bility and the slope of the coexistence line with greater precision. The approximate agreement of theory and experiment suggests that the basic assumptions made in the derivation of the theory are tenable.

Equation (1) was used with the directly determined slope of the coexistence line to determine a value of mixed-phase compressibility consistent with the known variation of transition pressure with temperature. This value is included in Table II and is represented by the dashed line of Fig. 5.

Another interesting observation from the ambient temperature experiments concerns the rate of this recrystallization transition in bismuth. Note that there is no systematic dependence of observed transition pressure on metal thickness. Therefore, the transition must have occurred in a time considerably less than the shock transit time of the thinnest plate because all evidence of the transient shock configuration has disappeared. The shock transit time through the 6-mm plate is a little more than 3 μsec. This suggests that the relaxation time for this recrystallization reaction at 42°C and 27 kilobars is less than 1 μsec. Unfortunately it was not possible to use still thinner bismuth plates in an effort to refine this estimate of relaxation time. The estimate, however, shows the transition rate to be much faster than "widely held opinion"[8] expected.

This observation of a recrystallization rate fast compared to shock transit time shows the transition in bismuth to be unique among the three shock-induced transitions in metals investigated to date. Specifically, a small dependence of transition pressure on plate thickness was reported for Armco iron.[7] In addition, preliminary experiments with antimony show a striking increase in apparent transition pressure as plate thickness is reduced. The experimental results for the shock-induced transition in antimony will be published at a later date.

An experiment was performed to verify that the bismuth samples used in the shock-wave experiments transformed as reported by Bridgman under static conditions. This precaution was taken because no attempt was made to insure that the bismuth used was of the highest purity; and the possible effects of impurity concentration on transition behavior are unknown. This is not to suggest that poor grade material was used. Spectrographic analysis showed that the bismuth contained only traces of impurities.

The static experiments were done by copying all essential details of the technique used by Bridgman[11] for determining the electrical properties of materials at high pressure. Bridgman had found that the resistance of a sample of bismuth decreased many fold in the transition of interest here. This rapid change in resistance with pressure made the identification of the transition quite simple.

At room temperature Bridgman reported the transition pressure to be 25 650 kg/cm². The value determined in this investigation was 26 080 kg/cm² with an uncertainty of approximately ½%. The disagreement between the two numbers is larger than the uncertainty in the recent determination; but the difference is small compared with that between static and dynamic determinations of transition pressure. Therefore, some feature of the dynamic experiment must be basically different from that of the static case. At the present time the cause of the disagreement between the two types of experiments is unknown.

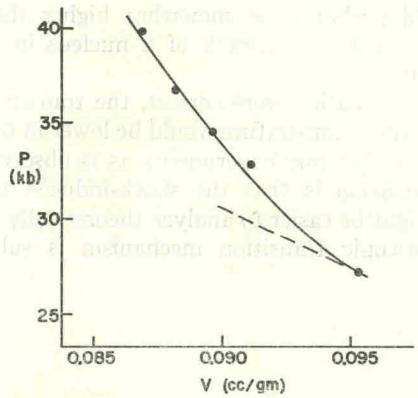

FIG. 5. Experimental Hugoniot in the vicinity of the transition point; and limiting slope of the Hugoniot above the transition point consistent with the directly determined slope of the coexistence line in the p-T plane.

Though the reason for the disagreement is unknown, one may speculate on possible causes. From the point of view of the continuum theory it can be argued that the effective hydrostatic pressure behind the shock is less than that determined from shock-wave measurements because of residual strength of materials effects.

An alternative suggestion more satisfactory to the authors is based on speculations concerning possible differences in the detailed mechanisms of transformation in dynamic and static experiments. In the dynamic case the transformation region must move with shock velocity through the material; and the rate of transformation must be high or no transformation would be observed within the limited time available. On the other hand, in the static case the transformation can begin to occur anywhere within the sample and can proceed at a relatively slow rate. The constraints on the shock-induced transformation imposed by hydrodynamic considerations probably force the transformation mechanism to be quite different than in the static case where the recrystallization can be accomplished through the growth of nuclei of the new phase. Probably some array of climbing dislocations as suggested by Smith[12] could satisfy the dynamic constraints and produce the required recrystallization. The critical pressure or activation energy for the motion of such a dislocation array would be that characteristic of a perfect lattice

[11] P. W. Bridgman, Proc. Am. Acad. Arts Sci. **81**, 165 (1952).

[12] C. S. Smith (private communication).

and would probably be somewhat higher than that needed to cause the growth of a nucleus in a static experiment.

If this speculation were correct, the transition pressure at a given temperature would be lower in the static than in the dynamic experiments as is observed. Another conclusion is that the shock-induced transformation might be easier to analyze theoretically because the microscopic transition mechanism is subject to severe constraint and should be relatively easily determined.

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