Preliminary experimental work directed toward this end is underway. Details of the calculations of quadrupole interactions in fields of axial symmetry will be published elsewhere.

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Double-Probe Method for Determination of Electron Temperatures in Steady and Time-Varying Gas Discharges

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THE single-probe method of Langmuir and Mott-Smith[1] is not well suited for measurements in time-varying discharges and in particular not in decaying plasmas following the interruption of a discharge. In the latter case this follows from the fact that efforts to operate the probe above plasma potential are defeated by the fact that the plasma potential constantly recedes so as to maintain itself positive with respect to the probe. The use of two probes connected in a floating circuit overcomes the difficulties of the single-probe method and permits the determination of such quantities as electron temperature and density in both steady and time-varying discharges. Dow[2] has described a double-probe method for determining the electron temperature in the ionosphere. He appears to do this from values of i_e very close to the regions of V_{D1} or V_{D2} only (see Fig. 1). In these regions, the method appears to be less accurate and uses data which are generally discarded in the method here described.

Two probes are connected together through a resistor and a variable potential source V_B. The entire measuring system is permitted to float. By means of a scope across the resistor, the instantaneous current I_D can be determined. In practice one varies V_B and determines I_D and V_D, the potential difference between the probes.

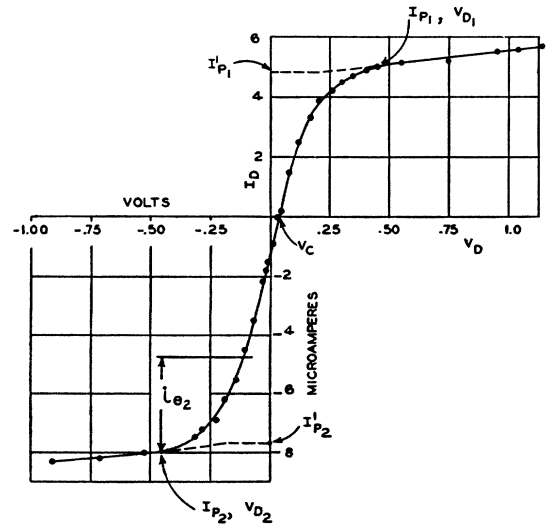

FIG. 1. Current *vs.* voltage characteristic of floating double-probe system immersed in plasma.

A typical plot is shown in Fig. 1. These data were obtained in an argon-filled hot-cathode diode, 100 μsec. following the interruption of a discharge.

From the equality of the total electron and ion currents to the probes, it follows that:

$$\left(\frac{I_{p1}+I_{p2}}{ie_2}-1\right)=k\exp[-11{,}600(V_d/T_e)]=\Gamma, \tag{1}$$

where

$$k=(A_1/A_2)(j_{01}/j_{02})\exp[+11{,}600(V_c/T_e)]. \tag{2}$$

A_1 and A_2 are the areas of probes 1 and 2. j_{01} and j_{02} are the random electron current densities at probes 1 and 2. ie_2, the electron current to probe No. 2, is equal to the difference between I_d and I_{p2}. The other symbols are defined in Fig. 1. The slope of log Γ *vs.* V_d yields T_e. Figure 2 is a plot of (1) for the data of Fig. 1. For this case, $T_e=1065°$K. The linear regions beyond I_{p1} and I_{p2} in Fig. 1 correspond to saturated ion current only, to one probe or the other. Since the current to one of the probes in these regions is purely ionic, the current flow is generally determined by space charge and not by orbital-limited-current relations.[1]

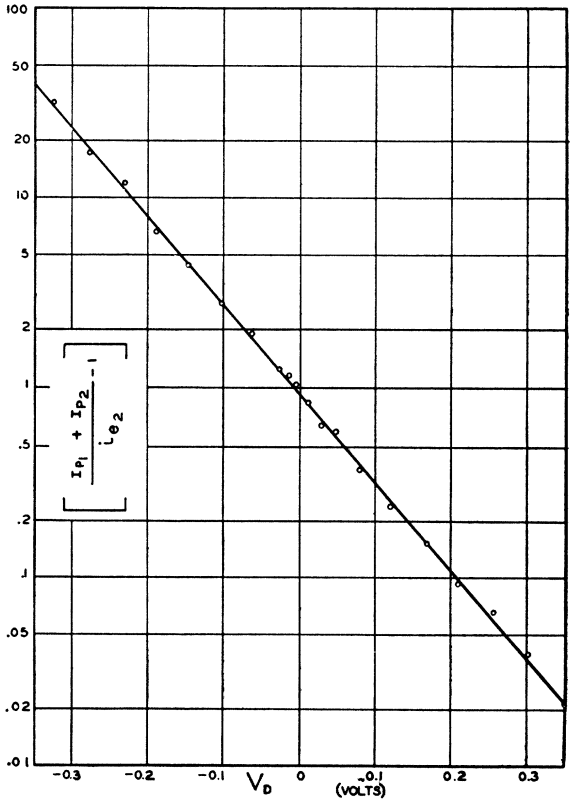

FIG. 2. Logarithmic plot for determination of electron temperature.

A more rapid determination of T_e can be obtained from Fig. 1, and the relation

$$T_e=11{,}600G(1-G)(dV_d/dI_d)V_{d=0}(I_{p1}+I_{p2}), \tag{3}$$

where

$$G=\frac{[ie_2]V_{D=0}}{I_{p1}+I_{p2}}. \tag{4}$$

If the slope of the regions of positive ion saturation is considerable, then in place of I_{p1} and I_{p2} one uses quantities obtained as follows: Extend the positive ion saturation curves linearly as shown in Fig. 2 and use for I_{p1} and I_{p2}, the ordinates at points $\frac{2}{3}$ of

the horizontal distance between the points of saturation (V_{D1} and V_{D2}) and the wall potential condition ($V_D = V_c$). These points are designated as I'_{p1} and I'_{p2} in Fig. 2. For the case of Fig. 2 this short method yields $T_e = 1025°K$.

[1] I. Langmuir and H. M. Mott-Smith, Gen. Elec. Rev. **27**, 449 (1924).
[2] W. G. Dow, Phys. Rev. **76**, 453 (1949).

Tests of Self-Regenerating Fillings for Geiger Counters

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ONE of the serious difficulties which faces the users of Geiger counters of the self-quenching types, is that the operating conditions change with time. This effect is due to the progressive decomposition of the quenching vapor. In the end enough vapor is decomposed so that the counter becomes useless. Unfortunately, this decomposition is a necessary concomitant of the quenching mechanism.[1] It has therefore seemed worth while to examine possible vapors with a view to seeking any which might show a synthesis as well as a decomposition in the discharge. Since it is well known that ammonia can be made by the Haber process, and since this gas will also produce self-quenching action in counters, some counters were filled with this gas and tested.

Some of these counters have now been in continuous use for over two years, operating, except for occasional unavoidable interruptions, at as high counting rates as possible. They have recorded some 3×10^{10} counts. These results appear consistent with the original hypothesis that the ammonia molecule is not only decomposed in quenching but is resynthesized in the active part of the discharge.

Counters were tested which were one cm in radius, 8 cm long, with 4 mil tungsten central wires, and filled to a total pressure of about 15 cm Hg with 80 percent ammonia and 20 percent argon. Another set with only ammonia (no argon) was also run. Cathodes of evaporated silver, evaporated copper, solid copper, aquadag, and nickel were tried. Counters containing 10 cm ammonia only operated at around 1200 volts with plateaus of some 100 to 125 volts, i.e., operating characteristics were comparable to those usually found with the conventional argon-alcohol fillings, although the latter sometimes have longer plateaus. At pressures of 5 cm of ammonia, the operating voltages are 850 to 900 and the plateaus 50 to 75 volts in length. Adding argon gives shorter plateaus but lower starting potentials.

These counters exhibited two interesting characteristics. First, the counters seem to show an increase in background during a long run. This background may be due to a large number of spurious counts. In some cases the background increases very much. However, if the counter is allowed to "rest" for a while, the background returns to normal. This effect has been noted also by Simpson.[2] Of the counters tested, those with aquadag cathodes recovered the fastest.

The second characteristic of these counters was an increase in photo-sensitivity. The counter with the aquadag cathode became photo-sensitive after some 3×10^8 counts, the one with solid copper cathode after 1.5×10^8 and that with nickel after 10^9 counts. The photo-sensitivity remained after "rest" periods. In one case, to see whether this sensitivity would decrease with time, a counter was taken out of the run; it is still photo-sensitive after ten months "rest." This photo-sensitivity extends to yellow and in two cases to red light.

The experiments are being continued and will be reported in detail at a later date.

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[2] J. A. Simpson (private communication).

Reproducibility of Photo-Neutron Standards

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THE construction of two nearly identical radium beryllium photo-neutron standards has given us an opportunity to ascertain the degree of reproducibility which can be expected in making standards of this type. These standards were constructed following the suggestion of Gammertsfelder and Goldhaber[1] by enclosing a capsule of compressed radium containing approximately 1 gram of radium in the center of a beryllium sphere 4.00 cm in diameter. Each of the two spheres was turned and the two halves threaded to have the same dimensions to within ±0.0001 inch. The radium was enclosed in a sealed capsule of platinum-iridium having walls 0.2 mm thick. The external dimensions of the capsules, which were right cylinders, are 0.84 cm in diameter and 0.86 cm in height. The capsules were mounted in the geometrical center of the sphere in cavities machined just large enough to accept them, as shown in Fig. 1. These standards are prepared for

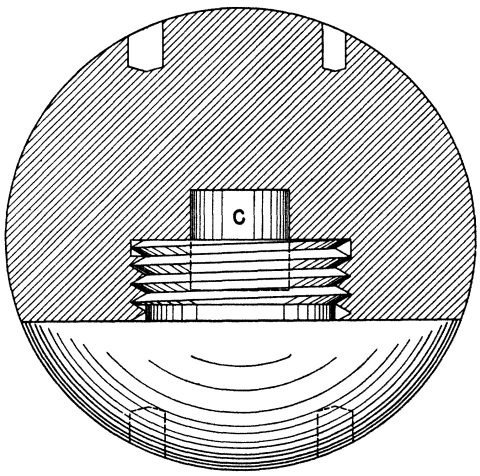

FIG. 1. Primary photo-neutron standard consisting of a 4-cm diameter beryllium sphere with 1-gram capsule of radium (*C*) at the center.

the purpose of serving as a national primary standard for measurement of sources of neutrons. They were made in duplicate so that one may be retained at the National Bureau of Standards as a reference source and the other loaned for comparison measurements when this seems desirable.

Although the radium capsules were made as nearly identical as possible it was found that from measurement of the external gamma-radiation the amount of radium contained in each after completion was not quite the same. In each case the radium salt had been compressed to maximum density. The ratio of the radium contents for standard I to standard II was found to be

$$I_\gamma/II_\gamma = 0.9897 \text{ with std. dev.} = 0.052 \text{ percent.}$$

After assembly in the beryllium spheres the ratio of the neutron intensity emitted by these sources was determined. These measurements were made by means of a long counter made in accordance with the procedure described by Hanson and McKibben.[2] The counter tube was filled with B^{10} enriched BF_3. For each measurement the standard was mounted on a base provided with pins which fitted into small holes in the beryllium sphere. This base was mounted at a fixed position on the axis of the neutron counter at a distance of approximately 21 cm. Therefore, it was comparatively easy to interchange the two standards for observations and have them at the same distance from the detector. The support was arranged so that the sources could be rotated about their vertical axes and measurements were repeated for each 90° of rotation to correct for any lack of symmetry. The