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LAMS - 188

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January 11, 1945

This document contains 3 pages

January 5, 1945

TO: G. B. Kistiakowsky

FROM: R. E. Peierls

SUBJECT: Detonation Rate for Plane and Expanding Waves

We have considered further your suggestion that the difference in rate of tamped TNT found by Linschitz[1] may well be a difference between the properties of plane and expanding spherical waves. It appears that this explanation is entirely reasonable from a theoretical point of view and also that it seems to fit all facts so far available.

According to Linschitz the rate found in the slow components of lenses and in charges of tamped TNT set off by plane waves from a pentolite charge which in turn was detonated by a conical lens exceeded, by an amount of the order of 5 percent, the rates found for charges set off by single boosters both by Linschitz and at Bruceton[2].

It is known from the theory of G. I. Taylor[3] that if one neglects the finite size of the reaction zone, plane and expanding waves show a difference in behavior in as much as the pressure behind a plane front has a finite slope whereas the slope behind an expanding wave front is infinitely steep. In other words the

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1) LAMS-187; also, forthcoming report by Linschitz.

2) OSRD-1219; also, Bruceton progress report of January 4, 1945.

3) BM-49 (AC-639).

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pressure differs from the detonation pressure in a plane wave by an amount of the order of x/ℓ where x is the distance from the front and ℓ the length over which the wave has travelled from the point of initiation (age).

On the other hand for an expanding wave the pressure difference is of the order of $\sqrt{x/\ell}$.

It is clear that by the time the age of the wave is very large compared to the size of the reaction zone, the idealized theory holds in good approximation. But, this will be correct only in as far as the variation of the theoretical pressure curve over a distance d representing the width of the reaction zone is negligible. According to the above this pressure variation is of the order of d/ℓ or $\sqrt{d/\ell}$ respectively in the two cases.

Some calculations by Skyrme indicate that the correction to the detonation velocity is proportional to the square of the pressure variation, and would therefore be expected to be of the order of $(d/\ell)^2$ and d/ℓ respectively. Hence if we assume a detonation zone of the order of 3 mm and consider experiments in which the age is of the order of 10 cm the correction will be negligible in the case of plane waves but will be of the order of a few percent for expanding waves. Hence, the rate observed for plane waves is in fact the correct ideal detonation rate whereas that for expanding waves should vary with radius so that on doubling the distance from the booster the rate should rise by about one-half the difference between the two values found at present.

No doubt present rate measurements were not all made with the same size of charge and on reviewing the results one might find a systematic variation of the typ indicated although this is probably near the limit of accuracy.

It would not be unreasonable to expect cylindrical waves to be in an intermediate position between spherical and plane waves and this should also apply to the case of the thin slab lenses used by Linschitz.

Spherically convergent waves should behave as plane waves as long as the radius to which the wave has converged is not too small compared with the initial radius. The speeding-up due to convergence is proportional to the square of the difference of these radii according to the results of Keller[4]. If the interpretation of the facts suggested here is confirmed the effect ought to exist equally in other explosives and may then be one of the most convenient ways of estimating the size of the reaction zone.

Skyrme is attempting to put the theory of this effect on a better basis, in particular to confirm that the corrections are proportional to the inverse first and second power of the age as stated above and, if possible, to estimate the coefficient in terms of the reaction zone.

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4) LA-143.

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