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Minutes of the Fourth Annual Conference on Gaseous Electronics, Sponsored by the Division of Electron Physics

THE fourth annual Conference on Gaseous Electronics, sponsored by the Division of Electron Physics of the American Physical Society, was held on October 4, 5, and 6, 1951, at the General Electric Research Laboratory "The Knolls" at Schenectady. Abstracts of some of the papers there presented are printed hereunder. The first of these abstracts belongs, however, to the 1950 Conference, from the Minutes of which (Physical Review **82**, 566 (1951)) it was inadvertently omitted.

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E6. The Use of an Arc-Cathode as a Source of Emission for High Power Tubes.*† P. H. Kafitz, D. H. Goodman, and D. H. Sloan, *University of California, Berkeley*.—The metal vapor arc has been investigated as an electron source for high power, high frequency vacuum tubes. In the arc-cathode tube, a trigger spark near the cathode provides copper vapor for the main high frequency discharge that is created and maintained by the rf fields in the grid-cathode region. When the grid is positive, many of the electrons accelerated toward the grid pass on through to the anode, thus traversing a region that is at high vacuum. Condensation of the neutral metal vapor and a high degree of ionization in the arc plasma help to preserve the high vacuum condition for a considerable time. One tube, pump-operated as a self-excited oscillator, developed 100 kilowatts at 100 megacycles on pulsed operation. The peak current drawn from the discharge plasma was 3 amp/cm^2 of grid area. Direct current tests indicate that the maximum emission may exceed this by a factor of 10 to 100. Pulse lengths up to 40 microseconds have been obtained.

* Part of a thesis to be submitted by the first of the authors to the University of California in partial fulfillment of the requirements for the degree of Doctor of Philosophy. This work was supported by the Air Materiel Command, U. S. Air Force.
† Presented at the 1950 Conference on Gaseous Electronics.

A2. Attachment of Thermal Electrons in Oxygen. Manfred A. Biondi, *Westinghouse Research Laboratories*.—Microwave techniques[1] are used to measure the removal of electrons in oxygen. At sufficiently high gas pressures and low electron densities, attachment of electrons to oxygen molecules becomes the dominant removal process. The cross section for attachment of thermal electrons (0.04 ev average energy) is found to be $Q_a = 1.2\times10^{-22}$ cm^2, independent of pressure over the range 8–25 mm Hg. This value agrees with the calculated cross section for radiative capture of electrons. On the other hand, it disagrees with the Bloch-Bradbury theory of electron capture by excitation of molecular vibration[2] which predicts a cross section of 10^{-19} cm^2 for thermal electrons in O_2. It is hoped that future studies of the attachment in O_2 as a function of electron energy will resolve this discrepancy.

[1] M. Biondi, Rev. Sci. Instr. **22**, 500 (1951).
[2] F. Bloch and N. Bradbury, Phys. Rev. **48**, 689 (1935).

A3. Ionization and Attachment in Oxygen. Melvin A. Harrison and Ronald Geballe, *University of Washington*.—Ionization currents have been measured in oxygen using plane-parallel electrodes separated as far as four centimeters. The curves thus obtained cannot be fitted by assuming that ionization alone takes place. If the effects of attachment are also considered, good fits are possible. Values for the coefficients of both of these processes have been determined for E/p in the range from 30 to 75 volts/cm/mm. The first Townsend coefficient behaves normally and does not exhibit the sudden dropping-off found by K. Masch[1] for $E/p<40$, which probably was due to the increasing importance of attachment. Furthermore, an appreciable attachment probability persists to considerably larger E/p (>60) than indicated by previous results,[2,3] which may have been obscured by ionization. An explanation of the process now becomes possible in terms of atomic rather than molecular ions.

[1] K. Masch, Arch. f. Elektrotechnik **26**, 587 (1932).
[2] N. Bradbury, Phys. Rev. **44**, 883 (1933).
[3] R. H. Healey and J. W. Reed, *The Behavior of Slow Electrons in Gases* (Amalgamated Wireless, Limited, Sydney, 1941).

A4. Probability of the Formation of He_2^+, Ne_2^+, and A_2^+ from Excited Atoms. J. A. Hornbeck, *Bell Telephone Laboratories*.—Rough measurements of the probability of forming molecular ions in the noble gases have been obtained from studies[1] of the pulsed Townsend discharge in which the pressure is varied at constant E/p_0, the ratio of electric field to gas pressure. Equations based on the established formation process[2] when fitted to the data give values of two parameters; first, the ratio η_{exc}/η_i, where η_{exc} and η_i are first Townsend coefficients, i.e., the number of excitations (of the proper kind) and ionizations/volt/electron, and second, the product $\tau\sigma$, where τ is a mean lifetime before decay by radiation of the several excited atomic states involved and σ is a mean cross section for the process. The results are: $\tau\sigma\times10^{22}$ cm^2 sec $=0.5$ in helium, 0.5 in neon, and 0.9 in argon; the order of magnitude of η_{exc}/η_i is 0.2 in helium at $E/p_0=14$ volts/cm$\times$mm Hg, 0.2 in neon at $E/p_0=15$, and 1 in argon at $E/p_0=30$. These results indicate that molecular ions should cause observable deviations from the Paschen breakdown (similitude) law; also dc measurements of η as usually defined should show a pressure dependence at low E/p_0.

[1] J. A. Hornbeck, Phys. Rev. **83**, 374 (1951).
[2] J. A. Hornbeck and J. P. Molnar, Phys. Rev. (to be published).

A5. Positive Ions in the Afterglow of a Low Pressure Helium Discharge.* Arthur V. Phelps,† *Massachusetts Institute of Technology*.—The positive ions responsible for the ambipolar diffusion coefficient for helium reported by Biondi and Brown[1] have been identified as He^+ ions. The positive ions which diffuse to the walls were studied with a mass spectrometer. The average electron density was determined from the shift in the resonant frequency of the microwave cavity. As the pressure of the helium was increased, the dominant ion in the afterglow was found to change from He^+ to He_2^+. The rate of conversion of He^+ ions to He_2^+ ions was estimated from the electron density decay data to be about one-third the value predicted by Bates.[2] These experiments show that there is good agreement between the theoretical predictions and recent experimental determinations of the mobility of the He^+ ion in helium. The dominance of the He_2^+ ion at the higher pressures lends support to the proposal[3] that the He_2^+ ion is responsible for the large electron-positive ion recombination coefficients observed by Biondi and Brown.

* This work has been supported in part by the Signal Corps, the Air Materiel Command, and ONR.
† Now at Westinghouse Research Laboratories, East Pittsburgh, Pennsylvania.
[1] M. A. Biondi and S. C. Brown, Phys. Rev. 75, 1700 (1949).
[2] D. R. Bates, Phys. Rev. 77, 718 (1950).

A6. The Formation and Decay of Metastable Mercruy Molecules. A. O. McCoubrey, *Westinghouse Research Laboratories.*—The program on the persistent band fluorescence of mercury vapor[1] has now achieved the point where the observations can be classified in a physically interpretable manner. The following results have been obtained: (a) The ratio of intensity of the visible band (4850A) to that of the ultraviolet band (3350A) is essentially proportional to the square of the vapor density N. (b) Both bands decay according to a curve which is characterized by two time constants. The longer of these has been studied quite extensively; it is found to obey a relationship of the type $1/\tau = A/N + B + CN^2$. (c) By the use of two different enclosure geometries the diffusion contribution has been separately evaluated; the collision radius obtained therefrom is 7A. These results may be interpreted according to the following picture. Incident 2537A radiation creates $^3P_1$ atoms which upon collision are converted to the $^3P_0$ metastable state. The metastable atoms then combine chemically with normal mercury atoms to form the $^3O_u^-$ state of Hg_2. This state decays both spontaneously by the emission of the ultraviolet band and by collision-induced radiation of the visible band.

[1] Phys. Rev. 82, 567 (1951); 76, 1259 (1949).

B1. Preliminaries on Photoionization in N_2 and O_2 in the Vacuum Ultraviolet.* G. L. Weissler and Nathan Wainfan, *The University of Southern California.*—Using a normal incidence vacuum spectrograph as a monochromator, radiation from a constant intensity light source is passed through an exit slit into a chamber which contains at low pressures either N_2 or O_2. Photoionization produced in these gases is measured as a function of wavelength with a low voltage ionization chamber. Energy measurements of the radiation passing through the exit slit are made with a sensitive thermocouple, and the number of photons per second entering the ionization chamber is determined. From this and the ions collected the photoionization cross sections can be obtained. A detailed description of the apparatus will be given together with preliminary results.

* The aid of the ONR is gratefully acknowledged.

B2. Dissociative Attachment of Electrons to Diatomic Molecules. T. Holstein, *Westinghouse Research Laboratories.*—According to the Franck-Condon principle, the reaction $XY + e \rightarrow X + Y^-$ proceeds in two stages. The electron is first captured by the neutral molecule without alteration of the positions and velocities of the nuclei; the resultant XY^- complex then dissociates into the final products. Now, in the region where the potential curve of XY^- lies above that of XY, the molecular ion is unstable towards autodetachment. Hence, the cross section Q for the reaction is equal to the cross section Q_c for the formation of XY^-, multiplied by the probability e^{-T_s/τ_A} that XY^- dissociate without autodetachment. (Here, τ_A is the autodetachment lifetime and T_s the "stabilization" time required for the nuclei to reach the crossing point of the XY and XY^- potential curves.) Q_c itself is readily obtained in terms of τ_A from the "one-level dispersion" formula often employed in the theory of nuclear reactions. The final expression for Q contains τ_A which, for the present, we treat as a phenomenological constant. Values of τ_A required to effect agreement with experiment, e.g., for the case of O_2, are $\sim 10^{-15}$ sec, which, though somewhat smaller, is still of the order of magnitude of auto-ionization times computed for light atoms.[1]

[1] Ta-You Wu, Phys. Rev. 66, 291 (1944).

B4. Cleanup of Helium in an Arc Discharge. M. J. Reddan and G. F. Rouse, *National Bureau of Standards.*—The results of an investigation of the cleanup of helium gas in an arc discharge by a negatively charged tantalum wire probe were reported earlier. More recent studies have been made with a tube in which the probe is a nickel cylinder. A particularly important feature of the tube design is that the amount of gas recoverable from the probe can be clearly distinguished from that which is recoverable from parts of the tube near the probe. The following statements apply to a nickel probe: 1. Severe sputtering of nickel onto the glass wall of the tube occurs at probe potentials as low as 100 volts. 2. Over-all recovery of gas has averaged about 85 percent. 3. Heating the sputtered layer to 325°C for three hours drives off gas to about 70 percent of the total recovered. 4. Heating the probe to 825°C for 1.5 hours yields gas to about 30 percent of the total recovered. 5. Using the number of atoms recovered from the probe as a measure of the number trapped in the probe, one finds that the rate of cleanup increases with probe voltage in a manner quite like that reported previously for tantalum. At a probe potential of about 100 volts, three out of every ten thousand ions which strike will stick in the probe.

B5. Tritium Tracer Experiment for Investigating Gas Cleanup in Hydrogen Thyratrons. Sol Schneider, *Signal Corps Engineering Laboratories.*—As a means of studying the cleanup of hydrogen in pulse-operated thyratrons, standard hydrogen thyratrons are filled with a 1 percent tritium (H_2^3), 99 percent hydrogen (H_2^1) mixture to normal pressure (600 microns). These tubes are then operated in a line-type pulse modulator circuit. At various stages during the life of the tube, from initial filling to destruction, the tubes are disassembled and the parts are checked for activity using an "inside" beta-counter and autoradiographs. The "inside" beta-counter is calibrated against standard beta-sources, and the activity can be interpreted in terms of quantities of tritium. The activity on the surfaces of the parts of the tube as indicated by the "inside" beta-counter neglects the variations in distribution of the tritium over the surface of the parts. The autoradiographs, however, give detailed pictures of the distribution of tritium on any surface. Examination of autoradiographs has indicated considerable tritium on those surfaces which are covered with evaporated materials, subjected to heavy ion bombardment, or are in a strained state. Examination of the distribution of tritium with respect to depth for both the glass and metal parts are now being made.

C1. Ambipolar Diffusion of Electrons and Ions into a Cylinder. Joseph Slepian and L. S. Frost, *Westinghouse Research Laboratories.*—Previously reported experiments in ambipolar diffusion done under the direction of the senior author gave results at variance with the behavior expected from Schottky's theory of ambipolar diffusion. This paper extends the study and shows how experimental data and theoretical predictions are brought into agreement in the absence of a magnetic field and under suitable experimental conditions. The causes of the previous disagreement are shown to be (1) operation of the arc at a voltage above normal, resulting in reduced rates of decay of ion density; (2) the presence of probe currents due to electron emission from the probe; (3) insufficient ion current densities in the early experiments to assure equal ion and electron densities, as required by the theory; and (4) an extension to the theory necessary because of the appreciable size of the ionic mean free path relative to the tube radius. New experimental data is presented illustrating all these considerations, and equations are derived governing causes (3) and (4).

C2. Energies of Positive Ions in a Cold-Cathode Discharge in a Magnetic Field.* JOHN BACKUS AND NORMAN E. HUSTON. *The University of Southern California.*—Studies are being made of the energy distribution of positive ions in a cold-cathode discharge in a strong magnetic field. The discharge is of the Philips ionization gauge type previously described[1] operating at about 0.3 amp at 800 volts in a magnetic field of 2000 gauss, using copper cathodes in argon gas at about 1–3 microns pressure. The discharge is shut off periodically for approximately 50 microseconds by means of a pulsing unit to be described, and the ion current to the cathode during the off period is observed on an oscilloscope. Analysis of this current shows that the ions flowing to the cathode after the discharge is extinguished have an approximately Maxwellian distribution with a temperature equivalent of 0.8 to 1.3 volts, depending on the discharge current.

* Supported by the Research Corporation and ONR.
[1] A. Guthrie and R. K. Wakerling, *Electrical Discharges in Magnetic Fields* (McGraw-Hill Book Company, Inc., New York, 1949), Chapter 11.

C3. On the Discharge Mechanism in Hot-Cathode Rare-Gas Diodes, Especially with Negative Arc Drop. G. MEDICUS AND G. WEHNER, *WCESD, Wright Field.*—By decreasing the work function of the anode (evaporation of Ba) and at the same time increasing the work function of the cathode (indirectly heated Ta cathode), the voltage-current characteristic is shifted so that regions of negative dc voltage drop appear. Emf's of 0.8 volt at amperages in the order of 0.5 amp were obtained in Xe of about 200μ Hg pressure. In this case about 0.3 percent of the cathode heating power was directly transformed into electrical energy. The effect is brought about by the electrostatic field existing between the high work function cathode and the low work function anode short circuited outside, which is superimposed to the space charge field of the discharge. The electrons emitted from the cathode have a potential energy with respect to the anode that is roughly equal to the work-function difference between cathode and anode. Otherwise such a emf discharge in essence behaves like a normal low voltage arc discharge with the characteristic potential maximum between the electrodes.

C5. Reliability of Probe Measurements in Hot-Cathode Gas Diodes. GOTTFRIED WEHNER AND GUSTAV MEDICUS, *Wright Field.*—Probe measurements in gas discharges can give quite erroneous results owing to changes in the work function ϕ of the probe that may be in the same order of magnitude as the plasma electron velocities or as the plasma potentials to be measured. The different influences which determine the ϕ-change (oxidation, contamination with barium compounds, sputtering and evaporation from the probe) were separated by studying several diodes with different kinds of cathodes. The probe characteristics were recorded by an X-Y plotter which reduced the recording time to some seconds per run. In oxide or barium cathode tubes the work function of a tungsten probe near the cathode decreases so fast that reliable results can only be obtained if the time between measuring and cleaning procedure is less than some seconds. In the anode region the influence of oxygen released from an oxide cathode predominates (ϕ-increase) because most of the barium compounds return to the cathode after becoming ionized. With the proper probe cleaning procedure no deviation from the Maxwellian velocity distribution of the plasma electrons could be found, even in oxide cathode tubes (pressure 150μ) with the probe only ten mm away from the cathode and over a range of four powers of ten in probe current.

C7. Magneto-Ionic Resonance in Microwave Cavities. BENJAMIN LAX, *Air Force Cambridge Research Center.*—The complex resonant frequency ω of a cavity containing a non-uniform plasma in a magnetic field can be calculated exactly from

$$\omega^2-\omega_\mu{}^2=j\frac{\omega}{\epsilon_0}\frac{\int \mathbf{J}\cdot\mathbf{E}_\mu{}^*dv}{\int \mathbf{E}\cdot E_\mu{}^*dv}$$

if **E**, the perturbed electric field, and **J**, the current density in the magneto-ionic gas given by the product of the conductivity matrix and **E**, are known. The subscript μ indicates unperturbed quantities. For the first-order effect of the plasma take $\mathbf{E}\approx\mathbf{E}_\mu$. Applying this to a cylindrical cavity in an axial magnetic field gives for the TE_{111} mode a split resonance. The frequency shifts $\Delta\omega_0\sim 1/(\omega_\mu+\omega_b)$ and $\Delta\omega_e\sim 1/(\omega_\mu-\omega_b)$ are respectively those of the ordinary and extraordinary modes of the cavity, each with the same proportionality factor, for a given plasma density and gyromagnetic frequency ω_b. Experimental verification of the theoretical results will be presented.

D2. High Frequency Discharge at Low Pressures Characterized by Secondary Electron Resonance.* ALBERT J. HATCH AND H. BARTEL WILLIAMS, *New Mexico College of A. and M. A.*—Gas discharge characteristics have been studied at frequencies from 30 to 90 mc/sec using flat electrodes of aluminum, copper, and silver-plated copper at separations of one to four cm inside a bell jar. Pressures have been held at one micron Hg or less. For each spacing a cut-off frequency is observed below which it is impossible to obtain breakdown with field strengths of several hundred volts/cm. Double values of breakdown field strength are observed above cutoff, with lower values of 15 to 20 volts/cm being observed in certain cases. The cutoff and double breakdown values define a breakdown region not previously reported. This type of breakdown observed first by Gutton[1] in 1924 appears to be initiated by multiplication of secondary electrons at the electrode surfaces, these electrons oscillating between the electrodes in approximate resonance with the applied high frequency potential. Theories reported by Alfven and Cohn-Peters[2] and Gill and von Engel[3] to describe this type of discharge have not been very successful. A new approach to the theory has been developed which gives promising correlation with observations.

* Supported by the Navy Bureau of Ordnance.
[1] C. Gutton, Compt. rend. **178**, 467–470 (1924).
[2] H. Alfven and H. J. Cohn-Peters, Arkiv f. Mat., Astron. Fysik **31**, 1 (1944).
[3] E. W. B. Gill and A. von Engel, Proc. Roy. Soc. (London) **A192**, 446–463 (1948).

D4. Electron Distribution Functions in Combined DC Space Charge and AC Fields. IRA B. BERNSTEIN AND T. HOLSTEIN, *Westinghouse Research Laboratories.*—Most previous treatments of this problem have assumed the effect of dc space-charge fields, such as ambipolar fields, to be small. Here it is considered dominant. This implies that the electron can be considered as moving with constant energy w (equal to the kinetic energy u plus the electrostatic potential energy φ) in the space-charge well. The effects of collisions and the ac field are regarded as perturbations. In particular it is assumed that on the average the electron executes many oscillations in the well before suffering appreciable energy change due to collisions and the ac field. This indicates the desirability of introducing the variable w into the Boltzmann equation instead of u. The mathematical elaboration of these ideas leads to a difference-differential potential equation which can be solved under certain simplifying assumptions regarding the cross sections. The distribution function and specific ionization rate thus derived are compared with the corresponding quantities for the case of no space-charge field.

D5. Further Results of Studies of Microwave Oscillations in Gaseous Discharges. ROGER P. WELLINGER, JOSEPH A.

SALOOM, AND JAMES E. ETTER, *University of Illinois.*—In the process of investigating the causes of microwave oscillations in gaseous discharges, a new series of measurements has been made on the Wehner oscillator, using improved microwave circuitry and a more stable discharge. It was found that under certain conditions the band width of the oscillator spectrum was as broad as seven percent, but by proper adjustment of the discharge parameters the band width could be made to be as narrow as approximately 0.3 percent. Measurements have shown that the broad band width was associated with the presence of several simultaneous oscillations at different frequencies. Only when the oscillator operated in one dominant mode was it possible to obtain accurate quantitative measurements on the wavelength characteristics of the oscillations. The rf power distribution in the discharge was measured using biased probes, which indicated the presence of bunched electrons in the discharge. By using small rf probes, the phase difference between rf signals present at any two points in the discharge was measured. By changing various elements of the Wehner oscillator a correspondence between this oscillator and the gas discharge diode oscillators investigated by previous workers is shown. The envelope of the diode oscillator is equivalent to one of the elements of the Wehner structure.

D6. Retrograde Arc Motion of Supersonic Speed. CHARLES G. SMITH, *Raytheon Manufacturing Company.*—A mercury arc in a vertical magnetic field was raced around a carboloy cylinder projecting about three mm above the mercury. Arc current and field were parallel except at the carboloy anchor. Revolutions per second were observed by probe methods. The motion was retrograde (contrary to amperes law) for all fields. The speed curve rose rapidly between 1000 and 3000 oersteds and leveled off at 120 meters per sec (approximately sonic speed in the Hg vapor). At about 9000 oersteds the curve rose rapidly to about twice the plateau value and continued a less rate of rise to the highest field, 16,500 oersteds. Studies could be made of an arc running around in a shallow groove cut in the carboloy near its top. This arc was above the junction of liquid and carboloy. Its speed curve showed a short plateau but with speeds about three times those noted above. Ultimate speeds about six times sonic were found. These and other observations seem to leave us without a satisfactory theory of the retrograde motion.

D7. The Tungsten Arc in Mixtures of Argon and Helium.* T. B. JONES AND MERRILL SKOLNIK, *Johns Hopkins University.*—An experimental study was made of the properties of the electric arc with one-fourth-inch diameter tungsten-rod electrodes in mixtures of argon and helium pressure. The current range was from 10 to 100 amperes. Measurements were obtained of the plasma gradients and of the variations of the arc voltage as a function of the composition of the mixture for constant current. The change in arc appearance with the mixture was also observed. It was found that the properties of the arc in mixtures were a cross between the properties observed in the pure gases. With mixtures ranging from pure argon to argon containing 85 percent helium, the properties of the argon arc were more dominant, while the influence of the helium was more pronounced for concentrations of helium greater than this amount When the properties of the argon arc were more dominant, the chief effect of the helium was observed at the cathode region. In general, small amounts of argon in helium have greater effect on the arc characteristics than small amounts of helium in argon. However, the dependence of the arc properties on the presence of the lower ionization potential gas is considerably less than that observed in glow discharges.

* This work was supported by the ONR

D8. Electrical Phenomena in the Hissing Arc.* T. B. JONES AND B. H. LIST, *Johns Hopkins University.*—When the carbon arc begins to hiss in air, several phenomena occur simultaneously: (1) there is an abrupt drop in arc voltage of about ten volts; (2) the anode spot begins to move in a rapid random manner; (3) audiofrequency and radiofrequency oscillations are produced by the arc; and (4) there is a darkening of the anode, indicating a lower anode temperature. A study of the hissing arc at atmospheric pressure in air, nitrogen, oxygen, argon, helium, and carbon dioxide showed that these characteristic changes occurred only in air, nitrogen, and oxygen. The abrupt drop in voltage was shown to be related to the mechanism of supplying positive ions in the vicinity of the anode. The magnitude of the voltage drop is believed to be dependent upon the ionization potential of the chemical products formed in the arc. Both types of oscillations were independent of circuit parameters. The low frequency random oscillations of voltage, current, and sound were produced by the rapid motion of the anode spot. The radiofrequency oscillations occurred in narrow bands at 1, 2, 4, 8, 16, 32, and 64 megacycles per second. It was shown that these oscillations might be caused by motions of positive ions in the arc plasma.

* This work was sponsored by the ONR.

E2. Band Spectra in Pulsed Nitrogen Discharges.* C. F. HENDEE,† *Northwestern University.*—When the high voltage trigger pulse is applied to the external electrode of a condenser discharge flash tube, a short duration light flash is emitted that precedes the main light flash associated with the discharge of the condenser. This light flash has been studied oscillographically and has a duration generally between 10^{-6} sec and 10^{-7} sec. Using this technique to produce a discharge in nitrogen, the light pusle shapes of the first and second positive bands have been studied. The first positive band pulse has a decay time about ten times that of the second positive band, and decreases with increasing pressure. The decay time *vs* pressure curve is of the form expected when a metastable level is involved. This may be due to a slight metastability in the upper $B^3\pi g$ level of the first positive band system or to metastability of the $a^1\pi$ level[1] from which the $B^3\pi g$ level may be populated by the process suggested by Nicholls.[2]

* This work has been supported by the Bureau of Ships under contract NObs-28373, Dr. W. S. Huxford, Director.
† Now at Philips Laboratories, Inc., Irvington-on-Hudson, New York.
[1] G. Herzberg, Phys. Rev. 69, 362 (1946).
[2] R. W. Nicholls, Nature 162, 231 (1948).

E4. Positive Point-to-Plane Corona Studies in Air.* M. MENES AND L. H FISHER, *New York University.*—Measurements were made of formative time lags of the positive point-to-plane corona in dry air, using points of radii 0.07, 0.2, and 0.3 mm, gaps of 5, 10, and 15 mm, and steady ultraviolet illumination. Pressures ranged from 700 to 30 mm Hg. Pre-onset current-voltage measurements with illumination were made for these geometries. The formative time lags at a given pressure and gap geometry increase with decreasing overvoltage, showing a limiting upper value at onset. These threshold lags range from less than 0.1 μsec near atmospheric pressure to 1 μsec at 30 mm Hg and show a slight but not marked dependence on point radius, gap length, or illumination level. The steady-state current curves are continuous and reversible up to onset, and unless breakdown occurs, remain so through and beyond onset. Space-charge effects are noticeable below onset. The steady-state corona manifests itself as a burst pulse glow in all but one point-gap combination where pre-onset streamers occur. Moisture was found to favor streamer formation. The short threshold lags together