Citation:

H. Kamerlingh Onnes & Beckman, B., Measurements on resistance of a pyrite at low temperature down to the melting point of hydrogen, in:
KNAW, Proceedings, 15 II, 1912-1913, Amsterdam, 1913, pp. 1384-1386

Physics. — "*Measurements on resistance of a pyrite at low temperatures, down to the melting point of hydrogen.*" By BENGT BECKMAN. Communication N°. 132*g* from the Physical Laboratory at Leiden. (Communicated by Prof. H. KAMERLINGH ONNES).

(Communicated in the Meeting of February 22, 1913).

In an earlier publication [1]) I examined resistance as a function of temperature in the case of a pyrite crystal from Gellivare, Malmberget, Sweden. Those measurements embraced the temperature interval + 100° C. to — 193° C. The resistance was well represented by the formula

$$W = W_0 e^{at}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where W_0 is the resistance at 0° C. and t the temperature on the centrigrade scale. The spec. resistance at 0° C. in ohms per cube of 1 cm. was $w_0 = 0{,}00294$; a was 3.53×10^{-3}.

The measurements were made with a WHEATSTONE bridge. The ends of the crystal were galvanized with copper; as electrodes amalgamated copper plates were used. The resistance at 0° C. was 0.101 ohms. To determine the magnitude and the variation of the contact resistances and of the connections with the temperature, a little copper prism of the same dimensions as the crystal was placed between the electrodes and short-circuited, and the resistance of the short-circuited crystal support and the connections were measured at the various temperatures.

I have now had an opportunity of continuing these measurements on a pyrite through a larger temperature interval (down to — 258° C.). This last investigation was made in the cryogenic laboratory of the University of Leiden, and for the opportunity I owe the director of the laboratory, Prof. H. KAMERLINGH ONNES, great thanks.

To obtain these measurements I have used another method, which eliminates the possible errors of the contact resistances. The crystal was pressed between two copper electrodes, through which the current was conveyed to it. Two other electrodes were firmly pressed against the longest side of the crystal. The voltage between these was measured with the compensation apparatus [2]).

In Table I the results of the measurements in Upsala 1910 are

1) BENGT BECKMAN: Uppsala Univ. Årsskrift 1911. Mat. o. naturvetenskap 1, p. 28.

2) See H. DIESSELHORST, Zeitschrift f. Instrumentenkunde 26, p. 182, (1906), where Fig. 2 gives a survey of the mounting.

TABLE I.

Change of the resistance of pyrite with the temperature. Measurements in Upsala 1911

	$\left[\frac{W}{W_0}\right]obs.$	$\left[\frac{W}{W_0}\right]calc.$
+ 100°.9 C.	1.422	1.436
+ 54 .2	1.223	1.215
+ 44 .5	1.180	1.173
0	1	1
— 78 .6	0.726	0.754
— 193	0.508	0·495

TABLE II.

Change of the resistance of pyrite with the temperature. Measurements in Leiden, 1912

t	$\left[\frac{W}{W_0}\right]obs.$	$\left[\frac{W}{W_0}\right]calc.$
+ 15°.8 C.	1.063	1.058
— 183	0.519	0.520
— 252.8	0.405	0.404
— 258	0.390	0.396

given and in Table II these last results of 1912. The values $\left[\frac{W}{W_0}\right]_{cal}$ are calculated from the formula (1), where now

$$a = 3.59 \times 10^{-3}.$$

The results are well represented by this formula. The values of $\frac{W}{W_0}$ at low temperatures that were found in the last observations are in better agreement with the formula than the earlier ones.

The results for $t = -78°.6$ C. and $-193°$C. in these deviate a little from the calculated values, but in different directions. The deviations do not exceed $4^{0}/_{0}$, which corresponds to a difference of 0.004 ohms at the most.

The last measurements may also serve to control whether the results of the earlier ones were not fully accurate owing to the contact resistances. The deviations that I have just mentioned might arise from this source of error, but, as they go in different directions at $t = -78°.6$ C. and $t = -193°$ C. one is inclined to think that these deviations may originate in other errors too, for instance in variations of the temperature bath at $t = -78°.6$ C. (solid carbonic acid and ether).

O. REICHENHEIM [1]) and J. KOENIGSBERGER [2]) have examined pyrite from Val Giuf, Graubünden and have found a minimum of resistance at about $t = -10°$ C. This pyrite has a specific resistance of 0.0240 at 0° C., thus eight times larger than mine. An explanation of this difference of the conductivity is given by J. KOENIGSBERGER [3]).

My pyrite shows no minimum of resistance above —258° C. The resistance throughout the whole temperature interval follows the formula (1), which is the same, mathematically, as

$$\frac{1}{W}\frac{dW}{dt} = const.$$

It seems very probable that there does not exist any minimum below — 258° C., but that the resistance at still lower temperatures approaches asymptotically to a limit value, as is the case in, for instance, not perfectly pure gold and platinum.

A. WESELY [4]) has recently examined a pyrite crystal from the same place af origin, Malmberget, Gellivare. He found a still smaller spec. resistance, $w_0 = 0.00247$ and a temperature coefficient at 0° C. of 0.00228.

Physics. — "*Investigation of the viscosity of gases at low temperatures. I. Hydrogen.*" By H. KAMERLINGH ONNES, C. DORSMAN and SOPHUS WEBER. Communication N°. 134*a* from the Physical Laboratory at Leiden by H. KAMERLINGH ONNES.

§ 1. *Introduction.* [5]) The investigation of the dependence of the viscosity of gases upon the temperature at densities near the normal,

[1]) O. REICHENHEIM, Inaug. Dissert. Freiburg 1906.

[2]) J. KOENIGSBERGER, Jahrbuch der Rad. u. Elektr. 4, p. 169, 1907.

[3]) J. KOENIGSBERGER, Phys. Zeitschr. 13, p. 282, 1912.

[4]) A. WESELY, Phys. Zeitschr. 14, p. 78, 1913.

[5]) This Comm. includes the paper on the same subject by KAMERLINGH ONNES and DORSMAN, which is referred to in Comm. Suppl. No. 25. (Sept. 1912) § 6, note 1.