The Report of the Joint Commission for the Investigation of the Effects of the Atomic Bomb in Japan

VOLUME VI

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MEDICAL EFFECTS OF ATOMIC BOMBS

The Report of the Joint Commission for the Investigation of the Effects of the Atomic Bomb in Japan; Volume VI

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NOTE

This report consists of six volumes, the first five of which are declassified. Distribution for both classified and declassified volumes has been made as indicated on page 2.

Section 10H

POPULATION AND CASUALTIES, HIROSHIMA

Prepared by Averill A. Liebow, Lt. Col., MC

Data Concerning General Population and Casualties Collected by Marvin E. Habel, Capt., F.A., and Dr. Motosaburo Masuyama.

Data Concerning Special Groups Collected by Averill A. Liebow, Lt. Col., MC, and Jack D. Rosenbaum, Capt., MC.

Data Concerning Hiroshima School Children Collected by Majors Motohashi, Misono, Hongo, Hata, and Nakatomi

The Objectives of the study were the achievement of:

1. The best estimate of the population on the day of the bombing.
2. An accurate estimate of the total casualties.
3. The construction of a curve indicating the percentages of casualties in relation to distance.
4. An estimate of the "Standardized Killed, and Casualty Rates" so that the atomic weapon could be compared with others.
5. A comparison of casualty data shown in the ultimate general mortality curve, with that of groups under known conditions of exposure and shielding.
6. A classification of the causes of fatalities and of the types of casualties produced by the atomic bomb.

1. ESTIMATE OF THE POPULATION

A. Estimate from Rice Rationing Figures and Evacuation Data.

Preliminary investigation revealed that the best estimate of the population before the bombing was from the rice rationing figures. These, according to Japanese procedure, were reported by the precinct or block-association leaders (Chonaikai) to the Ration Bureau (Busshika), which in turn reported to the Bureau of Ward-(Machi-) Administration (Choseika). The figures as of the last of July were lost by fire which resulted from the bombing, but those of 30 June 1945 are available (table 1) together with those of 30 October. The latter are given merely as an index of those who had come back to the city, and do not give a true idea of casualties. These figures are grouped under "Rengo-Chonaikai" or wards which are named and

and illustrated in the accompanying map (figure 1). The boundaries of individual precincts are more difficult to outline exactly. It is to be noted that this figure (table 1) must be increased by approximately 20,000 since quasi-families, made up of groups of associated workers, were not included.

Certain other factors must be considered in adjusting this figure to a probably correct value. It was planned to create firebreaks in the city by destroying a certain number of homes and evacuating the displaced persons into the country. In July, 3400 families were evacuated. Each of these numbered, on the average, 3.63 individuals. Thus, 12,350 must be subtracted from the total. The final distribution is shown in table 2c. The total population of Hiroshima on 6 August 1945 is estimated at 255,200.

At the time of the bombing, there was an influx of workers from distant villages to help in clearing firebreaks. These were in patriotic workparties (Giyutai). According to the records, they comprised 1,768 men and women on 6 August 1945. This number is not nearly as great as was reported by some.

An estimate of incoming and outgoing passengers at the railroad stations was also made, but was ignored in the final tabulation.

B. Estimate from Newspaper Circulation.

An independent estimate was made according to newspaper circulation. At the time there was permitted to circulate only one paper, The Chugoku News. Almost every family group took a paper and only one was permitted to each family. Thus a minimal population estimate of 230,700 is afforded. The larger estimate is considered closer to the actual figures and is used

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Table 1

RICE RATIONING FIGURES OF RENGO-CHONAIKAI (1945)

District No.		1/VII	1/XI	District No.		1/VII	1/XI
1.	Usida	7019	7235	18.	Fukuromati	6036	63
2.	Onaga	8034	8263	19.	Ote	6076	247
3.	Yaga	1887	2237	20.	Nakashima	9196	2387
4.	Aozaki	6187	7479	21.	Hirose	4980	221
5.	Kozin	5508	3134	22.	Honkawa	5237	164
6.	Danbara	10342	3977	23.	Kanzaki	9637	375
7.	Hijiyama	10440	11075	24.	Funairi	5983	3207
8.	Niho	4074	5332	25.	Eba	6000	5844
9.	Kusuna	2178	2517	26.	Osiba	10057	6309
10.	Oko	4793	5603	27.	Misasa	12393	5517
11.	Ninami	10187	8029	28.	Temma	7389	1566
12.	Ujina	12110	12835	29.	Kannon	18429	10392
13.	Ninoshima	1765	1800	30.	Fukushima	4065	2889
14.	Hakushima	7104	1739	31.	Koi	7780	9283
15.	Noboricho	8082	164	32.	Furuta	3830	5431
16.	Takeya	12353	895	33.	Kusatsu	7107	9158
17.	Senda	9165	3184	Total*		245423	148551

* N. B. 1. Zyunsyotai (quasifamilies) and Sizisyotai (designated families) are excluded. Their population estimated by Mr. Yamane is ca. 20000.

2. Military personnel and a few farmers are also excluded.

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Table 2a. Population Sampling Study

Sampled Districts and Questionnaires

Rengo Chonaikai Districts	Total Census Districts	Number of Census Districts Sampled	Number of Questionnaires Sent	Number of Questionnaires Answered
1. Usida	25	14	240	195
2. Onaga	20	13	240	212
3. Yaga	9	5	80	61
4. Aosaki	17	13	260	226
5. Kozin	13	4	80	57
6. Danbara	20	10	160	122
7. Hijiyama	31	20	400	301
8. Niho	13	10	200	177
9. Kusuna	8	4	80	69
10. Oko	15	9	180	149
11. Minami	28	13	240	190
12. Ujina	54	26	500	432
13. Ninoshima				
14. Hakushima	8	3	60	47
15. Noboricho	3	0	0	0
16. Takeya	6	1	20	14
17. Senda	12	6	120	89
18. Fukuromati	2	1	20	4
19. Ote	2	0	0	0
20. Nakashima	13	4	80	73
21. Hirose	4	2	2	0
22. Honkawa	1	0	0	0
23. Kansaki	2	0	0	0
24. Funairi	23	7	100	64
25. Eba	8	8	160	110
26. Osiba	34	16	187	171
27. Misasa	20	8	113	88
28. Temma	14	3	58	44
29. Kannon	26	18	300	202
30. Fukushima	15	5	60	48
31. Koi	36	16	266	197
32. Furuta	22	15	280	223
33. Kusatsu	19	11	220	174
Grand Total	523	265	4706	3739

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Table 24. Population Sampling Study

Dead and Injured in Sampled Population

Number of District	Number of Persons Reported on	DEAD		INJURED		UNHURT	
		Number	Percent	Number	Percent	Number	Percent
1.	452	21	4.6	148	32.7	283	62.7
2.	584	18	3.1	147	25.2	419	71.7
3.	202	4	2.0	29	14.4	169	83.6
4.	421	11	2.6	27	6.4	383	91.0
5.	773	81	10.4	336	43.5	356	46.1
6.	916	190	20.7	344	37.6	382	41.7
7.	781	18	2.3	238	30.5	525	67.2
8.	1063	10	1.0	85	8.0	968	91.0
9.	7	0	0.0	1	14.3	6	85.7
10.	279	3	1.1	68	24.4	208	74.5
11.	747	41	5.5	317	42.4	389	52.1
12.	1018	21	2.1	148	14.5	849	83.4
13.	188	1	0.5	0	0.0	187	99.5
14.	422	108	25.6	149	35.3	165	39.1
15.	718	445	62.0	197	27.4	76	10.6
16.	748	345	46.1	284	38.0	119	15.9
17.	759	137	18.1	319	42.0	303	39.9
18.	523	429	82.0	51	9.8	43	8.2
19.	677	511	75.5	133	19.6	33	4.9
20.	918	530	57.7	236	25.7	152	16.6
21.	344	262	76.2	66	19.2	16	4.6
22.	476	445	93.5	20	4.2	11	2.3
23.	914	666	72.9	159	17.4	89	9.7
24.	335	37	11.1	118	35.2	180	53.7
25.	529	18	3.4	104	19.7	407	76.9
26.	840	99	11.8	340	40.5	401	47.7
27.	1001	228	22.8	465	46.5	308	30.7
28.	564	277	49.1	182	32.3	105	18.6
29.	1153	197	17.1	446	38.7	510	44.2
30.	288	31	10.8	106	36.8	151	52.4
31.	807	29	3.6	186	23.0	592	73.4
32.	374	6	1.6	37	9.9	331	88.5
33.	720	21	2.9	54	7.5	645	89.6
Grand Total	20,541	5,240	25.5	5,540	27.0	9,761	47.5

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Table 2a. Population Sampling Study

Dead and Injured in Total Population

District Number	Estimated Population	Estimated Dead	Estimated Injured	Estimated Unhurt
1.	7,900	364	2,583	4,953
2.	9,000	279	2,268	6,453
3.	1,900	38	274	1,588
4.	6,200	161	397	5,642
5.	5,600	582	2,436	2,582
6.	10,400	2,153	3,910	4,337
7.	11,400	262	3,477	7,661
8.	4,100	41	328	3,731
9.	2,200	0	315	1,885
10.	4,800	53	1,171	3,576
11.	11,100	611	4,706	5,783
12.	12,100	254	1,755	10,091
13.	1,800	9	0	1,791
14.	7,200	1,843	2,542	2,815
15.	8,200	5,084	2,247	869
16.	12,500	5,763	4,750	1,987
17.	9,300	1,683	3,906	3,711
18.	5,100	4,182	500	418
19.	5,500	4,152	1,078	270
20.	9,300	5,366	2,390	1,544
21.	6,200	4,724	1,191	285
22.	6,500	6,077	273	150
23.	10,900	7,946	1,897	1,057
24.	6,900	766	2,429	3,705
25.	6,900	235	1,359	5,306
26.	11,000	1,298	4,455	5,247
27.	12,500	2,850	5,812	3,838
28.	7,500	3,682	2,423	1,395
29.	18,500	3,164	7,159	8,177
30.	4,000	432	1,472	2,096
31.	7,800	281	1,794	5,725
32.	3,800	61	376	3,363
33.	7,100	206	532	6,362
Grand Total	255,200	64,602	72,205	118,393

in the subsequent calculations.

C. Distribution of Population in Relation to Distance from the Center.

The Census Bureau of Hiroshima, under the direction of the Vice-Mayor, Mr. Morishita, was requested to make an estimate of the distribution of the population, according to the ring segments of the Joint Commission Map. This was made on the basis of the rice rationing figures as of April, 1945. The ratios were then applied to the final estimate as of August 6. The distribution of population thus obtained is shown in table 3. The inhabited area in each of these zones was determined by planimetry and from this the population densities were calculated. Variation in population densities by ring zones is given in table 3. Population densities for the total and inhabited areas are of the same order of magnitude as in London county.

2. ESTIMATE OF TOTAL CASUALTIES

The method selected was that of the analysis of questionnaires concerning the location and fate of the individual and of members of his family and friends of whom he had certain knowledge at the time of the bombing. A random sample was selected as follows:

A designation number 270, was chosen on the basis of selecting a total of approximately 5000 people from half of the districts. The populations of the individual precincts were then added one by one and the first precinct selected was the one in which the cumulated population fell closest to 270. Two hundred and seventy was then added to this new total and the populations of the precincts were further cumulated, the one chosen being that which fell closest to the new total, and so on. In all, 265 precincts of 523 available were chosen for distribution of the questionnaires. The persons for question-

TABLE 3

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Distribution of Population (Excluding the Military)

Zone	Total Area (sq. miles)	Inhabited Area	Population (In Round Numbers)	Population Density per acre (Inhabited Areas)
0-500	.31	0.17	6,230	57.2
501-1000	.90	0.67	24,950	58.2
1001-1500	1.52	1.26	45,270	56.1
1501-2000	2.12	1.92	67,900	53.1
2001-2500	2.73	1.94	30,600	24.6
2500-3000	3.34	1.81	30,600	26.4
3001-4000	8.49	2.43	29,400	18.9
4001-5000	10.91	1.00	20,310	31.7

SAMPLE QUESTIONNAIRE

(Translated)

Be sure to answer each question. (Answers to these questions are for the purpose of helping the American and Japanese governments to determine the effects of the Atomic bomb on Hiroshima.)

1. Questions about yourself.

a. What is your name? (Family name first)

b. How old are you? (In years)

c. Where are you living now? (Give address)

d. Were you in Hiroshima-Shi when the Atomic Bomb fell? (Yes or No)

e. If you were, give address in Hiroshima-Shi

f. If you were not, where were you?

g. Were you inside a building? (Yes or No) (Ken or Shi or Machi or Mura)

h. Were you injured?

2. Questions about your family.

Fill in the following information for each member of your family. Use one line for each person:

Give the name of each person in your family.	What is his relationship to you?	How old is he?	Where was he when the bomb fell? (Give address if possible.)	What happened to him? Was he killed, injured, or uninjured?

3. Questions about your other relatives and friends who were in Hiroshima Shi on 6 August at the time of the bomb, and who were killed or injured. (Same table, as Par. 2, with addition of another column: Were you told about what happened by someone else or did you see this person yourself?)

ing were selected on a sampling ratio of 1 to 20. Fortunately, the 10-year census of the Japanese Government had been made in November, 1945, and the census cards were available at City Hall. The cards of persons between the ages 13 and 60 from the designated precincts were arranged in a random order. The sampling ratio was applied without exception to these cards by girls of the 2nd Hiroshima Girls' High School. The names and addresses of the persons thus designated were then copied on the questionnaires (figure 2) and the forms were issued to the precinct leaders. The completed forms were collected by the students.

It was obvious that many people had been evacuated to adjacent villages, and some even to such distant places as Osaka and Tokyo. Such towns as showed significant changes in population between 1944 and 1945 were discussed with the census officials at the Prefectural Office in an effort to determine whether the changes were due to increments in the population following the bombing. Where this was the case, questionnaires were also issued by the random method, in a sampling ratio of 1 to 51. Only questionnaires returned by individuals who had been in the city or who had had relatives or friends there were subjected to analysis.

The names of individuals and members of their families were then arranged in a card index, duplications were excluded, and a tabulation was made according to the location of the persons reported (Appendix table 1 (10H)). This tabulation then summarized the fate of the indexed population in relation to their position at the time of the bombing. This information is condensed, according to wards rather than precincts in tables 2a, b, and c. In all 4706 questionnaires were issued and 3739 were returned, as recorded in table 2a. In these, information concerning 20,586 people was made available

The results upon analysis showed that 25.5% of the population had been killed, 27.0% had been injured and 47.5% had escaped apparently unscathed. These percentages may be applied to the population data contained in table 2c. The percentage of deaths calculated from table 2b on the basis of the total sampled population differs only slightly from that calculated in table 2c. This indicates that the sample is representative of the population as a whole. The number of dead, then, is estimated at 64,602, the injured at 72,205 and the uninjured at 118,393. This does not include the military population.

Sources of Error:

1. Inevitable inaccuracies resulted from lack of certainty concerning the exact position of some of the individuals indexed but these probably are not large.

2. In some instances, entire families may have been wiped out and no friends may have survived for questioning. That this is a small factor, however, is indicated by the high percentage of casualties in the central 500 meter ring, as found in the ultimate tabulation.

3. CONSTRUCTION OF THE DISTANCE-CASUALTY CURVE

The percentages of individuals killed or injured in each of the Rengo-Chonaikai districts are recorded in table 2b. A glance at the map (figure 1) will reveal that these districts which represent wards, in many instances overlap several rings. Individual precincts for which casualty data were available, however, (Appendix table 1 (10H)) were sometimes entirely contained within one or another ring. This allowed of a summation of casualty data for all such precincts according to distance. The only criterion in selecting the precincts was that they did not overlap the rings. This selection

TABLE 4

Hiroshima

Casualties, By Zones

ZONE	Percentages			Number of Individuals in Sample
	Killed	Injured	Uninjured	
0- 500	96.5	2.7	0.8	423
501-1000	83.0	11.3	5.7	1162
1001-1500	51.6	32.9	15.5	1872
1501-2000	21.9	41.2	36.9	1378
2001-2500	4.9	34.0	61.1	857
2501-3000	2.7	38.4	58.9	263
3001-4000	2.5	22.7	74.8	1601
4001-5000	1.1	8.2	90.7	1422

does not disturb the random sampling. The data for killed and injured, by distance, are recorded in table 4, where also is indicated the number of individuals in the sample, and are shown graphically in the curve, figure 3. This curve then represents the general mortality in the city, without regard to shielding.

The distance at which the chances of survival are 50% as determined from this curve is 1250 meters. The 50% point for death or injury of any sort is approximately 2100 meters. These figures apply, of course, only to Hiroshima, as they depend on factors of shielding that differ with the city.

4. STANDARDIZED KILLED AND CASUALTY RATES

By definition, the Standardized Killed or Standard Casualty Rate represents the number of individuals killed or total casualties respectively, assuming a population density of 1 per 1000 square feet. The values for the Standardized Killed Rate are obtained by calculating the "vulnerable area," which is the sum of the products of the fraction of killed by the areas of the respective ring zones. A similar procedure is employed in finding the Standardized Casualty Rate. The "vulnerable area" for the killed is 2.85 square miles and for all casualties 9.36 square miles. This gives a Standard Killed Rate of 79,452 and a Standard Casualty Rate of 260,938. These are minimal figures, as even in the ring zone farthest from center that was considered, the killed still were estimated at 1.1% and the casualties at 9.3%.

The Standard Casualty Rates for high explosive bombs for a population half in the open and half in British houses is (according to the report of the British Mission to Japan) between 35 and 40. Assuming for a moment that

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Data For Calculating Standardized Killed and Casualty Rates

1 Zone	2 Area (sq. miles)	3 Fraction Killed	4 Fraction Casualties (Killed and Injured)
0- 500	.31	.965	.992
501-1000	.90	.829	.942
1001-1500	1.52	.516	.845
1501-2000	2.12	.219	.631
2001-2500	2.73	.049	.388
2501-3000	3.34	.027	.410
3001-4000	8.49	.025	.252
4001-5000	10.91	.011	.093
Vulnerable Area* (square miles)		2.85	9.36
Standardized Rates		79,452 (SKR)	260,938 (SCR)

*"Vulnerable Area" = Sum of products of Columns 2 and 3 for the killed, and Columns 2 and 4 for the total casualties.

such a population is comparable to the Japanese in Hiroshima, the number of tons of high explosive necessary for the same effect in producing casualties would be approximately $\frac{260,900}{40} = 6525$.

5. COMPARISON OF CASUALTY RATES IN SPECIAL GROUPS WITH THE GENERAL MORTALITY CURVE

In this section the casualty rates of groups under known conditions of exposure are compared with points on the casualty curve of the population at large. This information is helpful in revealing the various factors that contributed to, or detracted from the general mortality.

A. The Otake District Workmen's Groups: These groups yield data concerning 1. The fate of individuals at 1000 meters shielded by wooden buildings. 2. The fate of individuals in the open and unshielded at 1000 meters. 3. The fate of individuals in the open and unshielded at 2400 meters.

The Otake District Workmen's Groups had been designated by the Prefectural Government to take part in the activities of destroying buildings in Hiroshima to provide firebreaks. Each group of work parties dispatched from Otake and surrounding villages was in charge of a foreman. The medical and civil authorities of the town had kept careful records of the fate of the citizens who had been sent some 25 km. into the city of Hiroshima. Arrangements were made with the mayor and with Dr. Nagaoka, a prominent physician of the city, to interview the surviving foremen and to examine the patients still in the town. The group was all assembled at the school on 8 November 1945. The foremen and patients were interviewed and examined by members of the Commission.

The events of August 6th are reconstructed as follows for various groups:

1. Individuals shielded by Japanese buildings at 1000 meters.

a. Mr. Nagato's group was arranged in 5 subgroups in the vicinity of the Temma Bridge, in the position shown in the accompanying map (figure 4). Each subgroup consisted of between 24 and 30 men, a total of 135. In the reconstruction sketch of the scene* (figure 5) all of the groups were standing in the shadow of the two-story buildings to the left of the large road. One group was at the far left where there was an alley-way and where the buildings were one-, rather than two-storied. Immediate burns appeared only in this group and 3 of the 10 men involved subsequently died of burns. Two others died immediately when a building collapsed, and one sustained severe contusions. All of the other men returned to Otake on foot. All subsequently showed evidence of radiation effect, manifested by loss of hair, and all but ten had petechiae. Seventy-two of one hundred thirty died of radiation effect, the first of these on 26 August and almost all by 13 September. None of these had more than trifling injuries. The incidence of radiation deaths in the various groups was as follows: Group I, 14 of 27; Group II, 15 of 27; Group III, 13 of 27; Group IV, 11 of 24; Group IX, 19 of 25.

b. Mr. Morimoto's group was situated a short distance down the street from the Nagato group. The group comprised 33 men. All were shielded by two-story buildings. None of them was burned but four men died at once when a building collapsed. Twenty-one subsequently died apparently of radiation effect, the first man on 25 August, and the others by the end of the first week in September. Four of the survivors also had epilation at

*Reconstruction by Maj. A. L. Ganung, A.C. Photographic Branch of Air Information Division, AC/AS-2.

the time they were examined by the Commission. The foreman of this group had been killed and the information was obtained from Mr. Nagato. In this group twenty-one of twenty-nine died of radiation effect.

c. Summary: Thus at 1000 meters, under conditions of shielding by buildings of Japanese type, the fatalities from radiation effect were 93 deaths in a total of 159 men (58.5%). The incidence in the various subgroups was remarkably constant, varying from approximately 46 to 76%.

2. The results of exposure without shielding, at 1000 meters.

a. A group of 106 individuals from Kuba village who were engaged in loading stone on the east bank of the Temma River near the Temma Bridge in the situation pictured in figure 6 all sustained severe burns. Forty-eight died on the spot or within 2 days, apparently as the result of burns. Most of forty-eight others died by 10 August, also apparently on account of burns but some lived until the 20th of August and 2 or 3 had evidence of radiation effect in addition to burns. Of the 10 who survived and in whom the burns healed, all had evidence of radiation effect and at the time of writing (20 November 1945) were still too weak to work. It may be assumed that those who died earlier also had radiation effects but these did not become manifest as sufficient time had not elapsed.

b. Groups from Ogata District: All of these individuals were in the open, unprotected by houses and were somewhat east of the Kuba group that has just been described. There were 27 men from Mitsubishi village, all of whom died on the spot.

Of 60 men from Tachido village, close to those just mentioned, 53 died on the spot; 7 lived for some time. Of these, 3 died as the result of

burns within 3 days. Four others had relatively slight burns but all died about two weeks after the bombing, with evidence of radiation.

c. In these similar, exposed groups there were only 10 survivors out of a total of 193 men.

3. The results of exposure, without shielding, at 2400 meters.

The group, of which Mr. Hino was foreman, was on Koi Bridge, the location of which is shown in the accompanying map (figure 4) and a photograph of which is available (figure 7). These 580 individuals were on the march to Hiroshima. Only 1 of 10 subgroups was still on the bridge; the others were on the Hiroshima side. The buildings at this point on the shore were scattered and small. Two men were killed at once, the result of severe injury caused by a falling building. All of the other people sustained severe burns except three who happened to be beneath the eaves of a building. Seven women died within a week as the result of burns. All of the others survived and most of them were examined by the Joint Commission. There was no evidence of radiation effect in any of these people.

SUMMARY

The general conclusion that can be drawn is that at 1000 meters, approximately 58.5% of persons shielded merely by Japanese buildings, but not by concrete, will die of radiation effect. In contrast with this, as will be brought out in the later sections, is that deaths from radiation effect in concrete buildings at that distance are rare. Comparison with the general mortality curve figure 3 (10H) shows that at 1000 meters the general mortality is 70%. Thus, ignoring the few who were in concrete shelters or buildings, only 11.5% more people died of other causes at this

distance who would not have died of radiation effect.

At 1000 meters, in the open, the mortality from instantaneous burns is approximately 95%. The two points, shielded and unshielded, are plotted against the general mortality curve in figure 3.

At 2400 meters, even in totally unshielded individuals the death rate from burns falls to very low levels and there is no clinical evidence of gamma radiation effect.

B. Casualties Among School Children at Hiroshima: An analysis of the casualty data of the school children yields a comparison of largely "shielded" with largely "exposed" groups at various distances.

It was thought by the Commission, before the sampling method previously described had been considered, that an analysis of the effects on sizable groups distributed in known circumstances throughout the city would yield an approach to casualty-distance curve. These data within their limitations are presented for comparison with those in the preceding section, and to bring out certain information concerning primary casualties that are not otherwise available.

The schools seemed most useful for this type of analysis since it was expected that records were probably kept of the fate of the children. Accordingly, the principals or surviving headmasters of schools were contacted through the agency of the most trustworthy Japanese physicians. Among them were the following: Drs. Misono, Motohashi, Miyazaki, and Nakatomi. They obtained the report of casualty figures as of approximately 28 October 1945. It was found not only that good records had been kept but that the headmasters in many instances had made earnest efforts to trace families by letter, messenger or personal contact. Furthermore, it was discovered that the children were not only in schools but also in patriotic work parties (Gakuto Giyutai) throughout the city, either in factories or engaged in the clearing of firebreaks. The distribution of members of one private school, whose casualties are not included in the general tabulation, are summarized in the case of the Yasuda Private School by the principal, Rio Yasuda (Appendix 2 (10H)).

HIROSHIMA

Table 6

CASUALTIES AMONG SCHOOL CHILDREN

(As of 28 October 1945)

FIRST GROUP (WITHIN APPROXIMATELY 1 KILOMETER)

Key No.	District	Distance	Situation	Total Number	Known Dead	Missing	Untraced	Injured	Well
1	Motokawa Primary School	0.5	Pupils inside or outside of the school or at home	192	192				
2	Otemachi Primary School	1.0	"	430	35	16		166	213
3	Dobashi	0.9	Motokawa Higher Primary School Pupils: Clearing firebreaks	80	80				
		0.9	3rd Year Class of First Prefectural Middle School: Clearing firebreaks	54	54				
	Kcamicho	0.8-1.1	3rd Year Class of Sutoku Middle School: Clearing firebreaks	150	50	100			

RESTRICTED

FIRST GROUP (WITHIN APPROXIMATELY 1 KILOMETER)

Key No.	District	Distance	Situation	Total Number	Known Dead	Missing	Untraced	Injured	Well
		0.8-1.1	1st Year Class of First Prefectural Girls' School: Clearing firebreaks	230	230				
			1st and 2nd Year Classes of Municipal Girls' School: Clearing firebreaks	600	580				20
5	Eastern approach of the Sinohashi	0.8	1st Year Class of Second Prefectural Middle School: Clearing firebreaks	360	360				
6	Northern Section of Hattiobori	0.7-1.0	1st and 2nd Year Classes of Sutoku Middle School: Clearing firebreaks	500	500				
7	First Prefectural Middle School	1.0	Inside the wooden School building or on the campus	165	161				

FIRST GROUP (WITHIN APPROXIMATELY 1 KILOMETER)

Key No.	District	Distance	Situation	Total Number	Known Dead	Missing	Untraced	Injured	Well
8	First Prefectural Girls' School	0.6	Inside or outside the wooden school building	174	174				
9	Power Distribution Office	0.4	Males of 2nd Year Classes of Third Primary School: Operating Plant	8	5	3			
10	Koamicho	0.6-1.1	1st and 2nd Year Classes of Municipal Middle School: Clearing firebreaks	497	158	170	35		134
Total				3440	2579	289	35	166	371

RESTRICTED

HIROSHIMA

Table 6

CASUALTIES AMONG SCHOOL CHILDREN

(As of 28 October 1945)

SECOND GROUP (WITHIN APPROXIMATELY 1.1-1.5 KILOMETER)

Key No.	District	Distance	Situation	Total Number	Known Dead	Missing	Untraced	Injured	Well
11	Nakajima Primary School	1.3	Inside or outside of the school building or at home	608	1	230		305	72
12	Terimacho Primary School	1.3	"	764	232	10		305	217
13	Hakujima Primary School	1.3	"	603	43			469	71
14	Hirose Primary School	1.2	"	318	32	39	79		168
15	Takeya Primary School	1.3	"	308	76	48	80		104

RESTRICTED

SECOND GROUP (WITHIN APPROXIMATELY 1.1-1.5 KILOMETER)

Key No.	District	Distance	Situation	Total Number	Known Dead	Missing	Untraced	Injured	Well
16	Zakobamachi	1.0-1.5	Second Prefectural Girls' School Clearing firebreak	43	36	2	4		1
		1.0-1.5	1st and 2nd Year Girls of Third Higher Primary School: Clearing firebreaks	155	36	27	53		39
17	Fujimibashi	1.3	Boys of Third Higher Primary School: Clearing firebreaks	132	50	32	19		31
18	Kakomachi	1.3	Second Municipal Girls' School Inside Sumori Factory	50	13	2	5		30
19	Kokutaijimachi	1.1	1st Year Class of First Prefectural Middle School: Clearing firebreaks	150	150				

RESTRICTED

SECOND GROUP (WITHIN APPROXIMATELY 1.1-1.5 KILOMETER)

Key No.	District	Distance	Situation	Total Number	Known Dead	Missing	Untraced	Injured	Well
20	Sentei	1.1-1.3	Prefectural Girls' School: Clearing firebreaks	80		80			
21	Attached Middle School of the Higher Normal School	1.5	Inside or outside of the ferro-concrete building	40	7				33
22	Prefectural Printing Office	1.1	Second Higher Primary School Operating Plant	11	9	2			
23	"	1.3	Inside or outside of the School building or at home	1421	8	9		544	860
Total				4683	693	481	240	1643	1626

HIROSHIMA

Table 6

CASUALTIES AMONG SCHOOL CHILDREN

(As of 28 October 1945)

THIRD GROUP (WITHIN APPROXIMATELY 1.6-1.9 KILOMETER)

Key No.	District	Distance	Situation	Total Number	Known Dead	Missing	Untraced	Injured	Well
24	Kansaki	1.6	Inside or outside of the school building or at home	211	63			77	71
25	Sendamachi Primary School	1.9	"	247	31	22		75	119
26	Danbara	1.9	"	441	20			191	230
27	Western approach of Hijiyama-Bashi	1.7	3rd Year Class of First Prefectural Middle School: Clearing firebreak	70			70		
28	Hijiyama-Bashi	1.7	1st Year Class of First Primary School: Clearing firebreaks	27	5				22

THIRD GROUP (WITHIN APPROXIMATELY 1.6-1.9 KILOMETER)

Key No.	District	Distance	Situation	Total Number	Known Dead	Missing	Untraced	Injured	Well
29	Tsurumi-Bashi near Senda Primary School	1.7	Attached Middle School of the Higher Normal School: Walking on the road	175	108		67		
30	Yokogawa	1.5	Municipal Girls' School: Inside of Sumino Factory	50			6		44
31	In front of the Hiroshima R. R. Station	1.8	1st Higher Primary School: Working inside Post Office	39			25		14
Total				1260	227	22	168	343	500

RESTRICTED

HIROSHIMA

Table 6

CASUALTIES AMONG SCHOOL CHILDREN

FOURTH GROUP (WITHIN APPROXIMATELY 2.0-2.9 KILOMETER)

Key No.	District	Distance	Situation	Total Number	Known Dead	Missing	Untraced	Injured	Well
32	Misasa Primary School	2.1	Inside or outside of school building or at home	817	15	5	448	349	
33	Funairi Primary School	2.2	"	184	3		35		146
34	Kojin Primary School	2.2	"	148	7	5	73		63
35	Ushida Primary School	2.3	"	393	21				372
36	Ushiba Primary School	2.5	"	703	13	2		355	333
37	Minamicho Primary School	2.8	"	339	14	1	98		226
38	Hijiyama Primary School	2.9	"	1142	3	1		128	1010

FOURTH GROUP (WITHIN APPROXIMATELY 2.0-2.9 KILOMETER)

Key No.	District	Distance	Situation	Total Number	Known Dead	Missing	Untraced	Injured	Well
39	Second Prefectural Middle School	2.1	Inside or outside of the school building	10	2				8
40	East Drill Field	2.0-2.5	2nd Year Class of Second Prefectural Middle School Clearing firebreak	360	10		350		
			1st Year Class of Second Prefectural Girls' School Clearing firebreak	130	1		64		65
41	Monopoly Bureau	2.6	1st Year Class of Second Prefectural Girls' School Operating Plant	103	1		5		97
42	Hiroshima Printing Co. Ltd. (Kannoncho)	2.1	2nd and 3rd Year Classes of First Prefectural Girls' School: Operating Plant	230					230
43	Asahi Weapons Factory (Ninami Kannon)	2.5	4th Year Class of First Prefectural Middle School: Operating Plant	200					200

RESTRICTED

FOURTH GROUP (WITHIN APPROXIMATELY 2.0-2.9 KILOMETER)

Key No.	District	Distance	Situation	Total Number	Known Dead	Missing	Untraced	Injured	Well
44	Daiwa Heavy Industrial Co. (Kannon	2.5	Pupils of Second Primary School: Operating Plant	85	3				82
45	Printing Department of R.R. Office (Osuguchi)	2.6	Pupils of First Primary School Operating Plant	41			15		26
46	Storage Dept. of R.R. Office (Osuguchi)	2.6	"	44			5		39
47	Sansei Pharmaceutical (Nishikamiyacho)	2.6	"	65					65
48	Gas Plant	2.2	Third Primary School: Operating Plant	15			5		10
49	Hirose Factory (Dashio-machi)	2.8	First Primary School: Operating Plant	42	3		15		24
50	Hiroshima Higher School	2.8	Inside or outside of the school building	70			10		60
Total				5121	96	14	1123	832	3056

RESTRICTED

HIROSHIMA

Table 6

CASUALTIES AMONG SCHOOL CHILDREN

(As of 28 October 1945)

FIFTH GROUP (WITHIN APPROXIMATELY 3.0-4.0 KILOMETER)

Key No.	District	Distance	Situation	Total Number	Known Dead	Missing	Untraced	Injured	Well
51	Ujina Primary School	3.1	Inside or outside of the school building or at home	468					468
52	Koi Primary School	3.1	"	696	9				687
53	Yaga Primary School	3.9	"	200					200
54	First Higher Primary School	3.0	"	2	1				1
55	Second Municipal Girls' School	3.3	"	130				23	107
56	Third Higher Primary School	3.3	"	14				1	13

RESTRICTED

FIFTH GROUP (WITHIN APPROXIMATELY 3.0-4.0 KILOMETER)

Key No.	District	Distance	Situation	Total Number	Known Dead	Missing	Untraced	Injured	Well
57	Shinko Metal Co. (Osumachi	3.0-4.0	Third Higher Primary School Operating Plant	15					15
58	Showa Engineering Co.	3.0-4.0	First Higher Primary School: Operating Plant	43				2	41
59	Kodama Iron works		"	42					42
60	Kumachira Factory (Ujina)		Third Higher Primary School: Operating Plant	16				1	15
61	Hiroshima Flying Machine Co. (Koi)	3.1	2nd Year Class of First Prefectural Middle School: Operating Plant	150					150
			2nd and 3rd Year Classes of First Prefectural Girls' School: Operating Plant	188					188

RESTRICTED

FIFTH GROUP (WITHIN APPROXIMATELY 3.0-4.0 KILOMETER)

Key No.	District	Distance	Situation	Total Number	Known Dead	Missing	Untraced	Injured	Well
62	Kansai Engineering Works (Ena)	3.2	3rd Year Class of First Hiroshima Middle School: Operating Plant	50	1				49
63	Mitsubishi Engineering Co. (Kamon	3.0-3.5	2nd Year Class of Sotoku Middle School: Operating Plant	200					200
64	Hiroshima Branch of the Army Clothing Depot	3.0	Attached Middle School of the Hiroshima Normal School: Operating Plant	80				10	70
Total				2314	11			37	2266

RESTRICTED

The position relative to the center of the explosion and the activities in which the students were engaged are recorded in table 6 and in the accompanying map (figure 8) where the numbers refer to the marginal numbers in the table which identify the groups. In this tabulation "missing" refers to those who could not be accounted for after the explosion and for whom a definite search had been made by families or friends. These must then be presumed to be dead. "Untraced" refers to those concerning whom no information was received after letters had been sent or other attempts had been made to trace the family. It is considered fair to exclude them from the calculations on the basis that they fared the same as the rest of the group.

The data are imperfect in the following respects:

1. The exact number present at any one place is not known. The figures given under "total" in the chart represent the number assigned and not the number actually present. In some instances the rolls had not as yet been called. "Total number", therefore, is over-estimated by between 10-20%. This percentage is based on comparison of the "assigned" and "estimated present" of the Yasuda School Group, Appendix 2, table 1.

2. The school population is not representative of the population as a whole, not only on account of the age group that is concerned, but on account of the distribution of the indoor and outdoor groups. It will be seen from table 6 that the activities of the children can be rather sharply defined as "outdoor" and "indoor" duties. The outdoor group comprises those engaged in clearing fire-

breaks; these may be assumed to be completely unshielded. The indoor group comprises those largely in school or in the factories; most of these were doubtless indoors and the group in general can be regarded as protected.

The percentages of "unshielded" and of "shielded" individuals in the various zones is indicated in table 7. It is obvious that there is a striking disproportion in the first ring zone as compared with the others. This is merely an accidental result of the particular assignment of the students and bears no relation to the population of the city as a whole.

Valuable information, however, is obtained by plotting in the form of histograms, the casualties in the two groups under the assumptions concerning the "missing" and "untraced" that have been previously outlined (figures 9 and 10). The data are also recorded in tables 8, 9, and 10.

"Unshielded Group." In the unshielded group, the high mortality of those in the 1st zone is again apparent and is compatible with the figure obtained from the Otake group. It must be remembered, however, that since the "totals" presumed present were probably underestimated, the percentages of casualties were probably higher than are recorded. Another remarkable finding is the sudden fall in mortality in the 2.0 - 3.0 km. zone as compared with those closer to the center. This may well be associated with the rapid falling off of the intensity of gamma rays, as well as of the forms of radiation responsible for the burns of the skin. The presumption is that the incidence of leukopenia in the group beyond 2.0 km. would be

TABLE 7

HIROSHIMA

PERCENTAGE OF "UNSHIELDED" AND "SHIELDED" SCHOOL CHILDREN IN EACH ZONE

Distance	Unshielded		Shielded	
	Number Traced	Percent	Number Traced	Percent
0-1000	2436	70.9	969	29.1
1001-1500	484	20.9	3959	89.1
1501-2000	135	22.4	957	87.6
2001-3000	76	1.9	3922	98.1
3001-4000	0	0.0	2077	100.

TABLE 8

HIROSHIMA

CASUALTIES OF "UNSHIELDED" SCHOOL CHILDREN

Distance	Total Number	Known Dead	Missing	Untraced	Injured	Well
0-1000	2471	2012	270	35	----	154
1001-1500	560	272	141	76	----	71
1501-2000	272	113	- -	137	----	22
2001-3000	490	11	- -	414	----	65
3001-4000	- -	-	- -	- -	----	-

TABLE 9

HIROSHIMA

CASUALTIES OF "SHIELDED" SCHOOL CHILDREN

Distance	Total Number	Known Dead	Missing	Untraced	Injured	Well
0-1000	969	567	19	--	166	217
1001-1500	4123	421	340	164	1643	1555
1501-2000	988	114	22	31	343	478
2001-3000	4631	85	14	709	832	2991
3001-4000	2314	11	-	37	--	2266

TABLE 10

HIROSHIMA SCHOOL CHILDREN

FATALITIES AND TOTAL CASUALTIES IN "UNSHIELDED" AND "SHIELDED" GROUPS

Distance	Total Number	Number Traced	Percent Dead	Percent Total * Casualties	Total Number	Number Traced	Percent Dead	Percent Tot. Casualties
0-1000	2471	2436	93.7	93.7	969	969	60.5	77.6
1001-1500	560	484	85.3	85.3	4123	3959	19.2	60.7
1501-2000	272	135	83.7	83.7	988	957	14.2	50.1
2001-3000	490	76	14.5	14.5	4631	3922	2.5	23.7
3001-4000	-	-	-	-	2314	2077	0.5	0.5

*Assumes missing persons are dead and omits untraced persons from total number in computing percentages.

less, and the prognosis in the face of the inevitable infections less.

C. Total Casualties in Buildings: In this section are collected comparative casualty data of persons in concrete and in wooden buildings. Comparisons with the general mortality curve may also be made, in the case of the concrete structures beyond 1000 meters and of the wooden buildings beyond 1400 meters.

The data concerning the total casualties in buildings were collected from various sources for comparison with the general mortality curve. No pertinent data, whether or not it is compatible with the general trend, is omitted. Only concrete buildings which more or less retained their external integrity are under consideration. For comparison the casualties in buildings of Japanese type are plotted to the same scale; all of these structures, however, collapsed shortly after the blast. Buildings in which the fate of considerable numbers of individuals is known were chosen.

The sources of data were as follows:

1. The Communications Bureau report by Dr. Hachiya, Director of the Communications Bureau or Post-Office Hospital (Teishin Byoin), Hiroshima, (as of late August 1945). Buildings I, 2, 3, 5, 6, 7, I, and IV.

2. Survey by the Joint Commission of all surviving employees of the City Hall, Building 4, as of November, 1945. Approximately 35% of the people in the building at the time of the explosion were still employed there.

3. Buildings II, III, and V from the Yasuda School report (see

Appendix 2 (10H)). In each of these reports the injuries of the visitors were ignored and the fate only of personnel actually employed in the building is considered.

The buildings are represented by columns in the chart (figure 11, and tables 11, and 12. Their distance from zero is proportional to the actual distance from the point above which the bomb exploded. The mortality in each is indicated by the black section in the column. Where the injury rates are known, they are also indicated. The mortality figures have greater comparative value since the definition of "injury" is vague. Using the same ordinates and abscissa, the general mortality curve as obtained in Section 10H is also plotted. This shows at a glance that, despite the diversity of sources, a remarkable curve is obtained for the mortality rate in the concrete buildings which is at a much lower level than the general curve. The immediate death rate of individuals in buildings of Japanese type is much higher than of those in concrete buildings but it must be remembered that the former collapsed.

In preparing the casualty tables the date upon which the inventory of the casualties was made must be considered. In the concrete buildings beyond 1000 meters and in the wooden buildings beyond the 1400 meter ring, the immediate casualties represent practically all of the ultimate casualties. Deaths from radiation become increasingly significant as the center is approached from these limits. The information in the case of wooden buildings I and V comes from the Communications Bureau report, as does that for most of the concrete buildings. Therefore, this is an entirely comparable series. In the case of wooden building I, the

mortality figures are incomplete since many of the radiation deaths doubtless occurred later than 1 September 1945. Comparing the mortality in Building I, with the 1000 meter shielded group in the Otake study, perhaps 20% more deaths are to be expected in this building than are indicated. In the concrete buildings, 1, 2, and 3, the mortality figures must also be regarded as incomplete.

SUMMARY

Up to approximately 2000 meters, the immediate mortality in concrete buildings is at a much lower level than the general mortality and decreases with distance. In collapsing wooden buildings, the mortality rate is more variable but lies intermediate between the general rate and the rate among those protected by concrete. In both groups of buildings, the total casualty rate is much more variable than the mortality rate, as is to be expected.

TABLE 11

HIROSHIMA

MORTALITY AND CASUALTY RATES IN CERTAIN WOODEN BUILDINGS

Building	Distance (meters)	Total No.	Dead	Injured		Total Casualties	Uninjured
				Severe	Slight		
I Public Eng. Office	1100	180	61 (33.9%)	34 (18.9%)	70 (38.9%)	165 (91.7%)	15 (8.3%)
II Koa Sewing Machine	1400	55	9 (16.4%)	-	-	9 +	37 -
III Homare Aviation Factory	1600	210	15 (7.1%)	11 (5.2%)	-	26 +	184 -
IV Railroad Post Office	1800	221	8 (3.6%)	23 (10%)	19 (09%)	50 (23%)	171 (77%)
V Ohashi Shoe Factory	1900-2000	184	14 (7.6%)	19 (10.3%)	-	33 +	151 -

RESTRICTED

RESTRICTED

TABLE 12

HIROSHIMA

MORTALITY AND CASUALTY RATES IN GERMAN CONCRETE BUILDINGS

Building	Distance (meters)	Total No.	Dead	Injured Severe	Injured Slight	Total Casualties	Uninjured
1. Hiroshima Post Office	200	400	193 (48%)	52 (13%)	78 (20%)	323 (81%)	77 (19%)
2. Hiroshima Telegraph Office	500	301	45 (15%)	23 (08%)	36 (12%)	104 (35%)	197 (65%)
3. Central Telephone Office	600	474	61 (13%)	118 (25%)	123 (26%)	305 (64%)	169 (36%)
4. City Hall	1100	216	19 (8.3%)	?	?	?	?
5. Communications Office	1200	692	56 (08%)	91 (13%)	186 (27%)	333 (48%)	349 (52%)
6. Post Office Branch	1600	346	16 (05%)	25 (07%)	59 (17%)	102 (29%)	244 (71%)
7. Postal Savings Office	1600	750	31 (04%)	175 (23%)	185 (25%)	391 (52%)	359 (48%)

Casualties within month of bombing.
Except #4, City Hall - as of 10 November 1945.

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6. CASUALTIES CLASSIFIED BY CAUSE:

A partition of injuries and fatalities by cause is possible to a limited extent, and only for the group in the Joint Commission records. In that group, which represents 6663 survivors of at least 20 days, the distribution of the various diagnoses is as follows:

Burns	34.8%	(2315)
Mechanical Injuries	45.3%	(3016)
Radiation Effect*	20.5%	(1363)

Of the 6663 persons in the group 1487 (22.3%) were uninjured. If then only the injured are considered the diagnoses are distributed as follows:

Burns	44.2%
Mechanical Injuries	57.6%
Radiation Effect	26.0%

Multiple injuries were common.

Obviously this partition does not apply to the cause of death.

Probably close to two-thirds of the deaths occurred on the first day, chiefly on account of burns. Those who were severely injured and could not move under their own power, either on account of flash burns or trauma, were consumed in the flames that razed the inner parts of the city outlined by a circle with a radius of 2.4 kilometers. Review of hospital statistics is not reliable since the casualty rate depends upon the districts from

*As manifested in epilation or purpura or both.

which the hospital population was drawn and this varied widely. Between 70 and 90 per cent of the patients hospitalized within the first two weeks had burns (Section 3H, page 15). These figures, and the descriptions of eyewitnesses indicated that most of the deaths within the first week were associated with flash burns.

There is not doubt that radiation effect contributed considerably to the mortality from burns and infected traumatic lesions, but no quantitative estimate can be made. The expected mortality under specified conditions at certain distances, however, is available from data presented in pp. 15-18 of this section.

Had there been no other injury and assuming all persons to have been indoors in Japanese buildings, the deaths that would have occurred from radiation may be estimated. Thus, in the first ring zone (0 to 1000 meters) the population is approximately 32,000 (table 3) and the expected mortality from radiation alone is 58.5% (Section 10H, page 17). In the second ring zone (1.1 to 1.5 kilometers) the population is approximately 45,000. No accurate percentage for the expected mortality from radiation is available for that set of conditions but a conservative estimate would be 10%. Thus, 4500 persons would have died in that zone under the assumptions made. A total of at least 23,500 deaths would then have resulted from radiation alone (ignoring those in which minor injuries or burns were fatally complicated by the effects of the radiation). Thus, 35% of the total number of 64,500 deaths that were actually estimated to have

occurred in the city, could be ascribed to radiation effects, if, within the inner 1.5 kilometers, there had been no other causes of death.

7. GENERAL SUMMARY OF SECTION 10H

1. The best estimate of the civilian population of Hiroshima at the time of the bombing on 6 August 1945 is 255,200. Of these approximately 64,500 (25.5%) had died by the middle of November, 1945, and there were in addition approximately 72,000 (27%) injured.

2. The standardized killed rate (that representing the number that would have died had the population density been 1 per 1000 square feet) is in the neighborhood of 79,500; the standard casualty rate is 261,000. This indicates an unprecedented casualty producing effect.

3. Inspection of the casualty-distance curve reveals that the point at which the chances of death were 50 per cent lies at 1250 meters. The 50 per cent point for injury or death is at 2100 meters.

4. The mortality rate of individuals in concrete buildings is much lower than that of individuals in wooden buildings, and in both it is less than that of the general population at comparable distances.

5. The mortality in a completely unshielded group at 1000 meters is in the neighborhood of 95 per cent; in a similar group at 2400 meters, the mortality is less than 10 per cent.

6. In completely exposed groups, as determined from the study of school children engaged in repairing firebreaks, the mortality falls precipitously beyond 2000 meters.

7. The mortality from radiation effect in a group at 1000 meters

shielded by wooden buildings and suffering no other injuries is 58.5%. When this point is related to the general mortality curve it is evident that only 11.5% more individuals at this distance died of other factors who would not have died of radiation alone.

7. Applying data in the preceding paragraph to the city as a whole, at least 35% of the deaths would have been caused by radiation effects, had there been no other injuries within the innermost 1.5 kilometers.

8. The causes of injury among the 5236 injured of the group of 6663 20-day survivors studied at Hiroshima by the Joint Commission are classified as follows:

Burns	44.2%
Mechanical Injuries	57.60%
Radiation Effects	26.0%

These data do not apply to causes of death.

Appendix 1 (10H) Hiroshima Population Sampling Study (Primary Data)

HIROSHIMA

Table 1 . Population Sampling Study

Casualties by Ward Districts and Precincts

Ward and Precinct	Dead	Injured	Uninjured	Total For District
1. USIDA	21	148	283	452
a. Shinmachi	0	1	18	
b. Kanda	0	0	7	
c. Honmachi	0	9	26	
d. Asahamachi	0	7	3	
e. Minamimachi	1	15	37	
f. Uncertain	20	116	192	
2. ONAGA	18	147	419	584
a. Katako	0	1	1	
b. Akebonocho	2	2	23	
c. Higashikaniyamachi	2	20	25	
d. Atagomachi	5	35	44	
e. Wakakusa	0	1	3	
f. Uncertain	9	88	323	
3. YAGA	4	29	169	202
4. AOSAKI	11	27	383	421
a. Higashiaosaki	0	2	35	
b. Horikoshi	4	3	18	
c. Aosaki	3	10	68	
d. Mukainadahonmachi	0	0	24	
e. Koiso	0	0	3	
f. Uncertain	4	12	235	
5. KOZIN	81	336	356	773
a. Osugamachi	14	50	44	
b. Matsubaramachi	38	179	120	
c. Enkobashimachi	9	7	7	
d. Kozinmachi	6	33	57	
e. Nishikaniyamachi	9	60	110	
f. Futabanosacho	5	7	18	

Appendix 1 (10H)

HIROSHIMA

Table 1. Population Sampling Study

Casualties by Ward Districts and Precincts

Ward and Precinct	Dead	Injured	Uninjured	Total for District
6. DANBARA	190	344	382	916
a. Daiyamachi	6	13	6	
b. Kyobashimachi	20	18	22	
c. Matobamachi	24	53	33	
d. Danbaraohatamachi	10	21	62	
e. Danbarasuehiromachi	3	14	47	
f. Danbarashinmachi, Kami	4	15	39	
g. Danbarahigashiuramachi	2	5	20	
h. Kanayamachi	14	11	25	
i. Kirinokimachi	6	5	7	
j. Hijiyamachi	64	137	53	
k. Matsukawamachi	4	15	9	
l. Danbaramachi	12	19	44	
m. Inarimachi	4	4	7	
n. Dotemachi	17	13	7	
o. Danbarahigashi	0	1	1	
7. HIJIYAMA	18	238	525	781
a. Osumachi	2	46	174	
b. Minamikaniyamachi	2	26	58	
c. Dambarahigashiuramachi	0	4	9	
d. Dambarashinmachi, Shimo	3	12	29	
e. Danbarayamazakimachi	2	23	18	
f. Danbarahinodemachi	5	52	83	
g. Minamidanbara	1	32	51	
h. Shinonomemachi	3	43	102	
i. Danbaraminamimachi	0	0	1	

Appendix 1 (10H)

HIROSHIMA

Table 1. Population Sampling Study

Casualties by Ward Districts and Precincts

Ward and Precinct	Dead	Injured	Uninjured	Total for District
8. NIHO	10	85	968	1063
9. KUSUNA	0	1	6	7
a. Nihomachi				
b. Tanna	0	1	5	
c. Uncertain	0	0	1	
10. OKO	3	68	208	279
a. Kasumimachi	1	13	26	
b. Deshiomachi	0	26	54	
c. Okomachi	0	0	17	
d. Asahimachi	2	29	111	
11. MINAMI	41	317	389	747
a. Hijiyamahonmachi	6	30	8	
b. Minamimachi	33	246	287	
c. Midorimachi	2	41	94	
12. UJINA	21	148	849	1018
13. NINOSHIMA	1	0	187	188
14. HAKUSHIMA	108	149	165	422
a. Higashihakushimamachi	13	14	19	
b. Hakushimakyukencho	8	24	39	
c. Hakushimahigashinakamachi	2	5	2	
d. Hakushimanakamachi	5	24	35	
e. Hakushimanishinakamachi	7	7	16	
f. Hakushimakitadori	2	4	3	
g. Nishihakushimamachi	26	17	31	
h. Uncertain	45	44	20	

Appendix 1 (10H)

HIROSHIMA

Table 1. Population Sampling Study

Casualties by Ward Districts and Precincts

Ward and Precinct	Dead	Injured	Uninjured	Total for District
15. NOBORICHO	445	197	76	718
a. Kamiyanagicho	10	19	17	
b. Shimoyanagicho	28	15	7	
c. Hashimotocho	1	1	1	
d. Ishimiyacho	2	2	3	
e. Yamaguchimachi	7	9	0	
f. Yayoimafhi	1	4	1	
g. Noboricho	72	50	13	
h. Hariyacho	6	2	1	
i. Teppocho	70	16	3	
j. Hachobori	126	26	9	
k. Komachi	22	12	1	
l. Horikawamachi	22	4	0	
m. Kaminagarekawamachi	77	33	18	
n. Ginzanmachi	1	4	2	
16. TAKEYA	345	284	119	748
a. Kitahiratsukamachi	3	4	10	
b. Hiratsukamotomachi	2	3	1	
c. Higashihiratsukamachi	10	8	12	
d. Nishihiratsukamachi	5	5	1	
e. Tsurumimachi	76	103	19	
f. Takaramachi	20	31	15	
g. Showamachi	11	32	18	
h. Yakenbori	19	10	0	
i. Shimonagarekawamachi	24	8	3	
j. Tanakamachi	13	8	1	
k. Mikawamachi	26	1	1	
l. Takeyamachi	40	19	7	
m. Fugimimachi	58	26	14	
n. Hiratsukamachi	37	26	17	
o. Yokomachi	1	0	0	

Appendix 1 (10H)

HIROSHIMA

Table 1. Population Sampling Study

Casualties by Ward Districts and Precincts

Ward and Precinct	Dead	Injured	Uninjured	Total for District
17. SENDA	137	319	303	759
a. Hiranomachi	12	21	46	
b. Minamitakeyamachi	21	22	10	
c. Sendamachi	104	276	247	
18. FUKUROMATI	429	51	43	523
a. Shinkawabamachi	32	2	3	
b. Nakamachi	33	9	11	
c. Tatemachi	24	0	0	
d. Harimayamachi	21	0	1	
e. Togiyamachi	26	0	0	
f. Kamiyamachi	74	6	3	
g. Nishisakanayamachi	11	0	1	
h. Fukuromachi	28	12	0	
i. Komachi	49	17	21	
j. Shionoyacho	28	0	1	
k. Onomichimachi	11	0	0	
l. Sarugakucho	40	3	0	
m. Saikumachi	52	2	2	
19. OTE	511	133	33	677
a. Zakobamachi	171	31	8	
b. Kokutaijimachi	139	54	12	
c. Otemachi	201	48	13	
20. NAKASHIMA	530	236	152	918
a. Nasashimahonmachi	93	4	0	
b. Zaimokucho	55	1	0	
c. Tenjinmachi	100	3	1	
d. Kobikigumi	3	0	0	
e. Motoyanagigumi	10	0	1	
f. Nakashimashinmachi	29	0	0	
g. Nakakakomachi	3	0	0	
h. Shimokakomachi	0	2	0	
i. Kakomachi	202	70	10	
j. Yoshizimahagoromomachi	4	36	28	
k. Yoshizimamachi	7	34	13	
l. Yoshizimahonmachi	24	86	99	

Appendix 1 (10H)

HIROSHIMA

Table 1. Population Sampling Study

Casualties by Ward Districts and Precincts

Ward and Precinct	Dead	Injured	Uninjured	Total for District
21. HIROSE	262	66	16	344
a. Teramachi	48	11	5	
b. Nishibikimido	48	1	0	
c. Nishikyukencho	13	0	0	
d. Nishikimachi	12	6	0	
e. Hirosekitamachi	45	13	5	
f. Hirosemotomachi	19	8	0	
g. Hirosemachi	77	27	6	
22. HONKAWA	445	20	11	476
a. Takashomachi	99	1	1	
b. Kajiyamachi	19	0	0	
c. Tsukamotomachi	18	0	0	
d. Sakwanmachi	72	3	1	
e. Aburayamachi	20	0	0	
f. Nekoyamachi	39	8	0	
g. Karasayamachi	58	2	0	
h. Tokaichimachi	116	6	9	
i. Tatamiyamachi	4	0	0	
23. KANSAKI	666	159	89	914
a. Nishichihomachi	32	0	1	
b. Nishishinmachi	49	2	1	
c. Kawaramachi	89	10	7	
d. Koamimachi	365	39	9	
e. Funairinakamachi	131	108	71	
24. FUNAIRI	37	118	180	335

Appendix 1 (10H)

HIROSHIMA

Table 1. Population Sampling Study

Casualties by Ward Districts and Precincts

Ward and Precinct	Dead	Injured	Uninjured	Total for District
25. EBA	18	104	407	529
a. Ebaminatomachi	2	7	37	
b. Ebahigashimachi	1	11	42	
c. Ebamotomachi	0	16	61	
d. Ebaminamimachi	8	15	85	
e. Uncertain	7	55	182	
26. OSIBA	99	340	401	840
a. Kusunokimachi I	24	57	86	
b. Misasamotomachi I	49	182	166	
c. Mitakimachi	14	55	55	
d. Osibamachi	7	41	59	
e. Shinjomachi	5	5	35	
27. MISASA	228	465	308	1001
a. Kusunokimachi II	11	25	37	
b. Misasamotomachi II	14	51	47	
c. Yokokawamachi	84	159	83	
d. Uchikoshimachi	10	37	31	
e. Nakahiromachi	72	132	49	
f. Minamimisasamachi	31	51	35	
g. Yamatemachi	6	10	26	

Appendix 1 (10H)

HIROSHIMA

Table 1. Population Sampling Study

Casualties by Ward Districts and Precincts

Ward and Precinct	Dead	Injured	Uninjured	Total for District
28. TEMMA	277	182	105	564
a. Shinichimachi	26	4	0	
b. Nishidaikumachi	13	1	0	
c. Yokoboricho	42	5	1	
d. Enokimachi	70	22	3	
e. Sakaimachi	0	1	13	
f. Temmamachi	126	149	88	
29. KANNON	197	446	510	1153
30. FUKUSHIMA	31	106	151	288
31. KOI	29	186	592	807
32. FURUTA	6	37	331	374
a. Takasu	1	5	9	
b. Furue	5	32	322	
33. KUSATSU	21	54	645	720
a. Kogomachi	2	22	132	
b. Kusatsumachi	18	25	498	
c. Minamimachi	1	7	15	

APPENDIX 2 (10H)

CASUALTY STUDY OF YASUDA GIRLS' HIGH SCHOOL

Certain factors concerning protection from atomic bomb injury are brought out by a study made of casualties among the personnel connected with the Yasuda Girls' High School. Information concerning these casualties was obtained from the following sources:

1. A survey made of all the teachers and pupils present at the school on 1 and 2 November 1945. Personnel present on these dates were questioned in detail concerning symptoms and injuries. Physical examination and sample hematological examinations were made as in the general survey group at Hiroshima. The 98 individuals examined represented 11.1 percent of the total school population estimated to be present at their assignments at the time of the bombing.

2. Interviews with teachers and pupils concerning the sequence of events on the morning of 6 August, the activities and location of personnel, and the fate of members of the school population.

3. The official report made by the principal of the school.

Personnel of the school totalled 1146 on 6 August 1945. On that morning attendance was taken, but the attendance records were burned and subsequent estimates were made by the teachers from memory. Except for a small group present at the school and a few individuals at the school dormitory, the school population was engaged in work service at 4 factories in Hiroshima or in making firebreaks in the vicinity of the Hiroshima Prefectural Office. The distribution of the school population and the casualty figures furnished by the school principal are presented

in table 1. The locations referred to in this text and table are shown on the map (figure 1).

No significant additional information was obtained concerning the groups at the school building, the dormitory, and in the vicinity of the prefectural office. It is probable that most of the missing in the last group represent fatalities whose bodies were not recovered. This assumption seems warranted on the basis of knowledge concerning the fate of other groups exposed outdoors at comparable distances from the center. Moreover, the failure of the school authorities to trace their victims by November 1945 is presumptive evidence that they had been killed. The percentage of deaths in the group, assuming the "missing" to have been killed is 97.3% and the total casualties are 99%. These figures confirm those of the Otake group discussed in Section 10H.

More information was available concerning the groups at the four factories.

The Homare Aviation factory was made up of a group of one-story Japanese-style buildings with metal roofing. Of the 210 girls working there, most were in one building which faced the center of the explosion, but which was partially shielded by an intervening building of the same type. Most of the girls were able to escape from the building before it collapsed and caught fire after the explosion, by spread from an adjacent warehouse. The fire is said to have started some five minutes after the explosion. Flash burns occurred only among the small group of girls working at open windows in the southeast corner of the building. Girls in the southwest corner of the building were not

flash-burned, because although windows were open they were shielded by the intervening building. Fatalities and serious injuries occurred among those who were trapped in the collapsing building and sustained mechanical trauma, secondary flame burns or both. Minor secondary injuries from flying glass and debris before the building collapsed were very frequent. These data are summarized in tables 1 and 2. It will be noted that table 2 records minor injuries as well as the major injuries that are alone recorded in table 1.

The Ohashi factory comprised a group of two-story Japanese style buildings with slate roofs. Of the 184 school girls estimated to be present almost all were in one building which faced south towards the explosion. About one-third of the girls were on the second floor but with few exceptions, they were able to escape from the building before it collapsed and burned when fire spread from nearby straw roofed houses. The collapse of the building is said to have occurred several minutes after the flash. However, 6 girls at the east end of the building on the second floor, farthest from the staircase, were unable to escape and died of crush injuries and flame burns. Many girls working at open windows on the south side of the building sustained flash burns. The data are summarized in tables 1 and 2.

At the Komitsu factory the 51 persons present indoors were distributed among 6 one- and two-story Japanese-style buildings. Windows had been removed or were open. All buildings collapsed almost at once following the explosion but did not catch fire until some 20 minutes had elapsed. All personnel escaped except one pupil who was pinned under a fallen

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Appendix 2. Table 1

TOTAL CASUALTIES AT YASUDA SCHOOL

Building and Location	Assigned	Estimated Present	Dead	Missing (probably dead)	Alive	Severe Secondary Injury
School (1200 meters)	124	75	6	39	30	14
Dormitory (1600 meters)	2	9	0	0	9	2
Outdoors (clearing firebreaks) Prefectural Office (900 meters)	334	300	21	271	8	5
Homare Aviation (1600 meters)	251	210	15	0	195	11
Ohashi Shoe Factory (1900-2000 meters)	214	184	9	5	170	19
Komitsu Sewing Machine (1900 meters)	127	51* 55**	1 (9 Sept)	0	50* 54**	0
Koa Sewing Machine (1400 meters)	94	55**	9	0	46#	0

*Indoors
**At factory indoors and outdoors
#4 Cases of "radiation sickness" developed in this group.

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Appendix 2 - Table 2

Yasuda School - Joint Commission Survey of Survivors

	Unhurt	Secondary Injury*	Flash burns	Total	Percent of estimated present surveyed
Homare	13	28	2	43	20.5
Ohashi	12	20	9	41	22.3
Komitsu	2	6	0	8	15.7
Koa	1	5	0	6	10.9
Total	28	59	11	98	19.6

*All minor injuries usually from flying debris and glass

ceiling and died 9 September 1945 (cause of death unknown). No flash burns occurred within the buildings although they were frequent among personnel unprotected on the factory grounds. Data are summarized in tables 1 and 2. The buildings are said to have fallen towards the blast.

The Koa factory consisted of a group of one-story Japanese buildings with galvanized metal roofs. The buildings collapsed immediately following the explosion and 9 of the 55 school personnel in the buildings were killed instantly by falling ceilings and timbers. The collapse is said to have occurred towards the center. Four cases of "radiation sickness" subsequently developed among the survivors. These are the only cases known to have occurred among the entire school population, and it may be significant that this was the factory closest to the hypocenter. Two indoor flash burns occurred in the Koa group, but the exact location of the patients in relation to windows could not be ascertained.

SUMMARY

All the data accruing from this review once more indicate the tremendous casualties to be expected among those outdoors within one km. of the center. These figures are compatible with those of the Otake group (Section 10H). Casualties among those inside the buildings have been plotted according to incidence and distance for comparison with those in concrete buildings in Section 10H.

Other information of interest is that the collapse of some buildings was a slow process, not occurring at once and occupying minutes

for its completion. (Ohashi Factory, 1950 meters, and part of Koa Factory, 1400 meters). The collapse occurred toward the center of the blast in some instances as at Komitsu (1900 meters) and Koa (1400 meters) factories. The time of onset of fires varied from 5 to 20 minutes.

LOCATION AND POPULATION
OF WARD DISTRICTS.

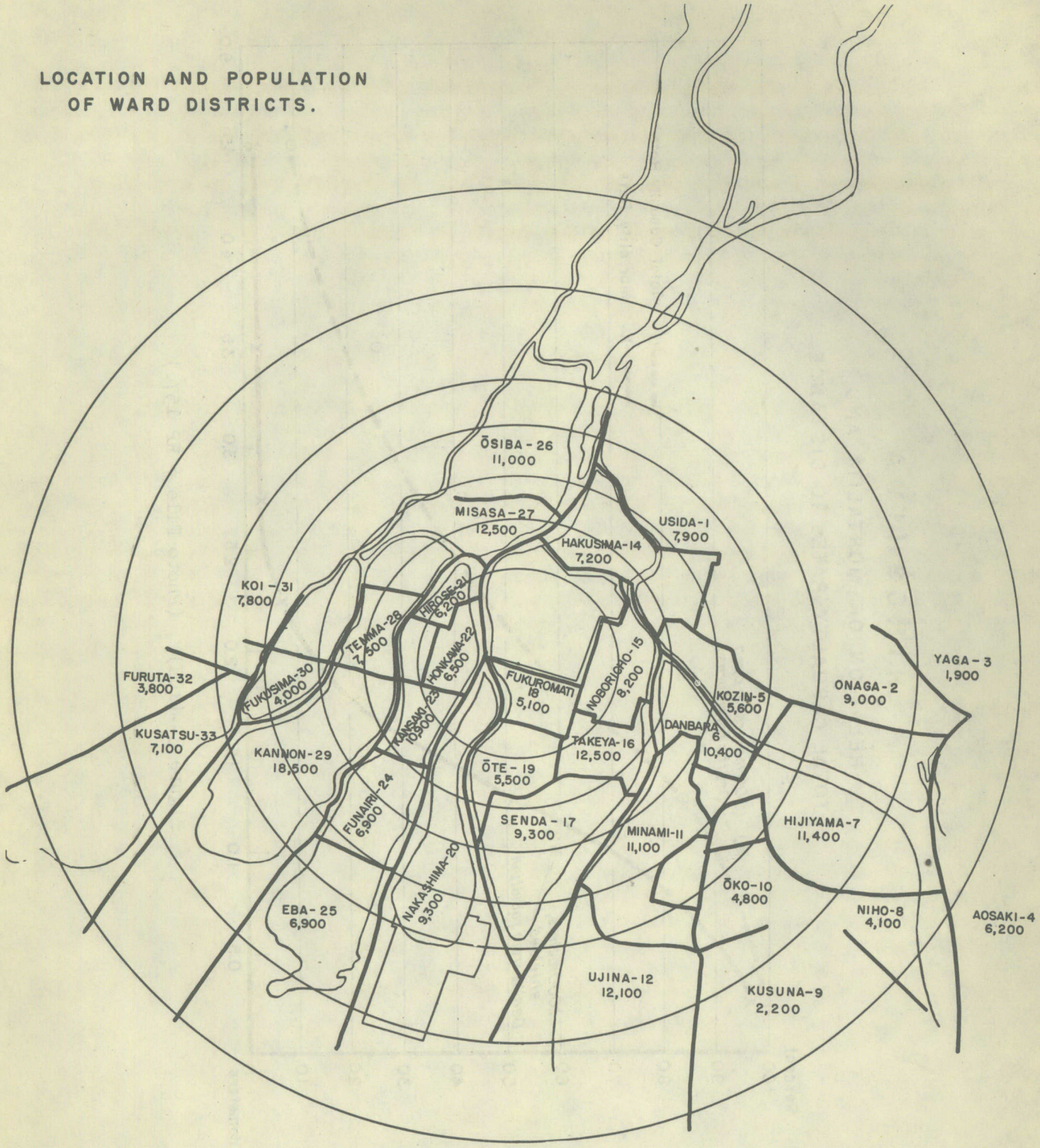

Figure 1--(10H). (Photo File # HP 159.)

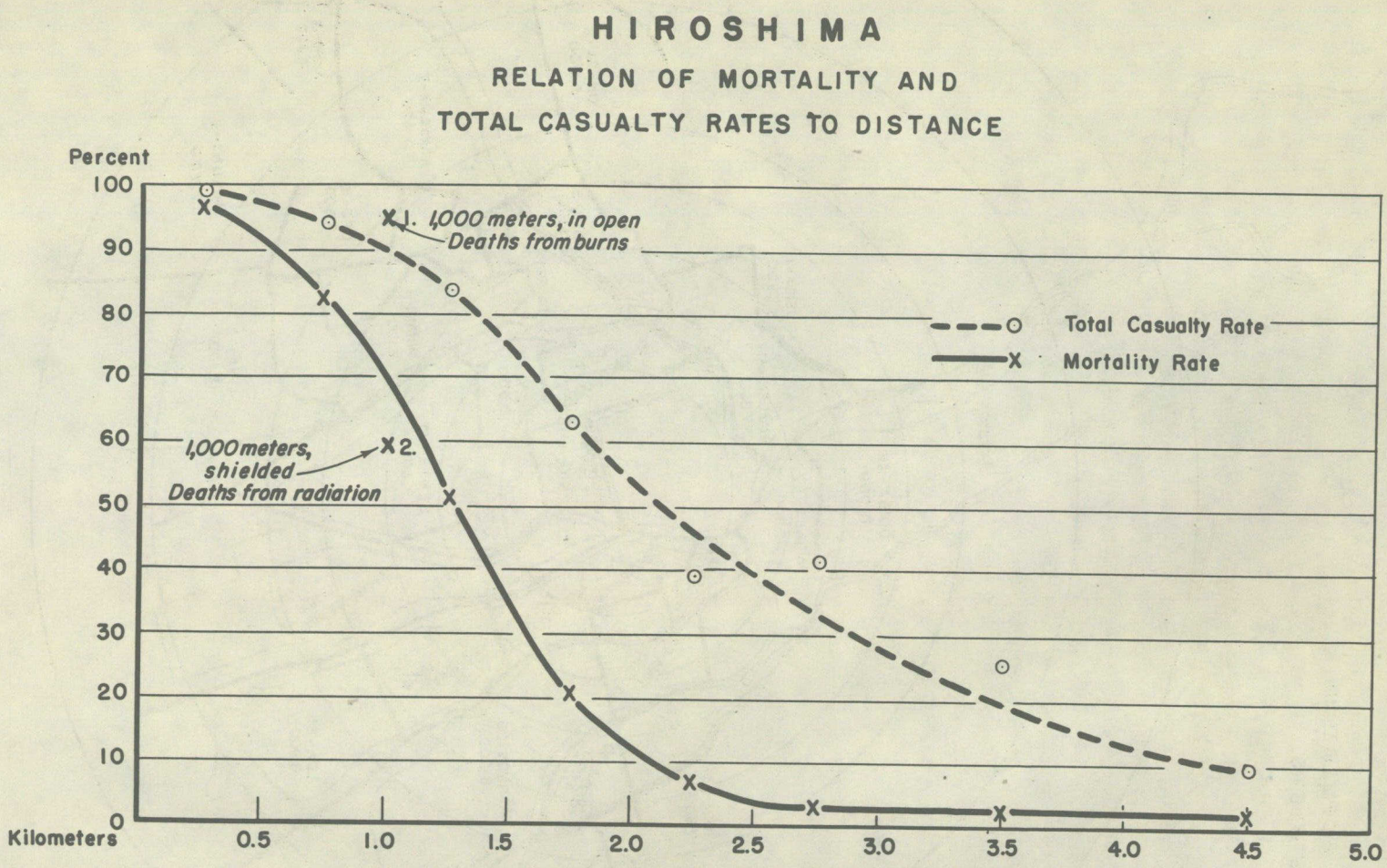

Figure 3--(10H). (Photo File # HP 157.)

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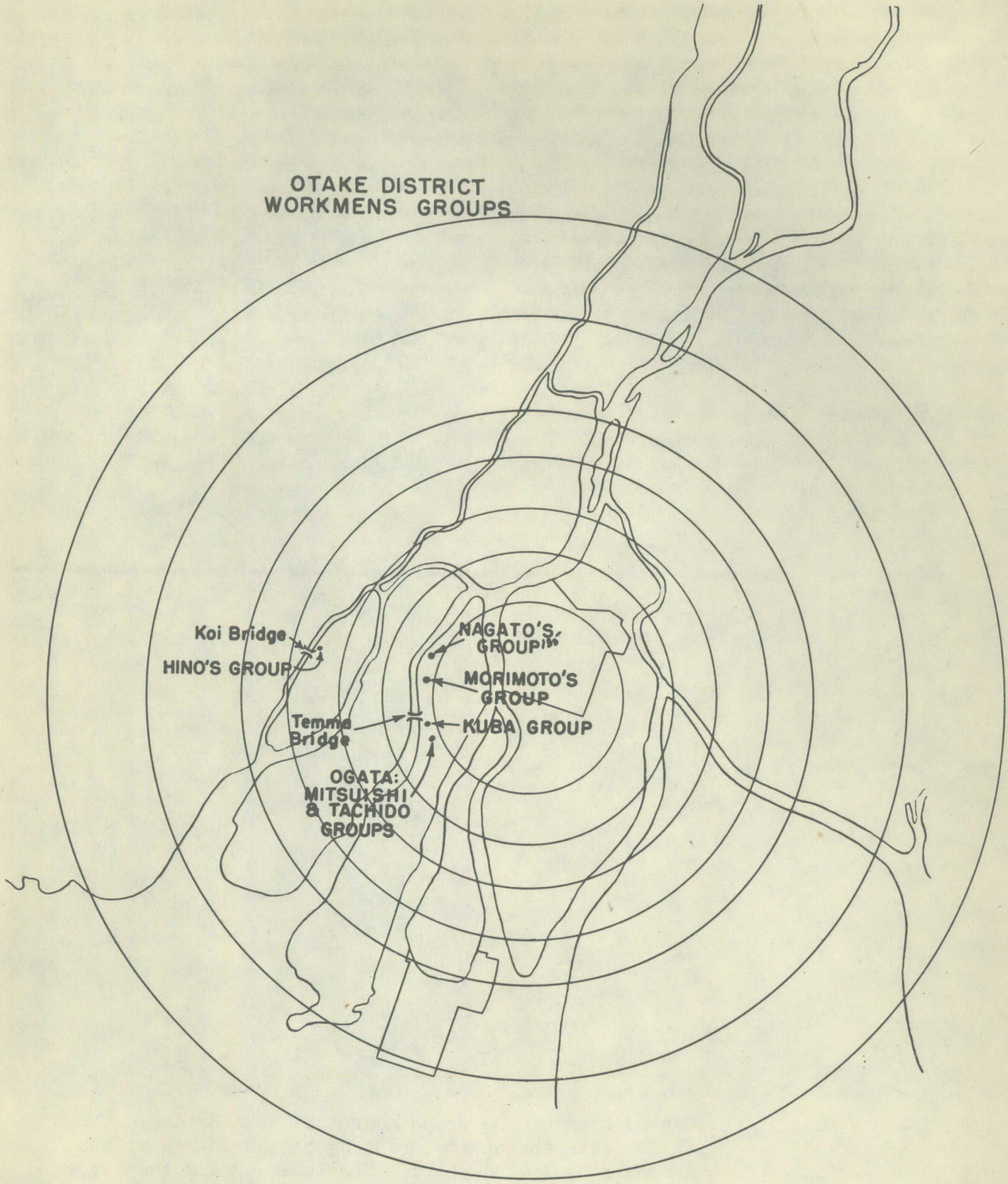

Figure 4--(10H). (Photo File # HP 158.)

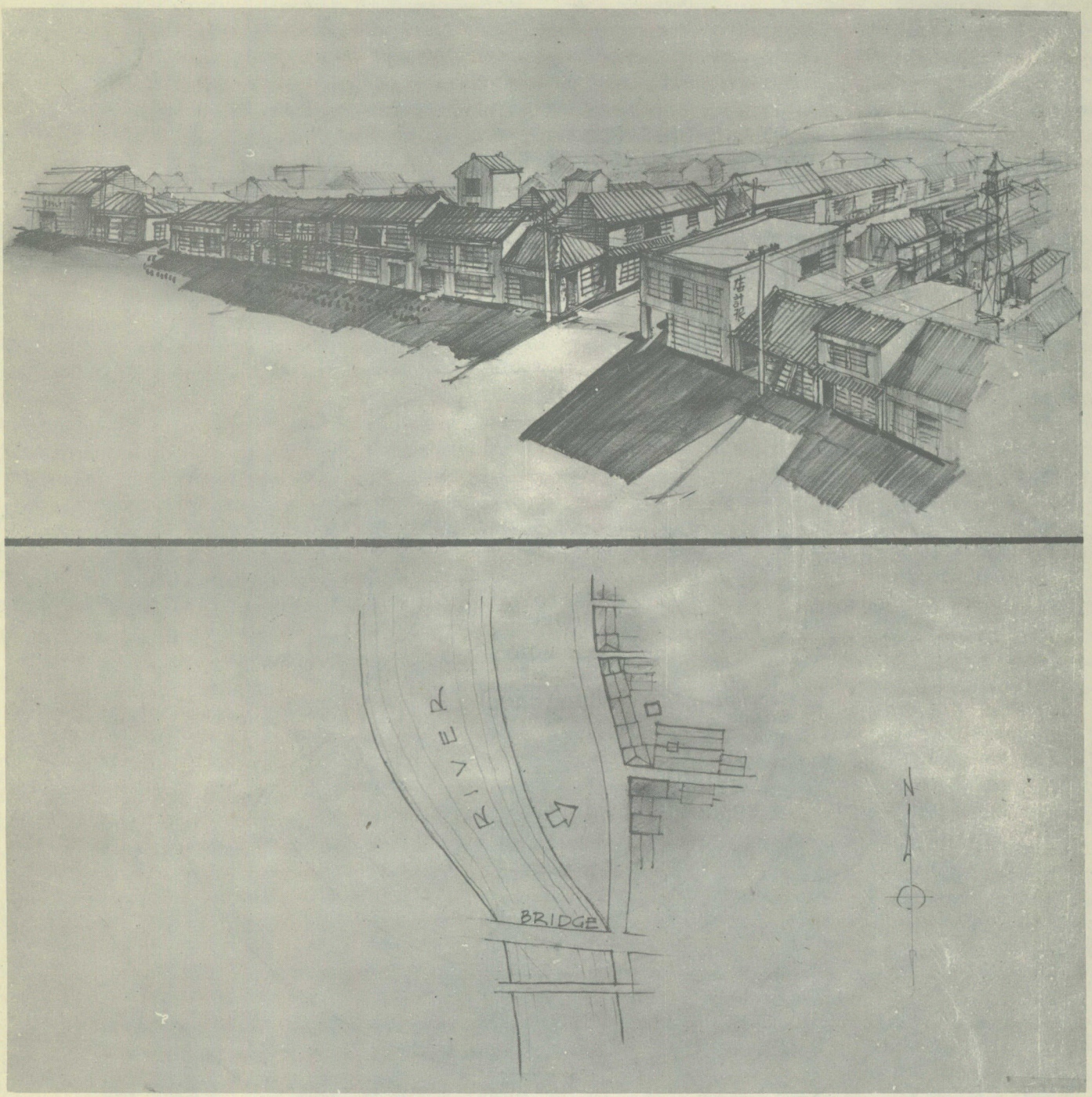

Figure 5--(10H). A reconstruction of the scene near the Temma Bridge. The street appears in perspective with the shadows cast by the buildings at the time of explosion of the bomb roughly indicated. The lower sketch shows the relation of the scene to the bridge. The arrow points to the center of the explosion. (Photo File # HB 324.)

Figure 6--(10H). Bank of Temma River. Temma Bridge in background. Site under clearance for fire-break at the time of bombing by groups of men from Kuba and Ogata (Tachido and Mitsuishi Villages). Almost all of these died of burns. (Photo File # HG 270.)

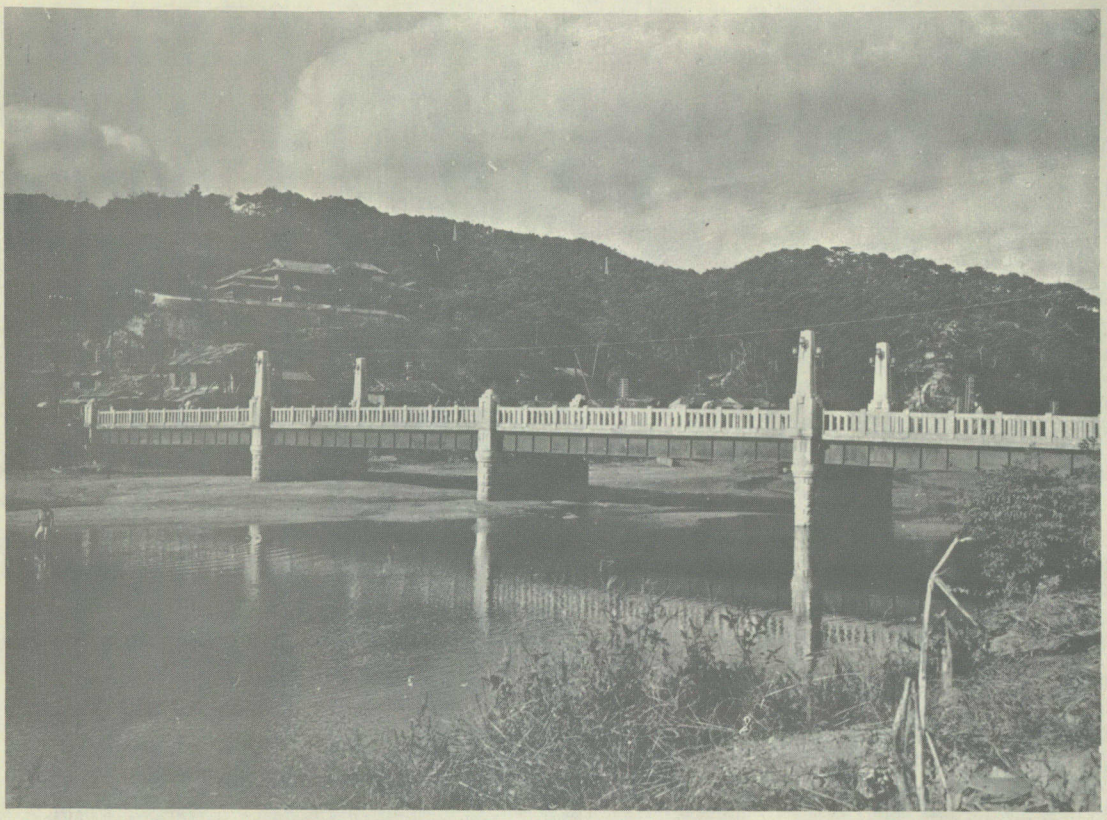

Figure 7--(10H). Koi Bridge, 2400 meters from hypocenter. The site where Foreman Hino's group from Otake village was exposed at the time of the bombing. The hills are on the Koi side. None is found on the Hiroshima side between the bomb and the people. These people were all burned, but they survived, with few exceptions. (Photo File # HB 323.)

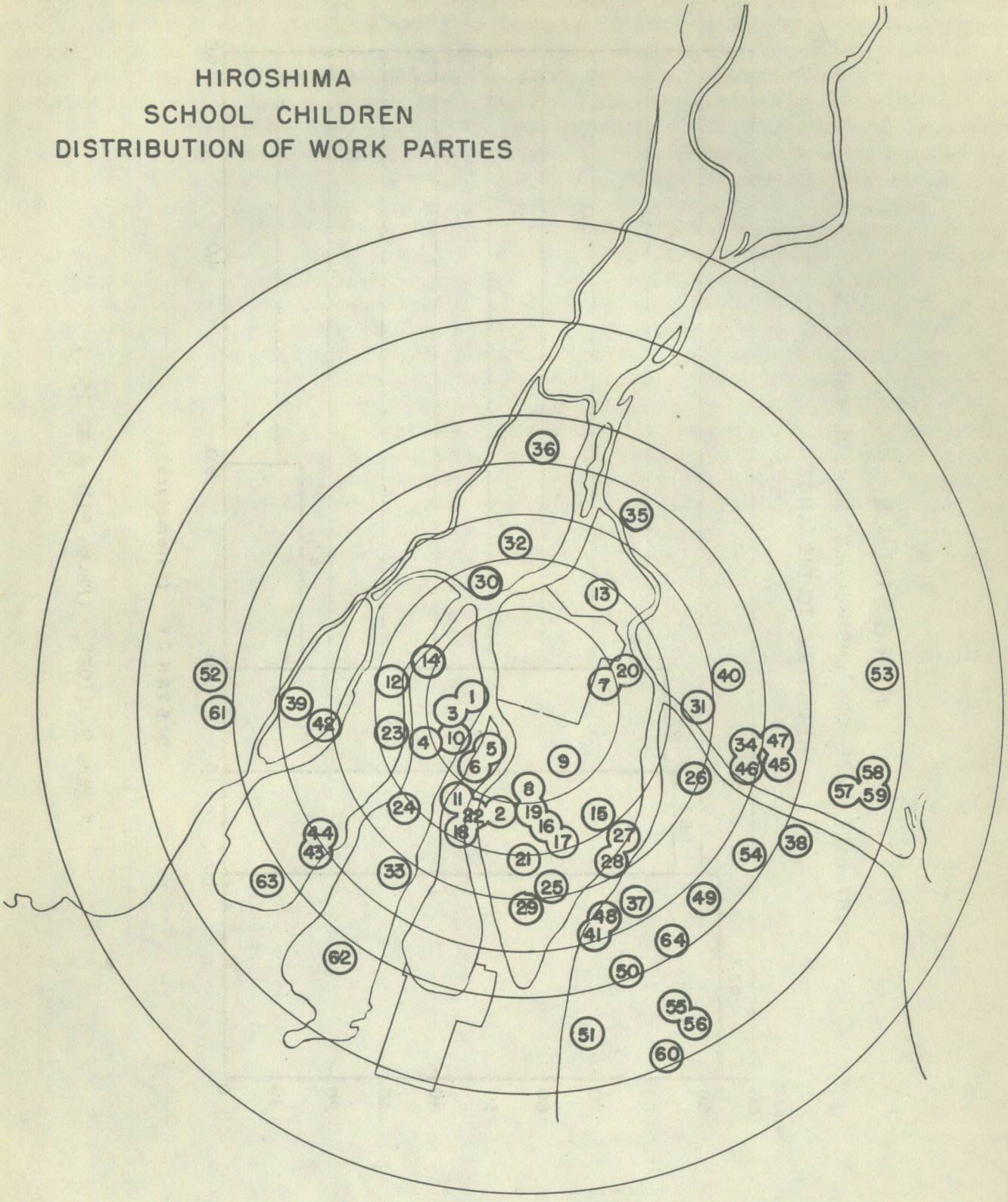

Figure 8--(10H). (Photo File # HP 154.)

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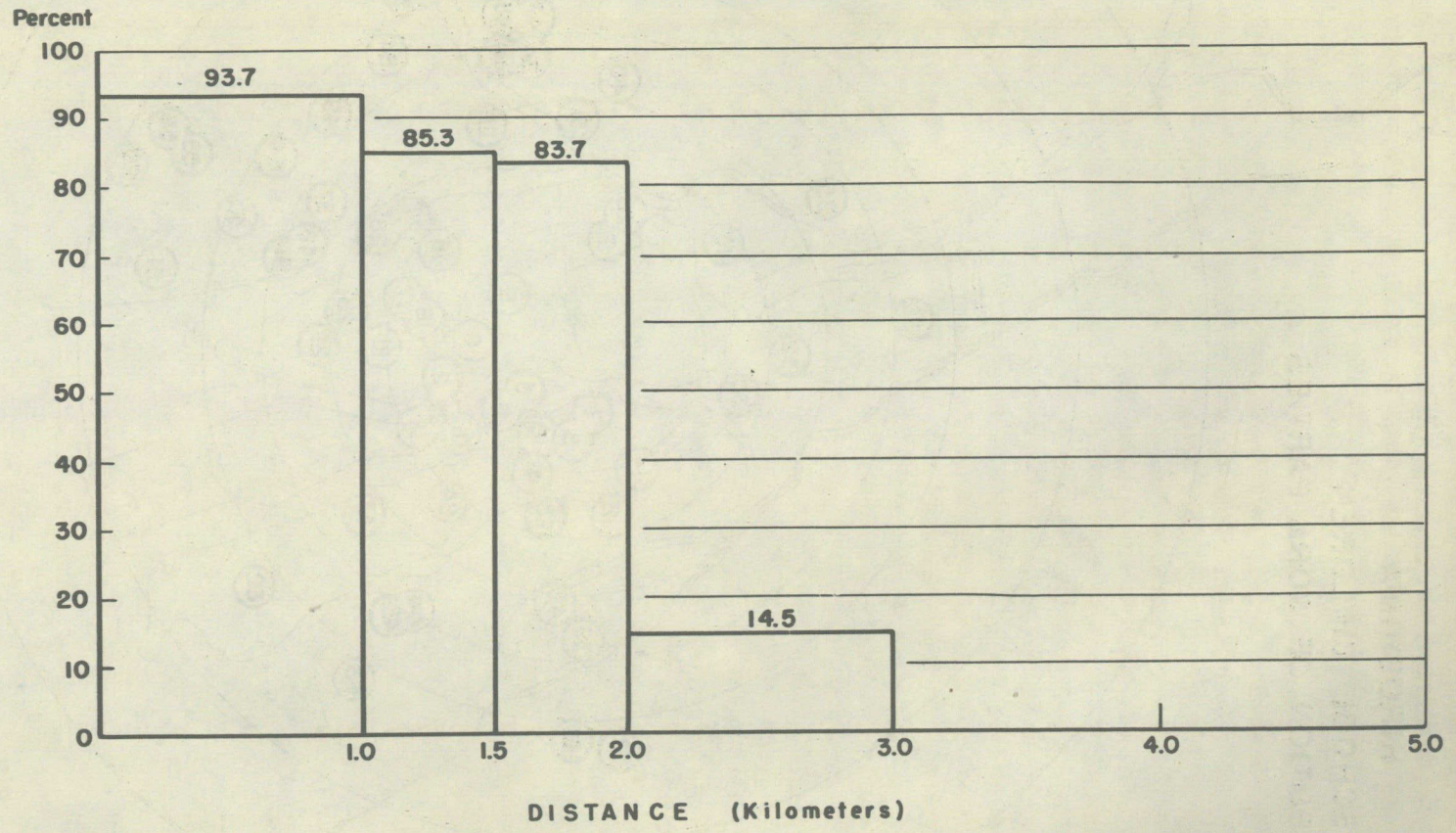

Figure 9--(10H). (Photo File # HP 156.)

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MORTALITY AND CASUALTY RATES OF "SHIELDED" SCHOOL CHILDREN RELATIVE TO DISTANCE

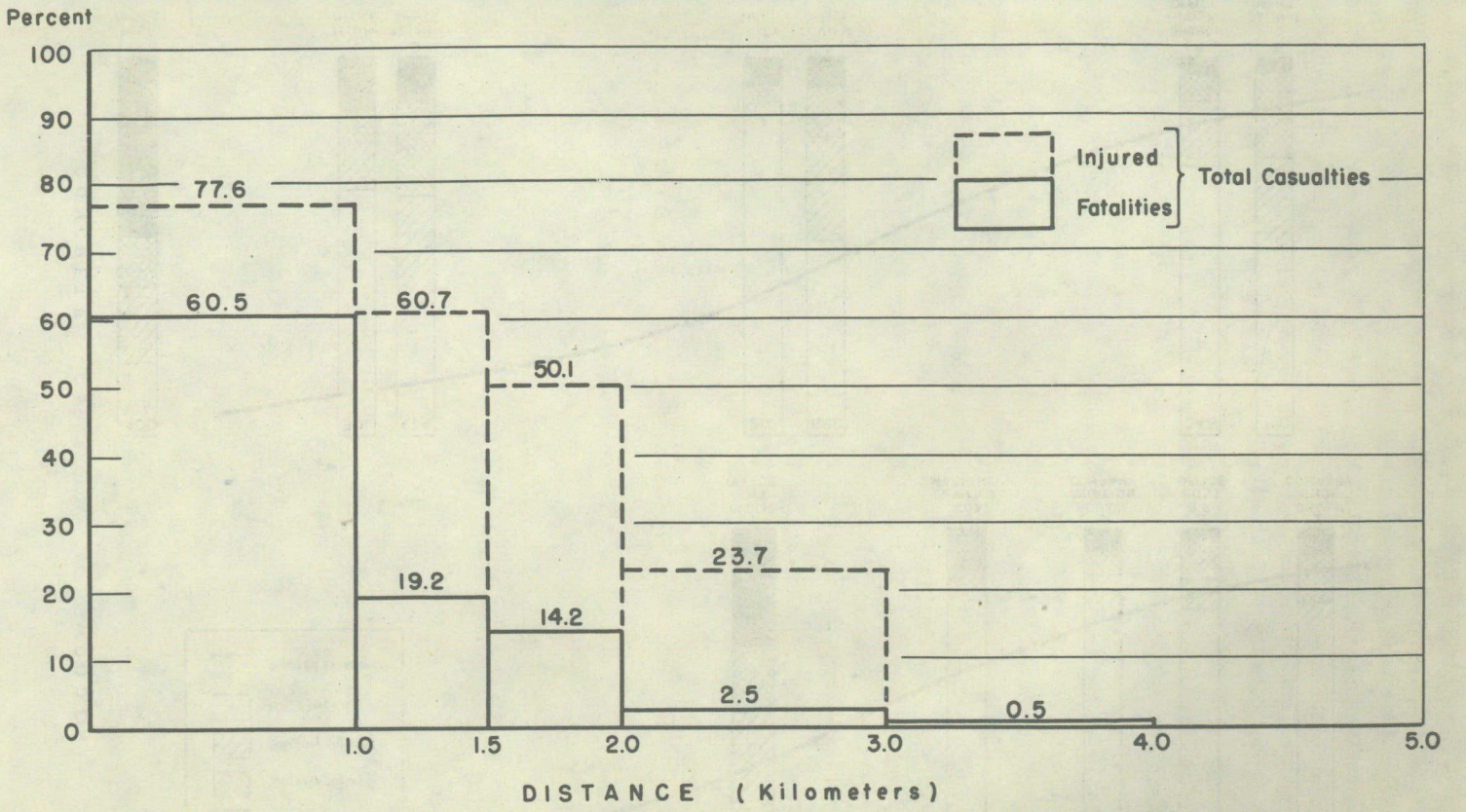

Figure 10--(10H). (Photo File # HP 155.)

HIROSHIMA

MORTALITY AND CASUALTY RATES
WOODEN AND CONCRETE BUILDINGS COMPARED

(AS OF LATE AUG. 1945)

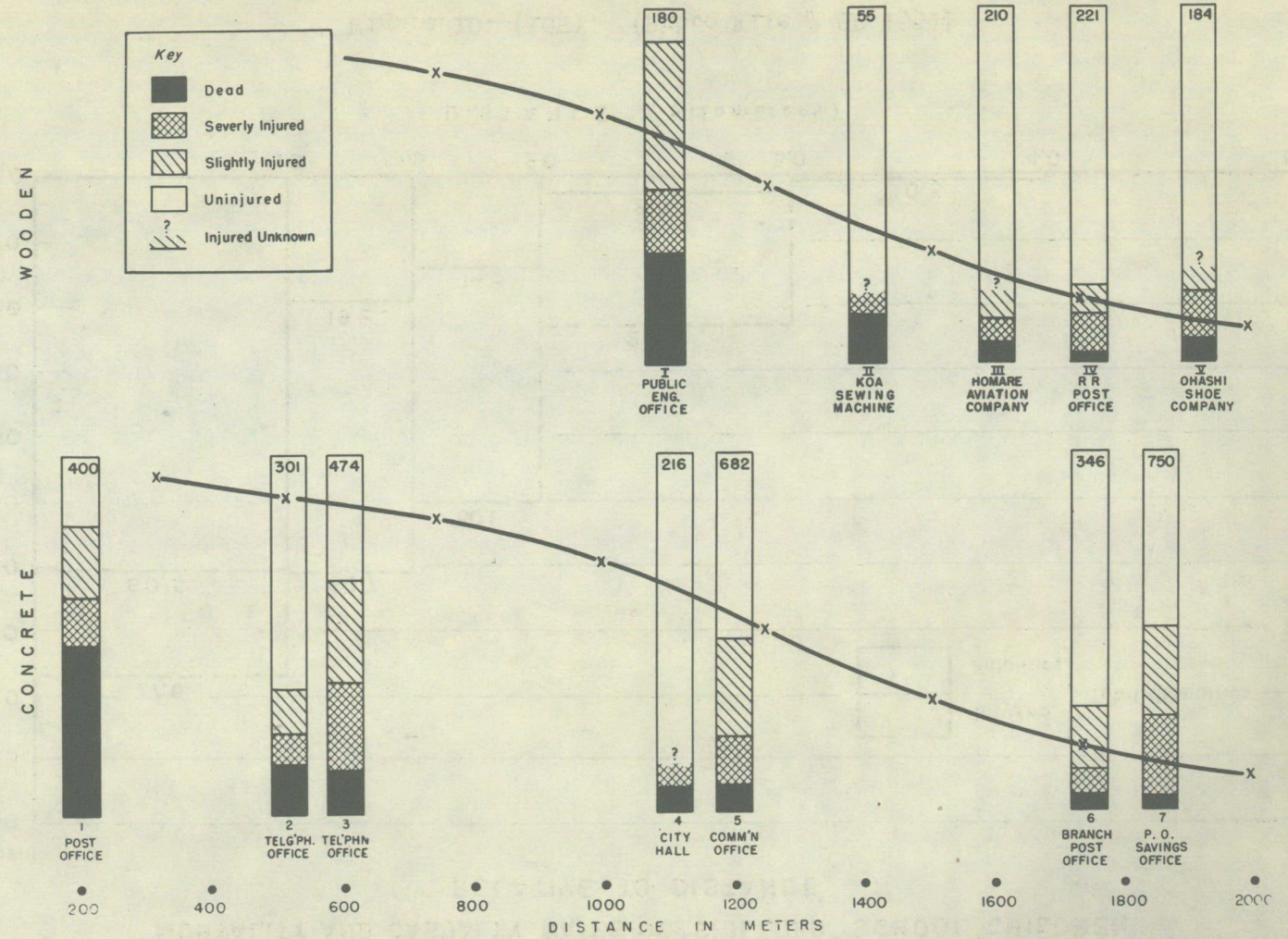

Figure 11--(10H). Comparison of Mortality and Casualty Rates (first 2 - 3 weeks) in Wooden and Concrete Buildings. The height of each column = 100%. The number of people in each building is indicated at the top of each column. Each column is placed in its proper relation to the point above which the bomb exploded.

The curve of the ultimate general mortality is superimposed (see figure 3(10H)). The indicated mortality figures in buildings 1, 2, 3, and I are incomplete for reasons stated in the text. (Photo File # HP 153.)

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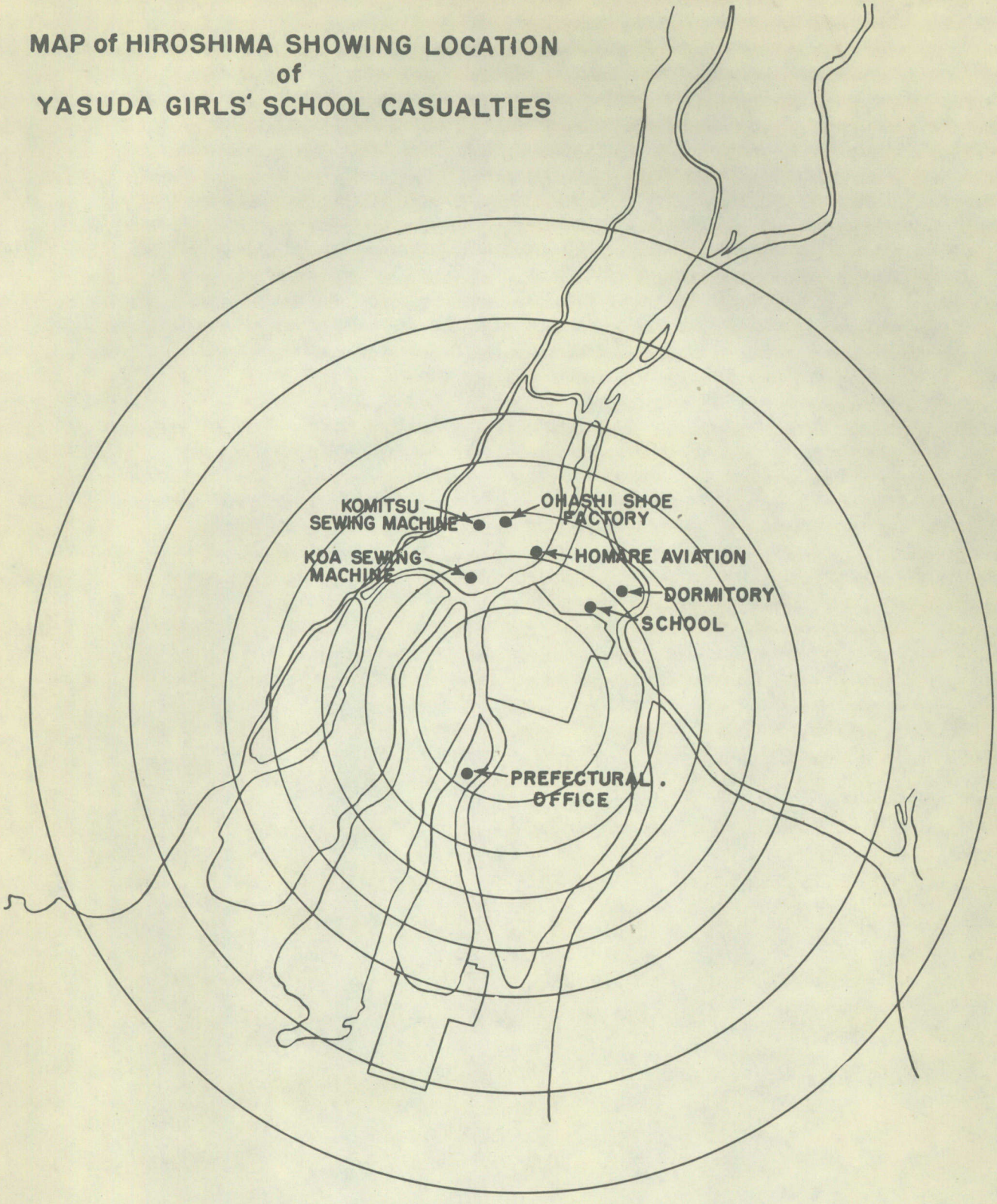

Appendix Figure 1--(10H). (Photo File #HP 160.)

Section 10N

POPULATION AND CASUALTIES, NAGASAKI

Prepared by George V. LeRoy, Lt. Col., MC
Data Collected by Marvin E. Habel, Capt., F. A., and Dr. Motosaburo Masuyama

General.

The primary objective of the medical mission was to conduct a casualty study in the cities attacked by the atomic bombs. It was necessary, therefore, to attempt to obtain as exact information as possible on the number of people exposed to the effects of the bomb and on the number and types of casualties. Because the effects of the blast extended to virtually every part of the city, it was desirable to consider that the entire population was at risk and to proceed accordingly. There is a census department in the Nagasaki Municipal Government, but it was learned there that the most reliable data on population was kept by the rice rationing authorities. To regulate the distribution of this staple the city was divided into 24 districts called "rengo chonaikai". Each of these rationing districts was further subdivided into block associations. The block associations, of which there were approximately 300 before the bombing, were composed of groups of city blocks which were related to a "main" thoroughfare. The names of the block association and of the principal thoroughfare were similar, and were used interchangeably. The block associations may be considered as equivalent to precincts, and the rationing districts (rengo chonaikai) to wards in an American city. Each of these small units had a "leader" who kept the records of the persons entitled to a rice ration. In practice most leaders knew the heads of all the families in his block association. He submitted a monthly report of the number of households and quasi-households (workers' dormitories), and the total number of inhabitants in his block. When the rice was ready for delivery, he received it and distributed it to his constituents. When the government required a census, as it did in November 1945, the census cards were distributed and the count was made by

the rice rationing authorities. In addition to the normal residents of each ration district, there were the transients who worked in the factories and who were registered for ration purposes in other districts, or in the nearby villages and rural communities. Information on this group was obtained from the police officials, the factory managers, and indirectly by a study of the railroad commuters. In the vicinity of Nagasaki the number of military personnel was negligible. Furthermore, there were no organized groups of temporary workers engaged in various activities as was the case in Hiroshima. It is apparent then that the number of people at risk on 9 August was at least the registered population and the transient labor force.

Before accepting any estimates of the size of the population on the day the atomic bomb was dropped, it is necessary to consider some of the sources of error.

(a) Movement of the Population away from the Cities: It was known that after the B-29 raids started in December 1944, there was a steady drift of population from the target cities into the comparative safety of the villages and the countryside. An unsuccessful effort was made to determine the magnitude of this emigration in Nagasaki. An estimate, only, can be obtained from the count of the rationed population which was 207,000 in May, and 195,000 in July 1945. The small number of evacuees was doubtless attributable to the fact that the city had experienced only 5 small-scale air raids before 9 August.

(b) Loss of Records: This factor had little effect on the problems of obtaining records in Nagasaki. Early investigators were told by the Japanese that records had been destroyed, but "research" often disclosed the required information.

(c) Peculiarities of Japanese Administrative Methods: This factor is difficult to assess but caused real concern to all the student of population. The average Japanese official has no passion for accuracy, and remains unperturbed when figures do not balance and totals fail to agree. The normal sources of information on the trend of populations - statistics of births and deaths - were of no value, because in Japan these vital data are not legally registerable. The police records of the movement of people into and away from their districts were generally admitted to be inaccurate, and in the case of Nagasaki were said to have been largely destroyed. The percentage of the population who were not registered for any of a variety of reasons was not known. Various officials estimated that as few as 80% of the residents of the city were on the rice ration lists. Other officials intimated that the lists were occasionally padded, or at least that the names of departed citizens were frequently not deleted. In addition to these qualifying factors, there is a final one - the nature of the records themselves. All the tables that were available were reproduced by hand from original sources, and a careful scrutiny invariably disclosed obvious errors in copying, as well as mistakes in arithmetic.

The Population of Nagasaki Before 9 August 1945.

Estimates of the Population:

Five reasonable estimates of the pre-raid population are available:

(a) 270,000: This value was cited by Mr. Hisakichi OKADA, Mayor of Nagasaki City, in the course of an interrogation by representatives of the Manhattan District, Corps of Engineers, USA, in September 1945. He did not give the source of his estimate.

(b) 260,000: This value was estimated by Prof. J. Bronowsky, a member of the British Mission to Japan, which was affiliated with the U.S.

Strategic Bombing Survey. It was based on the rice rationing figures for May 1945, corrected for the estimated non-registered fraction of the population.

(c) 207,086: This value is the total number of registered persons in May 1945, according to the Municipal Section of Food Distribution (Busshika).

(d) 195,290: This value is the total number of registered persons in July 1945, according to the Prefectural Branch of the Provincial Food Stuff Agency (Shokuryo Eidan). It was obtained and verified by Captain Marvin E. Habel, FA, AUS, who was officer-in-charge of a special group detailed by the Joint Commission to re-study population and casualties.

(e) 211,304: This value was calculated by Captain Habel on the basis of research in Nagasaki in January 1946. It is based on the previous figure (d), plus the estimated transient population. The data for this estimate was collected by Dr. Motosaburo MASUYAMA, Tokyo Imperial University, a statistician, and a serious student of the problem of population and casualty rates.

The members of the Commission responsible for this report have chosen to accept the opinion of Capt. Habel, contained in his report dated 19 March 1946.

"It is the considered opinion of the study group that the minimum figures for population are the more reliable (i.e. 195,290). It is very likely that in the maximum estimate the labor group includes people whose homes were in other districts of Nagasaki but who worked in the factory districts. Thus they may have been counted as members of their residential district and also as part of the factory district population in the maximum estimate. No doubt the large proportion of the labor group was at work when the bomb fell; but

it was impossible to determine how large a number came from each residential district. Since the factory district suffered the more severly, counting these as a part of the residential district would tend to overestimate rather than underestimate casualties. For this additional reason, the minimum figures are more accurate.

"The minimum population...was estimated to have been 195,290 and the maximum 211,304 on 9 August 1945."

The Distribution of the Population.

The population of each of the 24 ration districts according to the report of July, 1945, is presented in Table 1. The boundaries of the 20 districts which were located within the seven ring zones of the polar coordinate system are shown on the map (Figure 1). The outer ring of these coordinates is 5.0 Km. from the center and in the area comprising these zones lived 88.9% of the population. For all practical purposes, it is quite valid to omit from the analysis the four districts which were situated more than 5.0 km. distant for the total casualty rates in them were:3.6%, 2.4%, 1.2% and 0.8% respectively.

Since distance was an important factor in determining casualty rates, it was desirable to estimate the population of as many ring zones as possible. This was accomplished by finding the location of each block association on a large-scale city map marked with the polar coordinates. Suitable adjustments were made for the units which overlapped the ring boundaries. It was possible in this way to obtain very good estimates for the five inner zones. Satisfactory approximations were made for the remainder of the city. The inhabited portion of each ring zone was marked out on a map and measured with a planimeter. The estimated area, population and population density of the ring zones are presented in Table 2 and shown graphically on the map, (Figure 2)

TABLE 1

POPULATION OF PATION DISTRICTS, JULY 1945

NAME	POPULATION	NAME	POPULATION
Shiroyama	8984	Irabayashi	14083
Yamazato	14442	Katsuyama	8887
Zenza	9228	Togiya	8660
Inasa	14116	Minamioura	6323
Nishiurakami	4324	Nita	7899
Nishizaka	6551	Sako	8495
Naminohira	3610	Kaminagasaki	8937
Koshima	8421	Tomachi	9153*
Shinkozen	8707	Tategami	6239
Asahi	9598	Kosakaki	5651*
Akunoura	8382	Kogakura	2093*
Kitaoura	7933	Doinkubi	4574*

TOTAL: 195,290

*Located outside the polar coordinates on the map; or more than 5.0 km. from the center.

TABLE 2

AREA AND POPULATION OF THE RING ZONES

RING ZONE	AREA SQ. MILES	POPULATION	POPULATION DENSITY Per Acre
1	1.15	30,999	42
2	0.62	14,363	37
3	0.44	6,568	24
4	0.30	6,822	35
5	0.66	21,222	50
6, 7, plus	2.33	115,316	77
TOTAL:	5.5	195,290	56

THE POPULATION AT RISK

In the course of the preparation of this report consideration has been given to the importance of attempting to estimate the size of the population exposed to the action of the atomic bomb. This question occurred because of the irregular terrain of Nagasaki. Everyone who has inspected the city since the bombing has been impressed by the contrast between one section devastated by the blast, and another which was directly adjacent, or at a comparable distance from the bomb, in which the damage to buildings was minimal. By means of terrain maps it is possible to estimate the regions of the city which were shielded from the direct blast by hills located between them and the airburst. The importance of this shielding, however, should not be overestimated, for although the terrain may have protected from gamma radiation, heat and direct blast effects, the concussion wave which followed enveloped everything within its effective range. In the tabulation of casualties by districts (Table 7), which follows, it will be seen that there was no district in which there were no casualties. Similarly, there was no district in which every building escaped damage of some sort. Taking all these matters into account, it seemed proper to assume that the entire population was at risk, or exposed to the liability of some sort of injury. In the discussion of the actual casualty rates, however, inconsistencies between the ones in certain ration districts can be explained in part by differences in the known degree of exposure of the people. This relationship is presented roughly in the Map (figure 3), where the shaded portions represent regions shielded to a considerable extent by terrain features.

THE CASUALTIES

Total Number Killed and Wounded.

Three responsible estimates of the number of casualties have been made. There is close agreement between them, even though the methods of calculation were different in each case. The number of the dead differs considerably, but this may be explained by the fact that the estimates cited were made at different times after the bombing. Each estimate, and method by which it was computed, will be considered separately.

(a) Official estimates: In an interview with the representatives of the Manhattan District, CE, USA, Mr. OKADA, the Mayor of Nagasaki City, stated that the total casualties were 65,000. He did not cite his authority for this figure. The apparent basis, however, is found in a report submitted to higher authorities by the Governor of Nagasaki Prefecture, entitled "Confidential Defense Extra Report No. 20", dated 3 September 1945. The figures in this report are as follows:

TABLE 3

Wounded, reported from aid station	40,992
Known dead	19,743
Missing*	1,927
Total Casualties	62,662

An inspection of the data on which this estimate is based reveals several errors in calculation and of judgement. A better treatment of the available figures is as follows:

*The category "missing" includes persons presumed to be dead; and so reported by relatives who were unable to find any recognizable remains among the debris in the place where the victim was "known" to have been.

TABLE 4

Patients treated in aid stations, in the city and in nearby towns	39,585
Died in city aid stations and reported to police	1,682
Died in aid stations of surrounding towns and reported to police	1,775
1. Known wounded at time of report (1 Sept.)	36,128
2. Police Office estimates of total dead based on:	25,286
3. (a) Death certificates issued	19,743
(b) Missing as above	1,927
(c) Dead estimated by police from the reports of survivors; no certificates were issued for these and it is believed that the figure refers to unidentifiable bodies	3,616

Adding these figures in two ways, one gets a minimum estimate for known casualties on 1 September 1945 of 55,871 (1 plus 3); and a maximum estimate of known casualties of 61,414 (1 plus 2). Since it is known that a certain number of victims did not exhibit symptoms of radiation disease until after 1 September, these estimates are probably too low.

(b) Estimate of Prof. John Bronowsky of the British Mission to Japan: Total killed: 34,153. This estimate is for the number of killed, only. It is of special interest because of the method of calculation. The pre-raid population, based on the May 1945 rice rationing report was 207,086. The earliest rationing data available for the post-raid period was obtained in November, but it probably represented the situation in October. The total population by this tabulation was 117,112. This rationing roster was incomplete; and there were complete post-raid returns only for blocks whose

pre-raid population was 165,813. It was then assumed that the population change in each ration district was of the same order as the average change in those blocks for which post-raid information was available. Their computation was made on this basis, and the population of Nagasaki City for November 1945 was estimated to be 143,617. A report was then obtained from the Police Stations of the number of permits to leave the city that had been issued. This number was 29,313. Subtracting then:

1. Pre-raid Population.....	207,086
2. Post-raid Population.....	143,617
3. Permits to leave city.....	29,316
(1 minus 2 minus 3).....	34,153

The interesting feature of this computation is (2), the population in Nagasaki in October-November 1945. A census was taken by the Prefectural authorities after this estimate was prepared. One copy of the census report was obtained by the Intelligence Section of the U. S. Strategic Bombing Survey, and another was obtained by the Joint Commission. The totals for the population were:

1. U.S.S.B.S. Copy.....	140,606
2. Joint Commission Copy.....	142,748
3. Prof. Bronowsky's computation.....	143,617

(c) Estimates made by the Random Sampling Method: A study group under the direction of Captain Habel was sent to Nagasaki in January, 1946, at the request of the Joint Commission. The details of the random sample method which they employed to determine casualty rates is discussed in Section 4 of the Hiroshima report. This technique provided information on the mortality rate and the wounded rate for each ration district. It was prepared in such a manner that four sets of figures were submitted:

1. Minimum casualty estimate for minimum population estimates.
2. Maximum casualty estimate for minimum population estimate.
3. Minimum casualty estimate for maximum population estimate.
4. Maximum casualty estimate for maximum population estimate.

In Nagasaki, the "minimum population estimate" was the report of the rice rationing districts for July, 1945. The "maximum population estimate" was this value plus an estimate of the transient labor force. The "minimum casualty estimate" was obtained by multiplying the district killed and wounded rate (obtained from the random sampling questionnaire) by the "minimum population estimate" for each district. (See table 7) These district products were then added to get the figures for the city. The "maximum casualty estimate" for the "minimum population estimate" was obtained by multiplying the killed and wounded rate for the entire city (obtained from the random sampling questionnaires) by the population: 195,290. The latter estimate is about 10,000 lower for killed and about 2,000 higher for wounded. When the results of the random sampling study were arranged on the basis of the ring zones, (see tables 2 and 9) the number of killed and wounded was found to agree very closely with the "maximum caualty estimate for the minimum population." For this reasons the larger estimate has been considered the more accurate. The casualties in Nagasaki City are shown in Table 5.

TABLE 5

KILLED AND WOUNDED IN NAGASAKI*

	NUMBER	PERCENT OF POPULATION
Total killed	39,214	20.08
Total wounded	25,153	12.88
Total Casualties	64,367	32.96

*This is the maximum estimate, based on the minimum population estimate.

It was believed that the practice of weighing the killed and wounded rate on a district basis (See table 7) yielded an underestimate in districts which occupy 2 or more ring zones, since the number of survivors available for sampling was greater in the more distant zone. For this reason the random sampling data were re-arranged, and results of the questionnaire were compiled on a basis of the ring zone in which each ration district subdivision was located. This permitted an estimate of the killed and casualty rate on a ring zone basis. Since the distribution of population by ring zones had been estimated (see table 2), it was possible to weight the killed and casualty rate in this way when the total numbers were calculated. The total number of killed and wounded estimated in this manner is practically the same as the figures in Table 5. (See Appendix 10 N)

The estimates derived by the three methods are tabulated for comparison in Table 6. The discrepancies are not great, and considering the time at which each was made, the agreement is surprisingly good. It should be mentioned that many of the deaths from the syndrome of radiation injury had occurred when the official count cited was made.

TABLE 6

COMPARISON OF CASUALTY DATA

	KILLED	WOUNDED	TOTAL CASUALTIES
Official Japanese - Sept. (Direct Count of Killed & Wounded)	19,743	36,128	58,871
British Mission to Japan - Oct. -Nov. (Computation from population change)	34,153		
Joint Commission -Jan. 1946 (Random sampling method) (1)	39,214	25,153	64,367

BREAKDOWN OF CASUALTY RATES

The geographic basis for the random sampling method was the subdivision

TABLE 7

CASUALTY RATE IN RATION DISTRICTS

DISTRICT	PRE-RAID POPULATION	% KILLED	% INJURED	% TOTAL CASUALTIES
Shiroyama	8984	89.4	5.7	95.1
Yamazato	14442	64.5	18.5	83.0
Zenza	9228	54.3	25.2	79.5
Inasa	14116	29.2	28.1	57.3
Nishiurakami	4324	22.6	18.6	41.2
Nishizaka	6551	7.1	21.8	28.9
Naminohira	3610	4.6	3.9	8.5
Koshima	8421	3.3	6.1	9.4
Shinkozen	8707	2.5	20.6	23.1
Asahi	9598	2.4	24.1	26.5
Akunoura	8382	1.5	11.4	12.9
Irabayashi	14083	1.4	13.2	14.6
Katsuyama	8887	1.4	13.2	14.6
Togiya	8660	1.2	11.9	13.1
Minamioura	6323	0.8	4.2	5.0
Nita	7899	0.7	4.9	5.6
Sako	8459	0.4	6.9	7.3
Tomachi	9153	0.3	3.3	3.6
Kaminagasaki	8937	0.2	8.6	8.8
Tategami	6239	0.2	4.1	4.3
Kitaoura	7933	0.1	4.5	4.6
Kosakaki	5651	0.0	2.4	2.4
Kogakura	2093	0.0	1.2	1.2
Doinokubi	4574	0.0	0.8	0.8
Total	195290			
Total Casualties, Weighted by districts*		(29,570)	(23,262)	(52,832)

*These figures are lower than those used in Table 5. See above for discussion.

of the city into rice-rationing districts. A sufficient number of blocks (1) in each district were sampled to permit the calculation of killed and wounded rates by districts. The figures are presented in Table 8, and the casualty experience for each district is shown on the map, Figure 4.

A close inspection of this map shows that the effect of the bomb as measured by the casualty rate has been fairly symmetrical, with a few conspicuous exceptions. Considering the variations in the type of buildings located in the various districts, and the generally irregular terrain, the symmetry of the casualty-producing effect is more striking than the lack of it. For example, Inasa (see map, figure 3), on the west bank of the Urakami River, and Zenza and Nishizaka on the east bank, were located within approximately the same ring zone. The character of the districts was quite different, however. Inasa was mainly a residential section and included many small hills which afforded partial protection to some portions of the district. Zenza and Nishizaka were chiefly industrial sections, and except for perhaps one-fourth of the latter district were completely flat and unshielded by terrain features. In spite of these differences, the combined casualty rate for Zenza and Nishizaka was 57.5% which is quite similar to the rate for Inasa.

(1) See Appendix 10 N for detailed data used in preparing the estimate.

which was 58.6%. Another example of symmetrical effect was demonstrated in the case of Shinkozen on the east bank of the harbor; and Asahi and Akumoura on the west bank. The built-up areas of the latter districts were located in about the same relation to GZ as the Shinkozen district. Shinkozen was a commercial and residential section, rather hilly and with about one-fourth of the area shielded by hills. Asahi and Akumoura were shipbuilding centers with a scattered residential section. Small, steep hills provide shielding for about one-third of the area. In spite of these differences, the combined casualty rate for the west bank districts was 20%, and for Shinkozen 23%.

The best example of asymmetrical effect due to protection by terrain features can be seen by comparing the casualty rates for the Nishizaka, Katsuyama and Kaminagasaki districts. The inhabited portions of all three were located at about the same distance from the bomb. Between these districts and the approximate position of the bomb's airburst there was a range of hills varying in elevation from sea level in Nishizaka to about 1000 feet in Kaminagasaki. A rough estimate of the proportion of each district shielded from the direct blast of the bomb is: Nishizaka, 25%; Katsuyama, 50%; Kaminagasaki, 100%. The casualty rates for these districts were: 28.9%, 14.6%, and 8.8%, respectively. There are less striking examples of asymmetry in Ring Zone 7, which is the area located 4.0 to 5.0 km. from the center. There were six ration districts within this zone: Tategami, on the west bank of the harbor; Naminohira, Minamioura, and Kitaoura on the east bank; and Nitta and Koshima which were farther east and inland. The terrain features of these districts and the casualty rates are tabulated for convenience in comparison. (see Table 8.)

TABLE 8

DISTRICT	TERRAIN FEATURES	CASUALTY RATE
Tategami	50% shielded by hills	4.3%
Naminohira	Inhabited portion was all on the shore of the bay, completely exposed to the blast.	8.5%
Minamioura	A small portion of inhabited area was on the shore of the bay. The ramainder was scattered on the lee side of low hills.	5.0%
Kitaoura	A small portion of inhabited area was on shore of bay. The remainder was at least 50% shielded by low hills.	4.6%
Nitta	Less than 50% was shielded by low hills.	5.6%
Koshima	There was no shielding of any important extent. The inhabited portion lay in a valley whose axis pointed directly to GZ.	9.4%

The portions of the city where a substantial shielding effect was provided by terrain features are shown in the map. (figure 3). The areas outlined are only approximations based on the contour lines drawn on the main reference map.* The height at which the airburst occurred has not been released by officials of the United States AAF. The value used for estimating the length of the shadows cast by the hills was 470 meters (1500 feet), a calculation made by the Japanese physicist, Professor NISHIMA. It is not possible to comment on the accuracy of this estimate. It is difficult to generalize about the influence of terrain on the basis of these data. No district, however, was completely protected because of its location. Windows were broken in every building in the city, and roof tiles and other detachable materials were blown loose. The most that can be said is that high hills such as those between the bomb and Kaminagasaki provided substantial

*Nagasaki City Plan; AMS L902, Type C (AMS 1), 1945. 1:12, 500.

protection to the residents. Minor differences in terrain, and variations in the type of buildings in a district seemed to have little detectable influence in the casualty rate.

It is possible to use the data obtained in the random sampling study to estimate casualty rates in the various ring zones. The location of blocks which were sampled was determined on the city plan map. The killed rate and wounded rate was summated for those blocks whose boundaries were entirely within one or another of the ring zones of the polar coordinate system. It was possible in this way to obtain data from a sufficient number of blocks in the seven rings zones. The casualty rates for these ring zones were as follows: See Table 9; also Appendix 10N.

TABLE 9

Ring Zone	Distance, Meters	% Killed	% Wounded	Total % Casualties
#1	0-1000	88.4	6.0	94.4
#2	1000-1500	51.5	26.0	77.5
#3	1500-2000	28.4	38.1	66.5
#4	2000-2500	6.1	28.7	34.8
#5	2500-3000	2.1	16.5	18.6
#6	3000-4000	1.2	9.9	11.1
#7	4000-5000	0.7	6.3	7.0
Average for City		20.08%	12.88%	32.96%

The killed rate and the total rate was then plotted against distance and smoothed curves were drawn. (figure 5). This graph should be compared with the similar one prepared from the casualty data for Hiroshima. These curves are very significant. They are the only reliable estimates of the relation between the casualty-producing power of the atomic bomb and distance. It can be seen from the graph that chances of survival were only 50%

at a distance of 1300 meters, or 0.8 miles. The chances of escaping injury of any sort were 50% at 1750 meters, or 1.1 miles.

STANDARDIZED KILLED AND CASUALTY RATE

An expression has been developed by students of the casualty-producing effects of explosives to facilitate a comparison of the efficacy of various weapons. The standardized killed rate (SKR), and the standardized casualty rate (SCR), are computed in such a way that the numbers of killed and wounded within the range of any weapon are adjusted to a standard density of population. The density value commonly used is 43 per acre, or one person for every 1000 square feet exposed to the risk of injury. The computation of SKR and SCR for one atomic bomb in Nagasaki is as follows:

TABLE 10

Ring Zone	Area at Risk (Sq. Miles)	Risk Rates Per Cent Killed	Risk Rates Per Cent Casualties
#1	1.21	88.4	94.4
#2	1.52	51.5	77.5
#3	2.12	28.4	66.5
#4	2.73	6.1	34.8
#5	3.34	2.1	18.6
#6	8.49	1.2	11.1
#7	10.91	0.7	7.0
	Vulnerable Area (V. A.) in square miles	2.70	4.69

(V.A. is the sum of the product of "area at risk" and "risk rate" for each of the 7 zones.)

Standardized Killed Rate = 75,271

Standardized Casualty Rate = 130,748

(SKR and SCR are calculated by multiplying V.A. by 27,878,000 - the number of square feet in one square mile - and then dividing through by 1000.)

For readers unfamiliar with the SKR for other weapons, a few typical values are cited:

	SKR
500 pound high explosive aerial bombs	6
2000 pound high explosive aerial bombs	20

Using these expressions, the number of 2000 pound HE bombs required to kill the same number of people as this one atomic bomb can be calculated readily:

$$\frac{75,271}{20} = 3,700 \text{ bombs}$$

TYPES OF CASUALTIES

There are no comprehensive records available which contain the proportion of each of the three main types of casualties that were produced by the explosion of the atomic bomb. This is undoubtedly a consequence not only of the almost incredible confusion of the first few days after the bombing, but also of the pressure of work in the aid stations. Actually, it would have been impossible at the outset to classify the patients as burned, wounded or injured by gamma radiation, because the symptoms of the latter were not apparent until about 14 August. Certain incomplete data were obtained, however, and this will be presented with the understanding that they were rough approximations at best:

a) Omura Naval Hospital: 658 patients were evacuated to this institution by hospital train, between 9-13 August. It is not unreasonable to assume that this group were representative of the type of patients who could be moved from the city, or who were able to get to the station. The classification of the injuries in this group was:

TABLE 11

Burns	177
Wounds	356
Burns and Wounds	85
Total	618
Total per cent burned	42% (177 plus 85)
Total per cent wounded	71% (356 plus 85)

The mortality rate for patients in this hospital was 22% (169 out of 758), at the end of September, 1945.

b) The records of the Ishahaye Naval Hospital showed that 689 patients were admitted up to about 15 September. The mortality rate for this installation was 34%.

c) The records of the Ureshino Naval Hospital showed that 211 patients were admitted up to the middle of September. The mortality rate was 18%.

d) The records of the Kawatana Naval Hospital showed that 276 patients were admitted up to the middle of October. The mortality rate was 27%.

The mortality rates cited in a, b, c, and d, are all crude rates but the majority of the patients that contributed to them were those who were admitted during the first week after the bombing.

e) The 216 Army Field Hospital (temporary) took over one of the aid stations which had been operated by the medical aid association of the city. A report of the Commanding Officer, dated 2 September, submitted the following information:

Burns (90% were second degree)	63%
Wounds	70%
Radiation Injury	In excess of 30%.

The mortality rate for 395 hospitalized patients until 2 September was 30%.

In view of the number of wounds, and general unhygienic circumstances, the reported incidence of tetanus is interesting:

Omura Naval Hospital	0.4%
216 Temporary Field Hospital	1.01%

d) Joint Commission Study of Survivors: An analysis of the questionnaires for 3846 injured survivors, completed between 1 October and 20 November, yielded the following data:

*Burns	34%
Wounds	65%
Radiation Injury	In excess of 35%

The extent to which conclusions may be safely drawn from this group is uncertain. The Sample was definitely not a random one in the true sense; however, it was sufficiently large, representing approximately one-sixth of all the injured who were alive after 1 October (3846 of 25,153) that it cannot be neglected. A thorough discussion of the limitations of this group will be found in the Statistical Section. It is impossible to manipulate these various data in any way which will produce an accurate answer to the question: What were the percentages of each type of injury? It is reasonable to conclude that under the circumstances, the best approximation would be the maximum rate for each category, or, in round numbers;

TABLE 12

PROPORTION OF TYPES OF CASUALTIES

Wounds	70%
Burns	65%
Radiation Injury	35%, plus

*Percentages do not add up to 100% because many patients had multiple injuries.

SUMMARY

From the study of the data which was collected on population and casualties, the following estimates seem most reasonable:

a) The population of Nagasaki on 9 August 1945 was 195,290.

b) The total number of dead by 1 January 1945 were 39,214. The wounded survivors at the same time were 25,153. This means a total of 64,367 casualties, or 33% of the population.

c) The standardized killed rate (SKR) for one Nagasaki-type atomic bomb is 75,271.

d) The proportion of the types of injury among these casualties were: Wounded: 70%; burns: 65%; radiation injury: more than 35%.

APPENDIX 10 N

POPULATION AND CASUALTIES

In Nagasaki, the irregular terrain, the uncertainty as to the precise city limits, and variations of the names of the block association (or Machi), contributed to the difficulties of a population and casualty study. The figures which are cited in section 10 N represent the best estimates available. The crude data on which some of these estimates are based is presented below. The random sampling study (See Appendix 10 H) provided the material for the casualty estimates in section 10 H. The crude data for each ration district is presented in Table A. From this crude data, the total casualties can be calculated in two ways. The first is as follows:

(1) $\frac{\text{Number of dead (or injured)}}{\text{Number of persons reported on}}$ = Per cent dead (or injured)

(2) Per cent dead (or injured) x Population = Total dead (or injured)

Substituting the data from Table A in equation (2) gives:

			(Using percentages cited in Section 10 N)
Dead:	195,290 x 20.8%	= 40,620	(39,214)
Injured:	195,290 x 13.0%	= 25,387	(25,153)
	Total Casualties:	= 66,007	(64,307)

The second way to treat the data is shown in Table 7 (10 N) where the per cent dead and injured in each ration district is multiplied by the pre-raid population. This method weights each ration district separately, and gives smaller values for the totals, as follows:

Dead: 29,570

Injured: 23,262

Total Casualties 53,832

A third method of estimation is accomplished by the rearrangement of the random sampling data shown in Table B. It was desired to know the killed and total casualty rate for each ring zone. Using the Nagasaki City Plan Map, block associations, for which random sampling data was available, were selected which appeared to be located entirely within one or another ring zone. The crude data are presented in Table B. In this tabulation 66 of the 229 block associations are used in the calculation of killed and casualty rates. The others over-lapped two ring zones. , The estimated pre-raid population of each ring zone was determined by locating on the City Plan Map each of the block associations listed in the May, 1946 ration report. The results are shown in Table C. The totals for each Ring Zone were corrected to take the population change between May-July into account. The correcting factor was

0.94 derived from $\frac{195,000 \text{ - July population}}{207,000 \text{ - May population}}$

In Table D the per cent killed and per cent injured in each ring zone is multiplied by the corrected pre-raid population to obtain estimated total killed and injured. The results:

Dead:	37,997
Injured:	19,174
Total casualties	57,172

are in fair agreement with the first group of figures. Since the first group of figures was obtained without weighting, or making any guesses as to the location of districts, etc., it has been selected as the preferred estimate of killed and wounded. It is believed that the tendency to overestimate will partially compensate for the family units which were completely wiped out. Such units naturally were not included, and their exclusion would result in an underestimate.

TABLE A. PART 1

NAGASAKI

RANDOM SAMPLING STUDY
Crude Data

RENGO CHONAIKAI DISTRICTS	TOTAL CENSUS DISTRICTS	NUMBER OF CENSUS DISTRICTS SAMPLED	NUMBER OF QUESTIONNAIRES SENT	NUMBER OF QUESTIONNAIRES ANSWERED
1. Shinkozen	37	37	60	47
2. Katsuyama	19	19	309	261
3. Kaminagasaki	12	5	240	209
4. Togiya	22	22	360	284
5. Irabayashi	18	13	360	291
6. Koshima	11	5	200	181
7. Nitta	12	4	240	205
8. Sako	13	12	220	189
9. Kitaoura	12	7	219	195
10. Minamioura	10	5	161	144
11. Naminohara	6	6	100	89
12. Tomachi	9	6	180	152
13. Tategami	6	6	100	93
14. Akunoura	11	4	200	164
15. Asahi	13	5	240	209
16. Inasa	21	6	220	187
17. Shiroyama	9	4	26	17
18. Yamazato	18	10	113	98
19. Zenza	19	13	61	60
20. Nishizaka	17	12	91	79
21. Kosakaki	5	4	100	75
22. Kogakura	5	5	40	39
23. Doinokubi	7	7	140	133
24. Nishiurakami	12	12	120	104
Grand Totals	324	229	4100	3505

TABLE A, PART 2

NAGASAKI

RANDOM SAMPLING STUDY
Crude Data

NUMBER OF PERSONS:

DISTRICT NO.*	REPORTED ON	DEAD	INJURED	UNHURT
1	632	16	130	486
2	726	10	96	620
3	818	2	70	746
4	862	10	103	749
5	987	14	35	938
6	785	26	48	711
7	592	4	29	559
8	508	2	35	471
9	668	1	30	637
10	501	4	21	476
11	283	13	11	259
12	675	2	22	651
13	441	1	18	422
14	863	13	98	752
15	615	15	148	452
16	1276	372	359	545
17	1028	919	59	50
18	2069	1335	383	351
19	1572	854	401	317
20	647	46	141	460
21	290	0	7	283
22	249	0	3	246
23	522	0	4	518
24	549	124	102	323
Total	18158	3783	2353	12022
Per cent Dead		20.8**		
Per cent Injured			13.0**	
Per cent Unhurt				66.2**

*See Table A, Part 1.

** There are minor differences between these percentages and the percentages used in Scction 10N which were 20.08, 12.88, and 67.04, respectively. This is due to the late arrival from Japan of the complete data shown in Tables A, B, and C.

TABLE B

NAGASAKI

RANDOM SAMPLING STUDY

Actual Data for Estimation of
Killed and Casualty Rate for Ring Zones

RING ZONE #1

Random Sampling Results

Ration District -Machi	Dead	Injured	Unhurt	Percent Dead	Percent Total Casualties
YAMAZATO					
Uenomachi	110	6	3		
Motoomachi	96	0	5		
Okamachi	88	2	4		
Yamazatomachi	421	27	18		
Hashigochicho	49	1	0		
ZENZA					
Sakamotomachi	195	15	21		
Iwakamachi	160	25	32		
SHIROYAMA					
Shiroyamacho	478	52	37		
Matsuyamacho	139	1	2		
Hamaguchicho	211	3	3		
NISHIURAKAMI					
Nishiurakamimachi	14	1	0		
TOTALS	1961	133	125	88.4	94.4

TABLE B

NAGASAKI

RANDOM SAMPLING STUDY

Actual Data for Estimation of
Killed and Casualty Rate for Ring Zones

RING ZONE #2

Random Sampling Results

Ration District -Machi	Dead	Injured	Unhurt	Percent Dead	Percent Total Casualties
YAMAZATO					
Motoharacho	115	53	132		
Epiramachi	66	3	8		
Ohashimachi	299	251	133		
Senomachi	49	29	46		
Takaomachi	42	11	2		
ZENZA					
Megamemachi	44	11	3		
Urakamimachi	191	61	42		
Morimachi	134	118	84		
NISHIURAKAMI					
Nishigo	19	5	8		
INASA					
Takenokubomachi	326	105	104		
TOTALS	1285	647	562	51.5	77.5

TABLE B

NAGASAKI

RANDOM SAMPLING STUDY

Actual Data for Estimation of
Killed and Casualty Rate for Ring Zones

RING ZONE #3

Random Sampling Results

Ration Districts -Machi	Dead	Injured	Unhurt	Percent Dead	Percent Total Casualties
ZENZA					
Funaguracho	12	6	9		
Zenzamachi	75	109	76		
NISHIZAKA					
Katobukicho	7	8	11		
Hamahiramachi	5	10	21		
TOTALS	99	133	117	28.4	66.5

RING ZONE #4

NISHIZAKA					
Yachiyomachi	3	13	15		
Mifunemachi	2	3	4		
Nishizakemachi	10	19	187		
INASA					
Inasacho I	13	33	39		
Inasacho II	8	83	164		
Inasacho III	24	118	196		
TOTALS	60	267	605	6.4	35.1

TABLE B

NAGASAKI

RANDOM SAMPLING STUDY

Actual Data for Estimation of
Killed and Casualty Rate for Ring Zones

RING ZONE #5

Random Sampling Results

Ration Districts -Machi	Dead	Injured	Unhurt	Percent Dead	Percent Total Casualties
INASA					
Asahicho I	0	12	31		
Asahicho II	1	9	11		
Asahicho III	6	14	44		
ASAHI					
Hiradokoyamachi	1	69	244		
NISHIZAKA					
Daibacho	2	33	43		
SHINKOZEN					
Funatsumachi	0	1	15		
Uragotomachi	1	2	0		
Gatomachi	3	10	32		
Iwamachi	1	0	10		
KATSUYAMA					
Kaminishiyamamachi	1	6	72		
KAMINAGASAKI					
Nishiyamamachi	12	32	285		
Katafuchicho	0	27	277		
TOTALS	28	215	1064	2.1	18.6

TABLE B

NAGASAKI

RANDOM SAMPLING STUDY

Actual Data for Estimation of
Killed and Total Casualty Rate for Ring Zones

RING ZONE #6

Random Sampling Results

Ration Districts -Machi	Dead	Injured	Unhurt	Percent Dead	Percent Total Casualties
AKUNOURA					
Akunouramachi	10	70	556		
Senowakimachi	0	0	22		
Mizimouramachi	3	26	158		
SHINKOZEN					
Edomachi	0	1	6		
Hiradomachi	0	0	1		
Sembamachi	0	7	31		
Kozenmachi	1	3	18		
KATSUYAMA					
Furumachi	0	4	30		
Koyamachi	0	3	49		
TOGIYA	0				
Togiyamachi	0	2	26		
Suwanomachi	0	4	43		
IRABAYASHI					
Sakurababamachi	1	4	76		
Nakagawamachi	0	0	101		
TOTALS	15	124	1117	1.2	11.1

TABLE B

NAGASAKI

RANDOM SAMPLING STUDY

Actual Data for Estimation of
Killed and Total Casualty Rate for Ring Zones

RING ZONE #7

Random Sampling Results

Ration Districts -Machi	Dead	Injured	Unhurt	Percent Dead	Percent Total Casualties
TATEGAMI					
Tategamimachi	0	10	114		
Higashitategamimachi	1	3	122		
KITAOURA					
Ouramotomachi	0	15	153		
Ourahigashiyamacho	1	1	108		
SAKO					
Kannaimachi	1	4	77		
Yoriaimachi	0	4	38		
KOSHIMA					
Kamikoshimamachi	2	17	196		
TOGIYA					
Yasakamachi	2	9	35		
Yanohiramachi	0	0	36		
TOTALS	7	63	918	0.7	7.1

OUTSIDE RING ZONES

TOMACHI	2	22	651		
KOSAKAKI	0	7	283		
KOGAKURA	0	3	246		
DOINOKUBI	0	4	518		
TOTALS	2	36	1698	0.1	2.2

TABLE C

NAGASAKI

ESTIMATION OF POPULATION BY RING ZONES

DISTRICT	RING #1	RING #2	RING #3	TOTAL
Yamazato	10644	4195	-	14839
Inasa	4986	5114	2061	16161
Zenza	4440	2341	4304	11085
Shiroyama	8650	-	-	8650
Nishiurakami	4153	3581	-	7734
Nishizaka	-		600	-
Totals	32873	15231	6965	

DISTRICT	RING #4	RING #5	RINGS #6 & 7 & REST OF CITY	TOTAL
Nishizaka	2316	4291	-	7207
Inasa	3000	1000	-	
Asahi	932	6525	1864	9321
Shinkozen	-	1590	7958	9548
Katsuyama	986	4437	4437	9860
Kaminagasaki	-	4662	4663	9325
Totals	7234	22505	122700 *	207308 *

Sources: a) Rice Rationing Data for May 1945.
b) Map of Nagasaki: AMS L-902

* Includes 103,778 in other ration districts. and outside city limits.

TABLE D

NAGASAKI

RANDOM SAMPLING STUDY

ESTIMATION OF KILLED AND INJURED BY RING ZONES

RING ZONE	POPULATION	KILLED	INJURED	TOTAL CASUALTIES
1	30,900	27,316	1,854	29,170
2	14,317	7,373	3,722	11,095
3	6,547	1,859	2,495	4,354
4	6,799	435	1,951	2,386
5	21,155	444	3,491	3,935
6	25,000	300	2,475	2,775
7	30,000	210	1,920	2,130
Outside Zones	60,572	60	1,267	1,327
Total	195,290	37,997	19,174	57,172

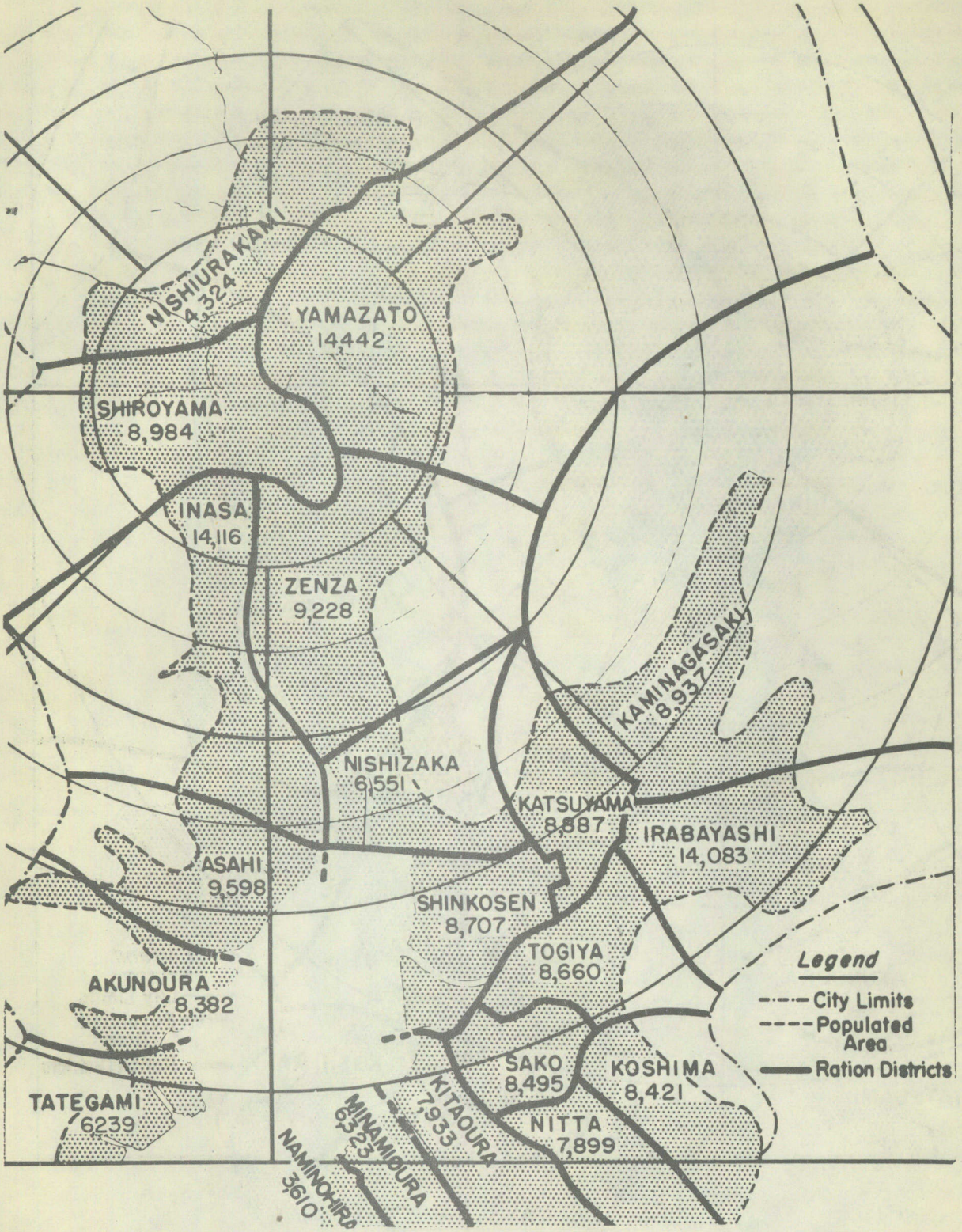

Figure 1--(10N). Outline map of Nagasaki showing ration districts and the population thereof in July 1945. The heavy polar coordinates are 1,000 meters apart. (Photo File # NP 161.)

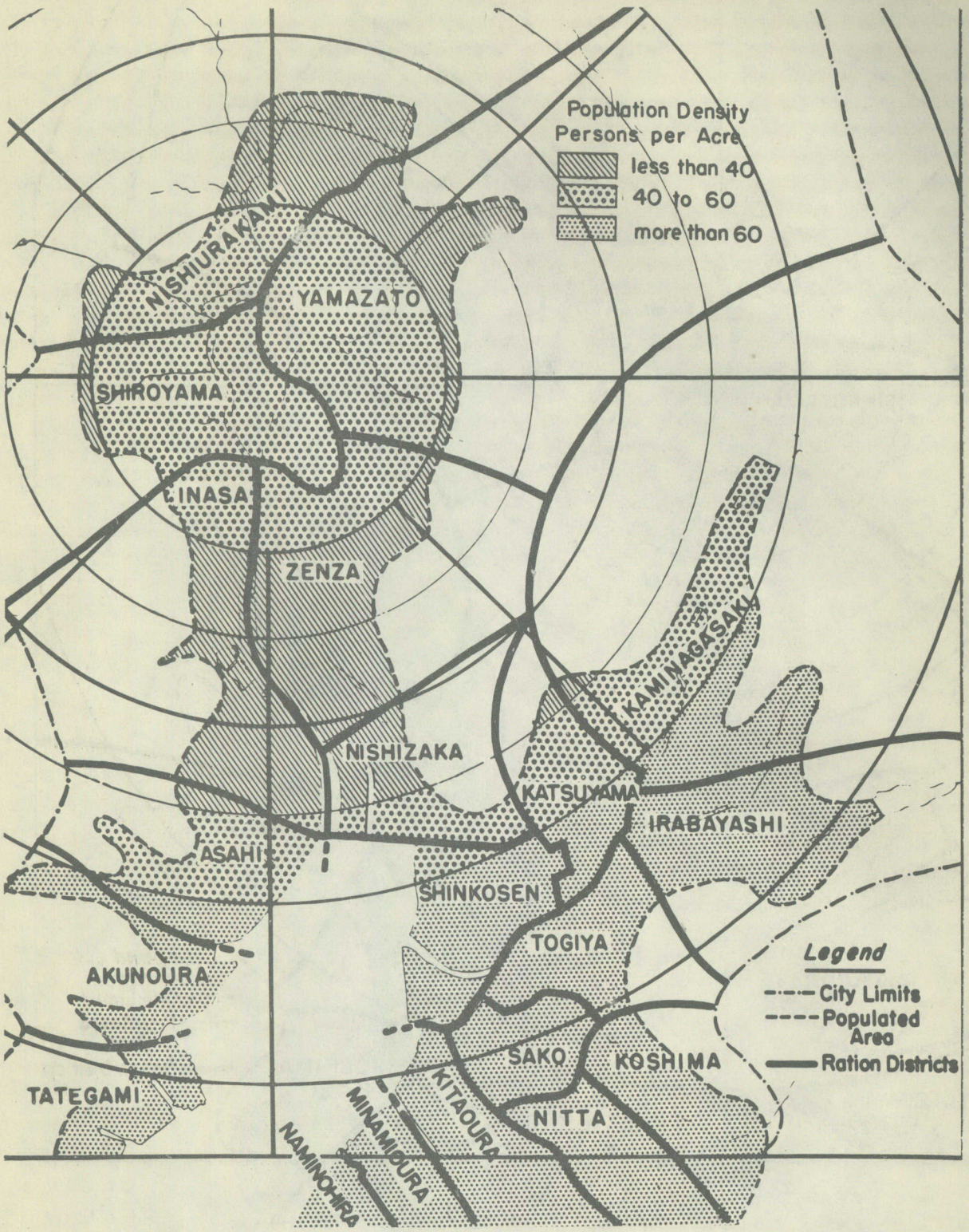

Figure 2--(10N). Outline map of Nagasaki showing population density per acre in the Ring Zones. (Photo File # NP 164.)

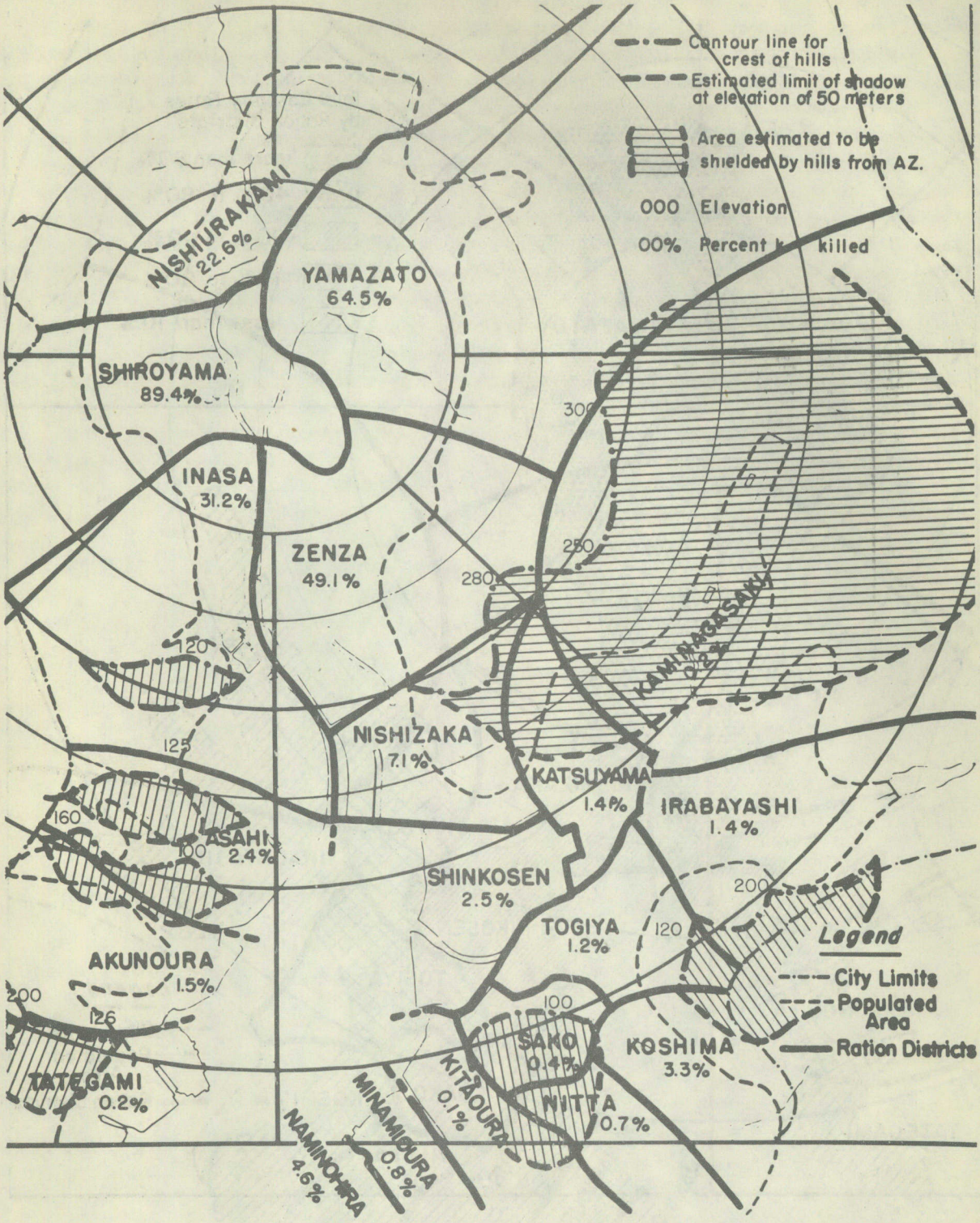

Figure 3--(10N). Outline map of Nagasaki showing portions of the city shielded by terrain features from the direct rays of the atomic bomb. The mortality rate for each ration district is shown. (Photo File # NP 162.)

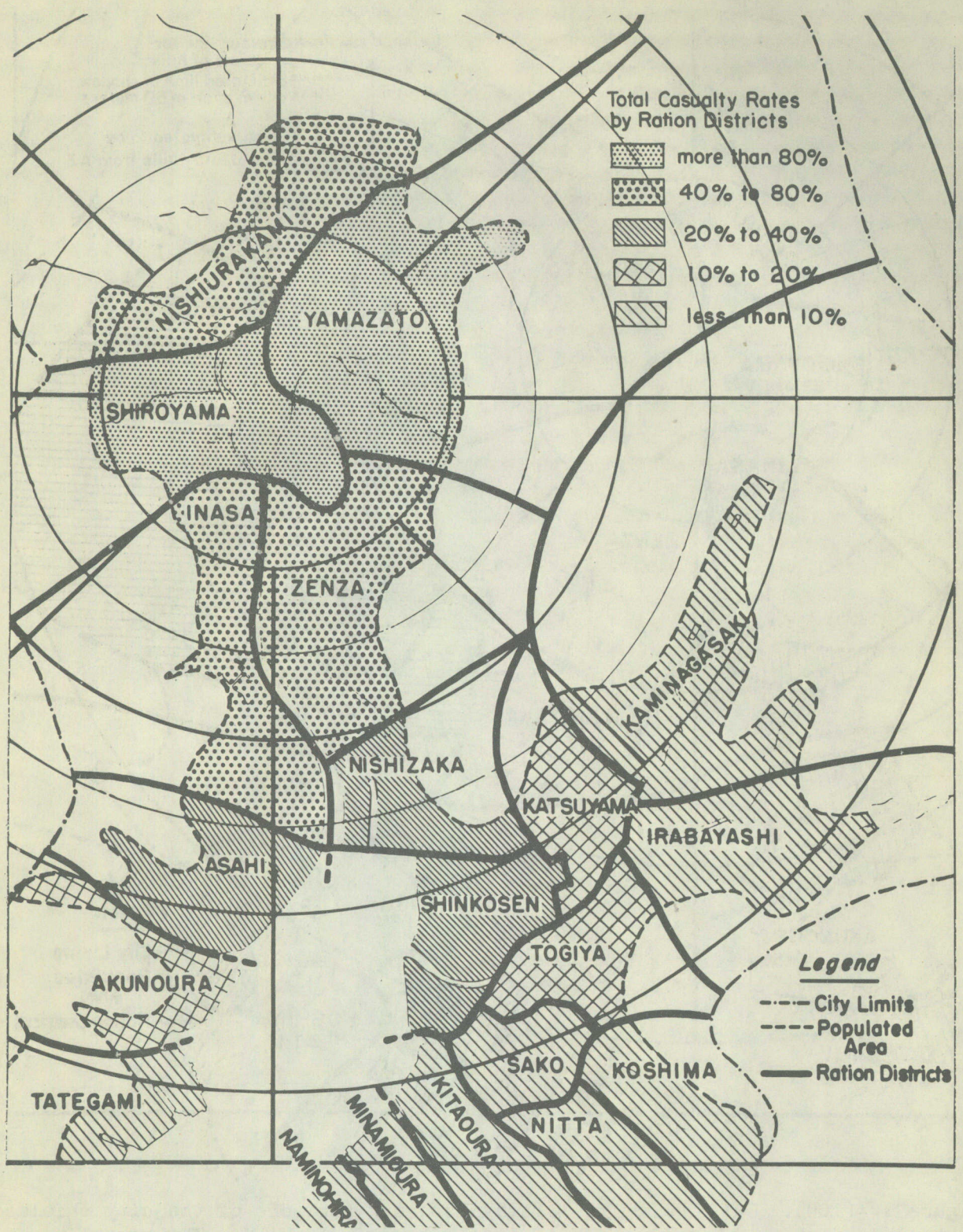

Figure 4--(10N). Outline map of Nagasaki showing the total casualty rate in each ration district. (Photo File # NP 165.)

RESTRICTED

KILLED RATE AND TOTAL CASUALTY RATE
NAGASAKI

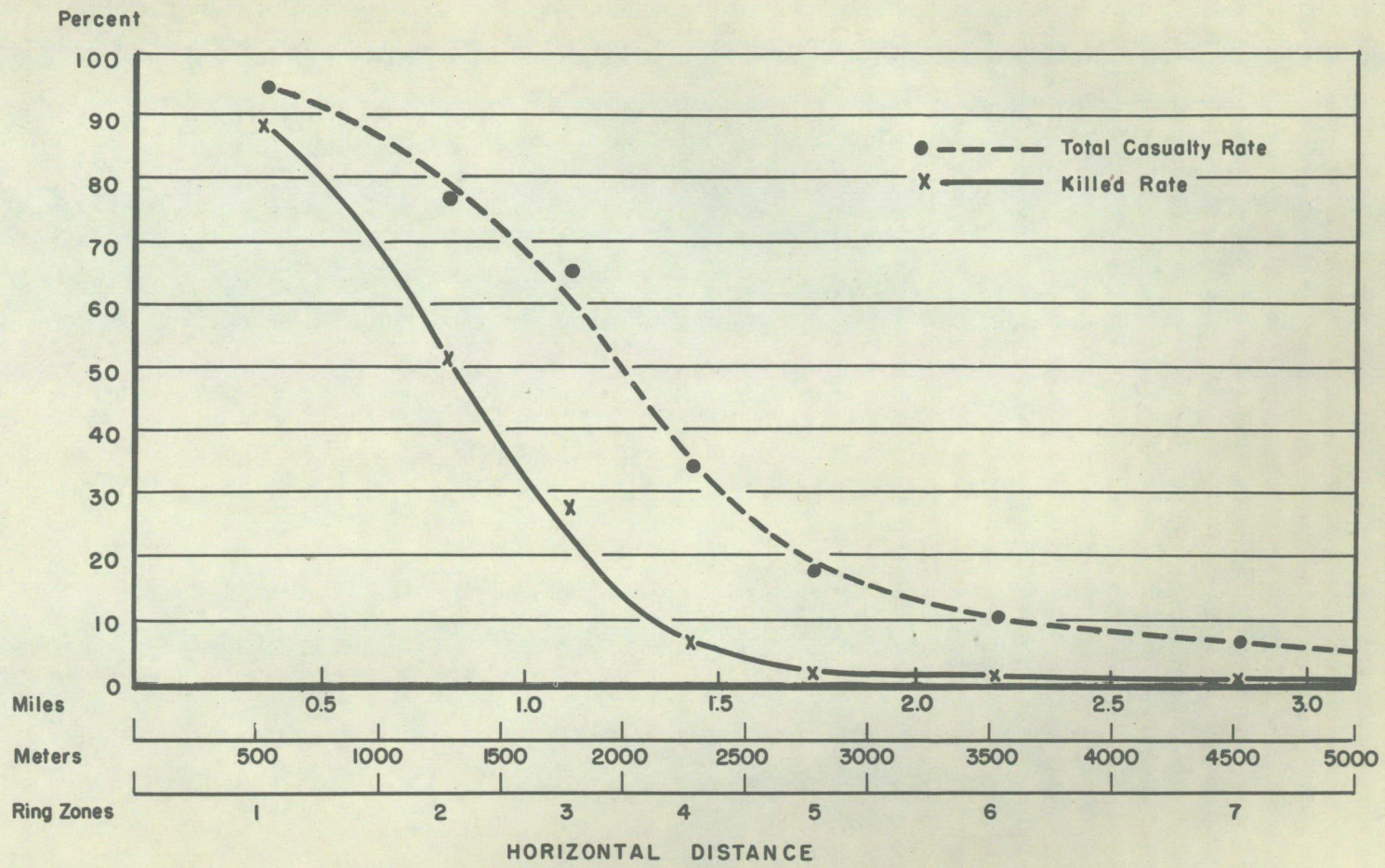

Figure 5--(10N). Smoothed curves of killed rate and total casualty rate. See Table 9 (10N). (Photo File # NP 166.)

Section 11H

BUILDING AND PROTECTION STUDIES *

Prepared by Averill A. Liebow, Lt. Col., MC, and Herbert S. Swanson, Lt. Col., CE

Data Collected by Averill A. Liebow, Lt. Col., MC, Jack D. Rosenbaum, Capt., MC, Milton L. Kramer, Major, MC, William Vance, 1st Lt., SnC, Dr. Koiti Murati, and Dr. Takeo Murai

A study of factors in protection is not only of fundamental scientific interest but has practical application as well. In a sense every one was partially "shielded", at least by the diluting effect of distance, and by the absorbing effect of air. In this section the additional factors of intervening buildings and the like are specifically considered.

The buildings or shelters that come under study are shown in an air view (figure 1), and on a map (figure 2).

The method was to gather, in correlation with the filtration factors, the fundamental data concerning symptoms and position of the patient, whenever possible by personal questioning and examination and to correlate this with the shielding factors.

Many leads were obtained during the course of the routine clinical survey as a result of interviewing patients or groups of patients who had been in some particular building at the time of the explosion. An example of this was the group of school girls from Hijiyama School who had served at Chugoku Communications Trench and who were brought back to the scene for a reconstruction of the course of events.

A source of error in such studies, aside from those inherent in the medical data, is the fact that position may not have been accurately recalled. This, of course, is particularly true in the hearsay cases.

*Filtration Factors Calculated Under Direction of Prof. Harry L. Bowman, Chief of Physical Damage Section, USSBS

Summary and Conclusions

The essential conclusions are stated before a detailed account of the method and the specific observations are presented.

The factors of protection from blast and burns have already been discussed in the preceding section but they may be recapitulated:

Against Blast: The best shelter against blast injury is afforded by concrete sunken in earth. Such a shelter has a one piece interior with no loose trim. The lesson of the underground communications shelter at the Chugoku Army Headquarters is that the ports should be closed; baffles are insufficient to protect against blast.

Against Burns: At more than 600 meters from the bomb (and no one in Hiroshima was closer) the shade even of a tile roof or a wooden wall is sufficient to protect from the radiant heat.

Against Radiation Injury: The correlation of the shielding effects of concrete buildings and shelters with the survival data of patients is summarized in figure 4.

1. At 250 meters (650 meters Airburst) more than 150 inches of water (5 ft. 4 in. of concrete) are necessary to protect against death from radiation effect, and more than 250 inches of water (9 ft. of concrete) are necessary to protect against radiation injury.

2. At 450 meters (750 meters from Airburst) at least 150 inches of water (5 ft. 4 in. of concrete) are necessary to protect against death. At least 250 inches of water (9 ft. of concrete) are necessary to protect against radiation effect.

3. At 550 meters (815 meters from airburst) at least 100 inches of water (3 ft 6 in of concrete) are necessary to protect against death and 250 inches of water (9 ft of concrete) are necessary to protect against radiation injury.

4. At 750 meters (960 meters from airburst) at least 50 inches of water (1 ft 9 in. of concrete) are necessary to protect against death and more than 250 inches of water (9 ft of concrete) are necessary to protect against radiation injury. If the structure has no windows facing center, then 200 inches of water (7 ft 3 in. of concrete) suffice to protect against radiation injury.

5. At 1000 meters (1165 meters from airburst) more than 4 inches of water (1.7 in. of concrete) are necessary to protect against radiation injury.

6. Beyond 1100 meters there were no individuals in concrete buildings who had clinical evidence of radiation effect.

Details of Study of Protection Against Radiation: These studies represent an inquiry into what shelters may be adequate to protect against radiation at various distances from the center. The attempt was to formulate the data in such terms as to make them applicable to other materials than were actually concerned in the particular case under consideration.

For the purposes of correlating factors in protection with the medical data, it was necessary to obtain exact building plans. Difficulties were encountered in some instances. The buildings "as constructed" were not "as planned" and adjustments were necessary from the records of actual measurements that had been made by the Joint Commission or USSBS or from photographs.

It is estimated that the inaccuracies introduced on that account are not large.

It was assumed:

1. That the radiation originated in a point source.

2. That the "rays" were parallel by the time that the buildings under investigation were reached.

Under these assumptions "shadows" cast by all structures in the paths of the rays could be projected on a plane. The plane selected was 1 meter above the floor level, as the most likely to pass close to the center of the sitting or standing human target. It was also assumed that all materials casting shadows exerted a filtration effect proportionate to their specific gravity. The various materials of which the buildings were constructed were reduced to a common denominator-filtration effect in terms of water. The filtration effect of the structures casting superimposed shadows obviously is additive and is so indicated in the diagrams.

It is obvious that in the case of radiation in consideration, a large factor of "scatter" must be considered and that the shadows are not sharp, as indicated. Consequently, the average shielding in terms of inches of water is indicated for selected areas in the drawings for purposes of easier correlation with the medical data. The test of whether a person near a window was in the direct line of the rays is whether or not a burn was sustained. This factor is considered in drawing conclusions from the correlations.

The general principle that a single case in which the facts are established beyond peradventure is worth a thousand dubious observations was employed. For this reason the observations concerning certain buildings are given considerable weight even though the patients were few.

Beams, mullions, etc., were usually askew to the path of the rays which made the problem of projection complex in the extreme. In calculating the "average filtration effect" of such structures as beams, conventions were adopted as indicated in the example which is described below.

In this example there is chosen a large room which is shown in both a sectional and an isometric drawing (fig 3). The plane of section is one meter above the floor for the reason already discussed.

EXAMPLE DRAWING OF TYPICAL ROOM

The conditions assumed:

GZ* point is 60 degrees from NORTH by WEST.

AZ** point is 60 degrees to ground level.

See table #2 for sizes and material assumed.

The height of the room, floor to ceiling, is 8' -0".

The gamma rays were assumed to travel in a line from the center of blast to the center of gravity of the building. This line is known as the AZ line and is 60° to ground. The rays projected shadows (shielding areas) of the walls, roof, etc., on a plane one meter above the floor level. The amount of protection is indicated in table #2. The greater the distance through the walls, roof, etc., the more shielding effect is offered. The shielding effect of each material is determined by the Specific Gravity. The AZ distance through a member is multiplied by its specific gravity, which gives the shielding effect in terms of inches of water, a useful common denominator.

The average depth of shield.

The shielding effect through any member has a maximum and minimum depth. In this report an average shielding effect is recorded. The illustration (insert of figure 3) shows how this average is computed. This shadow is projected as an area on the plane one meter above the floor. This area is indicated as "A". The actual area measured in determining the

*GZ: Point above which bomb exploded.
**AZ: Actual air-burst.

depth of shield is indicated as "B," hich is in square inches. This area is multiplied by the AZ distance through the member in inches of water to give the volume of material interposed between the ray and the shadow.

All the volumes of shield of the protected areas are added. They are then divided by the area of the entire room. The result is the average depth of shield for the entire room.

The depth of shield for a person.

In determining this depth of shield, all the shielding effects of the sections protecting the person, such as the roof, walls, columns, girders and beams, are added together. This result is known as the person's depth of shield.

Table #1 indicated the depth of shield for each person in the example.

Table #1

Person's Number	Shielded by	Depth of Shield
1	Column & Roof	140. in. H_2O
2	Roof only	39. in. H_2O
3	Wall column and North wall	176. in. H_2O
4	Window glass	0.561 in. H_2O

TABLE 2a

EXAMPLE BUILDING

Shielding Section and actual size	Shield depth AZ thru member**	Area (sq in)	Material Type	SG	Eff. depth in Inches of Water ea. matl	total	Average Volume of Shield of Protected area
Outside North Wall--10" thk	37.0" 3.0"	2925	Concrete 9¼" Plaster 3/4"	2.3 1.0	85.1" 3.0	88.1"	263,193
Outside West Wall--10" thk	21.3" 1.7"	4065	Concrete 9¼" Plaster 3/4"	2.3 1.0	49.1" 1.7"	50.8"	206,640
Inside North Wall--6" thk	18.0" 6.0"	@	Concrete 4½" *Plaster 1½"	2.3 1.0	41.4" 6.0	@	@
Inside West Wall--6" thk	10.4" 3.5"	@	Concrete 4½" *Plaster 1½"	2.3 1.0	23.9" 3.5"	@	@
Inside Col. 20" sq.	42.7" 3.5"	540B 840A	Conc 18½" *Plaster 1½"	2.3 1.0	98.2" 3.5	101.7"	35,136

*3/4" thick plaster on each side of column or wall.
@Wall does not affect room protective areas.

**This refers to the thickness of material penetrated by the ray from AZ in its oblique passage through the member.

TABLE 2b

EXAMPLE BUILDING

Shielding Section and actual size	Shield Depth AZ thru member**	Area (sq in)	Material Type	S.G.	Eff. Depth in Inches of Water ea. matl	Eff. Depth in Inches of Water total	Average Volume of Shield of Protected Area
North Wall	37.0"	330B	Concrete 9¼"	2.3	85.1"	88.1"	18,615
Col. 10"x20"	3.0"	540A	Plaster 3/4"	1.0	3.0"		
West Wall	21.3"	540B	Concrete 9¼"	2.3	49.1"	50.834"	20,508
Col. 10"x20"	1.7"	720A	Plaster 3/4"	1.0	1.7"		
Roof 12" thk	0.6"	57,942	Tile 1/2"	2.6	1.5"		
	12 4"		Conc 10-3/4"	2.3	28.5"	38.688"	2,241,660
	8.7"		Plaster 3/4"	1.0	8.7"		
Parapet 6" thk North Wall	24.0"	1,992	Concrete 6"	2.3	55.2"	55,200"	109,958
Parapet 6" thk	13.8"	848	Concrete 6"	2.3	31.9"	31.9"	27,009

**This refers to the thickness of material penetrated by the ray from AZ in its oblique passage through the member.

The minimum depth of shield is - 39 inches of water.
The maximum depth of shield is - 182 inches of water.
The average depth of shield is - 44 inches of water.

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The shielding factors and medical observations for each of the nine buildings on which the summarizing chart, figure 4, is based are presented in detail.

1. BANKERS' CLUB: (250 meters; 650 meters from Airburst).

The Bankers' Club was a brick-faced, reinforced concrete structure (fig. 7). The roof consisted of concrete covered with tile and had a thickness of 13 inches. The important rooms in this building are indicated in figure 5, where the positions of certain persons are shown.

The fate of 23 people in this building is known and the clinical histories of certain of the patients have been outlined in Section 5. All but two died of radiation effect. The 21 deaths all occurred before 24 August. The 2 survivors both had striking leukopenia, and, ultimately, epilation. In all 18 persons who had blood counts there was severe leukopenia.

The shielding factors are indicated in tables 3a, b, c. It happens that the room on the side of the building closest to the bomb (room 3 in figure 5) offered the most protection, on account of the shadow of the wall through which the rays passed at an oblique angle. The fate of the individuals together with the individual shielding data are presented in table 4.

CONCLUSIONS:

At a distance of 250 meters (650 meters from Airburst) probably much more than 150 inches of water (5 ft 4 in of concrete) are needed to protect against death from radiation effect.

TABLE 3a HIROSHIMA

BANKERS CLUB USSBS BUILDING No. 11, Room 1

Shielded Area on a Horizontal Plane 1 Meter above 2d Floor

Shielding Section	Actual Thickness	Shield Depth (inches)	Shield Area	Material Type	Material Depth	Material S.G.	Eff. Depth in Inches of Water	Remarks
Roof	13"	13.662	41,280	Concrete Tile	13.137 .525	2.3 2.6	30.216 1.366 = 31.582	12½" Concrete ½" Tile
3d Floor	9"	9.458	41,280	Concrete Plaster	8.670 .788	2.3 1.0	19.943 .788 = 20.738	8¼" Concrete 3/4" Plaster
North Inside Wall	6"	24.636	3,104	Concrete Plaster	18.477 6.159	2.3 1.0	42.497 6.159 = 48.656	4½" Concrete 1½" Plaster*
West Inside Wall	6"	31.530	3,564	Concrete Plaster	23.647 7.883	2.3 1.0	54.389 7.883 = 62.272	4½" Concrete 1½" Plaster*
Girders	11"	11.823	5,160	Concrete Plaster	11.035 .788	2.3 1.0	25.382 .788	10¼" Concrete 3/4" Plaster

Minimum Depth of Shield - 51 inches of water.
Maximum Depth of Shield - 141 inches of water.
Average Depth of Shield - 65 inches of water.

*1½" Plaster = 3/4" Each Side

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TABLE 3b HIROSHIMA

BANKERS CLUB. USSBS BUILDING No. 11, Room 2

Shielded Area on a Horizontal Plane 1 Meter above 1st Floor

Shielding Section	Actual Thickness	Shield Depth (inches)	Shield Area	Material Type	Material Depth	Material S.G.	Eff. Depth in Inches of Water		Remarks
Room	13"	13.662	24,696	Concrete	13.137	2.3	30.216	= 31.582	12½" Concrete
				Tile	.525	2.6	1.366		½" Tile
3d Floor	9"	9.458	24,696	Concrete	8.670	2.3	19.943	= 20.738	8¼" Concrete
				Plaster	.788	1.0	.788		3/4" Plaster
2d Floor	9"	9.458	24,696	Concrete	8.670	2.3	19.943	= 20.738	8¼" Concrete
				Plaster	.788	1.0	.788		3/4" Plaster
North Inside Wall	6"	24.636	7,056	Concrete	18.477	2.3	42.497	= 48.656	4½" Concrete
				Plaster	6.159	1.0	6.159		1½" Plaster*
West Inside Wall	6"	31.530	5,616	Concrete	23.647	2.3	54.389	= 62.272	4½" Concrete
				Plaster	7.883	1.0	7.883		
Roof Girder	13"	53.377	3,969	Concrete	50.298	2.3	115.686	= 118.765	12¼" Concrete
				Plaster	3.079	1.0	3.079		3/4" Plaster
Skylight	10"	41.06		Concrete	41.06	2.3	94.438		10" Concrete

Minimum Depth of Shield - 74 inches of water
Maximum Depth of Shield - 227 inches of water
Average Depth of Shield - 111 inches of water

*1½" Plaster - 3/4" Each Side

TABLE 3c HIROSHIMA

BANKERS' CLUB. USSBS BUILDING No. 11, Room 3

Shielded Area on a Horizontal Plane 1 Meter above 1st Floor

Shielding Section	Actual Thickness	Shield Depth (inches)	Shield Area	Material Type	Material Depth	Material S.G.	Eff. Depth in Inches of Water		Remarks
Roof	13"	13.662	13,908	Concrete Tile	13.137 .525	2.3 2.6	30.216 1.366	= 31.582	12½" Concrete ½" Tile
3d Floor	9"	9.458	20,496	Concrete Plaster	8.670 .788	2.3 1.0	19.943 .788	= 20.738	8¼" Concrete 3/4" Plaster
2d Floor	9"	9.458	28,548	Concrete Plaster	8.670 .788	2.3 1.0	19.943 .788	= 20.738	8¼" Concrete 3/4" Plaster
North	10"	41.061	17,568	Hard Brick Concrete Plaster	4.106 33.875 3.080	2.1 2.3 1.0	8.623 77.913 3.080	= 89.616	1" Hard Brick 8¼" Concrete 3/4" Plaster
Parapet	9"	36.954	3,660	Hard Brick Concrete	4.106 32.848	2.1 2.3	8.623 75.550	= 84.173	1" Hard Brick 8" Concrete
Girder	11"	11.823	3,510	Concrete Plaster	11.035 .788	2.3 1.0	25.382 .788	= 26.170	10¼" Concrete 3/4" Plaster
North Wall Column	12½"	50.299	1,944	Concrete Plaster	47.219 3.080	2.3 1.0	108.604 3.080		11½" Concrete 3/4" Plaster

Minimum Depth of Shield - .384 inches of water (window glass)
Maximum Depth of Shield - 275. inches of water
Average Depth of Shield - 241. inches of water

TABLE 4. HIROSHIMA

BANKERS' CLUB

Shielding and Fate of Personnel

	Patient's No. Identifying Number	Shield (in inches of water)
Group A: Alive, with no evidence of radiation effect.		
	0	
Group B: Alive, with radiation effect.		
Room 3	16	130
	33	244
Group C: Dead, with radiation effect.		
Room 1*	29	52
	40	121
Room 2**	17	74
	22	74
Room 3***	30	130

*Average depth of shield - 51 inches of water.
**Average depth of shield - 111 inches of water.
***Average depth of shield - 241 inches of water.

2. NIPPON BANK: (450 meters; 750 meters from Airburst).

This building was of reinforced concrete with an exterior finish of natural block granite (fig. 9). The exterior and interior design was very ornate. The roof was of cement tile and was covered with a layer of sand and cinders 18 inches thick for protection against American fire bombs (Fig. 14). Although the building withstood the blast as far as its external structure is concerned, there was tremendous damage to the partitions in the interior (figures 10-13). The thickness of the walls and roof and of the essential supporting structures is indicated in figure 8 and tables 5a, b, c. The position and fate of the people in this building are shown in figure 8, and are summarized in table 6.

CONCLUSIONS:

Considering this building as a whole, the death rate is high. At 450 meters (750 meters from Airburst) at least 150 inches of water (5 ft 4 in of concrete) are necessary to protect against death. At least 250 inches of water (9 ft of concrete) are necessary to protect against radiation effect.

TABLE 5a. HIROSHIMA

Shielded Area on a Horizontal Plane 1 Meter above 3rd Floor

NIPPON BANK

USSBS BLDG. #24

Shielding Section	Location	Shield Depth	Area	Material Type	Material %	Depth	S.G.	Eff. Depth in Inches of Water
Beam	Rb_1	24.85"	5480	conc plast	88.6 11.4	22.05 2.80	2.3 1.0	50.7 2.8 = 53.5
Beam	RB_1	34.10"	4950	conc plast	93.2 6.8	31.86 2.32	2.3 1.0	72.9 2.32 = 75.22
Girder	RWG_3	34.10"	1470	conc	100	34.10	2.3	78.5
Girder	RWG_1	34.10"	3620	conc	100	34.10	2.3	78.5
Girder	RWG_2	34.10"	6260	conc	100	34.10	2.3	78.5
Beam	Rb_2	21.6"	5000	conc plast	89 11	19.20 2.40	2.3 1.0	44.2 2.4 = 46.6
Girder	RG_{2-a}	34.1"	4280	conc plast	94.4 5.6	32.18 1.92	2.3 1.0	73.80 1.92 = 75.72
Girder	RG_1	34.1"	10090	conc plast	95.4 4.6	32.53 1.57	2.3 1.0	74.80 1.57 = 76.37

TABLE 5b. HIROSHIMA

Shielded Area on a Horizontal Plane 1 Meter above 3rd Floor

NIPPON BANK
USSBS BLDG. #24

Shielding Section	Location	Shield Depth	Area	MATERIAL Type	%	Depth	S.G.	Eff. Depth in Inches of Water
Column	1C,1D,1G	85.1"	6810	conc	92.6	81.8	2.3	188.2
				plast	3.8	3.3	1.0	3.3 = 191.5
Column	1A,2A	39.00"	3720	conc	96	37.44	2.3	86.00
				plast	4	1.56	1.0	1.56 = 87.56
Windows	West Wall Center	.175"	9180	glass	100	.175	2.6	.455
Windows	West Wall side	.175"	2674	glass	100	.175	2.6	.455
Windows	North Wall	.148"	4980	glass	100	.148	2.6	.348
Wall	West	58.6"	38549	gran	21.5	12.60	2.5	31.5
				conc	75.0	44.00	2.3	101.2 = 134.7
				plast	3.5	2.00	1.0	2.0
Wall	North	49.7"	16058	gran	21.5	10.7	2.5	26.8
				conc	75.0	37.3	2.3	85.8 = 114.3
				plast	3.5	1.7	1.0	1.7

TABLE 5c. HIROSHIMA

Shielded Area on a Horizontal Plane 1 Meter above 3rd Floor

NIPPON BANK
USSBS BLDG. #24

Shielding Section	Location	Shield Depth	Area	MATERIAL Type	%	Depth	S.G.	Eff. Depth in Inches of Water
Partition	Between Rms 1 & 3	18.7"	9537	conc	81.8	15.3	2.3	35.2
				plast	18.2	3.4	1.0	3.4 = 38.6
Roof		16.1"	166,450	tile	3.7	.6	2.2	1.32
				cind	50.0	8.05	0.8	6.45
				conc	41.0	6.60	2.3	15.20 = 23.82
				plast	5.3	.85	1.0	0.85
Cinders	On Roof	21.6"	156,000	cind	100	21.6	0.8	17.3

TABLE 6. HIROSHIMA

NIPPON BANK, 3rd Floor

Shielding and Fate of Personnel

	Patient's Identifying Number	Shield (in inches of water)
Group A: Alive, with no evidence of radiation effect.		
Room 1	1(?)	211
	4(?)	211
	9	154-192
Room 3	6	41
	17	211
Group B: Alive, with radiation effect.		
Room 1	8	211
	6	87
	10	41
	14	41
Room 3	1	154-192
	8	94-134
	10	94-134
	12	41
	13	41
	18	94-134
	19	94-134
Group C: Dead, with radiation effect.		
Room 1	5	.455
	13	94-134
	16	41
	20	87
Room 3	11	41
	16	41
	19 (11H)	

? - doubtful diagnosis.

3. CENTRAL TELEPHONE OFFICE: (550 meters; 815 meters from airburst).

This building was complex and had a varying number of floors in different sections. It was constructed of reinforced concrete, with an exterior finish of rough cement and an interior finish of either plaster or smooth cement (figures 20-25). The walls were of varying thickness and this added to the complexity. This is reflected in the extreme variation in the shadows cast by the various structural members on the selected plane (figs. 18, 19 and tables 7, 8).

In the figures are shown the positions of certain persons. These were accurately known since they were determined by seating at desks and tables of specified positions. They were verified by the Joint Commission and independently by another group of investigators.* A summary of individual factors of shielding is given in table 9.

The group of persons listed in table 9 as on the "second floor rear" were in the east wing near its south end. Some were under the shadow cast by a tower, which accounts for the variation in shielding. The tables for the exact calculation are omitted, but the values may be deduced from analogous calculations for the roof (as used in relation to rooms A-2 and B-2, fig. 18) and for a similar tower which shields a portion of the first

*Additional information concerning persons in this building was supplied by Drs. T. Mikawa, T. Sato, and A. Koda, of the Division of Environmental Health of the Institute of Public Health, Tokyo. This group reinvestigated the casualties late in November, 1945, and their data were almost identical with that previously obtained by the Joint Commission.

TABLE 7a. HIROSHIMA

CENTRAL TELEPHONE OFFICE. USSBS BLDG. No. 43, Rooms A-3 and B-2

Shielded Area on a Horizontal Plane 1 Meter above 2d Floor

Shielding Section	Location	Shield Depth (inches)	Shield Area	Material Type	Material Percent	Material Depth (inches)	Material S.G.	Eff. Depth in Inches of Water	Remarks
Beam	3B4A	17.538	2,009*	Concrete	100	17.538	2.3	40.33	Mean width .925'
Beam	3B1B	17.38	5,709*	Concrete	100	17.38	2.3	39.97	Mean width .925'
Beam	3B4B	17.38	6,336*	Concrete	100	17.38	2.3	39.97	Mean width .925'
Beam	4B1Ba	17.38	4,968*	Concrete	100	17.38	2.3	39.97	Mean width .925'
Beam	4B1B	17.38	5,054*	Concrete	100	17.38	2.3	39.97	Mean width .925'
Girder	3G3a	25.	8,953*	Concrete	100	25.	2.3	57.5	Mean width 1.325'
Girder	3G4	25.	7,457*	Concrete	100	25.	2.3	57.5	Mean width 1.325'
Girder	4G1	25.	6,786*	Concrete	100	25.	2.3	57.5	Mean width 1.325'
Shutter	3SF 2SF	1.63	537*	Steel	100	1.63	7.	11.41	Mean height .95'

*Shielding Area of one member.

TABLE 7b. HIROSHIMA

CENTRAL TELEPHONE OFFICE. USSBS BLDG. No. 43, Rooms A-2 & B-2

Shielded Area on a Horizontal Plane 1 Meter above 2d Floor

Shielding Section	Location	Shield Depth (inches)	Shield Area	Material Type	Material Percent	Material Depth (inches)	Material S.G.	Eff. Depth in Inches of Water	Remarks
Shutter	3SS 2SS	1.63	537*	Steel	100	1.63	7.	11.41	Mean height .95'
Wall (F)	3W1	23.1	17,100	Concrete Plaster Cement	90.41 2.74 6.85	20.88 0.54 1.58	2.3 1.0 2.9	48.76 .6 4.64 - 53.46	Mean width 14.6"
Wall (F)	4W3	23.1	50,764	Concrete Plaster Cement	90.41 2.74 6.85	20.88 0.54 1.58	2.3 1.0 2.9	48.024 0.540 4.582 - 53.146	Mean width 14.6"
Wall (S)	3W3	51.41	18,174	Concrete Plaster Cement	84.3 5.9 9.8	43.34 3.03 5.04	2.3 1.0 2.9	99.68 3.03 14.62 - 117.33	Mean width 1.275'
Wall	3P1F	12.00	28,619	Concrete Plaster	84. 16.	10.08 1.92	2.3 1.0	23.18 1.92 - 25.10	Mean width .625'
Wall	2P1S	25.	41,106	Concrete Plaster	84. 16.	21. 4.	2.3 1.0	48.30 4.00 - 52.30	Mean width .625'

*Shieldings Area of one member

TABLE 7c. HIROSHIMA

CENTRAL TELEPHONE OFFICE. USSBS BLDG. No. 43, Rooms A-2 & B-2

Shielded Area on a Horizontal Plane 1 Meter above 2d Floor

Shielding Section	Location	Shield Depth (inches)	Shield Area	Type	Material Percent	Depth (inches)	S.G.	Eff. Depth in Inches of Water	Remarks
Column	CA	11.54	633.6*	Concrete	100	11.54	2.3	26.54	Mean width .6'
Ceiling	2C	25.32	222,767	Concrete	31.15	7.89	2.3	18.15	
				Wood	47.54	12.04	0.5	6.02 - 27.02	Mean height 1.525'
				Plaster	6.56	1.66	1.0	1.66	
				Straw	14.75	3.73	0.32	1.19	
Roof	2R	27.66	46,733	Concrete	39.21	10.85	2.3	24.96	
				Mortar	31.37	8.68	1.6	13.89	
				Cinder	11.76	3.25	.8	2.6 - 46.74	Mean height 20"
				Plaster	7.84	2.17	1.0	2.17	
				Insulation	9.82	2.71	1.15	3.12	
Roof	3R	24.9	124,069	Mortar	31.37	7.81	1.6	12.5	
				Cinder	11.76	2.93	.8	2.34	
				Plaster	7.84	1.95	1.0	1.95 - 42.05	Mean height 18"
				Insulation	9.82	2.44	1.15	2.81	
				Concrete	39.21	19.76	2.3	22.45	
Window	Side	.149	680	Glass	100.	.149	2.5	.373	Mean width .09375"
Window	Front	.312	1,764	Glass	100.	.312	2.5	.780	Mean width .09375"

*Shielding Area of one member.

TABLE 7d. HIROSHIMA

CENTRAL TELEPHONE OFFICE. USSBS BLDG. No. 43, Rooms A-2 & B-2

Shielded Area on a Horizontal Plane 1 Meter above 2d Floor

Shielding Section	Location	Shield Depth (inches)	Shield Area	Material Type	Material Percent	Material Depth (inches)	S.G.	Eff. Depth in Inches of Water	Remarks
Cornice	CF4'	39.343	9,979	Concrete Cement	93.98 6.02	36.97 2.37	2.3 2.9	85.03 - 91.90 6.87	Mean width 2.075'
Cornice	CF3	39.343	5,544	Concrete Cement	93.98 6.02	36.97 2.37	2.3 2.9	85.03 - 91.90 6.87	Mean width 2.075'
Cornice	CS4	82.419	10,908	Concrete Cement	93.98 6.02	77.46 4.96	2.3 2.9	178.16 -192.54 14.38	Mean width 2.075'
Cornice	CS3	82.419	7,740	Concrete Cement	93.98 6.02	77.46 4.96	2.3 2.9	178.16 -192.54 14.38	Mean width 2.075'
Column	CB1	23.832	1,116	Concrete	100	23.832	2.3	54.81	Mean width .6'
Column	CC	42.	4,082*	Concrete	100	42.	2.3	96.60	Mean width 2.2'
Column	CB4	23.832	2,333*	Concrete	100	23.832	2.3	54.81	Mean width .6'
Beam	3B1A	17.538	2,119*	Concrete	100	17.538	2.3	40.33	Mean width .925'

*Shielding Area of one member.

RESTRICTED

TABLE 8a. HIROSHIMA

CENTRAL TELEPHONE OFFICE. USSBS BUILDING No. 43

Shielded Area on a Horizontal Plane 1 Meter above 1st Floor

Shielding Section	Location	Shield in inches Depth	Material Type	Percent	Depth	S.G.	Eff. Depth in Inches of Water
Cornice	CF 4	39.34	Concrete	93.98	36.97	2.3	85.03
			Cement	6.02	2.37	2.9	6.87 - 91.90
Cornice	CS 4	82.42	Concrete	93.98	77.46	2.3	178.16
			Cement	6.02	4.96	2.9	14.38 - 192.54
Cornice	CTS 4	39.34	Concrete	93.98	36.97	2.3	85.03
			Cement	6.02	2.37	2.9	6.87 - 91.90
Cornice	CTF 4	82.42	Concrete	93.98	77.46	2.3	178.16
			Cement	6.02	4.96	2.9	14.38 - 192.54
Column	CB 1	23.83	Concrete	100.	23.83	2.3	54.81
Column	CC	42.0	Concrete	100.	42.0	2.3	96.60
Column	CA	11.54	Concrete	100.	11.54	2.3	26.5
Arch. Col.	CA_1	30.0	Concrete	100.	30.0	2.3	69.
	CA_2	16.6	Concrete	100.	16.6	2.3	38.2
Beam	B_1	17.4	Concrete	100.	17.4	2.3	40.0
Girder	G	52.8	Concrete	100.	52.8	2.3	122.
Floor	) 2C2) 2C3))	25.32	Concrete	31.15	7.89	2.3	71.65
			Wood	47.54	12.04	0.5	6.02 = 88.95
			Plaster	6.56	1.66	1.0	6.56
			Straw	14.75	3.73	0.32	4.72
Tower Floors	TF 0.5	8.37	Concrete	100.	8.37	2.3	19.2
	TF 1	8.37	Concrete	100.	8.37	2.3	19.2
	TF 1.5	8.37	Concrete	100.	8.37	2.3	19.2
	TF 2	8.37	Concrete	100.	8.37	2.3	19.2
	TF 2.5	8.37	Concrete	100.	8.37	2.3	19.2

TABLE 8b. HIROSHIMA

CENTRAL TELEPHONE OFFICE. USSBS BUILDING No. 43.

Shielded Area on a Horizontal Plane 1 Meter above 1st Floor

Shielding Section	Location	Shield in inches Depth	Material Type	Percent	Depth	S.G.	Eff. Depth in Inches of Water
Steps	SS_1	11.80	Concrete	100.	11.80	2.3	27.1
	SS_2	11.80	Concrete	100.	11.80	2.3	27.1
	SS_3	11.80	Concrete	100.	11.80	2.3	27.1
	NS_1	21.0	Concrete	100.	21.0	2.3	48.3
	NS_2	21.0	Concrete	100.	21.0	2.3	48.3
	NS_3	21.0	Concrete	100.	21.0	2.3	48.3
Tower Roof Upper	TR	24.9	Mortar	31.37	7.81	1.6	12.50
			Cinder	11.76	2.93	.8	2.34
			Plaster	7.84	1.95	1.0	1.95 - 42.05
			Insulation	9.8	2.44	1.15	2.81
			Concrete	39.21	19.76	2.3	22.45
Roof	(Same as 3R above)						
Wall*	$2W_2$	26.6	Concrete	84.4	22.4	2.3	51.5
			Plaster	9.4	2.5	1.0	2.5 - 58.9
			Cement	6.2	1.7	2.9	4.9
Wall*	$2W_1$	12.7	Concrete	84.4	10.72	2.3	24.7
			Plaster	9.4	1.19	1.0	1.2 - 30.8
			Cement	6.2	.79	2.9	4.9
Wall	$3W_1$	23.1	Concrete	90.41	20.88	2.3	48.02
			Plaster	2.74	0.63	1.0	0.63 - 53.23
			Cement	6.85	1.58	2.9	4.58
Wall	$3W_3$	51.41	Concrete	84.3	43.34	2.3	99.68
			Plaster	5.9	3.03	1.0	3.03 - 117.33
			Cement	9.8	5.04	2.9	14.62
Window	Side	.149	Glass	100.	.149	2.5	.372
Window	Front	.312	Glass	100.	.312	2.5	.780
Floor 2d floor	1C	26.95	Concrete	29.27	7.890	2.3	18.15
			Wood	57.23	15.423	0.5	7.71
			Plaster	6.15	1.657	1.0	1.66 - 28.15
			Straw	7.35	1.980	0.32	.63

*8" walls

TABLE 9. HIROSHIMA

CENTRAL TELEPHONE OFFICE

Shielding and Fate of Personnel

	Patient's Identifying Number	Shield (in inches of water)
Group A: Alive, with no evidence of radiation effect.		
Second floor rear	27	195
	28	195
	29	195
	31	73
	32	195
Rooms C-1 & D-1	4	348
	6	419
	10	304
	11	304
	12	304
	13	323
	14	323
Group B: Alive, with radiation effect.		
Rooms A-2 & B-2	(?)36	67
	(?)37	153
	(?)38	187-250
	(?)39	134-186
	(?)40	80
	41	80

? - doubtful diagnosis (cont'd)

	Patient's Identifying Number	Shield (in inches of water)
Group B: Alive, with radiation effect.		
Rooms A-2 & B-2	(?)42	84
	(?)43	66
Second floor rear	17	73
	18	195
	19	195
	20	73
	21	73
	22	73
	23	73
	24	73
	25	195
	26	195
	30	195
	33	73
	34	195
C-1 & D-1	1	303
	2	182
	(?) 3	234
	5	346

(cont'd)

(?) - doubtful diagnosis.

	Patient's Identifying Number	Shield (in inches of water)
Group C: Dead, with radiation effect.		
Rooms A-2 & B-2	Fuya	59
	Ishimoto	59
	Kawasaki	117
	Nakata	67
Rooms C-1 & D-1	Matsumoto	151
	Yamanata	206

4. CHUGOKU ELECTRIC COMPANY (750 meters; 960 meters from Airburst).

This building consisted of 4 stories and a basement. Its external finish was of pink imitation granite in blocks which formed the exterior surface of reinforced concrete walls. The interior finish was of cement and plaster (figs. 28-34). Patients on the 3rd and 1st floors have come under study and their positions are indicated in figures 26 and 27. Shielding factors are presented in tables 10, 11 and 12.

CONCLUSIONS:

At 750 meters (960 meters from airburst) at least 50 inches of water (1 ft 9 in of concrete) are necessary to protect against death, and more than 250 inches of water (9 ft of concrete) are necessary to protect against radiation injury in a building with windows. From inspection of figures 26 and 27, it is obvious that there is a much higher incidence of fatal and other radiation injuries on that side of the building where the windows faced the explosion and where nothing more than penetration of glass was necessary for the rays to enter the proximal room. This is particularly striking in the rear wing of this building.

TABLE 10a. HIROSHIMA

CHUGOKU ELECTRIC COMPANY USSBS BLDG. NO. 26

Shielded Area on a Horizontal Plane 1 Meter above 3rd Floor

Shielding Section	Shield Depth	Area	Type	Material Percent	Depth	S.G.	Eff. Depth in Inches of Water	
North Wall	20.85"	1,185	Granite	2.7	.56	2.5	1.40	
			Concrete	88.3	18.42	2.3	42.39	= 47.71"
			Cement	5.2	1.08	2.9	3.13	
			Plaster	3.8	.79	1.0	.79	
Column	32.7"	796	Concrete	88.5	28.94	2.3	66.56	
			Cement	6.6	2.16	2.9	6.26	= 74.42"
			Plaster	4.9	1.60	1.0	1.60	
Girder	52.2"	282	Concrete	92.2	48.13	2.3	110.70	
			Cement	4.2	2.19	2.9	6.35	= 118.93"
			Plaster	3.6	1.88	1.0	1.88	
Beam	16.2"	688	Concrete	77.0	12.47	2.3	28.68	
			Cement	13.2	2.14	2.9	6.20	= 36.47"
			Plaster	9.8	1.59	1.0	1.59	
Partition	26.1"	133	Concrete	71.4	18 64	2.3	42.97	
			Cement	23.0	6.00	2.9	17.40	= 61.83"
			Plaster	5.6	1.46	1.0	1.46	

TABLE 11a. HIROSHIMA

CHUGOKU ELECTRIC COMPANY USSBS BLDG. NO. 26

Shielded Area on a Horizontal Plane 1 Meter above 1st Floor

Shielding Section	Shield Depth	Area	Type	Material Percent	Depth	S.G.	Eff. Depth in Inches of Water	
North Wall	20.85"	2,799.6	Granite	2.7	.56	2.5	1.40	
			Concrete	88.3	18.42	2.3	42.39	
			Cement	5.2	1.08	2.9	3.13	= 47.71"
			Plaster	3.8	.79	1.0	.79	
Column	32.7"	2,480.1	Concrete	88.5	28.94	2.3	66.56	
			Cement	6.6	2.16	2.9	6.26	= 74.42"
			Plaster	4.9	1.60	1.0	1.60	
Girder	52.2"	438	Concrete	92.2	48.13	2.3	110.70	
			Cement	4.2	2.19	2.9	6.35	= 118.93"
			Plaster	3.6	1.88	1.0	1.88	
Beam	16.2"	849.9	Concrete	77.0	12.47	2.3	28.68	
			Cement	13.2	2.14	2.9	6.20	= 36.47"
			Plaster	9.8	1.59	1.0	1.59	
Floor - 2d	13.37"	3,672.5	Cinder	27.8	3.71	.8	2.97	
			Concrete	58.2	7.78	2.3	17.89	= 24.52"
			Cement	7.0	.94	2.9	2.72	
			Plaster	7.0	.94	1.0	.94	

TABLE 11b. HIROSHIMA

CHUGOKU ELECTRIC COMPANY USSBS BLDG NO. 26

Shielded Area on a Horizontal Plane 1 Meter above 1st Floor

Shielding Section	Depth	Area	Type	Percent	Depth	S.G.	Eff. Depth in Inches of Water	
Floor - 3d	13.37"	2,810.5	Cinder	27.8	3.71	.8	2.97	
			Concrete	58.2	7.78	2.3	17.89	= 24.52"
			Cement	7.0	.94	2.9	2.72	
			Plaster	7.0	.94	1.0	.94	
Floor - 4th	"	1,959.8	"	"	"	"	"	
Floor - 5th	"	946.	"	"	"	"	"	
Roof	15.25"	730.1	Tile	12.2	1.86	2.2	4.09	
			Cinder	24.4	3.72	.8	2.98	
			Concrete	51.2	7.81	2.3	17.96	= 28.66"
			Cement	6.1	.93	2.9	2.70	
			Plaster	6.1	.93	1.0	.93	
Window	.1"	645.8	Glass	100	.1	2.6	.26	
West Wall	66.0"	1,565.6	Granite	2.7	1.78	2.5	4.45	
			Concrete	88.3	58.28	2.3	134.04	= 150.95"
			Cement	5.2	3.43	2.9	9.95	
			Plaster	3.8	2.51	1.0	2.51	

Average depth of shield - 222 inches.

RESTRICTED

TABLE 12. HIROSHIMA

CHUGOKU ELECTRIC COMPANY

Shielding and Fate of Personnel

	Patient's Identifying Number	Shield (in inches of water)
Group A: Alive, with no evidence of radiation effect.		
3d Floor	85	34
	86	24
	90	217
	(?)93	77
	94	125
	95	125
	97	24
	98	24
	104	24
	105	169
	108	24
	109	24
	111	169
	121	24
	127	24
	128	24
	129	24
	130	169

? - doubtful diagnosis.

	Patient's Identifying Number	Shield (in inches of water)
Group B: Alive, with radiation effect.		
3d Floor	91	169
	96	169
	99	169
	107	169
	117	24
	118	24
	119	77
	120	77
	121	24
	125	24
	126	24
	XVII	217
1st Floor	9	24
	10	.26 - 24
	11	24
	12	24
	13	77
	15	125
	17	217
	(?)23	169
	(?)27	.26
	(?)34	24
	(?)35	77
	36	.26

? - doubtful diagnosis.

	Patient's Identifying Number	Shield (in inches of water)
Group B: Alive with radiation effect.		
1st floor	37	24
	38	.26
	IV	.26
	V	24
	VII	77
	IX	24
	X	24
Group C: Dead, with radiation effect.		
3d Floor	87	.26
	102	24
	113	24
	114	24
	116	24
	124	24
1st Floor	31	24
	32	.26
	33	.26
	40	24
	41	24

5. CHUGOKU ARMY HEADQUARTERS COMMUNICATIONS TRENCH: (750 meters; 960 meters from airburst).

The Communications building at Chugoku Army Headquarters is situated within the moated military area. It is a concrete structure largely below ground level with additional protection afforded by earth on the roof (see insert of figure 35). The side of the building facing the explosion received additional protection from the stone facing of the moat. The strong construction of this shelter is apparent from an inspection of figures 37-39. The shielding factors are summarized in table 13. The shielding of the individuals is obvious in figure 35, and a separate tabulation, therefore, is unnecessary.

Information concerning casualties was obtained from the following sources:

1. Examination of survivors, all of whom were students at the Hijiyama Girls' High School.

2. Information from teachers and pupils of the school concerning the fate of others (both students and soldiers in the Communications Trench).

Twenty-six Hijiyama School girls were working in the building as switchboard operators and in other capacities on the morning of 6 August 1945. Of these 26 girls, 19 were subsequently examined by members of the Atomic Bomb Commission, 16 on 5 November and 3 on 14 November 1945. The position of these girls within the building is shown in fig. 35. The examination revealed that 8 of the girls were unhurt, and 11 sustained

minor contusions or lacerations caused by flying debris. One of the 11 girls injured had very dubious radiation sickness (questionable history of petechiae 1 - 3 September 1945). Another of the wounded girls probably had a mild cerebral concussion due to blast (unconscious for several minutes after the explosion with no mechanical head injury). Of the 7 students not examined in the survey, 2 were drowned in the castle moat while trying to escape from the area after the bombing. The other 5 were known to be living and well and to have suffered no serious ill effects after the bombing. Seventeen of the 19 girls examined had total and differential leukocyte counts at the time of examination. None was remarkable.

On the basis of the group studied, therefore, it appears that the building furnished complete protection against burns and probably against radiation sickness despite its proximity to the explosion. Blast was clearly perceived by all eye-witnesses present and was strong enough to produce minor secondary injuries due to flying debris. The doors and windows (figures 37, 38 and 39) on the west face of the building were open at the time of the explosion and most eye-witnesses thought that the blast came from the direction of the door.

Information of uncertain reliability was obtained from the school-girls concerning the fate of 13 of the soldiers present in the building on the morning of 6 August 1945. The position of these soldiers at the time of the explosion is shown in the figure. Of the 13 soldiers, 6 were said to be alive, 6 missing, and 1 had died in September, 1945. Of the

6 living, 3 had suffered minor secondary injuries, 1 had malaise and abdominal pain for an uncertain period, 1 was said to have had purpura and the last was asymptomatic. No information was available concerning the missing. The soldier who died was said to have had epilation and questionable purpura.

DISCUSSION:

It is probable that the underground trench afforded complete protection against radiation effects. The Commission is inclined to question the reliability of the statements concerning the soldiers who died, whose symptoms as given by hearsay indicated radiation effects despite very heavy shielding.

CONCLUSIONS:

In this structure which had no windows directly facing the blast and which was at the same distance as the Chugoku Electric Company building discussed in the preceding paragraphs, two hundred inches of water (7 ft 3 in of concrete) suffice to protect against radiation injury.

Blast effects indicate that ports of such shelters should be kept closed; baffles are insufficient.

TABLE 13. HIROSHIMA

CHUGOKU HEADQUARTERS BOMBPROOF COMMUNICATIONS CENTER. USSBS BUILDING NO. 211

Shielded Area on a Horizontal Plane 1 Meter above Floor

Shielding Section	Shield Depth (inches)	Shield Area	Material Type	Material Depth (inches)	S.G.	Eff. Depth in Inches of Water
Roof	142.8	1707	Concrete Earth	43.8 99.0	2.3 1.6	159 - 260 101
South Extr. Wall	142.2	362	Concrete Earth	32.2 110.	2.3 1.6	74 - 250 176
West Extr. Wall	70.2	36	Concrete	70.2	2.3	161
West Wall Windows	24.7	6	Concrete	24.7	2.3	57
Intr. Partitions	66.2	124	Concrete	66.2	2.3	155
Columns	44.3	25	Concrete	44.3	2.3	102
Roof Beams	6.5	90	Concrete	6.5	2.3	15

Average Depth of Shield - 275 inches of water.

6. BROADCASTING STATION, JOFK: (1000 meters, 1165 meters from airburst).

The Broadcasting Station, JOFK, was of reinforced concrete. The only persons in the building to have suffered from radiation effect were in a shelter on the roof that was completely demolished in the explosion. It is assumed that there were no windows in this building which was adjacent to the stair-housing on the roof whose windows and doors were large. The composition of the walls and roof was determined by inspection of the debris and the thickness of the structure was deduced from the width of the lines of attachment along the walls. A diagram of the structure is found in figure 40. The shielding factors are summarized in table 14.

CONCLUSIONS:

At 1000 meters (1165 meters from airburst) an average shield of 4.0 inches of water (1.7 inches of concrete) is insufficient to protect against radiation effect.

7, 8 and 9. BUILDINGS BEYOND 1100 METERS:

A series of 3 buildings, all situated beyond 1100 meters, was studied from the point of view of shielding factors. In the most exposed rooms where certain persons were known to have been, the findings give information concerning the average shielding effect, in none of which any person is known to have suffered clinical evidence of radiation effect.

A. At the City Hall (1200 meters), which is constructed of reinforced concrete, in a room on the third floor where the average depth of shield was 104 centimeters, with a minimum of 30 cm. and a maximum of 286 cm., none of 4 people had radiation effect. See figs. 42 and 43 and table 15.

B. At the Department of Communications Building (1400 meters from the point above which the bomb exploded) none of approximately 50 persons who were in various parts of this large room showed radiation effect. Shielding varied from 0.25 inches to 260 inches of water, with an average of 79 inches. See figures 44 and 45 and tables 16 a, 16 b.

C. At the Red Cross Hospital (1600 meters) the average depth of shield in one of the most exposed rooms was 52 inches of water, with a minimum of 0.41 inches and a maximum of 240 inches. Most of the persons in this room had radiation effect. See figures 46 and 47 and tables 17a.

CONCLUSIONS:

In no building of reinforced concrete structure beyond 1100 meters from the point above which the bomb exploded was there a certain case of radiation effect with clinical manifestations. It is possible, however, that leukopenia may have occurred at some time in these cases.

TABLE 14. HIROSHIMA

BROADCASTING STATION JOFK. USSBS BUILDING NO. 65

Shielded Area on a Horizontal Plane 1 Meter above Roof

Shielding Section	Depth (in inches)	Area (sq ft)	Type	Percent	Depth	S.G.	Eff. Depth in Inches of Water
Roof Area III	5.84	16.53	Tarpaper	4.35	0.254	1.	0.254
			Steel	4.35	0.254	7.5	1.90
			Concrete	69.6	4.06	2.3	9.35 - 12.77"
			Plaster	21.7	1.27	1.	1.27
Area 1	2.61	450.62	Plaster	97.	2.53	1.	2.53
			Steel	3.	0.079	7.5	.592 - 3.12"
Area 2	5.44	57.85	Plaster	97.	5.28	1.	5.28
			Steel 1/32" ea. side = 1/16"	3.	0.16	7.5	1.2 - 6.48"

The minimum depth of shield is - 3.12 inches.
The maximum depth of shield is - 12.77 inches.
The average depth of shield is - 3.80 inches.

RESTRICTED

TABLE 15. HIROSHIMA

HIROSHIMA CITY HALL USSBS BLDG. No. 28, Room 6

Shielded Area on Horizontal Plane 1 Meter above Top Floor

Shielding Section	Shield Depth (inches)	Shield Area (sq ft)	Material Type	Material Depth (inches)	Material S.G.	Eff. Depth in Inches of Water
Roof	27.8"	1,176	Tile	2.	2.6	5.2"
			Concrete	22.8	2.3	52.4" - 60.0
			Cinder	3.	.8	2.4"
Outside Wall	14.3	573	Concrete	12.8	2.3	29.4"
			Graphite	.6	2.	1.2" - 31.5
			Plaster	.9	1.	.9"
Hall Partition	8.63	874	Tile	2.46	2.6	6.4" - 20.6
			Concrete	6.17	2.3	14.2"
Room Partition	23.6	71	Tile	6.72	2.6	17.5" - 56.4
			Concrete	16.9	2.3	38.9"
Interior Column	36.4	210	Concrete	36.4	2.3	83.8"
Beams	37.2	119	Concrete	37.2	2.3	85.8"
Exterior Columns	22.	56	Concrete	22.	2.3	50.5"

Minimum Depth of Shield - 30 inches of water
Maximum Depth of Shield - 286 inches of water
Average Depth of Shield - 104 inches of water

RESTRICTED

TABLE 16a. HIROSHIMA

HIROSHIMA COMMUNICATIONS DEPARTMENT USSBS BUILDING #65

Shielded Area on a Horizontal Plane 1 Meter above Top Floor

Shielding Section	Shield Depth (inches)	Area (sq ft)	Material Type	Percent	Depth	S.G.	Eff. Depth in Inches of Water	
South Wall	8.08	1148.	concrete	89.6	7.25	2.3	18.59	= 19.43
			plaster	10.4	.75	1.0	.84	
West Wall	28.15	237.25	concrete	89.6	25.24	2.3	25.24	= 58.05
			plaster	10.4	2.91	1.0	2.91	
Roof	40.17	3798.75	concrete	82.7	33.24	2.3	76.45	
			cinder	12.0	4.83	.8	3.87	= 82.41
			plaster	5.3	2.09	1.0	2.09	
Column #1	16.06	455.	concrete	94.7	15.22	2.3	35.01	= 35.85
			plaster	5.3	.84	1.0	.84	
Column #2	20.07	455.	concrete	91.6	18.40	2.3	42.32	= 43.99
			plaster	8.4	1.67	1.0	1.67	
Girder #1 & 3	16.05	#1 - 280. #3 - 728.	concrete	89.6	14.38	2.3	33.07	= 34.74
			plaster	10.4	1.67	1.0	1.67	

TABLE 16b. HIROSHIMA

HIROSHIMA COMMUNICATIONS DEPARTMENT USSBS BUILDING #65

Shielded Area on a Horizontal Plane 1 Meter above Top Floor

Shielding Section	Shield Depth (inches)	Area (sq ft)	Material Type	Material Percent	Depth	S.G.	Eff. Depth in Inches of Water
Girder #2	9.48	672.	concrete plaster	82.4 17.6	7.81 1.67	2.3 1.0	17.96 1.67 = 19.63
Beam	46.59	303.75	concrete plaster	87.5 12.5	40.77 5.82	2.3 1.0	93.77 5.82 = 99.59
Parapet (front)	9.37	800.	concrete	100.	9.37	2.3	21.54 - 21.54
Parapet (side)	32.61	70.	concrete	100.	32.61	2.3	75.00 - 75.00
Windows (south)	0.105	782.	glass	100.	0.105	2.4	0.25 - 0.25
Windows (west)	0.36	18.75	glass	100.	0.36	2.4	0.87 - 0.87

Average depth of shield - 78.6 inches.

TABLE 17a. HIROSHIMA

RED CROSS HOSPITAL. USSBS BUILDING NO. 31

Shielded Area on a Horizontal Plane 1 Meter above Top Floor

Shielding Section	Shield Depth (in.)	Shield Area (sq ft)	Type	Material Percent	Material Depth	S.G.	Eff. Depth in Inches of Water	Remarks
Wall #3	4.04	Room 89.6 Hall 121.6	Plaster Wood	48.9 51.1	1.97 2.07	1.0 0.4	1.97 .83 - 2.7	2"x4" Studs 16" on Centers- Latted and Plastered.
Wall #4	4.84	144.0	Plaster Wood	56.1 43.9	2.72 2.12	1.0 0.4	2.72 .848 - 3.5	2"x4" Studs 16" on Centers- Latted and Plastered.
Column	39.14	Room 144.0 Hall 40.0	Plaster Concrete	5. 95.	1.97 37.17	1.0 2.3	1.97 85.49 - 87.4	
Roof	25.93	190.	Plaster Concrete	8. 92.	2.16 23.77	1.0 2.3	2.16 54.67 - 56.8	
Cornice Wall	21.72	120.	Concrete Tile	57. 33.	14.48 7.24	2.3 2.2	33.30 15.93 - 49.2	

TABLE 17b. HIROSHIMA

RED CROSS HOSPITAL. USSBS BUILDING NO. 31

Shielded Area on a Horizontal Plane 1 Meter Above Top Floor

Shielding Section	Shield Depth (inches)	Shield Area (sq ft)	Material Type	Material Percent	Material Depth	Material S.G.	Eff. Depth in Inches of Water
Beam #1	19.75	73.6	Concrete	90.	17.77	2.3	40.87 - 42.84
			Plaster	10.	1.97	1.0	1.97
Window	0.17	64.8	Glass	100.	0.17	2.4	0.41 - 0.41
Wall #1	21.73	94.4	Plaster	6.3	1.36	1.0	1.36
			Concrete	60.4	13.13	2.3	30.20 - 47.49
			Tile	33.3	7.24	2.2	15.93
Wall #2	32.59	83.2	Plaster	4.2	1.36	1.0	1.36
			Concrete	73.6	23.99	2.3	55.18 - 72.47
			Tile	22.2	7.24	2.2	15.93

Average Depth of Shield in room - 52.2 inches of water.
Average Depth of Shield in hall - 151. inches of water.

RESTRICTED

Figure 1--(11H). Buildings studied for correlation of shielding factors and survival. Radii are projected from the point above which the bomb exploded. The 500 and 1000 meter rings are indicated by the white circles. The zone of total destruction of the wooden buildings by blast and fire is outlined in black. (Photo File # Hg 271.)

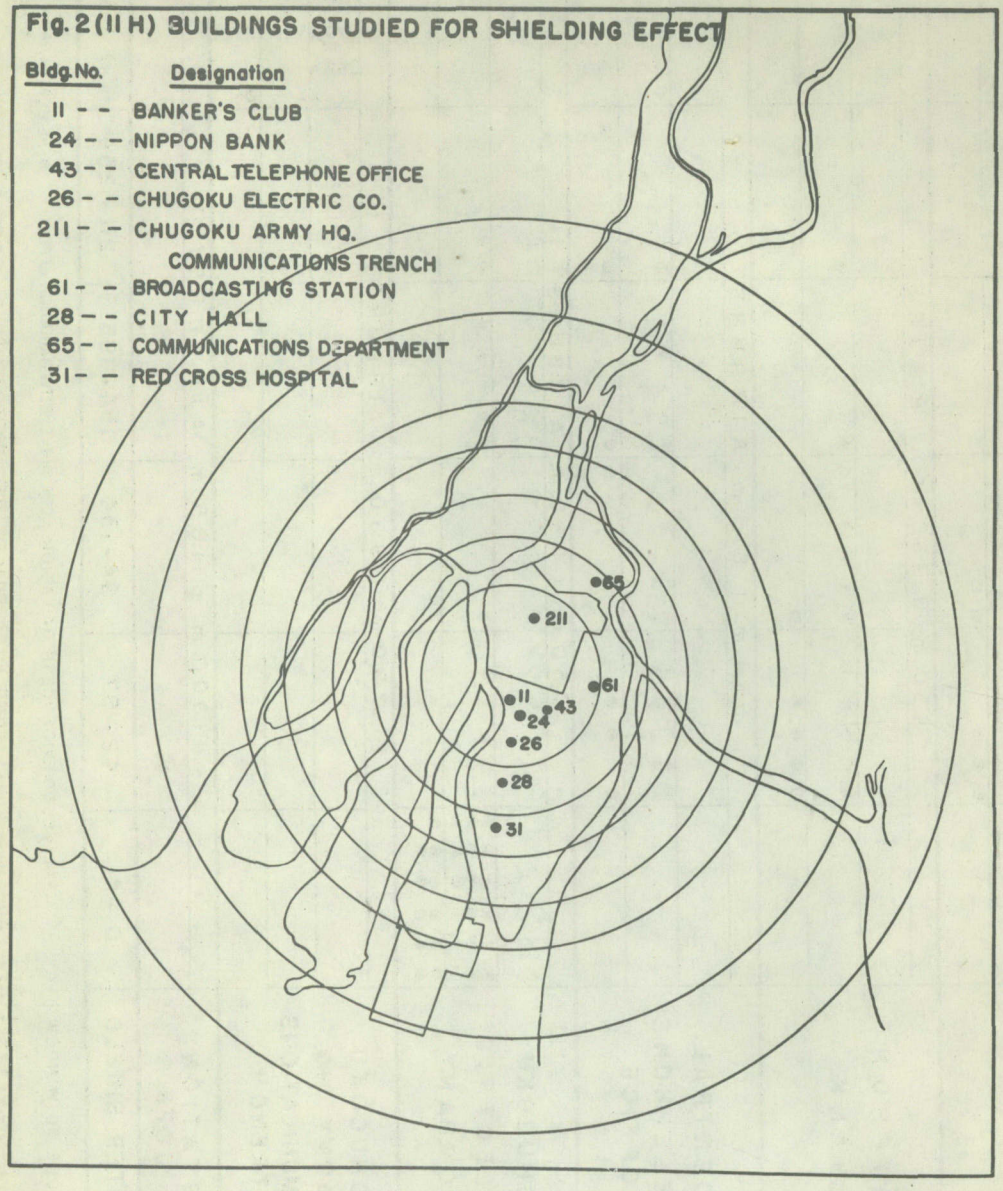
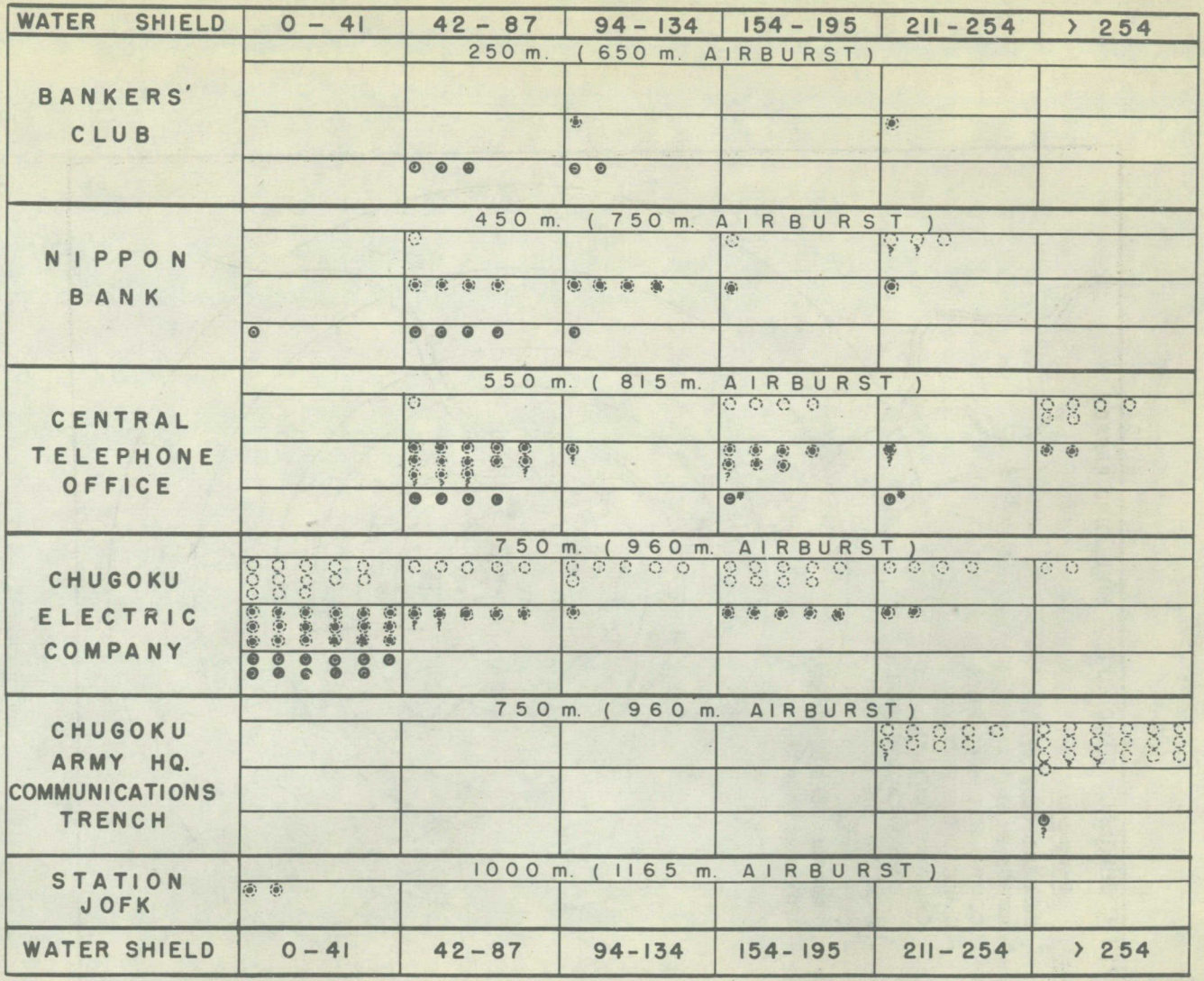


Fig. 2 (11 H) BUILDINGS STUDIED FOR SHIELDING EFFECT
Bldg. No. Designation
11 - - BANKER'S CLUB
24 - - NIPPON BANK
43 - - CENTRAL TELEPHONE OFFICE
26 - - CHUGOKU ELECTRIC CO.
211 - - CHUGOKU ARMY HQ.
COMMUNICATIONS TRENCH
61 - - BROADCASTING STATION
28 - - CITY HALL
65 - - COMMUNICATIONS DEPARTMENT
31 - - RED CROSS HOSPITAL
65
211
61
11
43
24
26
28
31

Figure 2--(11H).

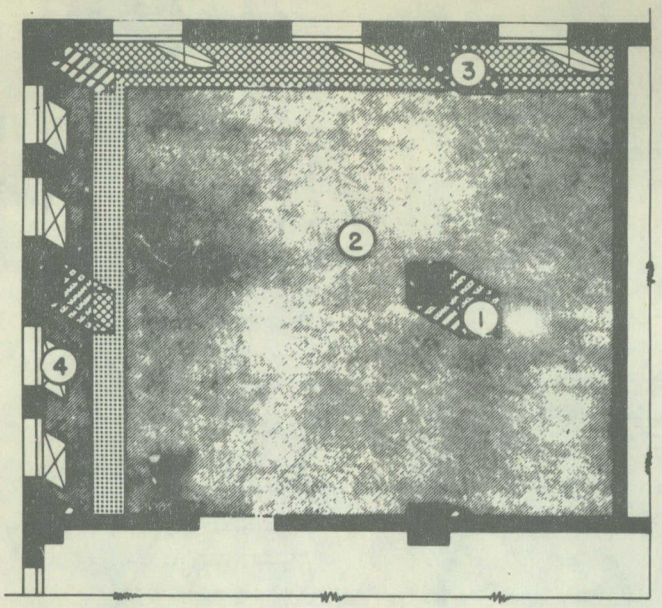
CORRELATION OF SHIELDING AND SURVIVAL FACTORS



*-CLOSE TO WINDOW ⊙-ALIVE, NO EVIDENCE OF RADIATION ⊛-ALIVE, WITH RADIATION EFFECT ⊙-DEAD, WITH RADIATION EFFECT

Figure 4--(11H). In this chart each vertical column represents a range of depths of shielding in terms of water equivalents. Each horizontal section (representing a building) is divided into three parts according to the fate of the survivors, which is indicated by the symbols. The greater shielding necessary for protection in buildings close to the bomb is striking.

RESTRICTED



LEGEND

EFFECTIVE DEPTHS IN INCHES OF WATER

.975 (NORTH WINDOW)

.561 (WEST WINDOW)

39 - 51

71

83 - 88 - 91

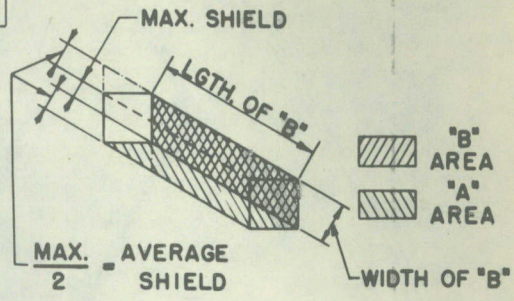
120 - 127

139 - 140

176 - 182

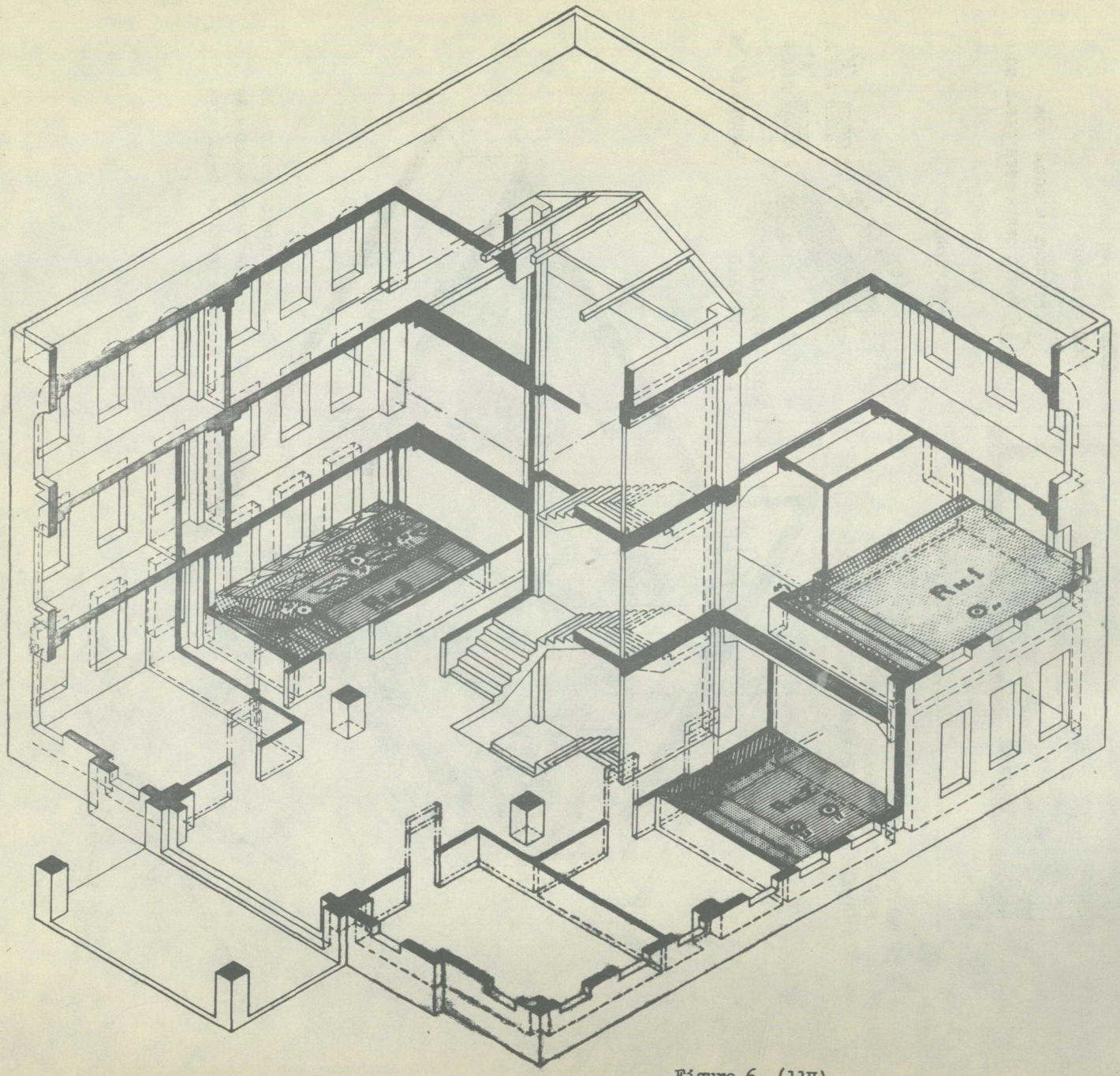
1 2 3 4 PERSONS IN ROOM: FOR SHIELD DEPTH - SEE TABLE NO. 1

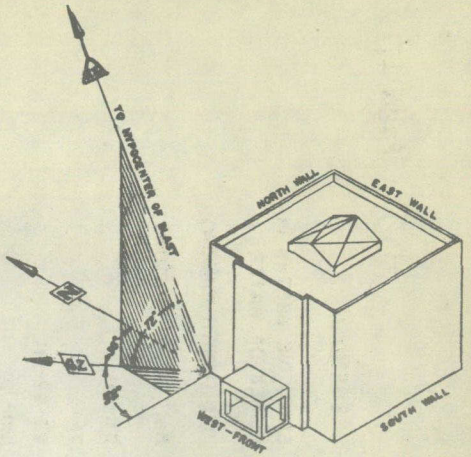
NOTE:
FOR STRUCTURAL DIMENSIONS - SEE TABLE NO. 2



MIN. DEPTH OF SHIELD = 39
MAX. DEPTH OF SHIELD = 182
AVE. DEPTH OF SHIELD = 44

Figure 5--(11H).





ISOMETRIC PLOT PLAN

LEGEND

EFFECTIVE DEPTHS IN INCHES OF WATER

.384 (NORTH SIDE WINDOWS)

52 - MIN.

74 - 78 - 90

100 - 110 - 114

121 - 127 - 132 - 135 - 141

164 - 184 - 190

227 - 244 - 249

278 - MAX.

ALIVE WITH RADIATION EFFECT

DIED WITH EVIDENCE OF RADIATION

DEPTH OF SHIELD IN THE ROOMS (INCHES OF WATER)

	RM. 1	RM. 2	RM. 3
MIN.	52	74	.384
MAX.	141	227	278
AVE.	68	111	241

SCALE IN FEET

Figure 6--(11H).

Figure 7--(11H). Bankers' Club (250 meters). General view looking away from the center of the explosion. Optical axis of camera in line with the point above which the bomb exploded. The wall at the left did not exert a shielding effect. The Nippon Bank can be seen to the rear and to the right of this building. (Photo File # HB 200; Date: 27 November 1945.)

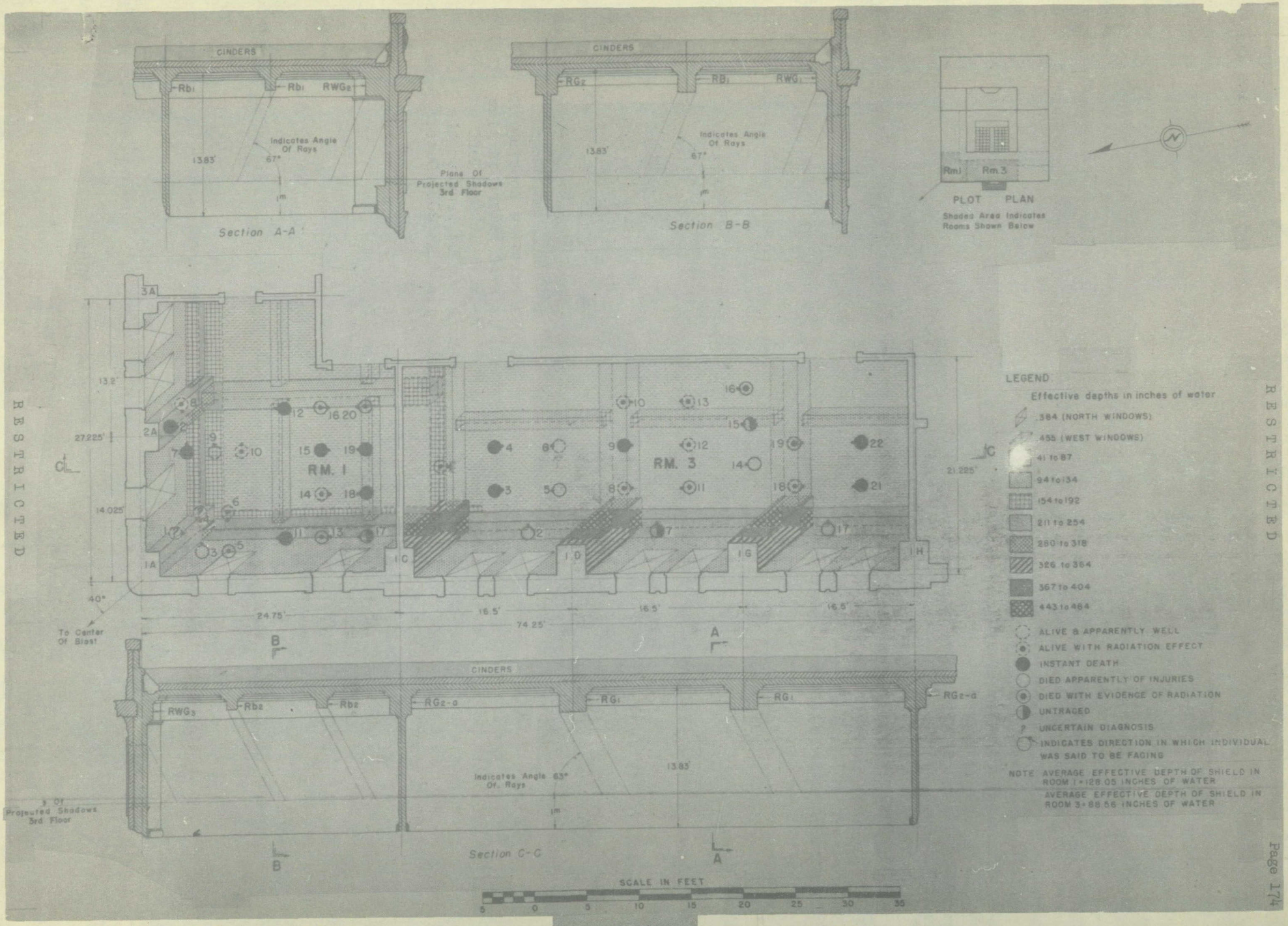


Figure 8--(11H).

Figure 9--(11H). 450 meters. Nippon Bank. General view looking away from the center of the explosion. Optical axis of camera in line with point above which the bomb exploded. (Photo File # HB 203; Date: 27 November 1945.)

Figure 10--(11H). Nippon Bank (450 meters). Room-1, third floor. Camera facing toward the point above which the bomb exploded. (Photo File # HB 309; Date: 15 November 1945.)

Figure 11--(11H). Nippon Bank (450 meters). Detail of partition between Room-1 (third floor) and the hallway. Note the exposed metal reinforcements bent away from the explosion. A section of the partition remains showing its internal structure of cement and plaster, but most of it has crumbled into rubble. (Photo File # HB 311; Date: 15 November 1945.)

Figure 12--(11H). Nippon Bank (450 meters). Room-3 (third floor). Camera facing the point above which the bomb exploded. (Photo File # HB 312; Date: 15 November 1945.)

Figure 13--(11H). Nippon Bank (450 meters). Room-3 (third floor). Camera facing in the direction opposite to that of preceding figure. The partition has been blastea away from the center of the explosion and has been pulled from its insertions in the ceiling. The twisted metal reinforcements remain but the cement and plaster have crumbled. (Photo File # HB 313; Date: 15 November 1945.)

Figure 14--(11H). Nippon Bank (450 meters). Section of the 18 inches of the mixture of sand and cinders that had been laid on the roof of the Nippon Bank to protect against fire bombs and through which ionizing radiations had to pass to produce their effects in certain individuals in the building. The original tile is visible beneath the protecting cover. (Photo File # HB 314; Date: 15 November 1945.)

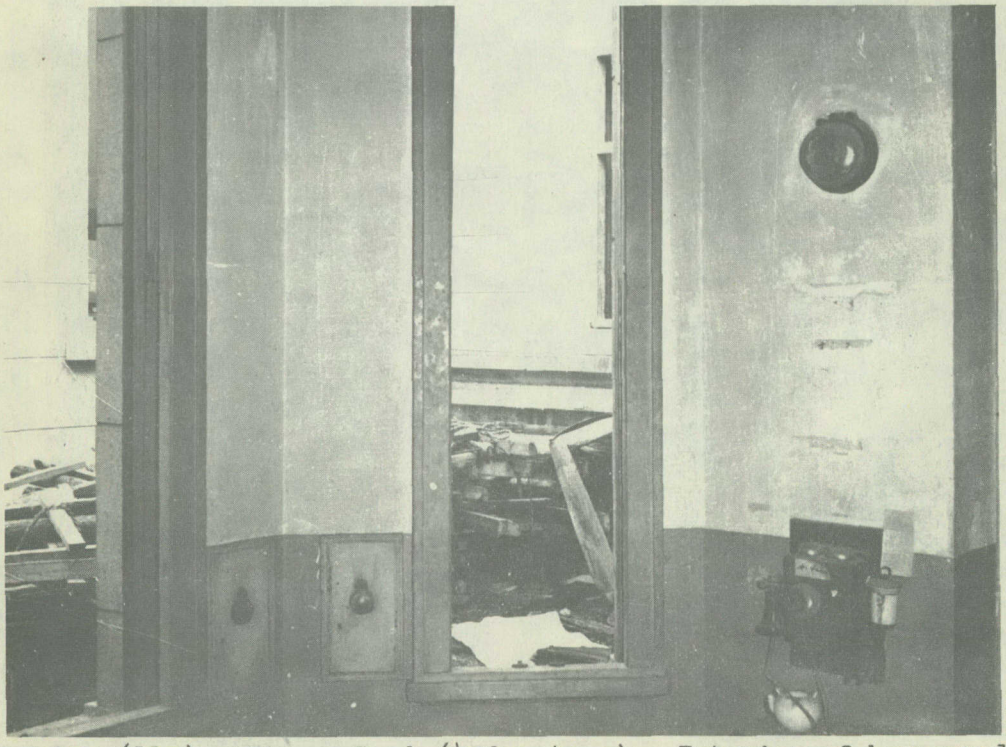


Figure 15--(11H). Nippon Bank (450 meters). Interior of hexagonal room on first floor, camera facing toward the point above which the bomb exploded. This room faces the courtyard from the rear of the building and can be seen in the insert of Figure 8. (Photo File # HB 306; Date: 15 November 1945.)

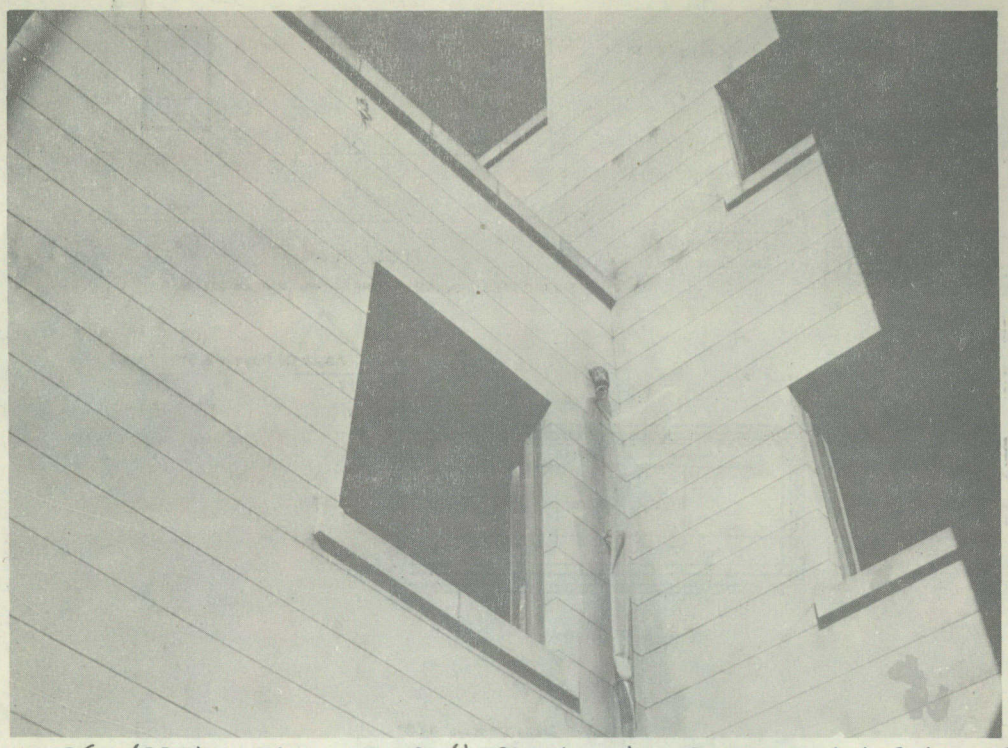


Figure 16--(11H). Nippon Bank (450 meters). Camera pointed toward the actual airburst of the explosion from the sill of the middle window of hexagonal room. (See preceding Figure.) (Photo File # HB 307; Date: 15 November 1945.)

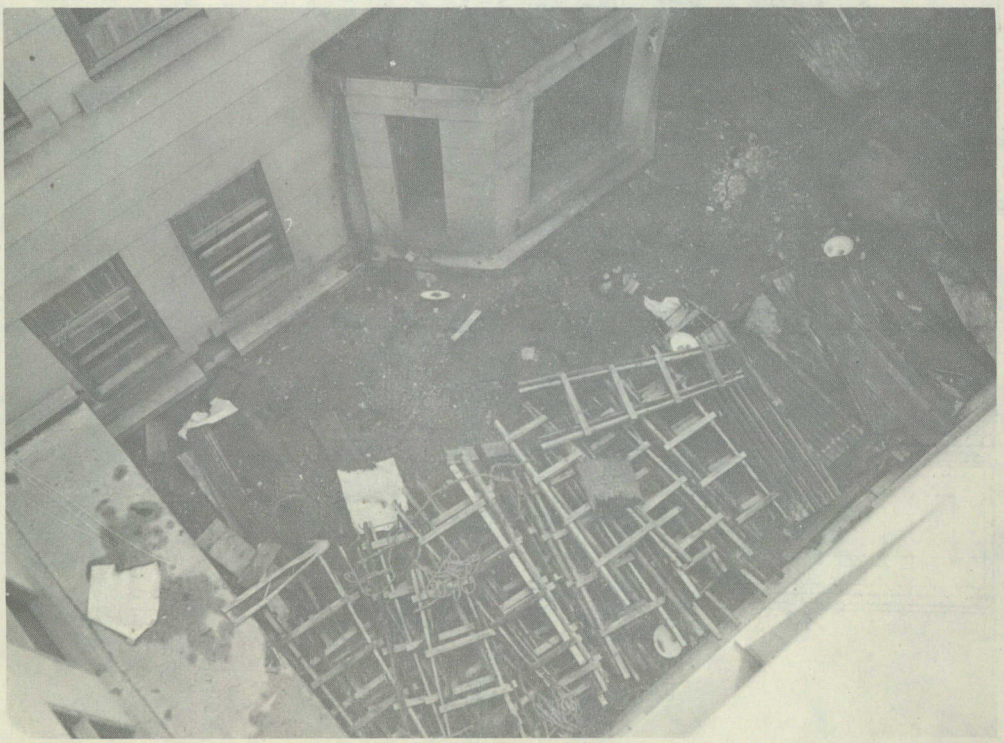


Figure 17--(11H). Nippon Bank (450 meters). Camera pointed from roof seen in preceding figure toward the hexagonal room, along a ray projected from the true center of the explosion. (Photo File # HB 308; Date: 15 November 1945.)

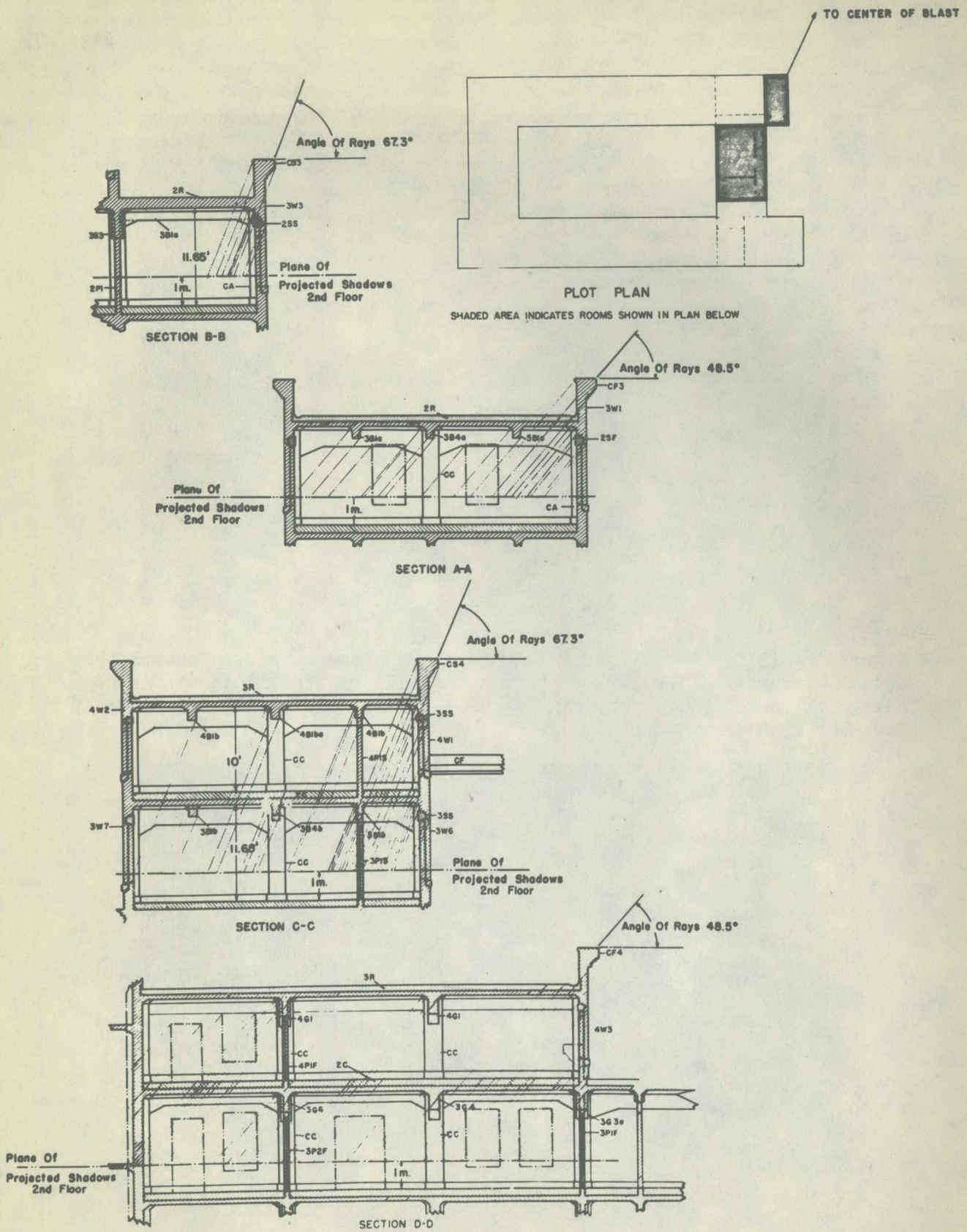


Figure 18--(11H).

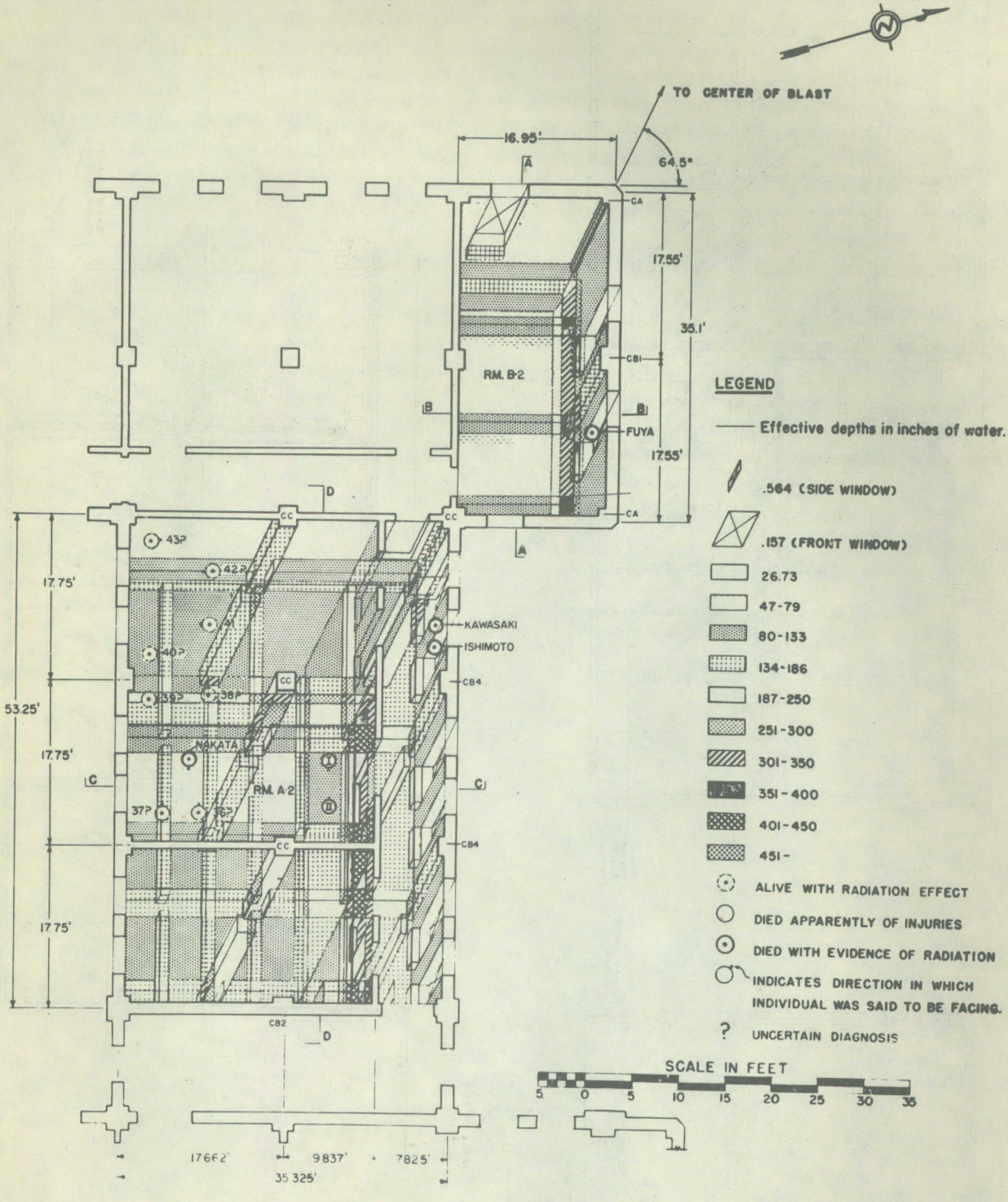


Figure 18--(11H) con'd.

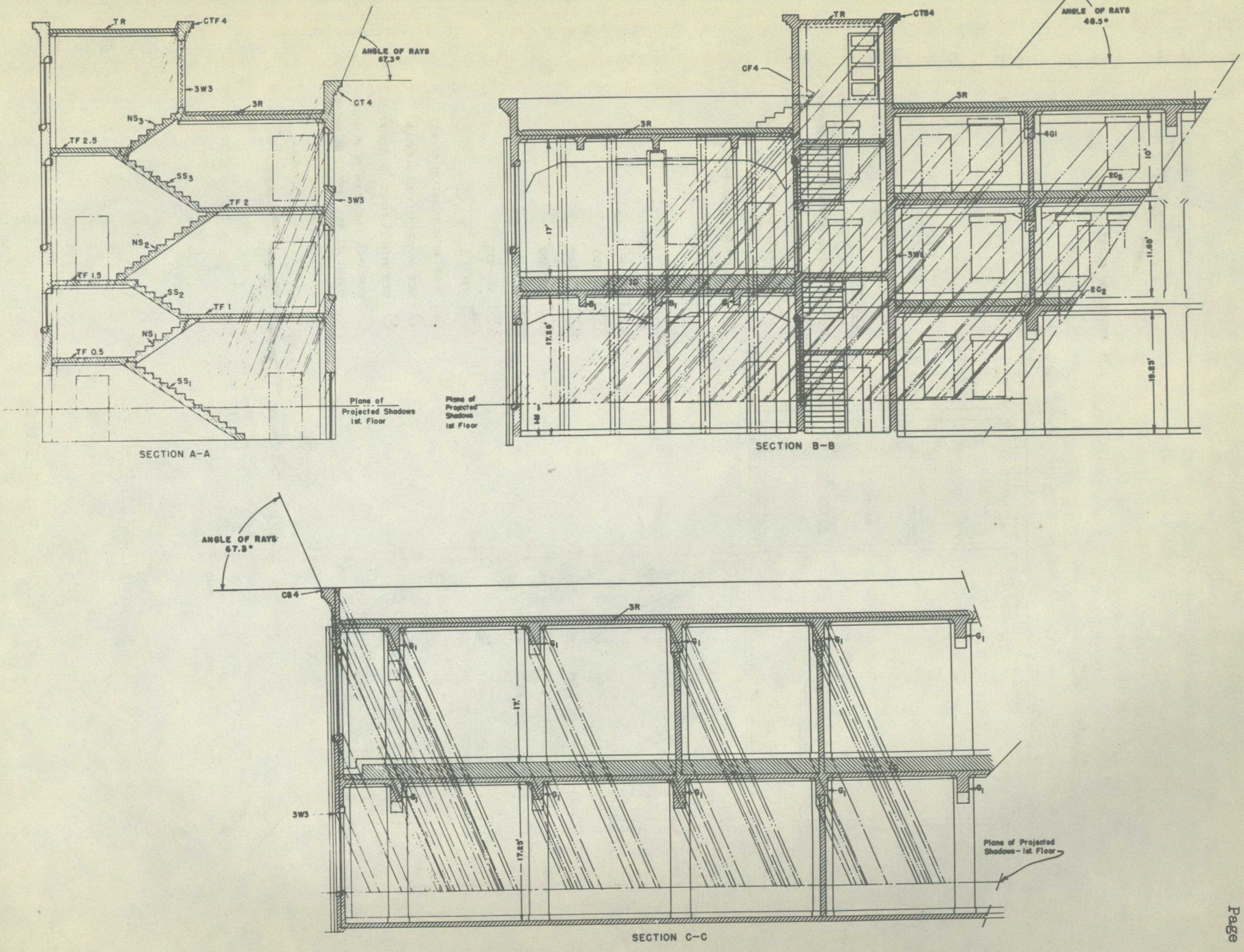
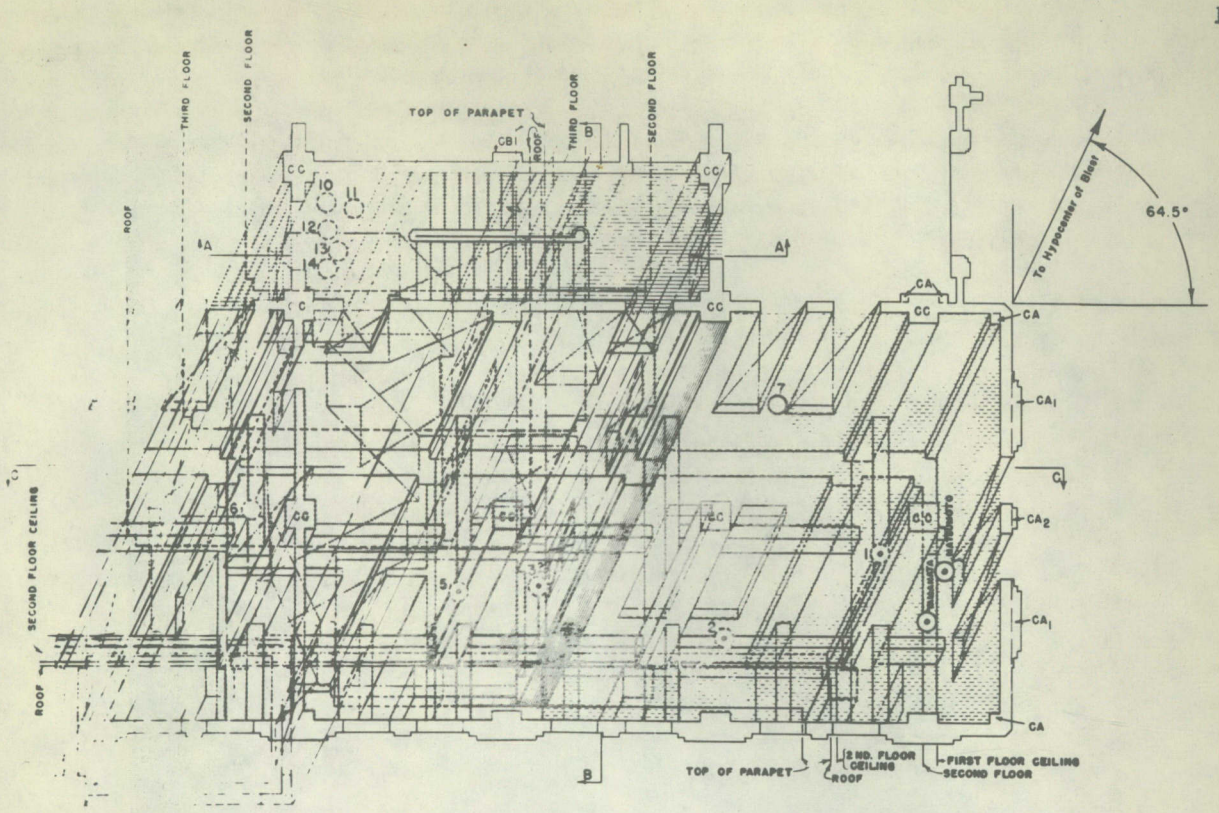
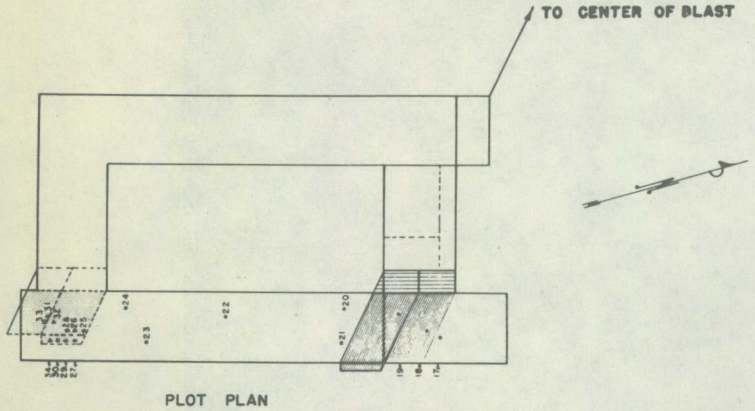


Figure 19--(11H).

RESTRICTED





NOTE:

IDENTIFICATION NUMBERS 17 TO 34 INCLUSIVE, REFER TO PERSONAL ON SECOND FLOOR ONLY.

LEGEND:

FIRST FLOOR:

AVERAGE EFFECTIVE DEPTH OF SHIELD 323 INCHES OF WATER. MIN. SHIELD 0.78" MAX. SHIELD 434".

AVERAGE EFFECTIVE DEPTH OF SHIELD 304 INCHES OF WATER. MIN. SHIELD 143" MAX. SHIELD 488".

AVERAGE EFFECTIVE DEPTH OF SHIELD 104 INCHES OF WATER. MIN. SHIELD 0.37" MAX. SHIELD 464".

ALIVE & APPARENTLY WELL.

ALIVE WITH RADIATION EFFECT.

DIED APPARENTLY OF INJURIES

DIED WITH EVIDENCE OF RADIATION.

? UNCERTAIN DIAGNOSIS

SECOND FLOOR: AVERAGE EFFECTIVE DEPTH OF SHIELD 217 INCHES OF WATER. MIN. SHIELD 0.37", MAX. SHIELD 462" — AREA CLEAR OF TOWER: AVERAGE SHIELD 170", MIN. SHIELD 0.37", MAX. SHIELD 405".

SCALE IN FEET

5 0 5 10 15 20 25 30 35

Figure 19--(11H) cont'd.

Figure 20--(11H). Telephone Bldg. (550 meters). General view looking away from the center of explosion, with which the optical axis of the camera is in line. (Photo File # HB 205; Date: 27 November 1945.)

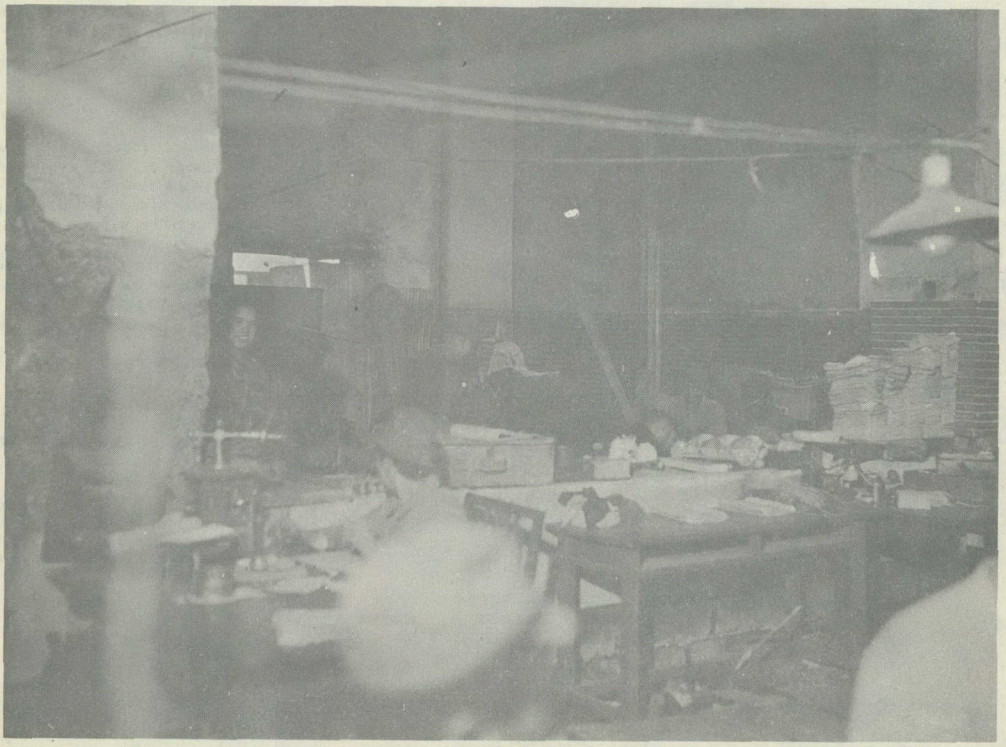


Figure 21--(11H). Telephone Bldg. (550 meters). Room I-C. First floor. Camera facing the center of the explosion. (Photo File # HB 315; Date: 15 November 1945.)

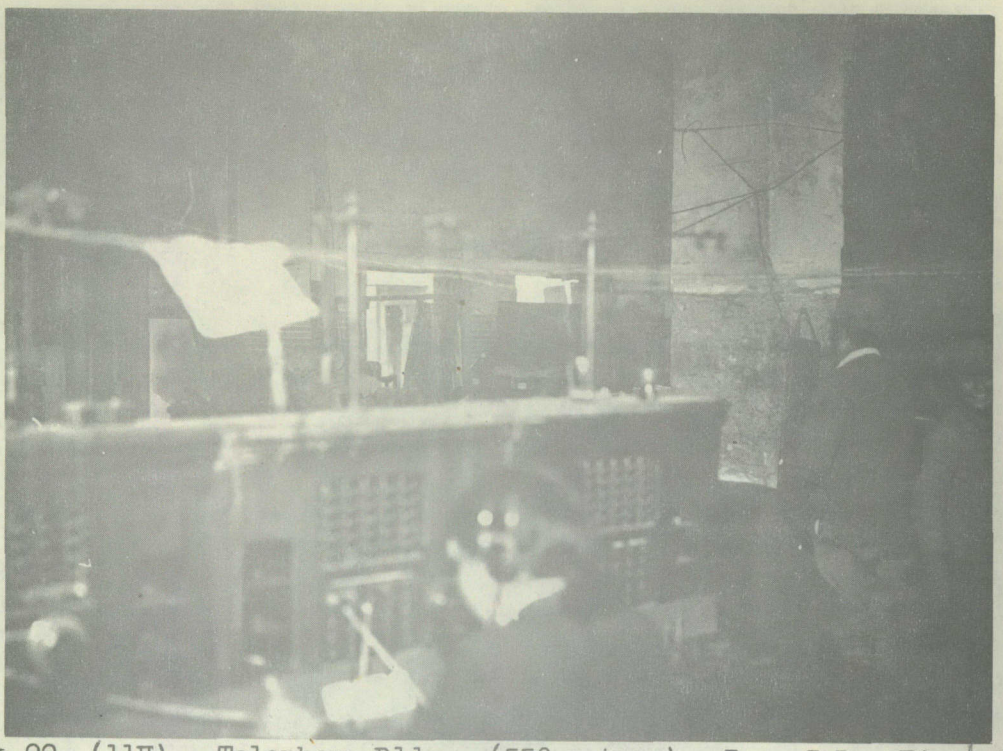


Figure 22--(11H). Telephone Bldg. (550 meters). Room I-D. First floor. Camera facing the center of the explosion. (Photo File # HB 316; Date: 15 November 1945.)

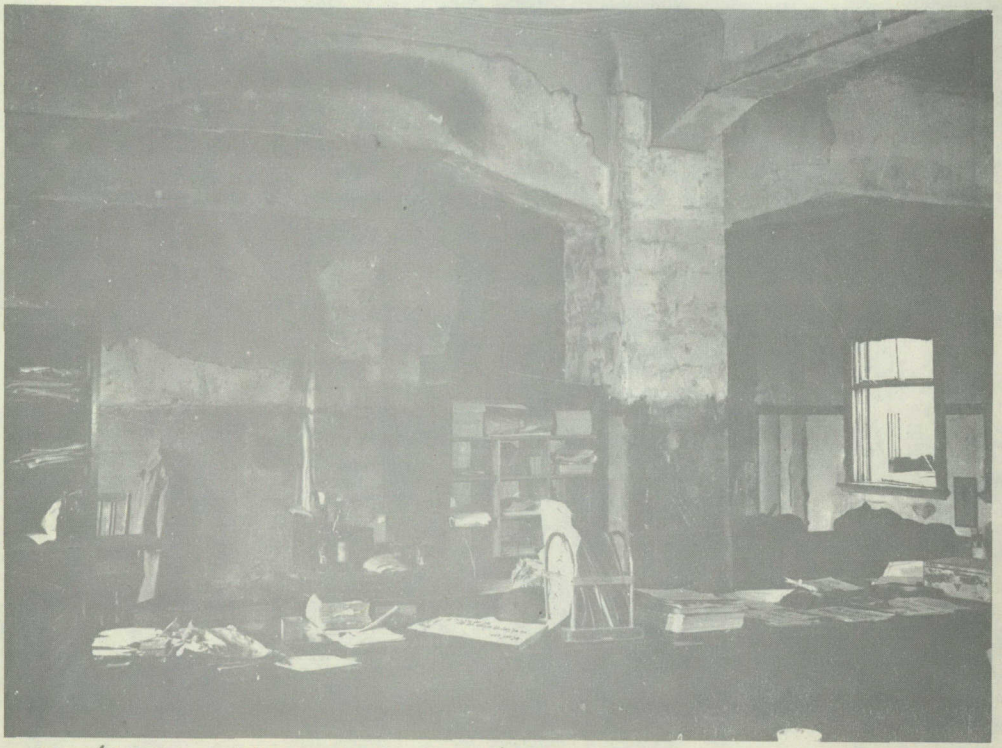


Figure 23--(11H). Telephone Bldg. (550 meters). Room A-2, second floor. Camera facing the center of the explosion. (Photo File # HB 317; Date: 15 November 1945.)

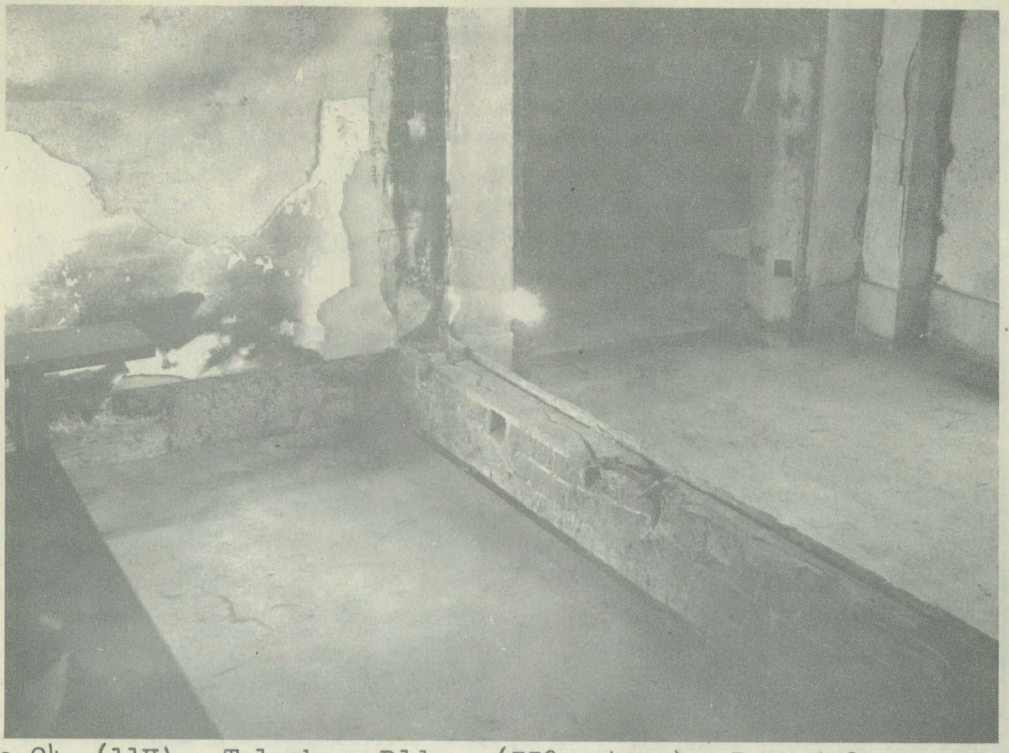


Figure 24--(11H). Telephone Bldg. (550 meters). Room A-2, second floor. Detail of base of partition. (Photo File # HB 318; Date: 15 November 1945.)

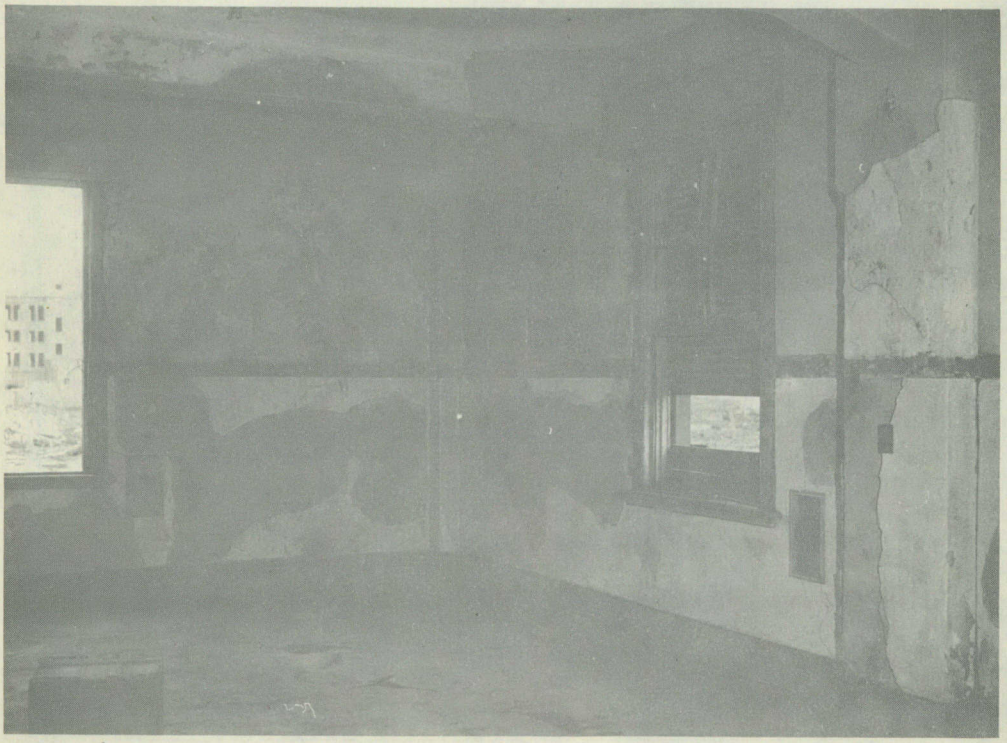


Figure 25--(11H). Telephone Bldg. (550 meters). Room B-2, second floor. Camera facing the center of the explosion. (Photo File # HB 319; Date: 15 November 1945.)

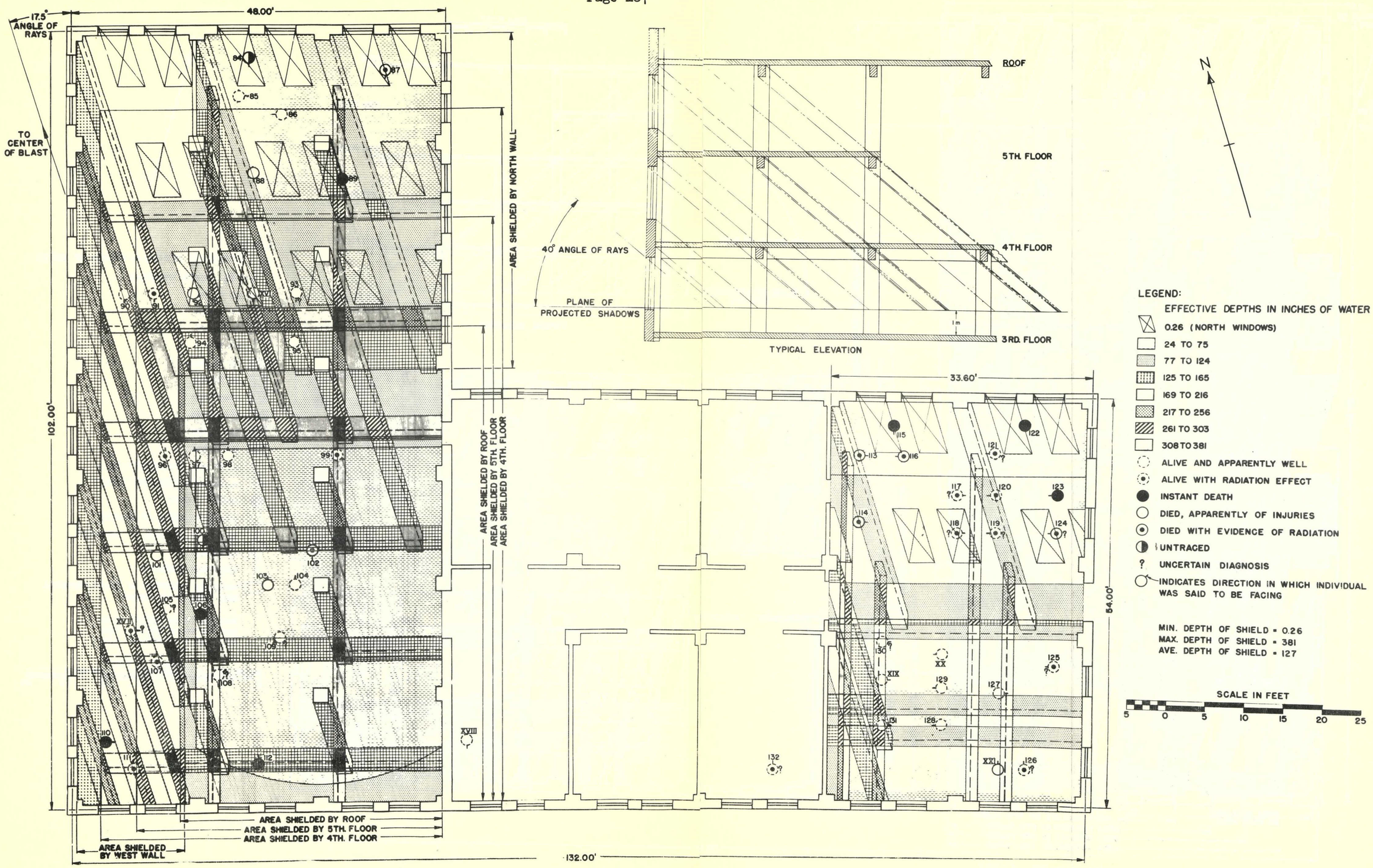


Figure 26--(11H).

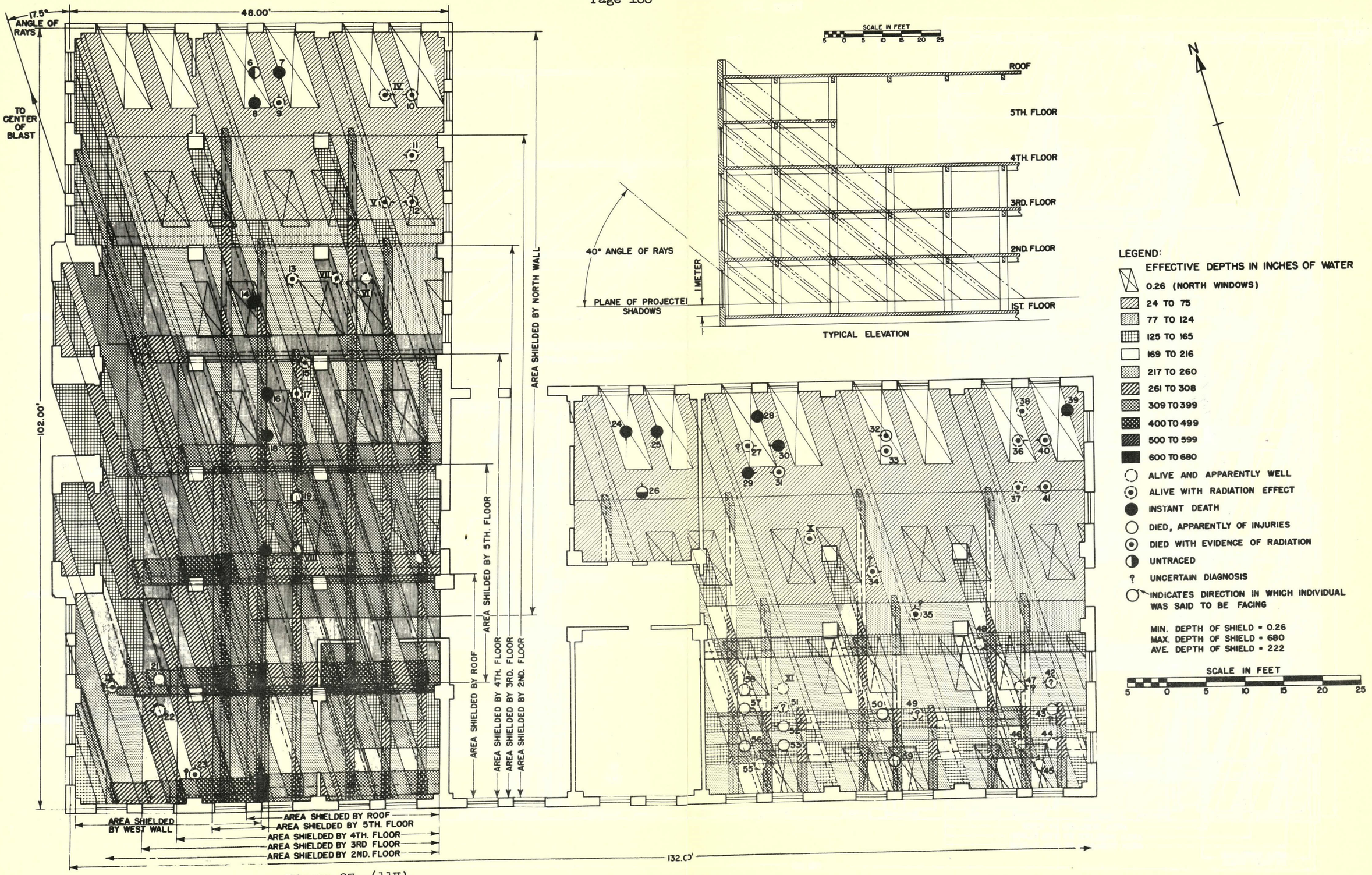


Figure 27--(11H).

Figure 28--(11H). Chugoku Electric Bldg. (750 meters). General view looking away from the center of the explosion, with which the optical axis of the camera is in line. (Photo File # HB 202; Date: 27 November 1945.)

Figure 29--(11H). Chugoku Electric Bldg. (750 meters). Room III-1, third floor. Looking toward the center of the explosion. Compare with figure 26. (Photo File # HB 304; Date: 15 November 1945.)

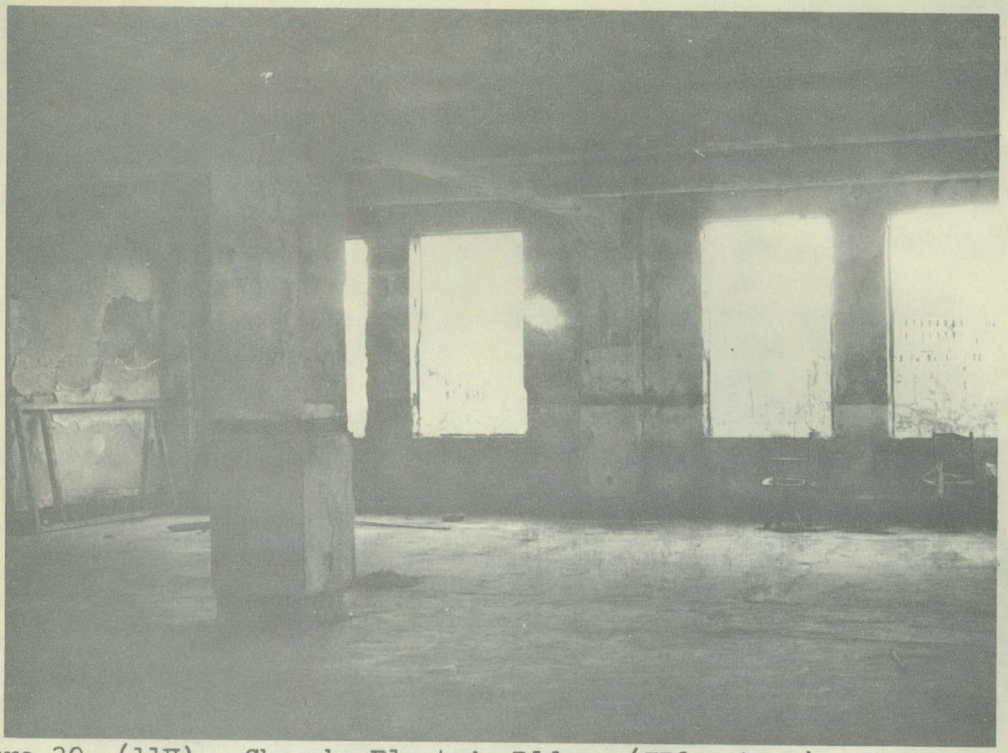


Figure 30--(11H). Chugoku Electric Bldg. (750 meters). Room III-2, third floor. Looking toward the center of the explosion. Compare with Figure 26. (Photo File # HB 305; Date: 15 November 1945.)

Figure 31--(11H). Chugoku Electric Bldg. (750 meters). Room I-1, first floor. The camera is pointed toward the center of the explosion. Compare with Figure 27. (Photo File # HB 300; Date: 15 November 1945.)

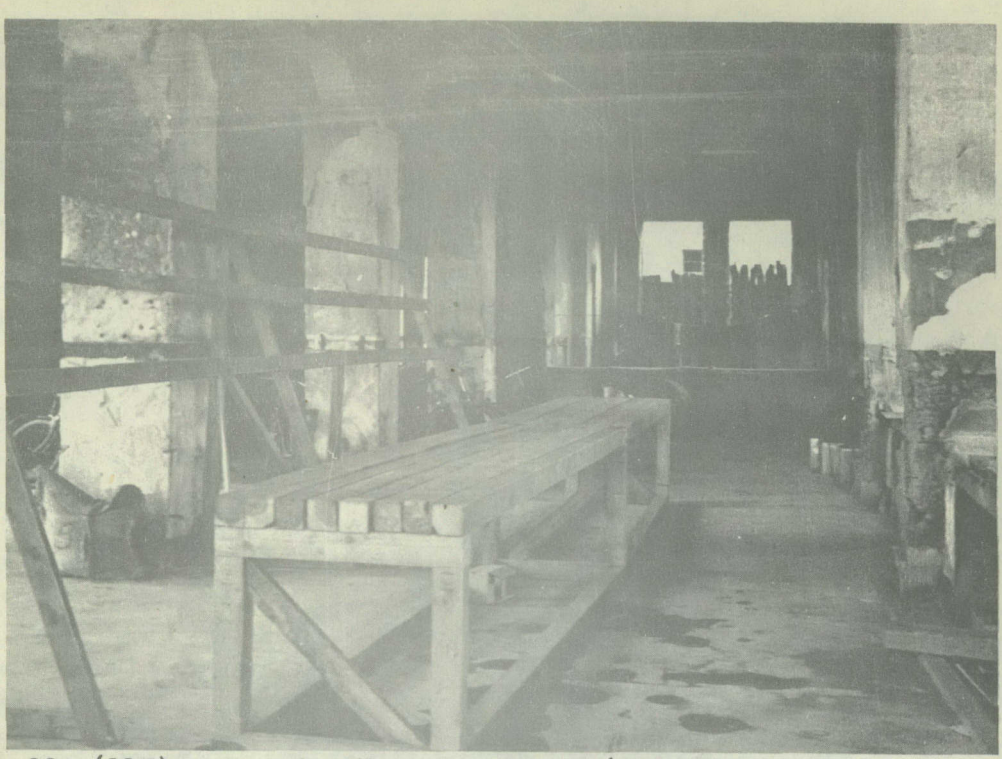


Figure 32--(11H). Chugoku Electric Bldg. (750 meters). Room I-1, first floor. The camera is pointed in a direction opposite to that in Figure 29, i.e. along a ray projected from the center of the explosion. Compare with Figure 27. (Photo File # HB 301; Date: 15 November 1945.)

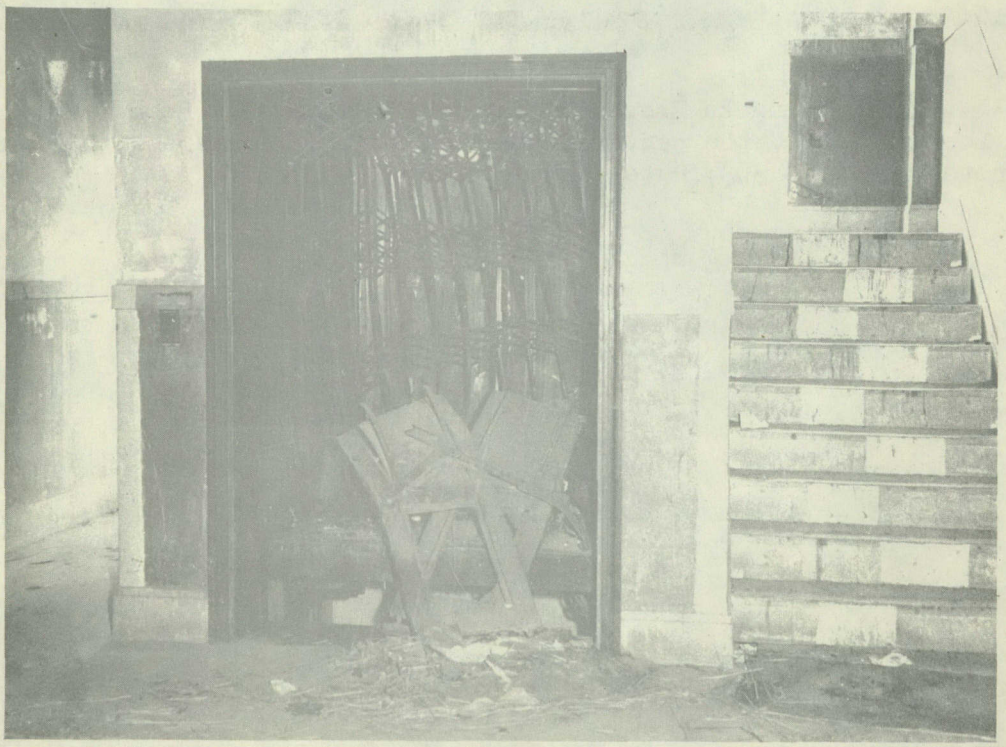


Figure 33--(11H). Chugoku Electric Bldg. (750 meters). First floor. Effect of the compression wave on an elevator and its housing. (Photo File # HB 302; Date: 15 November 1945.)

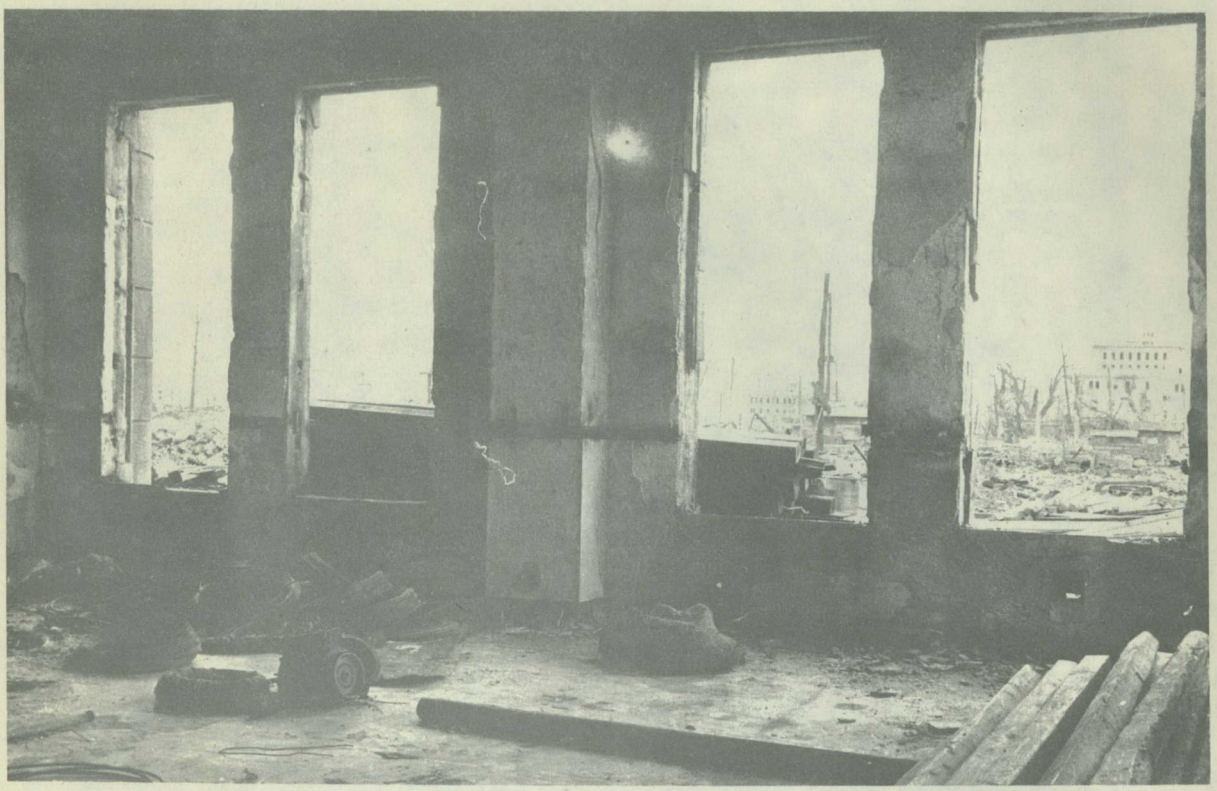


Figure 34--(11H). Chugoku Electric Bldg. (750 meters). Room I-2, first floor. Looking toward the center of the explosion. Compare with Figure 27. (Photo File # HB 303; Date: 15 November 1945.)

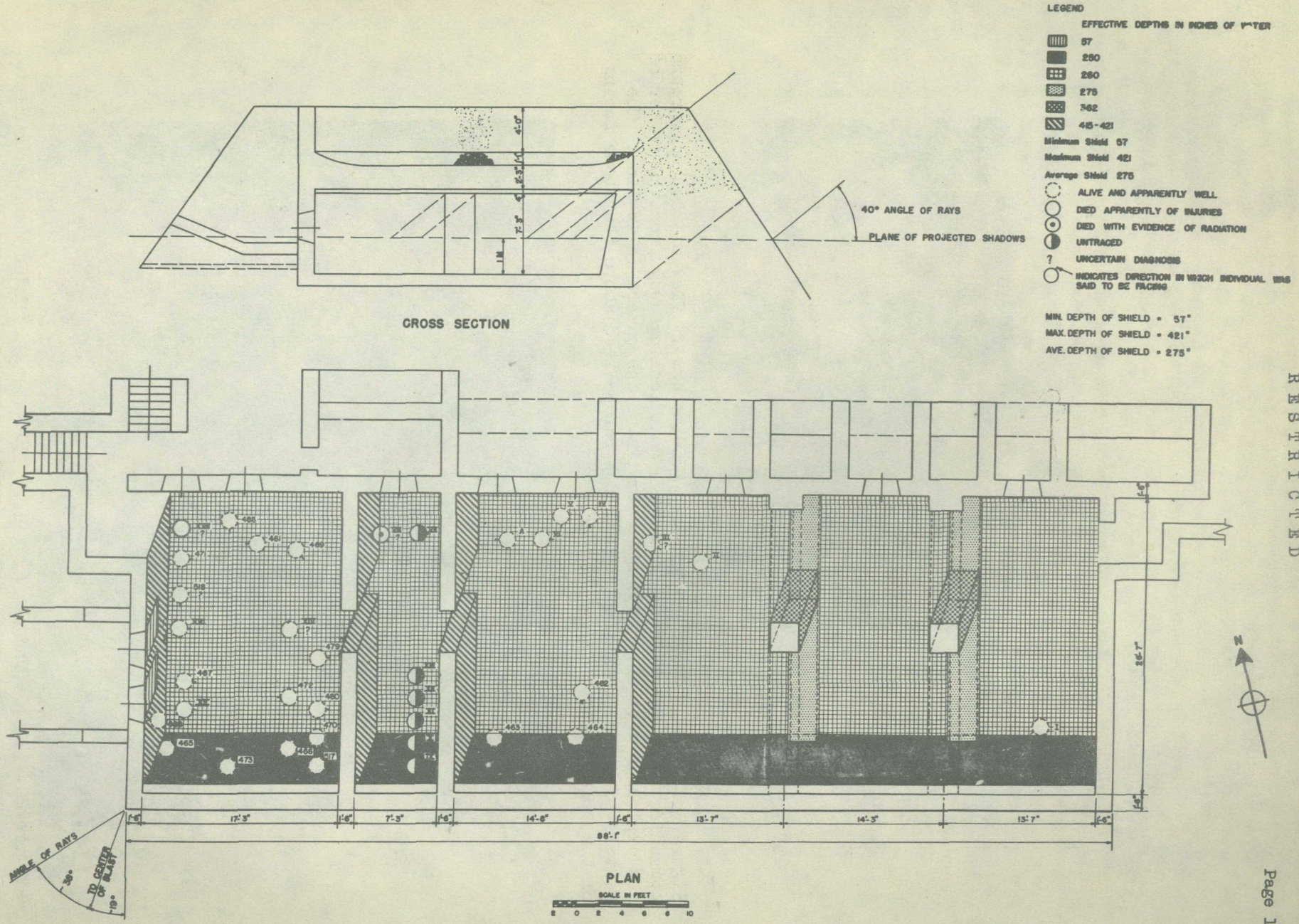


Figure 35--(11H).

Figure 36--(11H). Chugoku Army Hq. (750 meters). View of the underground communications trench from across the moat looking away from the center of the explosion with which the optical axis of the camera is in line. The ventilator of the communications trench can be seen above the stone facing of the moat. (Photo File # HB 209.)

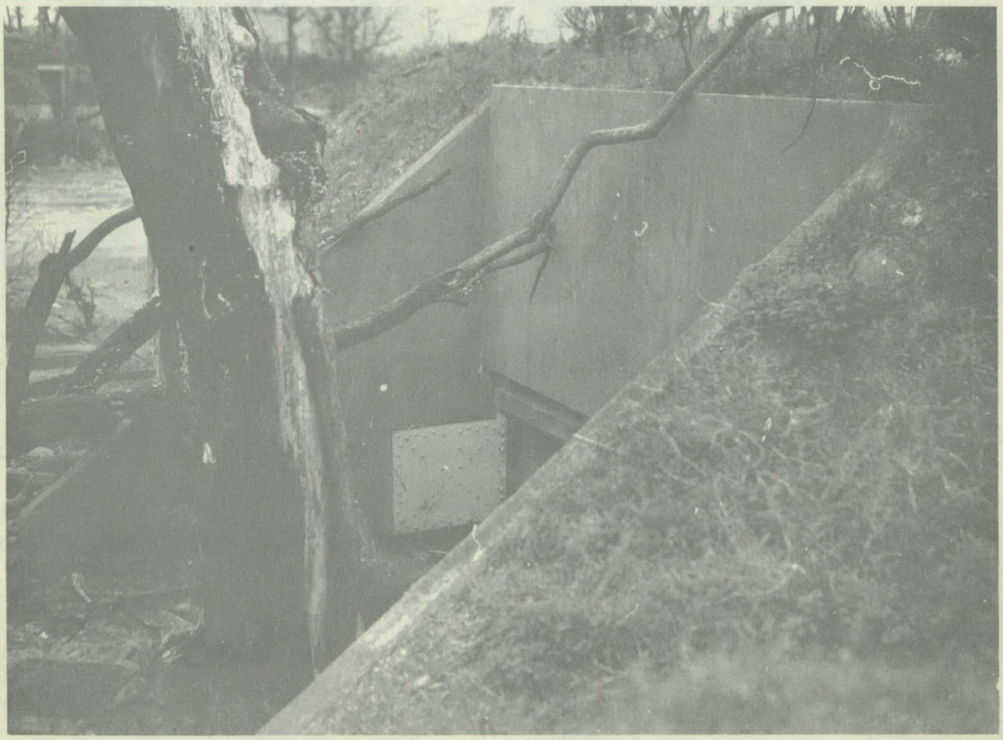
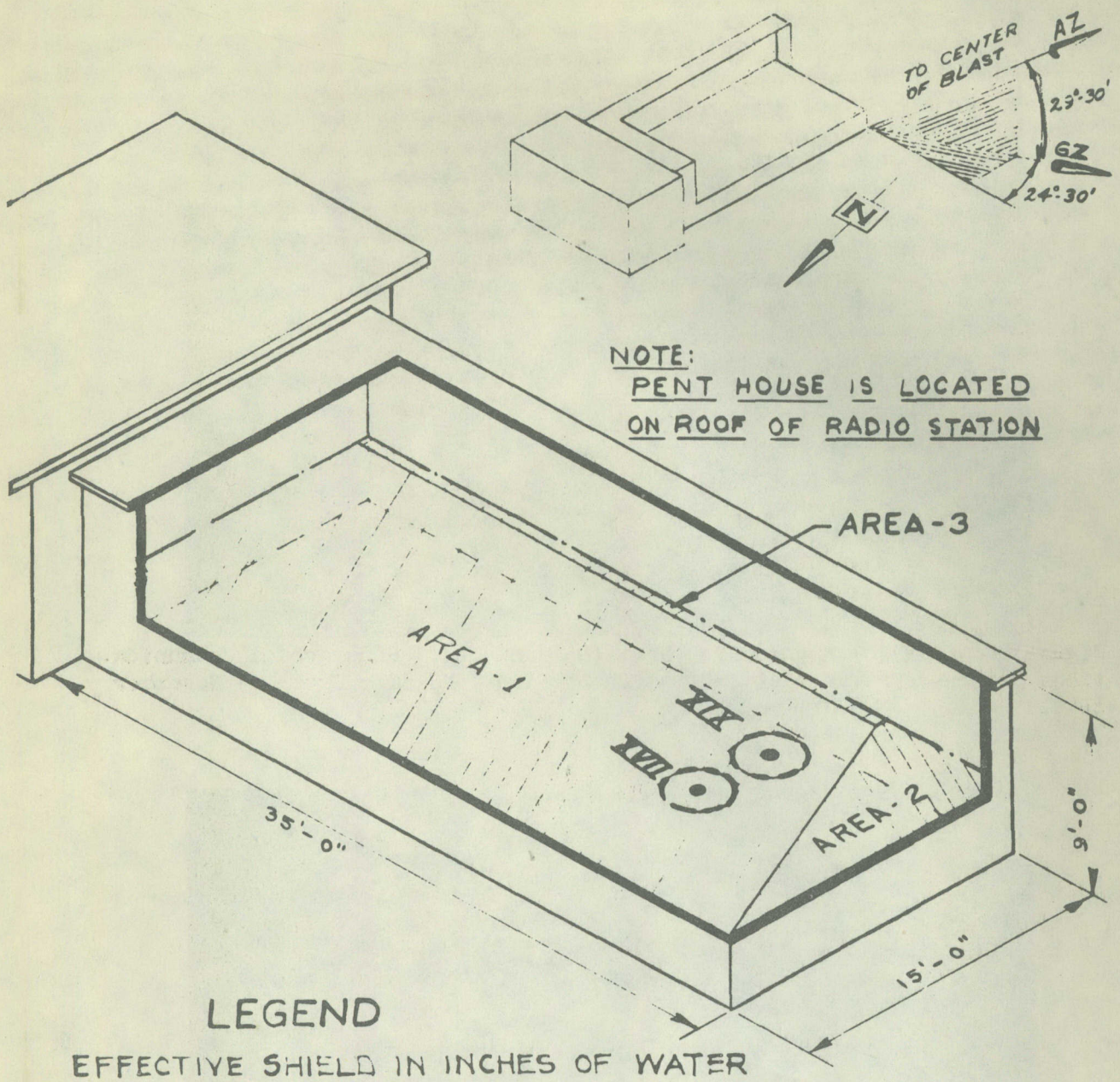


Figure 37--(11H). Chugoku Army Hq. (750 Meters). Underground Communications trench. Open metal port. Looking away from the center of the explosion, with which the optical axis of the camera is in line. (Photo File # HB 320; Date: 13 November 1945.)

Figure 38--(11H). Chugoku Army Hq. (750 meters). Underground Communications trench. Entrance at left. (Photo File # HB 321; Date: 13 November 1945.)

Figure 39--(11H). Chugoku Army Hq. (750 meters). Room whose ports are seen from the outside in Figures 37 and 38. (Photo File # HB 322; Date: 13 November 1945.)



LEGEND

EFFECTIVE SHIELD IN INCHES OF WATER

AREA-1 = 3.12"

AREA-2 = 6.48"

AREA-3 = 12.77"

AVERAGE SHIELD = 3.80"

THE PERSONS XVII & XIX ARE ALIVE WITH RADIATION EFFECT

Figure 40--(11H).

Figure 41--(11H). Broadcasting Studio (900 meters). General view looking away from the center of the explosion. Optical axis of camera in line with the center. (Photo File # HB 206; Date: 27 November 1945.)

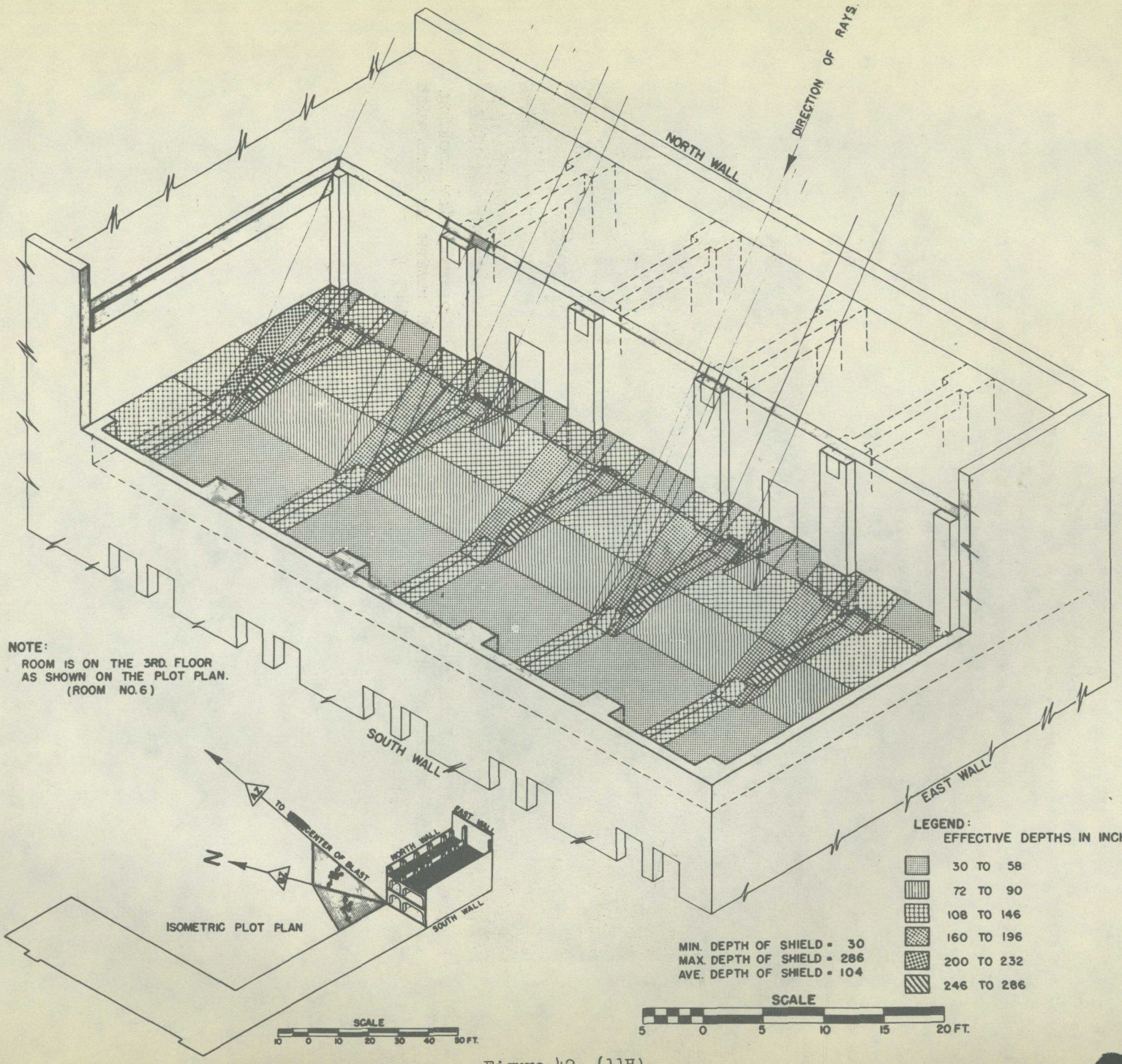


Figure 42--(11H).

Figure 43--(11H). City Hall (1200 meters). General view, looking away from the center of the explosion. Optical axis of camera in line with the center. (Photo File # HB 201; Date: 27 November 1945.)

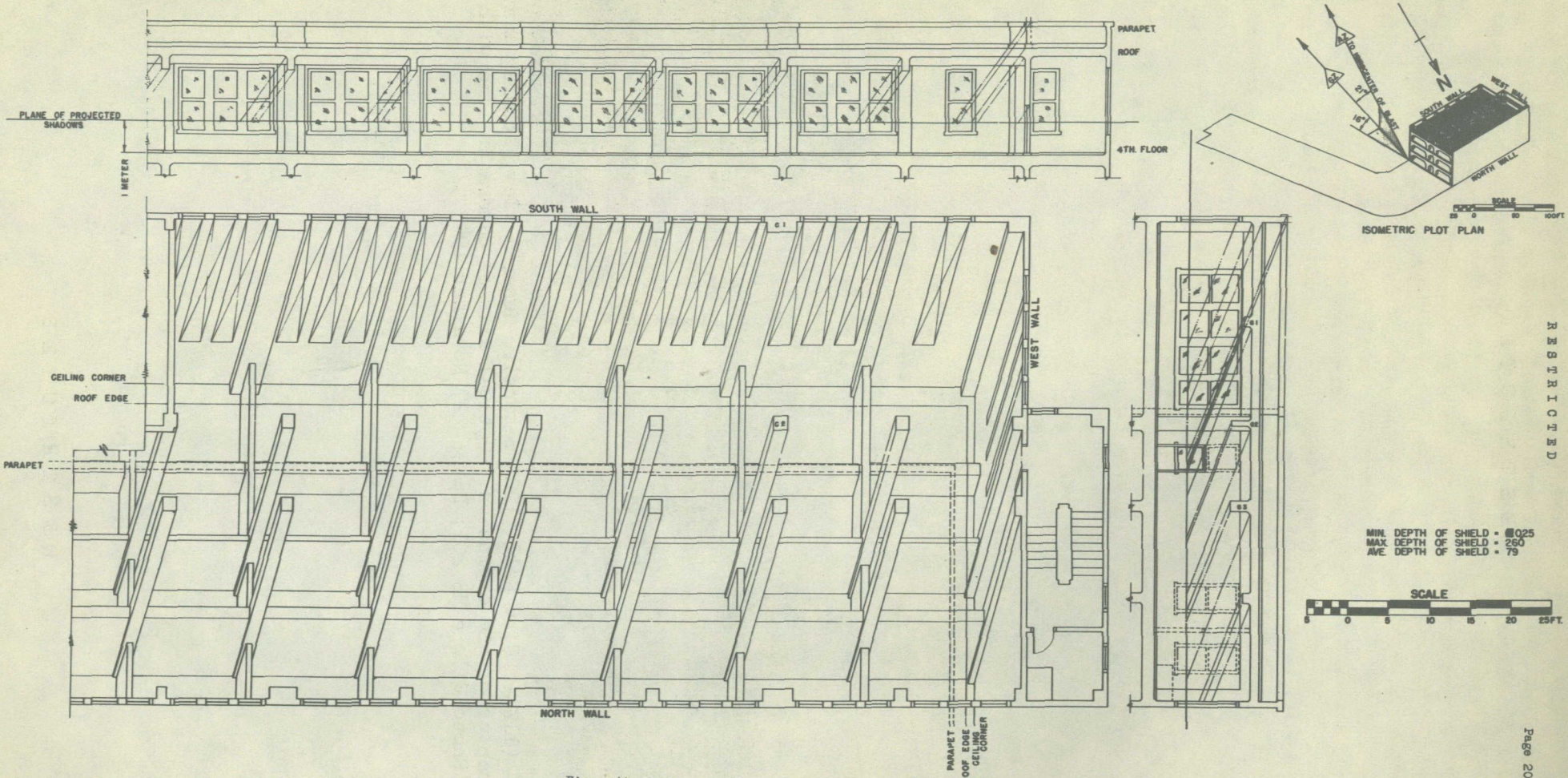
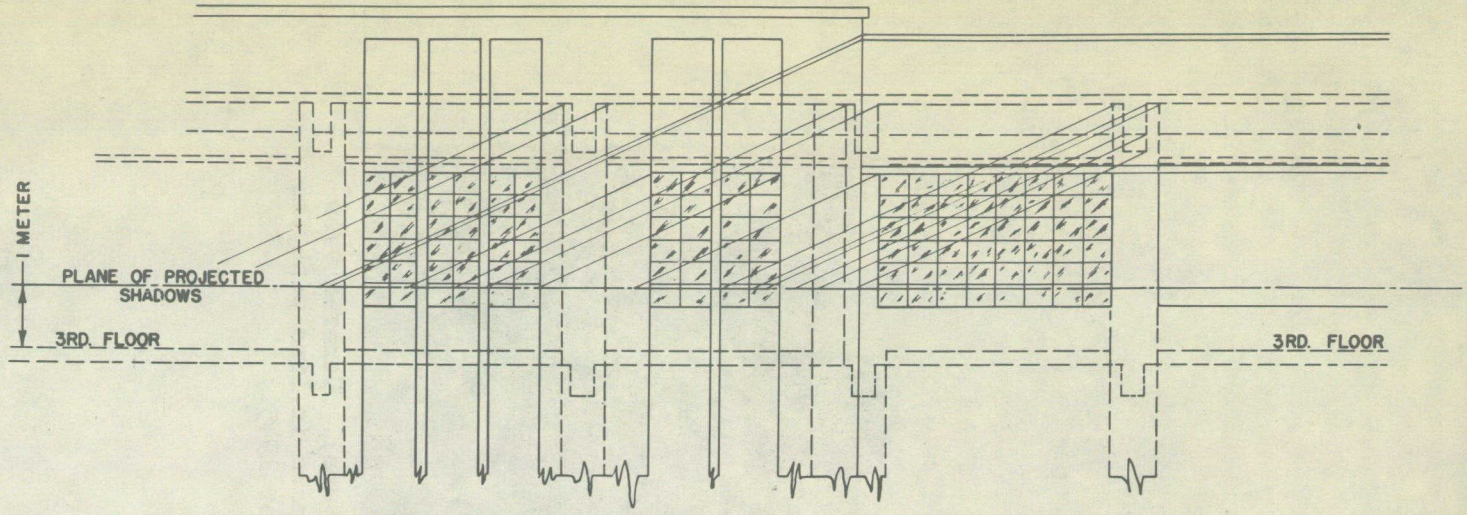
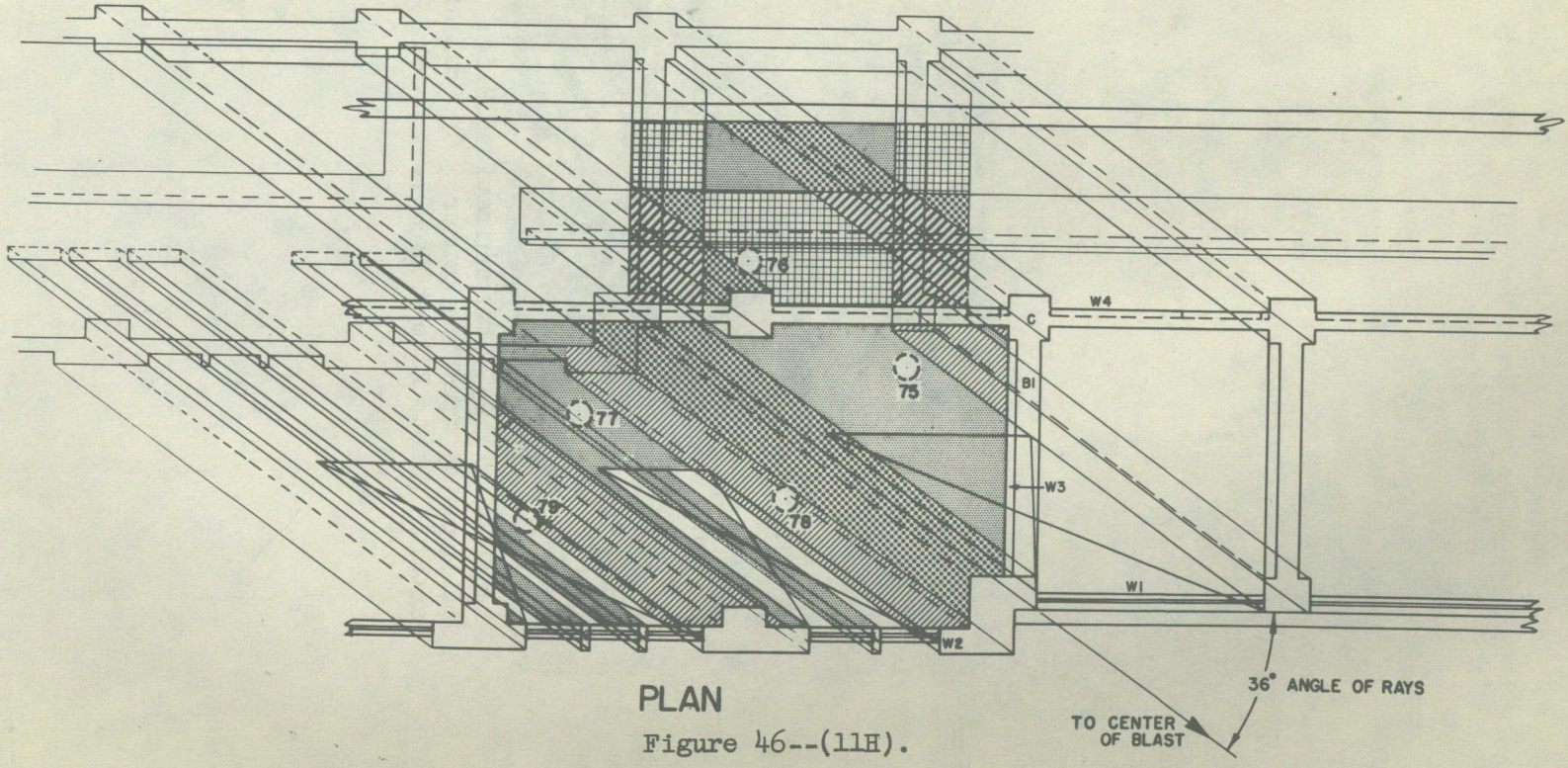


Figure 44--(11H).

Figure 45--(11H). Communications Bldg. (1400 meters). General view looking away from the center. Optical axis of camera in line with the center. (Photo File # HB 207-b; Date: 27 November 1945.)



FRONT ELEVATION



PLAN

Figure 46--(11H).

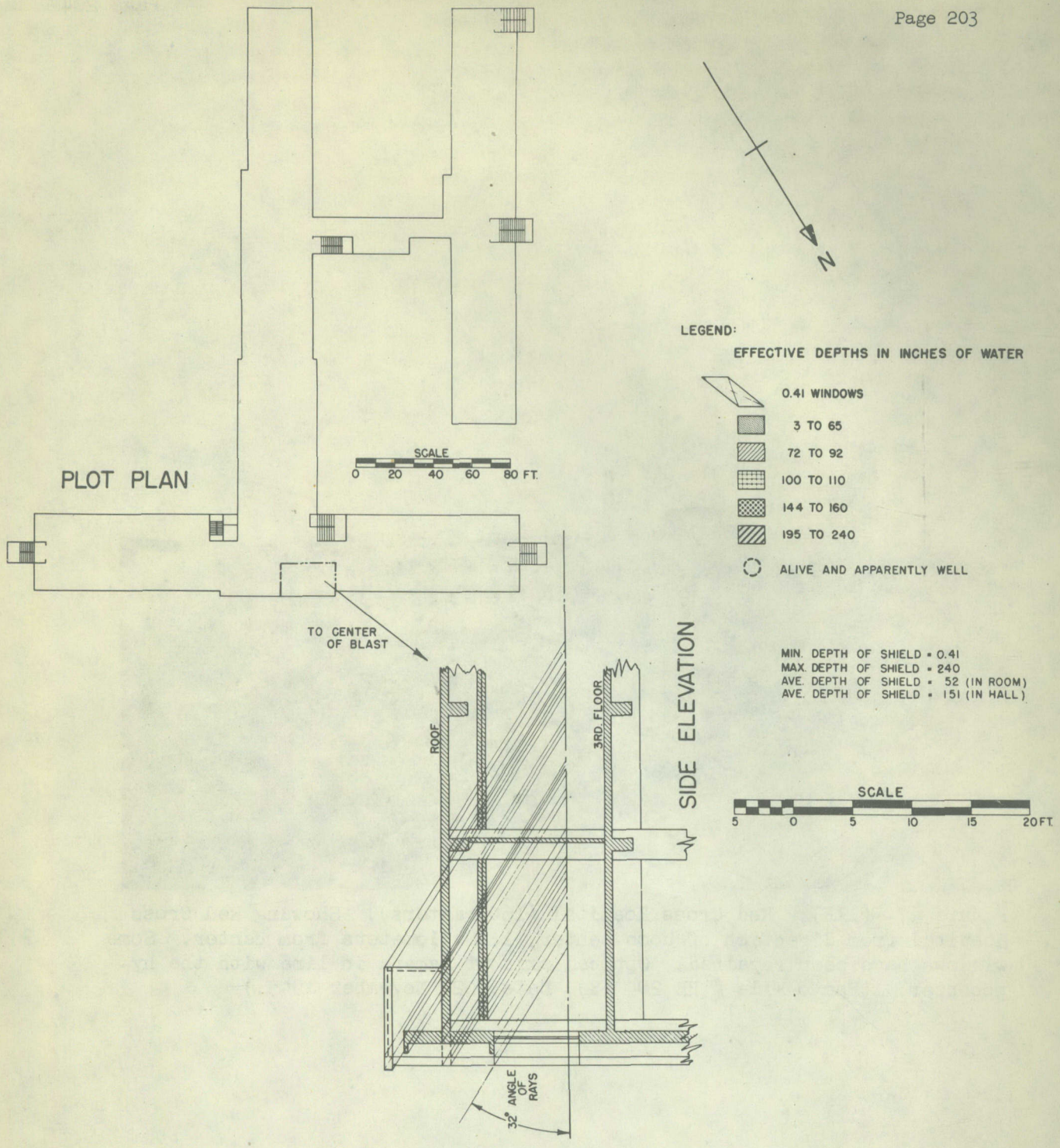


Figure 46--(11H) cont'd.

Figure 47--(11H). Red Cross Hospital (1600 meters). Showing Red Cross Hospital from direction of bomb center, 1.7 kilometers from center. Some windows have been repaired. Optical axis of camera in line with the hypocenter. (Photo File # HB 204 (K); Date: 27 November 1945.)

Section 11 N

BUILDING AND PROTECTION STUDIES, NAGASAKI

Prepared by George V. LeRoy, Lt. Col., MC, and Herbert S. Swanson, Lt. Col., CE

Data Collected by Herman Tarnower, Major, MC, Samuel Berg, Major, MC, M. Urabe, MD, and Members of the Joint Commission Team in Nagasaki

The circumstances of the investigation in Nagasaki were such that it was possible to obtain complete information on the effects of the atomic bomb on the occupants of only three buildings. Complete data was supplied for the occupants of certain rooms in some of the reinforced concrete buildings of the Hospital of the Nagasaki Medical College. It is possible from these studies to make certain estimates of the degree of protection against gamma rays and neutrons that was afforded by varying amounts of material. Incomplete records were obtained regarding the fate of the majority of groups of workers in three of the large industrial establishments. From these it is possible to judge the relative protection against injury offered by that type of construction. The groups will be described separately.

(1) Fuchi School is located on a low bluff approximately 1000 meters south of the center (See map, figure 1). It was built on a series of terraces and consisted of a single, heavy reinforced concrete portion three stories in heights which faced to the northeast. Two-story frame buildings surrounded a central courtyard and were attached to the concrete structure. Within the courtyard were several small shops, some of frame, and one of light steel and concrete construction. Behind the main courtyard was a terrace, also enclosed by the frame buildings which served as a playground. The various frame portions of the school were joined to each other by concrete fire-stairs. The main building which faced the blast was of heavy construction with walls 9 inches in thickness. The roof slab was 3½ inches thick, covered with a layer of tar and tile. The floor slabs were 4½ inches thick. On 9 August the students had not reported for school in accordance with existing regulations

concerning air raids. There were only 66 people in the building at the time the bomb exploded. The location and the fate of these people is shown in Table 1. Because of the small number of persons who were in other parts of the school, it is desirable to consider only the casualty data for those in the wooden buildings. It will be seen from Table 1 that of the 50 persons whose fate was determined (55 minus the 5 for whom no information was available), 92% were casualties, and 18, or 36% were killed; and of these 14 succumbed within 4 to 5 weeks to radiation sickness. It can also be seen that of the 50 persons exposed to the effects of the atomic bomb in wooden buildings at a distance of 1000 meters, 70% developed symptoms of radiation injury. Among these with symptoms, 40% subsequently died.

TABLE 1

OUTCOME	LOCATION			
	CAVES	CONCRETE BUILDING	OUTDOORS	WOODEN BUILDINGS
DEAD				
Died instantly	0	0	1	2
Died, burns & wounds	0	0	2	2
Died, Radiation injury	0	0	0	14
Total Dead	0	0	3	18
SURVIVED				
Uninjured	2	1	2	4
With burns and wounds	0	2	0	7
With Radiation injury	0	0	1	21
Total Survivors	2	3	3	32
UNTRACED				5
Total Persons	2	3	6	55

A comparison of the killed rate and the total casualty rate for all the persons in the wooden buildings of Fuchi School, with the same rates for the general population at the same distance, 1000 meters, is shown in Table 2. This relationship is also shown on the smoothed curves in Figure 12.

TABLE 2

	WOODEN BUILDINGS OF FUCHI SCHOOL	RANDOM SAMPLING STUDY, GENERAL POPULATION at 1000 meters
Killed Rate	36%	66%
Total Casualty Rate	92%	85%

The data for the persons in the wooden buildings was re-examined in an attempt to eliminate individuals who may have received some amount of shielding from the concrete fire-stairs, etc. It was possible to form a group of 36 persons who were in the wooden buildings on the north side of the courtyard. These people were protected from the effects of the bomb only by the wooden walls and tile roofs of the buildings. The fate of the members of this group is shown in Table 3.

TABLE 3

		NUMBER
DEAD	16	
Died instantly, and of burns and wounds		3
Died, radiation injury		13
SURVIVED	16	
With radiation injury		13
With other types of injury		2
Uninjured		1
No information available	4	
Total in wooden buildings on north side, school	36	32

This is a very important group of people. Of the 32 whose fate was determined,

only one escaped injury of any sort. Of the 29 who lived long enough for the symptoms of radiation injury to become manifest, only 3 were apparently unaffected. This gives a rate for the incidence of radiation injury at 1000 meters of at least 90%. Of the 26 patients in whom typical evidence of the syndrome of radiation injury developed, 13 or 50% died. This is a regrettably small group; but it is the only valid information that was obtainable in Nagasaki which would permit an estimate of the distance at which the LD 50 of ionizing radiation from the Nagasaki-type bomb was delivered.

No photographs of the Fuchi School before the bombing were available. Figure 2 is a general view of the ruins of school group, seen from the northwest. The majority of the casualties occurred in the wooden buildings whose foundation can be seen in the foreground. Two other views, Figures 3 and 4, show the ruins in the courtyard. After being demolished by the blast, the debris of the wooden buildings caught fire, as did the debris inside the concrete portion.

(2) Shiroyama National School is located on high ground, about 500 meters west of the center. (See map, figure 1). It is a reinforced concrete building with walls 8 inches thick, and roof and floor slabs 4½ inches thick. The south wing is a recent addition, and was less strongly built than the remainder of the building. In Figures 5 and 6 the appearance of the damaged school is shown, with the roof of the south wing caved in by the blast. It is said (1) that this wing collapsed at some time (several hours) after the bombing; but the evidence for this is not available at present. During the war a part of the floor space of the school was devoted to war-manufactures. On 9 August, there were 151 people in and around the school, most of whom were workmen. The general location and the fate of these people is shown in

(1) Report of the British Mission to Japan, classified.

Table 4. The physical conditions inside the school after the bombing are shown in Figures 7, 8, 9, 10 and 11.

TABLE 4

LOCATION	DIED INSTANTLY	DIED LATER	SURVIVED	TOTALS
Inside the school	38	70	9	117
Outdoors, in yard	12	5	0	17
In air raid shelter	2	4	11	17
TOTALS	52	79	20	151

The fate of the people on each floor of the school building is presented in Table 5.

TABLE 5

FATE OF PERSONS IN SHIROYAMA SCHOOL

OUTCOME	LOCATION IN SCHOOL: FLOOR			TOTAL
	3rd	2nd	1st	
DEAD				
Instantly	25	7	5	37
Burns and wounds	14	11	5	30
Radiation Injury	26	12	1	39
Unknown cause	1	1	0	2
Total Dead	66	31	11	108
SURVIVED				
Radiation injury	0	5	2	7
Other injuries	0	0	0	0
Uninjured	0	0	2	2
Total Survivors	0	5	4	9
Reference to Text Figures: Number	8 (11N)	9 (11N) 10 (11N)	11 (11N) 7 (11N)	

The details of the construction of the building were studied with respect to the amount of shielding afforded the rooms in which some of the

occupants survived. The engineer drawing, Figure 21, illustrates the conditions in two sections of the school in which there were survivors. By using the data in Table 6A it is possible to estimate the amount of protection in equivalent inches of water which the building provided to the occupants. On the 3rd floor all persons who received radiation injury died; and on that floor the maximum shielding was equivalent to 81 inches of water, or 30 inches of concrete. On the 2nd floor 5 of the 17 persons known to have received radiation injury survived. The location of 4 of these is shown in Figure 12, and the shielding for them was 58, 58, 58 and 101 inches of water, respectively. It is possible that their locations were plotted incorrectly, but in any case the maximum amount of shielding they could have received was 108 inches of water. The survivors on the 1st floor who are shown in Figure 21 were protected by the equivalent of 117, 117 and 146 inches of water respectively. (See Table 6B) The sole uninjured survivor, if he was in the location plotted was shielded by 117 inches of water, and the maximum shielding that he could have had anywhere on the 1st floor was 146 inches of water.

In this building, at a distance of approximately 700 meters from the airburst, the amount of shielding required to prevent fatal radiation injury was some amount between 81 and 58 inches of water, or 35 and 25 inches of concrete. Approximately 146 inches of water can be assumed to have been necessary to prevent any radiation injury at this distance. This amount of water is equivalent to 61 inches, or about 5 feet of concrete. These data are approximations at the best, but they appear to be consistent, and agree fairly well with

NAGASAKI

SHIROYAMA NATIONAL SCHOOL

Table 6A

Shielding Section	SHIELD Depth Inches	SHIELD Area Sq.Ft.	MATERIAL Type	MATERIAL Per cent	MATERIAL Depth Inches	MATERIAL Spec. Grav.	Effective Depth, Inches of Water	
Beam #4	19.93	On 1st Flr: 310.5 On 2nd Flr: 179.4	Conc. Plaster	88.9 11.1	17.93 2.00	2.3 1.0	41.24) 2.00)	43.24
Beam #3	22.53	On 1st Flr: 621.0 On 2nd Flr: 179.4	Conc. Plaster	90.6 9.4	21.53 2.00	2.3 1.0	49.52) 2.00)	51.52
Roof	9.18	On 1st Flr: 1386.0 On 2nd Flr: 1123.2	Conc. Plaster Tar Paper	87.3 11.0 1.7	8.10 1.00 .17	2.3 1.0 1.2	18.63) 1.00) .21)	19.84
Floor, 1st & 2nd:	7.73	On 1st Flr: 1386.0 On 2nd Flr: 1123.2	Conc. Plaster	86.9 13.1	6.73 1.00	2.3 1.0	15.48) 1.00)	16.48
Interior Wall	11.20	On 1st Flr: 1413.0 On 2nd Flr: 842.4	Wood Conc.	20.6 79.4	2.30 8.90	0.4 2.3	.92) 20.47)	21.39

Table 6A (Cont'd)

NAGASAKI

SHIROYAMA NATIONAL SCHOOL

Estimated Effective Shielding in Inches of Water
at a Plane 1 Meter above Floor Level

Floor	Maximum	Minimum	Average
3rd	81	16	48
2nd	108	35	67
1st	146	73	104

the data obtained from a similar analysis of the conditions in the Chinzei Middle School which follows.

TABLE 6B

NAGASAKI

SHIROYAMA NATIONAL SCHOOL

Estimated Effective Shielding in Inches of Water
For the Individual Survivors

Case Number	Floor	Shielding, in inches of Water
76	2nd	58
95	2nd	58
103	2nd	58
104	2nd	108
123	1st	117
151 *	1st	117
121	1st	146

* This person received no radiation injury, so far as could be determined. He was a 2-year old baby, and may have been further shielded by his mother, Case 123.

The experience of the occupants of this heavily constructed building at 500 meters is impressive: of 117 persons, 108 or 92% died; and only 2 escaped injury of any sort. The people who were in the air raid shelter fared much better; 10 of the 17 were uninjured. The 6 who died and the one who survived with radiation injury were all standing close to the entrance and thus failed to receive the benefit of the shelter. Unfortunately the amount of dirt covering this cave is not known, although it can be seen in Figure 25 (11N) that it is quite thick.

(3) Chinzei Middle School is located on high ground 500 meters southwest of the center. (See Map, figure 1) Its exposure to the exploding bomb was thus practically identical with that of the Shiroyama National School. It was a modern, four-story, reinforced concrete building of pleasing appearance. (See figures 17a, 17b in Section 3N for the before and after view). A wooden structure containing a gymnasium and a judo court was attached to the southwest portion of the main building. A part of the space in the school was devoted to war-work and contained shops of the Mitsubishi Corporation. At the time of the bombing there were 118 persons, mainly workmen, in the school. The location of these people in the two buildings, and the outcome of the occupants of each is shown in Table 7. The workmen in the wooden building who were not killed outright, died within a period of a week of burns, wounds, and radiation injury. The outcome of the people in the concrete building is presented in detail in Table 8. The appearance of the exterior of the school is shown in Figure 13; and views of the interior in Figures 14, 15, 16, 17, 18 and 19. The attached wooden building was completely demolished, and burned, and it is not illustrated.

TABLE 7

LOCATION	DIED INSTANTLY	DIED LATER	SURVIVED	TOTALS
Concrete building	46	30	15	91
Wooden buildings	22	5	0	27
Total	68	35	15	118

TABLE 8

FATE OF PERSONS IN CHINZEI MIDDLE SCHOOL

	LOCATION IN SCHOOL: FLOOR					
OUTCOME	4th	3rd	2nd	1st	Basement	Totals
DEAD						
Instantly	2	6	25	13	0	46
Burns and Wounds	1	0	6	6	0	13
Radiation Injury	0	0	8	7	1	16
Unknown cause	0	0	0	0	0	1
Total Dead	3	6	39	27	1	76
SURVIVED						
Radiation Injury	0	0	4	2	2	8
Other Injuries	0	0	0	4	0	4
Uninjured	0	0	1	0	0	1
Untraced	0	0	0	0	2	2
Total Survivors	0	0	5	6	4	15

Reference to Text Figures: Number 14(11N) 15(11N) 16(11N) 17(11N) 18(11N) 19(11N)

The details of the construction of the building were studied with respect to the amount of shielding that was afforded to the rooms in which there were survivors. An engineer drawing, Figure 20, was prepared to aid in the estimation of the amount of shielding from ionizing radiation afforded by the building. The maximum shielding occurred on the 1st floor at several places where the shadows of two heavy columns were superimposed, and at these points it was equivalent to 308 inches of water. The details

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TABLE 9A

Original data on the amount of shielding afforded by the various structural members, reduced to inches of water, at a distance 1,0 meters above the floor.

1 SHIELDING SECTION	2 SHIELD DEPTH	3 AREA IN SQ. FT.	BASEMENT ROOM 4 TYPE	5 MATERIAL PERCENT	6 MATERIAL DEPTH	7 SPEC. GRAV.	8 EFF. DEPTH IN INCHES OF WATER		9 ACTUAL THICKNESS
R.C. Roof	2.869	795	Conc. Tar Paper	94.12 5.88	2.700 .169	2.3 1.0	6.110) .169)	6.279	2 1/8"
Tile Roof	2.013	1080	Wood Tile	49 51	1.350 1.013	0.4 2.6	0.540) 2.634)	3.174	1 3/4"
1st 2nd Floors 3rd 4th	6.751	3188 3063 2594 1105	Conc. Plaster	85 15	5.738 1.013	2.3 1.0	13.197) 1.013)	14.210	5"
Beam #1	23.100	688	Conc. Plast.*	85 15	96.635 3.465	2.3 1.0	45.161) 3.465)	48.626	10"
Beam #2	30.030	581	Conc. Plast.*	88.46 11.54	25.565 3.465	2.3 1.0	61.100) 3.465)	64.565	13"
Beam #3	30.030	263	Conc. Plast.*	88.46 11.54	25.565 3.465	2.3 1.0	61.100) 3.465)	64,565	13"

*1½" Plaster = 3/4" on each side.

TABLE 9A (cont'd.)

1 SHIELDING SECTION	2 SHIELD DEPTH	3 AREA IN SQ. FT.	4 TYPE	5 MATERIAL PERCENT	6 DEPTH	7 SPEC. GRAV.	8 EFF. DEPTH IN INCHES OF WATER		9 ACTUAL THICKNESS
Column #A	20.031	214	Conc. Plast.	91.35 8.65	18.298 1.733	2.3 1.0	42.085) 1.733)	43.818	13"
Column #B	50.440	283	Conc. Plast.	94.24 5.76	47.530 2.910	2.3 1.0	108.319) 2.910)	111.229	26"
Column #D	46.560	158	Conc. Plast.	93.72 6.28	43.650 2.910	2.3 1.0	100.395) 2.910)	103.305	24"
Column #F	42.680	112	Conc. Plast	93.19 6.81	39.770 2.910	2.3 1.0	91.471) 2.910)	94.381	22"
East Wall	23.101	1438	Conc. Plast.	92.50 7.50	21.368 1.733	2.3 1.0	49.146) 1.733)	50.879	10"
Parapet North & West	USE SAME FIGURES AS FOR NORTH & EAST WALLS								
Trusses Steel	.184	51	Sheet Steel	100	.184	7.5	1.380		.095" Steel plate Assumed (Angle structurer)
Trusses Wood	4.103	205	Wood	100	4.103	0.4	16.412		2.115 Wood Sheet Assumed (6" x 6" Timbers)

*1½" plaster = 3/4" on each side.

Effective Depth of Shielding in inches of water.
299." Maximum
115" Average
0.5" Minimum

12 (11N)

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TABLE 9A

Original data on the amount of shielding afforded by the various structural members, reduced to inches of water, at a distance 1.0 meters above the floor.

1ST FLOOR

1 SHIELDING SECTION	2 SHIELD DEPTH	3 AREA IN SQ. FT.	4 TYPE	5 MATERIAL PERCENT	6 DEPTH	7 SPEC. GRAV.	8 EFF. DEPTH IN INCHES OF WATER		9 ACTUAL THICKNESS
R.C. Roof	2.869	2262	Conc. Tar Paper	94.12 5.88	2.700 .169	2.3 1.0	6.110) .169)	6.279	2 1/8"
Tile Roof	2.013	4524	Wood Tile	49 51	1.350 1.013	0.4 2.6	0.540) 2.634)	3.174	1 3/4"
Floors 2nd 3rd 4th	6.751	11025 8964 4692	Conc. Plast.	85 15	5.738 1.013	2.3 1.0	13.197) 1.013)	14.210	5"
Beam #1	23.100	1810	Conc. Plast.*	85 15	19.635 3.465	2.3 1.0	45.161) 3.465)	48.626	10"
Beam #2	30.030	1510	Conc. Plast.*	88.46 11.54	25.565 3.465	2.3 1.0	61.100) 3.465)	64.565	13"
Beam #3	30.030	2513	Conc. Plast.*	88.46 11.54	25.565 3.465	2.3 1.0	61.100) 3.465)	64.565	13"
Column #A	20.031	598	Conc. Plast.	91.35 8.65	18.298 1.733	2.3 1.0	42.085) 1.733)	43.818	13"

TABLE 9A (cont'd.)

1 SHIELDING SECTION	2 SHIELD DEPTH	3 AREA IN SQ. FT.	4 TYPE	5 MATERIAL PERCENT	6 DEPTH	7 SPEC. GRAV.	8 EFF. DEPTH IN INCHES OF WATER		9 ACTUAL THICKNESS
Column #B	50.440	330	Conc. Plast.	94.24 5.76	47.530 2.910	2.3 1.0	108.319) 2.910)	111.229	26"
Column #C	44.620	140	Conc. Plast.	93.48 6.52	41.710 2.910	2.3 1.0	95.933) 2.910)	98.843	23"
Column #D	46.560	350	Conc. Plast.	93.72 6.28	43.650 2.910	2.3 1.0	100.395) 2.910)	103.305	24"
Column #E	35.920	140	Conc. Plast.	91.90 8.10	32.010 2.910	2.3 1.0	73.623) 2.910)	76.533	18"
Column #F	42.680	580	Conc. Plast.	93.19 6.81	39.770 2.910	2.3 1.0	91.471) 2.910)	94.381	22"
Column #X	38.800	242	Conc. Plast.	92.50 7.50	35.890 2.910	2.3 1.0	82.547) 2.910)	85.457	20"
North Wall	19.400	4452	Conc. Plast.	92.50 7.50	17.945 1.455	2.3 1.0	41.274) 1.455)	42.729	10"
East Wall	23.101	960	Conc. Plast.	92.50 7.50	21.368 1.733	2.3 1.0	49.146) 1.733)	50.879	10"
Parapet North & West	USE SAME FIGURES AS FOR NORTH AND EAST WALLS								
Trusses Steel	.184	320	Sheet Steel	100.	.184	7.5	1.380		.095" Steel Plate Assumed (Angle Structure)

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TABLE 9A (cont'd.)

1	2	3	4	5	6	7	8	9
SHIELDING SECTION	SHIELD DEPTH	AREA IN SQ. FT.	TYPE	MATERIAL PER CENT	DEPTH	SPEC. GRAV.	EFF. DEPTH IN INCHES OF WATER	ACTUAL THICKNESS
Trusses Wood	4.103	640	Wood	100	4.103	0.4	16.412	2.115 Wood Sheet Assumed 6" x 6" Timbers

Note: The 308 " maximum shielding is due to the fact that 2 columns cast their shadows on the same place. The areas of this amount of shielding are small and are indicated on the drawing.

Effective Depth of Shielding in inches of water:

308"	maximum
94.8"	average
0.5"	minimum

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TABLE 9A

Original data on the amount of shielding afforded on the various structural members, reduced to inches of water, at a distance 1.0 meters above the floor.

2ND FLOOR

1 SHIELDING SECTION	2 SHIELD DEPTH	3 AREA IN SQ. FT.	4 TYPE	5 MATERIAL PERCENT	6 DEPTH	7 SPEC. GRAV.	8 EFF. DEPTH IN INCHES OF WATER		9 ACTUAL THICKNESS
R.C. Roof	2.869	2368	Conc. Tar Paper		2.700 .169	2.3 1.0	6.110) .169)	6.279	2 1/8"
Tile Roof	2.013	4736	Wood Tile	49 51	1.350 1.013	0.4 2.6	0.540) 2.634)	3.174	1 3/4"
Floor 3rd 4th	6.751	11025 5976	Conc. Plast.	85 15	5.738 1.013	2.3 1.0	13.197) 1.013)	14.210	5"
Beam #1	23.100	1304	Conc. Plast.*	85 15	19.635 3.465	2.3 1.0	45.161) 3.465)	48.626	10"
Beam #2	30.030	1147	Conc. Plast.*	88.46 11.54	26.565 3.465	2.3 1.0	61.100) 3.465)	64.565	13"
Beam #3	30.030	1695	Conc. Plast.*	88.46 11.54	26.565 3.465	2.3 1.0	61.100) 3.465)	64.565	13"

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TABLE 9A (Cont'd.)

1 SHIELDING SECTION	2 SHIELD DEPTH	3 AREA IN SQ. FT.	4 TYPE	5 MATERIAL PERCENT	6 DEPTH	7 SPEC. GRAV.	8 EFF. DEPTH IN INCHES OF WATER		9 ACTUAL THICKNESS
Column #A	20.031	353	Conc.	91.35	18.298	2.3	42.085)	43.818	13"
			Plast.	8.65	1.733	1.0	1.733)		
Column #D	46.560	350	Conc.	93.72	43.650	2.3	[illegible].395)	103.305	24"
			Plast.*	6.28	2.910	1.0	2.910)		
Column #E	35.920	140	Conc.	91.90	32.010	2.3	73.623)	76.533	18"
			Plast.*	8.10	2.910	1.0	2.910)		
Column #F	42.680	580	Conc.	93 19	39.770	2.3	91.471)	94.381	22"
			Plast.*	6.81	2.910	1.0	2.910)		
Column #X	38.800	242	Conc.	92.50	35.890	2.3	82.547)	85.457	20"
			Plast.*	7.50	2.910	1.0	2.910)		
Wall North	19.400	2990	Conc.	92.50	17.945	2.3	41.274)	42.729	10"
			Plast.	7.50	1.455	1.0	1.455)		
Wall East	23.101	680	Conc.	92.50	21.368	2.3	49.146)	50.879	10"
			Plast.	7.50	1.733	1.0	1.733)		
Trusses	4.103	396	Wood	100	4.103	0.4	16.412		2.115 Sheet (6" x 6" Timbers)

*1½" plaster = 3/4" on each side.

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17 (11N)

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TABLE 9A (Cont'd)

1 SHIELDING SECTION	2 SHIELD DEPTH	3 AREA IN SQ. FT.	4 TYPE	5 MATERIAL PERCENT	6 MATERIAL DEPTH	7 SPEC. GRAV.	8 EFF. DEPTH IN INCHES OF WATER	9 ACTUAL THICKNESS
Trusses Steel	0.184	792	Sheet Steel	100	0.184	7.5	1.380	0.095 Sheet (Angle Structure)

Parapet (USE SAME FIGURES AS FOR NORTH AND EAST WALLS)

Effective Depth of Shielding in inches of water:

216.0"	Maximum
73.7"	Average
0.5"	Minimum

of the shielding are shown in Table 9A, and by the use of this table and Figure 20 it is possible to estimate the effective shielding at any point in the building. The estimated amount of shielding for 14 of the survivors is shown in Table 9B. The location of Case 10 is undoubtedly incorrect, for the sketches placed him in front of a window. It is probably fair to assume that this patient actually received at least the average amount of shielding that was provided on the 1st floor, or 95 inches of water. From an inspection of Table 9B it is apparent that at this distance from the airburst the amount of shielding necessary to prevent fatal radiation injury was from 48 to 65 inches of water, or from 21 to 28 inches of concrete. On the basis of the one person with no evidence of radiation injury, the amount of shielding required to give complete protection is difficult to estimate. It was probably at least as much as the maximum for the building on the 2nd floor, or approximately 216 inches of water, or 93 inches of concrete.

TABLE 9B

CHINZEI MIDDLE SCHOOL

EFFECTIVE SHEILDING IN INCHES OF WATER FOR THE SURVIVORS*

Case No.	Floor	Shielding Inches, H_2O	Case No.	Floor	Shielding Inches, H_2O
1	Bas't	110	103	1st	110
2	Bas't	205	112	1st	110
3	Bas't	109	88	2nd	216 ***
4	Bas't	65	93	2nd	48
10	1st	0.5 **	94	2nd	48
92	1st	79	95	2nd	65
101	1st	110	97	2nd	65

* On Figure 20 cases 2,4,10,92,101, and 112 are marked as radiation injury, although in Table 8 they are not so listed.
** This persons location is obviously plotted incorrectly
*** This person was the sole uninjured survivor. Shield is estimated.

In the concrete building of this school 76 of the 91 occupants or 84% died; and only one of the survivors escaped any sort of injury. The two schools were of considerable interest because the conditions in each were so similar. The construction was alike, and they were equally distant from the bomb. Taking them together, it can be seen that at a distance of 500 meters from the point on the earth below an atomic bomb explosion, inside heavy concrete buildings, the following casualty rates occurred:

Killed Rate	88.4%
Total Casualty Rate	98.6%

This data is in close agreement with the location of the smoothed curves for the same rates at 500 meters in the general population, Figure 12, obtained by the random sampling study.

There were no survivors of the group of 27 people who were in the wooden building. The records showed that 22 of these were killed instantly, and that the remainder died within a period of less than 10 days of burns, wounds, and radiation injury. Data was obtained from a Prefectural report on the occupants of another group of wooden buildings - the Nagasaki Branch Prison. This was located on a low hill, Prison Hill (See Map, figure 1) 250 meters from the center. At the time of the bombing there were 118 persons in the prison area, guards and convicts. The buildings were completely demolished and there were no survivors. The killed rates in these wooden buildings located within 500 meters of the center was 100%. On the basis of these observations it seems very probable that any person who was within 500 meters of the center, and survived, received more protection from the radiant heat and the ionizing radiation than was afforded by a wooden building.

(4) Within 1500 meters of the center of the explosion were three large modern industrial plants devoted to war work. These were the Mitsubishi Steel

Factory, 1720 employees; the Ohashi Works, 6028 employees; and the Morimachi Works, 2201 employees. The three plants formed the majority of the unit known as the Mitsubishi Arsenal. The location of these industrial groups is shown on the Map, Figure 1. Each plant consisted of a number of buildings, varying in size and in the details of construction. The majority were steel-framed buildings of the north-light gantry type. A variety of materials was used in the roofs and the walls of the factories. Galvanized sheet metal, asbestos panels, and light weight concrete apparently the most commonly used. Almost all of the buildings contained large machine tools. The large amount of steel, and the irregular construction of these buildings made it impossible to prepare a study of the effective shielding as in the case of the two concrete school buildings. The appearance of the damaged factories is shown in Figures 11 (3N), 12 (3N), 3 (5N), 4 (5N) and 5 (5N). Data on the number of casulties in each plant was obtained from the officials of the Mitsubishi Corporation and is probably quite reliable. The figures were collected by the members of Nakajima's group, and are presented in detail in his report, Appendix 4N (19). For the purpose of this section, only the total figures for each plant are presented. The original report included studies of the blood counts and casualty rates in each building of the Morimachi Works, and in certain types of buildings in the other plants. The numbers involved were too small to be of much significance. Better data on the effect of building type on the occupants will be found in Section 9. The occupants of these three large plants fared appreciably better than the population as a whole. The killed and total casualty rate for each plant is tabulated in Table 10. The killed rate and total casualty rate obtained by the random sampling study for the population, generally, at the same distance from the center is included for comparison. The influence on the

TABLE 10

CASUALTIES IN FACTORY-TYPE BUILDINGS

Name of Plant	Meters Distance from Center	Reported in October		Random Sampling Study	
		Killed Rate	Total Casualty Rate	Killed Rate	Total Casualty Rate
Steel Factory:	650	53%	79%	82%	92%
	1300			48%	70%
Morimachi Works:	1300	27%	34%	48%	70%
	1500			38%	62%
Ohashi Works:	1100	20%	31%	60%	78%
	1500			38%	62%

incidence of casualties afforded by this type of industrial construction is shown graphically in Figure 12. Unfortunately it is impossible to ascertain the incidence of burns, wounds and radiation injury in the factory workers. Contemporary reports mention a large preponderance of mechanical injuries over burns, but the data are incomplete. It is to be expected that people indoors would be protected from the effects of heat and suffer more from flying debris, secondary missiles, etc.

(5) An effort was made to secure precise information on the fate of the occupants of the buildings of the Hospital of the Nagasaki Medical College, but it was not very successful. The Acting Dean, K. Koyano, submitted a report containing sketches of some of the reinforced concrete buildings with the location and the fate of as many of the occupants as could be determined. In many departments and clinics there were no survivors whose recollections were reliable. In this report 233 persons were accounted for, of whom 58, or 25% were known to be dead on 1 December. The only other information that was available on the personnel and patients of the Hospital was the police report dated 20 August. The figures in this report were as follows:

Number of patients, and personnel present.....658

Number of known dead.....198, or 30%

Number of known injured.....235

Total Casualties.....433, or 66%

On the basis of the change in the number of dead reported from the factories between the first accounting, and the "final" October figures, it is reasonable to assume that one-half of the injured ultimately died. Using these figures, the killed and casualty rate for the Hospital becomes: Killed Rate - 48%; Total Casualty Rate - 66%. The discrepancy between this killed rate and one

from the Dean's report may be explained in part by the fact that several of the hospital buildings were wooden structures that were completely demolished. The best rate for the Hospital as a whole would seem to be the last one cited, and this is the one shown on Figure 12. The incidence of radiation injury in the personnel of the Hospital could not be determined accurately. The Dean's report gave no information on this subject, and the only data available was in the questionnaire study. One hundred and forty-six persons who were inside the concrete buildings completed questionnaires, and of these 56, or 38% had clinical evidence of radiation injury. In spite of the fact that this figure is not altogether reliable, it is in striking contrast to the experience of the people inside the wooden portion of the Fuchi School, 90% of whom had radiation injury. Since the Hospital was about 200 meters closer to the bomb, the shielding influence of the concrete construction is apparent. The type of damage that occurred inside the Hospital buildings has been illustrated in Figures 20a, 20b (3N); and Figure 8 (5N).

It was possible to obtain some information on the location of a sufficient number of persons in the Surgical Clinic and the Polyclinic to justify a study of the shielding factors. Unfortunately it was not possible to determine the exact fate of each individual concerned; and the only information available was whether the individual was alive or dead in December 1945. In a few instances, it is known whether the occupants of the Polyclinic had radiation injury. The details of the construction of the Surgical Clinic (USSBS Building Number 33) are shown in the isometric drawing, Figure 22; and in Table 11A. The most important group of people for the purposes of this study were those who were in the basement, approximately 20 in number. All of these survived, and it is

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TABLE 11A; SURGICAL CLINIC, BLDG NUMBER 33

BASEMENT

1 Shielding Section	2 SHIELD Depth Inches	3 SHIELD Area Sq.Ft	4 MATERIAL Type	5 MATERIAL Percent	6 MATERIAL Depth	7 MATERIAL Spec. Grav.	8 Effective Depth in Inches	9 Actual Thickness Inches
1st Floor	9.97	1530	Conc. Plaster	87.5 12.5	8.72 1.25	2.3 1.0	21.306	6
2nd Floor	9.97	990	Conc. Plaster	87.5 12.5	8.72 1.25	2.3 1.0	21.306	6
3rd Floor	9.97	360	Conc. Plaster	87.5 12.5	8.72 1.25	2.3 1.0	21.306	6
North Wall	14.85	2160	Conc. Plaster	91.6 8.4	13.61 1.24	2.3 1.0	32.543	9
West Wall	17.11	124	Conc. Plaster	91.6 8.4	15.68 1.43	2.3 1.0	37.494	9
Columns, 2 Rows/Room	4.45	855	Conc. Plaster	90.9 9.1	4.04 0.41	2.3 1.0	9.702	2.7

SUMMARY: DEPTH OF SHIELDING EFFECT, INCHES OF WATER
Maximum: 96.5"; Minimum: 32.5"; Average: 66.9"

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TABLE 11A (cont'd): SURGICAL CLINIC, BUILDING NO. 33

FIRST FLOOR

1 Shielding Section	2 SHIELD Depth Inches	3 SHIELD Area Sq.Ft.	4 MATERIAL Type	5 MATERIAL Percent	6 MATERIAL Depth	7 Spec Grav	8 Effective Depth in Inches	9 Actual Thickness Inches
Roof	9.97	1441	Conc. Plaster Tar P'r	91.6 8.3 0.1	8.30 1.25 0.42	2.3 1.0 1.2	20.884	6
2nd Floor	9.97	8836	Conc. Plaster	87.5 12.5	8.72 1.25	2.3 1.0	21.306	6
3rd Floor	9.97	3520	Conc. Plaster	87.5 12.5	8.72 1.25	2.3 1.0	21.306	6
North Wall	14.85	8782	Conc. Plaster	91.6 8.4	13.61 1.24	2.3 1.0	32.543	9
West Wall	17.11	1812	Conc. Plaster	91.6 8.4	15.68 1.43	2.3 1.0	37.494	9
Columns, 2 Rows/room	4.45	12480	Conc. Plaster	90.9 9.1	4.04 0.41	2.3 1.0	9.702	2.7

SUMMARY: DEPTH OF SHIELDING EFFECT, INCHES OF WATER
Maximum: 178.7; Minimum: 32.5; Average: 56.3

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TABLE 11A (cont'd); SURGICAL CLINIC, BUILDING NO. 33

SECOND FLOOR

1 Shielding Section	2 SHIELD Depth Inches	3 SHIELD Area Sq.Ft	4 MATERIAL Type	5 MATERIAL Percent	6 MATERIAL Depth	7 MATERIAL Spec Grav	8 Effective Depth in Inches	9 Actual Thickness Inches
Roof	9.97	5377	Conc. Plaster Tar P'r	91.6 8.3 0.1	8.30 1.27 0.42	2.3 1.0 1.2	20.884	6
3rd Floor	9.97	5525	Conc. Plaster	87.5 12.5	8.72 1.25	2.3 1.0	21.306	6
North Wall	14.85	5984	Conc. Plaster	91.6 8.4	13.61 1.24	2.3 1.0	32.543	9
West Wall	17.11	1020	Conc. Plaster	91.6 8.4	15.68 1.43	2.3 1.0	37.494	9
Columns, 2 Rows/room	4.45	7800	Conc. Plaster	90.9 9.1	4.04 0.41	2.3 1.0	9.702	2.7

SUMMARY: DEPTH OF SHIELDING EFFECT, INCHES OF WATER
Maximum: 141; Minimum: 32.5; Average: 44.1

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TABLE 11A (cont'd): SURGICAL CLINIC, BUILDING NO. 33

THIRD FLOOR

1 Shielding Section	2 SHIELD Depth Inches	3 SHIELD Area Sq.Ft	4 MATERIAL Type	5 MATERIAL Percent	6 MATERIAL Depth	7 MATERIAL Spec Grav	8 Effective Depth in Inches	9 Actual Thickness Inches
Roof	9.97	5292	Conc. Plaster Tar P'r	91.6 8.3 0.1	8.30 1.25 0.42	2.3 1.0 1.2	20.844	6
North Wall	14.85	2868	Conc. Plaster	91.6 8.4	13.61 1.24	2.3 1.0	32.543	9
West Wall	17.11	540	Conc. Plaster	91.6 8.4	15.68 1.43	2.3 1.0	37.494	9
Columns, 2 rows/Rm	4.45	4660	Conc. Plaster	90.9 9.1	4.04 0.41	2.3 1.0	9.702	2.7

SUMMARY: DEPTH OF SHIELDING EFFECT, INCHES OF WATER
Maximum: 112.1; Minimum: 20.8; Average: 31.5

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known that a small number of them received radiation injury. The amount of shielding in the part of the basement where they were located varied from 75 to 96 inches of water. Accordingly, it may be stated that at a distance of 900 meters from the airburst the equivalent of 75 inches of water, or 32 inches of concrete, was more than sufficient protection to prevent fatal radiation injury. Since some of these people were uninjured, and since the maximum shielding was 96 inches of water, it appears that at this distance, 96 inches of water was sufficient to protect from radiation injury. The drawing of this building is especially interesting, since it illustrates on the first floor the effect of the additional shielding of the fire stairs. It can be seen that the people who were in the shadow of this additional material survived, while persons outside it died. The numbers on the drawing, Figure 22, indicate the amount of shielding in inches of water, equivalent, that was afforded in different parts of the building.

The results of the study of the Polyclinic (USSBS Building No. 26) are shown in Figure 23, and Table 12A. The symbols on the drawing indicate only whether the subject was dead or alive in December 1945. The amount of shielding that protected a few individuals who are known to have been uninjured is shown in Table 12B. There was fire in each of these buildings after the bombing, but it appears to have developed slowly, and probably was not responsible for many of the deaths. With respect to the estimates of the amount of shielding necessary to prevent radiation injury which were cited in the paragraph above, it is of interest to note in Table 12A, that some of the columns in the Polyclinic afforded the equivalent of 61 inches of water. Such columns were 18 inches thick.

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TABLE 12A; POLYCLINIC BUILDING NO. 26

FIRST FLOOR

1 Shielding Section	2 SHIELD Depth Inches	3 SHIELD Area Sq.Ft	4 MATERIAL Type	5 MATERIAL Percent	6 MATERIAL Depth	7 MATERIAL Spec. Grav.	8 Effective Depth in Inches	9 Actual Thickness Inches
Roof	12.7	841	Conc. Tile Plaster Tar P'r	71.4 14.3 10.7 3.6	9.07 1.82 1.36 0.41	2.3 2.6 1.0 1.1	27.35	7
3rd Floor	14.05	2190	Conc. Wood Plaster	64.5 25.8 9.7	9.07 3.63 1.35	2.3 0.5 1.0	24.00	7-3/4
2nd Floor	14.05	4084	Same as 3rd Floor				24.00	7-3/4
Columns Center	27.80	751	Conc. Plaster	91.6 8.4	25.3 2.3	2.3 1.0	61.00	18
Nor. Wall	13.90	630	Conc. Plaster	84.6 15.4	11.75 2.14	2.3 1.0	29.10	9-3/4
Beams, 2nd, 3rd Flr & Roof	22.90	1253	Conc. Plaster	87.5 12.5	20.0 2.9	2.3 1.0	49.00	12
North Wall	12.35	4480	Conc.	100.0	12.35	2.3	28.40	8
West Wall	15.00	1070	Conc.	100.0	15.0	2.3	34.50	8
Inter.Wall	12.35	3990	Conc. Plaster	81.3 18.7	10.05 2.3	2.3 1.0	25.40	8

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TABLE 12A (cont'd); POLYCLINIC, BUILDING NO. 26

FIRST FLOOR

1 Shielding Section	2 SHIELD Depth Inches	3 SHIELD Area Sq.Ft	4 MATERIAL Type	5 MATERIAL Percent	6 MATERIAL Depth	7 MATERIAL Spec. Grav.	8 Effective Depth in Inches	9 Actual Thickness Inches
Partitions	5.11	3360	Wood Plaster	40.0 60.0	2.04 3.07	0.5 1.0	4.09	2-1/2
Balcony, 2nd	14.05	239	Conc.	100.0	14.05	2.3	32.30	7-3/4
Windows, North	0.145	936	Glass	100.0	0.145	2.8	0.406	.09
Windows, West	0.179	210	Glass	100.0	0.179	2.8	0.501	.09
			Second Floor					
Roof	12.70	1015	Conc. Tile Tar P'r Plaster	71.4 14.3 3.6 10.7	9.07 1.82 0.41 1.36	2.3 2.6 1.1 1.0	27.35	7
3rd Floor	14.05	1988	Conc. Wood Plaster	64.5 25.8 9.7	9.07 3.63 1.35	2.3 0.5 1.0	24.00	7-3/4
Wall, North	12.35	1795	Conc.	100.0	12.35	2.3	28.40	8
Wall, West	15.00	926	Conc.	100.0	15.00	2.3	34.50	8

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TABLE 12A (cont'd); POLYCLINIC: BUILDING NO. 26

SECOND FLOOR

1 Shielding Section	2 SHIELD Depth Inches	3 SHIELD Area Sq.Ft	4 MATERIAL Type	5 MATERIAL Percent	6 MATERIAL Depth	7 MATERIAL Spec. Grav.	8 Effective Depth in Inches	9 Actual Thickness Inches
Interior Walls	12.35	2362	Conc. Plaster	81.3 18.7	10.05 2.30	2.3 1.0	25.4	7
Partitions, North & South	5.11	975	Wood Plaster	40.0 60.0	2.04 3.07	0.5 1.0	4.09	2-1/2
Beams, Roof & 3rd Flr	22.90	902	Conc. Plaster	87.5 12.5	20.00 2.90	2.3 1.0	49.00	12
Columns Nor.Wall	13.90	214	Conc. Plaster	91.6 8.4	12.70 1.20	2.3 1.0	30.40	18
Columns, Central	27.80	405	Conc. Plaster	85.0 15.0	11.6 2.3	2.3 1.0	29.00	9-3/4
Windows, North	0.145	342	Glass	100.0	0.145	2.8	0.406	.09
Windows, West	0.179	186	Glass	100.0	0.179	2.8	0.501	.09

SUMMARY: POLYCLINIC, FIRST FLOOR: 201 " Maximum 164" SECOND FLOOR
.406 Minimum .406
106 " Average 92 "

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TABLE 12B

SHIELDING DATA FOR CERTAIN PERSONS IN POLYCLINIC, BLDG. No. 33

Number*	First Floor Effective Shielding Inches, H_2O	Outcome	Number	Second Floor Effective Shielding Inches, H_2O	Outcome
1	163	Lived,R.I.**	1	105	Lived,R.I.
7	235	Lived,R.I.	6	170	Lived,R.I.
12	113	Died, R.I.	7	125	Died, R.I.
13	153	Lived	9	28 - 61***	Died, R.I.
16	158	Lived	11	117	Lived
19	139	Died	13	28 - 61	Died, R.I.
25	88	Lived,R.I.	14	28 - 61	Died, R.I.
30	112	Lived,R.I.			
31	110	Lived			
35	232	Lived			

Notes: * Number: refers to number on Figure 23; and to numbers in the Special Report prepared by Dr. K. Koyano, on file at the Army Institute of Pathology.

** R.I.: indicates that the person in question had clinical symptoms of radiation injury. Where there is no notation, the person did not have symptoms of radiation injury.

*** The movement of this individual one foot in either direction would change the amount of shielding through the range shown.

Comments: The location of these persons was established from free-hand sketches of the Polyclinic, and are very likely rather inaccurate with respect to the structural details of the building. For example, the moving of Number 7 (First Floor) a foot or so in either direction would reduce the amount of shielding by 122 inches!

The agreement of this data with the information gained from a study of the Surgical Clinic (Building No. 33) is not too close. The main information of value to be obtained from the latter building is the fate of the 19 people in the basement; and accordingly the deductions as to the amount of shielding required at this distance is based on the fate of that group, rather than on the fate of the people in the Polyclinic.

(6) It has been demonstrated in the Statistical Section (9) that the people who were inside caves and tunnel-shelters suffered the least effects from the atomic bomb. A special study of the survivors from the cave behind the Shiroyama School, and from three caves on the side of Prison Hill, directly beneath the bomb, was made by the Japanese members of the Joint Commission, and is filed in the Army Institute of Pathology. There is no doubt but that people well inside caves were completely uninjured. Those close to the entrance, or situated within sight of the airburst fared the same as people outdoors. Two of the eye-witness accounts (Appendix 3N, 16 and 17) describe the conditions in caves almost directly beneath the airburst of the bomb. Unfortunately none of the studies include measurements of the thickness of the earth and rock that formed the roof of the caves, and afforded the protection against the ionizing radiation. The appearance of the exteriors of two of the shelters of this type is shown in Figures 24 and 25, and from these a general impression of the thickness can be gained. In the absence of specific measurements, no further discussion of this type of shelter is warranted.

The effectiveness of trench-shelters, and of other types of air-raid shelter was not studied by the Joint Commission. Reference to the usefulness of this type of protection is found in the Report of the British Mission to Japan. On the basis of the data presented for the School and Hospital buildings, however, it is possible to estimate the amount of heavy material required to protect persons from the radiation of the atomic bomb.

SUMMARY

The significant findings reported in this section are of three sorts:

A. Effect of heavy construction.

(1). It has been shown that heavy reinforced concrete construction as close as 500 meters to the center (700 meters from the airburst) afforded a very small measure of protection to the occupants, about 10% of whom survived the bombing, as compared with no survivors among people at the same distance in the open, or in wooden buildings.

(2). In reinforced concrete buildings, such as those of the Hospital, at a distance of 900 meters from the airburst, the effect of heavy construction was appreciable; and the killed rate among the occupants was about 2/3 that of people selected at random, and presumed to be in less substantial quarters. The incidence of radiation injury in survivors in the Hospital buildings was at least one-half as great as the incidence among people inside wooden buildings at an equivalent distance.

(3). In modern-type factories devoted to heavy industry, the killed and total casualty rates were considerably lower than for the population at random, who may be assumed to have been in less protected locations.

(4). Deep caves were the safest shelters in Nagasaki.

B. The intensity of the ionizing radiation: One example is available which permits an estimate of the point at which the intensity of the ionizing radiation was such that approximately 50% of those affected by it died. This point was the wooden building of the Fuchi School, approximately

1100 meters from the airburst.

C. Shielding factors.

(1). At a distance of approximately 700 meters from the airburst, the intensity of the ionizing radiation was such that at least 3 feet of concrete was necessary to prevent fatal radiation injury. At the same distance, from 5 feet to 7½ feet of concrete was required to protect against radiation injury.

(2). At a distance of approximately 900 meters from the airburst, the intensity of the ionizing radiation was such that approximately 32 inches of concrete was more than sufficient to prevent fatal radiation injury. At this same distance approximately 3½ feet of concrete was adequate shielding to prevent radiation injury.

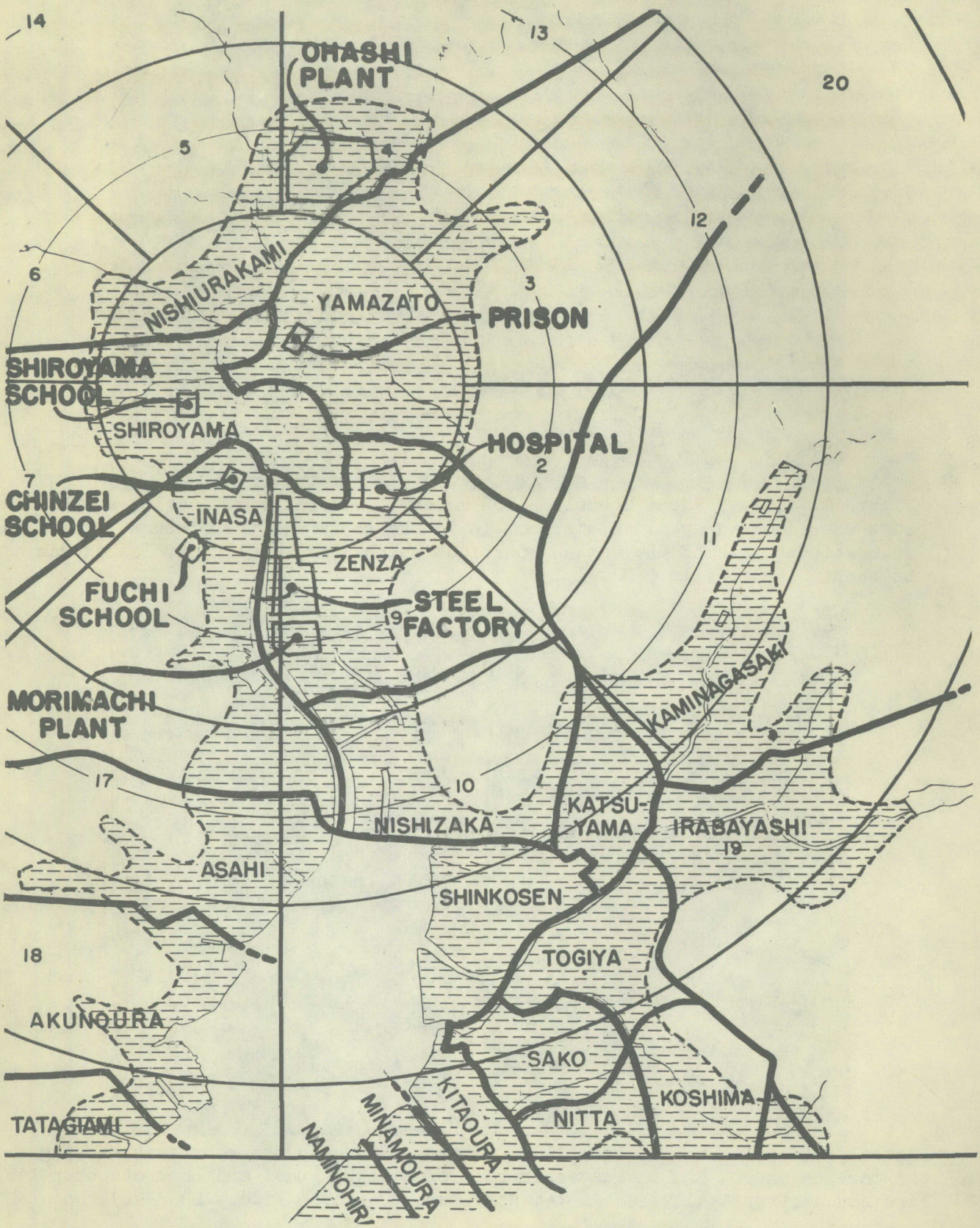

Figure 1--(11N). Map of Nagasaki showing location of buildings referred to in Section 11N. (Photo File # NP 163.)

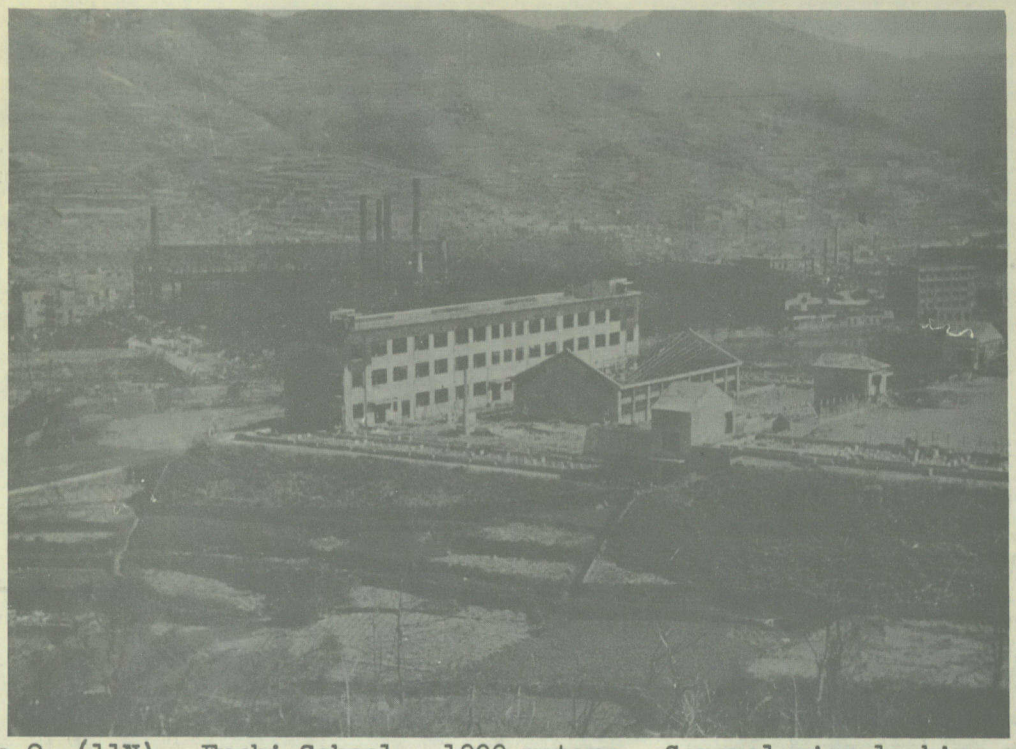

Figure 2--(11N). Fuchi School. 1000 meters. General view looking southeast over damaged area. The school is in the center of the picture. The foundation stones of the wooden portions which were totally demolished can be seen. (Photo File # NG 117.)

Figure 3--(11N). Fuchi School, 1000 meters. Scene is the courtyard showing the machine shops, and the caved in roof of a light steel and concrete shop. Fire has destroyed all the blasted structures. (Photo File # NB 317.)

Figure 4--(11N). Fuchi School, 1000 meters. Scene in the upper courtyard. The structure at the left is a reinforced concrete fire-stairs which joined two wings of the wooden buildings. (Photo File # NB 322.)

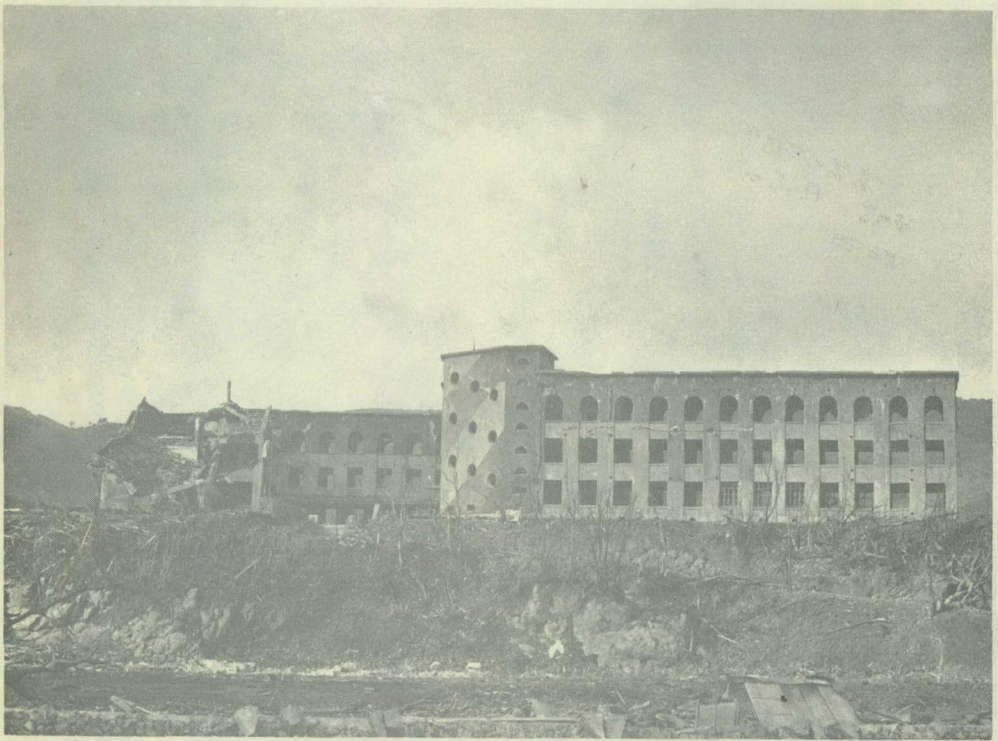

Figure 5--(11N). Shiroyama National School, 500 meters. General view from the east, the direction facing the bomb. Notice the caved-in portions of the south wing. (Photo File # NB 408a.)

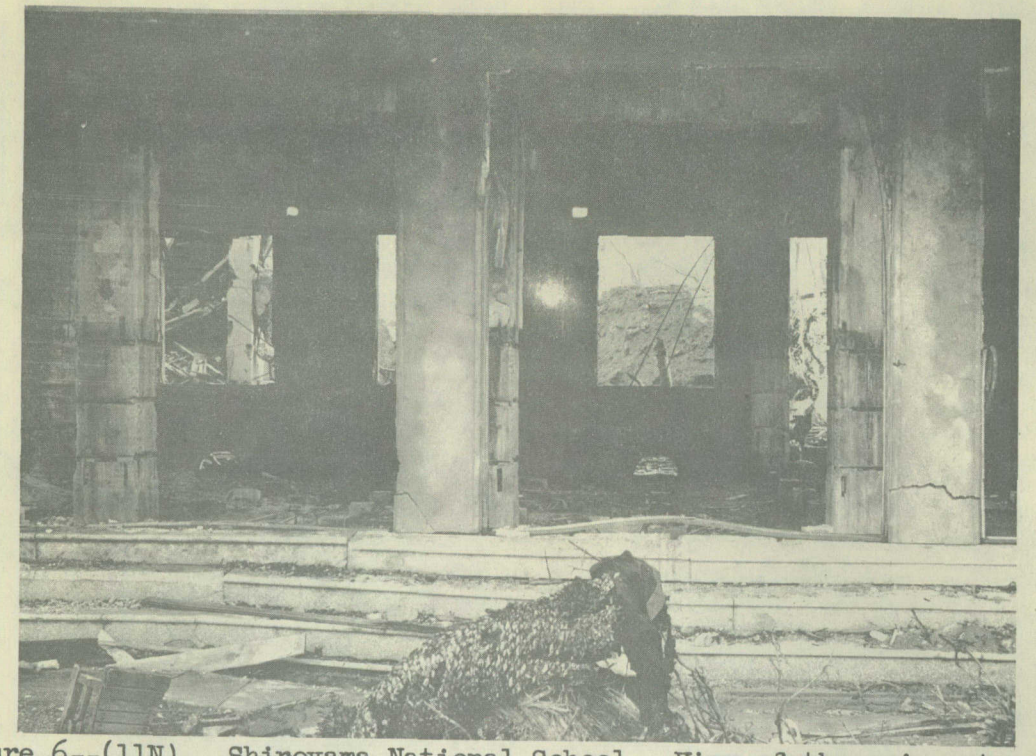

Figure 6--(11N). Shiroyama National School. View of the main entrance. Notice the depression of the stone steps due to blast. (Photo File # NB 323.)

Figure 7--(11N). Shiroyama National School, 500 meters. Close-up view of the South wing showing the collapse of the roof and the 3rd floor. (Photo File # NB 308.)

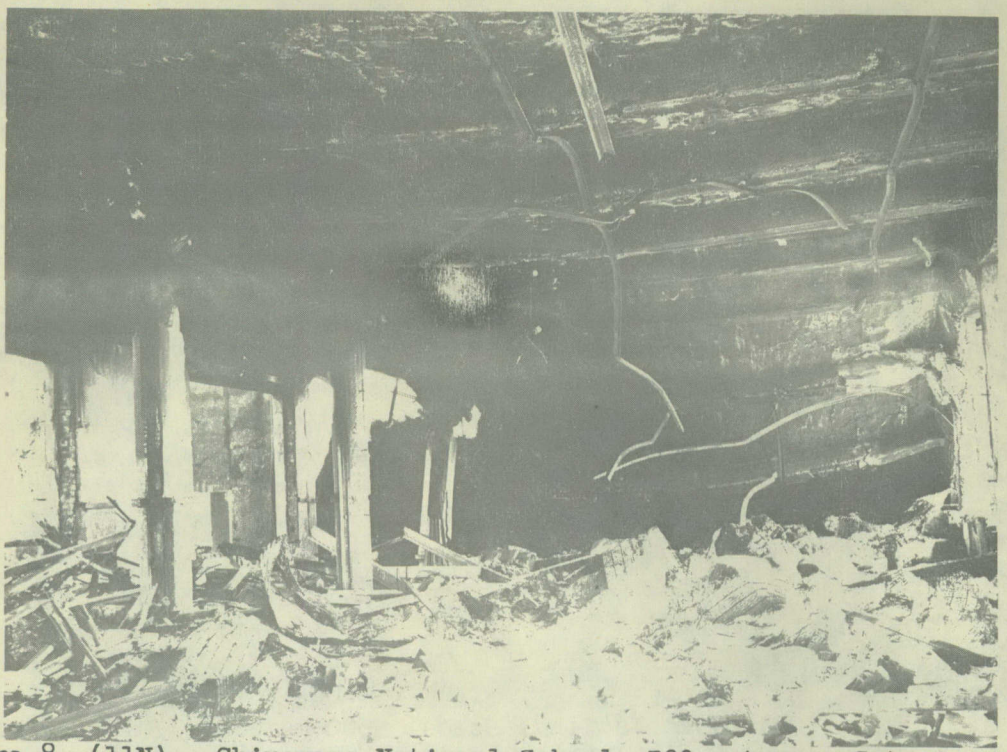

Figure 8--(11N). Shiroyama National School, 500 meters. Interior view, 3rd floor of the south wing, showing the collapsed roof. There were no survivors among the 66 people who were on the 3rd floor. (Photo File # NB 315.)

Figure 9--(11N). Shiroyama National School, 500 meters. Interior view of second floor, west wing. There was only one survivor of the 7 people in this room. (Photo File # NB 312.)

Figure 10--(11N). Shiroyama National School, 500 meters. Interior view, 2nd floor, south wing. This wing was originally divided into 4 rooms by partitions, all of which have been wrecked. Of the 29 people in these rooms, only 4 survived. (Photo File # NB 311.)

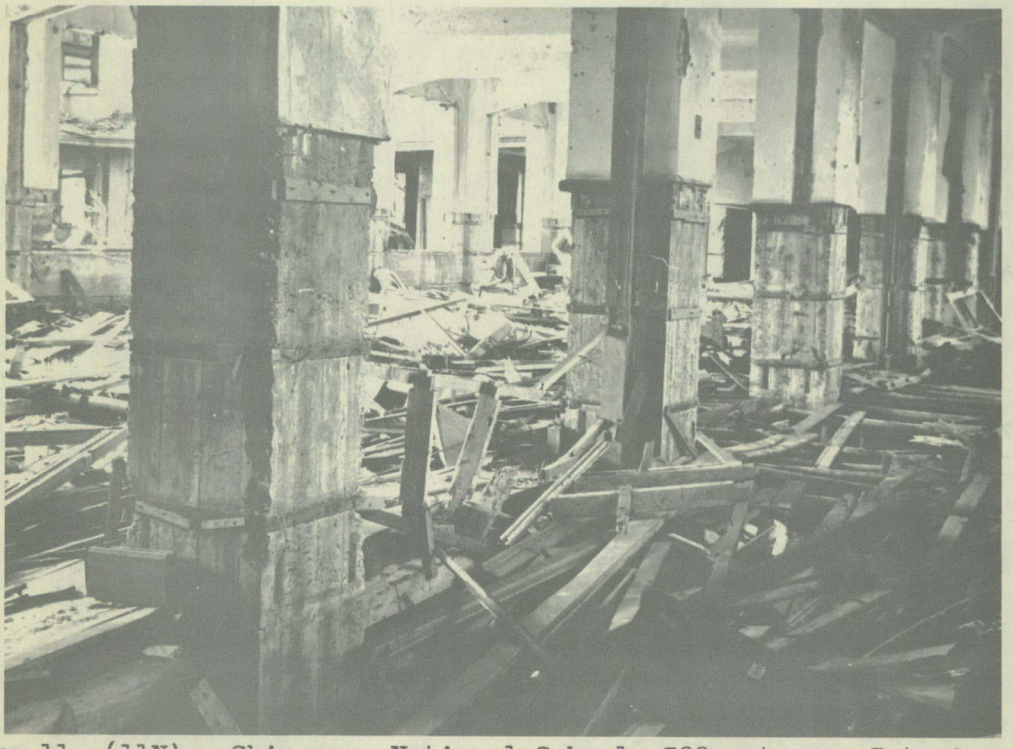

Figure 11--(11N). Shiroyama National School, 500 meters. Interior view, 1st floor, north wing. Notice the shattered remains of the wainscotting and interior trim. This did not burn. One person of 7 survived in this room. (Photo File # NB 309.)

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KILLED RATE AND TOTAL CASUALTY RATE

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MODIFICATIONS DUE TO SHIELDING AFFORDED BY BUILDINGS

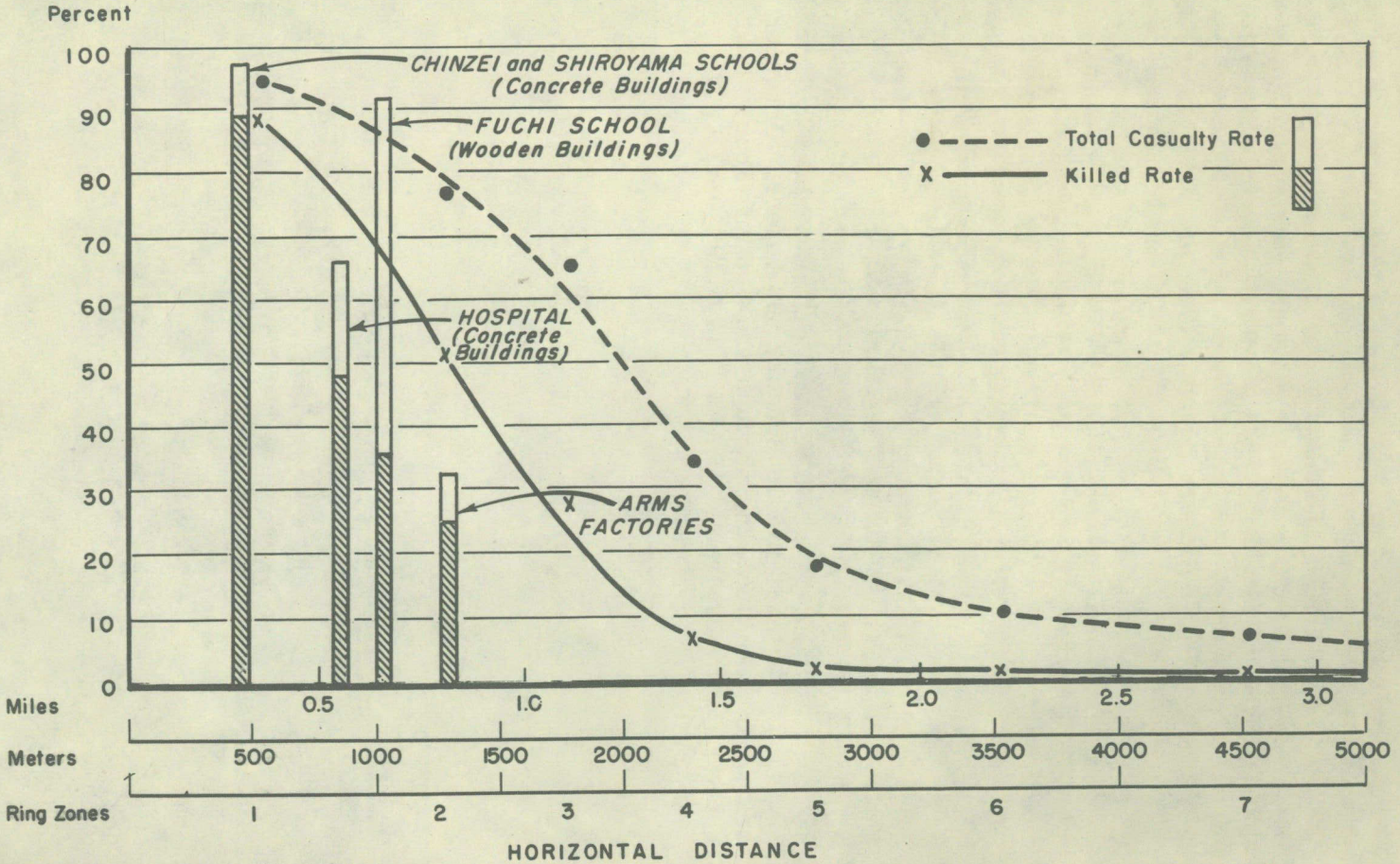

Figure 12--(11N). Smoothed curves for killed rate and total casualty rate, shown in relation to similar rates for specific buildings. (Photo File # NP 166b.)

Figure 13--(11N). Chinzei Middle School, 500 meters. Interior view, 1st floor, looking into the cellar, through the broken floor. Four of the 5 people in the cellar survived. (Photo File # NB 303.)

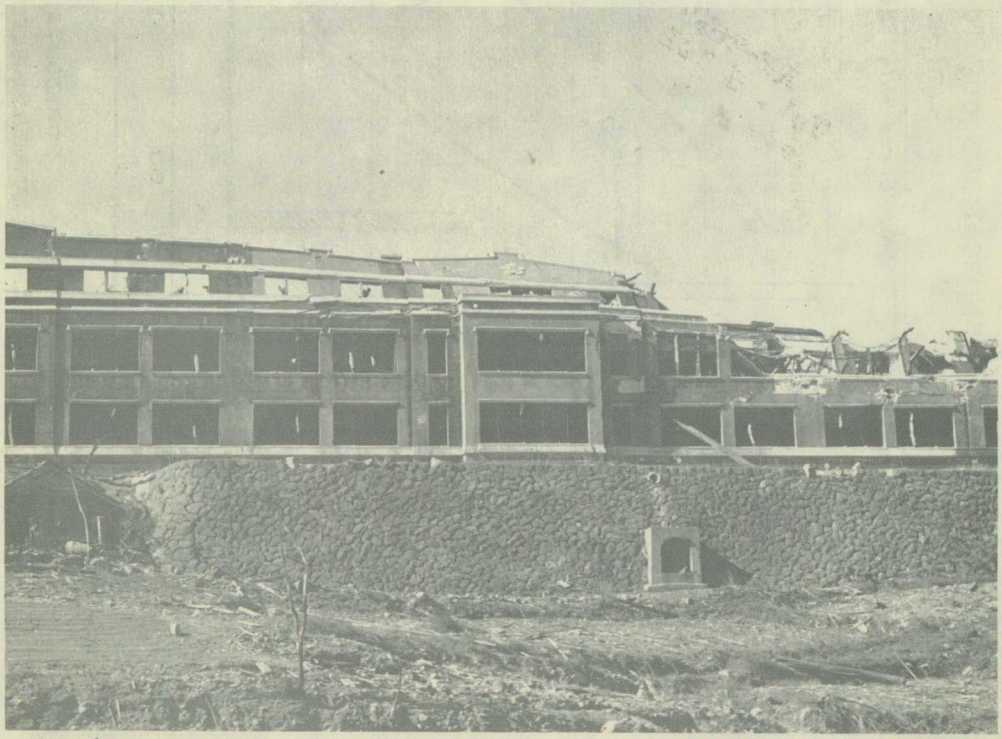

Figure 14--(11N). Chinzei Middle School, 500 meters. Exterior view of the front of the school, facing east, showing the damage to the roof and the upper two floors. See also Figure 17a,b (3N). (Photo File # NB 409b.)

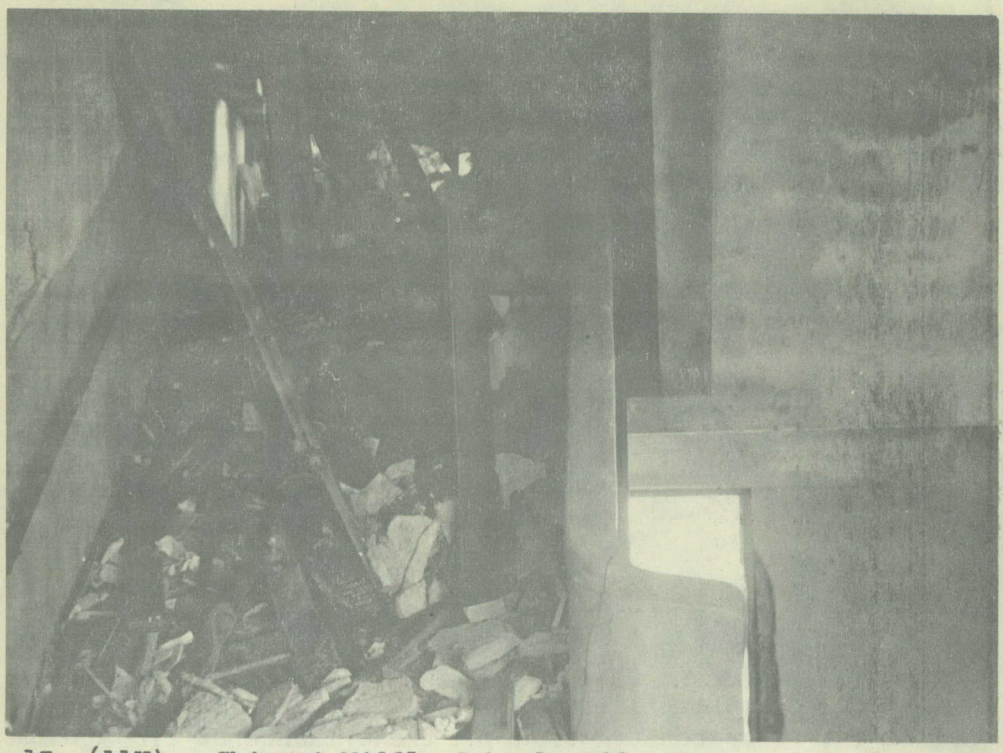

Figure 15--(11N). Chinzei Middle School, 500 meters. Interior view, 4th floor, showing the depression of the roof. There were no survivors on this floor. (Photo File # NB 307.)

Figure 16--(11N). Chinzei Middle School, 500 meters. Interior view, 3rd floor. This room was empty at the time of the bombing. There were, however, no survivors on other portions of this floor. (Photo File # NB 306.)

Figure 17--(11N). Chinzei Middle School, 500 meters. Interior view, 2nd floor. Notice the heavy construction and the evidence of fire damage to the wooden structures which were stripped from the walls by the blast. All 36 persons in this section of the 2nd floor died. (Photo File # NB 305.)

Figure 18--(11N). Chinzei Middle School, 500 meters. Interior view, 1st floor, showing a room used as a shop. There were 2 survivors among the 13 people in this room. (Photo File # NB 302.)

Figure 19--(11N). Chinzei Middle School, 500 meters. Interior view, 1st floor, south wing. Notice the debris that has been stripped from the walls. There were no people in this room at the time of the blast. (Photo File # NB 301.)

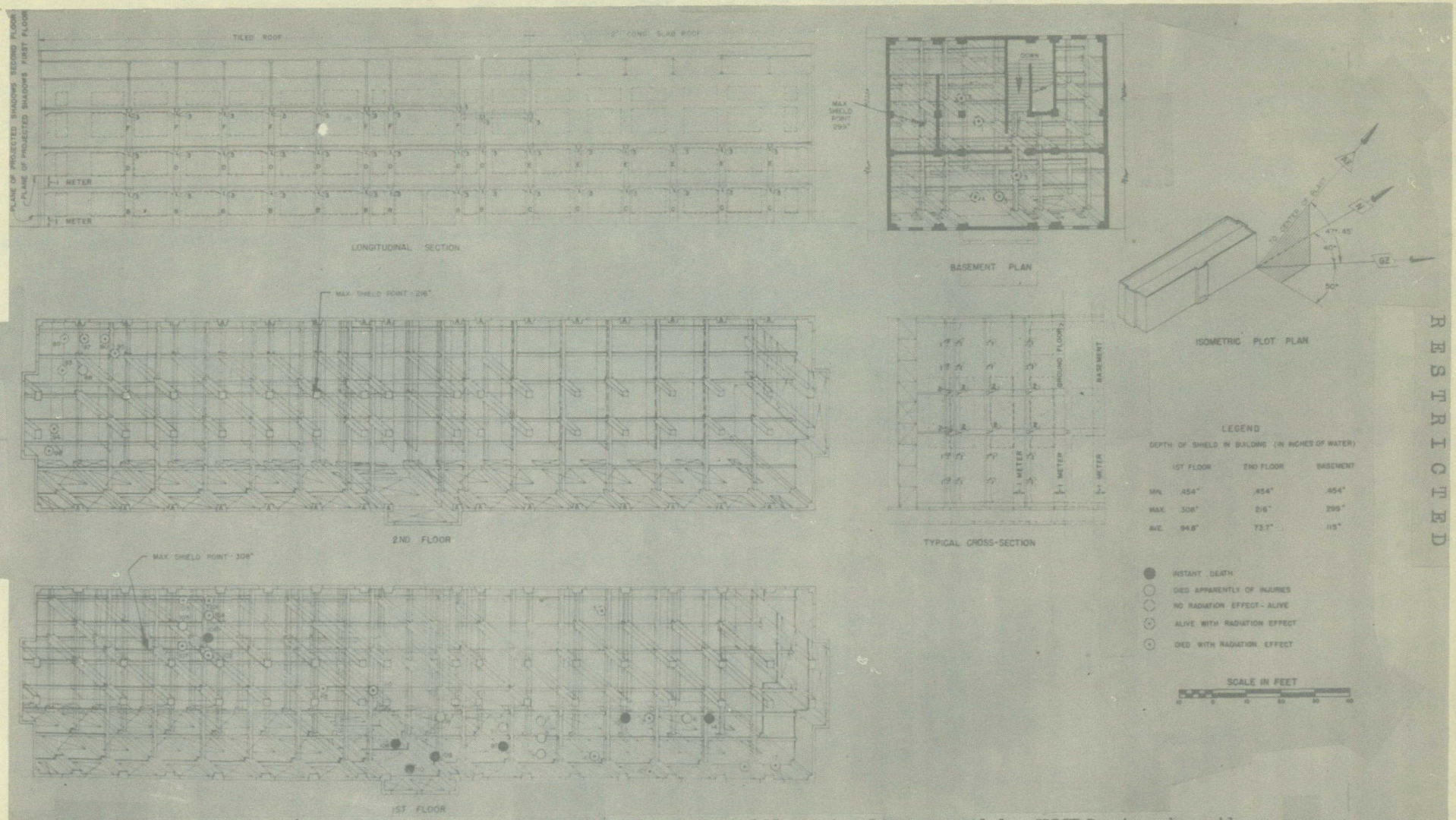

Figure 20--(11N). Engineer drawing of Chinzei Middle School prepared by USSBS, to show the effective shielding of portions of the building in which people were located.

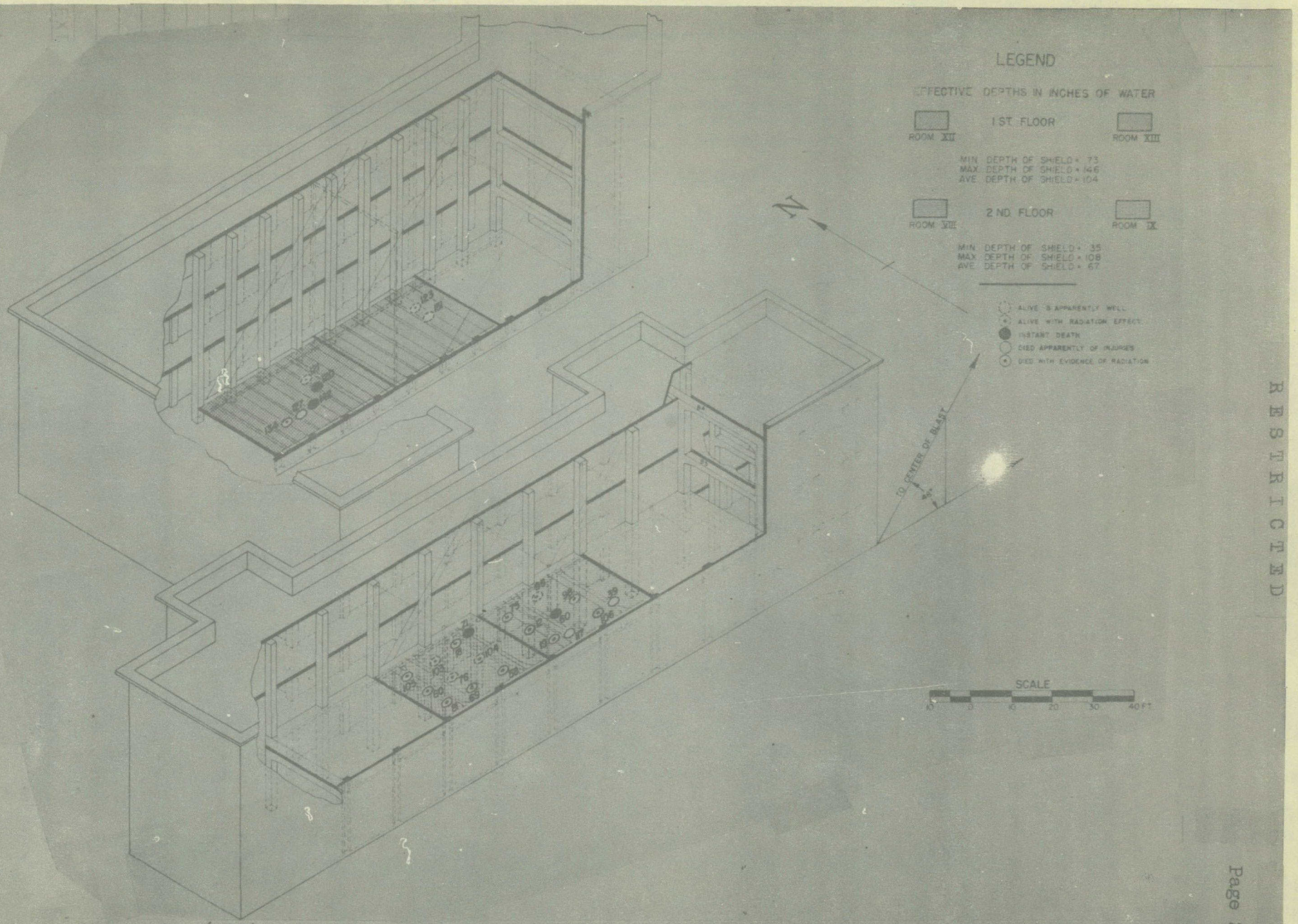

Figure 21--(11N). Isometric drawing of the Shiroyama National School, prepared by USSBS, to demonstrate the shielding in the portions of the building where occupants survived.

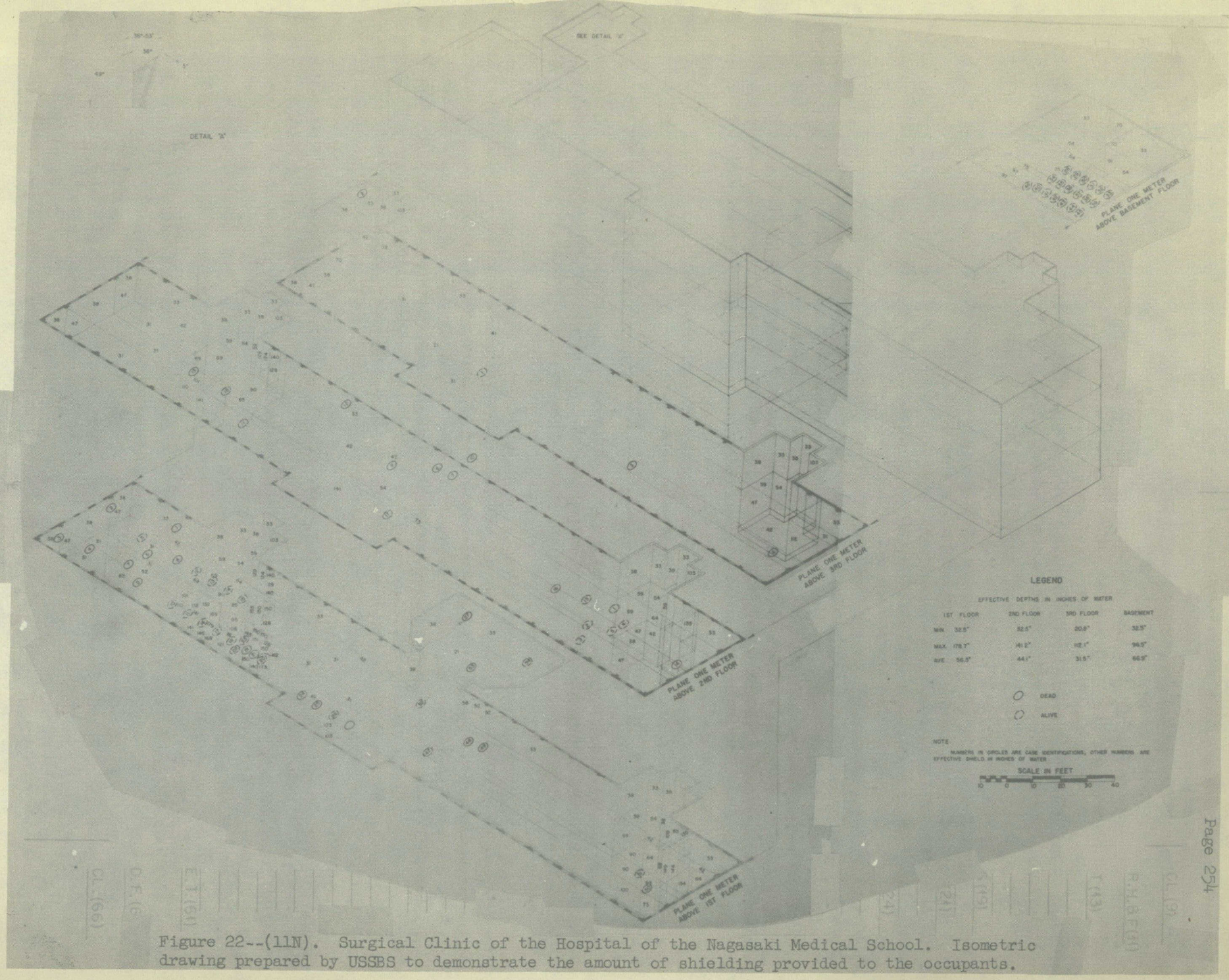

Figure 22--(11N). Surgical Clinic of the Hospital of the Nagasaki Medical School. Isometric drawing prepared by USSBS to demonstrate the amount of shielding provided to the occupants.

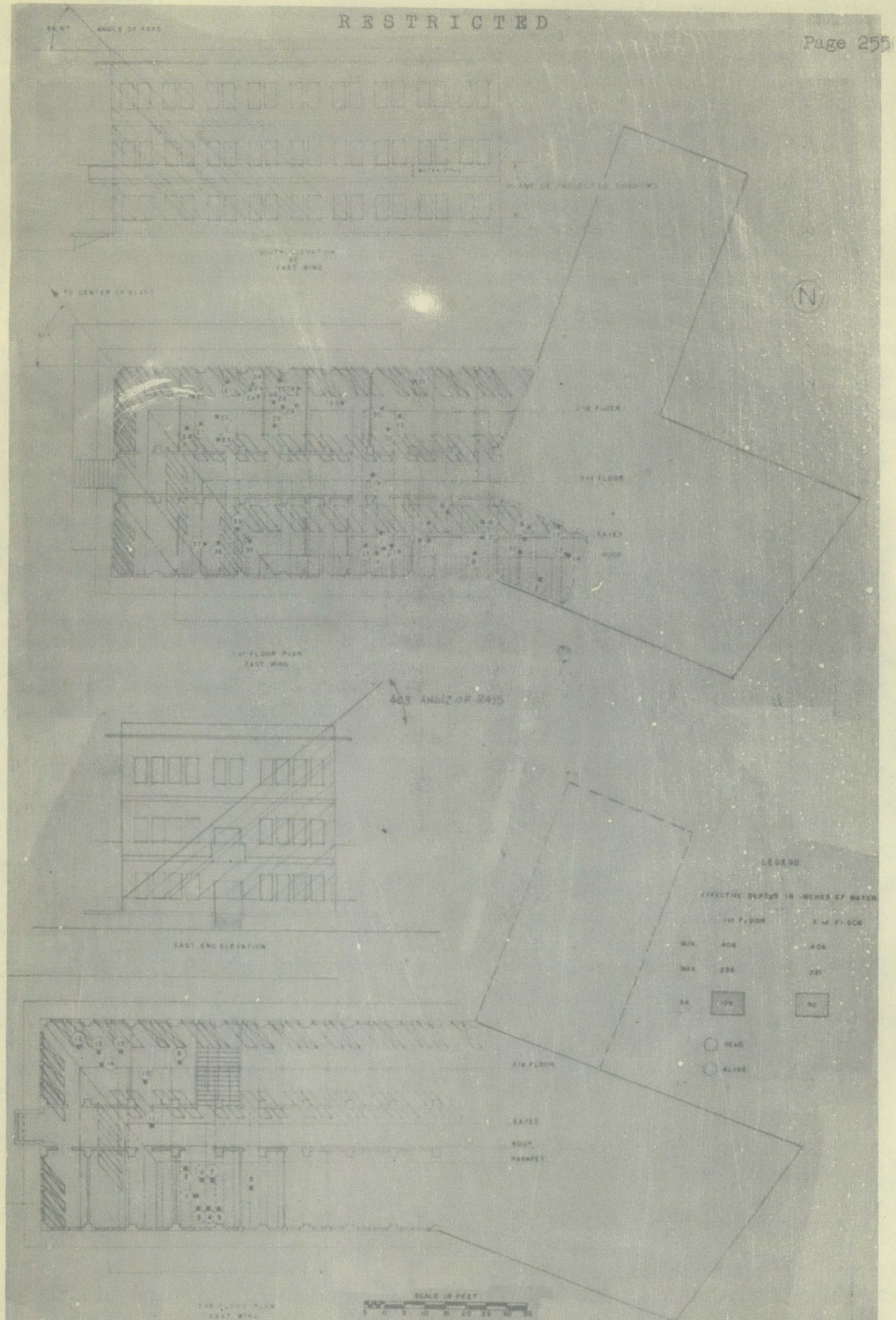

Figure 23--(11N). Polyclinic of the Hospital of the Nagasaki Medical College. Engineer drawing prepared by USSBS to illustrate the type and amount of shielding afforded the occupants by the building construction.

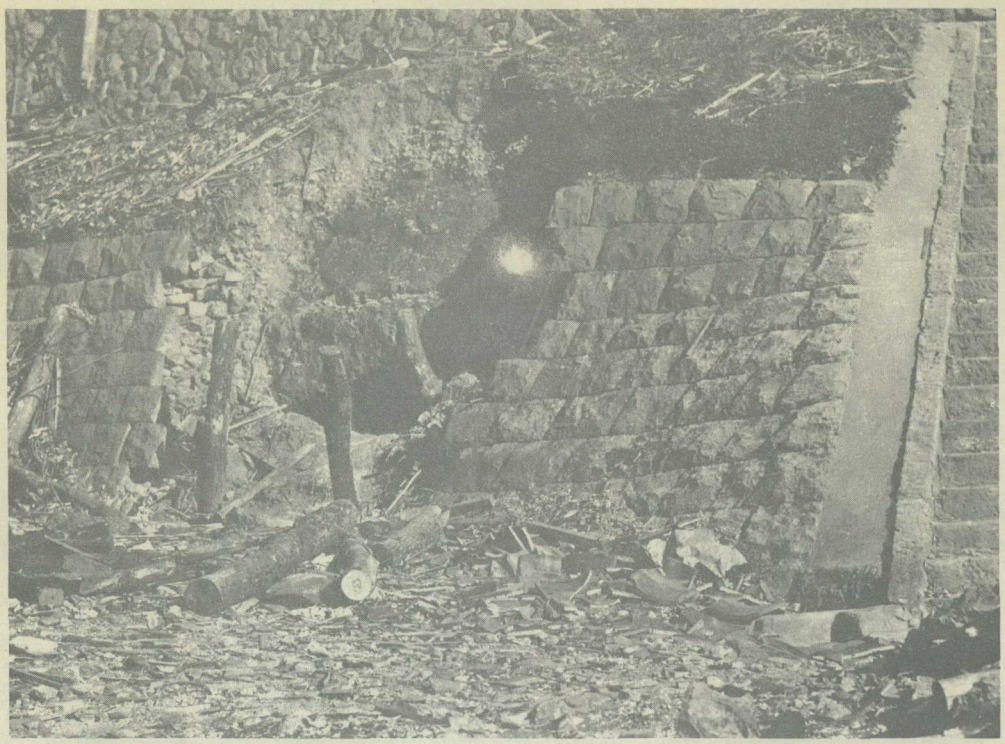

Figure 24--(11N). Exterior view of a cave in Okamachi (Cave # 1), 200 meters north of the center. People well inside the cave survived; those at the entrance were instantly burned to death. (Photo File # NB 328 A.)

Figure 25--(11N). Shiroyama National School, 500 meters. Cave shelter behind the school. The three entrances are partially concealed by mounds of earth which act as barriers. People who were inside the cave and were not burned survived. (Photo File # NB 329.)

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