condition is satisfied on the very tip of the needle, then the needle grows in length.


Fig. 3

From the microscopic point of view, the growth of the needle can be explained in the following manner. In sufficiently strong field, the migration of the atoms over the surface towards the sections of maximum field causes sufficient supersaturation of the "two-dimensional gas" to initiate and grow new atomic layers. If sufficient supersaturation takes place on several sections of the surface, then several stubs grow simultaneously (see Fig. 3). If the supersaturation is reached only on the tip of the needle, then growth of the needle takes place. The growth of the needle stops when the rates of field evaporation and inflow of material to the maximum-field sections becomes equalized. The crystal surface, like Drechsler steps, then assumes a quasistationary state.

Thus, at sufficiently high temperatures and fields, conditions are realized for a relatively rapid growth of the needle in directions perependicular to the close-packed faces, including the face located on the tip of the needle.

This process can be used, in particular, to sharpen electron and ion field emitters without breaking the vacuum in the instrument. This greatly extends the possibilities of studying crystals well purified in vacuum by methods of field-emission microscopy.

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CONTAINMENT OF A PLASMA FILAMENT IN A TOKAMAK TO-1 BY AN AUTOMATIC-CONTROL SYSTEM

L.I. Artemenkov, P.I. Kozlov, P.I. Melikhov, P.A. Mukhin, and L.N. Papkov
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The main discharge characteristics were investigated experimentally in a TO-1 Tokamak without a jacket, in which the plasma filament was kept in equilibrium by an automatic-control system. Three stages of discharge were observed: macroscopically unstable, "free" motion, and contact with the diaphragm. The discharge duration and the energy content of the plasma increase with increasing equivalent time constant of the control winding.

The plasma filament in the TO-1 Tokamak is maintained in equilibrium along the major radius by an impedance-type automatic control system [1]. This system, as well as the main characteristics of the apparatus and preliminary results of the experiments, were described in a paper delivered at the Fourth International Conference on Nuclear Fusion [2].

The conclusion drawn in the paper concerning the efficacy of the control system was based on the substantial improvement of the main macroscopic characteristics of the discharge with the regulators turned on. When operating with the regulators turned off, the control winding, whose time constant is 16 - 18 msec, is short-circuited. With the regulators turned on, the equivalent time constant of the control winding τ_e can vary in a wide range and can reach values 1 - 2 sec and more. We note that a warm copper jacket with the same time constant should be several dozen centimeters thick.

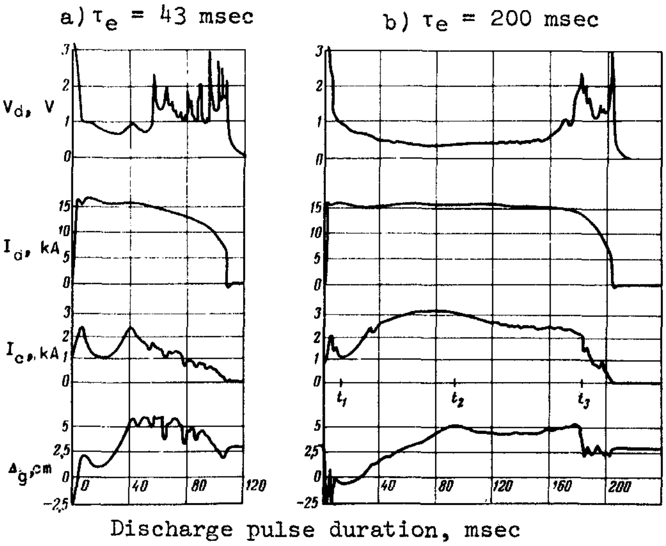
The principal feature of the control system is that it amplifies the current induced in the control winding when the plasma filament is displaced. The equilibrium displacement of the filament from the magnetic axis of the winding, other conditions being equal, is inversely proportional to the gain K of the induced current. Theoretically, the gain can reach values $\sim$10, as against K = 1 in an unslotted superconducting jacket. In the described experiments, the gain was constant at 1.8.

It is of interest to determine the equivalent time constant of the control winding when impedance systems are used to contain automatically a plasma filament with current. Experiments were therefore performed on the TO-1 installation to determine the macroscopic characteristic of the plasma filaments as functions of τ_e in the range 0.04 - 2 sec.

Figure 1 shows typical sets of discharge oscillograms at an initial hydrogen pressure 2×10^{-4} Torr, longitudinal magnetic field 8.2 kG, and vertical correcting field 23 G for two values of the equivalent time constant of the control winding.

The plasma current pulse duration, which reached 400 msec in the experiment, was strongly dependent on the vertical correcting field (which was turned on before the start of the discharge). This dependence is apparently due to processes that occur during the filament formation stage and is not connected with the operating speed of the regulators.

The oscillograms of the signals from the magnetic probes used to measure the displacement of the plasma filament along the major radius (Δ_g) can be subdivided in accord with three principal stages of the motion.


a) τ_e = 43 msec

b) τ_e = 200 msec

Fig. 1. Discharge voltage V_d, plasma current I_d, ampere-turns of control winding I_c, and displacement of plasma filament along the major radius Δ_g for two values of the equivalent time constant τ_e as functions of the time.

The first stage, $0 - t_1$, has a duration (10 - 15 msec) that does not depend strongly on τ_e, and is characterized by abrupt variations of all the registered quantities, thus indicating that the discharge has a nonstationary character. The filament interacts strongly with the diaphragm, as shown by the luminescence intensity of the impurity lines, and the conductivity is low. During the second stage $t_1 - t_2$ the filament interacts weakly with the diaphragm (the impurity lines vanish) and is shifted to the outer side of the chamber. The plasma conductivity increases and reaches 5×10^{16} cgs esu. During the third stage, $t_2 - t_3$, there is practically no outward displacement of the filament, and the average voltage across the discharge increases. Intense impurity lines appear.

Let us consider in greater detail the second stage, which is characterized by a weak interaction of the filament with the diaphragm. The filament motion time $\Delta t = t_2 - t_1$ and the average filament displacement velocity v_τ as a function of τ_e, determined from the oscillograms, are shown for this stage in Fig. 2. We see that both curves reach their stationary values at $t \geq 200$ msec, while the plasma current pulse duration T_p increases monotonically.

We attribute the growth of T_p with increasing τ_e to the improved thermal insulation of the filament, since the filament conductivity averaged over the pulse increases, and the total magnetic flux of the magnetic circuit is given. This assumption is confirmed by measurements of the diamagnetic effect.

The velocity $v_\tau(\tau_e)$ of the filament displacement when all the forces acting on it are fixed is shown dashed in Fig. 2. This dependence is determined from the expression

$$\delta(I_d \Delta_g) = A\left(\delta I_c + \frac{\Delta t}{\tau_e}\bar{I}_c\right), \qquad (1)$$

where δ is the variation over the time Δt, A is a dimensional coefficient determined from a model experiment, and I_c is the control-winding current averaged over Δt.

It follows from (1) that if all the forces acting on the filament remain constant during the time Δt, and the discharge current I_d is constant, then at sufficiently large τ_e the rate of outward displacement of the filament is negligibly small in the state of dynamic equilibrium.

A comparison of the plots of $v_\tau(\tau_e)$ and $v(\tau_e)$ leads to the conclusion that this displacement can be neglected in practice if $\tau_e > 0.4$ sec. The rate of outward displacement of the filament $v(\tau_e)$, as seen from Fig. 2,

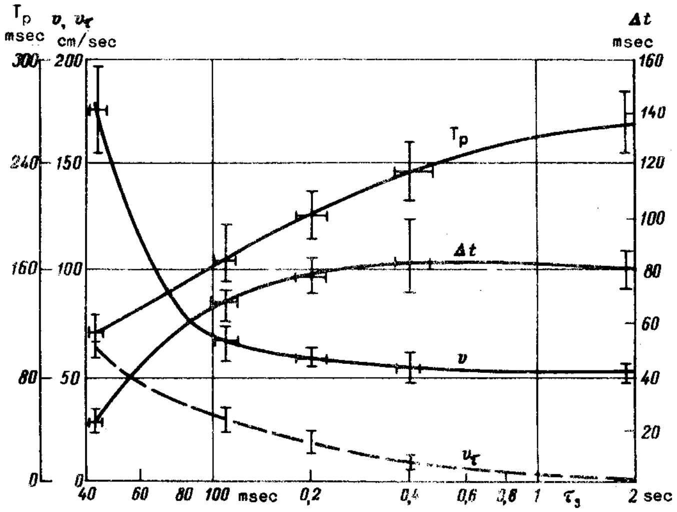


Fig. 2. Dependence of the plasma-current duration T_p, of the time $\Delta t = t_2 - t_1$, of the velocity v of "free" motion of the filament, and of calculated filament displacement velocity v_τ on τ_e.

changes little if $\tau_e > 0.2$ sec and amounts to ∿50 cm/sec. This contradicts the experimentally observed growth of the plasma pressure in the entire range of variation of τ_e. This discrepancy can be explained by assuming that the increased pressure is offset by the effect of the decreased inductance of the filament.

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OBSERVATION OF EXCESS γ-RADIATION FLUXES FROM THE REGION OF THE NORTHERN GALACTIC POLE

A.M. Gal'per, V.G. Kirillov-Ugryumov, B.I. Luchkov, and Yu.V. Ozerov
Moscow Engineering Physics Institute
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A γ telescope with a tracking spark chamber, registering γ quanta of energy higher than 100 MeV, was installed for the first time in January 1969 on the satellite Cosmos-264. The preliminary data were published in [1, 2]. We present here the results of a search for discrete γ-radiation sources.

The telescopes consisted of scintillation counters C_1 and C_2 and a directional Cerenkov counter $\check{C}$ with organic-glass emitter. The electronic circuit separated the events $\bar{C}_1 C_2 \check{C}$ produced upon conversion of the γ quanta in a lead converter one radiation length thick, and triggered the spark chamber. The upper wide gap of the chamber measured the directions of the conversion-pair components. In the succeeding four gaps, interlined with lead plates, an electronic shower developed, and its registration increased substantially the reliability of the γ-quantum event. To decrease the background produced by the charged cosmic particles on board the satellite, an additional (movable) counter was placed on the outside, and its operation was revealed by lighting of lamp L. The telescope was calibrated beforehand in beams of monochromatic electrons with energies from 100 to 1500 MeV. The effective telescope area was 90 cm^2, the average registration efficiency was ∿0.2. A detailed description is given in [2].

The satellite orbit was almost circular with altitude ∿270 km, inclination 70°, and revolution period 89.7 min [3]. The angle between the axis of the telescope and the direction to the zenith was 57°, so that γ quanta from the secondary atmospheric flux did not enter the aperture of the instrument. The γ telescope scanned the section of the sky in the region of the constallations Virgo, Canes Venatici, Bootes, and others. In two days' work there were obtained about 9000 stereo photographs, the events in most of which, as shown by the scanning, were produced by particles passing outside the solid angle of the telescope ("side background"). The particles entering the aperture of the telescope were subdivided, in accord with their manifestation in the spark chamber, into the following type: 1) single straight track (p-background) produced by protons and cosmic-ray nuclei registered as a result of missed counts of the anticoincidence counter C_1; 2) electron shower, but the lamp L is lighted (γ-background); 3) electron shower, lamp L is not lighted (γ-quanta). The events identified as