Dr. A. LEBRET. *The variation of the Hall-effect in Bismuth with temperature.*
(Including an investigation of the variation of the Electric Resistance of Bismuth with temperature).

The preliminary numbers have been communicated in n⁰. 15 of this series. The method, according to which the measurements have been performed, we described in this communication at p. 1 a. f.

For obtaining the low temperatures we used a solution of solid carbonic acid in alcohol, the high temperatures have been obtained with the help of a bath of liquid glycerine.

A vessel of hard soldered copper [1]), already briefly described on p. 4. , and more at large in my inaugural dissertation on p. 61 a. f., served to contain the liquid of the high as well as to contain that of the low temperatures.

I examined two plates of bismuth, originary from different sources. One has been made from the same bismuth as served us for the preliminary measurements, communicated in n⁰. 15. We call it bismuth I. The bismuth, from which the second plate has been made, we call bismuth II.

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[1]) See engraving I.

The following numbers have been obtained at different temperatures for the Hall-constant, compared to that at 21°, which we call R^{I}_{21} for the first plate, and R^{II}_{21} for the second.

Magnetic field about 3000 (c. g. s.)
Plate of Bismuth I.
α. Low temperatures.

Temperature.	Constant of Hall.
— 74 °	1.256 R^{I}_{21}
— 72 °	1.250
— 65.5°	1.245
— 58.5°	1.246
— 52.5°	1.244
— 47.5°	1.241
— 40.5°	1.211
— 36 °	1.211
— 27.5°	1.190
— 23 °	1.180
— 14 °	1.139
— 7 5°	1.110
0 °	1.056
+ 7 °	1.050
+ 11 °	1.046

β. High temperatures.

21 °	R^{I}_{21}
246.5°	0.280 R^{I}_{21}
95 °	0.697
157.5°	0.411
198.5°	0.313

124 °	0.532	
93 °	0.700	
76 °	0.784	
43.5°	0.927	
11.5°	1.052	

Plate of Bismuth II.

α. Low temperatures.

— 69 °	0.366	R^{II}_{21}
— 64 °	0.889	
— 59 °	0.915	
— 51 °	0.970	
— 47 °	0.985	
— 41.5°	1.007	
— 35.5°	1.016	
— 31.5°	1.030	
— 25 °	1.032	
— 19.5°	1.034	
— 12 °	1.040	
— 8 °	1.034	
— 4 °	1.034	
+ 0.5°	1.034	
+ 7.5°	1.028	
+ 21.5°	1.002	

β. High temperatures.

26.5°	0.980	R^{II}_{21}
203 °	0.288	
242.5°	0.175	
219 °	0.217	
124.5°	0.540	

105 °	0.634
84.5°	0.725
56.5°	0.869
22.5°	0.996
152 °	0.429

The numbers have been ranged in these tables in the same order, in which the measurements were performed.

In order to get an easy survey, they have been set out in curves in the engraving [1]) added.

The Hall-constant in bismuth I proves not to be a linear function of the temperature, as the preliminary measurements formerly communicated made presume. The deviation from the straight line however is not clearly perceptible at the temperatures above — 38°, the lowest at which a preliminary observation has been performed. The values formerly obtained, very sufficiently agree with the later. In judging this, one should attend to the Hall-constant at 21° now being taken as unit, and formerly that at 14°.

The variation of the Hall-constant in bismuth II agrees at the temperatures above 20° with that of the Hall-constant in bismuth I. On the contrary we perceive very distinctly at about — 20° a maximum, and at lower temperatures a sensibly smaller value of the Hall-constant.

For bismuth I the existence of a maximum probably would appear clearly, if we had experimented at still lower temperatures.

DRUDE and NERNST [2]) found a maximum of the Hall-

[1]) See engraving III, curves 1 and 2.

[2]) WIED. Ann. 42. p. 568, 1891.

effect in bismuth at about 100°. The value however, which was found after cooling the plate was not the same as that observed before heating.

LEDUC [1]) found the maximum value at 29°.

CLOUGH and HALL [2]) found for nickel a maximum Hall-effect between 170° and 200°, and for steel a steady increase when heating to the highest temperature 319°, at which was observed. HALL [3]) found this increase also for cobalt within the smaller limits, at which those measurements have been performed. As the Hall-coefficient appears to be zero for the melted state [4]), these two metals must show a maximum Hall-effect at a certain temperature.

If yet for antimony a maximum value should be found which in this case probably would prove to lie at a low temperature at which for this metal no observations as yet have been performed, then it would be proved experimentally that the Hall-effect in all metals, for which it has a great value, shows at some temperature a maximum value, which is many times greater than the value at temperatures, far distant from that temperature.

The chemical analysis [5]) of the two species of bismuth showed that in bismuth I traces of iron were

1) C. R. 102. p. 358, 1886.

2) Proc. of the Americ. Acad. 20. p. 189, 1893.

3) Phil. Magaz. 15. p. 341. 1883; Sill. Journ. 29 p. 117, 1885.

4) See Wied. Ann. 42. p. 568, 1891.

5) This investigation has been kindly performed by Mr. F. H. EYDMAN at Delft, under the guidance of Professor HOOGEWERFF of the Polytechnic School there.

found too small to be weighed, in bismuth II noother substances were found.

The absolute value of the Hall-effect in bismuth I at 21° was about 7, that in bismuth II 13 [1]).

At last it may be mentioned here, that I have also examined the influence of the temperature on the resistance of bismuth I. I was induced to this investigation by the opinion expressed by LEDUC [2]), that the variation of the electric resistance of bismuth with temperature would be almost the same as that of the Hall-constant. Calling the specific resistance W, the Hall-constant R, then a new quantity $D = \frac{R}{W}$ would be almost independent of the temperature.

The contrary was proved by my measurements: when raising the temperature the resistance increases, the constant of HALL diminishes.

The method according to which the resistance was measured of a spiral wire of bismuth (obtained by infusing melted bismuth into a glass spiral), consists in this, that the differences of potential at the ends of the spiral wire in question are compared with those at the ends of a known resistance. If we join together the two ends of each of these resistances with the aid of a great resistance, so that each of the joining wires contains one of the two insulated windings of a differential galvanometer, the needle will remain at rest for a deter-

1) VON ETTINGSHAUSEN and NERNST give 10.1, HALL 8.6. The influence of the purity appeared before and also now from my measurements, to be very great.

2) See Lumière électrique 29, pag. 230, 1888.

Engraving I.

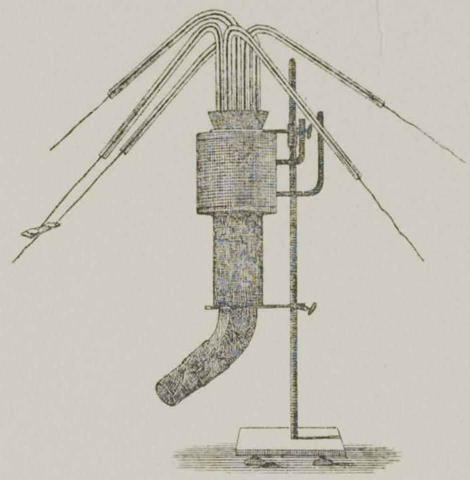

Fig. 1.

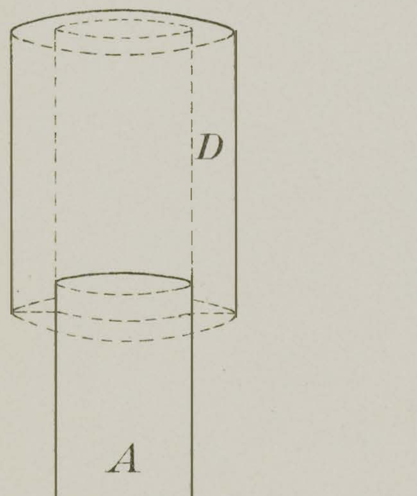

Fig. 2.

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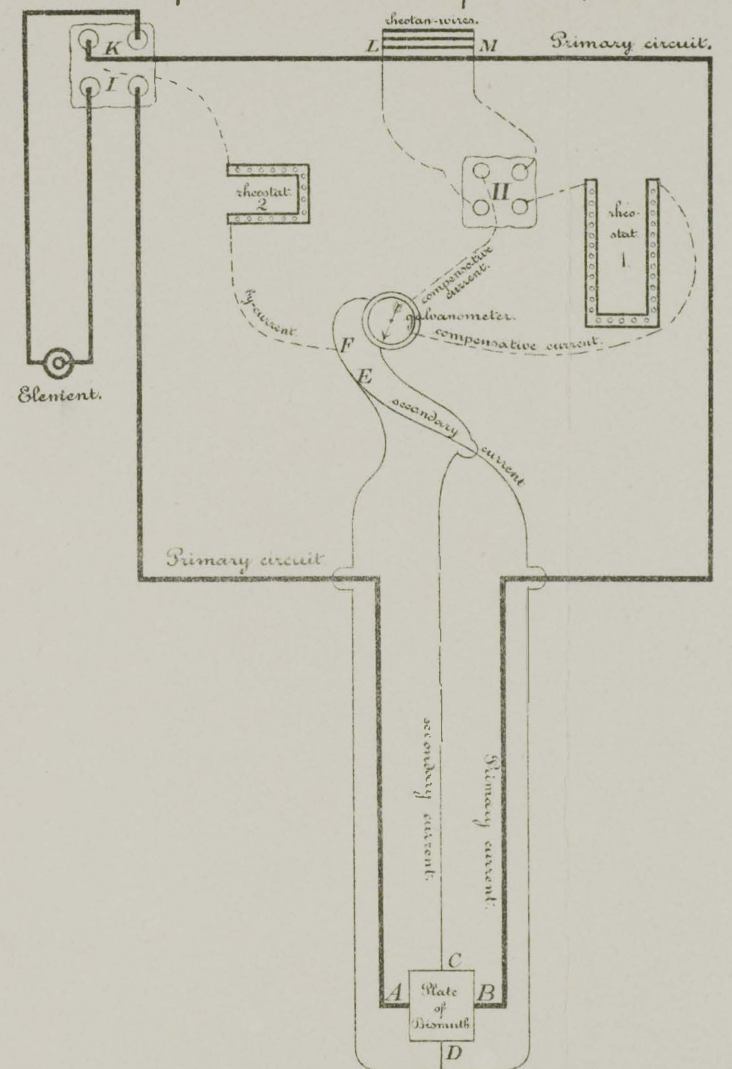
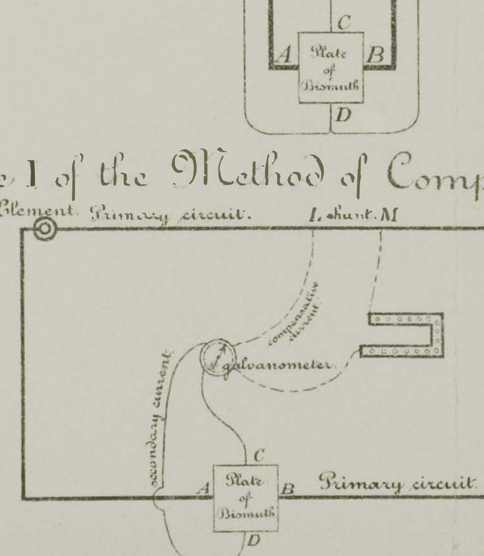
Scheme II of the Method of Compensation.



Scheme I of the Method of Compensation.



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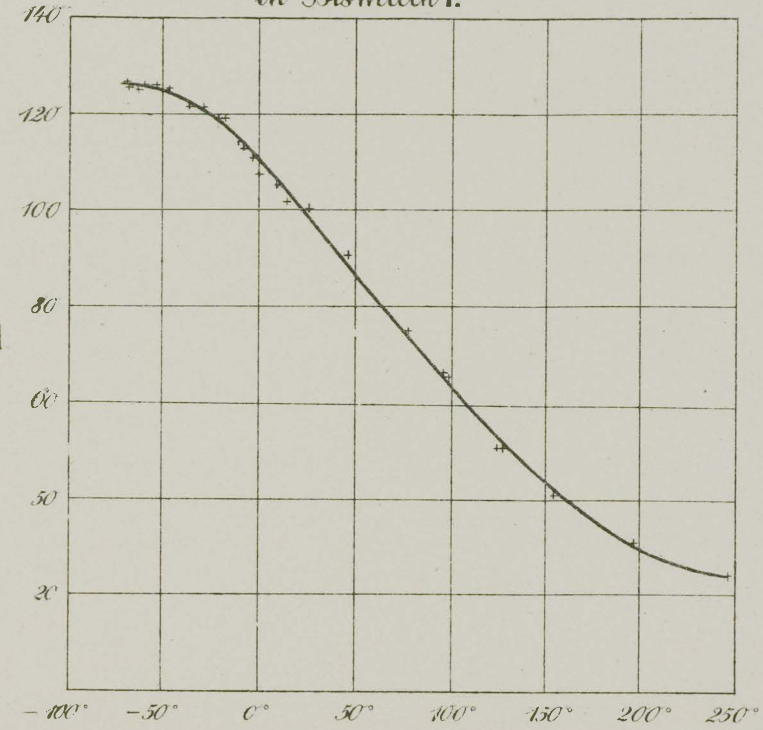
Engraving III.

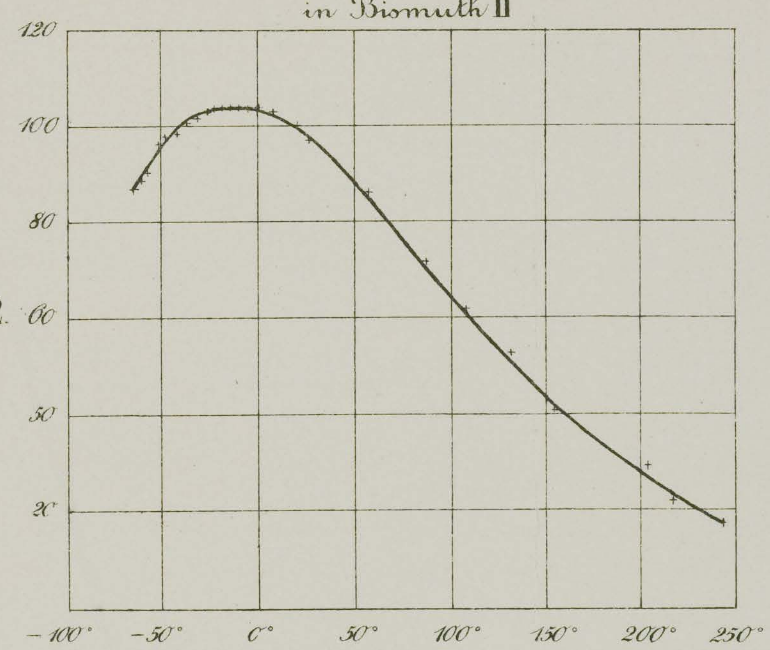
Variation of the Hall effect with temperature.
in Bismuth I.

Fig.1



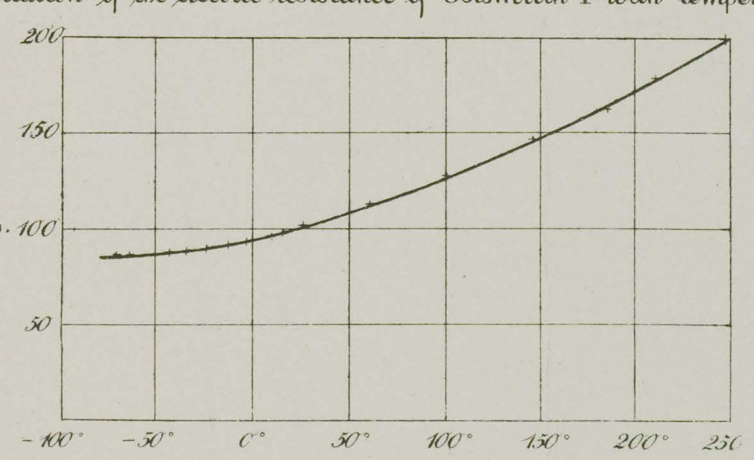
Variation of the Hall effect with temperature.
in Bismuth II

Fig.2.



Variation of the electric resistance of Bismuth I with temperature.

Fig.3.



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minate choice of the resistance in one of the galvanometer-circuits.

If the resistance of the spiral wire of bismuth varies by cooling or heating, then another choice of the resistance in the galvanometer-circuit will be necessary to keep the needle at rest and from this the variation of the resistance of the bismuth can immediately be calculated.

We obtained the following values, expressed in the resistance at 18°, which we will call r_{18}.

Temperature.	Resistance.
— 76 °	$r_{18} \times$ 0.88
— 71 °	0.89
— 64 °	0.895
— 44 °	0.905
— 39 °	0.91
— 25 °	0.925
— 15,5°	0.935
— 5 °	0.955
+ 7,5°	0.985
+ 10 °	0.995
+ 20 °	1.01
+ 51 °	1.11
+ 99 °	1.23
+ 147 °	1.43
+ 174 °	1.62
+ 217 °	1 82
+ 246 °	2.01

These numbers served to delineate the curve 3. [1])

[1]) See engraving III.

COMMUNICATIONS

FROM THE

PHYSICAL LABORATORY

AT THE

UNIVERSITY OF LEIDEN

BY

PROF. DR. H. KAMERLINGH ONNES.

No. 20.

Dr. P. ZEEMAN. Measurement of the refractive index of incandescent platinum.

(*Translated from: Verslagen der Afdeeling Natuurkunde der Kon. Akademie van Wetenschappen*, **28 September 1895**, *p.* 116—119).

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