Physics. — *Thermal conductivity of tin at low temperature.* By W. J. DE HAAS, S. AYOAMA and H. BREMMER. (Communication N⁰. 214*a* from the Physical Laboratory Leiden.)

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§ 1. *Introduction and method.* The sample of tin we examined was a small rod of pure tin from KAHLBAUM 9 cm long and 1.8 mm thick. The measuring method was in principle the same as that used first by LEES [1]). Afterwards it was used by many others in a somewhat modified form, e.g. recently by GRÜNEISEN and GOENS at low temperatures [2]).

The rod to be investigated is mounted in a metal cylinder which can be evacuated. The lower extremity of the rod is fixed to the bottom of the cylinder and takes the temperature of the vessel while a known quantity of energy is electrically conducted to its upper extremity. To determine the thermal conductivity the temperature of the rod had to be measured at two places. GRÜNEISEN and GOENS did this by means of thermo-elements. We followed a different way, which may be sketched here preliminarily only, as we will soon communicate the complete description of the apparatus. The temperature of the upper end of the rod was determined with a gas thermometer, while the lower end as has been mentioned had the temperature of the metal cylinder. The extremities were soldered with the same tin from which they were prepared to the metallic gas thermometer and to the bottom of the vessel respectively. The vessel was placed in liquid hydrogen or oxygen the temperatures of which were determined with a platinum resistance thermometer.

As was done also by other investigators the energy was supplied electrically viz. by a constantan wire of about 300 Ω resistance which was wound in a special way and connected to the bottom of the gas thermometer. Corrections for the loss and gain of energy by radiation and convection as far as not due to the tin rod, were determined by a separate experiment, in which the tin rod was taken away of course.

The gas thermometer was filled with helium; its sensitivity was regulated by choosing for each experiment a suitable zero pressure. Before each measurement (before the energy was supplied to the rod) the gas thermometer was compared with the plantinum resistance thermometer. For this calibration heliumgas was admitted in the metal vessel in order

1) Phil. Trans. 208, 381, 1908.
2) Z. f. Phys. **44**, 615, 1927.

to secure good thermal contact between the bulb of the gas thermometer and the bath of the liquid.

§ 2. *The temperatures.* As will be known the hydrogen temperatures range from 12° K (solid hydrogen) to 20° K (boiling point under normal pressure), the oxygen temperatures from 76° K (boiling point under 13 cm pressure) to 90° K (boiling point under 76 cm).

Our apparatus however enabled us to bridge the gap between these two temperature intervals. We had only to supply more energy and to increase the temperature gradient in the rod.

Let T_0 be the temperature of the bath (in this case the boiling point of hydrogen under normal pressure), T_1 the temperature of the gas thermometer, i the energy supplied electrically per second, $w(T)$ the thermal resistance the rod would have if it had the same temperature over its whole length.

We then have:

$$i = \int_{T_0}^{T_1} \frac{dT}{w(T)}$$

If T_1 is taken successively for two neighbouring values T_a and T_b, to which in stationary state the energy currents i_a and i_b belong, we can write:

$$i_a - i_b = \int_{T_b}^{T_a} \frac{dT}{w(T)}.$$

If T_a—T_b is small, this gives the thermal resistance for the mean temperature between T_a and T_b.

We may assume namely that between T_a and T_b $w(T)$ is a linear function of T, which assumption is also made for measurements in the hydrogen and oxygen regions. Here too it is allowed with a view to the accuracy of 1%.

For the points between the hydrogen and oxygen temperatures, however, we must know the difference of two energy currents. That is why in this interval the accuracy is less.

§ 3. *Results.* In the table 1 we give the values w determined by measurements for the thermal resistance of the rod (unit Watt^{-1}). We cannot derive from these with sufficient accuracy the coefficient of thermal conduction in absolute terms because of the indefinite form of the contact places at the extremities of the rod.

TABLE 1.

T	*W*	*T*	*W*
12.5	110	34.8	288
14.8	120	54	371
15.4	130	76	433
20.7	174	97	470
22.9	194		

In fig. 1 the *T*—*W* curve has been plotted. The form of this curve is essentially the same as that found by GRÜNEISEN and GOENS in their

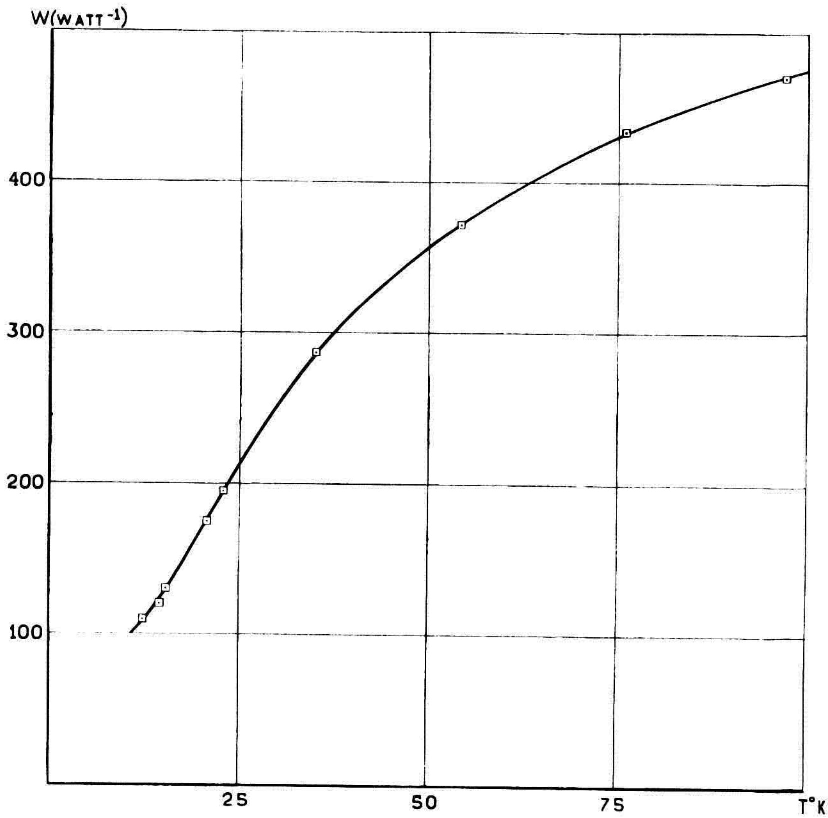

Fig. 1.

researches on pure metals at low temperatures. Both our curve and theirs show a point of inflection.