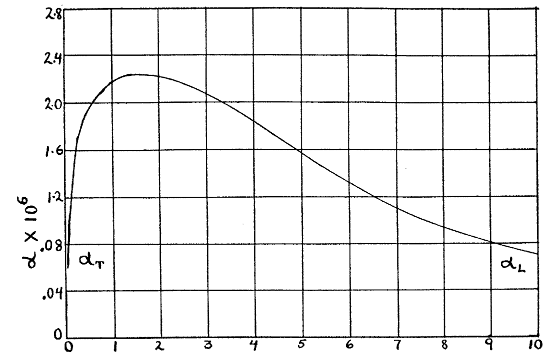

FIG. 1. Coefficient of recombination of ions in oxygen, the function of pressure. The abscissae give the pressure in atmospheres. At 1 atmos. $\alpha_T=2\times10^{-6}$, $\alpha_L=6.8\times10^{-6}$, $\eta=2\times10^6$.

theoretical evaluation is very difficult and which may be quite large, so that $d=(12Dt/\pi\eta)^{\frac{1}{2}}$. Let n be the number of electrons so that in a time dt the number of electrons attaching will be given by $dn=nh\bar{c}dt/\lambda$, where h is the probability of attachment and $\bar{c}/\lambda$ is the collision frequency. If n is the number of electrons after a time t and n_0 is the number at $t=0$, then $f=(n/n_0)e^{-h\bar{c}t/\lambda}$.[8] Hence $f=e^{-\pi h d^2\eta/4\lambda^2}$, which neglecting the variation of λ and h with electron energy can be written $f=e^{-a(p/760)^2}$. Since again $4\pi e(k_+ + k_-)=b(760/p)$ the equation for α becomes

$$\alpha=\alpha_T e^{-a(p/760)^2}+[1-e^{-a(p/760)^2}]b(760/p),$$

where p is the pressure in mm of Hg. There are at present no reliable extensive data to check this theory and our experience indicates that they will be very difficult to obtain. Insertion of the values of the constants into the equation indicates from the unsatisfactory data on hand that η will have to be of the order of 10^6. The shape of the curve for O_2 is indicated below. The 1902 data of Langevin[9] strongly indicate a behavior of this sort and in the limits of high and low p it is naturally in agreement with the character of the results of Gardner and Mächler.

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University of California,
Berkeley, California,
May 8, 1937.

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Thin Film Field Emission

Recently, Malter[1] reported the existence of anomalous secondary electron emission from specially treated electrolytic aluminum oxide. The same type of phenomenon has been produced by evaporating $BaOB_2O_3$ or quartz on to a metal plate and treating the film with caesium and oxygen; the treatment is similar to that used in the case of aluminum oxide. Films showing first and second order interference colors, roughly from 600A to 6000A thick, are best in the production of this effect.

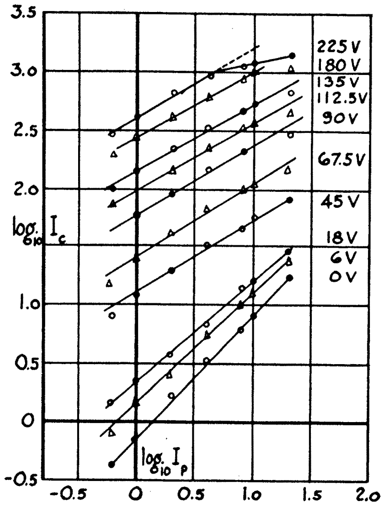

FIG. 1. $\text{Log}_{10} I_c$ plotted against $\log_{10} I_p$ for various collector voltages. Currents are expressed in μa.

A summary of measurements made on treated barium borate films in a tube similar in structure to that used by Malter[1] is presented in the accompanying figures. They

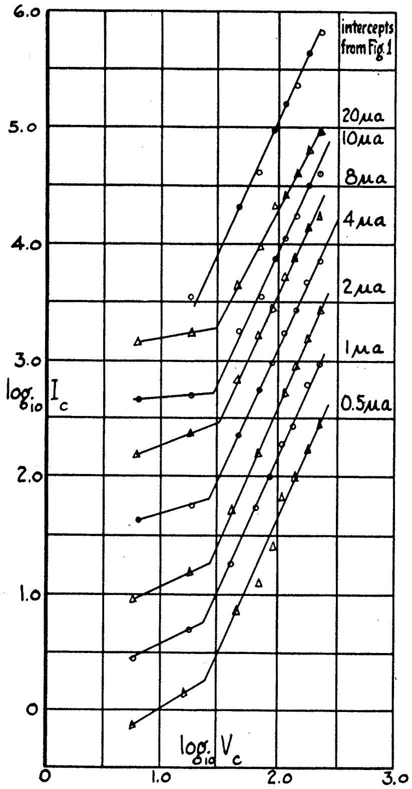

FIG. 2. $\text{Log}_{10} I_c$ plotted against $\log_{10} V_c$ for various primary currents. I_c is in μa, V_c in volts. The zero of the ordinate for each successive line is moved up 0.3 units.

are in general agreement with his data. Fig. 1 gives a logarithmic plot of the current to the collector, I_c, as a function of the incident bombarding current, I_p, for constant voltage on the collector, V_c. Fig. 2 gives a similar family with I_c and V_c as variables, and I_p as the parameter. The points were taken with 650 volt primary electron beam covering an area of 0.3 cm^2 on the target.

Fig. 1 clearly indicates that the collector current, provided it is less than 1.2 ma, is proportional to some power of the primary current; the exponent decreases from, roughly, unity at zero collector voltage, to the constant value of 0.59 above 25 volts. With similar restrictions on collector current and voltage, the family of curves in Fig. 2 is also a group of parallel straight lines. Within these regions the data can thus be expressed by the relations:

$$I_c = aI_p^n V_c^m,$$

where a, n, and m are constants for a given energy and area of the bombarding beam and activation of the surface. For the data presented, $a = 2.5 \times 10^{-3}$, $n = 0.59$, and $m = 2.23$. The consistency of the relations can be further checked by the fact that the intercepts of the curves in Fig. 1, plotted in Fig. 2, belong to the family of latter curves and *vice versa*. The intercept curve is shown in Fig. 2; the ordinate scale is shifted up 2.4 units for this curve.

As in the case of aluminum oxide, the treated borate surfaces exhibit a time lag between the incident current and the current to the collector, both when the primary current is turned on and off, and when the collector potential is turned on. All the points were taken at the maximum value of I_c with time.

Barium borate, without any treatment, exhibits anomalous emission but to a lesser extent than treated surfaces. Without treatment the current to the collector is much smaller, the build up is much slower and decay very rapid. The collector voltage must be raised to 200 volts or more to observe the anomalous character of the collector current.

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May 14, 1937.

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Experiments on the Magnetic Moment of the Neutron

In order to perform experiments in which polarized beams of neutrons are used, such as determining the sign and magnitude of the magnetic moment of the neutron, it is desirable to have as large a polarization as possible. Various types of single magnet experiments have been performed in an effort to obtain larger effects. As pointed out before,[1] these experiments with a single magnet eliminate difficulties due to adiabatic transitions when the neutrons pass through regions where angular velocity of the changing magnetic field is of the same order of magnitude as the Larmor frequency, $g\mu H/h$, of the neutron.

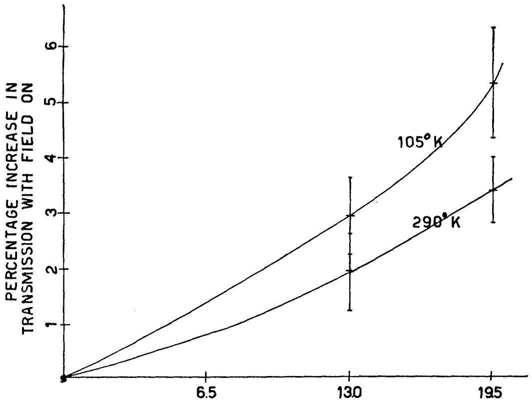

FIG. 1. Change in magnetic scattering with velocity of neutrons.

The experiments[1] involving the transmission of neutrons through three 0.65 cm iron plates magnetized to saturation and then demagnetized have been repeated using neutrons which were emitted from an "howitzer" cooled to approximately the temperature of liquid air. Both experiments were then performed using two plates instead of three. The experimental set-up was identical in the two sets of measurements. The results of these four experiments are compared graphically in Fig. 1. It is seen that with three plates the magnitude of the effect (percentage increase in transmission of slow neutrons with the plates magnetized[1]) increases from 3.6 percent ± 0.6 percent to 5.3 percent ±1.0 percent. With the two plates the effects are smaller, being 1.9 percent ± 0.7 percent and 2.9 percent ± 0.7 percent, respectively.

From these data it is seen that using slower neutrons increases the effect. Also greater thicknesses of iron increase the effect if multiple scattering within the iron is not excessive. However, thicknesses much beyond that corresponding to the three plates reduce the slow neutron intensity to very small values compared to the fast neutron background.

These results are consistent with theory[2-4] in that the change in scattering cross section is proportional to the form factor, $\int \exp(i(\mathbf{k}_0-\mathbf{k})\cdot\mathbf{r})m(\mathbf{r})dt$, where $\mathbf{k}_0$ and $\mathbf{k}$ are the propagation vectors of the incident and scattered neutrons, respectively; and $m(\mathbf{r})$ is the magnetization density. For slower neutrons this expression becomes larger and the percentage increase in transmission with the plates magnetized should be greater. Furthermore, within the limits of experimental error the effect varies with the square of the thickness in agreement with the theoretical prediction.[1-4]

Several attempts were made to increase the effect through collimating the neutron beam as completely as possible by various methods. No improvement in the effect was found by this method.

Several types of experiments have been performed with a single magnet in which the scattered neutrons rather than the transmitted neutrons were detected. In one, the same three plates were used; but the central portion of the beam was blocked out with cadmium. Thus the majority of the neutrons detected were scattered neutrons. As is to be expected in this case, the number of neutrons counted was less with the plates magnetized. The percentage change was 1.1 percent ± 0.5 percent. Since it was possible for a small