SEP 22 1968

ORNL-P-2410 S
CONF-661001-23

REMOTELY OPERATED EQUIPMENT FOR FABRICATING
HFIR TARGET ELEMENTS*†

MASTER

M. K. Preston,** J. D. Sease, J. E. Van Cleve, Jr., and A. L. Lotts
CFSTI PRICES

ABSTRACT

H.C. \$2.00 MN. 50

One of the principal problems in the Transuranium Program at the Oak Ridge National Laboratory was the development of equipment for remotely fabricating High Flux Isotope Reactor target elements. The target element, which is composed of 35 actinide oxide-aluminum powder pellets clad with an aluminum tube contained in a target sheath, is fabricated by techniques that embrace powder-metallurgical, welding, metal-forming and inspection procedures. Equipment was developed to carry out all steps in the process in three hot cells in the ORNL Transuranium Processing Facility. All development stages have been successfully completed, and a portion of the equipment has been operated with radioactive material.

INTRODUCTION

The purpose of the Transuranium Program at the Oak Ridge National Laboratory is to produce gram quantities of the heavier transuranium elements by successive neutron captures in ^{239}Pu . The first part of the production path, the production of ^{242}Pu , was carried out at Savannah River Laboratory.

*Research sponsored by the U.S. Atomic Energy Commission under contract with the Union Carbide Corporation.

†Sponsor - A. R. Olsen.

**General Engineering and Construction Division.

RELEASED FOR ANNOUNCEMENT
IN NUCLEAR SCIENCE ABSTRACTS

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Facilities and equipment at ORNL will be used to further irradiate the ^{242}Pu and to recover the isotopes produced. Target elements containing primarily ^{242}Pu , ^{243}Am , and ^{244}Cm will be fabricated and irradiated in the High Flux Isotope Reactor (HFIR). After irradiation, the target elements will be processed in the Transuranium Processing Facility (TRU) to recover the product actinides and to recycle the target actinides to the HFIR.

One of the principal problems in this program was the development of suitable equipment for remotely fabricating the HFIR targets in TRU. To satisfactorily carry out the recycle of the target material, we developed equipment not only capable of fabricating the target elements, which dictate remote fabrication, but also equipment that is reliable, that is capable of producing an assembly with rigid specifications, and that is easily operated by general operators available in a multipurpose facility. This paper, which is a follow-up on a previous paper on the conceptual design of equipment for remotely fabricating targets,¹ contains a description of the equipment that has been developed and placed into operation. A sound-color movie² showing the operation of this equipment will be shown during the oral presentation.

BASIS FOR EQUIPMENT DESIGN AND DEVELOPMENT

The equipment design and development were influenced primarily by the design of the target element, which is to be irradiated in the flux trap of the HFIR, by its performance requirements and specifications, by the physical location of equipment in TRU, and by the restraints imposed by operation in that facility.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States nor the Commission nor any person acting on behalf of the Commission makes any warranty or representation expressed or implied with respect to the accuracy, completeness or usefulness of the information contained in this report or that the use of any information apparatus method or process disclosed in this report may not infringe privately owned rights or

B Assumes any liabilities with respect to the use of or for damages resulting from the use of any information apparatus method or process disclosed in this report

As used in the above person acting on behalf of the Commission includes any employee or contractor of the Commission or employee of such contractor to the extent that such employee or contractor of the Commission or employee of such contractor prepares disseminates or provides access to any information pursuant to his employment or contract with the Commission or his employment with such contractor

Target Element Design

For irradiation of transplutonium elements, actinide oxides are encased in a target element depicted in Fig. 1. The target region in the HFIR consists of 31 of these individual target elements, as shown in Fig. 2. The target element is composed of 35 individually jacketed pressed pellets, each containing approximately 12 vol % actinide oxide dispersed in aluminum. The pellets are contained in a type X8001 aluminum tube with discontinuous fins, which are attached to one end of the target rod sheath. The targets also have plenums at each end for accommodation of fission gas. These regions are supported with liners, which are also necessary, as shall be seen later, for support of the tube during the processing. Target elements of this design have performed satisfactorily in tests at the service conditions expected in HFIR.³

Process Description

In selecting a fabrication flowsheet for producing the target elements, the preeminent concern was that these rods must be fabricated remotely in TRU. Considerable attention was given to the simplification and adaptability of the process to remote operation. We were careful, however, not to compromise the process in any way that sacrifices required integrity of the target elements. The final flowsheet selected is summarized in Fig. 3.

In the process an actinide precipitate is first calcined at temperatures ranging to 1200°C depending on the particular elements involved. This material is then weighed and the proper amount of aluminum powder is added. Pellets are pressed from a blend of this mixture and jacketed with aluminum. Before processing, the dies are preloaded with an aluminum tube liner and

bottom cap powder. During processing and after filling with the actinide oxide-aluminum powder mixture, cap powder is added to the top of the die. This scheme provides primary containment of these high-specific-activity nuclides in a pellet (Fig. 4) with a density approximately 89% of the theoretical value. Commercial drill bushings of the appropriate size were selected as the pressing dies. These low-cost, mass-produced items can be discarded after a single pressing, thus reducing the spread of contamination and avoiding aluminum galling in the die.

As the pellets are pressed, they are accumulated in a magazine. Before the magazine is loaded, the pellets are checked for length and weight to confirm that the proper amount of actinide was loaded. When a batch for one target is accumulated, the pellets are first decontaminated in an ultrasonic water bath and then thermally treated at approximately 450°C in a vacuum to eliminate any remaining lubricant or water from the pellet.

Following thermal treatment, the pellets are inspected for surface blisters and loaded into the target tubes. After loading, the column length is measured so that the support liner can be cut. After introduction of the support liner, the target tube is end capped by a TIG welding process.

Both the end cap and the process used to weld the end cap were specially designed to circumvent the problems that are normally associated with welding small diameter aluminum tubing. Inability to close welds on such tubing because of gas blowouts is common; and, even when the welds are closed, they may be porous. In our process, this is eliminated through the use of a swage joint (Fig. 5). The final closure joint is mechanically closed by swaging a relatively gas-tight seal in the groove. Before swaging, helium

at less than 1 atm pressure is introduced. After obtaining the gas-tight seal, the welding chamber is pressurized to 1 atm, and the weld is then made with a greater pressure on the outside of the tube than inside. Blowout and porosity of the weld are eliminated, as shown in Fig. 6. After the end cap is attached, the target tube is inspected by a helium leak test and ultrasonically cleaned to remove any loose contamination from its exterior.

The target tube is then inspected for transferable contamination and radiographed at various positions along its length to certify the integrity of the weld and also to record the positions of the pellets. After radiography, the aluminum tube is collapsed onto the pellets by hydrostatic pressure of approximately 20,000 psi to enhance heat transfer. The target is straightened mechanically by pulling the target tube from both ends at a force of approximately 500 lb to an elongation of $1/8$ in. After the target tube is inspected for bow and diameter, the target sheath is fixed to the tube fins by mechanical staking at the bottom of the target. The assembly is dimensionally inspected, ultrasonically cleaned, and shipped to the HFIR.

DESCRIPTION OF TRU

The process will be carried out in TRU, which was described in detail at a previous conference.⁴ To briefly review this facility, it consists of nine heavily shielded cells served by master-slave manipulators. The nine shielded process cells are arranged in a line and each of the process cells is 7×7 ft in area. The cross section of the cell is shown in Fig. 7. Movable top plugs provide access to the cell. The front face of each cell,

which is shielded with 54-in. magnetite concrete, has a window, master-slave manipulators, and ports for installation of periscopes. Within the shielded cells, the process equipment is enclosed by a cell cubicle. Behind and below the cell cubicle and shielded from it by a removable concrete wall is a tank pit for housing waste collection equipment and processing and storage tanks. Service lines enter through removable plugs in the back and top of the cell, as shown in Fig. 6.

Three cells are being used for target fabrication. Access to each of these cells is gained through the use of the intercell conveyor. The conveyor canister, which is internally 8 in. in diameter and 8 in. in height, can be used for the transfer of small tools, samples, and replacement components for equipment. In addition, an 18- x 36-in. hatch is provided in the roof of the cubicle for removal of large equipment items into a movable shielded equipment caisson. Special bridge cranes were installed for movement of heavy objects inside the target fabrication cubicles. The service provisions for the target fabrication cells are drainage lines to the tank pits, electrical and piped services, which run through the roof plugs to the chemical makeup area, and similar connections that run from the chemical makeup area to the control equipment located in the operating area.

SPECIAL PROBLEMS IMPOSED IN EQUIPMENT DESIGN

The characteristics of the materials to be fabricated, the target element itself, and the restrictions imposed by the facility all caused special problems that had to be considered in the equipment design. First, attention had to be given to the use of materials resistant to the neutron and gamma

radiation that will be present in the hot cells during fabrication. Secondly, the effect that the long leads for electrical controls and for piping would have on the process was not clear. Thirdly, the crowded cell conditions meant that special attention had to be given to the conditions that would exist during normal operations and maintenance. Fourthly, the restrictions on access meant that various sensitive components that might require replacement frequently should fit within the intercell conveyor and that the equipment items themselves should be sized for the opening in the top of the cell cubicle. Finally, problems with air currents and vibrations were anticipated but could not be defined.

CRITERIA SELECTED FOR DESIGN

Initially, the basic criteria established for the design of the target-element fabrication process and its associated equipment were that the operation should be simple, reliable, and capable of producing elements to the specified tolerances and that the equipment should be small, require minimum maintenance, be well advanced technologically, and be resistant to damage by gamma and neutron radiation. The system had to be designed to minimize the spread of contamination and facilitate replacement of its components. Since a great number of components were to be handled, especially during the pellet fabrication operations, and since some target components could be damaged if manipulators were used for handling, we decided that the transfer arms or other special devices should be used to move target rod components between the various steps in the process. We also decided that the equipment should be designed to operate semiautomatically with minimum use of manipulators

for performance of physical operations required in the process. We believe that master-slave manipulators should be used primarily for equipment maintenance and for transfer of components to and from the intercell conveyor. Wherever possible, sensitive parts were to be small enough for charging to or discharging from the cubicle via the intercell conveyor. All equipment was to be demountable with the impact wrench and small enough for removal through the 18- x 36-in. hatch in the roof.

We further stipulated that the individual processes should be assigned to the cells according to the degree of contamination that could be expected from them. Generally, the operations with loose powders were to be performed in cell 3, those with pellets in unsealed tubes in cell 2, and those with sealed target elements in cell 1. We knew that the process should be designed to contain the material as early as possible in the process and that all possible steps should be taken to prevent the spread of contamination downstream in the process. Accordingly, we decided that auxiliary enclosures should be used to further minimize the spread of contamination and that a number of cleaning operations should be employed.

Although not all aspects of the criteria were kept we were able to maintain the primary requirements of the original criteria. We found that certain transfers could be much more readily and economically accomplished with the manipulators than with special devices designed for individual transfers. For example, the transfer of a magazine containing pressed pellets from the ultrasonic cleaning equipment to the thermal treatment station is done with manipulators.

DESCRIPTION OF DEVELOPED EQUIPMENT

The target fabrication equipment has been installed in the TRU facility and a portion has been operated with radioactive material. Prior to being installed in the TRU fabrication cells the equipment was thoroughly tested in mockup operations. We first unit-tested the equipment and made corrections needed to make it operate. The equipment was then installed in the mockup and operated as a complete system to substantiate its capability of making satisfactory target elements. All of the equipment items were disassembled and reassembled in the mockup to demonstrate the capability of remotely maintaining the equipment. In all of these phases of testing, various equipment items required modification and retesting.

The general mechanical features of the equipment are that it is modular and fits together in a manner such that individual items are dimensionally related to each other within close tolerances. Furthermore, virtually all of the equipment is of special design. We found it almost impossible to use commercial items that satisfy the requirements for operation in the TRU facility. A number of the machines are, however, modifications of commercial products.

Cell 3 Equipment

The functions of cell 3 are to prepare the actinide oxide and to fabricate and inspect the pellets. A photograph of this equipment, as installed in the cell mockup during the mockup testing phase of the program, is shown in Fig. 8. The following discussion of equipment will be keyed to the reference numbers on the photograph.

One of the principal problems in the design of equipment was that of obtaining a suitable mounting system to relate the machines dimensionally to one another. Especially, this was a problem with machines that had to work together with a conveyance mechanism. Our solution to this problem is an equipment mounting base (1) that is a welded pipe frame having pads on top for equipment mounting and lugs on the bottom for attaching the base to studs located on the cell floor.

The actinide precipitate is calcined in a 3-in. commercially available tube furnace (not shown in Fig. 8). Batches of material are weighed with a 400-g top-loading Sauter balance (2) modified for remote operation and read-out. The standard balance cover was replaced with a special cover to provide mounting surfaces for two motors and a transducer and to reduce its height so it would fit within the cell configuration. The aluminum powder add station (3), which is manipulator operated, is used to transfer the calcined actinide from its container to a blending bottle and for the addition of pre-weighed aluminum powder. By means of a valve, provisions for rotation, and a motorized vibrator to assure transfer, the material is easily transferred from one container to another.

The blender (4) is a 16.6 rpm geared Slo-Syn motor, and the blending bottle is held in place on the output shaft with a mounting ring. The blender in turn is mounted on a blender elevator, which provides the vertical motion required to obtain the clearance for placing the die holder on the die scale. The dispenser (5) consists of a bottle holder and a Syntron vibratory feeder with a special dispensing trough. All of these components are mounted on the platform of the blender elevator. The rate of feed of the powder into

the die assembly, which is important in obtaining homogeneous distribution of oxide, is controlled by a preset rheostat located in the electrical control panel. The die holder station (6) consists of a motorized actuator for placing the die holder on the die assembly before it is transferred to the die scale for loading the actinide-aluminum powder mixture. The die scale (7) is a 160-g top-loading Sauter balance, similar to the batch scale, which we modified for remote operation and automatic readout.

The cap powder station (8) is used to add the aluminum powder that forms the top cap for the pellets. An elevating loader lowers the powder dispensing mechanism into the proper position for addition of the powder. A powder funnel enters the top of the die assembly and seats on the aluminum liner tube; the indexing motor then rotates the plastic powder magazine so that one of the 40 preweighed cap powder loadings is over the funnel opening; and an air cylinder then engages the powder magazine and pushes it over the discharge hole to release the cap powder to the die assembly. The die assembly feed station (9) is used to hold and dispense dies for the pelletizing operations carried out in cubicle 3. The assembly is primarily a spring-actuated mechanism for feeding dies from the magazine into the central transfer arm (10), which is used to transfer the die assembly. The transfer arm swings through an arc of approximately 70° to serve the die magazine station, the die holder station, the powder dispensing and weighing station, the cap powder station, the pellet press, and the used die disposal station. The only other motion required is for the fingers to open and close to release or clamp the die assembly as required.

The pellet press (11) is an automatic hydraulic press with auxiliary equipment to perform certain other functions that are required to complete a pellet pressing cycle. Most of these functions are controlled by an auxiliary shaft which is indexed to six different stations by a hydraulically operated ratchet located at the base of the shaft. The press performs individual functions of loading a top punch, loading a die assembly, pressing the pellet, pressing out the bottom punch, pressing out the pellet, dropping the pellet to the pellet scale, and dropping the used die.

After pressing, the pellets are inspected in the pellet weighing and measuring station (12). After the pellet is weighed on the scale, the balancing motor is switched out of the circuit. Then, a small air jet on the scale beam under the pellet unbalances the scale bringing the top of the pellet into contact with the gage pin. A differential transducer reading at this point indicates the amount of unbalance of the scale and thus gives a direct indication of the pellet length. A master gage pellet is used periodically to calibrate the indications of the pellet weight and length measurements.

A pellet magazine (13) is used to receive the pellets, hold them while they are ultrasonically cleaned and thermally treated, and finally discharges them to cell 2. During this process, the identity of each individual pellet is maintained. Indexing mechanisms are provided at the various positions to rotate the cylinder inside the magazine. The magazine can be inserted into the indexer mechanisms with the cylinder in only one position; this assures that the pellets are placed in the cylinder in proper order. The pellets are cleaned in an ultrasonic cleaner (14) which consists of a two-compartment tank, the top portion of which is a cleaning tank and the bottom and larger portion of which contains the immersible ultrasonic transducer.

To remove any residual stearic acid and moisture from the pellets, they are thermally treated in a modified commercially available furnace (15), which operates at a maximum temperature of 800°C. Vacuum systems and heating controls are located outside the cubicle. After thermal treatment, the pellets are discharged at the pellet discharge station (16), which consists of an indexing motor assembly for individually unloading the pellets through a tube into cell 2.

Cell 2 Equipment

The functions of cell 2 are to complete the inspection of the pellets, load them into tubes, weld the tube and end cap, and perform the initial inspection of the end-cap weld. This equipment installed in the cell mockup is shown in Fig. 9. The equipment is mounted on a base (1) for spacing in a manner very similar to that used in cubicle 3. All of the equipment except the pellet inspection and loading equipment is mounted on this base so that the machines can work together with the transfer arm provided in this cubicle.

The pellet inspection and loading equipment (2) consists of four major components: the pellet diameter gage (2a), the pellet feeder (2b), the pellet loader (2c), and auxiliary enclosure (2d). Operationally, after the pellet is released from the indexing magazine in cubicle 3, a vibrator moves the pellet into position for a check of its diameter, which indicates any swelling of the pellet during the thermal treatment. The pellets are then fed individually into the target tube by the pellet feeder, which allows only one pellet to be fed at a time, and the pellet loader, a motor-driven push rod. An auxiliary enclosure is used to support and contain the equipment and is sealed

to the pass-through port between cubicles 2 and 3. The top and front are removable for access to the internal equipment and wiring by the manipulator and impact wrench.

The purpose of the tube holder and loading station (3) is to receive the target tube storage container (which contains the target tube), to position the target tube properly for the loading operation, and then to place the target rod into position for pickup by the transfer arm. A void measurement station (4) is used to determine the length of the void space on top of the pellet column after loading so that the length of the liner to be used can be determined.

The transfer arm assembly (5) is used to transfer the target tube between the operations of the tube holder and loading station, the target assembly machine, the helium leak-test station, and the target transfer station. The assembly is composed of four main components: the rotational assembly, the vertical motion drive assembly, the arm assembly, and the clamping-hand assembly. The transfer arm rotates by means of an electrically driven motor to align with the various stations. Positive mechanical stops, positioned by the manipulator, stop the rotation at the various stations. Mounted on the rotational assembly is the vertical shaft on which the vertical drive assembly travels. This assembly consists of a ball bushing outer race mounted in a housing, which also mounts a gear motor drive and brake. The arm assembly is fixed by a pin on the vertical motion drive housing and is shaped to clear other equipment and support the hand assembly at the proper radius. The clamping-hand assembly contains a small gear motor, which through a screw nut and linkage arrangement operates the clamping fingers.

The target rod assembly machine (6) is used to perform all the operations involved in attaching and sealing the end caps. These include the evacuation of the target tube, backfilling it with helium, end cap insertion, roll swaging to obtain a seal, and the actual welding operation. The target rod, after end-capping is transferred to the leak-test station (7), which operates with a helium mass spectrometer located externally to the cubicle in the chemical operating area of the TRU. After leak testing, the target rod is transferred by the transfer station (8) and cleaned in an ultrasonic cleaner (9) located in the wall between cubicles 2 and 1. The ultrasonic cleaning tank is enclosed in a transducer tank which is filled with water for transmission of the ultrasonic energy. These tanks are separately sealed to avoid draining the transfer tank during the cleaning operation, and thereby minimizing the amount of cleaning solution to be handled by the disposal system. A push rod rotates the target rod to facilitate proper cleaning and to transfer the target rod to cell 1.

Cell 1 Equipment

The general arrangement of the cell 1 equipment, which is used for the final inspection and fabrication of the target elements, is shown in Fig. 10. For spacing, the equipment is mounted on a base (1) similar to those previously described.

The purpose of the target rod receiver (2) is to receive the rod from the ultrasonic cleaner in the cell wall and position it for pickup by the transfer arm. The transfer arm (3) in cell 1 is almost identical in design to the arm in cell 2.

The first step of the processing in this cubicle is testing for surface contamination, which is done in the target dryer and smear station (4). The

dryer consists of a drying tube and a heater with connection for a compressed air supply. The surface smearing is done with two foam rubber pads encased in a holder. The radiography is done at the x-ray station; the film holder (5) is used to hold the target rod for x-ray inspection, to hold the x-ray film in proper relation to the target rod, and to provide unexposed film as it is needed. The x-ray tube (6) is mounted on a supporting platform in a position opposite the x-ray station. The x-ray film is held in a film spool container (7), which has stainless steel internal and external sleeves filled with depleted uranium. The containers are used to protect the film spool during transport via the intercell conveyor past the other eight cubicles, which are likely to have highly radioactive sources.

The dimensional inspection unit (8) is used to measure the diameter and straightness of the target rod before and after collapse and the dimensions of the target element after the target sheath is placed onto the tube. Six linearly variable differential transformers are mounted in a preadjusted cartridge which in turn is mounted in a carriage plate which operates on two vertical shafts. Vertical motion is provided by roller chain and sprocket drive powered by a Slo-Syn gear motor. The hydrostatic collapse chamber (9) is used to collapse the target tube onto the pellet. A high-pressure pump located outside the cubicle supplies 20,000 psi water through high-pressure tubing and a disconnect near the base of the hydrostatic collapse unit. The helium leak-test chamber (10) provided in this cell is identical to that described for cell 2.

The target sheath attachment fixture (11) is used to mechanically attach the lower end of the sheath to the thin target tube. This is done by means of plungers, which are forced into the sheath by the rotation of a cam powered by a standard air cylinder. Another ultrasonic cleaner (12) is provided in

cubicle 1 to remove any foreign material from the target prior to its shipment to the HFIR. Finally, the target element is discharged through the discharge station (13) for introduction to the carrier located on top of the cell.

Electrical Control Systems

All operations of the mechanical equipment previously described are controlled from panels in the operating area. These panels are designed for semiautomatic control in that each successive step is indicated by the panel lighting system.

PRESENT STATUS OF THE EQUIPMENT

All of the equipment has been operated with nonradioactive materials in the TRU cells, and the equipment in cell 1 has been used to inspect irradiated targets. Our experience indicates that the weighing devices will be the most difficult machines to keep calibrated and operating properly. We have had to remotely repair and maintain a number of other machines, but this has been done without incident. Although the equipment is performing satisfactorily in our preliminary hot-cell work, we can completely determine its reliability and adequacy only after extensive fabrication of recycle targets.

REFERENCES

1. W. C. Thurber and A. L. Lotts, "Development of Procedures and Equipment for Fabrication of High Flux Isotope Reactor Target Rods," pp. 27-38 in Proceedings of the 10th Conference on Hot Laboratories and Equipment, American Nuclear Society, Hinsdale, Illinois, 1963.
2. "Development and Fabrication of HFIR Target Elements," Motion Picture Department, Oak Ridge National Laboratory.
3. A. R. Olsen et al., "Irradiation of High Flux Isotope Reactor Target Prototypes," paper presented at the 12th Annual American Nuclear Society Meeting, Denver, Colorado, June 19-23, 1966.
4. W. E. Unger, B. F. Bottenfield, and F. L. Hannon, "Transuranium Processing Facility Design," pp. 3-10 in Proceedings of the 10th Conference on Hot Laboratories and Equipment, American Nuclear Society, Hinsdale, Illinois, 1963.

FIGURES

- Fig. 1 (ORNL-DWG 65-1383) HFIR Target Element.
- Fig. 2 (ORNL Photo 80115) HFIR Target Element Assembly.
- Fig. 3 (ORNL-DWG 66-7233) HFIR Target Fabrication Flowsheet.
- Fig. 4 (Y-70163) Transverse and Longitudinal Pellet Cross Sections.
- Fig. 5 (Y-70162) Cross Section of End Cap Before Welding.
- Fig. 6 (Y-67844) Cross Section of End-Cap Weld.
- Fig. 7 (ORNL-LR-DWG 60562) Transuranium Facility Cell Cross Section.
- Fig. 8 (Photo 82455A) Mockup of Cell 3 Target Fabrication Equipment.
- Fig. 9 (Photo 82454A) Mockup of Cell 2 Target Fabrication Equipment.
- Fig. 10 (Photo 82453A) Mockup of Cell 1 Target Fabrication Equipment.

Fig. 1 (ORNL-DWG 65-1383) HFIR Target Element - M. K. Preston, Remotely
Operated Equipment

Fig. 2 (ORNL-Photo 80115) HFIR Target Element Assembly - M. K. Preston,
Remotely Operated Equipment

Fig. 3 (ORNL-DWG 66-7233) HFIR Target Fabrication Flowsheet - M. K. Preston,

Remotely Operated Equipment

Fig. 4 (Y-70163) Transverse and Longitudinal Pellet Cross Sections -
M. K. Preston, Remotely Operated Equipment

Fig. 5 (Y-70162) Cross Section of End Cap Before Welding - M. K. Preston,
Remotely Operated Equipment

Fig. 6 (Y-67844) Cross Section of End-Cap Weld - M. K. Preston, Remotely
Operated Equipment

Fig. 7 (ORNL-LR-DWG 60562) Transuranium Facility Cell Cross Section -
M. K. Preston, Remotely Operated Equipment

1. EQUIPMENT MOUNTING BASE	10. TRANSFER ARM
2. BATCH SCALE AND SUPPORT STRUCTURE	11. PELLET PRESS
3. ALUMINUM POWDER ADD STATION	12. PELLET WEIGHING AND MEASURING STATION
4. BLENDER AND BLENDER ELEVATOR	13. PELLET MAGAZINE AND INDEXING MECHANISM
5. DISPENSER	14. PELLET ULTRASONIC CLEANER
6. DIE HOLDER STATION	15. PELLET THERMO-CLEANING STATION
7. DIE-SCALE ASSEMBLY	16. PELLET DISCHARGE STATION
8. CAP POWDER STATION	17. CONVEYOR PORT CLOSURE
9. DIE ASSEMBLY FEED STATION	

Fig. 8 (Photo 82455A) Mockup of Cell 3 Target Fabrication Equipment -

M. K. Preston, Remotely Operated Equipment

1. EQUIPMENT MOUNTING BASE	5. TRANSFER ARM ASSEMBLY
2. PELLET INSPECTION AND LOADING EQUIPMENT	6. TARGET ROD ASSEMBLY MACHINE
A. PELLET DIAMETER GAUGE	7. HELIUM LEAK TEST CHAMBER
B. PELLET FEEDER	8. TARGET ROD TRANSFER STATION
C. PELLET LOADER	9. TARGET ROD ULTRASONIC CLEANER
D. AUXILIARY ENCLOSURE (FRONT REMOVED)	10. TARGET TUBE STORAGE CONTAINER
3. TUBE HOLDER AND LOADING STATION	11. CONVEYOR PORT CLOSURE
4. VOID MEASUREMENT STATION	

Fig. 9 (Photo 82454A) Mockup of Cell 2 Target Fabrication Equipment --

M. K. Preston, Remotely Operated Equipment

1. EQUIPMENT MOUNTING BASE	8. DIMENSIONAL INSPECTION UNIT
2. TARGET ROD RECEIVER	9. HYDROSTATIC COLLAPSE STATION
3. TRANSFER ARM	10. HELIUM LEAK TEST CHAMBER
4. TARGET ROD DRYER AND SURFACE SMEAR STATION	11. TARGET ROD SHEATH ATTACHMENT UNIT
5. TARGET ROD X-RAY STATION AND FILM HOLDER	12. TARGET ELEMENT ULTRASONIC CLEANER
6. X-RAY TUBE AND SUPPORT	13. TARGET ELEMENT DISCHARGE STATION
7. FILM SPOOL SHIELDING CONTAINER	14. HEX CAN STORAGE UNIT

Fig. 10 (Photo 82453A) Mockup of Cell 1 Target Fabrication Equipment -

M. K. Preston, Remotely Operated Equipment