ICANS-XV
15th Meeting of the International Collaboration on Advanced Neutron Sources
November 6-9, 2000
Tsukuba, Japan

23.13
Conceptual Design of the Handling and Storage System for Spent Target Vessel

Junichi Adachi*, Shinobu Sasaki, Masanori Kaminaga and Ryutaro Hino

Japan Atomic Energy Research Institute
Tokai-mura, Naka-gun, Ibaraki-ken, 319-1195, Japan
*E-mail: adachi_j@cat.tokai.jaeri.go.jp

Abstract

A conceptual design of a handling and storage system for spent target vessels has been carried out, in order to establish spent target technology for the neutron scattering facility. The spent target vessels must be treated remotely with high reliability and safety, since they are highly activated and contain the poisonous mercury.

The system is composed of a target exchange trolley to exchange the target vessel, remote handling equipments such as manipulators, airtight casks for the spent target vessel, storage pits and so on.

This report presents the results of conceptual design study on a basic plan, a handling procedure, main devices and their arrangement of a handling and storage system for the spent target vessels.

1. Introduction

The Japan Atomic Energy Research Institute (JAERI) is promoting the High-Intensity Proton Accelerator Project in cooperation with the High Energy Accelerator Research Organization (KEK), and is designing a MW-class neutron scattering facility, which is one of the main facility in the project[1]. In designing of the neutron scattering facility, a spent mercury target vessel should be replaced with remote handling devices in order to protect radioactive exposure, since it would be highly activated by the spallation reaction between mercury of the target material and the proton beam induced from the accelerator. In the storage system design of the spent target vessels, it is necessary to consider decay heat of the target vessel and mercury contamination caused by vaporization of the residual mercury in the vessel.

This report presents the results of conceptual design study on a basic plan, a handling procedure, main devices and their arrangement of a handling and storage system for the spent target vessels.

2. Basic Plan

2.1 Design Bases

(1) The spent target vessel shall be handled and stored after draining of mercury. Decay heat

of the vessel can be cooled by natural convection in the air, but mercury in the vessel cannot be removed completely. The vessel shall therefore be stored in an airtight storage cask.
(2) The spent target vessel shall be handled remotely, since the cask does not have the biological shield. On the other hand, sufficient biological shield plugs shall be installed over storage pits in order to enable personnel to access in a storage room.

2.2 Exchange frequency and storage capacity of spent target vessel

It is planned that the target vessel is exchanged every four months and stored for eight years at the longest for cooling before the spent target vessel will be shipped to another long-term storage facility. The storage capacity is therefore 24 of the spent target vessels.

3. Transfer Root and Procedure for Spent Target Vessel

A transfer root for the spent target vessel is shown in Fig.1.

The spent target vessel removed and packed in the cask is transferred to a storage room and then stored in the storage pit. It is shipped to a post-irradiation test facility or a long-term storage facility after a cooling period.

A transfer procedure of the spent target vessel is shown in Figs.2 and 3, from withdrawal of the target vessel out of the helium vessel to storage in the pit. The spent target vessel is withdrawn from the helium vessel into the target trolley room with a target trolley, removed from the front end of the trolley and then packed in the cask. The cask is transferred to the storage room in the basement through a transfer port and put into the pit.

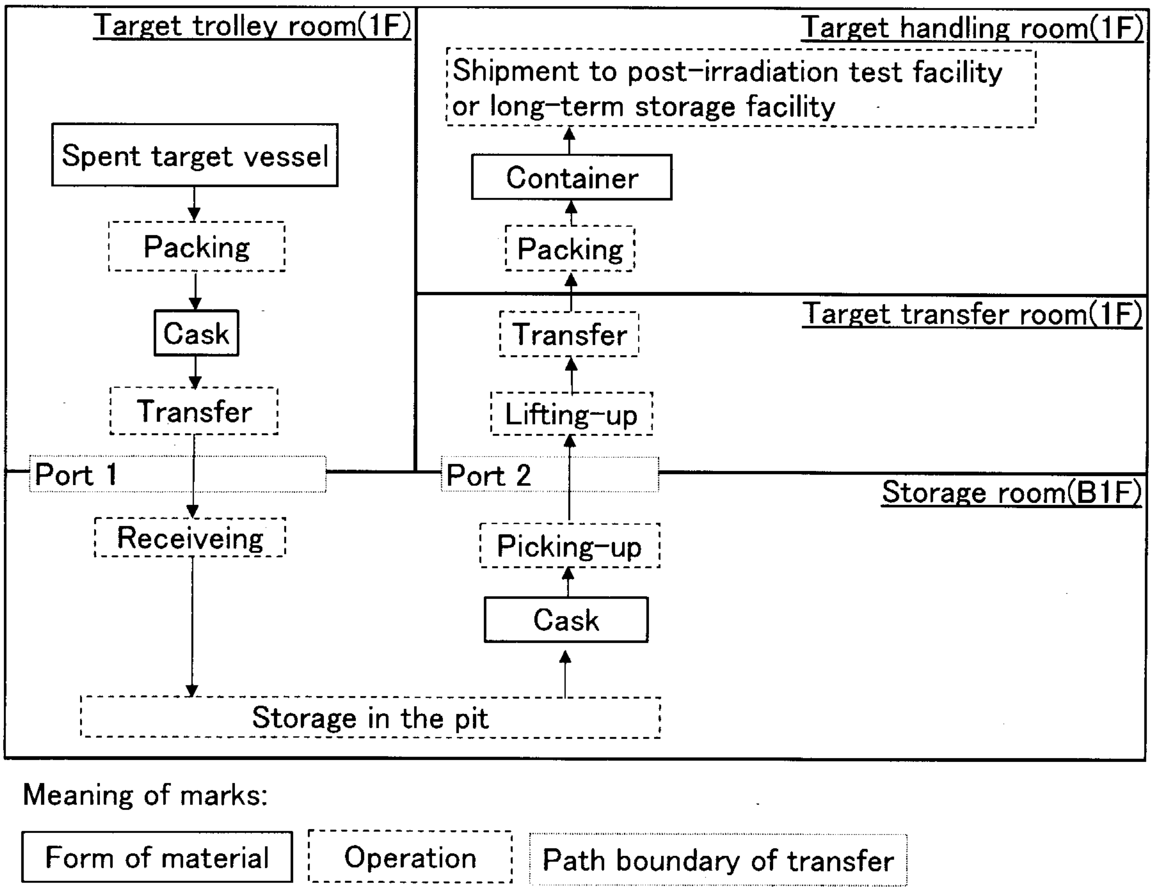

Fig.1 Transfer root of spent target vessel

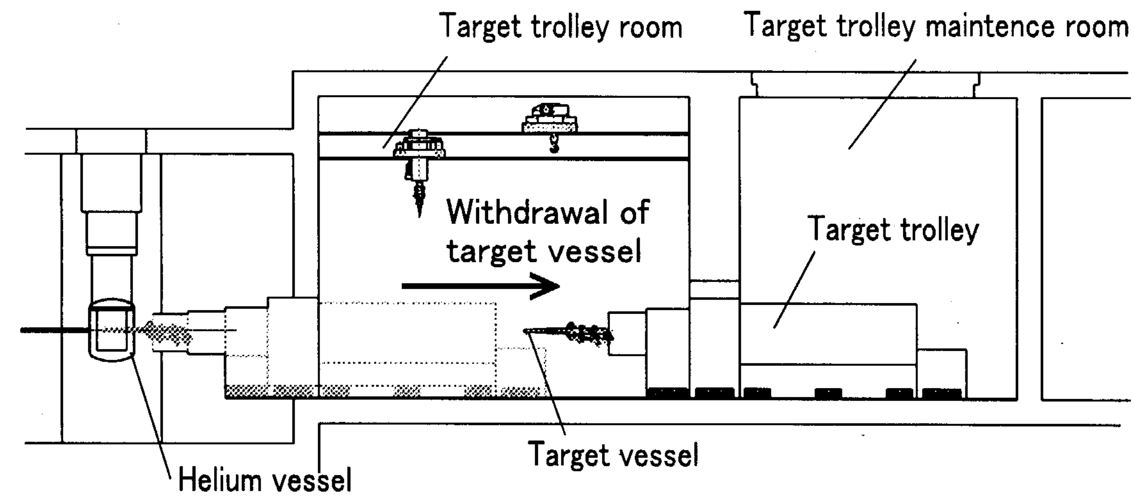

Fig.2. Withdrawal of a target vessel out of the helium vessel

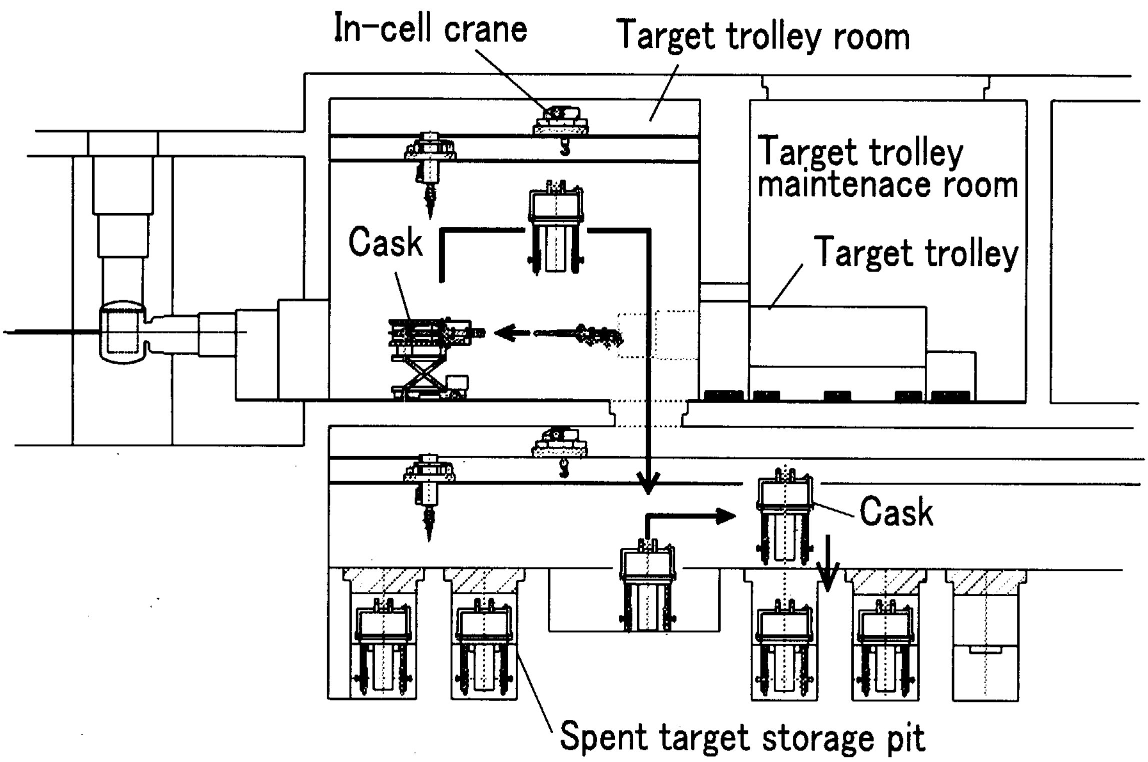

Fig.3 Transfer of the spent target vessel to storage room

4. System Arrangement

Shown in Figs.4 and 5 is arrangement for the handling and storage system of the spent target vessel. In the first floor, there are the target trolley room to exchange the target vessel, a target trolley maintenance room to maintain the target trolley, a transfer corridor to transfer a new target vessel contained in the cask and the target trolley room. The spent target storage room is located in the basement. The remote handling operations such as connection and disconnection of pipe connectors are carried out by means of wall-through master-slave and crane-mounted power manipulators and so on.

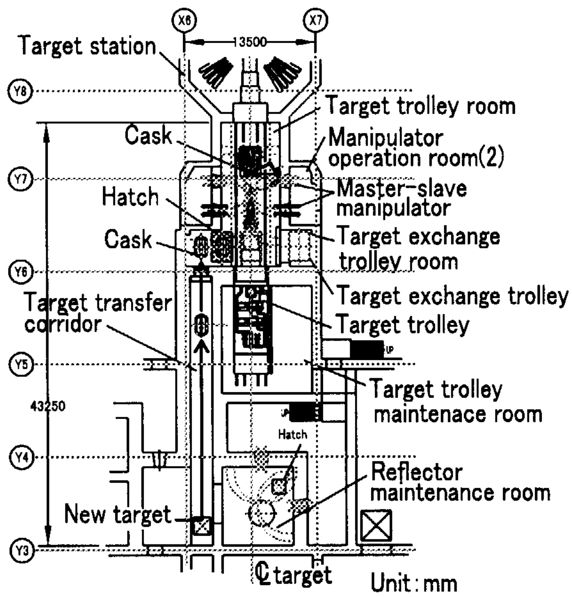

Fig.4 Arrangement of handling system for spent target vessel(First floor)

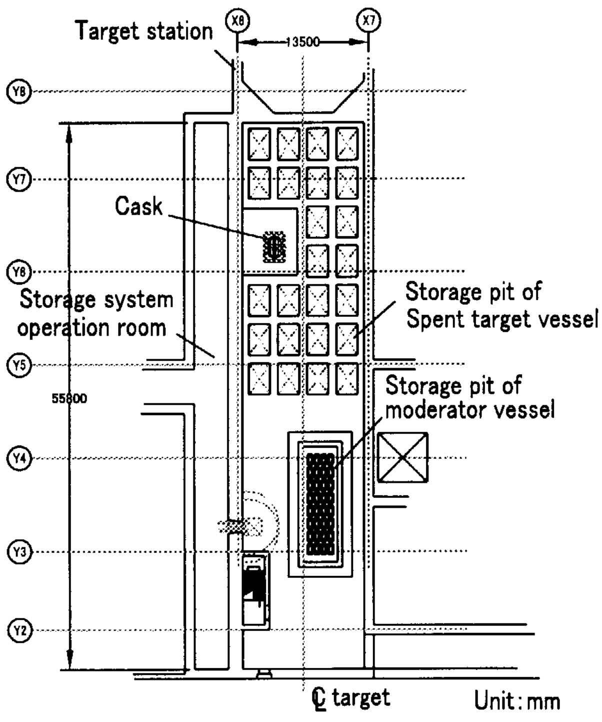

Fig.5 Arrangement of storage system (Basement)

5. Main Devices for Handling and Storage of Spent Target Vessels

5.1 Storage Cask

The storage cask is shown in Fig.6. Helium gas is filled in the cask instead of the air. The gap between the inside surface of the cask and the outside surface of the spent target vessel is devised to become as small as possible, in order to remove the decay heat of the vessel efficiently. The lower part of the cask is therefore slimmer than the upper part, and so the cask cannot therefore stand alone on the floor, while can be stably put on a rack in the storage pit as shown in Fig.6. Accordingly, it has legs that can open to stand stably on the floor. The legs of the cask open automatically by pushing up center rods as shown in Fig.7, when the cask comes in contact with the floor. The cask put on the floor is shown in Fig.8. On the contrary, they close by means of springs, when the cask is lifted up. The cask is also used to transfer the new target vessel.

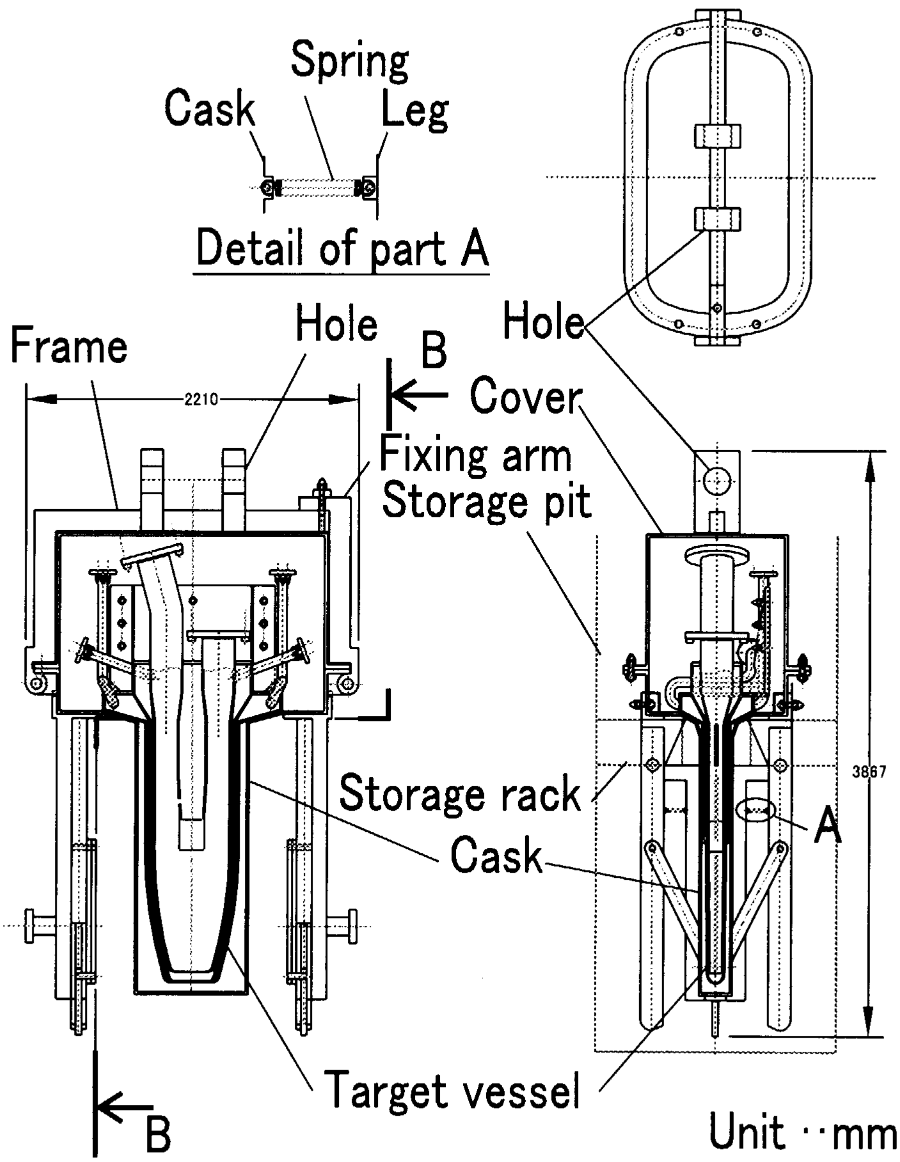

Fig.6 Cask for spent target vessel (in storage pit)

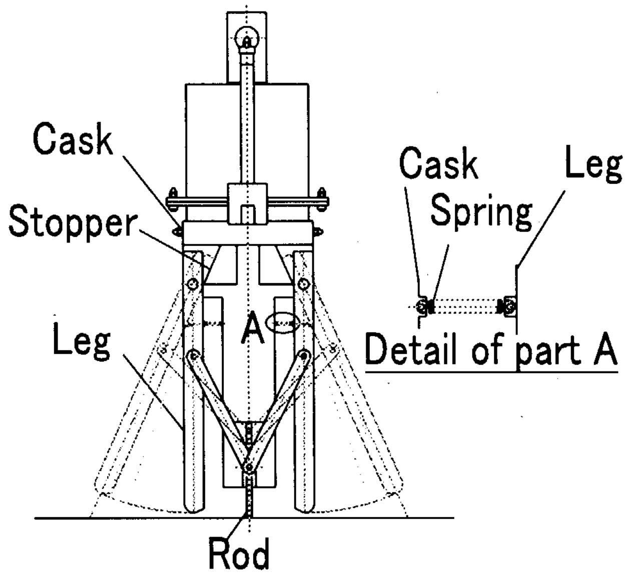

Fig.7 Opening mechanism of cask leg (View BB in Fig.6)

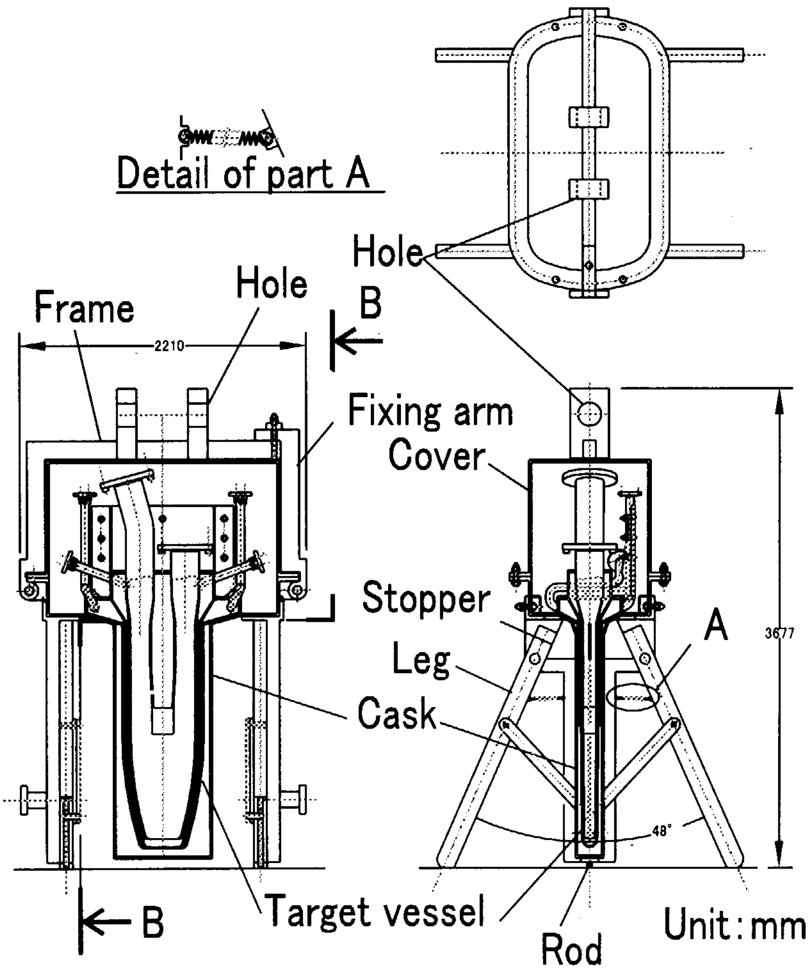

Fig.8 Cask for spent target vessel (on floor)

5.2 Target Exchange Trolley

A target exchange trolley is shown in Fig.9. It is used to remove the spent target vessel and to install the new target vessel, and has a lifter to lift up the target to a setting position.

A target inserting mechanism for the spent target vessel to insert into the cask is composed of springs, a hydraulic cylinder and a valve as shown in Fig.10. The valve is opened so that the cask could freely moves up and down when the spent target vessel is inserted into the cask and it is closed to support the cask rigidly after the spent target vessel has been inserted into the cask. The spent target vessel can therefore be inserted into the cask smoothly without any complex control system with sensitive sensors and actuators under high radiation field.

A porter is used for traverse between the target exchange trolley room and the target trolley room. It has a lifter to lift up the target exchange trolley. The target exchange trolley can have high reliability, since it does not need any complex steering mechanism.

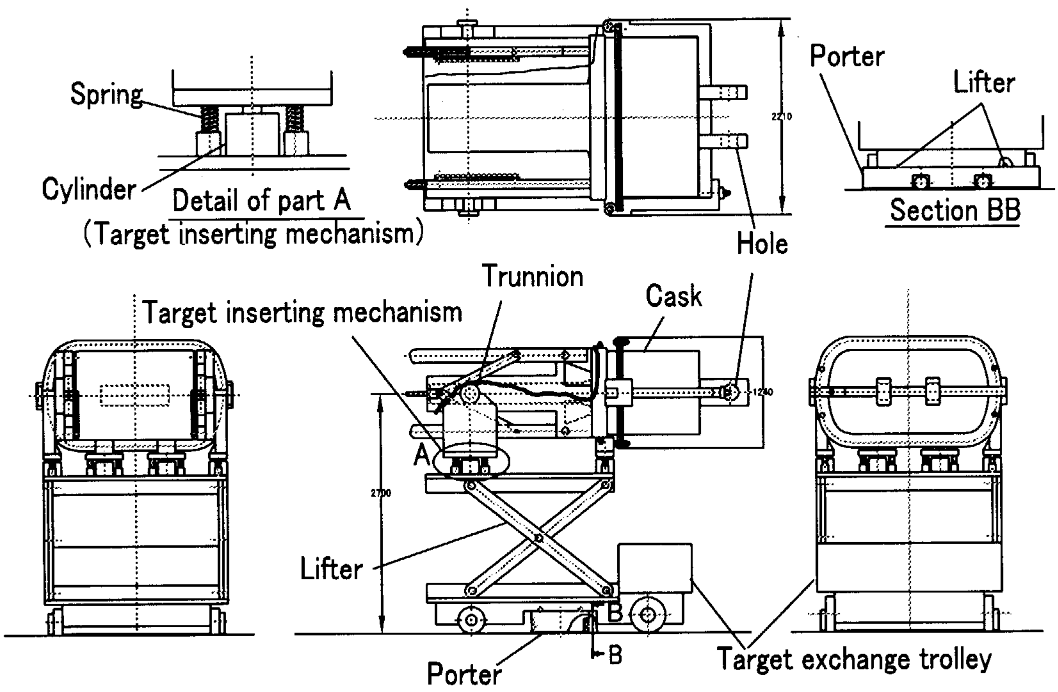

Fig.9 Target exchange trolley (loading cask)

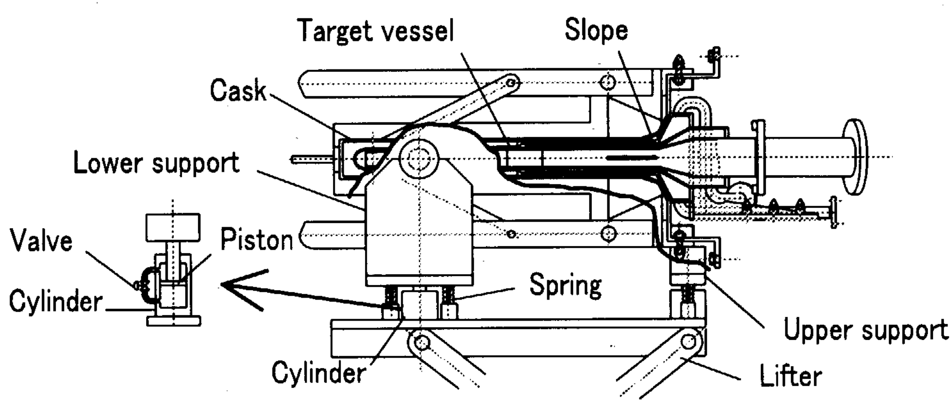

Fig.10 Target inserting mechanism

5.3 Handling Procedure of Spent Target Vessel

At first, the cask is loaded on the target exchange trolley, then the target exchange trolley is set in front of the target trolley and moved toward it to insert the target vessel into the cask. Pipe connectors and fixing bolts are next released by means of the manipulators, and the target exchange trolley is moved away from the target trolley to close the cover of the cask. The cask is then transferred to the storage room through the floor port and stored in the storage pit finally.

6. Conclusions

A conceptual design of the handling and storage system of the spent target vessels has been carried out in order to establish the spent target technology for the Neutron Scattering Facility. As the results, a plot plan of the system as well as a block flow diagram of handling and storage procedures are drawn up, which are aimed to protect radioactive exposure, to decrease mercury contamination and to remove the decay heat effectively. Conceptual structures of main components such as the spent target cask and the target exchange trolley are designed from viewpoints of assuring of high reliability and high operability.

Reference

[1]The Joint Project Team of JAERI and KEK, The Joint Project for High-Intensity Proton Accelerators, JEARI-Tech 2000-003(2000).