Physics. — *Influence of the Pressure on the Electric Conductivity of Gold.* (Preliminary communication). By A. MICHELS, P. GEELS, and Miss C. VERAART. 17th communication of the VAN DER WAALS-fund. (Communicated by Prof. J. D. VAN DER WAALS Jr.)

(Communicated at the meeting of October 30, 1926)

In our previous communication[1] we already drew attention to the desirability of determining anew the influence of the pressure on the electric conductivity of metals, and we recommended to do so at smaller pressure intervals than earlier observers.

By the kind assistance of Dr. C. HOITSEMA, Government Mint Master at Utrecht, we were put in possession of a quantum of very carefully purified gold, which was drawn out into wire of a diameter of $^1/_{10}$ mm. by the firm of HEREAUS at HANAU with particular precautions.

In order to compare the degree of purity with that of the material used by former investigators, — in which we had particularly in view P. W. BRIDGMAN[2] — we determined the influence of the temperature on the resistance of our gold wire.

If we put the resistance of the measuring wire at 0°, 26°, and 34° resp. at R_0, R_{26}, and R_{34}, the temperature-coefficient was for our metal:

$$\frac{R_{34}-R_{26}}{R_0(34-26)} = 0.00391\,(\pm 0.00001),$$

the corresponding coefficient of the gold used by P. W. BRIDGMAN being 0.00394.

From the equality of the two values we may conclude to a sufficiently equal degree of purity of the two metals.

We must, however, point out that a small difference still remains possible, because the hardness of the material may have an influence on the temperature coefficient, though it is not to be expected that this influence will be great for gold with its regular structure.

Secondly we thought we had to conclude from our values that also the temperature-coefficient experiences a slight influence from the fact that the gold wire was put under pressure.

The latter influence, too, lies at the limit of our accuracy of observation, so that we shall not be able to get a decisive answer to this question save by further measurements.

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[1] These proceedings **35**, (1926), 578.

[2] Proc. Amer. Ac. 52 (1917), 601.

As BRIDGMAN subjected the gold wire to a pressure of 12000 atm., and we so far only reached 250 atm., it was possible that there too a small source of deviation was to be found.

Before we proceeded to the measurement of the influence of the pressure, an investigation was made into the validity of the known formula on the increase of temperature of the wire in consequence of the measuring current

$$dt = \frac{K \varrho i^2}{h d^3}$$ 1)

This investigation had, at the same time, the purpose of finding the value of the constant in the formula, in which k is the constant in question, ϱ the specific resistance, d the diameter of the wire, i the intensity of the current, and dt the increase of the temperature resulting therefrom.

This constant did not in itself interest us so such, but we wanted to ascertain what was admissible for the gold wire as a maximal current, if the increase of temperature of the wire was not to exert any injurious influence.

For these investigations too a measuring wire was used of $^1/_{10}$ mm diameter. Small contaminations could not be of importance here, so for the sake of saving the purer, we used less pure material, the temperature-coefficient of which was, accordingly 3.7×10^{-3}.

The results are recorded in the subjoined table.

i in milli-ampères	Resistance	Temperature
15.475	R	t
36.70	$1.000276\,R$	$t + 0.074^{5}{}^\circ$
67.175	$1.001026\,R$	$t + 0.277^\circ$
89.575	$1.001881\,R$	$t + 0.508^\circ$

By the aid of the formula cited above the intermediate temperatures were interpolated between the lowest and the highest temperatures of the measuring-wire, which is elucidated by the subjoined table and adjoined graph.

i^2	Δi^2	temper. experim.	theoret. interp.
239^{5}	0	t	t
1347	1107^{5}	$t + 0.074^{5}$	$t + 0.072^{3}$
4513	4273^{5}	$t + 0.277$	$t + 0.279$
8024	7784^{5}	$t + 0.508$	$t + 0.508$

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1) Cf. O. D. CHWOLSON, Lehrb. d. Phys. IV 1. 1908. Thesis A. MICHELS, p. 24.

Within the errors of observation the theoretically interpolated values are the same as the temperatures found experimentally. From the foregoing it is easy to calculate the constant c entering into the formula:

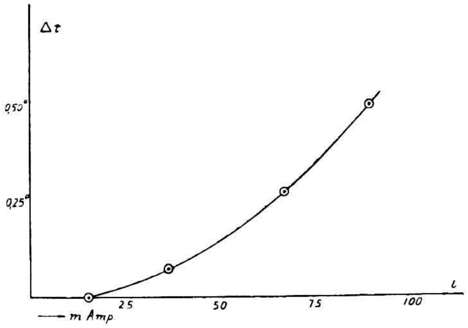

Fig. 2.

$$dt = ci^2$$

$$c = 0{,}0653$$

$$i \text{ in mA.}$$

$$dt \text{ in } \frac{1}{1000}{}^{\circ}.$$

The Measurement of the Influence of the Pressure.

The choice of our arrangement rendered absolute measurements unnecessary; so, different from the method used by us in determining the influence of the pressure on the electric conductivity of platinum, we could now use a WHEATSTONE bridge connecting scheme. This arrangement also enabled us to avoid a few sources of error.

Instead of one gold wire, we built two equal ones, enclosed in two identical mantles, and inserted each of the two gold wires into one of the two circuits of the WHEATSTONE bridge connecting scheme.

When now the two wires got an equal current, the influence of their increase of temperature was greatly diminished.

Our measuring current was about 6 mA., which according to our measurements given above, would yield an increase of temperature of $^1/_{500}{}^{\circ}$.

As we measured with an accuracy, where only temperature differences of $^1/_{1000}{}^{\circ}$ become troublesome, we may expect that the influence of selfheating was entirely eliminated.

A greater advantage, however, lay in the fact that it was possible to eliminate in this way the inevitable oscillations of the thermostat temperature as the two mantles were inserted in the same thermostat closely side by side, and through their identical construction obtained an equal lag in temperature.

The oscillation of the temperature never amounted to more than $^1/_{200}{}^{\circ}$ in a period of about 4 hours.

With our arrangement it is practically impossible that there is ever a difference of temperature of $^1/_{1000}{}^{\circ}$ between the two wires.

The resistances of the gold wires amounted to about 26 ohms each, and the variable resistance in the circuit to 100 ohms. The high value of the latter, which had to compensate the influence of the pressure on the gold wire, had also the advantage that variations in the transition resistances of the plugs of the rheostat could be neglected.

For the determination of the galvanometer current the measuring current was commuted, through which at the same time the thermo-electric forces disappeared from the results.

For the arrangement of the experiment we refer to these Proceedings cited above.

The pressures were measured by the aid of a pressure balance, the accuracy of which far exceeded that of the electric measurement. [1])

The accompanying table and the graphical representation II give the results of three series of observations between 0 and 250 atm.

These resistance measurements agreed with each other with a margin corresponding to a difference of temperature of 0.001 degree of the measuring-wire.

$$\frac{-\Delta w}{w} \,.\, 10^6.$$

Pressure in kg. per cm.²	101.5	251.5
16°	5.03	11.8

Just as in the course of the observations made on platinum, it appears here again, that the decrease of resistance is not in linear relation to the increase of pressure.

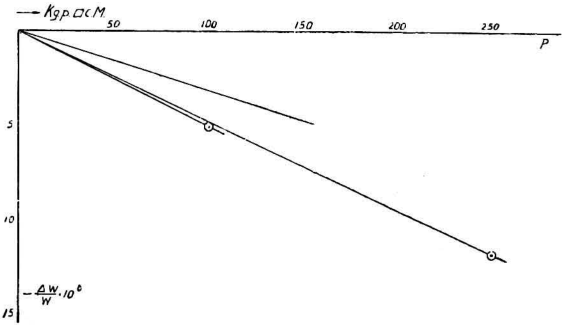

Fig. 2

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[1]) Cf. Ann. d. Phys. **73**. 1924.

The deviation of the straight line is, indeed, not so great as that found for platinum, but the distance of the point $101^1/_2$ atm. to the second line, is about five times as great as an error of observation.

In the graphs this is shown in this way that no curve has been drawn through the few points which have been determined, but by connecting these points with the origin.

The upper straight line in the graph represents the result at which BRIDGMAN arrives in the publication cited above.

BRIDGMAN states that he has found as a pressure-coefficient up to 1000 atm. 3.1×10^{-6}.

Though extrapolation to 1000 atm. is very unreliable here, it may be deemed doubtful whether at 1000 atm. it will be possible to us to obtain agreement with this value.

Here, too, it is, however, possible that the hardness of the material plays a part.

For the present no more points have been determined by us, as our purpose was only a preliminary investigation.

This investigation, however, has proved that it will be necessary to continue the measurements at least up to 1000 atm. in order to find more points of the curve, and also to examine the influence of the hardness.