LA-5278-MS

INFORMAL REPORT

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Decay of Overdriven Detonations in Nitromethane

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ABSTRACT

The decay rates of overdriven detonations initiated by
Composition B and PBX9404 are calculated. These calcula-
tions were requested in connection with a proposal to use
the measured rate of luminosity decay of an overdriven
nitromethane detonation to obtain a qualitative picture
of the profile of the initiating wave.

I. INTRODUCTION

An experimental method is being developed for
inferring the pressure profile near the front in a
shock or detonation wave by observing the decay of
light intensity in an overdriven nitromethane deto-
nation initiated by the shock or detonation in ques-
tion.

As part of this effort, we have calculated two
examples, using the one-dimensional characteristics
code RICSHAW. An instananeous-reaction unsupported
CJ detonation in a unit length of PBX9404 or Compo-
sition B initiates the overdriven detonation in a
semi-infinite slab of nitromethane, Fig. 1. The
nitromethane is also assumed to have instantaneous
reaction so that the initial match is to its com-
plete-reaction Hugoniot.

II. RESULTS

The results are given in Table I and Figs. 2
and 3. In the RICSHAW characteristic diagrams, Figs.
2a and 3a, the initiation point for the driver ex-
plosive is at x = 11, and the interface between the
two explosives is at x = 10. The variable x in the
remaining figures is in the coordinate system of
Fig. 1.

Analytic results for a similar problem suggest
a certain presentation of the results. In a materi-
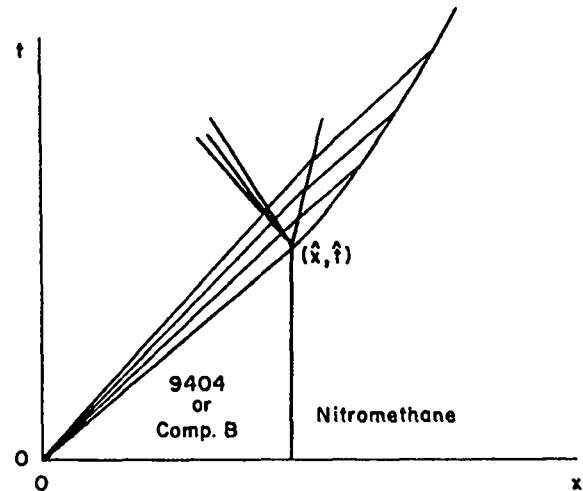al obeying the Walsh EOS (Hugoniot U = a + bu and

Fig. 1. Overdriven detonation in nitromethane ini-
tiated by PBX9404; x-t diagram.

the same p-u locus for the rarefaction) let an ini-
tially flat-topped shock be overtaken at $\hat{x}$, $\hat{t}$ by
the head of a rarefaction wave centered at x = t = 0.
The subsequent shock trajectory is given by (exact-
ly):

$$y - a = (\hat{y} - a)(t/\hat{t})^{-1/2} \; ; \quad y \equiv x/t . \tag{1}$$

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TABLE I

DECAY OF OVERDRIVEN DETONATION IN NITROMETHANE

<u>Explosives</u> (γ-law equation of state)

	ρ_o	D_j	P_j	γ_j
Nitromethane	1.13	0.6250	141	2.13
PBX9404	1.84	0.8800	356	3.00
Composition B	1.714	0.7991	290	2.769

<u>Nitromethane Front States, Composition B Driver</u>

T	X	P	U	1/SQRT(T)	Y=X/T	Y-YCALC
1.25141	1.00000	.20816	.27896	.89392	.79910	-.00000
1.40340	1.10000	.20201	.27268	.84413	.78381	-.00559
1.55639	1.20000	.19672	.26715	.80157	.77101	-.01010
1.71023	1.30000	.19232	.26245	.76467	.76013	-.01379
1.86475	1.40000	.18859	.25840	.73230	.75077	-.01685
2.01984	1.50000	.18534	.25482	.70363	.74263	-.01940
2.17543	1.60000	.18247	.25161	.67800	.73549	-.02156
2.33144	1.70000	.18002	.24884	.65492	.72916	-.02339
2.48781	1.80000	.17783	.24634	.63400	.72353	-.02495
2.64449	1.90000	.17586	.24407	.61493	.71848	-.02629
2.80145	2.00000	.17408	.24200	.59746	.71392	-.02744
∞	∞	.14102	.19968	0.00000	.62500	0.00000

<u>Nitromethane Front States, PBX9404 Driver</u>

T	X	P	U	1/SQRT(T)	Y=X/T	Y-YCALC
1.13636	1.00000	.23527	.30523	.93808	.88000	.00000
1.28375	1.10000	.22644	.29694	.88259	.85686	-.00805
1.43261	1.20000	.21878	.28956	.83548	.83763	-.01448
1.58275	1.30000	.21230	.28316	.79487	.82136	-.01971
1.73393	1.40000	.20704	.27785	.75942	.80741	-.02402
1.88590	1.50000	.20244	.27313	.72817	.79534	-.02760
2.03880	1.60000	.19839	.26891	.70035	.78478	-.03060
2.19227	1.70000	.19481	.26511	.67539	.77545	-.03314
2.34632	1.80000	.19167	.26175	.65284	.76716	-.03530
2.50086	1.90000	.18895	.25879	.63235	.75974	-.03715
2.65583	2.00000	.18649	.25609	.61362	.75306	-.03874
∞	∞	.14102	.19968	0.00000	.62500	0.00000

We guess that an analogous equation might describe fairly well the decay of the overdriven detonation in nitromethane:

$$y - D_j = (\hat{y} - D_j)(\hat{t}/t)^{-1/2} \quad , \qquad (2)$$

where we have replaced the sound speed a of Eq. (1), to which the shock velocity finally decays, by the nitromethane Chapman-Jouguet detonation velocity D_j, to which the detonation velocity finally decays. Here, of course, y = x/t is the trajectory of the detonation front.

In Figs. 2b, 2c and 3b, 3c we have plotted y and p from the RICSHAW calculations vs. $t^{-1/2}$, as suggested by Eq. (2). The curves are not as linear

as we had hoped, but should still be useful for extrapolation to later times. In Figs. 2d and 3d we show the difference between the RICSHAW y and that from Eq. (2) ("Y CALC"), to display the non-linearity in more detail.

The <u>magnification ratio</u>, illustrated in Fig. 2a, is the ratio of the length of run of the detonation front in nitromethane to the length of the portion of the profile in the driver explosive which influences it. For example, in Composition B, Fig. 2a, if we measure the nitromethane detonation front history over a travel of 1.1 cm, we can infer (approximately) only the front 1.1/13 = 0.85 cm of the Composition B pressure profile.
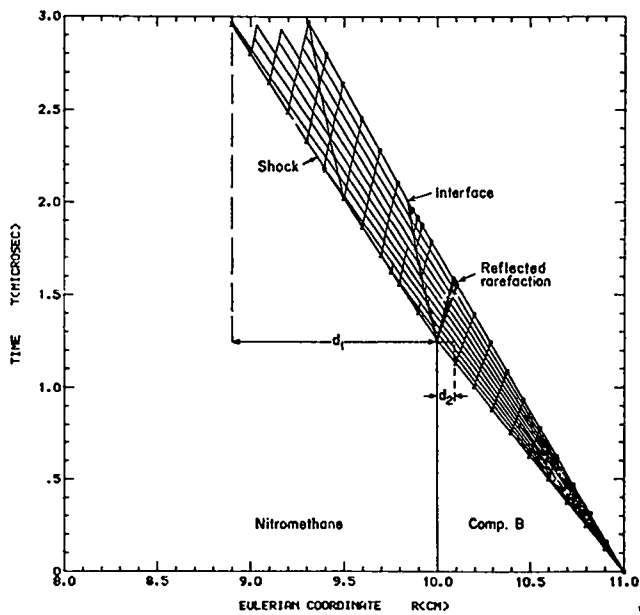
Fig. 2a.
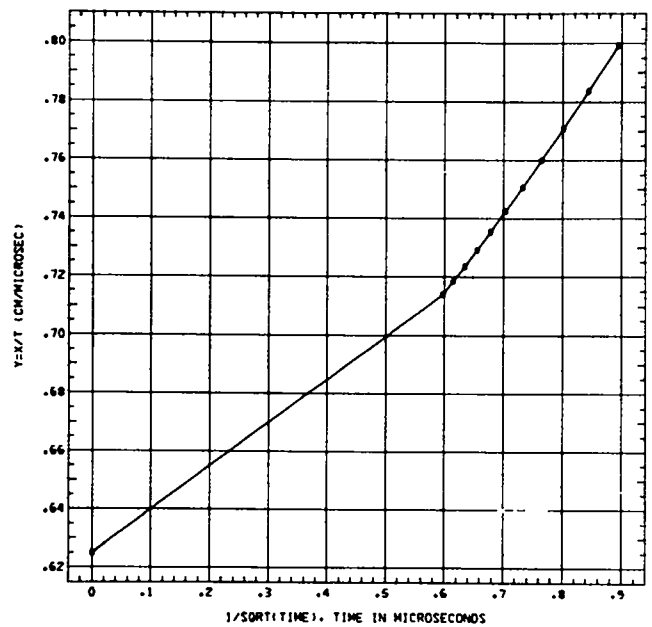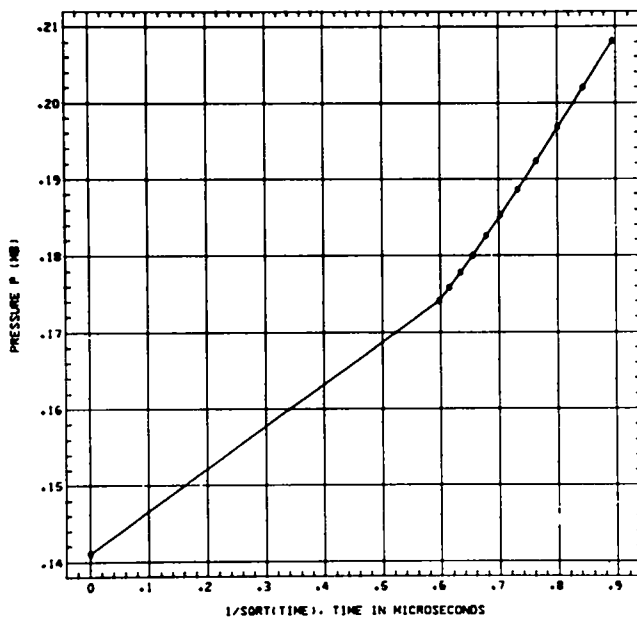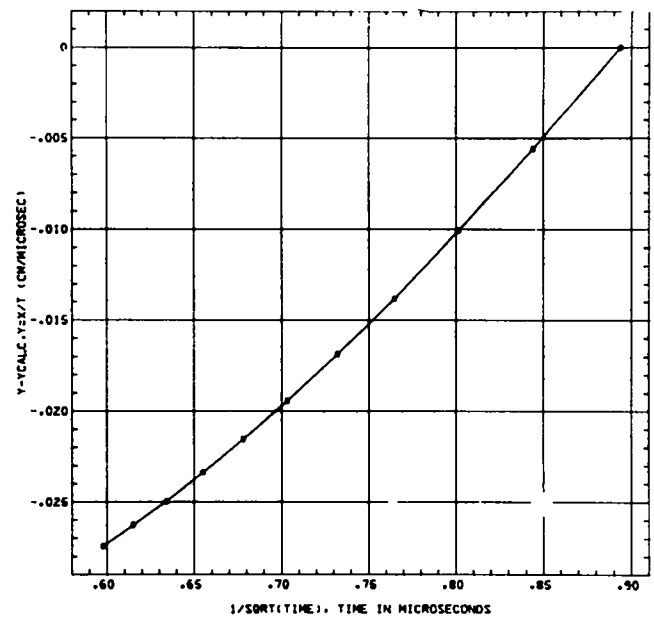

Fig. 2b.

Fig. 2c.

Fig. 2d.

Fig. 2.   Composition B/nitromethane
   a.   Characteristic diagram.   The magnification ratio is $d_1/d_2 = 13$.
   b. y vs. $t^{-1/2}$, see text
   c. p vs. $t^{-1/2}$
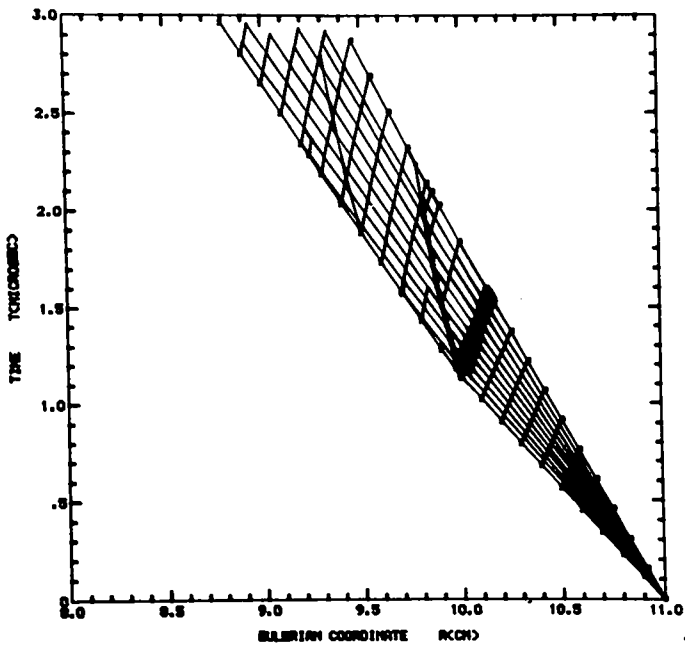   d.   Difference between RICSHAW y and that calculated from Eq. (2) vs. $t^{-1/2}$
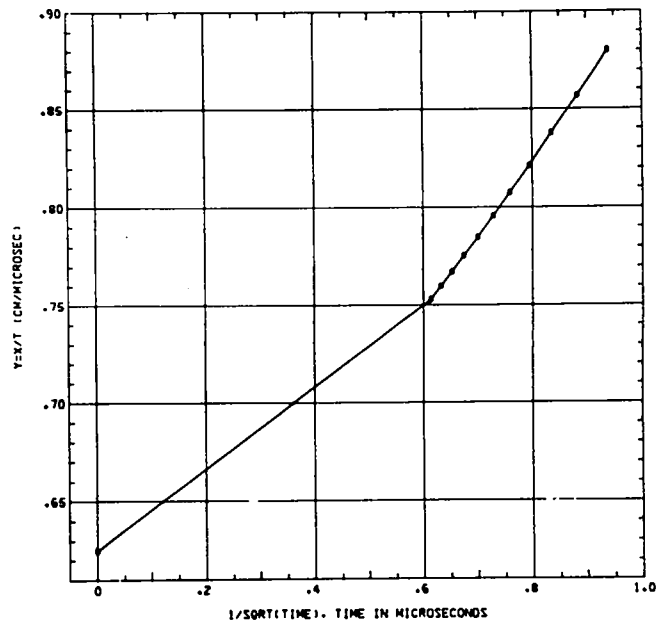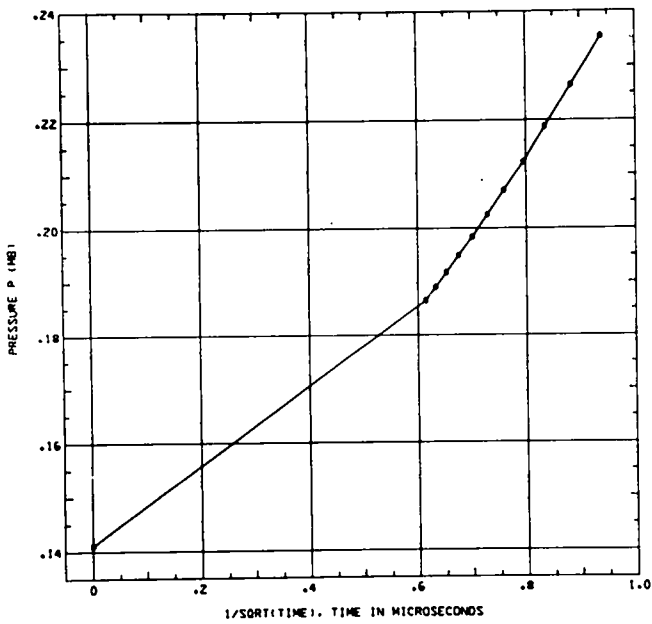
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Fig. 3a.
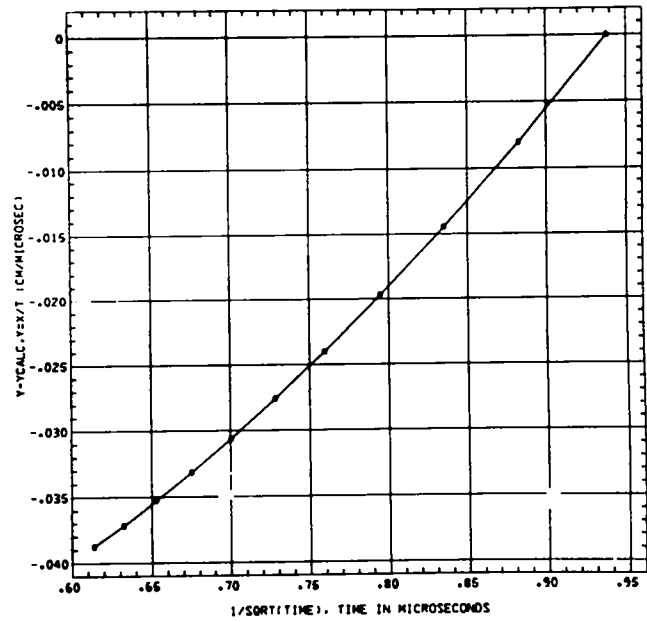

Fig. 3b.

Fig. 3c.

Fig. 3d.

Fig. 3. PBX9404/nitromethane, same as Fig. 2. The magnification ratio is 9.