The Two Kilocurie Cobalt-60 Gamma-Ray Irradiation Facility

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The gamma-ray irradiation facility with 2000 Curie Co^{60} had been installed in the Institute for Chemical Research of Kyoto University in the beginning of 1958. Some special considerations were taken on its design and construction; a unique mechanism for charging the gamma-ray source and the mechanical conveyor system for loading materials to be irradiated were designed. In this paper some features of the facility equipped with interesting mechanisms are explained.

INTRODUCTION

Utilization of radioisotopes has been developed very rapidly in these days, and its satisfactory fruits are seen in a wide range including medical, agricultural and many industrial fields.

Among others, various researches utilizing irradiation of gamma-rays have become very active. However, when it was not so active in this country as it is now, about three years ago, some research workers in Kyoto University recognized the importance of the research in this field and the present Co^{60} gamma-ray irradiation facility had been installed in the Institute for Chemical Research of the University in the beginning of 1958. This facility has some features as followings :

1. Compact in size and does not occupy large floor space due to heavy concrete used at important places.
2. Co^{60} source as large as 2400 Curies is containable.
3. The facility is designed to utilize the irradiation in full strength at the closest place to the location of the source.
4. The pool type storage and handling device are attached so that the radiation source can be removed from the facility and stored in the pool when it is not used.
5. A unique mechanism was designed for charging the source pencils into the source holder.
6. Leakage of radiation outside the facility is quite negligible.

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In the present paper the authors will describe some details on the facility and its features, which, to be hoped, can be of reference to the other workers having desires to install gamma-ray irradiation facilities

CONSTRUCTION

The external appearance of the whole facility is shown in Fig. 1. The pool on the left is about 2.9×2.4 meters with a depth of 1.2 meters and further in its bottom a square pit of 2×1.2 meters and of 2 meters deep is delved as a storage well. This depression with a depth of 3.4 meters from the water surface

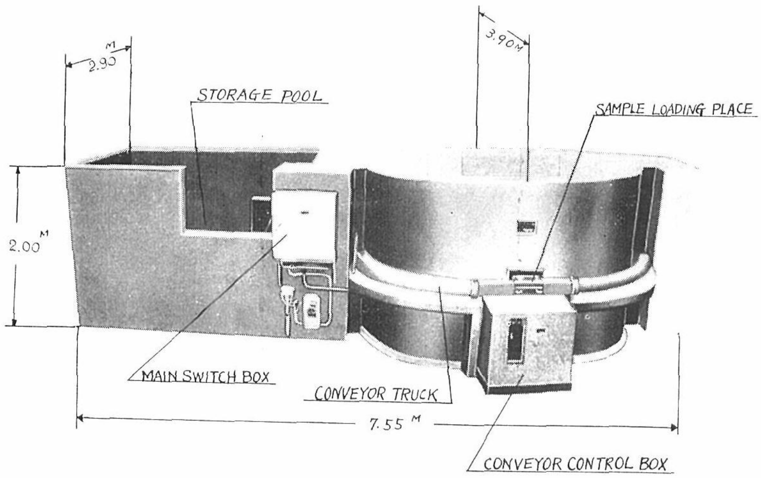

Fig. 1. External appearance of the gamma-ray irradiation facility.

is used for preservation of the gamma-ray source and when the source pencils are mounted into the source holder the heavy lead container is submerged onto the bottom of the deep pit and then each pencil in the container is transferred on the source transferring mechanism with a remote-controlled handling tool.

The source holder having 40 Co^{60} pencils is located deeply inside the shielding concrete, as shown in Fig. 2. Each pencil contains 9 cobalt slugs of 4/1 in. in diameter and 1 in. long. Each slug is encapsulated in thin aluminum jacket and 9 slugs are enclosed in a thin stainless case, forming a pencil with 10 in. active length, as shown in Fig. 3. The Co^{60} pencils used in the present facility were produced by the Atomic Energy Canada Limited at Chalk River and were given a nominal rating of 61.7 Curies for each pencil (June, 1957). The pencils are mounted in a circular holder of about 15 cm in inside diameter. The pencil-holder assembly and irradiation cavity are shown schematically in Fig. 4. Total activity of the source was about 2100 Curies in April, 1958.

The surroundings of the source holder are built with heavy concrete containing magnetite ore debris, however, some parts of the shield are consisted of ordinary concrete. Further, from engineering interests for shielding effect of concretes with different composition, heavy concrete in various combination

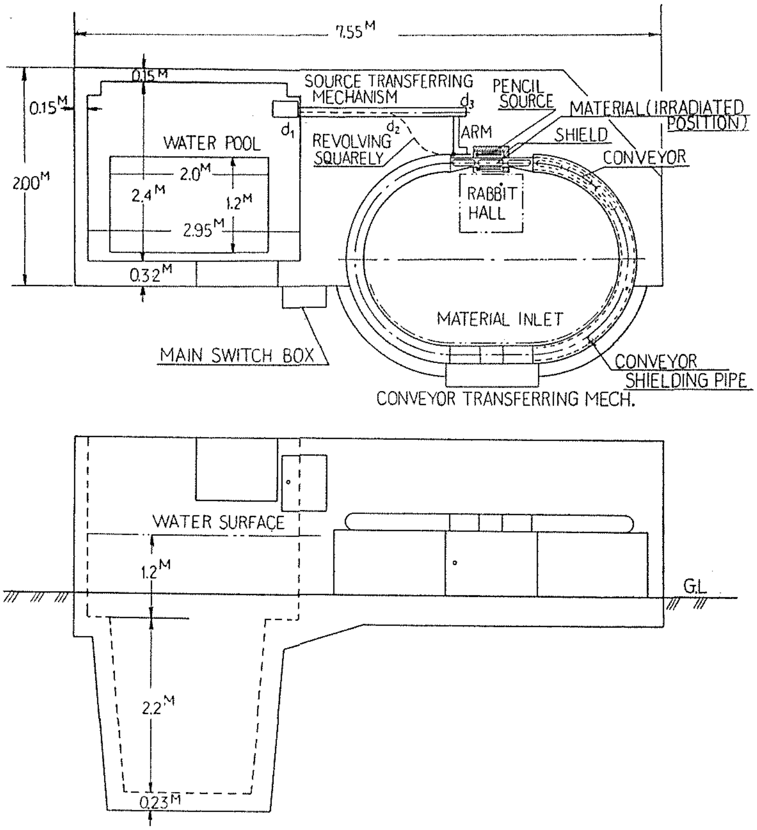

Fig. 2. Schematic diagram of the facility.

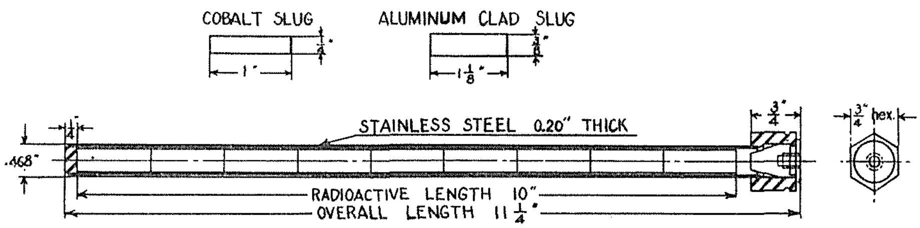

Fig. 3. AECL Co^{60} pencil with a nominal rating of 61.7 Curies (June, 1957).

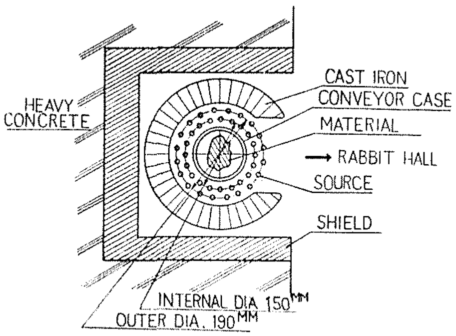

Fig. 4. Schematic diagram showing the source pencil assembly and the irradiation cavity.

is also used. For partitioning the place for preserving the source shielding by water is adopted as mentioned above. The leakage dose rate outside the facility basing on this design had been supposed theoretically to be far below the allowable amount and was actually measured after the mounting of all source pencils with 2100 Curies and found to be below 1 mr/hr everywhere outside the shield.

Above the facility a two-ton mono-rail hoist is installed, which travels and lifts electrically. This device is used for transportation of heavy source containers and concrete blocks.

CHARGING MECHANISM OF Co^{60} PENCILS

For the gamma-ray irradiation facility it is, in general, important how to charge the high intensity gamma-ray source into the facility so that workers are not exposed to the gamma-radiation above the tolerable level during the operation. In the present facility a unique mechanism was devised for this purpose, as shown schematically in Figs. 2 and 5.

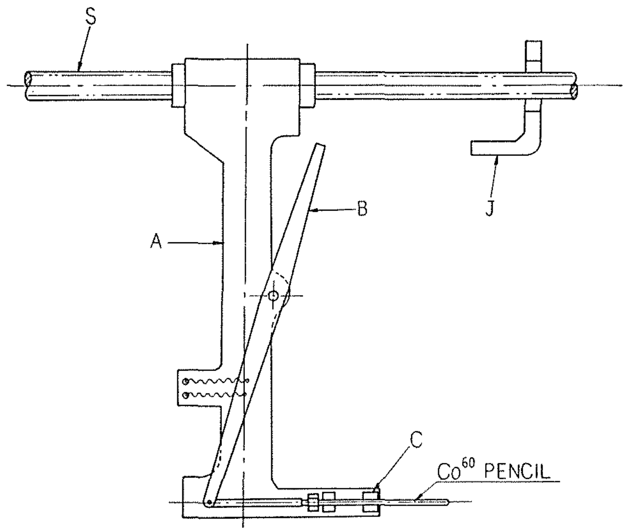

Fig. 5. Source pencil transferring mechanism.

At first, a Co^{60} pencil in the container, placed on the bottom of the deep pit filled with water with a depth of about 3.4 meters, is picked up by a remote-controlled handling tool and then transferred on the clamp of the transferring mechanism at d_1, indicated by "C" in Fig. 5, which shows the essential mechanism of the transferring device.

The arm, A, clamping a pencil, moves horizontally into the shield to the position d_2 by rotation of a guide screw, S, which is driven by a motor located in the box at d_1. It is noted that during this transfer the pencil is moved only in the water. When a pencil reaches d_2-position, the arm starts to revolve 93°16′ around the guide screw by means of an automatic device so as to shift up the pencil horizontally. Then the pencil is further transferred to the position d_3, where the pencil is pushed into a hole of the internal circle of the source holder automatically by the action of a lever B. Finally, the clamp device C, provided at the end of the arm, functions to open the griper, triggered by the contact of the lever B and the claw J, and then the pencil is released in the source holder. On the return trip of the arm the griper remains open for a while as the arm revolves down and moves back to the left and a run of loading the pencil is completed. Then the source holder is rotated by the desired angle so as to get ready for the next loading by the gear triggered by a micro-switch, which is put on by the back movement of the arm,

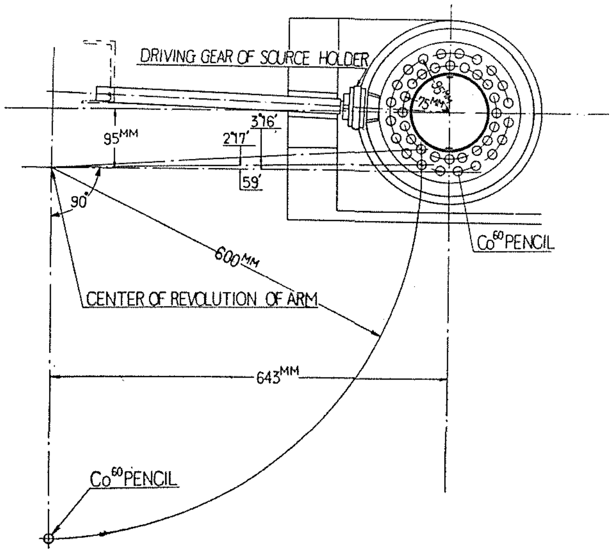

Fig. 6. Geometry of rotational movement of the arm carrying a Co^{60} pencil.

Upon loading the pencils into the holes of the external circle of the holder, the revolving angle of the arm is changed so as to be 90°59′, as shown in Fig. 6. This angle can be calculated by the geometry shown in Fig. 6. Except for the revolving angle of the arm the whole cycle of loading operation is completely the same for both internal and external circle arrangement of source pencils.

When the source pencils are desired to be taken out, one can do it by reversing the charging operation of the said cycle.

As can be inferred from the foregoing explanation, the guide screw S and source holder are located above the water, but a part of the arm is so dsigned as to be in the water. The level of water can be adjusted as desired, but normally the part of the arm under water is about 50 cm. By this device undesired stray radiation during the charge of Co^{60} pencils into the facility was made to be far below the allowable dose.

MECHANISM HOW TO TRANSFER THE SAMPLES TO BE IRRADIATED INTO THE IRRADIATON CAVITY

The loading of materials to be irradiated in an aluminum box is done in front of the facility. The box is transported into the irradiation cavity along the tunnel by means of the motor-driven conveyor mechanism. The conveyor system having 28 aluminum boxes as a train, as shown in Fig. 7, is made to move continuously or intermittently in both directions. By the push-buttons in the conveyor control box one can halt any assigned box in the irradiation cavity for any desired time more than 15 seconds or can rotate a train of boxes any times on the conveyor truck continuously. The unit is equipped with a safety device which prevents the driving motor from starting unless the iron lid of the loading opening is securely closed.

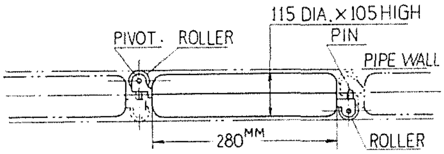

Fig. 7. Train of aluminum sample boxes.

The gamma-ray intensity at the mid-point of the cavity was measured to be about 2.3×10^5 r/hr when 37 Co^{60} pencils (1940 Curies, April, 1958) were mounted in the source holder[1], while the scattering radiation, coming through the conveyor guide pipe, was found at the sample loading opening to be only 2.5 mr/hr.

ACCESSORIES

A special remote-controlled handling tool was designed, as shown in Fig. 8. Its length can be easily adjusted such as that of a tripod for the camera.

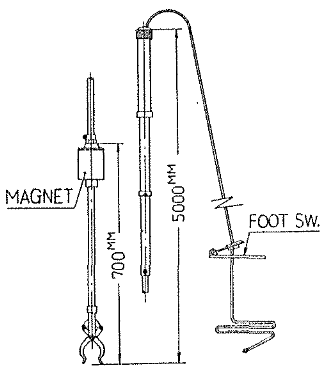

Fig. 8. Remote-controlled handling tool.

The tongs on the top are operated by a tiny water-proof electro-magnet with a lead connected to a foot switch.

To facilitate the work to handle the source in the water we have also a submerged lamp of 200 W.

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REFERENCE

(1) S. Shimizu, S. Tanaka and Y. Nakayama, This Bulletin **37**, 306 (1959).