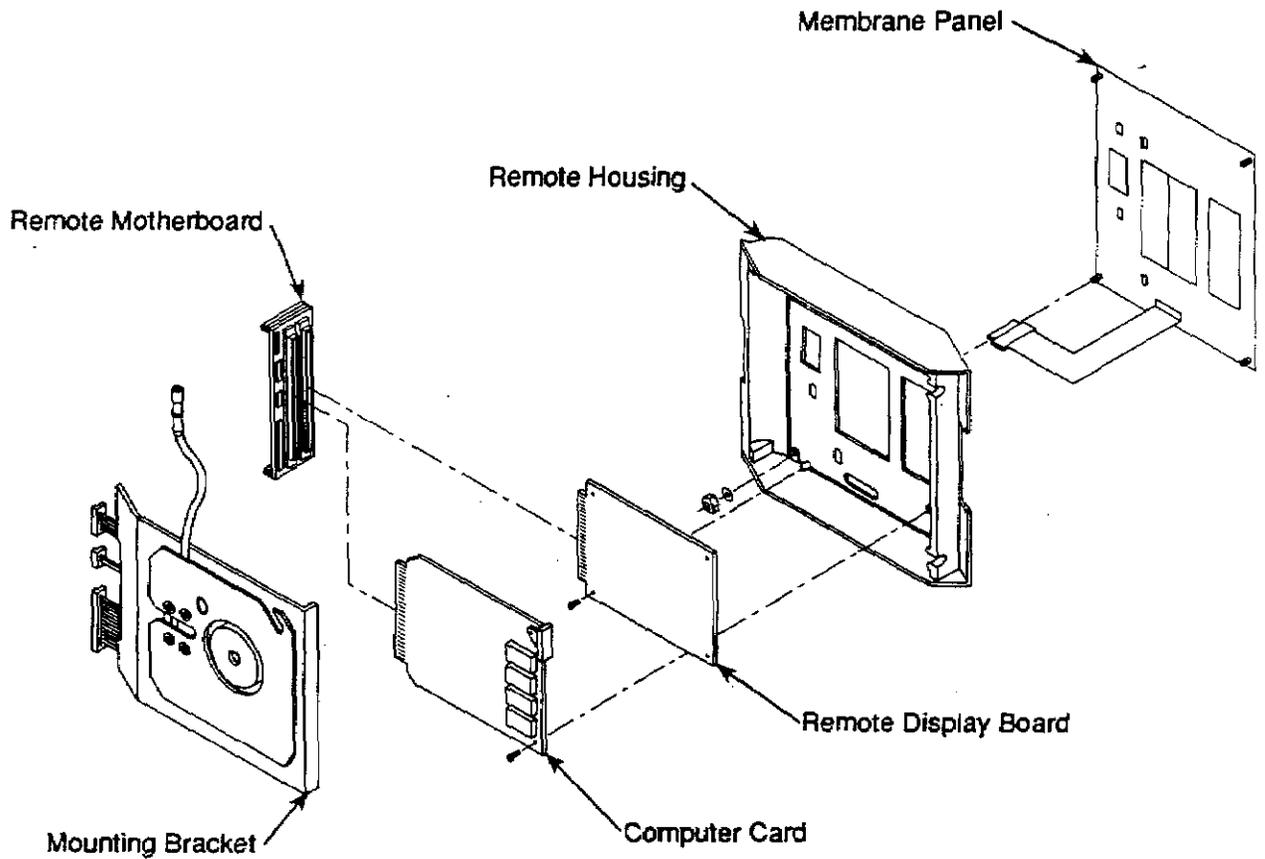


Figure 3-12. Temperature Display Module

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Note: Perform a complete system inspection after completing any procedure which requires any disassembly of the unit.

Caution: Use proper static precautions when handling printed circuit boards or integrated circuit chips.

4.1 Will Not Make Ice

Functional Description: The compressor delay board switches power to the compressor ON and OFF via relay K5. (K5 is not mounted on the board.) A time delay circuit on this board prevents the compressor from starting immediately after it has stopped. The delay is set at 4 to 6 minutes by the DIP switch array SA1. Closing these switches will shorten the delay to less than 1 minute for troubleshooting purposes. An ice bank sensor switch is normally closed with no ice in the tank. If the tank is full of ice, this switch will open, turning off the compressor.

1. Fill large and small tanks to proper water levels.
2. Connect power cord and turn system power ON.
3. Turn ice maker ON. If no ice is in the large tank, the compressor should start in four to six minutes.
4. If the compressor starts but will not make ice, consult a refrigeration technician to determine whether compressor assembly must be replaced.
5. If the compressor does not start, check for line voltage at both ends of F14 on the compressor delay board. If proper line voltage is not found, replace the fuse.
6. Check for line voltage at both ends of F9 and F13 on the compressor delay board. If proper line voltage is not found, replace the appropriate fuse.
7. Check for 12 VDC between TP1 and TP2 of the compressor delay board. If not found, replace the compressor delay board.
8. Check for 12 VDC between pins 3 and 6 of P48. If voltage is found, relay K1 is open. Replace the main board in accordance with Section 3, Main Board.
9. If the compressor does not start but the green ice making light on the control panel is lit, check for line voltage between pins 1 and 2 of P65 without opening the connector. If line voltage is found and there is no ice in the tank, replace the ice bank sensor in accordance with Section 3, Ice Bank Sensor.
10. Check for line voltage across pins 2 and 5 of P64. If not found, replace the compressor delay board in accordance with Section 3, Compressor Delay Board.
11. Check for line voltage across pins 1 and 2 of P66. If found, replace the compressor. If not found, replace the compressor relay in accordance with Section 3, Compressor Assembly.
12. Perform complete system inspection.

4.2 Cardioplegia Pump Will Not Run

Functional Description: The cardioplegia (CPG) switch on the control panel sends a signal to the system computer to start the pump. The system computer sends a signal to IC3 and IC4 on the main board to start the pump. The pump receives its power from the cardioplegia relay board and can run at three different speeds, all of which can be selected from the control panel. The pump is a magnetically coupled impeller-style pump. Note that if the impeller magnet cracks, the pump will not operate.

1. After startup, turn the CPG pump ON. Water should flow over the top of the small tank into the large tank. If it does not, switch to the small tank mode and check for flow in the external tubing. If flow is present, refer to paragraph 4.5, Valve Troubleshooting.
2. If the TCM will not switch to different modes, refer to paragraph 4.4, Membrane Switch Troubleshooting.
3. Remove rear and right side panels. Check for 115 VAC between pins 3 and 4 of P46 on the cardioplegia relay board with the pump ON and at maximum speed. If voltage is present continue with step 4. If line voltage is not present, refer to step 6.
4. Disconnect power cord and drain the TCM.
5. Check the impeller. Refer to Section 3, Cardioplegia Pump Assembly, for proper disassembly instructions. If the impeller spins freely, refer to Section 3, Cardioplegia Pump Assembly, to replace the motor.
6. Check for 115 VAC on both sides of F4 on the cardioplegia relay board. If voltage is present on just one side of the fuse, replace the fuse.
7. Check for 10 to 15 VAC on both sides of F3 on the cardioplegia relay board. If voltage is present on just one side of the fuse, replace the fuse. If no voltage is present, refer to Step 9.
8. Switch the CPG pump to the different speed settings. If the pump runs at certain speeds but not others, one of the relays K4, K5, or K6 has failed. Replace the cardioplegia relay board in accordance with Section 3, Cardioplegia Relay Board.
9. Check for 115 VAC on both sides of F2 on the cardioplegia relay board. If voltage is present on just one side, replace the fuse.
10. Check for 24 VDC on both sides of F2 on the main board. If voltage is present on one side, replace the fuse.
11. If voltage is present on F2 on the main board and F3 on the cardioplegia relay board, then IC3 or IC4 on the main board has failed or the cable between the main board and the cardioplegia relay board may be faulty. Check the cable. If it is good, replace the main board in accordance with Section 3, Main Board.

4.3 Main Pump Will Not Run

Functional Description: The following switches on the control panel will start and/or stop the main pump: COOLDOWN; REWARM; STANDBY; DEFROST; and MAINTAIN. When a switch is selected to start the pump, it sends a signal to the system computer. The system computer in turn sends a signal through relay K2 on the main board to start the pump. This pump always runs from line voltage. The pump is a magnetically-coupled impeller-style pump. Note that if the impeller magnet is cracked, the pump will not operate.

Set-up:

- Fill both tanks to maximum capacity and attach external closed loops.
 - Turn system power ON.
1. After startup, press COOLDOWN. Water should flow full force over the cold plate. If not, place the unit in rewarm and check for flow in the external closed loops. If flow is found, check for plugged tank screen, or see if the water in the tank is frozen.
 2. If TCM will not switch to cooldown or rewarm, refer to paragraph 4.4, Membrane Switch.
 3. Remove the front panel. Check for line voltage across P21, pins 2 and 4. With the TCM in cooldown mode and if line voltage is present, continue with step 4. If not, proceed to step 6.
 4. Disconnect power cord and drain the TCM.
 5. Check the impeller. If the impeller spins freely, replace the motor in accordance with Section 3, Main Pump Assembly.
 6. Check for line voltage on both sides of F6 on the main board. If voltage is present only on one side, replace the fuse.
 7. Check for 26 to 31 VDC on both sides of F2 on the main board. If voltage is present on only one side, replace the fuse.
 8. If proper voltage is found in steps 6 and 7, the pump relay K2 on the main board has failed. Replace the main board in accordance with Section 3, Main Board.

4.4 Membrane Switch

Functional Description: The membrane switches are a matrix of switches that, when pressed, send a signal straight through the main display board to the main board directly to the system computer card. If any one of the switches is pressed, all others are locked out. Therefore, any shorted switch will not allow the others to be used.

1. Remove front panel.
2. Turn system power ON.
3. Check all fuses for proper voltage. Remove power and replace any open fuses.
4. Turn system power OFF and disconnect power cord.

4.4 Membrane Switch (Continued)

5. Remove the two nuts securing the control panel so that it may be lifted.
6. Make sure the ribbon cable connected to P29 is secure at both ends.
7. Disconnect the six-pin ribbon cable from the cardioplegia display board.
8. Connect the power cord and turn system power ON.
9. Press REWARM or COOLDOWN.
 - If the TCM switches into either mode, the cardioplegia display board must be replaced in accordance with Section 3, Cardioplegia Display Board.
 - If the TCM will not switch into either mode, the main display board must be replaced in accordance with Section 3, Main Display Board.

Note: After replacing the appropriate membrane panel, if the TCM will not switch into any mode, replace the computer card in accordance with Section 3, Main Computer Card, A/D Timer Board and Communication Board.

4.5 Valve Troubleshooting

Functional Description: Valves 1, 2 and 3 are the main system valves and are energized by relays K4, K5 and K3 respectively on the main board. Valves 4, 5 and 6 are the cardioplegia valves and are energized by relays K1, K2 and K3 on the cardioplegia relay board. Refer to the chart below to determine when a valve should be energized. When any main system mode is selected, the system computer will send a signal to IC1 and IC2 that will energize or de-energize the appropriate relay on the main board. When any of the cardioplegia mode switches are selected, the system computer will send a signal to IC3 and IC4 that will energize/de-energize the appropriate relay on the cardioplegia relay board.

Note: This procedure may require switching modes to determine which valve has malfunctioned.

The chart below will help in determining which valve should be energized:

<p>Main System</p> <p>Cooldown Rewarm Defrost Maintain</p>	<p>Valve 1 Valve 2 Valves 1 and 3 Valve 1 or 2, depending on water temperature</p>
<p>CPG System</p> <p>Large-to-small tank Large tank Small tank</p>	<p>Valves 4 and 6 Valve 4 Valve 5</p>

4.5 Valve Troubleshooting

4.5.1 Excessive Noise During Operation

1. Turn system power OFF and disconnect power cord.
2. Remove any panels necessary to gain access to suspected malfunctioning valve.
3. Reconnect power cord and turn system power on.
4. Verify which valve is making noise by energizing all valves. This can be done by switching through all modes. Turn system power OFF and disconnect all wires to the valve making noise.
5. Without removing the existing noisy valve from the system, connect the wires removed in Step 4 to a replacement valve. Energize the new valve by switching to the appropriate mode.
6. If no noise is evident when the new valve energizes, remove the noisy valve and replace in accordance with Section 3, Valves.
7. If the noise is still heard with the new valve in place, replace the main board for valves 1, 2 and 3 or the cardioplegia relay board for valves 4, 5 and 6 in accordance with Section 3, Main Board or Cardioplegia Relay Board.

4.5.2 Valve Will Not Open/Energize

1. Turn system power OFF and disconnect power cord.
2. Check all fuse for proper voltages. Refer to Section 2, Check and Calibration.
3. Refer to chart in paragraph 4.5 to determine malfunctioning valve. Energize valve and check for 115 VAC at valve connection.
4. If 115 VAC is found and water will not flow through the valve, replace the valve in accordance with Section 3, Valves
5. If 115 VAC is not found and valve 1, 2, or 3 is suspected, check that connector P14 on the main board is secure. If secure, the relay controlling the valve may have failed. Replace the main board in accordance with Section 3, Main Board.
6. If valve 4, 5 or 6 is suspected check that connector P47 on the cardioplegia relay board is secure. If secure, the relay controlling the valve may have failed. Replace the cardioplegia relay board in accordance with Section 3, Cardioplegia Relay Board.

4.6 High Leakage Current

High leakage current is defined as greater than or equal to 100 microamps for 115 VAC units and 500 microamps for 220 to 240 VAC units.

Note: The most common cause for high leakage current is moisture on the components within the system. Allowing the system to sit overnight to dry may resolve the problem.

1. Turn system power OFF and disconnect power cord.
2. Remove front, rear, and side panels.
3. Check the leakage current for the power cord: disconnect the positive and negative wires from the power cord at terminal block #1 located near the circuit breakers. Insulate the connectors to prevent shorting. The leakage current of the power cord should be no more than 1 microamp per meter of cord. If it is, replace the cord.
4. Check the leakage current of the following system components by disconnecting them one at a time and in the following order. If the leakage current is less than 100/500 microamps with the components disconnected, troubleshoot suspected component. If the leakage current is greater than 100/500 microamps, reconnect component and proceed to the next check.
 - Compressor: Disconnect P66 on the compressor delay board. Check for any moisture under the compressor. Eliminate moisture with a high powered air hose.
 - Compressor Delay Board: Disconnect P48 and P63 on the compressor delay board. Check for moisture on the board. Eliminate moisture and/or replace the board in accordance with Section 3, Compressor Delay Board.
 - Cardioplegia Pump Motor: Disconnect P46 on the cardioplegia relay board. Check for moisture on the motor or for a short from the motor to the chassis. Eliminate moisture and/or short between motor and chassis and/or replace the motor in accordance with Section 3, Cardioplegia Pump Assembly.
 - Valves 4, 5 and 6: Disconnect P47 on the cardioplegia relay board. If the leakage current is less than 100/500 microamps, connect P47. Remove the plug from valve 4 and check the leakage current. Repeat procedures for valves 5 and 6. Replace any valves, if necessary, in accordance with Section 3, Valves.
 - Cardioplegia Relay Board: Disconnect P44 and P45 on the cardioplegia relay board. Check for moisture on the board. Eliminate moisture and/or replace the board in accordance with Section 3, Cardioplegia Relay Board.
5. Check the leakage current with all connectors disconnected from the main board: Disconnect all connectors from the main board. If the leakage current is greater than 100/500 microamps, replace the transformer or the circuit breakers. Refer to appropriate schematics for assistance. If the leakage current is less than 100/500 microamps, proceed to Step 6.

4.6 High Leakage Current (Continued)

6. Reconnect the plugs in the following order, checking the leakage current after each plug is seated. The table below indicates the order in which the connectors should be reconnected and the component that needs to be repaired or replaced if the leakage current is greater than 100/500 microamps.

<u>CONNECTOR</u>	<u>REPAIR/REPLACE</u>
P1	Dual temperature sensor
P2	Dual temperature sensor
P3	Cardioplegia temperature sensor
P5	Main water pressure switch
P6	Low Flow to Blanket switch
P7	Overtemp thermostat
P8	Remote module
P9	Audio alert
P12	Solid state relays and heaters
P13	Cardioplegia relay board
P14	Valves 1, 2, and 3
P15	Main display
P19	Not Used
P20	Hour meter
P21	Main pump
P22	Compressor delay board
P24	Main board
P25	Main board

4.7 Unit Takes Too Long to Heat

Functional Description: Pressing the REWARM switch allows the computer card to send a signal to energize solid state relays K2 and K3, open valve 2, and start the main pump. When the water temperature reaches 42 °C, the computer card de-energizes K2 and K3, turning the heater off. Water should flow through the external tubing and the heating chamber.

1. Verify condition by setting up the system and checking rewarm mode. Refer to Section 2, Set-up and Check Rewarm Mode.
2. If system takes too long to heat, check for water trickling over the cold plate. Replace valve 1 if water is flowing over cold plate, otherwise, proceed to Step 3.
3. When in rewarm mode and water temperature is less than 42 °C verify line voltage at both heaters. If line voltage is found at both heaters proceed to step 7.
4. If the line voltage is not found at either heater, check for 24 VDC across pins 3 and 4 of P12 on the main board for heater #1 and pins 5 and 6 of P12 for heater #2. If DC voltage is not found replace main board in accordance with Section 3, Main Board.
5. If 24 VDC is found at P12, check for 24 VDC across heater relays K2 and K3. If voltage is found, replace faulty heater relay in accordance with Section 3, Solid State Relays.

4.7 Unit Takes Too Long to Heat (Continued)

6. If 24 VDC is not found across heater relays, check for 24 VDC across pins 1 and 2 of P12. If voltage is found, replace main board in accordance with Section 3, Main Board. If no voltage is found across pins 1 and 2 of P12, replace overtemp relay K4 in accordance with Section 3, Solid State Relays.
7. Use a clamp-on current probe to check for 4 to 8 amps for each heater when the unit is in the rewarm mode and the water temperature is less than 42 °C. If no current is measured for either heater, disconnect overtemp thermostat connector P7 on the main board and check the current reading again. If current is present, replace overtemp thermostat in accordance with Section 3, Overtemp Thermostat.
8. If no current is present at one or both heaters, replace faulty heater in accordance with Section 3, Heater Assembly.

4.8 Low Flow to Blanket Light

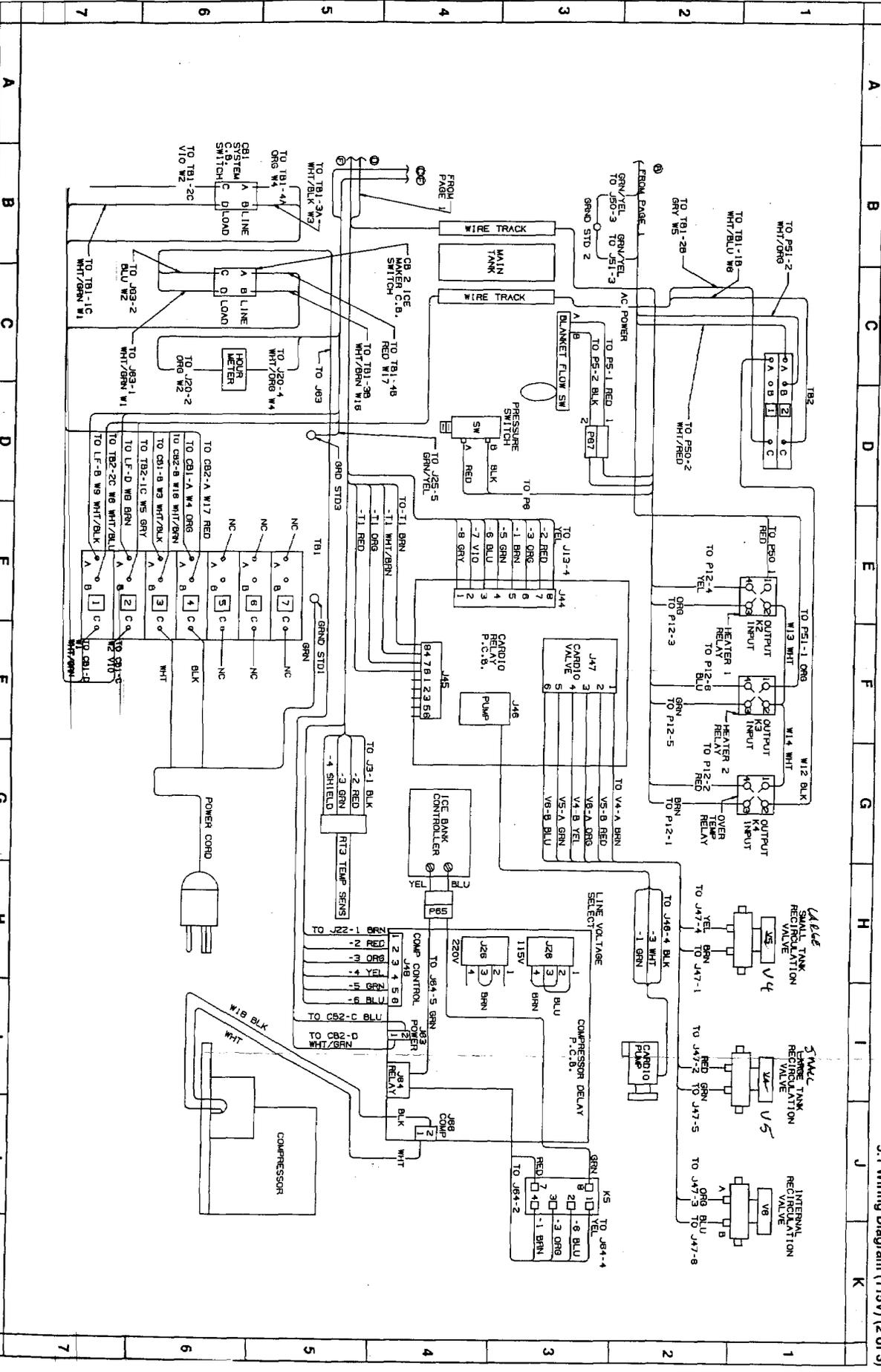
Functional Description: The low flow to blanket light will illuminate when no flow is detected and the main pump is running in cooldown, rewarm or maintain modes. In this case, the blanket flow switch is open. If a blanket is not connected, this light will illuminate in cooldown, rewarm or maintain modes.

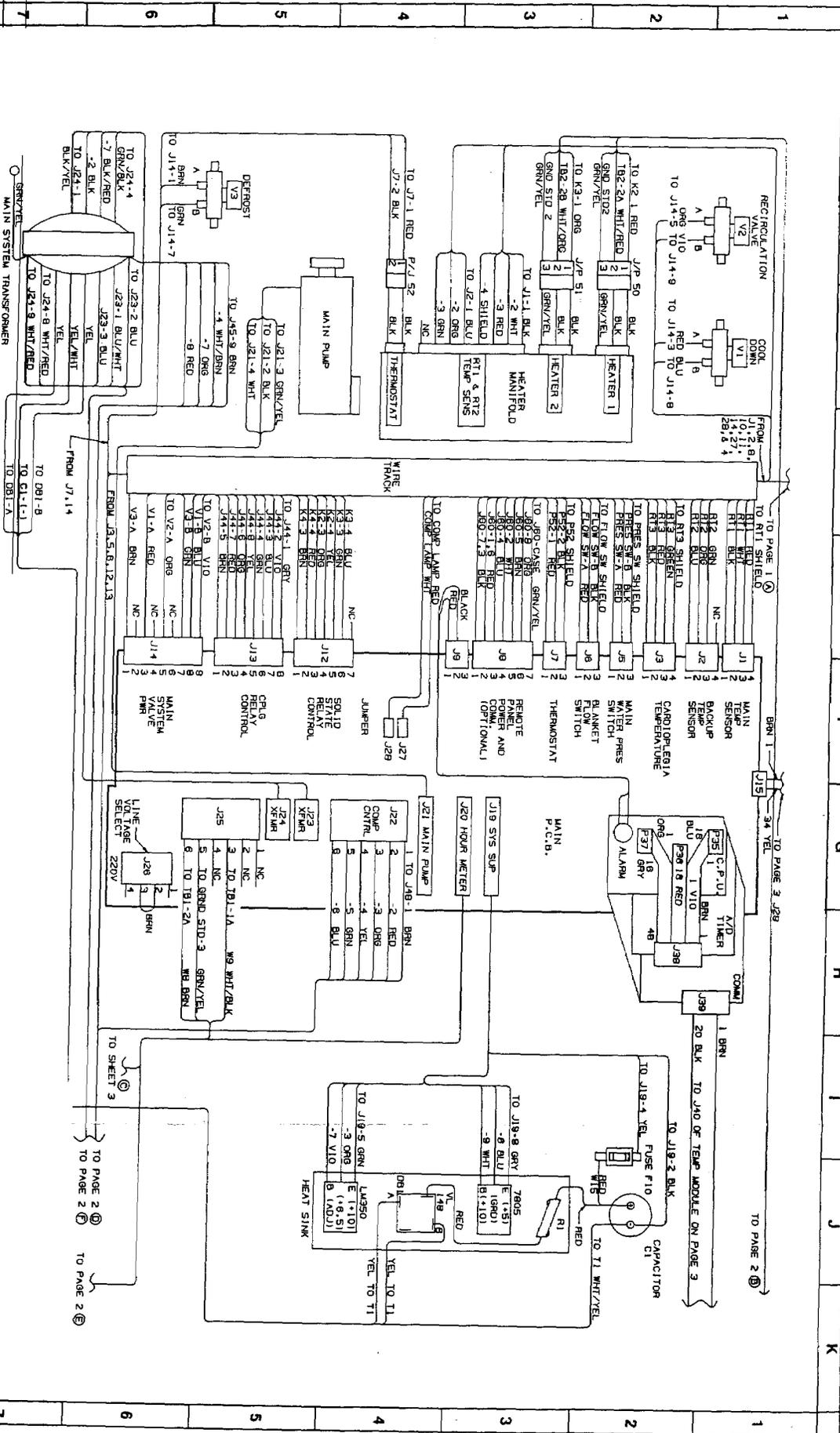
Note: On units with software version 2.0, the low flow to blanket light illuminates when the TCM is in defrost mode.

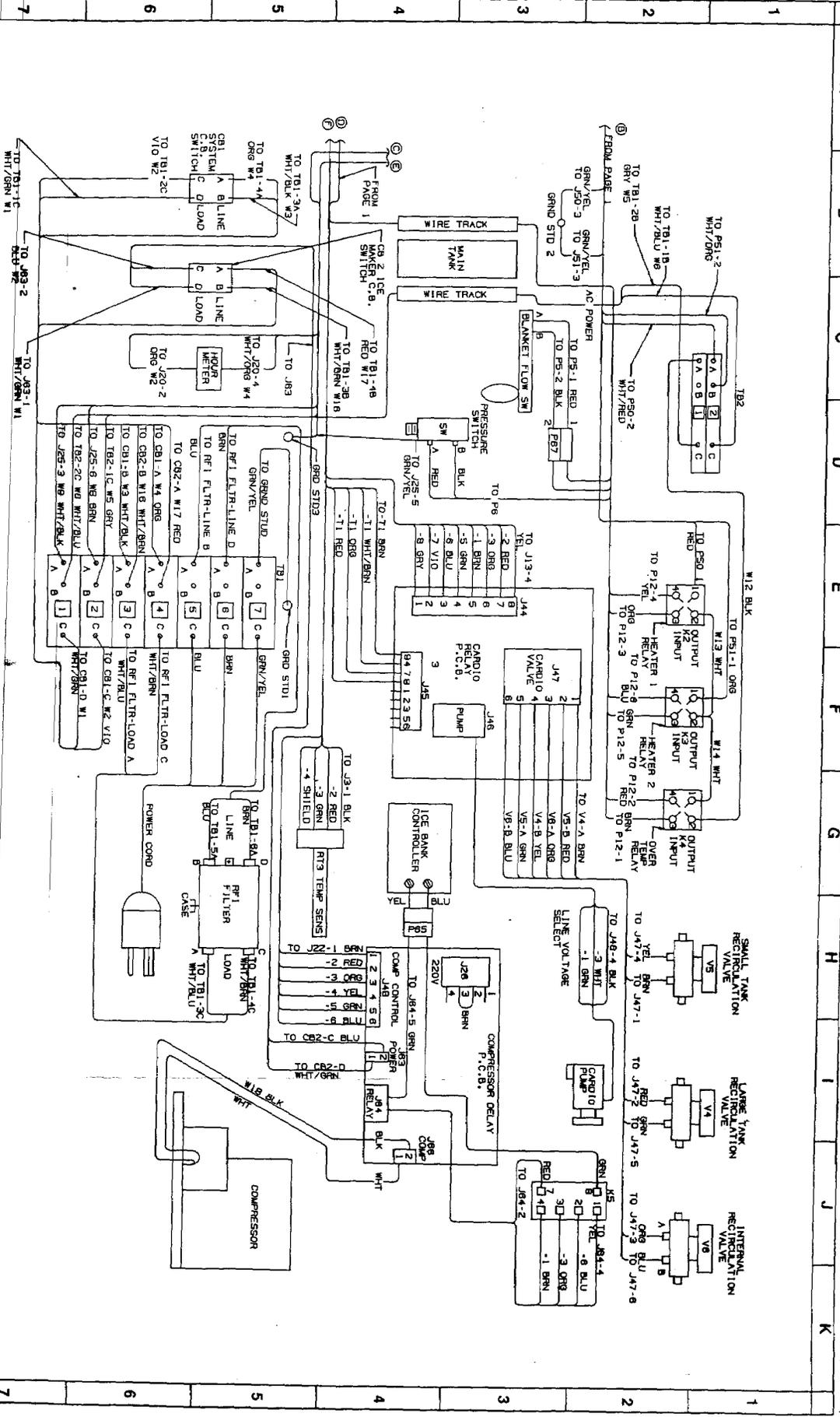
1. Set-up the system, refer to Section 2, Set-up.
2. Press COOLDOWN.
 - If low flow to blanket light is illuminated, remove front panel and disconnect P6. Use a jumper to short pins 1 and 2 of J6 on the main board. If the low flow to blanket light extinguishes, replace the blanket flow switch. If the low flow to blanket light remains illuminated, replace the main computer card in accordance with Section 3, Main Computer Card, A/D Timer Board and Communication Board.

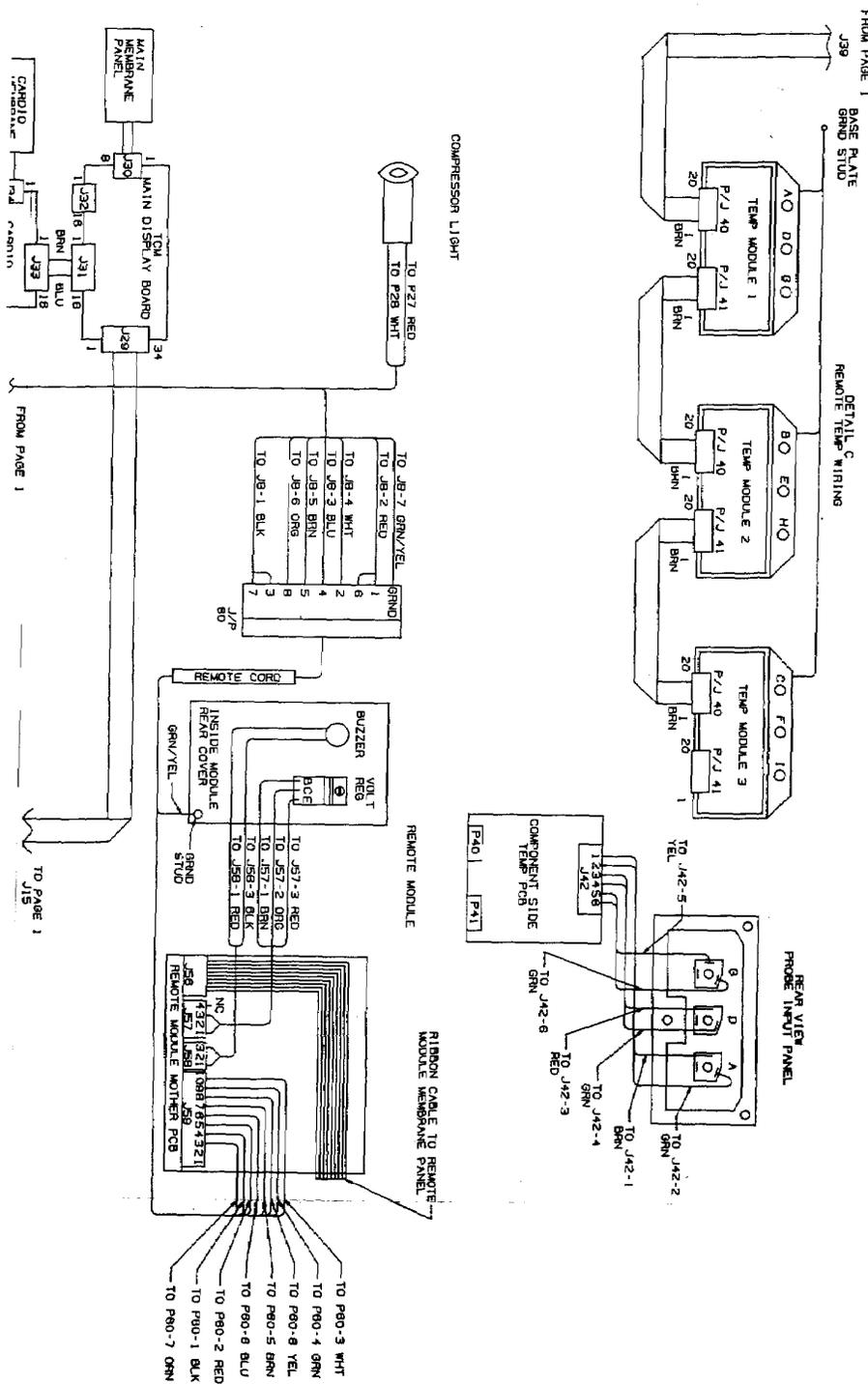
Table of Contents**Section 5. System Diagrams**

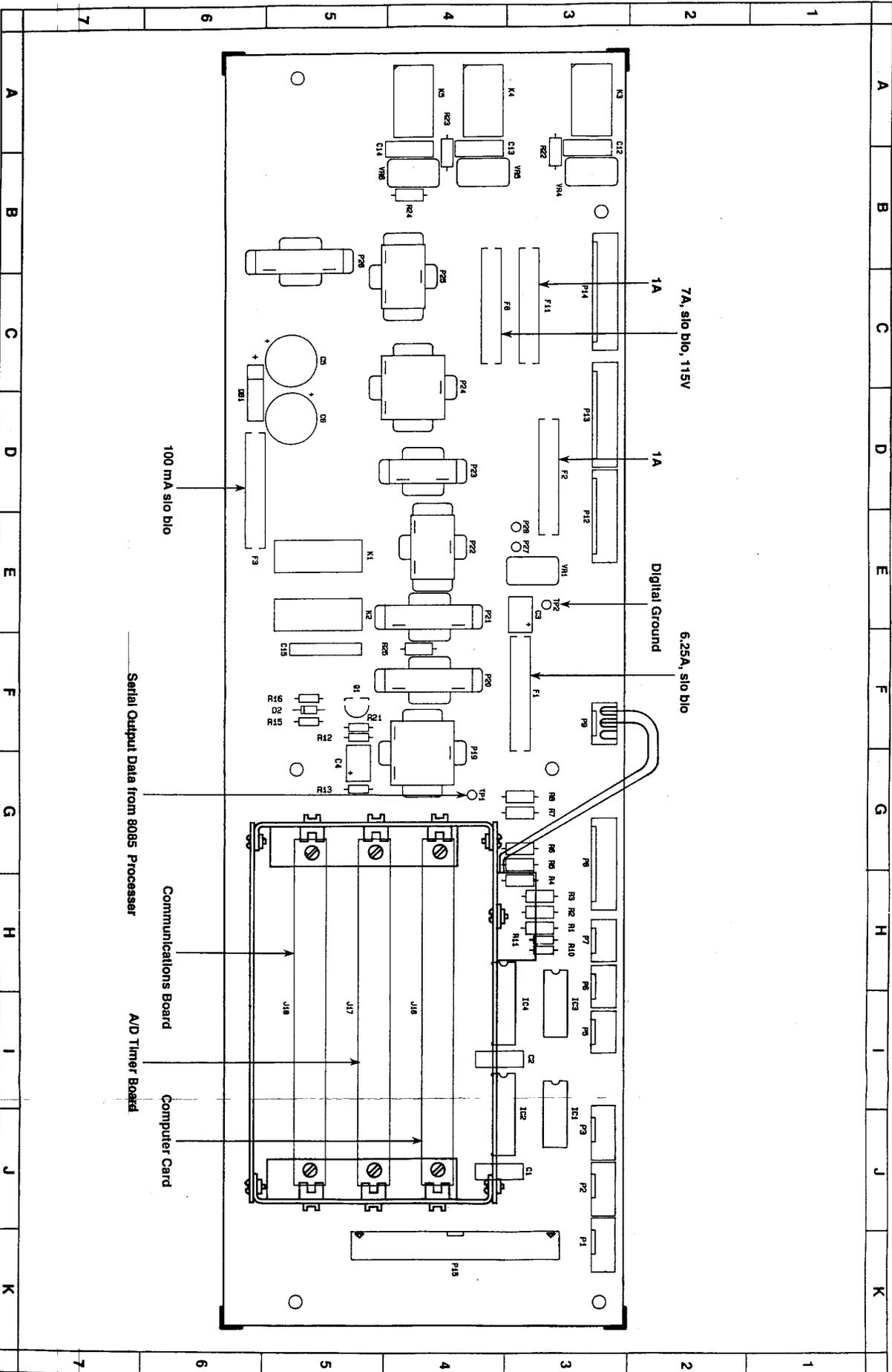
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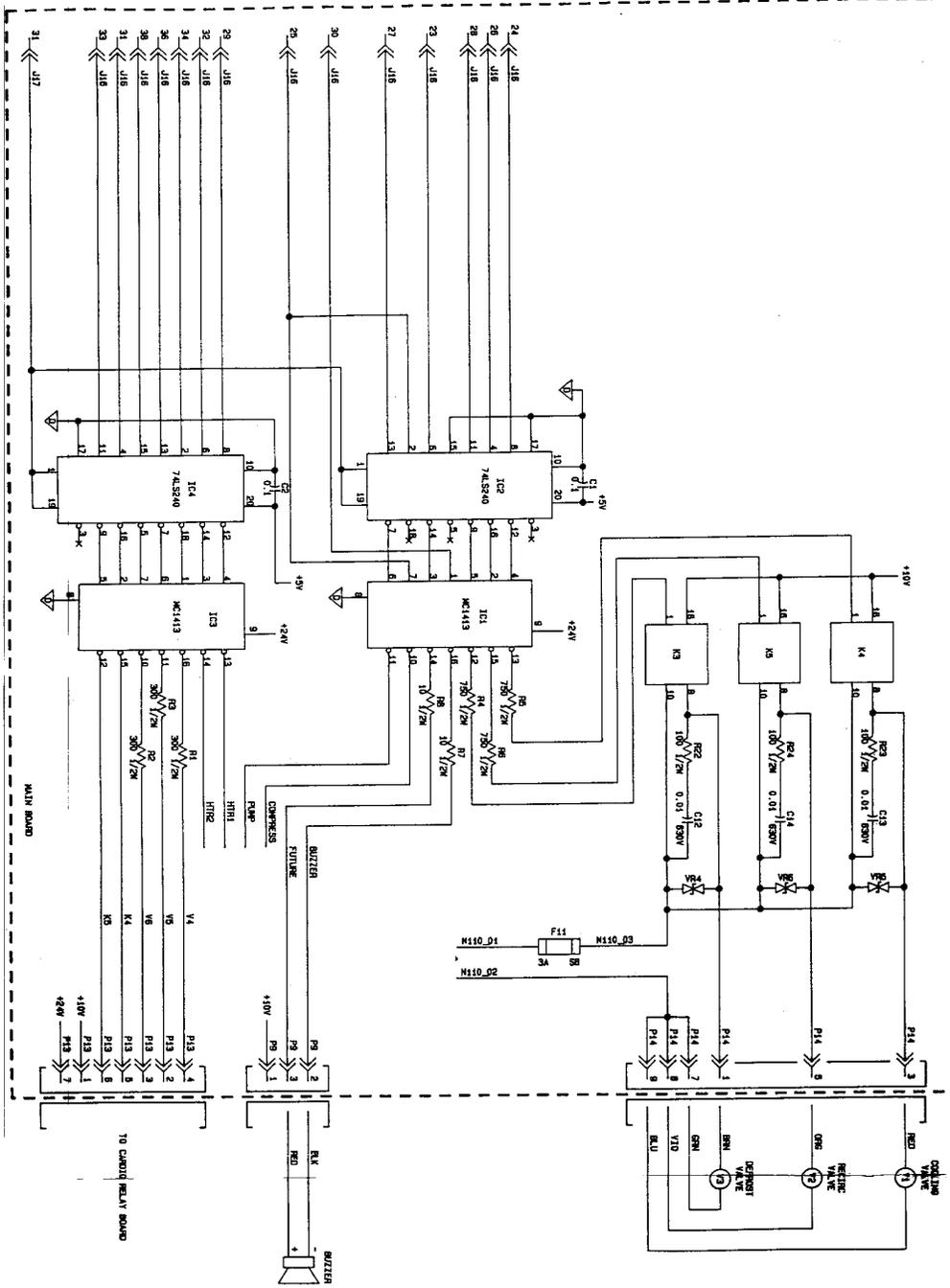


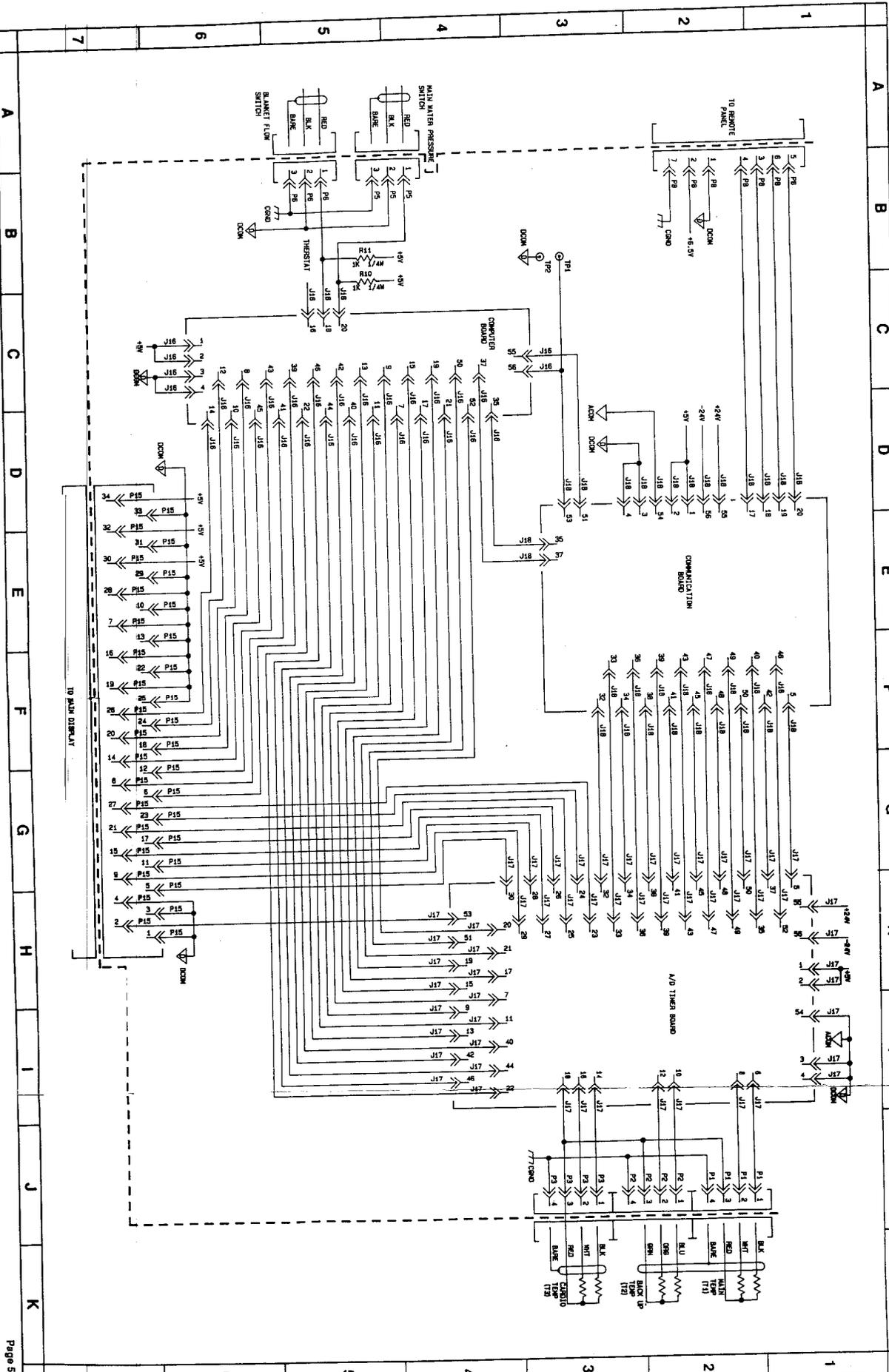


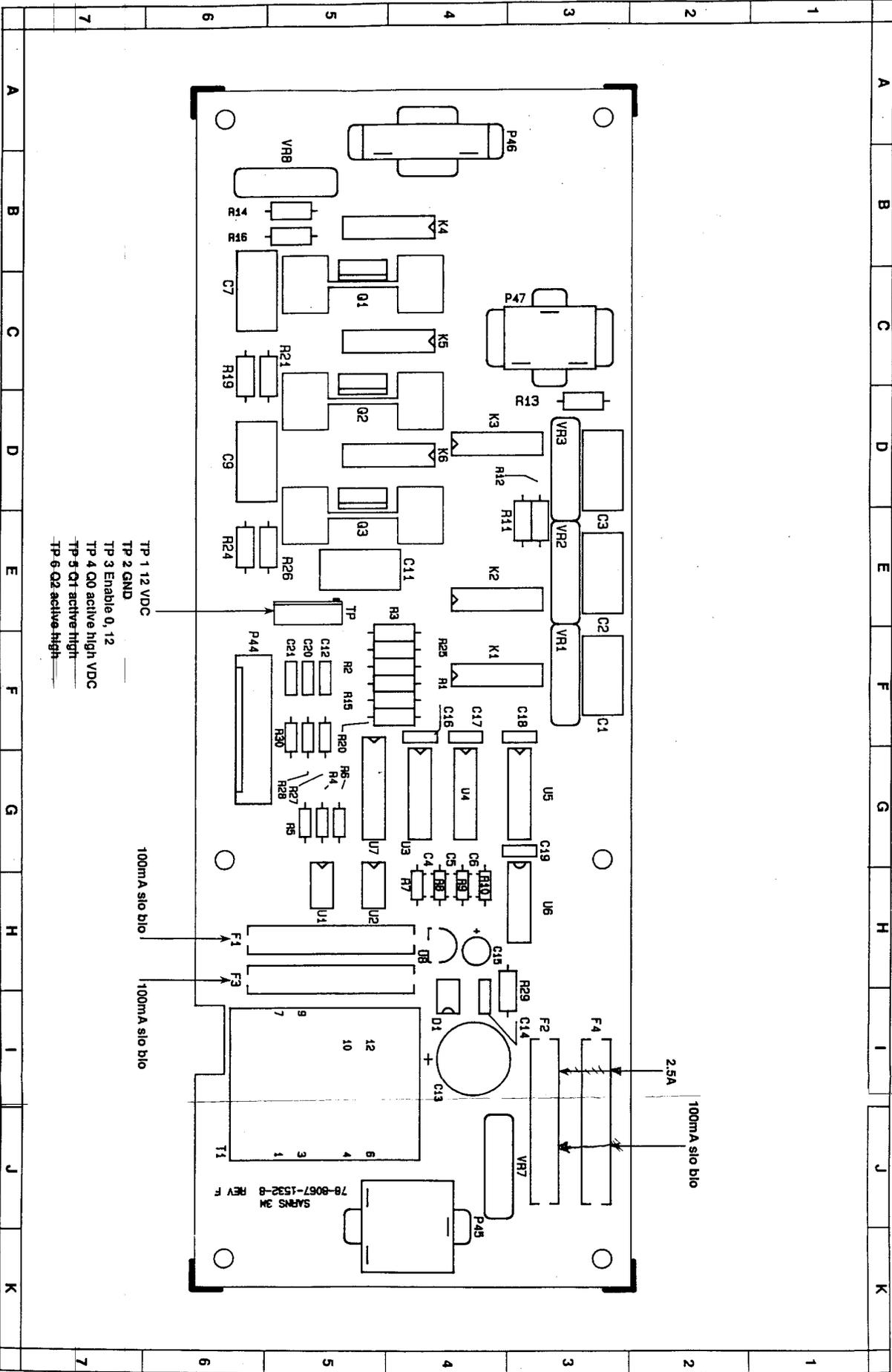


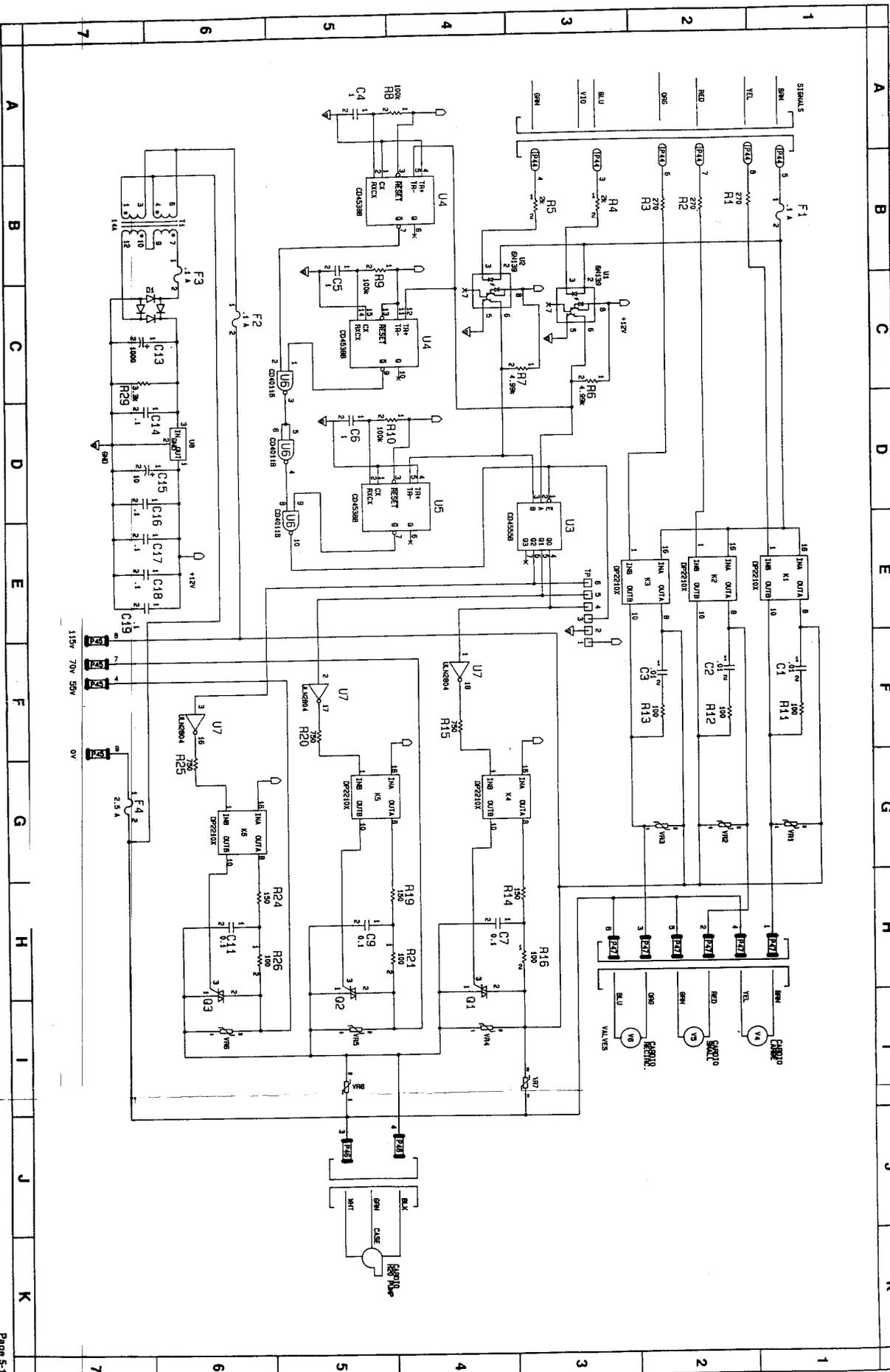


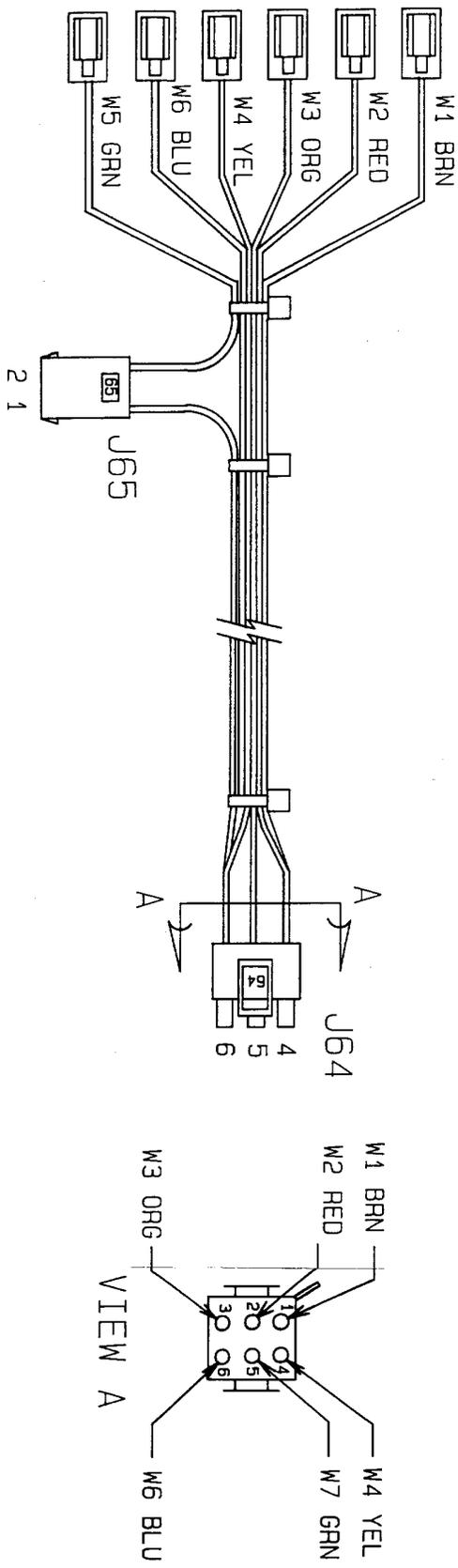




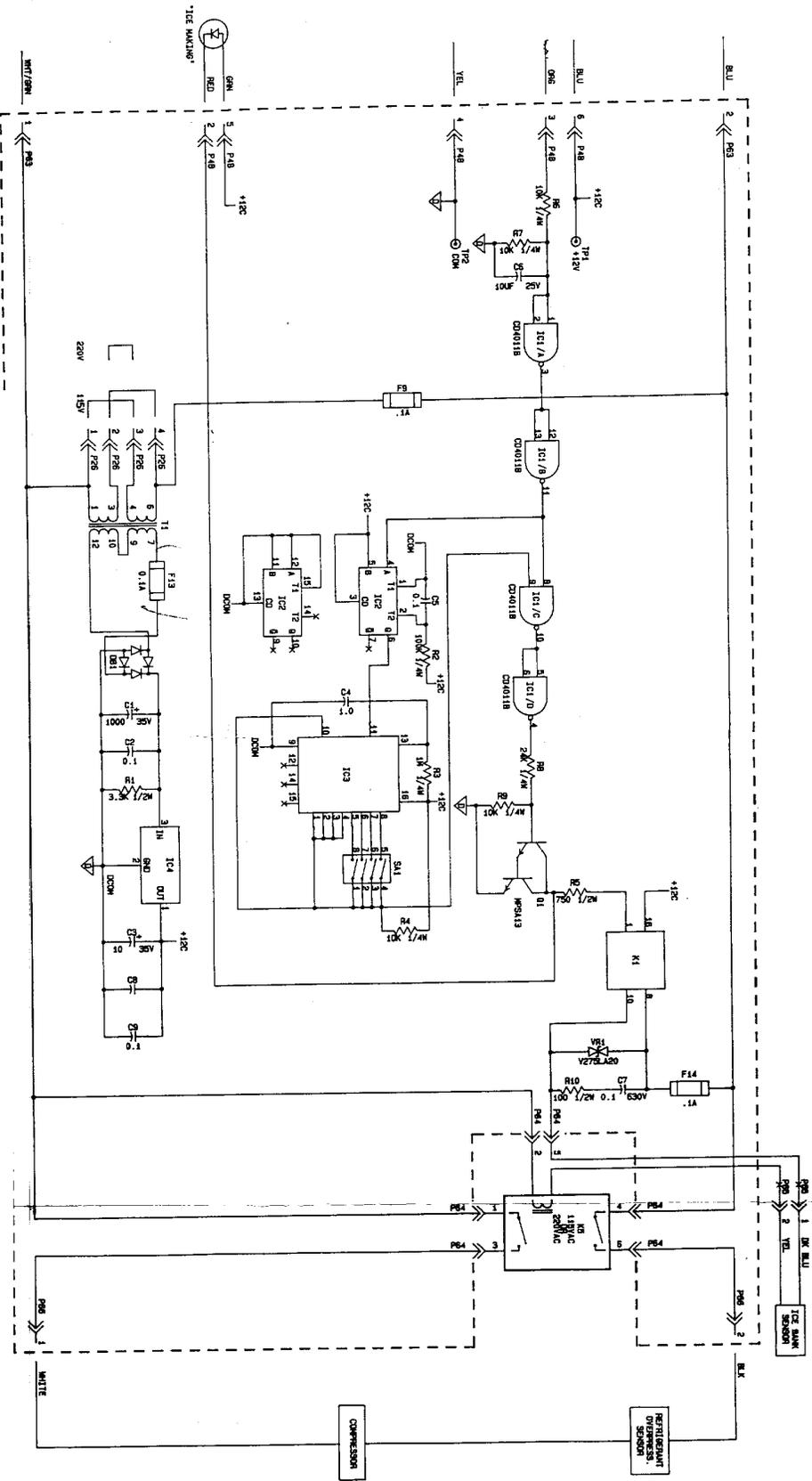


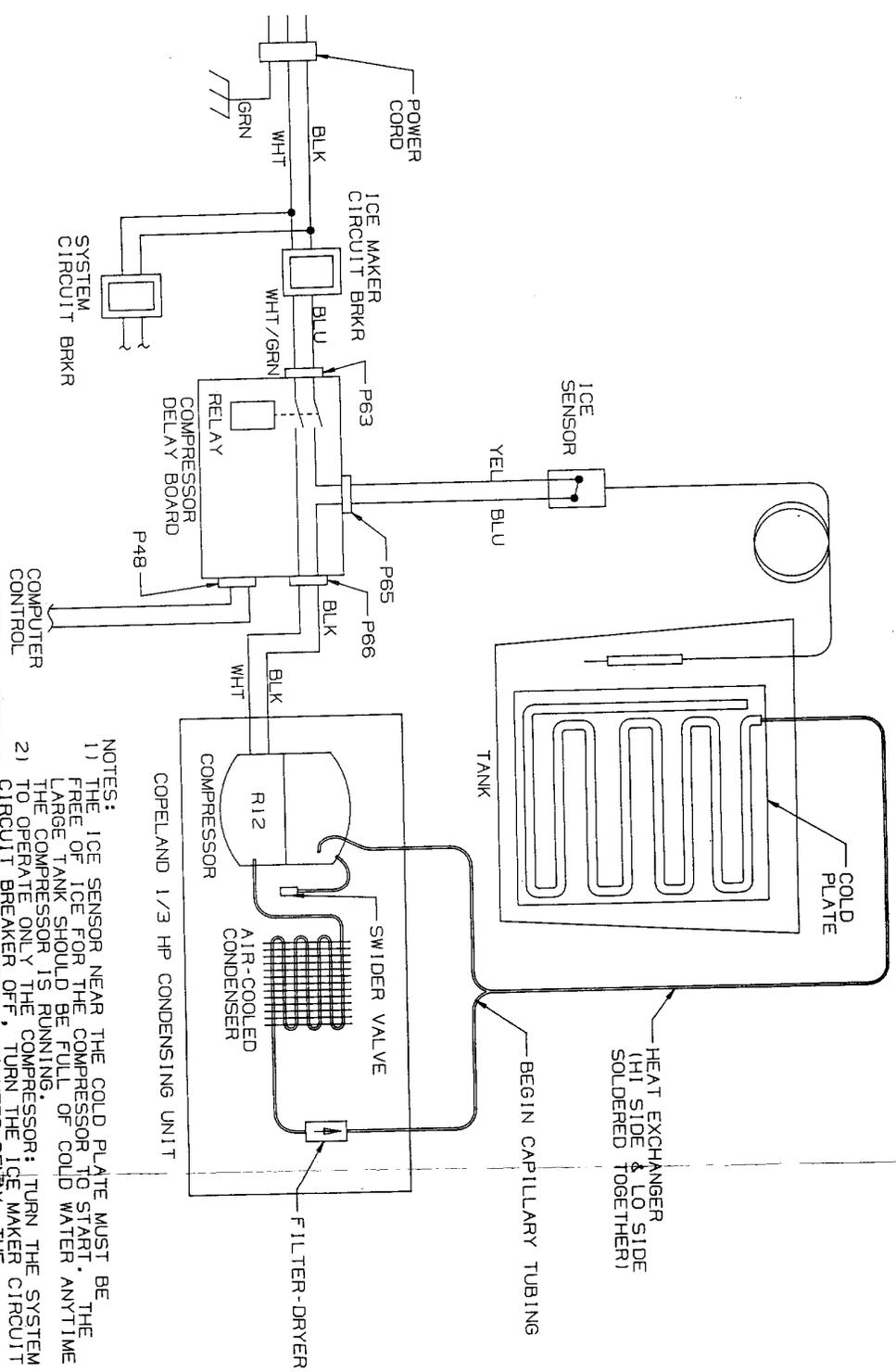






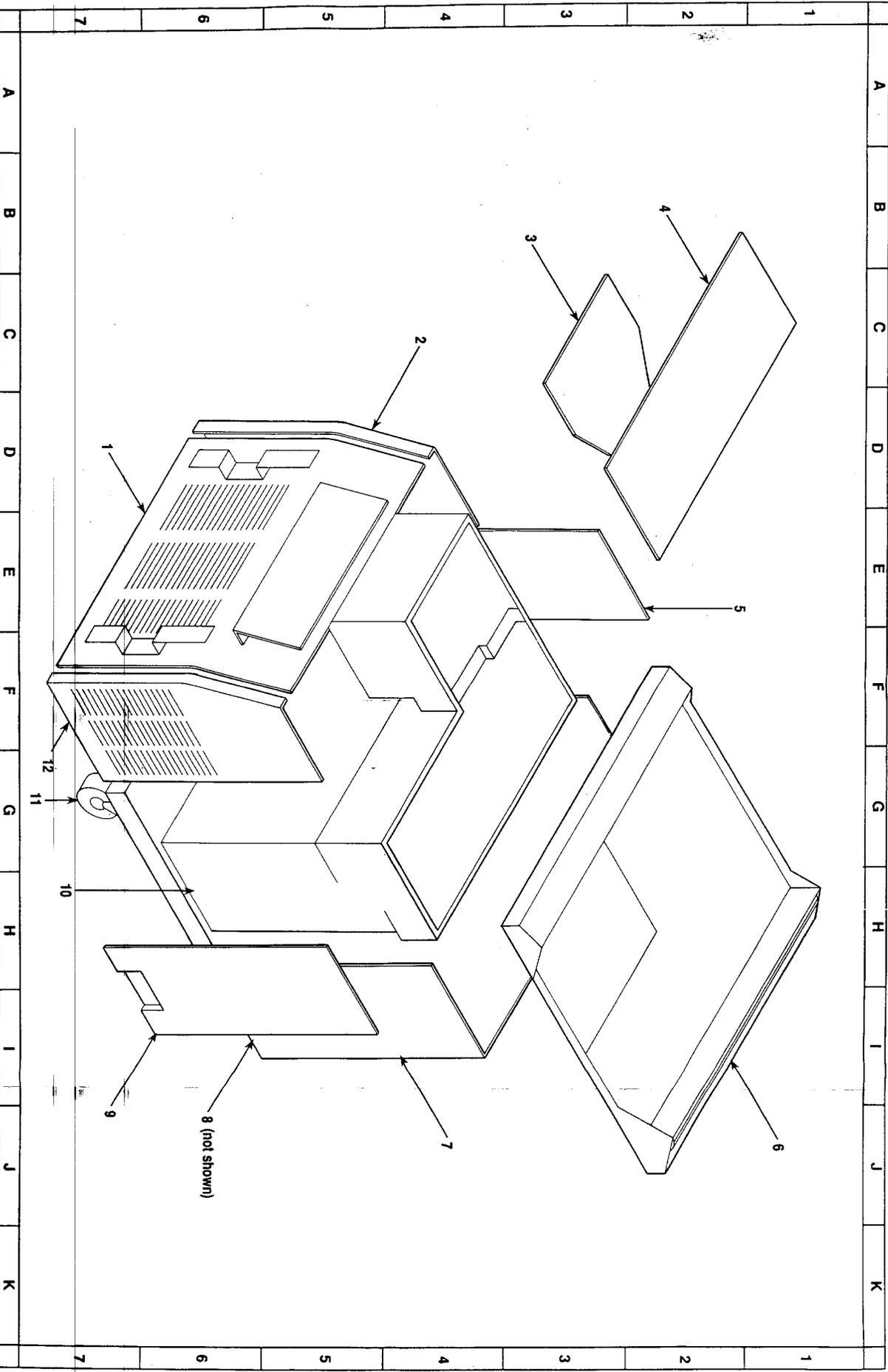
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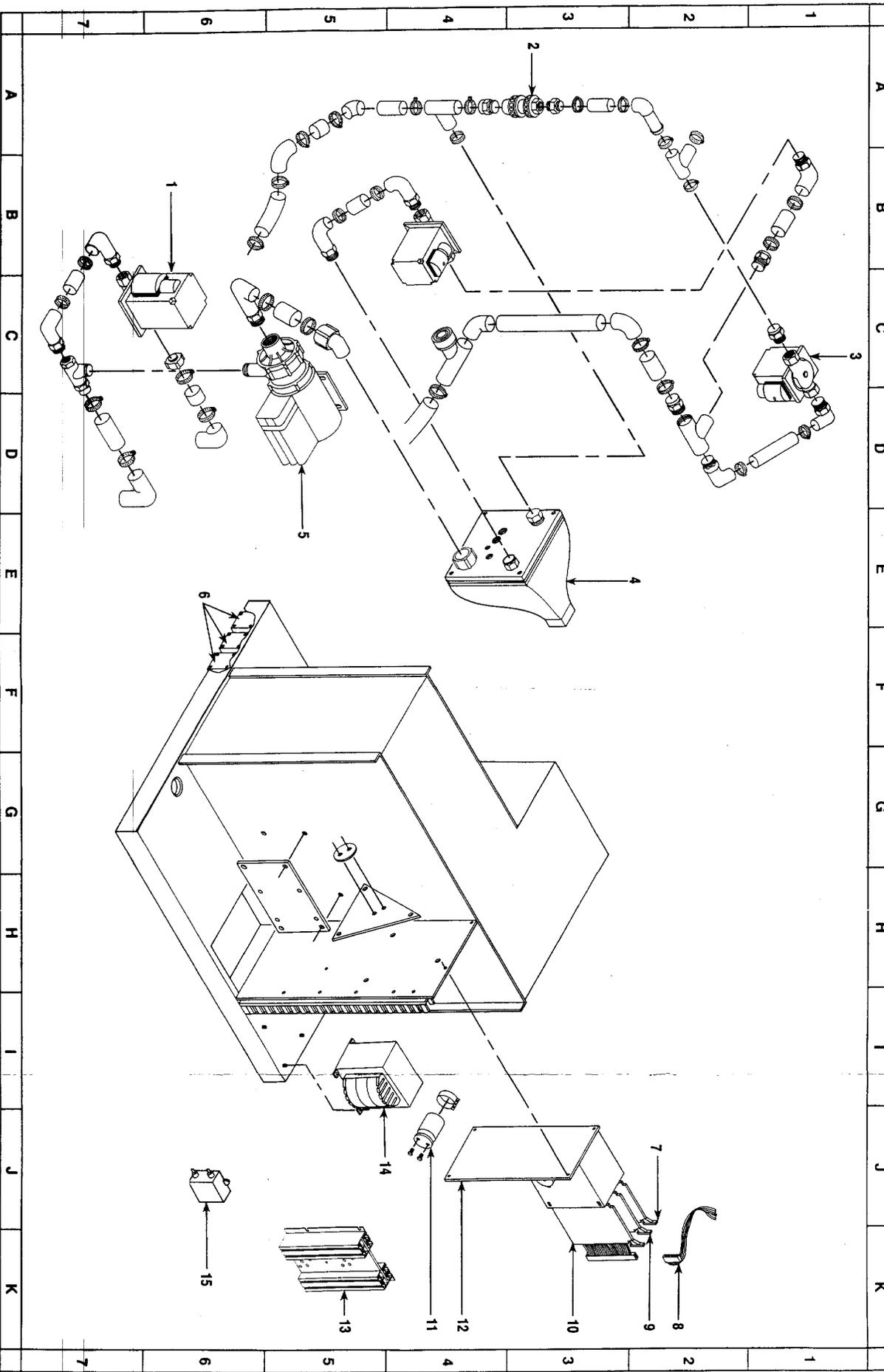


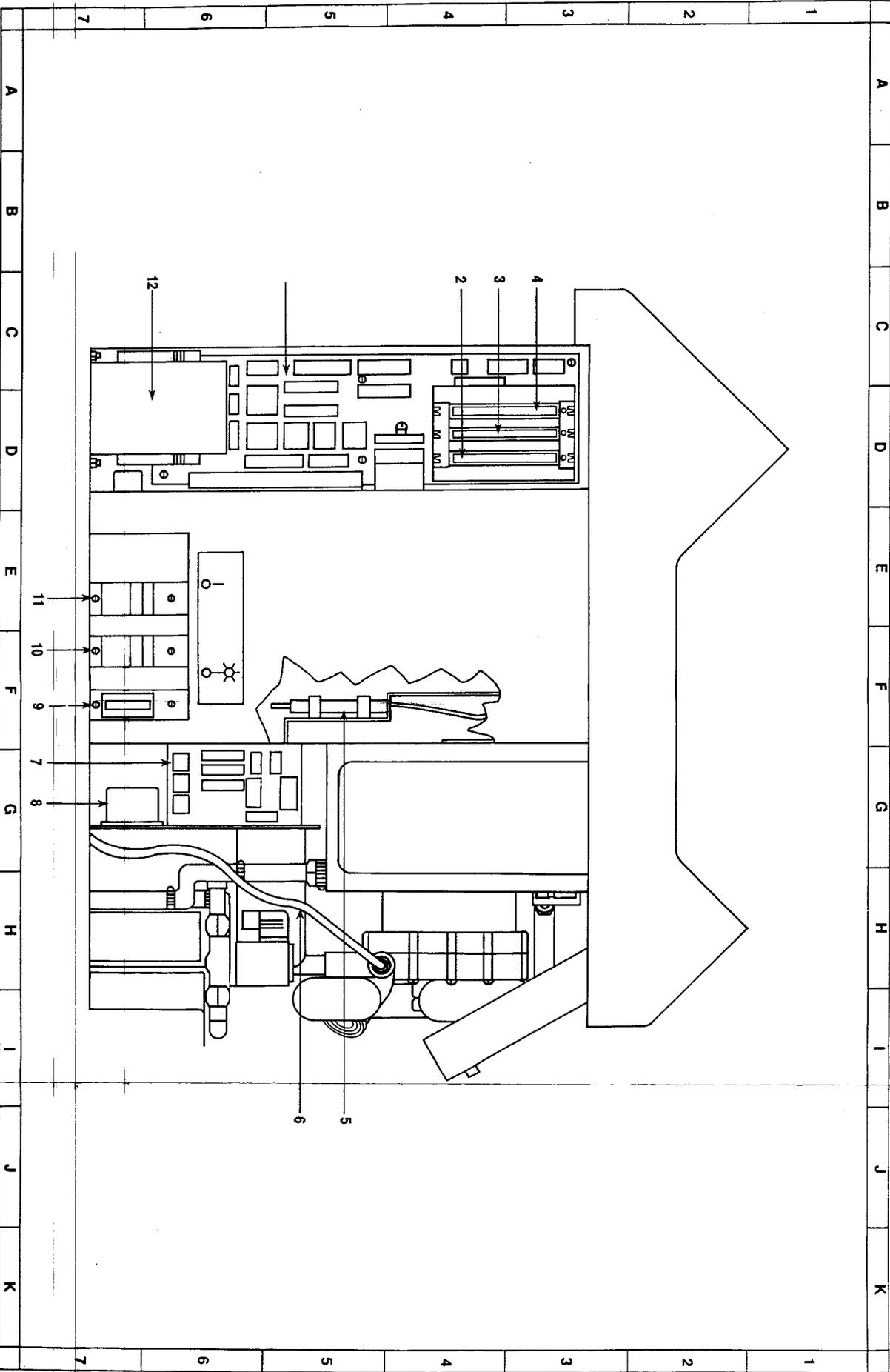


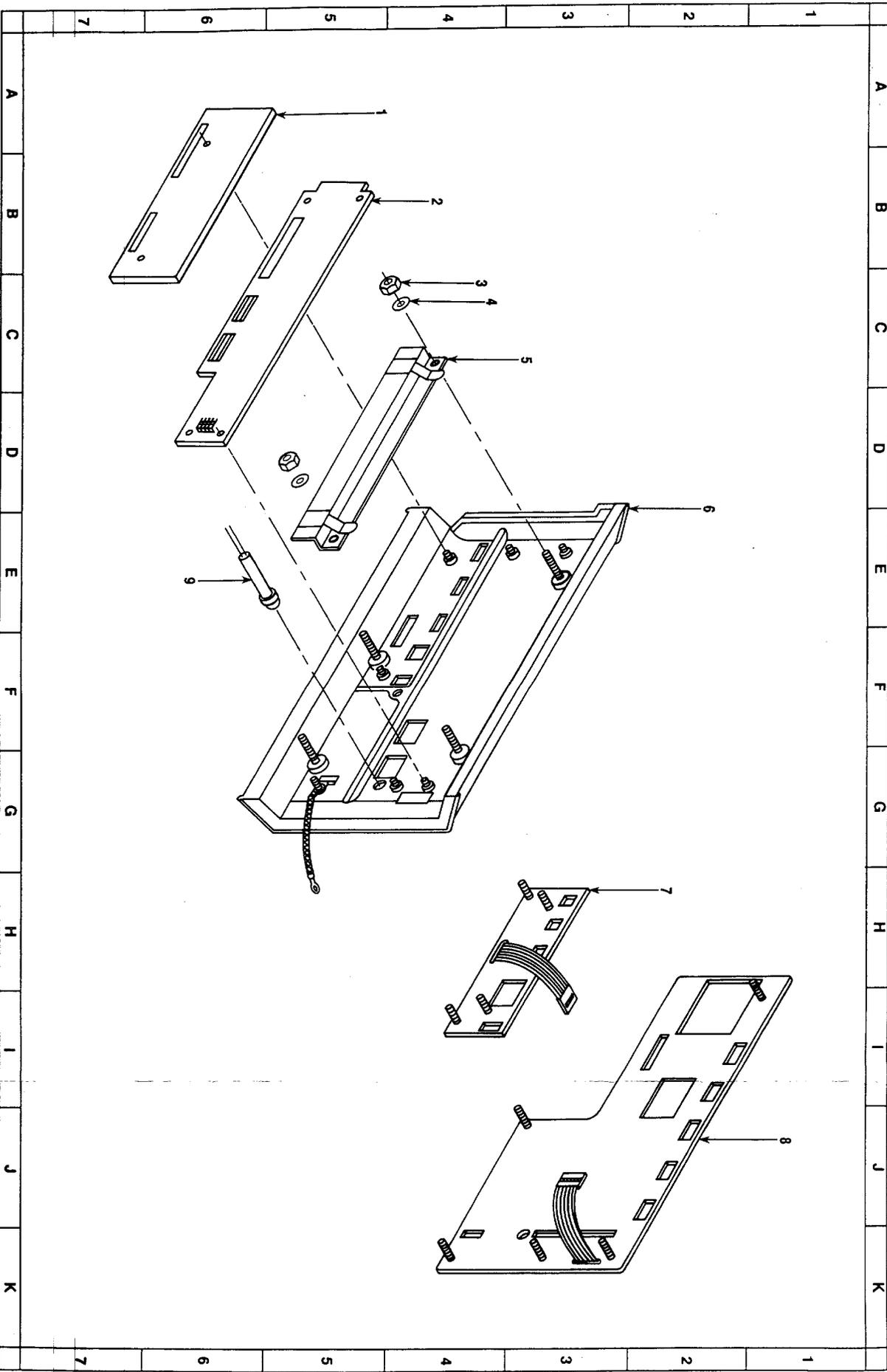
- NOTES:**
- 1) THE ICE SENSOR NEAR THE COLD PLATE MUST BE FREE OF ICE FOR THE COMPRESSOR TO START. THE LARGE TANK SHOULD BE FULL OF COLD WATER ANYTIME THE COMPRESSOR IS RUNNING.
 - 2) TO OPERATE ONLY THE COMPRESSOR: TURN THE SYSTEM CIRCUIT BREAKER OFF. TURN THE ICE MAKER CIRCUIT BREAKER ON. AFTER 5 MINUTES DELAY, THE COMPRESSOR SHOULD START.
 - 3) VOLTAGE AT P66 ON THE COMPRESSOR DELAY BOARD SHOULD BE THE SAME AS THE AC LINE VOLTAGE.

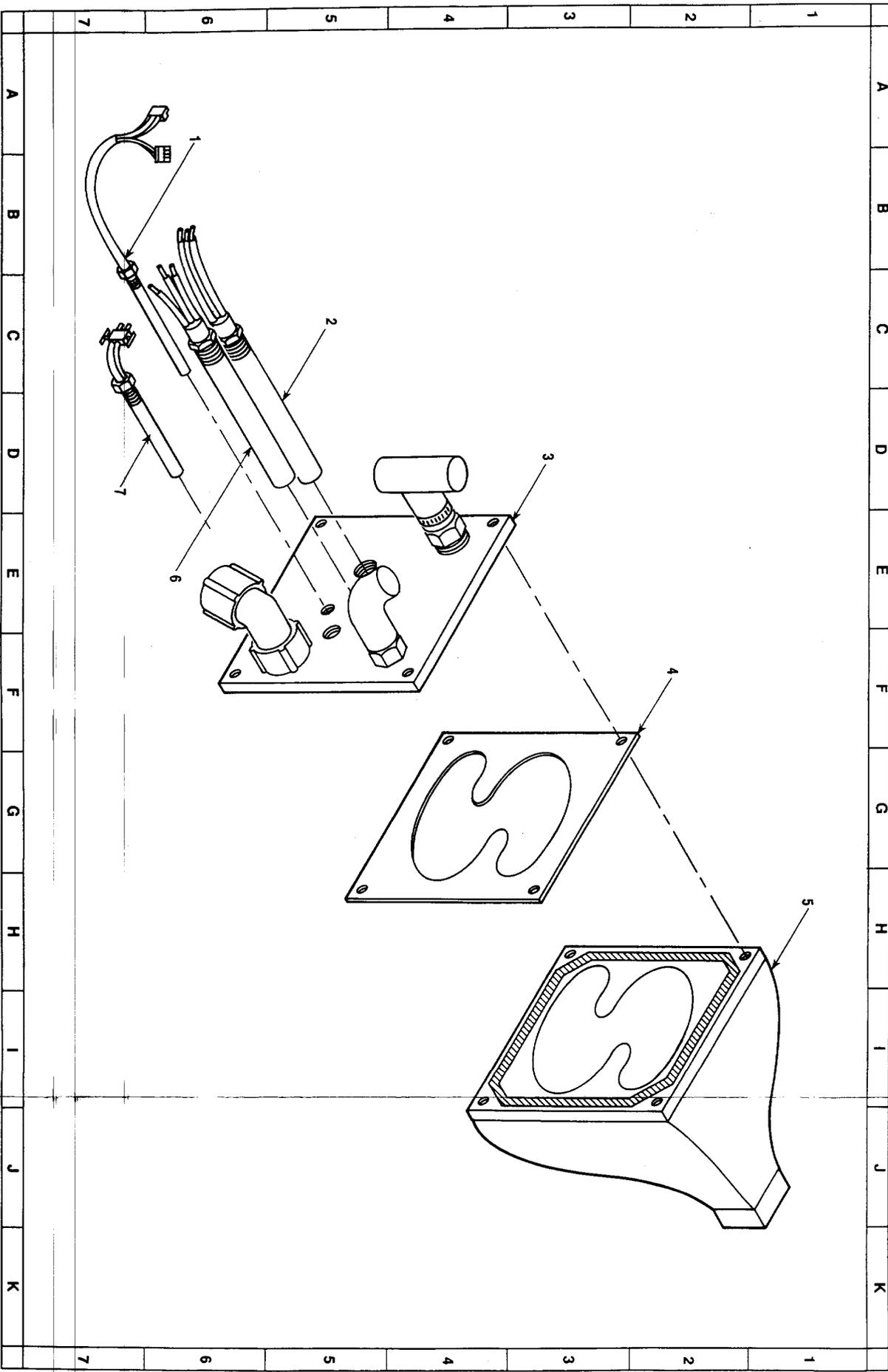
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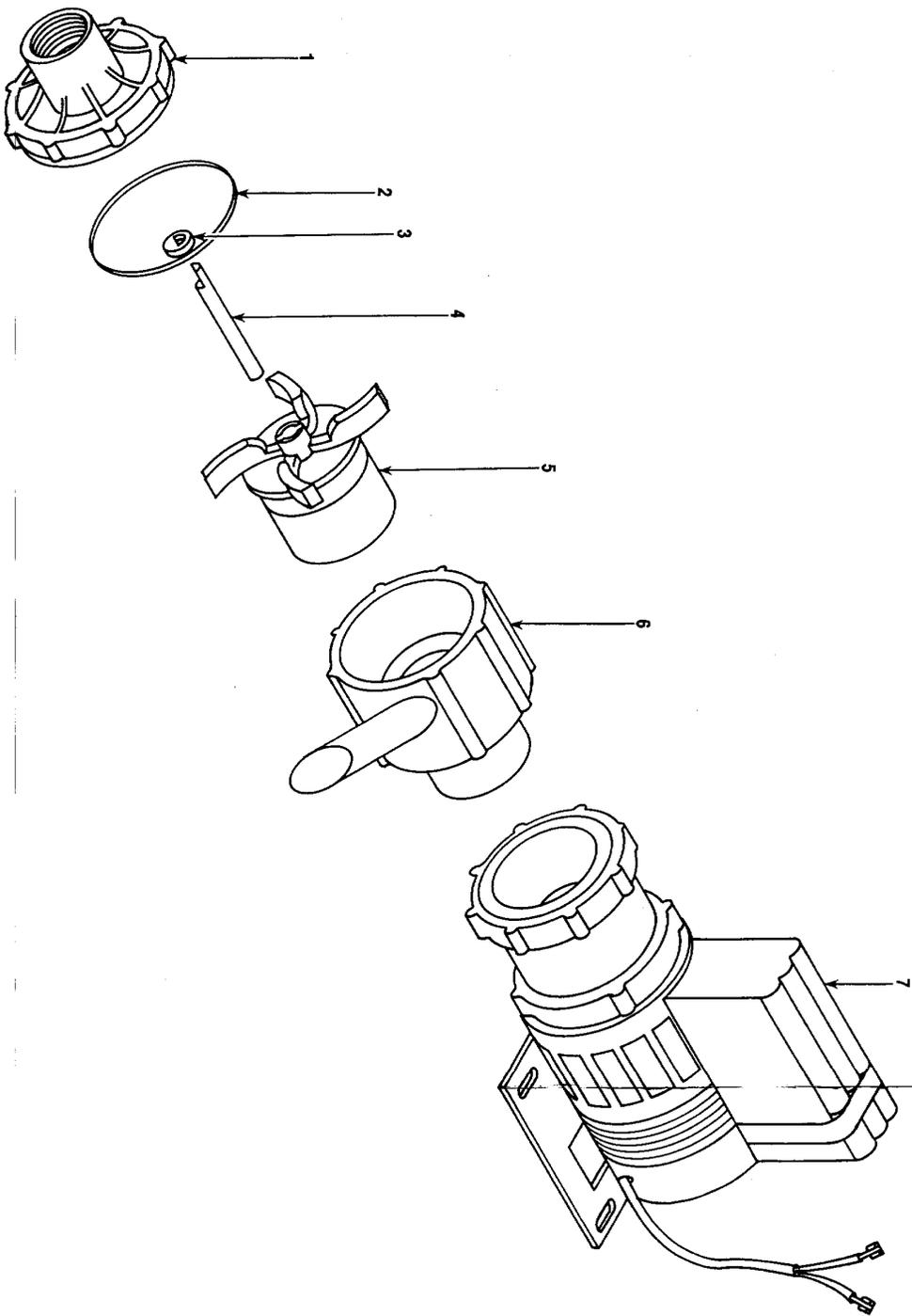




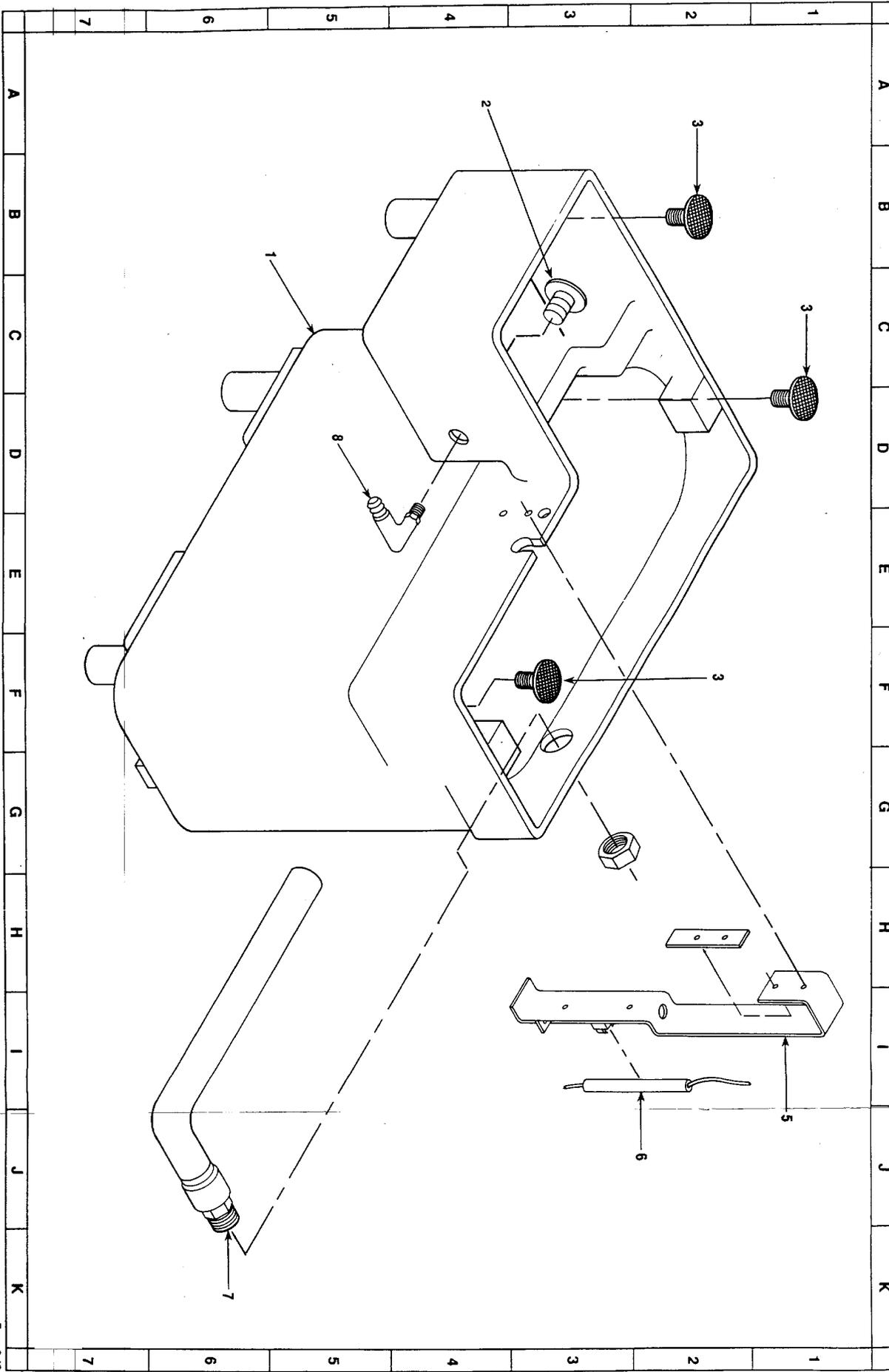


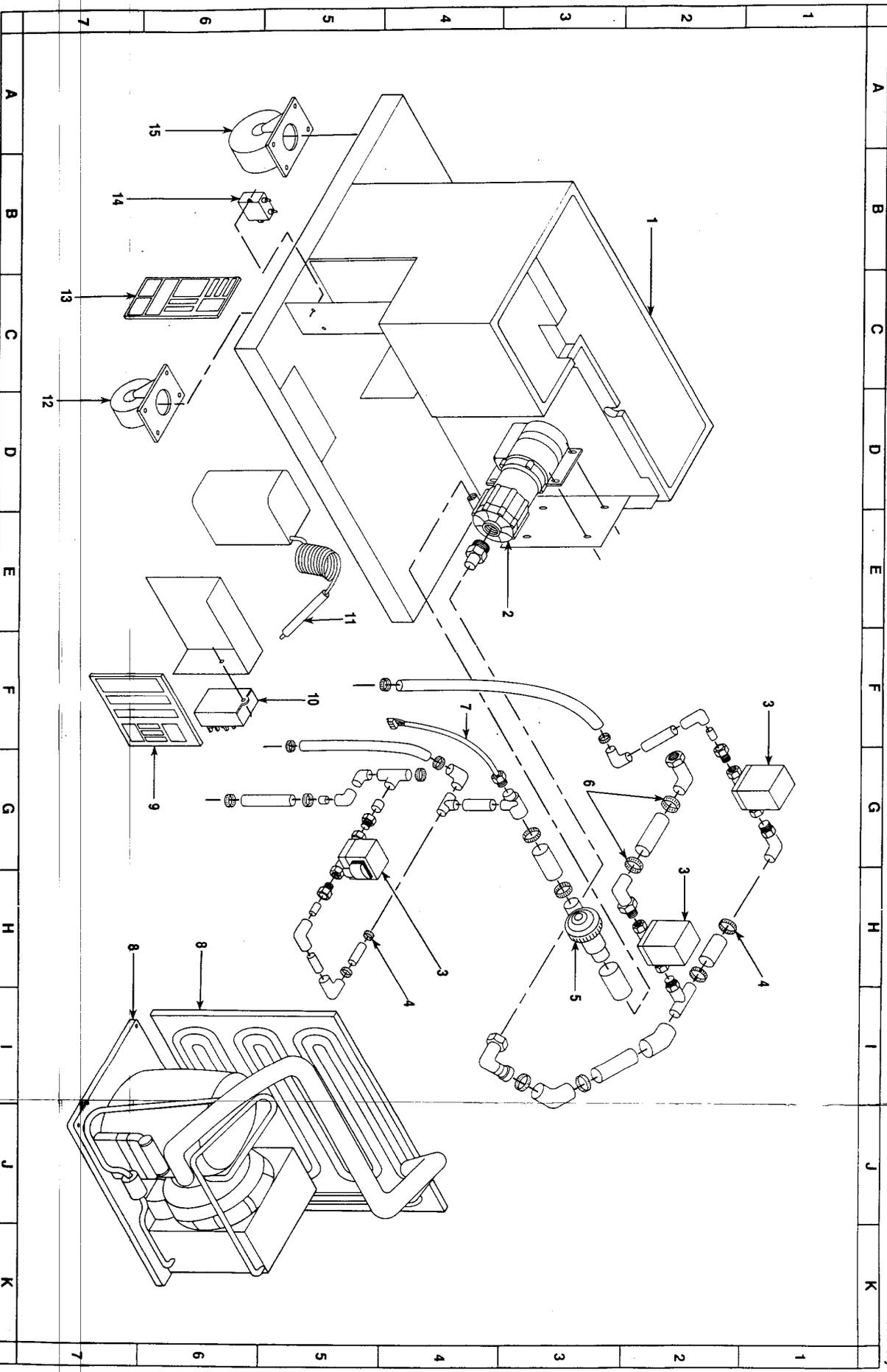


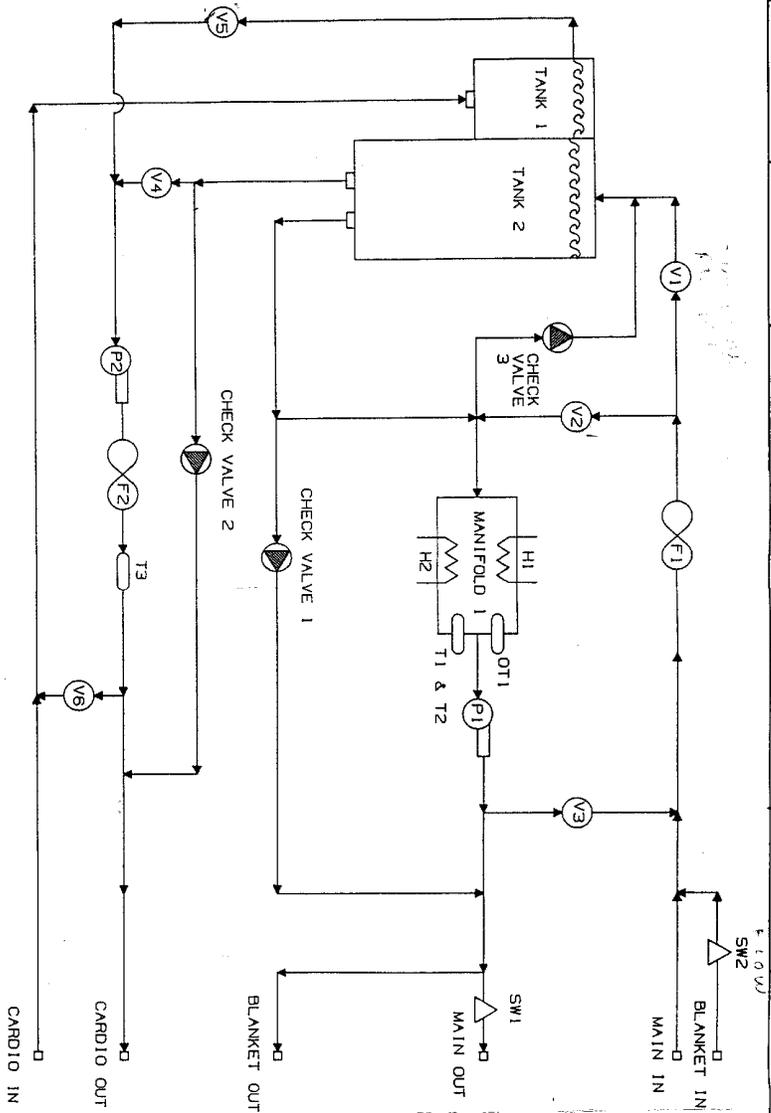




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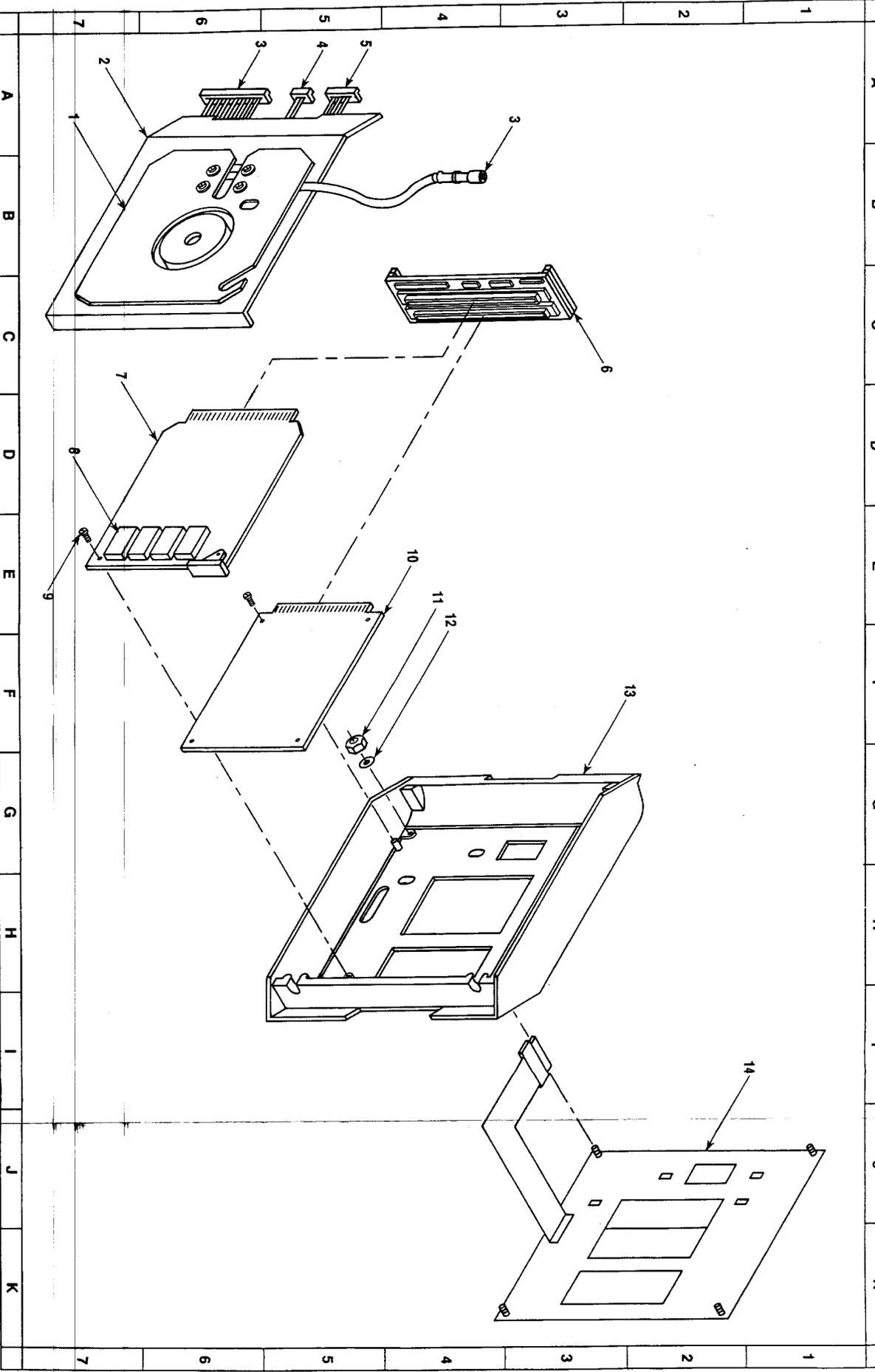


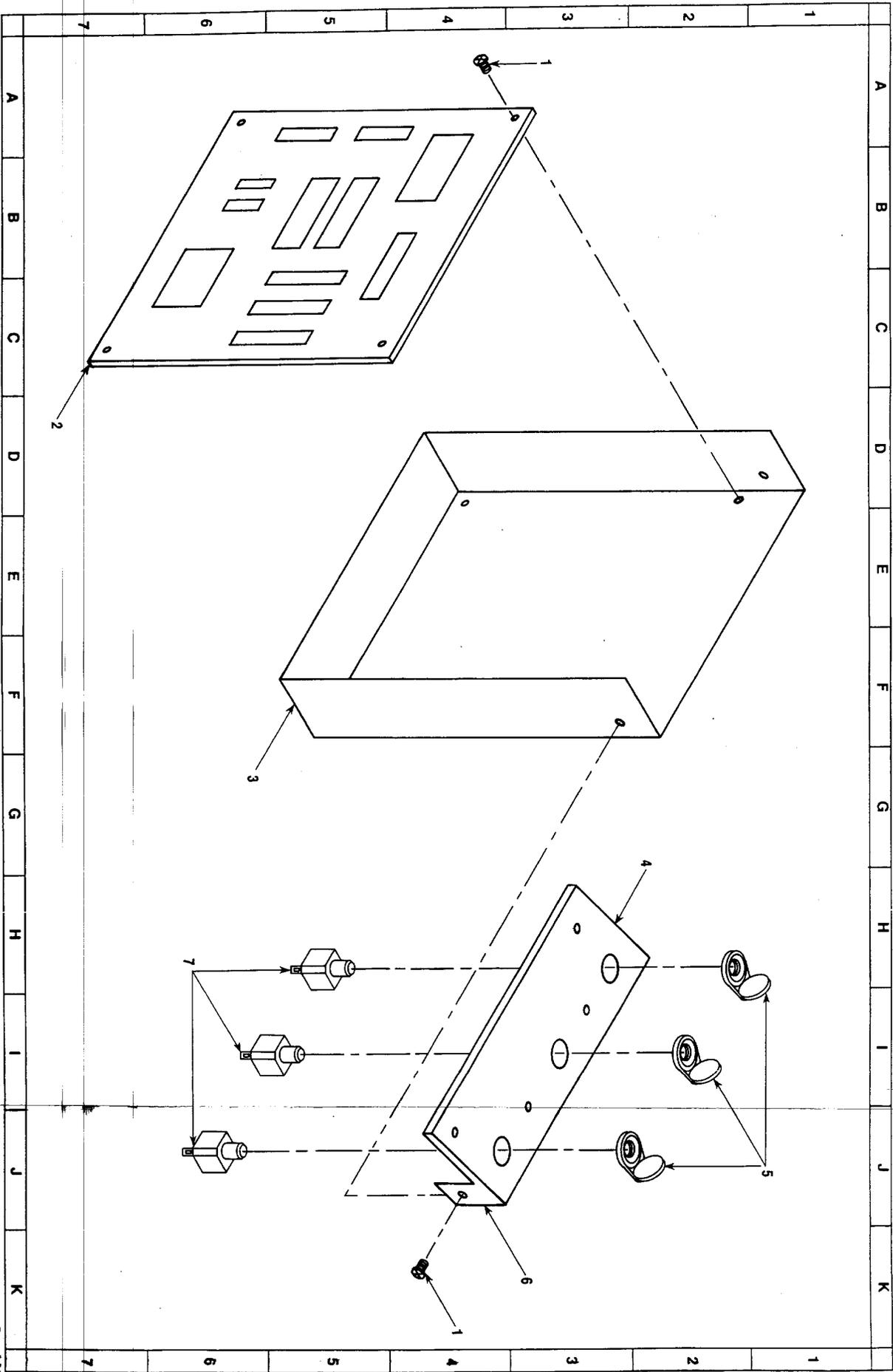


THE COMPLETE HYDRAULIC CIRCUIT, WITH ALL PARTS, IS COMPRISED OF THE FOLLOWING:

- TK1 - CARDIOPLEGIA TANK-OVERFLOW INTO MAIN TANK.
- TK2 - MAIN ICE TANK.
- P1 - MAIN OUTPUT PUMP, 20 LPM.
- P2 - CARDIOPLEGIA OUTPUT PUMP.
- F1 - MAIN LINE FILTER.
- F2 - CARDIOPLEGIA LINE FILTER.
- V1 - COOL VALVE N.C.
- V2 - RECIRCULATION VALVE N.C.
- V3 - DEFROST VALVE THERMOSTAT N.C.
- V4 - CARDIOPLEGIA TANK 2 DRAW VALVE N.C.
- V5 - CARDIOPLEGIA TANK 1 DRAW VALVE N.C.
- V6 - CARDIOPLEGIA RECIRCULATION VALVE N.C.

- MAN1 - HEATER MANIFOLD FOR MAIN OUTPUT. ALSO CONTAINS T1, T2, OT1.
- SW1 - SWITCH FOR MAIN OUTPUT.
- SW2 - SWITCH FOR BLANKET OUTPUT.
- H1 - 700W/120V (1000W/220V) FOR FINE CONTROL.
- H2 - 700W/120V (1000W/220V) FOR FULL POWER HEAT.
- T1 - MAIN OUTPUT THERMISTOR.
- T2 - MAIN REDUNDANT OUTPUT THERMISTOR.
- T3 - CARDIOPLEGIA OUTPUT THERMISTOR.
- OT1 - MAIN OUTPUT OVERTEMP THERMISTOR.





INSPECTION REPORT TCM II

Customer I.D. _____
 Date _____
 Service by _____
 Call # /RGA # _____
 Call cleared _____

I PRELIMINARY INSPECTION System: PN _____ S- _____ SN _____ Run Hours _____

Temperature Display Module PN 15746 SN _____
 Inspect the system visually (note findings)

Customer Comment: _____

Check line voltage _____ VAC
 Check leakage current N _____ R _____
 Check power cord strain relief Yes _____ No _____
 Remove panels Yes _____ No _____

II CHECK AND CALIBRATION

Add connection loops and water Yes _____ No _____
 Check fuses 1-10; note any replacements _____

Verify the Startup Conditions:

Self test Yes _____ No _____
 Prime functions Yes _____ No _____

Check modes and alarms:

Cooldown mode Yes _____ No _____
 Defrost mode Yes _____ No _____
 H₂O > 42.5°C alarm (Over-Temp Fixture) Yes _____ No _____
 Maintain mode (30-35°C in ≤ 3 min.) _____ min _____ sec
 Rewarm mode (25-35°C in ≤ 3 min.) _____ min _____ sec
 Service alarm Yes _____ No _____
 Pump Not Primed alarm Yes _____ No _____
 system filters clean Yes _____ No _____
 tank screens clean Yes _____ No _____
 Low Flow to Blanket alarm Yes _____ No _____

Check Cardioplegia Water Supply:

Large to Small tank motor speed 1 (low) _____ 2 (med) _____ 3 (high) _____
 Large tank Yes _____ No _____
 Small tank Yes _____ No _____
 CPG H₂O° display Yes _____ No _____

Check compressor:

sight glass Yes _____ No _____
 4-6 min time delay Yes _____ No _____
 cooling fan Yes _____ No _____
 clean condensor Yes _____ No _____
 ice formation Yes _____ No _____

Calibrate system (A-D):

R18 to 2.500 VDC ± .001 actual _____ adjusted _____
 R23 to .005 VDC ± .005 actual _____ adjusted _____
 R29 to 4.000 VDC ± .002 actual _____ adjusted _____
 (P1 into J3) less (P2 into J3) ≤ .015 VDC actual _____
 2.820 VDC ± .02 actual _____

Check Temperature Display Module:

high and low alarms Yes _____ No _____
 channel temperature Yes _____ No _____
 Cooldown switch Yes _____ No _____
 Rewarm switch Yes _____ No _____
 Maintain switch Yes _____ No _____
 CPG on/off switch Yes _____ No _____
 CPG H₂O° display switch Yes _____ No _____

Check Gradient 6°/10° :

Maintain mode Yes _____ No _____
 Rewarm mode Yes _____ No _____

Calibrate Temperature Probe Module (25° ± 1°) :

R2 on Module ADG actual _____ adjusted _____
 R2 on Module BEH actual _____ adjusted _____
 R2 on Module CFI actual _____ adjusted _____

Check Temperature Display Module:

Channel	10° Probe Reading	40° Probe Reading	Channel	10° Probe Reading	40° Probe Reading
A	_____	_____	H	_____	_____
D	_____	_____	C	_____	_____
G	_____	_____	F	_____	_____
B	_____	_____	I	_____	_____
E	_____	_____			

FINAL INSPECTION

Replace panels; check that unit functions properly Yes _____ No _____
 Inspect the system visually Yes _____ No _____
 Check the leakage current N _____ R _____
 Requires additional service Yes _____ No _____
 Install inspection label Yes _____ No _____

Comments _____

PARTS INSTALLED	QTY.	DESCRIPTION	CHARGE CODE	INV. CODE	OLD LOT NO.	NEW LOT	ANALYSIS CODE
78-8066-6136-5	1	INSP. FORM					

LABOR HOURS	SC	WTY	GEN	INT	N.C	TOTAL