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EXAMINING THE HIGH-VOLTAGE GLOW DISCHARGE BY PHOTOGRAPHY

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Systematic photographing of the high-voltage glow discharge has been used to find out the dimensions of the concentrated beam of energetic electrons and to ascertain the form of the cathode in the high-voltage glow discharge.

I. INTRODUCTION

As regards the form of the cathode layer in the high-voltage glow discharge (HVGD) we have found no suitable references which could give information about it. The method of photographing the cathode layer has been elaborated, which enables us to observe the form of the cathode layer and to study its influence on the concentration of the electron beam emitted from the surface of the cold cathode in the HVGD.

II. DEVICE

The experimental device (see Fig. 1) consists of a glass discharge chamber in the form of a cross, the arms of which are closed by means of metallic covers (see also [1]). The upper cover includes the insulated cathode K, the effective surface of which, formed by one part of the hollow cylindrical plane of the radius R_K = 25 mm, is defined by means of the screening S. The anode is formed by the target T, connected with the lower metallic cover or with the central electrode CE (8 mm dia) after this has been introduced into the space between the cathode and the target. All the three electrodes K, CE and T are water-cooled. The left-side cover is provided by a glass window, in front of which a camera is placed. Its optical axis is parallel with the focal line of the beam of the energetic electrons, accelerated by means of the cathode voltage U_K. The vacuum in the discharge chamber (approx. 10 Pa) is provided by the pumping stand with a mechanical rotary pump and is mearured with a Pirani gauge vacuum meter.

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As gas in the vacuum chamber air at a pressure of 3 to 17 Pa was used. The pressure values were regulated by an air inlet from the atmosphere into the chamber by means of a needle walve.

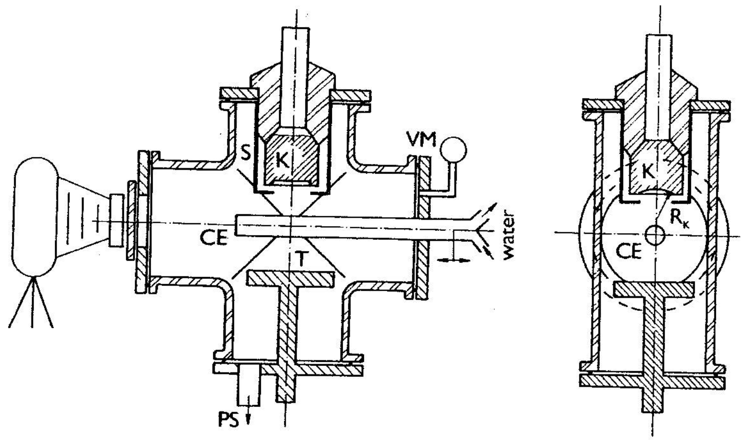

Fig. 1. Scheme of the discharge chamber with photo-camera (K — cathode, S — screen, CE — central electrode, T — target, VM — vacuum meter Pirani, PS — pump stand).

III. MEASUREMENT

Systematic photographing of the HVGD was performed at different values of the discharge parameters: cathode voltage U_K, cath. current I_K and air pressure in the discharge chamber p. The connection of the electrodes is shown in Fig. 2. As long as the central electrode CE is being introduced into the inter-electrode space between K and T (see for example the photograph of the discharge in Fig. 3), the

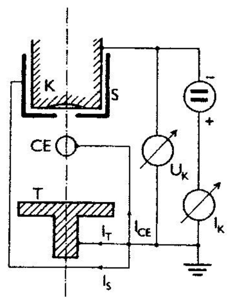

Fig. 2. Electrical connection of the eletrodes: — cathode voltage; I_K — cath. current; I_{CE}, I_T, I_S cathode, central electrode and screen (U_K — curent components).

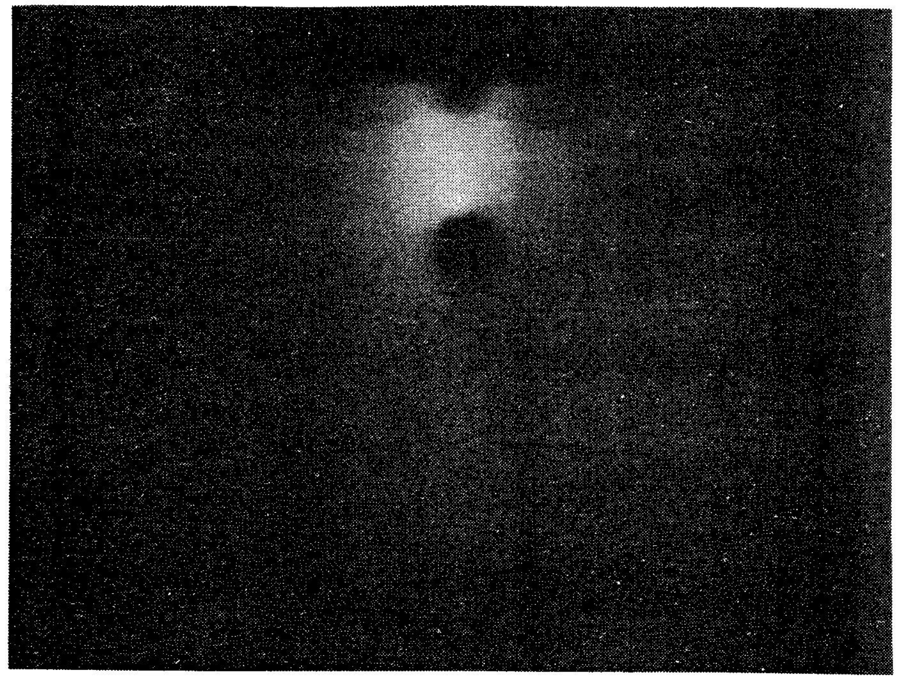

Fig. 3. Photograph of the electron beam from cathode into central electrode ($I_K = 300$ mA; $U_K = 4.7$ kV; $p = 13.7$ Pa).

current meter I_K measures the current component $I_{CE}(I_K = I_{CE})$, because the components in the target I_T and in the screen I_S are negligible. On the contrary, when CE is shifted out of the inter-electrode space, $I_K = I_T$, $I_{CE} \doteq 0$ and $I_S \doteq 0$. Fig. 4 presents a set of photographs of the HVGD taken at the cathode current $I_K = 50$ to 350 mA, the cath. voltage $U_K = 2.6$ to 7.5 kV and the air pressure $p = 3.6$ to 16.6 Pa. By means of these photographs we evaluated the dependence of the dimension parameters (see Fig. 5) of the cathode layer and of the concentrated beam of energetic electrons on the pressure p. The course of the focal length f is drawn in Fig. 6, that of the angle α of the beam of accelerated electrons in Fig. 7 and that of the thickness l of the cathode layer in the plane of symmetry in Fig. 8.

During the experiments no significant sputtering of the aluminium cathode was observed, which is due to the presence of oxygen in the gas used [2].

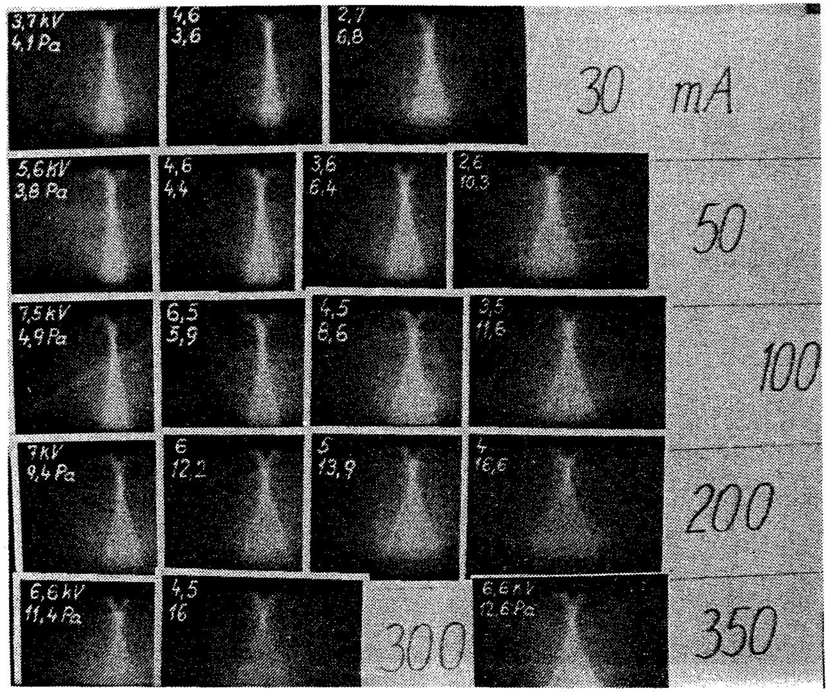

Fig. 4. Set of photographs of the electron beam from cathode into terget:

$I=$ 30 mA,	$U=$2.7—4.6 kV,	$p=$ 3,6— 6.8 Pa
50	2.6—5.6	3.8—10.3
100	3.5—7.5	4.9—11.6
200	4.0—7.0	9.4—16.6
300—350	4.5—6.6	11.4—16.0

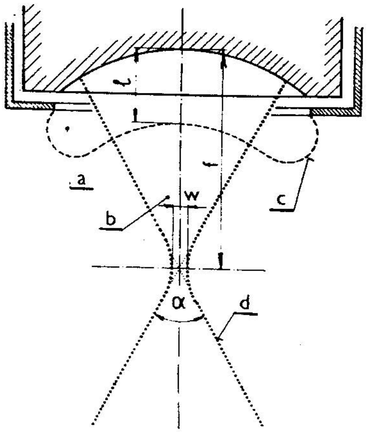

Fig. 5. Dimension parameters of the cathode layer and of the beam of accelerated electrons (a — cathode layer; b — space of the beam of energetic (accelerated) electrons; c — limit of cathode layer; d — limit of electron beam; l — length of the cathode layer; f — focal length; w — width of the electron beam in focus; α — angle of the electron beam).

IV. CONCLUSION

The results of photographing the HVGD have shown that — The electron beam is concentrated in the focal length f, which is visibly greater than the cathode plane radius $R_K = 25$ mm. According to Fig. 6$f \doteq 32$ mm = const. for a pressure $p \leqslant 8$ Pa; with increased pressure f decreases and nears the value of radius R_K.

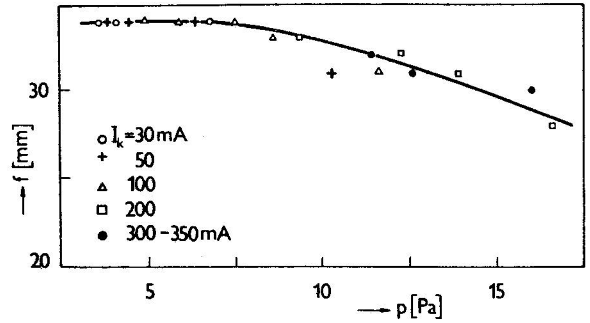

Fig. 6. Focal length f vs air pressure for cathode current $I_K = 30$—350 mA.

— The angle α of the electron beam essentially depends on the air pressure in the discharge chamber (see Fig. 7). The influence of the cathode voltage U_K and the current I_K is not significant.

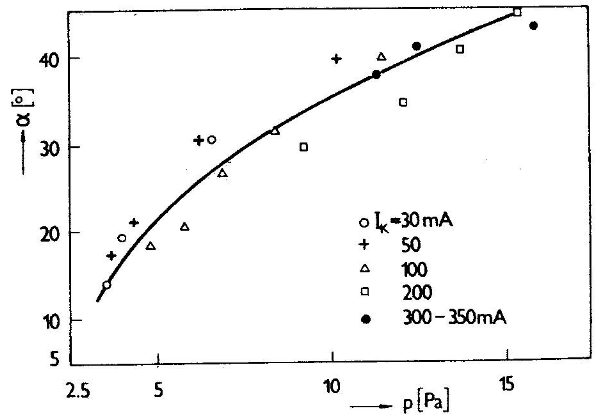

Fig. 7. Beam angle α vs air pressure for cathode current $I_K = 30$—350 mA.

The same relation is valid for the thickness l of the cathode layer (see Fig. 8). — The width w of the electron beam in focus, estimated from the photographs, is approx. 2 mm, and within the limits of observation mistakes does not change with the discharge parameters.

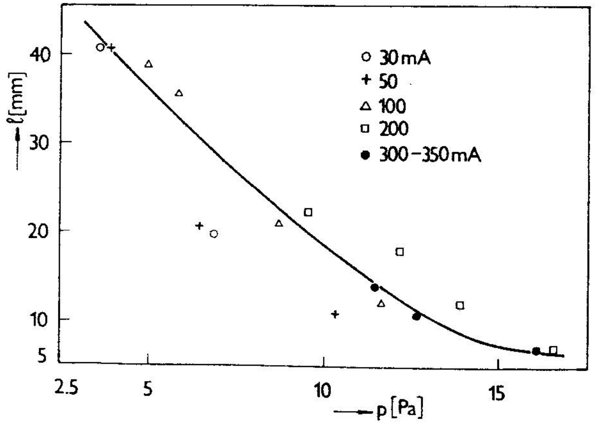

Fig. 8. Length of cathode layer l vs air pressure for cathode current $I_K = 30$—350 mA.

REFERENCES

[1] Kramář, J.: Probe measurement in high-woltage glow discharge Acta Phys. Slov. (in this issue.)
[2] Rocca, J. J. et al.: J. Appl. Phys. *56* (1984), 790.

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ИССЛЕДОВАНИЕ ВОСОКОВОЛЬТНОГО ТЛЕЮЩЕГО РАЗРЯДА ФОТОГРАФИЧЕСКИМ МЕТОДОМ

Для определения размеров сфокусированного пучка высокоэнергетических электронов и формы катодного слоя в высоковольтном тлеющем разряде использовался метод систематического фотографирования.