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TITLE: **ACCELERATION OF METAL PLATES**

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ACCELERATION OF METAL PLATES*

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High-explosive charges have been used to accelerate stainless steel plates to velocities of 6–7 km/s. A two-stage system has been used in which the first stage is a plane-wave detonating system that accelerates the plate down a short barrel. The second stage consists of a hollow cylindrical charge through which the moving plate passes. After an adjustable delay this charge is detonated on the outer circumference of the entry side of the charge. Flash radiographs and witness plates show no breakup in the first stage but bowing and frequent breakup in the second stage.

1 INTRODUCTION

High-velocity plates are used in equation-of-state (EOS) research in order to achieve high pressure and internal energy states of interest in areas that include 1) studying phase transitions, 2) obtaining EOS data needed in running hydrodynamic calculations, 3) studying the constitution of the earth's interior, and 4) designing systems for the recovery of shocked materials.

Recently plane-wave explosive-driven plate systems used in our research have been limited to velocities of approximately 6 km/s. As plates were made thinner, or thicker explosive was used, the plates would fragment during acceleration.

In the last two years advances have been made which allow the achievement of higher velocities by proper cushioning or shock-smoothing at the HE-plate interface and by using staging in which a first flyer plate strikes a second system that drives a second higher velocity flyer plate. A system of this type is discussed below.

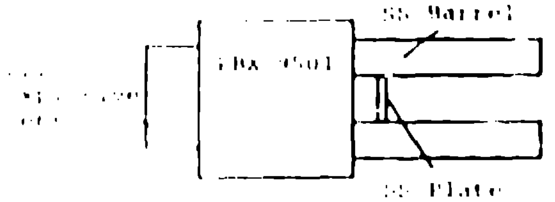

FIGURE 1
First stage of plate acceleration system

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2. DESIGN OF SYSTEM

The design of this system is shown in Fig. 1. The first stage contains a plane-wave-driven cylinder of PBX 9501 explosive having a 7.62-cm diameter and 7.62-cm length. Resting against the face of the explosive is a stainless-steel barrel having an OD and ID of 5.08 cm and 1.91 cm, respectively, and a length of 6 cm. A 0.15-cm-thick plate of stainless steel (304 or 316) is placed in the barrel at a standoff 0.32 cm from the explosive face. Tests have been performed using only this first stage and they are reported below.

The first and second stages together are shown in Fig. 2. The second stage consists of a foam plastic shock mitigator (to protect the second charge from barrel shocks) followed by another PBX 9501 charge and a barrel similar to the first barrel. The second PBX 9501 charge has an OD and ID of 5.08 and 1.91 cm, respectively, and a length of 3.81 cm. It is detonated by means of delay line running from the right end of the first charge to the left end of the second charge. It is constructed out of a foam plastic hollow cylinder containing the first barrel wrapped with

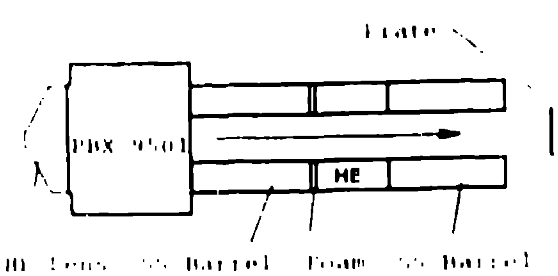

FIGURE 2
Two stage plate acceleration system

a 0.4-cm-thick layer of Detasheet on its faces and outer diameter. The length of delay is controlled by varying the cylinder diameter.

3 TEST OF SYSTEMS

The diagnostics used to test these systems were two 300-keV flash x-ray units pulsed 4 μs apart to give plate velocity and plate condition (to indicate flatness and breakup -- if any). A 2.54-cm-thick, 30-cm × 30-cm aluminum witness plate was placed 30 cm in front of the barrel to also indicate breakup of the plate.

Three shots were fired using only the first stage. The x-radiographs from one of these experiments are shown in Fig. 3. The plate emerges from the barrel flat and having an average velocity of 6.40 ± 0.05 km/s. The witness plate is shown in Fig. 4. Both radiographs and the witness plate indicate no plate breakup.

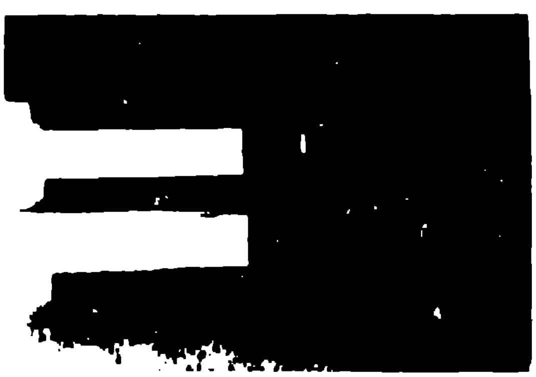

FIGURE 3
Two flash x-radiograph exposures of the plate from the first stage only with a thin barrel extension added to the main barrel

Eight shots were fired using both the first and second stages. In four of the shots the plate broke up and no velocities were obtained. In the remaining four [illegible] time delays and second charge lengths were used. These plate velocities varied between 6.6 [illegible] 7.0 km/s. The x-radiographs and witness plate from the highest velocity shot are shown in Figs. 5 [illegible] 6. Although there was no breakup the plate has [illegible] derable distortion, primarily bowing caused by a [illegible] pressure gradient in which the highest pressure [illegible] axis. This results from convergent HE gas prod[illegible] flow caused by the convergent detonation wave in [illegible] second high explosive. This is manifested in all of [illegible] two stage experiments.

FIGURE 4
Entry side of witness plate from a test of the first stage only.

FIGURE 5
Two flash x-radiographs of a plate from a two stage experiment. Motion is to the right

4 CONCLUSIONS

Stainless steel plates can be driven [illegible] at a velocity of 6.4 km/s and remain intact with no observable breakup in a one stage explosive system. [illegible] second stage (convergent high explosive) system [illegible] added to this, radial pressure gradients frequently cause plate breakup and always result in plate [illegible]. In the two stage system, velocities as high as 7.0 [illegible] have been obtained.

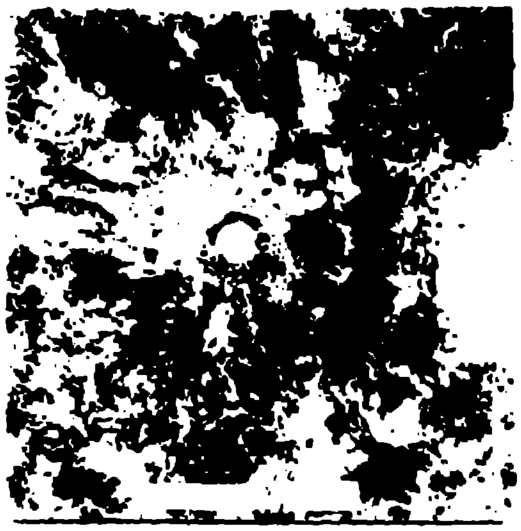

FIGURE 6
Entry side of witness plate from a test of the two-stage system