I. PHYSICAL ELECTRONICS

Prof. W. B. Nottingham
S. Aisenberg
W. M. Bullis
D. H. Dickey
J. D. Hobbs
J. M. Houston
W. J. Lange
W. J. O'Brien
L. W. Sprague
L. W. Swenson

A. ELECTRON EMISSION PROBLEMS

1. Energy Dependence of Electron-Produced Poisoning of Oxide Cathodes

The cathode poisoning effect to be studied in this project results from the decomposition of anode surface deposits in tubes containing oxide cathodes. This decomposition occurs when the cathode is bombarded by electrons. The initial problem has been to design and construct a tube suitable for the study.

In this tube it is necessary to separate the bombarding process from the emission tests. The energy of the electrons must be controlled accurately while a constant cathode-anode potential is maintained; the emission tests themselves must not cause any further poisoning of the cathode, otherwise every measurement will be only a measurement of the effect of the electron energy of this constant voltage.

A tube has been designed and constructed to satisfy these conditions; a tube in which two tungsten filaments as well as the cathode are used as emitters. The cathode is also used in activation to create anode surface impurities. One filament is used as an emitter for the bombarding process; during this process the cathode and second filament, while kept hot, are at floating potentials. These latter electrodes become poisoned by the products of decomposition. The energy of the bombarding electrons can be controlled and the time of bombardment made standard. With the bombarding filament at floating potential, the emission from either the poisoned cathode or second filament may be measured. From these measurements the energy dependence of the poisoning effect may be studied.

J. D. Hobbs, L. W. Swenson

2. Emission as a Function of Activation of an Impregnated Oxide Cathode

The constants in the Richardson equation are to be measured for an impregnated cathode obtained from the Raytheon Manufacturing Company. The apparatus and circuitry have been assembled. To date, no measurements have been made.

W. J. O'Brien

B. THEORY OF GAS DISCHARGES

1. Ambipolar Diffusion and Ionization in a Plasma

The problem of ambipolar diffusion in a cylindrical gas discharge tube is being investigated theoretically with particular attention to the case of both direct ionization and cumulative ionization (which is due predominantly to ionization of metastables). For the purpose of simplification, the density of metastable states was assumed to be proportional to the electron density. This assumption is not strictly true and will be investigated further.

The resulting second-order nonlinear differential equation for the electron density contains a parameter τ, which is a measure of the relative importance of cumulative ionization as compared to direct ionization. The solution of the differential equation was expanded in a power series where the coefficients are functions of τ. The requirement that the electron density shall be approximately zero at the tube wall makes it possible to connect the first zero, z_o, of the solution of the differential equation with the ambipolar diffusion coefficient, the frequency of direct ionization, and the tube radius. The first zero as a function of τ was calculated to about 1 percent by inversion of the series solution of the differential equation. It is now possible to express the relative importance of direct and cumulative ionization in terms of the ampipolar diffusion coefficient, the direct ionization frequency, and the tube radius, subject, of course, to the assumptions previously mentioned. An attempt is being made to formulate a practical and sensitive experiment to test the validity of the theory and the assumptions.

S. Aisenberg

C. EXPERIMENTAL STUDIES

1. Clean-Up and Diffusion of Helium in Ionization Gauges

It has been shown experimentally that helium diffuses through pyrex at a rate that depends on the temperature. Helium has been found to clean up in an ionization gauge at a rate proportional to the number of ions produced by electron bombardment in the gauge. These facts may be expressed in equation form as

$$\frac{dN}{dt} = -a\,i\,N + D$$

The first term states that the clean-up is proportional to the electron current i and the number of atoms present, and the second term expresses the rate of arrival of atoms by diffusion which is constant at a given temperature. The solution of the above equation is

$$(N - N_\infty) = (N_o - N_\infty)\exp(-ait)$$

where N_o is the number of helium atoms present at the beginning of a clean-up run, time $t = 0$, and $N_\infty = (D/ai)$ is the number present when the clean-up rate is just equal to the diffusion rate.

A plot of $\ln(N - N_\infty)$ as a function of time should result in a straight line of slope $-ai$.

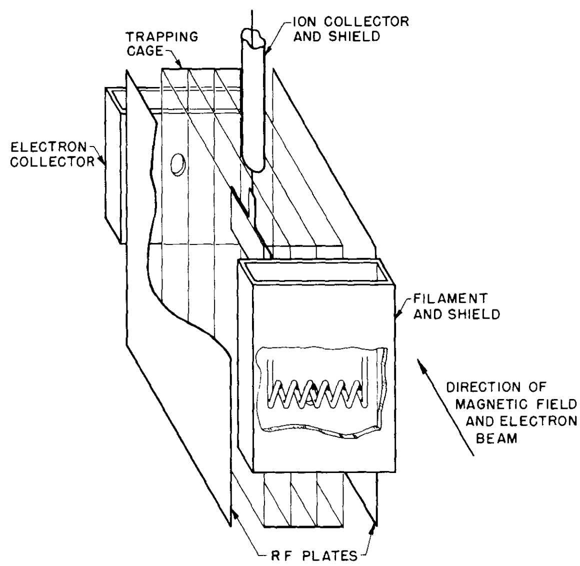

Fig. I-1
Omegatron.

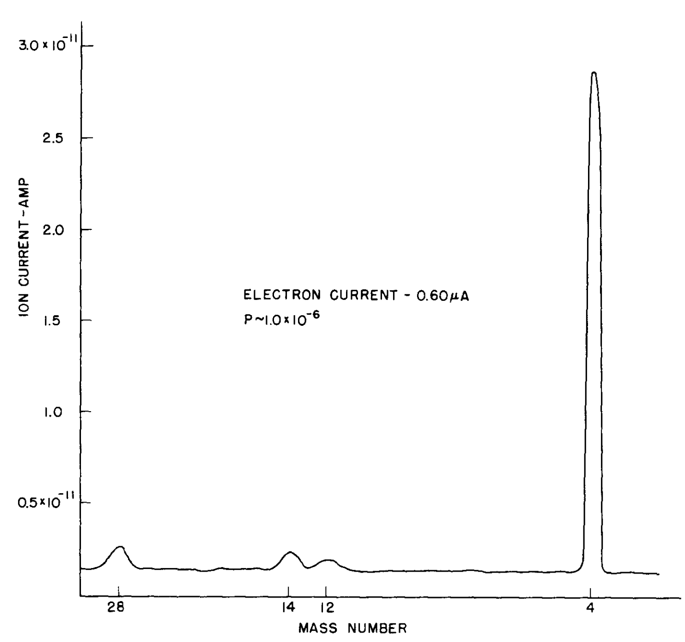

Fig. I-2

Experimental results are in fair agreement with this theory. Systematic variations are observed and are now being investigated in detail.

D. H. Dickey

2. Vacuum Studies

The use of a Brown recorder and a motor-driven oscillator has simplified the study of the operation of an omegatron. Although this research is not completed, it has progressed to the point where we feel that the omegatron can be used in the study of certain vacuum problems. Figure I-1 shows the omegatron as we have constructed it. Best operation has been achieved with all electrodes at the same potential as the ion collector, except the filament, which is about 100 volts negative, and the wire grid trapping electrode, which is 0.75 volt positive. The function of this last element is to constrain the ions to the region in which the ion collector is located. The magnetic field is about 3200 gauss, the electron current is around 1 μamp, and the rf voltage is 1 volt or less. Figure I-2 shows a scan of the mass range from 3 amu to 30 amu. The scale has been adjusted to make the helium peak fall at exactly 4 on the mass scale, the helium having been admitted to the system for reference.

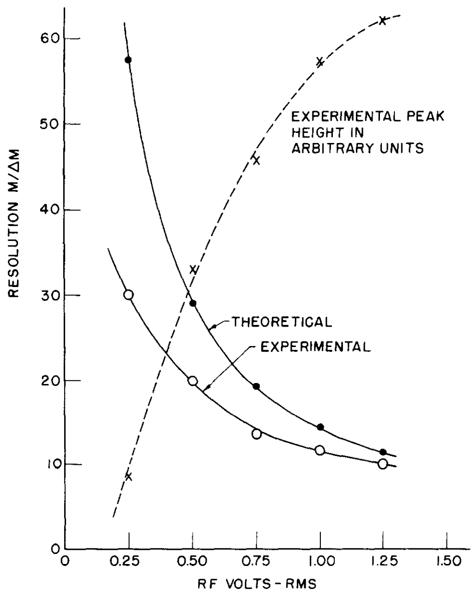

Fig. I-3

Helium resonance peak variation with rf voltage.

A study of the effect of rf voltage on the helium resonance peak is shown in Fig. I-3. This figure is somewhat misleading in that we have found that the effect of operating at too high an electron current is to distort and even split the peaks. Disagreement between theory and experiment is believed to be due to the fact that the electric and magnetic fields are not ideal.

W. J. Lange