Polymer-type Elasticity in Non-polymer Crystals

During the course of some current research[1] on the growth and breaking strains of various needle crystals, it appeared that the elastic moduli of α-hydroquinone had not yet been measured, so far as we could ascertain. While a determination of all the elastic constants proved impracticable, we have measured the Young's modulus along the *c*-axis of the crystal, both by a simple cantilever method and in direct tension.

Bending tests on six crystals gave a mean value for Young's modulus of $0{\cdot}430 \times 10^6$ lb./in.^{2} ($30{\cdot}2 \times 10^3$ kgm./cm.^{2}) with a coefficient of variation of 6·2 per cent. Two tensile tests gave a mean value of $0{\cdot}441 \times 10^6$ lb./in.^{2} ($31{\cdot}0 \times 10^3$ kgm./cm.^{2}). The crystals obeyed Hooke's law up to at least 0·1 per cent strain.

The value of E found for hydroquinone is quite exceptionally low for a crystalline material, being about a quarter of that for ice[2], which has itself one of the lowest published values. Of the relatively few results published for non-polymeric organic substances[3], hexamethylene tetramine is one of the lowest with Young's modulus in the <100> direction of $2{\cdot}03 \times 10^6$ lb./in.^{2} (143×10^3 kgm./cm.^{2}). The majority of inorganic salt crystals are considerably stiffer than this. Low stiffness in a continuous elastic solid, such as that of hydroquinone, is generally shown only by polymers, and in fact the modulus of hydroquinone is similar to that of many resins.

The low elastic moduli of polymers must be due, in the main, to the easy deformation of molecular networks and zig-zag chains which in the engineering sense are 'deficient structures', a state of affairs which presumably seldom occurs in non-polymer crystals. However, ten years ago, Powell[4] suggested a complicated lattice structure for the α-hydroquinone crystal which the engineer would certainly regard as deficient and which seems to admit of elastic deformations of the polymeric type. If Powell's proposed structure is substantially correct, it would account for the exceptionally low modulus which we have found, and conversely the elastic constant lends support to Powell's suggestion.

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[2] Jona, F., and Scherrer, P., *Helv. Phys. Acta*, **25**, 35 (1952).

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Polarization of Atmospherics

In a recent communication[1], Prof. S. R. Khastgir has illustrated a complex type of trace obtained with a twin-channel cathode-ray direction-finder when receiving atmospherics. He has claimed to have deduced from this record information regarding the polarization of the echoes received after various numbers of reflexions between the Earth and the ionosphere. I believe that the record which he gives as an example can be explained almost completely by the combination of a ground-wave and the echo received after only one ionospheric reflexion.

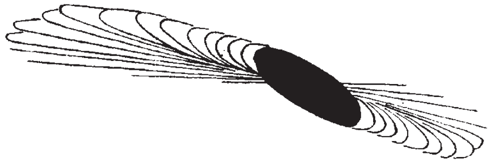

Fig. 1. Cathode-ray direction-finder trace

A sketch of the record is shown in Fig. 1. Ideally, a trace on a cathode-ray direction-finder is a straight line at an angle corresponding to the bearing of the flash[2], but Prof. Khastgir's Fig. 1*a* exhibits ellipticity and rotation of the bearing. The deflexions in the initial stages are linear, in a nearly horizontal direction, and then as time advances, the trace becomes elliptical with a clockwise rotation of the major axis, and the amplitude decreases.

The orientation of the trace is not stated, so it will be supposed arbitrarily that the horizontal and vertical deflexions represent the outputs of the east–west and north–south amplifiers respectively; in other words, that north is at the top of the diagram. The actual orientation of the loops is of minor importance, however, since they could be rotated into the north–south and east–west planes without changing the character of the record, except to rotate it through an equal angle. It is therefore valid to refer to equivalent north–south and east–west aerials whatever the true orientations. The amplitudes of successive cycles in the oscillatory outputs of the two amplifiers have been measured from the original photograph and can be represented by the solid curves in Fig. 2. The trace shown in Fig. 1 is asymmetrical, probably due to overloading of the output stages of one amplifier, so data have been taken only from the westerly part of the record. Thus the amplitudes have been plotted in Fig. 2 at ¾, 1¾, 2¾, etc., cycles of oscillation, and the east–west curve can then be extrapolated back to zero on the scale of cycles, which will be taken as time $t = 0$.

These curves are of the form to be expected if the instrument had narrow band-width and if a short impulse was applied to the east–west amplifier, followed by one applied to the north–south amplifier. The curves represent the subsequent ringing of the tuned circuits. No details of the frequency, band-width or number of tuned circuits were given, but the broken curves show the response (normalized in amplitude) of an amplifier with two tuned circuits

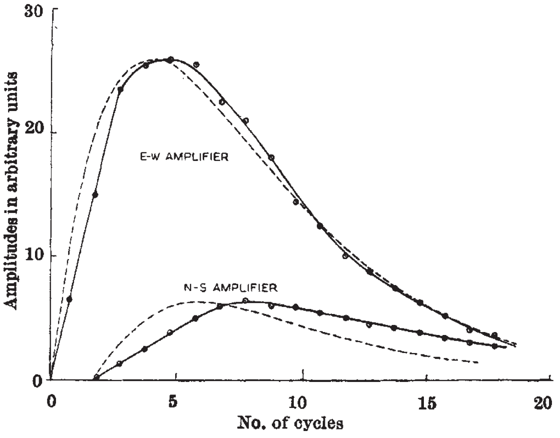

Fig. 2. Envelopes of voltages from cathode-ray direction-finder amplifiers: —⊙—, measured from cathode-ray direction-finder trace; – – –, theoretical envelope for amplifier with two tuned stages of equal selectivity