ESTIMATING DAMAGE AND CASUALTIES FROM ATOMIC BOMB ATTACK*

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THE estimation of the damage and casualites which may result from an atomic bomb attack on our cities constitutes one of the principal bases for Civil Defense planning. We must determine, at least approximately, the nature and extent of the damage that may result from such an attack and the place where this damage may occur before we can formulate effective plans to combat the damage.

Estimates of this sort have four chief uses.

First, they provide a basis for target analysis. In this procedure civil defense planners attempt to duplicate the thinking of the enemy, and to decide where he might try to place his bomb or bombs in order to cause the greatest injury to the city and its people.

Second, the estimates afford basic information for use in reducing the physical hazards in a city in advance of an attack. For example, if mapping and analysis indicate that a certain part of a city is highly susceptible to damage by fire, fire breaks and auxiliary sources of water may be provided to reduce the risk.

Third, they provide information which is essential in organizing and disposing Civil Defense forces in anticipation of an attack.

And fourth, they provide the means of estimating damage and casualties with minimum delay following an attack. After the bomb has fallen there will be no time actually to count the casualties or to determine which parts of the water system are inoperable. Civil defense forces must know within a very few minutes, on the basis of previously prepared estimates and plans, where their services are needed and what they are to do. A brief delay may mean the loss of many thousand lives and a great increase in damage by fire.

The atomic bomb causes casualties in four ways:

1. By fire, that is, by the fire of burning buildings.
2. By nuclear radiation.
3. By heat flash from the intensely hot fire ball of the exploding bomb.
4. By falling or flying debris.

Of these, fire was a major cause of casualties in Hiroshima and Nagasaki and would be in any American city which might experience an atomic bomb attack. Actual percentages of casualties due to the various causes in the Japanese cities are not directly applicable to our cities because of the marked difference in the types of structures and because our people presumably would seek shelter.

Damage to structures in our cities would be caused, as in Japan, by fire and blast. Of these, fire is the more destructive. It may originate in a small area and extend far beyond the point of origin.

In an atomic bomb attack two types of fires may be expected which do not occur in peace time, namely, fire storms and conflagrations. These are both great fires formed by the merging of many small fires, and both are too large to be controlled by ordinary fire fighting methods. They must be dealt with in much the same manner as a forest fire; by checking the flames at fire breaks.

Fire storms may be compared to tremendous bonfires. They occur under

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conditions of no wind or light wind, and develop their own system of winds which blow strongly toward the center from all sides. Therefore the individual fires spread primarily toward the center, coalesce and gradually die out as they exhaust the available fuel.

Conflagrations may be considered as fire storms on the march. They advance under the influence of strong ground winds until they have consumed all the fuel in their paths. They are very difficult to control and may be much more destructive than fire storms.

The work of estimating the damage and casualties which may result from an atomic bomb attack has been divided between the Federal Civil Defense Administration and the local civil defense organizations. For its part the Federal agency has analyzed all available information regarding the probable effects of the bomb and has developed simple, practicable methods for estimating damage and casualties. On the other hand the local civil defense organizations have undertaken the task of preparing the actual estimates for their own cities.

In developing the methodology, the Federal Civil Defense Administration has endeavored to make maximum use of pertinent material already available in the cities and has taken into account the fact that many of the local civil defense workers are employed on a part-time basis. Therefore, the agency has rejected a number of methods, which are excellent technically, because they require expenditures and staffs beyond the capacities of the cities.

The general procedure is the same in estimating any type of damage or casualties. First, the distribution of each critical feature or condition of the city

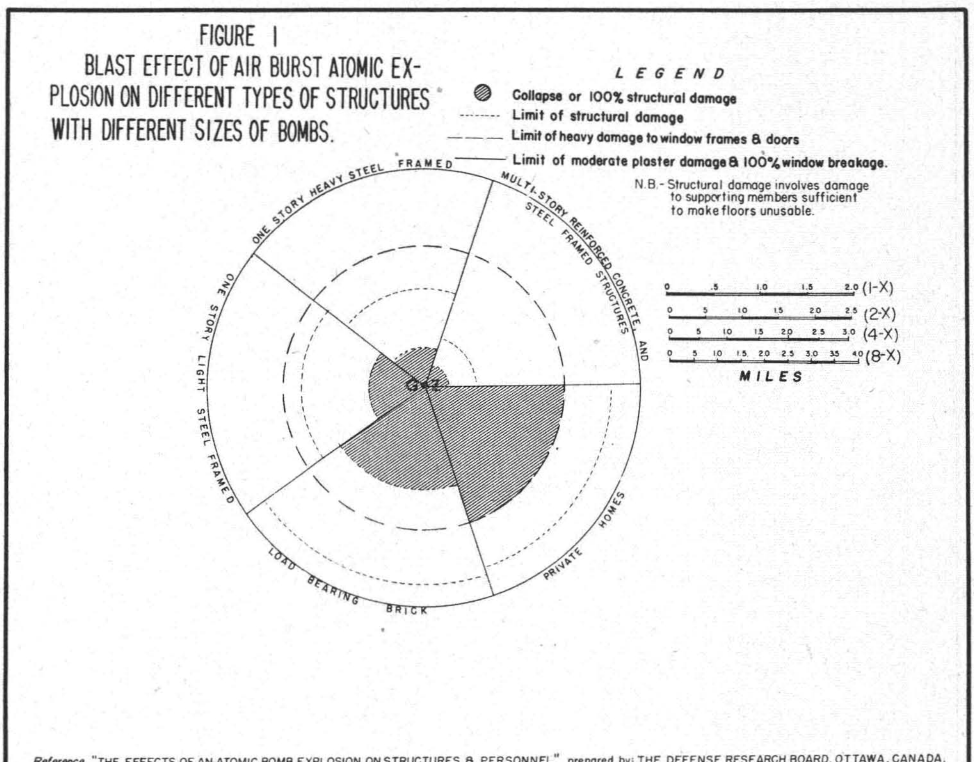

FIG. 1. Blast effect of air burst atomic explosion on different types of structures.

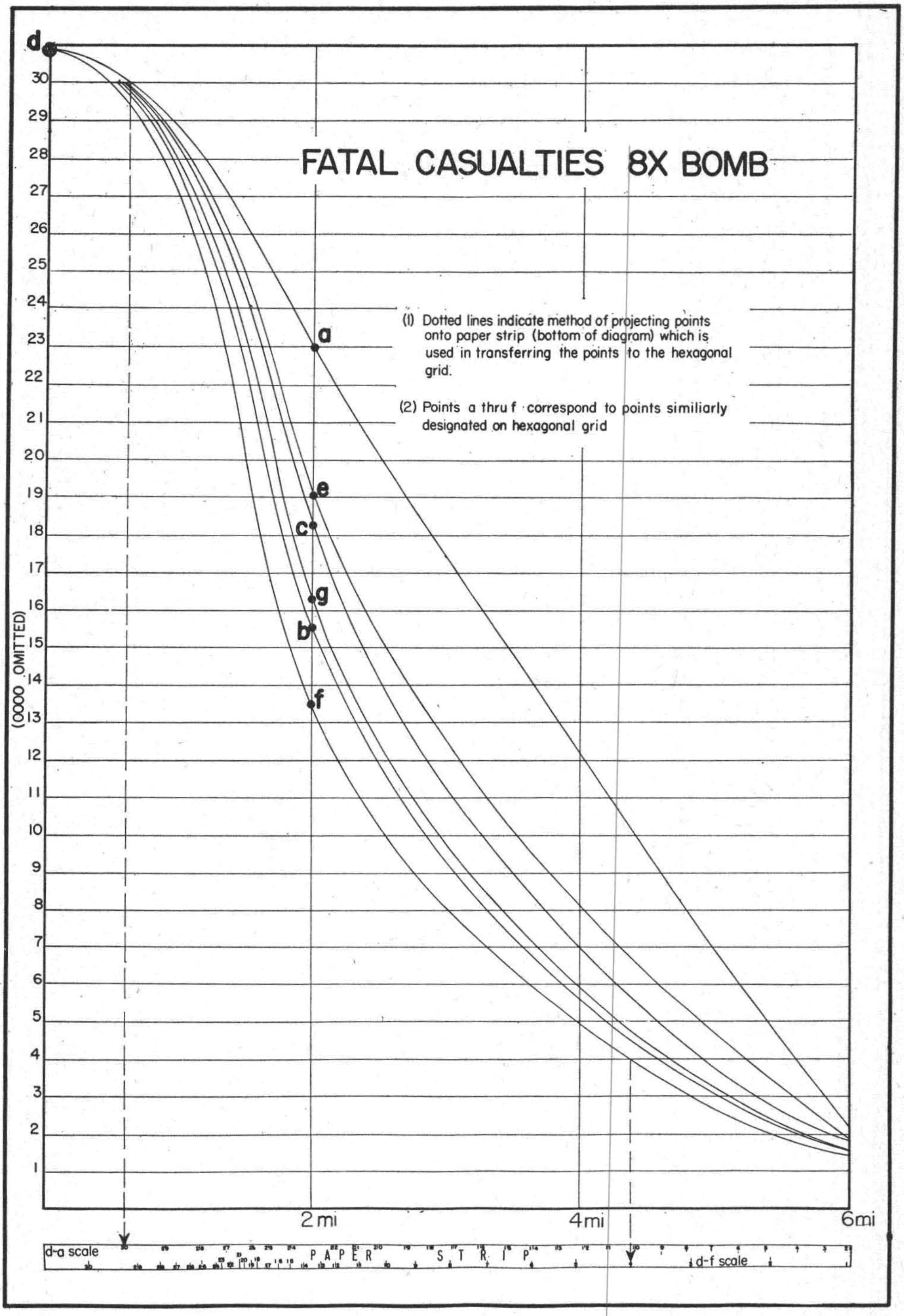

FIG. 2. Curves for fatal casualties 8X bomb.

is represented on a separate map or aerial mosaic; for example, the distribution of population in the daytime or the location of fire stations.

Next, a transparent overlay of tracing paper or acetate on which have been drawn concentric circles representing the boundaries of recognized zones of damage or casualties for a particular size of bomb is superimposed on the maps. Buildings or people located within a given zone are assumed to have sustained a certain type of damage or percentage of casualties.

As a simple illustration, the possible blast damage to the average structures in an American city may be estimated as follows. Assuming the use of a so-called 1X or "nominal" bomb similar to that employed against Hiroshima, an overlay is prepared with concentric circles of appropriate size and this is superimposed on the map of the city.

Then it may be assumed that all average buildings within a radius of 5/10 of a mile from ground zero (GZ), the point directly below the bomb, would be destroyed. In the next ring from 5/10 to one mile, the buildings would be damaged beyond repair, and from one mile to $1\frac{1}{2}$ miles the buildings would be damaged sufficiently so that they would have to be vacated during repairs. Beyond this

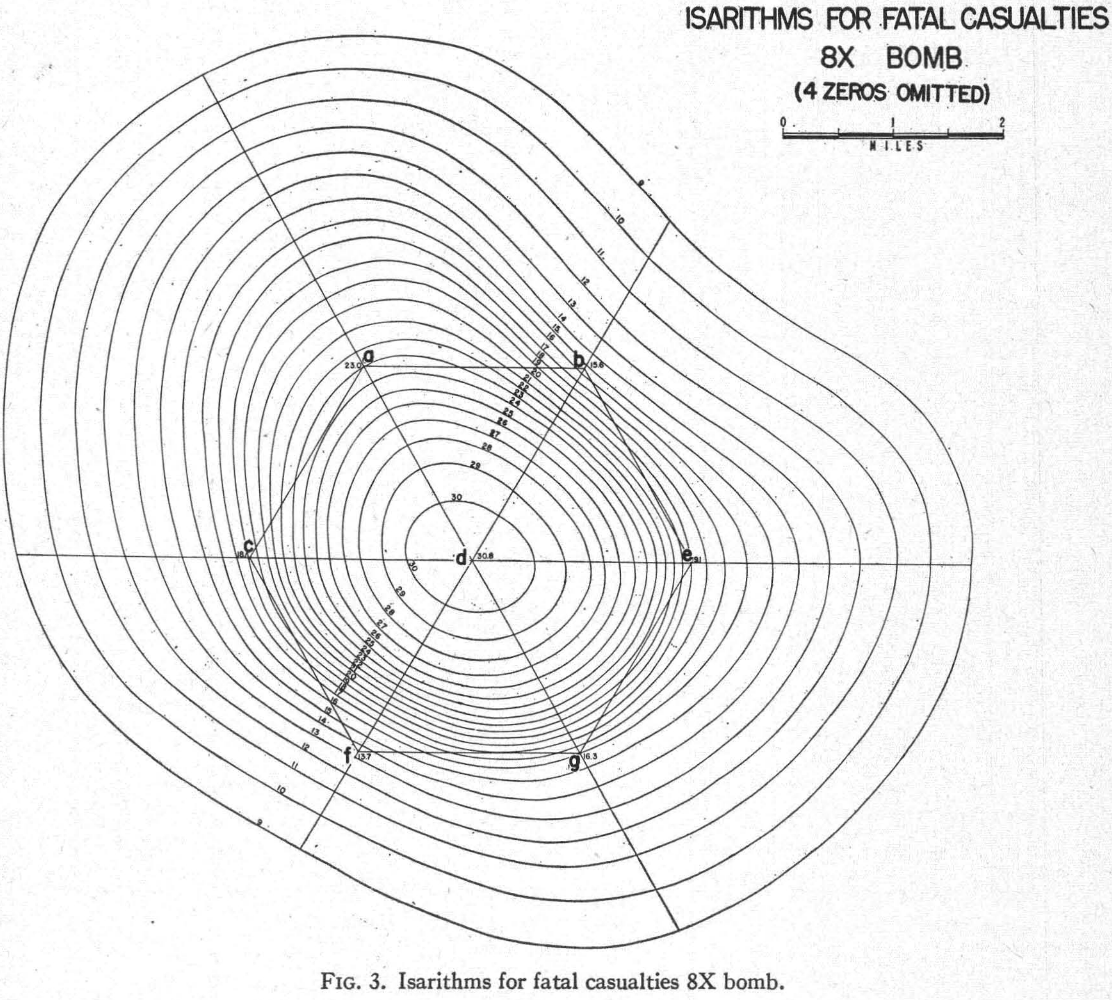

FIG. 3. Isarithms for fatal casualties 8X bomb.

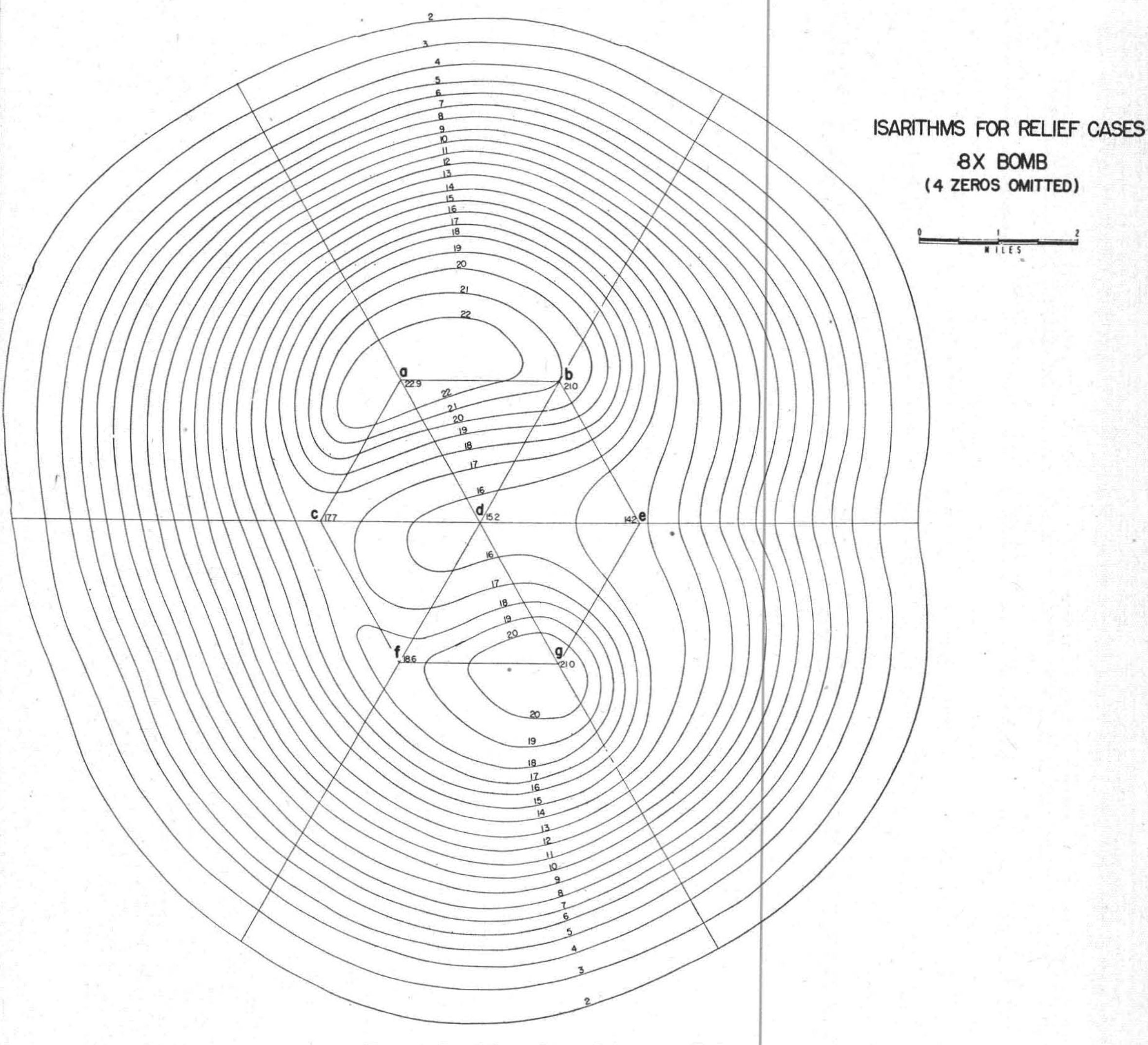

FIG. 4. Isarithms for relief cases 8X bomb.

radius the buildings would not be damaged so severely as to necessitate vacating them while repairs are in progress.

If an 8X bomb were used, that is a bomb eight times as powerful as the 1X, the corresponding radii of damage would be only twice as large as those indicated. The radii of damage for specific types of buildings may be determined by reference to the diagram Figure 1.

A knowledge of the limits of the different kinds of damage to various types of buildings is extremely important for reconnaissance following a bomb attack. Wardens approaching the damaged area would report the type of damage at various points. From this and a knowledge of the location of ground zero, the civil defense headquarters would then determine the size of the bomb and estimate the casualties.

The process of estimating casualties and the number of people who would become relief cases is considerably more complicated than the procedure described above. As the initial step, a conventional dot map is prepared for a city to indicate the distribution of the population at a definite time of day.

Then a grid composed of equilateral triangles measuring two miles on a side, at map scale, is drawn on the dot map, the triangles being arranged to form a hexagon with the center at or near the center of population of the city.

Next, the radial lines of the hexagon are extended, and, if the city is large, additional triangles may be added to cover the built-up area.

Following this it should be assumed that an atomic bomb of definite size is detonated with ground zero located successively at each one of the intersections of the grid.

Then the casualties are estimated separately for each hypothetical location and the total casualties for each are recorded on the map at the corresponding grid intersection.

These casualty figures are plotted against distance from the center of the hexagon as indicated in Figure 2. In this illustration the 2-mile points correspond to the points of the hexagon. For the city on which the illustration is based, it proved impracticable to calculate casualties for points six miles from the center of the hexagon. Therefore, the casualties at these points were estimated by inspection as 1/10 the values of the corresponding 2-mile points.

Smooth curves are drawn from the point "*d*" which represents the center of the hexagon, through the 2-mile points "*a*" "*e*" "*c*," etc., to the 6-mile points.

Next, the intersections of one curve and the lines of 30(0,000), 29(0,000), etc., are projected to a strip of paper at the bottom of the diagram, and this strip is used to transfer these intercepts to the corresponding radial line of the hexagon, Figure 3.[1] In like fashion the intercepts for the other curves are transferred to the other radii. Then smooth curves are drawn through points of corresponding value on these radii as in ordinary contour mapping.

When the pattern of isarithms has been developed it should be transferred to the standard base map of the city which represents streets and landmark features.

To obtain a quick estimate of casualties after a bomb has been exploded, it is only necessary to determine the size of the bomb and the location of ground zero. From this information the map for the proper bomb size may be selected and the location of *GZ* determined with respect to the isarithms. If, for example, the *GZ* is on the isarithm of 12 the fatal casualties will be estimated as 120,000.

Figure 4 represents the pattern of isarithms for relief cases of the same city. Relief cases were computed on the basis of the uninjured within three miles of ground zero. It was assumed that these people would be in need of food and housing at least temporarily as a result of damage to their homes.

The double peak of this diagram indicates that the number of relief cases is greater when the *GZ* is somewhat removed from the center of population "*d*" than it is at that point. This is due to the fact that most of the relief cases are located, not near the ground zero where the percentage of casualties is greater, but somewhat farther away where the percentage of uninjured is larger.

[1] In Figure 3 the general term isarith (a line of equal value) is used in preference to coining specific terms for each type of line.