RECORDING ARC DISCHARGES AT THE CATHODE IN MODELS OF MHD DEVICES

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The analysis of current-voltage characteristics for channel models of MHD devices gives reason to believe that, in specific cases, the uniformly distributed discharge at the cathode is "stripped" and that an electric arc appears [1]. It has also been surmised [2] that a "unidirectional" arc exists, which penetrates the boundary layer and extends on one side into the cathode glow and on the other side into the uniform current in the body of the plasma stream. These phenomena have been observed both on "cold" [2], and hot electrodes made of silicized graphite [1].

In order to verify these assumptions, a series of experiments was performed on a channel model to detect arc discharges. The work was carried out in a stream of air ($T_G \sim 3000^\circ$ K) with an applied electric field ($U_{EFF} = 80$ V, $f = 50$ Hz); the temperature range of the operating surface of the electrode T_W was from 1200 to 2000° C, and the additive content varied from 0 to 1.2% by weight of the flow rate. The channel model and the measurement circuit are described in [1]. Together with the usual oscillograms for the current-voltage characteristics (electrode-electrode and electrode-probe types), the experiments also gave the corresponding values of current and voltage displayed on a time scale.

Fig. 1 gives a typical current-voltage electrode-probe characteristic for an electrode made of silicized graphite; Fig. 2 gives an oscillogram of the current and voltage displayed on a time scale.

The section OD of the electrode-probe oscillogram (Fig. 1) (the potential drop in a gas layer of thickness ~5 mm as a function of the current flowing in the electrode circuit) corresponds to an operating regime in which the electrode under investigation acts as an anode, and the segment OABC corresponds to an operating regime where this electrode acts as a cathode. We see from Figs. 1 and 2, that the arcs are struck at a specific breakdown voltage U_1^*, corresponding to the point B, after which the voltage decreases and the current increases. While the arc is burning, the voltage remains practically constant during one-half period or decreases a little (point C). After the voltage reaches a value corresponding to the point A, the conditions necessary for maintaining an arc regime disappear and the electrode again begins to operate in a distributed discharge regime.

Here, as in the initial sector OB, a sinusoidal variation of current and voltage in the electrode circuit is observed. The oscillograms obtained for the variation of voltage and current in the electrode circuit of a channel model for a MHD device correspond in shape to the voltage and current oscillograms of the stabilized arc between the electrodes of a variable current plasmatron.*

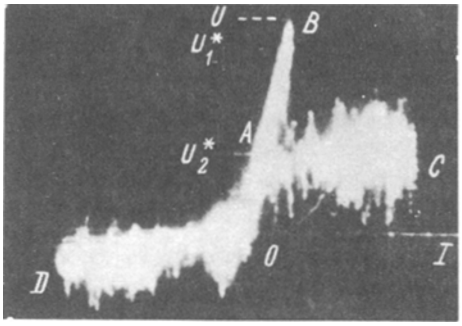

Fig. 1

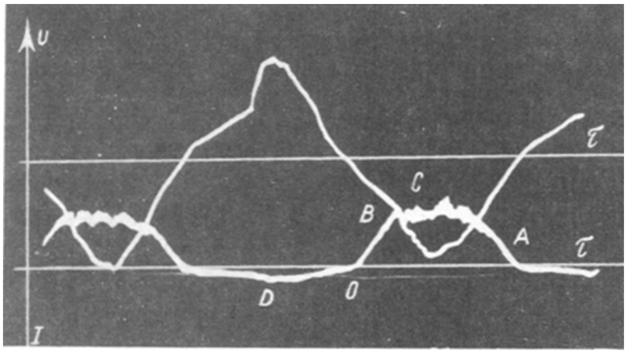

Fig. 2

We confirmed cathode operation in an arc regime by taking motion pictures of electrodes made from silicized graphite and porous tungsten through which a small amount of argon was bled. The record was made with a high-speed motion-picture camera on standard 35 mm KN-4 film with a marker time of 0.001 second. Special windows in the channel model enabled the camera to be aligned both at an angle to the plane of the electrode as well as in this plane. When the camera

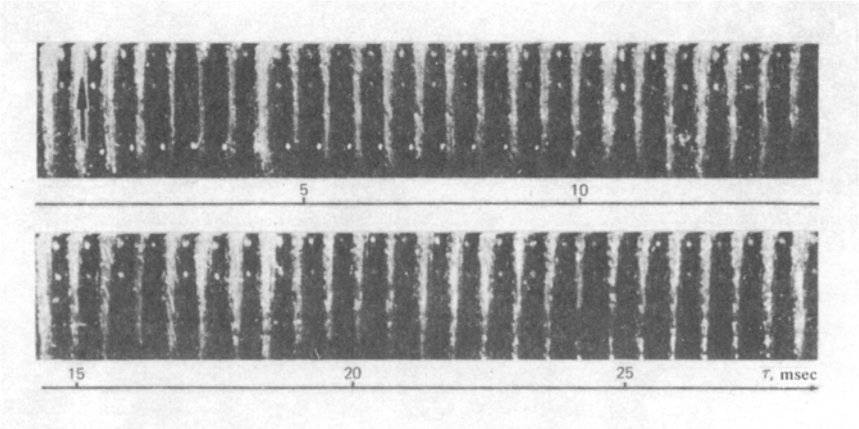

Fig. 3

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* These oscillograms were obtained by M. R. Zhukov, G. Yu. Dautove and Yu. I. Sukhinin.

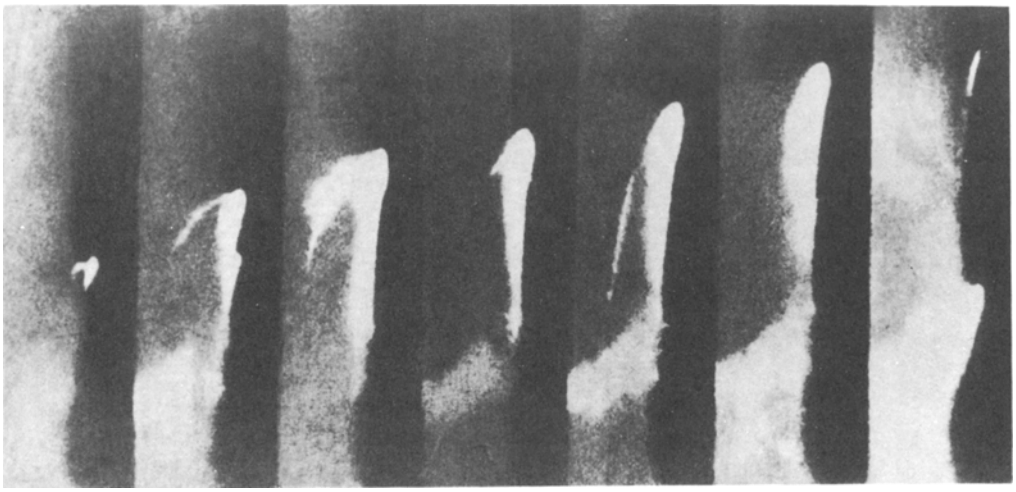

Fig. 4

was aligned in the plane of the electrode a more precise picture could be obtained of the effect of blowing argon through a porous electrode. On all the frames one could observe the birth, development, and disappearance of one or more spots whose brightness was considerably greater than that of the working surface of the electrode, the insulating channel walls, and the flowing gas. While the motion picture was being made the temperature of the operating surface of the electrode varied from 1400 to 1800° C for graphite and from 1200 to 1500° C for tungsten. An analysis of the motion-pictures showed that the frequency for appearance of the spots (0.02 sec) was equal to the power-supply frequency (50 Hz), and that the lifetime of a spot was always less than the half-period of the supply voltage.

It was noted that the strength of the breakdown voltage U_1^* decreased as the temperature of the electrode operating surface increased, and that the voltage U_2^*, for which the arc regimes ceased, decreased as the concentration of additive increased.

Arc discharges are observed only at the cathode. The cathode spots can move both with the stream as well as against it, which may be explained by the effect of different magnetic fields produced by ancillary elements of the apparatus.

On the frame showing the origin of the arc spots taken at the silicized graphite cathode (Fig. 3), only the spots can be seen without any indication of an arc core. At the tungsten cathode through which argon is injected (Fig. 4), the arc has a form similar to that of a comma whose tail is bent in the direction of the stream. It is possible that there is a small core here which penetrates the boundary layer made thicker as a result of the injection of argon. The length of this luminous formation is of the order 1–2 mm (the distance between the electrodes is 50 mm). This confirms the supposition that the arc is unidirectional.

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