last quantity was determined by measuring at $T = 295°$ K the force acting on a gold specimen, the susceptibility of which was previously determined by the method of Huey. It will be seen that at a certain value of the magnetic field there is a break in the straight line, analogous to that in the curve for $E_y(H)$. It was found that the value of the magnetic field at which the change in the angle of the force occurs is $\sim$ 8500 oersted.

The cited data show that some sort of phase transformation occurs at $H \approx 8500$ oersted. A detailed description of the results will be published in the near future.

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Ejection of Electrons from Metals by Fast Molecules

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IZMAILOV AND THE AUTHOR[1] have examined the question of ejection of electrons from metals by molecules of neutral gases. It was shown that the mechanism of "potential" ejection of electrons from metals by molecules of neutral gases takes place for those values of energy of gas molecules, at which they are sufficiently close to the metal at a distance x_0. The value of x_0 is related to the kinetic energy of the gas molecule by the expression

$$U(x_0) = mv_\infty^2/2, \tag{1}$$

where $U(x_0)$ is the potential energy of the repulsive force at the instant when the gas molecules stop near the metal surface, m is the mass of the molecule, and v_∞ is its velocity at a distance $x \gg x_0$. In Ref. 1 we expressed $U(x)$ as

$$U(x) = B/x^p. \tag{2}$$

From (1) and (2) we obtain

$$x_0 = (2B/mv_\infty^2)^{1/p}. \tag{3}$$

In the absence of reliable data on the values of the constant B and exponent p in expression (2) we are forced, as in Ref. 1, to restrict ourselves to an expression of the form $N = f(x_0)$ for the number of electrons N ejected from one cm^2 of metal surface by a stream of gas molecules. At the present time it seems possible to estimate the parameters in (2) and, consequently, to express N in terms of macroscopic parameters of the gas stream.

From Ref. 1 it is possible to obtain an expression for the charging of the gas stream

$$\frac{N}{n} = \frac{2\pi}{3}\left(\frac{\pi}{10p}\right)^{1/2}\frac{Q^2C}{B}\,mv_\infty^2\,x_0^{p-7}\,\lambda^{-1/2}e^{-\lambda}. \tag{4}$$

$$C = (e^2/4\pi^2\hbar^2)\,(w_i^{1/2}/w_a\varphi_0^{1/2}), \tag{4a}$$

$$\lambda = \left[\frac{2}{3}\left(2m_0\varphi_0^3\right)^{1/2}/\hbar e^2\alpha\right]x_0^5 = \beta x_0^5/2Q, \quad Q = e\alpha, \tag{4b}$$

where n is the concentration of gas molecules, e and m_0 the charge and mass of the electron, φ_0 the work function of the electrons in the metal, w_a the potential barrier on the metal surface, w_i the Fermi level, and α the polarizability of the gas molecules.

Substituting in (4) the value of x_0 from (3) and expressing it in terms of the velocity and of the parameter B, we obtain for $p = 7$

$$N/n = K_1\,(v_\infty/B)^{19/14}\exp\left(-K_2B^{5/7}/v_\infty^{10/7}\right), \tag{5}$$

$$K_1 = (4\pi/3)\,(\pi/70)^{1/2}\,Q^2C\,(2Q/\beta)^{1/2}\,(m/2)^{19/14}, \tag{5a}$$

$$K_2 = (\beta/2Q)\,(2/m)^{5/7}. \tag{5b}$$

The quantities entering in (5a) and (5b) can be determined for a given metal and gas from the tables of physical constants. The quantities appearing in (2) can be estimated. We do not know of any reliable data for the potential of the repulsive force between the solid and the gas. To determine the potential between the metal and the gas we proceed from the following premises: (1) The potential can be either a power or an exponential function. (2) If the parameters of the potential are known for each phase separately, the interphase potential is determined as an average[2] in the following form

$$B_{12} = (B_{11}B_{22})^{1/2}, \quad p_{12} = 1/2\,(p_{11} + p_{22}), \quad (x_{12})_0 = 1/2\,[(x_{11})_0 + (x_{22})_0], \tag{6}$$

where the symbols correspond to those in (2) and (3). (3) The value of the energy of interaction between the gas molecules and the metal and their equilibrium internuclear distance x_0 serve as a starting point for determining the parameters of the potential (2) from the relation

$$B = U_0 x_0^7. \tag{7}$$

U_0 for metals corresponds to the heat of sublimation of the atoms[3] reduced to 0° K; $(x_{11})_0$ corresponds to the internuclear distance for closely packed atoms. It is possible to assume for $(x_{11})_0$ a value double the atomic radius. For the particular case of O_2/Fe interaction it is possible to obtain from Ref. 4 $(U_{O_2})_0 = 1.697 \times 10^{-14}$ ergs, $(x_{O_2})_0 = 3.5$ A. For iron, according to Ref. 5, $(U_{Fe})_0 = 6.46 \times 10^{-12}$ ergs, $(x_{Fe})_0 = 2.88$ A, from which, according to (6) and (7), $U_{O_2/Fe} = 3.29 \times 10^{-13}$ ergs, $(x_{O_2/Fe})_0 = 3.19$ A and $B = 1.22 \times 10^{-65}$.

For other metals with other values of heat of sublimation we get $U_0 \sim 1 \times 10^{-11}$ to 1×10^{-12} ergs, and for gases $U_0 \sim 1 \times 10^{-14}$ to 1×10^{-15} ergs. It is therefore possible to expect that for other gas–metal cases $B \sim 1 \times 10^{-64}$ to 1×10^{-66}.

The constants for Fe according to Ref. (6) and the values of K_1 and K_2 calculated from (5a) and (5b) follow:

$$w_a = 11.9 \text{ ev}, \; w_i = 7.13 \text{ ev}, \; \varphi_0 = 4.77 \text{ ev},$$
$$C = 3.75 \times 10^{17}, \; \beta = 2.48 \times 10^{6}, \; \alpha = 1.76 \times 10^{-24}.$$
$$Q^2 C = 2.68 \times 10^{-49}, \; B = 1 \times 10^{-64},$$
$$K_1 = 1.5 \times 10^{-99}, \; K_2 = 1.94 \times 10^{55}.$$

The table lists the values of N/n as functions of the velocity v_∞. From these it is evident that at a relative velocity of the O_2 molecule to the Fe surface of $v_\infty = 4$ km/sec there appears an appreciable probability of ejection of electrons from the metal. Starting with a velocity $v_\infty = 10$ km/sec nearly all the gas molecules that collide with the surface of the metal are ionized. In Fig. 1 we show a family of curves $\log N/n = f(\log v_\infty)$ for intermediate values of $B = 1 \times 10^{-66}$ to $B = 5 \times 10^{-64}$. From the figure it is also evident that for $B = 1 \times 10^{-66}$, which corresponds to a low value of U_0, ionization occurs for too low values of velocity; this indicates that the values of B should be 1×10^{-66} or larger. With the exception of the rare gases, the above theory is applicable to all gases with appreciable electronegative properties. In analogy to the preceding, it is possible to calculate N/n for any other combination of gas and metal.

v_∞ km/sec	N/c
3.0	$3.59 \cdot 10^{-22}$
3.5	$1.01 \cdot 10^{-17}$
4.0	$9.44 \cdot 10^{-14}$
4.5	$2.32 \cdot 10^{-11}$
5.0	$6.68 \cdot 10^{-9}$
5.5	$4.78 \cdot 10^{-6}$
7.5	$3.9 \cdot 10^{-3}$
10	0.75

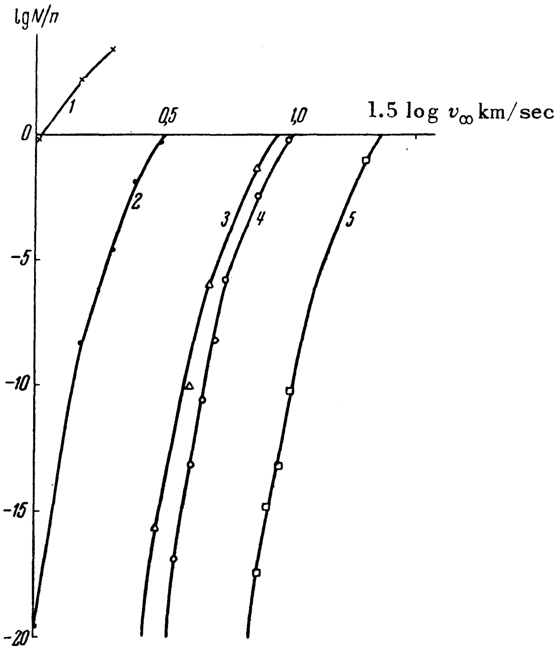

FIG. 1. Values of B for curves: 1 – 1×10^{-66}; 2 – 1×10^{-65}; 3 – 7.5×10^{-65}; 4 – 1×10^{-64}; 5 – 5×10^{-64}.

In conclusion we note that this mechanism of charging, along with others, may possibly explain the production of ionized regions in the atmosphere upon the entry of meteors. The velocity of meteors ranges from 8 to 100 km/sec,[7,8] the maximum number of cases being with $v = 40$ km/sec.

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Translated by L. B. Leder
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Concerning the Temperature Dependence of the Photoelectromotive Force

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EXPERIMENTAL INVESTIGATIONS of the crystal photoeffect[1] and photoelectromotive force, occurring when the capacitor method is used to investigate semiconductors,[2] show that these effects have a maximum with respect to temperature. This maximum, however, is difficult to explain on the basis of the proposed theoretical formulas.

Lashkarev and Kosonogova[3] have shown that the dependence of the non-barrier-layer photoelectric force in copper oxide on the intensity of light is described by the formula

$$V = (kT / e) \ln (1 + BJ). \qquad (1)$$

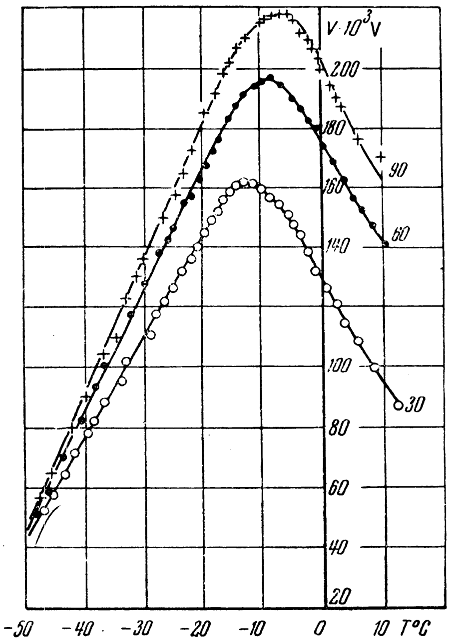
By comparing (1) for small intensity with the theoretical formulas obtained by Lashkarev[4] it is possible to assume that for the crystal photoeffect $BJ \approx \Delta\sigma_- / \sigma_T$.

Thus both effects (non-barrier photoelectromotive force and photoelectric force in the capacitor method) may be described by relations (1) of like form but of somewhat different content. It is essential that in the case of the crystal photoeffect $\Delta\sigma_-$ (light-induced increment of conductivity at the base of the anti-barrier layer or on the boundary of the neutral contact) is due to the minority carriers, while in the capacitor method there is no need for restriction to the minority carriers.

The experimenter usually deals with samples of finite thickness, and therefore (1) can be written more precisely as

$$V = (kT / e) [\ln (1 + B_1 J) - \ln (1 + B_2 J)]. \qquad (2)$$

But since the factor B_2, which must take into account the absorption of light in the sample and possibly also the diffusion of the minority carriers toward the second electrode, is very small, the second logarithm in Eq. (2) does not exert a notable influence on the intensity dependence of the photoelectromotive force. In this case Eq. (1) is satisfied to a good degree.



Matters are different in temperature investigations. It is shown in Refs. 1 and 2 that Eq. (1) cannot give even a qualitative explanation of the existence of a maximum in the photoelectromotive force *vs.* temperature curve. Ryvkin,[2] to reconcile the experimental data with Eq. (1) makes assumptions that are far from obvious concerning the mechanism of recombination at low temperatures. The need for such a reconciliation between the experimental data and the theoretical ones disappears if one takes into account the finite thickness of the sample. Making the same assumptions concerning the temperature dependence of σ_T and $\Delta\sigma$ it is possible to rewrite Eq. (2) in the form

$$\vartheta = T \ln \frac{1 + a_1 x}{1 + a_2 x}, \qquad (3)$$

where

$$\vartheta = Ve / k, \ a_{1,2} = \text{const}(T), \ b = W / k, \ x = e^{b/T}, \ a_1 > a_2.$$

Let us test Eq. (3) for an extremum. It is necessary for us to determine the temperature for which

$$\frac{d\vartheta}{dT} = \ln \frac{1 + a_1 x}{1 + a_2 x} - \frac{(a_1 - a_2) x \ln x}{(1 + a_1 x)(1 + a_2 x)} = f(x) - \varphi(x) = 0. \qquad (4)$$