INFLUENCE OF NEGATIVE IONS ON A PULSED TORCH DISCHARGE[1)]

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In the main channel of a pulse excited torch discharge in air at atmospheric pressure corona discharges may be observed. Their formation is connected with the presence of negative ions, for the creation of which there are favourable conditions in this type of discharge. In gasis where the production of negative ions is difficult, a corona discharge does not arise.

ВЛИЯНИЕ ОТРИЦАТЕЛЬНЫХ ИОНОВ НА ПУЛЬСИРУЮЩИЙ ФАКЕЛЬНЫЙ РАЗРЯД

В воздухе при атмосферном давлении в главном канале импульсно-возбуждаемого факельного разряда можно наблюдать коронные разряды. Их образование связано с присутствием отрицательных ионов, для рождения которых в этом типе разряда существуют благоприятные условия. В газах, в которых образование отрицательных ионов затруднено, коронный разряд не возникает.

I. INTRODUCTION

The object of our study was a unipolar high frequency discharge burning in free air atmospheric pressure and fed by a power source of 40 MHz. The discharge was fed by 800—1000 W of high frequency power supplied from a self-excited generator in Hartley's connection and was generated periodically by 0.01 s pulses followed by interruptions of the same duration.

The pulsed torch discharge is not influenced much by the convective flow of warmed air, so that its parts can be well discerned. The waved, sharply confined central channel of this discharge is composed of a chain of mutually linked negative sparks [2]. The expression "*negative spark*" for the denotation of the individual parts of the central channel has been chosen due to their resemblance to similar

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Fig. 1. The pulsed torch discharge burning in free air in atmospheric pressure (40 MHz).

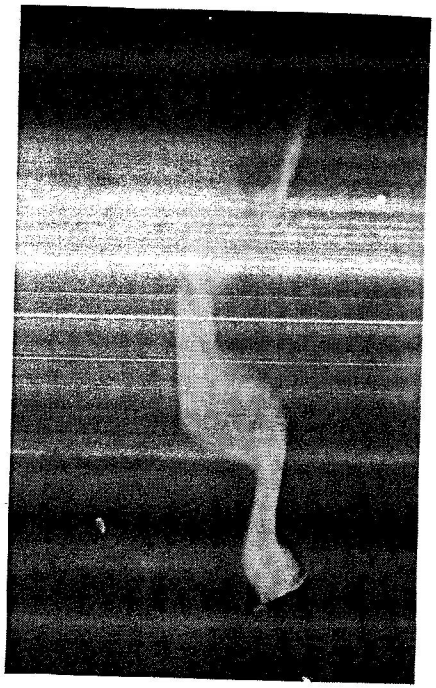

Fig. 2. The pulsed torch discharge burning in Na vapours in atmospheric pressure (40 MHz).

discharge patterns observed in the Lichtenberg figures. It has been shown that all conditions for the creation of a negative spark in a torch discharge are well fulfilled [3]. This has been also confirmed by investigations using a high speed camera [1].

II. CORONA IN THE CHANNEL OF A PULSED TORCH DISCHARGE

In places where the sharply confined central channel of a pulse excited torch discharge burning in free atmosphere changes its direction a new discharge form may observed. This form distinctly differs by its diffuse appearance from the sharp-edged central channel. In this work we use for this discharge form the name corona. Diffuse radiation emanating from the corona is on the side opposite to that of the direction of the main channel, in the place where the previous negative spark converges with the new spark path (see Fig. 1).

In Fig. 2 is a photograph of the discharge burning in natrium vapours under otherwise the same conditions as in Fig. 1. The three central channels are produced by three consecutive high frequency pulses; they can be distinguished only due to

the drift of the discharge on the electrode surface during the exposition. In this case there is no corona near the central channel. Similarly no corona can be observed in a pulsed torch discharge in argon.

III. NEGATIVE IONS

The outstanding difference between pulsed excited torch discharge in air and in natrium vapours, specified by the presence of corona discharges in the discharge in air, can be explained by the influence of negative ions. This is confirmed by the following facts:

1. At atmospheric pressure, at which the discharge burns three body collisions, leading to the creation of negative ions, are very frequent.
2. The existence of negative ions in the vicinity of the torch discharge has been proved shortly after its discovery [4].
3. In an atmospheric torch discharge there are present molecules of oxygen, water, hydroxyl groups and nitrogen oxides [5], forming often and easily negative ions.
4. If the electrode polarity is changed, the electrons in the discharge channel change the direction of their motion. During this change their energy gets low values, convenient for the creation of negative ions. This occurs just in places near the end of each negative spark, where also the corona discharge appears.
5. By the sputtering of different elements in pulse torch discharges it has been found that the most frequently excited levels are the atom energetic levels between 2 and 5 eV [6]. The hydroxyl group OH manifests itself very intensively in the spectrum of a torch discharge in different gases even in the presence of a very small amount of water vapours in the gas [7]. The energy necessary for the formation of OH negative ions is 1.83 eV [8]. For electrons having this energy the respective effective cross section attains its maximum. In Na vapour discharges no hydroxyl group has been spectrally proved even in the presence of wet air as buffer gas [6]. The dissociation energy of the H_2O molecule leading to the formation of an OH group is 5.11 eV [8].
6. The attachment frequency between the negative ions O_2^- formation at a pressure $p = 1.3 \times 10^3$ Pa, and thermal electrons (400 C) is $\nu_a = 3 \times 10^5\, s^{-1}$ [9]. At atmospheric pressure $\nu_a = 2.3 \times 10^9\, s^{-1}$ because three-body collisions depend on p^2. The frequency of a high frequency power source is $4 \times 10^7\, s^{-1}$. The lifetime of free electrons until their attachment is about 60 time shorter in comparison with the period of the high frequency voltage feeding the discharge.

IV. CONCLUSION

Whenever the polarity of a torch discharge electrode changes so that it becomes temporarily an anode, detachment of the negative ions takes place, partly by collision with accelerated electrons, partly by action of photons. The electrons delivered in this way propagate in the direction of the electric field gradient, that is from the region close to the discharge path back to the discharge itself. They are accelerated by the electric field, form avalanches and through collisions with neutral molecules causes excitation, which manifests itself by a diffuse corona radiaton.

In the central channel there remains at each polarity change an excess of positive ions recombining here in the channel with eventual negative ions. No electrons are delivered in this recombination. Therefore the corona discharge is situated on the opposite side of the central channel.

The probability of the negative ions creation in Na vapours is small [9]; therefore the corona in this form of discharge cannot be observed.

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