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SPENT LWR FUEL ENCAPSULATION AND DRY STORAGE DEMONSTRATION

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ABSTRACT

In 1977 the Spent Fuel Handling and Packaging Program (SFHPP) was initiated by the Department of Energy to develop and test the capability to satisfactorily encapsulate typical spent fuel assemblies from commercial light-water nuclear power plants and to establish the suitability of one or more surface and near surface concepts for the interim dry storage of the encapsulated spent fuel assemblies. The E-MAD Facility at the Nevada Test Site, which is operated for the Department of Energy by the Advanced Energy Systems Division (AESD) of the Westinghouse Electric Corporation, was chosen as the location for this demonstration because of its extensive existing capabilities for handling highly radioactive components and because of the desirable site characteristics for the proposed storage concepts. This paper describes the remote operations related to the process steps of handling, encapsulating and subsequent dry storage of spent fuel in support of the Demonstration Program.

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INTRODUCTION

Demonstration of encapsulation and interim storage of spent light-water reactor fuel in dry configurations is underway at the E-MAD facility in Nevada (see Figure 1). This facility is located in the southwest corner of the Nevada Test Site and is operated for the Department of Energy (DOE) by the Advanced Energy Systems Division of the Westinghouse Electric Corporation. Initial use of the E-MAD facility for remote handling and encapsulation of spent reactor fuel assemblies was in support of the DOE Spent Fuel Handling and Packaging Program (SFHPP) Demonstration. The objective of this demonstration was to develop and test the capability to satisfactorily encapsulate typical spent fuel assemblies from commercial nuclear power plants and to establish the suitability of one or more surface and near surface storage concepts for the interim dry storage of the encapsulated spent fuel assemblies. This paper describes the remote operations related to the process steps of handling, encapsulating and subsequent dry storage of spent fuel in support of the Demonstration Program.

DESCRIPTION OF THE E-MAD FACILITY

The E-MAD facility was chosen as the location for this demonstration because of its extensive existing capabilities for handling highly radioactive components and because of the desirable site characteristics for the proposed storage concepts. The major features of the facility are shown in Figure 2. The E-MAD facility contains a number of hot cells of varying size, each having

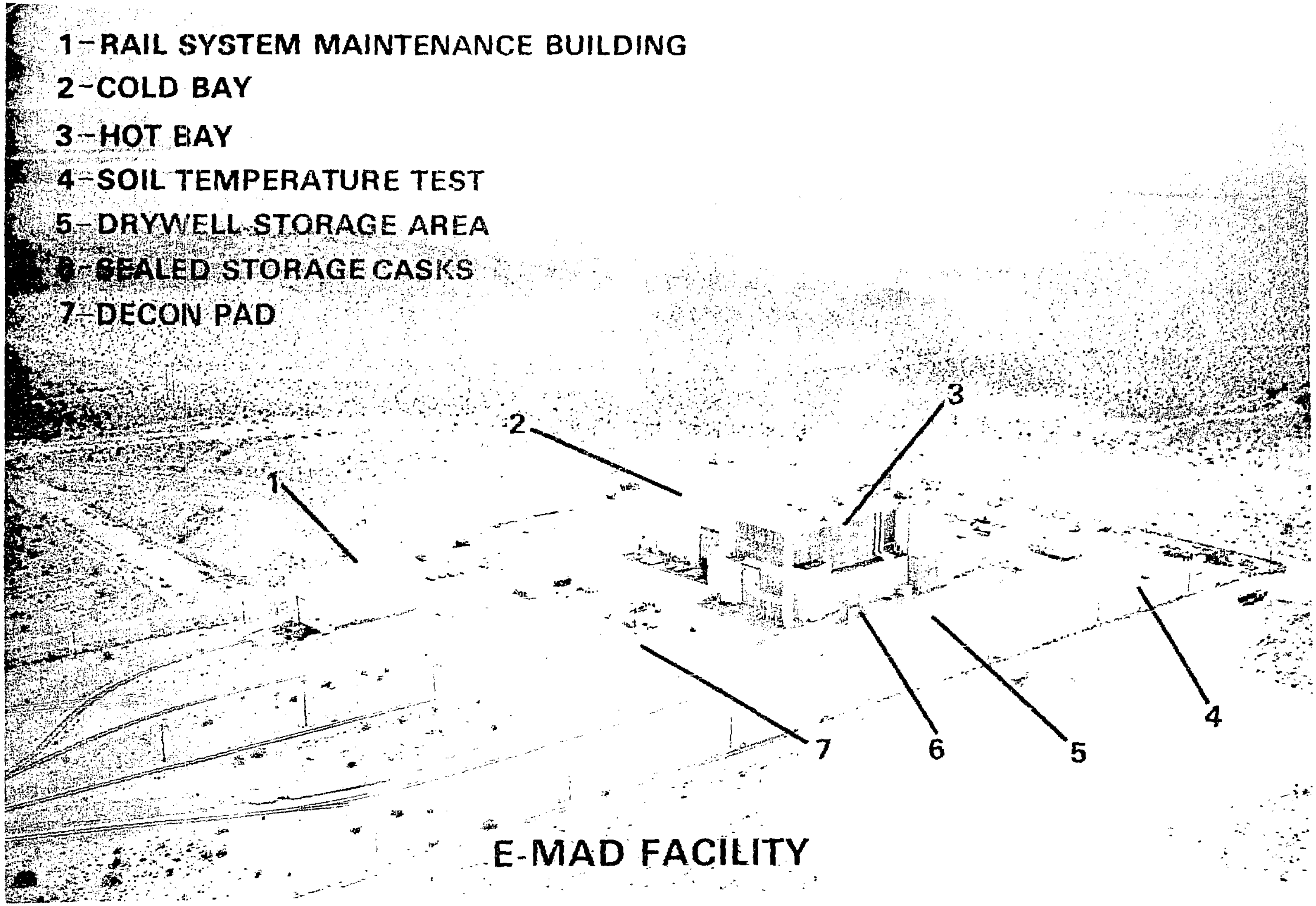

Figure 1. E-MAD Complex in Area 25 of the Nevada Test Site

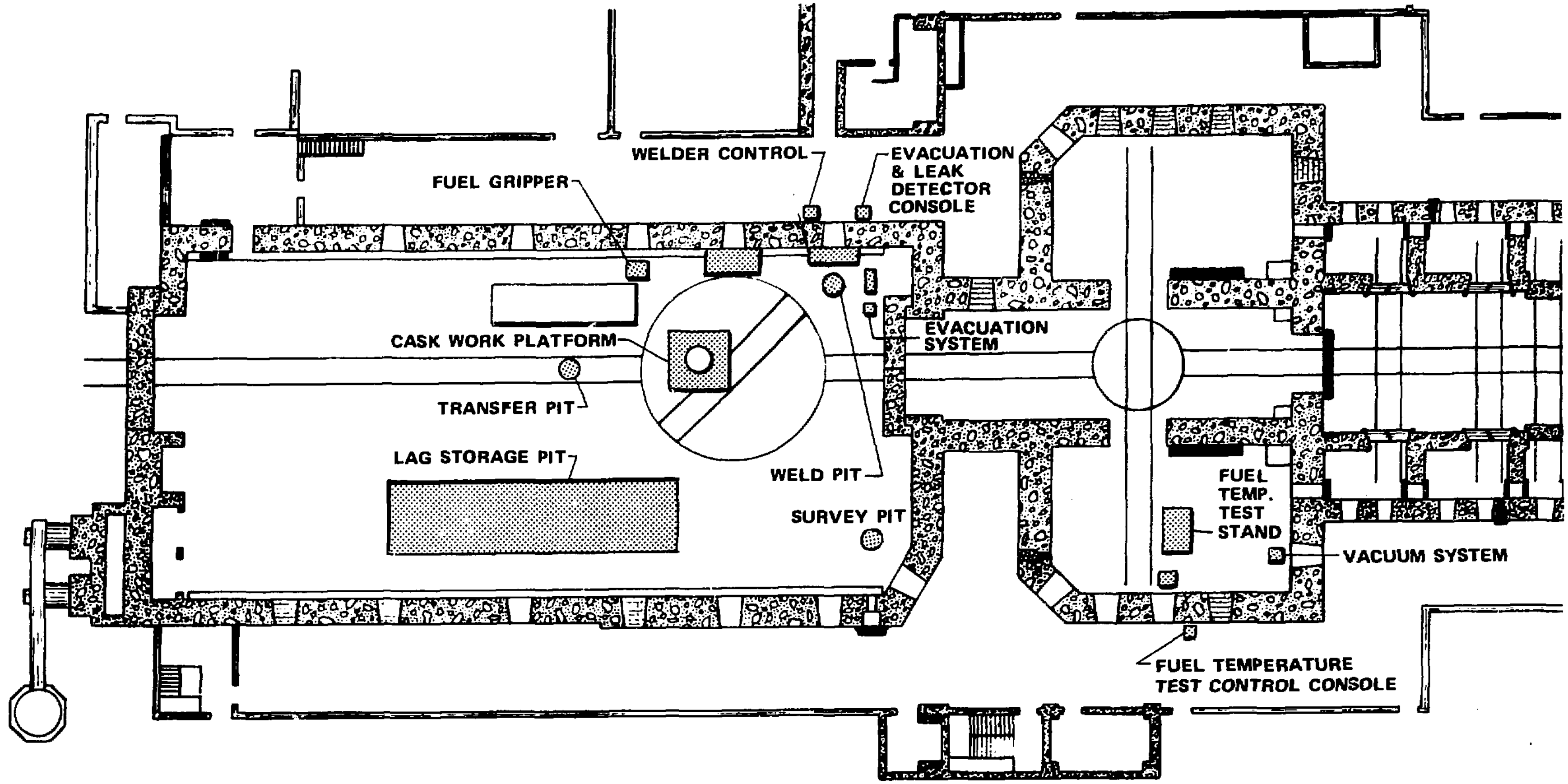

Figure 2. E-MAD First Floor Plan Showing Locations of Demonstration Work Stations and Equipment

the capability of handling highly radioactive objects from shielded work locations using a variety of remote handling devices. The main cell or Hot Bay is a high bay area constructed of heavily reinforced concrete shield walls with numerous lead glass viewing windows. The bay is 43 meters long, 20 meters wide, and 23 meters high. Two large shield doors exist in the Hot Bay through which movement of equipment into and out of the Hot Bay is accomplished. The main door to the bay is located at the north end and allows truck or railcar access into the bay. A second shield door exists at the south end of the bay for access into the Hot Hold and Transfer Tunnel.

The Hot Bay is equipped with a number of remote handling systems to support remote operations within the Hot Bay. These include:

- A travelling overhead bridge crane with a 36.3 te (40-ton) capacity main hook and a 9.1 te (10-ton) capacity auxiliary hook.

- A Wall Mounted Handling System, consisting of two identical articulated travelling boom assemblies with manipulators, installed on the east wall of the Hot Bay.

- Pairs of heavy duty master/slave manipulators at most of the first floor viewing windows.

These systems can be seen in Figure 3 which shows a spent fuel canister package being inserted into a sealed storage cask inside the Hot Bay.

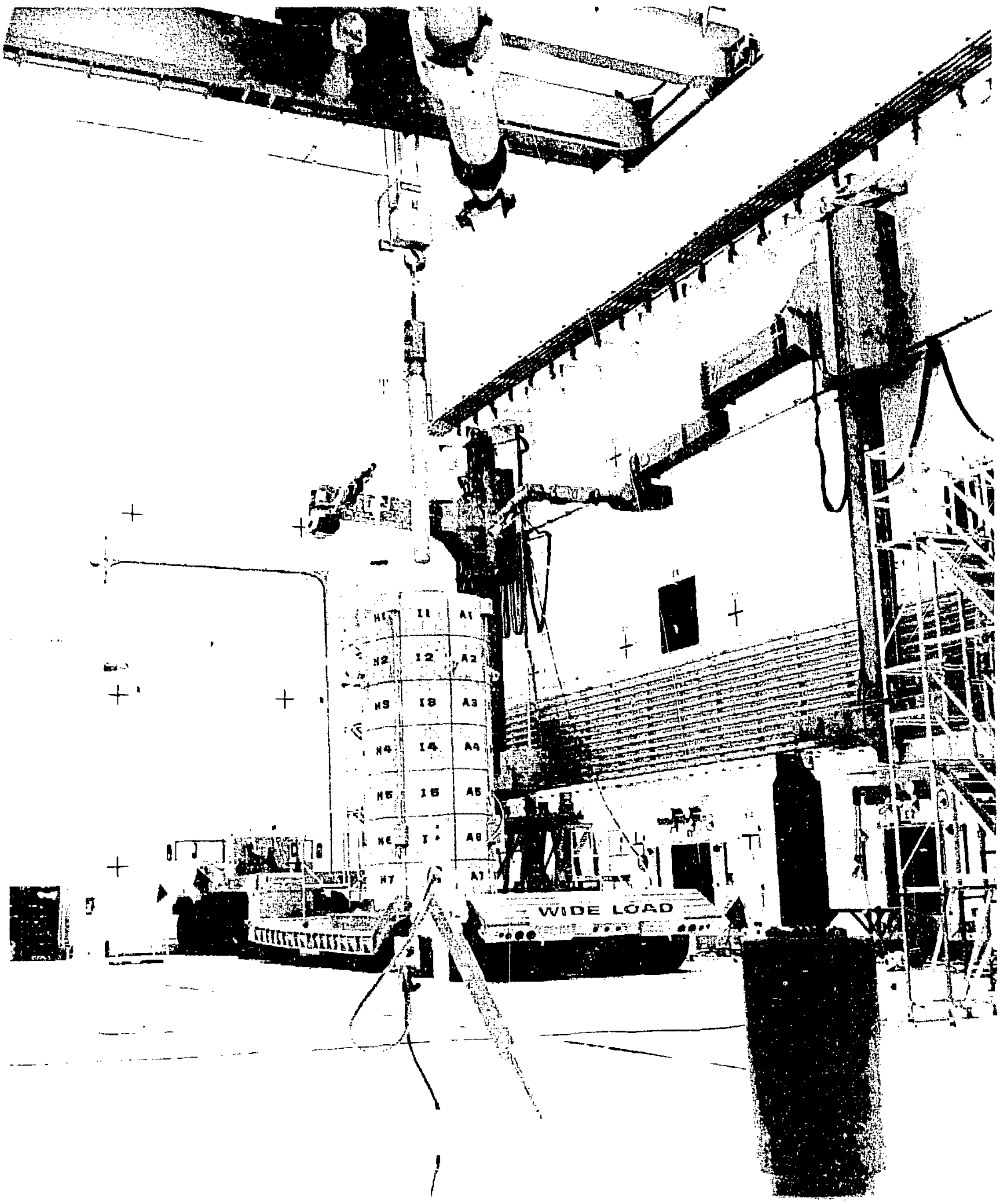

Figure 3. View of E-MAD Hot Bay Showing Major Remote Handling Systems Being Used to Install a Spent Fuel Canister Package into a Sealed Storage Cask

The modifications made to E-MAD, together with associated equipment and components developed in support of the SFHPP Demonstration, permit the receipt, visual inspection, and encapsulation of either PWR or BWR spent fuel assemblies. Capability is also provided for the leak testing of completed canisters, lag storage of canisters within E-MAD (24 storage locations), and the emplacement of canisters into interim storage configurations outside E-MAD. The designs of the process equipment and storage configuration are described in Reference 1.

The SFHPP Demonstration involved the remote handling and encapsulation of three spent PWR fuel assemblies; two encapsulated assemblies were placed in a near surface drywell storage configuration shown in Figure 4 and the third was placed in a surface Sealed Storage Cask storage configuration shown in Figure 5. In addition, thirteen spent PWR fuel assemblies have been received and encapsulated for use in the spent fuel geologic storage test in the Climax granite stock at the Nevada Test Site.

PROCESS STEPS

The development of a remote handling system along with the design, fabrication, and assembly of supporting hardware and test equipment were performed to support the major process steps required for handling, encapsulation, and interim storage of spent fuel assemblies at the E-MAD facility. The designs of the process steps and equipment and the system components were strongly influenced by the need for compatibility with the E-MAD facility, the desire to utilize existing E-MAD features and equipment to the maximum extent practicable, and the desire to provide a high degree of safety and a high probability of success without the need for costly and time-consuming interim modifications. Design considerations related to high volume production had low priority.

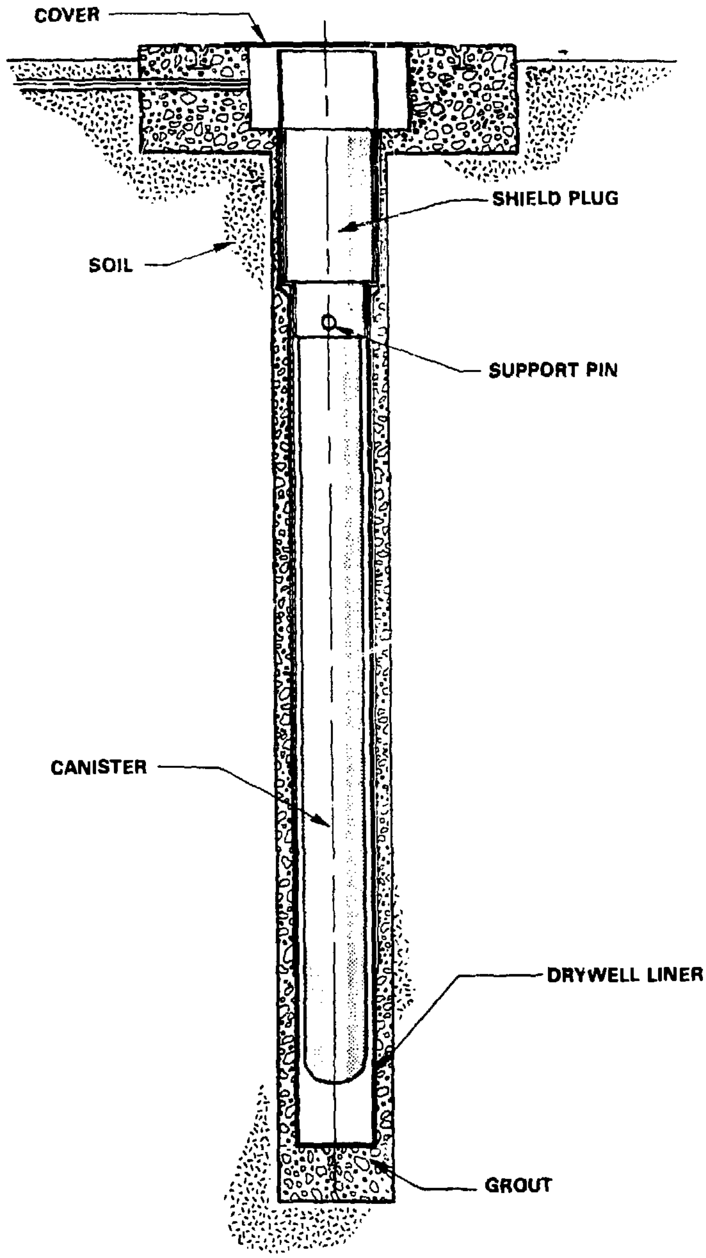

Figure 4. SFHPP Demonstration Drywell Storage Configuration

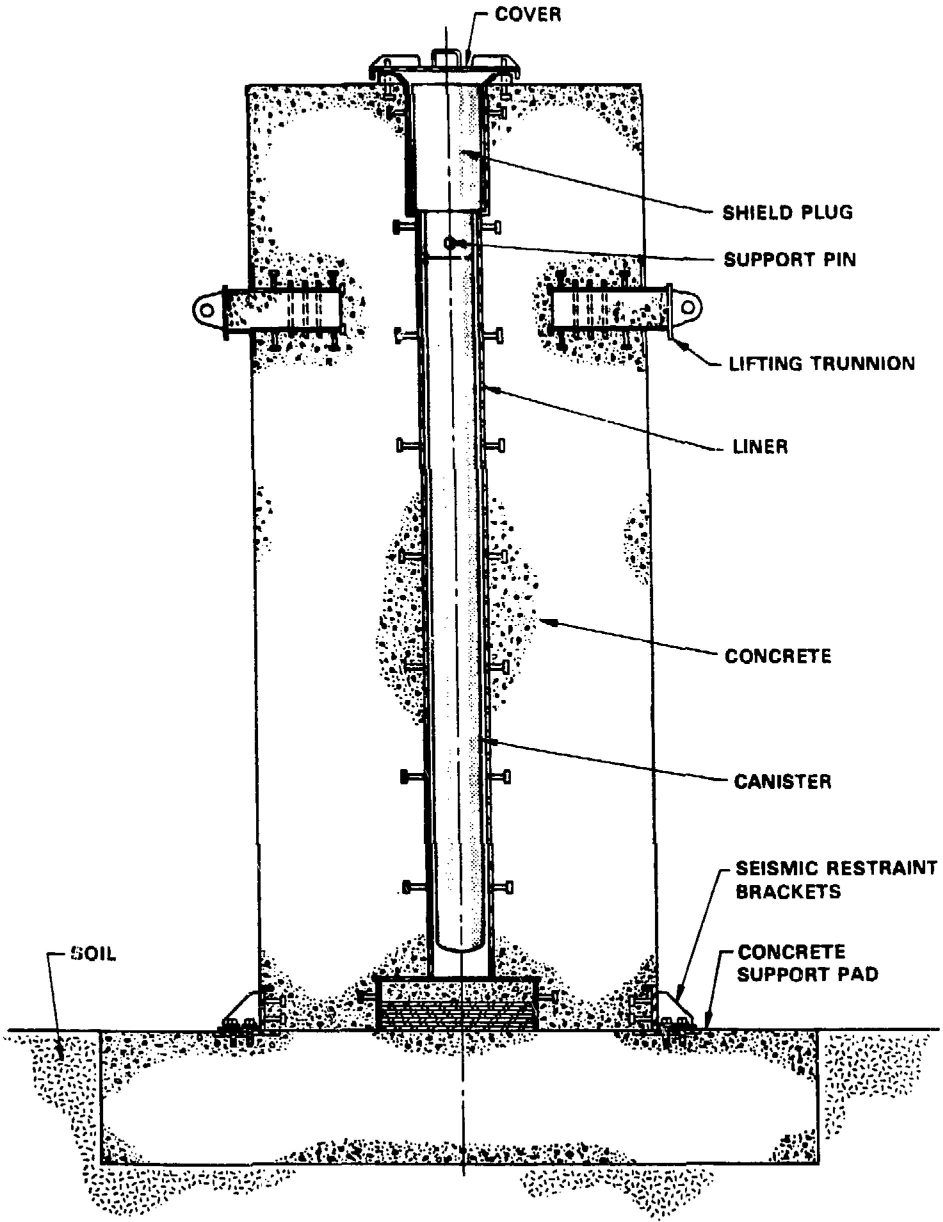

Figure 5. SFHPP Demonstration Sealed Storage Cask Configuration

Initial operations in the sequence of events are performed "hands-on" and include receipt and unloading of the shipping cask from the trailer followed by positioning of the shipping cask in the work stand. All subsequent operations are performed remotely. The major process steps are described in the following sections. The entire sequence of events, including hands-on operations, occurs in one continuous 8-hour period.

Preparation of Spent Fuel Shipping Cask for Unloading

The spent fuel shipping cask, transporter trailer, and truck tractor are washed down at another Nevada Test Site location to remove road dirt prior to arrival of the vehicle at E-MAD. The shipping cask is visually inspected for damage, and then the vehicle is backed into the Hot Bay. Shipping cask vendor instructions are followed to prepare the transporter and cask for cask off-loading. Using the cask lifting yoke and the E-MAD overhead crane, the cask is upended, lifted off the transporter, and placed in the cask work platform. The cask is shown being moved from transporter to the work platform in Figure 6. Hands-on cask operations include installation of the cask vent line, venting of the cask internal pressure through the Hot Bay ventilation system stack, removal of the cask closure lid holddown bolts, and attachment of the lid lifting fixture.

Unloading of Fuel Assembly from Shipping Cask and Placement into Canister in Weld Pit

After the cask unloading preparations have been completed, subsequent operations are performed remotely. The next step is to use the overhead crane to remove the shipping cask closure lid and place it on its stand to allow access to the fuel assembly as shown in Figure 7. The overhead crane

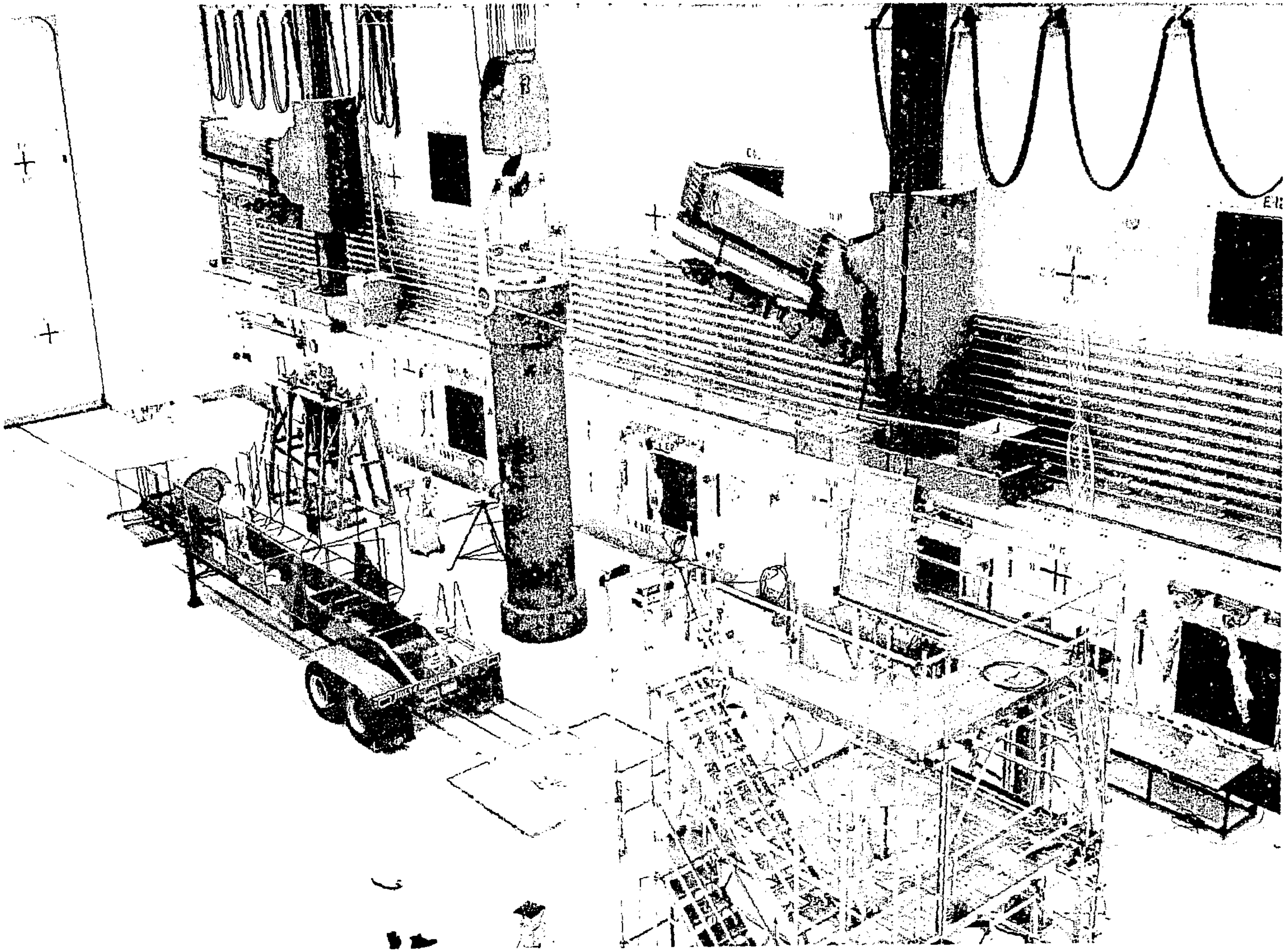

Figure 6. Shipping Cask Being Moved from the Transporter to the Hot Bay Cask Work Platform

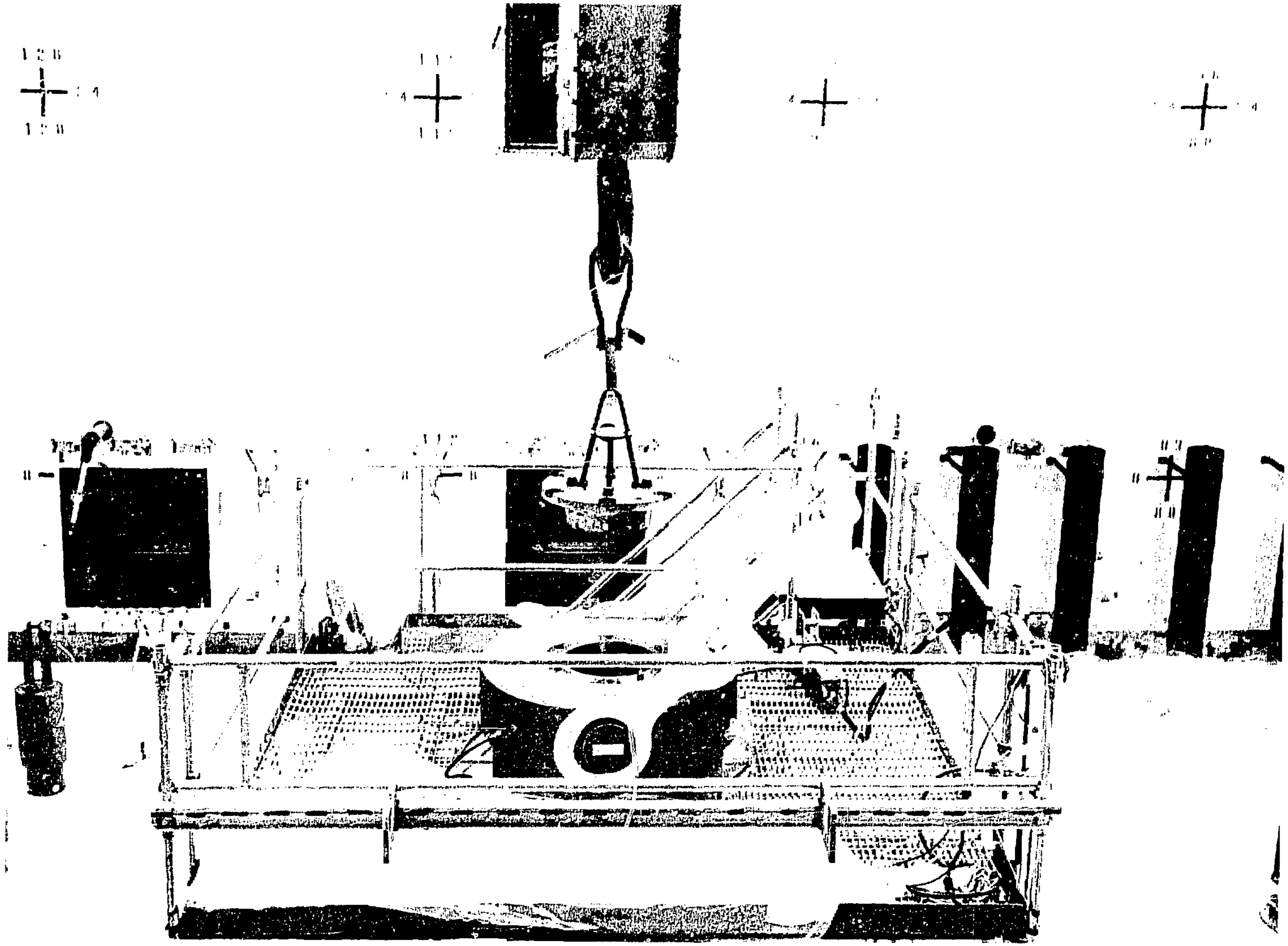

Figure 7. Shipping Cask Closure Lid Being Remotely Removed

is then used to pick up the PWR fuel assembly handling tool from its stand shown in Figure 8 and insert the tool into the shipping cask to engage the fuel assembly.

After engaging the fuel assembly with the handling tool, the overhead crane is used to lift the fuel assembly out of the shipping cask, and then the assembly is visually examined along the full length of each side by a TV camera held by one of the Wall Mounted Handling System manipulators shown in Figure 9. Video tape records are made for future reference. After this examination, the fuel assembly is moved to the weld pit and placed into an empty canister that had been previously placed in the weld pit as shown in Figure 10.

Installation and Welding of Canister Closure Lid

Following installation of the fuel assembly into the canister, the closure lid is picked up, aligned over the canister, and lowered into the top of the canister as shown in Figure 11. The closure lid torque tool is used to thread the closure lid into the canister upper body. With the closure lid fully threaded in, a Wall Mounted Handling System manipulator is used to install the seal welding machine on the closure lid in penetration for welding.

Sealing of the canister is accomplished by fusion welding of a small lip, machined as part of the closure lid, to the top surface of the canister body. This fusion weld is accomplished by a fully contained welding machine, shown

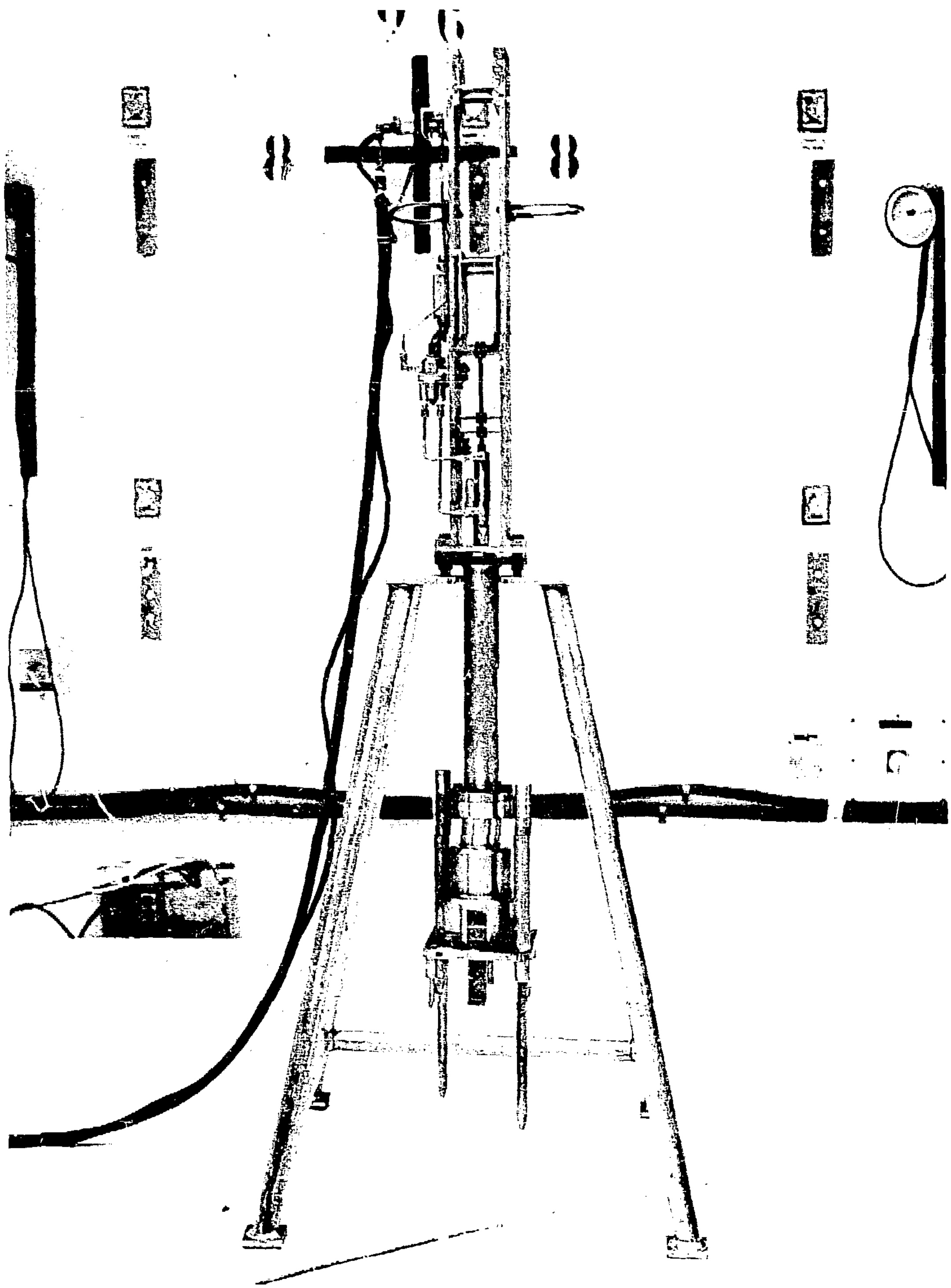

Figure 8. PWR Fuel Assembly Handling Tool in Its Storage Stand in Hot Bay

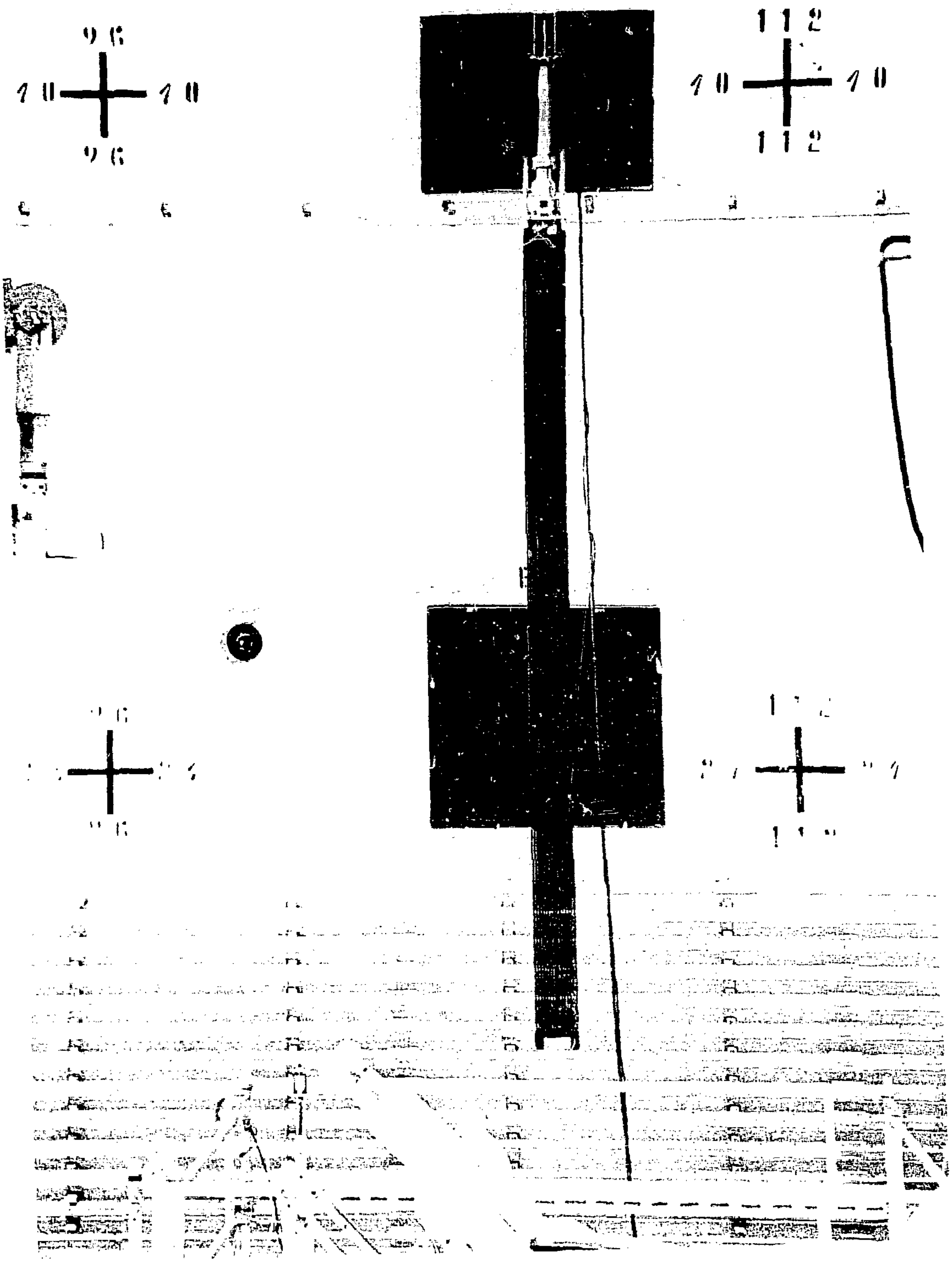

Figure 9. PWR Fuel Assembly Suspended from the Overhead Crane While Being Examined by a TV Camera

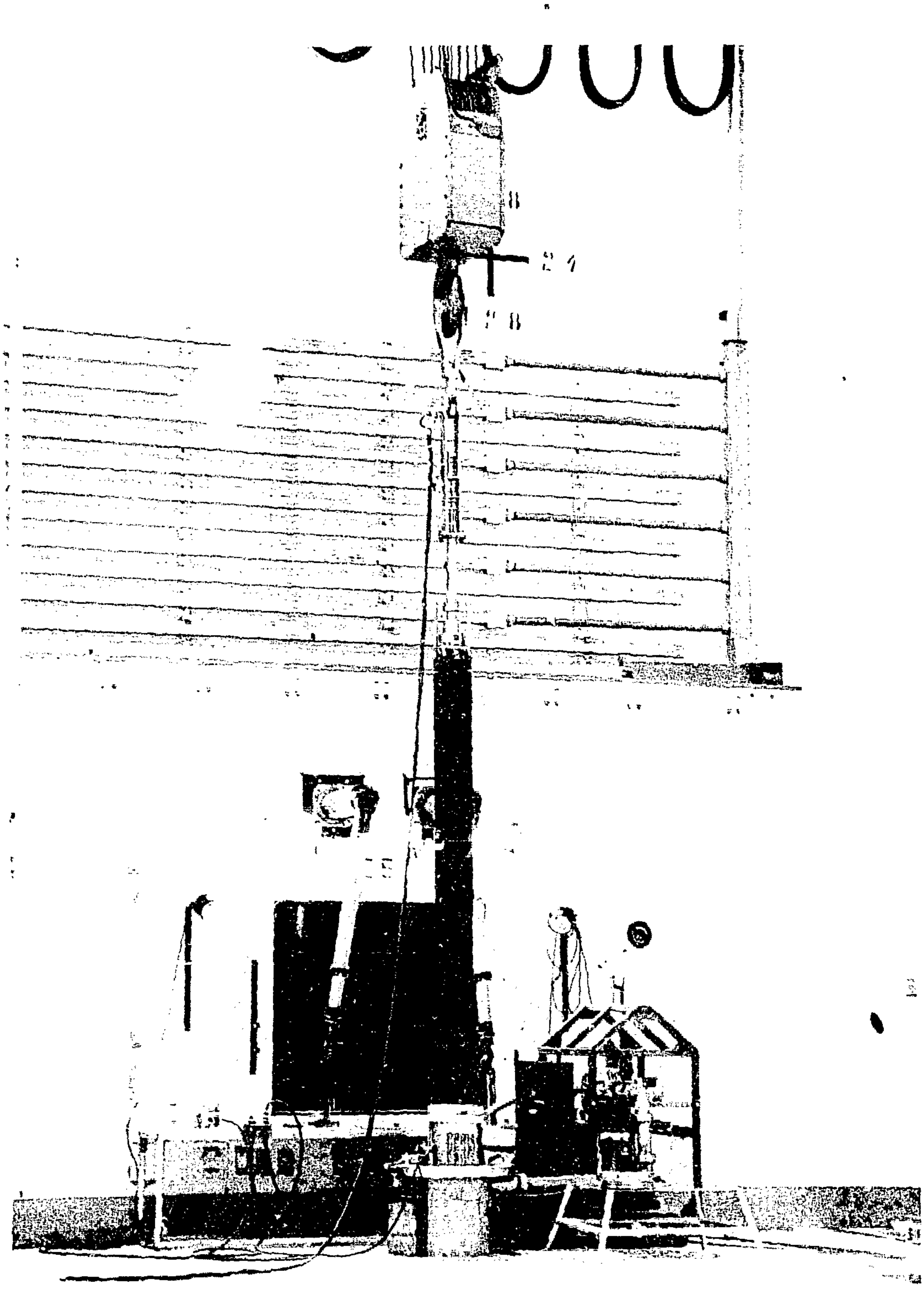

Figure 10. PWR Fuel Assembly Suspended from Overhead Crane Being Lowered into Canister in Weld Pit

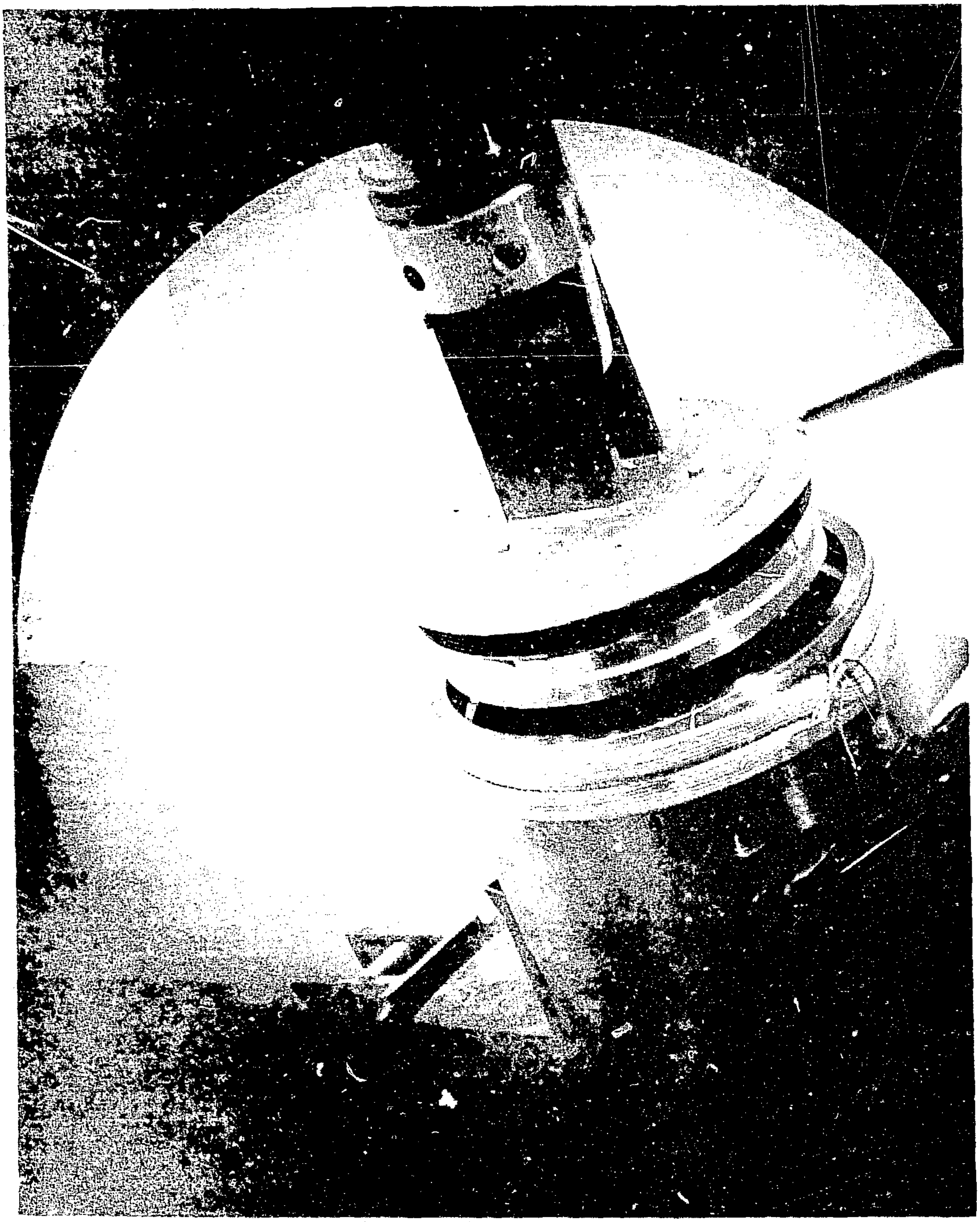

Figure 11. Canister Closure Lid Being Threaded into Canister

in Figure 12, designed specifically for remote operation on a canister. Figure 13 shows a photograph of a completed seal weld taken through one of the E-MAD periscopes.

Canister Evacuation and Helium Backfill

Following seal welding, the closure lid cap is removed and the evacuation/backfill hose is connected to the closure lid as shown in Figures 14 and 15. The air in the canister is evacuated and the canister is backfilled with helium to a pressure of approximately one atmosphere. After helium filling is complete, the evacuation/backfill hose is removed and the fitting on the closure lid is capped and torqued.

Leak Check of Complete Canister

After the canister has been filled with helium and the closure lid fitting torqued, the Wall Mounted Handling System is used to place the vacuum chamber hood over the weld pit, as shown in Figure 16, for the helium leak check operation.

Installation of Canister Package Shield Plug

After the vacuum chamber hood is removed, the overhead crane is used to pick up a shield plug and place it on the canister as shown in Figure 17. A keyway in the shield plug extension mates with the support key on the canister body and the shield plug vertical alignment pipe rests on the canister closure lid to automatically align the canister support pins with the flat-bottomed holes in the canister body. A support pin torque tool held by the Wall Mounted Handling System is used to thread the support pins in to mate with the holes in the canister body, thus completing the shield plug attachment operation.

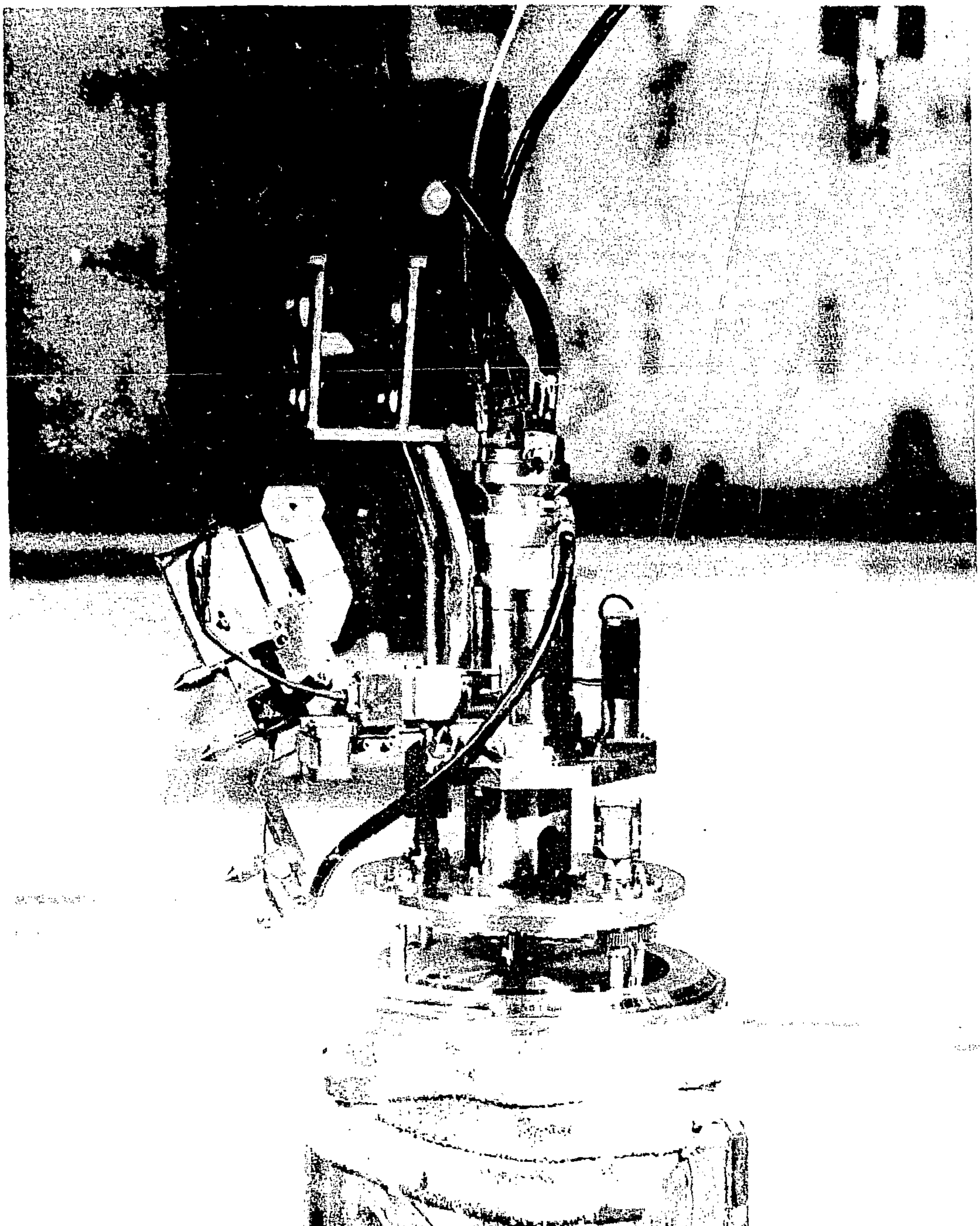

Figure 12. Canister Closure Lid Being Seal Welded

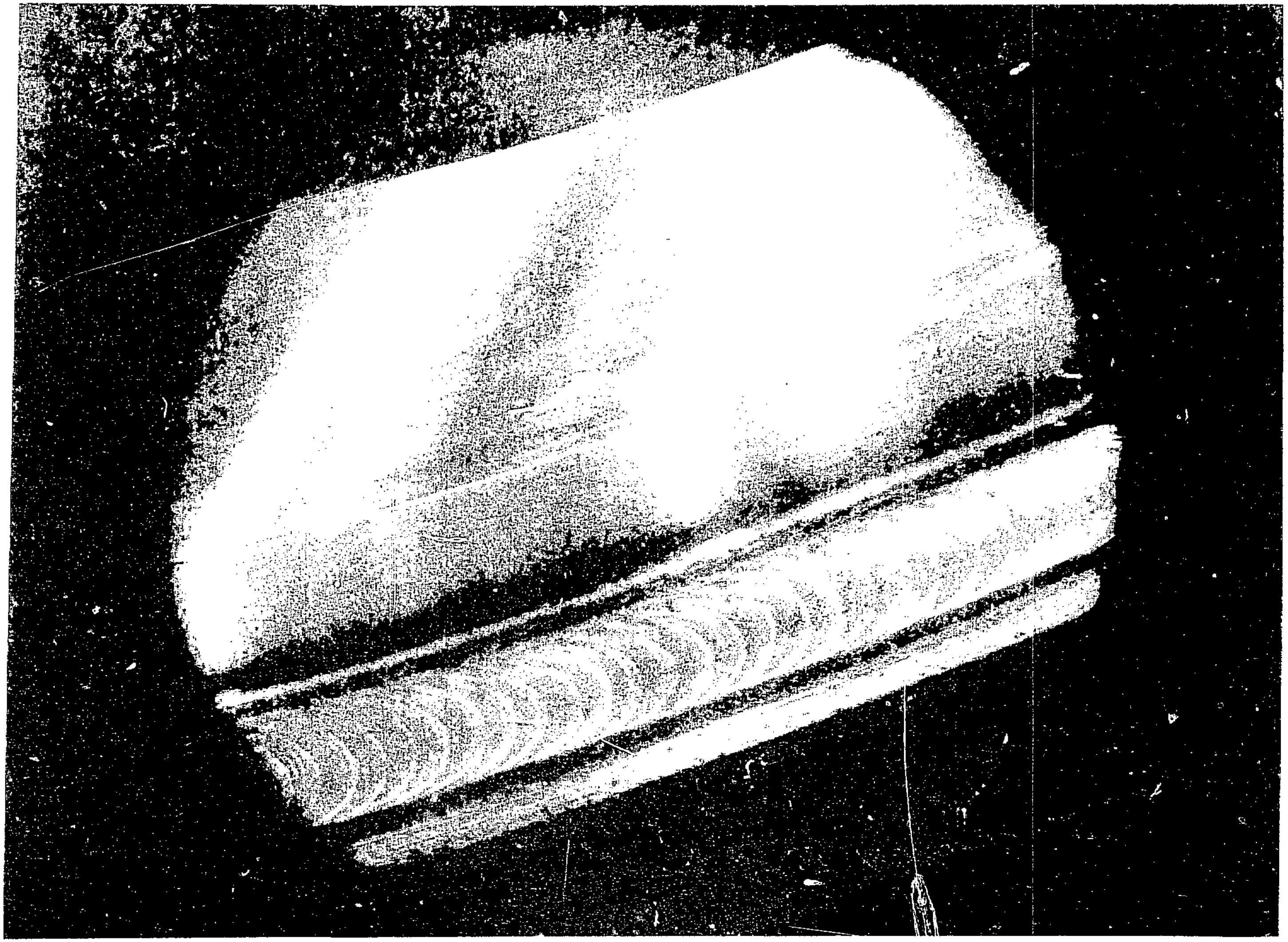

Figure 13. Periscope View of Completed Seal Weld

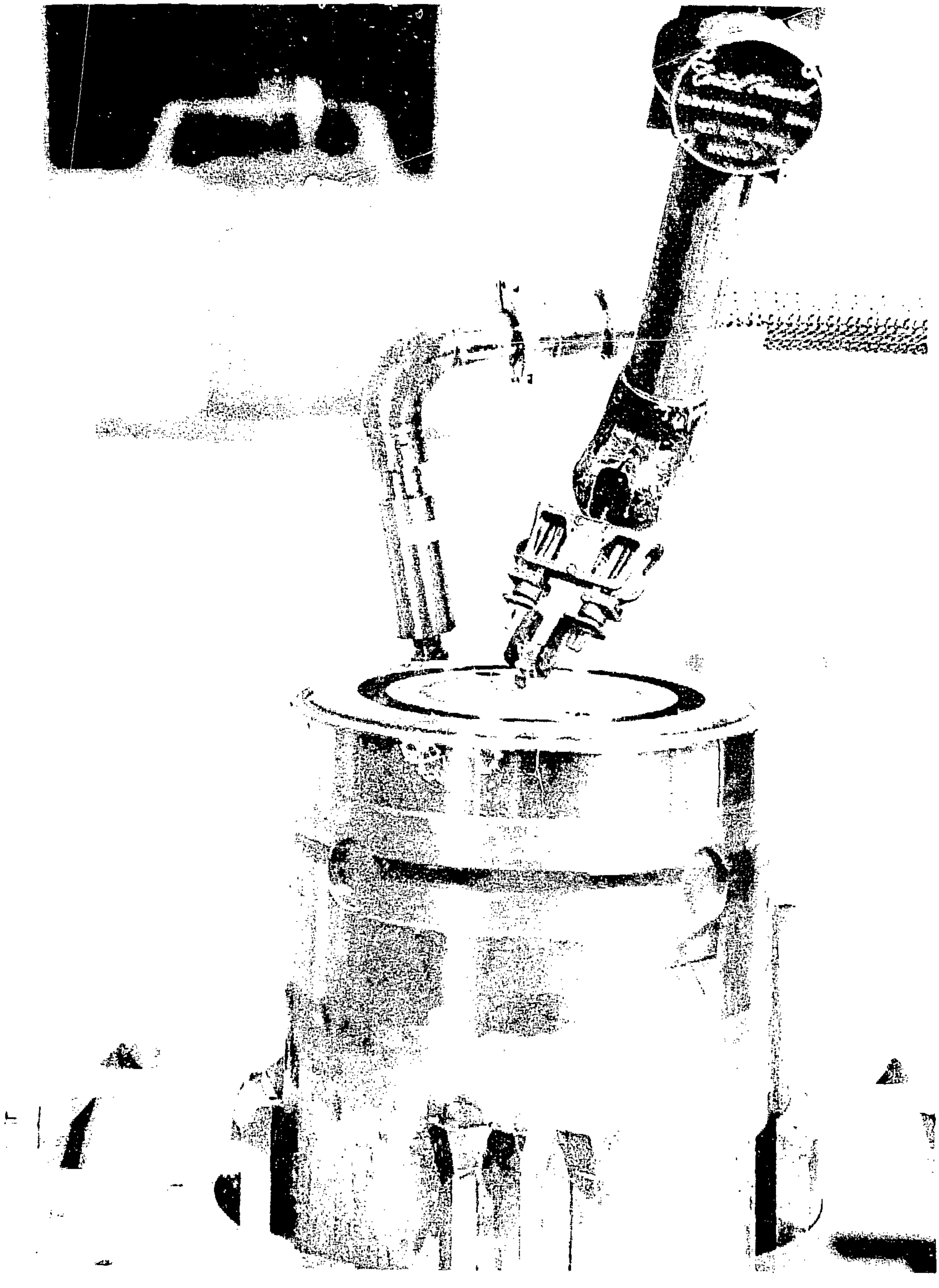

Figure 14. Removing Closure Lid Cap for Evacuation and Backfill

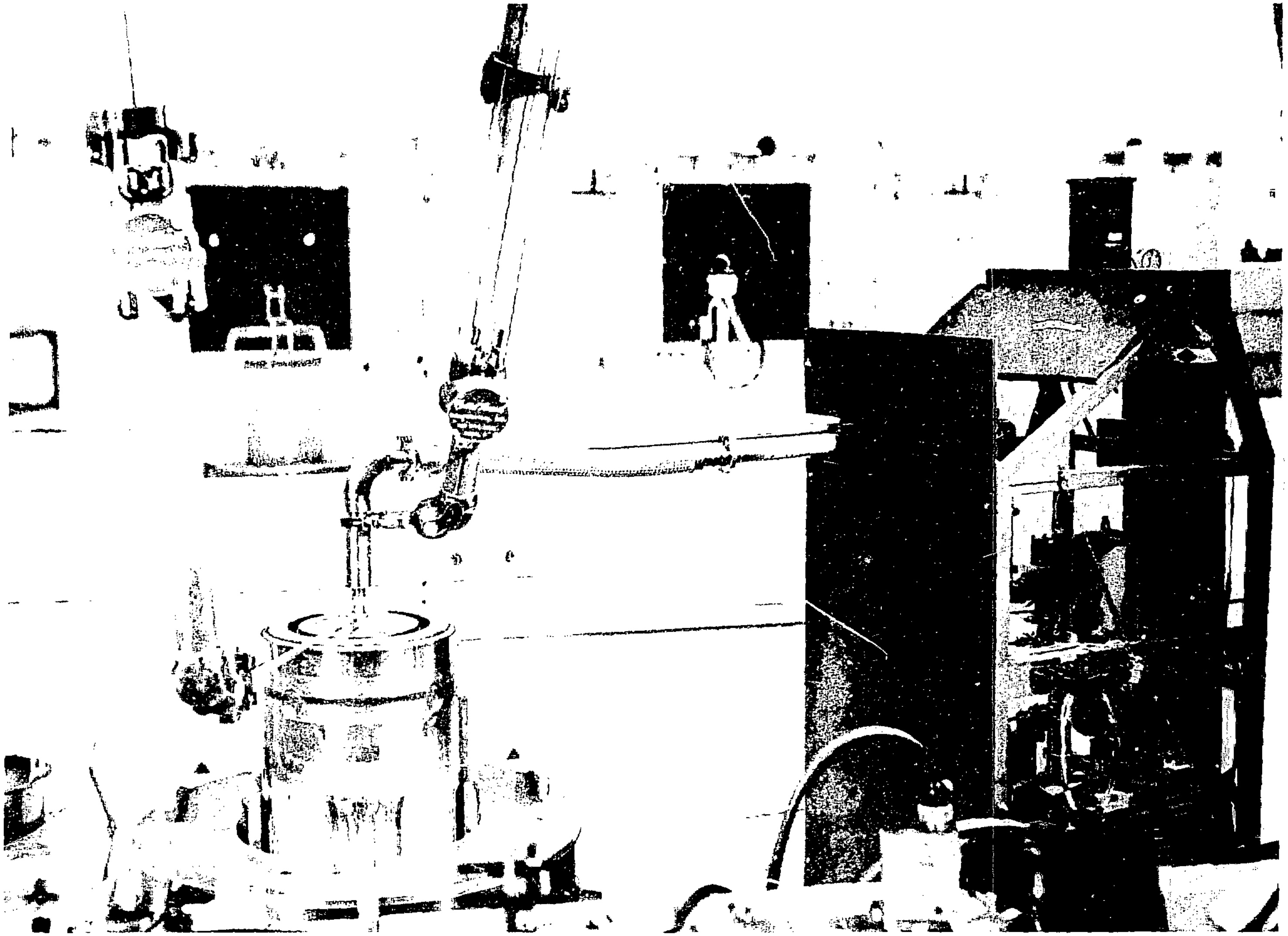

Figure 15. Installation of Evacuation/Backfill Hose

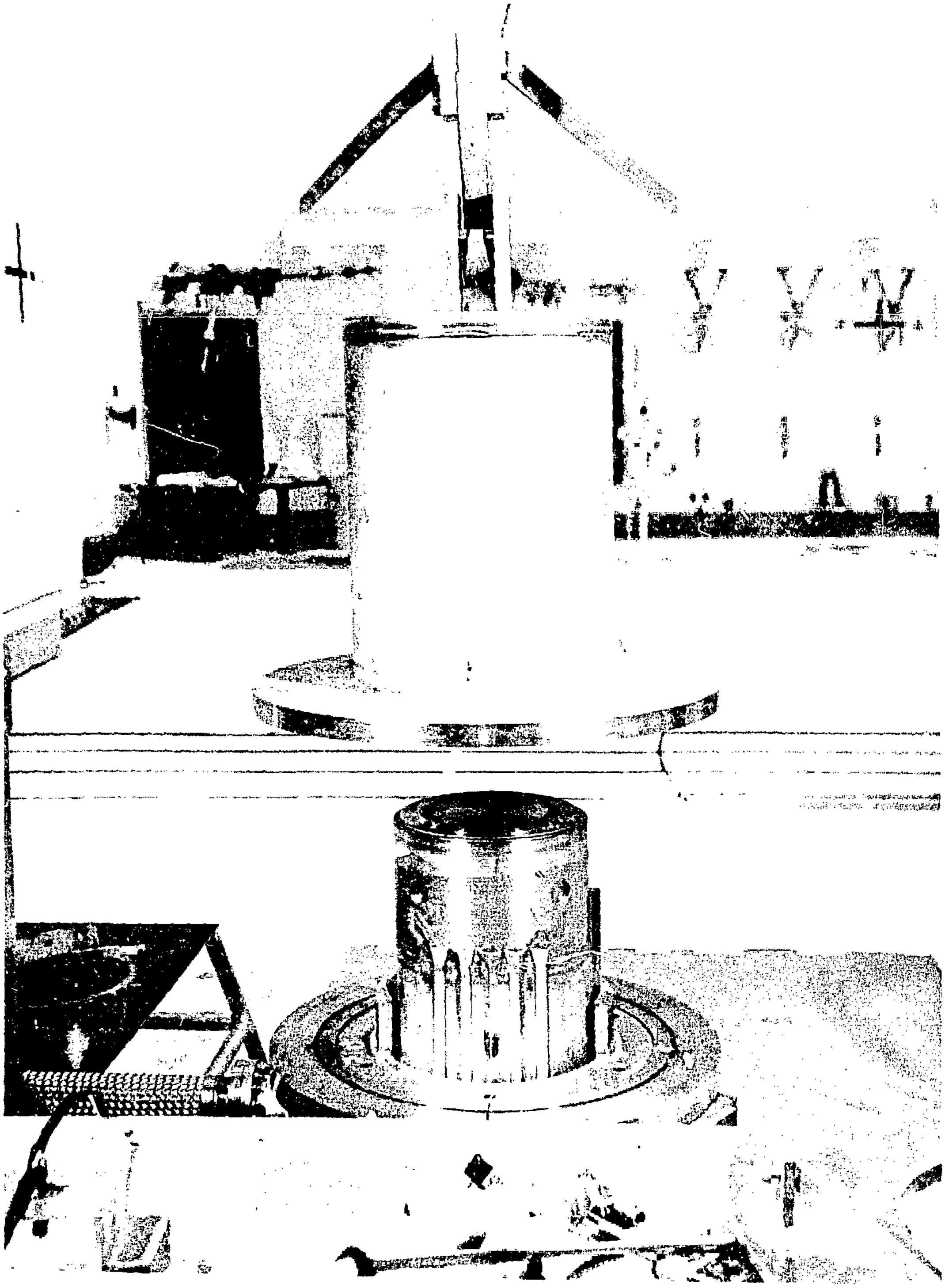

Figure 16. Vacuum Chamber Being Installed in Preparation for Canister Leak Check

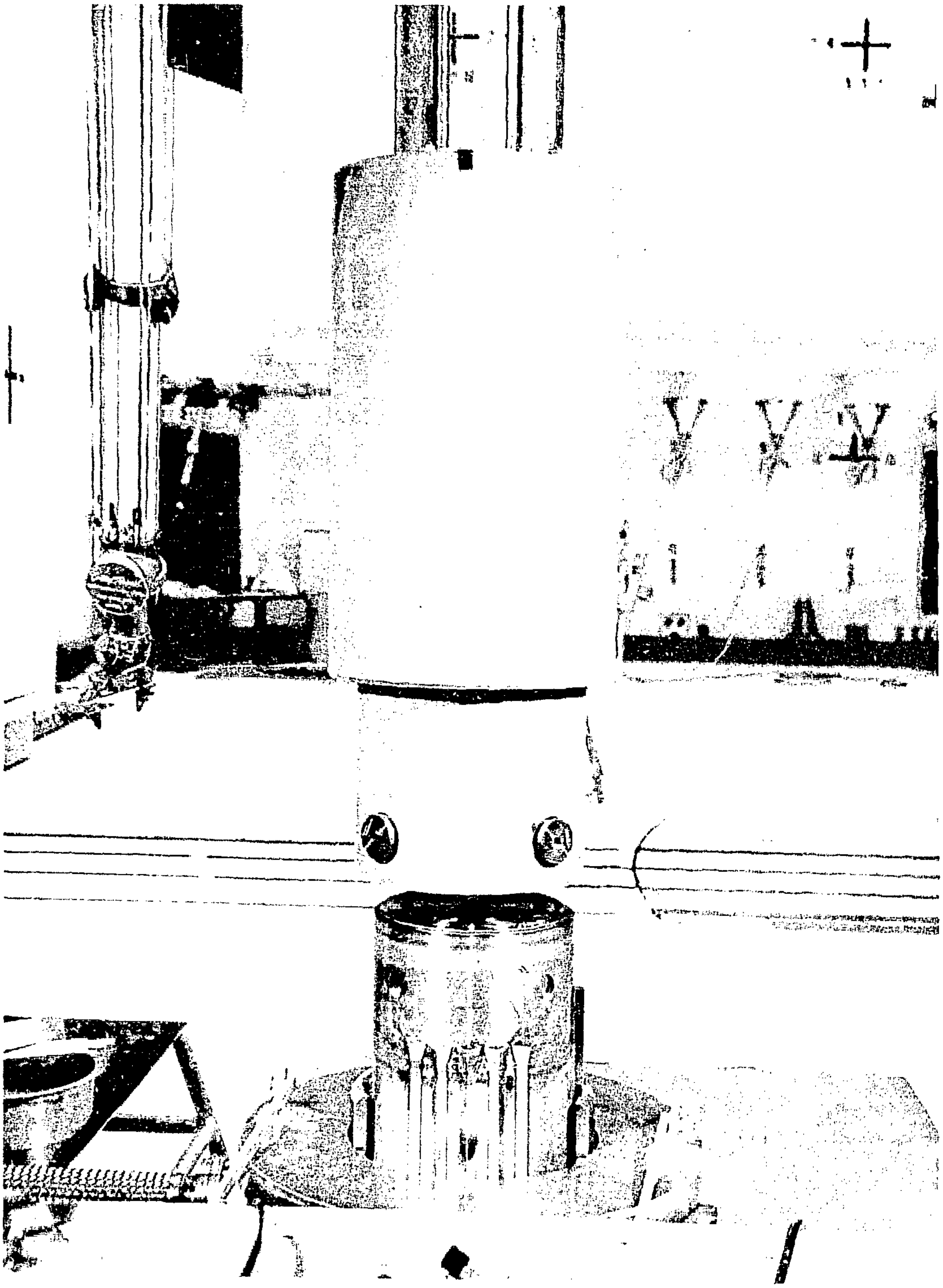

Figure 17. Shield Plug Being Lowered over Canister in Preparation for Attachment to Canister

Surface Contamination Check of Completed Canister

After the shield plug is connected to the canister, the overhead crane is used to move the canister package to the survey pit located in the southwest corner of the Hot Bay in front of the pass-through drawer and manipulator stations at viewing windows as shown in Figure 18. The 11-foot deep survey pit is a remote work station which provides accessibility to a sealed canister package suspended from the overhead crane to obtain survey swipes to evaluate canister surface contaimination. A pit is required to permit the canister to be lowered sufficiently so that the top of the canister can be reached by the manipulator. During the survey operation, the canister is moved vertically by the overhead crane while the manipulator operator takes swipes of the canister at a number of locations as shown in Figure 19. The swipes are then placed in the pass-through drawer for transfer to the operating gallery for counting.

Transfer of Canister Package to Drywell Storage

At this point the canister package can be inserted into the lag storage pit for temporary storage or inserted into the transfer pit in preparation for transfer to a drywell outside the Hot Bay (at this time the canister package could also be installed in a sealed storage cask, which is described in the following section). The transfer pit is located between the rails near the center of the Hot Bay as shown in Figure 2 and is designed to accommodate a canister package in a configuration essentially identical to the drywell configuration shown in Figure 4. The location and configuration of the transfer pit permit the canister package to be picked up by the transfer vehicle for movement to an outside drywell as shown in Figures 20 and 21.

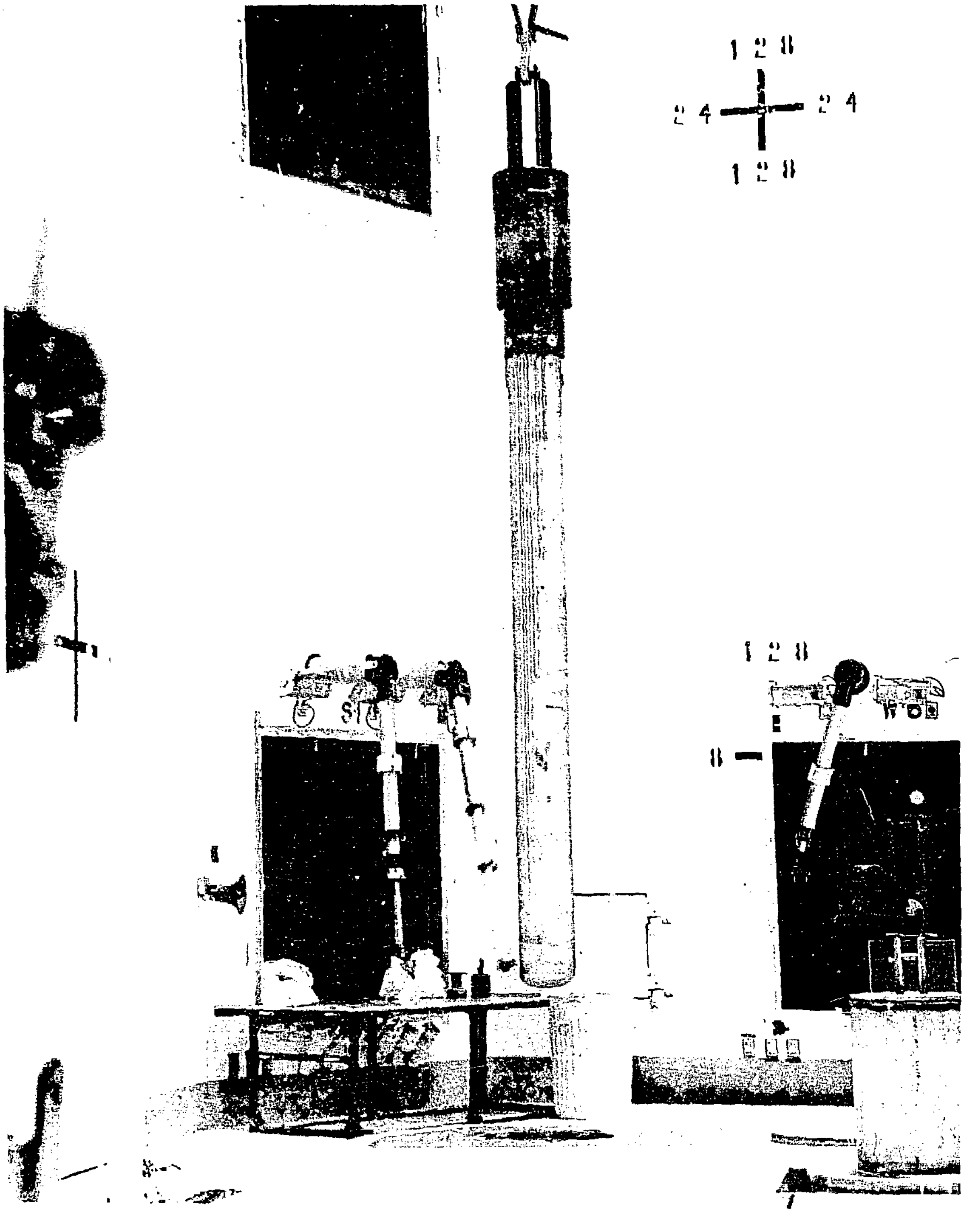

Figure 18. Completed Canister Package Suspended from Overhead Crane over Survey Pit

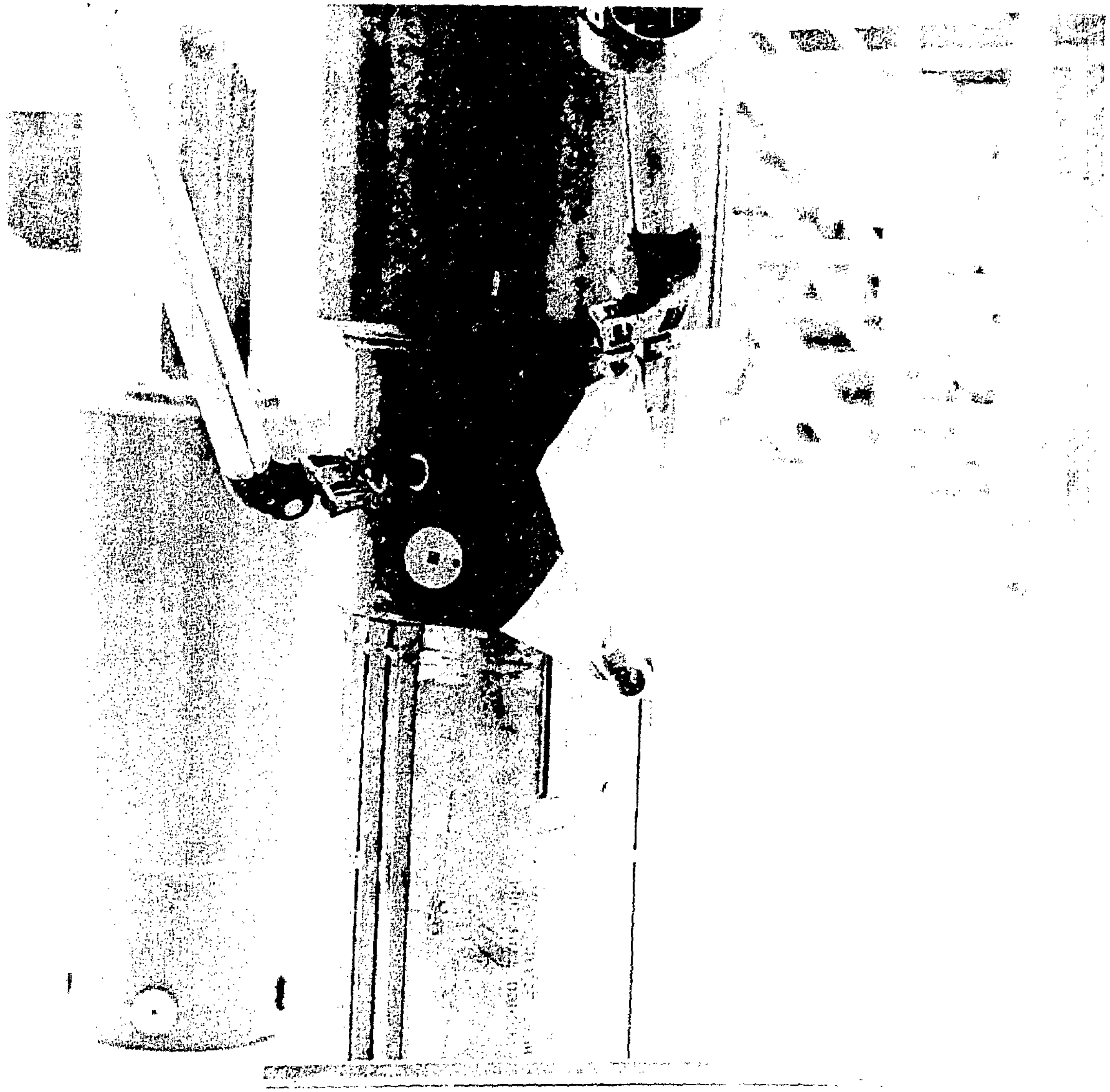

Figure 19. Canister Package Being Remotely Swiped at Survey Pit for Contamination Check

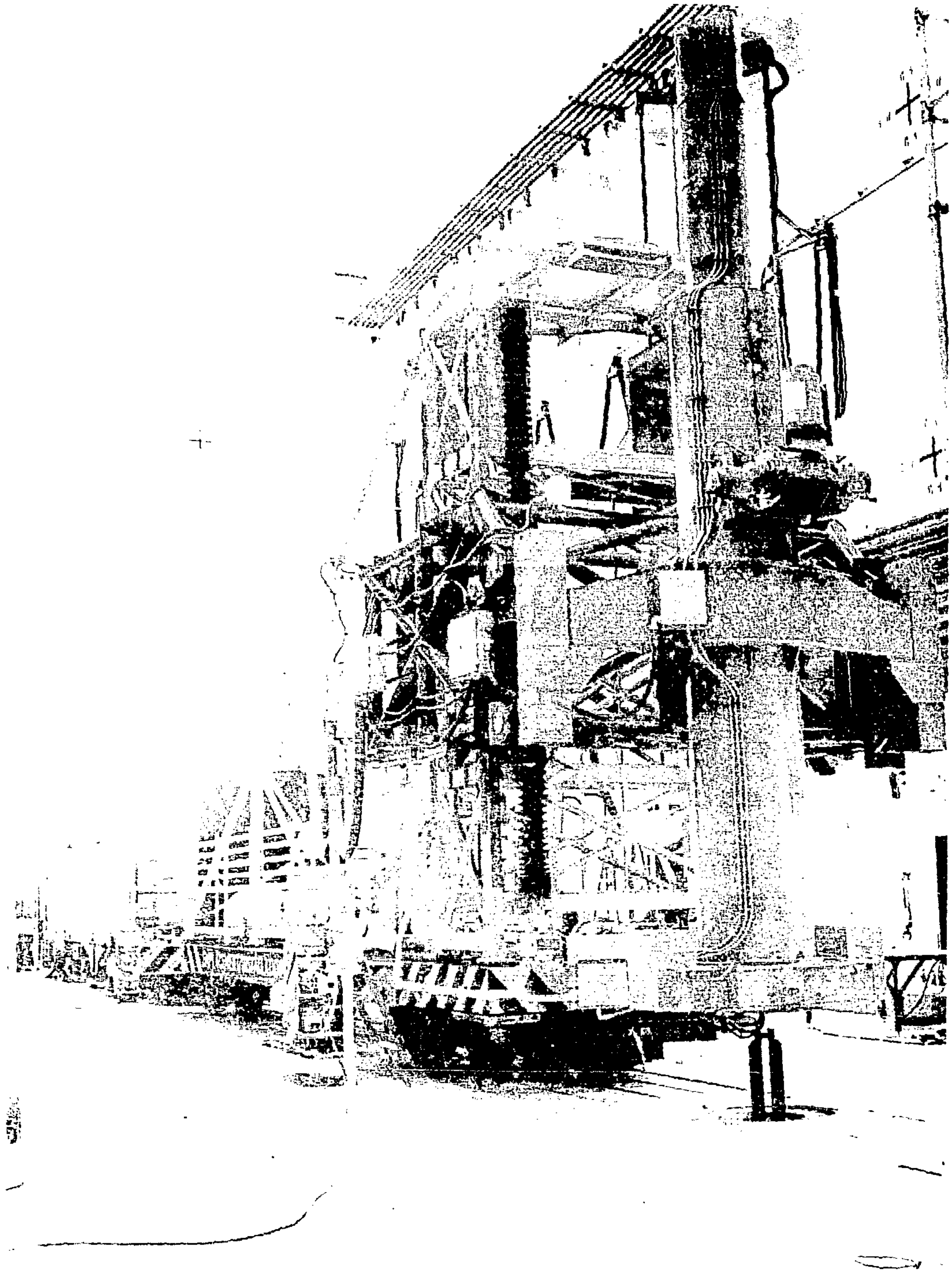

Figure 20. Transfer Vehicle Being Centered Over Transfer Pit in Hot Bay

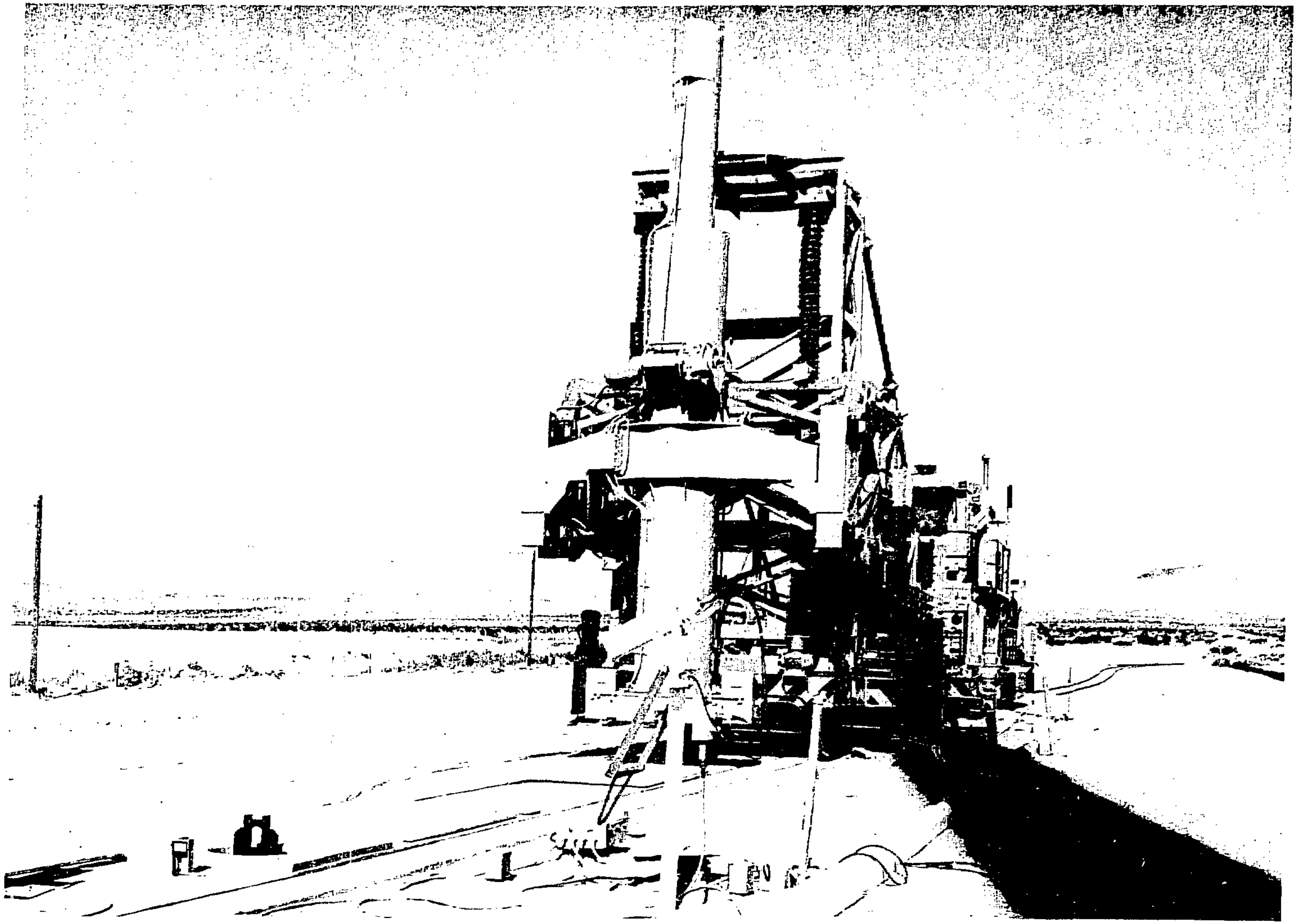

Figure 21. Transfer Vehicle After Completion of Canister Package Transfer to Drywell

Transfer of Canister Package to Sealed Storage Cask Storage

If, instead of transferring a canister package to a drywell, it is desired to place the package into a Sealed Storage Cask (SSC), a different mode of transfer is used. The SSC is transportable by truck to permit loading a canister package into the SSC in the E-MAD Hot Bay. Figure 3 shows a canister package being lowered into a SSC. This figure shows closed circuit TV cameras held by the two Wall Mounted Handling System units. These TV cameras are used by the crane operator to guide the canister package into the SSC. The truck subsequently moves the SSC to the storage site outside the E-MAD building where the SSC is lifted off the truck and placed on a foundation pad by means of a large mobile crane as shown in Figure 22.

SUMMARY

The equipment and modifications made to E-MAD to support the SFHPP Demonstration are generic in the sense that they can be used (or easily modified) to fulfill encapsulation requirements for any experimental program involving the use of encapsulated spent fuel assemblies or any radioactive waste form.

Presently, E-MAD offers encapsulation and testing equipment, experience, baseline data, and qualified computer models which are available to support other technology development programs. To further meet the future needs of nuclear waste isolation programs, the following additions to E-MAD are being installed.

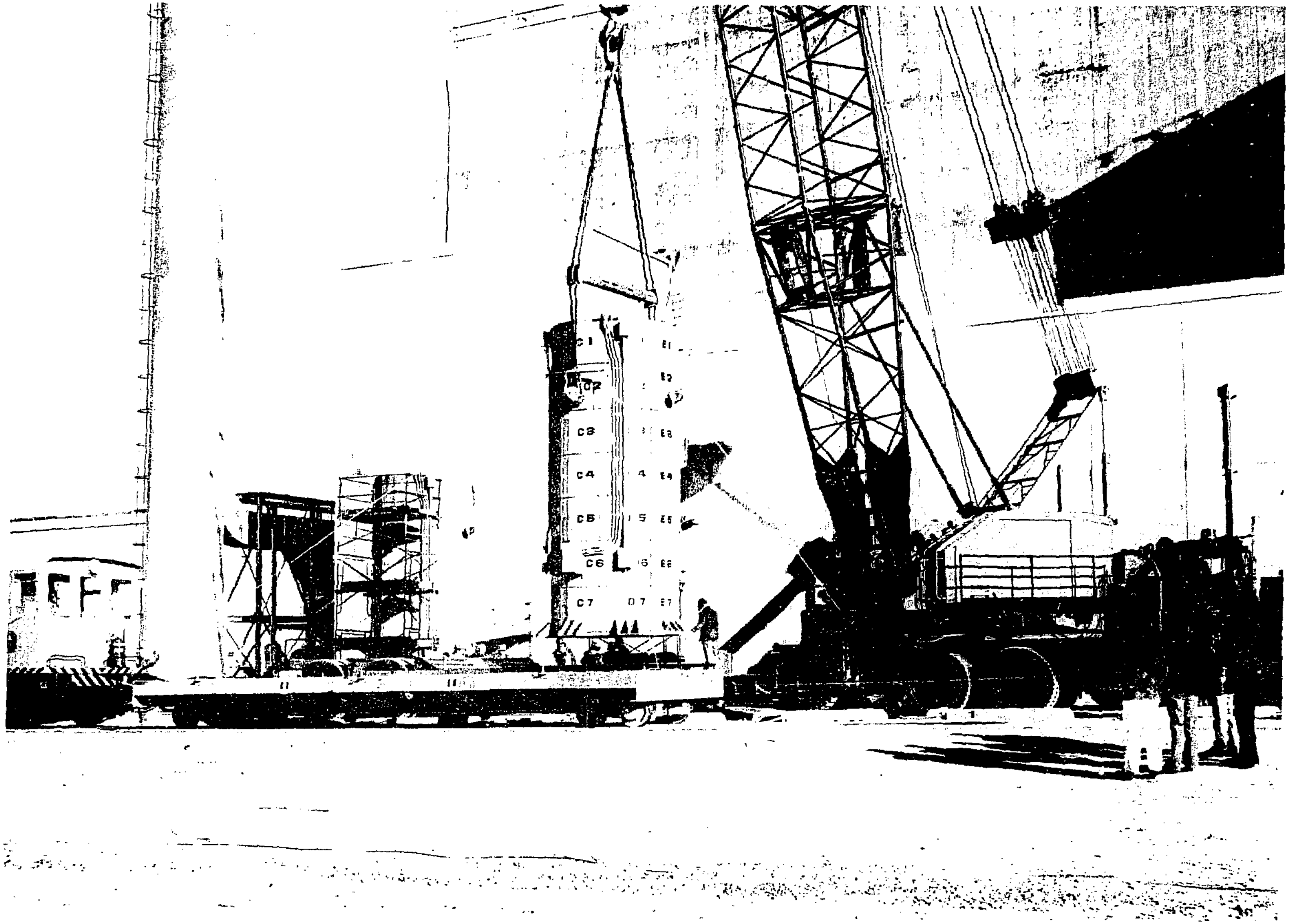

Figure 22. Sealed Storage Cask Containing Canister Package Being Lifted by Mobile Crane for Final Emplacement.

1. A fuel assembly calorimeter to accurately determine the thermal heat output of a spent fuel assembly. This hardware will provide for the remote handling and insertion of the fuel assembly into the calorimeter and subsequent remote operation of the test.

2. A canister cutting tool to remotely gain access to an encapsulated fuel assembly for post-demonstration examination.

REFERENCES

1. R. J. Steffen, et al., "Equipment Designs for the Spent LWR Fuel Dry Storage Demonstration," Trans. Am. Nucl. Soc., This Meeting (1980).

ACKNOWLEDGEMENT

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