trons and the localized magnetic moments for alloys containing 20 at.% Pd, and positive exchange at a higher palladium content, in full agreement with our investigations of the electric resistance of these alloys [6].

Similar results were obtained in investigations of alloys of Ag and Au with small additions of 4f-metals [7].

With increasing temperature, the relative role of the scattering of the conduction electrons, due to the exchange interaction, decreases against the background of a contribution, linearly increasing with the temperature, of the scattering connected with the electrostatic potential.

The reversal of the sign of the exchange interaction between the conduction electrons and the localized magnetic moments, and the difference in the behavior of the impurity thermal emf at higher temperature, are due to the appearance of d-carriers at palladium concentrations exceeding 30 at.%.

[1] J. Kondo, Progr. Theor. Phys. 32, 37 (1964).
[2] J. Kondo, ibid. 34, 372 (1965).
[3] J. Kondo, Proc. IX Low Temper. Conf. LT9, p. B, 1004 (1965).
[4] A. A. Abrikosov, Usp. Fiz. Nauk 97, 401 (1969) [Sov. Phys.-Usp. 12, No. 1 (1969)].
[5] S. V. Maleev, Zh. Eksp. Teor. Fiz. 51, 1940 (1966) [Sov. Phys.-JETP 24, 1300 (1967)].
[6] N. V. Volkenshtein, L. A. Ugodnikova, and Yu. N. Tsiovkin, ZhETF Pis. Red. 9, 189 (1969) [JETP Lett. 9, 110 (1969)].
[7] D. Gainon, P. Donze, and J. Siero, Solid State Comm. 5, 151 (1967).
[8] J. Friedel, Can. J. Phys. 34, 1190 (1956).

INVESTIGATION OF THE NORMAL AND ANOMALOUS NERNST-ETTINSHAUSEN EFFECTS IN FERROMAGNETIC METALS BELOW THE CURIE POINT

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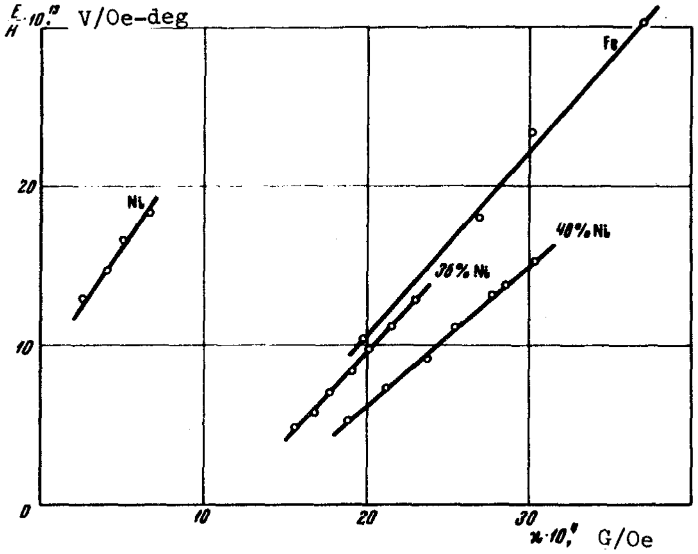
Until recently, studies of the Nernst-Ettingshausen (NE) effect in ferromagnets were limited to themperatures below the Curie point. The purpose of the present investigation was to study the NE effect in ferromagnetic metals in the paramagnetic state, i.e., at temperatures above the Curie point.

The objects of the investigation were pure iron and nickel, and also iron-nickel invar alloys containing 36 and 40% Ni. The measurements were made in the temperature range from 200 to 900°C, using the method described in [1]. Unlike in [1], the magnetic field was produced in a wafer-type solenoid cooled with water and producing field intensities up to 10 kOe. We measured simultaneously the magnetic susceptibility. The experimental data were used to calculate the values of the "true" NE constant $Q = Q' - \Delta Q_h$, where $Q' = E/H\nabla T$ is the measured NE constant, $\Delta Q_h = \Delta E_h/H\nabla T$ is a correction representing that part of Q' which is connected with the Hall effect, ∇T is the temperature gradient along the thermal current q, and H and E are the intensities of the magnetic field transverse to q and of the transverse electric field (the NE field) respectively. The intensity ΔH_h appears in all cases when the absolute thermal emf is not equal to zero. The correction ΔQ_h can be determined from the experimentally known values of the electric resistivity, the Hall constant, and the absolute thermal emf. The latter is calculated from the values of the differential thermal emf measured with a standard whose absolute thermal emf is determined from exact measurements of the Thomson effect. Our calculations have shown that in the case of iron and invar alloys $\Delta Q_h/Q \approx 0.05$ and in the case of nickel $\Delta Q_h/Q \approx 0.35$.



It is seen from the figure that in the investigated temperature intervals above the Curie point, Q is linearly connected with the magnetic susceptibility κ,

$$Q = Q_p\kappa + Q_0, \qquad (1)$$

where Q_p and Q_0 are parameters characterizing respectively the anomalous and normal NE effect in the paramagnetic state. The existence of a linear relations between Q and κ for ferromagnetic transition metals above the Curie temperature was predicted theoretically by one of the present authors [2]. A similar linear relation between the Hall constant and the magnetic susceptibility was established experimentally by Kikoin [3], Kevane and Levgold [4], Volkov and Kozlova [5], and was then derived theoretically in [2].

It follows from the theory [6] that in the isotropic case the NE constant Q_0 of non-ferromagnetic metals should be positive. In most cases, the experimental data confirm this conclusion. The only exceptions so far are copper, silver [7], gold [8], zinc [9], molybdenum and tungsten [10]. It is seen from the data that iron in the paramagnetic state has likewise negative Q_0. Acording to modern theory, negative Q_0 may indicate an appreciable anisotropy of the relaxation time, or else that formula (1) contains besides the term $Q_p\kappa$ one more term connected with the spin-orbit interaction and making a negative contribution to Q_0.

[1] R. P. Vasil'eva, Fiz. Metal. Metallov. 8, 881 (1959).
[2] E. I. Kondorskii, Zh. Eksp. Teor. Fiz. 55, 2367 (1968) [Sov. Phys.-JETP 28, No.12(1969)].
[3] I. K. Kikoin, ibid. 10, 1242 (1940).
[4] C. I. Kevane and S. Levgold, Phys. Rev. 91, 1372 (1953).
[5] D. I. Volkov and T. M. Kozlova, Fiz. Metal. Metallov. 20, 255 (1965).
[6] F. J. Blatt, Electron Conduction in Solids, McGraw-Hill, 1960.
[7] H. Zahn, Ann. Physik 9, 98 (1907).
[8] H. Zahn, ibid. 14, 886 (1904).
[9] F. Unwin, Proc. Roy.Soc. Edinburgh 34, 208 (1914).
[10] A. Smith, Phys. Rev. 8, 79 (1916).