# EFFECT OF THE HELIUM PURITY ON THE VALUE OF THE NORMAL CATHODE FALL OF THE POTENTIAL

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The influence of some experimental methods of the purification of the gas (helium) on the value of the normal cathode fall of the potential was studied. The application of a Ba — getter and cataphoresis was found to be the most effective method of gas purification giving a value of 120 V for the normal cathode fall of the potential in helium.

## I. INTRODUCTION

One of the most important parameters in various applications of glow discharge is the value of the normal cathode fall of the potential $U_{kn}$. It is depending on various factors especially on the sort of gas, its purity, on the material and form of the cathode [1].

The basic characteristics of the glow dischange are influenced in a normally available vacuum apparatus with a limiting vacuum of $5 \times 10^{-7}$ torr by an udersirable admixture in the gas used in the discharge tube. This undesirable admixture appears in the apparatus by a release from the walls, electrodes and oils in the vacuum system, or the gases used as a filling are not pure enough before getting into the apparatus.

The object of this work was to study the influence of some of the experimental methods of the gas purification on the value of the normal cathode fall of the potential $U_{kn}$ using sorption molecular sieves, Ba-getter and cataphoresis. We have studied these methods in case of helium.

## II. EXPERIMENT AND METHOD OF MEASUREMENT

The method of the „discharge in heavy conditions" was applied for the measurement of $U_{kn}$ [3]. Basically this method consisted in measuring the

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voltage between the electrodes as a function of the distance at a constant discharge current. By the gradual approaching of electrodes, the voltage sinks slowly at first and then disappears the positive column faster. When the value of $U_k$ is reached, the voltage between the electrodes changes only slightly. Finally, after a further decrease in the distance between the electrodes, the voltage sharply increases. (See Fig. 1.).

The discharge tube for measuring the normal cathode fall of the potential $U_{kn}$ was constructed specially for this purpose. The inner diameter of the tube was 25 mm and the length 450 mm. Experimental evidence presented by Chistiakov [1] has shown that chemically active metals which are able to be well degassed, are the most suitable materials for electrodes. We used a plan-parallel molybdenum electrode system with a diameter of 23 mm. One of the electrodes was charged with a glass cylinder with a diameter of 24 mm a length of 55 mm and was hung up on the wire. By rolling up this wire into the threads of a metal shaft it was possible to set precisely the distance between electrodes. The parallelism of the electrode system was guaranteed by the mentioned glass cylinder.

The discharge tube was connested with a sorption element filled with molecular sieves Calsit 13 X, a bulb with a Ba-getter and another discharge tube for the cataphoresis. The vacuum apparatus was pumped for 270 hours before the discharge tube was filled up with helium and we obtained the limiting vacuum of $5 \times 10^{-7}$ torr. The molecular sieves were activated for 10 hours at a temperature of 200 °C and for 2 hours at a temperature of 450 °C [2]. The electrode system was degassed by high-frequency heating and heated to a sufficiently high temperature in a strong glow discharge.

## III. EXPERIMENTAL RESULTS

Spectroscopic pure gas (helium) contained apart from admixtures of active gases also admixtures of other inert gases. We removed the active admixtures with molecular sieves and a Ba-getter. The other inert gases (like Ne and Ar[1]) were separated by cataphoresis [4] in a separate discharge tube with a length of 540 mm and a diameter of 12 mm. It was possible to isolate this discharge tube from the vacuum system, to remove all impurities and to prevent a back diffusion of impurities. The variation of the $U_{kn}$ during the cataphoresis is shown in Fig. 2. The smallest value of $U_{kn}$ which was able to reach without the application of the mentioned methods purification was that of 140 V. Application of molecular sieves showed only little effect on the value of $U_{kn}$.

[1]) The apparatus was dirty from Ar trace gas (from preceding measurement in Ar)

(See Fig. 3). On the contrary, after scattering the Ba-getter, the value of $U_{kn}$ dropped to 134 V.

At last we purified helium with cataphoresis running for 80—90 minutes at a discharge current of 25 mA. After application of the cataphoresis a value of 120 V was obtained.

We also verified the relation $I = SJp^2$ [5] by measurement of function dependence $U_k = f(I)$, where $I$ is the maximum discharge current between the normal and the anomal glow discharge, $J$ is a constant depending on the gas ($J = 2 \times 10^{-6}$ Acm$^{-2}$ torr$^{-2}$ for helium), $S$ is the area of the cathode, $p$ is the gas pressure. The results which are shown in Figs. 1, 2, 3 were measured at a pressure of 24 torr. The maximum discharge current between the normal and the anomal glow discharge calculated according to the relation $I = SJp^2$ is 4.7 mA. As it is shown in Fig. 3 the mentioned value is in good agreement

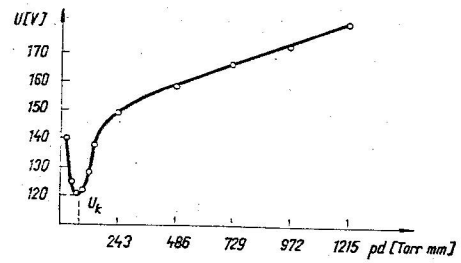


Fig. 1. Voltage $U$ as a function of $pd$.

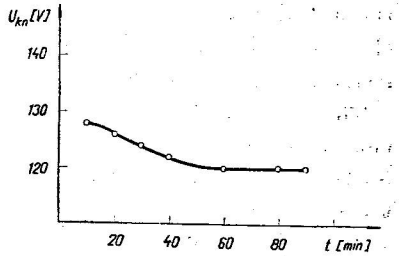


Fig. 2. Dependence of $U_{kn}$ on the duration of cataphoresis.

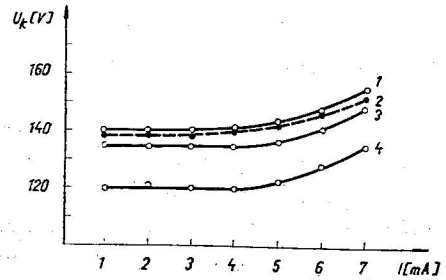


Fig. 3. The dependence of the cathode fall $U_k$ on the discharge current $I$. 1 — the values of $U_k$ without application of purification; 2 — the values of $U_k$ after the application of the molecular sieves; 3 — the values of $U_k$ after the application of the Ba-getter; 4 — the values of $U_k$ after the application of the cataphoresis.

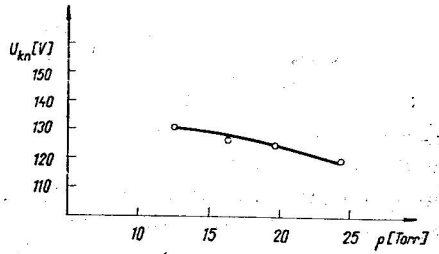


Fig. 4. Dependence of $U_{kn}$ on the pressure in helium.



with our experimental value. Likewise as in [6] a weak dependence of $U_{kn}$ on the pressure was observed. (See Fig. 4).

## IV. DISCUSSION

The effect of removing admixtures, which occur in a normally used vacuum apparatus on the value $U_{kn}$ is studied. The admixture consisting of active gases can be, e. g. $N_2$, $O_2$, $H_2$, $CH_4$: Apart from these spectroscopic pure helium contains 0.0064 % of Ne. Although moleculules of $O_2$, $N_2$, $H_2$ have an ionization potential below that of helium, their presence caused an increase of the value of $U_{kn}$. It means, that the mentioned admixture did not form with the body gas Penning mixtures. There can be a possible explanation that a big part of the electron energy was dissipated because of the dissociation of molecules of these active gases [5]. Further, when collisions of metastable atoms for example with molecules $H_2$ [5] occur

$$He^* + H_2 \rightarrow He + (H_2)^*,$$

the excited hydrogen molecules are not metastable and the energy is dissipated as a radiation. From this point of view hydrogen molecules in helium destroy the metastable of the body gas.

Cataphoresis segregation removed the Ne and Ar admixtures from helium, because both gases have an ionization energy smaller than that of helium [4, 7]. The diminishing of $U_{kn}$ with the removing of Ne atoms can be explained according to [5] by collisions

$$He^* + Ne \rightarrow He + Ne^*.$$

The excited neon atoms radiate immediately either the whole or part of their energies with an amission of light. This causes an increase of the value $U_{kn}$.

The lowest value of $U_{kn} = 120$ V obtained in our measurements appears to be higher by about 9 % than value reported in [1]. This difference could be explained probably by an insufficient degassing of some metal parts of the movable system of the anode.

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