The Superconductive Transition

In 1931 de Haas and Voogd[1] showed conclusively that the electrical resistance of a single crystal of very pure tin vanishes discontinuously at the transition temperature. In this experiment the external magnetic field was zero, and the transition curve was extrapolated to zero measuring current. They showed also that physical or chemical impurity produces an extended transition region. Since then it has been generally assumed[2] that such an abrupt change of resistance also takes place when the transition occurs in a (longitudinal) magnetic field, extended transitions being ascribed to impurities. Experiments carried out in this Laboratory[3,4] on very pure lead exhibiting transitions extending over a wide range of magnetic field cast doubt, however, on the validity of this assumption.

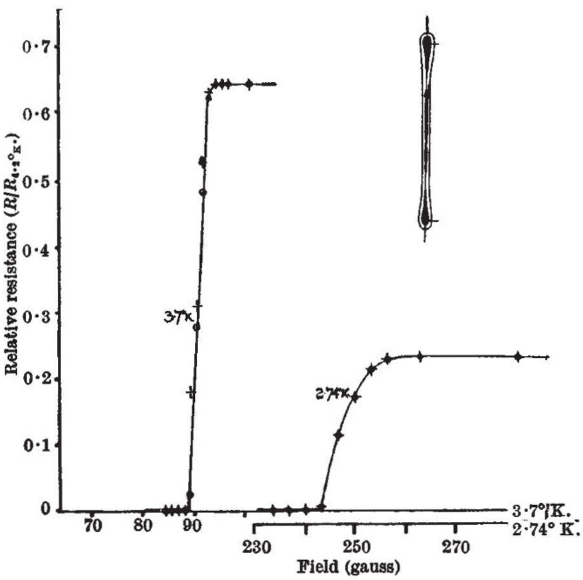

Fig. 1. ⊙ Ascending; + descending

The true shape of the transition curve is clearly of fundamental significance when analysing the mechanism of the disappearance of the electrical resistance, and we have therefore investigated this problem more carefully. Specimens of very pure tin, lead and mercury which had been prepared *in vacuo* were examined in a longitudinal magnetic field. Preliminary experiments showed that the way in which the leads were attached strongly affected the transition, and finally a method was adopted (to be described in detail elsewhere) by which the potential leads were attached free of strain, without solder and without causing distortion of the magnetic field over the length of the specimen. Under these conditions, in all three metals, the transition curves were of a similar general shape (see Fig. 1). The width of the transition region increases rapidly with the *absolute* value of the critical field (H_c), which means that for a given value of H_c/T a transition in lead is more extended than in tin. Incidentally, this behaviour makes it clear that the transition broadening cannot be simulated by inhomogeneities in the external field. The ultimate criterion for the purity of our specimens was, in the case of tin, provided by comparison of the transition in zero field with those observed by de Haas and Voogd[1]; this showed that our specimen corresponded to their purest single crystal.

It was remarkable, in view of the purity of our specimens, that in no case did we observe hysteresis, a phenomenon commonly ascribed to the transition of pure single crystals. It had been suggested by one of us[5] that resistance hysteresis[6] may be due to the geometrical shape of the ends of the wires, and we therefore investigated a mercury specimen which ended in bulbs carrying the contacts. In every other respect its preparation was identical with the specimen of Fig. 1, thus ensuring similar purity and crystalline state. The result, illustrated in Fig. 2, shows quite marked hysteresis with *discontinuous* jumps, thereby demonstrating that these features are produced, in fact, by the overall geometry of the specimen. A full explanation of this curious behaviour cannot be provided at this juncture. A most puzzling feature is that on occasion the whole transition from zero to normal resistance, when hysteresis is present, can cover a narrower range of magnetic field than the reversible transition of the straight specimen.

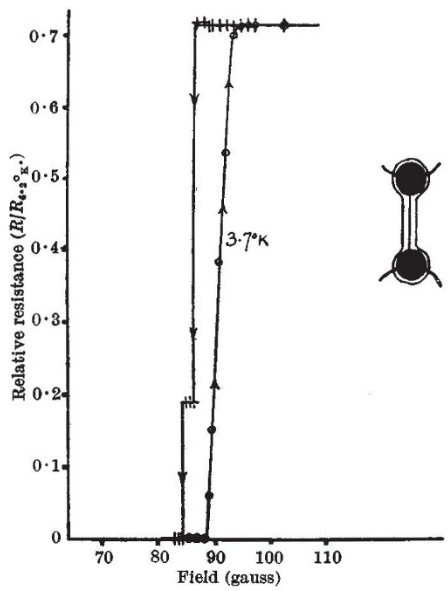

Fig. 2

Summarizing our results, we have found no evidence whatever (once the disturbing effect of geometrical shape is removed) that either discontinuous change of resistance or hysteresis are to be regarded as characteristic attributes of the superconductive transition in a magnetic field.

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