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An explanation of the 'fringes' on Berg-Barrett topographs reported by Armstrong and Schultz. BY A. R. LANG, *H.H. Wills Physics Laboratory, University of Bristol, England.*

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Armstrong & Schultz (1964) have observed arrays of fine dark lines on Berg–Barrett X-ray topographs of zinc single-crystal cleavage surfaces. The lines lie roughly parallel, with a spacing of 3 to 7½ μm. The arrays are reported as occurring at edges of the crystal, at cleavage steps, at intersections of low-angle boundaries with the cleavage surface, and at etch pits or hillocks. In their paper Armstrong & Schultz reproduce and discuss one array parallel to a cleavage step. The geometry is as shown in Fig. 1. *OP* is a step in the cleavage surface *XY*. Fe *Kα* radiation is reflected from (01̄13) planes such as *OQ*. An incident ray *OA* makes about 11° with the cleavage plane and a diffracted ray *OB* emerges at about 8° to the cleavage-plane normal. The array appears in the image of the region *PX*. The lines run roughly parallel to the edge *P* and about 20 to 30 are seen, covering a band about 100 μm wide to the left of *P*. The optically measured height of the step is only 1·9 μm. In the writer's opinion, Armstrong & Schultz discard too readily an explanation of the lines simply as dislocation images. Though aware of some of the difficulties involved, they suggest instead that the lines are Pendellösung fringes (Kato & Lang, 1959) associated with transmission through the 90°-'wedge' formed by the boundary surface *XPO*. Now examination of their photographs shows that the lines are not continuous. They run for about 100 μm, on the average, between ends or junctions with neighbours. Such behaviour precludes their being Pendellösung fringes. Apart from this basic objection, there are certain other objections to the Pendellösung fringe hypothesis that deserve stating more explicitly. This will now be done; and to replace Armstrong & Schultz's interpretation an explanation in terms of a physically likely deformation structure is proposed.

Kato (1961) has shown how the Pendellösung fringe pattern observed with a broad incident beam (or with specimen scanned by a narrow beam) is built up by the superimposition of many fringe patterns of the type observed when a narrow beam is used as in section topographs (Lang, 1957). If we confine our attention to a single incident ray such as *OA* in the case under consideration, the waves in the crystal that give rise to the external diffracted beam have loci of constructive interference along hyperbolae having *OA* and *OB* as asymptotes. Two such hyperbolae are sketched in Fig. 1. In the topographs we are concerned with the superimposition of many such intensity distributions generated as the point of incidence is translated from *O* to *P*, carrying with it the hyperbolae contained within *AOB*. It is evident from the orientation of the hyperbolae that such translation can produce a fringe pattern on *PX* only close to *P*, and certainly no wider than *PQ*. In fact, as *PQ* measures only 2·7 μm, there is room only for the first Pendellösung fringe to appear since the calculated fringe spacing is about 3 μm.

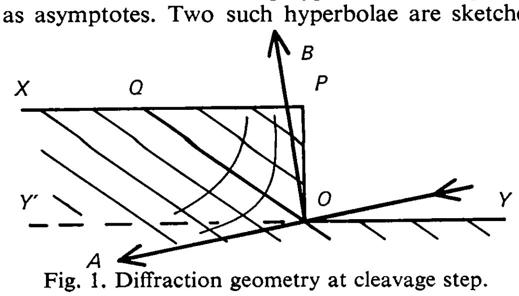

Fig. 1. Diffraction geometry at cleavage step.

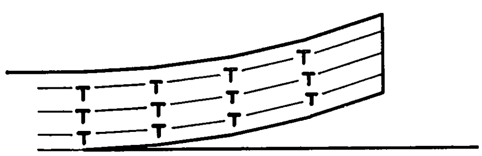
Fig. 2. Proposed deformation structure at cleavage step.

Armstrong & Schultz consider possible effects of anomalous transmission, but its presence would not allow a large number of Pendellösung fringes to become visible even if the geometry of the hyperbolae were more favourable than in Fig. 1. Expressions for the integrated reflexion from an absorbing crystal in the Laue case (Ramachandran, 1954; Kato, 1955; Hart & Lang, 1965) show that its oscillatory component due to Pendellösung interference has the normal attenuation coefficient. The linear absorption coefficient, μ, of Fe *Kα* radiation in zinc is such that $1/\mu$ is 12·8 μm, so at best only the first few fringes could ever be observed.

Topographic experience with many crystals suggests that arrays of lines separated by 3 to 7½ μm can be interpreted as dislocation arrays. The 3 μm spacing corresponds roughly to the minimum separation for individual resolution of dislocations in specimens of medium atomic number [see *e.g.* Lang (1965) and Lang & Polcarová (1965)]. With separations above about 10 μm the dislocation alignment becomes less regular and the array stands out much less obviously on the topograph. However, special deformation structures may be present at a cleavage step. It is not unusual for the lower cleavage surface to extend as a crack some distance under the cleavage step, *i.e.* along *OY'* in Fig. 1. In Fig. 2 a possible deformation structure in the thin sheet above the crack is drawn schematically. The dislocations on the (0001) glide planes are shown aligned in walls: this is a low-energy configuration. If such alignment had occurred to some degree the walls seen in plan would appear as an array of lines probably somewhat stronger than images of individual dislocations, and they need not be continuous. Armstrong & Schultz do remark that optical interferometry showed some bending in the area where arrays were found parallel to a cleavage step. This observation supports a model such as Fig. 2.

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