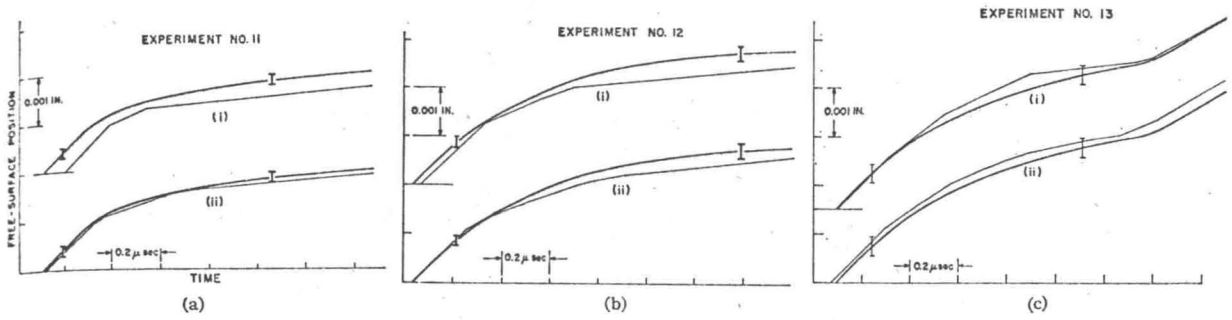


FIG. 11. A comparison of the measured curves (the continuous curves) with (i) the predicted motion of the free surface using a simple elastic–plastic model, and (ii) the predicted free surface motion using the empirical stress–strain relation.

ally) and allowed to rest there for a time until acted upon by the tension waves generated at S. The relaxation time at zero stress thus accounts for a small cusp at point C in Fig. 9.

To confirm the characteristics of the release path already discussed and to obtain the form of the remainder of the reverse strain path, one must resort to a parameter variation study using a computer to translate various reverse strain paths into predicted free surface motions for comparison with the measured free surface position histories. The computer program used for the study solves problems of one-dimensional shock wave propagation using the method of characteristics. It approximates smooth wave shapes by a series of discrete stress jumps, and uses an elastic–plastic stress–strain relation which must be approximated by a series of straight line segments. Given a set of initial conditions and a stress–strain relation for each material in the problem, it computes the subsequent behavior of the configuration based on the usual conservation equations. It does not allow an explicit treatment of rate effects.

In matching the free surface position histories of experiments 11–13, the shock-loading portion of the stress–strain path used by the computer was obtained by interpolation of the measured relations described earlier. The tailing over of the curve near the 10.5-kbar stress level accounted for the effects of strain rate on the shock-loading wave shape. Various unloading paths were tried until a best fit of the late-time motion of all three experiments was obtained. The computer program was unable to incorporate the small cusp at point C into the reverse strain path; accordingly, a somewhat elongated straight line was used to approximate the path in this region. As a result of the parameter variation study, a reverse strain path, incorporating the features already discussed, was found to give the best agreement with the measured results in all three experiments. The best fit was obtained by assuming a tailing off of the reverse strain path to a lesser slope near the maximum negative stress similar to that measured in in the compressive stress–strain relations near the maximum positive stress. The apparent tailing off was again attributed to the rate effect in aluminum.

The complete stress–strain path normalized to a 10.5-kbar impact stress is presented as the solid line in Fig. 10, and the stress–strain points defining the end points of the line segments comprising the path are given in Table IV(a). The path contains a composite of many strain rates in the range 10^2–10^6 sec^{-1}. The strain rate is least near the extremes of stress and at point C, for example. However, the strain rate is a function not only of the stress, but also of the position within the material. A single stress–strain path to describe an experiment, therefore, cannot be completely well defined.

The measured free surface position histories are compared with the computer output in Fig. 11(ii) which show enlargements of the portion of the free surface motions affected by the rarefaction waves (the solid lines in Fig. 8). For comparative purposes, a fit of the data was also found assuming an elastic–perfectly plastic model.[5] The compression path consisted of two straight lines, the first representing the elastic range of the material and the other the plastic yielding path parallel to the hydrostat. The reverse strain path consisted of an elastic relaxation through a change of stress equal to twice the elastic limit, followed by a reverse yielding path parallel to the hydrostat. The complete path is shown as a dashed line in Fig. 10, and its stress–strain points are given in Table IV(b). The measured free surface position histories are again compared with the computer output in Figs. 11(i).

TABLE IV. Points on the stress–strain paths.

	(a) Empirical σ_x	$\Delta V/V_0$		(b) Elastic–plastic σ_x	$\Delta V/V_0$
↑	0	0	↑	0	0
	4.80	0.00424	Compression	6.50	0.00593
	6.80	0.00620	↓	10.50	0.01133
Compression	8.39	0.00804	↑		
	9.59	0.00960	Reverse	10.50	0.01133
↓	10.50	0.01106	strain	−2.50	−0.00052
↑	10.50	0.01106	path	−9.38	−0.00982
Reverse	3.01	0.00443	↓		
strain	−2.99	−0.00142			
path	−7.57	−0.00750			
↓	−8.95	−0.00970			