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April 10, 1945

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GROUND SHOCK RESULTING FROM DETONATIONS ON OR ABOVE THE SURFACE -

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An earlier discussion [1] indicated that a charge of a given weight detonated on the surface of the ground should be about as effective in producing ground shock as a charge equal to 15 percent to 25 percent the given weight, if this smaller charge was detonated at "optimum depth." (The optimum depth is that depth of burial which results in the maximum crater diameter. The optimum depth, d, for any charge is given by

$$d = 2\ W^{1/3}$$

where d is in feet and W is the charge weight in pounds.) This analysis was carried out on the basis of energies involved in cratering. The method was crude, but the results have agreed well with the few cases that have been suitable for comparison, and the general assumption is now that a surface charge is about as effective as 20 percent of its weight would be if buried at the so called optimum depth defined above. The purpose of the calculation was to allow the accumulated data on ground shocks, most of which is for buried charges, to be used in predicting the effects of surface detonations. It has recently become desirable to attempt to predict the ground effects due to charges detonated in air. The method described below is admittedly very crude and is designed only to indicate the order of magnitude of the results.

Any attempt to use crater volumes as an indication of ground energies must admit that as the height of the charge increases the geometry becomes less favorable for crater formation. This statement agrees with the observation that

1) Memo from Reynolds to Bainbridge, July 1944.

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the extrapolation of the best crater curves available at present [2] indicate craters of zero diameter under conditions such that there is still some energy getting into the ground. This means that the assumption that a fixed percentage of the earth shock goes into cratering leads to a lower limit for the energy in the earth from an air burst. The crater is an indication of energy in the sense that a certain amount of earth is removed and lifted to a certain height. This is discussed in 1). For the purpose of applying data collected for certain weights of charge to charges of other weights, it will be assumed that scaling of linear dimensions goes as $W^{1/3}$ where W is the charge weight. (Unless otherwise specified, linear dimensions will be in feet and charge weight in pounds). This scaling law agrees with the data on hand [2]. The energy involved in cratering is not strictly proportional to the volume of the crater since it depends on the volume times the height to which this is lifted. Because of the changing geometry as the height of the charge increases, the vertical height to which the earth is thrown probably does not scale directly and the energy on the crater assumption is likely to be proportional to between the third and fourth power of the crater diameter.

Recognizing that crater volumes indicate a lower limit for ground energies, and are as good a basis as is available for a limited range of charge heights, there is another method which gives a crude estimate of ground energies for greater heights and which can be tied into the crater method at intermediate heights. This method is based on an integral which is proportional to the energy reaching the ground in the blast wave. The assumption is then that the reflection coefficient is independent of the changing geometry resulting from changes in the height of the charge. The method is admittedly crude, but should serve as an upper limit for the energy in the ground.

2) NDRC Div 2: "Weapon Data." Data sheets 3B1 and 3B1a.

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An illustration of the use of these methods is given here for the scaled charge height $= \dfrac{\text{height of charge in feet}}{(\text{charge weight in pounds})^{1/3}}$ of .47 (5000-T at 100 ft, or 100-T at 27.5 ft), using an intermediate point at .24 (5000-T at 50 ft). The method uses reference 1. The scaled crater diameter for a surface detonation is

$$\frac{D}{W^{1/3}} = \frac{\text{diameter of crater in feet}}{(\text{charge weight in pounds})^{1/3}} = 3.7.$$

The scaled diameter = 2.7 for the scaled height of .24; the ratio of diameters is thus $\frac{3.7}{2.7} = 1.37$. Raised to the third power this is = 2.55 ; raised to the fourth power it is = 3.5. Thus the crater method indicates that about 1/3 as much energy gets into the earth when the charge is at a scaled height of .24 as does when the charge is detonated on the surface. Comparing the scaled height of .47 with that of .24 by the same method indicates a further reduction by a factor of about 1/10. If the second method is used to make the same comparison the procedure is as follows: The quantity representing the energy incident on the earth in the blast wave is taken as the product ptv where p is the peak pressure, t the duration and v the wave velocity. This can equally well be taken as Iv where I is the impulse. Choosing the 5000-T case, the impulse on the ground under the charge is roughly (scaled from data sheet 3a2 in reference 1) 45 pound seconds per sq. in. for the .24 scaled height, and 24 pound seconds per sq. in. for the .47 scaled height. The velocities are about 9100 ft per second and 8800 ft per second respectively. This indicates that the ratio of energies is about 1/2 as the charge height is increased from .24 to .47. A consideration of the solid angles of importance in imparting energies to the ground can be made by assuming that energy is not imparted to any significant degree when the pressure on the ground is less than a certain value. Assuming that the flat maxima encountered in the Mach effects

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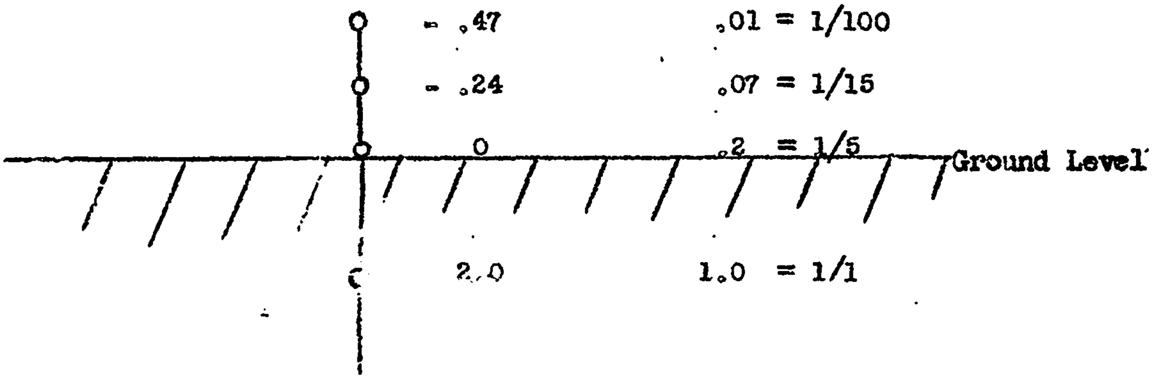
indicate that very roughly the areas involved on the ground are about the same for the two heights, the ratio of solid angles is about 1/4.

Considering all of the above results the following ratio of effective weights is suggested for a 5000-T shot,

DEPTH / WT 1/3	EFFECTIVE WT.
- .47	.01 = 1/100
- .24	.07 = 1/15
0	.2 = 1/5
2.0	1.0 = 1/1



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