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PRE
QUARTERLY PROGRESS REPORT
JANUARY – MARCH, 1957

ATOMICS INTERNATIONAL

A DIVISION OF NORTH AMERICAN AVIATION, INC.

NAA-SR-1922
CHEMISTRY-SEPARATION PROCESSES FOR PLUTONIUM AND URANIUM
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PRE

QUARTERLY PROGRESS REPORT

JANUARY - MARCH, 1957

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TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

A site was selected for the PRE* west of the SRE† at Santa Susana based on operational considerations and relative cost.

Preliminary tests indicate the feasibility of prewrapping fuel rods and eliminating in-cell wire-wrapping of sealed fuel rods.

A mock-up oxide-drossing furnace was ordered and auxiliary equipment such as gas hood and ingot grapples is being designed. A prototype of the remotely-operated slug dimension inspection device is nearly ready for construction. Devices for other inspection requirements are being studied.

A pneumatic crane and rectilinear manipulator was ordered for use in the mock-up. A rotating shielded plug valve was designed and will be tested in the mock-up for transfer of fuel rods between the SRE and the PRE.

A pilot gas-handling system is being built for further testing in the Vanowen hot caves. An electrostatic precipitator for collecting cesium, a canned pump, and a cold trap for adsorption of xenon and krypton are part of the gas-handling system. Reactive metal gettering to scavenge oxygen, nitrogen, and hydrogen from the process cell inert atmosphere is being investigated.

Preliminary tests revealed that inflatable seals hold vacuum well enough to contain the process cell atmosphere. Further tests of a half-scale door mock-up have been initiated.

Radiation intensity during transfer of fuel from the SRE to the transfer casket was calculated to provide certain design criteria. Equilibrium temperatures inside the transfer coffin were calculated.

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* Pyroprocessing-Refabrication Experiment

† Sodium Reactor Experiment

I. INTRODUCTION

PRE is a fuel reprocessing experiment directed to the development of a low cost process for metallic uranium fuel decontamination and refabrication. High temperature techniques are to be used for partial decontamination, re-enrichment, and recasting of uranium fuel followed by refabrication of the uranium slugs into fuel rods suitable for re-irradiation in SRE.

A cold mock-up of individual pieces of process and supporting equipment will precede design and construction of units for the PRE facility. The facility will be designed and built at the Santa Susana site beginning in early FY 1960. The remote operation and maintenance of mocked-up equipment will provide a rational basis for establishing the design criteria of the PRE facility.

II. PRE PROGRESS

A. PRE SITE AND FACILITY (D. Janeves, F. Kamensky)

Geophysical survey of PRE facility sites and preliminary order-of-magnitude cost analysis have led to choice of the site at a location about 300 feet west of the present SRE building at Santa Susana. This choice was based on estimated site development, excavation, utility and transportation cost as well as relative ease of material transfer and minimal interference with SRE operations during PRE facility construction.

B. HOT CELL STRUCTURE (D. Janeves, F. J. Kamensky)

Construction of a scale model, 1/2-in. = 1 ft, of the hot cell structure has been initiated. The model will serve the dual purpose of providing general information on the basic cell configuration and of being a visual aid in determining equipment layout and material flow patterns.

Four alternative designs of the shielded door-wall of the fabrication cell have been studied each involving the use of "guillotine doors" rather than a massive one-piece structure as shown in the PRE proposal. Several design variations of these doors have been drawn using various combinations of door actuation, mounting, and supporting. Study of the scale model indicates that the most practical configuration is that in which the upper and lower doors open away from each

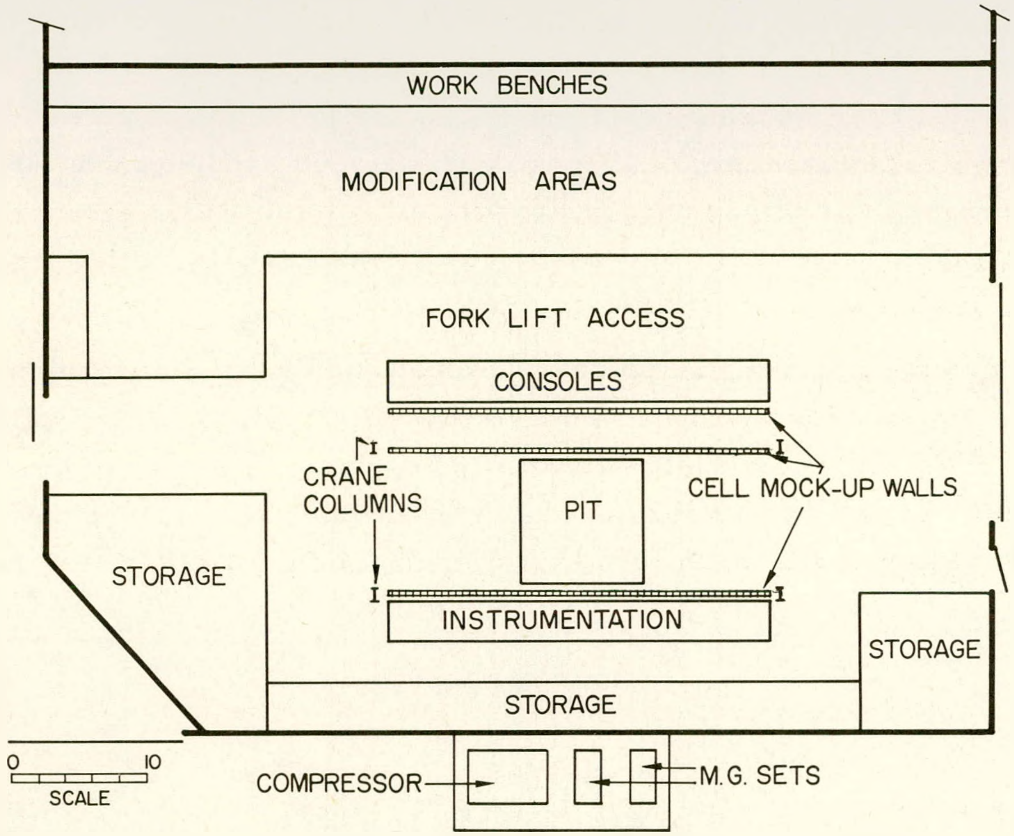

Fig. 1. General Arrangement, PRE Mock-Up Area

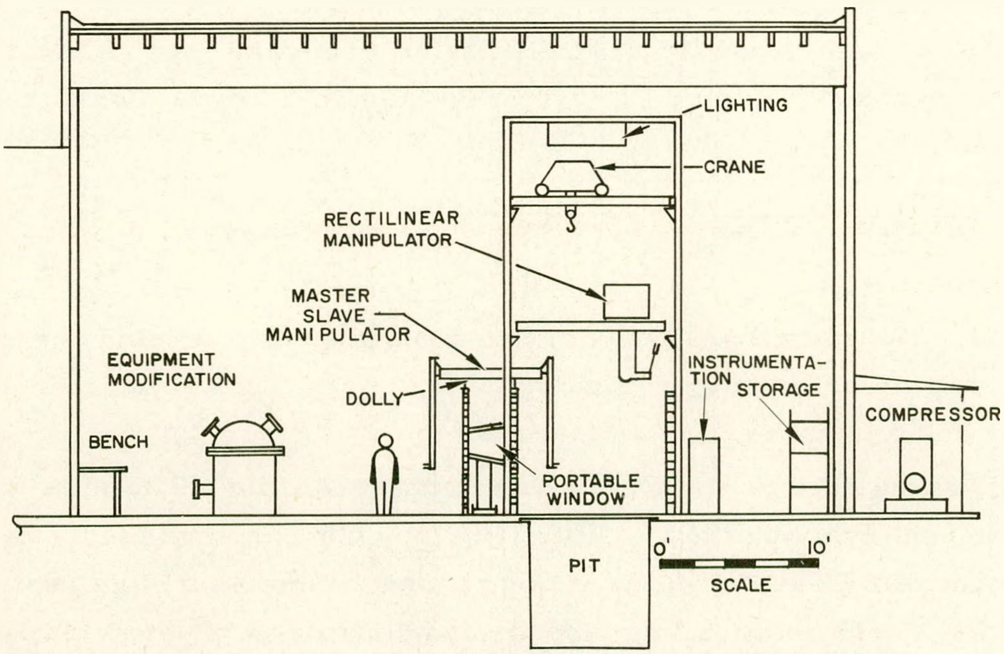

Fig. 2. Sectional View - PRE Mock-Up Area

other in the same vertical plane and close toward their stepped mating surfaces. The bottom door section recesses into its own envelope below the floor level of the mock-up pit. The door sections counter-balance each other through a cable system. This arrangement greatly decreases the load placed on the mechanism for opening and closing the shielded closure for the associated cell opening. Alternative applications of the same operational principle are being studied for actuation of other shielded doors in the PRE cells.

C. MOCK-UP GENERAL (D. J. Stoker)

Space in Atomics International's Van Nuys facility, now being constructed, will be available for PRE mock-up effort in place of Raymer facility space proposed earlier. The mock-up layout and function will be the same in the new location as described in NAA-SR-1855, the previous quarterly report.

Bids have been let for a pit to mock-up fabrication equipment, and a crane and manipulator supporting structure. Occupancy of the new mock-up facility is expected about June 1, 1957 at which time modifications to the area will be completed. A general arrangement view and a sectional view of the mock-up area are shown in Fig. 1 and 2.

Approximately 3600 square feet are now available, with periodic increases required until January 1959, when 6000 square feet will be utilized. The space is divided into mock-up area, modification area, and storage area. During the mock-up program over 120 pieces of equipment will be operated at some time and possibly many times in the cell mock-up. When the equipment is not in the mock-up enclosure, it will be either in storage or in the modification area undergoing necessary changes.

D. FABRICATION CELL

1. Fuel Rod Fabrication (D. Janeves, K. L. Mattern)

Detail design drawings of the fuel rod fabrication device are nearly complete and component fabrication has been scheduled for the near future. These drawings cover the greater portion of the major assemblies of the fuel rod fabrication device. Various sub-assemblies including the NaK loader, chill-block-positioning device, fuel-rod-cap inserter and the cap-to-tube welding unit will be fabricated as independent components and bench-tested under simulated operating conditions. These components will be installed and operated in the integrated fuel rod fabrication device after the unique characteristics of each component has been demonstrated outside the enclosing bell jar.

2. Fuel Rod Wire Wrapping (G. P. Streechon)

Preliminary design of a remotely-operated and maintained fuel rod wire-wrapping device has been completed. Detailed drawings have been postponed pending the outcome of tests to determine the possibility of out-of-cell wire wrapping of the fuel tube before the fuel slugs are loaded. Out-of-cell prewrapping of the fuel rod tubes would eliminate the need for designing a wire-wrapping device.

If tests indicate the feasibility of prewrapping fuel rods, the standard design of fuel rods would be modified. A collar to which the spacing wire could be welded would be shrunk on the empty tube before prewrapping as shown in Fig. 3. Temperature-cycling tests, simulating in-pile fuel rod temperatures, were conducted on a wire-wrapped fuel rod segment with a shrunk-on welding collar. there was no evidence of welding collar creep at any time during the temperature-cycling tests.

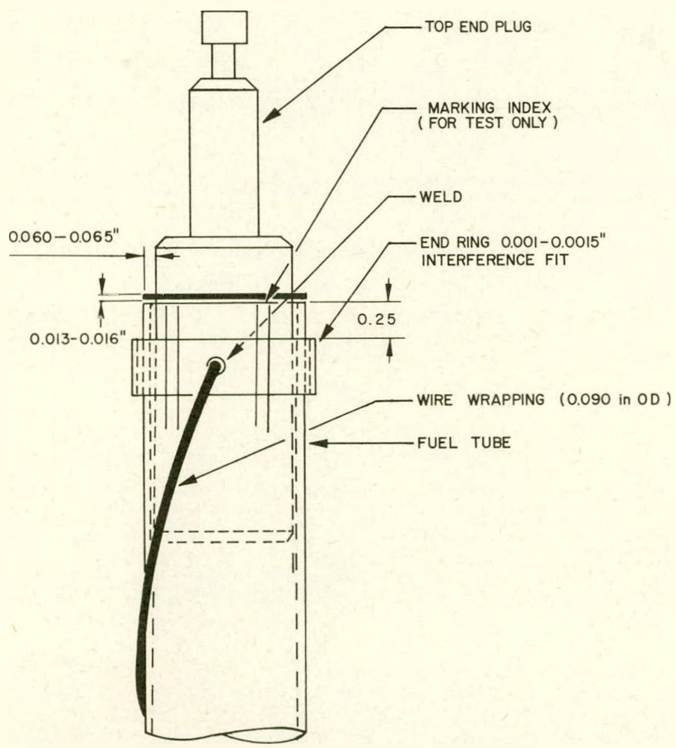

Fig. 3. End-Ring Detail of Fuel Tube

3. Inspection Devices

a. Cyclographic Testing (N. P. Grisanti)

In the cold fuel fabrication sequence now used for SRE fuel, the wire wrapping operation is performed after the cyclographing of the NaK-filled fuel-rod assembly in order to avoid the possibility of masking a defect with the wire. Recent cyclograph tests were performed on prewrapped fuel rods made of slugs with simulated bond defects. These tests indicate that prewrapped tubes can be used in PRE, thus eliminating the problem of remotely wrapping the 0.090-inch wire on the radioactive fuel rod while the rod is inside the PRE fabrication cell. A simulated unbonded area, of the smallest rejectable size according to SRE specifications, was successfully revealed by cyclographic testing of a wrapped tube. The inside diameter of the coil was notched for this test to permit passage of the wrapping wire as the fuel rod was moved through the coil during the test.

E. PROCESS CELL

1. Tilt-Pour Oxide-Drossing Furnace (J. L. Ballif, J. Savage)

AEC approval was secured and the purchase order placed for a tilt-pour furnace to simulate oxide drossing in the mock-up. Vendor's engineering prints have been received, approved, and returned. Delivery of furnace is expected May 1957. It is intended to have furnace installation complete before the end of FY 1957.

Design engineering work has commenced on accessories for the oxide-drossing furnace. The accessories are as follows:

a) Irradiated slug loading device.

b) Ventilation hood for furnace top.

c) Ingot-casting mold and stripping equipment.

The ventilation hood, Fig. 4, carries the viewing and temperature-sensing equipment and serves as a point of attachment for the electrostatic precipitator. The precipitator will collect volatile cesium from the furnace off-gas. The hood is movable and is designed for remote maintenance.

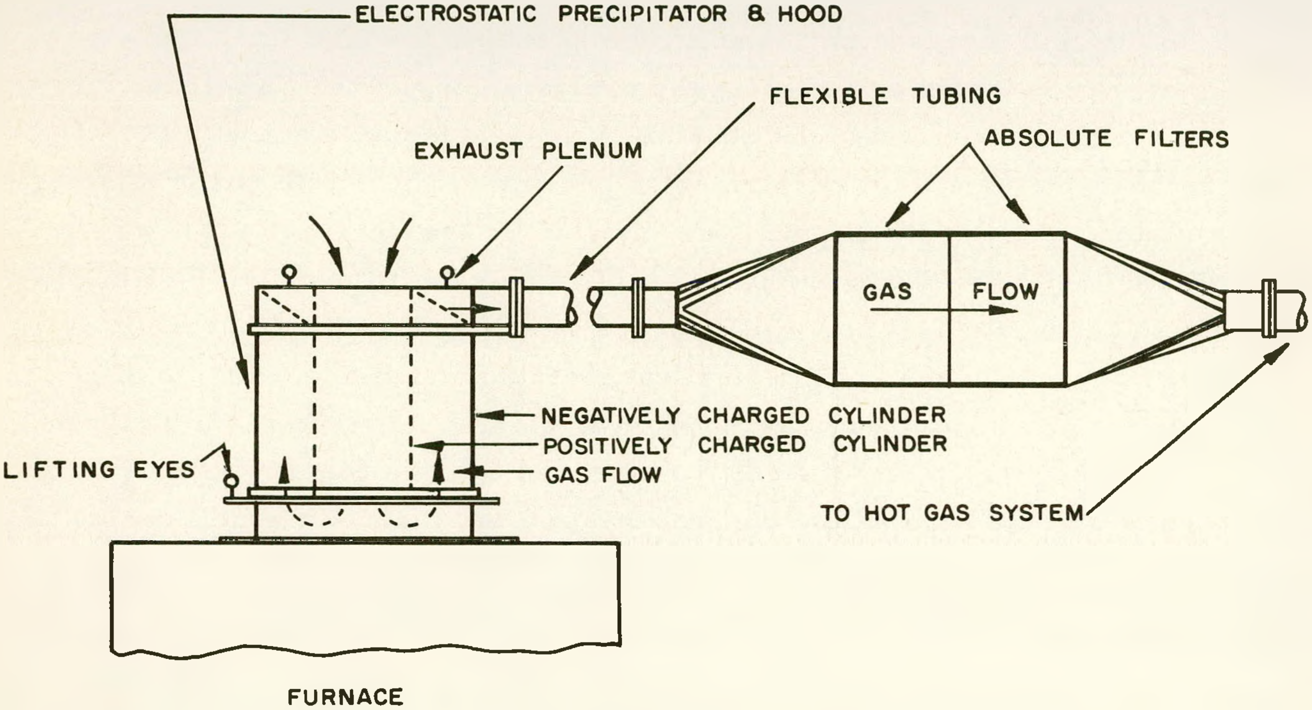

Fig. 4. Ventilation Hood and Precipitator

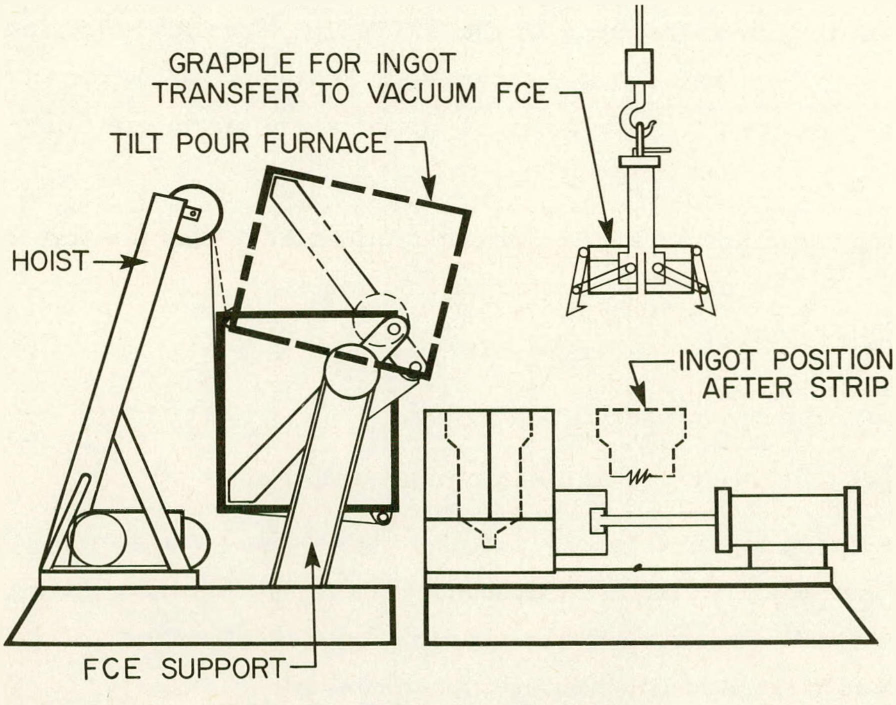

Fig. 5. Drossing Furnace

The ingot mold, Fig. 5, receives the molten charge from the oxide-drossing furnace preparatory to being charged into the vacuum-casting furnace. The ingot configuration is dictated then by two considerations: first, the shape and inside dimensions of the vacuum-furnace crucible: and second, by the means of grappling employed. Figure 6 shows the present ingot concept which allows adequate clearance in the vacuum-furnace crucible, includes a tapered plug to fill the bottom-pour opening, and has a head suitable for grappling. Figure 5 shows the mold-casting device which incorporates a split mold. In splitting the mold, the ingot, Fig. 6, is stripped and moved out from under the furnace pouring lip ready for grappling. This is accomplished by means of a gas-operated cylinder actuated in a single motion. This device is designed to incorporate ease of remote maintenance.

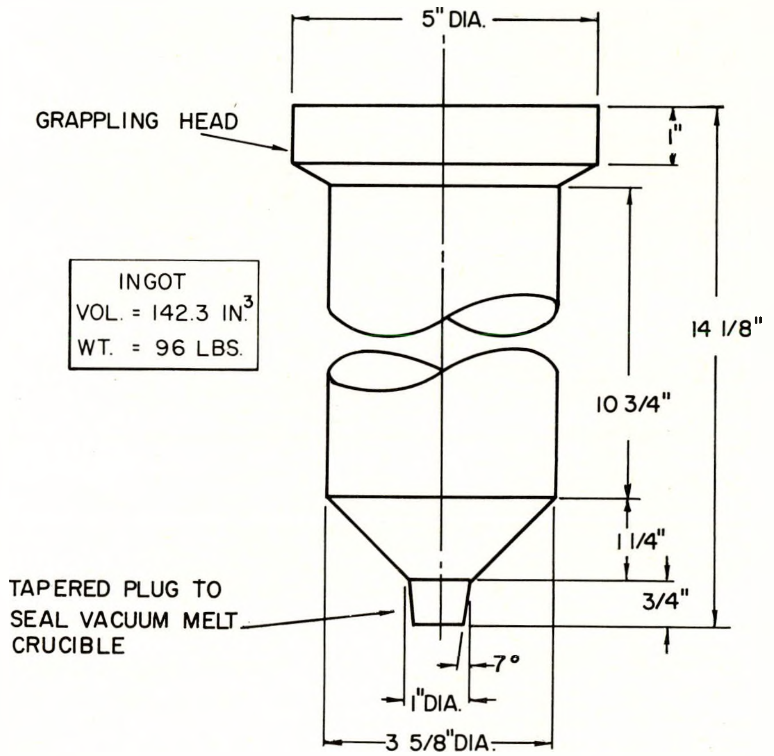

Fig. 6. Uranium Ingot from Oxide-Drossing Furnace

Work is in progress on availability and cost of crucibles and on application of flame-spraying processes to crucible for relining. For the purpose of drossing rare earth fission products in PRE, it is essential to line the crucible with UO_2, ThO_2, or BeO. Little work has been done with flame spraying of these materials although flame spraying has been used commercially for Al_2O_3, stabilized ZrO_2, $ZrSiO_4$, and WC. Commercial flame-spraying processes use either a powder feed or rod feed. Powder-feed guns seem more feasible for PRE crucible relining requirements. Inquiries are proceeding on the alternative flame-spraying processes for refractories.

2. Vacuum-Casting Furnace (E. G. Kendall, D. J. Stoker)

Vendor information and bids were reviewed and used as a guide in the preparation of a purchase specification for the vacuum-casting furnace. This specification detailed requirements on the following components:

a) Vacuum melting and casting chamber
b) Static and centrifugal mold casting unit
c) Vacuum system including pumps, piping, valves, and gauges
d) Power equipment including motor-generator set, instruments, controls, and control panel

Additional requirements were included to insure ease of remote maintenance and operation of the furnace and vacuum system. Flexibility has been incorporated into the designs in order to permit investigation of both the stopper-rod and fusible-plug methods of tapping the crucible.

The purchase specification did not include the induction coil, crucible, and insulation assembly as further design was necessary to permit remote handling of these units. The conceptual design of the furnace chamber is shown in Fig. 7. Bids from three qualified vendors are being reviewed. Delivery of the furnace is expected in the first quarter of FY 1958.

The induction coil shown in Fig. 8 and its support is specially designed to facilitate remote handling, operation, and maintenance. The coil is in two sections. The upper section is used for melting the charge and the lower for tapping the crucible by melting the fusible plug in the bottom of the crucible. Included in Fig. 8 is the first design of the crucible and the insulation assembly. All of the above components have been designed with provisions for remote operation and maintenance.

Detail design has commenced on the radiation shielding and insulation, and on the crucible. These will be fabricated in the Atomics International shops.

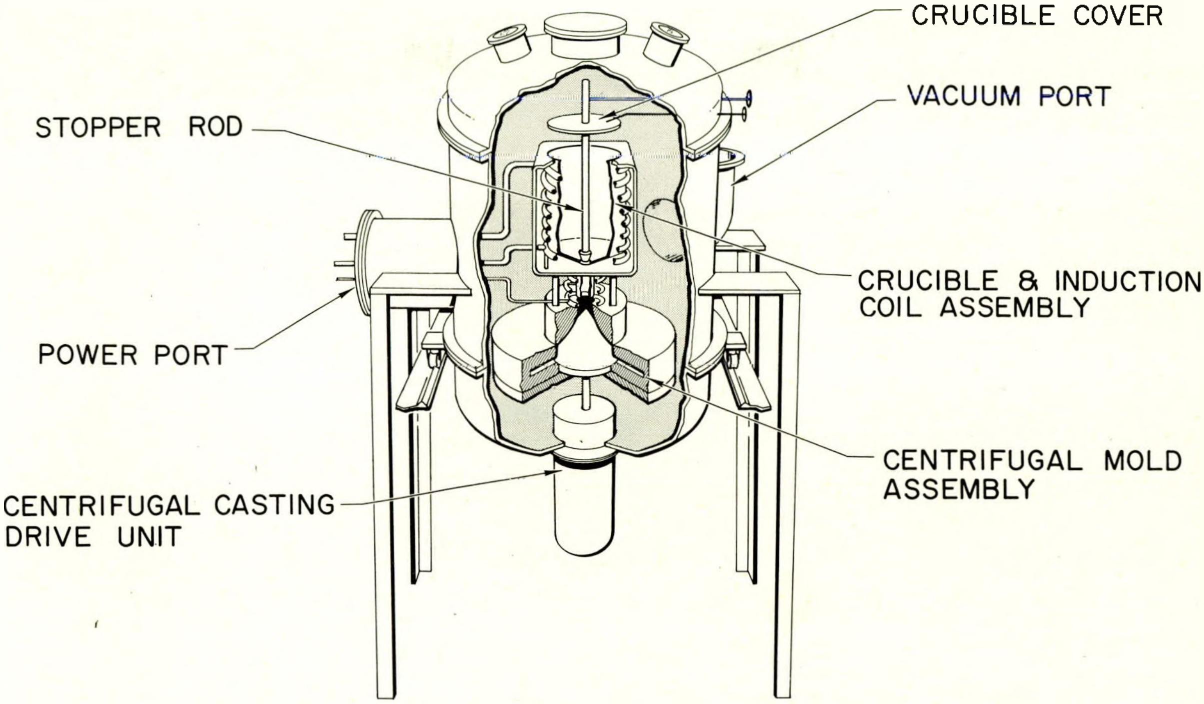

Fig. 7. Vacuum Casting Furnace

Design was initiated on a remotely operated high frequency and cooling lead connection. This connection will be actuated by an impact wrench attached to the hot cell crane.

For calculation of re-enrichment required after the spent fuel is partially decontaminated in PRE, isotopic analysis of cast ingots to be charged into the vacuum furnace will be required. Preliminary investigation of emission spectrograph results indicates that this method is well adapted for remote operation. Modification of commercially available instruments is being investigated.

3. Alternate Process Equipment (S. Berger)

Preliminary study was initiated to plan for inclusion of plutonium recovery in the PRE fuel cycle. In this way PRE can be made sufficiently versatile so that alternate reactor fuels including breeder type fuels may be handled. Preliminary investigations are being conducted to study known recovery processes. This will permit, a) choosing the one most adaptable to multikilogram scale-up and b) studying the economics of plutonium feed-back to a natural uranium feed.

The fused salt extraction process has been proposed for separation of plutonium from uranium. In this method uranium fluorides are formed in which the plutonium exists as a trifluoride. The uranium-plutonium salt, having a melting point above uranium metal, may be readily separated from the uranium at a temperature below the melting point of the salt and above the melting point of the metal. The plutonium is subsequently reduced with magnesium. The basic chemical reactions involved are as follows:

$$4Pu + 3\,UF_4 \rightarrow 4\,PuF_3 + 3U \qquad 3Mg + 2PuF_3 \rightarrow 3\,MgF_2 + 2Pu$$

The flow diagram, Fig. 9, envisions a two-stage recovery and a single-stage extraction of the plutonium. The reduction operation for the final recovery of the plutonium is not included in the diagram.

It is assumed that for each contacting of the uranium-plutonium mixture with UF_4 about 95 per cent of the plutonium is removed as PuF_3. Figure 10 presents the total plutonium removed in the fused salt extraction of Fig. 9 as a function of per cent recovery per contact. The fused-salt plutonium extraction process is used only after 3 to 5 complete cycles of fuel irradiation in SRE and decontamination in PRE.

Calculations have been carried out to determine the equilibrium concentrations of the various plutonium isotopes starting with plutonium-enriched natural uranium fuel. The equilibrium concentrations in w/o for an assumed α of 0.6, where $\alpha = \frac{Pu^{239}}{U^{235}}$ are as follows:

$$U^{238} = 95.75$$
$$U^{235} = 0.71$$
$$Pu^{239} = 0.43$$
$$Pu^{241} = 0.17$$
$$Pu^{240} = 0.17$$
$$Pu^{242} = 2.77$$

This indicates that about 3-1/2 per cent by weight of the assumed fuel, at equilibrium, is isotopes of plutonium.

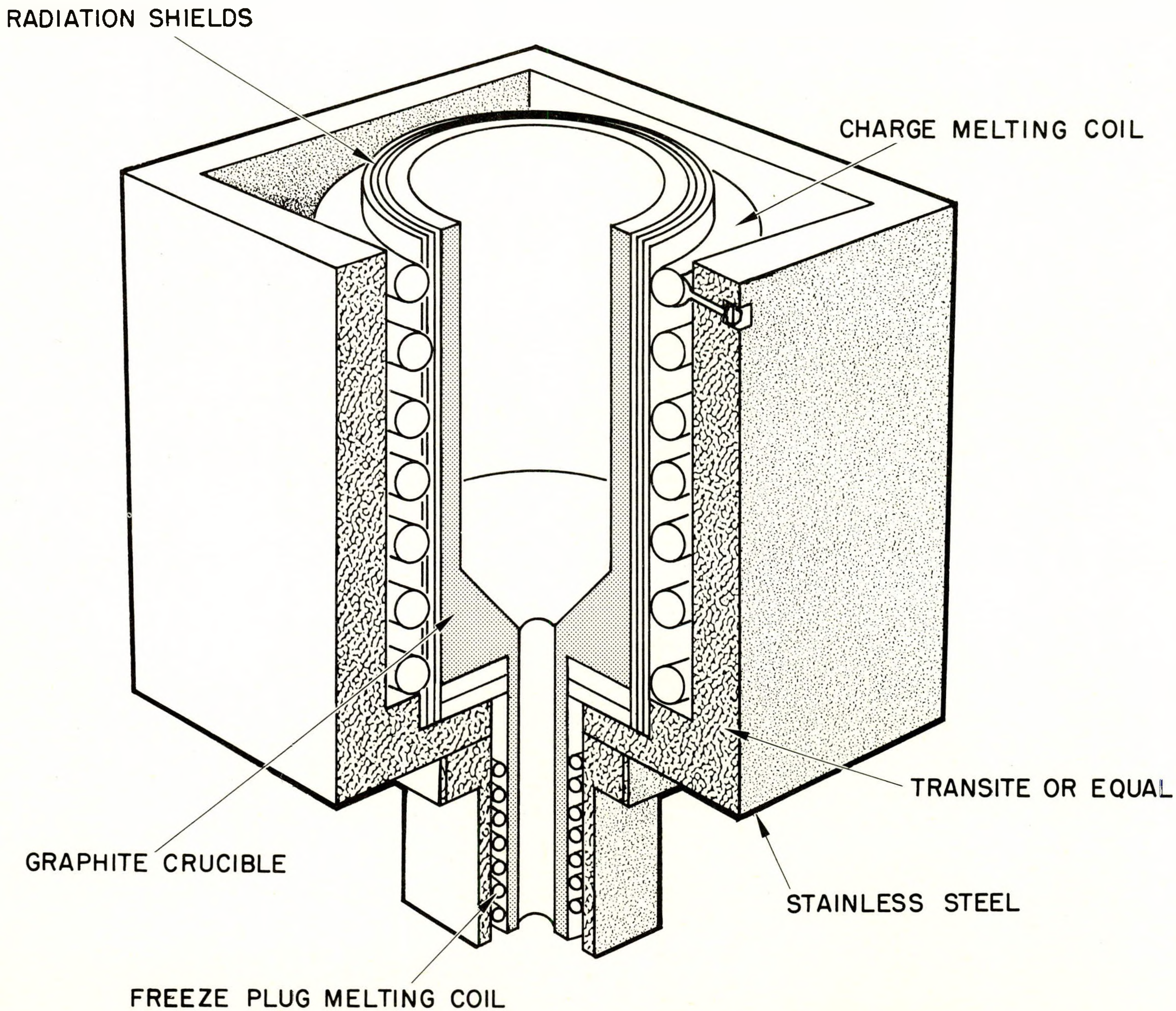

Fig. 8. Preliminary Design - Crucible and Insulation Assembly

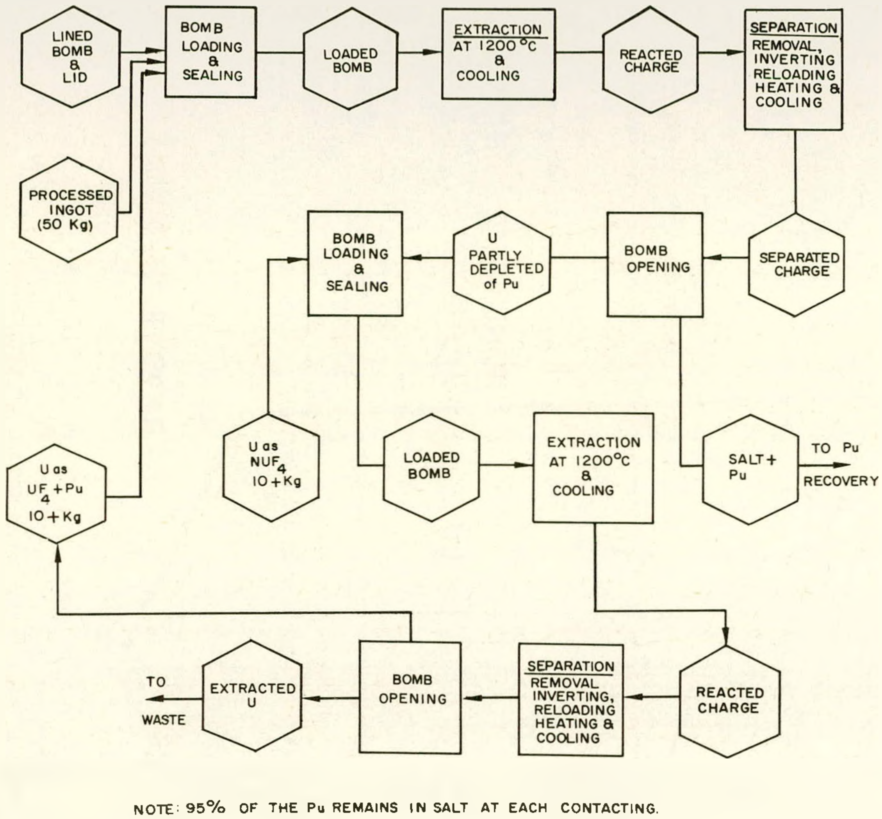

Fig. 9. Flow Diagram for Fused Salt Plutonium Extraction

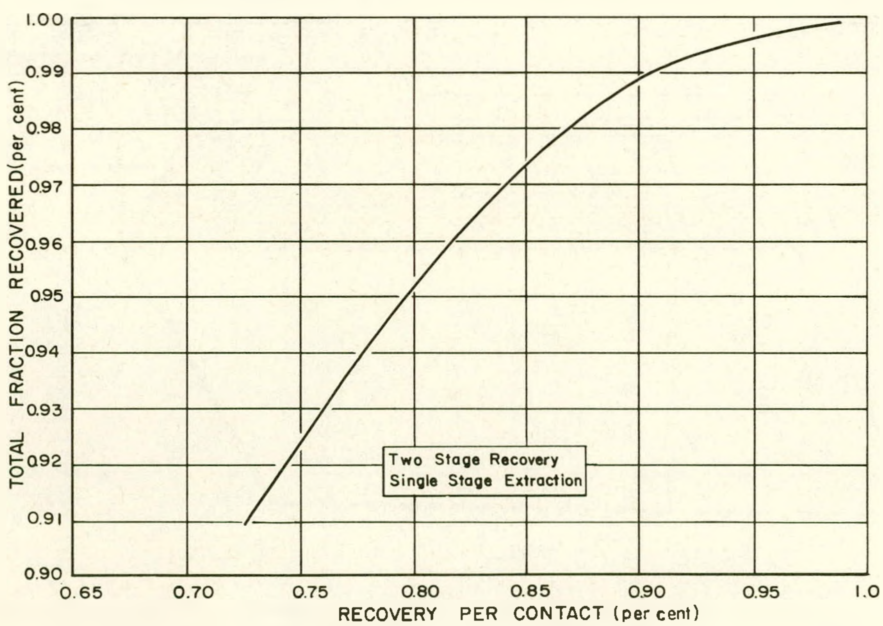

Fig. 10. Plutonium Recovery Efficiency

If we assume a 90 per cent separation per contact, total recovery will exceed 98 per cent of the plutonium. Therefore, a breeding gain of Pu^{239} should be in the order of 2 per cent.

4. Preparation of Finished Slugs (J. Guon)

A remote dimensional inspection device for cast PRE slugs has been designed and is now being detailed for construction, Fig. 11. The device employs a commercially-available lathe and three indicating gauges. Dimensions to be measured are length of 6 ± 0.002-inches, diameter of 0.750 ± 0.001-inch, out-of-round of ± 0.001 inch, and bow of ± 0.001 inch per 6 inch length of 3/4 in. diameter slug. The entire apparatus is designed to be remote operating and indicating.

Systems are being investigated for other required inspections such as slug density and sub-surface defect location. Ultrasonics and dynamic balance for sub-surface defect location are under study. An order was placed for a commercially-available electrical-discharge machine equipped with a thin disc electrode assembly suitable for cutting off and facing cast PRE slugs. Modification of this standard unit for PRE application will be made after operation of the cold mock-up.

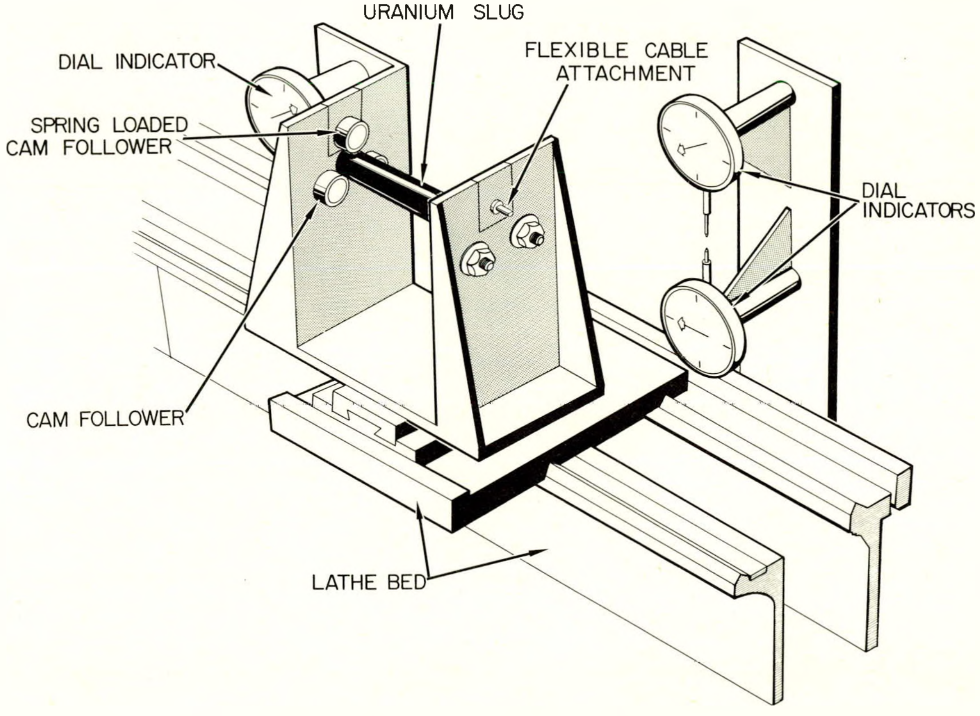

Fig. 11. Uranium Slug Inspection Device

A literature search for information relating to theory, operation, and application of electrical discharge machining has been initiated.

The mock-up to study disassembly of casting molds in the east cave at the Vanowen facility of A.I. has been completed and tested. This mold assembly, suitable for remote disassembly, consists of: a graphite trough, graphite distributor, graphite funnels, brass top plate, copper liners molds, brass base plate, brass tie rod, and steel nut. Molds are transferred from the west cave in a steel transfer bucket and moved to the center of the east cave cart. The bucket is inverted with a trunion yoke since the center of gravity of the bucket is slightly above the trunnion. Securing pins are removed with the manipulator and the bucket lifted free of the invested cast-mold assembly. The steel nut is removed with a pneumatic impact tool and the base plate removed. Liners are removed, with either manipulator fingers or a special tool. After all molds have been removed, the top nut is replaced and molds placed into the press stand. The mold is lifted and the bottom of the bucket removed. The press is activated and the top plate and trough separated from the casting. The molds are lifted from the press and set on the cropper base. The casting is lowered into the cropper, cooled in liquid nitrogen, and cropped. Slugs and riser are lifted from the cropper and stored in the dog house. Other scrap will be disposed of through the transfer cell and shielded cask (see NAA-SR-1676).

F. HOT CELL SUPPORTING SERVICES

1. Material Handling (G. P. Streechon)

a. Rectilinear Manipulator

A purchase order was placed for one commercially-available rectilinear manipulator, with bridge and carriage modified to allow an overhead in-cell crane to remove the manipulator carriage remotely. This manipulator will be installed and operated in the PRE mock-up at the Van Nuys facility. Investigations are under way to determine the extent of modifications necessary to adapt the manipulator's components for remote maintenance. Structural details for the manipulator and crane support structure at the Van Nuys facility have been checked and approved prior to transmittal to an outside contractor. Scheduled completion date is May 30, 1957.

b. Master-Slave Manipulators (G. Streechon)

A purchase order was placed for one pair of Mark VIII Master-Slave Manipulators for use in the PRE mock-up at the Van Nuys facility. Delivery date of April 30, 1957 is scheduled.

Preliminary drawings have been completed for a traverse dolly which will permit these manipulators to travel parallel to the operational face of the mock-up and will position them at any desired operating station.

c. Cranes (N. P. Grisanti)

In-cell crane development has continued largely along the lines of the "modified standard" crane described in the preceding quarterly report (NAA-SR-1855). Preliminary development studies of the "ideal" in-cell crane, with out-of-cell motors, continue as a secondary effort.

A modified standard crane with piston air motors will be installed in the hot cell mock-up for test operation. The first tests, aimed at determining the limitations of crane application to all in-cell operations, will include crane operation in conjunction with impact wrenches and special devices adaptable to the crane hook. Other tests will evaluate: the crane, modifications of it, the merit of the air system for motivation, and its adaptability to remote maintenance procedures.

The evolution of other in-cell equipment designs points to the desirability of improving the nominal 2-foot wall approaches characteristic of the modified standard crane. This improvement can be limited to one or two walls in each cell depending on the location of devices in the cell requiring crane power for actuation. The most obvious method of achieving better wall approach is to recess the in-cell wall at and above the crane rails. The resulting wall ledges may complicate cell housekeeping and wall shielding as well as increase the structural complexities of the cells. These problems are now being re-evaluated with a 12-inch to 18-inch ledge in mind.

2. Lighting and Viewing (G. Gustovich)

a. Lighting

Detailed drawings of the "sky-hook" and mercury lamp assembly are now being completed. Special cooler-luminaires, Dean Plate material, have been ordered and should be received within two months. The entire light assembly (including extension rods, cooler-luminaire fixture, seal assembly, lock and clamp mechanism, electrical and coolant assemblies, seal enclosure housing, special hook attachments, etc.) will be fabricated and assembled in the next quarter.

b. Closed Circuit Television

The closed circuit TV unit was received and a preliminary operational acceptance test performed.

Preliminary design for the mock-up installation has been completed on the following TV items:

1) Portable shield and camera stands.

2) Lead and lead-glass camera shields.

3) Camera cooling-housing assemblies.

4) Vidicon temperature indicator system.

5) Electrical and coolant disconnects, in-cell supply panels, cable layout, and external control equipment.

6) Assembly for annealing the viewing window in the camera housing.

7) Special lifting hooks, mounting plates, and lifting attachments for the camera housings.

Construction and installation, in the PRE mock-up, of the equipment listed below will be completed in the next quarter:

1) TV equipment.

2) Support stands and lifting hooks.

3) Mock-up shield.

4) Cooling assembly.

5) Support plates and lock mechanisms.

c. <u>Periscope</u>

Preliminary design of periscope support equipment, as listed below, has been completed.

1) Special seal and glove box mounting flanges, out-of-cell glove box-support hangers, purging equipment, tool rack, plumbing, etc.

2) Bubble-seal flange and lock assembly, in-cell bubble-seal support and alignment frame.

3) Shield and seal-cover plates for in-cell periscope removal, detailed design, construction and fabrication of some of the maintenance-support equipment will be pursued in the next quarter.

d. <u>Windows</u>

Preliminary studies of viewing-window design, have included:

1) In-cell protective window, support frame, seal, and lock mechanism.

2) Window maintenance, in-cell cover plate, seal-bolting methods, viewing requirements, purging techniques, etc.

3) Sealed window installation and maintenance techniques, viewing area required, etc.

4) Access lock and upper-cell crane area viewing-window requirements.

5) Shielding and sealing techniques between sealed window and cell-wall casing.

6) Helium-purging techniques during window installation. A detailed window design will be completed early in the next quarter in order to expedite the purchase, for mock-up studies, of a viewing window which will conform to the actual window requirements in the proposed PRE cell structure at Santa Susana.

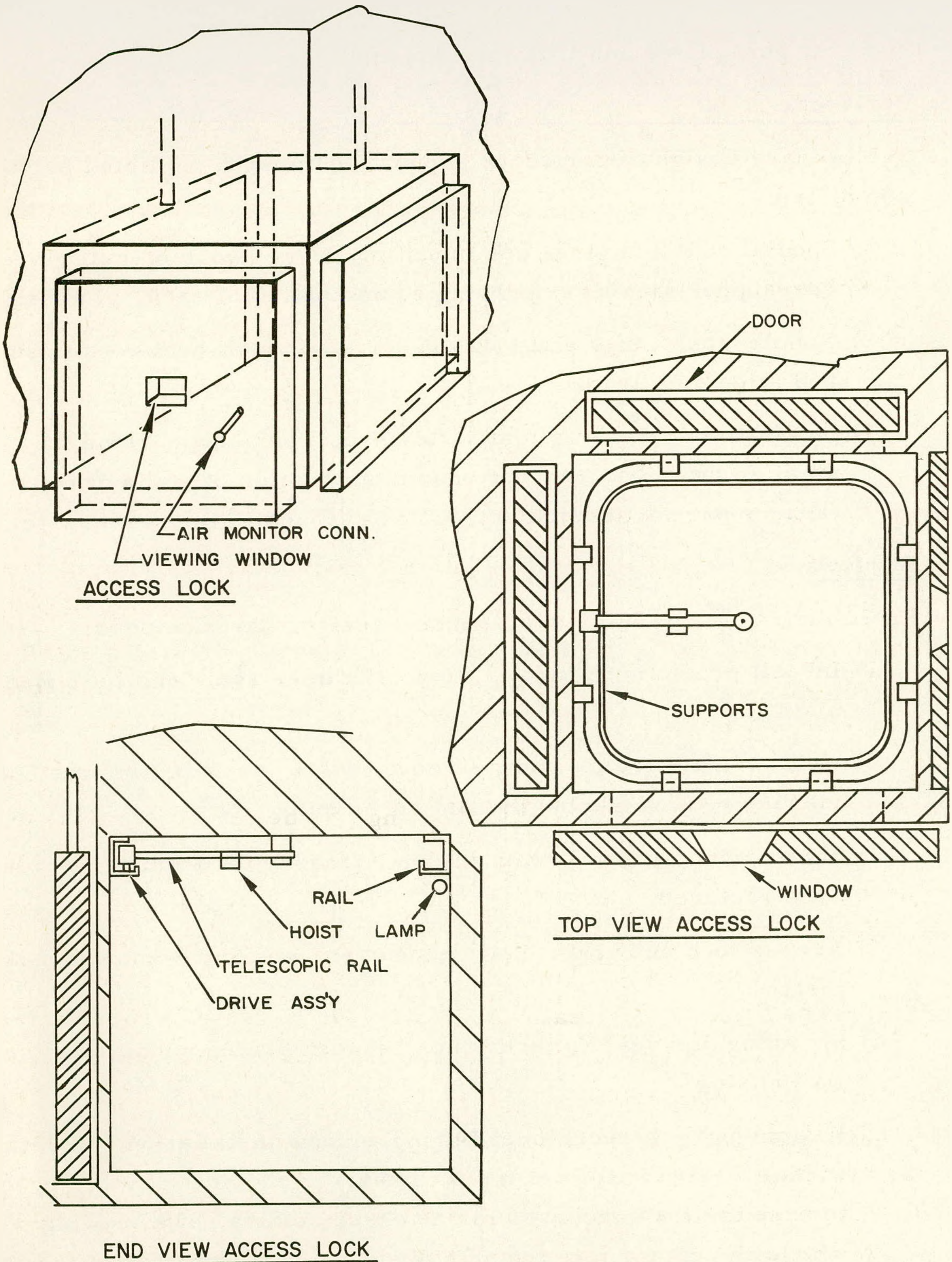

Fig. 12. Access Lock and Jib Hoist

e. Radiation Instrumentation

Preliminary design has been made of the following equipment and methods determined for in-cell operation of radiation instrumentation:

1) Helium-cooled housing assembly for radiation detector probes.

2) Disconnects for electrical and coolant lines.

3) Feeder panels for electrical and coolant distribution.

4) Jib-hoist installation in access lock to manipulate probes for radiation monitoring of equipment moved through the lock shown schematically in Fig. 12.

5) Air monitor piping to sample the atmosphere in the access lock before opening the outer lock door.

3. Inter-Facility Fuel Transfer (F. J. Kamensky)

A new concept has been developed for the transferring of fuel slugs and fuel rods in and out of the SRE hot cell. This new method will utilize the existing 20-inch diameter roof plug hole in the SRE hot cell (used by the SRE group for moderator can maintenance) by replacing the existing plug with a rotary shielded valve. This system will require no changes or modifications in any SRE operations or equipment.

The outside dimensions of the valve housing will be the same as the existing SRE roof plug. The housing will fit into the roof-plug hole without modification or loss in shielding. A 17-inch diameter cylindrical valve plug will be supported on a horizontal shaft in the housing. There will be a 5-1/2-inch diameter hole through the cylinder normal to the axis of rotation (supporting shaft) and aligned (in the open position) with a similar vertical hole through the housing. A bevel gear will be attached to the cylinder in the vertical plane. The bevel gear will be driven by a bevel pinion on a vertical spline shaft through the top of the housing. When the fuel-rod casket is properly positioned on top of the plug, the mating spline socket through the casket will couple with the spline shaft in the housing. The valve will be manually operated from above the casket when the casket is in place. By turning the shaft from above the casket the cylinder can be rotated on its axis shaft. By rotating the cylinder through 90° from the open position the 5-1/2-inch diameter

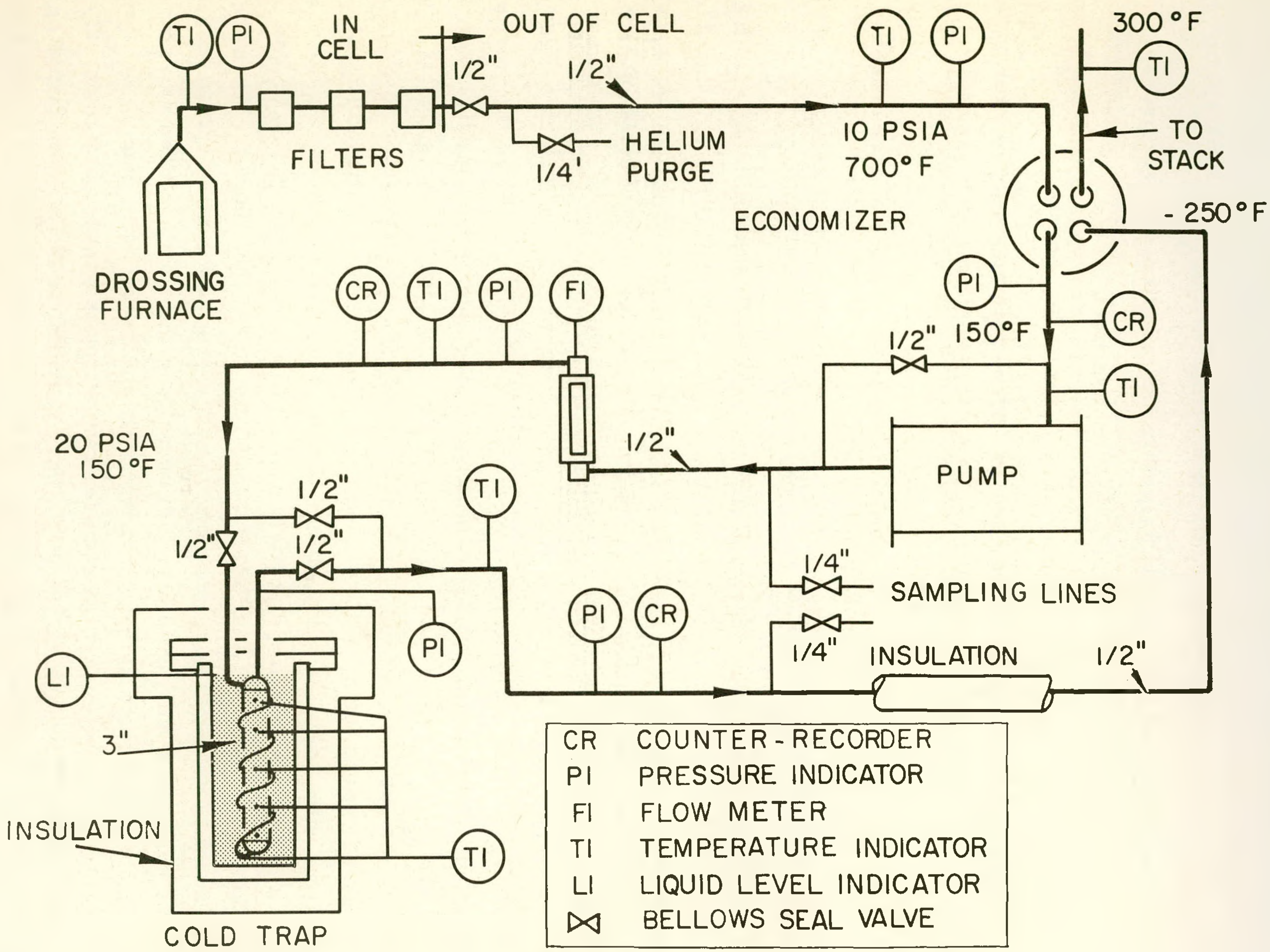

Fig. 13. Process Diagram for Gas Handling System

hole in the cylinder will be normal to the hole in the housing and the valve will be closed. The principle is the same as a plug valve.

To obtain maximum shielding the valve plug can be made of steel filled with lead. The upper half of the housing will be made of cast lead and the lower half of the housing of cast iron or steel.

G. HOT CELL AUXILIARY PROCESSES

1. Cell Atmosphere System (D. J. Stoker, J. L. Ballif, D. W. Reed, R. K. Owen, S. Berger)

a. Pilot Plant Gas Handling System

A literature survey was made concerning the adsorption of xenon and krypton on packed beds. Considerable work has been done on the adsorption of xenon and krypton on both charcoal and silica gel using nitrogen as a carrier gas[1, 2, 3, 4, 5, 6,] but no information was found using helium as a carrier gas.

In its initial operations the PRE prototype system will attempt to remove cesium, krypton, and xenon from the Vanowen hot cave drossing furnace off-gas. The fuel drossed in the cave has aged sufficiently so that no radio-iodine remains. Scavenging the nonradioactive gases (oxygen, nitrogen, and hydrogen) will be postponed until results of a separate study on reactive-metal gettering is completed.

The process diagram for the gas-handling system is illustrated in Fig. 13. The system will be completely welded gas tight. The cesium will be trapped on an electrostatic precipitator mounted in the furnace above the melt. A glass wool filter is inserted in the furnace off-gas line. Xenon and krypton will be adsorbed on a silica gel bed at liquid nitrogen temperatures.

Monitor chambers will be placed both before and after the freeze-out trap to measure the combined krypton and xenon activity quantitatively. The purpose of these monitors will be to determine the running efficiency of the freeze-out trap and to check the calculated values. These chambers are being constructed at the present time and will be calibrated using known amounts of Kr^{85}.

The gas from several Vanowen hot-cave oxide-drossing runs will be passed through the pilot gas-handling system to determine the rate of active gas evolution during drossing operations and the composition of the gases.

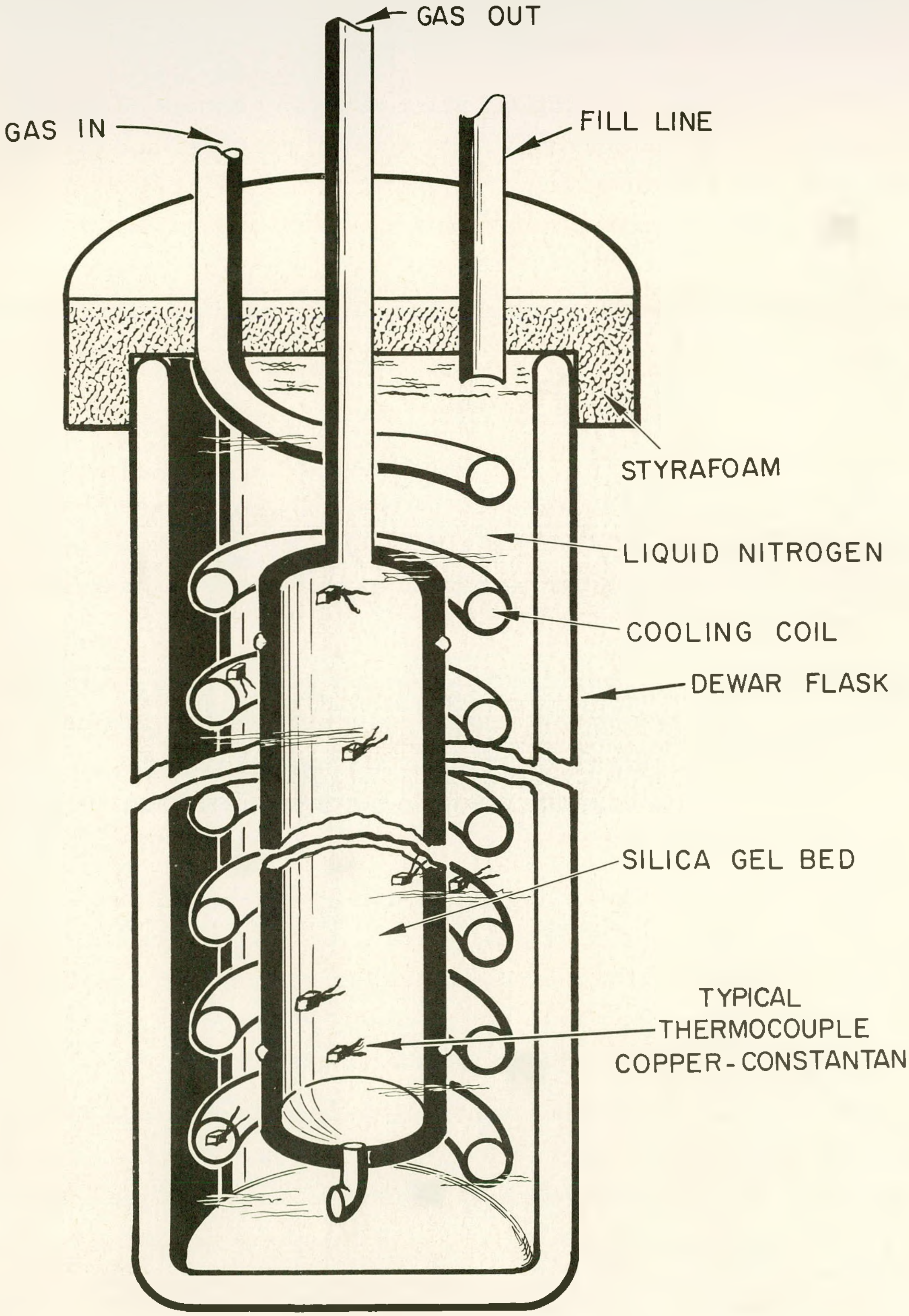

Fig. 14. Gas Adsorber and Cold Trap

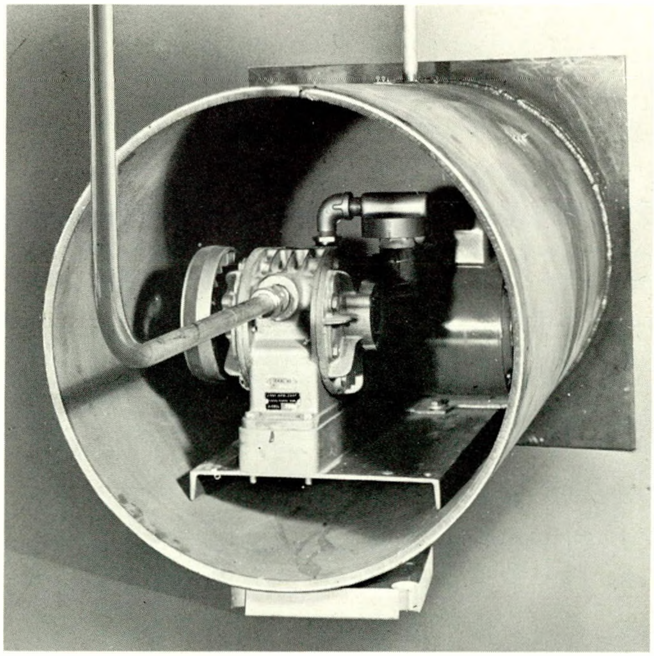

Fig. 15. Pump for Gas Handling System

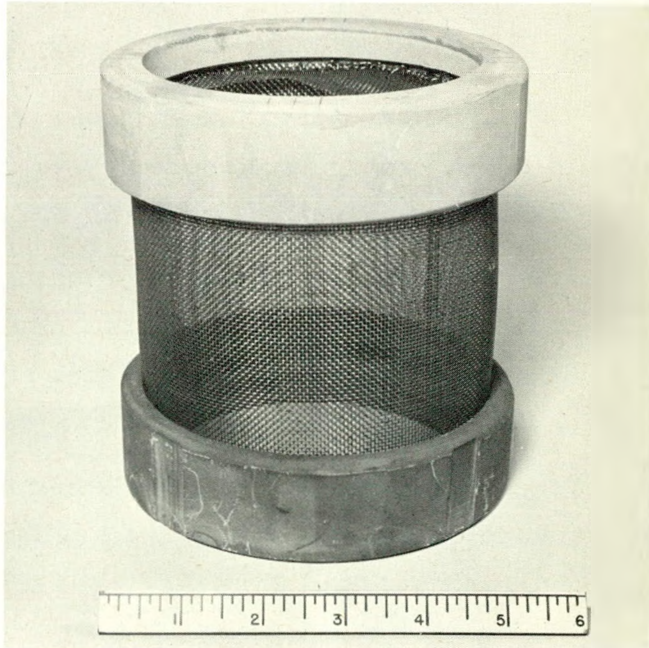

Fig. 16. Electrostatic Precipitator

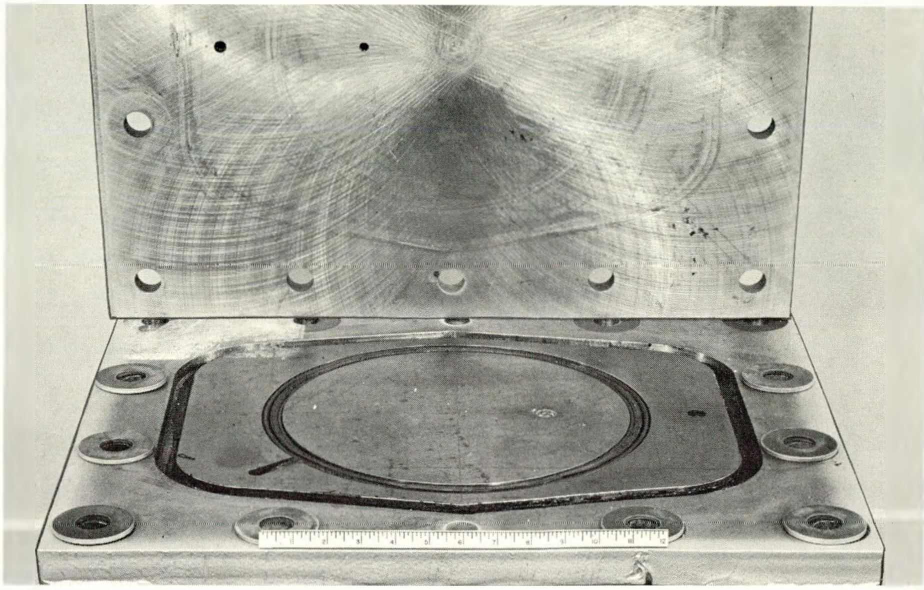

Fig. 17. Seal Mounting Plate Assembly

When the gas evolution pattern has been established, the gas-handling system will be operated independently of cave operations using a tracer gas simulating PRE off-gas. The object of these operations will be to determine the characteristics of xenon and krypton adsorption on a silica gel bed at liquid nitrogen temperatures using helium as a carrier gas.

The gas adsorber and cold trap have been designed, Fig. 14, and are now being fabricated. The adsorber was designed with sufficient capacity to handle the probable gas evolution rate in the PRE oxide-drossing furnace.

The pump used in the pilot gas-handling system is canned, Fig. 15, and operates while completely surrounded by the helium atmosphere being pumped. The canned pump has been operated at 2 ft^3/min of helium with a suction pressure of 10 lb/$in.^2$ absolute and a discharge pressure of 20 lb/$in.^2$ absolute.

The heat exchanger is a commercially-available all-welded model. It is scheduled for delivery at the beginning of the next quarter. The valves will be of the bellows seal type with welding sockets for attachment of system piping.

b. Cesium Collection

Electrostatic precipitators described in the previous quarterly (NAA-SR-1855) have been used in two hot-cave drossing runs. Prior operations without the precipitator resulted in cesium distribution throughout the piping and the diffusion pump oil.

Results of the first run are incomplete but indicate that the precipitator has had an effect on cesium collection downstream of the precipitator. With the precipitator, no appreciable quantities of cesium were found in the piping or pump oil downstream from the precipitator. The bottom Lavite ring and screen were visibly discolored after the run, Fig. 16. Analytical results indicate less than 5 per cent of the original cesium was retained on the precipitator. Table 1 contains other analytical data on cesium deposition. No cesium balance was possible. A description of the oxide-drossing furnace and further analytical results of Run No. 14 are contained in the quarterly report of the process initiation unit (NAA-SR-1997).

No analytical results are available from Run No. 15 but again no appreciable cesium has been found downstream of the precipitator. Autoradiographs of the screen and Lavite from Run No. 15 give beta-gamma readings of 2.5 to 60 r/hr with a ratio of 8 to 1 beta. Gamma energies determined from use of adsorption shields were greater than 0.3 Mev.

TABLE I

CESIUM DEPOSITION*

Location	Per Cent
Lavite rings	2.04
Furnace body	1.70
Furnace lid	3.80
SiO_2 sleeve	4.0
Cold "fingers"	4.0
Forepump oil	None
Diffusion Pump oil	None
Slag from melt	67.
Melt	12.
Screen (Electrostatic)	3.94

*For Run No. 14

c. Reactive Metal Gettering

A small resistance-heated furnace has been built for the determination of melting points of various combinations of calcium, magnesium, barium, lithium, sodium, and lead. The object is to find low-melting eutectics of reactive metals which in the molten state will scavenge oxygen, hydrogen, and nitrogen. It is believed that the use of molten metal instead of solid sponge or turnings will greatly increase the capacity for gettering of a given volume of gas evolved during melting.

d. In-Cell Components of the Gas-Handling System

As presently envisioned the cesium removal unit and the particulate filters will be the only components of the gas-handling system in the process cell. Design work has begun on an electrostatic precipitator and a filter train which can be mocked-up and operated in conjunction with the operation of the oxide-drossing furnace in the PRE mock-up. This precipitator and filter will be installed in the mock-up primarily to check mechanical handling and maintenance of the equipment.

e. Atmosphere Containment - Seals Test Equipment

The inflatable-seals test stand was designed and built in the third quarter of 1957 to evaluate, on a laboratory scale, the use of inflatable seals on the hot-cell vacuum-lock doors. This apparatus can also be used to determine the best ways of manipulating the seals system so as to keep lock vacuum at a level consistent with safe, efficient operation of the hot cells. In addition, leakage data determined with this apparatus can be extrapolated to give an estimate of probable maximum daily leakage of hot cell atmosphere past the seals into the vacuum lock and its pumping system.

The heart of the test stand assembly is the seal mounting plate, Fig. 17. This is a 21 by 25 by 1-1/4 inch mild steel plate welded to caster-equipped angle-iron legs. Milled into the upper surface of the lower plate are two concentric channels 11/16-inch wide by 1/2-inch deep which receive the inflatable seals. The outer channel is a rectangle 18-3/4 by 9 inches with the long sides pulled 3 inches out of line at the midpoints and with the corners rounded to a 3-inch radius. The inner channel is a 12-inch radius circle. Holes drilled through the plate from the bottom of the outer channel adjacent to the inner channel serve as pressure supply leads from the seals to the pressure plumbing manifold on the underside of the stand, Fig. 18 and 19. A parallel vacuum manifold has a valved tie in to the pressure system and valved leads to the center of the inner ring (inner chamber) and to the annulus between the two rings (outer chamber) through holes drilled through the plate. A 21 by 25 by 1 inch mild steel cover plate is fastened to the seals mounting plate by 7/8-inch bolts on 6-3/8 inch centers. The distance between the two plates (throw space) can be changed by varying the number of spacer washers on these bolts. Plugged 1/8 inch NPT holes in the cover plate provide access to the inner and outer chambers for vacuum measurements and gas bleed-ins for leak checks, Fig. 19.

The inflatable seals themselves are circular neoprene bladders of square cross section with a solid bead strip glued to the top surface. They are so molded that on deflation the bead retracts into the seal body, Fig. 17. On inflation the bead is thrust from the body of the seal so that a cross-section in this condition

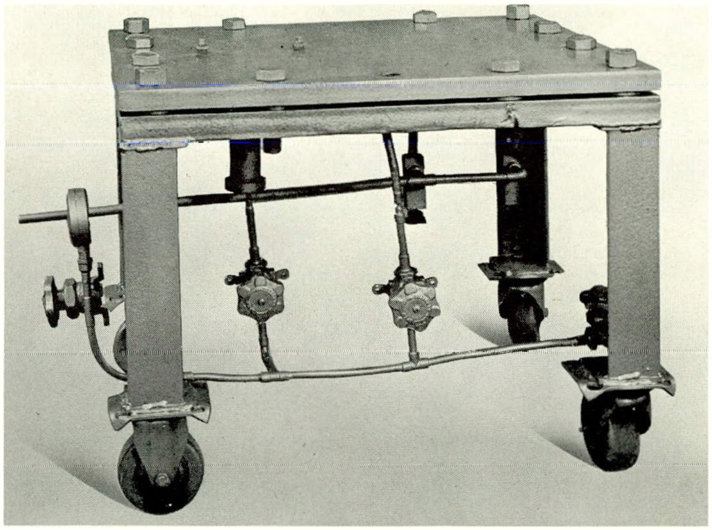

Fig. 18. Seal Mounting Stand and Manifold

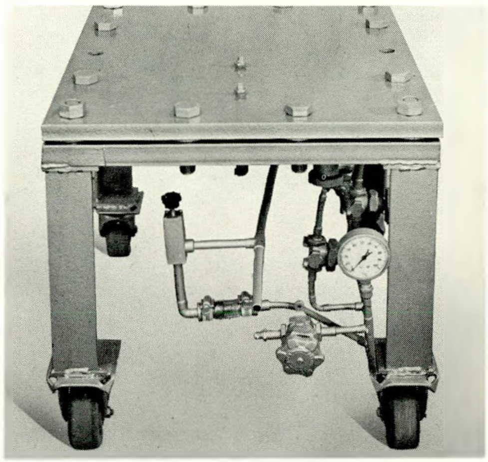

Fig. 19. Seal Mounting Stand, End View

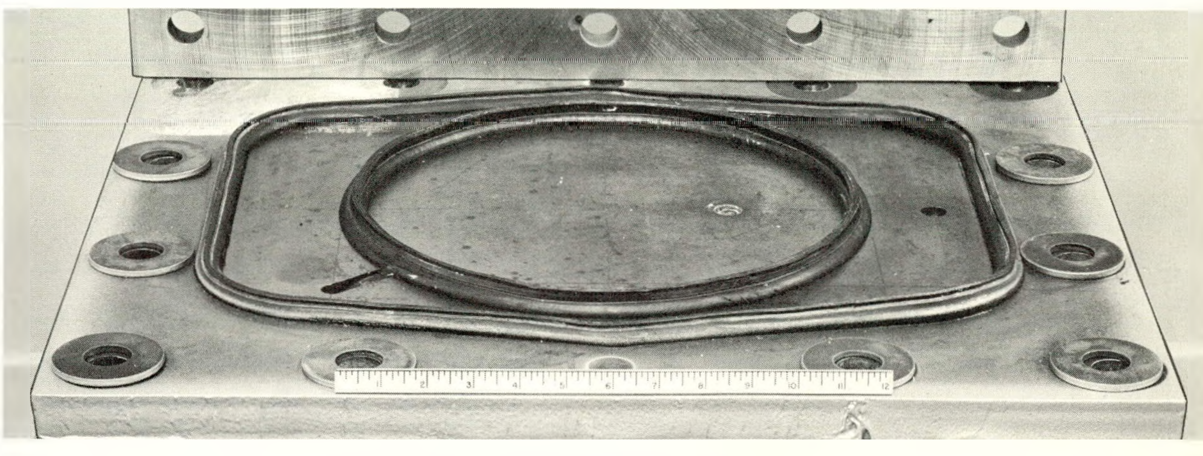

Fig. 20. Seals on Seal Plate

would be a square surmounted by a semicircle crowned with the solid bead, Fig. 20. Inflation pressure is supplied through a 1/4-inch tube vulcanized to the bottom or the side of the seal body. The seals are rated at 20 pounds inflation pressure and tested at 40 pounds by the manufacturer. No indications of possible seal failure were noted at inflations up to 60 pounds during the initial test program.

The procedure followed for a seal test run on this apparatus is as follows:

1) The cover plate is removed from the stand.

2) The seals are mounted in the channels with the pressure supply tubes passed through the lead holes and tightly connected to the pressure lines below with compression fittings or wire ties.

3) The cover is replaced and bolted down with the proper number of spacer washers used to give the desired "throw" space.

4) The seals are inflated with cylinder nitrogen to the specified pressure. They are then deflated and reinflated to this pressure to insure uniform seating of the seal. Helium can be substituted for the nitrogen when a check for suspected diffusion or leakage of inflation gas is needed.

5) The vacuum manifold, up to the chamber valves, is pumped down to check for faulty connections. The vacuum source is a commercial leak-test apparatus with a mechanical roughing pump.

6) The chambers are then pumped down in the desired sequence to a steady vacuum level. This level is noted and the system is then leak checked using helium or acetone as a tracer to determine the locations and approximate sizes of any leaks present.

After assembly and a preliminary check for leaks the relation of seal inflation preassure to vacuum level attained with chamber surfaces was determined with the hot-rolled cover plate in the "as received" condition. Following this, the cover plate was Blanchard ground to evaluate the effect of a more uniform bearing surface on seal efficiency. In both tests the effect of pumping down the outer chamber as an aid to holding better vacuum levels in the inner chamber was checked. Leakage across the inner seal from a helium-filled outer chamber to an evacuated inner chamber was measured with a standard helium leak detection unit. Leak rate per lineal inch was extrapolated for calculating daily leak volumes through the proposed vacuum lock seals in PRE.

(1) Sample Calculations:

a) Inner Chamber

1-foot diameter inner seal inflated with N_2 to 40 psig. Vacuum = 0.08 microns Hg.

Pumping Speed (from pump chart) at 0.08 microns: 16 liters per minute.

1) $\frac{0.075 \times 10^{-3} \text{ mm Hg}}{750 \text{ mm Hg}} \times 16$ liters lpm = 16×10^{-7} liters per minute of gas at STP leak past the 3-foot of seal perimeter.

2) For a 6-foot-square seal leakage would be $8 \times 16 \times 10^{-7}$ = 1.28×10^{-6} liters per minute or 0.013 cc/min.

3) In 24 hours (1.44×10^3 minutes) leakage past this 6-foot seal would be $1.44 \times 10^3 \times 1.28 \times 10^{-5}$ = 0.0184 liters or 18.4 cm^3 of gas at STP.

b) Outer Chamber

4 ft-3 in. perimeter seal inflated with N_2 to 50 psig. Vacuum = 10 microns Hg. Pumping speed (from pump chart) at 10 microns = 93 liters per minute.

1) $\frac{1 \times 10^{-2} \text{mm} \times 93}{750 \text{ mm}} = 1.24 \times 10^{-4}$ liters per minute leak past the 4 ft-3 in. -perimeter of the seal.

2) For a 6-foot-square seal leakage would be $6 \times 1.24 \times 10^{-4}$ = 7.44×10^{-4} liters per minute or 0.75 cc/min.

3) In 24 hours (1.44×10^3 minutes) leakage past this 6-foot-square seal would be $7.44 \times 10^{-4} \times 1.44 \times 10^3$ = 1.06 liters or 1,060 cm^3 of gas at STP.

In preliminary tests the inner seal was capable of holding a vacuum of less than 0.08 microns of mercury pressure if inflated to 40 or 50 psig of nitrogen under any combination of the other variables listed above. Leak rate at this vacuum level was below the detectable range of one part in 200,000 of helium on the leak test apparatus used, Table II. The outer seal was found incapable of holding a vacuum level below 200 microns unless a bedding of Apiezon Q was placed in the bottom of the mounting channel. With this modification better vacua were obtained but performance was still far below that of the inner seal. Blanchard grinding of the cover plate did not change this situation. However, during attempts to improve performance by decreasing throw space a slow loss of outer seal inflation was noted. After reworking the pressure plumbing, the outer seal, inflated to 50 psig of nitrogen held vacuum to 10 microns. Leakage at this level appeared to be irregularly distributed along the length of the seal (Table III). It appears that this seal was defective and will be replaced for further tests. These results are plotted as Fig. 21 and 22.

TABLE II

INFLATABLE SEAL TEST

Run No.	Seal Preparation Inner and Outer	Seal Inflation N_2 Pressure (psig)	Throw Space* (in.)	Inner Chamber Steady Vacuum (microns)	Outer Chamber Steady Vacuum (microns)
(Milled surface on cover plate, 175 microinches, (RMS), 1/4-in. square bead inflatable seals)					
1	greased†	20	3/8	60	200
2	greased	30	3/8	8	200
3	greased	40	3/8	0.08**	200
4	greased	40 inner 50 outer	3/8	††	200
5	greased	50	3/8	††	50
6	greased-bedded***	40	3/8	††	45
7	bedded***	50	3/8	0.08	35
8	greased-bedded***	50	3/16	††	25

*Distance seal bead moves during inflation, in order to contact cover plate.

†Bead of seal greased with Dow Corning silicone vacuum grease. Vacuum reached 10 microns but decreased to 60 microns.

**Leak checked by bleeding helium into outer chamber. No leaks within limits of leak detector, 1 part in 200,000.

††Vacuum measured on outer chamber. No records for inner chamber. Outer seal bedded in Dow-Corning silicone vacuum grease.

***Outer seal bedded in Apiezon Q.

TABLE III

INFLATABLE SEAL TEST

Run No.	Seal Preparation Inner and Outer	Seal Inflation N_2 Pressure (psig)	Throw Space* (in.)	Inner Chamber Steady Vacuum (microns)	Outer Chamber Steady Vacuum (microns)
(II A. Blanchard ground Cover Plate, 100-150 RMS, 1/4-in. bead seals.)					
9	bedded†	50	3/16	0.08	30
(II B. 1/4-in. bead inner seal, 3/16-in.-bead outer seal)					
10	bedded†	50	3/16	0.10	60**
(II C. Reworked valving and pressure supply clamps)					
11	bedded†	50	3/16	††	12
12	bedded†	50	3/16	††	10
13	bedded†	50	3/16	††	10
14	bedded†	50	3/16	0.08	10
15	bedded†	50	3/16	0.08	10
16	bedded†	50	3/16	0.08	11

*Distance seal bead moves during inflation in order to contact cover plate.

†Outer seal bedded in Apiezon Q.

**Outer seal found to be losing inflation pressure.

††Vacuum measured on outer chamber. No records for inner chamber.

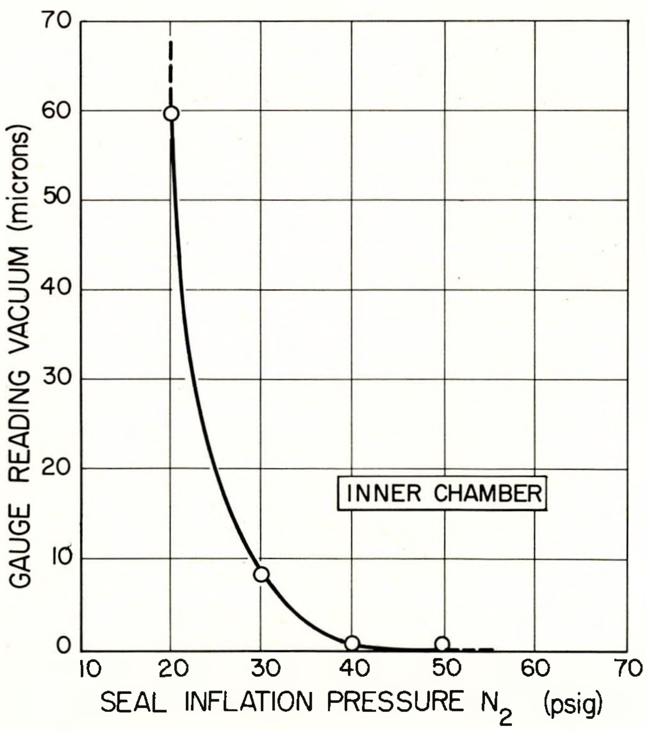

Fig. 21. Seal Inflation vs Vacuum, Inner Chamber

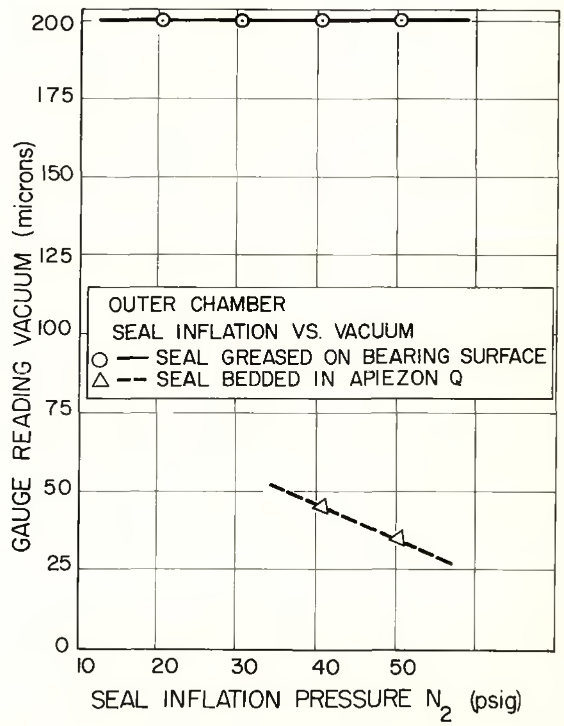

Fig. 22. Seal Inflation vs Vacuum, Outer Chamber

Since, with inner-seal leakage below the limits of sensitivity of the tests, a cross-calibration with a standard leak could not be performed, the nominal pumping speed of the roughing pump was taken from a pump chart and converted to STP to give a maximum leak rate for the seal. This leak rate was then used to calculate a maximum probable daily leak for a lock-door seal six feet square. The same procedure was followed for the outer seal data, (See sample calculations.)

The results obtained can be summarized as follows:

1) The circular inflatable seal checked held a vacuum of 0.08 microns of mercury.

2) The rectangular inflatable seal checked held a vacuum of 10 microns of mercury.

3) Extrapolating the data to fit a 6-foot square seal on a vacuum lock door, leakage into the lock in 24 hours would be:

   a) 18.4 cm^3 of gas at STP for the circular seal.

   b) 1060. cm^3 of gas at STP for the rectangular seal.

In view of these results it is highly probable that inflatable seals can be used to provide the levels of vacuum and leak rate necessary to the proper operation of the hot-cell vacuum lock.

2. Radiation Control (S. Berger)

a. Shielding From Roof Plug Mechanism

The transfer of fuel, either to or from the SRE hot cells, will be accomplished through a roof-plug transfer mechanism on top of the SRE hot cell. A ten inch lead shielding casket will be positioned and sealed above the transfer lock before the fuel is actually moved. The weight of the casket will be supported entirely by the two inch overlap of the shield on the roof. A similar configuration will be used for transfer of fuel from the casket to the PRE fuel transfer tunnel.

The radiation intensity at point "A" (Fig. 23) is due to the direct streaming of gamma rays through the interface between the casket and the roof plug, and the subsequent scattering at point B. The intensity has been calculated for various dimensions of the following two variables:

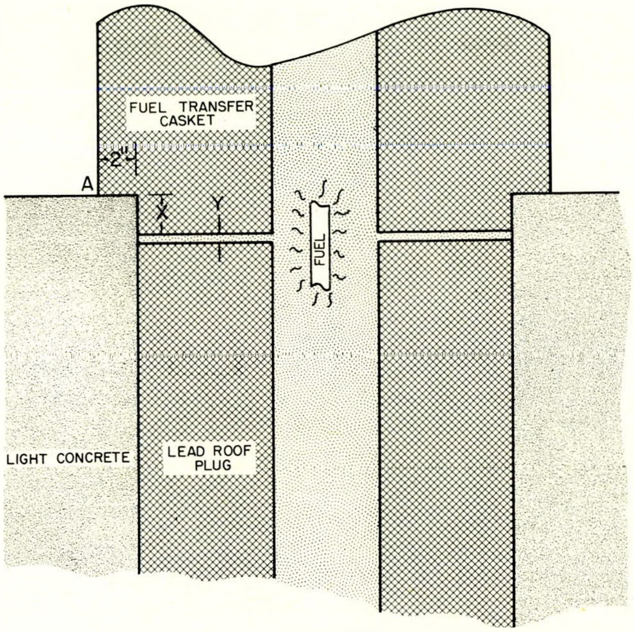

Fig. 23. Roof Plug and Casket

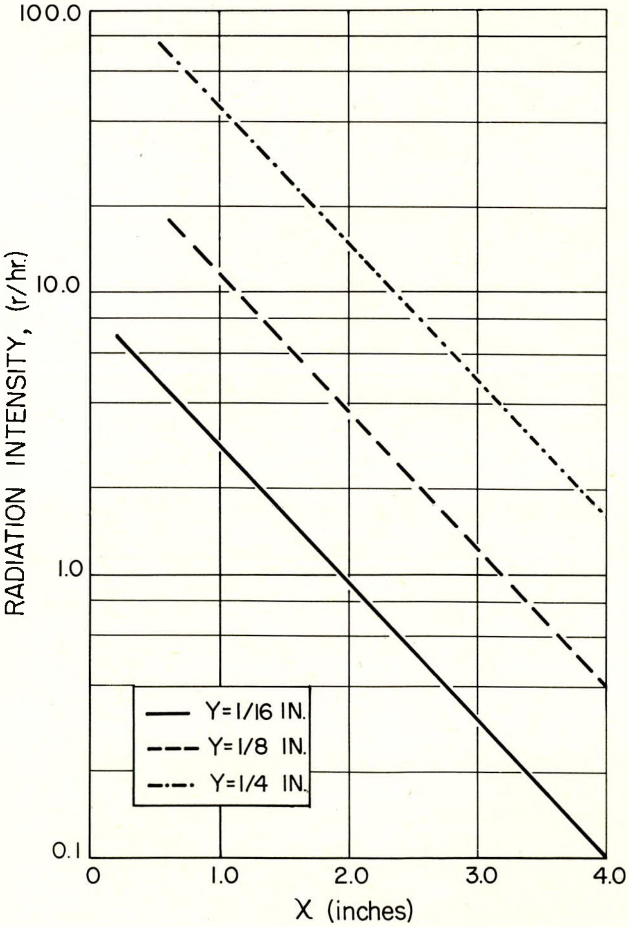

Fig. 24. Radiation Intensity at Edge of Casket Plug

1) Distance casket seats into the roof, i.e., "X".

2) Interface opening, i.e., "Y".

Figure 24 indicates the value of these intensities in r/hr at point "A".

Table IV shows the thickness of steel or lead which must surround the casket with the required width to reduce the intensity to 7 mr/hr.

TABLE IV

SHIELDING REQUIRED TO REDUCE INTENSITY ON ROOF TO 7 MR/HR

X (in.)	Y (in.)	Thickness of Lead (in.)	Thickness of Steel (in.)	Width Shielding (in.)
1	1/16	2.5	5	13
2	1/16	2.0	4	8
3	1/16	1.5	3	6
4	1/16	1.0	2	3
1	1/8	3.0	6	17
2	1/8	2.5	5	12
3	1/8	2.0	4	10
4	1/8	1.5	3	7
1	1/4	3.5	7	21
2	1/4	3.0	6	16
3	1/4	2.5	5	14
4	1/4	2.0	4	11

b. Expected Equilibrium Temperature of Fuel Slug Can

The SRE slugs will probably be delivered to the fabrication cell of PRE in the form of a six-slug cluster enclosed in a stainless steel can. This can, during transfer from SRE to PRE, will be placed in an 8-inch-lead container as shown in Fig. 25. The equilibrium temperature of the can in the shield due to the β and γ activity was calculated. It was assumed from previous calculations that each unprocessed slug of SRE fuel will deliver about 11 watts of thermal power (based on 3000 Mwd/ton burn-up at 20 Mw and 10 days cooling). For six slugs, therefore, there will be a total of 66 watts or 225 Btu/hr liberated. Assuming that the ambient air temperature, T_a, is 80° F and that heat losses are by both radiation and conduction, the temperature of the can, T_e, is about 300° F. This is well below any temperature which would require cooling of the transfer casket.

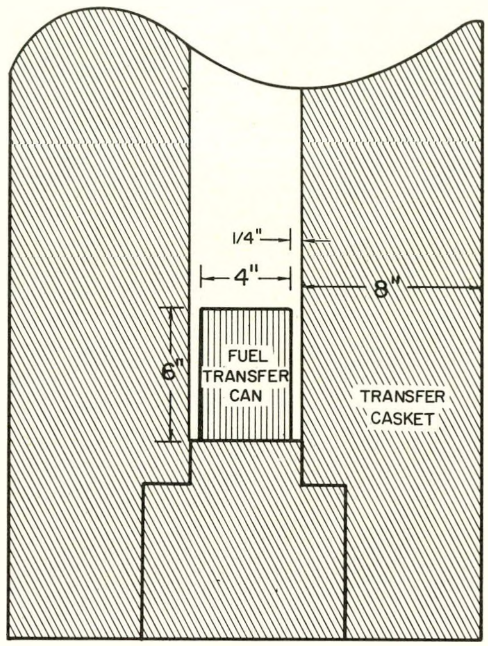

Fig. 25. Fuel Transfer Can in Casket

3. Equipment Decontamination (S. Berger, J. W. Savage)

Work has commenced on the design of an abrasive-blast cabinet for decontamination of equipment. The cabinet is needed for PRE development and for eventual use in the maintenance cell. Initial assumptions are that the cabinet will be remotely operated and will use metallic shot to minimize the dust handling problem.

The possibility of using such a cabinet for multiple operations is being considered. Additional functions under consideration are:

a) Dismantling of equipment by flame-cutting techniques.

b) Flame-spraying of a ThO_2, BeO, or possibly UO_2 ceramic coating onto crucibles.

A number of contacts have been made with vendors and manufactures of abrasive-blasting equipment, flame-cutters, and flame-spraying equipment.

Abrasive blast manufacturers have exhibited willingness to undertake manufacture to any design. Flame-cutting equipment for our purposes may require special design. Commercial flame-cutters are equipped either for linear mono-directional cutting or for pattern cutting.

Investigation of decontamination by ultrasonic cleaning methods with both single and vapor degreaser units has been considered. Since this method appears applicable to decontamination by remote control, a small unit has been purchased for experimentation in the PRE mock-up.

III. PLANS FOR FOURTH QUARTER OF FY 1957

1) Occupancy of the new mock-up space at the Van Nuys facility is planned. Power, water, and compressed air service willbe installed.

2) Study of equipment layout and conceptual design of hot cells will continue.

3) Construction of components for the fuel rod fabrication devices, originally planned for the third quarter, will be initiated early in the fourth quarter.

4) Further tests will be made to prove acceptability by SRE of prewrapped fuel rod tubes. These tests will probably eliminate the necessity for in-cell fuel rod wrapping.

5) Design of in-cell prototype fuel-rod leak-test equipment will be initiated. Delivery of mass-spectrograph leak-test equipment is expected. Design of a slug-transfer counting device will be initiated.

6) Installation and initial operation of oxide-drossing furnace equipment using a copper-nickel alloy to simulate uranium in the mock-up will begin. This will permit study of procedures and operations. Natural uranium metal with artificially-added non-radioactive cesium metal will be melted in an inert atmosphere induction furnace to determine the effectiveness of a proposed electrostatic precipitator design and to determine operational gas temperatures. The electrostatic precipitator has been designed and is under construction.

7) Fabrication of vacuum-furnace coil and crucible assembly, centrifugal mold assembly, and of other accessory equipment will begin so that their delivery will coincide with the delivery of the vacuum furnace, expected early in FY 1958.

8) Fabrication of the remote-dimension inspection device will be completed and operation will begin in the Vanowen hot caves. Optical devices for dimensional inspection and other inspection devices will be studied.

9) Installation and operation of an abrasive-blast unit and an ultrasonic-decontamination unit are planned.

10) Work on remote maintenance and repair devices will continue.

11) The crane-and-manipulator support structure at the mock-up will be completed. Mark VIII manipulator delivery is expected. A rectilinear manipulator is due early in the first quarter of FY 1958.

12) Fabrication of the slug transfer chute mock-up model will be initiated. Design of the material transfer lock (between the process cell and the fabrication cell) will be completed.

13) A lead-glass shielding window will be ordered for use in the mock-up. Delivery is expected in the second quarter of FY 1958. Delivery of the periscope is expected during the fourth quarter of FY 1957. Lighting mock-up equipment will be fabricated.

14) Completion of design and construction of a half-scale mock-up of a vacuum-lock door suitable for incorporation in the general mock-up of the PRE hot cells is planned. This mock-up will be used to check out seals and will be suitable for studying remote maintenance techniques. Further evaluations of existing types of inflatable seals will be made and possible modifications in seal construction will be studied.

15) Initiation and partial completion of the Xe and Kr evolution rate studies, initiation of the Xe and Kr adsorption studies, and a continuation of the liquid-metal "getter" study are planned.

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