Owing to the large spread observed in measurements of V_s by Trump *et al.*,[5] and indeed of all other observers in this region,[2–4] it is difficult to make reliable estimates of the values of the γ which were effective in these measurements by applying the Townsend sparking criterion to their values of V_s. This spread probably indicates the extremely high dependence of the total emission on the nature of the electrode surface in the presence of oxide films. However, an approximate estimate indicates that on the basis of the Townsend breakdown criterion, the value of γ must have been enhanced by a factor of at least 10^4 to account for the observed deviations in V_s.

It is, however, significant to note that cold electron emission $\sim 10^4$ times greater than would be expected for clean surfaces has been obtained with macroscopic fields of $\sim 10^5$ volts/cm in the presence of oxide films, so that an effective enhancement of this order of the coefficient γ due to the presence of positive ions of the gas on this oxide layer on the cathode would appear to be not impossible.

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Microwave Spectrum of NO_2

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THE microwave absorption spectrum of gaseous nitrogen dioxide has been observed at approximately 26,660 Mc. The spectrograph employed has been described elsewhere.[1] Stark effect modulation was used throughout. The Zeeman effect was measured by winding a coil of approximately 5000 turns of No. 18 wire on a 4-inch diameter coil form. The coil was centered on $\frac{1}{2}\times$1-in. wave guide such that only 10 percent of the guide was subject to a fringing field. The direction of the static magnetic field was perpendicular to that of the microwave E vector, giving rise to Zeeman transitions of the type $\Delta M=\pm 1$. A slight splitting of one of the lines was observed in the absence of the applied dc field due to the component of the gravitational field parallel to the guide axis.

The observed spectrum of nitrogen dioxide is shown in Table I. The frequency range of the apparatus was from 18,000 to 31,000 Mc. The relative intensities were measured to approximately ± 10 percent. The intensities shown do not indicate the temperature coefficient of any of the lines, but only the relative intensities at each temperature. The fact that both of the sets of triplets arise from the same energy level to within 40 wave numbers was established by the constancy of the relative intensities at the two temperatures. The last column of Table I shows the measurements of the Zeeman effect in weak fields. $\Delta\nu$ represents the splittings of the centers of gravity of the two symmetrically displaced components. These measurements were made with the simultaneous application of Stark and Zeeman effects. The effect of varying the Stark voltages upon each magnetic field splitting was determined, and an extrapolation to zero voltage was made when necessary.

TABLE I. Observed spectrum of NO_2.

Line freq. (Mc)	Rel. int. (30°C)	Rel. int. (−75°C)	$\Delta\nu$(Mc/gauss)
26,647.17	147	143	
26,633.83	149	153	0.21$\underline{7}$
26,619.38	178	183	0.44$\underline{0}$
26,603.65	6	—	
26,577.02	176	184	0.47$\underline{1}$
26,569.21	176	184	0.23$\underline{3}$
26,563.25	144	151	

The NO_2 molecule has a magnetic moment of one Bohr magneton arising from one uncompensated electron spin and an electrical polarity of approximately $\frac{1}{3}$ Debye unit. The lines observed are interpreted as arising from the electric rather than the magnetic moment of the molecule. The various angular momenta involved in the molecule include the angular momentum due to motion of the nuclear framework denoted by **L**, and the electron and nuclear spin momenta **S** and **I**, respectively. The hamiltonian may be written as

$$H=\left[\frac{L_a^2}{2I_a}+\frac{L_b^2}{2I_b}+\frac{L_c^2}{2I_c}\right]+A\,\mathbf{L}\cdot\mathbf{S}+2g_I\beta_I\beta[\mathbf{I}\cdot\mathbf{S}-3r^{-2}(\mathbf{S}\cdot\mathbf{r})(\mathbf{I}\cdot\mathbf{r})]$$
$$+[(16\pi/3)\beta g_I\beta_I]|\psi(0)|^2+2\beta\mathbf{S}\cdot\mathbf{H}. \quad (1)$$

The electronic and nuclear magnetons are denoted by β and β_I, respectively. A is a constant, while $\mathbf{r}$ is the radius vector from the N^{14} nucleus to the free electron spin. The proportionality constant A is a function of L and of K, the axial component of L. This hamiltonian does not include the interaction between the electrical moment of the molecule and the applied electric field giving rise to the Stark effect. The first term is the familiar energy of an asymmetrical top. The second member of (1) represents the interaction between the electron spin and the magnetic field produced by the rotation of the molecule. The third member is the dipolar coupling between the electron and nuclear spins, the fourth is the Fermi overlap term, and the final member is the Zeeman energy.

Quadrupole coupling has been excluded since its value is much smaller than the dipolar term, and the above is intended only as a first, preliminary approximation. The contributions of the magnetic moments appropriate to molecular rotation and nuclear spin to the Zeeman energy are also excluded, as they are extremely small compared with that of the electron spin.

It seems likely that the strong lines of Table I arise from transitions of the type $\Delta F=\Delta J=\Delta L$. The six lines are then ascribed to the six possibilities $J=L\pm\frac{1}{2}$, $F=J-1$, J, $J+1$ for given initial L. In principle, there are other multiplet components where $\Delta F\neq\Delta J$ or $\Delta J\neq\Delta L$, but theory shows that they are so weak that they would scarcely be observed. Any other interpretation appears hard to reconcile with the observed intensity behavior. However, it has not as yet been shown that the observed spacing of the components and the Zeeman behavior can be explained on the basis of the hamiltonian function (1). This problem is being investigated further.

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Remarks on the Optics of Radio Waves

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IT is common practice in optics, primarily in the range of the visible spectrum, to consider an obstacle (e.g., a plane wall) as a *minor* disturbance if its thickness d times 2π is small compared to the wavelength measured inside. This is indeed a correct approximation for all practical cases as long as the index of refraction n