LETTERS TO THE EDITORS

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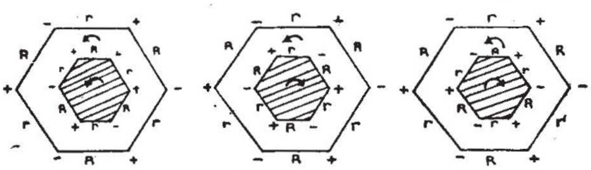
Terminology of Interpenetrating Twins in α-Quartz

AMONG those concerned with piezo-electric applications, it would appear that there is some confusion in the terminology for describing the interpenetrating twins which occur in α-quartz. For piezo-electric purposes, the highest quality Brazilian quartz is normally used, and there are three types of twinning of importance. These are: type 1, the rotational (Dauphiné) twin; type 2, the reflexion (Brazilian) twin; and type 3, a compound twin which can be regarded as a combination of types 1 and 2. Quartz technologists have their own terms for these twins; thus the first type is termed an 'electrical twin'; the other two types are broadly spoken of as 'optical twins', but their more exact descriptions are not well established.

While it has been customary to term the second type an optical twin and the third type a combined electrical and optical twin (compound optical twin), this nomenclature is sometimes, and it is thought incorrectly, reversed.



a. Type 1. Electrical twin (Dauphiné) *b.* Type 2. Optical twin (Brazilian) *c.* Type 3. Compound optica twin.

The accompanying illustrations show sections perpendicular to the trigonal (optic) axis in quartz crystals twinned respectively in each of the three ways. For clarity the sections are drawn as regular hexagons, the parent crystal completely enclosing the twinned areas (shaded hexagons). In practice, the twinning is usually irregular and often extends inwards from the outside of the crystal, but the diagrams retain the fundamental relationships, such as crystallographic orientation and electrical polarity. In each instance, optical activity is indicated by an arrow curled in the sense of rotation of plane-polarized light looking along the optic axis towards the source. Also, the parent crystal is chosen to be left-handed according to this convention. In denoting electrical polarity, the untwinned and twinned portions of the crystal are considered separately. Then the polarities marked at the vertices of the hexagons show the signs of the piezo-electric charges which would be produced at the prism edges on compression of the corresponding diameter. Finally, the lettering indicates the type of rhombohedral face occurring above each prism face, as represented by the sides of the hexagons. *R* and *r* indicate what are termed mineralogically the positive and negative rhombohedral faces respectively.

In all three types of twin, the optic axis is the twin axis. The rotational twin (Type 1) corresponds to a rotation of 60° about the optic axis without change of optical sense. Positive and negative rhombohedra are thus brought into coincidence, that is, *r*-faces of the twinned portion become parallel to *R*-faces of the parent crystal and vice versa. Also the sense of polarity of the twinned material is reversed with respect to that of the parent crystal. That is, the crystal as a whole is elastically and electrically inhomogeneous, but optically it is homogeneous. It is therefore appropriate to term this an electrical twin, and obviously this type of twin cannot be detected by direct optical means.

The reflexion twin (Type 2) corresponds to a reversal in the sense of the screw about the optic axis, without any rotation about this axis. That is, the sense of optical activity of the twinned portion is reversed whereas its orientation remains uniform with the rest of the crystal. The crystal is elastically homogeneous but optically inhomogeneous, and because of the reversal of the screw axis the twinned portion is of opposite electrical polarity. It should be noted that the cause of this reversed polarity is unrelated to electrical twinning as described above. This type of twin should be regarded as a purely optical twin, but confusion can arise because of the accompanying electrical inhomogeneity. If the crystal is described as a combined electrical and optical twin it might be thought that the reference was to a combined Dauphiné and Brazilian twin, which is incorrect.

The other twin (Type 3) corresponds to a reversal in the sense of the screw axis together with a rotation through 60° about this axis. That is, it can be regarded as a combination of the first two types of twin. The crystal is both elastically and optically inhomogeneous, but there is no reversal in the electrical polarity of the twinned portion. This type of compound twin is comparatively rare.

It would seem, therefore, that the following terminology should be adopted among those using quartz for piezo-electric purposes. Type 1 should continue to be termed 'electrical twinning'. Type 2 should be termed 'optical twinning', or 'simple optical twinning' where there is any risk of ambiguity. Finally, type 3 should be termed 'compound optical twinning'.

L. A. THOMAS.

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Mechanism of the Oxidation of Coal

IT is well understood that the mechanisms of the oxidation of oils[1], the curing of rubber[2], the polymerization of unsaturated compounds[3], the overall combustion of higher hydrocarbons[4], as well as of certain biological processes[5], involve the formation of peroxidic bodies sometimes initiating chain reactions. Little attention has been directed hitherto to the possible role of such bodies in processes concerned with the solid phase.

The importance of the spontaneous oxidation of coal needs no emphasis; apart from fire risk, weathered coals may lose up to 15 per cent in calorific value[6], and the coking property of gas-making coals may be destroyed. There have been occasional suggestions in the literature that the initial oxidation may involve peroxidation[7], but so far as we are aware, no serious attempt has been made to investigate the matter. Recently we have adapted Yule and Wilson's method of estimating peroxygen[8], for the purpose of studying the behaviour of typical coals during oxidation; and the results have proved informative.