HIGH-CURRENT PLASMA ELECTRON GUN WITH 50 kA PULSE CURRENT

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Guns with plasma cathodes are presently used effectively to form pulsed high-current beams of relatively low energy ($\sim 10^5$ eV) [1 - 3].

In the gun described in [4], the expanding cathode plasma, whose concentration decreases in the direction of the accelerating electrode, is incapable of effectively cancelling the space charge in the region of the anode hole during the process of beam formation. Large total currents, two or three times larger than the current to the Faraday cylinder, develop in the accelerating gap, and as a result the current-transmission coefficient of the gun is small. This coefficient is further reduced by the settling of the beam charge on the anode electrode, owing to the limited transparency of the grid.

We describe here a high-current plasma electron gun [5] containing a cathode based on spark sources and an anode with a hole; the gun differs from the earlier ones in that the coefficient of current transmission and the stability of the kiloampere electron beam are increased by filling the anode hole with a plasma generated by a group of spark sources disposed on the anode electrode uniformly and normally to the walls of the hole.

A schematic diagram of the gun and a simplified block diagram of its supply are shown in Fig. 1. The spark sources (1), ignited by block BP1, generate a plasma that fills the cathode electrode (2) and flows into the accelerating gap (3) whose length is 1 - 2 cm.

In synchronism with the plasma formation in the cathode, the spark sources (4) ignited by block BP3 produce a plasma in the hole of the anode electrode (5). Such a method of plasma formation keeps its concentration high in the regions next to the electrodes. The pulsed voltage generator GIN, triggered by block BP2, develops across a 2 ohm active load a voltage pulse of amplitude up to 100 kV and duration ~ 200 nsec at the base. An anode-voltage pulse formed by the pulse generator is fed to the gun electrodes with a delay ~ 0.5 - 1.5 μsec relative to the triggering of BP1 and BP3.

The time sequence of the supply voltage pulses and the triggering of the recording apparatus are controlled by a synchronizer.

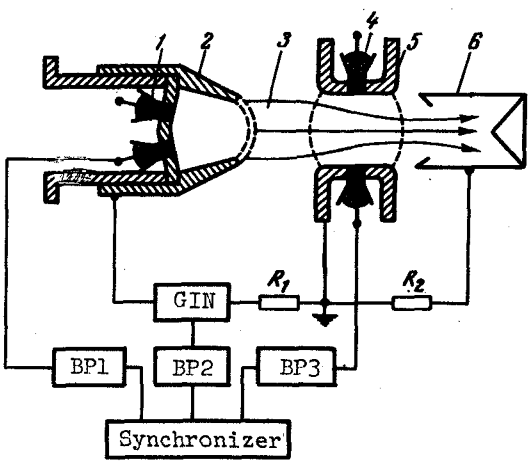

Fig. 1. Diagram of experimental setup.

The total current and the current to the Faraday cylinder are determined by oscillography of the voltage drops across the resistors R_1 and R_2.

Current formation is initiated by an external potential difference applied to the gun electrodes. In the initial stage, the current circuit is short circuited by the anode. After 10 - 50 nsec (the delay time depends on the operating conditions of the anode-plasma generators) the current to the Faraday cylinder (6) increases persistently to a maximum value almost equal to the maximum of the total current.

The Faraday-cylinder current pulse with maximum amplitude is formed by varying the ignition currents I_c and I_a in the cathode and anode units and by varying the delay τ_d of the pulsed anode voltage.

Figure 2 shows oscillograms of the total current I_{tot} = 58 mA (a) and of the current to the Faraday cylinder I_{Fc} = 52 kA (b) and $I_a = I_c$ = 700 A, τ_d = 0.8 μsec, and an accelerating voltage 80 kV. It is seen from the oscillogram that the current to the Faraday cylinder reaches 90% of the total current. The high current transmission coefficient is due to the cancellation of the space charge by the ions of the dense anode plasma and to the pinching of the high-intensity beam by its own magnetic field. The scatter of the maximum values of the current to the Faraday cylinder does not exceed ±10%.

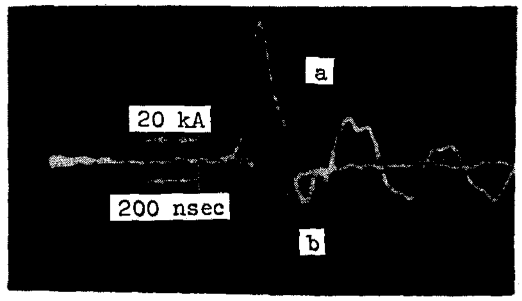

Fig. 2. Oscillograms of the total current (a) and of the current to the Faraday cylinder (b).

An experimental source of pulsed bremsstrahlung x-rays based on such a gun has a pulsed power $\sim 10^9$ r/sec with exposure dose ∿100 r/pulse and an effective energy 15 - 25 keV.

[1] S.P. Bagaev, F.Ya. Zagulov, B.M. Koval'shuk, and G.A. Mesyats, Izv. Vuzov Fizika, No. 1, 145 (1968).
[2] D.V. Iremashvili, S.V. Kuril'nikov, N.I. Leont'ev, and T.A. Osepashvili, Proc. Seventh Inter-university Conf. on Electron Accelerators (in Russian), Atomizdat, No. 3, p. 21, 1970.
[3] D.V. Iremashvili, S.V. Kuril'nikov, N.I. Leont'ev, T.A. Osepashvili, A.P. Timoshenko, and Yu.K. Udovichenko, Zh. Tekh. Fiz. 41, 1624 (1971) [Sov. Phys.-Tech. Phys. 16, 1278 (1972)].
[4] K.V. Suladze, B.A. Tskhadaya, and A.A. Plyutto, ZhETF Pis. Red. 10, 282 (1969) [JETP Lett. 10, 180 (1969)].
[5] D.V. Iremashvili, S.V. Kuril'nikov, N.I. Leont'ev, and T.A. Osepashvili, Authors' Certificate (Patent) No. 1456684/26-25, 31 December 1971.

REORIENTATION OF MAGNETIC FIELD AT THE NUCLEUS OF A DIAMAGNETIC ATOM IN A RARE-EARTH ORTHOFERRITE

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The spontaneous reorientation of the magnetic moment from one crystal axis to another was observed in a number of rare-earth orthoferrites in a definite temperature interval [1, 2].

We report here a new effect of reorientation of the induced magnetic field at the nucleus of the diamagnetic tin atom in the orthoferrite $Nd_{0.95}Ca_{0.05}Fe_{0.95}Sn_{0.05}O_3$.

Rare-earth orthoferrites are weak ferromagnets. The resultant magnetic moment of the orthoferrite lies in a direction perpendicular to the plane in which the magnetic moments of the iron sublattices lie. In investigations of rare-earth orthoferrites with small admixtures of tin, we have recently observed that strong magnetic fields H_{eff}^{Sn} are induced at the nuclei of the diamagnetic