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JULY 16th NUCLEAR EXPLOSION: INCENDIARY EFFECTS OF RADIATION

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ABSTRACT

A few simple experiments were performed at Trinity to determine the probable incendiary effect of the atomic bomb explosion. The results suggest that the risk of fire due to the radiation in the early stages of the atomic bomb explosion is very small and is likely to be much less than the risk of fire from causes existing in the buildings at the time of the explosion. There is no doubt, however, that combustible material within the flame zone from the explosion is likely to be readily ignited and may set the debris on fire.

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... OF RADIATION

INTRODUCTION

It was suggested by Fermi, Manley and others, that the radiation emitted in the early stages of the explosion of the atomic bomb might be sufficiently intense to ignite inflammable materials up to considerable distances from the center and that this feature of the explosion might be of importance in the production of damage in a city. As it is extremely difficult to estimate the chance of igniting inflammable materials in these circumstances, it was arranged that a small number of incendiary specimens would be exposed during the trial at Trinity.

DESCRITPION OF SPECIMENS

The specimens exposed at each of five stations included two shallow wooden boxes one foot square, six inches deep, filled with excelsior, and covered with small mesh-wire netting. The excelsior consisted of strands of wood, the largest of which were about .04" x .02" x 4" long, although most of the strands were much finer than this. In addition to the boxes of excelsior, two other exhibits were located at each station, and these comprised a piece of dry pine board 1" thick, and a piece of fir lumber to which was nailed a section of galvanized corrugated iron 0.025" thick. It will be noted that the excelsior provided an example of highly inflammable material while the other materials were more representative of portions of Japanese housing construction.

Exhibits of this nature were set out at 275, 400, 800, 1600, and 3200 feet from a point on the ground immediately underneath the bomb in a line extending westwards from the center. At each station the specimens were backed by a mound of earth and secured to heavy wooden stakes driven into the ground. They were covered by tarpaulin until the area was evacuated at 1:30 AM on the morning of the test. During the period after the area had been evacuated a slight shower of rain occurred but it is thought that this was insufficient to affect the scorching of the specimens.

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CONDITION OF SPECIMENS RECOVERED

The blast from the bomb was somewhat more severe than was anticipated and at the nearer distances only portions of the specimens were recovered and, in fact, nothing was recovered from the station at 275 feet. The condition of the various specimens recovered is described in Table 1, from which it will be noted that at 400 and 800 feet there was considerable burning on the backs of the specimens and it appeared that they had been enveloped in the flame from the explosion; most of the scorching and burning of the specimens at these distances is no doubt due to this cause. Measurements of the diameter of the flame zone have confirmed that these specimens were actually within this zone. At the greater distances, however, the specimens were scorched only on the side facing the bomb and it appears that this was due solely to radiation from the bomb. Photographs of the more interesting specimens are shown in Figs. 1, 2, and 3.

The condition of the specimens recovered shows that there had been considerable damage especially at the nearer distances by the impact of earth picked up in the blast wave. At 800 feet, for instance, much of this earth was fused, and was sufficiently hot to melt holes in the piece of corrugated iron exposed (see Fig. 3). The wood specimens were also severely damaged by the impact of pieces of earth and had the appearance of being heavily sand-blasted. This made it difficult to assess the scorching produced on the exposed wooden surface at the 1600 ft station (see Fig. 2) since most of the carbonised layer was eroded away. At 3200 feet, however, this sand-blast effect was slight and it appears that the scorched layer was substantially undamaged.

The condition of the specimens suggests that highly inflammable materials might be ignited at distances of 1600 feet, but certainly not at distances of 3200 feet. There was no indication of actual combustion of the pieces of wooden board exposed except within the flame zone from the explosion, where most of the specimens were appreciably burnt.

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A measurement was made of the total radiation emitted during the explosion (LA-353) and it is interesting to compare this measurement with the degree of scorching produced on the wood specimen at 3200 feet from the center. The measured total radiation at 10,000 yards from the center was 0.29 calories/cm^2. Assuming an inverse square law, this would correspond to a total radiation of 25 calories/cm^2 at the position of the furthest specimen at 3200 feet. Assuming that half this radiation is absorbed by the specimen (the rest being reflected or reradiated) and that it is received sufficiently rapidly to correspond to an instantaneous heat source at the surface of the wood, it is possible to calculate the depth at which certain maximum temperatures should be obtained in the wood, and values of 315° C at a depth of 1/2 millimeter attained after 0.31 seconds, and 440° C at a depth of 1/4 millimeter attained after 0.16 seconds are obtained. Since it appears that wood should char to the point of ultimate self-ignition at 250° C and should ignite in from 1 to 3 minutes at 350° C (MFPA Proceedings, Vol. 19, page 106), it would be expected that charring would be observed at both the depths indicated above. Examination of the specimen exposed at 3200 feet shows that this is not the case, as the charred layer does not appear to be thicker than 1/10 millimeter, although it was noticed that there was about 0.3 millimeter shrinkage of the charred area which may correspond to some distillation of the surface. It should perhaps be noted that at this station the blast wave did not arrive until 1.3 seconds had elapsed. The degree of air motion in the period following the arrival of the blast wave would be so great that the surface temperature of the wood would be expected to fall extremely quickly to that of the surrounding air. It is thought that this cooling effect is much more significant than any fanning action of the high-speed air. At the nearer stations the heating by radiation would be greater and the charring might be expected to extend to a greater depth. The severe "sand blasting" of the specimens (see Fig. 2) prevented any reliable estimates of the depth of charring at the nearer distances. It is thought that further discussion of the

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conditions necessary for inflammation of combustible materials is outside the scope of the present note.

In examining the site after the shot, it was noticed that scorching of the fir lumber used to support signal wires extended out to about 6300 ft, at which distance the total radiation is computed as 6.6 calories/cm^2.

It was also noticed that some sporadic fire damage occurred and an example of this is shown in Fig. 4, when a portion of a heavy wooden platform on the ground at a distance of 1000 ft from the center was ignited, apparently by the impact of some very hot material. This instance might easily have lead to a major fire.

CONCLUSION

The experiments suggest that the risk of fire due to the radiation in the early stages of the atomic bomb explosion is very small and is likely to be much less than the risk of fire from causes existing in the buildings at the time of explosion. There is no doubt, however, that combustible material within the flame zone from the explosion is likely to be readily ignited and may set the debris on fire.

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TABLE I

CONDITION OF SPECIMENS RECOVERED

Distance from Center	Boxes filled with excelsior	Pieces of dry pine board	Dry lumber covered with corrigated iron
275 ft	Not recovered.	Not recovered.	Not recovered.
400 ft	Boxes completely destroyed. No wire mesh found. Side of one box recovered burnt thru near edge. Bottom of one box found scorched, warped and split but apparently protected, as found, by earth except for exposed corner which was burnt off.	Not recovered. Part of one stake recovered on ground badly burnt all over.	Only badly burnt stump of stake seen.
800 ft	Badly scorched and slightly burnt side of one box found with small piece of wire mesh attached. Pieces of fused earth adhering to wire and some wires fused. Badly scorched bottom of one box found. Underside only slightly scorched and apparently protected by ground. Some wire mesh adhering to upper surface apparently driven right down and trapping some charred fragments of excelsior which had mostly burnt. See Fig. 1.	Specimen found in position but with earth bank blown away. Badly scorched on back and burnt on front. Holes burnt in front surface apparently by hot fused lumps of earth. See Fig. 2.	Specimen found in position. Iron badly perforated apparently by impact of pieces of molten earth which melted the iron. Edges torn and twisted. Wood badly scorched on back and front. Scorching on front less when iron was in contact with wood except where iron had been perforated. See Fig. 3.
1600 ft	Boxes destroyed and scattered. Severe scorching on wood facing bomb. No excelsior found.	Specimen in position. Front badly scorched but much of carbonized layer removed by sand-blast effect. Surface badly pitted. Back not scorched. See Fig. 2.	Specimen not recovered.
3200 ft	Boxes found intact in position. Slight scorching of edges of box facing bomb. Some strands of excelsior scorched slightly and few burnt through but no sign of inflammation. Slight compression in bulk of excelsior. See Fig. 1.	Specimen in position. Very thin scorched layer on front of dark brown color. "Sand-blast" damage negligible. Back not scorched. See Fig. 2.	Specimen in position - corrugated iron quite unaffected. Wood under, but in contact with, iron not scorched. Only exposed wood on front scorched. Back not affected. See Fig. 3.

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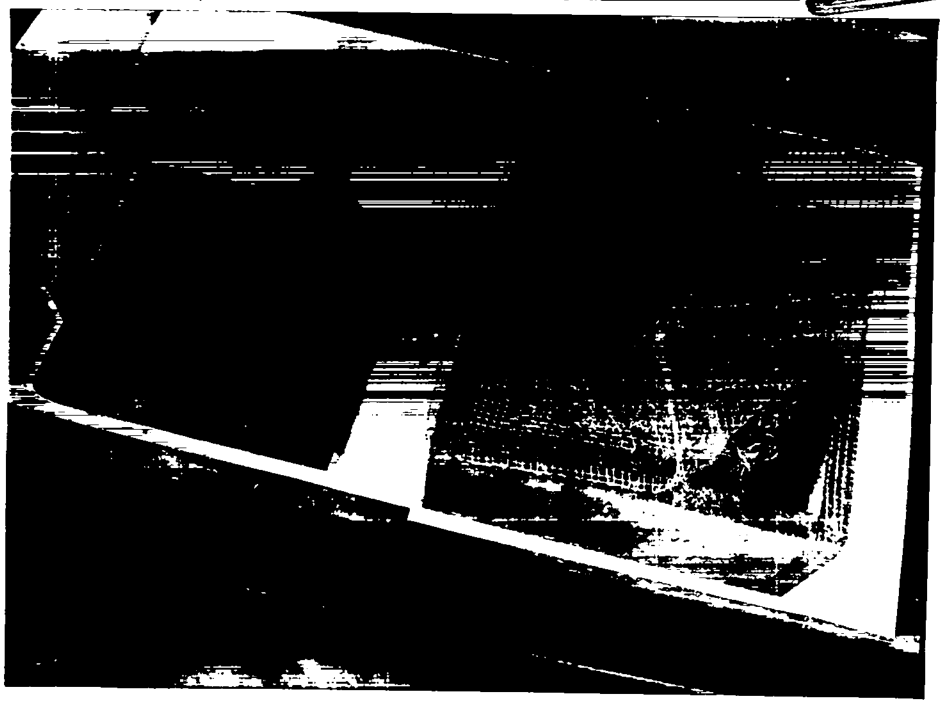

Fig. 1. Portions of wooden boxes containing excelsior and recovered from stations at 800 ft (left) and 3200 ft(right).

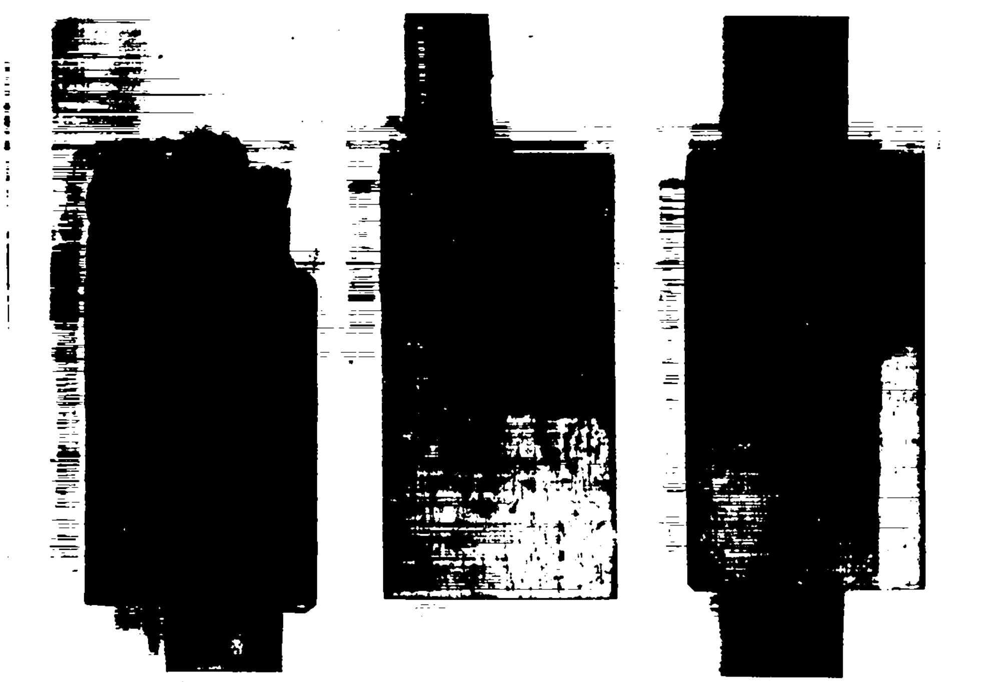

Fig. 2. Dry pine board specimens recovered from stations at 800 ft (left), 1600 ft (center) and 3200 ft (right). The lower half of each specimen was originally embedded in the ground and the stakes to which they were attached were ordinary fir lumber.

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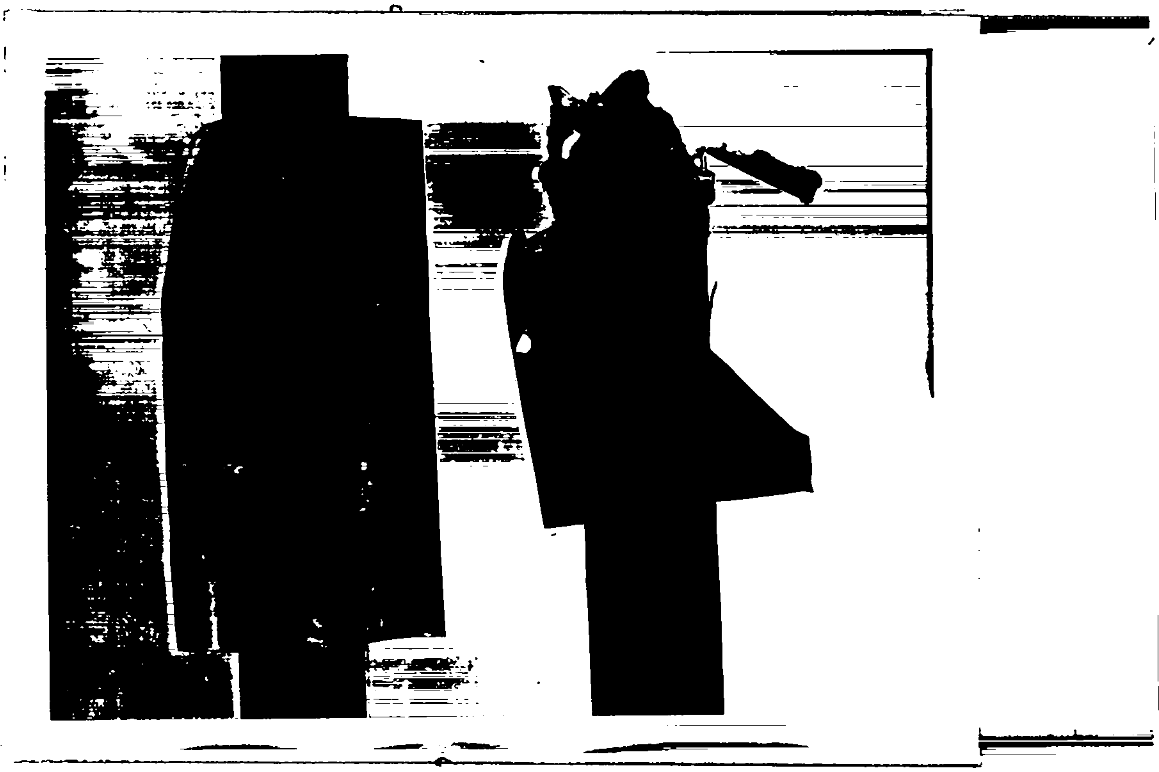

Fig. 3. Corrugated iron specimens nailed to fir lumber - specimens recovered from 3200 ft (left) and 800 ft (right).

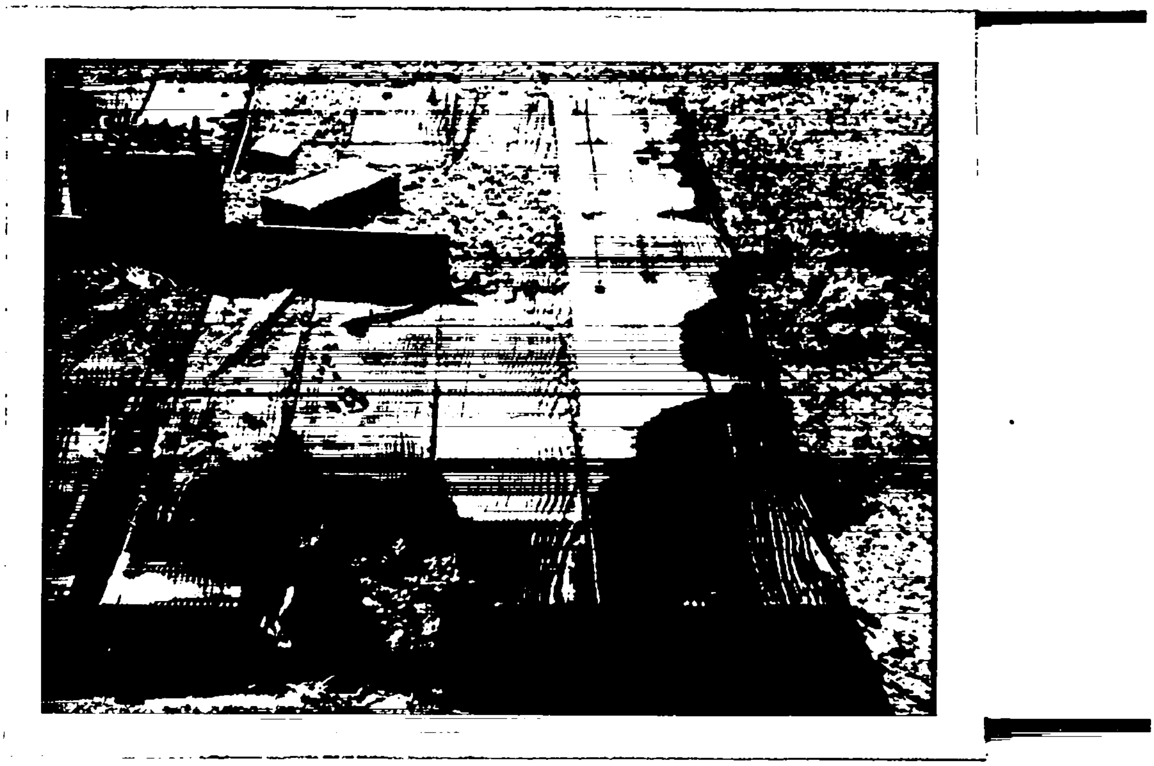

Fig. 4. Example of sporadic burning on the edge of a thick wooden platform situated 1000 ft from the center.

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