or approximately ± 7 per cent at half amplitude. This spread can be reduced by reducing the angle of the stable phase-point, with a corresponding reduction in number of protons caught up per cycle by the wave, and hence in the mean output current.

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Polymorphism arising from Screw Dislocation

Frank[1] predicted from theoretical considerations that crystal growth may proceed owing to the presence of screw dislocations. Spiral growth-steps confirming these ideas were observed by Griffin[2] in beryl crystals and by Dawson and Vand[3] in n-paraffin crystals. The dislocation responsible for the growth of a crystal may be described by means of a Burgers vector. For a simple screw dislocation, this vector is one structural unit in length and perpendicular to the growing face, so that a spiral growth-step one unit in height is generated. In a certain number of cases the Burgers vector is several units in length, the original length being determined by the detailed shape of the primary nucleus or other accidents of growth.

In many layer structures, several kinds of stacking having nearly equal energies are possible, the best-known example being the cubic and hexagonal stacking of layers of spheres. If the crystal grows by successive deposition of fresh layers, then a random disorder in the succession of the layers would result. However, if the crystal grows by means of a screw dislocation, then it consists of a single sheet spirally wound around the screw dislocation, the pitch of the screw so formed being equal to the Burgers vector. When the growth-sheet is several packing layers thick, any original packing mistakes in the sheet would repeat themselves throughout the crystal with the periodicity of the Burgers vector. Crystals so formed may be regarded as exhibiting polymorphism, the particular polymorphic form being defined by its unit-cell dimension and the arrangement of the stacking within the unit cell.

In order that this type of polymorphism could be observable, the following conditions must be fulfilled : (a) more than one possibility of stacking of layers should be available ; (b) the crystal growth should proceed by means of screw dislocations having a Burgers vector more than one structural unit in length ; (c) the screw dislocation system should be stable, that is, the Burgers vector should remain the same throughout the growth of the crystal.

If the last condition is not fulfilled, then twins or multiple intergrowths, each in a different polymorphic form, would result.

It is possible that this type of polymorphism may be quite widespread in Nature. The best example is that of silicon carbide, which is known to exhibit a wide variety of polymorphic forms. In silicon carbide, the screw dislocations must be very stable, as large crystals all in the same polymorphic form occur. Another substance which shows this type of polymorphism is graphite ; but, owing to its softness, its polymorphism can be studied only on very small crystals. A more detailed discussion will be published elsewhere. I wish to thank Prof. J. Monteath Robertson for his interest, and Drs. I. M. Dawson and F. C. Frank for valuable discussion.

Note added in proof. In a recent paper, Frank[4] has advanced a similar explanation of polymorphism (polytypism) of silicon carbide.

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Growth Spiral Patterns on Carborundum Crystals

Observations on growth spirals on carborundum crystals have been reported earlier[1], affording experimental evidence of Frank's theory of crystal growth depending upon dislocations. Some new and unpredicted features of these growth spirals are reported here.

In Fig. 1 is shown part of an interlaced spiral in which in any one orientation *seven* steps are seen to group together. On following these steps to the other side of the interlaced portion, the same sequence of spacing repeating itself has been observed (not shown in Fig. 1). Under low magnification these grouped steps give an appearance resembling optical band spectra.

On another crystal a similar grouping of *five* steps has been observed. In addition, on one face of a crystal the number of steps grouped together has been observed to change in certain regions.

These features can be explained thus. The different polytypes of carborundum have the Ramsdell's zig-zag sequence[2] or Zhdanov[3] symbol of $[(33)_n 32]$. Using Frank's notation[4], the structure can be written as $[(\nabla\nabla\nabla\Delta\Delta\Delta)_n\nabla\nabla\nabla\Delta\Delta]$. Whichever layer has the slowest velocity of growth in any one orientation—say, the first ∇ after a series of Δ's—then it will repeat itself after six such layers, making the growth steps 15 A. high, until we reach the last layer $\nabla\nabla\nabla\Delta\Delta$, which will be only 12·5 A. high. After this the whole sequence will go on repeating itself. Thus, depending upon the number n, we will have a certain number of steps grouping themselves together. The observation of the changing number of grouped steps together suggests a change in type from one part of the crystal to another. This may account for the disagreement between crystal symmetry and X-ray diffraction data sometimes observed[5].

The observation of this grouping of steps is another visual confirmation by crystal growth patterns of the repeat sequence predicted by X-ray phenomena.