Since the break of the third chromosome occurred between scarlet and sooty (more exactly between pink and curled), 50% of recombinations would be expected. In fact, there is observed 46.5% of recombinations. In all intervals in which the crossing-over frequencies have been studied in the homozygous translocation, the crossing-over values are but slightly, if at all, different from the standard.

* These results in a more extended form are in publication in *Biologisches Zentralblatt.* Independently Muller and Painter have come to similar results on the basis of study of numerous translocations obtained by them in *Drosophila* (Muller and Painter, 1929).

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Muller, H. J., "The Production of Mutations by X-Rays," *Proc. Nat. Acad. Sci.,* **14,** 714–726, 1928.

Muller, H. J., and T. S. Painter, "The Cytological Expression of Changes in Gene Alignment Produced by X-Rays in Drosophila," *Am. Naturalist,* **63,** 193–200, 1929.

MAGNETIC SUSCEPTIBILITY OF NITRIC OXIDE AT 296°K. AND 216°K.

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In the course of attempts to improve and simplify present methods for measuring the magnetic susceptibility of gases, the following observations on the susceptibility of NO were made, and as the work is being continued on entirely different lines, it is proposed to publish this result separately in a short paper.

Apparatus.—The method is essentially that of hanging a test body surrounded by the gas to be measured in an inhomogeneous magnetic field, as it has been used by Glaser,[2] Vaidyanathan,[3] Hammar,[4] and others. The chief improvement lies in getting rid of the relatively enormous forces on the test body without having recourse to paramagnetic substances, which make the apparatus so sensitive to small temperature changes. Figure 1 shows the essential features of the test body. It is made entirely of pyrex glass, the parts being fused together. P represents the pole pieces of the magnet,[5] and the position of the test body as shown is an equilibrium position with a vacuum inside and outside the tubes ABCD. The tubes A and B are connected with the surrounding gas through the tube E which is hooked to a quartz fiber suspension. The tubes C and D can be sealed off at F. In the following

measurements, a paramagnetic gas (air) was sealed off in C and D which displaced the equilibrium position of the test body in the sense indicated by the arrows in the figure. Measurements were then made by comparing the deflections when different gases at different pressures were admitted to the surrounding chamber and the tubes A and B. The whole system was immersed in a bath to a depth of about 10 inches.

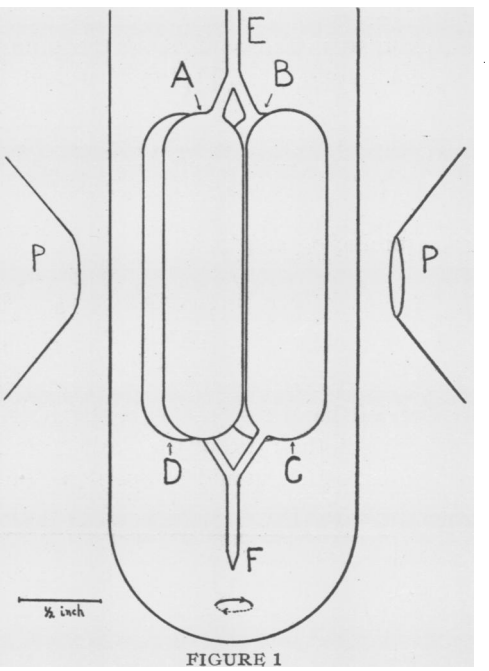

FIGURE 1

Theory of Measurements.— Without writing down the fundamental integrals which govern the forces here in play, we may say that if a gas G_1, at a temperature T_1, and pressure P_1, has a volume susceptibility $K_1(T_1, P_1)$, and gives under these conditions the same deflection as G_2, whose volume susceptibility is $K_2(T_2, P_2)$, then

$$K_1(T_1, P_1) = K_2(T_2, P_2). \qquad (1)$$

K may be written quite generally[6]

$$K(T, P) = c\frac{P}{T}\left[(1 - a)\frac{N\overline{\beta^2}}{3kT} - a\chi\right], \qquad (2)$$

where N, P, k, T have their usual significance, and $a\chi$ represents the contribution of a diamagnetic component which, unless it is present in great excess, is small compared to $(1 - a)N\overline{\beta^2}/3kT$, and β represents the magnetic moment of a molecule. Now, if in formula (1) $T_1 = T_2$, we get

$$c\frac{P_1}{T_1}\left[(1 - a_1)\frac{N\overline{\beta_1^2}}{3kT_1} - a_1\chi_1\right] = c\frac{P_2}{T_1}\left[(1 - a_2)\frac{N\overline{\beta_2^2}}{3kT_1} - a_2\chi_2\right]. \qquad (3)$$

In the following, in comparing air and NO, $a_1\chi_1$, and $a_2\chi_2$ may be neglected. We then get

$$\left[\frac{P_1}{P_2}\right]_{T_1} = \left[\frac{(1 - a_2)\overline{\beta_2^2}}{(1 - a_1)\overline{\beta_1^2}}\right]_{T_1}, \tag{4}$$

an expression independent of the temperature. Writing β_{O_2} for β_2, and Θ (which applies to NO) for β_1, we get, putting $a_1 = 0$,

$$\left[\frac{P_{NO}}{P_{O_2}}\right]_{T_1} \div \left[\frac{P_{NO}}{P_{O_2}}\right]_{T_2} = \left[\frac{\overline{\beta_{O_2}}}{\overline{\Theta^2}}\right]_{T_2} \div \left[\frac{\overline{\beta_{O_2}}}{\overline{\Theta^2}}\right]_{T_1}, \tag{5}$$

or assuming β_{O_2} constant,[7]

$$\left[\frac{P_{NO}}{P_{O_2}}\right]_{T_1} \div \left[\frac{P_{NO}}{P_{O_2}}\right]_{T_2} = \frac{\overline{\Theta^2_{T_2}}}{\overline{\Theta^2_{T_1}}}. \tag{6}$$

The left-hand side of (6) contains only measurable quantities, and the right side is the ratio of the atomic moments of NO at two different temperatures, which should be one if the moments are constant.

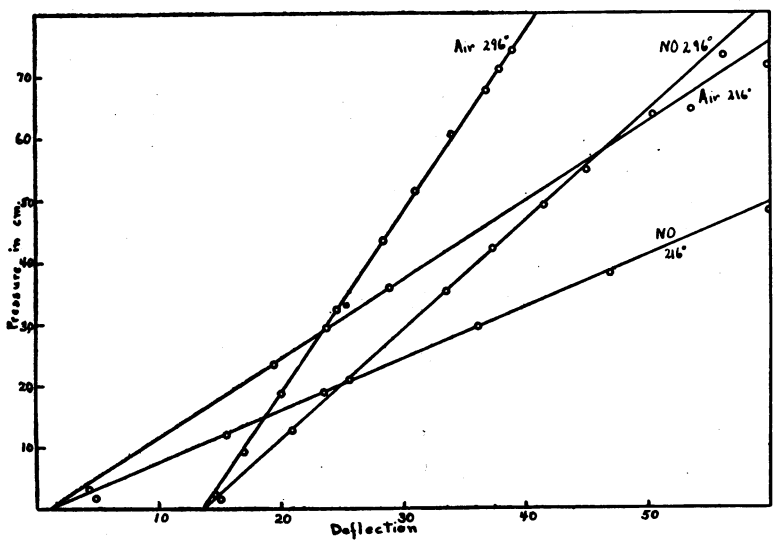

FIGURE 2

Observations.—The gases used were air and NO—both were thoroughly dried and passed slowly through traps cooled in solid CO_2, the lowest temperature used in the experiment.

The observations are plotted in figure 2. The deflections are in cm. on a scale at a distance of about 150 cm. from the mirror on the test

body. The observed points depart from the straight lines drawn in the figure, which is to be expected, as the test body is in a different position in the field for different deflections. The fact that over a considerable range, however, the points do lie on a straight line makes it very easy to read off the pressures needed for equation (6). The temperatures at which the experiment was carried out were 296°K. and 216°K., the latter being produced by a solid CO_2 bath.

The numerical result obtained from figure 2 is:

$$\frac{\bar{\theta}^2_{296°}}{\bar{\theta}^2_{216°}} = 1.08 \tag{7}$$

The error is possibly 3%.

Discussion of Results.—Van Vleck[6] has calculated the susceptibility of NO. Briefly, his results are:

(1) That the general formula for the molecular susceptibility of a paramagnetic gas is:

$$\chi = \frac{N\bar{\theta}^2}{3kT} \tag{8}$$

(2) That NO, having a doublet in the normal state with energy spacing of the order of magnitude of kT, will have different concentrations of these two states at different temperatures. In the lower state the atomic moment is zero, and in the upper state, the atomic moment is 2 Bohr Magnetons.

(3) Using these facts and applying the Boltzman distribution, the formula

$$\bar{\theta}^2 = \frac{4\beta^2(1 - e^{-x} + xe^{-x})}{x + xe^{-x}}, \tag{9}$$

$x = \frac{h\nabla\nu}{kT} = \frac{173.2}{T}$ is obtained. Substituting the values for T in this expression, there results

$$\frac{\bar{\theta}^2_{296°}}{\bar{\theta}^2_{216°}} = 1.07, \tag{10}$$

which is in very good agreement with the value 1.08 actually observed for this ratio.

[1] NATIONAL RESEARCH FELLOW.

[2] Glaser, *Ann. Physik*, **75**, 459, 1924.

[3] Vaidyanathan, *Ind. J. Ph.*, **2**, 138, 1928.

[4] Hammar, *Proc. Nat. Acad. Sci.*, **12**, 594, 1926.

[5] The large electromagnet used was very kindly lent me by the Mt. Wilson Observatory.

[6] Van Vleck, *Phys. Rev.*, **31**, 587, 1928.

[7] Onnes and Oosterhuis, *Konink Akad. Wetenesch Amst. Proc.*, **15**, 1404, 1913. Communication No. 134d, Phys. Lab., Leiden.

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*HYPER-FINE STRUCTURE IN SPECTRAL LINES— ESPECIALLY THOSE OF SINGLY IONIZED PRASEODYMIUM**

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Fine structure in spectral lines has been reported from time to time for a few lines in each of several elements. In the majority of cases this complexity has been observed in the case of lines arising from the neutral atom, though a few lines, identified as belonging to the spectra of singly ionized helium, aluminum and lanthanum, have also been found to consist of two or more components. So far as we are aware no line definitely identified as belonging to the spectra of an element in a stage of ionization higher than the first has been reported as having more than a single component. This can hardly be taken to mean necessarily that lines radiated by atoms in the higher states of ionization are, on the whole, simpler than those in the arc and first spark spectra. The spectra of highly ionized atoms are comparatively difficult to produce and many of the stronger lines are found in regions of the spectrum where high dispersion apparatus cannot be so readily utilized. All but the more recent observations of complex structure are mentioned and discussed in reports by Ruark[1] and Chenault,[2] and by Meggers and Burns.[3] Bach and Goudsmit[4] used very high precision apparatus in studying the Zeeman effect upon certain hyper-fine lines of bismuth. McNair[5] has studied the Zeeman patterns of the hyper-fine lines in the 2537 line of mercury. Schuler[6] has observed close components in certain lines of lithium and in the *D* lines of sodium. King[7] in making a careful study and classification of lines in the spectra of praseodymium has pointed out the complex structure of many of these lines, the vast majority of which are believed to belong to the first spark spectrum. Very recently King[8] has reported the existence of hyper-fine structure in lines from several other rare-earth elements.