ON

UNILATERAL CONDUCTIVITY IN TOURMALINE CRYSTALS:

by

Professor S. P. Thompson
and
Dr. Oliver J. Lodge.

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On Unilateral Conductivity in Tourmaline Crystals.

By Professor S. P. THOMPSON *and* Dr. O. J. LODGE*.

IN thinking of the possible physical conditions of structure which might permit an explanation of the phenomena of pyroelectricity of the tourmaline and other crystals, an hypothesis suggested itself independently to each of the present writers. At the Glasgow Meeting of the Association in 1876, a paper was read by the second-named of them, upon a Mechanical Model illustrating the phenomena of electric currents‡. The physical illustrations there given of the relation of electromotive force and resistance to the particles of matter in a conducting circuit led the way to the suggestion that the internal polarization of each particle of the crystal, which had been assumed by Sir William Thomson as a sufficient cause of the phenomena of pyroelectricity, might become explicable if it could be shown that such bodies as possessed pyroelectric properties possessed also a unilateral conductivity for electricity.

The term unilateral conductivity is defined as follows:—Let a certain direction from a point A to a point B in a homogeneous substance be considered. Then if it is found that the

* Read before Section A of the British Association at Dublin, September 1878.

† See Phil. Mag. Nov. and Dec. Suppl. 1876.

resistance to the passage of electricity (or heat) is greater or less when the flow is in the sense AB than it is when in the sense BA, such a substance possesses a unilateral conductivity for electricity (or heat, as the case may be) in the given direction. Some apparent cases of unilateral conductivity for electricity had been described by Dr. A. Schuster (*vide* Brit. Assoc. Rep. 1874). It was to be expected that a phenomenon of unequal heating, the analogue of the unequal electrification of the tourmaline when warmed, would be found. It was also imagined, by a reversal of the known phenomena of pyroelectricity, that a pyroelectric crystal when electrified from without might have its ends unequally warmed. If the development of opposite electrical states at the two ends, and the establishment of a difference of potential between them, were a result of a unilateral conductivity, all the analogies of the conduction of heat and electricity pointed to the probability that the tourmaline would be found to possess a unilateral conductivity for heat also.

The first named of the authors, therefore, proposed the following experiment. Let a slice be cut from a tourmaline crystal having its two faces principal planes of section of the crystal, and therefore containing the crystallographic, optic, and pyroelectric axis. Let the slice be covered with wax, and let it be warmed by a hot wire inserted in a central hole after the method of De Sénarmont. The tourmaline we know to be a negative uniaxial crystal; and the isothermal line marked out by the melting of the wax will be an ellipse having its minor axis along the crystallographic (and optic and pyroelectric) axis. If the crystal, however, possess unilateral conductivity for heat, the isothermal lines will be no longer symmetrical about the point of application of heat, but will be displaced along the crystallographic (and optic and pyroelectric) axis toward one extremity. We therefore, as a preliminary trial, procured such a slice of tourmaline (which we will call tourmaline "A") from Mr. Ahrens. It was roughly circular, of about 2 millims. thickness, and measured along the axis 25·3 millims., across 25·6 millims. Experiment proved that when the point of a hot silver wire was introduced into the central hole, the isothermal line bounding the melted area possessed the form of a distorted ellipse, always displaced toward the analogous pole of the crystal. Two series of measurements were made:—one, of the areas marked out by the melting of the wax; the other, using Meusel's double iodide of copper and mercury, which changes at 94° (*circa*) to a black tint. This method gave isothermals of a higher temperature than the wax. The extremities of

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