THE HALL, ETTINGSHAUSEN, NERNST AND LEDUC EFFECTS IN CADMIUM, NICKEL AND ZINC.

BY A. E. CASWELL.

SYNOPSIS.

Transverse Magnetic Effects in Cadmium, Nickel and Zinc.—The Hall, Ettingshausen, Nernst and Leduc effects were all measured for each metal on the same thin strip, which after being provided with various thermocouples and potential wires was heated electrically in vacuum and placed in a magnetic field of 4,000 to 5,200 gauss. Coefficients are given for cadmium (40 to 50°), nickel (− 11 to 57°) and zinc (− 25 to 77°). The Hall and Ettingshausen effects were not found of opposite sign as has usually been observed, but both came out positive.

SINCE the thermoelectric, galvanomagnetic and thermomagnetic effects observed in metals have not been determined for the same specimens and since these properties vary considerably in different specimens of the same substance the writer undertook to construct an apparatus with which to measure the transverse magnetic effects and the thermoelectric effects in the same specimen over a wide range of temperatures. So far he has been unable to determine the thermoelectric effects, especially the Thomson, with any degree of accuracy for any specimen sufficiently thin to give satisfactory results for the magnetic effects.

A considerable part of the work has been done under the auspices of the National Research Council in the Palmer Physical Laboratory of Princeton University. The writer takes pleasure in acknowledging his indebtedness to Dean Magie, who very kindly placed all the resources of the Laboratory at his disposal, and in expressing his deep appreciation of the uniform courtesy and generous coöperation shown him by all the members of the Princeton staff.

In the following paragraphs the most reliable results obtained for the transverse mangetic effects are given, being comparable in accuracy with the better results published elsewhere. Moreover, the published data are somewhat meager.

The specimens used were rolled to a uniform thickness of 0.01035 cm. from sticks of Kahlbaum's c. p. reagent cadmium, and of Kahlbaum's c. p. I zinc, and sheets of c. p. nickel. They were 1.2 cm. in breadth and 4.2 cm. in length, being firmly held at the ends by copper clamps through which the primary currents of electricity and heat were led into and out of the specimens. Four copper-constantan thermocouples were attached at intervals of 1.2 cm. along the longitudinal axis of the specimen, and two others were attached at the centers of its upper and lower edges. By means of these the temperatures of different points on the specimen were determined, the copper wires of the thermocouples being also used to determine electric potential differences. The thermoelements were used with a potentiometer reading to one-twentieth of a microvolt, the galvanometer being a Leeds-Northrup High Sensitivity Type R. The specimen, together with its clamps, was placed within an evacuated tube connecting two flasks of the Dewar type in which liquids could be placed with which to maintain steady temperature conditions. The tube was placed between the poles of a large Pye electromagnet by means of which fields were produced ranging from about 4000 to 5200 gauss.

In order to reduce the loss of heat through the thermocouples these were made of No. 44 copper and No. 34 constantan wire.

The results obtained are collected in Table I; R, P, Q and S being, respectively, the coefficients of the Hall, Ettingshausen, Nernst and Leduc effects. The Hall coefficient is defined by the equation $E = R(HI/D)$, where H is the intensity of the magnetic field in gausses, I is the primary electric current through the specimen in amperes, D is the thickness of the specimen in cm., and E is the resulting electric difference in potential between the two edges expressed in volts. Similarly, the Ettingshausen coefficient is given by the equation $T = P(HI/D)$, where T is the resulting temperature difference between the edges expressed in degrees Centigrade. The coefficient of the Nernst effect is given by $E = QHB(dt/dx)$, where B is the breadth of the specimen in cm. and dt/dx is the primary temperature gradient. The coefficient of the Leduc effect is given by $T = SHB(dt/dx)$, the symbols having the same significance as before. The sign of these effects is taken as positive when, the magnetic field being directed away from the observer and the primary current of heat or electricity flowing from left to right, the upper edge of the specimen is at the higher temperature or potential.

Table I.

Hall Effect.		Ettingshausen Effect.		Nernst Effect.		Leduc Effect.	
Temp. °C.	$R \times 10^{13}$.	Temp. C.	$P \times 10^{8}$.	Temp. °C.	$Q \times 10^{12}$.	Temp. °C.	$S \times 10^{7}$.
Cadmium.							
+42.0	+ 8.50	+51.2	+5.96	+39.4	0	+39.4	− 1.87
+49.3	+ 11.67						

Nickel.

+57.2	+770.7	+55.8	+3.67	−11.4	+ 8.36	−11.8	0
				+37.6	+ 27.47	+38.9	−10.17

Zinc.

−24.7	+ 15.33	−17.1	0	−16.2	+290.0	−16.2	+37.59
+25.5	+ 8.20	+45.2	+1.76	+37.2	− 6.25	+37.2	+ 4.00
+32.6	+ 8.38	+60.7	+2.27				
+39.9	+ 8.18	+76.7	+3.02				
+41.2	+ 8.23						
+76.7	+ 9.82						

University of Oregon,
Eugene, Oregon,
March, 1922.