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Nuclear-Explosive-Driven Experiments*

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ABSTRACT

Ultrahigh pressures are generated in the vicinity of a nuclear explosion. We have developed diagnostic techniques to obtain precise high pressures equation-of-state data in this exotic but hostile environment.

INTRODUCTION

Dynamic shock wave experiments using conventional laboratory techniques are limited to pressures considerably below 1 TPa for most materials. Underground nuclear explosives provide a means for reaching considerably higher pressures but in a much more hostile environment. We have developed experimental techniques which can be used in this environment to obtain precise equation-of-state (EOS) data at pressures from 1 to 100 TPa. There are two basic types of shock-wave experiments in which Hugoniot data are obtained: 1) absolute measurements in which both the shock velocity and particle velocity are determined, and 2) measurements made relative to a standard material whose Hugoniot is known. We have performed both types of experiments using a Doppler-shift technique for the absolute measurement and the impedance-matching technique for the relative measurements. This poster-session paper summarizes our experimental methods and shows some of the details of the techniques.

EXPERIMENTAL TECHNIQUES

Figure 1 gives an overview of our high-pressure program with a summary of past results and a list of the personnel involved. Figure 2 illustrates the Doppler-shift technique and shows some experimental details along with the results of our measurement at 2.0 TPa. Figure 3 summarizes the impedance matching technique and shows the experimental details of our previous measurements. Figure 4 summarizes a symmetric-impact technique that is being developed to obtain absolute Hugoniot data for a standard material at pressures up to ∿10 TPa.

SUMMARY

Experiments using underground nuclear explosives have extended the accessible pressure range up to ∿10 TPa. These measurements have stimulated improved theoretical treatments and provide bench marks for checking sophisticated EOS theories. We are planning an impedance-matching experiment to obtain additional data for a number of sample materials and thus provide consistency checks for the

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various EOS theories. Future experiments at even higher pressures should provide tests of statistical models, which are assumed to be valid at extremely high pressures.

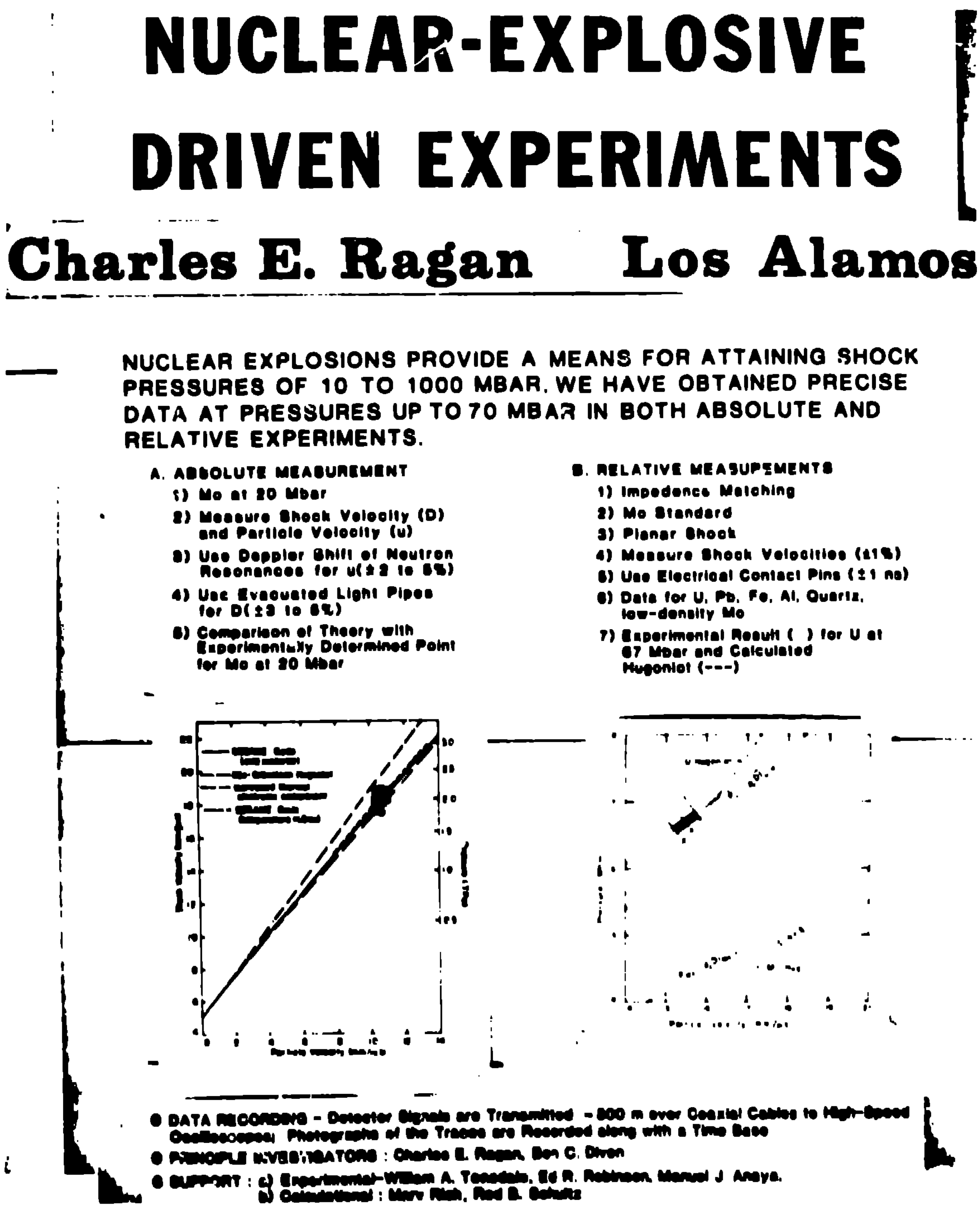

Fig. 1 Overview of the Los Alamos high-pressure experimental EOS program using underground nuclear explosives with a summary of previous absolute and relative measurements.

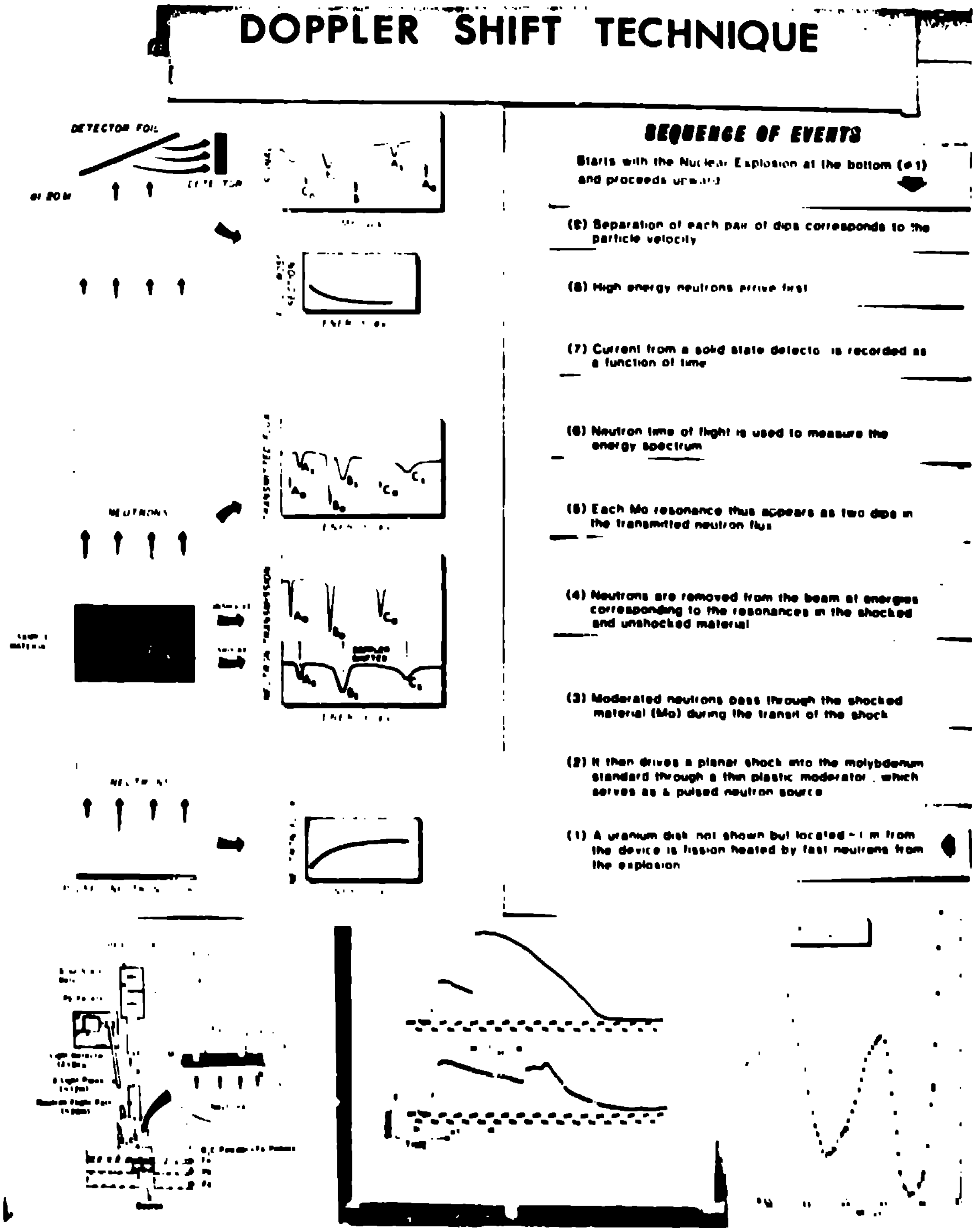

Fig. 2 A summary of the Doppler-shift technique for measuring the particle velocity . Various phases of the process are indicated in the upper portion, and the experimental details are shown at the lower left. The lower right shows the digitized data from a solid state detector and the center signals are from photomultiplier detectors at the tops of the light pipes.

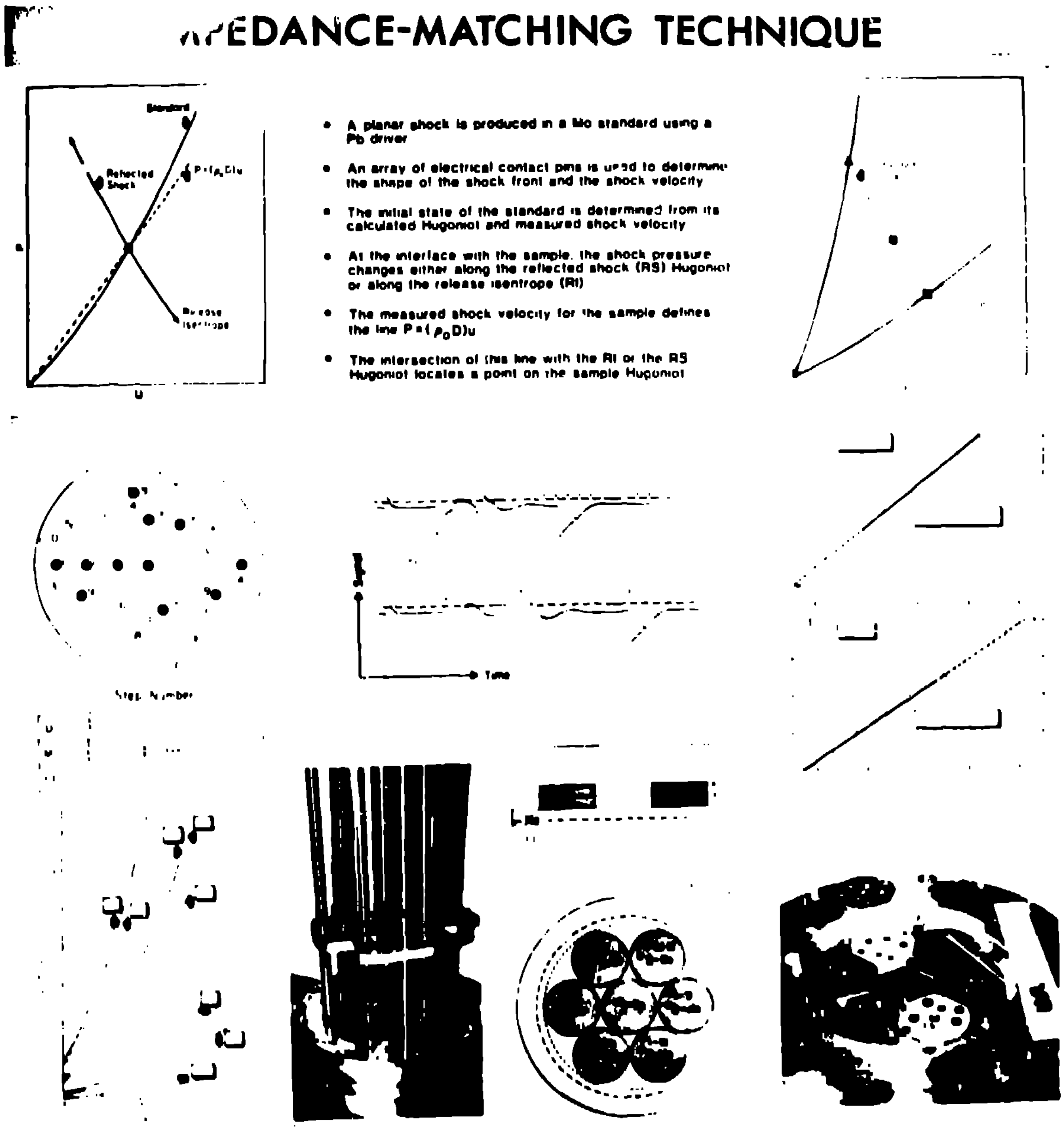

Fig. 3 Summary of the impedance-matching technique illustrating the analysis procedure for determining a Hugoniot point from measurements of shock velocities in a standard and a sample material. The results of the measurement on uranium at 6.7 TPa are shown in the central position and the lower part shows the details for the experiment with 13 samples.

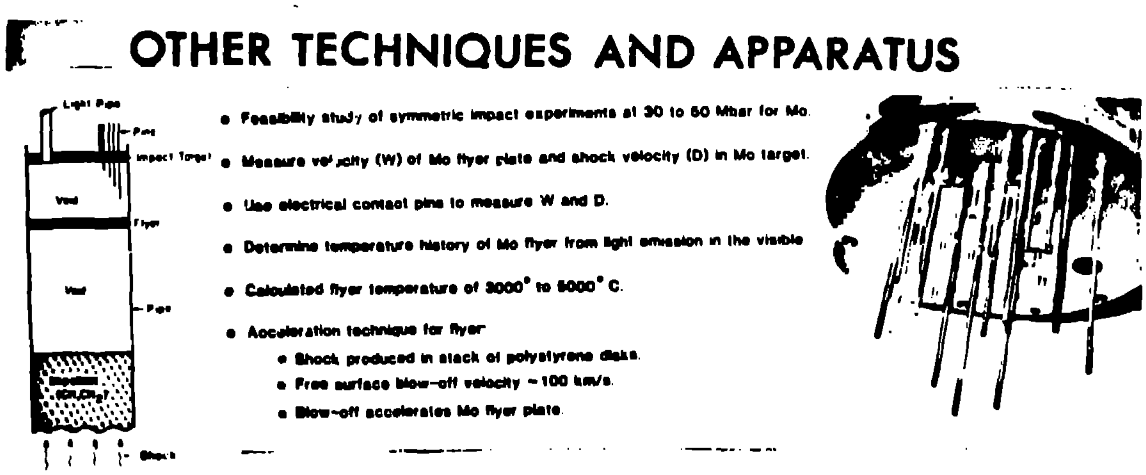

Fig. 4 Details of a feasibility study using a nuclear explosion to drive a flyer plate in a symmetric impact experiment, which can provide absolute Hugoniot data for a standard material.