pression curve for the sample material. In the present paper two characteristically different wave profiles are observed in the various stress ranges. These are (1) a single elastic compressive wave of stress less than the HEL and (2) a two-shock front profile consisting of an elastic wave, whose amplitude is the HEL, and a slower moving higher pressure wave. Since different assumptions are employed in the data reduction in each of the two cases the method of data reduction for each experiment will be described.

The stress vs. compression states for each experiment are calculated assuming steady wave conditions and applying the conservation of mass and momentum conditions across each shock front. Thus, from the conservation of mass

$$\frac{\Delta V}{V_0} \equiv \eta = \frac{\Delta u}{U - u_i}, \tag{9}$$

and from the conservation of momentum

$$\Delta\sigma = \rho_0 (U - u_i)\Delta u, \tag{10}$$

where V_0 is the specific volume ahead of a shock front, ΔV is the magnitude of the change in specific volume imparted by the shock front, η is the strain or compression, Δu is the change in particle velocity, u_i is the particle velocity ahead of the shock front, $\Delta\sigma$ is the change in stress imparted by the shock front in a direction normal to the shock front. All velocities are in laboratory coordinates.

(a) *Elastic range experiments*

Experiments conducted within the elastic range were accomplished with the symmetrical impact configuration. Under these conditions a single shock front propagates with amplitude equal to the input particle velocity and travels with a fixed shock propagation velocity. In the experiment the particle velocity is measured with an accuracy of $\pm 0{\cdot}3$ per cent while the shock velocity is measured with an accuracy of ± 1 to $1\frac{1}{2}$ per cent. These values should be contrasted to the explosively driven experiments which produce multiple shock fronts whose free-surface velocities are measured with an accuracy of ± 3 per cent while the shock propagation velocities are measured with an accuracy of 1 to 2 per cent.

The shock velocity and particle velocity values observed are shown in Table 2 along with the computed stress and compression data. The experiments in the elastic range are conducted over a range of stress from 15 to 100 kbar with measurements in three crystallographic orientations. Typical records from which these data are obtained have been previously shown[32]. Increased shock velocity is observed with increasing particle velocity in all crystallographic orientations. This behavior will be compared to ultrasonic determinations of higher order elastic constants in the discussion section.

One special experiment was conducted on a 60° orientation sample. This crystallographic orientation is the natural growth direction of the artificially grown sapphire boules. For this reason, the availability, low cost and high quality of the material in the large diameters required for this work, make the 60° orientation more desirable than other orientations. On the other hand, this crystallographic orientation is apparently not a 'specific direction,' that is, a longitudinal motion applied along the disk axis may produce both a quasi-longitudinal and a quasi-shear wave[35]. However, even though sapphire has trigonal symmetry the elastic stiffnesses do not vary significantly with orientation. For example, the longitudinal wave speeds in the 0° and 90° orientations differ by only $\frac{1}{2}$ per cent. Hence, the nonsymmetric response would be expected to be small if not insignificant.

To determine the extent of the effect, a 60° orientation sample was impacted at 28 kbar with a quartz gauge which precisely measures the input stress to the sample. This same experiment also included a quartz gauge measurement of the resulting shock wave profile after propagation through a distance of

Table 2. Shock compression data for sapphire

$\rho_0 = 3{\cdot}986$ g cm^{-3}

Configuration	Sample thickness	First wave u_1	U_1	σ_1	V_1/V_0	Second wave u_2	$\bar{U}_2$	U_2	σ_2
	mm	mm μsec^{-1}	mm μsec^{-1}	kbar		mm μsec^{-1}	mm μsec^{-1}	mm μsec^{-1}	kbar
				0° orientation					
H	2·54	0·0333	11·29	15·2	0·9970				
H	5·11	0·0401	11·2	17·9	0·9964				
H	2·56	0·0463	11·1	21·3	0·9958				
H	2·57	0·0810	11·25	36·7	0·9929				
H	5·11	0·0943	11·2	42·1	0·9916				
H	2·54	0·1122	11·3	50·4	0·9901				
B	10·89	0·38	11·65	175	0·9674	Second wave not observed			
B	10·90	0·34	(11·6)[a]	157	0·9707	Second wave not observed			
B	6·450	0·31	(11·5)[a]	142	0·9730	0·49	8·05	7·56	196
T	12·70	0·30	11·55	138	0·9740	0·69	8·88	8·61	271
T	6·400	0·32	11·6-11·4	148	0·9722	0·71	8·76	8·49	262
C	10·86	0·33	11·55-11·6	150	0·9715	0·86	9·12	8·91	337
C	6·401	0·37	11·5-11·4	170	0·9677	0·83	8·55	8·24	319
H	12·68	0·41	11·77	195	0·9652	1·08	8·82	8·52	419
H	6·400	0·46	11·64	210	0·9605	0·94	8·91	8·67	370
				0° orientation					
H	2·59	0·1213	11·2	52·6	0·9892				
H	2·58	0·1477	11·2	64·1	0·9868				
B	10·86	0·342	11·39	155	0·9700	0·474	6·90	5·97	186
T	10·89	0·291	11·57	134	0·9748	0·69	8·63	8·25	264
H	10·80	0·381	11·76	179	0·9676	0·98	8·72	8·44	378
				60° orientation					
H	3·21	0·0370	11·1	16·1	0·9967				
HQ		0·0653		28·2	0·9943				
	12·67		11·16	28·5					
H	3·21	0·0703	11·2	31·3	0·9937				
H	3·19	0·0780	11·1	34·5	0·9930				
H	3·20	0·1268	11·1	55·7	0·9886				
H	3·15	0·225	11·2	102	0·9796				
B	12·832	0·267	11·23	120	0·9762	0·456	8·07	7·60	177
C	12·750	0·374	11·38	170	0·9671	0·895	8·62	8·34	341
C	12·800	0·35	11·43-11·40	160	0·9694	0·83	8·53	8·14	314
H	12·817	0·282	11·54	130	0·9756	0·99	9·39	9·18	388

t measured due to partial experimental failure.
lues shown are those assumed to calculate first wave parameters.