IN SITU REMEDIATION OF PLUTONIUM FROM GLOVEBOX EXHAUST DUCTS AT THE DEPARTMENT OF ENERGY ROCKY FLATS PLANT

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Abstract

Plutonium and other miscellaneous hold-up materials had accumulated in glovebox exhaust ducts at the Rocky flats Plant over the 40 years of weapons production at the site. A Duct Remediation Project was undertaken to assess the safety impacts of this material, and to remove it from the ductwork. The project necessitated the development of specialized tools, equipment and methods to remediate the material from the ventilation systems while it was continuously operating. The project succeeded in removing over 40 kilograms of plutonium bearing material from one of the major weapons production buildings at the plant.

I. Introduction

The Duct Remediation Project at the rocky Flats Environmental Technology Site in Golden, Co was conceived as a result of an independent review of criticality safety conducted in 1989 by Scientech Inc. This review concluded that plutonium dust and other materials had been deposited in the glovebox exhaust ventilation over 40 years of weapons production at the facility. The presence of these deposits raised several safety concerns, including the risk of an uncontrolled criticality accident within the ducts and the additional radiation exposure to workers. As a result of this review, a congressional oversight committee, the Defense Facilities Safety Board recommended that a project be undertaken to assess, characterize, and ultimately remove the plutonium bearing holdup deposits.

II. Material Locations

Removal of the material presented a difficult technical challenge, as the system from which it was to be removed was required to stay operational throughout the remediation process, without detrimental impact to its' function. Specifically, the hold-up materials were discovered in glovebox ventilation exhausts, which are cylindrical stainless steel pipes, ranging in diameters of 10 to 61 centimeters. These ducts connect each process glovebox to a four stage HEPA filter plenum as shown in Fig. 1.

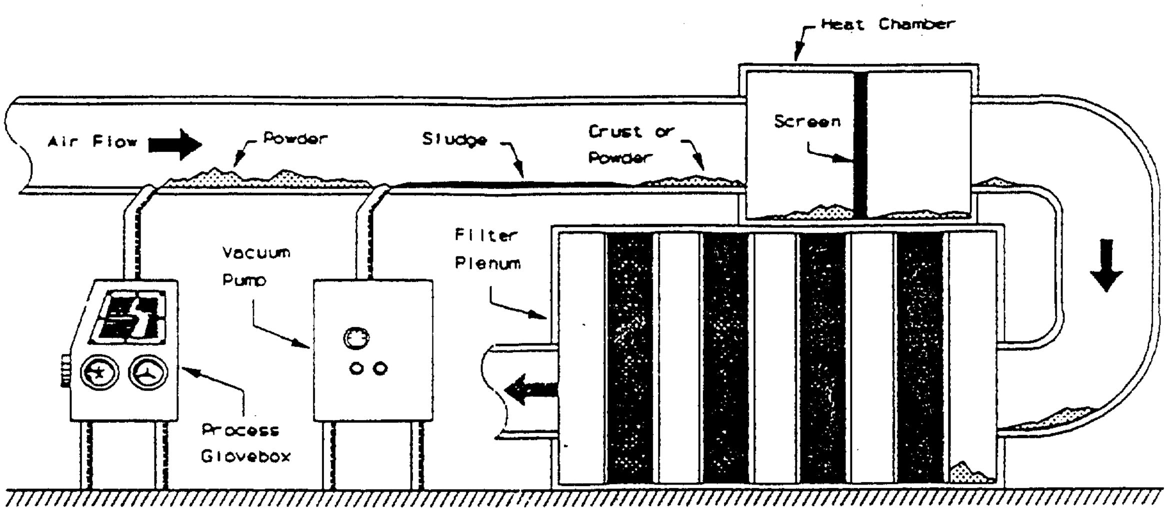

Fig. 1. General duct system configuration.

Initially, process knowledge of the activities conducted inside the gloveboxes was used to identify probable hold-up materials and there characteristics. This review detailed the machining, foundry and chemical operations which had been performed over the course of weapons production years. These operations had produced vapors, particulate contamination, dust and powders. The resultant deposits in the production building ventilation systems ranged from powders, flaky crusts and crystals to sludges and oils. The chemical constituents included fluorides, chlorides, oxides, calcium, magnesium, graphite, oil and plutonium oxides. The deposits were distributed throughout the ducting systems. Heavy deposits were found anywhere that pressure differentials or velocity variations occurred, primarily in expansion joints, elbows, valves, and duct intersections. Figure 2 through 8 (photos of system).

III. Key Areas

There are several key areas which are important to the development and implementation of a remediation project of this scope and difficulty. These include: characterization of material types and quantifies, development of remediation methods and tools, design and construction of engineered access locations, and coordination of day-to-day operations.

The initial effort in the project was the characterization of material in the glovebox exhaust ductwork. A method was developed which measured the amount of fissile material within a duct system by measuring the gamma radiation levels emitted from material in the ducts. This allowed for accurate measurements to be performed without breaching the duct or disturbing the exhaust system. These non-destructive assay

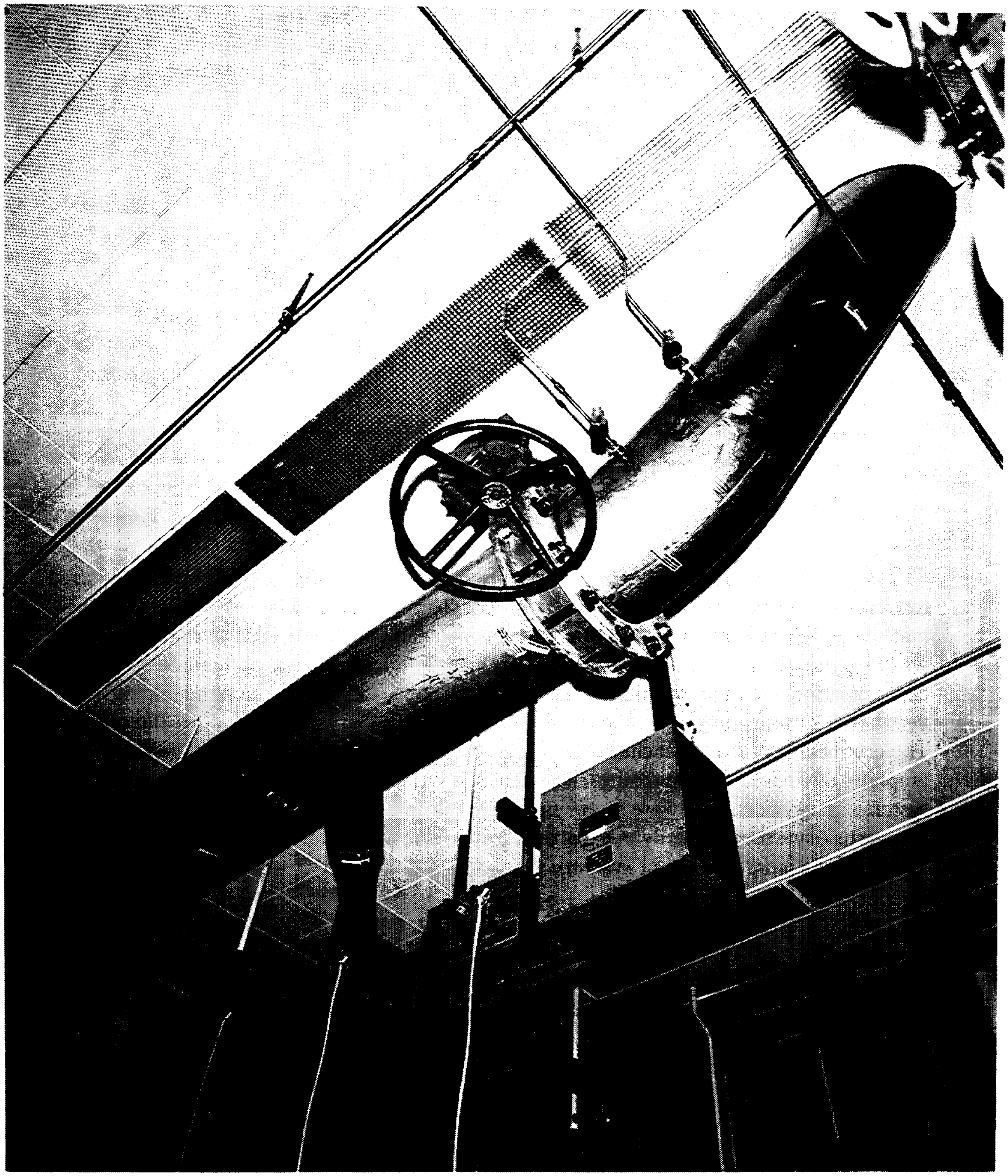

Fig. 2 Exhaust System

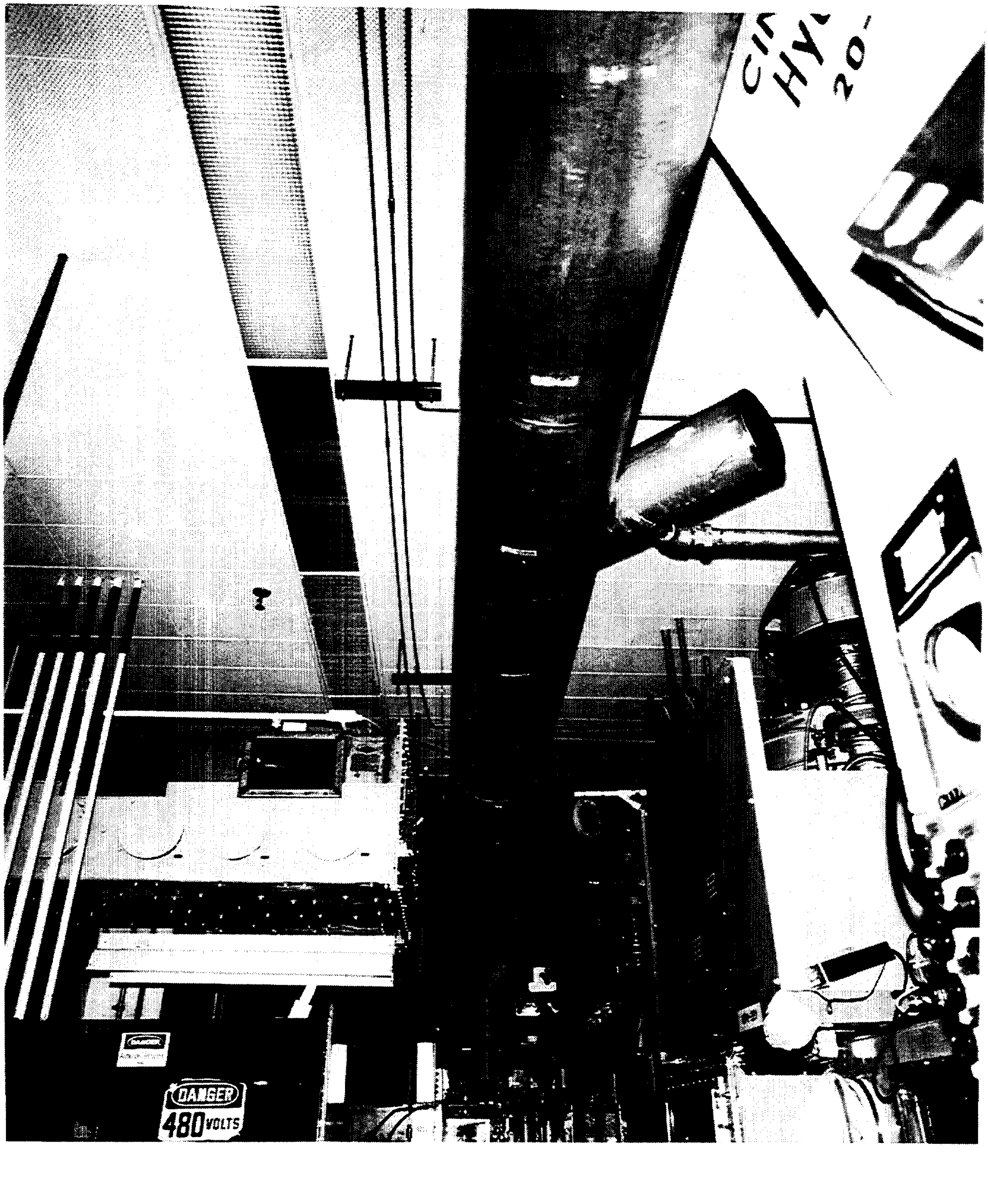

Fig. 3 Exhaust System

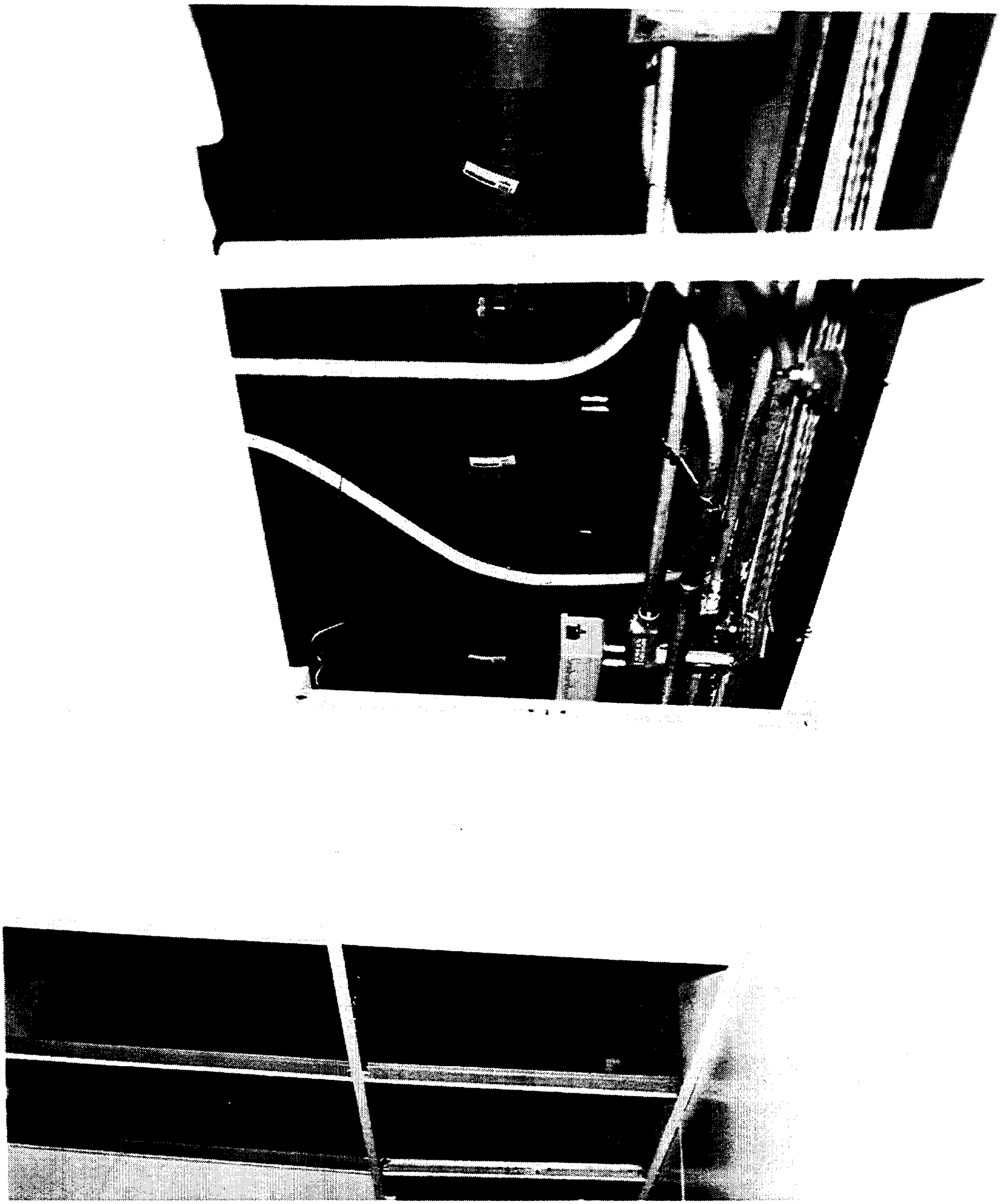

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Fig. 4 Exhaust System

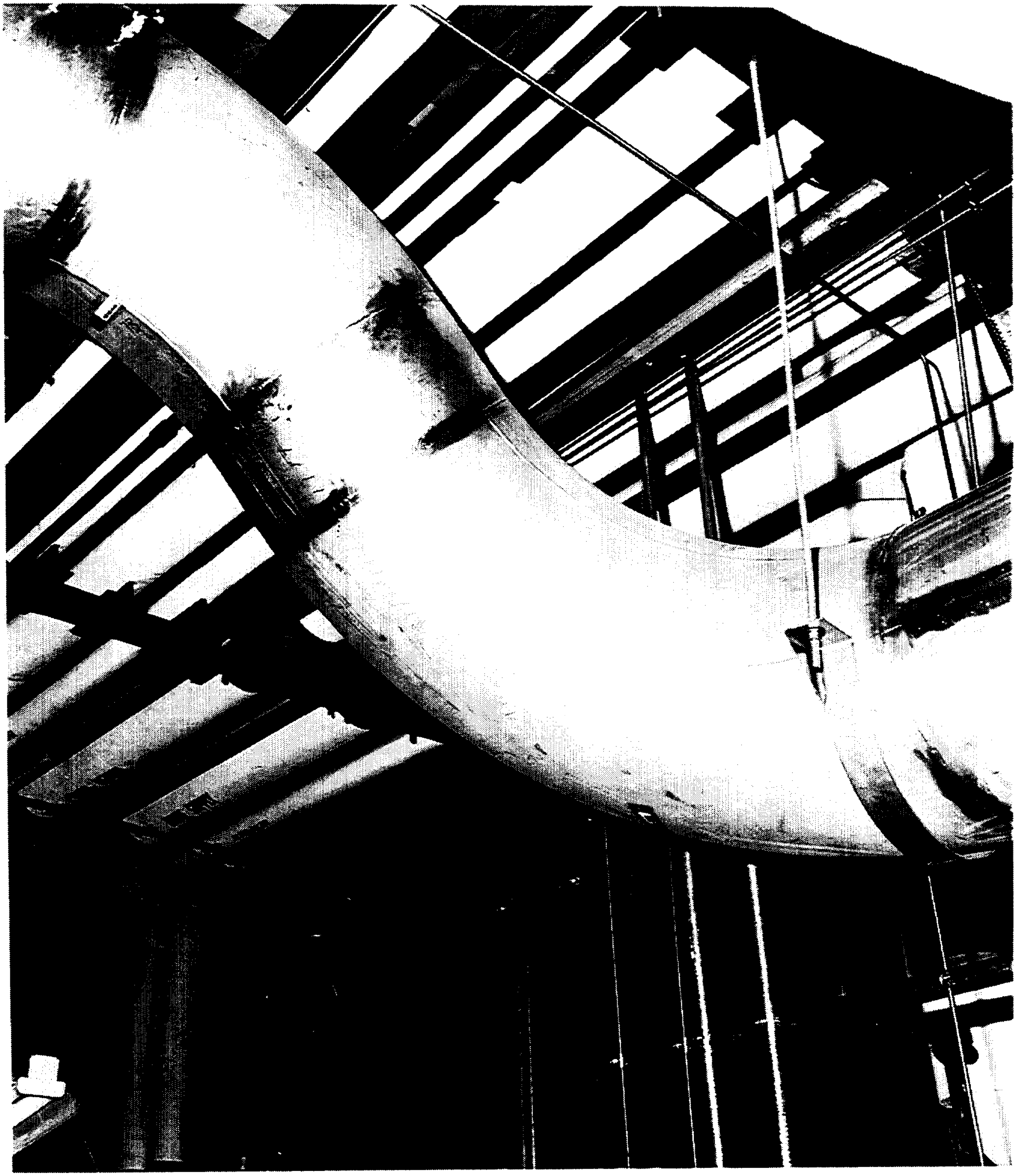


Fig. 5 Exhaust System

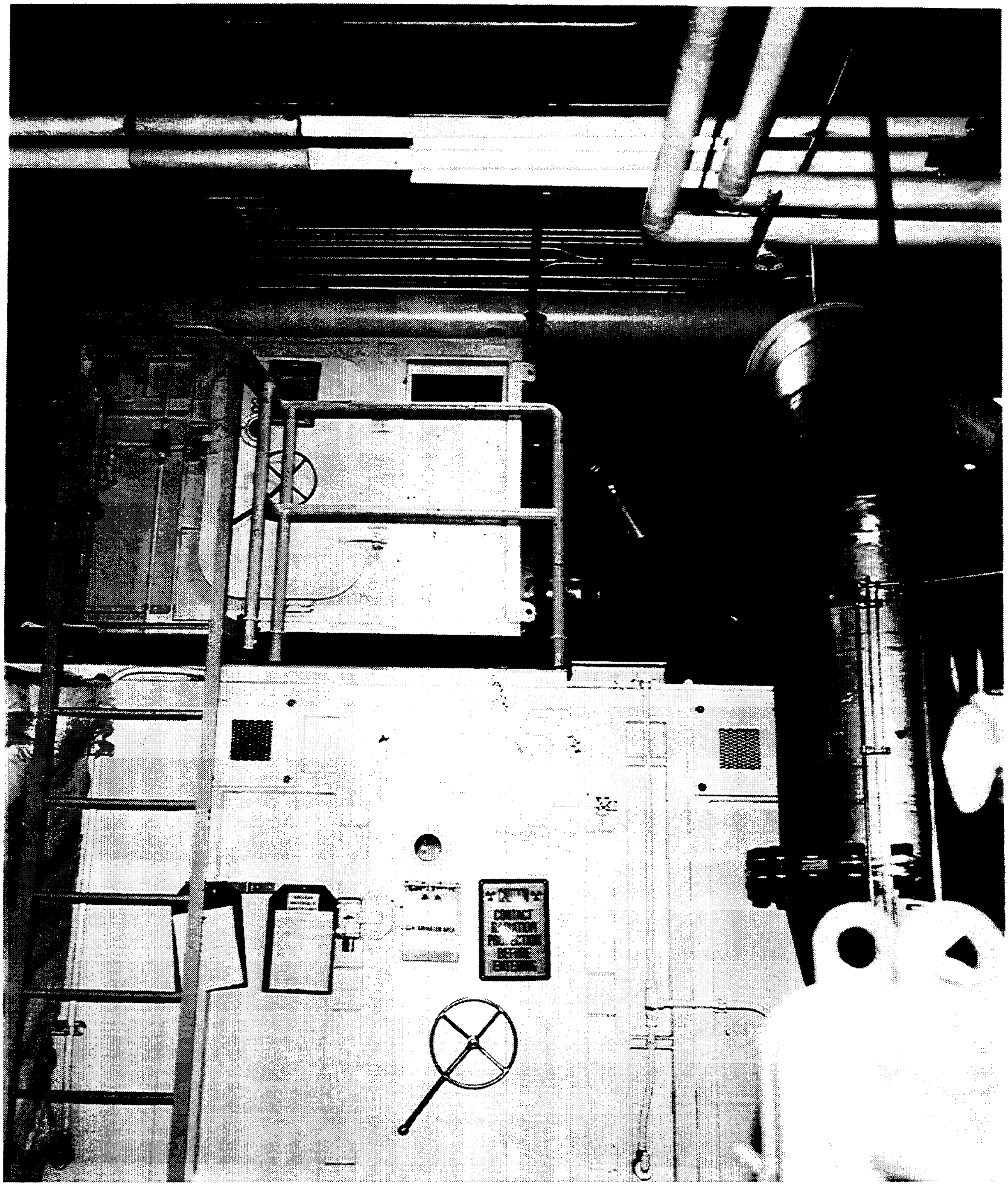


Fig. 6 Exhaust System

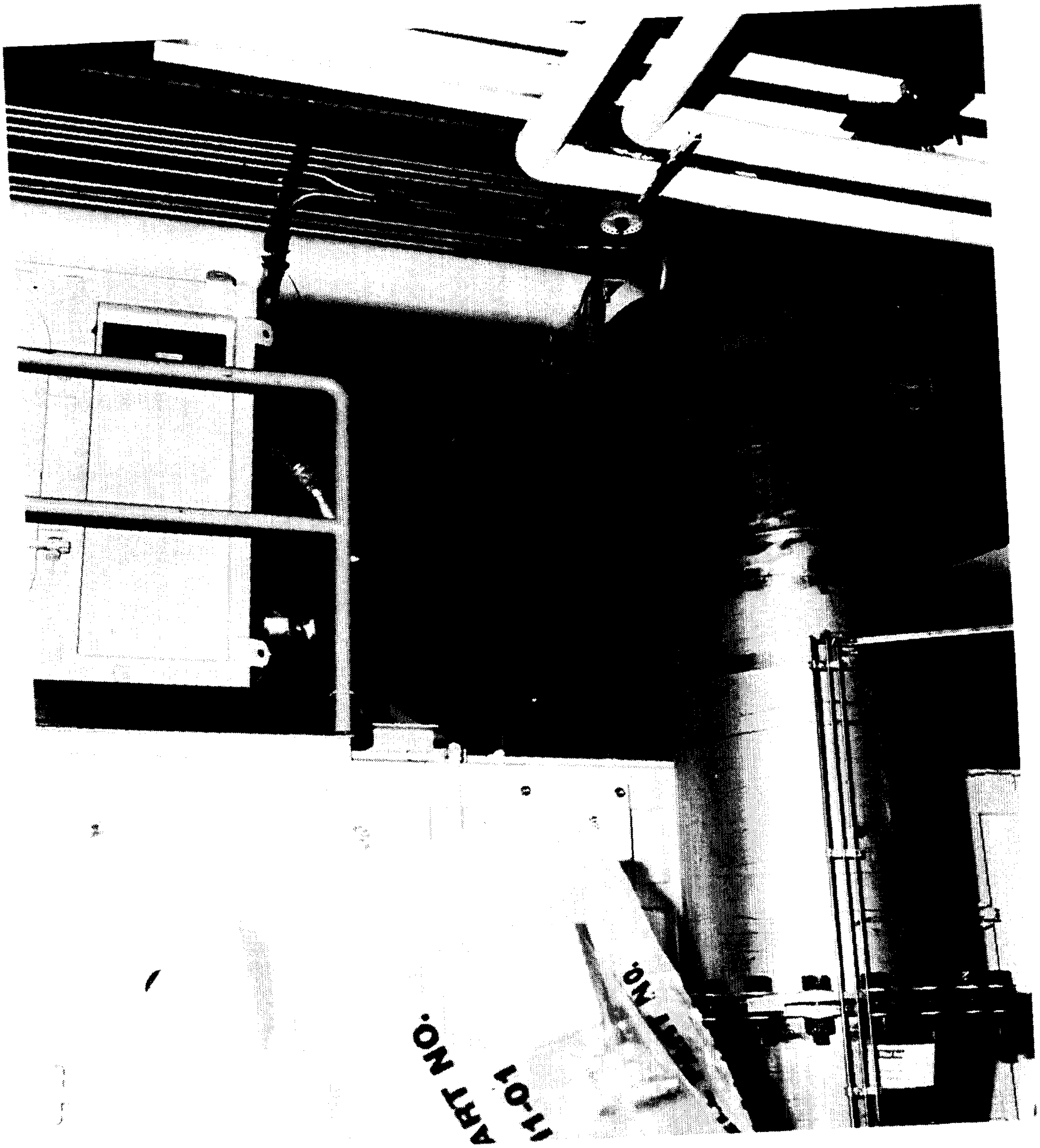


Fig. 7 Exhaust System

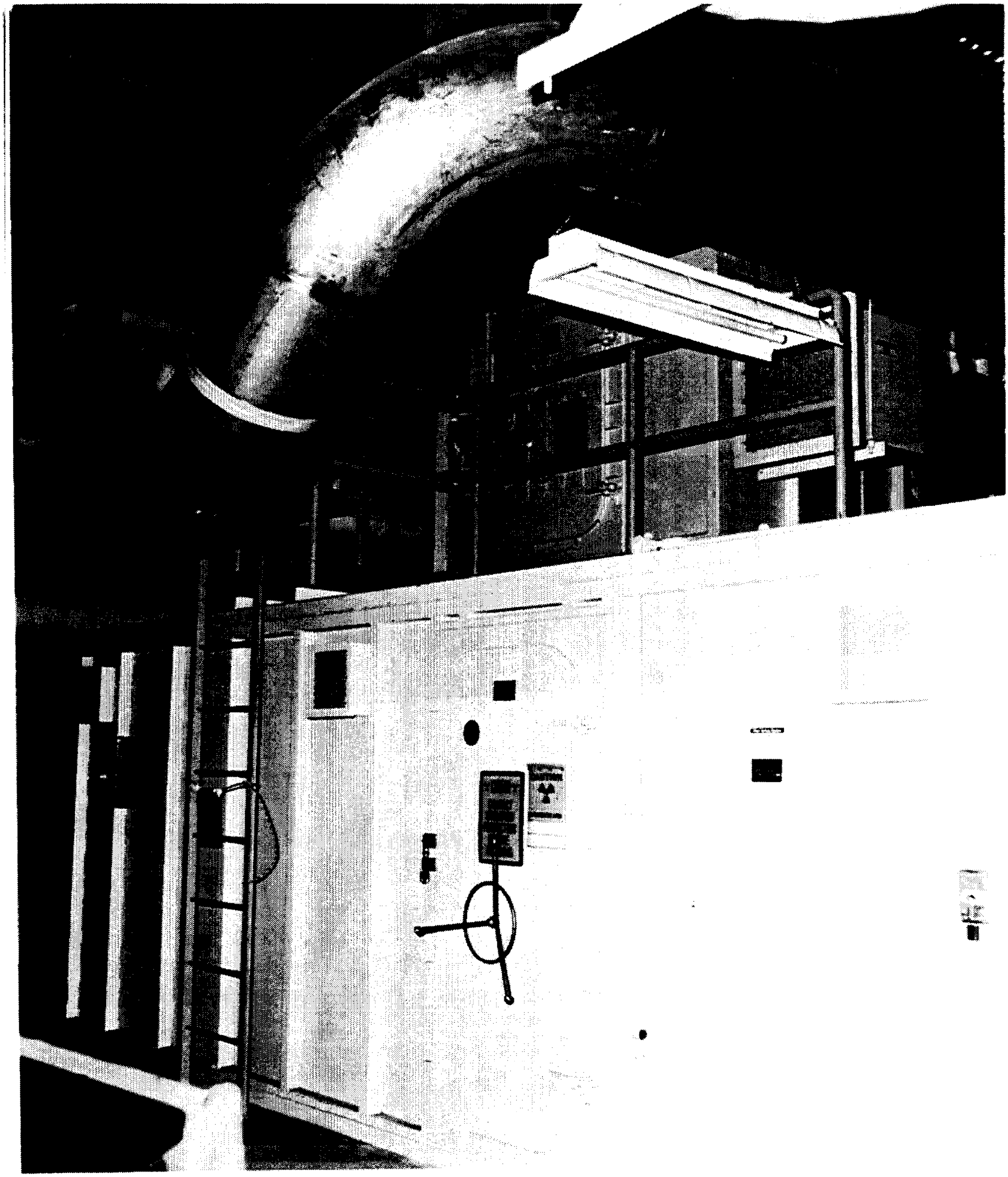


Fig. 8 Exhaust System

measurements were utilized throughout the project life to determine areas of significant accumulations, and to verify the amounts of fissile material which was removed. Figure 9.

Following the material quantification, visual characterization was undertaken to discern the material type and form, which then laid the groundwork for remediation tool and technique development. Various types of hold-up materials were encountered throughout the life of the project. The most readily occurring form was a dry, gray or greenish powder, which was collected by a specially designed, critically safe vacuum system using specialized nozzles. Figure 10 illustrates some of the commonly occurring material types, their distribution characteristics within a duct, and the most effective tool or nozzle used for that area. The vacuum system, which was wholly contained inside a glovebox, became the primary remediation tool, and was highly effective with many of the material forms encountered. Other, more difficult types of material required more specialized tools, such as free-standing oil, sludge, crust, flake and crystalline forms.

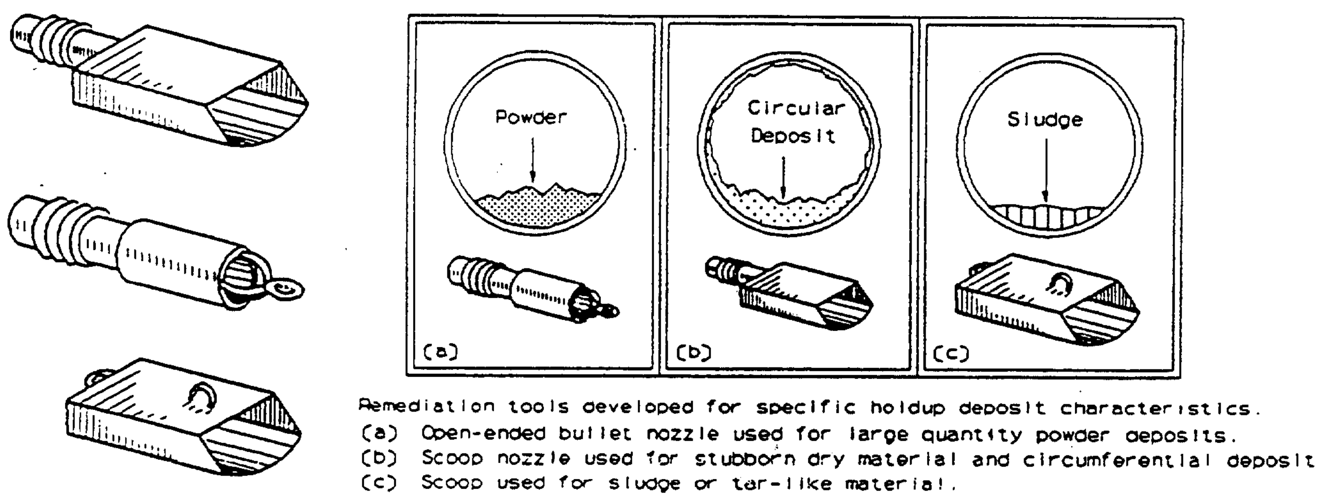


Fig. 10 Material deposition in ductwork.

Tool development was largely influenced by the type of deposit encountered. Some examples are towels and solvents for free-standing liquids, specially designed scoops for light crust and flake, specialized vacuum nozzles for loose powders, and vibration and rotary mechanical equipment for the hard crust deposits. Each piece of equipment had to be safe from a criticality and operational perspective. Figure 11 & 12. Furthermore, the equipment required design such that it would be easy to position in ducts, from distances up to 30 meters away from the working glovebox. The remote positioning of remediation and inspection became the greatest single hurdle encountered during the project. In order to overcome these technical problems, a method was developed which used magnets to position equipment. Initially ferrous magnets were used, with limited success. The need for stronger magnetic strength but reduced weight led to the use of rear-earth (neodymium) magnets. These magnets, mounted in handles, were used to pull hoses and

Fig. 9 Non-destructive Assay

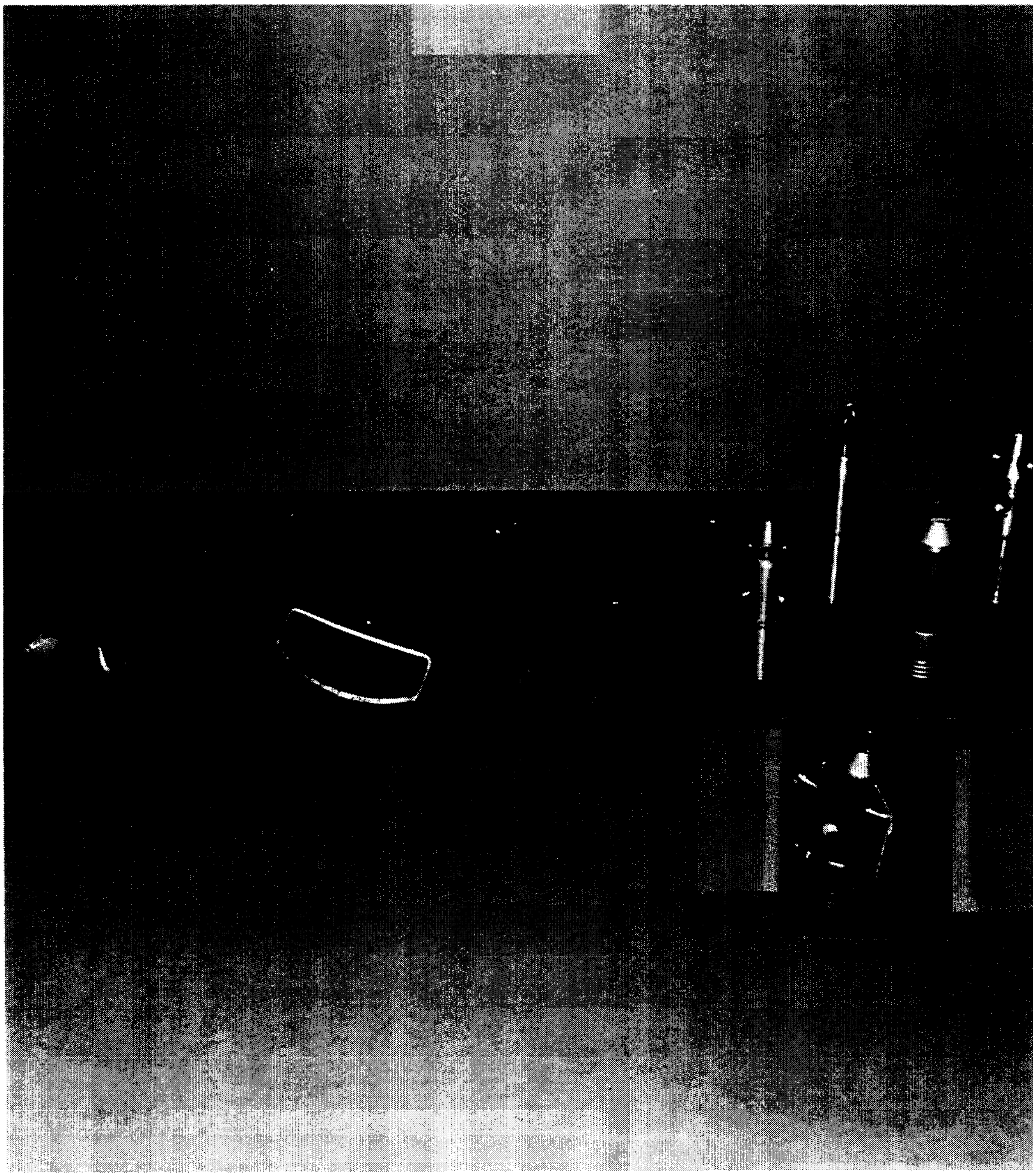


Fig. 11 Tools

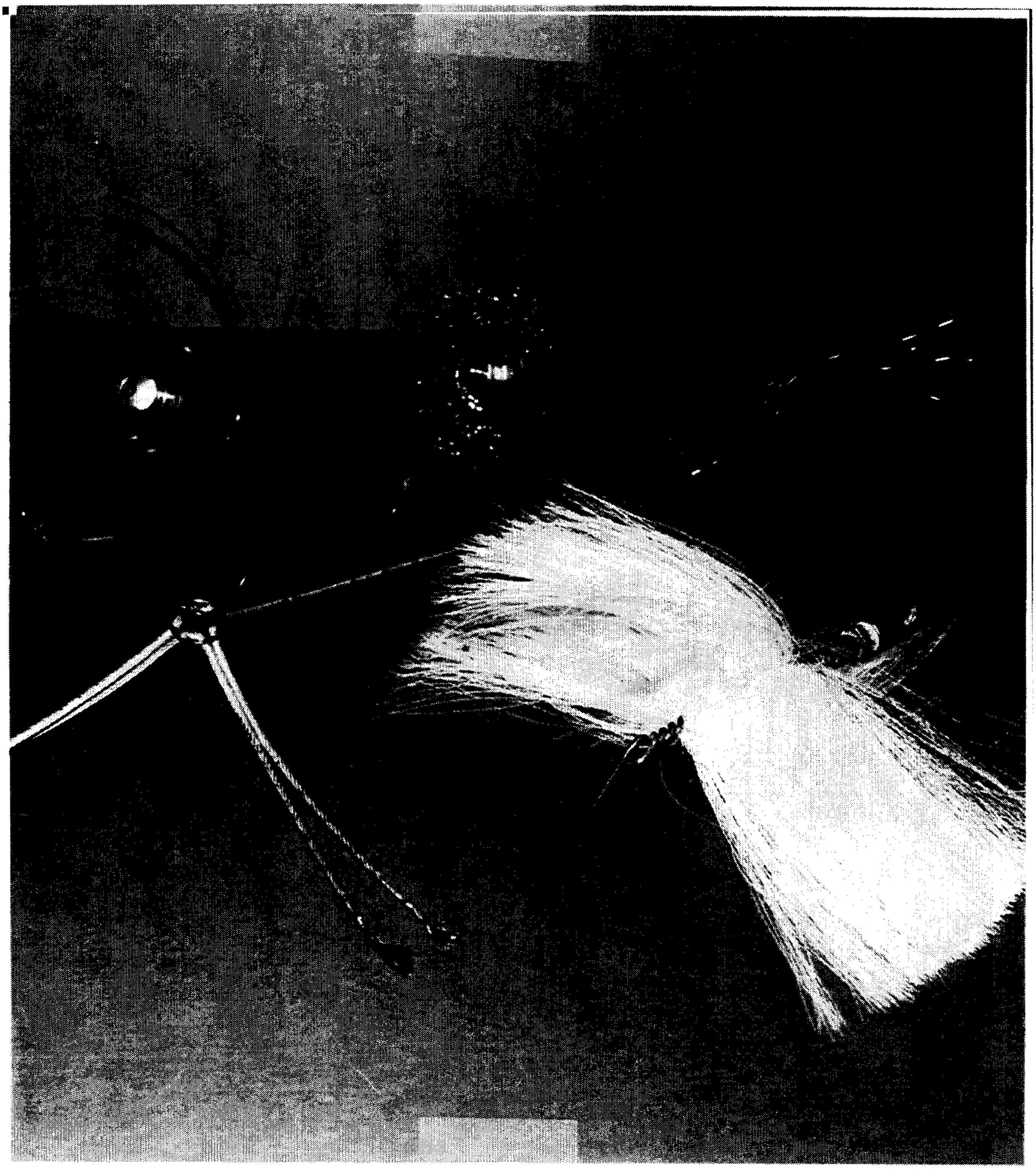


Fig. 12 Tools

ropes by means of magnetic "helpers' taped to the hoses. They were effective only because the ductwork was constructed of non-magnetic stainless steel. The magnet technique was used in coordination with a push-pull technique which involved two locations separated by the duct to be cleaned. The combination of these methods provided the best remediation results. Figure 13 illustrates the typical glovebox exhaust configuration and was readily cleaned using the above methods. Figures 14 & 15.

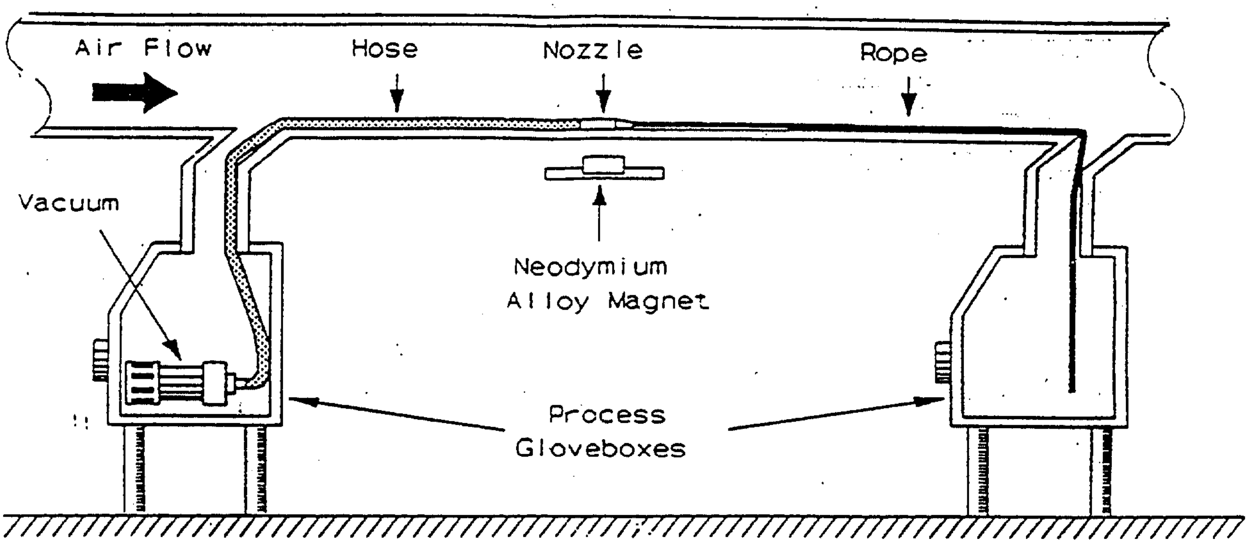


Fig. 13 Glovebox exhaust duct configuration.

One of the significant tools utilized in the remediation program was the video probe system (fig. 16). These video systems consisted of a video probe cable, which varied in lengths from 15 to 45 meters, a processor, and a video monitor.

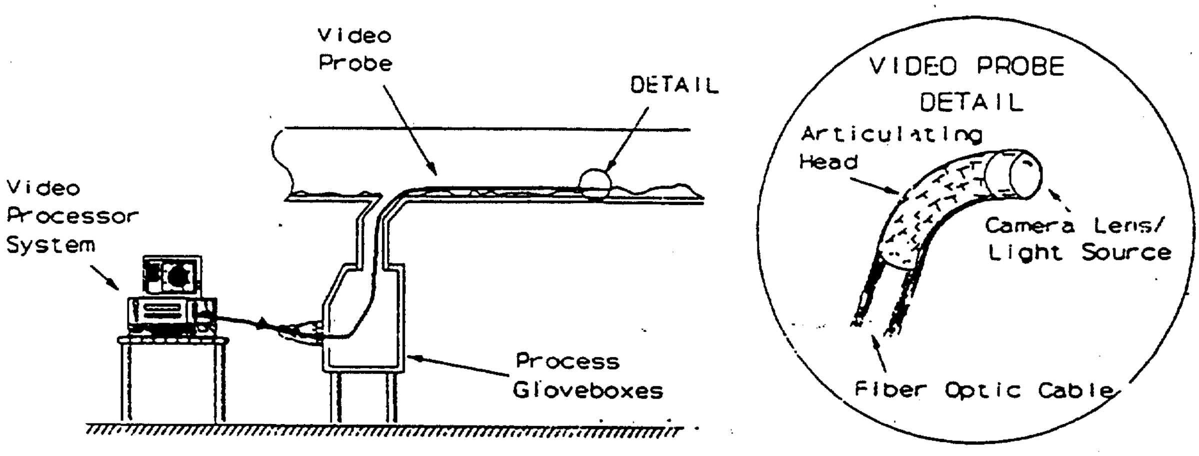


Fig. 16 Video characterization.

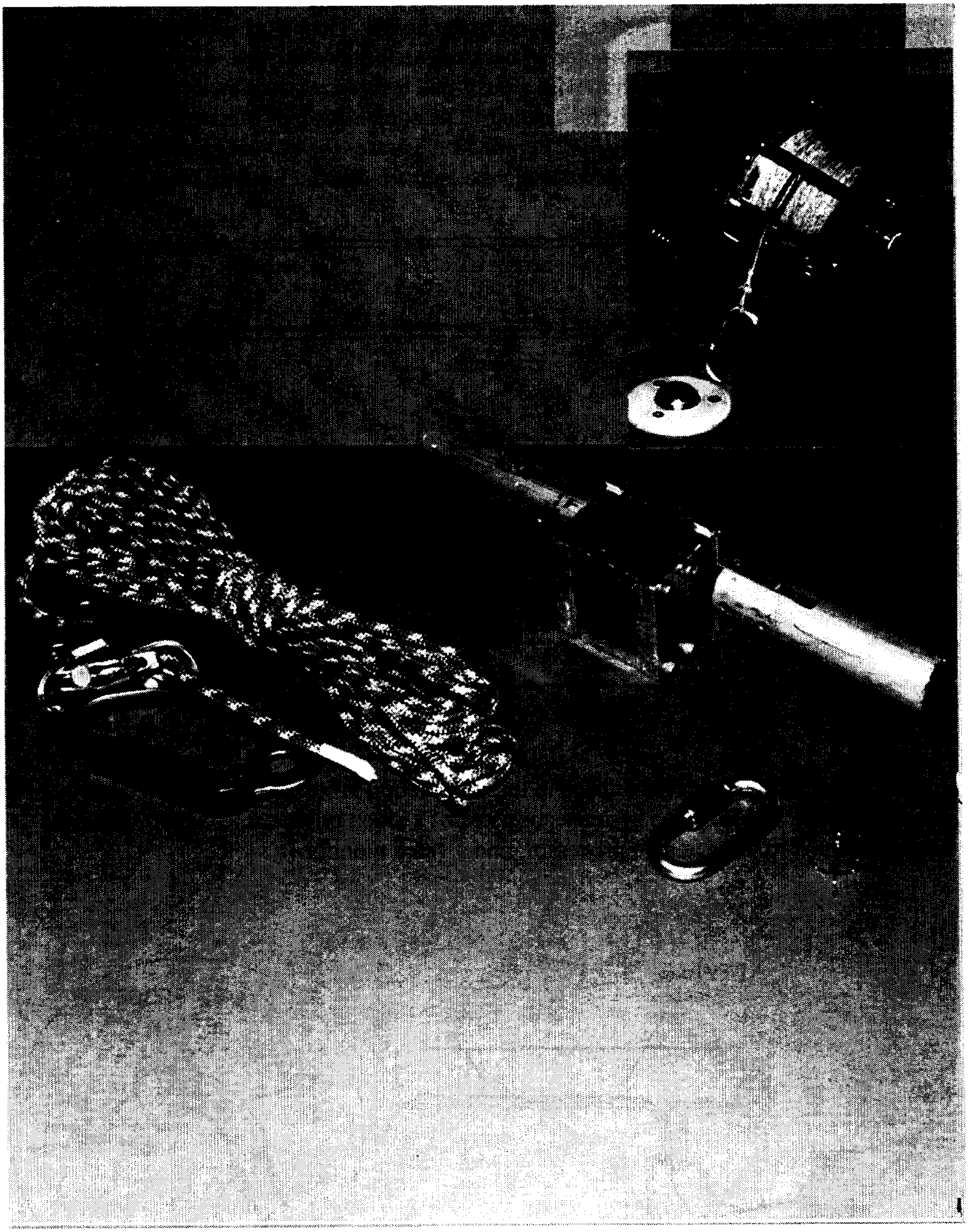


Fig. 14 Tools

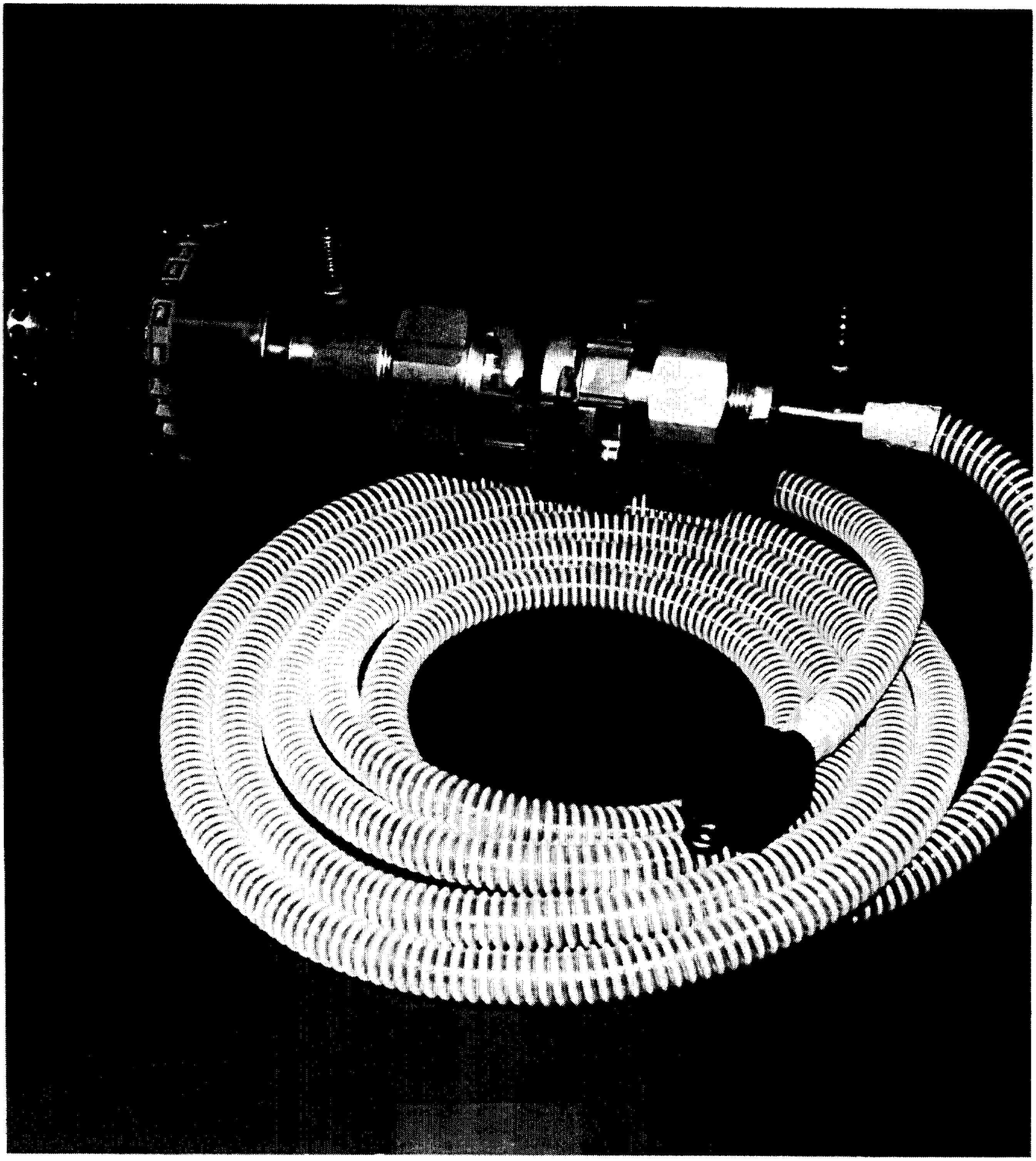


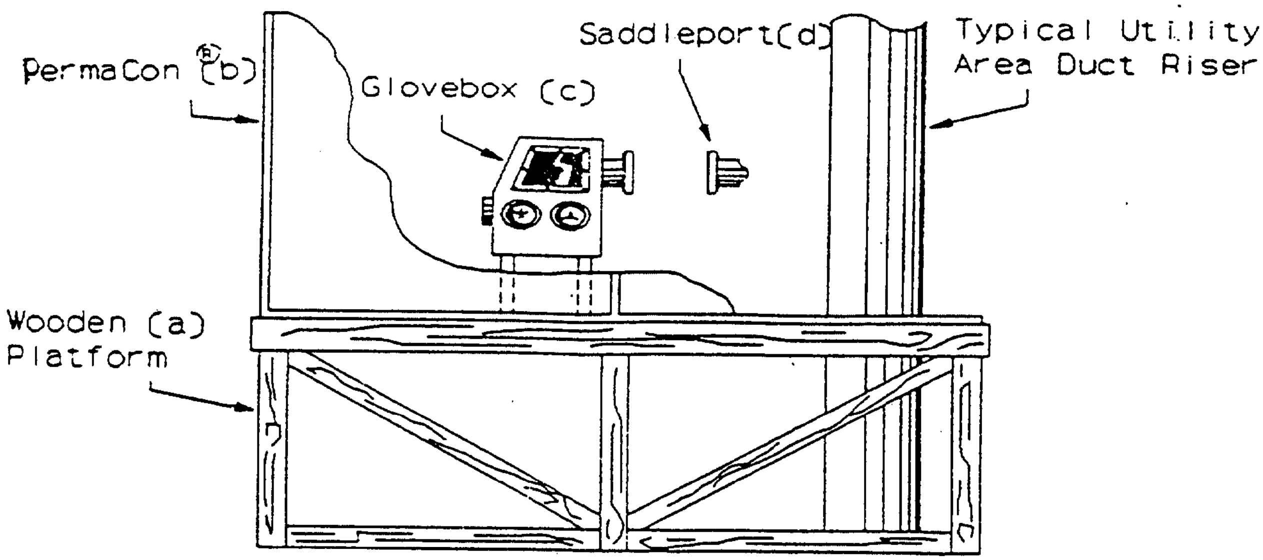
Fig. 15 Tools

The probes themselves were roughly 15 millimeter diameter fiber-optic cables which contained a remote light source, an articulating head, and a durable outer coating. The video display of the duct interior could be viewed by the remediation team, and recorded on a common video cassette. During operations, the video systems provided a means of physically characterizing the duct material deposits, which aided in tool and technique development. Also, the video probe system used extensively during material removal to identify areas of hold-up, assist in removal, and verify the effectiveness of cleaning methods.

To aid in the development process, a "mock-up' facility was constructed. This mock-up, complete with full-scale glovebox/exhaust system was used to perform remediation team training, and to develop, test and modify tools and methods. Tool development was an ongoing process, and the mock-up was used extensively during the height of remediation efforts. The mock-up also provided off-shift training on procedures and techniques, and ensured immediate responsiveness to tooling design or modification requests. Techniques and tooling changes were often driven by the type of hold-up material found in the ductwork, as well as the physical configuration of the ducts themselves.

IV. Removal Operations

While the implementation of specialized tools and techniques provided significant material removal capabilities, some areas of ductwork were inaccessible by the above methods. Over one hundred meters of header piping could not be cleaned from the process gloveboxes. In order to remediate these areas, engineered access locations were developed. This involved installing a glovebox on a line, operating ventilation system without shutdown or loss of contamination control. These access locations had to adhere to many constraints, such as user operability, design requirements and standards, and space limitations. Operations personnel would spend up to six hours at a time, 12 hours per day in locations, thus the engineering design was driven primarily by human factors and usability considerations. These locations typically consisted of a glovebox which was "hot-tied" into the existing exhaust header by adjustable legs on a wooden platform, was enclosed by a hard walled contamination-containment structure. Figure 17 shows the relative configuration of a saddleport location and the surrounding structure. Figures 18 & 19.



Schematic of engineered access to utility area duct.
(a) Platforms had location specific dimensions.
(b) PermaCon ® modular panels formed HVAC pressure enclosures.
(c) A uniquely designed glovebox served to provide duct access
(d) The "saddleport" transition piece fit the glovebox to the duct.

Fig. 17 Typical PermaCon®/Glovebox saddleport location.

The structure provided contamination control, largely through the use of airflow and cascading pressures. Airmover units were designed to establish and maintain the required working pressure within the structures. This equipment was built to newly established criteria for the Duct Remediation program. Some of the special features which were created to meet the criteria are listed below:

1. Two internal HEPA filters, with independent pressure testing ports for certification. .
2. Designed to allow filter changes during operation without loss of filtration.
3. Stainless steel construction of filter chambers and internal surfaces to facilitate decontamination if required.
4. Readily accessible wiring, to allow integration with external control and monitoring systems.
5. Minimization of noise levels.
6. Portability to allow use at other locations. This imposed a size restriction as well, requiring size compatibility with the existing freight elevators and passageways in the building.

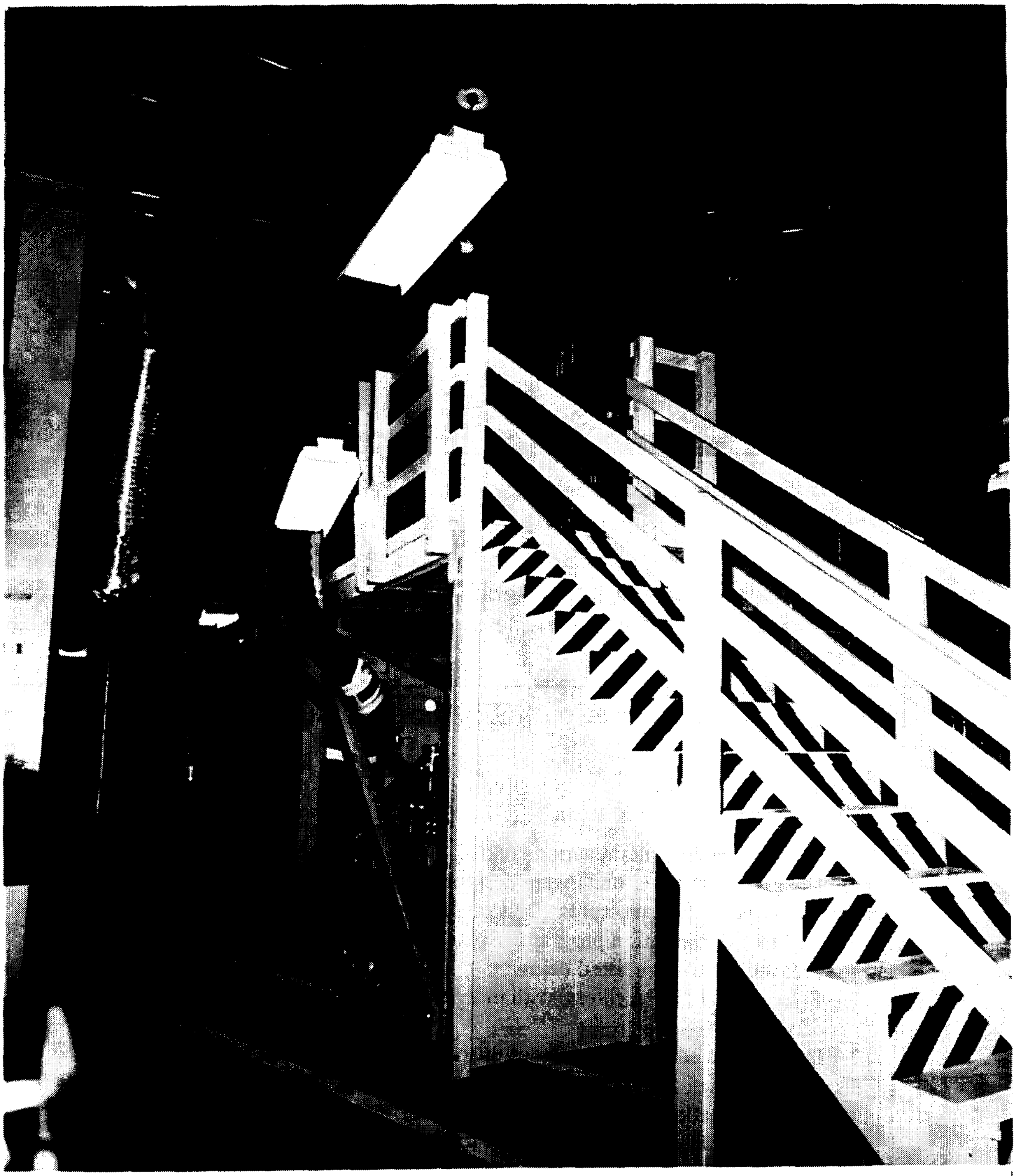


Fig. 18 Structure Access

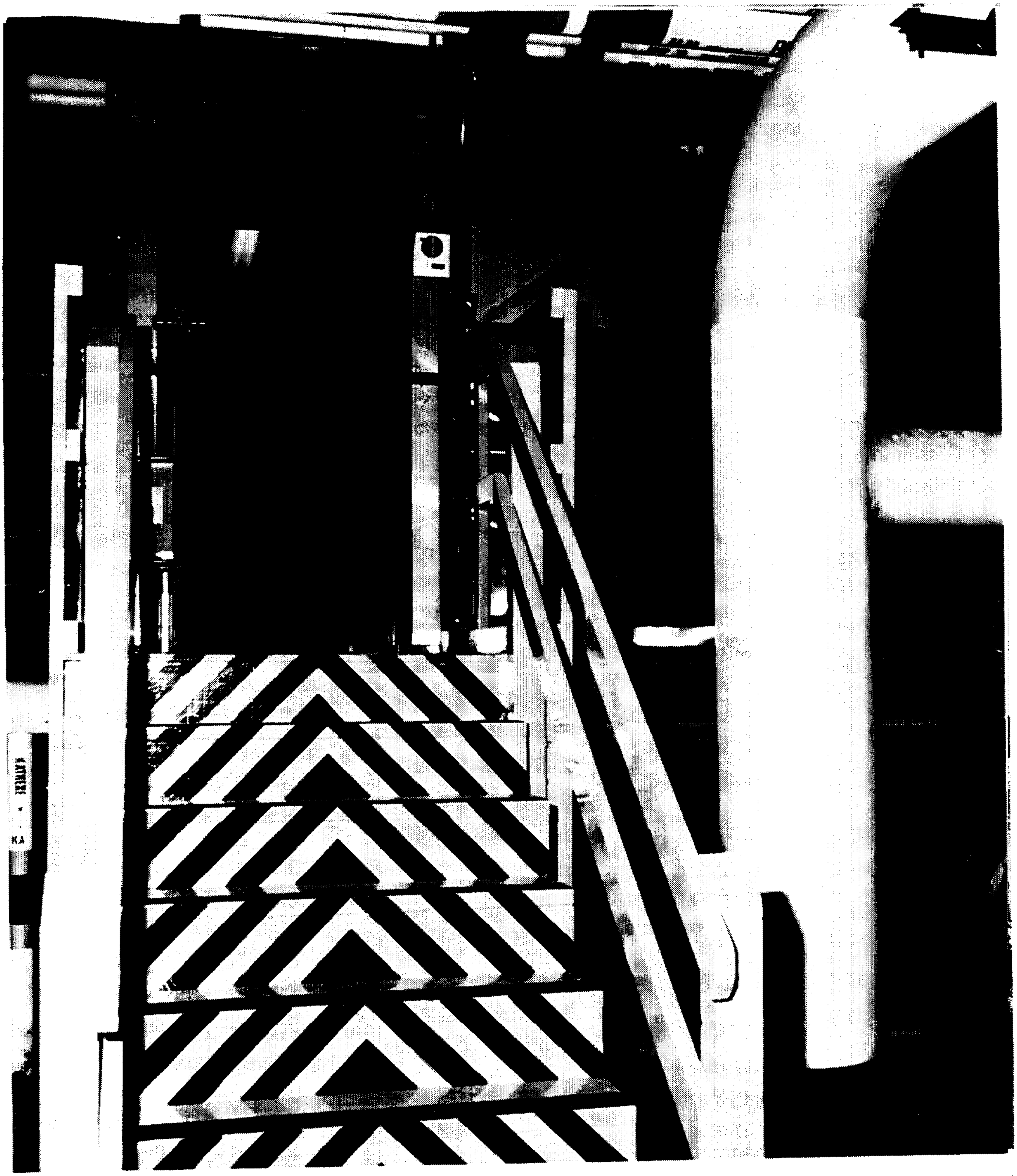


Fig. 19 Structure

Eight air mover units were procured to support operations at all of the remediation locations. The design requirements of these airmovers have since been adopted as the standard for controlled environment ventilation.

The most important engineered access element of the project was the duct access glovebox. The new gloveboxes were designed and built to meet strict operational and design requirements. A standardized glovebox was preferred, to simplify design and allow flexibility in construction and installation. However, as existing space considerations would not allow a single box design, a basic box with a right and left hand vision (mirrored) was designed for use in all locations (Fig. 20). This right/left standard box still allowed ease of fabrication and installation flexibility. Figure 21.

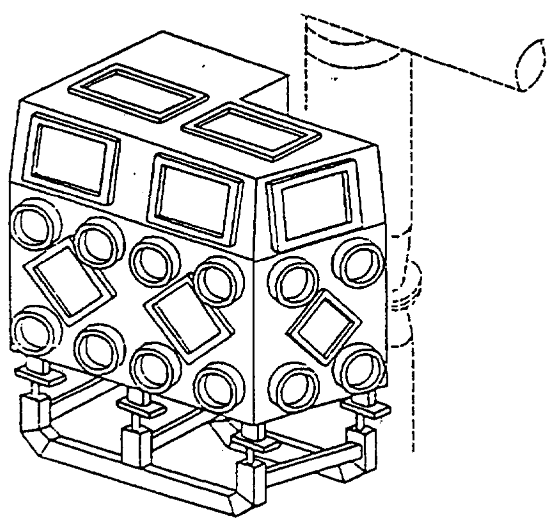


Fig. 20 Engineered access glovebox.

The gloveboxes had to be large enough to provide adequate space for remediation equipment and waste materials, while allowing operators to work in the box efficiently and safely. All of the boxes were designed using materials which would allow later decontamination and storage for possible reuse. Each box was mounted on a tube steel frame which could be adjusted during installation for saddleport/ducting height requirements.

Glovebag technology was used extensively to provide contamination control as each glovebox was connected to the live duct exhaust system. Glovebags were designed to fit each particular locations" requirements, and commonly included several gloves, a bag-out port to remove the material and contaminated tools, and a frame for rigidity. Figure 22 shows the use of glovebag to effect a location's glovebox connection. These glovebages offered a significant operational improvement over the traditional plastic sleeving method. Gloves allowed for increased dexterity. The transparent plastic used in glovebag construction allowed better visibility for complicated activities. These attributes led to the development of glovebags designed for occupancy during remediation operations. The

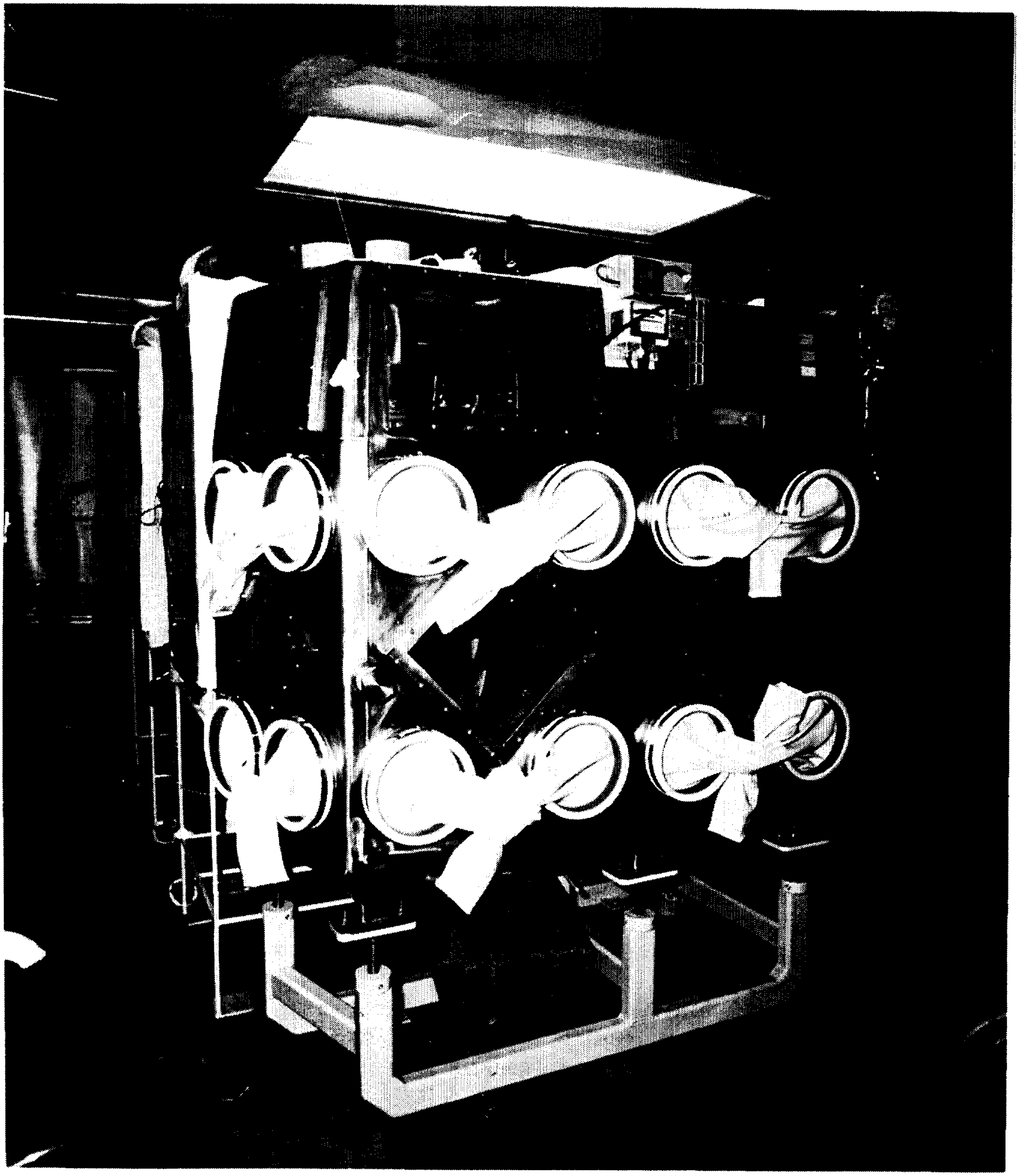


Fig. 21 Glovebox

person-size bags were used to allow personnel to access highly contaminated filter plenums to remove accumulated duct material without ever entering the hazardous environment. Glovebags replacing the use of sleeving in most contamination control applications at Rocky Flats. Figures 23 & 24.

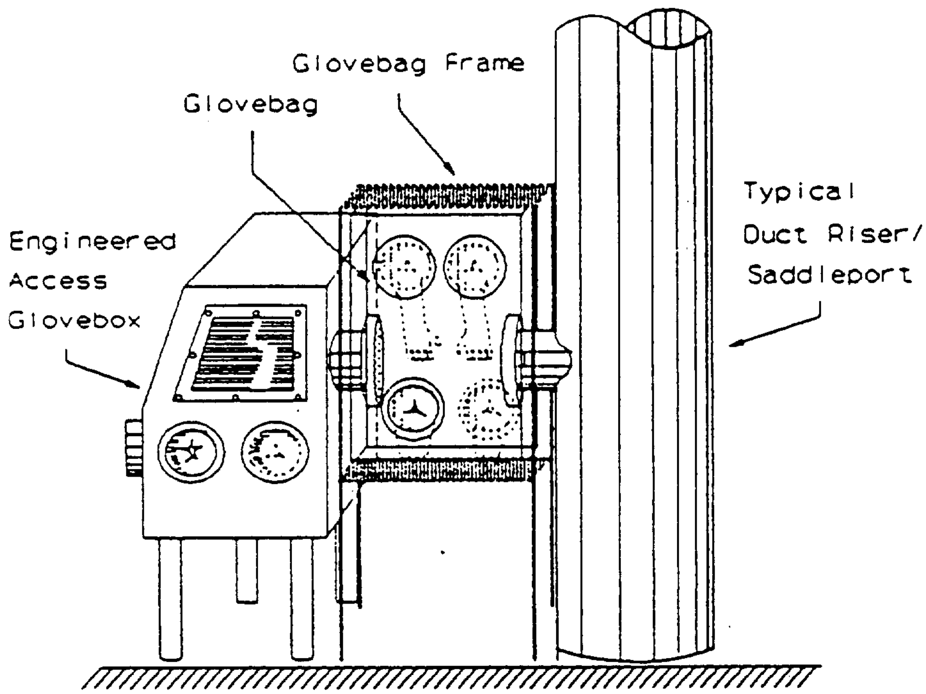


Fig. 22 Contamination containment glovebag detail.

V. Project Success

The largest factor which contributed to the success of the project was the personnel assigned to remediation activities during the life of the project, two crews, each working alternate 12 hour shifts, would brush, scrape, vacuum the hold-up material from ducts. Crews, consisting of three to eight operators would start each shift with a pre-evolution briefing, wherein the job supervisor would describe the purpose and specific tasks for that shift's operation. Also covered would be the necessary safety rules and precautions, and lessons learned from previous remediation shifts. Following the pre-evolution briefing, the team of operators would dress in standard work attire, and would report to the process area. It is notable that in a majority of circumstances, these operators conducted remediation in work clothes, and were not often required to wear special anti-contamination clothing or respiratory protection. Two operators would work in the glovebox, operating the vacuum and remediation equipment, while additional operators would use magnets to pull and position the vacuum nozzle or equipment. Another operator would record the time and location of the operations and important events, such

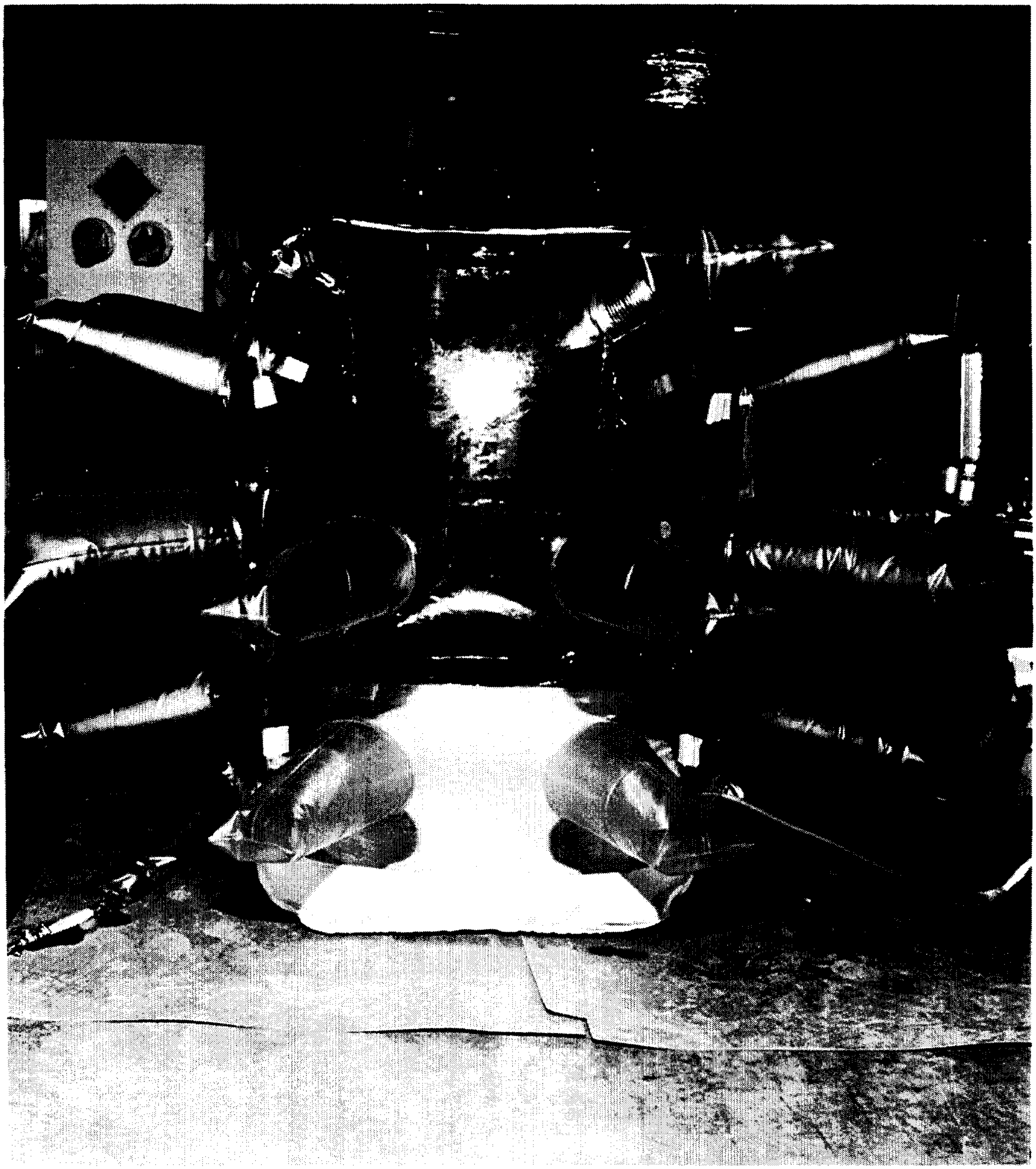


Fig. 23 Glovebag

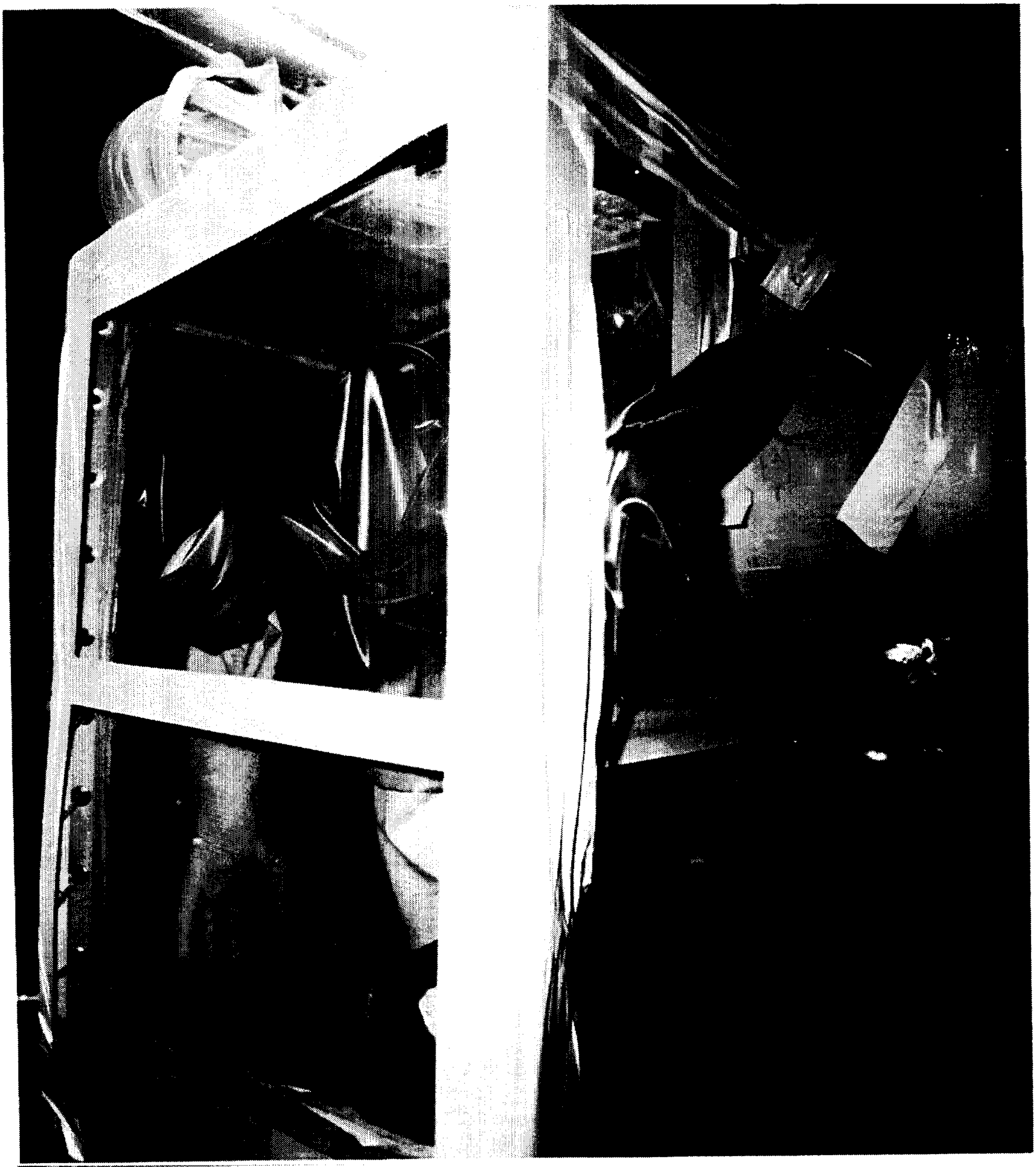


Fig. 24 Glovebag

as duct locations containing large quantities of hold-up material. Shift engineers, who were trained in all aspects of remediation, oversaw the operations and the video equipment. The videos were compared to non-destructive assay measurements to verify remediation methods and to document the successful completion of operations. The shift engineers and operators generated many important suggestions for remediation techniques. These suggestions were instrumental in increasing the efficiency and effectiveness of the operations. The interaction and cooperation between those with technical backgrounds and those with the operational knowledge is regarded as a major contributing factor to the success of the project.

VI. Conclusions

The Duct Remediation Project spanned more than three years of operation, and at times utilized the support of over 100 full time engineers and operators. This project succeeded in removing over 40 kilograms of bulk material from active glovebox exhaust systems. Furthermore, the project was conducted in an increasingly safety-conscious environment, and always maintained a safety-first focus. Only three minor worker injuries occurred during the three year project. No instances of worker radiation exposure over administrative limits were reported. Conduct of Operations enhancements were continuously implemented, resulting in increased safety and efficiency of the remediation operations. The pioneer project was the first large scale in-situ remediation performed at Rocky Flats, and is being used as a bench mark for other remediation projects throughout the Department of Energy nuclear complex. Through the efforts of the Rocky Flats Production, Operations, Engineering, and Support functions, a major remediation task was accomplished.