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MASTER

REMOTE TARGET REMOVAL FOR THE OAK RIDGE 86-INCH CYCLOTRON

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ABSTRACT

A remotely operated target remover has been placed in operation at the 86-Inch Cyclotron located in Oak Ridge. The system provides for the remote removal of a target from inside the cyclotron, loading it into a cask, and the removal of the cask from the 1.5 m (5-ft) shielding walls. The remote system consists of multiple electrical and pneumatically operated equipment which is designed for controlled step-by-step operation, operated with an electrical control panel, and monitored by a television system. The target remover has reduced the radiation exposures to operating personnel at the facility and has increased the effective operating time. The system is fast, requires a minimum of skill to operate, and has demonstrated both reliability and durability.

INTRODUCTION

The 86-Inch Cyclotron, located in Oak Ridge, Tennessee, was placed in operation in 1950. The main use of the cyclotron is the production of medical radioisotopes and other commercially used radioisotopes. Previously, the induced radioactivity in the targets has been allowed to decay to radiation levels permitting the targets to be removed from the irradiation position by personnel using long tongs and placed in transfer casks. The casks were transferred to a hot cell, and the targets were mechanically disassembled and loaded into casks for shipment.

The remote target removal system was designed to remove the target from the cyclotron and load it into a removal cask without personnel entry into the cyclotron cell. The objectives were to comply with the ALARA principal of reduction of personnel radiation exposure to as low as reasonably achievable and to increase the effective operating time of the cyclotron by shortening the target decay time used to reduce personnel radiation exposure.

CYCLOTRON DESCRIPTION

The cyclotron is located approximately in the center of a 13.7-m long × 12-m × 12-m high (45-ft long × 40-ft × 39-ft high) cell shielded by 1.5 m (5 ft) of normal concrete. The largest component of the cyclotron is the 227-t (250-ton) steel magnet yoke which is 6.9 m (22 1/2 ft) long, 1.8 m (6 ft) high, and 1.7 m (5 1/2 ft) in cross-section (see Fig. 1).

Mounted inside the U-shaped yoke are the four copper-wound magnet coils which are oil cooled. Nested inside the four magnet coils are the tank, the tank extension adapter, and the vacuum manifold which make up the vacuum chamber for the cyclotron. The tank contains the internal assemblies of the cyclotron which include the dees, liners, ion source, shorting spiders, and trimming capacitors.

The tank has a top opening which provides for installation of components and a bottom opening with a vacuum lock door which allows access to the target area. All targets are inserted and removed from the cyclotron through the bottom opening.

GENERAL

The remote removal of the target is accomplished with four basic pieces of mechanical equipment. A target dolly, a target transfer table, a transfer cask and table, and a monorail-type crane. The target dolly inserts and removes the target from the cyclotron and transports it to the target transfer table, the transfer hand removes the target from the dolly and inserts it into the cask, and the cask is removed from the cyclotron with a remotely operated crane. The remote operation is electrically operated and controlled and is monitored by a television and two cameras.

TARGET DOLLY

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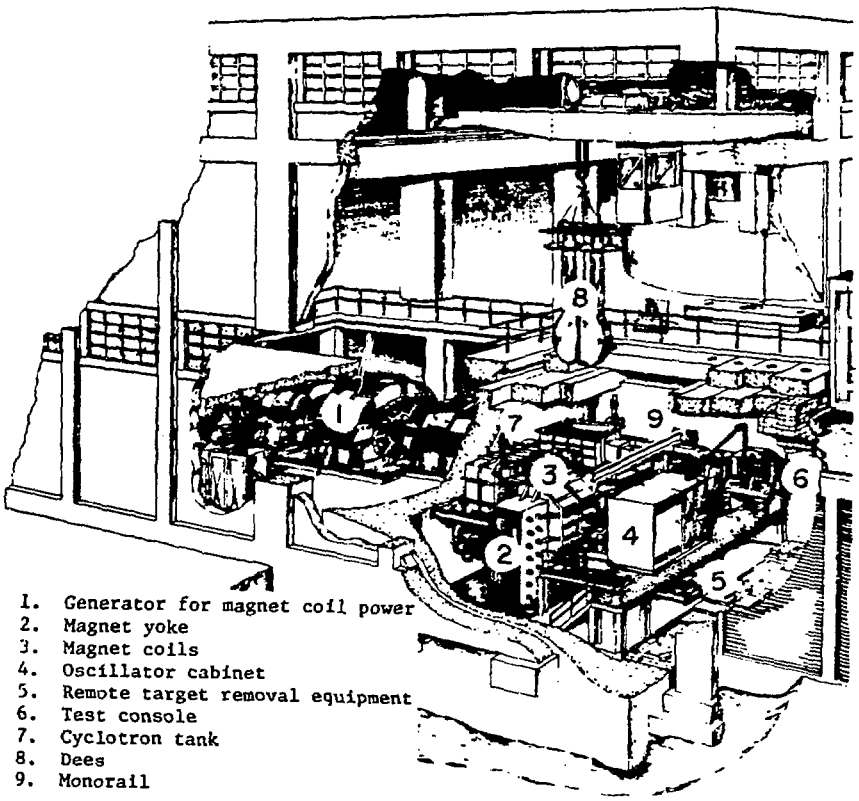

Fig. 1. The 86-Inch Cyclotron

retrieving the target, and positioning it for transfer into the cask (Fig. 2). The target dolly has the following features:

1. A mating flange on top of the dolly which is compatible with the bottom of the cyclotron (vacuum lock door) so that a vacuum of 10^{-6} torr can be maintained in the target dolly unit.

2. Remote positioning so it can be raised against the bottom of the cyclotron to form a seal with the flange of the vacuum lock door and lowered to break the seal.

3. A self-contained system that can insert and remove a target while the target dolly is coupled to the bottom of the cyclotron.

4. Electrical insulation so that the intensity of the proton beam impinging on the target can be measured.

5. A water system for target coolant which can dissipate the heat.

6. Remote attachment to a water and air supply system.

7. A mechanism for locating the target to a position under a target transfer table for lifting the target by the transfer hand.

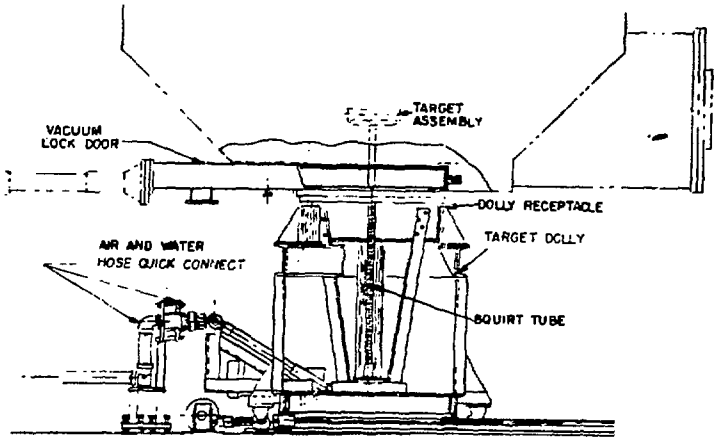

Fig. 2. Target Dolly

All of these features are remotely controllable from outside the cyclotron cell. A similar dolly has been used during past years, but the design had to be refined to incorporate the remote technology required. Costs for the new target dolly in 1981 were about $55,000.

TARGET TRANSFER TABLE

The function of the target transfer table (Fig. 3) is to remove the target assembly from the target dolly and place it in the prepositioned transfer cask. The transfer hand consists of a protruding metal plate which meshes against the bottom of the target head when it is positioned by the target dolly. The transfer hand can be raised, and lowered, and moved horizontally to position the target assembly in the cask — a very simple design for remote operations. The challenge in the design for this operation was to provide a remote disconnect which contained the water coolant supply so the target assembly could be removed from the target dolly. A 13-cm (5-in.) diam quick-disconnect was designed and built for this purpose.

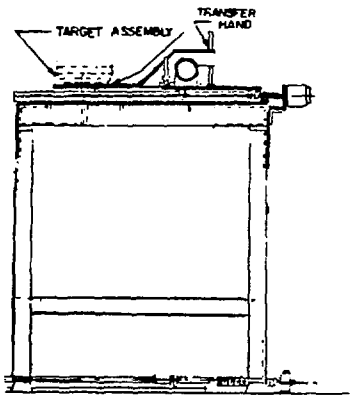

Fig. 3. Target Transfer Table

TRANSFER CASK AND TABLE

The transfer cask (Fig. 4) is unique because of the weight limitations. The cask design specifications included a minimum shielding of 10 cm (4 in.) of lead, a maximum weight of 900 kg (one ton), and a remotely operated, vertical-lift door. The cask door is operated with pneumatic cylinders mounted on the cask table. After the transfer hand positions the target assembly in the cask, the cask door is remotely closed using pneumatic cylinders. The cask is then free to be removed by the crane.

CRANE (MONORAIL)

The monorail crane was modified to provide a remote control system. A ribbon-type flexible control cable which floated with the monorail is used to power the controls. A guide system was field fabricated to guide the cask into position on the cask table.

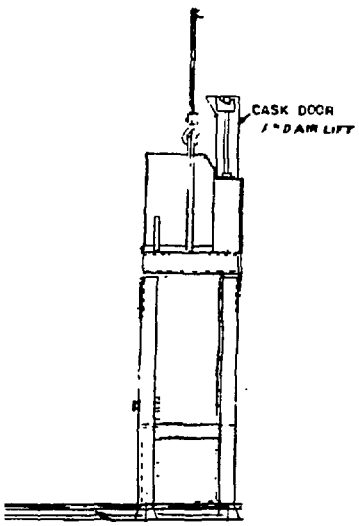

Fig. 4. Transfer Cask and Table

CONTROL SYSTEM

The control system is a semiautomatic, electrically operated system which is controlled by a series of limit switch actuations. Sensitive manipulations in the sequence of operation are automatically stopped at critical points and must be manually initiated to continue to the next operation. A light indicates that the target assembly is in the proper position for the next operation and the next operation is manually initiated. This series of operations continues until the target is loaded and the cask is removed from the cell. There are 23 controls or monitoring switches in the operation. The remote operations are monitored by two television cameras and one television.

There are two control panels with complete operation; one in the cyclotron cell at the site and the other at the TV control stat'on. Two other control stations have limited operation, one in the cyclotron control room for specific operations related to the cyclotron operation and the other in a shielded area in the entrance maze where the crane can be visually monitored in case of unusual circumstances.

OPERATION SEQUENCE

The operation sequence of the system consists of the following remote operations after the target has been irradiated (see Fig. 5):

The target assembly is electrically lowered into the dolly receptacle, the pneumatically operated vacuum lock door on the bottom of the cyclotron is closed, and the dolly receptacle is vented to raise the pressure to atmospheric. These remote operations can be performed in the cyclotron control room as well as the remote loading station.

The target dolly receptacle is lowered using pneumatically operated cylinders, breaking the seal at the cyclotron. The water system is blown dry, air and water disconnects are pneumatically released, and the target dolly is transferred (chain driven) underneath to the target transfer table. Movements are controlled by electrically activated limit switches and monitored by two television cameras. The target assembly is then raised by the squirt tube (Fig. 5) on the target dolly and located for the transfer hand. The squirt tube is a combination target positioning pedestal and target coolant transfer tube. The electrically operated transfer hand is positioned under the target assembly, the target assembly is unlocked by a lifting motion of the hand, and it is raised from the squirt tube. The squirt tube is relocated by lowering into the dolly receptacle. The transfer hand travels with the target inside the prepositioned cask and positions the target on the supports inside the cask cavity. The transfer hand is lowered and retrieved from the cask.

The cask door is lowered using two pneumatic cylinders mounted on the cask table. The cask is lifted by the crane to the controlled vertical position and transferred from the cyclotron cell to the hot cell where the target assembly is removed.

Introduction of the target assembly into the cyclotron is accomplished by manually placing the unirradiated target assembly into the cask and reversing the preceding operations until the target is positioned for bombardment. A digital readout is provided for determining the controlled height of the target in the cyclotron.

SUMMARY

The remote operation has accomplished the objective of reducing radiation exposure to operating personnel and increasing the effective operating time of the cyclotron by reducing the downtime formerly allowed for target decay prior to direct removal with a long tong. The system has been in operation since December 1981 with only minor difficulties.

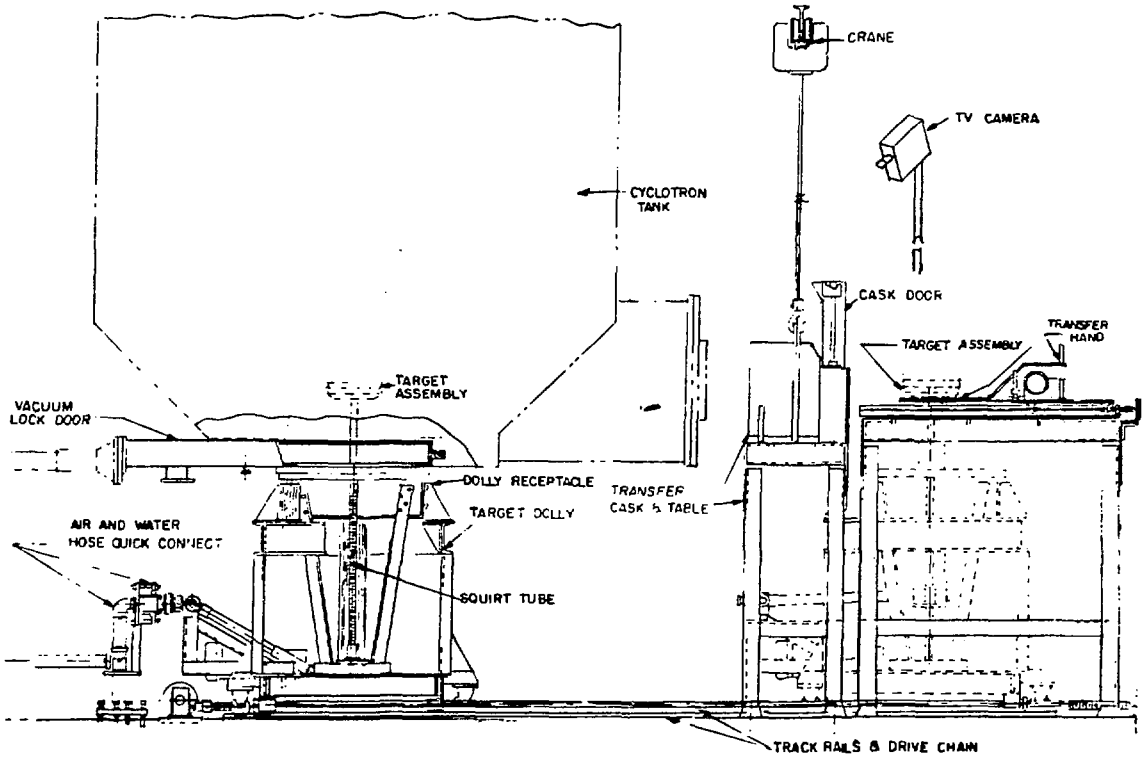

Fig. 5. Remote Equipment for Target Handling