In carrying out a more serious test of the hypothesis, we have recently, among other things, examined by X-rays the effect of removing progressively the xylan (initially 19.8 per cent) of cellulose fibres from manilla hemp, using an apparatus specially designed for taking strictly comparable photographs on one and the same film². By this means very accurate comparisons were possible, but again no really fundamental change was revealed. Briefly, it may be said that removing xylan from fibres of high xylan content merely makes their X-ray photographs more like those of fibres of low xylan content! The point of this apparently pointless verdict is that the X-ray photographs of fibres of low xylan content—ramie and Italian hemp, for example—show certain diffraction features typical of a more perfect state of crystallisation. The result of these experiments is therefore definitely in favour of the view that the incorporation of xylan is a sort of mixed crystallisation.

A number of common fibres were also purified by removal of lignin and encrusting hemicelluloses. As would be expected, the effect of this treatment was in general to clarify the X-ray photograph, and in most cases to lead to improved definition through a sharpening of the crystallite orientation. Otherwise, nothing of any great significance was observed. Much depends on the care with which the chemical pre-treatment is carried out, for it is possible to injure the crystallite orientation instead of improving it. Miles Thomas and Hewitt³ report a diminished intensity in photographs of purified fibres; but we have not observed such an effect.

The photographs and experimental details of the work will be published in due course. In the meantime attempts are being made to obtain an X-ray pattern from xylan alone.

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¹ Norman, *Science Progress*, **27**, 299; 1933.

² Cf. Astbury and Woods, *Phil. Trans. Roy. Soc., A*, **232**, 333; 1933.

³ *NATURE*, **136**, 69, July 13, 1935.

Sub-Boundaries in a Crystal Grown by the Bridgman Method

INTEREST in irregularities observable in single crystals has arisen through the large discrepancies between the results of experimental studies of some of the physical properties of crystals and theoretical studies based on the idea of a single uniform lattice extending throughout each single crystal.

An observable irregularity has been found in working with a single crystal of copper grown by the Bridgman method. In trying to get an undistorted section parallel to the 311 planes for use as an X-ray polariser¹ many surfaces had to be cut, etched and examined under the microscope. The appearance of one such section, shown in the photomicrograph (Fig. 1), suggests that the crystal had broken down into a large number of small ones, the outlines of which are seen as the curved lines. The etching had been done with nitric acid, which develops the cube planes, so that the whole surface was covered by tiny cubes each having one corner projecting.

It was noticed that, as nearly as could be judged

by eye, not only were the whole of the cubes similarly orientated, as would be expected in a single crystal, but also some of the individual cubes actually crossed the curved boundary lines. Both effects were easily seen distributed over the whole 7 mm. of crystal and they are detectable in the photomicrograph. The arrow is parallel to a cube face. The grinding marks are parallel to the two edges of the page. X-ray photographs showed that if the crystal had broken up into smaller ones, their orientation was unchanged within the limits of the experimental accuracy.

FIG. 1. Etched section of a single crystal copper rod cut parallel to (311) planes showing, to left of arrow, sub-boundaries crossed by cube faces. ($\times 30$.)

Sir Harold Carpenter kindly pointed out that the markings are similar to the 'sub-boundary' or 'veined' structures observed in many metals. In the literature, these have been studied in the individual grains (crystals) of polycrystalline material but their nature is apparently not understood yet. Smithells and Rooksby² suggest that the sub-boundaries are formed under the influence of stresses set up during the rapid cooling of the metal (tungsten). Such a hypothesis would be untenable for copper as the observations here reported were made upon a crystal cooled very slowly. Furthermore, Northcott³ was able to suppress veining in polycrystalline copper by quenching from 1,000°C. The etching which is favourable for revealing sub-boundaries is not always favourable for showing the crystal orientation. In preparing the specimen illustrated, the acid was applied to the clean dry surface held by the side of a running tap, so that the action could be stopped quickly after about one second.

Since these sub-boundaries can be found in single crystals, it is evident that their possible influence upon some physical properties can be studied in types of experiment not possible with polycrystalline material where they have been observed hitherto.

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¹ George, *NATURE*, **136**, 180, Aug. 3, 1935.

² Smithells and Rooksby, *NATURE*, **120**, 226; 1927.

³ Northcott, *J. Iron and Steel Inst.*, **126**, 274; 1932.