For these reasons we developed a system capable of measuring optical absorption spectra of minerals while they are in a dynamically produced, high-pressure shock state. Our system is described and its present capabilities illustrated in the discussion of results for periclase and ruby.

EXPERIMENTAL TECHNIQUE

Time-resolved spectral measurements of a solid during shock loading have not been performed previously, although single-frame spectra of shocked liquids [*David and Ewald*, 1960] and time-resolved spectra of shocked liquids [*Yakusheva et al.*, 1971] using explosive argon light sources have been reported. The use of such explosive sources is not practicable in a shock facility such as that at Caltech, where a high-performance gun is used to accelerate flyer plates that produce intense shock waves in minerals upon impact. The spectrograph system described below, although specifically designed for use in our system, could be adapted for use with most shock facilities, including those using high explosives. Briefly, light from an electrical arc discharge is focused on the sample by an optic system and is internally reflected back along a similar path (Figure 1). The ingoing and outcoming rays diverge slightly (13°) and permit the latter to be focused on the entrance slit of a simple reflection grating spectrograph. The exit part of the spectrograph is a slit, elongated in the direction of dispersion, which is the object scene for a streak camera. The resulting image is a plot of light intensity as a function of wavelength and time.

Light source. The light source is a confined electric discharge in air and is viewed axially

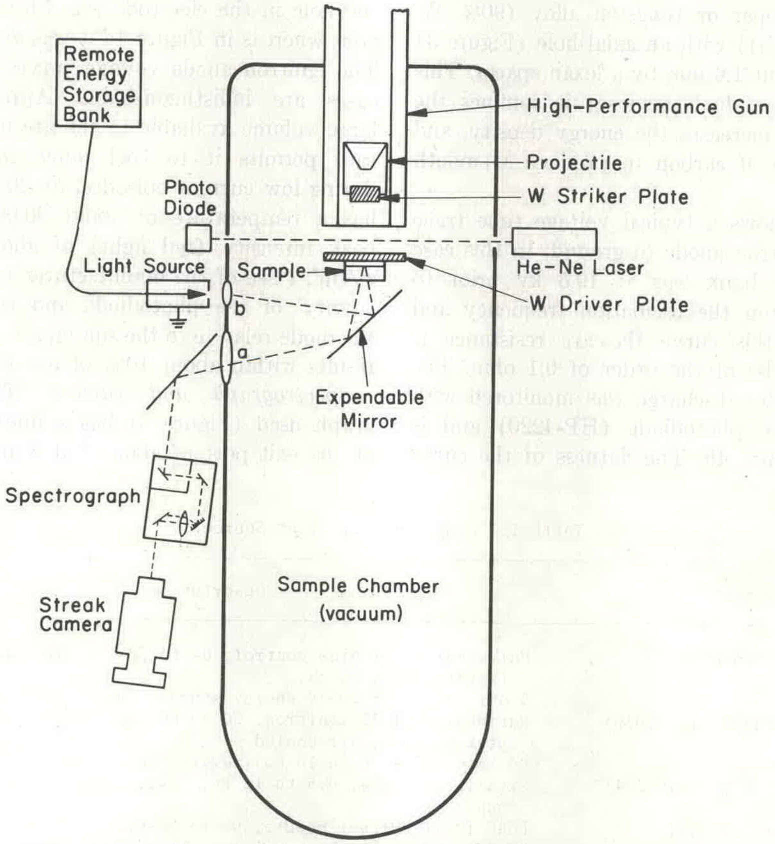

Fig. 1. Schematic cross section of spectrographic system designed to measure optical absorption spectra during shock loading to pressures in excess of 500 kb. Lens a is 308 mm, $f/2.5$; lens b has a positive meniscus of 58 mm and a 7.5 diopter.

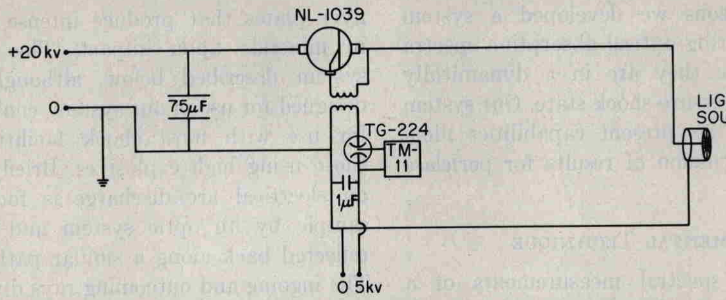

Fig. 2. Circuit diagram of a high-intensity point light source used to measure spectra in shocked solids. Components are described in Table 1.

through the ground electrode. The design is modified from that of *Preonas and Swift* [1970]. The electrical energy is stored at 20 kv in a 75-μF capacitor bank (15,000 joules). The circuit is shown in Figure 2, and the components are described in Table 1. The discharge is between a central copper electrode and a ground electrode (copper or tungsten alloy (90% W, 6% Cu, 4% Ni)) with an axial hole (Figure 3) separated about 1.6 mm by a lexan spacer. This spacer serves a dual purpose; it confines the arc and thus increases the energy density, and it is a source of carbon to produce a smooth spectrum.

Figure 4 shows a typical voltage time trace from the ignitron anode to ground. In this case the capacitor bank was at 19.5 kv prior to discharge. From the oscillation frequency and damping of this curve the arc resistance is estimated to be of the order of 0.1 ohm. The intensity of this discharge was monitored with a red-sensitive photodiode (HP-4220) and is shown in Figure 4*b*. The flatness of the curve between 25 and 45 μsec is not real but is produced by saturation of the diode. The peak intensity is probably within about 10% of the value of saturation. Comparison of the curve in Figure 4*d* with that in Figure 4*b* illustrates the sensitivity of light intensity to the detailed geometry of the gap. In the case of Figure 4*b*, the hole in the electrode was 1.6 mm in diameter, whereas in Figure 4*d* it was about 3.2 mm. The ignitron anode voltage curves for the two cases are indistinguishable. Apparently, the large volume available to the arc in the second case permits it to cool much more rapidly during low current episodes. At 20 kv the light has a temperature of about 60,000°K and a peak intensity (red light) of about 5×10^3 w/cm^2. (Use of the manufacturer's 'typical sensitivity' of the photodiode and calibration of the diode relative to the sun on a clear day yield results within about 10% of one another.)

Spectrograph and camera. The spectrograph used (Figure 5) has a linear dispersion at the exit port of about 100 A/mm. The exit

TABLE 1. Components of Light Source

Component	Description
Power supply (main)	Universal Voltronics control, 0- to 32-kv direct current (reversible), 25 ma.
Capacitor bank	5 Aerovox 15-μF 20-kv energy storage capacitors in parallel.
Switching ignitron (NL-1039)	National NL-1039 ignitron, 20-kv peak anode voltage, 100-ka peak current, air cooled.
Power supply (trigger)	Beckman 1150-1 0 to 10 kv (reversible), 9 ma.
Triggered spark gap (TG-224)	Signalite TG-224, 0.5 to 18 kv, 6 kilojoules, triggered spark gap.
Trigger module (TM-11)	EG&G TM-11 trigger module, 0- to 30-kv output remote trigger.
Cable	RG-221, 14-kv 50-ohm coaxial cable (armored).
Transformer	Three turns of coaxial cable (RG14/U), ignitron on center conductor.