Dynamic pressure measurements to 300 kilobars with a resistance transducer

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Abstract. A method has been developed for measuring the pressure–time profiles of the stress waves produced in solids by explosives. The system uses the linear variation of resistance with pressure in a manganin wire. Various pressure profiles are presented, illustrating a range of shock phenomena; in particular a two-wave structure has been detected in glass and granite between pressures of 100 and 200 kb. A large rounded pressure wave observed in glass is attributed to the adiabatic compressibility initially increasing with increasing pressure, a variation opposite to that usually found in solids. A simple treatment is given by which the pressure–volume relationship can be found in this region from measurements of the pressure–time profile. The resulting curve for glass is not inconsistent with measurements by conventional methods in the high pressure single shock region.

1. Introduction

In most materials intense compressions are propagated as shock waves. The material properties on either side of the shock are conventionally described by a 'Hugoniot Equation of State', that is a relation between pressure and volume applicable to the shock process. Shock and free surface velocities can be measured, and particle velocity inferred from the latter. A pressure–volume point is obtained by substituting these values in the Rankine–Hugoniot equations (Rice *et al.* 1958). This technique has been used satisfactorily up to at least 5 Mb.

Recently however, interest has focused on compression waves in geological materials at pressures below 100 kb. With such materials at these pressures, compression characteristics often depart from the simple form required for the propagation of a single shock. Such departures have been reported for marble (Dremin and Adadurov 1959), granite (Lombard 1961) and quartz (Wackerle 1962); they have been attributed to either polymorphic transitions or large elastic waves. The more complex pressure–time profiles of stress waves under such conditions were found to cause existing methods for the measurement of shock and free surface velocities and their subsequent interpretation to yield misleading or erratic results. It was therefore decided to attempt to devise a pressure transducer which would enable the pressure profile generated by a substance to be recorded directly. It is shown how this was achieved, and how in some cases a pressure–volume adiabat can be calculated from the pressure–time profile.

2. The pressure transducer

The resistance of most metals decreases with pressure (Bridgman 1952) and increases with temperature. When a metal is subject to an isothermal compression the resistance alters due to two effects, the change of dimensions and a variation of resistivity, the latter effect predominating. In a dynamic experiment the pressure impulse is accompanied by a temperature rise, which for the more incompressible metals is of the order of a few hundred degrees Celsius. Bridgman (1949) has shown that the temperature coefficient of resistance for metals is nearly independent of pressure, and recent data over larger ranges (Kaufman *et al.* 1962) has tended to confirm this observation. The pressure and temperature in a dynamic experiment affect the resistance in opposite directions, but in practice with common metals the temperature effect is dominant and the resistance increases.