TABLE 5

Thicknesses of Lead Required for Shipment of Radium by Railway Express and Allowable Hours in Transit[a]

Quantity of radium, mgs.	Thickness of lead, in.								
	0.25	0.5	1	1.5	2	2.5	3	3.5	4
	Allowable hours in transit								
Under 15 mg.	40	60	110						
15 mg. and under 25	20	30	55	110					
25 mg. and under 35	14	20	36	73	146				
35 mg. and under 45	10	15	28	55	110				
45 mg. and under 55		12	22	44	88	170			
55 mg. and under 65		10	18	36	73	142			
65 mg. and under 75			16	31	63	122			
75 mg. and under 85			14	27	55	106			
85 mg. and under 95			12	24	48	95			
95 mg. to 100 incl.			11	22	44	85	170		
200 mg.				11	22	43	86	172	
300 mg.					14	28	56	112	
400 mg.					11	22	44	88	172
500 mg.					8	17	34	68	136
600 mg.						14	28	56	112
Minimum weights of lead, lbs.	0.5	0.75	3.25	9.25	9.5	36	58.5	91	135

[a]These figures provide adequate protection to undeveloped photographic film under conditions of shipment provided by the express companies. Radium cannot be sent through the United States mail.

C. PROTECTION FROM X-RAYS

1. *Special Features*

Although the problem of protecting personnel from x-radiation is similar in many respects to that of protecting them from gamma rays, actual conditions frequently are very different. Physiological effects to be expected are much the same in kind, though not always in degree, and the tolerance dosages measured in terms of ionization are the same. Since the intensities and wave lengths of the radiations differ considerably in many applications from those encountered in the use of gamma rays, the details of protective arrangements must be modified to correspond.

The source of x-rays, the x-ray tube, because of its more extensive volume and the necessity of providing electrical conductors, increases the difficulties of adequate shielding. Such a bulky source also scatters diffuse radiation in the vicinity, an effect that is the more pronounced because of the much higher intensities of radiation commonly used. In dealing with the protection of personnel engaged in this work, the electrical hazard from the high potentials also must be discussed since this is about as frequent a source of injury as exposure to the radiation.

2. *Protection from Electric Shock*

For industrial applications of x-rays, this problem can be divided into two general cases depending on the two types of generating equipment ordinarily used. One is the portable or semiportable unit in which all parts are built into a single enclosure and shielded electrically. In the use of this unit, the operator cannot take advantage of the electrical protection offered by insulating the surface of floors and surrounding objects. Rubber shoes and gloves may reduce danger of shock to some extent, but the only sure protection from shock is a continuous grounded metal enclosure for all parts of the unit, so that it is quite impossible for the operator to touch any part that is above ground potential. This includes high voltage and low voltage cables, control panels, and all other exterior parts. The electrical bonds between these parts not only must insure permanent electrical union of the parts, but also should be substantial mechanically. In some cases, a single heavy cable connecting some part of the grounded system to a permanently earthed point, such as a water pipe, may be sufficient. However, in some types of equipment, high frequency currents may develop that will cause sparks to ground unless several grounds are used at frequent intervals. This is particularly true of long high-voltage cables. These sparks may be harmless in themselves, but may cause insulation failures that will permit the direct current voltage to break through.

The second type of x-ray generating equipment, which is less common, is built into one or more rooms, requiring all work to be brought to the x-ray tube. The same general rules apply to this type of equipment, but greater precautions must be used where parts cannot be permanently shielded. If the high voltage is generated in a separate room, provision must be made so that it is impossible to enter the room with the generator in operation. If high voltage conductors are not enclosed in grounded shields, they must be at a sufficient distance from all points where personnel may normally walk so that there is no possibility of injury from a spark. This distance is about 7½ feet for voltages below 225 kilovolts and correspondingly greater for higher voltages. Suitable signal lights are recommended to indicate the various conditions of generating equipment, and should be so arranged that they are not readily misinterpreted. In all cases, a pilot light should indicate when the main switch controlling the generator is closed.

Overload circuit breakers of a sensitive and quick-acting type should be included in the primary circuit and adjusted to throw at 20 per cent above normal load.

The control panel of all x-ray generators should be located so that the x-ray tube is completely in view of the operator. This may be accomplished by some type of indirect viewing device to screen the operator from scattered radiation; or a suitable filter, transparent to visible light but sufficiently opaque to x-rays, may be placed in the line of sight.

Since many electrical shocks prove fatal only because of failure to apply restorative treatment at once, it is imperative that all personnel concerned with the operation of an x-ray unit be familiar with the methods of artificial respiration and