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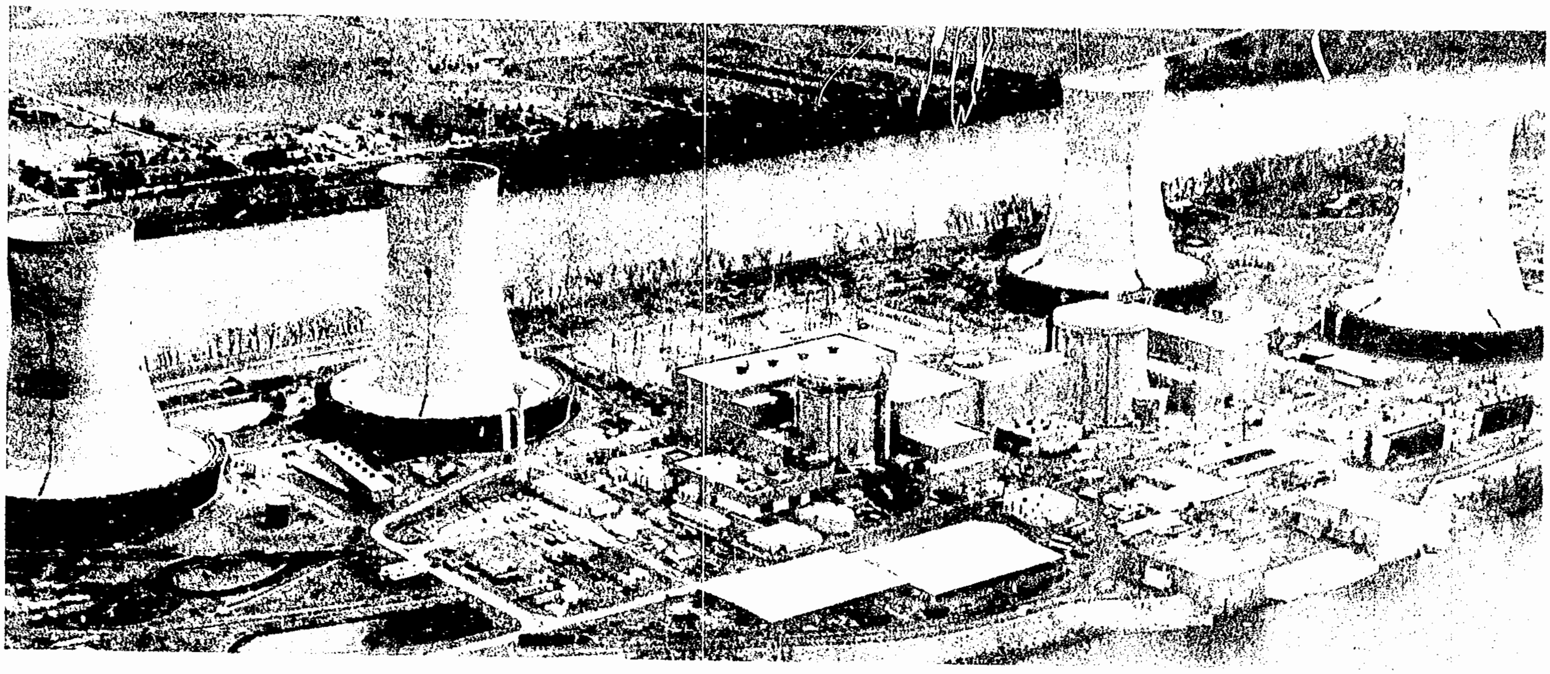

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DEVELOPMENT OF A PROTOTYPE GAS SAMPLER FOR EPICOR II PREFILTER LINERS

John M. Bower

U.S. Department of Energy
Three Mile Island Operations Office
Under Contract No. DE-AC07-76ID01570

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DISCLAIMER

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ABSTRACT

Sampling the gas in the EPICOR II prefilter liners will provide data to aid in the development of technology for safely processing highly loaded ion exchange media used to decontaminate water from the TMI-2 Auxiliary and Fuel Handling Buildings. Engineers of EG&G Idaho, Inc., developed special tooling to sample gases from the liners. Operated remotely, the Prototype Gas Sampler removes and reinstalls resin liner vent plugs, and allows for the development of procedures for purging the liners with inert gas while safely handling potentially combustible gases. This report discusses the need for developing the sampler and includes a description of the prototype and its associated systems.

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DEVELOPMENT OF A PROTOTYPE GAS SAMPLER FOR EPICOR II PREFILTER LINERS

INTRODUCTION

The March 1979 accident at Three Mile Island Unit 2 resulted in the transfer of approximately 500,000 gallons of water to tanks in the Auxiliary and Fuel Handling Buildings. This contaminated water was processed through EPICOR II, a three-stage ion exchange media cleanup system during the period from November 1979 to August 1980.

The system consists of three resin beds in series. The first bed, called a prefilter, performed gross removal of cesium and strontium. The two remaining beds accomplished final cleaning. Curie loading in the prefilters is in the range of 160 to 2,200, with radiation levels up to 2,800 R/hr on contact.

Prior to shipment of one loaded prefilter from TMI in May 1981 to Battelle Columbus Laboratories (BCL) for characterization, the liner was placed in a shielded pit in the Chemical Cleaning Building and manually vented. No gas sample was obtained. However, the area combustible gas detectors alarmed when the liner was vented. Shortly after the liner arrived at BCL, a gas sample was drawn that confirmed the presence of hydrogen gas and indicated a depletion of oxygen; the liner contained 12% hydrogen and 0.2% oxygen. Based on this information, it was decided that the EPICOR II prefilter liners stored at TMI should be sampled for gas, vented, and purged with inert gas if required, prior to shipment from the island.

EPICOR II Liner Description

The EPICOR II liner is a four-foot diameter, five-foot high, right circular cylinder containing approximately 30 ft^3 of ion exchange media. It is of welded construction, fabricated from carbon steel. The walls and

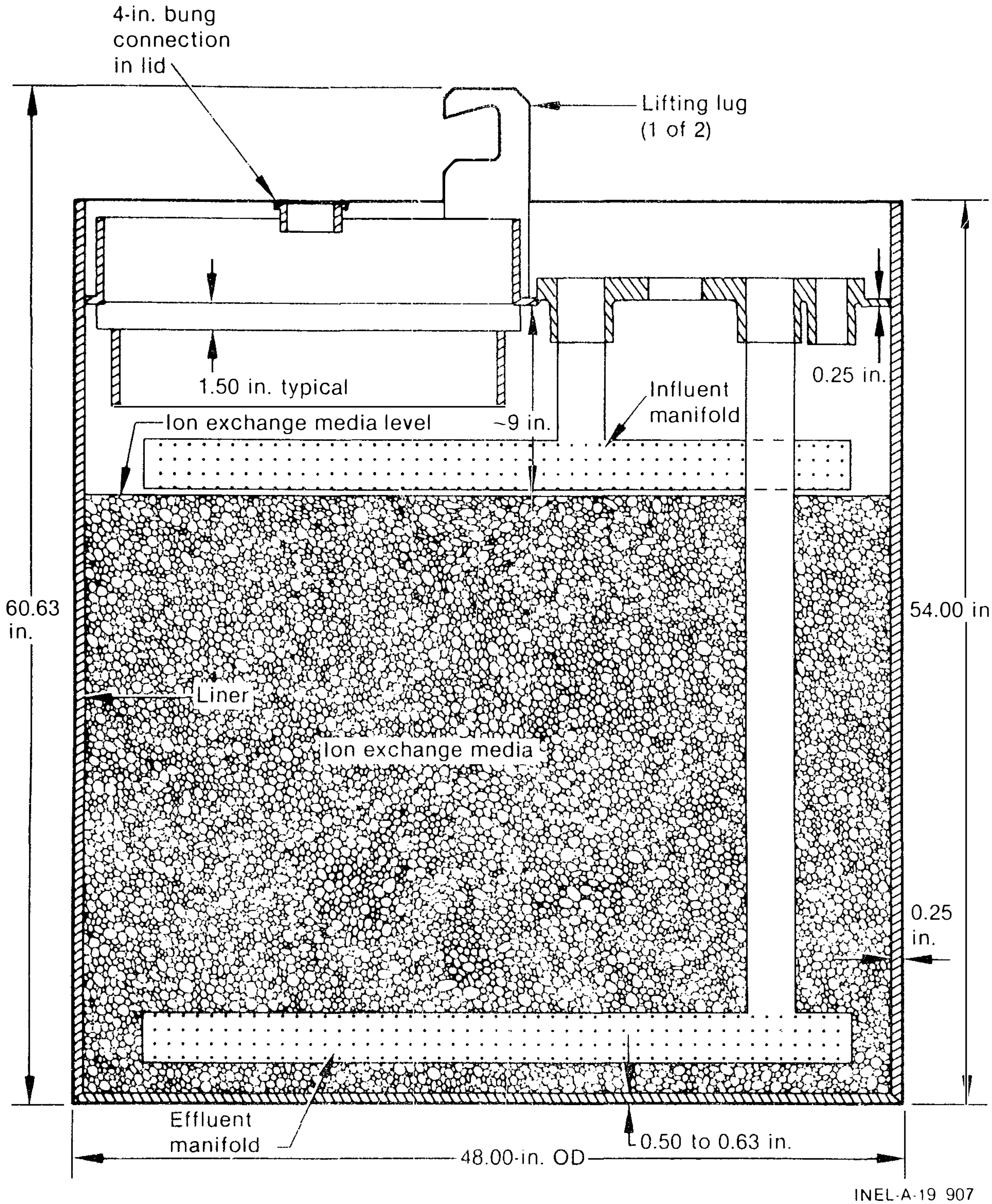

Figure 1. Cross-sectional view of a typical EPICOR II liner.

top are 1/4 in. thick, the bottom 1/2 in. thick. Phenoline 368 coating is on the inner surfaces of the liner to retard corrosion. Figure 1 shows a cross-sectional view of a typical EPICOR II liner.

The liners are believed to contain three types of organic ion exchange media (anion, cation, and mixed bed) and, in some cases, also inorganic zeolites.[a] This material fills the liner to within approximately nine inches of the top. Therefore, there is a void above the bed where gases may collect, nine inches high and four feet in diameter. Access to this void is through the manway (a 55-gallon drum lid sealed to the liner top), the 2-in. pipe-threaded vent port, and the 2-in. pipe-threaded inlet port in the influent manifold. Since the vent is not always in the same location, the liner configuration determines which of the three ports is the vent. This in turn leads to various locations for the influent and effluent ports. Various configurations of the liner tops are shown in Figure 2. The liner is handled by a lifting bar that engages the two lugs extending 6.5 in. above the side walls of the liner.

Liner Storage

After loading, the liners were removed from their service position in the Chemical Cleaning Building and transferred to the Solid Waste Staging Facility using a shielded transfer cask.

The Solid Waste Staging Facility is an array of concrete vaults, each of which is seven feet in diameter and thirteen feet deep. Each vault has a three foot thick concrete cover with a rain seal between the cover and vault lip. There is a total of 120 vaults in two modules, each containing ten rows of six vaults. This facility is located out of doors adjacent to the Unit 2 cooling towers. Figure 3 shows a cross section and plan of one of these modules.

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a. The EPICOR company considers resin make up to be proprietary information.

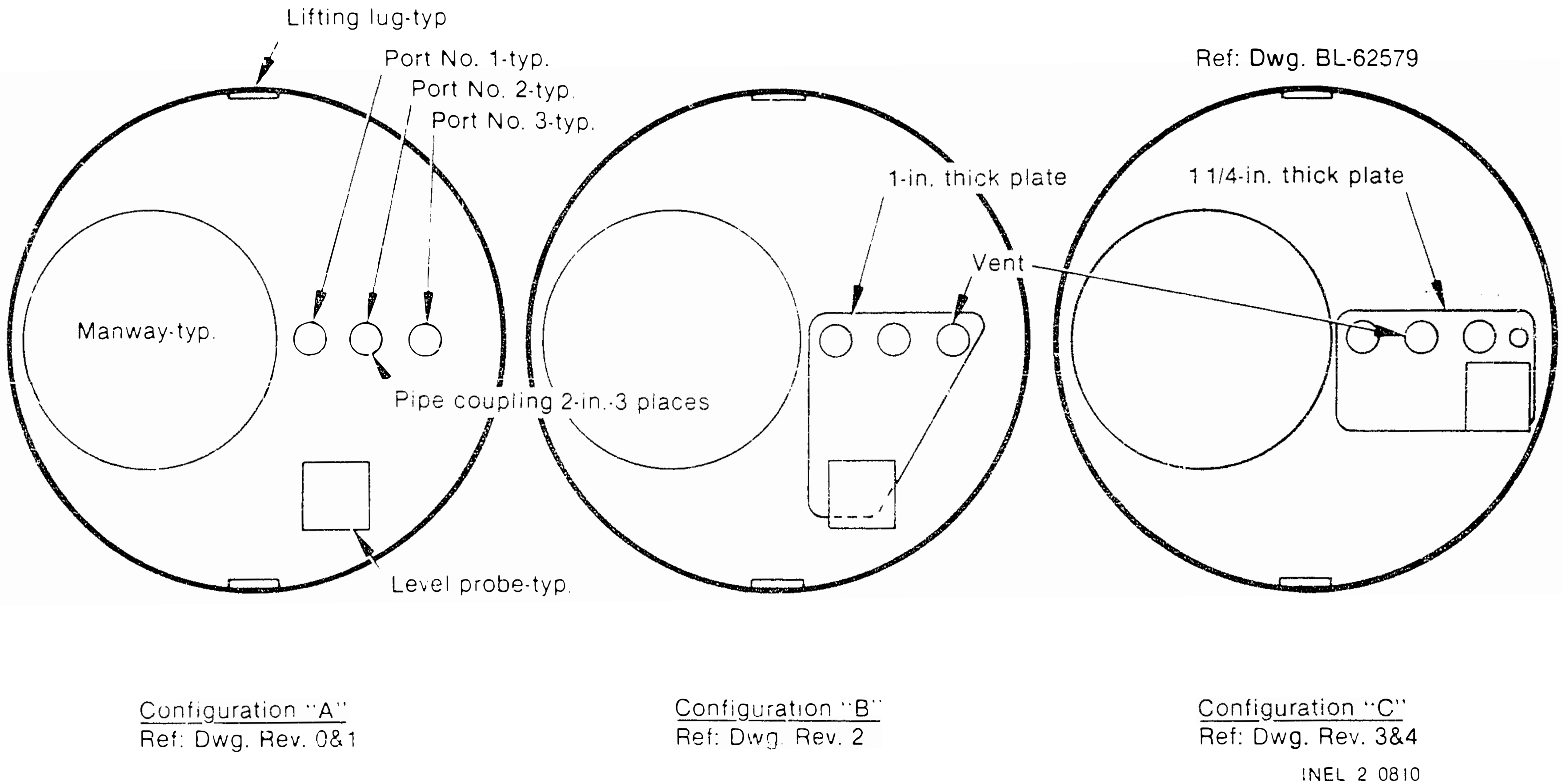
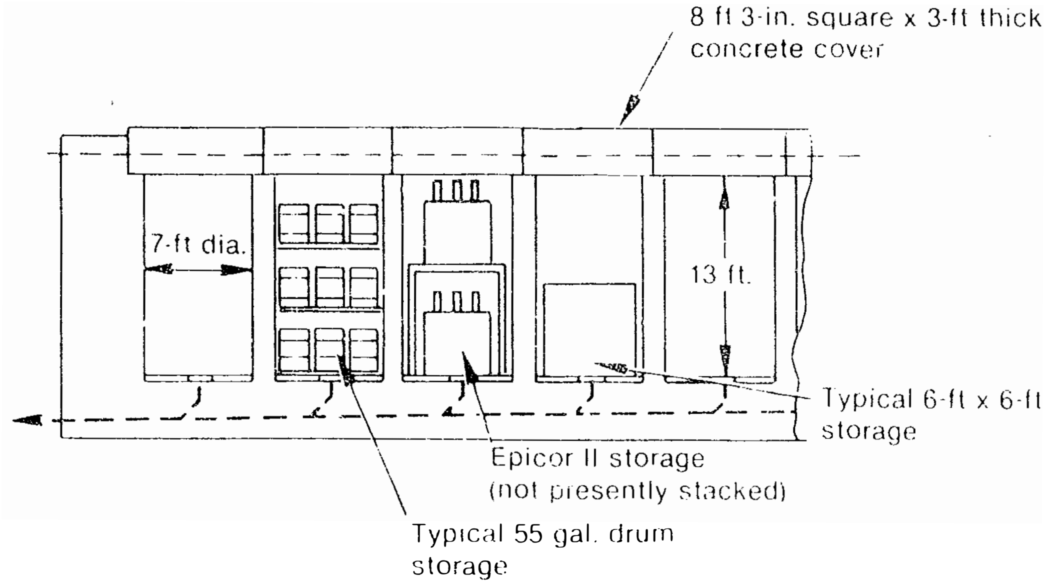
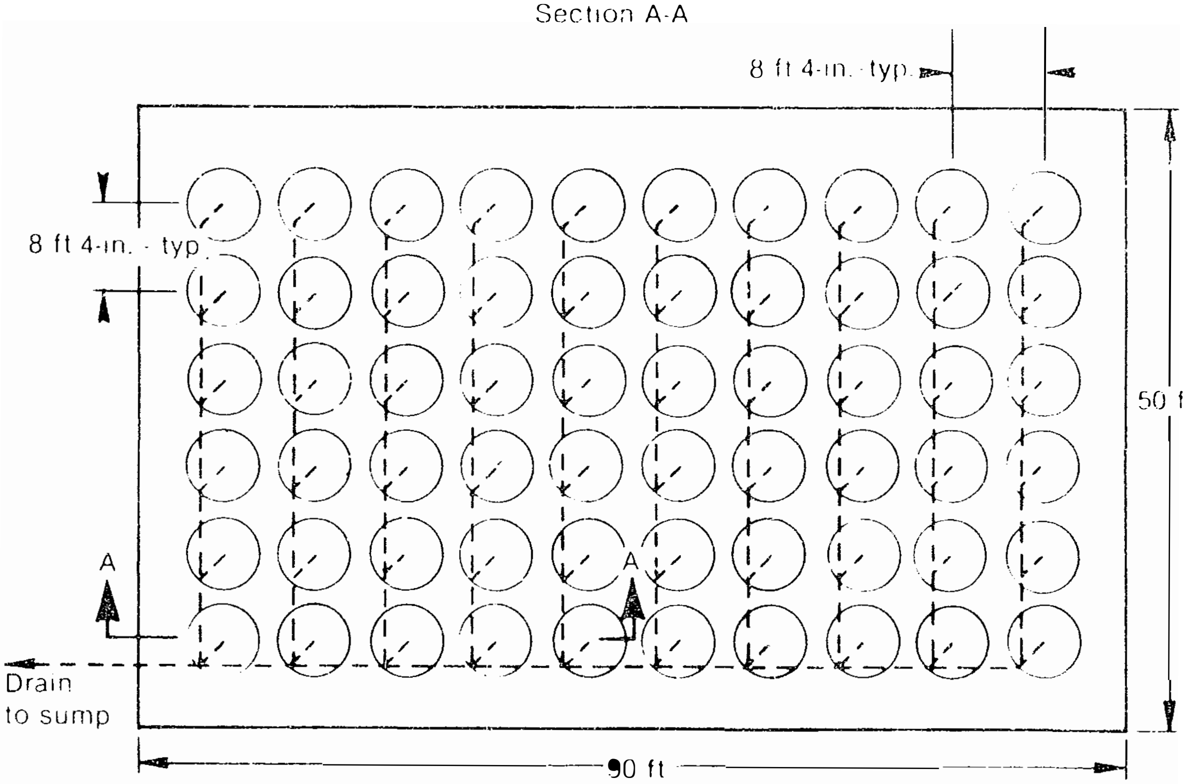


Figure 2. Various liner top configurations.



Section A-A



Plan View Module A

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Figure 3. Solid waste staging facility.

The liners, in the transfer cask, were lifted above the vault using the mobile crane and then lowered until they were sitting on the vault floor. Presently, 49 highly-loaded prefilter liners are sealed and stored in the facility, one to a vault.

The gas sampling and venting must take place in these vaults prior to moving the liners. The liners are approximately centered, but their orientations are not known. Once they have been vented and resealed to ensure acceptable gas composition, they can be loaded into an appropriate shipping cask. This will be done over a six-month to one-year period.

DESIGN OF THE PROTOTYPE GAS SAMPLER

Breaching Containment of the Liners

An evaulation to determine the most appropriate method to breach the gas-containment boundary of the liners was undertaken by GPU and EG&G Idaho after Prefilter 16 was shipped to Battelle. Prefilter 16 was vented at TMI when located in its service position at the Chemical Cleaning Building. The liner was in a pit with two shield plugs over the top of the pit, the plugs having holes positioned directly over the liner ports. A shaft surrounded by a shroud was engaged in the 2-in. pipe plug and manual force applied to the shaft.

Two main problems developed during removal of the pipe plug. First, the amount of torque required to break the plug loose was far greater than anticipated. Second, a combustible gas detector alarmed and continued to alarm for some time. This detector did not indicate the amount of gases present, only that a combustible mixture existed in the vicinity of the liner vent port.

Breach methods evaluated included (a) flexing the drum lid to break its seal, (b) puncturing the liner mechanically or with acid, (c) installing a self-tapping threaded valve, (d) removing the drum lid, and (e) unscrewing the 2-in. pipe plug. Unscrewing the 2-in. pipe plug was chosen, considering it had successfully beer used on Prefilter 16.

Objectives and Design of the Gas Sampler

The objectives of the prototype gas sampler are two. First, information is to be obtained which will aid in determining what reactions occur in this type of radioactive waste. Data on the liners will include identity of the gases, quantities present, and pressure within the liner. Second, the device is to vent hazardous gases from the liners to ensure the liners' safe storage and shipment. Venting must be controlled into a filter system.

Because the objectives and the environment for the sampling/venting imposed several operating constraints, it was decided that the operation be done at the Solid Waste Staging Facility. The Chemical Cleaning Building is in use, and the desire is to vent the liners prior to any movement.

The following basic design requirments were developed to meet these objectives and constraints:

- Safely operate in a hydrogen environment
- Breach the liner's gas-containment boundary in a fully remote mode
- Withstand the radiation field of the liner
- Discharge any gases to a controlled system
- Obtain measurement of liner pressure
- Reseal the liner
- Operate in an outdoor environment
- Have a life capable of venting 50 liners.

DESCRIPTION OF THE PROTOTYPE GAS SAMPLER

The sampler performs three basic functions in a remote mode. First, it precisely aligns the tool with the 2-in. pipe plug. Second, it shrouds or houses the plug in order to capture any gases released from the liner. Finally, it applies a torque wrench to unscrew the plug.

The sampler is lowered onto the liner by a hoist system with a suspension point some 16 ft above the top of the liner. This enables the sampler to be positioned such that the channel-shaped guide brackets attached to the sampler base plate are engaged onto the liner's two lifting ears as shown in Figure 4. These guide brackets provide a rough alignment of the sampler onto the liner, and transmit the torque out of the sampler back into the liner during plug rotation. Clearance between the brackets and lifting ears prevents binding. Bronze is used on the inside surface of the brackets to reduce spark potential.

Whereas the sampler is positioned over the liner by this action, it does not achieve precise alignment for the 7/8-in. square tool tip (see Figure 5) to be engaged in the pipe plug. Precise alignment is obtained using an air-motor-driven threaded tool positioning system that can move the tool centerline anywhere within a 2-in. diameter area. The system is a Model 250 Trachyon Corporation air motor driving a bronze threaded drive nut as shown in Figure 6. A threaded eye bolt is attached to the carrier assembly containing the tool drive and sample housing (shroud). The carrier assembly moves relative to the base plate and guide brackets, thereby enabling the tool to be moved relative to the liner lifting ears that are restraining the sampler base plate. The carrier assembly is pushed away from the drive nut, whose axial position is stationary on the base plate, or pulled toward it, depending on the direction of nut rotation. Two of these systems, 90° apart, allow the tool to be located within the 2-in. diameter area at a speed of approximately one in. per minute. Surfaces that have relative motion are made of nonsparking material. The sampler is electrically grounded to the liner and to its remote operating facility by way of a 100-foot grounding wire.

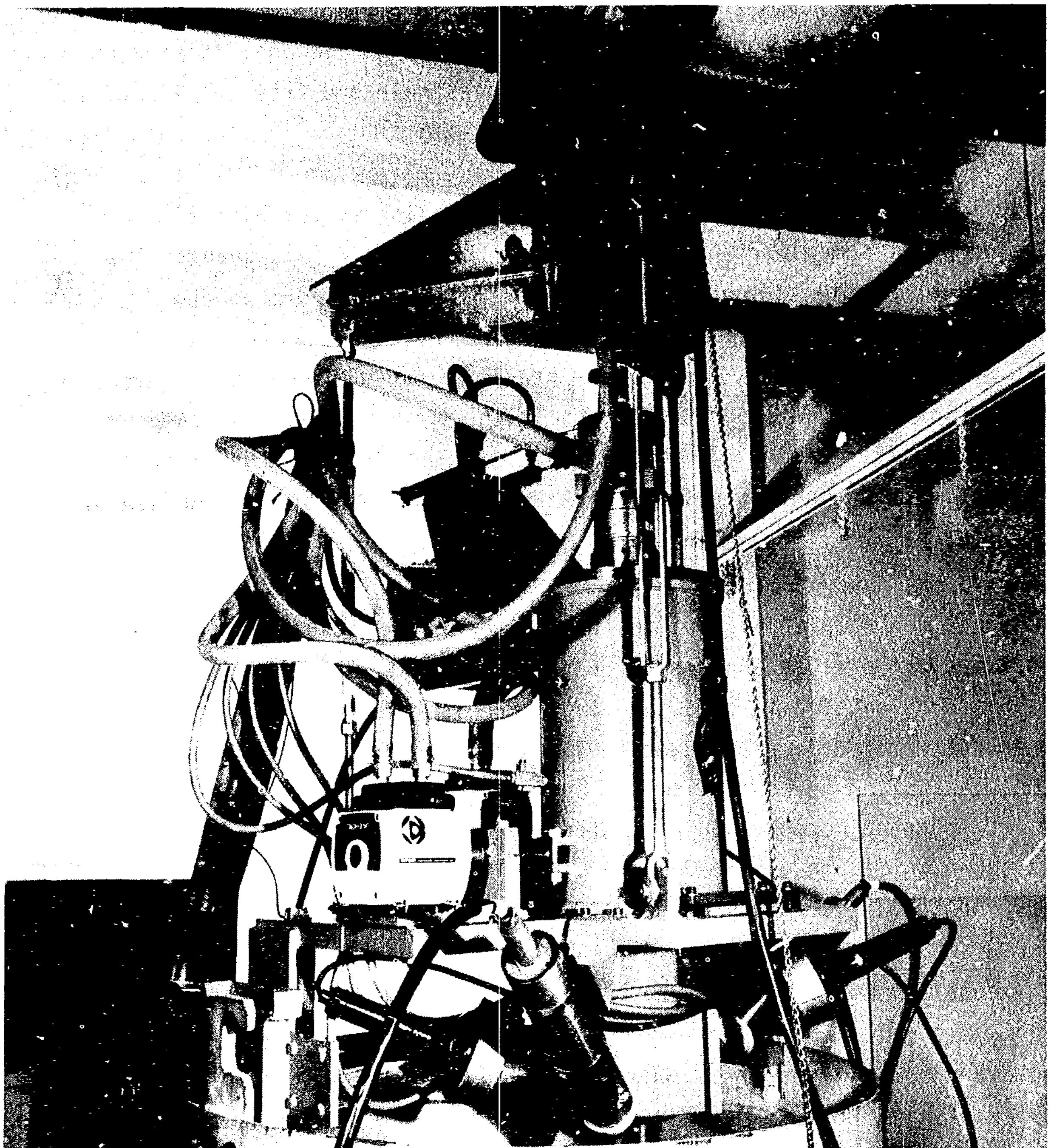
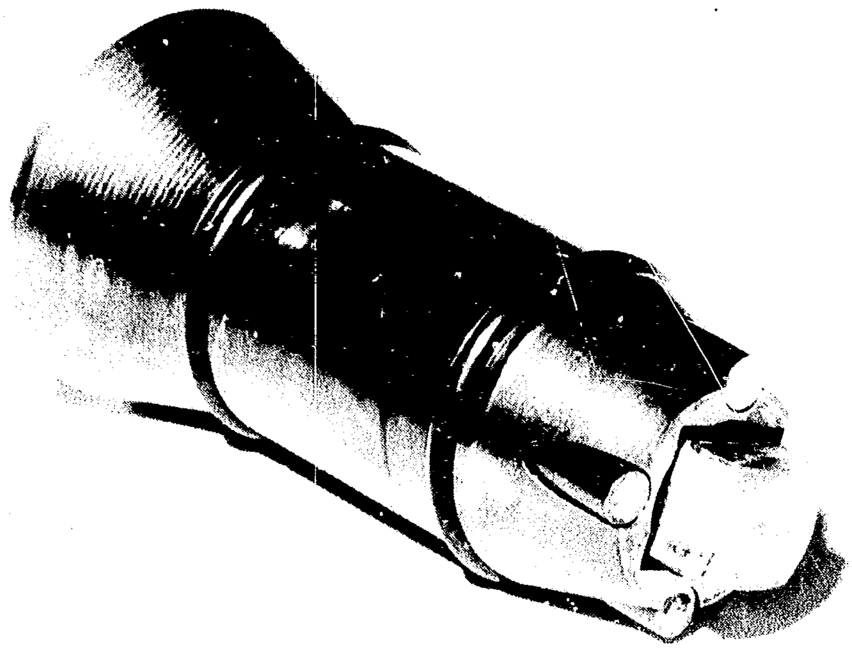


Figure 4. Sampler engaged on liner's two lifting lugs.



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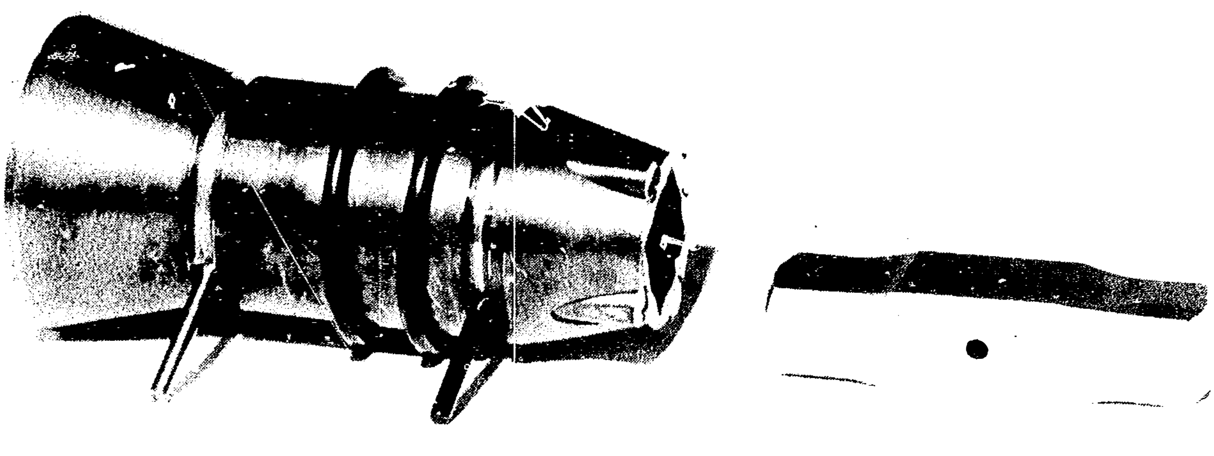

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Figure 5. Tool with 7/8-in. square tip, inserted and removed.

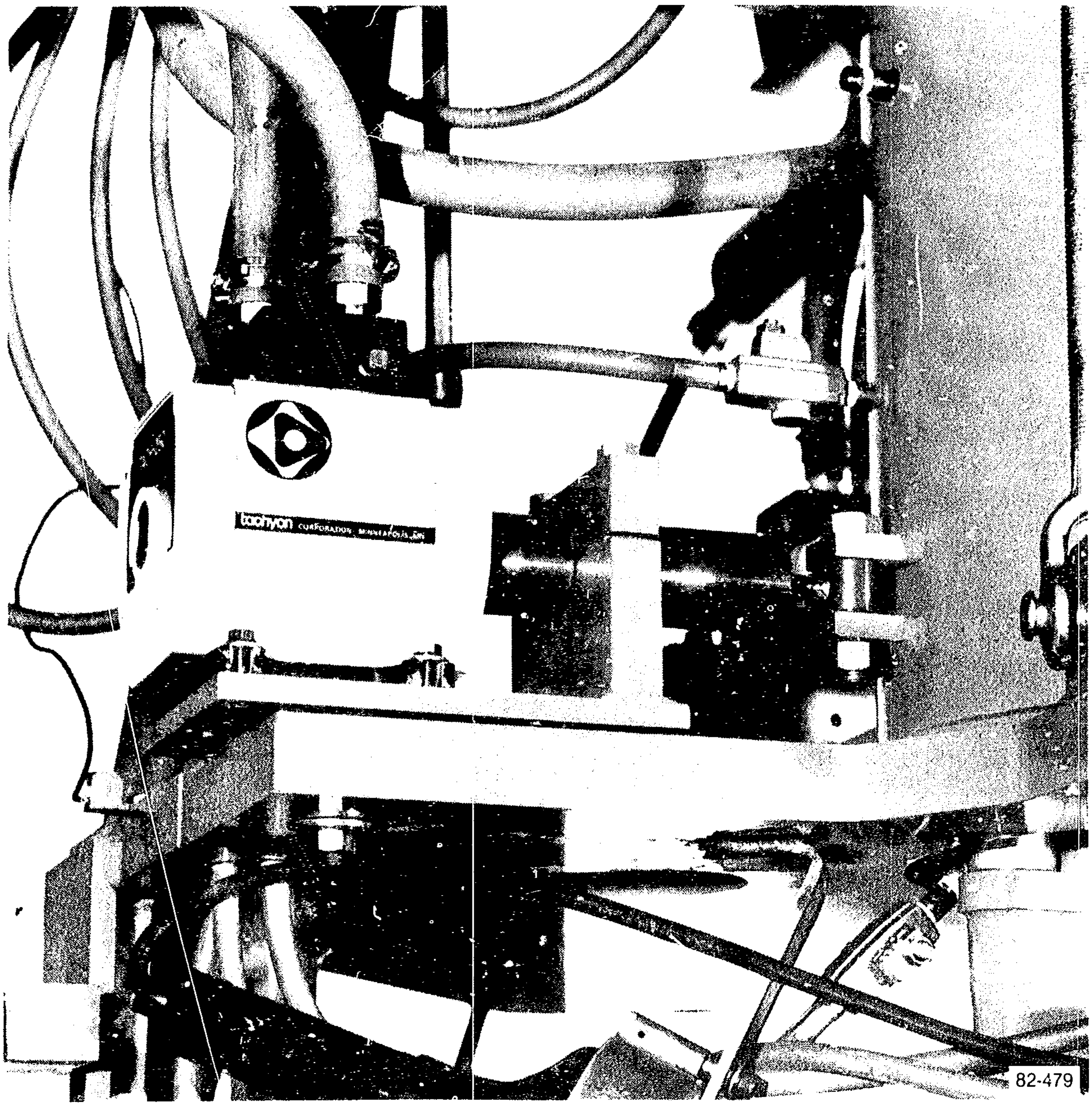

Figure 6. Sampler positioning system.

Visual indication of the tool-tip position relative to the plug is provided by a TV system. Two Model 2505-012 Cohu cameras, attached to the sampler approximately 120° apart, view the plug region during alignment. Their signal is transmitted to 9-in. monitors located by the control panel. Figure 7 shows an image from one of these monitors.

During alignment, the sampler is suspended from the hoist with the guide brackets engaged over the lifting ears and the bottom of the sample housing about 5 in. above the liner. Figure 8 shows the sampler in this position with the tool engaged. When the tool is engaged in the plug, the sampler is lowered until the bottom of the housing is seated on the liner.

The 5-in. inside diameter housing surrounds the tool drive. This housing is sealed against the liner with a Buna N rubber gasket. Double O-rings seal the tool drive shaft where it passes through the upper end of the housing. Enough of the sampler's weight rests on the housing to ensure a good seal and to prevent the housing from being lifted by liner pressures within the liner up to 19 psig. A Lexan window allows one of the TV cameras to view the plug during removal or insertion. Figure 9 shows the monitor image through this window. Figure 10 shows a cross section view of housing and drive system.

Two 1/4-in. ports in the housing allow the introduction of purge gas and withdrawal of sample gases. The purge gas port is located in the bottom section of the housing, the sample port in the upper. The ports are connected to flexible stainless steel lines.

The drive system used to remove the plug is a Model PT-6 Mountz pneumatic torque wrench. This non-impact system is capable of producing 2,500 ft-lb of torque with a maximum unloaded speed of 5 rpm. It is driven by 70 psi air with a maximum flow of 40 CFM. The amount of torque is controlled by varying the air pressure and speed by varying the air flow to the wrench. Therefore, by reducing the air pressure lower torques can be applied, and by reducing air flow lower speeds can be obtained. An air pressure regulator and a ball valve are used to control the torque wrench.

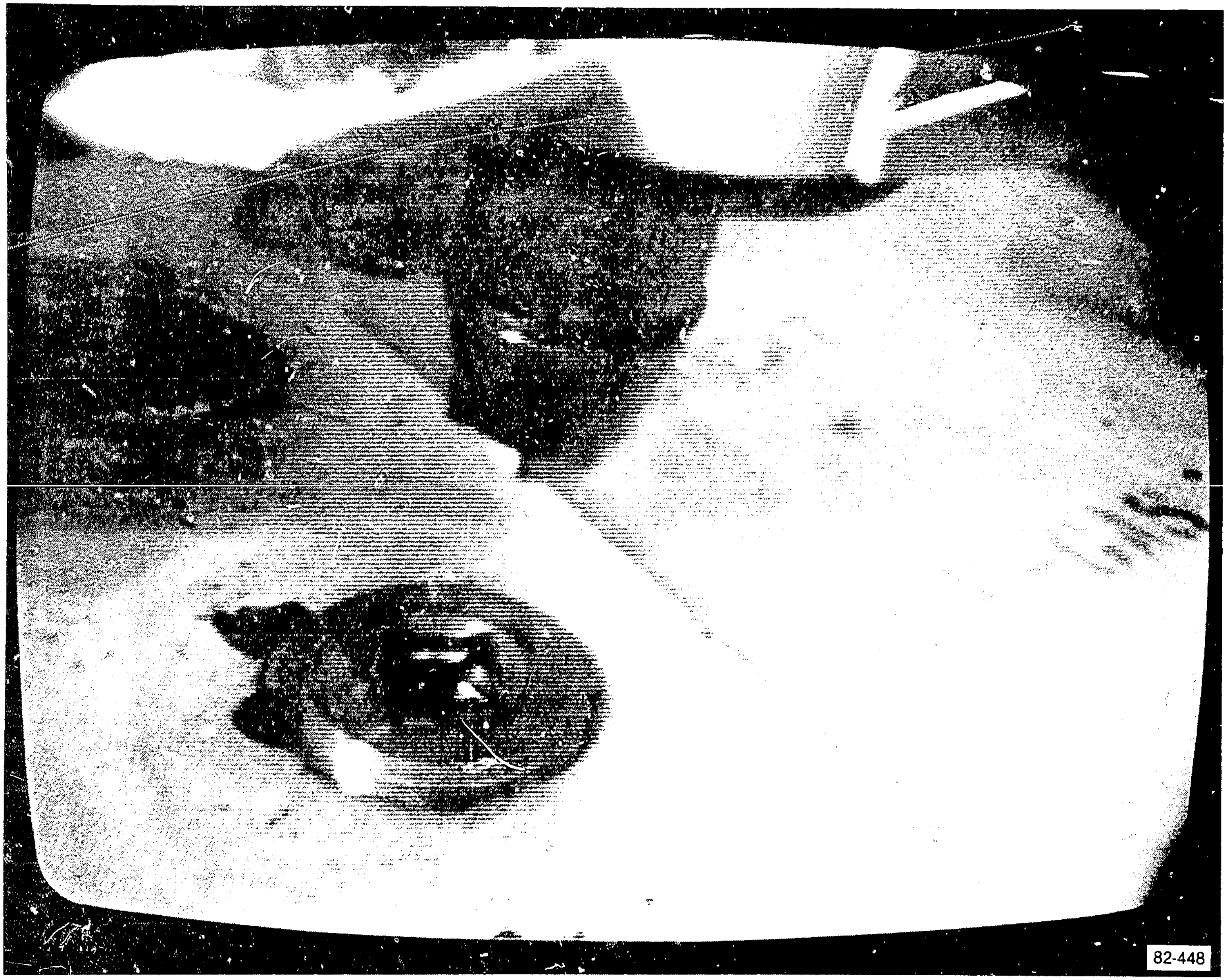

Figure 7. TV monitor image of tool tip and plug alignment.

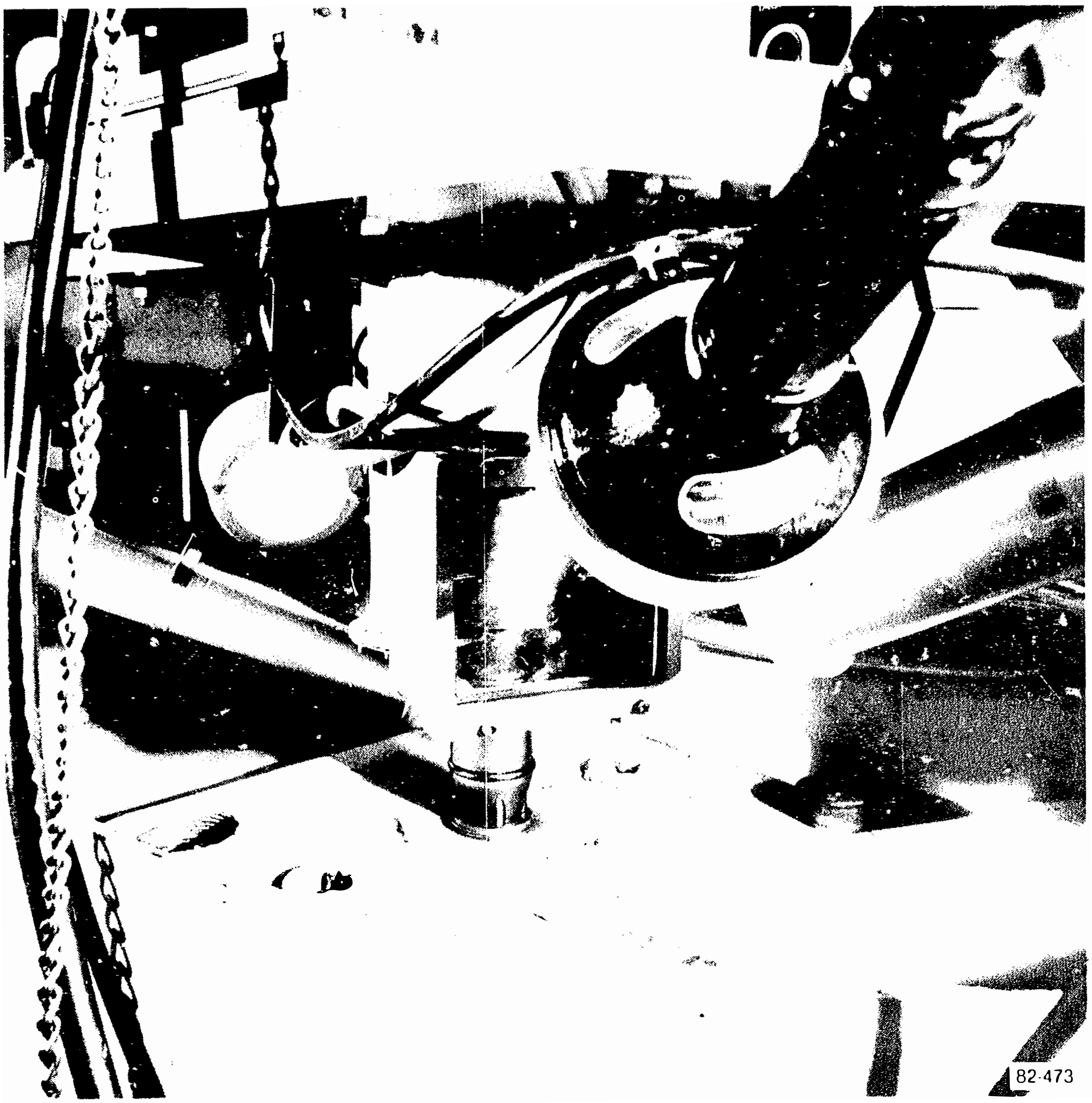

Figure 8. Sampler engaged with housing raised.

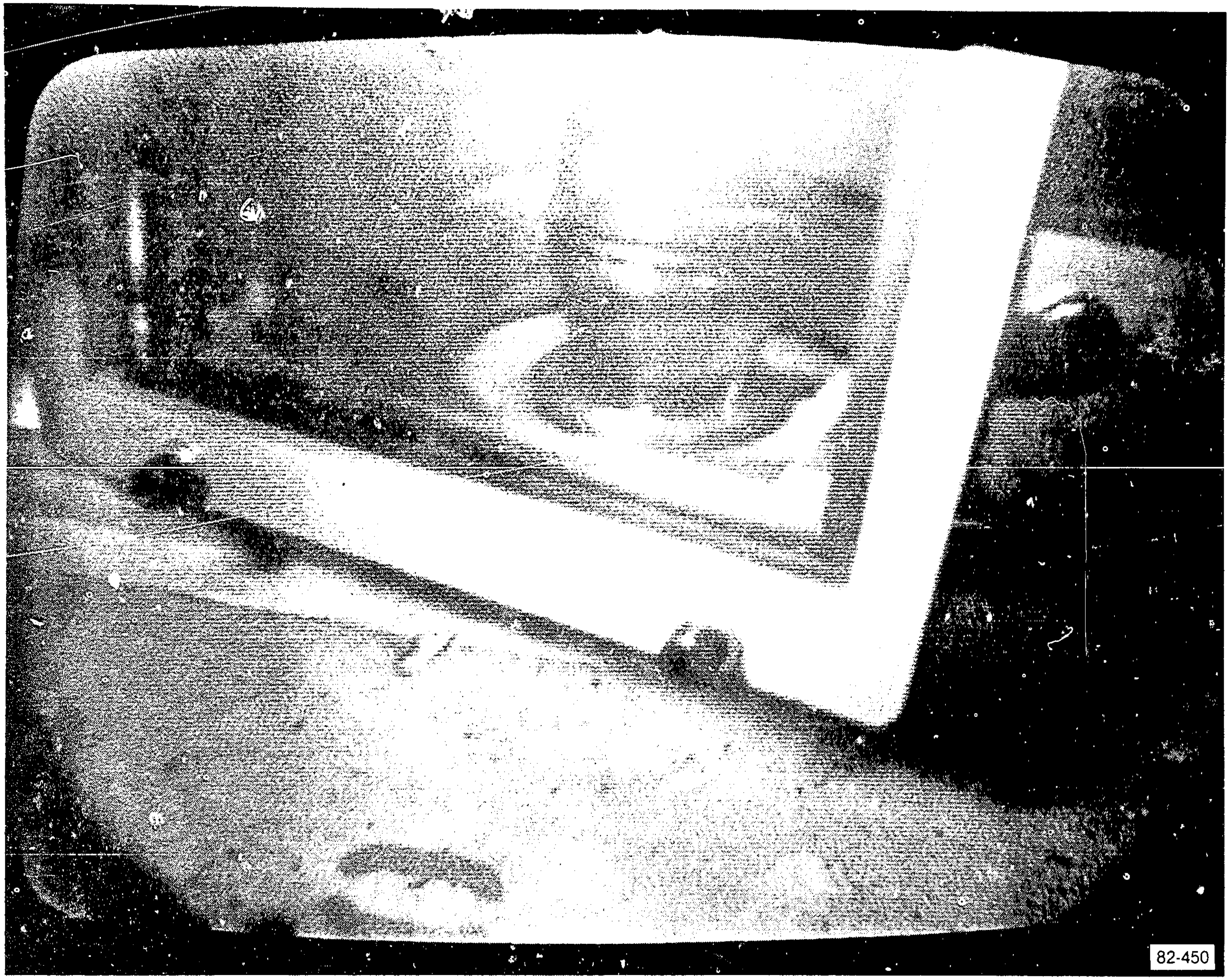

Figure 9. TV monitor with image of plug insertion and removal.

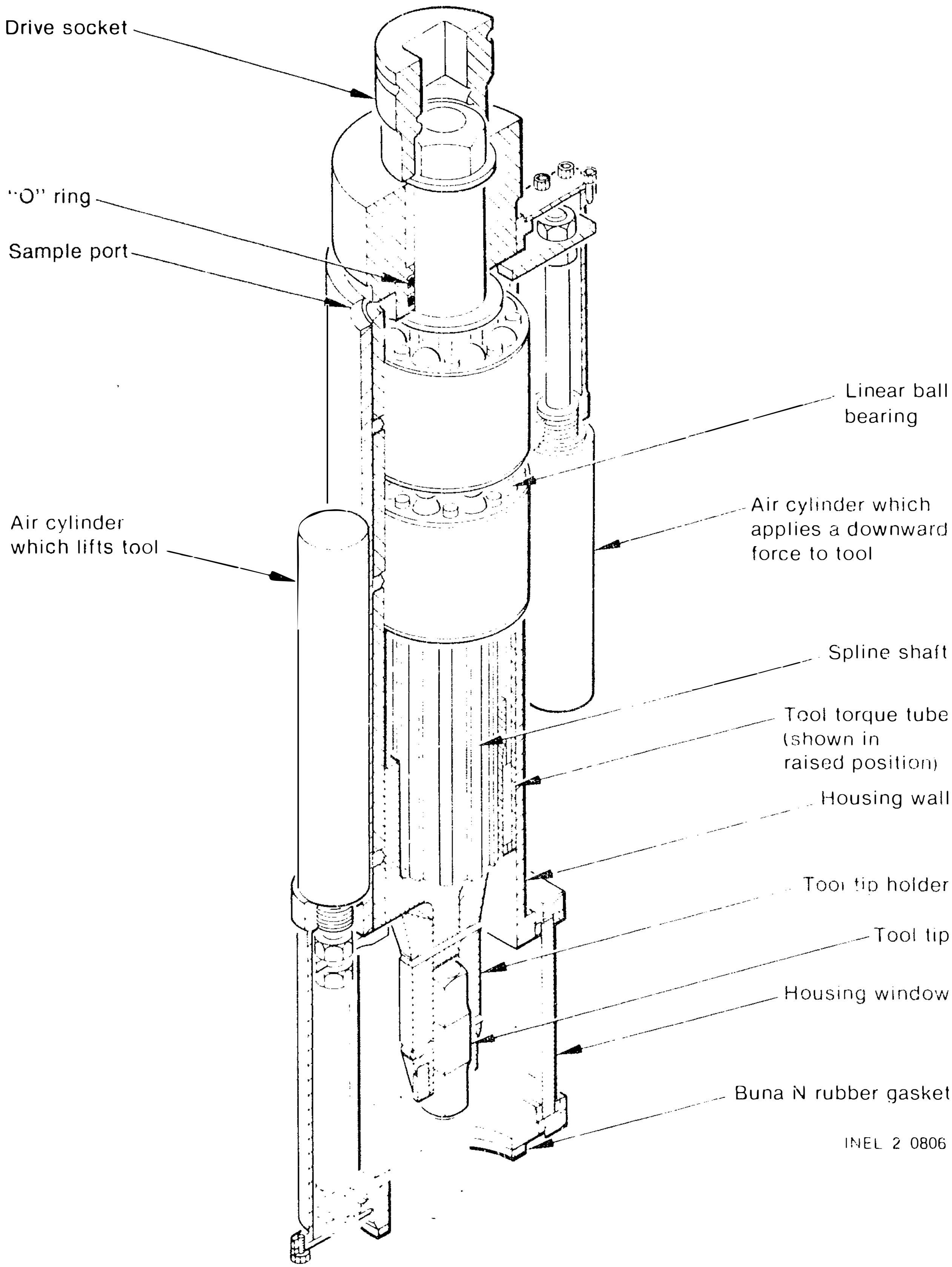

Figure 10. Cross-sectional view of sampler housing.

A ball bearing spline permits vertical movement of the plug during unthreading/threading and lifting of the plug from the port. Air cylinders mounted on the housing allow the tool tip to be either raised or lowered. This enables the plug to be lifted clear of the port after unscrewing, since the tool tip is designed to secure the plug to itself with sufficient force to pick the plug up, but not of such force to prevent the tool from disengaging from the plug after reinstallation. Also, a downward force can be applied to the tool to force it into the plug. Figure 11 is a cross-sectional view showing these cylinders.

The two air cylinders that operate a cable mechanism to change the direction of rotation, i.e., from plug removal to plug installation, are shown in Figure 12. All of the air that operates the sampler is exhausted from the storage module. An overall view of the sampler is shown in Figure 13.

The sampler is used in conjunction with a concrete block house that rests on top of the storage module after the module's cover has been removed. This block house contains a mirror-window arrangement that enables viewing of the sampler while it is being lowered into position on the liner. Also included in the total apparatus is the hoist system and piping that is used to blanket the storage module with an inert gas. This, along with inerting the sampler housing prior to plug removal, helps reduce the dangers associated with hydrogen. An operations trailer houses the sampler's control panel, TV monitors, TV camera controls, gas chromatograph, air compressor, and operations personnel. This remote operation's facility is connected to the sampler by a 100-ft umbilical.

Gas Sampling Technique

The sampler removes the vent plug, and the plug is lifted up out of the port. The gases contained in the housing, including those vented out of the liner, are circulated to mix the liner gases with the housing purge gases. Following this circulation, a sample of the gases are passed through a Perkin Elmer gas chromatograph. The gas volume is then discharged through a monitored HEPA filter system into the atmosphere.

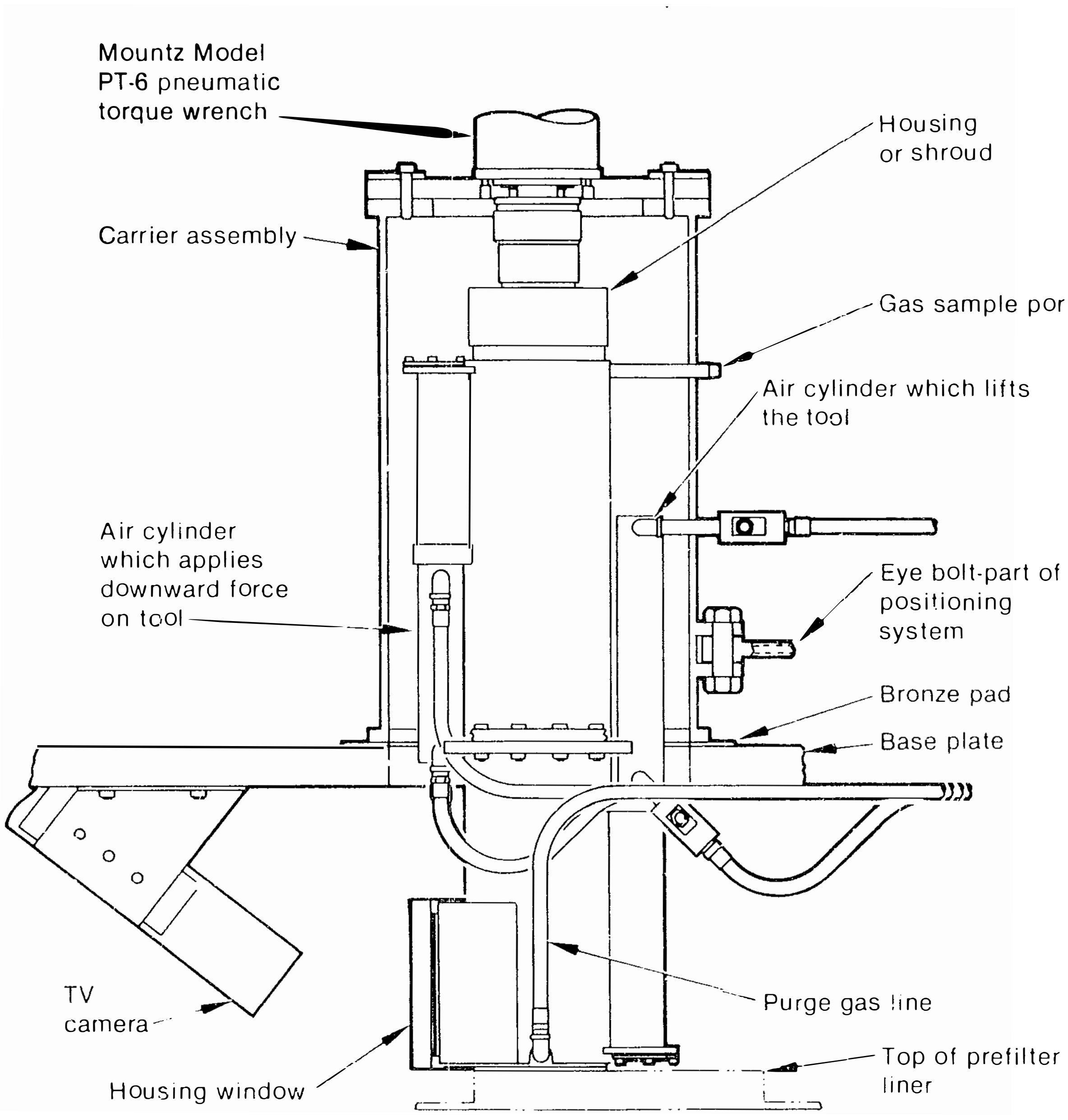

Figure 11. Cross-sectional view of sampler.

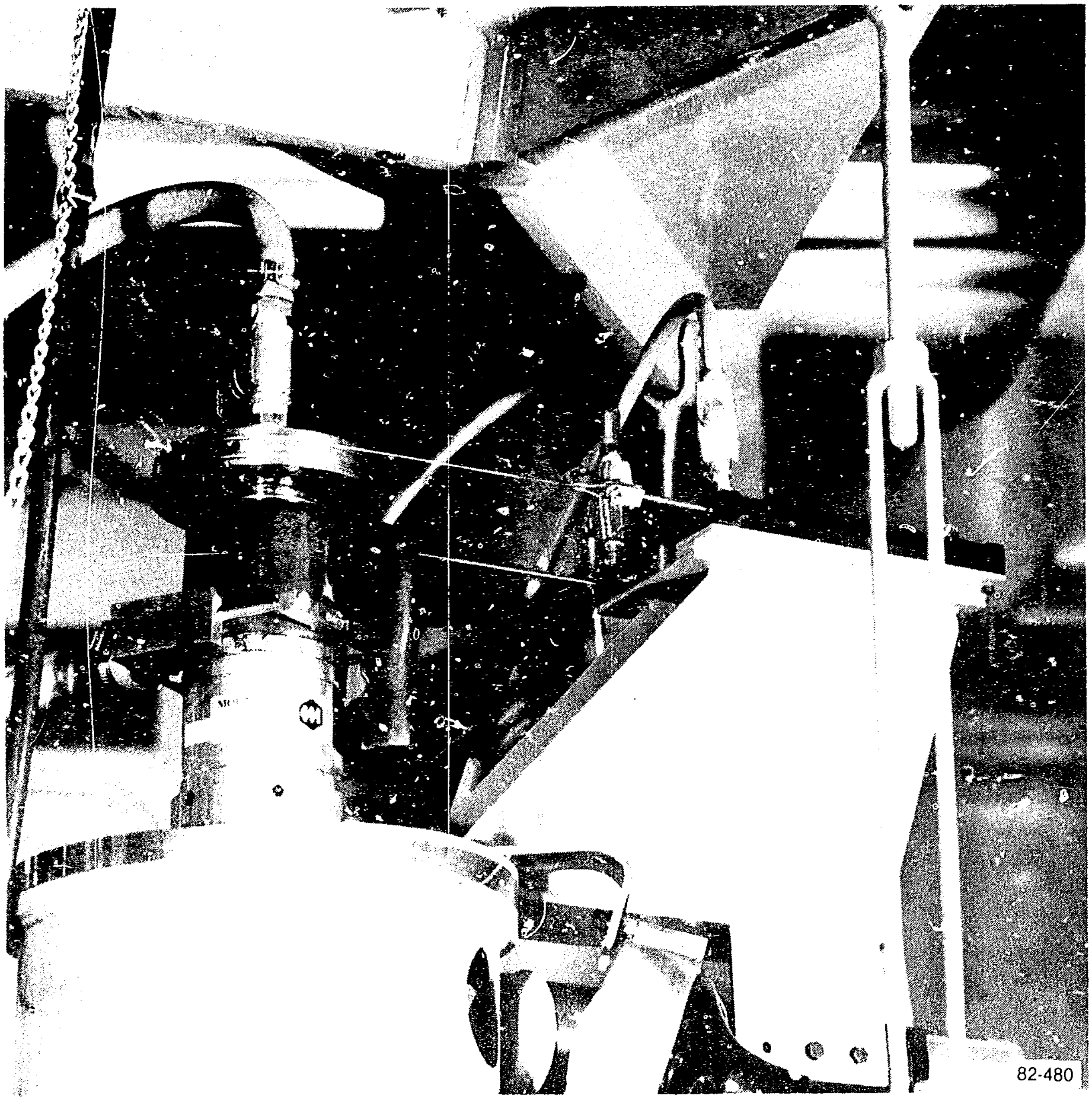

Figure 12. Direction control for Torque Wrench rotation.

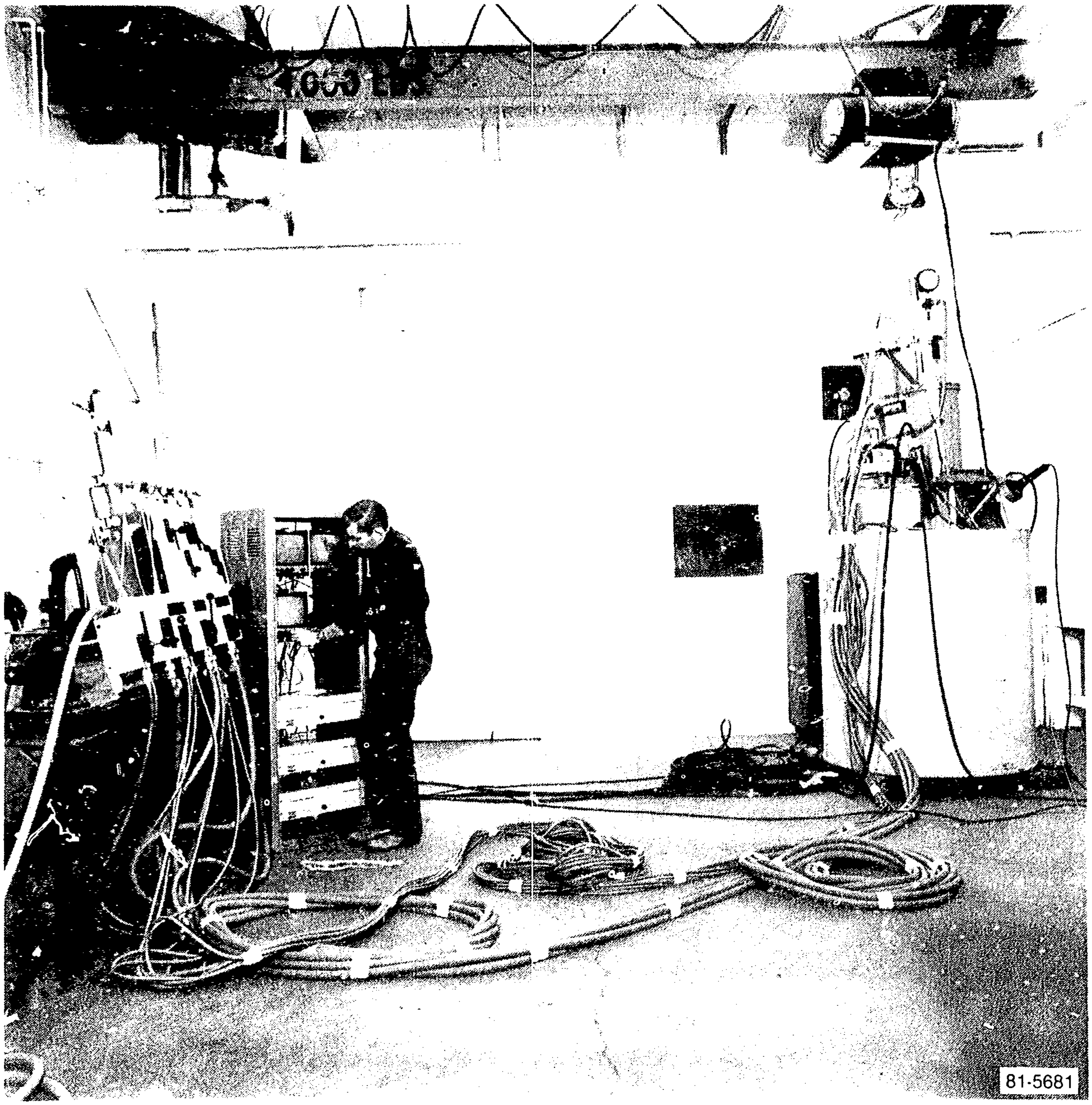

Figure 13. View of sampler, liner, and control panel.

Purging of the liner is accomplished by pressurizing the housing to 5 psig and pumping down to 1 psig. Other samples are taken until the absence of gases other than the purge gas indicates the liner has been completely purged. When determined that the liner is completely purged, the plug is reinstalled in the port by the sampler. Preliminary testing with helium introduced into the liner took 10 to 15 repetitions of the cycle to purge all the helium.

After sampling, the plug is lowered back into the port, the direction of tool rotation is placed in the tighten position, and the plug is screwed back into the port. Control of torque is by regulating the air pressure applied to the pneumatic torque wrench. Tool tip disengagement is accomplished either by the tool lift cylinder or by raising the entire sampler with the block house hoist system. After the sampler has been lifted up into the block house, the entire structure is removed from the storage module.

Testing

Several tests relating to the entire sampling/venting operation have been conducted in preparation for the first liner. Among them were explosion testing with hydrogen gas, checkout of the sampler, and data gathering on the first liner.

Scoping model tests with hydrogen were performed. These involved hydrogen explosions in 55-gallon drums to aid in predicting the liner's drum lid response, and operation of the TV camera and light in a hydrogen environment. One of the primary concerns with an explosion is the spread of radioactivity. Based on the results of these tests, bounding conditions were identified and safety barriers developed. Safety assessment documents were prepared addressing the performance of the sampling/venting operation (see reference 1). A test to demonstrate safety of the complete system is planned at the solid Waste Staging Facility on a non-radioactive liner containing resin and hydrogen gas.

The sampler itself has gone through functional testing both at INEL and at TMI. Operator training was conducted with GPU personnel and an integration test of the sampler, block house, and trailer will be conducted on a liner in one of the storage modules. Qualification of the operators will then be performed.

GPUN classified the forty-nine liners into several subgroups according to the composition and configuration of ion exchange media contained in the liner. Present plans are to sample the first radioactive liner from each subgroup over a period possibly up to two weeks, to establish the hydrogen generation rate. This information is required to verify that the liner can be transported to its destination, arriving there without containing a critical amount of combustible gases.

CONCLUSION

A total of 49 EPICOR II prefilter liners are stored at TMI, with varying levels of radioactivity. These liners will be shipped from TMI starting in August, 1982, at a rate of approximately five liners per month.

The prototype gas sampler provides a safe, controlled method to obtain a representative sample of the gases in the void space above the resins contained in the prefilters. These gases can be vented from the prefilters, thereby preparing the liners for safe shipment. Characteristics designed into the sampler reduce the hazards associated with handling hydrogen. These include the use of non-sparking materials, slow removal of the plug without impact, minimum use of electrical devices, use of inert cover gas, and testing.

The complete cycle, from initial positioning of the sampler to reinstallation of the plug is performed at the storage site and remotely from a shielded structure up to 75 ft away. Personnel radiation exposure is thereby minimized and the safe handling of the prefilters permitted.

Data concerning the gases resulting from the highly loaded EPICOR II ion exchange media will be obtained. The amount of each gas identified and information on their rate of generation will be available to aid in identifying possible disposal methods and handling of similar radioactive wastes.

The program has demonstrated an integrated approach to solving technical problems associated with handling radioactive wastes generated by the TMI accident. Input from several organizations, including the operating utility, government agencies, and consulting firms was involved. Evaluation of possible approaches, step by step review, close coordination, and the addressing of safety issues resulted in the development of a successful system.

REFERENCE

1. R. C. Green, A Conceptual Safety Assessment of the EG&G Designed EPICOR II 4 x 4 Liner Sampling Tool, December 11, 1981.