STEPPED PROPAGATION OF LONG POSITIVE SPARK IN AIR [[1]](#footnote-1)\*)

DOI: 10.34854/ICPAF.2020.47.1.010

1Bazelyan E.M., 2Popov N.A.

1AO “Krzhizhanovskii Power Engineering Institute”, bazelyan@eninnet.ru,
2Lomonosov Moscow State University, Skobeltsyn Institute of Nuclear Physics,
 NPopov@mics.msu.su

Stepped propagation of spark discharges is typical characteristic of air gaps with a sharply non-uniform distribution of the electric field. The mechanism of step formation in *positive* leader is still unclear, although the existence of steps is beyond doubt. They were observed in laboratory gaps up to 15 m long at a voltage with a front duration from hundreds to thousands microseconds [1,2]. Similar results were obtained in a number of other laboratories [3] (see also the overview part of [4]).

The results of numerical simulation of spark discharge in a long air gap of atmospheric pressure at a positive voltage with a long front duration will be presented. The calculations were performed within the framework of a model similar to [5]. It is shown that, at linearly rising voltage pulse with *dU/dt* of less than 30 kV/μs, the generated ionization wave propagates in the gap at a speed of 1-2 orders of magnitude lower than the minimum speed of streamers in air under normal conditions. The electric field behind the front of such a wave along the entire length of the primary channel is kept within 20-22 kV/cm (*E/N* = 80 - 90 Td), sustaining the electron density Ne = 1011 - 1012 cm-3 during hundreds of microseconds. The parameters of primary channel changes sharply under the action of secondary ionization wave, initiated by an additional voltage pulse of nanosecond duration. The propagation of secondary ionization wave to the head of primary channel initiates streamer flash with an initial propagation velocity of about 109 cm/s, which leads to a sharp increase in the brightness of the emission from the channel. The reason for the amplification of the emission is the active production of electronically excited particles in the discharge channel.

The calculation results of the parameters of the constricted plasma channel (according to the model [6]) at currents *I* ≤ 10 mA typical for the primary ionization wave will be presented. At such currents and times of *t* ≤ 100 μs, the gas temperature did not exceed 1000 K, and the electric field in the channel did not drop below 5 kV/cm. According to such parameters as gas temperature, longitudinal electric field and electron density, the channel of stepped long positive spark is fundamentally different from the channel of a positive leader, which is able to exist and propagate only in a quasi-continuous form.

One of the authors (N.P.) thanks the Russian Science Foundation for the financial support (project No. 19-17-00183).

References

1. Стекольников И.С., Шкилев А.В*.* *//* ДАН СССР. 151 (1963) 837*.*
2. [Александров Г.Н., Горин Б.Н., Редков В.В., Стекольников И.С., Шкилев А.В. *//* ДАН СССР. 183 (1968) 1048.
3. Les Renardieres Group Positive discharges in long air gaps// Electra. 53 (1977) 31.
4. Kostinskiy A.Y. et al. // J. Geophys. Res. Atmos. 123 (2018).
5. Aleksandrov N.L., Bazelyan E.M. // J. Phys. D: Appl. Phys. 29 (1996) 740.
6. Popov N.A. // Plasma Physics Reports. 32 (2006) 237.
1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLVII/R/ru/LL-Bazelyan.docx) [↑](#footnote-ref-1)