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A Compact Cobalt-60 Irradiation Facility

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A compact gamma-ray irradiation facility housing 2000 Ci ^{60}Co source and providing exposure rates up to 1.59×10^5 r/h in the center of the sample chamber of 15 cm diameter by 30 cm height is described. It consists of an annular source cage having twenty ^{60}Co pencils and a cylindrical drawer holding the movable sample chamber, surrounded by a main lead shield. The design is based on the fact that a stationary source requires less shielding and is easy operate. Dose measurements were made using fluoroglass dosimeters. The isodose curves in the sample chamber are presented.

I. INTRODUCTION

In 1957 a 2000-Ci ^{60}Co gamma-ray irradiation facility[1-3] with particular features was constructed in our Institute as the first multi-curie facility in this country. For the past twelve years it has been used for chemical, biological, and physical studies; results have been published in this Bulletin[4] and other journals. Since this facility had to be dismantled in 1969 owing to the rearrangement of the west campus of the University where the facility was located, a new compact unit was designed as an annex of the Radioisotope Research Laboratory of Kyoto University and has recently been completed. Main aim of the design is laid upon compactness and easy operation. In this report some accounts are given of the new facility also equipped with 2000 Ci ^{60}Co.

II. MECHANICAL STRUCTURE

Our facility is a conveniently operated and mechanically simple unit of the so-called gamma-cell type designed as to be capable of housing a ^{60}Co source with a total activity up to about 4000 Ci. The essential features of the mechanical construction have been based on the design principle adopted for the compact irradiation unit by Rice and Smythe of the Atomic Energy of Canada, Ltd.[5] The cutaway perspective of the facility is shown in Fig. 1.

1. Drawer

A circular array of twenty or forty pencil-type source elements in the form of a "squirrel cage" is mounted inside the radiation shield bomb, a steel encased lead barrier. Inside both the annular source cage and the shield a long lead cylinder or drawer containing an irradiation chamber can be moved vertically, as shown in Fig. 1. The sample to be irradiated can be loaded in the irradiation chamber when the drawer is raised until the chamber is outside the shield. After

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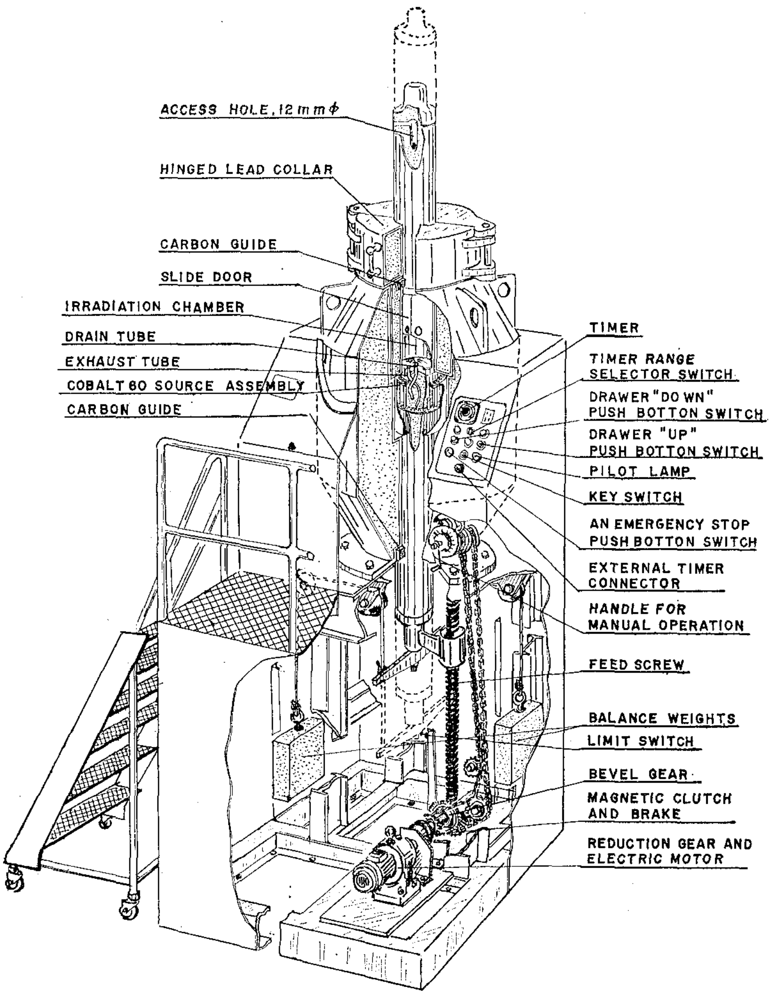

Fig. 1. Cutaway perspective of the facility.

loading the drawer is moved down until the sample is in the center of the source cage. By this means, an operator can load the sample in the chamber without suffering exposure from stray or leakage gamma rays, since when the sample is loaded the lower part of the drawer is moved up inside the source cage. The hinged lead collar shield is used to compensate for the momentary reduction of shielding.

The drawer and inner surface of the shield are covered by stainless steel with a minimum clearance between them. Smooth vertical movement of the drawer is achieved by the carbon guide rings placed at the top of the inner plug and the bottom of the main shield, respectively, as shown in Figs. 1 and 2. The drawer can be moved up and down by means of a feed screw with a nut which is fixed to the lower extension of the drawer. The feed screw is rotated by a system consists of a bevel gear, a magnetic cluch and brake mechanism and a reduction gear connected to an electric motor. The weight of the drawer is counter-balanced

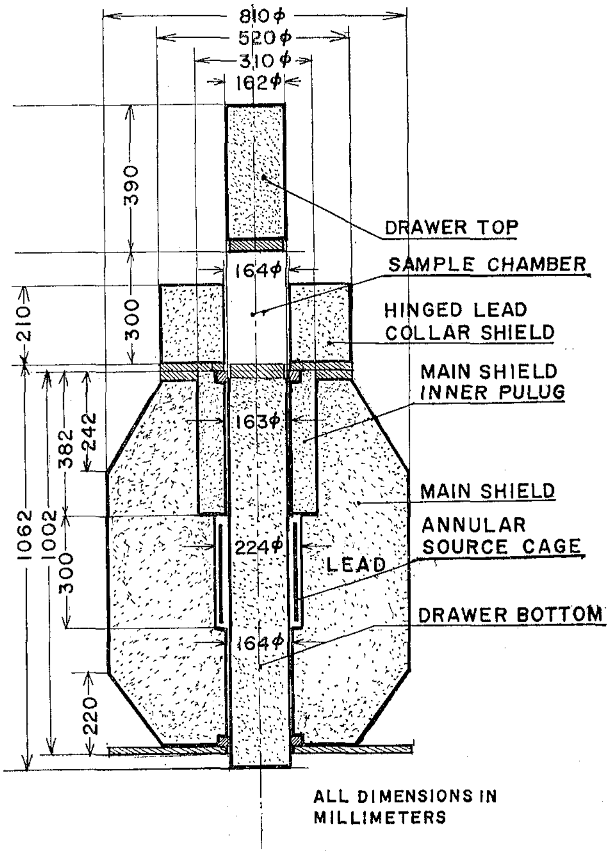

Fig. 2. Vertical section of the main shield and a movable drawer holding a sample chamber. The figure shows the chamber raised to the sample loading position.

by a weight through a steel wire and a pully.

The drawer movement is controlled from the panel by the push buttons and the timer switch for preset irradiation. Upper and lower limits of the drawer travel are determined by an adjustable limit-microswitch which drives the magnetic cluch and brake system. Time required for travel of the sample chamber from the loading position to the irradiation position is 11 sec. In the event of power failure the drawer can be also moved by a mannual operation handle connected to the chain and sprocket system which rotates the feed screw.

2. Sample irradiation chamber

The sample chamber is a stainless steel cylinder with walls of 5-mm thickness. The inside dimensions of the chamber are 15 cm diameter by 30 cm height. The chamber has a door that can be slid along inside the chamber. A hole in the drawer top provides entry for the access tubes or wires to the sample chamber and two spiral tubes, going out from the bottom of the chamber to the outside of the drawer, are used for exhaust and drain.

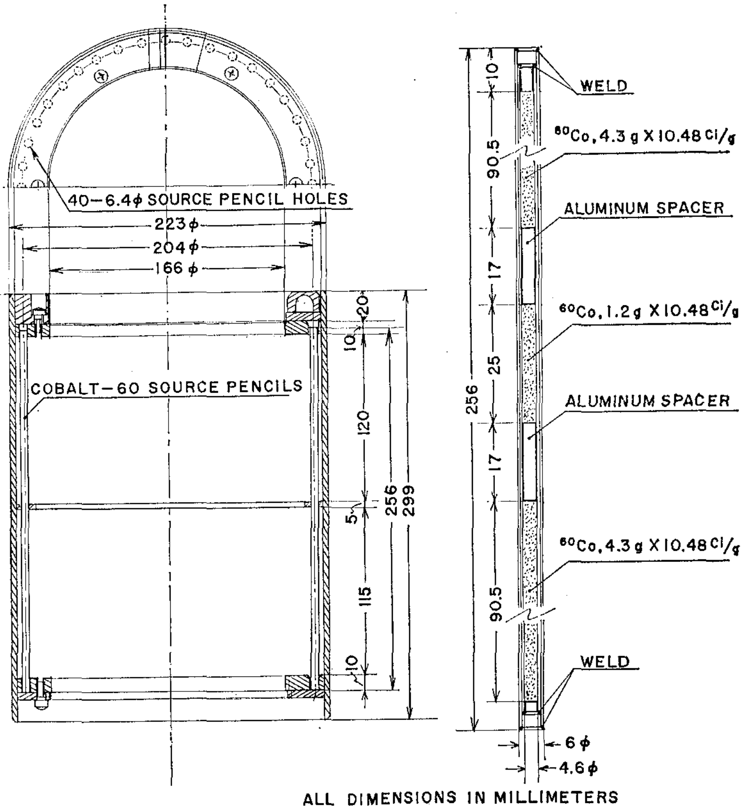

Fig. 3. Vertical and horizontal sections of the annular source cage and cross section of the ^{60}Co source pencil.

III. ^{60}CO SOURCE

The annular source cage is made of stainless steel and can hold up to forty source pencils in a vertical position. At present, however, only twenty source pencils are mounted in the cage. The annular geometry of source pencils provides a symmetrical field in the sample chamber. Dimensions of the cage and the pencil are shown in Fig. 3. In each pencil, of the double stainless steel, ^{60}Co pellets sources are packed into three separated parts; total activity is 102.7 Ci (March 1969). All ^{60}Co pellets were prepared by the General Electric Co. in U. S. A., and each pellet of 1 mm $\phi \times 1$ mm thick has the nominal rating of specific activity of about 10.48 Ci per gram (March 1969). Total activity of the present source having twenty ^{60}Co pencils is about 2054 Ci (March 1969).

IV. MEASUREMENTS OF DOSE RATES

The dose rate in air in the sample chamber was measured using the Toshiba fluoroglass dosimeters. For the doses between 10 mr and 3 kr Model FD-P8-3 glass dosimeters (8 mm × 8 mm × 4.7 mm) were used and for doses from 1 r to 10 kr Model FD-R1 glass rods (1 mm $\phi \times 6$ mm) were used. The gamma-ray field intensity at the center of the chamber was measured using these dosimeters and found

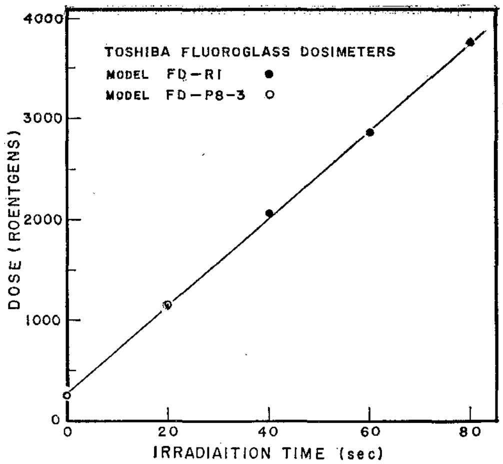

Fig. 4. Measured dose at the center of the sample chamber as a function of exposure time using the Toshiba fluoroglass dosimeters. Total activity of the ^{60}Co source (twenty pencils) mounted is 2054 Ci (June 1969).

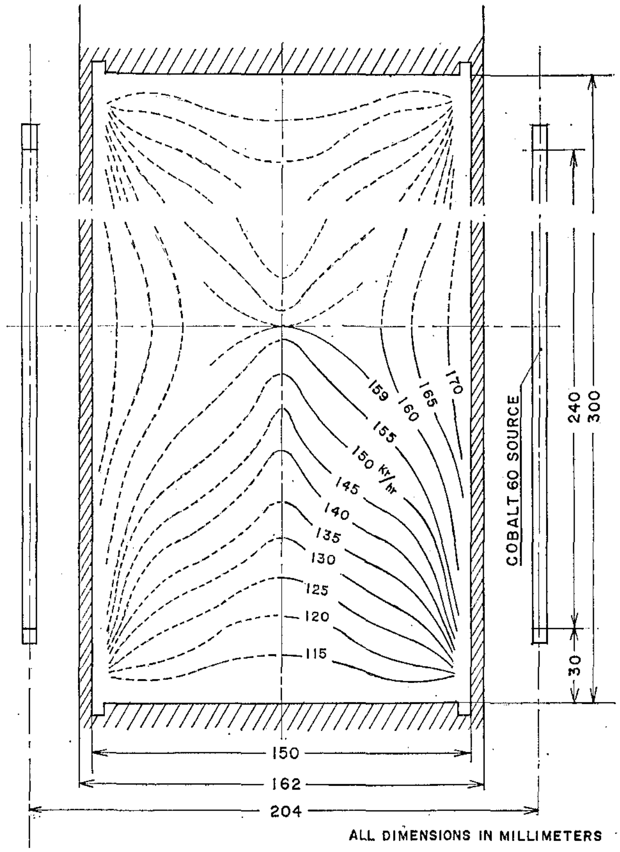

Fig. 5. Measured isodose curves on the central vertical plane of the sample chamber. Total activity of ^{60}Co source (twenty pencils) mounted is 2054 Ci (June 1969).

to be 1.59×10^5 r/h (June 1969); in Fig. 4 is shown the total measured dose as a function of irradiation time. It is noted that the minimum dose for irradiation we can obtained at the center of the chamber is 224 r, which is an exposure dose during the interval for the down- and up-movement of the drawer after the sample loading into the chamber. The dose at zero irradiation time in the figure shows this value.

Since the gamma-ray field in the irradiation chamber is symmetrical with respect to a central axis and also to a central horizontal plane, the dose rates at 24 points in a quadrant of the central vertical plane were measured using the fluoroglass dosimeters. The isodose curves in the central vertical plane for the present loading of twenty pencils (total 2054 Ci) are shown in Fig. 5. The broken curves were drawn by assuming the symmetrical feature of the gamma-ray field. Deviations from symmetry of the field was revealed to be only 3% by measurements at 30 points in the chamber.

The leakage dose outside the unit was also measured using a G-M survey meter and found to be less than 0.2 mr/h and 0.5 mr/h at the outside surface and top of the main shielding, respectively. The leakage of the stray gamma rays through the clearance between the drawer and the main shield was found to be 4 mr/h when the drawer was raised to the sample loading position, These features of minute leakage of gamma rays permit the operator to use the facility without appreciable radiation hazard.

ACKNOWLEDGMENTS

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