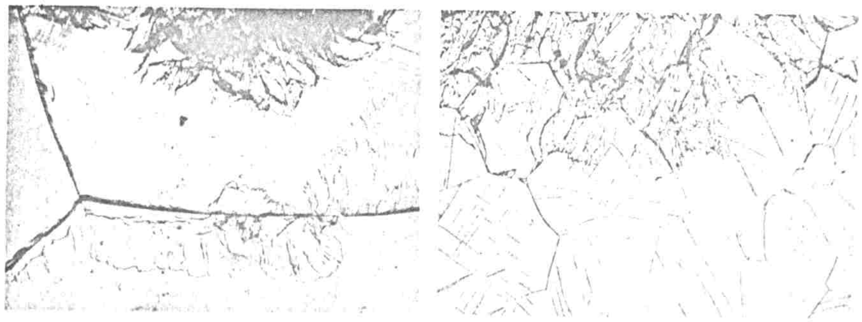
Fig. 9—Structural changes in single-crystal bismuth after 50 pct completion of I-II transitions. (*a*) After 50 pct completion; (*b*) final structure in transformed region after repolishing. X100. Reduced approximately 42 pct for reproduction.

(*a*) (*b*)

Fig. 10—Structural changes in polycrystalline bismuth after various stages of completion of I-II transition. (*a*) After 38 pct completion; (*b*) after 41 pct completion. X100. Reduced approximately 42 pct for reproduction.



(*a*) (*b*)

to that of the residual structure after transition, required an annealing treatment of 220°C for 5 hr which resulted in ten to twenty grains intersecting an equivalent polished area as demonstrated in the original structure photomicrographs of Figs. 6 and 8.

Two factors that could contribute to the enhanced boundary migration are stored strain energy and preferential orientation of the structure as indicated by the difference in resistivity after pressurization. The stored strain energy arises from the fact that, just as increasing pressure progressively induces shear stresses in the grain boundaries of Phase I bismuth, so also will decreasing pressure once the material has transformed back from Phase II to I. Undoubtedly, substantial boundary migration and deformation occur progressively in Phase I reaching a maximum at atmospheric pressure. The available stored strain energy at atmospheric pressure due to this deformation could materially affect the rate of boundary migration.

A better understanding of how the transformations occur and the rather unusual residual structure can be gained from the examination of partially transformed specimens. For the purpose of obtaining partially transformed samples for examination, the I-II transition was interrupted after a certain percentage of voltage change, as indicated by the oscilloscopic recorder, by simply reducing the pressure by 100-atm increments. Partial transformation in a single-crystal sample is shown in Fig. 9.

Referring to (*a*) of Fig. 9, the boundary between the transformed and untransformed region is quite evident. The transformed region is typical of that observed in all cases for the I-II transition containing an image of the polycrystalline nature of Phase II. There is a small amount of slip in the untransformed area, undoubtedly due to deformation induced by the volume change of the transformed portion of the sample. Photomicrograph (*b*), which is of the transformed area in the region of the initial transformed-untransformed boundary after repolishing, shows an interesting characteristic. The initial boundary is gone, and the only visible variation from the original single-crystal structure consists of a very few small isolated grains, one of which is shown in the center of the photomicrographs.

There appear to be at least two plausible explanations for this reversion back to near single-crystalline form and the presence of the isolated regions. First, substantial boundary migration occurs to reduce the progressively increasing shear stresses in the polycrystalline form of Phase I transformed from the Phase II region, as was previously described. The second possibility is that the untransformed Phase I region controls the direction of growth and possibly the orientation of the nuclei of Phase I transformed from Phase II, similar in effect to the growth of single crystals from a "seed" crystal. This is probably due, at least in part, to the large anisotropy of the linear compressibility of bismuth which, under pressure, could tend to enhance growth of nuclei similarly oriented to the untransformed volume and, due to the greater energy involved, retard the growth rate of those with a different orientation. This effect would be more prevalent in the region of the interface between the transformed and untransformed region. At a distance removed from the interface, nucleation and growth of unfavorably oriented material occur to a limited extent, as shown by the small isolated regions. However, the enhanced growth rate of the favorably oriented nuclei effec-