6 POWER AND CONTROL SYSTEMS

Each of the cabinets that make up the CRAY EL series system maintains its own voltage distribution network. Each of the cabinets has its own AC input cord, but all of these cords are connected to circuit breakers at the rear of the primary cabinet in the incoming AC module (refer to Figure 6-1).

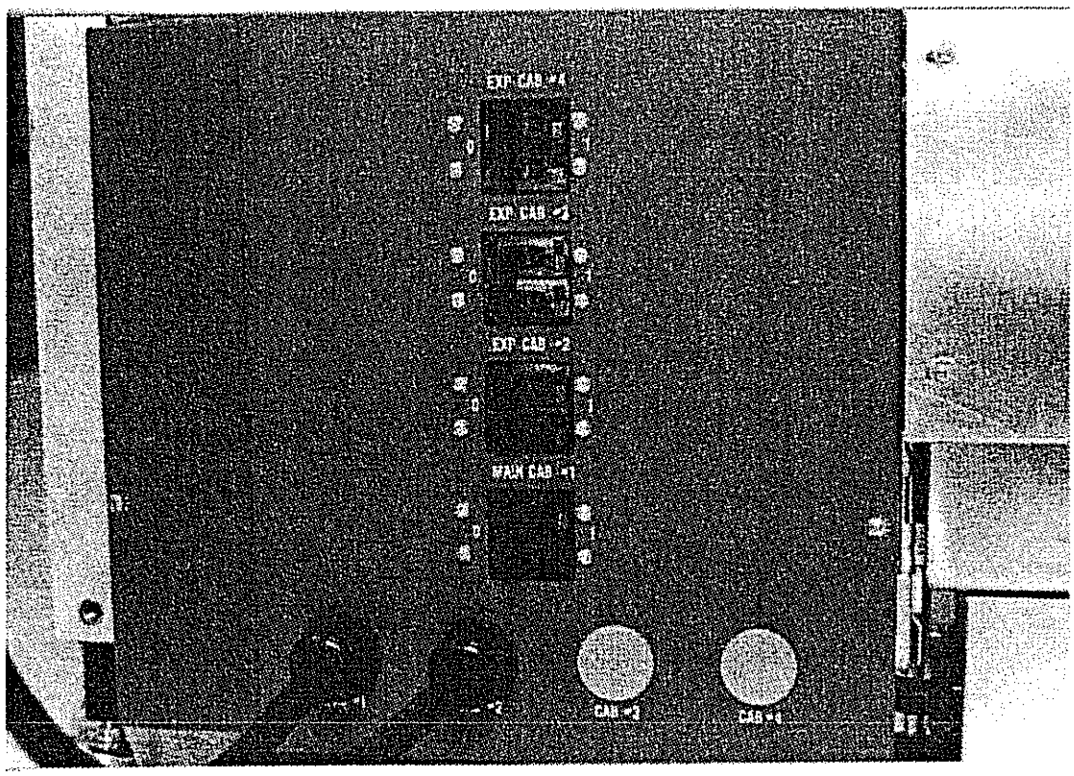

Figure 6-1. Incoming AC Module

The AC entering the CRAY EL series system is 200 to 250-Vac, single-phase, 50- to 60-Hz power that is presented to a 2-pole circuit breaker. After passing through the circuit breaker in the incoming AC module, the AC is next subjected to line filtering. The actual filtering takes place onboard a device called the capacitor ride-through module, but this filtering is not a function of the capacitor ride-through module. Refer to Figure 6-2 to trace the AC input.

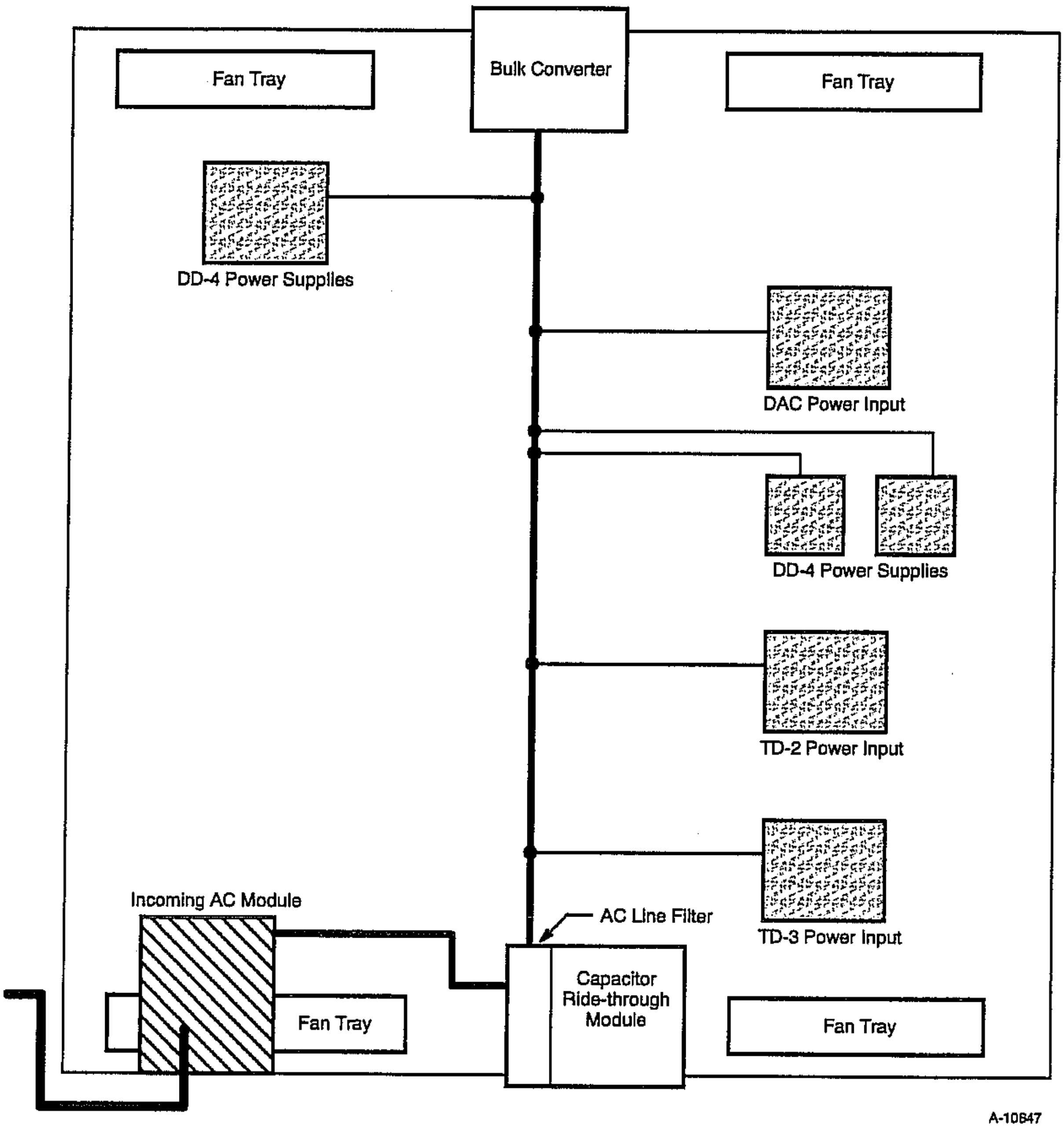

Figure 6-2. AC Distribution

After it is filtered, the AC input voltage is sent to a device called the bulk converter. The bulk converter is a module containing several power supplies, each of which is described in this section. As indicated in Figure 6-2, the 200 to 250 Vac can be tapped to run some of the peripheral devices. This provision is available at several levels along the power trace, called the vertical wireway, between the input line filter and the bulk converter. There is no fixed configuration for the CRAY EL series system peripherals. The AC input value is made available by three connector MOLEX plugs (or similar type) mounted as bulkhead connectors.

CRAY ELS Engineering has standardized the wiring within the vertical wireway so the product specialist will be able to recognize AC and DC wires without measurement. First, any green wire with a yellow stripe can be considered safety ground. It is always good practice to connect this wire first or to disconnect it last when performing maintenance that requires wiring. The CRAY EL series system has been designed so that the entire chassis will be safety grounded as long as the green/yellow wire remains connected.

NOTE: All wires dealing with high-voltage values are double insulated.

The active high-voltage AC, or hot wire, within the CRAY EL series system is heavy gauge (14 to 16 ga.) black wire. Likewise, any high-voltage DC is carried along heavy gauge red wires. Remember that these wire color codes are specific to the CRAY ELS system and were selected by the Engineering department as an internal standard. There may be instances when vendor equipment has red or black wires that do not conform to this color code.

DANGER

High voltage hazard. Wait for the system to completely power down before you touch any wire bundles. Bundles of heavy gauge black/green or red/green wire within the CRAY EL series system contain hazardous voltages. Verify power loss by performing a voltage check; failure to do so will result in death or serious injury.

Voltage Hazards

Three levels of voltage hazard exist within the CRAY EL series system. These levels are:

1. Safety Extra Low Voltage (SELV)

   It is safe to touch enabled connections carrying SELV levels of potential. These are commonly called signal voltage levels.

2. Extra Low Voltage (ELV)

   Mild electrical shock could result with contact. It can be dangerous to wear jewelry when working on equipment at this level of voltage.

3. High Voltage (HV)

   HV levels can cause severe electrical shock or death. Persons having physical problems (heart conditions, etc.) should practice extreme caution.

The CRAY EL series system is designed so that all voltage levels are behind protective covers. To reach an open contact point of high voltage, it is necessary to remove the outer decorative cover; remove the inner electromagnetic interference (EMI) cover; and then remove a contact or plug cover. Inside the peripheral drawers, only SELV or ELV values of power exist, and the top EMI cover must be removed to allow exposure. A further precaution is provided by the power connector used within the CRAY EL series system. This connector has the center (ground) prong longer than the other (power) connectors. This forces a condition of ground first on connect and ground last on disconnect, which adds a measure of protection to the process.

The operator will be exposed only to SELV levels of voltage hazard, as long as the operator does not remove an inner protective cover. The product specialist, after removing the protective covers, will be exposed to ELV and HV levels of hazard. Normal protective measures should be observed.

Inside the bulk converter module, the input AC is applied to the input side of a pair of 12-Vdc power supplies. The outputs of these two supplies provide the 12 Vdc required to operate the fans for the cooling system in the CRAY EL series system. As shown in Figure 6-3, each 12-Vdc supply feeds two fan trays, one bottom and one top. Also note that the fan trays supplied by each power supply are in opposite diagonal corners of the chassis. The reason for this placement is that a cooling chimney can be operated with only one fan tray. If a problem occurs in a fan power supply, only one fan tray in each chimney will be halted, allowing the CRAY EL series system to continue operation until repairs can be initiated.

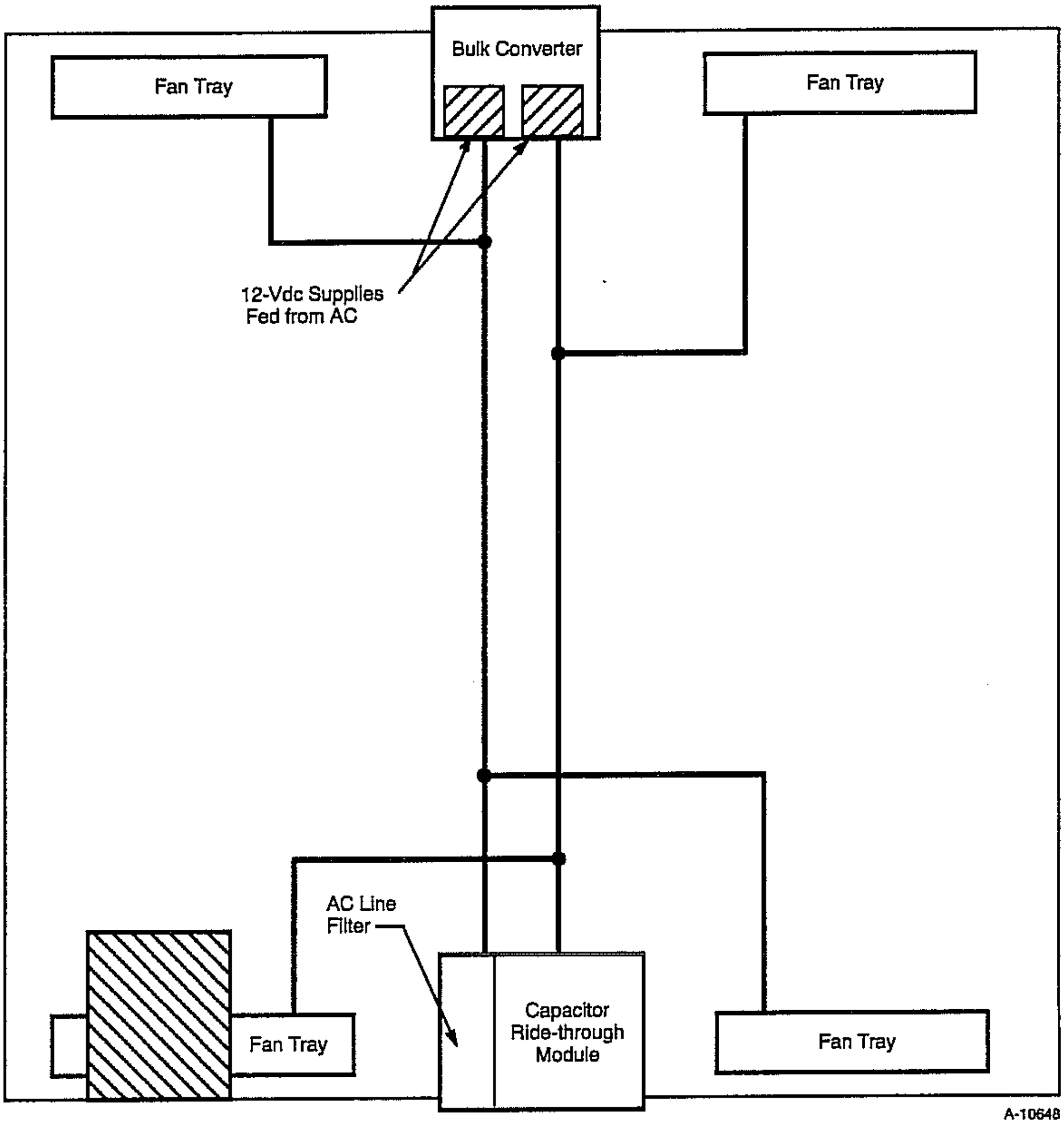

Figure 6-3. 12-Vdc Distribution

The fans used in the fan trays of the CRAY EL series system are DC muffin fans. There are nine fans in each of the fan trays, and the fans are connected to a self-monitoring system. If any one fan should fail in a fan tray, the entire fan tray will stop operating and the appropriate LED on the monitor panel will illuminate.

The control panel also requires 12 Vdc for both normal operation of the control panel, and in case of a power failure, to provide a signal to the AC FAIL LED on the warning panel.

The bulk converter module also contains two 380 Vdc power supplies, as shown in Figure 6-4. These power supplies provide the DC necessary to operate the main components of the CRAY EL series system and also provide the Inhibit signal that can be sent to all devices requiring high voltage DC. In most cases, as noted in Figure 6-4, this high-voltage DC is the input to specific local power supplies within the various subassemblies of the CRAY EL series system.

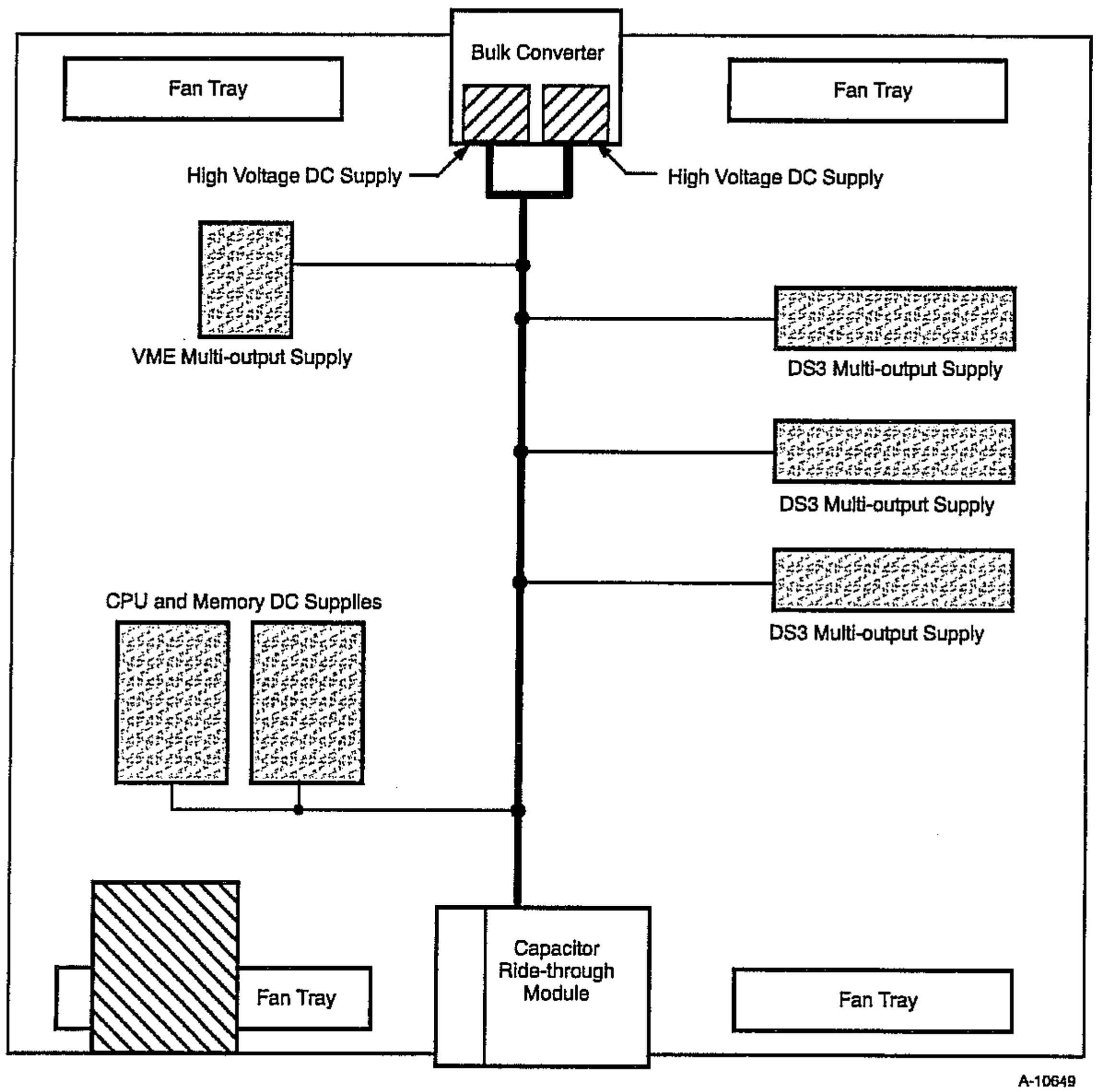

Figure 6-4. High-voltage DC Distribution (380 Vdc)

The high-voltage DC is supplied within the vertical wireway by means of 4-position mate and lock connectors. These connectors are located at the various peripheral-drawer levels, which provides the configuration versatility that is one of the primary advantages of the CRAY EL series system. These DC connectors are all deep contact connectors to provide maximum protection for the product specialist.

As can be seen in Figure 6-3 and Figure 6-4, the 12-Vdc and 380-Vdc power supplies also input their voltages into the capacitor ride-through module. This module is designed as a large storage container that can be used to supply power in case of momentary AC line faults. The capacitor ride-through module, as its name implies, is primarily a bank of capacitors in a sealed box, thus its more common name, the capacitor box. This capacitor box is designed to maintain the 12-Vdc power and the 380-Vdc power for up to 10 seconds, depending on the load.

The capacitor box is disabled when the CRAY EL series system is shut off. The circuit breakers located on the incoming AC module have a shunt switch that is engaged when the circuit breaker is placed in the OFF position. This shunt switch is directly connected across the capacitor box output, providing a short circuit to the capacitors when it is engaged. This shunt consists of an opto-isolated power resistor/transistor circuit that completely discharges the capacitors to protect the operator and the product specialist from potentially fatal injury.

During the power-up sequence, when the capacitors have reached a potential of approximately 200 Vdc, an output signal is sent to the control panel that illuminates the Capacitor Bank x Ready LED.

Also included as part of the power system of the CRAY EL series system are the CPU and memory power supplies. These two power supplies are mounted on the mainframe card cage and are identical power supplies. They are fed from the 380-Vdc power bus and provide an output of 6-Vdc to feed the logic on the respective processor modules and memory modules.

Figure 6-5 shows a representation of the various power connectors on the bulk converter and on the capacitor box. Associated with this figure is Table 6-1, which lists the various power connectors, their locations, and what their basic functions are. Following the table are two diagrams, Figure 6-6 and Figure 6-7, which provide a reference to the location and function of the various outlets within the vertical wireway.

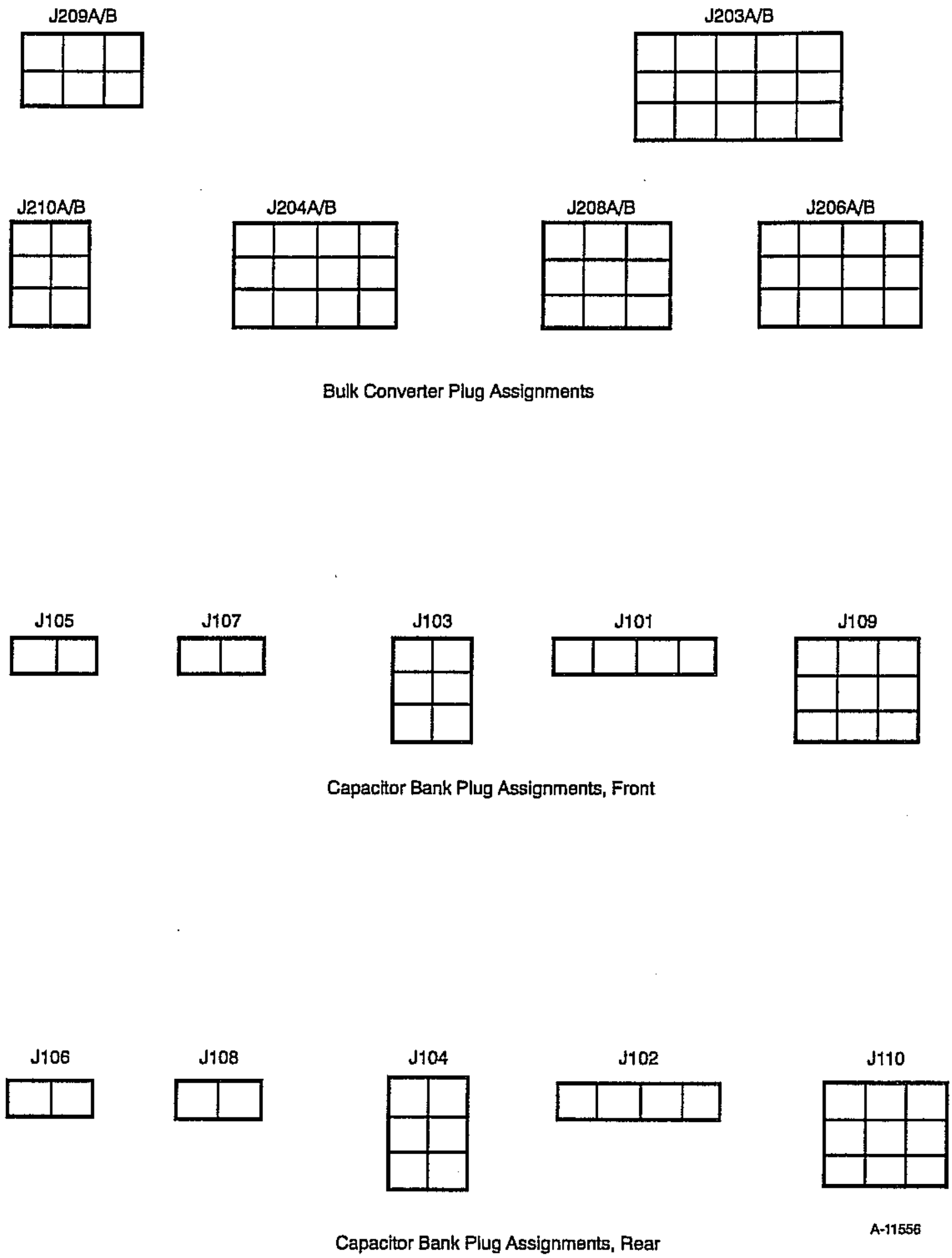

Figure 6-5. Plug Assignments

Table 6-1. Power Connectors

Connector	Subassembly	Function
J109/J110	Capacitor box	Provides filtered AC output to vertical wireway
J208A/J208B	Bulk converter	Receives filtered AC input from vertical wireway
J204A/J204B/ J206A/J206B	Bulk converter	Returns filtered AC to vertical wireway for distribution to peripherals
J203A/J203B	Bulk converter	Provides 380-Vdc output for distribution
J210A	Bulk converter	Provides12-Vdc output for distribution
J103	Capacitor box	Sends Capacitor Bank Ready signal to control panel
J4	Control panel	Receives 12-Vdc input from bulk converter Receives AC FAIL signal from bulk converter
J2	Control panel	Receives FAN FAIL signals from fan trays Receives Capacitor Box Ready signals from capacitor boxes

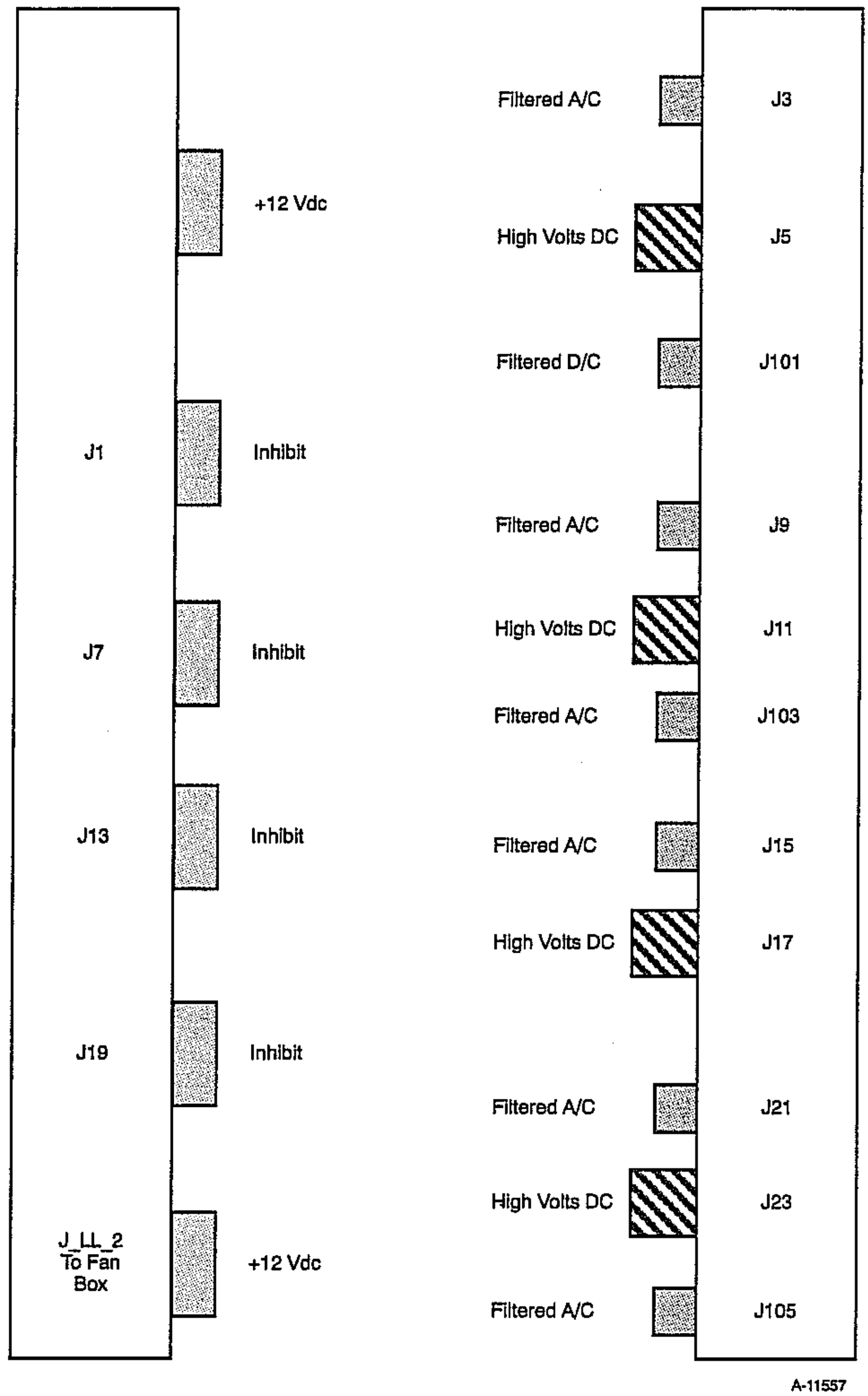

Figure 6-6. Front Vertical Wireway (Control Panel Side) Distribution Plug Assignments

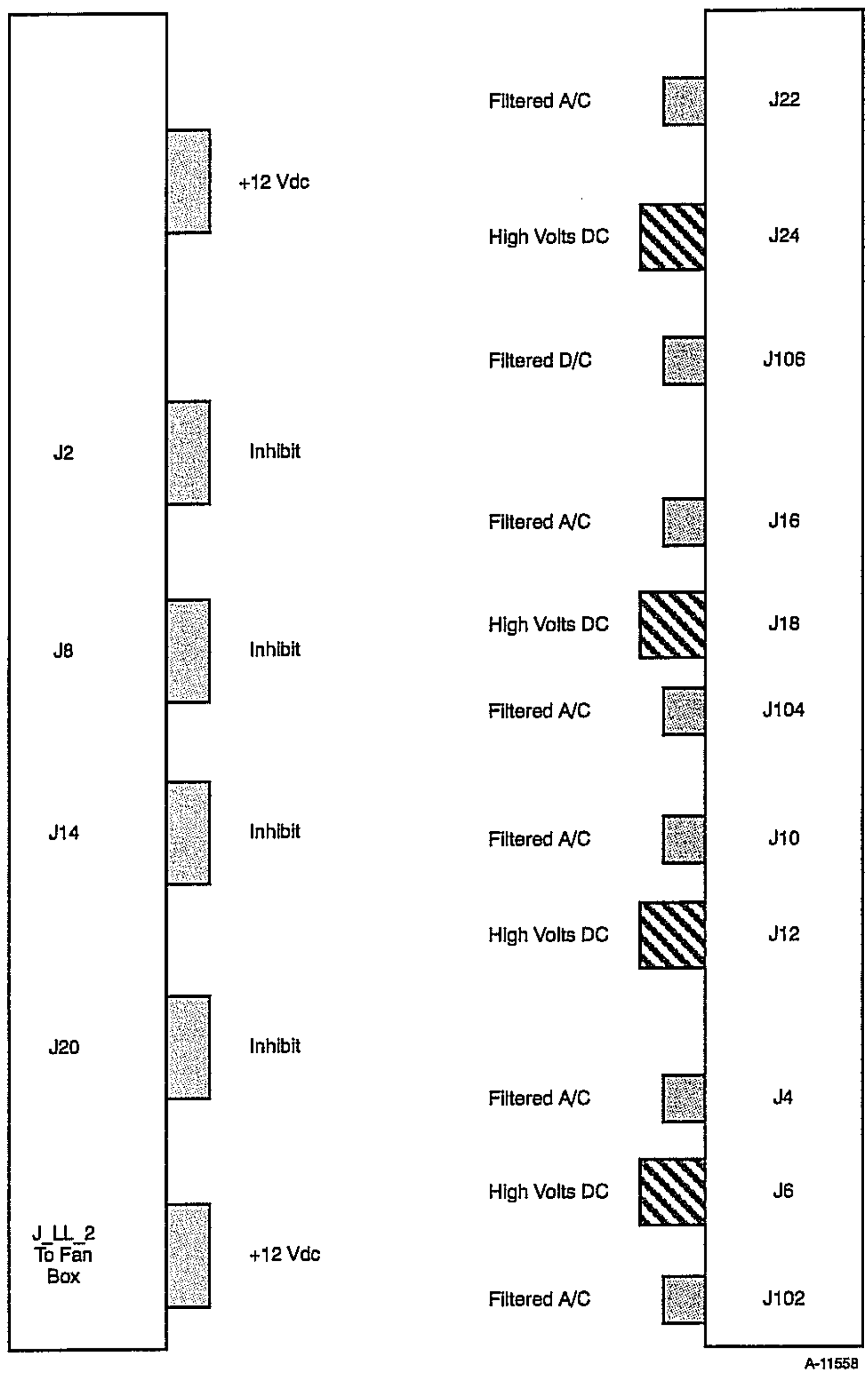

Figure 6-7. Rear Vertical Wireway Distribution Plug Assignments

Power Circuit Troubleshooting Hints and Procedures

CAUTION

Do not connect/disconnect any of the 380-Vdc MOLEX connectors while power is applied. Arcing may occur at the connector. Arcing can damage equipment or injure personnel.

NOTE: All 380-Vdc power supplies are protected by input fuses.

High Voltage DC Faults

If a capacitor box problem is suspected, the capacitor box can be isolated from the high voltage DC bus, and the system can be operated with the capacitor box disconnected until a replacement can be installed. With the capacitor box disconnected, there will be no ride-through capability, and the Capacitor Bank x Ready LED will not illuminate on the control panel. To isolate the problem as the capacitor box, disconnect J101 and J102 from the capacitor box.

Inhibit Faults

The power-supply inhibit line is used to prevent too much current draw through the bulk converter during power-on. The bulk converter controls the inhibit line and will inhibit the output of the DC power supplies while the high DC voltage is less than approximately 180 volts. The power supplies are enabled by supplying a ground through the inhibit line. If the inhibit line for a particular supply is broken, either through a loose plug or a broken wire, then that individual supply will not provide an output.

Because the inhibit lines all use a common connection, if one individual line is shorted to ground (through insulation breakdown or reversal of plug connections) all power supplies will be affected. The power supplies will all try to enable their outputs immediately, and the bulk converter may detect an overcurrent condition, depending upon configuration. The symptoms of this condition are that the high voltage DC does not appear to be enabled, the fans run, and no alarms are sounded. The immediate assumption may be that there is a fault with the high voltage DC, while the actual fact is that the problem could be a shorted inhibit wire.

Input AC Circuit Breaker Tripping

Depending on how often or how quickly the breaker is tripping, there are several problem-isolation techniques that may be used.

Breaker Tripping Immediately

If the breaker trips immediately after it is set, there are three possible faults:

- Short circuit across breaker from the EPO button because it is depressed or because of a faulty wiring harness or a faulty EPO switch.
- Too much current flowing through the breaker because of a short circuit in the power system.
- Trip signal being sent to breaker because of fault sense from the control panel or a faulty opto-isolator board in the incoming AC module.

To aid in problem isolation, follow the power fault flowchart shown in Figure 6-8.

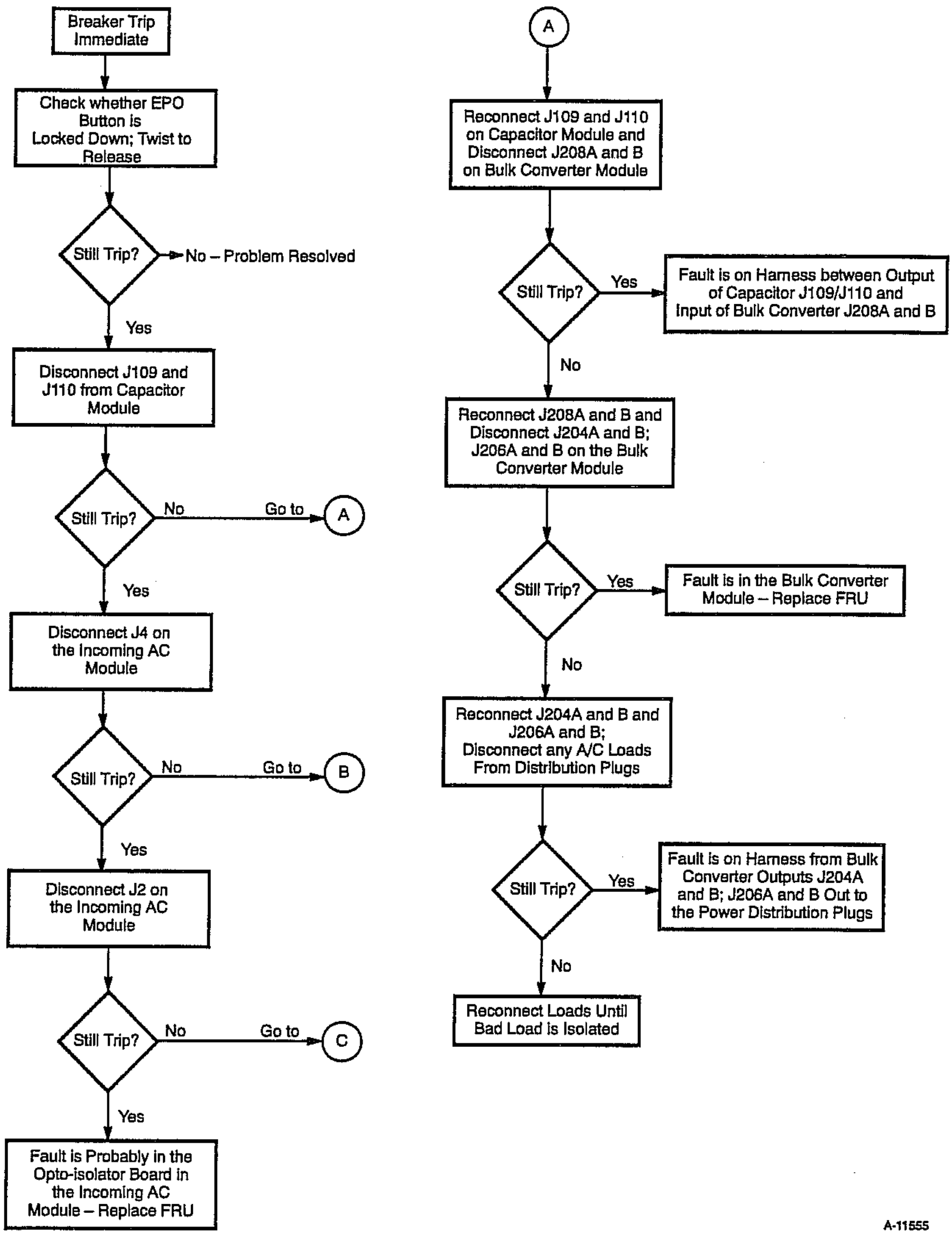

Figure 6-8. Power Fault Flow

Breaker Tripping Intermittently

Intermittent breaker trips can be caused by the same conditions that cause the immediate breaker trip, but they require a slightly different approach to isolation:

- Check the control panel for any indications of a possible valid cause.
- Check the wire harness from the EPO button, control panel J1, AC distribution, etc. for cuts, breaks, or insulation damage.
- Consider using a power monitor for measuring the system input voltages for spikes, brownouts, etc.
- Consider replacing the incoming AC module and the control panel module for isolation. The control panel can be left disconnected for problem isolation; disconnect all the cables from the control panel, except the EPO switch.

WARNING

Do not disconnect the EPO switch. It must remain in the circuit as a safety precaution.

Processor Module and Memory Power Supplies

The processor module and the memory power supplies are fed from the 380-Vdc source and are identical power supplies. Because they are identical, the supplies can be interchanged to confirm a bad power supply.

There are no indicators on the power supplies to indicate a current limit condition. If there is no output from one supply, it is good practice to check for short circuits on the output side of the power supply. Pull all relevant modules (including termination modules in the case of a suspected bad processor module power supply) one at a time from the mainframe card cage to determine if one of the modules is producing a short circuit. If no short circuit is found, investigate the capacitor banks that are mounted immediately below the power supplies. These capacitors are easily swapped between the two positions available. Swapping a shorted capacitor should correct the fault.

VME Power Supply

The VME power supply is mounted on the back panel of the VME drawer. Intermittent power faults have been traced to the 380-Vdc input connector needing an extra quarter-turn on the clamp screws.

There are no other field repair procedures possible with the VME power supply.

Bulk Converter

The bulk converter is the source of the Inhibit signal. If no high voltage DC power is present in the cabinet, but 380 volts is measured between pins 1 and 4 (the two outside pins) of the MOLEX connector, it is probable that the Inhibit signal is being sent in error. To determine if this is true, override the Inhibit signal for a particular supply. This can be accomplished by removing the Inhibit MOLEX plug from the bulkhead connector and shorting the two pins of the plug (SELV level). This should confirm whether or not the Inhibit signal is present.

Control Panel/EPO Button

If power cannot be reapplied to a system because the input circuit breaker trips each time it is thrown and no fault indicators are illuminated, it is possible that either the EPO button is latched or faulty or that the control panel is shorting the circuit breaker trip circuitry in error. Connector J4 on the incoming AC module is the input from the EPO button, and J2 is the control panel trip circuit input. These can be removed one at a time for isolation purposes. Take care to ensure that a genuine fault condition is not being overridden. Inhibiting all 380-Vdc power supplies is recommended before attempting this isolation technique.

Faults that cause a power-off are retained and displayed on the warning panel. These indicators are cleared when power is reapplied if the fault condition is no longer present. Currently there is no manual reset switch. Removing plug P4 from the control panel while power is switched off removes the battery backup voltage and clears all indicators.

Control System

The control of the CRAY EL series system is a minor responsibility of the product specialist. All of the voltage values are fixed, with some specified allowable tolerances. Even during preventive maintenance periods, voltage values are not changed. You can change the output values of the processor power supply and the memory power supply to help isolate intermittent faults. The voltage adjustment potentiometers are located behind the pull-down door on the bottom of the front indicator panel, as shown in Figure 6-9.

Several other controls are located on the control panel: these are accessible by opening the pull-down door. One of these controls is a square button labeled SYSTEM OFF. This control can be located using Figure 6-9. Pressing the SYSTEM OFF button produces a momentary short circuit across each of the main circuit breakers being used on the incoming AC module, which forces them to trip and results in a removal of AC input voltage. Using this button is the recommended method of removing power from the system in a normal power-down operation.

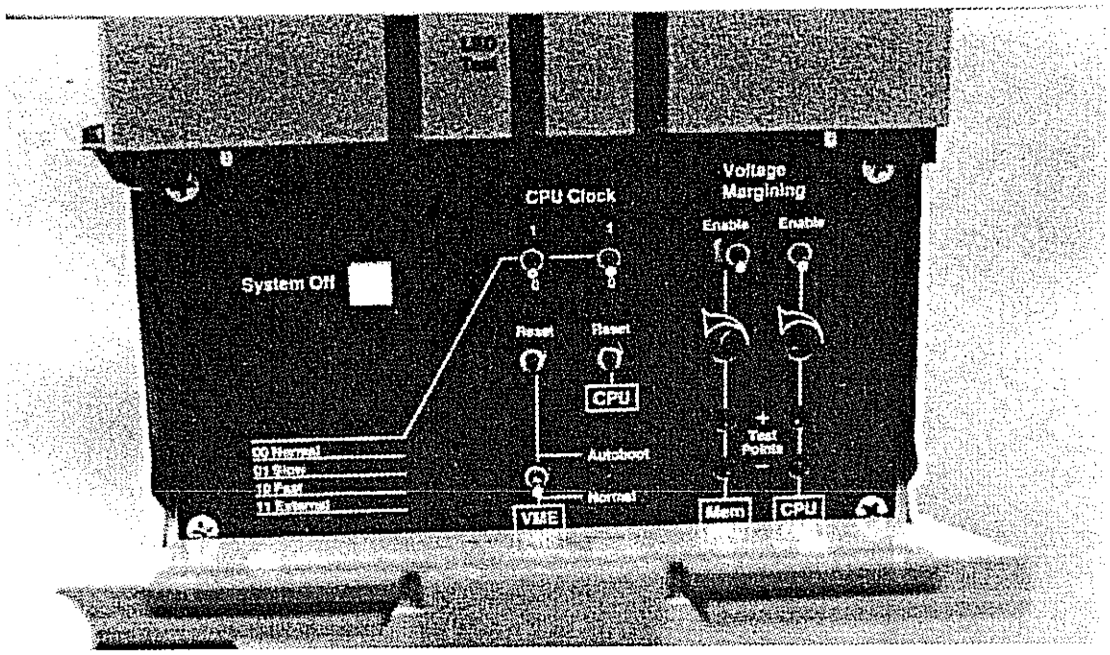

Figure 6-9. Control Panel Door

Other control devices located on the control panel include two reset buttons, one for the VME and one for the processor. Pressing these buttons causes a hard disconnect and reconnect of the associated subassemblies. This hard disconnect forces the associated subassembly to start over at ground zero, just as if the system had been disconnected from the incoming AC, then reconnected. Depressing these buttons terminates any processes running in the processor or the VME.

Another set of controls on the control panel consists of two toggle switches that are used together to set the internal clock speed. The clock switches are provided as a troubleshooting tool to be used in case of intermittent faults. The switches can be set to fast clock, which does not significantly increase the performance of the CPU. This point must be made clear to operating personnel, because the controls are accessible to them. The two switches that change the clock to predetermined settings are used as binary bits, providing settings of:

- 00 – normal
- 01 – slow
- 10 – fast
- 11 – external

The final control on the front of the CRAY EL series system is the emergency power-off (EPO) button, shown in Figure 6-10. As its name implies, this button is provided for use in an emergency situation. Depressing this button creates a short circuit across the AC circuit breakers on the incoming AC module, causing them to trip and disconnect the AC input voltage. The EPO is a push-and-lock device; once depressed, the short circuit is maintained across the AC circuit breakers, preventing reconnection of the incoming AC voltage.

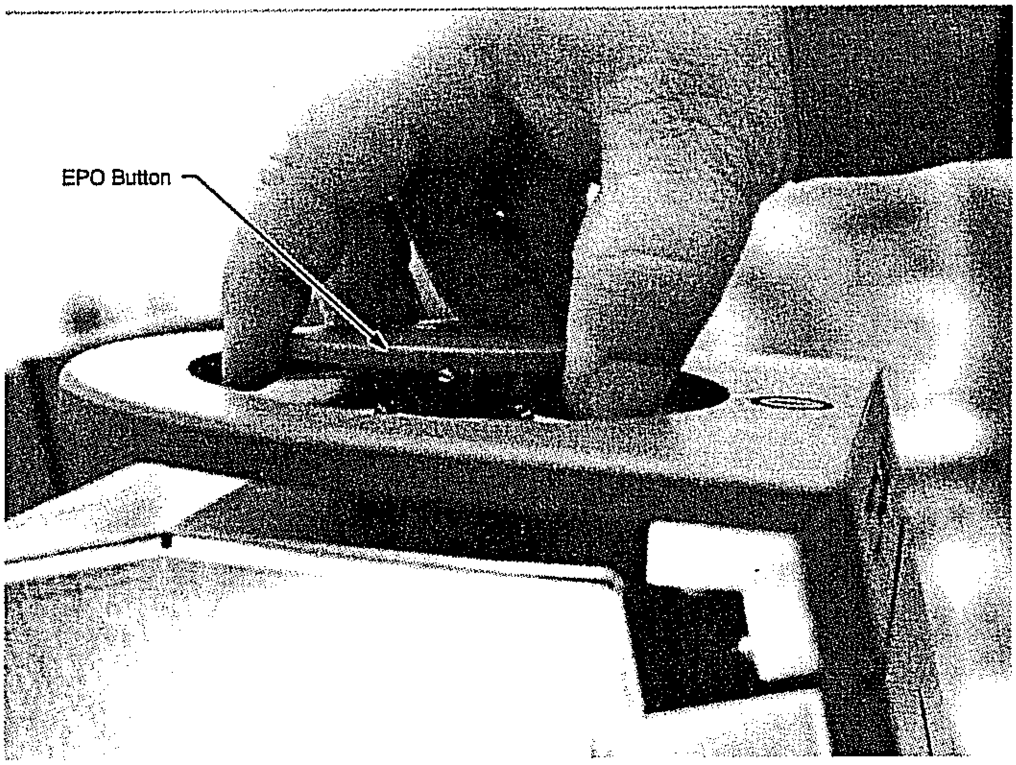

Figure 6-10. EPO Button

When the emergency has been dealt with and it is again safe to apply power to the CRAY EL series system, it is necessary to remove the short circuit across the circuit breakers. The EPO button is a twist-to-unlock device. When you twist the EPO approximately 1/8 turn counterclockwise, the locking mechanism is released, the EPO returns to its normal position, and the short circuit is removed from the AC circuit breakers, allowing a normal power-up sequence.

The normal power-up sequence of the CRAY EL series system is as follows: turn on the appropriate circuit breakers on the incoming AC module; there is one breaker for each cabinet in the system.

Monitoring Panel

A front-mounted LED panel, shown in Figure 6-11, monitors conditions in the CRAY EL series system. The monitor panel consists of amber and green LEDs connected to various subassemblies. The monitor panel contains LEDs for a four-cabinet system. If the system being monitored does not have four cabinets, the LEDs associated with the missing cabinets are not used. Details of this panel are shown in Figure 6-12.

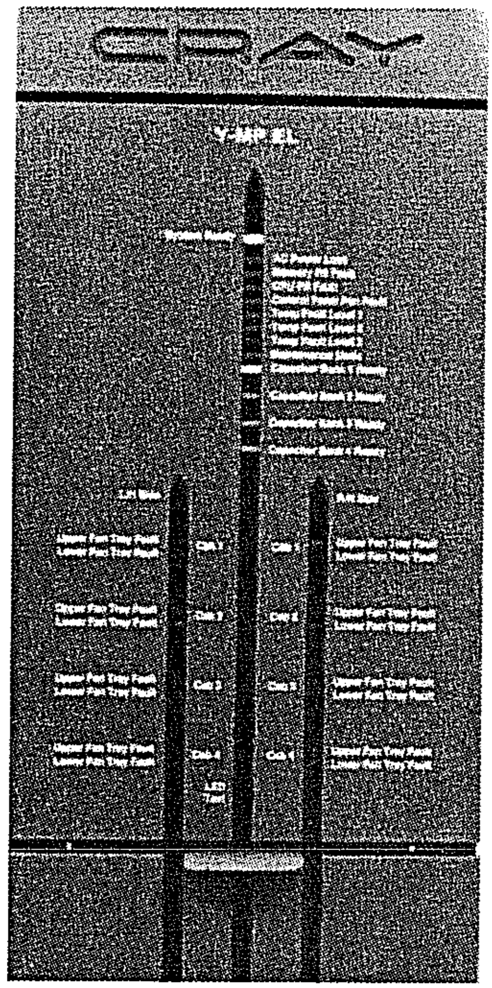

Figure 6-11. Control Panel

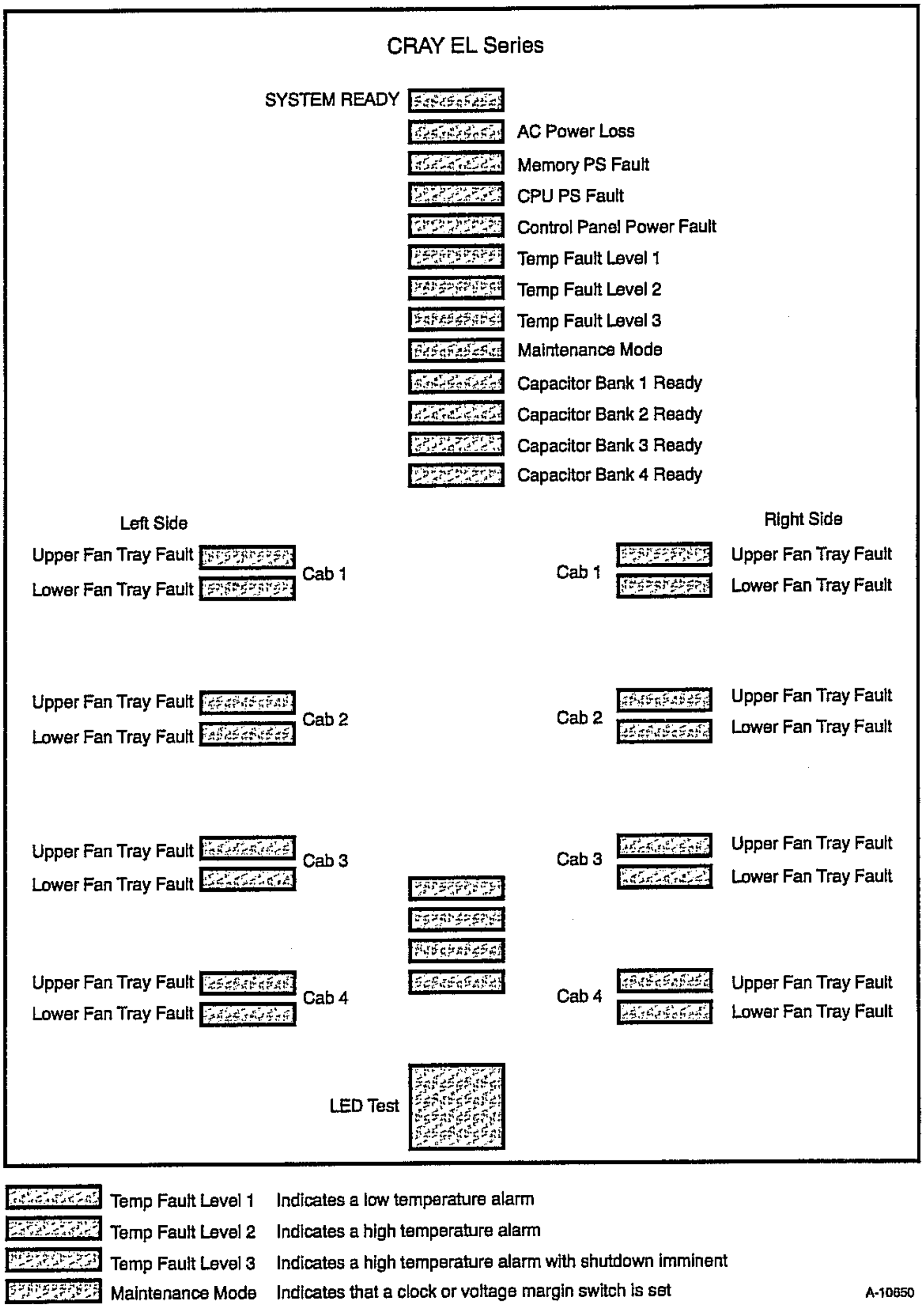

Figure 6-12. Control Panel Warning and Ready Indicators

Under normal conditions, a green LED should be illuminated at SYSTEM READY. A green LED should also be illuminated at each of the capacitor bank ready positions, each of which represents a cabinet in the system.

The remainder of the monitor panel represents fault indicators. This monitoring panel is only a report panel; it has no real memory and runs on a real-time fault report system. This means that if a fault occurs, the fault will be indicated. If the fault then disappears, the indication will also disappear, and no onboard memory will retain a record of the fault.

However, if a fault powers off the CRAY EL series system, the fault is retained by the monitor panel. The monitor panel has a battery backup that will maintain the condition of the LEDs for 72 hours. This battery backup is supplied by rechargeable batteries with a 35-hour charge cycle.

The monitor panel reports most faults in a straightforward manner. If a problem occurs, the problem illuminates the appropriate LED, and the legend next to the LED tells the operator what the problem is. However, there are three temperature faults reported. The first of these, Temp Fault Level 1, indicates that the conditions are too cold for the CRAY EL series system to operate and turns the circuit breakers off. The second condition report, Temp Fault Level 2, indicates that the internal temperature is above the preset normal temperature. The actual internal temperature is approximately 110 °F. While this temperature is not considered dangerous to the components, it is considered damaging to them. Level 2 does not remove power from the system, but indicates that the product specialist's attention is required. The final level, Temp Fault Level 3, indicates the internal temperature has reached approximately 160 °F and that AC power has been removed from the system.

An audible alarm is connected to the fault-monitoring LEDs on the CRAY EL series system and is sounded under the following fault conditions:

- Loss of AC power
- Loss of memory power
- Loss of CPU power
- Loss of control panel power
- Temperature fault level 1
- Temperature fault level 2
- Fan fault with an upper and a lower fan in the same chimney

The audible alarm is provided by a 3.7-KHz, piezoelectric ceramic device. This device has a duty cycle that sounds for 1 second every 10 seconds. The alarm is connected to the battery backup system on the control panel.

The maintenance mode LED is a warning light that illuminates whenever any of the condition-altering controls are used. The controls monitored are the CPU margin switch, the memory margin switch, and the clock speed switches. Changing any of these controls from their normal condition illuminates the maintenance mode LED.

The SYSTEM READY LED is illuminated when the following six conditions are met:

- Incoming AC present
- Processor voltage good
- Memory voltage good
- +12-Vdc good
- All capacitor banks are above 200 Vdc
- 3-minute timer has expired