533.9

DEMONSTRATION OF DEIONIZATION OF A MERCURY PLASMA

F. Kh. BAĬBULATOV

Novosibirsk State University

Usp. Fiz. Nauk 89, 305-306 (June, 1966)

WE know that the concentration of charged particles in a plasma is governed by the rate of ion-electron pair production and by the rate at which these pairs disappear through mutual neutralization. When the ionizing field is switched off the production of new pairs practically ceases; as a result of deionization the charged particle concentration then decreases, approaching a finite, but very small, value. For a mercury plasma under a pressure of 0.01—0.1 mm Hg deionization takes place mainly through the diffusion of the ion-electron gas to the walls of the discharge vessel as well as through reduction of the electron temperature as a result of inelastic electron scattering.[1] The time during which the ion-electron gas exists can be calculated from measurements of the current flowing between two electrodes, located within the plasma, to which a low voltage is applied. This can be demonstrated as follows.

A hf pulsed electrodeless discharge is excited in an ordinary PRK-4 mercury-vapor tube. An oscilloscope is used to measure the transit time in the plasma between two electrodes. This time is much longer than the excitation time of the ionizing hf field.

Figure 1 shows the scheme of the demonstration. Through a resistance R the capacitor C is charged to 6—7 kV by a rectifier, and is discharged through the gap G to the coil L_1 wound around the PRK-4 tube. Since the ionizing field and the emf across the coil L_2 are proportional to dI_1/dt (where I_1 is the current through L_1), beam 2 of a delayed-sweep double-beam oscilloscope can be used to display the time dependence of the ionizing field. A "floating" probe is obtained by connecting the battery B and switch S to the tube electrodes through the resistance R_1. Oscilloscope beam 1 measures the interelectrode current from the potential drop across R_1. The time constant RC and the discharge gap are selected to permit observation of both single discharges and discharges recurring at the rate of 10—15 per second. For this purpose a variation of the voltage across the rectifier UPU-1M is sufficient.

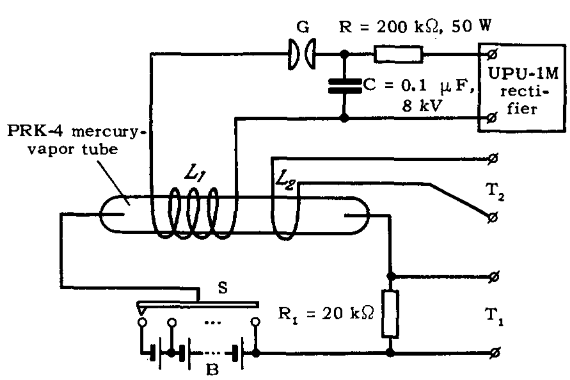

FIG. 1.

Demonstration. Using a 50-μsec sweep, we observe the ionizing field, which in the present case has the form of ordinary damped oscillations with a period of about 1.5 μsec and 12—15 μsec total duration. When a 1000-μsec sweep is used, the entire series of oscillations appears as a narrow vertical line at the beginning of the sweep. Beam 1 displays the passage of current between the electrodes for battery (B) voltages of 15, 12,. . . . , 3, 0 V with identical oscilloscope sensitivity. Figure 2 shows that conductivity persists for about 800 μsec, and is independent of the electrode voltage. Methodological considerations require that the experiment be performed below the first ionization potential, 4.9 V.

Construction. The PRK-4 tube and coils L_1 and L_2 are mounted on the upper lid of the metal housing of the apparatus, while the other parts and the discharge gap G are located inside. This is advantageous for the observations, because light does not strike the gap and

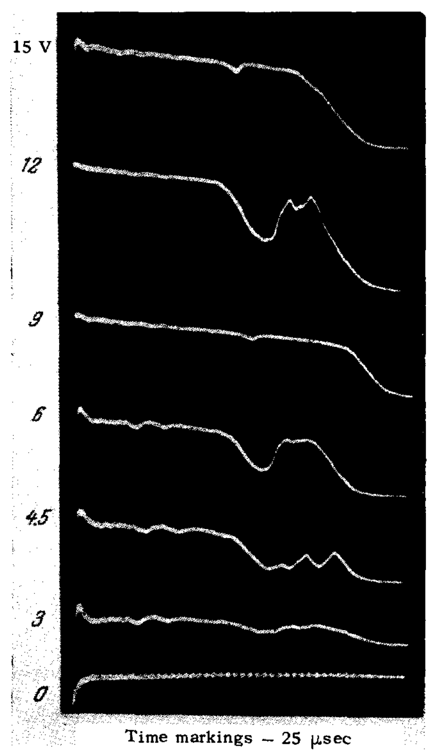

FIG. 2.

noise is reduced. The gap is between two hemispherical copper electrodes of 10-mm diameter; the separation is 2–2.5 mm. The coil L_1 wound around the tube consists of 8 turns in soft insulation; bare wire would destroy the tube as the coil strikes the envelope during a discharge. The leads T_1 and T_2 are located on the back of the housing for direct connection to the extended knobs of the S1-7 oscilloscope, thus ensuring a bright and sufficiently strong image.

[1] V. L. Granovskiĭ, Deionization of a Rarefied Gas, in Élektronnye i ionnye pribory (Electronic and Ionic Instruments), Gosenergoizdat, Moscow, 1940.

Translated by I. Emin