CONFERENCE ON GASEOUS ELECTRONICS

PROGRAM AND ABSTRACTS OF PAPERS

PRINCETON UNIVERSITY

RCA LABORATORIES

PRINCETON, N. J.
SEPTEMBER 4, 5, 6, 1952

DIVISION OF ELECTRON PHYSICS
AMERICAN PHYSICAL SOCIETY
1952 CONFERENCE ON GASEOUS ELECTRONICS

Thursday
September 4
9:00-10:00 A.M.

Registration in Lobby
of Frick Hall
Princeton University

PROGRAM

A. PLASMA AND SPACE CHARGE
Chairman: H. D. Hagstrum, Bell Telephone Laboratories

Thursday
September 4
10:00 A.M.
Frick Hall

A.1 ELECTRON VELOCITY DISTRIBUTIONS IN AN Hg-A DISCHARGE. *B. T. Barnes, General Electric Company.*

A.2 FIELDS IN THE CROOKES DARK SPACE OF A LOW PRESSURE GLOW DISCHARGE IN AIR AND N_2 AS REVEALED BY AN ELECTRON BEAM PROBE. *R. P. Stein, University of California.*

A.3 ON THE TRANSITION FROM FREE TO AMBIPOLAR DIFFUSION. *W. P. Allis, Massachusetts Institute of Technology and D. J. Rose, Bell Telephone Laboratories and MIT.*

A.4 INVESTIGATION OF BACK DIFFUSION OF PHOTO-ELECTRONS IN FREE ELECTRON AND ELECTRON ATTACHING GASES. *J. K. Theobald, University of California.*

Intermission

A.5 ON IONIZING AND HEATING A PLASMA. *Louis Witten, Princeton University.*

A.6 INSTABILITIES OF A COMPLETELY IONIZED PLASMA. *Martin Kruskal, Princeton University.*

A.7 SPECIFIC PRIMARY IONIZATION OF H_2, Ne AND A BY β-RAYS. *G. W. McClure, Bartol Research Foundation of the Franklin Institute.*

B. RADIATION AND SPECTRA
Chairman: M. A. Biondi, Westinghouse Research Laboratories

Thursday
September 4
2:15 P.M.
Frick Hall

B.1 ADDITIONAL OBSERVATIONS ON THE RADIATION TIME-LAG IN THE SHORT-TIME SPARK DISCHARGE. *H. Fischer, Air Force Cambridge Research Center.*

B.2 A SHORT AFTERGLOW IN NITROGEN. *W.B. Kunkel, University of California.*

B.3 SHOCK WAVES IN THE EXPANSION OF LOW PRESSURE SPARKS. *R. G. Fowler, W. R. Atkinson, R. J. Lee, University of Oklahoma.*

B.4 TIME VARIATION OF ION CONCENTRATION IN FLASH DISCHARGE PLASMAS. *H. N. Olsen and W. S. Huxford, Northwestern University.*

Intermission

B.5 SOME AFTERGLOW SPECTRA OBSERVABLE IN INCANDESCENT LAMPS. *Carl Kenty, General Electric Company.*

B.6 OH ROTATIONAL DISTRIBUTIONS IN MIXTURES OF H_2O AND D_2O IN A HIGH FREQUENCY DISCHARGE. *H. P. Broida, National Bureau of Standards.*

B.7 THE SPECTRUM EMITTED FROM THE CATHODE SPOT OF A MERCURY ARC. *S. V. Galginaitis, University of Louisville.*

C. FUNDAMENTAL PROCESSES

Chairman: S. C. Brown, Massachusetts Institute of Technology

Friday
September 5
9:15 A.M.
Frick Hall

C.1 EXPERIMENTAL INVESTIGATION OF IONIZATION PROBABILITY CURVES NEAR THRESHOLD. *R. E. Fox, W. M. Hickam, T. Kjeldaas, Jr., Westinghouse Research Laboratories.*

C.2 THRESHOLD LAW FOR IONIZATION OF ATOMS BY ELECTRONS. *G. W. Wannier, Bell Telephone Laboratories.*

C.3 EFFICIENCIES OF MULTIPLE IONIZATION. *W. H. Bennett and B. W. Harned, Naval Research Laboratory.*

C.4 A MICROWAVE METHOD FOR MEASURING MEAN ENERGY TRANSFER PER COLLISION AND THE VELOCITY DEPENDENCE OF COLLISION CROSS SECTION FOR SLOW ELECTRONS IN GASES. *O. T. Fundingsland, A. C. Faire, A. J. Penico, Air Force Cambridge Research Center.*

C.5 A NEW MICROWAVE TECHNIQUE FOR THE STUDY OF DISCHARGES IN GASES. *M. A. Lampert and A. D. White, Federal Telecommunication Laboratories.*

C.6 DISSOCIATIVE ATTACHMENT OF THERMAL ELECTRONS TO IODINE MOLECULES. *M. A. Biondi, Westinghouse Research Laboratories.*

Intermission

C.7 DRIFT VELOCITIES OF IONS IN OXYGEN, NITROGEN, AND CARBON MONOXIDE. *R. N. Varney, Bell Telephone Laboratories.*

C.8 THEORY OF THE MOBILITY OF He_2^+ IN HELIUM. *S. Geltman, and H. Margenau, Yale University.*

C.9 MOBILITIES OF THERMAL IONS IN NOBLE GASES. *L. M. Chanin and M. A. Biondi, Westinghouse Research Laboratories.*

C.10 THE QUENCHING OF MERCURY RESONANCE RADIATION (2537Å) BY NITROGEN. *C. G. Matland, Westinghouse Research Laboratories.*

Luncheon at RCA Laboratories 1:15 P.M.

D. FUNDAMENTAL PROCESSES AND MECHANISMS OF GAS DISCHARGES

Chairman: E. O. Johnson, RCA Laboratories

Friday
September 5
2:00 P.M.
RCA Laboratories

D.1 FREQUENCY SPECTRA FROM POINT-TO-PLANE CORONA. *F. E. Luborsky and S. I. Reynolds, General Electric Company.*

D.2 NEW DATA ON POSITIVE AND NEGATIVE POINT-TO-PLANE CORONA. *L. B. Loeb and M. R. Amin, University of California.*

D.3 SIMILARITY CONDITIONS OF HIGH PRESSURE DISCHARGES. *W. Elenbaas, N. V. Philips' Gloeilampenfabriecken, Eindhoven, Holland.*

D.4 A ROCKET MEASUREMENT OF UPPER ATMOSPHERE DENSITY BY PASCHEN'S LAW. *H. L. Smith and H. C. Early, University of Michigan.*

Cocktail Party and Banquet at Princeton Inn 6:30 P.M.

E. SURFACE PHENOMENA

Chairman: R. A. Varney, Bell Telephone Laboratories

Saturday
September 6
9:00 A.M.
Frick Hall

E.1 EFFECT OF ADSORPTION OF COMMON GASES ON ELECTRON EJECTION BY NOBLE GAS IONS. *H. D. Hagstrum, Bell Telephone Laboratories.*

E.2 A HIGH VACUUM, HIGH SPEED ION PUMP. *J. S. Foster, University of California.*

E.3 SPUTTERING AT LOW ION VELOCITIES. *G. Medicus and G. Wehner, Wright Air Development Center.*

E.4 INVESTIGATION OF CATHODE SPUTTERING BY MEANS OF PROBE MEASUREMENT. *G. Medicus and G. Wehner, Wright Air Development Center.*

E.5 CLEANUP OF HELIUM GAS IN AN ARC DISCHARGE. *M. J. Reddan, National Bureau of Standards.*

E.6 ON THE THEORY OF THE HIGH FREQUENCY SECONDARY ELECTRON RESONANCE DISCHARGE MECHANISM. *A. J. Hatch and H. B. Williams, New Mexico College.*

E.7 CONFIRMATORY MEASUREMENTS IN THE HIGH FREQUENCY SECONDARY ELECTRON RESONANCE DISCHARGE MECHANISM. *H. B. Williams and A. J. Hatch, New Mexico College.*

Thursday, September 4

10:00 A.M. Frick Hall

SESSION A

PLASMA AND SPACE CHARGE

Chairman: H. D. Hagstrum
Bell Telephone Laboratories

ELECTRON VELOCITY DISTRIBUTIONS IN AN Hg-A DISCHARGE

B. T. Barnes
GENERAL ELECTRIC COMPANY, CLEVELAND, OHIO

Probe characteristics were obtained using a tube 1.5″ in diameter containing Hg at 0.8-25 microns and 3.5mm of argon, operated at .20, .40, .80 and 1.50 amperes. At the higher currents interaction between electrons maintained a Maxwellian distribution of velocities, at least over the energy range 0-8ev. At the lower currents a Maxwellian distribution over the range 0-4ev, with an apparent deficiency of electrons of energies >7ev, and perhaps an excess in an intermediate range, seems typical. High probabilities of inelastic loss for 6-9ev electrons may account for the deficiency of fast electrons at the lower currents.

Results obtained with the usual probe techniques were roughly confirmed by runs for which the probe temperature was kept nearly constant. Square-wave pulses of current with a frequency of 29 per second were superposed on a steady current controlled by a pentode. The probe potential in the intervals between pulses was measured with an electronic voltmeter. The average total current was kept constant as the steady current was varied over a wide range. This technique was not usable when the ion current far exceeded the electron current, but conventional methods are fairly reliable in this range.

FIELDS IN THE CROOKES DARK SPACE OF A LOW PRESSURE GLOW DISCHARGE IN AIR AND N_2 AS REVEALED BY AN ELECTRON BEAM PROBE*

R. P. Stein
DEPARTMENT OF PHYSICS
UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA

Following the 1907 technique of F. W. Aston[1] the fields in the Crookes Dark Space, of normal and abnormal glow discharges in clean dry air and relatively pure N_2, have been studied by traversing the dark space with a 12,000 volt electron beam, using modern techniques, from 20-150 microns Hg and 0-17μ amp/cm^2 for air, and 50-450 microns and 0-53μ amp/cm^2 for N_2. Most discharges were 9 cm in length and the electrode diameter was 5.9 cm. There was little positive column and anode spot under conditions of most measurements. The fields in general fell off linearly with distance from the cathode as reported by Aston. It is found that using the observed linear fall, the variation of positive ion drift velocity with the ratio E/p, of field strength to pressure and assuming reasonable values of secondary electron emission by ion bombardment a solution for the ionization by electrons per cm in the field direction can be computed. The shape of these curves is very sensitive to the field at the cathode where present measurements are not precise. If likely corrections for disturbances are used the ionization α as a function of distance from the cathode is of the form predicted by P. L. Morton[2] from his study of ionization in non-uniform fields with coaxial cylinders at corresponding values of E/p.

* This investigation was supported by the Office of Naval Research.

[1] F.W. Aston, PROC. ROY. SOC. A 84, 526, (1911).

[2] P.L. Morton, PHYS. REV. 70, 358, (1946).

ON THE TRANSITION FROM FREE TO AMBIPOLAR DIFFUSION

W. P. Allis
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

and

D. J. Rose
BELL TELEPHONE LABORATORIES, MURRAY HILL, NEW JERSEY
AND MASSACHUSETTS INSTITUTE OF TECHNOLOGY

In a steady-state dc positive column or a microwave discharge the electron and positive ion currents are equal to each other and to the ionization rate in the discharge volume. At very low charge densities (breakdown), only free diffusion occurs; at very high charge densities, the combination of diffusion and mobility arising from the space charge field results in "ambipolar diffusion" wherein both types of particles appear to diffuse together. The behavior of the discharge throughout the transition between these extremes is investigated. Expressions are derived for an effective electronic diffusion coefficient in terms of which the currents and ionization rate can be expressed. Approximate spatial distributions of the charged particles are obtained. Numerical solutions of the appropriate equations are presented for the case of equal electron and ion energies. Analytic approximations are obtained for the case of electron energy >> ion energy, as is the case in normal steady-state discharges. The transition is not completely monotonic with increasing power; i.e., the net space charge at the center of the tube passes through a maximum in the transition region.

INVESTIGATION OF BACK DIFFUSION OF PHOTO-ELECTRONS IN FREE ELECTRON AND ELECTRON ATTACHING GASES*

J. K. Theobald
UNIVERSITY OF CALIFORNIA
BERKLEY, CALIFORNIA

Electron losses by back diffusion to the emitting surface have been measured in plane parallel geometry for the gases argon, hydrogen, and nitrogen for electrons emitted with two average energies, viz. 0.2 and 0.5 electron volts. Results were compared with those predicted by the Thompson[1] equation.

Energy distributions of the photo electrons were determined by retarding potential measurements, with an accuracy of 20%. The Thompson equation fits the data for hydrogen and nitrogen reasonably well, i.e. within that accuracy, but deviates badly for argon, being low by a factor of five. The losses appear to be determined by X/p and emissive energy as predicted by the Thompson equation, but the values do not support the use of the equilibrium electron mobility constants in that equation when the electron energy differs markedly from the average energy of electrons in equilibrium with the field at the value of X/p in question. This is shown by the indication that values of the mobility constants deduced from the experimental curves and the Thompson equation depend on the electron energy of emission in such a way that mobility appears greater for those electrons of lower energy of emission, and is emphasized by the discrepancy in argon, where the equilibrium energy is much higher than the emitted energy.

It is thus indicated that use of the Thompson equation in computing back-diffusive losses for electrons produced by metastable atoms or positive ions, with energies of the order of 10 eV, will give losses lower than the true values.

*These studies have been supported by the Office of Naval Research.

[1] J.J. Thompson, CONDUCTION OF ELECTRICITY THROUGH GASES, Third Edition, Vol. 1, p.466 (1928).

ON IONIZING AND HEATING A PLASMA

Louis Witten
PRINCETON UNIVERSITY, PRINCETON, NEW JERSEY

Of various methods of achieving total ionization of a plasma, the two most promising have been analyzed. The first uses an axial oscillating magnetic field. w^2/B remains constant as B changes, u is unchanged (w is the electron velocity component perpendicular to B, u is the component parallel to B). When B is high, collisions produce secondary electrons having, say, w^2 corresponding to 6 volts and u^2 to 3. B decreases to $\frac{1}{100} B_{max}$, thus decreasing w^2 to 0.06 volts. Collisions produce an isotropic distribution, $w^2 \approx 2$ volts, $u^2 \approx 1$. B is increased again increasing w^2 to 200 volts. These primaries produce other secondaries and the process repeats. A square-wave variation of B would almost certainly operate as envisaged. A sine wave gives too small an energy gain per cycle for the process to sustain itself.

Alternatively an oscillating axial electric field, $E_o \sin \omega t$, could be applied. Free electrons acquire enough energy during a cycle to produce ionization on collision. If the field frequency exceeds an "average" collision frequency, ν, of electrons; total ionization can be achieved. The number of electron-ion pairs e-folds in time $\sim \frac{1}{\nu}$ until total ionization is approached. The particles can be contained during the process by a constant axial magnetic field.

INSTABILITIES OF A COMPLETELY IONIZED PLASMA

Martin Kruskal
PRINCETON UNIVERSITY, PRINCETON, NEW JERSEY

First order perturbations of equilibrium of a plasma have been investigated theoretically in two ideal cases.

Case 1: A plane bounded plasma supported against gravity by a horizontal magnetic field. In the limiting two-dimensional case in which the magnetic lines are not bent, it is found that the familiar instability of a heavier fluid supported by a lighter one occurs; any sinusoidal perturbation across the field e-folds in a time interval approximately $(\lambda/2\ \pi\ g)^{1/2}$, where λ is its wavelength and g is the gravitational acceleration. In the different limiting case of no gravitational force, however, stability occurs; any sinusoidal perturbation bending the magnetic lines is oscillatory with period given approximately by the quotient of its wavelength along the field by the progression velocity of hydromagnetic waves.

Case 2: An infinite cylinder of plasma confined by the magnetic field produced by a current in the plasma parallel to the axis. Any transverse sinusoidal perturbation is found to e-fold in a time interval approximately the quotient of its wavelength by sound velocity.

SPECIFIC PRIMARY IONIZATION OF H_2, Ne, AND A BY β-RAYS

G. W. McClure
BARTOL RESEARCH FOUNDATION OF THE FRANKLIN INSTITUTE,
SWARTHMORE, PENNSYLVANIA

In order to test the theory of primary ionization as given by Bethe and to provide data required for the interpretation of experiments utilizing low-pressure Geiger-Mueller counters, the specific primary ionization of several gases has been measured using incident β-rays of energy variable between 0.2 and 1.6 Mev.

The apparatus employs a magnetic spectrograph to select a monoenergetic beam of electrons from a Pr^{144} source. The electron beam passes through a sequence of 3 G-M counters whose active volumes are separated by 1 mil Al foils. The first counter, A, traversed by the beam contains a low-pressure filling of the gas to be investigated and the last two counters, B and C, contain an ordinary self-quenching mixture. From the coincidence rates BC and ABC, the specific primary ionization of the gas in counter A may be calculated.

It is shown that by proper adjustment of two parameters in the Bethe formula, the theory fits the data for H_2, Ne and A within experimental errors ($\sim$2%) over the energy range attainable with the apparatus.

Thursday, September 4

2:15 P.M. Frick Hall

SESSION B

RADIATION AND SPECTRA

Chairman: M. A. Biondi
Westinghouse Research Laboratories

ADDITIONAL OBSERVATIONS ON THE RADIATION TIME-LAG IN THE SHORT-TIME SPARK DISCHARGE

Heinz Fischer
AIR FORCE CAMBRIDGE RESEARCH CENTER

Radiation time lags Δt between the time of the current maximum and that of the emitted radiation maximum have been observed by different authors[1,2,3] in electrical breakdowns under very different conditions. New investigations in the oscillating spark discharge demonstrate that the radiation maximum occurs always approximately at the time when the spark-current goes through zero.

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[1] H. Fischer and M. Reger, Paper delivered at the Gaseous Electronics Conference in Pittsburg on Nov. 5, 1949.

[2] J. D. Craggs and W. Hopwood, PROC. ROY. SOC. 59, 755 (1947).

[3] W. S. Huxford and N. N. Olsen, JOURNAL OF THE SMITE 55, 285 (1950).

A SHORT AFTERGLOW IN NITROGEN

W. B. Kunkel
UNIVERSITY OF CALIFORNIA
BERKLEY, CALIFORNIA

A powerful r.f. glow discharge was used to excite strong afterglows in a large flow system at pressures ranging from 0.5 to 10 mm Hg. Air and nitrogen displayed their well known long lived luminosities with remarkable intensity. In addition an extremely bright afterglow of short duration was produced in pure nitrogen. Its visible life was of the order of 0.1 sec. Its spectrum consisted of the first positive group appearing in the same form as in the discharge itself and of the bands of molecular ions. The latter were completely suppressed when 0.1% oxygen was added to the stream. Similar short bright glows have been observed by Kaplan[1] and by Herman[2] in pulsed systems containing electrodes. It has been suggested[2] that the radiation may be due to electron-ion recombination. Although this interpretation need not be accepted there can be no doubt that large concentrations of ions can, under suitable conditions, survive in pure nitrogen for 100 milliseconds. Possible mechanisms causing the delayed excitation are being discussed.

*Supported by the Wright Air Development Center.

[1]J. Kaplan, PHYS. REV. 42, 807 (1932).

[2]R. Herman, COMPTES RENDUS 220, 593 (1945)

SHOCK WAVES IN THE EXPANSION OF LOW PRESSURE SPARKS

R. G. Fowler, W. R. Atkinson, R. J. Lee
UNIVERSITY OF OKLAHOMA, NORMAN, OKLAHOMA

Self luminous shock waves have been recognized in the post discharge expansion of low pressure spark discharges, and computations verify the identification.

Expansion of the hot gas after excitation by the discharge current is accompanied by light production which is as yet not understood. Ion concentration indicated by Stark-broadening show a space distribution which can only be accounted for by assuming belated ionization, or failure of the Holtzmark theory. Production of luminosity is largely independent of the direct actions of the discharge current stream; is probably accomplished via recombination; and seems to be thermal in character, suggesting Saha processes.

TIME VARIATION OF ION CONCENTRATION IN FLASH DISCHARGE PLASMAS

H. N. Olsen* and W. S. Huxford
NORTHWESTERN UNIVERSITY
EVANSTON, ILLINOIS

The hydrogen atom is used as a spectroscopic probe for measuring ion concentrations in low pressure flash discharges through argon and neon. Photomultiplier techniques were developed for observing time-variations of individual spectral lines and continuous radiation. From observed wave-length distributions of broadened H_α and H_β lines, ion concentrations ($\sim 10^{17}$ ions/cm^3) were determined at various instants of time during the discharge phase. For this Holtsmark's theory of spectral line broadening by interionic Stark fields was applied[1]. A comparison of ion concentrations and intensities of the continuous spectrum as a function of time shows that the radiation is chiefly a bremsstrahlung continuum. The observed low values of electron-ion recombination coefficients indicate, furthermore, a negligible contribution of recombination continuum to the radiation. The degree of ionization is about 10% with a corresponding electron temperature of 11,000°K. The plasma energy is one third of the discharge capacitor stored energy, and the net charge separated in the plasma is greater by a factor of 10 than the charge removed from the capacitor. Electron mobilities determined from estimated current densities are lower than those calculated from the usual mobility equations.

[1]Paper X9, Washington Meeting of the American Physical Society, May 3, 1952.
*Now at Linde Air Products Co., Tonawands, N.Y.

SOME AFTERGLOW SPECTRA OBSERVABLE IN INCANDESCENT LAMPS

Carl Kenty
GENERAL ELECTRIC COMPANY
CLEVELAND, OHIO

Burned out street series lamps (600 mm 99.5% A, .5% N_2) with Tesla coil excitation exhibit several afterglow spectra. Most prominent are flamelike clouds of orange glowing active nitrogen (A.N.) which rise and swirl by convection[1] and persist several seconds. A blue flame issues from a gap in the filament where sparking occurs. This rises faster than the A.N. and persists much longer. Its spectrum consists of a number of unidentified lines or narrow bands in the green and blue. A beautiful green afterglow[2] occurring in rare cases is due to a few p.p.m. of O_2 or oxygen bearing gas. It is the auroral green line 5577 and associated band. Also occurring rarely is a violet afterglow. Its spectrum consists mainly of two bands in the violet. These last two afterglows, unlike the others, are quickly cleaned up by the discharge. New lamps rarely show any afterglow because of impurities, chiefly H_2O and H_2; 100 hours of burning are frequently necessary to clean up these. Many old lamps exhibit a weak phosphorescence on the inner surface of the bulb. This can be seen to persist up to 15 minutes by the dark adapted eye.

[1] R.S. Mackay, AM. J. PHYS., 18, 319 (1950).

[2] H.G. Jenkins and J.N. Bowtell, NATURE 163, 401 (1949).

OH ROTATIONAL DISTRIBUTIONS IN MIXTURES OF H_2O AND D_2O IN A HIGH FREQUENCY DISCHARGE

H. P. Broida
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D.C.

Recent studies[1] of OH emission from flames have indicated that thousands of collisions are not effective in producing rotational equilibrium. Since similar non-equilibrium distributions had been previously observed in electric discharges[2,3] through water vapor, a further study of the discharge has been made. Rotational intensities of OH and OD ($^2\Sigma$ - $^2\pi$ transition) have been measured in a 150 megacycle electrodeless discharge operating at pressures from 0.05 mm to 10 mm Hg. Mixtures of H_2O and D_2O vapors with helium, argon, nitrogen and oxygen have been observed.

In all cases evidence of abnormal rotation is found. Discharges through pure water show two maxima in the OH and OD intensity distributions. These intensity maxima occur at the same energy for both molecules. With increasing pressure, the maximum intensity corresponding to the lower energy increases relative to the other maximum but there is no shift in the energies of the maxima. With all diluents, the intensities from the lower energy states are greatly increased.

These results show that there are two processes forming the excited OH and OD and that collisions with other molecules have little effect on the rotational non-equilibrium.

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[1] H.P. Broida, J. CHEM. PHYS., 19, 1383 (1951).

[2] O. Oldenberg, PHYS. REV., 46., 210 (1934).

[3] E.R. Lyman, PHYS. REV., 53,379 (1938).

THE SPECTRUM EMITTED FROM THE CATHODE SPOT OF A MERCURY ARC

S. V. Galginaitis
UNIVERSITY OF LOUISVILLE
LOUISVILLE, KENTUCKY

Although it has long been known that the light emitted from the cathode spot of a mercury arc includes a continuous spectrum, the exact nature of this continuum has been rather difficult to determine. The primary cause of the difficulty is the elusiveness of the cathode spot, making for some trouble in obtaining a good picture of its spectrum.

A discharge tube was designed to eliminate this difficulty. The cathode was limited to a very small area, and viewed from above by means of a hole in the anode. The spectrum of the light emitted from the cathode spot showed the presence of a continuum. The two most intense continuous regions extended from about 3400 A to 4600 A, and from about 4850 A to 6000 A. The first region contained a maximum at 3700 A, and the second at 5350 A.

The positions of the maxima did not change as the current through the arc was varied from 1.5 to 3.6 amperes.

Friday, September 5

9:15 A.M. Frick Hall

SESSION C

FUNDAMENTAL PROCESSES

Chairman: S. C. Brown
Massachusetts Institute Of Technology

EXPERIMENTAL INVESTIGATION OF IONIZATION PROBABILITY CURVES NEAR THRESHOLD

R. E. Fox, W. M. Hickam, T. Kjeldaas, Jr.
WESTINGHOUSE RESEARCH LABORATORIES
EAST PITTSBURGH, PA.

The structure of ionization probability (P_i) curves for a few volts above threshold is investigated with a mass spectrometer employing the "retarding potential difference method" for obtaining ionization by monoenergetic electrons.[1] It is found that, for electron energies sufficiently low as to cause ionization only to the lowest level of the ion, the P_i curve increases linearly with the excess electron energy. In cases, however, where the ion has other energy levels in this region (e.g., the $^2P_{1/2}$ and $^2P_{3/2}$ ground states of the krypton ion) the P_i curve exhibits breaks in slope corresponding to these levels. Detailed analysis of the krypton curves yields a value of 0.66±.01 ev for the separation of the ground states, in excellent agreement with the spectroscopic value. Breaks in the P_i curves for xenon and argon are in agreement with the spectroscopic values within ±0.1 ev. Moreover, the structure of the P_i curve for krypton near the break shows the presence of autoionization arising from excited states of the atom lying higher than the lowest state of the ion. Preliminary studies of some double ionization processes will be reported.

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[1] R. E. Fox, W. M. Hickam, T. Kjeldaas, Jr., and D. J. Grove, PHYS. REV. 84, 859 (1951).

THRESHOLD LAW FOR IONIZATION OF ATOMS BY ELECTRONS

Gregory H. Wannier
BELL TELEPHONE LABORATORIES, MURRAY HILL, NEW JERSEY

The derivation of the threshold law for this fundamental process of mass spectrometry is an extension to three bodies of Wigner's general threshold theory[1] worked out for two bodies. It is shown that there are two factors sensitive to the energy excess:

(1) The probability of having two rather than one electron escape from the ion core,

(2) The rate of escape in a favorable configuration.

The first factor is specific to three body problems. It is obtained by assuming ergodic conditions, subject to the conservation laws. The probability of double escape is then proportional to the fraction of possible orbits in phase space leading to double escape. This fraction comes out to vary as

$$(\text{energy excess})^{\sqrt{\frac{91}{48}}-\frac{1}{4}} = (\text{energy excess})^{1.127}$$

The second factor yields no dependence on the energy excess because it is finite even at the threshold; this is in agreement with the corresponding two body reaction. The combination of the two factors thus yields a cross-section proportional to the fractional power above of the energy excess. The curve differs in appearance very little from a straight line, but it does have a noticeable upward curvature and enters the threshold point with zero slope.

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[1] Eugene P. Wigner, PHYS. REV. 73, 1002, 1948.

EFFICIENCIES OF MULTIPLE IONIZATION

Willard H. Bennett
and
Boyd W. Harned
NAVAL RESEARCH LABORATORY
WASHINGTON, D.C.

The relative efficiencies of multiple ionization for atomic gases and of the various types of ionization for molecular gases are being investigated, using a non-magnetic mass spectrometer. In this instrument all voltages are held constant while the mass spectrum is traversed by varying the frequency. For each of the various frequencies corresponding to the various e/m ratios, the trajectories of the ions reaching the collector are identical with the trajectories at each of the other frequencies for each of the respective ion species reaching the collector. Used in this way, this instrument provides an accurate measure of the relative ionization probabilities for the various ion species.

A separate tube is used for observing the total ionization cross-sections for each of the gases from which the cross-sections for each type of ionization can be computed.

Measurements have been taken up to 5 kilovolts and the tube has been re-designed in order to suppress the radiation responsible for the photo-electric background currents which otherwise occur in serious amounts at ionizing voltages above about 300 volts.

A MICROWAVE METHOD FOR MEASURING MEAN ENERGY TRANSFER PER COLLISION AND THE VELOCITY DEPENDENCE OF COLLISION CROSS-SECTION FOR SLOW ELECTRONS IN GASES

O. T. Fundingsland, A. C. Faire and A. J. Penico
AIR FORCE CAMBRIDGE RESEARCH CENTER

A microwave method previously reported[1] for determining the collision probability P_c for momentum transfer of slow electrons in gases has been modified to include modulation of the electron energy. Transient variations in σ_r/σ_i, the ratio of real to imaginary parts of the complex conductivity, are measured during the modulation pulse. The plots of σ_r/σ_i versus time are compared with theoretical curves obtained from an approximate solution to the Boltzmann Transport equation. It is assumed that the collision frequency is proportional to the h-power of electron velocity over the significant range of the distribution function for energies near thermal equilibrium with the gas. A derived relation between the exponent h and G, the mean fractional transfer of energy per collision, is completely determined by the measured values of initial slope, $\frac{d}{dt}\left(\sigma_r/\sigma_i\right)_{t\to o}$, and the initial and final values of σ_r/σ_i. In monatomic gases, where G can be assigned a value $\frac{2m}{M}$, twice the ratio of the electronic to atomic masses, the energy dependence of P_c is thus obtained for small excursions from thermal equilibrium. In polyatomic gases more elaborate curve fitting is necessary to yield unique values of both G and h. Exploratory data will be reported for neon, helium, argon and nitrogen.

[1] A. D. Phelps, O. T. Fundingsland, and S. C. Brown, PHYSICAL REVIEW 84, 559 (1951)

A NEW MICROWAVE TECHNIQUE FOR THE STUDY OF DISCHARGES IN GASES*

Murray A. Lampert** and Alan D. White
FEDERAL TELECOMMUNICATION LABORATORIES, INC.
NUTLEY, NEW JERSEY

In recent years microwave measurement techniques have been applied with notable success to the study of discharges in gases, particularly rf initiated discharges. This paper is concerned with the exploration of dc discharges by a new microwave technique.

With this technique, small regions of a dc discharge in narrow-bore tubing are exposed to a very low-power pulsed microwave signal and the resultant gas tube current pulse is monitored on a cathode-ray oscilloscope. The experiments indicate that, depending on gas pressure, there are two or three regions in noble-gas dc discharges which are sensitive to the presence of microwave power. The most sensitive region is near the cathode, the others are near the anode and Faraday dark space respectively. At low levels of incident rf power, the likeliest basis for this phenomenon is the existence of a relative potential minimum. Therefore, by this technique, the potential minima can be located and explored without the use of metallic probes. Using rectification data to determine the shape and width of the potential near a minimum is an indirect process, similar in difficulty to that involved in determining the shape and depth of a scattering potential from the observed scattering.

Results obtained with this new method are consistent with potential distributions determined by other techniques.

*This work was sponsored by the US Army Signal Corps.
**Now with RCA Laboratories, Princeton, N.J.

DISSOCIATIVE ATTACHMENT OF THERMAL ELECTRONS TO IODINE MOLECULES

Manfred A. Biondi
WESTINGHOUSE RESEARCH LABORATORIES
EAST PITTSBURGH, PENNSYLVANIA

Microwave techniques[1] are used to study electron attachment following a pulsed discharge in iodine. To assure that the electrons have thermal energies (T_e = 300° K.) during the measuring interval, helium at approximately 1 mm pressure is added to the iodine vapor to act as a "recoil gas." The measured attachment cross section is 4 x 10^{-16} cm^2. The large value of this cross section suggests that the attachment results from the dissociation reaction

$$I_2 + e \rightarrow I + I^- + K.E.$$

The present result, obtained with electrons of 0.04 ev average energy, disagrees with measurements of attachment in iodine by Buchdahl.[2] Using an electron beam of controlled energy, he found a maximum attachment cross section of 4 x 10^{-17} cm^2 for electrons of 0.4 ev energy. In view of possible errors in his measurements at low electron energies, the discrepancy between the two results may be removed.

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[1] M. A. Biondi, REV. SCI. INSTR. 22, 500 (1951).

[2] R. Buchdahl, J. CHEM. PHYS. 9, 146 (1941).

DRIFT VELOCITY OF IONS IN OXYGEN, NITROGEN, AND CARBON MONOXIDE

Robert N. Varney
BELL TELEPHONE LABORATORIES
MURRAY HILL, NEW JERSEY

Measurements of ionic drift velocities in O_2, N_2, and CO have been made by the microsecond pulsed Townsend technique previously used in these Laboratories on other gases[1,2]. The results in O_2 are similar to those for rare gases and give an extrapolated mobility at zero field of 2.25 ± 0.1 cm^2/volt-sec. In N_2 and CO, the log-log plot of drift velocity against E/p, the ratio of field strength to pressure, rises in the customary way but then takes an actual dip, spread over some 50 units of E/p, before finally resuming a monotonic increase. Data and possible explanations will be presented.

[1] J.A. Hornbeck, PHYS. REV. 84, 615, (1951).

[2] R.N. Varney, PHYS. REV. - to appear October 15 or November 1, 1952, Presented at MIT Conference on PHYSICAL ELECTRONICS, March 27-29, 1952.

THEORY OF THE MOBILITY OF He_2^+ IN HELIUM

S. Geltman*
and
H. Margenau
YALE UNIVERSITY, NEW HAVEN, CONNECTICUT

A theoretical study has been made of the low-field mobility of the helium molecular ion, He_2^+, in helium. First, the forces between He_2^+ and He are calculated by means of perturbation theory. Use of the Chapman-Enskog theory of diffusion then permits the calculation of the mobility as a function of temperature. The mobility at 18°C and 760mm. is found to be 18.1 cm^2/volt-sec. as compared with the experimental value of 21.4 cm^2/volt-sec. found by Tyndall and collaborators.[1] This experimental result was originally attributed to He^+ ions but has since been reinterpreted[2] as resulting from He_2^+ ions.

Further, the experimental temperature variation of the mobility of He_2^+ is analyzed by means of the Langevin theory of ionic mobilities. When account is taken of ionic clustering, the observed temperature dependence is understood on the basis of a simple model for the He_2^+ - He potential. The discrepancy between theoretical and experimental temperature dependence of mobility is ascribed to certain approximations in the calculated potential.

*Now at the Westinghouse Research Laboratories, East Pittsburgh, Pennsylvania.

[1]PROC. ROY. SOC., A134, 125 (1931); A149, 426 (1935).

[2]Meyerott, PHYS. REV., 66, 242 (1944); Hornbeck, PHYS. REV., 84, 615 (1951).

MOBILITIES OF THERMAL IONS IN NOBLE GASES

Lorne M. Chanin
and
Manfred A. Biondi

WESTINGHOUSE RESEARCH LABORATORIES
EAST PITTSBURGH, PENNSYLVANIA

The mobilities of positive ions in their parent gases[1,2] have been measured using modern pulsing and timing techniques. In the present experiment ions are generated by a pulsed discharge; they are then admitted through a grid into a drift region where their time of flight is measured in a constant electric field. This method permits us to measure mobilities at low values of E/p ($\sim$ 1) where the ions are essentially in thermal equilibrium with the gas in which they move. Our data indicate the presence of two groups of ions corresponding to the molecular and atomic ions of the parent gas.[2] The data at higher E/p ($\sim$ 10) agree with that of Hornbeck and extend into the low E/p region where the measured ion mobilities may be compared directly with theory.[3,4,5] Preliminary results for helium, neon, and argon will be given.

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[1] A.M. Tyndall and C.F. Powell, PROC. ROY. SOC., A134, 123 (1931).

[2] J.A. Hornbeck, PHYS. REV., 84, 615 (1951).

[3] T. Holstein, J. CHEM. PHYS., 56, 7 (1952).

[4] H.S.W. Massey and C.B.O. Mohr, PROC. ROY. SOC., A144, 188 (1934).

[5] S.Geltman and H. Margenau, Conference Paper, MOBILITY OF He_2^+ IN He.

THE QUENCHING OF MERCURY RESONANCE RADIATION (2537Å) BY NITROGEN

C. G. Matland
WESTINGHOUSE RESEARCH LABORATORIES
EAST PITTSBURGH, PENNSYLVANIA

The experimental techniques developed for the measurement of the imprisonment time of mercury resonance radiation[1] have been used to determine the cross section for a quenching collision between a nitrogen molecule and an excited mercury atom in the 6^3P_1 state. It has been shown[2] that such collisions result in transitions of the excited mercury atom from the 6^3P_1 state to the metastable 6^3P_o state. As a result of the reduced population of the 6^3P_1 state, the resonance radiation is effectively quenched.

Mercury vapor, in the presence of a known pressure of nitrogen gas, is excited by 2537Å radiation. After the source of excitation is cut off, the decay time of the imprisoned radiation is observed. The quenching collision cross section σ_Q is calculated from the measured decay time and the known value of the imprisonment time in the absence of a foreign gas.[2] Measurements have been taken over the temperature range 325-525°K; σ_Q is found to increase from 0.6×10^{-16} cm^2 at the lower temperature to 1.1×10^{-16} cm^2 at the upper temperature.

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[1] D. Alpert, A.O. McCoubrey and T. Holstein, PHYS. REV. 76, 1257 (1949).

[2] See for example, A.C.G. Mitchell and M.W. Zemansky, RESONANCE RADIATION AND EXCITED ATOMS (The Macmillan Company, New York, 1934) p. 250.

Friday, September 5

2:00 P.M. RCA Laboratories

SESSION D

FUNDAMENTAL PROCESSES AND MECHANISMS OF GASEOUS DISCHARGES

Chairman: E. O. Johnson
RCA Laboratories

FREQUENCY SPECTRA FROM POINT-TO-PLANE CORONA

Fred E. Luborsky
and
Stanley I. Reynolds
GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

The corona characteristics in a point-to-plane gap have been studied with direct and with alternating voltage applied. The frequency spectra of corona currents and voltages from 500 cycles/sec. to 10 megacycles/sec. have been obtained for this gap under various conditions. The corona level of these spectra all start to decay in the range of 100-900 kilocycles/sec., except in pure nitrogen. These curves are discussed in terms of the pulse shape which might generate such a frequency distribution.

As the voltage across the gap is raised, the corona noise starts abruptly. This voltage corresponds to the corona threshold. The corona threshold was found to decrease with increasing humidity or decreasing gap.

A linear relation was found between the current and the voltage function $V(V-V_o)$ in agreement with the results of previous investigators. The corona power dissipated in these gaps was calculated from the frequency spectra and found to be negligible compared to the power loss at the applied frequency. The avalanche size was calculated from the observed noise levels as a function of voltage. The size of the avalanche increased exponentially with voltage. Low frequency oscillations between the positive point-to-plane in air were found, and studied as a function of voltage and gap distance. These oscillations were shown to be associated with the high field region adjacent to the point.

NEW DATA ON POSITIVE AND NEGATIVE POINT-TO-PLANE CORONA*

Leonard B. Loeb and M. R. Amin
DEPARTMENT OF PHYSICS
UNIVERSITY OF CALIFORNIA, BERKLEY, CALIFORNIA

Through the data reported by Geballe and Harrison on dissociative attachment of electrons in O_2 at the 1951 Conference it has been possible to clarify the incredibly short rise and decline of the Trichel pulse of 4×10^{-8} sec in air reported by W. N. English[1] from photomultiplier studies. This leads to rough basic relations accounting for most of the past mysteries of the Trichel pulse mechanism. Application of fast oscillographs to electrical and photomultiplier studies of the positive burst pulse corona in room air reveals that the previous pulses[2,3] observed lasting a millisecond with 10^9 ions are composed of an initial pulse lasting 2×10^{-7} sec with 10^7 ions followed by a succession of short pulses of 10^6 ions. The first pulse is one that spreads over the whole point. The smaller pulses are the pulses occurring following short dead times where space charges have cleared from a section of the point. These pulses continue until after a millisecond the gap is so badly fouled that the discharge ceases. Measurement of ion crossing or clearing times reveal them in milliseconds. The data from both polarities indicate short dead times for individual pulses while clearing times are in milliseconds. These observations bring Geiger counter action and burst pulses into close relationship.

* These studies have been supported by the Office of Naval Research.

1 W. N. English, PHYS. REV. 77, 850 (1950).

2 W. N. English, PHYS. REV. 74, 170 (1948).

3 A. F. Kip, PHYS. REV. 55, 549 (1939).

SIMILARITY CONDITIONS OF HIGH PRESSURE DISCHARGES

W. Elenbaas
N. V. PHILIPS' GLOEILAMPENFABRIEKEN
EINDHOVEN, HOLLAND

We will consider:

A) High pressure discharges in long closed tubes (wall stabilized);

B) Long open arcs (convection stabilized);

C) Short arcs (electrode stabilized).

The energybalance equation for every volume element may be written as: electrical input = radiation loss + conduction loss ± convection loss.

The losses by diffusion of electrons and ions and by dissociation have been neglected; this being permissible if the pressure is sufficiently high. In case A) the convection loss may be neglected, whereas in case B) the convection loss is the main loss and the other losses may in the main be neglected. In case C) the radiation loss and conduction loss are again the main losses. The boundary conditions are also different for the three cases. For case A) equal wall temperatures are required; in case B) the convection determines the boundary of the discharge, whereas in case C) the electrode configurations must be the same. From eq. (1) and the boundary conditions we obtain the following similarity conditions:

Case A)

1) Equal inputs per cm of length.
2) Equal amounts of gas per cm of tube length.
3) Equal wall temperatures.

Case B)

1) Equal inputs per cm of length.
2) Equal Grashofnumbers (in which the electrode distance figures as the characteristic length).

Case C).

1) Equal inputs per cm of length.
2) Equal values of pl^2 (p = pressure; l = electrode distance).
3) Equal electrode configurations.

A ROCKET MEASUREMENT OF UPPER ATMOSPHERE DENSITY BY PASCHEN'S LAW*

Haldon L. Smith and Harold C. Early
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

A measurement of ambient atmospheric density has been obtained utilizing the principle of Paschen's law in connection with a specially designed spark gap incorporated into the nose of an Aerobee rocket. The reliability of a spark breakdown technique as applied to a density determination was checked by several tests, including measurements taken in a large vacuum chamber. Investigations were made into the statistical deviation from the mean calibration curve, the consequences of initial ionization and ozone, and the effects of wind.

A rocket-borne gap was developed for which the breakdown path was parallel to the surface of the nose cone. The gap section consisted of a series of alternate metal and dielectric segments assembled in a laminated fashion. The Paschen's law data obtained compares favorably with data derived from Alphatron pressure gages included in the instrumentation.

*Sponsored by the Air Force Cambridge Research Center.

Saturday, September 6

9:00 A.M. Frick Hall

SESSION E

SURFACE PHENOMENA

Chairman: R. A. Varney
Bell Telephone Laboratories

EFFECT OF ADSORPTION OF COMMON GASES ON ELECTRON EJECTION BY NOBLE GAS IONS

Homer D. Hagstrum
BELL TELEPHONE LABORATORIES, MURRAY HILL, NEW JERSEY

Measurements have been made of the effect of adsorption of H_2 and N_2 on total yield (γ_i) and kinetic energy distribution of electrons ejected from atomically clean W by He^+ and Ne^+ ions. Measurement of the rate of adsorption of adsorbable impurities introduced with the noble gas, or otherwise present in the apparatus, show the monolayer of nitrogen to be 98% pure N_2 with He present, 92% pure N_2 with Ne present. The hydrogen monolayer is observed to contain about 1/3 the number of molecules of the nitrogen layer. Its purity is correspondingly reduced. H_2 and N_2 adsorption rates were adjusted to a monolayer adsorption time of 10 minutes. The monolayer adsorption time for residual gases in the apparatus, no gas being admitted, was greater than 10 hours. Adsorption of a monolayer of H_2 reduced γ_i (He^+) by 10%, γ_i (Ne^+) by 18%. Adsorption of a monolayer of N_2 reduced γ_i (He^+) by 18%, γ_i (Ne^+) by 23%. Adsorption of either H_2 or N_2 reduced the relative number of fast electrons ejected by either He^+ or Ne^+. Ions of 200 ev kinetic energy were employed throughout the experiment.

A HIGH VACUUM, HIGH SPEED ION PUMP

John S. Foster
UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA

A vacuum pump has been developed in which residual gas particles are ionized and delivered to a higher pressure region by magnetic and electric fields. The active element is a P.I.G. type discharge, using a hot cathode, and a magnetic field of about 1300 gauss. Pumping speeds of more than 3000 liters per sec. and a base pressure of 10^{-6} mm have been obtained. At present the highest starting pressure is about 10^{-2} mm. No backing pump is required for a gas flow of less than 0.02 cc/sec. (NTP), if the noble gas contamination is small. Operation is automatic, and continuous running has been obtained for a period of at least two weeks.

E. 3.

SPUTTERING AT LOW ION VELOCITIES

G. Medicus and G. Wehner
WRIGHT AIR DEVELOPMENT CENTER
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

Below 100 volts ion velocity the sputtering rate is so small that conventional measuring methods are not sensitive enough to collect reliable data in reasonable time. Langmuir's method of measuring the decrease of emission is confined to the case of Th on W. The method described in the accompanying paper[1] makes it possible to study sputtering of bulky materials down to 40 volts ion velocity within hours. Very thin deposits of foreign material on the probe (1/1200 of a monolayer), not yet detectable by changes in the work function, cause marked changes of the reflection coefficient for collected electrons however, and are indicated in the probe characteristic above plasma potential. This method was used to increase the sensitivity for sputtering measurements by another order of magnitude. Preliminary results for Pt in Xe indicate no sputtering threshold. Between 60 volts and the measuring limit of 25 volts, sputtering decreases nearly exponentially with decreasing ion velocity. This is not in agreement with Langmuir's[2] sputtering theory which would predict no sputtering below a 140-volt threshold.

---

[1] G. Wehner and G. Medicus, CONFERENCE ON GASEOUS ELECTRONICS, Princeton, N.J., September, 1952.

[2] K.H. Kingdon and Irving Langmuir, PHYS. REV. 22, 148, 1923.

E.4.

INVESTIGATION OF CATHODE SPUTTERING BY MEANS OF PROBE MEASUREMENTS

G. Medicus and G. Wehner
WRIGHT AIR DEVELOPMENT CENTER
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

The parallel shift of a probe characteristic along the voltage axis by changes of the work function of the probe is a very sensitive means of detecting and measuring thin layers of foreign material on a Langmuir probe. Under certain conditions layers of foreign material down to 1/100 monolayer can be measured. The foreign matter is sputtered onto the probe from a small electrode in its vicinity. It is difficult to reach the degree of purity necessary to avoid "creeping" of the probe characteristic. However, it was possible, thus far, to keep the work function of a pure W-probe and the plasma potential of a low voltage rare gas discharge constant within 0.01 volt for hours by means of a new bakeable high vacuum valve and by conventional cleaning processes (baking, glowing, and sputtering). Sputtering of different materials in different gases, as a function of gas pressure and ion velocity, is being studied.

CLEANUP OF HELIUM GAS IN AN ARC DISCHARGE

M. J. Reddan
NATIONAL BUREAU OF STANDARDS, WASHINGTON, D.C.

Studies of the cleanup of helium gas by cylindrical metal probes placed in an arc discharge have been continued. Data on nickel and molybdenum will be presented.

Tube design and the experimental procedures followed were influenced by the following facts:

1. A movable probe permits trapped gas to be recovered from the probe without affecting gas which is trapped on the walls nearby.

2. A certain amount of sputtering from the probe is unavoidably present.

Measurements of cleanup produced by ion impact on the probe have been made. The effect was studied by measuring the total amount of gas driven from the probe at the conclusion of a cleanup run. It was found that the rate of cleanup is time dependent, and decreases rapidly during a given run.

Although primary interest has been centered on the impact effect, considerable attention was devoted to the role played by sputtering in gas cleanup. The amounts of gas recovered from the sputtered material were recorded, and provisions were made to measure and control the potential of the sputtered layer.

ON THE THEORY OF THE HIGH FREQUENCY SECONDARY ELECTRON RESONANCE DISCHARGE MECHANISM*

Albert J. Hatch and H. Bartel Williams
NEW MEXICO COLLEGE OF AGRICULTURE AND MECHANIC ARTS
STATE COLLEGE, NEW MEXICO

New developments in the theory of the low pressure high frequency secondary electron resonance breakdown mechanism will be presented.

The first of these is a re-interpretation of the simple algebraic resonance theory. One of the previous assumptions in this theory was that the ratio of the electron arrival velocity to the electron emission velocity was a constant, $k = v/v_o$. It will be shown that k is not a constant but a function of several parameters, including the electrical phase angle, ϕ, at which the secondary electrons are emitted. As a result the algebraic theory actually describes electron resonance for a wide range of ϕ values (for a given set of parameters) rather than for a single value of ϕ.

Another development is the establishment of a criterion for this breakdown mechanism. This criterion leads to a more complete description of the discharge mechanism than the algebraic resonance theory. Application of this criterion to the calculation of breakdown field strength has not been completely successful, however, partly because of incomplete accurate knowledge of secondary emission characteristics.

*Supported by the Navy Bureau of Ordnance.

CONFIRMATORY MEASUREMENTS IN THE HIGH FREQUENCY SECONDARY ELECTRON RESONANCE DISCHARGE MECHANISM*

H. Bartel Williams and Albert J. Hatch
NEW MEXICO COLLEGE OF AGRICULTURE AND MECHANIC ARTS
STATE COLLEGE, NEW MEXICO

Electron multiplication in the high frequency secondary electron resonance breakdown mechanism at low pressures is believed to occur primarily by secondary electron emission at the electrode surfaces. Two sets of measurements which partially confirm this type of electron multiplication will be described.

The first set of measurements was of the arrival electron energy required to give $\delta = 1$ for gassy surfaces. For aluminum and copper these values were as low as 30 and 23 electron volts, respectively, and confirmed early literature on secondary emission.

The second and more important set of measurements was of the actual electron arrival energies under conditions of incipient discharge. Observed values of arrival energy were greater than required to give $\delta = 1$. The experimental procedure will be described. Results will be presented and compared with values predicted by the theory.

* Supported by the Navy Bureau of Ordnance.