Title
1500 - CURIE Co 60 BIOMEDICAL IRRADIATOR

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The irradiator is designed to produce dose rates ranging from 3 million r/hr to 7 r/hr, with infinitely variable dose rates obtainable between these limits by the use of two capsules of Co^{60} source material. The two primary uses of the irradiator are animal irradiation and studies of chemical systems. The irradiator is also a self-supporting shipping container as well as in-place shield head. By the use of an extraction mechanism, either source may safely be entirely removed from the confines of the irradiator in order to obtain extremely high rates of ionization. The weight and dimensions of the assembled irradiator allow it to be easily handled and transported.

PRELIMINARY DESIGN CONSIDERATIONS

Objectives. The irradiator is designed with two primary objectives in mind. The Biomedical Group at Lawrence Radiation Laboratory desired an irradiation facility capable of producing infinitely variable dose rates, uniform over large areas for animal irradiation studies, ranging from 2000 r/hr at 1 meter down to 7 r/hr at 5 1/2 meters. A second objective was very high ionization rates for studies of chemical systems; this requirement called for a dose rate in the neighborhood of 3 million r/hr.

The requirements for animal irradiation necessitated employing kilocurie amounts of Co^{60}. Point-source geometry was chosen as offering the simplest and most economical approach, with the animal cages arranged on isodose arcs in front of the irradiator. Shielding for this type of geometry and source strength required a rather massive structure.

The chemical system studies required that the system be close to the source material of the above strength. Two possible solutions were evident: either the apparatus of the chemical system to be studied could be moved through the shielding to the source, or the source could be moved through the shielding to the apparatus. The latter procedure was chosen as more feasible, because of the complexity of moving the apparatus to be irradiated.

Owing to lack of facilities at Lawrence Radiation Laboratory for loading kilocurie amounts of Co^{60}, it was necessary to design the irradiator so that it would also serve as a shipping container. The empty irradiator would be shipped to the supplier of the source material, loaded with the required isotope, returned to Berkeley, and placed in operation with no additional isotope transfer.

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*Work done under the auspices of the U. S. Atomic Energy Commission.

Weight-handling limitations at Berkeley and at the loading facility required maximum shield efficiency with minimum shield weight. The shielding had to meet specifications of the Interstate Commerce Commission and Bureau of Explosives.

For moving the source through the shielding and extending it into the treatment room, the extraction mechanism was designed to be mounted after the irradiator was loaded and returned to Berkeley.

SOURCES

Specifications. Two sources are employed; both are cylindrically encapsulated in double-walled and welded stainless steel containers. One capsule contains 1400 curies of Co^{60} and the other contains 140 curies of Co^{60}. Both sources have a specific activity of approximately 167 curies per gram.

Dose Rates.

1400-curie source:

2000 r/hr at 1 meter,
70 r/hr at 18 feet.

Extracted:

3×10^6 r/hr at approx $\frac{1}{2}$ in.

140-curie source:

200 r/hr at 1 meter,
7 r/hr at 18 feet.

An infinite number of dose rates between these limits is obtainable by proper positioning of the subject to be irradiated.

When the irradiator is fully assembled and loaded with the sources, the maximum dose rate at the shield surface is 80 mr/hr. the dose rate at 1 m from the center of the unit is 4 mr/hr maximum.

IRRADIATOR ASSEMBLY

The assembled irradiator is cylindrical and is essentially solid lead with stainless steel cladding on all external and internal exposed surfaces. The irradiator shown in Fig. 1, consists of six major subunits, the forward shielding section, the rear shielding section, the irradiation port plug, the source wheel, source nests, and extraction mechanism.

Source Wheel. The source wheel is 14 1/2 in. in diameter and both faces are shallow cones increasing from the rim to the axis. The wheel is fabricated of lead, clad in 1/4 in. stainless steel sheet. The source capsules, housed in nests, are mounted on the periphery of the wheel, with an angular spacing of 120 degrees. The wheel is centrally located within the irradiator and is keyed to a shaft, mounted in three ball bearings, which extends to the circular face of the rear shielding section.

Shielding Sections. The shielding sections are roughly equal in size and have mating stepped interfaces. When they are assembled, stainless steel "dishes" in the interfaces of both sections join to form a close-fitting cavity for the source wheel. The irradiator is circumferentially clad in 1/4-in. stainless steel sheet and the interface flanges and ends of the sections are 1-in. stainless steel plate.

The forward section has a conical irradiation port, with a 60-degree included angle, that is offset from the axis of the irradiator assembly. A matching conical irradiation port plug is fitted to this port during transport, but is permanently removed after installation of the irradiator for operation.

The rear section has a stepped extraction port, offset, and coaxial with the irradiation port. Normally, a stepped extraction-port plug is fitted to this port and is removed only for mounting of the extraction mechanism.

Extraction Mechanism. The extraction mechanism consists of two coaxial shafts, free to rotate about each other, and stepped internally for shielding purposes. The extraction mechanism is manually operated by the two knurled sections at the operator end of the unit.

Shipping Cradle. The shipping cradle consists of two open-end box-shaped steel 4WF-13 beam weldments, bolted to the central flange structure of the irradiator itself, by five 3/4-in. bolts at each of the four corners of the flange.

The shipping cradle protects the irradiator unit during transport and provides the means for handling it. Rectangular holes in each lifting ear facilitate handling by a fork lift.

When the irradiator is fully loaded with the isotope and ready for installation in the wall of the irradiation facility building, the forward section of the cradle is removed and the irradiator, with the rear section still in place, is skidded into position and bolted to the wall. The rear section is then unbolted and removed. The unit is then ready for the mounting of operational gear.

Assembly. The completely assembled unit in transportable condition, weights 8900 pounds and occupies approximately 32 ft^3.

The source nests are machined from stainless steel and house the source capsules (Fig. 2). The capsules are inserted into the nests, and the nest plugs screwed into place directly behind the capsules, where they act as retainers. The nest plugs are inserted by the specially designed manipulator-operated magnetic contact tool shown in Fig. 2.

Source Loading. The sources are loaded into the nests by the isotope supplier. These nests are then secured in the source wheel by removing the irradiation port plug and inserting the nests into the recesses in the source wheel through the irradiation port.

Treatment Room. The treatment room, shown in Fig. 3, is 21 × 18 ft in area and 8 ft high. The walls and ceiling are poured concrete slabs 4 ft thick. The irradiator is centrally located in one 21-ft wall and the axis of the irradiation port is 4 ft from the floor. This geometry assures the most uniform irradiation to subjects during exposure. Entrance to the treatment room is through an interlocked door from the control room to a labyrinth and thence to a rear corner of the treatment room.

The intersection of the physical limits of the treatment room with the 60-deg cone from the irradiation port bounds the volume available for primary irradiation.

OPERATION

Prior to exposure of either source, subjects to be irradiated are placed at predetermined positions within the treatment room.

Source Exposure By Rotation. The source wheel is normally in the "safe" position, which places either source 120 deg away from the irradiation port on a 5-5/8-in. radius. Either source is moved into the irradiating position by manual rotation of the wheel after the necessary interlock steps have been accomplished.

Source Exposure By Extraction. Either source is extracted manually. With the source wheel in the "safe" position, the extraction port plug is removed and the extraction mechanism guide mounted in its place. The extraction mechanism is inserted in the guide and brought to near contact with the source wheel.

The source wheel is then rotated until the axis of the source nest to be extracted is on a line with the axis of the extraction mechanism. The nest and extraction mechanism are then coupled together by threading the internal shaft of the extraction mechanism into the rear of the nest: The thread is right-hand, and seats the interlocking scallops on the nest and on the outer shaft of the extraction mechanism.

The source nest is then removed from the wheel by turning the extraction mechanism counterclockwise, which unscrews the nest from the left-hand threads in the source wheel recess. This accomplished, the source may be extended a maximum of 13 in. beyond the front face of shield. The extent of extraction of the nest may be governed by a stop collar on the extraction mechanism outer shaft.

The source nest is replaced by reversing the above procedure. The extraction mechanism shaft passing through the source wheel prevents the wheel from moving while the nest is removed, so that the threads of the nest may easily engage the threads in the recess when the nest is being replaced.

INTERLOCKS

Three separate interlock systems govern the operation of the irradiator.

Gamma Sensing Interlock. A gamma-sensitive probe continually monitors the treatment room. If the level of ionization within this room exceeds a certain value, this system automatically locks the labyrinth entrance. This probe assembly has a built-in calibration unit which allows a check of the probe if electronic or mechanical malfunction is suspected. The probe, located in the wall between the treatment room and the control room, may be withdrawn by hand, calibrated, and re-inserted for further monitoring.

Position Interlock. The source wheel cannot be rotated to the irradiating position until the operator completes an electrical circuit of timers, key switch stations, and solenoids. The procedure insures that the operator has cleared the treatment room of personnel, locked the entrance door, and activated an alarm which warns other personnel of impending irradiation.

Scram Interlock. A scram system protects anyone who unwittingly finds himself inside the treatment room or labyrinth when the warning system is activated, or when the source is disclosed or being disclosed. This system is actuated by one of two scram switches on the walls of the treatment room. Operation of either switch opens the positioning interlock circuit and either locks the wheel in place or, if the wheel has been rotated, returns it to the safe position by an electric motor drive and locks it.

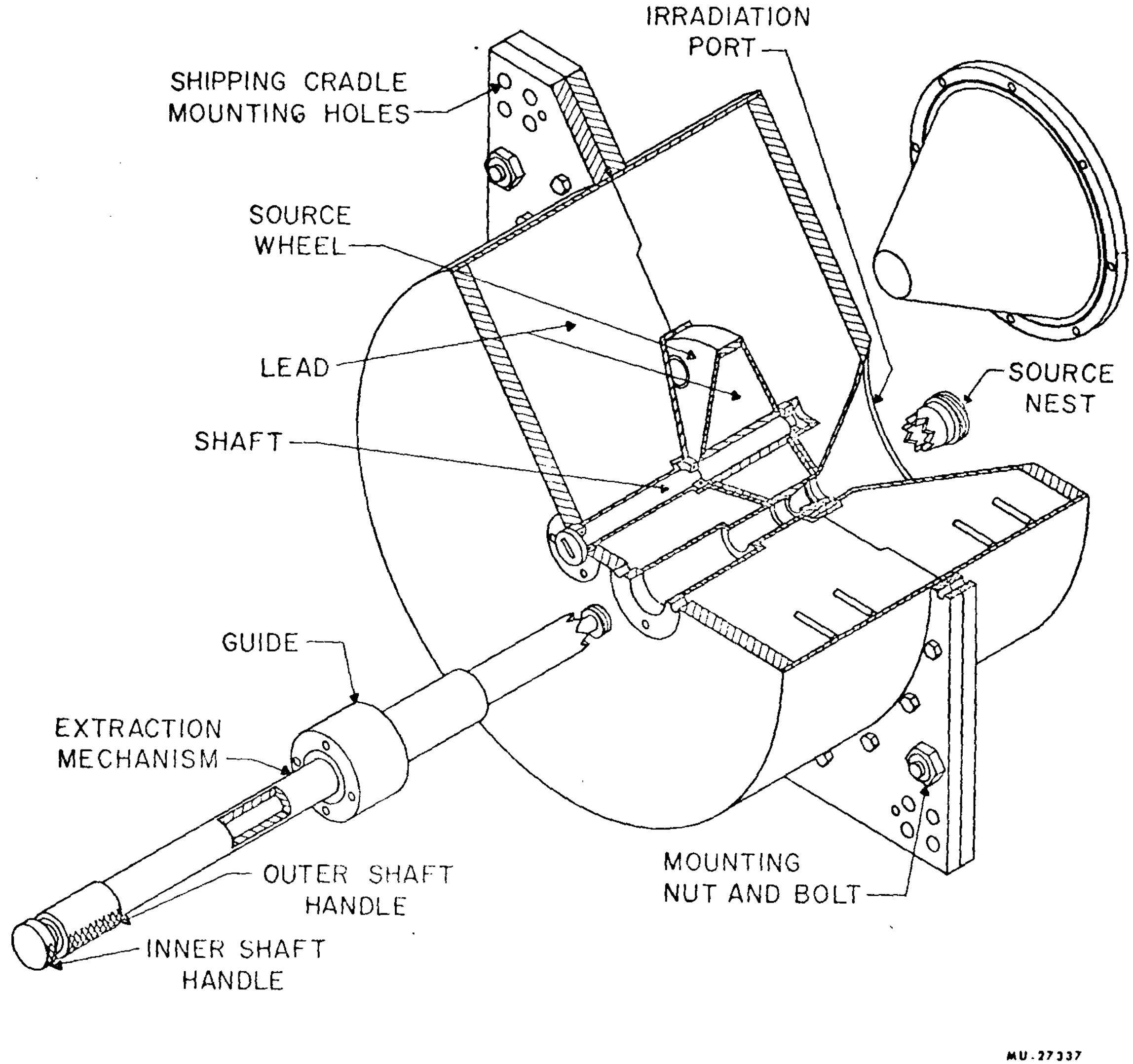


FIG. 1 IRRADIATOR ASSEMBLY CUT-A-WAY VIEW P. A. BOHM BIOMEDICAL IRRADIATOR

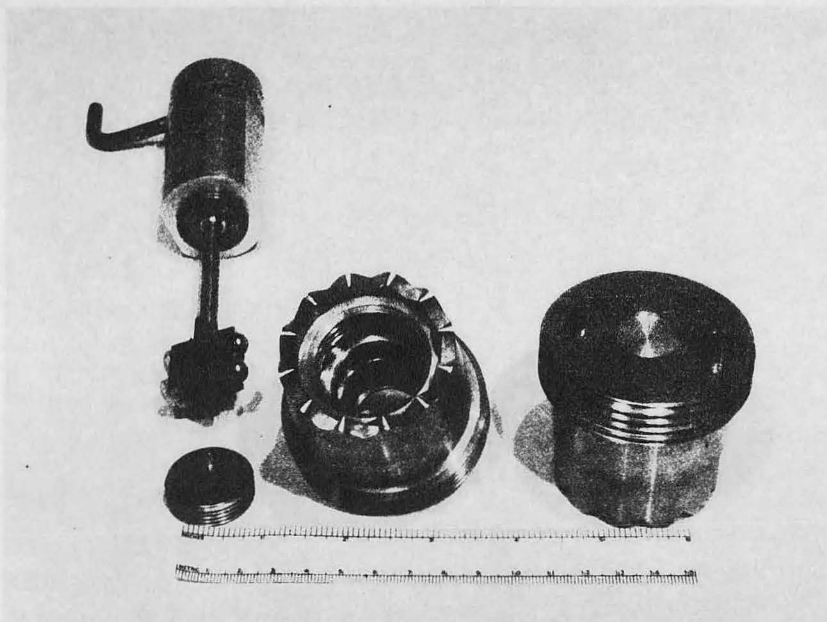
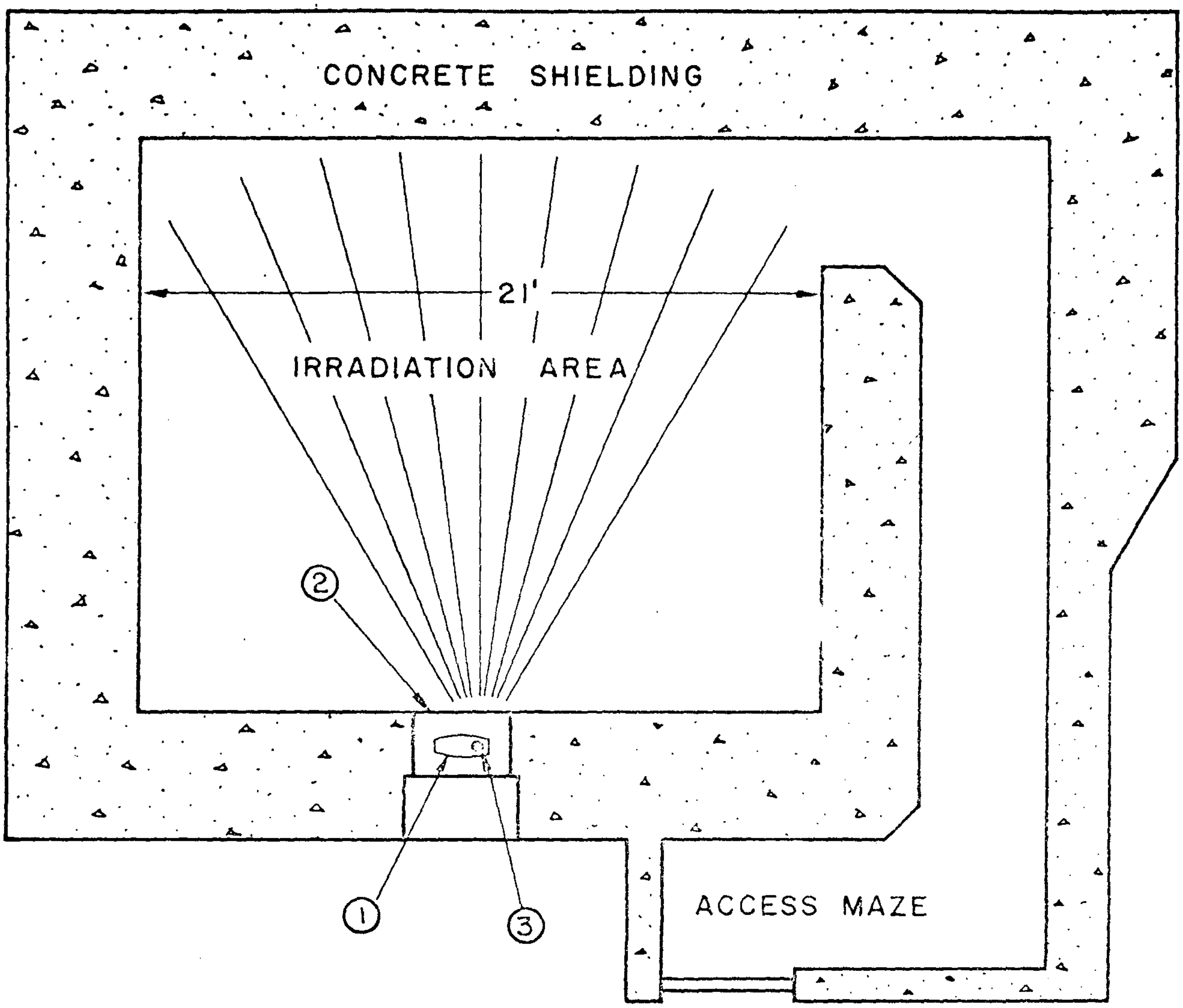


FIG. 2. NEST, NEST PLUG, AND NEST PLUG TOOL
P. A. BOHM BIOMEDICAL IRRADIATOR

FIG. 3 LAYOUT OF IRRADIATION FACILITY P. A. BOHM BIOMEDICAL IRRADIATOR



① WHEEL CONTAINING SOURCES
② IRRADIATOR
③ SOURCE CAPSULE

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