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STUDIES ON THE POCKET DOSIMETER FOR PREVENTION OF RADIATION INJURIES

V. THE DISTRIBUTION OF SCATTERED RADIATION IN EMPLOYMENT OF X-RAY APPARATUS INDUSTRIAL PURPOSES

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The use of industrial X-ray apparatus has of late greatly increased, and espcially in heavy industries such iron and steel mills. It is only natural to anticipate considerable radiation injuries to occure in connection with these industrial X-ray work and much investigation has already begun on this particular problem. While detection and treatment of radiation injuries belong essentially to the medical field, industrial X-ray apparatus is used in environment which are entirely detached from medicine. For this reason, thorough instruction on safe guard against radiation hazards is necessary especially for men working in industrial roentgenology. A portable industrial X-ray apparatus is used in an iron factory in our city. We were able to measure the scattered radiation produced by this apparatus when used for the nonbreak test on welding work of an iron gas tank as is shown in Fig. 1. We hope that our present report may be of some help in prevention of the radiation injuries in industrial fields.

The industrial X-ray apparatus utilize the electro-magnetic wave of as high an energy as from 100 kV to 300 kV, or sometimes million volt nuit. Owing to the scattered radiations having short wavelength as primary beam and to their strong penetration through substances, the protection from these scattered radiations is highly difficult. Generally, keeping sufficiently away from the radiation source and scattering radiation source is the most effective means of protecting the human bodies from injuries due to the radiation having strong penetrating power. Since the object to be tested here is a metal possessing considerable thickness, it is at times quite effective to utilize these metalic objects themselves as protective material.

X-RAY APPARATUS AND MEASURING METERS

The X-ray apparatus used was a portable industrial X-ray apparatus E-175B-1 (*Toshiba Electric Co.*), unbroken tested object was the welding lines of a spherical iron tank having diameter of 12 meters as showed in Fig. 1, and the iron plate of the tank was 16 mm in thickness. The radiographed conditions were as

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follows, the tube voltage was 110 kVp, tube current 5mA, time of exposure 2.5 minutes, and radiographed 20 times a day on the average. The focus-object dis-

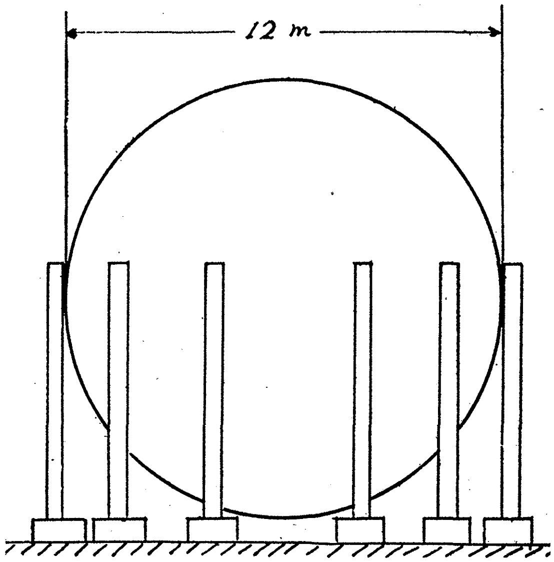

Fig. 1 The outline of iron tank, the object of examination of the scattering radiation distribution as part of nonbreak test

TABLE I

The radiation quatities workers exposed to

Position number	Tank Wall	Detected Quantity
1	outside	5.9mr
2	inside	5.9
3	outside	7.8
6	inside	7.8
7	inside	3.9
9	inside	5.9
10	inside	3.9
11	inside	5.9

tance was 70cm. Meters used for measurement of scattered radiation were 1) a dosage rate meter (DR-1 *Kobe Kogyo Co.*), 2) a count rate meter SU-P2 (*Kagaku-Keukyusho Ltd.*), and 3) pocket condenser chambers (abridged throughout the present paper as "pocket chamber") (*Toshiba Electric Co.*). The pocket chambers were used to detect the exposed radiation quantities of workers, DR-1 was used for examination of the scattered radiation distribution of gross quantities, and for detection of small quantity distribution SU-P2 was used.

RESULTS

I. Exposed doses of workers

We measured the scattering radiation to which the men working around the radiation apparatus were exposed. The radiography to outward from inside against to the tank wall at the point marked in Fig.2 with above conditions (110 kVp, 5mA, 2.5min.). In Fig .2 are shown the position of workers having the pocket chambers. This figure is a schema viewing from above. Workers No. 1 and 3 were outside of tank, 6, 7 and 9 moved around within the dotted line during the radigraphy. Table I shows its results rectified with the correction factor of these pocket chambers.

II. Scattering radiation distribution

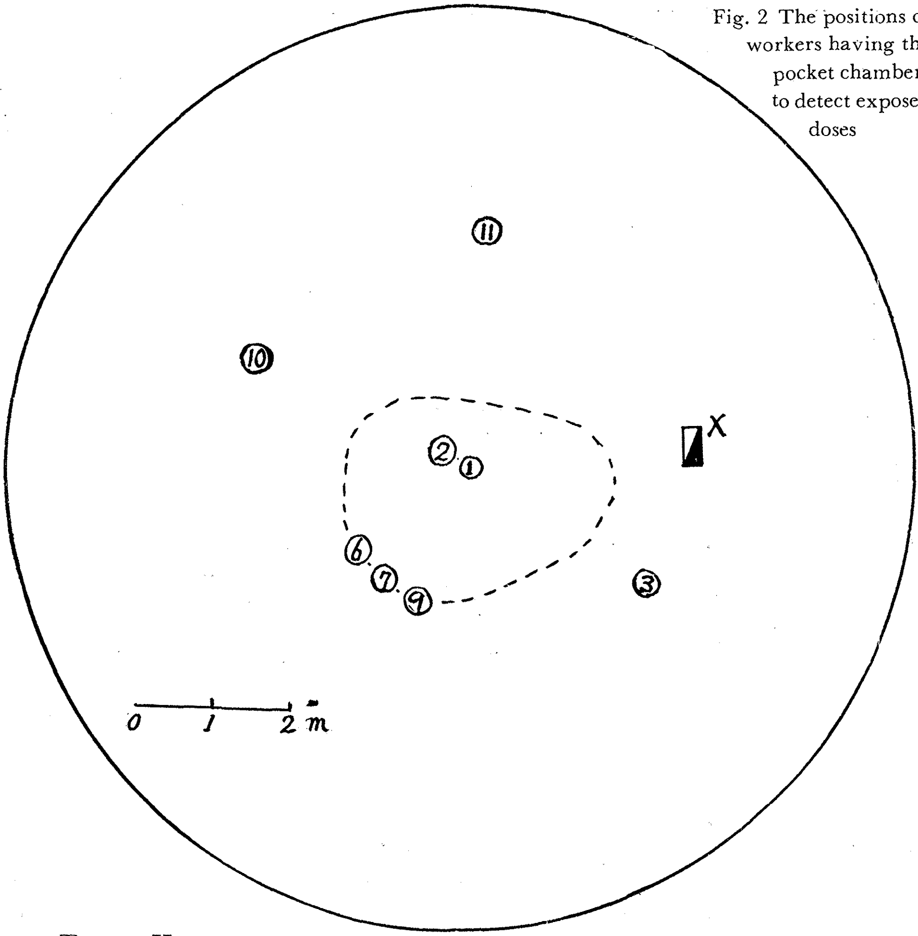

Fig. 2 The positions of workers having the pocket chambers to detect exposed doses

TABLE II Doses registered by ocketp chambers set on the position corresponding to respective numbers of Fig. 3

Position Number	Tank Wall	Detected Quantity
1	inside	3.9 mr
2	outside	0
3	inside	15.6
4	inside	11.6
5	inside	5.9
6	inside	3.9
7	inside	2.0
8	outside	0
9	outside	0
10	outside	0
11	outside	0

a) Pocket chambers

In Table II is shown the distribution of scattered radiation which was measured by the the pocket chambers set on the positions corresponding to the numbers given in Fig. 3, when the apparatus operated under the radiogrphic conditions 110kVp, 5mA and 20min. exposure from within outward. All measured points were 70 cm in hight above the iron plate or ground. The pocket chambers numbered 2, 8, 10 and 11 were set on the bases of the supporting pillar outside, and number 9 was placed on the ground below the tank center.

b) Dosage rate meter DR-1

1. When irradiated from inside to the outside of the tank, the distribution of scattered radiation within the tank as measured with DR-1 was as shown in Fig.

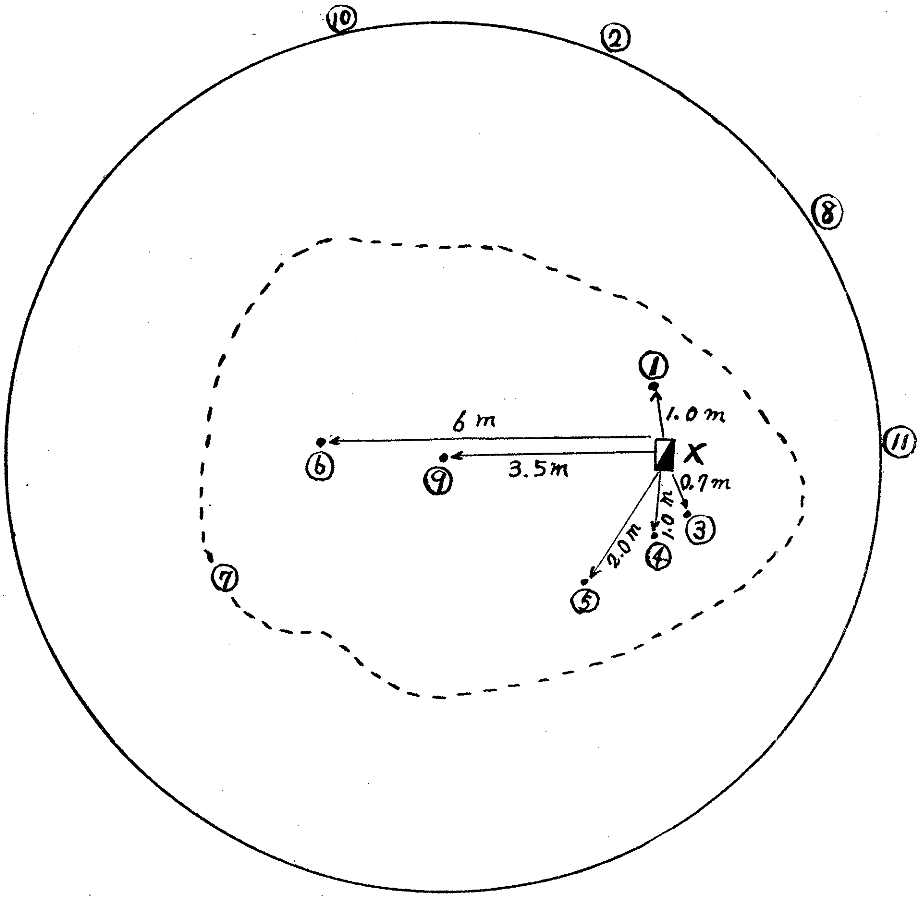

Fig. 3 The positions of pocket chambers set to detect the scattering radiation

4. In the lower schema of Fig, 4 is shown a side view of AB sections chema of the examined points. Ordinarily wemeasured at 50 cm above the floor, but on the points 4 and 7measurment was made at various hights besides 50cm. These results are shownin Table III. The distance from the source to each point is represented in this table as curvature distance along to inside of tank wall. The unit is shown in mr/hr (milli-roentgen per hour).

2. The distribution of scattered radiation outside of the tank is shown in Fig. 5

when irradiated outward from the inside. The unit is shown in mr/hr. The intensity of X-ray penetrating through the tank wall as represented in quantities is small, the intensities of the main beam flux is only 50mr/hr at the distance

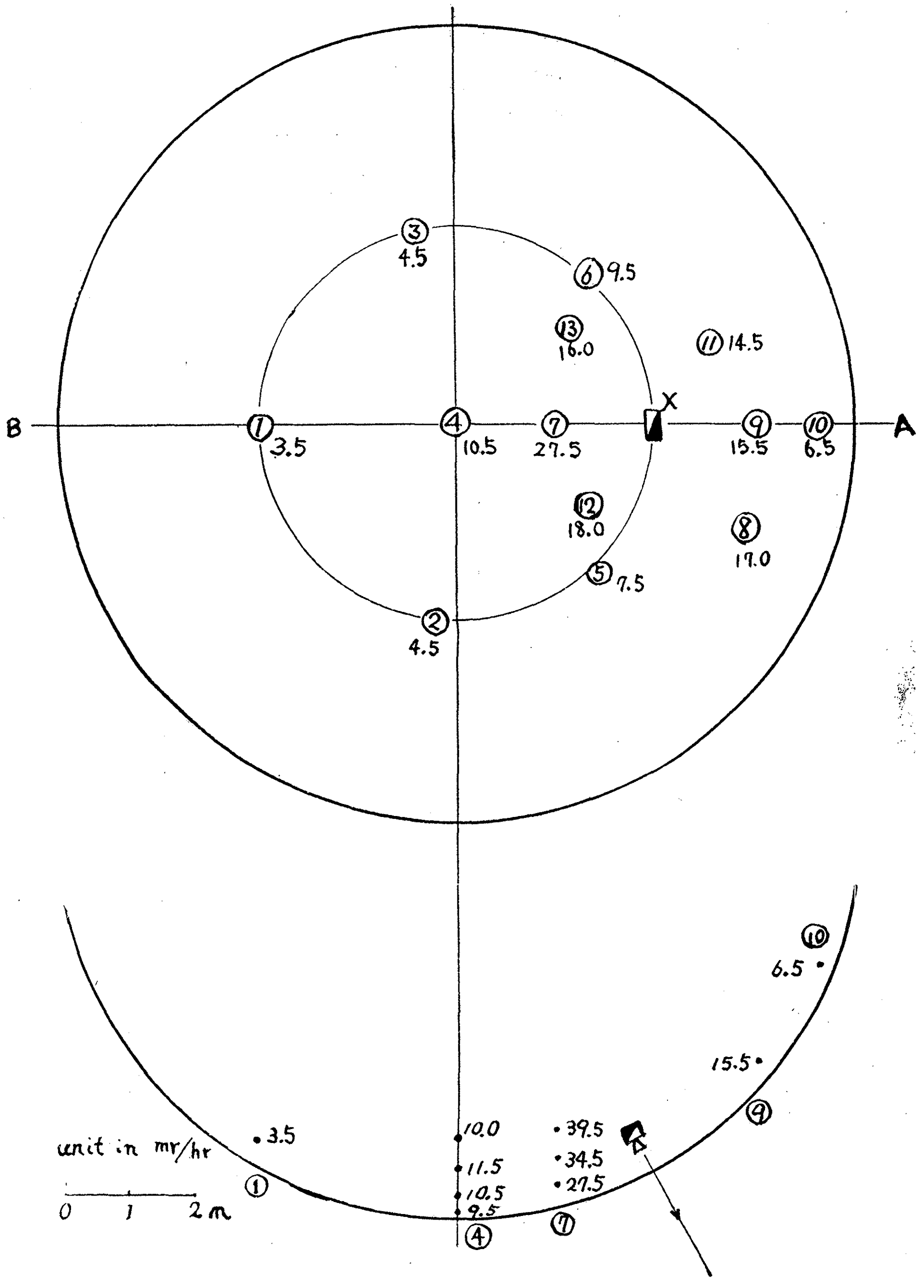

Fig. 4 The points examined with a dosage rate meter DR-1 and obtained values

of 20cm from the outside of the tank wall. In the space separated from this main beam flux, the radiation quantities further become reduced. The upper part of

TABLE III

The scattering radiation quantities which measured with dosage rate meter on various distances inner tank

Position Number	Detected Quantities Hight above Floor				Distances from X-ray source
	20 cm	50 cm	100 cm	150 cm	
1		3.5 mr			6.0 meters
2		4.5			5.0
3		4.5			5.0
4	9.5	10.5	11.5mr	10.0	3.0
5		7.5			2.5
6		9.5			2.0
7		27.5	34.5	39.5	1.5
8		17.0			2.5
9		15.5			1.5
10		6.5			4.0
11		14.5			1.5
12		18.0			1.5
13		16.0			2.0

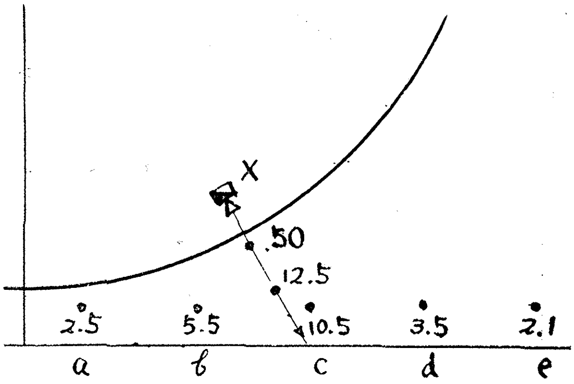

Fig. 5 The points outside the tank examined with DS-I and obtained values

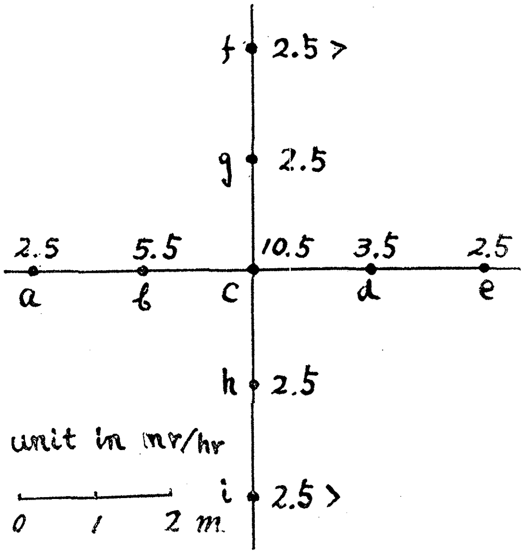

Fig. 5 is a side view and the lower is a plane view in which the points of measurements and values obtained are described.

c) Count rate meter SU-P2

1. To compare with DR-1, we measured the scattered distribution of the inside and outside of the tank with SU-P2 when irradiated outward from within. The obtained results are shown in Fig. 6. Scrutiny of the results shows that the

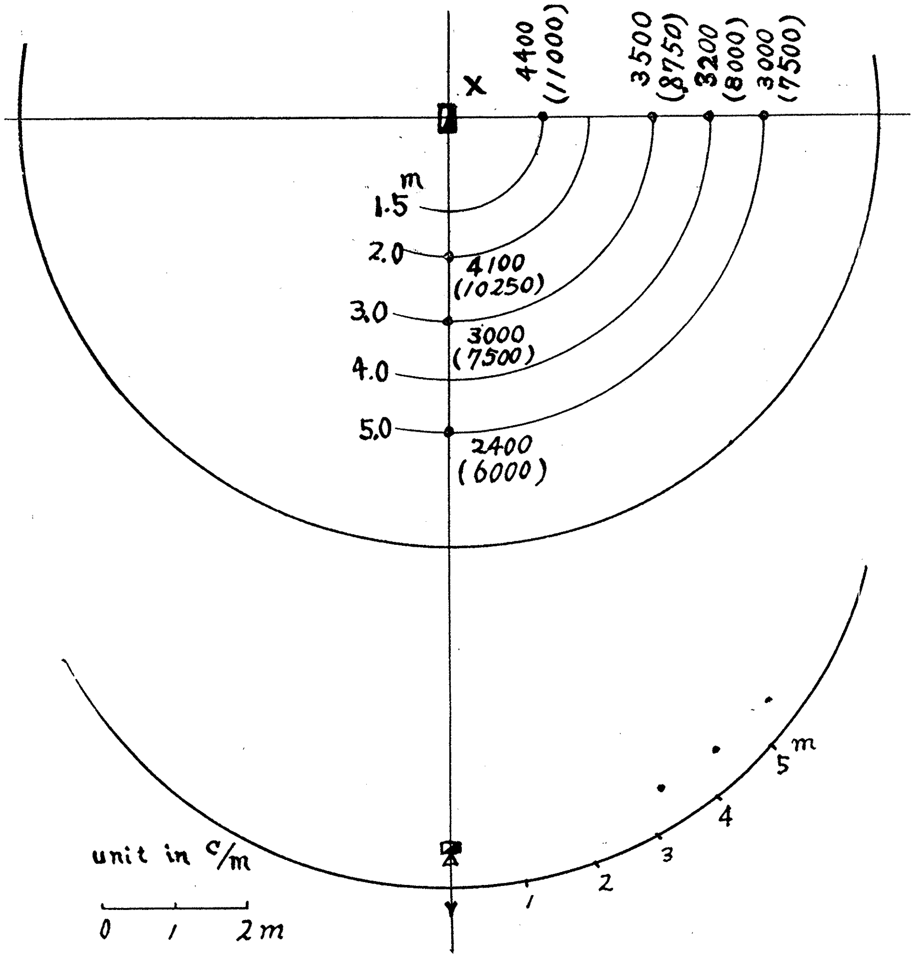

Fig. 6 The values (counts per min.) measured with count rate meter SU-P2 and measuring points when radiated outward (inside the tank)

counting numbers decrease with the distance, but this reduction does not correspond with the reversal square law. It is presumed that this phenomenon is caused by the following reasons: 1) one count corresponds with one particle irrespective of the energy of one incident particle because the measuring meter is *Geiger-Müller* tube, 2) the scattering particles are not reduced in accordance with the reversal square law for distance traversed, because the wall is closed concave sphere and produces the irregular scattered radiation. This measurement be made under the conditions of 110kVp, 2 mA exposure. The values converted to the condition of 5 mA irradiation are shown in brackets.

2. When irradiation was inward from the outside, the distribution of scattered

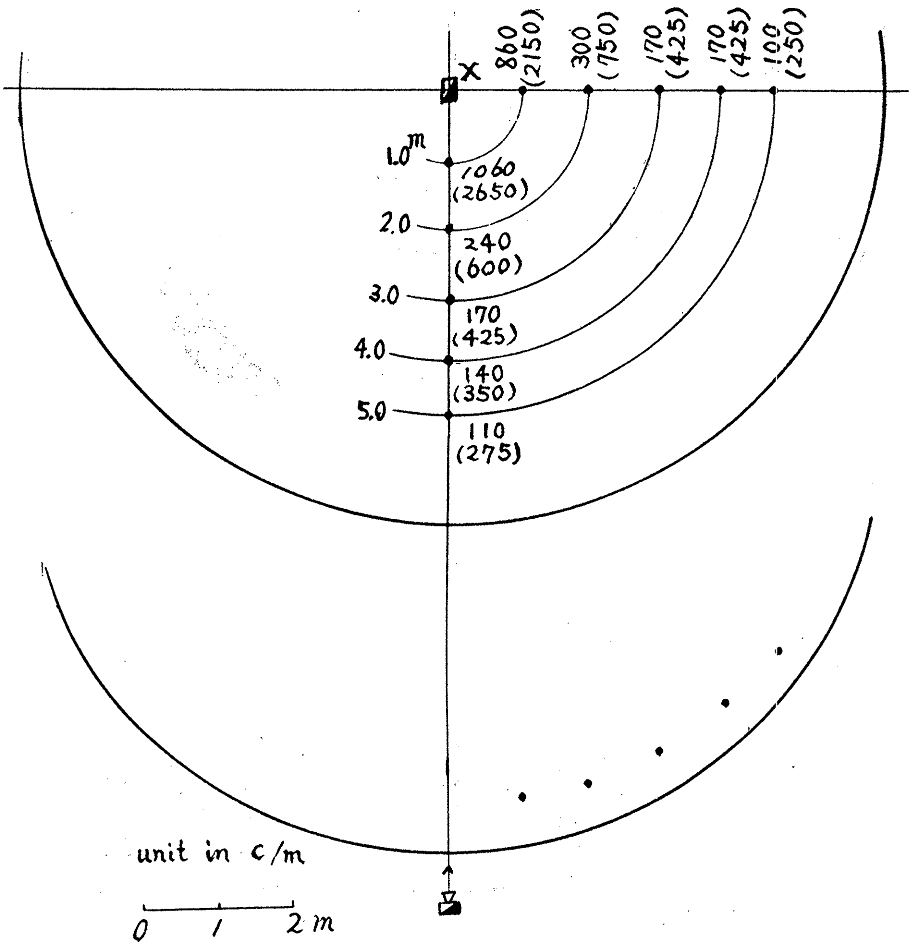

Fig. 7 The values obtained with SU-P2 and measuring points when radiated inward (insid the tank)

radiation which we detected with a count rate meter in the tank and in the surrounding vicinity of the main beam flux, is shown in Fig. 7. It is clear that the scattered radiation quantities of the inside are very small under this condition of irration, 110kVp, 2 mA. In the brackets are shown converted values of 5 mA exposure.

3. In Fig. 8 are shown the scattered radiation distributions of outside (X-ray source side) when irradiated toward the inside of the tank under the condition of

110 kVp and 2 mA. The upper schema of Fig. 8 is the side view, and in lower shema is shown the plan view in which the points of measurements and gained values are described. The numbers in brackets are values converted to 5 mA ir-

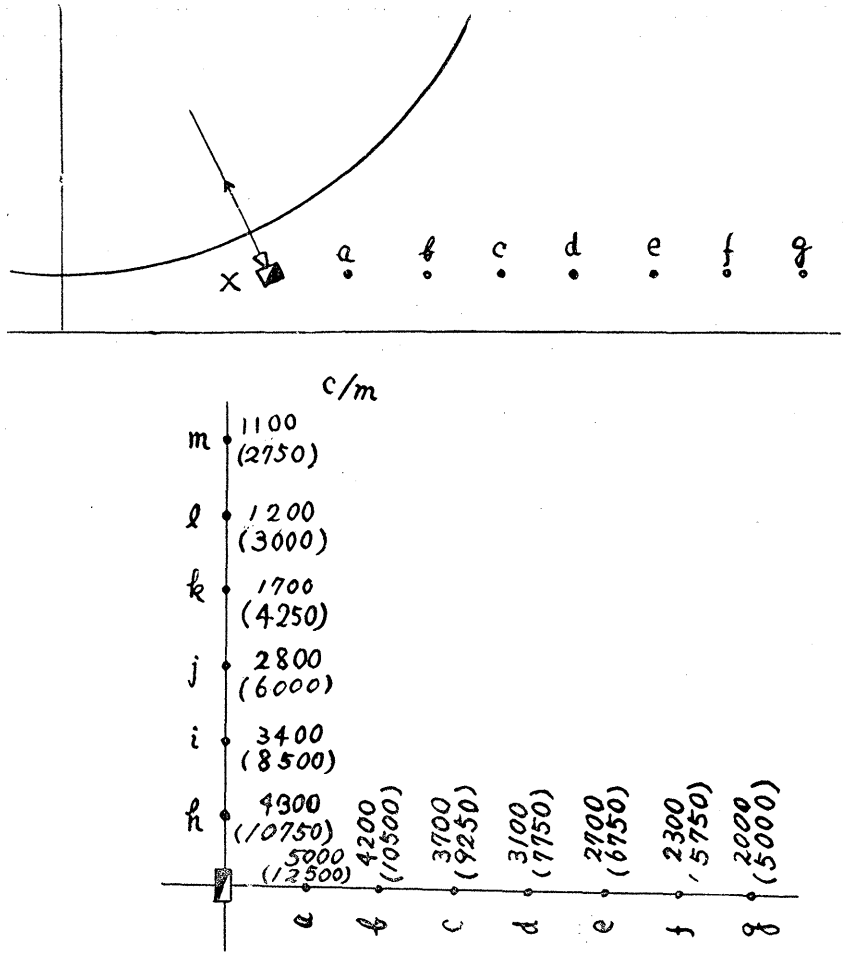

Fig. 8 The values obtained with SU-P2 and measuring points when radia invard (outside the tank)

radiating condition.

SUMMARY AND CONCLUSIONS

1. Owing to the environment of the industrial X-ray work being spherical iron tank, the scattered radiation quantities were not always inversely proportional to the square of distances from the radiation source. Therefore, to show exactly the safety region in distance was difficult. However, if we assume that the safety regions are the space in which the radiation quantities are smaller than 10 percent

of the maximum tolerance doses of 0.3 r/week which was adopted in the Recommendations of the International Committee of Radiation Protection (1954), it is necessary that to maintain a distance of more than 6 meters from the radiation source when one radiographs under the conditions of 110 kVp, 5 mA 2.5 minutes exposure, and twenty times per day.

2. On the side opposite the radiation source through the iron wall (16 mm thickness), all spaces may be considered safe except the spaces lying within the main beam flux, because the radiation quantities of direct beam penetrating the iron wall are very little, and the iron wall further prevents to some extent the scattering radiation produced on the source side reaching the opposite side.

3. We could not accurately correlate the counted numbers of the count rate meter with the roentgen unit.

4. Although the values which were obtained with the pocket chambers at the points shown in Fig. 3 were not large, yet as shown in the results II, a (Table II), the indications with the pocket chambers carried by the workers was much large. This is importance to bear in mind when we employ the pocket chambers.

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