Rehabilitation of a Radioactive Building

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FOR some three or four decades, a cancer clinic in Atlanta, Ga., was housed in a four-story building which gradually accumulated radioactive contamination on the floors, walls, and fixtures. The building was vacated about 1953 and left abandoned until 1961. That year, without knowledge of the amount of contamination in the building, certain rooms were cleaned, remodeled, and used as offices and sleeping quarters.

When the contamination became known to the Fulton County Health Department, surveys were conducted to determine the extent of contamination and possible exposure of persons, and decontamination and reclamation procedures were performed to make the building safe for occupancy. Nine rooms were considered heavily contaminated, and the rest of the building was contaminated to a lesser degree. Radium 226 was found in only one area, a 2-inch spot in the wall of the radium storage room.

Because of the 8-year lapse, the procedures and practices followed in the clinic were difficult to ascertain, but it was reliably established that radon needles, inserted at cancerous sites, were used in treatment therapy. The glass needles were manufactured in the building by means of a radon pump located on the third floor. The needles were about 12 mm. long and about 1 mm. in diameter. The building became heavily contaminated in many areas with radon and daughter products, presumably from spillages, leaks, crushing, and disposal operations. Mopping and cleaning had spread contamination on floors, and soil pipes had been contaminated by pouring radioactive solutions down sink drains.

In some areas radon needles were imbedded in the walls under several layers of paint. The possible explanations for this contamination are solely speculative; perhaps a fan blew piles of loose needles onto freshly painted walls, or paint brushes were laid on loose needles, or needles fell into open paint buckets. The needles themselves and the most heavily contaminated areas gave readings well in excess of 100,000 counts per minute per 62 sq. cm. alpha and 80,000 counts per minute beta. All alpha measurements were made with the same size probe involving an area of the same size, 62 sq. cm.

The procedures used to eliminate the radiation hazard to those using the building are related in the hope that our experience may be helpful to others faced with a similar decontamination problem.

Contamination is reported in counts per minute (cpm) or equivalent values. This is a necessary and proper method of recording surface contamination. Reference to specific quantities such as microcuries per area would tend to be misleading, because the danger is not so much mass concentration as activity which would contaminate aerosol dust and droplets, with the inherent dangers of inhalation and ingestion of particles contaminated with alpha and beta emitters.

Surveys and Decontamination Methods

Preliminary surveys were made with the following instruments: Eberline PAC–3G alpha proportional survey meter; Victoreen Thyac model 489 beta-gamma survey meter; El Tronico model PR–7 beta-gamma survey meter; and Victoreen CDV 700 beta-gamma survey meter.

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Wipeable contamination was detected by rubbing a 3-inch circle of Whatman No. 4 filter paper over a 9-inch by 9-inch area and reading it with a suitable instrument for alpha and beta activity. If the paper was active, the spot was termed wipeable.

Exposure was principally in the form of alpha and beta emissions from dusty and radioactive walls and floors. Gamma activity was negligible.

A general low-level contamination of upwards of 150 cpm was measured in various areas of the building, with certain rooms and areas running to values of several hundred thousand counts per minute.

A detailed survey was made and all contaminated areas marked off with chalk or a grease pencil. The next step was to establish a definite decontamination and reclamation procedure.

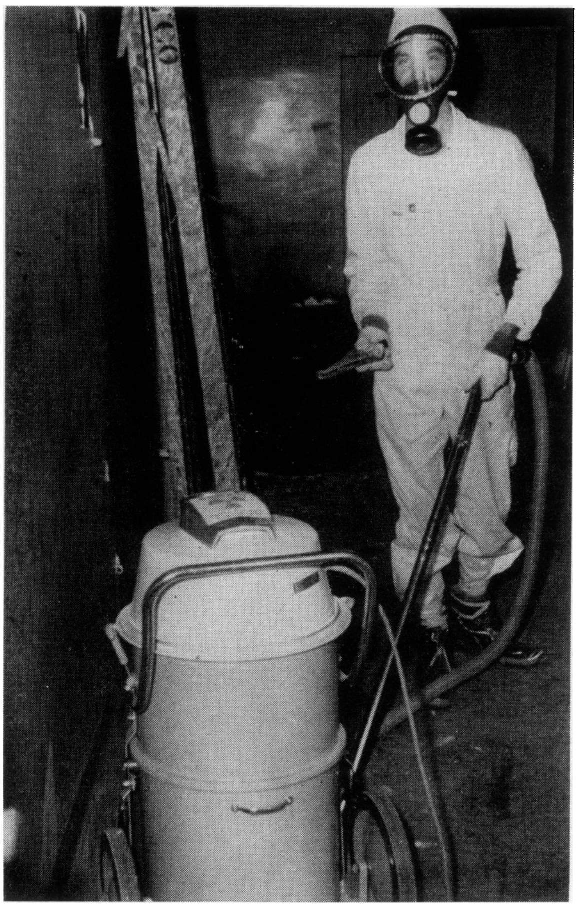


Figure 1. Protective clothing worn by decontamination workers and vacuum cleaner used in the most heavily contaminated room

It was decided to vacuum, working inward, all dusty areas, sponge-mop all contaminated walls, and mop floors. Mopping was done with a solution of trisodium phosphate except where excessive contamination required an etching solution of two parts hydrochloric acid and one part water.

Working personnel were supplied by the public works department and supervised by the authors. All persons working in contaminated areas wore protective clothing and full-face respirators with type H ultra filters. The cuffs and legs of their heavy coveralls were taped with masking tape, and they wore plastic cover boots, plastic gloves within canvas gloves, and surgical caps as head cover (fig. 1). Air samples were taken frequently to check airborne radiation levels.

Removed contaminated materials were carefully placed in 55-gallon steel drums, loaded on a truck by personnel in protective clothing, pushed off with poles, and buried in a marked dump under 10 feet of earth.

After satisfactory decontamination, reclamation was accomplished by painting (sealing) or shielding. A description of the procedures followed in the treatment of the most heavily affected room indicates how the most difficult job of reclamation was accomplished. Less contaminated rooms requiring less treatment were cared for by the simpler methods of vacuuming, mopping, painting, and covering.

Reclaiming a Heavily Contaminated Room

At the request of the tenant, room 301 (usually referred to as the pigeon room because pigeons had gained entrance through an open window and used it as a roost for many years) was the first room to be decontaminated on the third floor. This was both the filthiest and most radioactive room in the building (fig. 2). Pigeon droppings lay 4 to 5 inches deep in a large wooden chemical hood, and the terrazzo floors were covered with from ½ to 1 inch of dust, droppings, and feathers; even the walls did not escape the birds' bombardment. A large central-type air conditioner, a large airduct, chairs, dead pigeons, and a radiator in the room were also covered with these materials.

Through the dust and grime the floor meas-

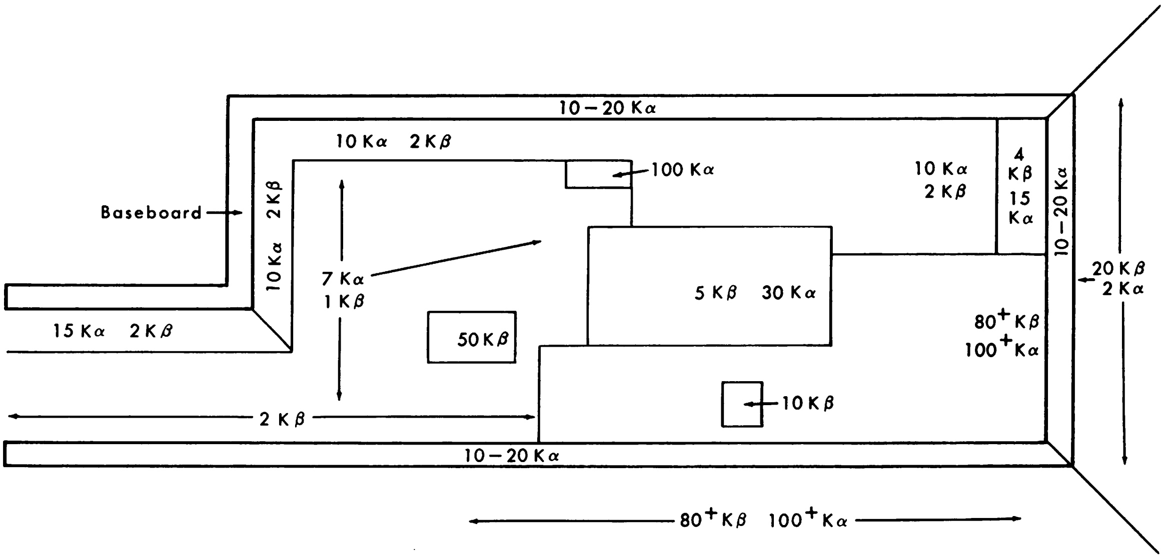


Figure 2. Contaminated areas in the most heavily contaminated room before reclamation

ured more than 100,000 cpm per 62 sq. cm. alpha and well beyond the survey meter's capacity of 80,000 cpm beta. Contamination ran consistently high along the edges of the room and continued up the terrazzo baseboard. The walls showed low surface contamination except for two walls in the far right corner with readings of 100,000+ cpm alpha and 80,000+ cpm beta. All contamination was highly wipeable and averaged 30,000 cpm alpha for wall wipes and 6,000 cpm alpha for floor wipes.

An alpha probe was contaminated to 6,000 cpm alpha by accidentally touching the floor while making a reading. Paint on the ceiling and walls was blistering and flaking badly. Removal of paint from one test spot revealed nine coats plus a primer coat.

Before work was begun, an area of the hall just outside the room was posted as a contaminated area, and the floor covered with 15-pound asphalt roofing felt. The vacuum cleaner, supplies, and such items were stored in this area, and no one was allowed to leave it after entering until he had been alpha and beta surveyed and had removed protective clothing.

Vacuuming was done with a Cambridge Absolute Model 80–A commercial type vacuum cleaner. Disposable filters were carefully placed in the disposal drum after use, as was the gathered debris.

The vacuum cleaner proved unsuccessful at picking up the dirt in the "pigeon room" because the feathers and rubbish were so thick that the hose and trap constantly became clogged. Therefore, one workman carefully handswept the floor with a broom while a second person collected as much airborne dust as possible with the vacuum cleaner. An air sample taken with a Gelman volume pump and millipore filter showed 300 cpm per liter of air at that time. The collected material was shoveled into the steel drum for burial as were the droppings in the wooden hood. (Air samples from other rooms were all below background level.) The floors, walls, ceiling, furniture, and fixtures were then vacuumed. Next a 36-inch wide strip of 15-pound asphalt roofing felt was laid on the floor, making a path from the door to the far corner of the room. This somewhat reduced the trackability since the floor itself was still highly wipeable.

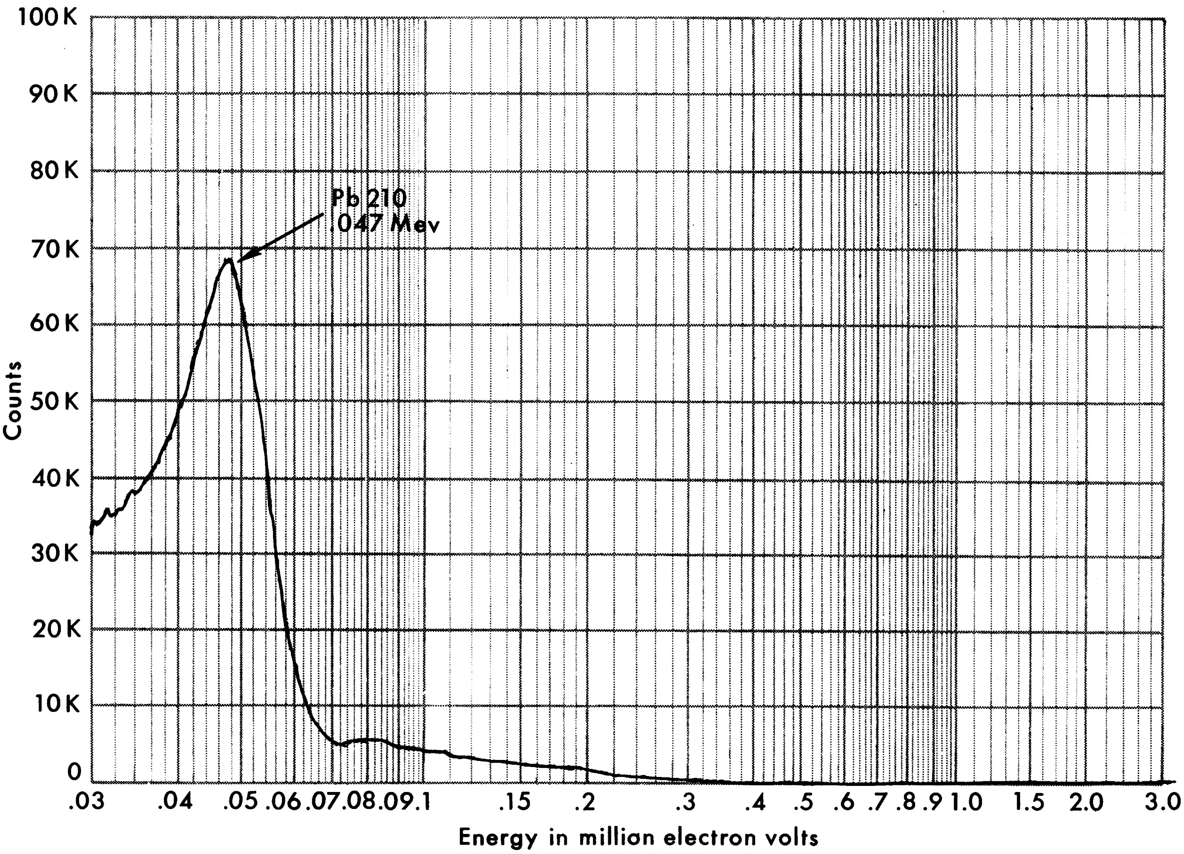
The air-conditioning duct was taken down from the ceiling supports, cut into small pieces with an acetylene torch, and the pieces were put into the disposal drum and buried. All furniture was also broken up in pieces small enough to fit in a drum. Next, the air-conditioning unit was cut in two for easier handling since it was more than 10 feet tall. The unit was buried as is, except for vacuuming and cleaning, because it was too large to be placed in another container, and cutting it into smaller pieces, as was done with the ductwork, was too difficult. The hood was then broken down and the wooden pieces placed in drums for burial. Windows and framing were removed next, and the openings closed with plywood until decontamination was over.

Floor and walls were again vacuumed and then mopped with a trisodium phosphate solution to remove surface dust. A path of new 15-pound asphalt roofing was laid to replace the old one which had been rolled, canned, and buried. During mopping the water was changed approximately every 20 square feet and four new sponge heads used. The water was disposed of by dumping down the already contaminated sink drains and soil pipes, which were replaced after decontamination was completed.

After drying, the walls still showed wipes of 30,000 cpm alpha and the floors, 6,000 cpm alpha. Dips taken in the mop water showed 300 cpm alpha when dry. Dips were 3-inch circles of Whatman No. 4 filter paper dipped into the water or solution and allowed to dry.

The ceiling and side walls were again scrubbed down with trisodium phosphate (12 oz. per gallon). Excess liquid was lifted with a cello sponge mop. The cleaning resulted in absolutely no reduction of activity. Sponges and brushes used in the process became contaminated to 6,000 cpm beta. No alpha measurements were made because of the poor geometry of the sponges and brushes. The walls were resurveyed with an Eltronic Model PR–7 geiger counter with the tube shielding removed and only the plastic shield covering the tube. Large areas of contamination concentration were circled with a china marking pencil. The circles were around 1 foot in diameter. Next, a CDV–700 Victoreen G.M. counter with beta shield in place was used to subdivide the larger circles into smaller ones. This was an exceptionally useful instrument since little gamma radiation

Figure 3. The 0.047 Mev gamma peak of lead 210, with its associated X-rays, of one of the "decayed" radon needles



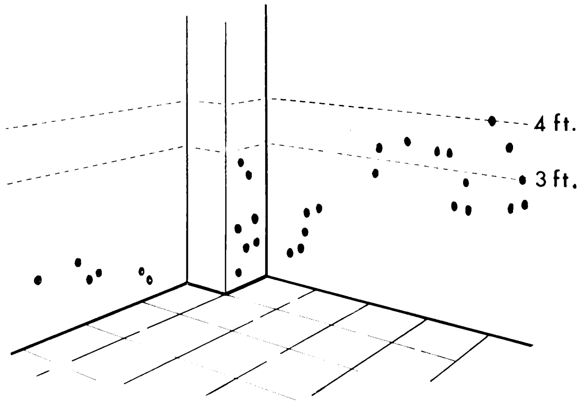


Figure 4. Typical locations of radon needles imbedded in contaminated walls

was present and the probe is completely shielded except for a small 1-inch by ½-inch beta window. Very small areas could thus be checked and the contamination narrowed almost to points, which were then circled with a different color china marker.

After the first four or five small circles, a small bump was visible in the center of each. With a sharp pocketknife, one bump was removed to a small piece of tar paper. The bump turned out to be a needle approximately ½-inch long that registered more than 100,000 cpm alpha and about 80,000 cpm beta. The needle was analyzed in a Nuclear Measurements Corporation Model G SS–1 Gamma Spectrometer, which indicated the activity was caused by lead 210 (fig. 3). In all, 43 needles were detected and removed (fig. 4). By checking the color of paint to which the needles were stuck, it was determined that they were put into the walls between the fourth and fifth coats of paint. All needles of corresponding size were saved; those smaller were buried. After the larger needles had been removed, it was noticed that numerous smaller fragments remained in the paint. Because the fragments were too numerous and too small to be dug out of the wall with a knife, all 10 coats of paint were removed from the contaminated corner with paint remover (strypeeze).

The next step was decontamination of the terrazzo floor and baseboard. Floors and baseboard were again mopped with trisodium phosphate solution, dried, and resurveyed. No reduction in radiation was noticed. The floor was then etched with HCl (2 parts acid to 1 part water) and an 0.2 normal sodium hydroxide neutralizing solution. The procedure used was to pour the acid on and brush it into the spot. When effervescence ceased, the thick liquor was removed with paper towels. Then the sodium hydroxide was poured on the spot, and when pH test papers showed a basic reaction, the base solution was removed with clear water until a neutral pH was recorded. During the acid operation an air sample for radon and daughter products was run. No excess values were obtained (see table). Decontamination was done in 4-foot square areas with spot etchings wherever possible.

After the acid etching, a solution of trisodium phosphate and 8 oz. liquid soap per gallon was applied to the floor, and it was scrubbed with a mechanical scrubber. The soap was added to help lift the dirt and contamination out of the small holes in the concrete and float it in an emulsion that could be easily and neatly picked up. Dips in the emulsion registered

Result of tests of air samples during hydrochloric acid treatment

Location	Sample time	Delay (minutes)	Counts per minute per liter of air	Percent of maximum permissible concentration for radon and daughters
6 inches above 40K alpha spot	10	40	1. 5	1. 5
6 inches above 40K alpha spot	10	40	1. 5	1. 5
6 inches above 40K alpha spot during acid etch	10	40	1. 5	1. 5
6 inches above 40K alpha spot after acid etch	10	40	. 5	. 5
6 inches above 40K alpha spot 24 hours after acid etch	10	40	. 5	. 5

NOTE: Maximum permissible concentration for radon and daughters = 100 $\mu\mu c$ per liter of air. Procedure followed is that given in "Control of Radon and Daughters in Uranium Mines and Calculations on Biological Effects." PHS Publication No. 494. Readings for all samples per liter of air per minute were 8.33.

50,000 cpm alpha and 20,000 cpm beta. Next was a clear water rinse, a trisodium phosphate rinse, and another clear water rinse. The floor was then resurveyed after drying overnight and remaining active areas were spotted with HCl and neutralized (fig. 5).

The sole remaining problem was the constant threat of recontamination from paint peeling and flaking off the walls and ceiling. With 10 coats already on the wall, additional paint would only increase peeling. Instead, it was decided to build false ceilings and walls with removable baseboards. All loose paint chips would fall to the floor behind the false wall and be trapped behind the baseboard. Every 6 months to a year the baseboards can be removed and the collector base vacuumed of all accumulated particles (fig. 6).

A solid type of acoustical tile was installed as a false ceiling, and 2 x 4 studs were bolted around the walls in such a way that no obstruction existed from the ceiling to the floor. Quarter-inch mahogany paneling was used as the new false wall because less pounding would be necessary in the installation and thereby lessen chances of knocking paint from the old wall. The paneling extended to within 2 inches of the base 2 x 4, allowing the nozzle of a vacuum cleaner to be inserted for cleaning. The baseboard was attached by screws so that it was easy to remove for cleanup.

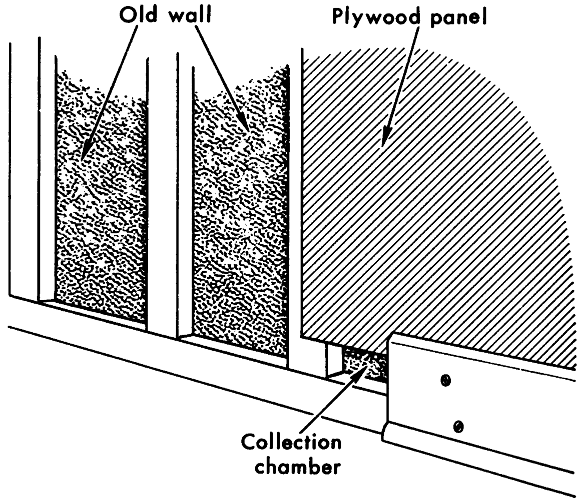


Figure 6. Design of false walls of paneling used for shielding and removable baseboards

The floors were then revacuumed, mopped, and painted with a rubber-base concrete floor enamel. At the same time the base 2 x 4's were also given a thick coat of paint. Finally the floor was tiled and rechecked for beta. Beta radiation was background, and the room was released.

Summary

Following is a brief summary of the steps followed in restoring a heavily contaminated building to a stable and useful structure.

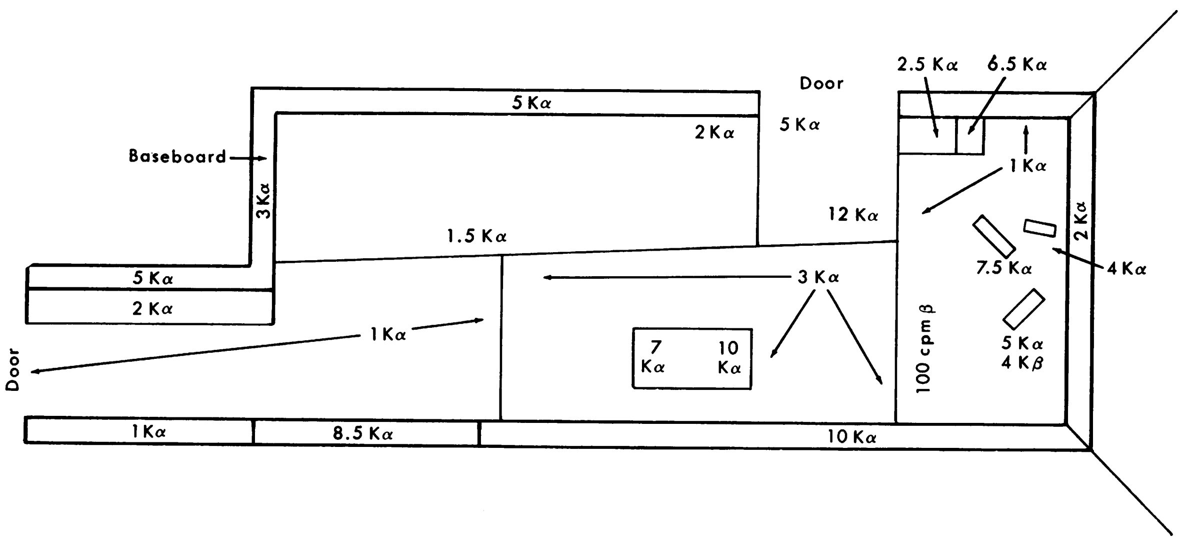


Figure 5. Active areas in the heavily contaminated room after mopping and acid etching of floors. Extra door had been cut to adjoining office

1. Set up and post a work area just outside the room being decontaminated where all equipment is stored and workmen are checked before leaving. This also serves as a breathing area where respirators are removed.

2. Padlock the door of the room during decontamination.

3. Vacuum the room.

4. Clear room of all movable objects.

5. Revacuum.

6. Scrub floors with trisodium phosphate solution (8 oz. per gallon of water) and cover with asphalt felt.

7. Sponge-mop walls and resurvey.

8. Remove sources of radioactivity in walls by plucking or removing paint with paint remover.

9. Sponge-mop floor with trisodium phosphate solution.

10. Remove felt floor covering and apply HCl solution (2 parts acid to 1 part water).

11. After effervescence, lift acid with trisodium phosphate solution.

12. Power brush into floor a solution of 8 oz. liquid soap and 8 oz. trisodium phosphate per gallon of water.

13. Lift scum with cellulose sponges and clear water.

14. Mop floor with trisodium phosphate solution.

15. Rinse with clear water and resurvey.

16. Seal floor with rubber-base concrete floor enamel.

17. Tile floor with asphalt tile.

18. Paint baseboards if necessary.

19. Install false walls of plywood paneling if necessary.

20. Final survey.

Conclusion

Probably many buildings used in the past for some type of radium treatment have been put into service again by new tenants or owners without knowledge of their histories. With the complete lack of control over radium usage that once prevailed, locating these potentially hazardous buildings is difficult. If these buildings are identified, however, decontamination can be accomplished and need not be the insurmountable job in cost and effort that it at first seems to be.

Processing and use of radium itself is not the only problem. Even today radon seeds are treated carelessly once gamma activity diminishes. Crushed seeds may lead to alpha and beta contamination that may not be detected by instrumentation normally found in institutions using the seeds, but the hazard of ingestion of these particles exists and should be found and eliminated.

Dr. Jacobs Heads Foreign Quarantine

Dr. Louis Jacobs assumed the position of chief of the Division of Foreign Quarantine, Public Health Service, on July 1, 1964. He succeeded Dr. James Telfer, who retired after 28 years with the Service.

Until July, Dr. Jacobs was the chief psychiatric consultant for the Service's foreign quarantine program in Europe. Earlier, he had been the superintendent of the National Training School for Boys in Washington, D.C.

Dr. Jacobs, a native of St. Paul, Minn., received a B.A. degree from the University of Pennsylvania in 1932 and an M.D. degree from the Jefferson Medical College in Philadelphia in 1936. He interned at the Public Health Service Hospital in Lexington, Ky., and in 1942 completed residency training at the New York State Psychiatric Institute and Hospital. In 1947 he received a master of public health degree from Johns Hopkins University.