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Will D. Phillips and Graham M. Hairr

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AN ENCLOSURE FOR HUMAN PATIENT RADIOISOTOPE THERAPY*

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A gloved enclosure suitable for housing human patients has been designed and constructed at the Lawrence Radiation Laboratory. Patients being treated with massive whole-body doses of chelated Y^{90} have remained for 24 hours in this enclosure in relative comfort. The radioisotope was completely contained within the enclosure system.

In 1959 researchers at the Donner Laboratory of Biophysics and Medical Physics (University of California) began experiments with animals in order to develop new techniques for transplanting organs. Their procedure was to suppress the body's "immune mechanism" by high-level whole-body irradiation from internally administered radioisotopes. By the fall of 1961, sufficient success had been achieved to warrant advancing to irradiation of human patients for bone marrow transplantation in lymphatic leukemia therapy. An enclosure was needed for the patient to prevent contamination of the hospital room, personnel, and equipment during the treatment.

The Engineering Section of the Health Chemistry Department of the Lawrence Radiation Laboratory was called on to provide an enclosure that would meet a variety of requirements.

The enclosure was to provide a high-quality physical confinement for any radioactive fluids or dust resulting from spills. As the amount of activity required to suppress the immune or foreign-body-rejection response is about 6 to 10 mC of chelated Y^{90} per pound of body weight, the total activity involved is almost 1.5 C in some cases.

The enclosure was to be operated at a negative pressure relative to the hospital room and was to be exhausted outside to the open air after passing through suitable filters. The air flow through the enclosure was to be adequate for the patient's comfort.

The enclosure had to provide beta shielding for the attending medical team. At the same time good visibility of the patient was required.

The enclosure was to be of suitable height to give the impression of being part of the room, in order to minimize the feeling of confinement.

Since the patient would spend about 24 hours in the enclosure, a comfortable cot or small bed was needed.

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

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Sufficient glove ports were needed to enable the medical team to reach all area inside the enclosure.

Sufficient tube openings, pass-in drawers, and auxiliary enclosures were needed for all the medical procedures involved. The most complex of these procedures was collecting, filtering, and intravenously recycling all the patient's urine during the first 6 hours of confinement, in order to maintain the dosage of the radioisotope.

In the event of a medical emergency it could become necessary to quickly remove the patient from the enclosure.

Because of limited storage space at the hospital, the enclosure had to be mobile, and of such dimensions as to pass through doors and elevators.

With these requirements and limitations in mind, a design was worked out by the Engineering Section of the Health Chemistry Department under the guidance of the medical doctors involved. Actual experience with patients has brought about various improvements, chiefly in the associated equipment.

Basically, the enclosure is a rectangular plywood box mounted on two glove box dollies faced toward each other, as shown in Fig. 1. The enclosure section is 7 ft long, 3 ft wide, and 4 ft high. The sides are largely made up of 3/4-in. Plexiglass panels, two on each side, held in place against a gasket with simple turnstops. All four panels are quickly removable, as also is the center support on one side. Good visibility is provided by two 60-watt fluorescent lights.

Rotating 8-in. glove ports have been inset in a revolving Plexiglass disc in each of the window panels. These versatile glove ports give considerably more access convenience than do fixed ports.

The patient rests on an ambulance cot which has been modified with adjustable arm rests. The head and knee sections are adjustable from outside the enclosure by means of pumps and hydraulic cylinders, which actuate shafts that raise or lower the head and knee sections of the cot. Two hand bars attached to the ceiling enable the patient to shift his position.

The entire floor of the enclosure is covered with a plastic tray to catch any spilled liquids and to simplify cleanup measures. The hydraulic fluid lines have quick-disconnect two-way shutoff fittings at the cylinders on the cot, should it be necessary to quickly remove the patient on this body support.

Tubing inlets are located in the one fixed center brace. A pass-in, pass-out aperture is provided at one end for passing food, towels, etc., into or out of the enclosure.

An air flow of approximately 10 cfm is maintained in the enclosure by means of a blower mounted on one of the dollies. Room air is drawn in through a filter at one end of the box and out into a plenum chamber at the opposite end. From the plenum the air is drawn through a filter on top of the box to the blower and then exhausted outdoors. The air-flow rate is indicated by a ping pong ball in a Plexiglass tube. It is controlled by means of a damper and air relief opening ahead of the blower. A standby blower is also connected into the ventilation system to insure maintenance of this important function.

Conversation with the patient can be carried on through the inlet air filter at the end of the enclosure or by means of an intercommunication system on one side, where the speaker is clearly visible.

The radioisotope container and the recycling system are located in a shielded annex box at the foot end of the enclosure, as shown in Fig. 2. The annex may be disconnected and removed when the recycling is completed. This step is necessary to allow the enclosure and dollies to fit in the hospital elevator.

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After the 6-hour urine-recycling period is over, the patient remains in the enclosure for an additional 15 to 24 hours. During this time the body eliminates some 99% of the remaining activity through the urine. The urine is collected by means of an indwelling catheter and tube through a shielded outlet in the floor in shielded collection bottles. Radiation from the first five urine collections, which span a 10-hour period, have ranged from 2 r per hour to about 150 mr per hour measured in the container (without shielding).

At this writing four patients have been treated in the enclosure. There has been no contamination, either surface or airborne, in the hospital room. The medical team received only moderate radiation exposures.

The experience gained and the techniques developed in this small program offer encouragement to future more ambitious programs.

FIG. 1 HUMAN PATIENT ENCLOSURE W. D. PHILLIPS HUMAN PATIENT ENCLOSURE

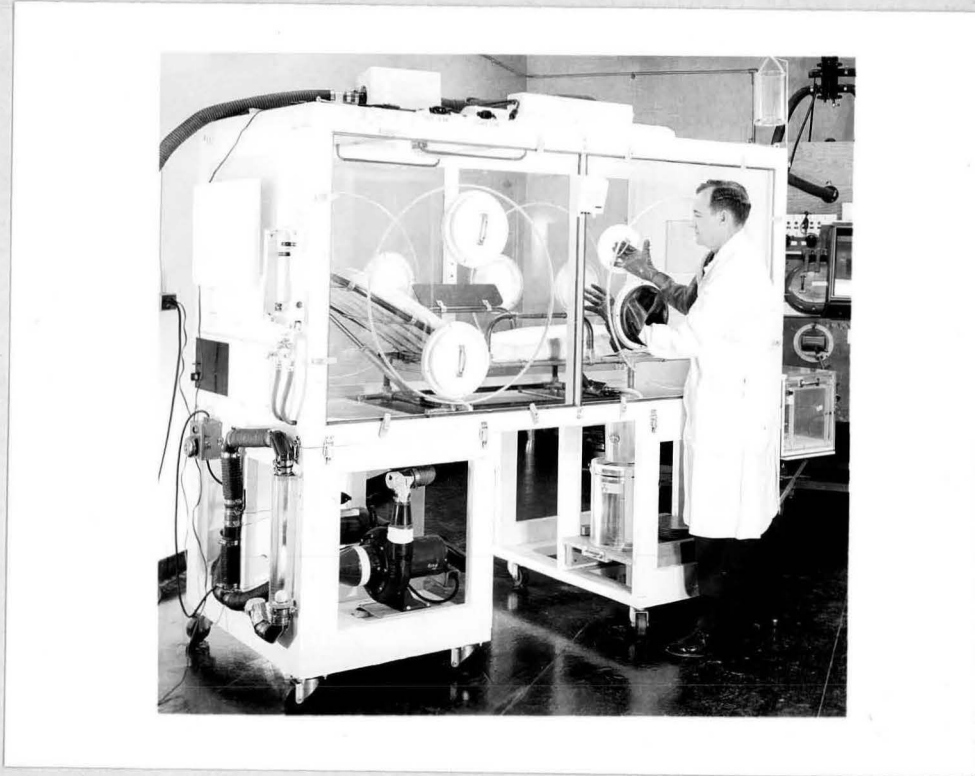


Fig. 1

FIG. 2 PUMP ANNEX W. D. PHILLIPS HUMAN PATIENT ENCLOSURE

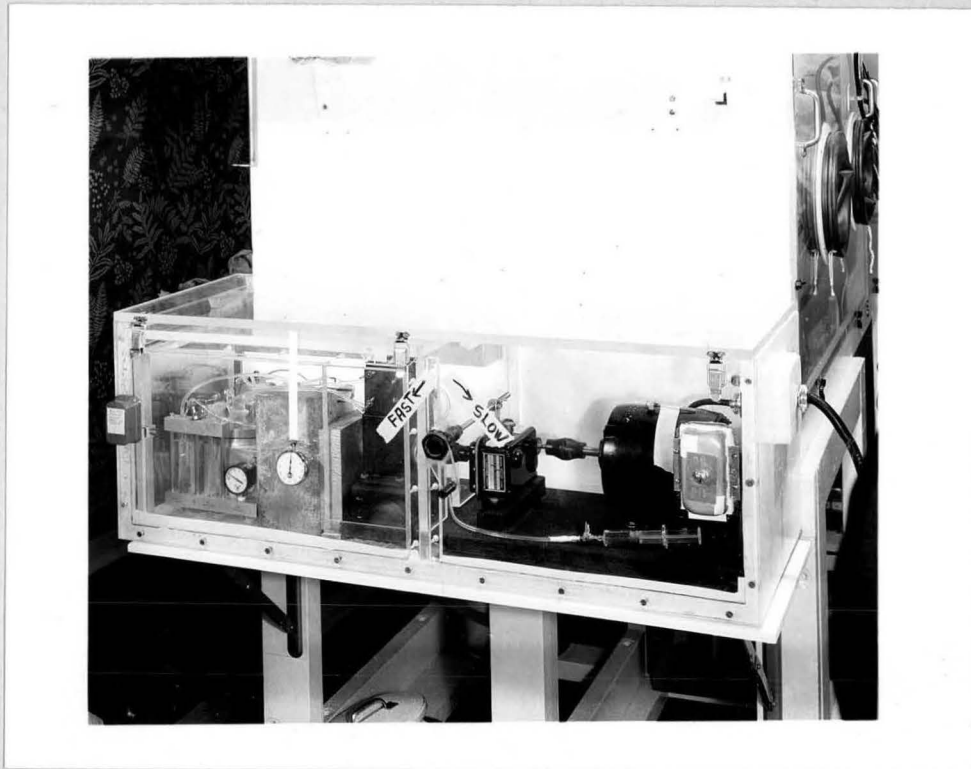


Fig. 2