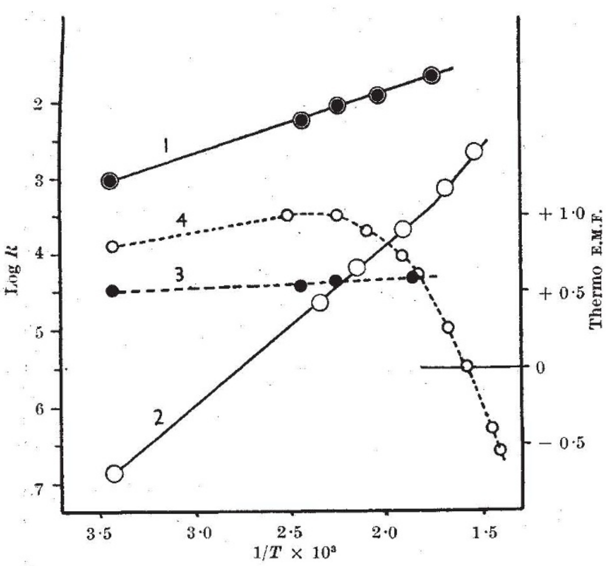
Semi-conducting Properties of Stannous Sulphide

IN a previous communication[1], we reported that two mechanisms are discernible in the electrical conductivity of stannous sulphide: positive-hole conduction, depending on the departure of the material from stoichiometric composition; and, at higher temperatures, a second mechanism with higher activation energy, fairly reproducible from one sample to another. This high-temperature conduction, we suggested, represents the intrinsic electronic conductivity of the crystal lattice.

We have recently obtained evidence confirming this view from simultaneous measurements, over a wide temperature range, of (*a*) the conductivity and (*b*) the thermo-electric effect of the couple gold – stannous sulphide – gold. At temperatures corresponding to the first leg of the log (conductivity) $- 1/T$ curve, the direction of the thermo-electromotive force is indicative of positive-hole conduction (plotted as positive in the graph); its magnitude varies with the stoichiometric composition of the sulphide (0·5–0·6 millivolts per degree for well-conducting material, with activation energy of conduction 0·16 e.v.; 0·8–1·0 millivolts/degree for the same specimen after hydrogen treatment, with $E_1 = 0{\cdot}43$ e.v.), but varies little with temperature while only one conduction process is effectually operative. At temperatures approaching the discontinuity in the log conductivity $- 1/T$ curve, the Seebeck electromotive force decreases, becoming negative at temperatures rather above the onset of the high-temperature conduction process (see graph). At high temperatures the current carriers are therefore electrons, and the activation energy of conduction can be regarded as the energy of excitation of an electron to the conduction band of the crystal.

Schottky and Waibel[2] observed an analogous change in the magnitude and sign of the Hall coefficient of cuprous oxide (also a positive-hole conductor at ordinary temperatures, due to the stoichiometric excess of oxygen) at temperatures near the break in the conductivity curve. The behaviour of stannous sulphide thus provides a second instance of the clear identification of the intrinsic conductivity of a semi-conductor.



Curve 1. LOG $R - 1/T$ CURVE FOR SUBLIMED STANNOUS SULPHIDE.
Curve 2. SAME, AFTER TREATMENT WITH HYDROGEN AT 250°.
Curve 3. THERMO-ELECTROMOTIVE FORCE – $1/T$ CURVE FOR SUBLIMED MATERIAL.
Curve 4. THERMO-ELECTROMOTIVE FORCE CURVE OF MATERIAL AFTER HYDROGEN TREATMENT.

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[1] *Nature*, **152**, 75 (1943); full account in course of publication.
[2] *Phys. Z.*, **36**, 912 (1935).

Serological Reactions Caused by the Rare Human Gene Rh_z

A RARE allelomorph of the *Rh* gene has been described[1,2] and provisionally denoted by Rh_y. This gene differs from the six *Rh* allelomorphs previously found in giving a negative reaction with γ serum, but at the same time a positive reaction with *H* serum. The Greek letters here used for the *Rh* antibodies are those suggested by Fisher[3], but various names have been used:

Γ = anti-Rh_1 (more recently anti-Rh', Wiener) = rho_1 = serum 1 (Murray).
γ = *St* = serum 4.
Δ = standard 85 per cent reacting = *rho* = serum 3.
H = anti-Rh_2 (more recently anti-Rh'') = serum 2.

The reactions of this allelomorph 'Rh_y' with the other two antibodies Γ and Δ were unknown, since in the examples found it had as partner the gene Rh_1, which is itself positive with these two antibodies. Consequently the reaction of the rare gene *per se* was obscured.

On theoretical grounds, Fisher[3] considered that there were probably two genes which were γ negative and *H* positive, and predicted that one would be Δ negative and the other Δ positive, and that both would be Γ positive. One he called Rh_y and the other Rh_z and assigned to them these reactions.

	Γ	γ	Δ	*H*
Rh_y	+	−	−	+
Rh_z	+	−	+	+

A family has recently been examined in which the father's blood was of the type γ negative *H* positive, which we would previously have called Rh_1Rh_y. The father was the second person in whom this rare gene was found. In a child by his second wife, the rare gene is caught in combination with *rh*, so that its reactions with Γ and Δ are no longer obscured but disclose themselves (for *rh* is negative with both these antibodies). The child's blood was Γ positive and Δ positive, so that the gene present is Fisher's Rh_z. Had the child got Rh_1 from its father its cells would have been negative with *H*, for Rh_1rh is + + + −.

Fisher's main hypothesis gains some support since it demanded that neither Rh_z nor Rh_y would be Γ negative. If later this theory is fully substantiated, the symbols Rh_y and Rh_z will be equivalent to the antigenic formulæ *CdE* and *CDE*.

In previous communications[1,2,4], certain bloods have been called genotype Rh_1Rh_y; they may have been Rh_1Rh_y or Rh_1Rh_z. In the family here described,