inhibition of the losses due to a radial conducting limiter, such as the anode, could also be considered.[5] In view of the necessary approximations made in the evaluation of T, n, σ_{ee}, σ_{eN}, and ∇n, it is encouraging to find agreement between $v_{\rm exp}$ and $(v_p + v_D)$ to within such a small factor. The strength of our deductions lies in the variation with B ($v_{\rm exp} \propto B^{-2}$, not B^{-1}) rather than the absolute magnitude of $v_{\rm exp}$. At a first glance, our results support a classical diffusion behavior in the afterglow, which is in agreement with other experiments.[6-8] However, the variation range of B is too small for a decisive conclusion on the absence of anomalous diffusion, and an extension up to 2000 gauss, with another set of coils, is planned.

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†Now on leave of absence from Saclay, France.

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MEASUREMENT OF THE THERMOELECTRIC POWER OF A FULLY IONIZED, LOW-TEMPERATURE PLASMA*

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During the progress of an experiment on an alkali-metal plasma (the Q-1 device[1]), it was found possible to measure the Seebeck coefficient, or the thermoelectric power,[2] of the plasma. The purpose of this note is to describe the measurement and to compare the result with a calculation based upon an approximate theory. Figure 1 shows a schematic of the apparatus. The plasma is generated by allowing a collimated beam of alkali-metal neutrals, in this case potassium, to impinge upon a hot tungsten plate. The neutral atoms are singly ionized on contact and, together

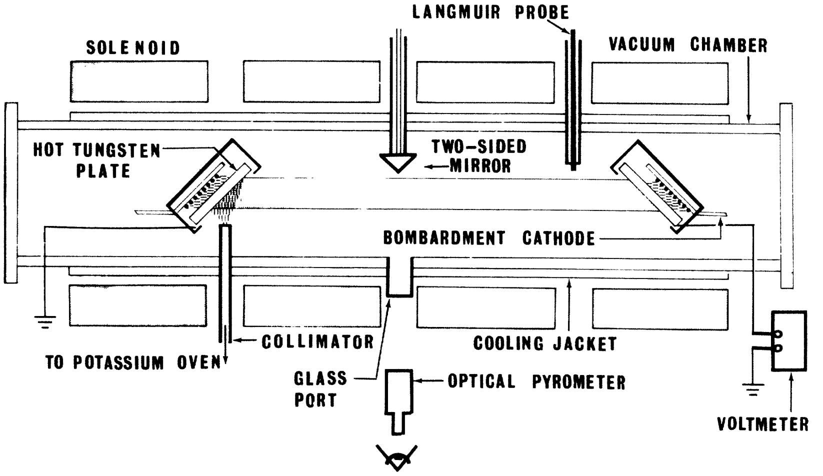

FIG. 1. Schematic of the Q-1 device as used in the measurement of the Seebeck coefficient. The tungsten plates were heated by electron bombardment.

with electrons that are thermionically emitted from the plate, form a neutral plasma. The plasma is confined radially by a strong magnetic field (4000 gauss for these measurements) and axially by the hot plates. The vacuum chamber walls are cooled to a temperature low enough to condense the neutral potassium, thereby insuring virtually 100% ionization. The plasma column was 2 cm in diameter and one meter long. The plasma density was 5×10^{11} cm^{-3} and may be assumed constant throughout the column. One of the plates was electrically grounded and the other allowed to float. The potential of the floating plate was measured with an electrometer type voltmeter. The resistance to ground from this plate was of the order of 10^5 ohms while the plasma resistance was of the order of 3 ohms. The plate temperatures were measured by means of a two-sided mirror and a Leeds and Northrup optical pyrometer.

Lewis and Reitz[3] have calculated the Seebeck coefficient of a partially ionized cesium plasma using formulas derived by Wilson. Following their procedure, in reference 2, p. 204, the following relation for the absolute thermoelectric force per degree is given:

$$S=(K_2-\zeta K_1)/eK_1T, \qquad (1)$$

where ζ is the thermodynamic potential given by

$$\zeta=kT\ln[\tfrac{1}{2}nh^3(2\pi mkT)^{-3/2}] \qquad (2)$$

for a Maxwellian velocity distribution of electrons of density n. For T, we may use the average of the two plate temperatures. From reference 2, page 7,

$$K_s=\frac{2^{\frac{1}{2}p+2}\mu n}{3\pi^{1/2}M^{\frac{1}{2}p+1}}(kT)^{s+\frac{1}{2}p-1}\Gamma(s+\tfrac{1}{2}p+\tfrac{3}{2}). \qquad (3)$$

The quantities μ and p have entered into the calculation because the Boltzman equation has been solved by assuming that the velocity distribution function is almost Maxwellian, and that there is a relaxation time

$$\tau=\mu c^p,$$

where c is the electron velocity. Spitzer[4] has shown that for a fully ionized plasma, p has a value of 3. Equation (1) becomes

$$S=(k/e)\{5-\ln[\tfrac{1}{2}nh^3(2\pi mkT)^{3/2}]\}, \qquad (4)$$

or, for the plasma under consideration, with $T=2800$°K,

$$S=24.9k/e=2.14\times10^{-3}\text{ volt/degree.}$$

The measurements were taken by maintaining the grounded plate at a fixed temperature, T_c, while varying the temperature of the floating plate. The resulting voltage is due to the emf of the thermocouple junctions formed by the plasma, the tungsten plates, and the various conductors leading to the voltmeter. However, since the thermoelectric power of a plasma is much greater than that of metals,[3] the net voltage is the absolute thermoelectric force of the plasma well within the error of the measurements, which was of the order of 4 or 5%. The experimental results are plotted in Fig. 2 against the temperature difference, ΔT, between the plates. That zero voltage did not occur at zero temperature differential was attributed to a small difference in the reflectivities of the two sides of the mirror. As a check of experimental conditions, after the measurements were taken, the plasma density was varied while plate temperatures

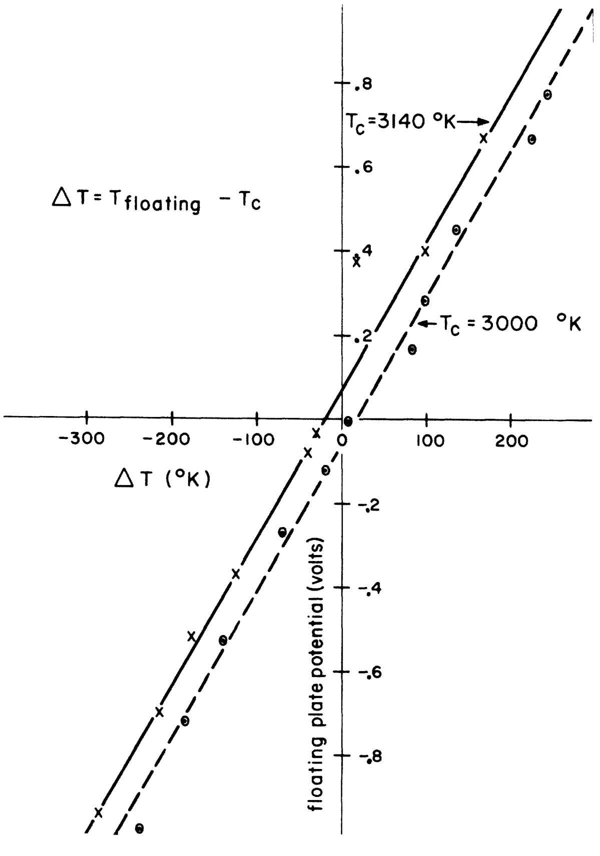

FIG. 2. Plot of the plasma thermocouple potential as a function of temperature difference.

were held constant. The small change in the floating plate voltage was much less than that caused by the temperature difference between the plates. The slope of the striaght lines fitted to the experimental points give a value for S of 3.81×10^{-3} volt/degree, for a ratio of measured to calculated values of 1.78. This is as good an agreement as one could expect because of the approximations made in the theory. The value obtained from the experiment also compares favorably with the value of 2.06×10^{-3} volt/degree calculated from Eq. (5) of reference 3.

The writer would like to acknowledge discussions with J. M. Dawson and A. Lenard.

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VARIATION OF THE ELECTRON DENSITY ALONG A PLASMA COLUMN

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In connection with studies of noise radiation and scattering from a plasma column,[1] it was found that there can be an appreciable variation in the electron density along a plasma column. The experimental studies of this effect have been carried out by using a hot-cathode, low-pressure, mercury discharge tube in which the plasma column had a length of 140 cm and a diameter of 13 mm. The wall thickness of the glass tube surrounding the plasma was 1.4 mm, and the variation of the diameter of the glass tube was less than 4%. The mercury gas pressure was controlled by the temperature of the mercury, and the glass tube surrounding the plasma was kept at a higher temperature than that part of the tube which contained liquid mercury. The temperature of the mercury could be varied from 10 to 60°C corresponding to a pressure variation from 0.5×10^{-3} to 25×10^{-3} mm Hg. The electron density was measured by means of the microwave cavity method; the cavity, which operated in the TM_{010} mode, could be moved along the plasma tube.

Figures 1, 2, and 3 show the electron density as a function of the distance from the cathode for three different temperatures of the mercury bath with the beam current as parameter. Strong low-frequency oscillations may occur in the plasma under certain conditions. The data shown in the figures were, however, obtained under conditions of very low or no oscillations in the electron density.

At low plasma densities, the frequency shift

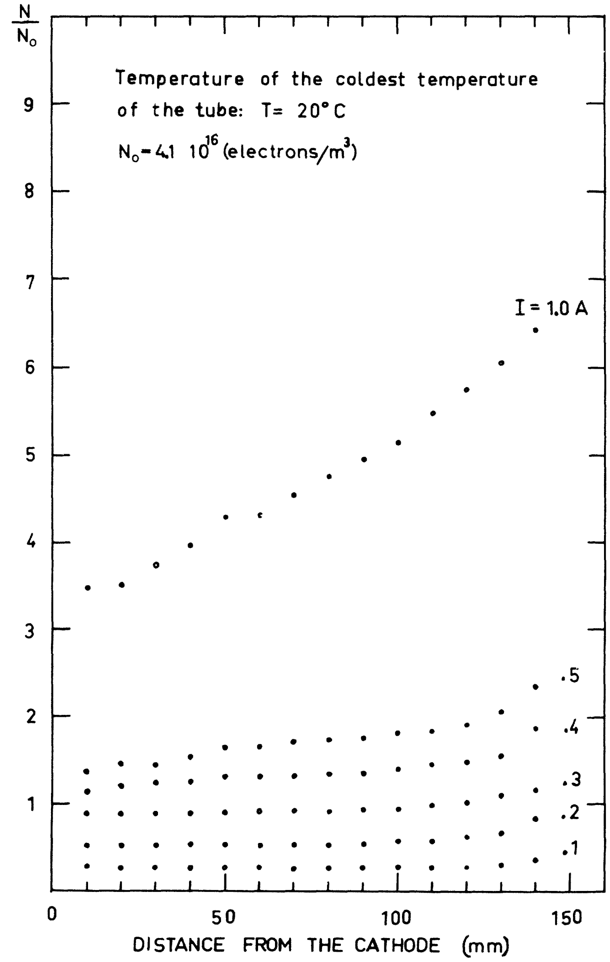

FIG. 1. Electron density as function of distance from cathode for $T = 20°C$ for several values of beam current.

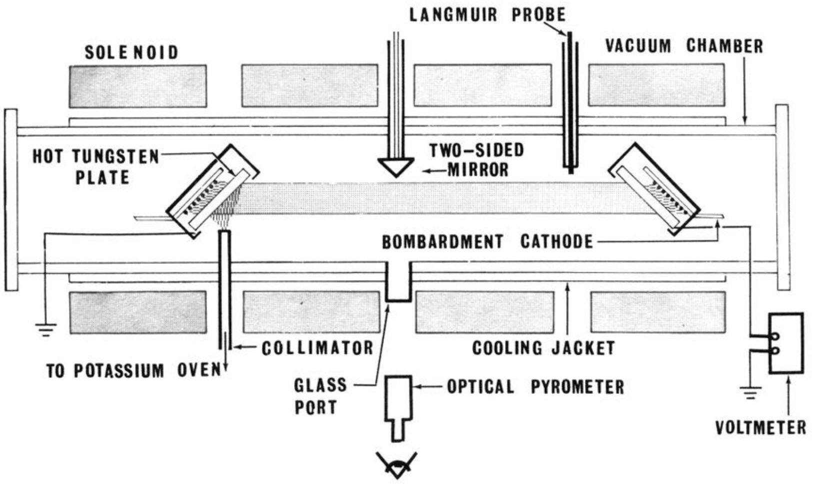

FIG. 1. Schematic of the *Q*-1 device as used in the measurement of the Seebeck coefficient. The tungsten plates were heated by electron bombardment.