# PROBE MEASUREMENT IN THE HIGH-VOLTAGE GLOW DISCHARGE

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With the Langmuir double probe the electron density and temperature in the space of the electron beam were measured. Further measurement concerning the energy in the beam of energetic electrons in the vicinity of the focus was performed.

## I. INTRODUCTION

During the research into the quality of the beam of energetic electrons accelerated by the cathode voltage $U_K$ probe measurement was performed from the hollow cylindrical cathode in the high-voltage glow discharge (HVGD) in rarefied air to obtain information about the density $n_e$ and the temperature $T_e$ of slow electrons moving at random and about the distribution of the potential in the inter-electrode space, also to obtain knowledge about the energy of energetic electrons in the vicinity of the beam focus.

## II. DEVICE

The experimental device (see Fig. 1) is assembled on a glass body in the form of a cross. It contains a water-cooled copper target T acting as anode and a water-cooled aluminium cathode K, the effective cylindrical plane of which, of radius $R_K = 25$ mm, is formed by the steel screen S. One side-cover of the glass cross is provided with a vacuum tight opening, which enables us to perform an axial shift of the probe and to set its different positions in the vertical direction. As gas in the vacuum chamber air at a pressure of 5 Pa was used. The pressure value was regulated by the air inlet from the atmosphere into the chamber by means of a needle valve.

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## III. MEASUREMENT

The Langmuir double probe LDP (Fig. 1) consisted of two equal tantalum electrodes (diameter ∅ 0.3 mm, the distance between the electrodes 4 mm) protruding out of corundum tube. The individual points of the probe characteristic were measured by means of the probe dc current $I$ and the dc voltage $U$ connected with the probe electrodes. The measurement was carried out at the following discharge parameters: cathode voltage $U_K = -2400$ V, cathode current $I_K =$ 30 mA, air pressure $p = 5$ Pa; connection of electrodes K, S, T and the situation of LDP are visible in Fig. 2. Owing to the linear course of log $I$ on $U$ in the part of the characteristic between the regions of saturated current it was supposed that the condition of the electron velocity distribution according to Maxwell-Boltzmann is satisfied.

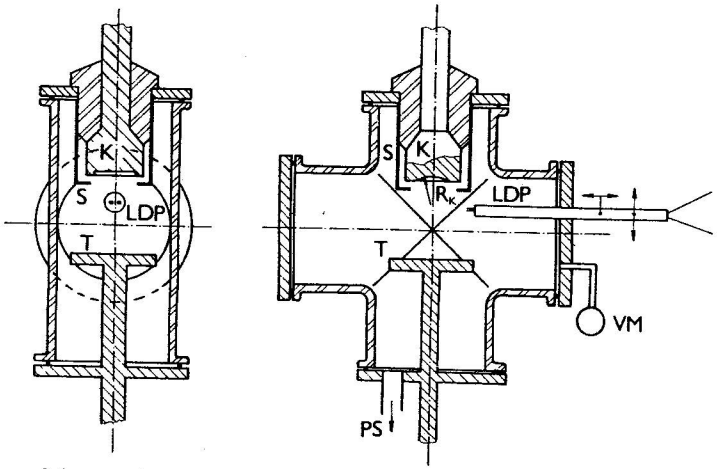


Fig. 1. Scheme of the experimental device (K — cathode, S — screen, T — target, LDP — Langmuir double probe, VM — vacuum meter, $R_K$ — cathode radius, PS — pump stand).

In the space of the electron beam near the cathode layer (see level $I$ in Fig. 3). the electron temperature $T_e \approx 90000$ K and electron density $n_e \approx 2.5 \times 10^{16}$ m$^{-3}$ were estimated, near the focal line (level II) $T_e \approx 50000$ K, $n_e \approx 5 \times 10^{16}$ m$^{-3}$. In the surrounding space outside the region of the electron beam, $T_e \approx 2 \times 10^5$ K and $n_e \approx 10^{14}$ m$^{-3}$ were measured.

An analogous measurement was performed with the thermoelectric probe in the form of a thermocouple as proposed at the symposium [1]. The probe of the form of the bead of diameter ∅ 1 mm obtained by welding Pt and PtRh wires of the diameter ∅ 0.4 mm. The mV-meter connected with these wires stated the temperature of the thermoelectric probe, representing the electron beam energy affecting the probe in a given place. The potential in this place was measured by means of



a high-resistance V-meter connected between the target and one thermocouple wire. The measurement was carried out at the cathode voltage $U_K = -2600$ V, the cathode current $I_K = 60$ mA and the air pressure $p = 5$ Pa. The measurement results are drawn in Fig. 4 and 5.

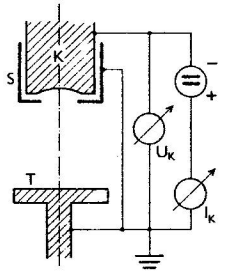


Fig. 2. Electrical connection of the electrodes: cathode, screen and target ($U_K$ — cathode voltage, $I_K$ — cath. current).

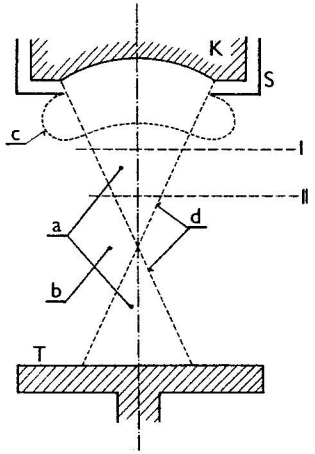


Fig. 3. Inter-electrode space (a — the space of the beam of energetic electrons, b — surrounding space, c — limit of cathode layer, d — limit of the electron beam).

## IV. CONCLUSION

The measured values of the temperature and the density of slow electrons agreee with the results of Mc Clure [2], who gives for the HVGD in deuterium $D_2$ the electron temperature $T_e = 21400$ K and the density $n_e = 2.4 \times 10^{15}$ m$^{-3}$. A great disagreement appears in comparison with the results of Gusjeva and al. [3], who give the temperature of slow random electrons only $T_e = 2000$ to 3000 K, in the region of cathode layer of HVGD in nitrogene $N_2$.

The thermoelectric probe indicates that the greatest energy density of the electron beam, expressed by means of the thermoelectric voltage and the corresponding temperature, occurs in the region of the focal line. As may be seen in Fig. 4, the concentration of the electron beam into the focal line is not too sharp, this aplies to the direction of the axis $y$ as well as to the axis $z'$. According to that measurement the position of local line is at the distance of approximately 33 mm from the cathode summit.

The distribution of the potential near the focus (see Fig. 5) shows that the potential inside and outside the electron beam reaches only cca — 10 V against the target (anode). This is negligible in comparison with the cathode voltage $U_K =$ $-2600$ V, hence practically the whole voltage $U_K$ occurs in our HVGD at the cathode layer.

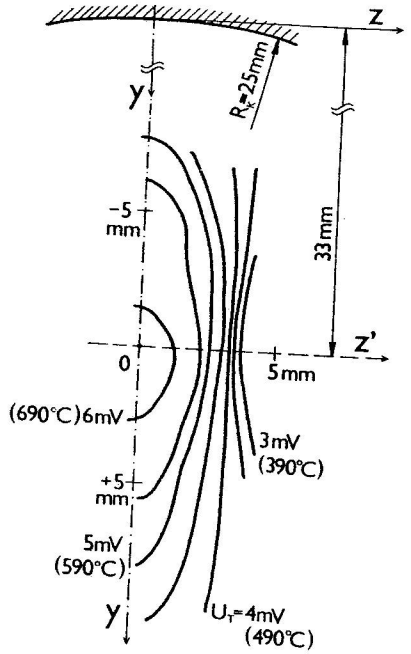


Fig. 4. Course of equipotential lines representing the distribution of electron beam energy in the vicinity of focus ($U_T$ — thermoelectric voltage as a measure of local electron beam energy; in breckets is the temperature of the thermoelectric probe corresponding to the volate $U_T$).

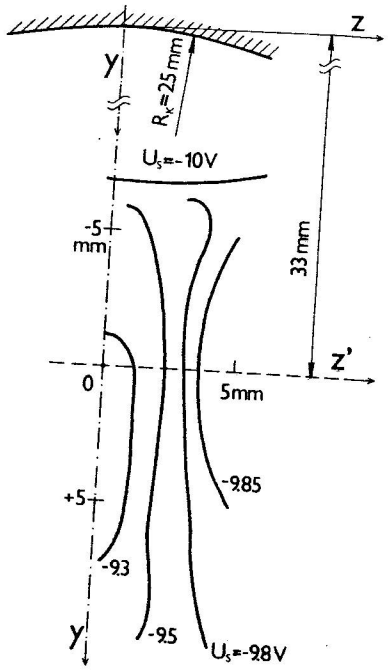


Fig. 5. Course of equipotential lines of local voltage ($U_s$ — local voltage relative to the target in space in the vicinity of the electron beam focus).

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## ИЗМЕРЕНИЯ В ВЫСОКОВОЛЬТНОМ ТЛЕЮЩЕМ РАЗРЯДЕ ПРИ ПОМОЩИ ЛЕНГМЮРОВСКОГО ЗОНДА

При помощи двойного ленгмюровского зонда измерены плотность электронов и температура в пространстве электронного пучка. Выполнены также другие измерения, касающиеся энергии в пучке высокоэнергетических электронов в области фокуса.