DEMOLITION OF AN ANALYTICAL LABORATORY HOT CELL FACILITY FOR FUTURE REFURBISHMENT

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ABSTRACT

An Analytical Laboratory Hot Cell Facility at Argonne National Laboratory-West (ANL-W) was in service for nearly thirty years. In order to comply with current DOE regulations governing such facilities and meet ANL-W programmatic requirements, a major refurbishment effort had to take place. Existing equipment was removed and disposed of, including working trays and supports, lead-follow manipulators, a steel metallographic cell, penetration plugs, and the cell ventilation exhaust system. The hot cell viewing windows were removed and sent to a contractor for refurbishment. Waste generation, minimization, characterization, and packaging issues were taken into account during planning and performance of the demolition activities.

BACKGROUND

The Analytical Laboratory (AL) located at Argonne National Laboratory-West (ANL-W) contains six interconnected hot cells used to provide chemical analyses of irradiated nuclear fuels and materials. The long service history and current programmatic requirements for the cells dictated that they be refurbished for further use.

Each hot cell is 183 cm (72 in) wide by 168 cm (66 in) deep by 376 (148 in) high, with a working tray located 96 cm (38 in) above the floor. The hot cell walls are made from high density barite concrete and are 61 cm (24 in) thick. A shielding door, 91 cm (36 in) wide by 203 cm (80 in) high provided access into each hot cell. Figure 1 depicts the hot cell operating corridor prior to the demolition effort. As shown on Figure 1, each hot cell has a leaded glass window to view the internal area of the hot cell. In addition to the hot cells, a steel metallographic cell, approximately 150 cm (60 in) on each side was attached to the rear of hot cell #6 via a transfer port.

The filtering for the ventilation system for the hot cells consisted of 26 high efficiency particulate air (HEPA) filters in parallel. These non-bagout type filters were also used for the remainder of the Analytical Laboratory contamination control ventilation exhaust systems.

SCOPE OF WORK

The work scope for the demolition effort included erection of temporary containments and provisions for temporary ventilation in support of the demolition of the metallographic cell, in-cell equipment, and existing ventilation system, and removal of the leaded glass windows for refurbishment by a subcontractor. Due to the unavailability of in-house manpower it was decided to contract this effort, as well as the decontamination effort, to an outside firm.

TEMPORARY CONTAINMENTS AND VENTILATION

To control the spread of contamination during the demolition of the hot cell equipment and HEPA filter bank, temporary containments were erected at the front and rear of the hot cells as well as around the existing HEPA filter bank. Since the contamination levels within the hot cells and metallographic cell were high, inner containments were erected as an additional barrier to help keep the levels of contamination in the main containments at a minimum. These inner containments were erected at the locations shown on Figure 2.

The containments were maintained at a negative pressure with respect to the surrounding areas by means of a temporary HEPA filtered ventilation system. The containments at the front and rear of the hot cells exhausted into the cells and subsequently through the temporary HEPA filter bank and out through the existing AL stack. This provided for air flow from the least contaminated to the most contaminated areas.

When the hot cell facility was operating, 500 cfm was exhausted from each cell. In order to provide an adequate air flow through the containments and maintain a negative pressure differential across the containments, the flow through each cell was increased to 1500 cfm. This was accomplished by exhausting 3000 cfm from each pair of cells through a 3 X 1 filter housing and a 3000 cfm blower that tied into the existing AL stack. All temporary filter housings had bagout capability.

DEMOLITION

Four major phases of demolition were associated with this project; removal of the metallographic cell, removal of the in-cell and associated equipment, leaded glass window removal, and ventilation system demolition.

The sequence of the equipment demolition phases was critical. It was decided to first remove the metallographic cell to provide clearer access to the rear of the hot cells. Next, the in-cell equipment was removed and the cell interiors were decontaminated (Reference 3). Window removal was the final stage in the demolition process. It was imperative that the cell interiors were free of equipment and decontaminated prior to window removal since the voids in the cells left by the removed windows would increase the potential for the spread of contamination as well as provide an unshielded path for radiation. The ventilation system demolition occurred in parallel with the above activities.

METALLOGRAPHIC CELL DEMOLITION

The steel metallographic cell, Figure 3, was located behind the eastern-most hot cell (#6) and communicated with this cell through a 20 cm (8 in) diameter transfer port. This structure was constructed of four layers of 3.8 cm (1.5 in) thick carbon steel, and weighed in excess of 15,000 kg (35,000 lb). It contained three leaded glass windows that were reused, two lead-follow manipulators, and miscellaneous analytical chemistry equipment.

The original intent was to dismantle the metallographic cell layer-by-layer and salvage the outer layers of steel. Welded construction of the cell, not evident from the drawings, rendered this method unfeasible.

The adopted approach was to size the cell using a plasma-arc torch and a track mounted oxygen/acetylene torch. Concerns using these methods included maintaining the integrity of the containments from the heat of the torch and steel, and handling the sections of the cell. The former concern was handled by placing fire-proof fiberglass blankets and water trays beneath the cutting areas and reinforcing the containments so that burn-through of one layer would not be critical. Personnel were protected by aluminized suits that maintained integrity to prevent skin burn and contamination incidents.

The lid of the metallographic cell was removed and the interior wiped in an effort to control loose contamination. The surface was then painted to fix any remaining contamination which kept the containment relatively clean during the demolition of the metallographic cell.

The cell was cut into 60 cm (24 in) square sections weighing roughly 450 kg (1000 lb). A predesigned padeye was welded to each section and attached to an A-frame support and two-ton chainfall with appropriate tackle. As the sections were removed, they were surveyed, bagged, and placed in a waste container for disposal.

IN-CELL EQUIPMENT REMOVAL

The hot cells contained a variety of analytical equipment used to perform analysis of various materials over the past 30 years. Much of the equipment was highly radioactive, and hence removal of the equipment from the cells would lower the radiation levels within the cells. Prior to arrival of the demolition contractor, ANL-W successfully removed an acid fume scrubber system contaminated with perchlorates located within hot cell #2 (reference 1), and removed all loose equipment and waste from all cells (reference 2).

Major items of equipment removed from the hot cells by the demolition contractor included the stainless steel working trays, lead-follow manipulators, in-cell lighting fixtures, support structures, conveyor system, and miscellaneous electrical services. The removed equipment was sized and packaged for near-surface disposal.

The salvage value of the existing equipment was negligible.. To minimize the radiation exposure to workers, the equipment had to be removed in an expeditious manner. The most effective method of equipment removal was by the use of a plasma arc torch. Remote operation and efficiency of the torch minimized the radiation dose received by the workers, while the torch was effective in sizing the equipment for efficient packaging for disposal. A drawback of using a plasma arc torch was the excessive smoke generated from the cutting operation. This loaded the filters, necessitating frequent filter changes.

Other tools used for equipment removal included a nibbler and reciprocating saws. Although effective, these tools required more time to size the waste which resulted in greater radiation exposure to the workers.

LEADED GLASS WINDOWS

The AL radiation-shielding windows are welded steel housings enclosing three internal polished slabs of leaded glass. The windows are filled with mineral oil that provides optical coupling of the internal glass slabs, minimizes surface reflections, and protects the polished glass surfaces. The windows are stepped from front to back, and their carbon steel frames are grouted into the cell wall. Over the years, the frames had been leaking oil and the clarity of the glass had degraded.

Programmatic and budget constraints dictated that the windows would be refurbished for future use in the hot cells. When the windows were initially installed, they were placed on two 8 cm (3 in) by 5 cm (2 in) steel bars in the window cavity, and grouted in place using a grout whose density was enhanced by steel shot. In order to remove the windows for refurbishment, the grout had to be removed from around the windows. This grout was carefully removed using an electric hammer and hand tools. Once the windows were free of obstruction, they were removed from the window cavities using a special cart designed for this operation, shown in Figure 4. After removal from the cavities, the windows, each weighing 2500 kg (5600 lb), were decontaminated and packaged in containers for shipment to the refurbishment contractor. A dedicated van was used to transport the windows.

VENTILATION SYSTEM DEMOLITION

The ventilation system consisted of 26 parallel HEPA filters. Flow from the cells, as well as analytical chemistry exhaust hoods, entered the filter bank through a plenum positioned above the filter bank. The flow went through the filters, into a lower plenum attached to an exhaust trench, to the exhaust fans, and out the AL stack. This arrangement allowed for exhaust flow through only a single set of HEPA filtration. Figure 5 shows the upper and lower plenums with the filters removed.

Demolition of the ventilation system commenced after a temporary ventilation system was installed and tested. The temporary system tied into the cell exhaust to maintain the cell pressure negative relative to the surroundings.

The filters were removed first, and bagged for future characterization and disposal. The plenums were dismantled using power tools, namely a reciprocating saw and a nibbler. Pieces were characterized, sized, and packaged for disposal.

The exhaust trench beneath the lower plenum had a raised curb that was attached to the plenum. This curb was removed with an electric hammer, and then the area and trench were wiped down in preparation for the decontamination effort.

WASTE

Waste handling and minimization activities provided a major role in the demolition. Each of the major removals discussed above, as well as many smaller activities, were evaluated to ensure that the waste volumes were minimized.

Sufficient samples were collected for characterization to assure applicable disposal facility requirements were met. Due to the high concentration of radioactive contaminants and the presence of hazardous materials (heavy metals, etc.), special considerations were taken into account during sampling to assure worker exposures were maintained as low as reasonably achievable (ALARA). Through the application of information obtained in earlier characterization activities, the need for sampling was minimized.

Samples were analyzed for heavy metals using the Toxicity Characteristic Leaching Procedure (TCLP) or Totals Analysis procedure found in the EPA Analytical Methods Manual SW-846. Radionuclide measurements were performed using methods including gross alpha-beta and gamma spectroscopy. The matrix of many of the samples required sample preparation prior to counting.

During the early phases of the project, waste characterization and packaging flow diagrams were developed to determine the appropriate minimization, sampling, and packaging methods. Through up-front planning, the most effective waste packaging method was designed into each phase of the demolition activities, resulting in packaging densities significantly higher than those normally found.

Projections of waste types and volumes anticipated during the demolition activities were spelled out in a waste forecast and minimization plan. The actual waste volume generated during the project was very close to the projected volume, primarily due to the detail that was placed in the waste minimization plan. Each identified component was taken into account during the development of the waste minimization plan. The projected and actual waste volumes are summarized in Table 1.

TABLE 1. FORECAST AND ACTUAL WASTE VOLUMES (FT^3)

Waste Type	Projected Volume	Actual Volume	Actual as % of Projected
Total Volume	9215	9579	104
Combustible Low Level Waste (LLW)	4500	4704	105
Compactible LLW	2000	2592	130
Contact Handled LLW	2500	2072	83
Mixed Waste	215	155	72
TSCA[1] Wastes	Not Projected	6	N/A
% of Mixed Waste	2.39	1.66	69

[1] TSCA = Toxic Substance Control Act

Category shifts in the waste types generated during the course of the project were noted. Many of the materials initially proposed for non-processing in the contact-handled low level waste (CH-LLW) stream were disassembled, segregated, and packaged such that the waste was acceptable at the compaction facility. When estimates were made on the waste after compaction or incineration, the volumes were reduced by approximately 15%.

Review of the volumes of mixed waste generated shows that they were maintained at less than projected levels. This was accomplished first by identifying the source early in the project and thus reducing the potential for cross contamination into other waste streams, and second by using decontamination methods that did not contribute to the waste volumes generated. This is a significant accomplishment considering the toxic contaminants present at the start of the project.

LESSONS LEARNED

A number of lessons were learned in the process of performing the demolition of this hot cell facility. This section discusses a few key points that are listed for the reader's benefit.

CONTAINMENTS

Originally all containments were fabricated from non-PVC bearing materials that were selected for their ease of disposal. However, the only available non-PVC sheeting was opaque and proved to be lower quality material requiring frequent and untimely repair. The non -PVC materials forced installation of windows with duct tape. Due to the nature of this material both the fabrication of containments as well as installation of windows was dependent upon the use of duct tape. Duct tape quality varies considerably and multiple-month pseudo-structural applications are not recommended by the authors.

Ultimately all containments were replaced with prefabricated, sewn reinforced PVC with integral floors and most importantly clear see through windows. The eventual replacement of these containments was driven by contamination control, the need for improved temporary ventilation system pressure differentials. The down side of the replacement was the volume of waste generated that was the initial driver for the selection of materials.

Inner containments, or small containments within the larger containments, were used to provide an additional barrier against the spread of contamination. These containments were placed around the metallographic cell as well as at the access doors to each of the hot cells, and were effective at keeping the levels of contamination within the outer containments at a minimum. Workers doffed their outer layers of personnel protective equipment within these inner containments. Waste was also bagged in these inner containments to aid in contamination control.

TEMPORARY VENTILATION SYSTEM

The use of temporary ventilation systems to either replace one being removed, as in the ANL-W situation, or as a supplement to existing systems, can make the demolition effort successful. Careful planning, engineering, and operational flexibility are the basic requirements. The purchase of quality filter housings with isolation dampers, bag-out capability and prefilters is an absolute must. Closely coordinated engineering support was very beneficial and allowed AL operations to continue through periods of changing configurations and system evolutions.

Cutting operations with the plasma-arc torch created excessive smoke and particulate that loaded the filters. Through the use of roughing filters (furnace filters) located at the exhaust ventilation inlets, and prefilters integral with the HEPA housings, the necessity for changing filters was minimized but still evident.

EQUIPMENT

Demolition of the metallographic cell was accomplished with a track mounted oxygen-acetylene torch. This proved effective in cutting though six inches of steel with one pass. Track mounting the device enabled workers to dismantle the cell remotely, minimizing their radiation exposure. A plasma arc torch provided an effective method of dismantling smaller equipment in that it was fast and effective. With either method, precautions must be taken to safely deal with the heat and combustion products.

CONCLUSIONS

The Analytical Laboratory hot cell facility at ANL-W required significant renovation in order to comply with DOE regulations and to support programmatic requirements. This led to the demolition of a facility containing high levels of contamination and radiation. Through up-front job planning, this effort was accomplished safely, efficiently, and produced less waste than forecast.

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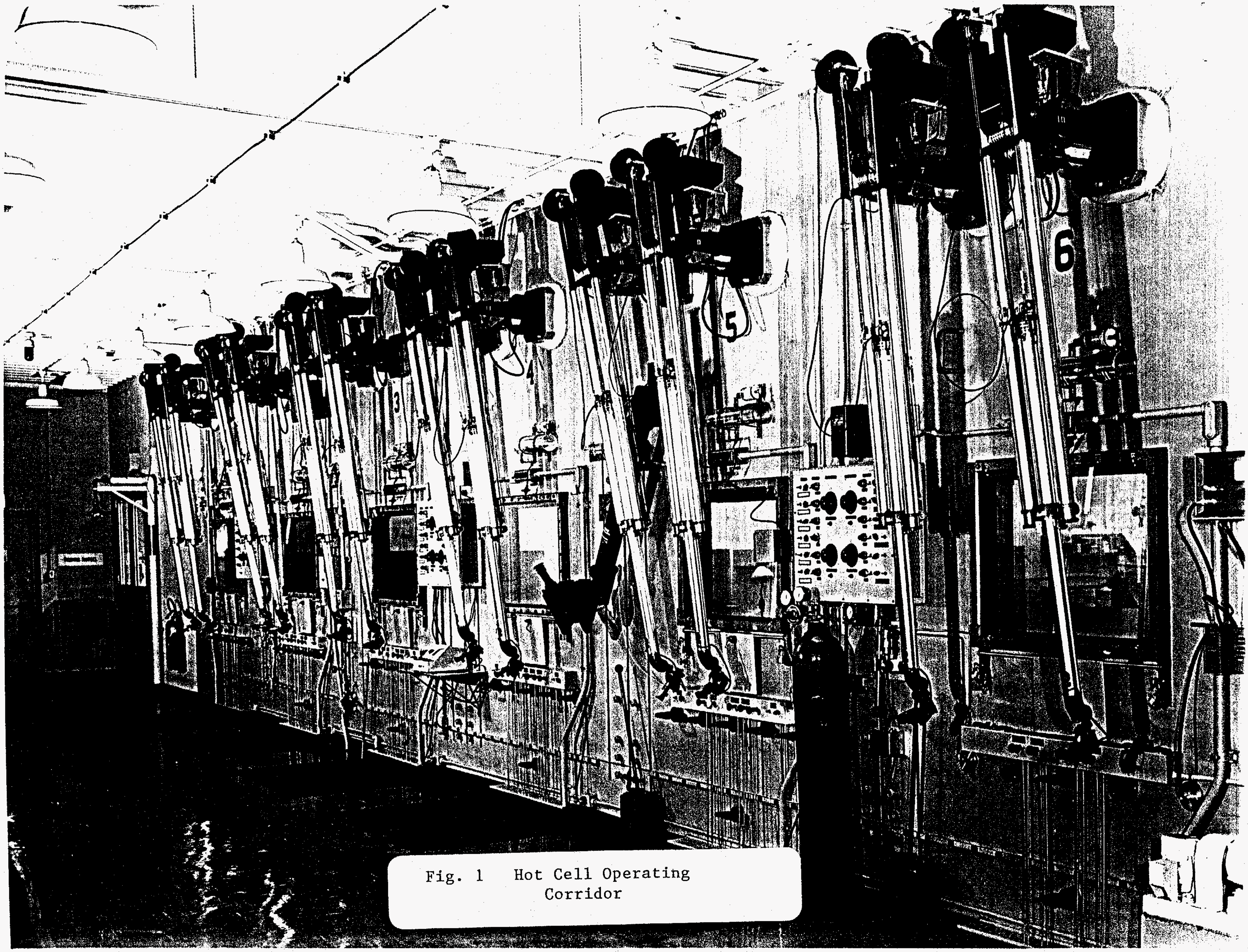

Fig. 1 Hot Cell Operating Corridor

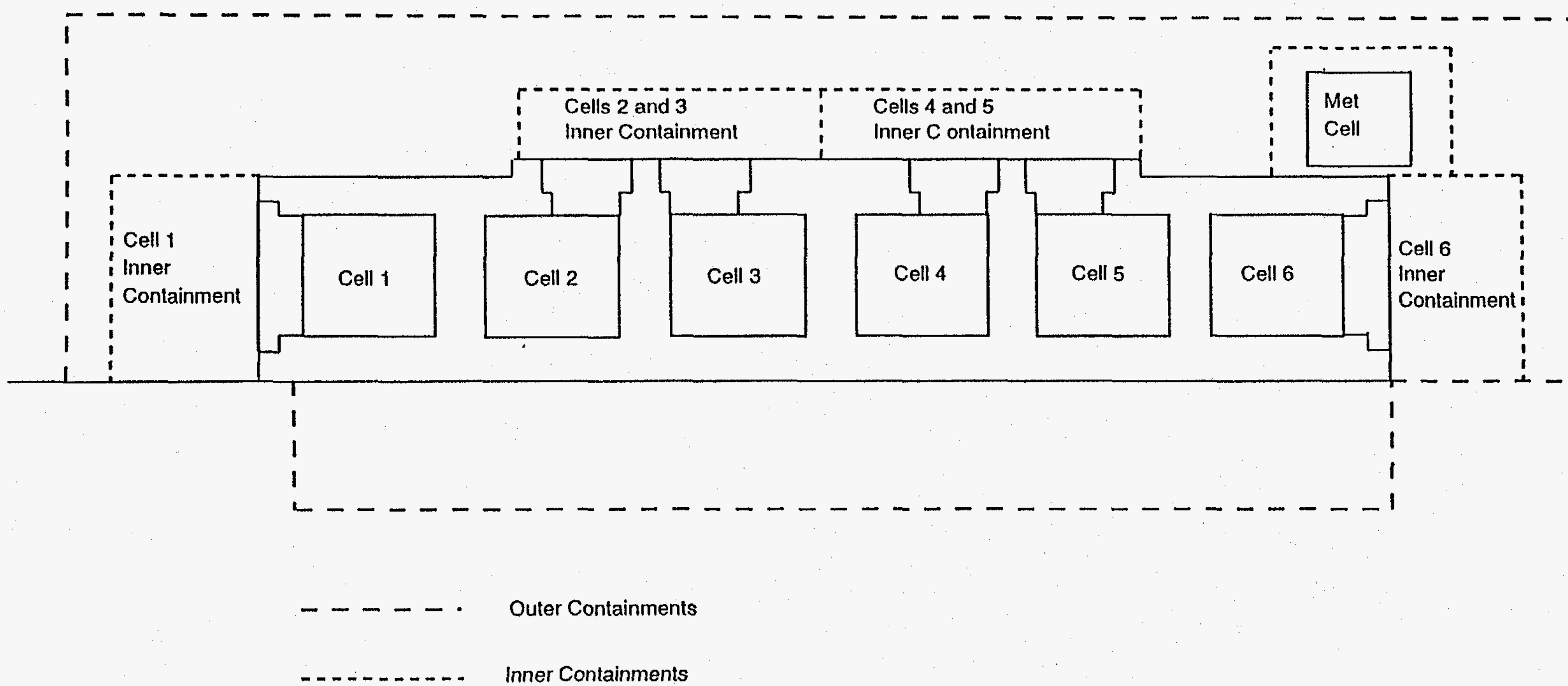

Fig. 2 Inner Containment Locations

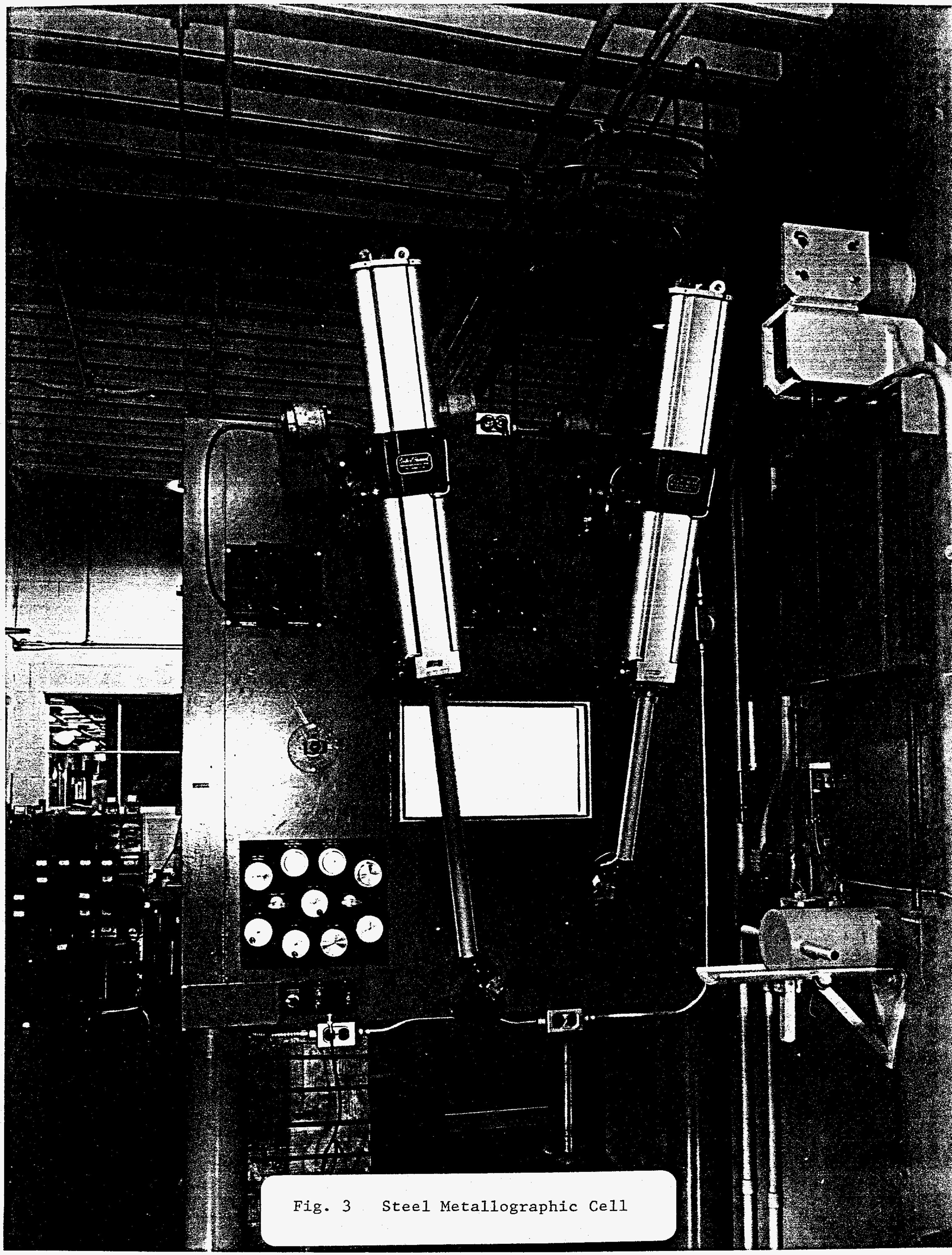

Fig. 3 Steel Metallographic Cell

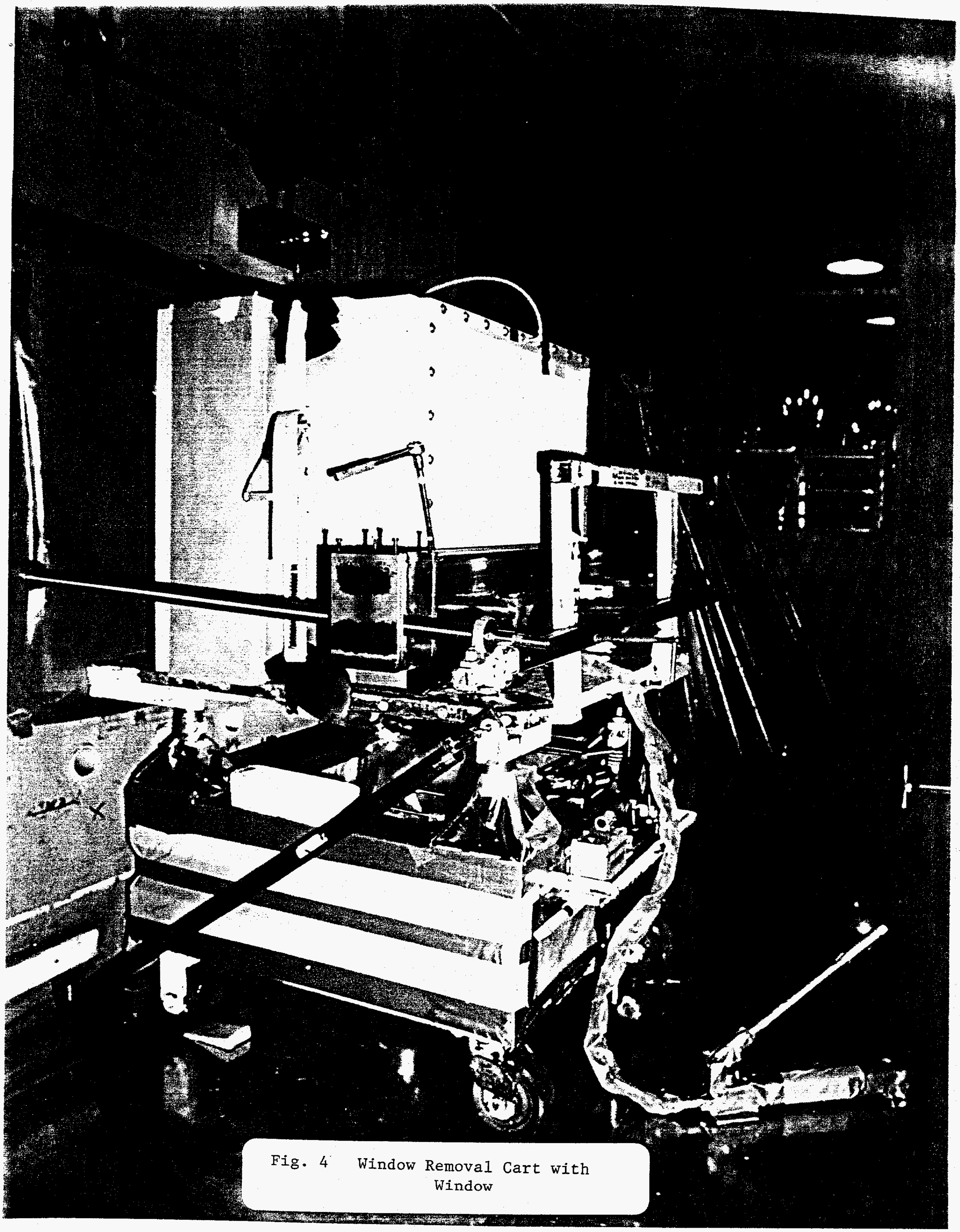

Fig. 4 Window Removal Cart with Window

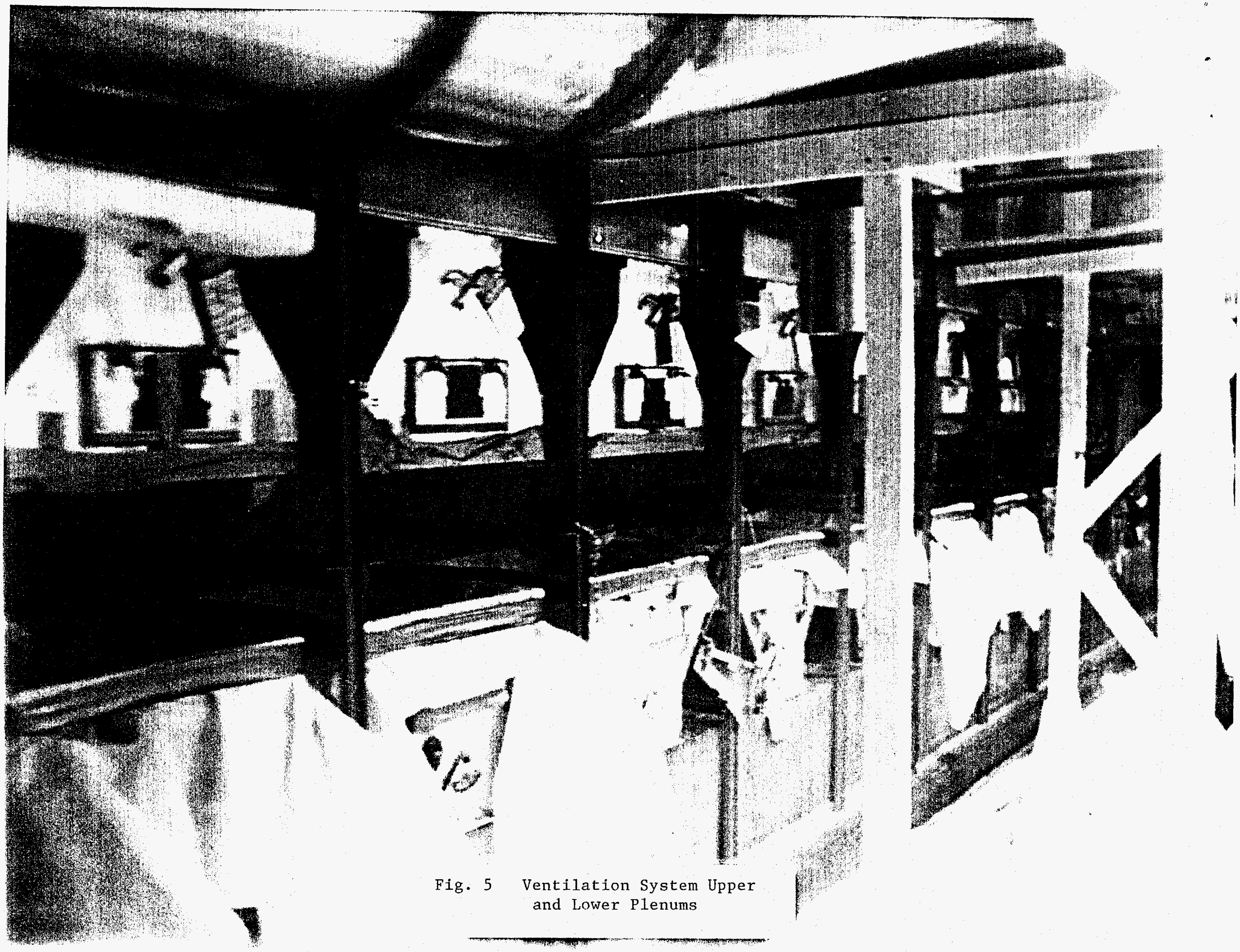

Fig. 5 Ventilation System Upper and Lower Plenums