Chapter 10
Facility & Safety Interlocks

10.0 INTRODUCTION

Personnel safety is of primary importance in the design of the OMEGA System. Three major classes of hazards are addressed at a fundamental level by interlock functions built into the utilities that are part of the laboratory facility supporting the laser system. These are

- control of the power source for the high voltages inherent in the laser amplifiers,
- control of the warnings issued when alignment laser emissions are present that could constitute an eye hazard, and
- active and passive monitoring of the location of personnel in the bays.

These and basic facility-monitoring features are included in the following specific facility interlock subsystems.

10.1 750 kVA

The primary power source for charging all amplifier power conditioning units (PCUs) is provided by Unit Substation #2, more commonly called the "750-kVA" substation. The output from this substation is remotely controlled and sensed from the Facility Interlock Executive (FIE). In addition to this control, there is a manual dump button circuit that is strung throughout the laser, target, and capacitor bays, as shown in Fig. 10.1-1. This circuit allows for the immediate dump of not only the 750-kVA substation but also the control power for the PCU's. Loss of control power causes the individual PCU to engage its dump resistor, thus dissipating all charge built up in the PCU capacitors. The dump circuit renders the power conditioning system "safe" for all personnel within a few seconds of being engaged but requires the manual reset of the circuit and substation and should be used only in cases of extreme personnel hazard. A connection to the fire alarm circuit ensures that the system is made safe in the event of a fire alarm anywhere in the LLE building.

10.2 ELECTRICAL HAZARDS

Laser Bay (Non-amplifier) Structures

All non-amplifier structures have individual breakers for ac power to isolate any power-related problems that may arise. Except for circuits greater than 110 VAC, the laser bay structures are fed from bus ducts in the capacitor bays that are connected to a dedicated, isolated transformer. The FCC structures are not directly above the capacitor bays; therefore, they are powered from an isolated transformer that also feeds the driver and PGR areas (T3).

Laser Bay Amplifier Structures

Laser bay amplifier structures were designed without ac power outlets to minimize the risk of interaction between service ac circuits and the high-voltage, high-current circuits for the flash lamps.

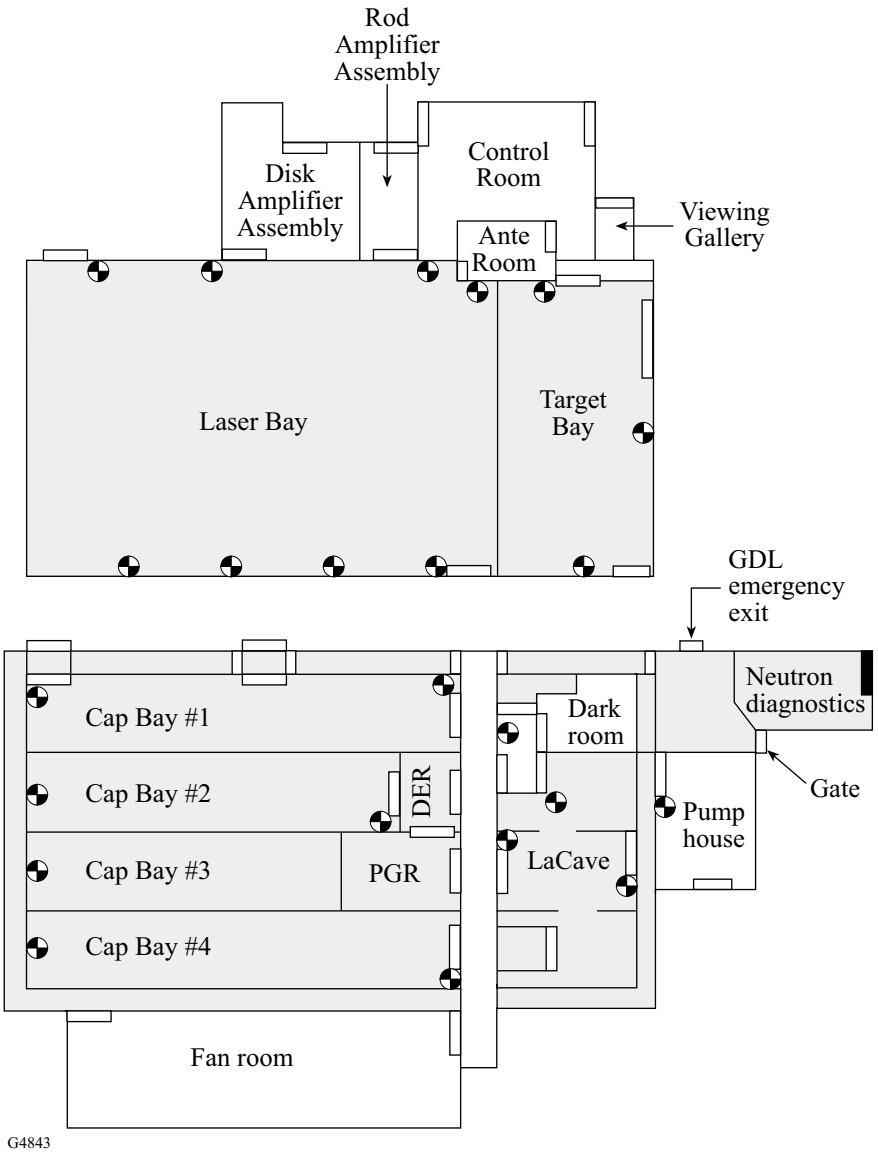

Fig. 10.1-1
"Dump" buttons are located on the walls of the facility. (There is also one at the Shot Director's station in the Control Room.)

The amplifier facility controller (AFC) in each amplifier structure is powered by 110 VAC but is mounted such that it is isolated from the structure.

The stage-E and F amplifier structures also have an integral crane assembly that requires 220 VAC. This power is supplied through a four-contact switch that disconnects all three phases and ground during the shot sequence (see Fig. 10.2-1). The interlock system controls and senses the status of this contactor.

Target Bay Structures

Target bay structures are also isolated in a similar fashion. Each is on individual breakers and is powered from clean power transformers.

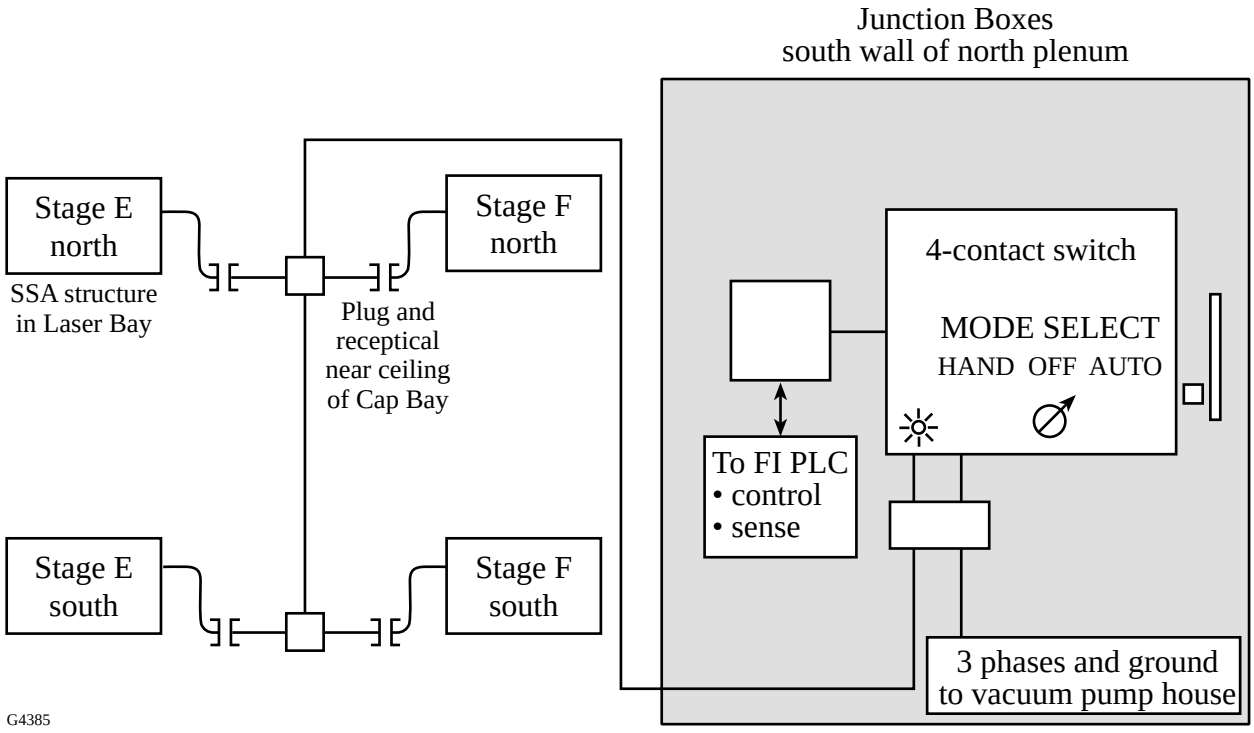

Fig. 10.2-1
SSA crane power disconnect and status sense.

Grounding

Due to the high-voltage, high-current associated with PCU discharge during an OMEGA shot, special attention was taken to isolate the power conditioning system from the rest of the OMEGA control network and to avoid around loops that would contribute to electrical signal problems. Primarily this is accomplished through the use of individual ground fields for the three main electrical systems in OMEGA (as is illustrated in Fig. 10.2-2). These are

- Buried building ground (BBG)
- The original exothermally bonded electrolytic ground (XIT#1) field
- A new XIT#2 ground field.

These fields are used to provide ten system grounding locations for various applications in the OMEGA System as is detailed in the OMEGA Upgrade System Grounding Plan.

The buried building circuit is a #4/0 AWG bare copper loop installed around the perimeter of the building with ground rods driven at intervals and connected to underground metallic piping. Each individual column of the structure that surrounds the laser and target bays is connected to this loop. The 750-kVA ground bar and the buried building ground bar that run north/south along the west wall of the capacitor bays are connected separately to this system.

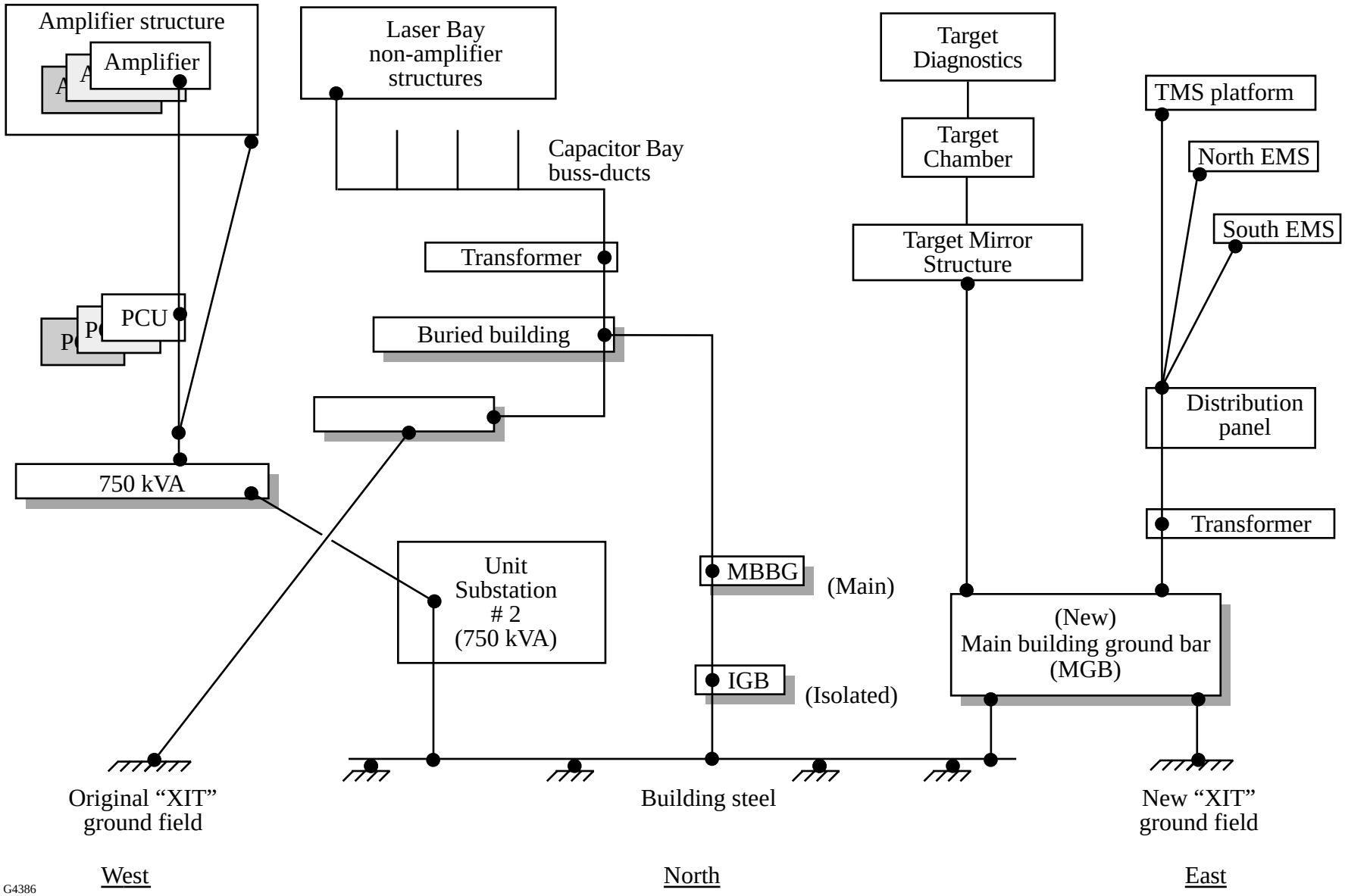

Fig. 10.2-2
OMEGA System grounding tree.

The XIT#1 ground field near the northwest end of the building is used to ground the structures that support the OMEGA laser amplifiers in the laser bay via the laser amplifiers structure (LAS) ground bar that runs parallel to the other two ground bars.

A remotely controlled contactor connects the LAS ground bar and the BBG ground bar. During PCU charging (a period no greater than 3 min) this contactor is lifted so that any accidental discharges will be directed into the XIT#1 ground field and will not raise the potential of the BBG.

Discharges of the amplifier cables to the amplifier structure do occur during OMEGA operations. Large potentials have been measured between the structure grounds and the power conditioning unit (PCU) where the current originated. A rewiring of the structure grounds to the associated PCU ground bar will be done during the first quarter of FY98 to minimize these potential differences.

The new XIT ground field was installed east of the target bay as part of the construction of the vacuum pump house. It is connected to the building steel, making it common with the buried building ground circuit.

10.3 LASER SAFETY AND EYE HAZARD

To ensure the safety of personnel with respect to non-shot sources of laser radiation, all entrances to the laser and target bay areas have lighted laser warning signs that indicate when any laser source is on. There are also laser warning signs installed within the laser and target bays to provide warning to personnel already within the bay areas.

The interlock system has a contactor within each laser source to sense its status as well as a trip circuit that allows the interlock system to disable any laser source or shutter it if such action is required. Hard-wired logic disables the sources when the warning lights are not active.

The laser sources in the bays are

- PGR oscillator
- IR laser at the stage-A alignment table (IRAT)
- UV laser at the stage-F alignment table (UVAT)
- Fiducial laser on Target Bay North End Mirror Structure
- Green laser in GDL fiber coupled to ASBO diagnostic in the Target Bay. (This source is also interlocked to the Viewing Gallery door sensor.)

The interlock system has four over-ride controls on the overhead lighting system.

Lights can be turned on and off remotely in the following areas:

- Laser Bay
- Target Bay
- Viewing Gallery
- Laser and Target Bay Emergency Lights

10.4 ACCESS CONTROL

Access to the laser, target, and capacitor bays as well as the viewing gallery is controlled through the use of door magnets and door sensors that are remotely controlled and/or sensed from the interlock system (see Fig. 10.4-1). The doors under control of the interlock system fall into two distinct categories.

Doors along the building perimeter do not have door magnets. They are mechanically locked at all times but have crash bars installed that allow for emergency egress at any time. These doors have door sense switches so that the operator can tell when a door is opened.

Doors within the confines of the laser system have electromagnets installed that are controlled through the interlock system. Most of these doors are locked during shot-critical preparations and the shot itself, minimizing access to the bays. Entrance through them requires contact with the control room for temporary bypass.

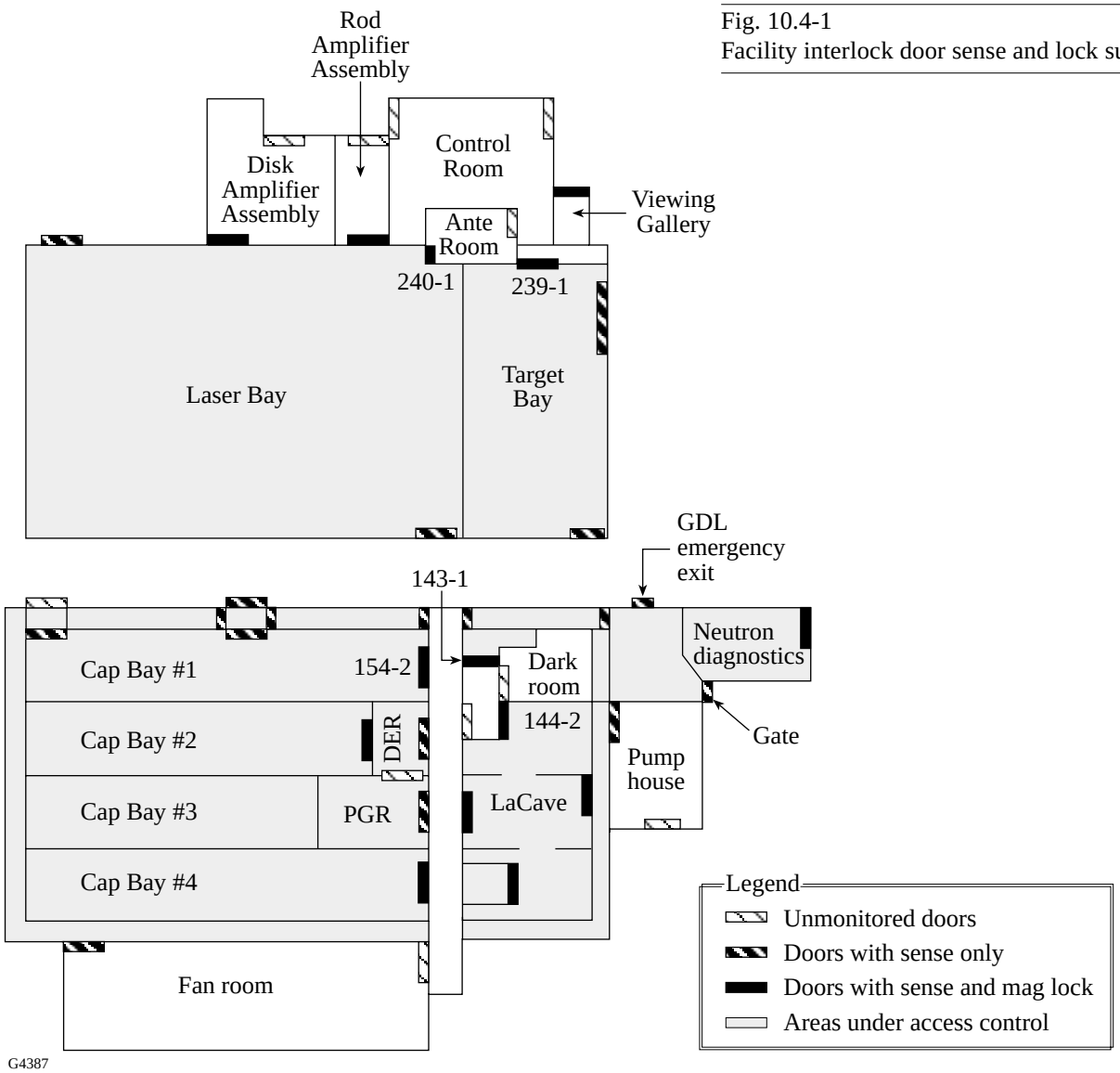

Fig. 10.4-1
Facility interlock door sense and lock summary.

All magnetically locked doors are bypassed during non-shot operations to allow access to the bay areas.

During the shot process a bay sweep is done, and the doors are locked as the sweep is completed. All doors are locked during the shot, and then unlocked after the shot is completed.

A real-time status display of the bay doors is monitored by the shot director in the Control Room. During shot operations no access to the bay occurs without direct knowledge of the shot director.

10.5 SURVEILLANCE AND COMMUNICATIONS

To provide additional safeguards for personnel, a minimal set of surveillance cameras are installed in the bay areas. These locations were chosen because they view either remote or high-traffic areas. They are:

- Cap bay #1
- Cap bay #2
- Cap bay #3
- Cap bay #4
- IRAT
- Target bay – Upper level (North)
- Target bay – Upper level (South)
- Oscillator Room
- UVAT
- PMA (North)
- PMA (South)
- Pulse Generation Room
- Driver line

The surveillance cameras are not intended to replace the bay sweep concept but are used to augment the search of the bay areas for personnel during the shot sequence.

A public address system is also installed in the bay areas so that announcements of the laser status and shot sequence information can be provided to personnel on the bay floors. This system can be accessed either manually from the shot supervisor station in the control room or automatically from the interlock computer. The latter option has been provided so that automated announcements concerning bay-access changes, shot-state changes, and laser safety status updates can be made directly from the interlock computer.

For point-to-point communications within the bay areas and out to the control room, a three-channel full duplex communications system has been installed. The backbone of this system is a wired network that connects roughly 50 prewired points. The use of a tethered headset allows communication to any other point. In each bay (Laser, Target, and Cap Bay) there is also a radio base station wired into the backbone system. Each of these act as two-way repeaters for up to four wireless belt packs. They are used by personnel who need to be highly mobile, where the tethered communicators are not practical.

Each bay also has a compliment of bells and beacons that will signal the change of state of the laser system and the beginning of the charge cycle in the PCU's.

10.6 RADIATION HAZARDS AND RADIOLOGICAL CONTROLS

The laser bay, target bay, and LaCave areas have lighted signs that indicate the potential radiation hazard of an upcoming high-yield shot. These signs, **"CAUTION – HIGH RADIATION AREA – DO NOT ENTER,"** will be turned on prior to a potential high-yield shot and remain on until the completion of the shot.

During the course of mulipulse, high-yield shots, activation of the target bay materials will occur. An additional set of lighted signs can be energized when this is the case. These signs will read "**CAUTION – RADIATION AREA – DO NOT ENTER WITHOUT FILM BADGE."** These signs will remain lit until it has been determined through measurement from the radiation safety team that they can be turned off.

10.7 CONTROL ARCHITECTURE

The control architecture of the interlock system, as illustrated in Fig. 10.7-1, was designed to implement the key safety features even if the control computer fails. To accomplish this, an industrial programmable logic controller (PLC) was used as the main interface to the building hardware. This PLC contains the ladder logic that allows it to continue to function autonomously should the main interlock computer crash or the communication link between the two fail.

All wiring from remote devices such as doors and lights returns via conduit to terminal blocks within the main laser relay panel (MLRP) located at the west end of cap bay #1. The PLC connects either directly to the terminal blocks or indirectly through relay logic that drives the device outputs.

The interlock control computer is located in the laser control room and is connected to the PLC via the laser system Ethernet®.

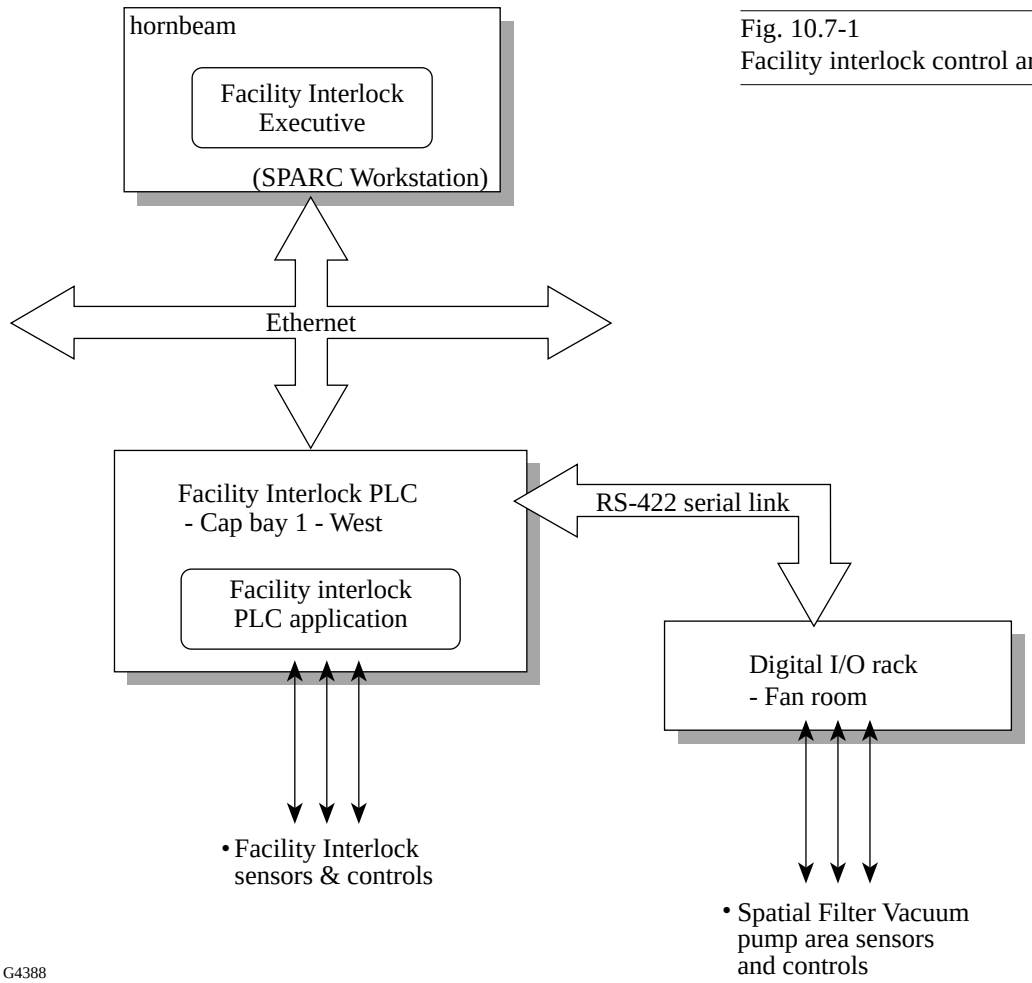

Fig. 10.7-1
Facility interlock control architecture.