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Shock Wave Compression of Benzene, Carbon Disulfide, Carbon Tetrachloride, and Liquid Nitrogen*·†

RICHARD D. DICK
Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87544

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Hugoniot data to several hundred kilobar have been obtained for benzene, carbon disulfide, carbon tetrachloride, and liquid nitrogen. Standard high explosive techniques were used for generating the shock waves. Experimentally measured quantities were transformed to pressure and volume data by the impedance match method. The shock-particle velocity data for the liquids are described by a linear relationship, however, a quadratic in particle velocity also provides an adequate representation of the data for carbon tetrachloride and liquid nitrogen. Benzene undergoes a transition at 133 kbar and carbon disulfide at 62 kbar. These transitions are accompanied by a volume decrease of approximately 16%. A double shock-wave structure, observed in many solids which undergo a transition, was not observed in benzene and carbon disulfide. There is some evidence that carbon tetrachloride and liquid nitrogen undergo a transition at 165 and 135 kbar, respectively. Hugoniot curves calculated from a Lennard-Jones and Devonshire (6-9) and a modified Buckingham exp-6 intermolecular potential fit the liquid nitrogen experimental Hugoniot curve between 20 and 170 kbar.

I. INTRODUCTION

These are the results of an investigation to determine some of the properties of benzene, carbon disulfide, carbon tetrachloride, and liquid nitrogen when shocked to pressures of several hundred kilobars. The pressures were produced by plane shock waves, created by detonating high explosives. The initial temperature of the three organic liquids was approximately 295°K and of the liquid nitrogen 75°K.

There is very little high-pressure data available on these liquids. Bridgman[1–7] has obtained most of the static pressure data. A limited amount of shock compression data were obtained by Walsh and Rice[8] for benzene, carbon disulfide, and carbon tetrachloride, using optical techniques. More extensive dynamic data for these liquids were collected by Cook and Rogers,[9] also using optical methods. Zubarev and Telegin[10] obtained some Hugoniot data for liquid nitrogen using techniques similar to those of this investigation.

The "impedance match method" was used to transform the measured shock velocities to pressure, particle velocity, and relative volume data. These data are presented in shock velocity-versus-particle velocity and pressure-versus-relative volume plots. In addition some rough electrical conductivity experiments were carried out on benzene, carbon disulfide, and carbon tetrachloride. The discovery that benzene and carbon disulfide undergo a transition prompted experiments to detect the presence of a double shock-wave structure associated with the transition; the results were negative.

II. EXPERIMENTAL TECHNIQUE

The impedance match method, as used in this study, requires the measurement of the shock velocity and the initial density of the material being examined and the shock velocity in a standard to determine the Hugoniot data. In this investigation 2024 dural was used as the standard. The Rankine–Hugoniot relations[11–13]

$$P-P_0=\rho_0 U_s U_p, \tag{1}$$

$$V/V_0=(U_s-U_p)/U_s, \tag{2}$$

for conservation of momentum and mass across the shock front provide the connection between the measured quantities and the Hugoniot point for the unknown material. The pressure and particle velocity

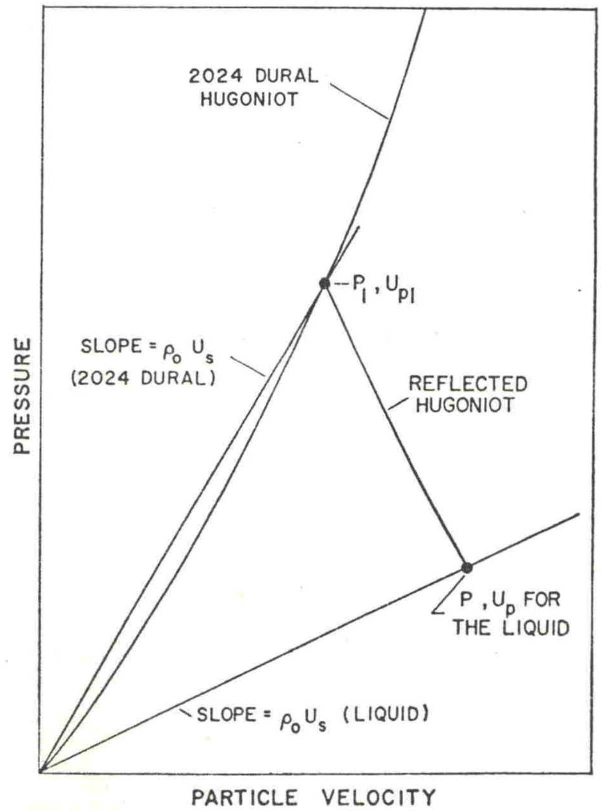

FIG. 1. Graphic representation of the impedance match method.