200 KEV ELECTRON BEAM PULSE SOURCE FOR THE COMPLEX VEPP-5 PREINJECTOR

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The electron beam source based on GS-34 valve cathode-grid unit with oxide cathode of 12 mm in diameter is described. Originally the high voltage DC source was used to supply the gun. The cathode emission characteristic was reduced by the vacuum breakdowns during gun operation. So the necessity of decreasing a high voltage from 200 kV to 140 kV has appeared. The use of the pulse transformer based gun supply with a pulse duration of ~1 mcs provided the gun operation without breakdowns at a voltage of 200 kV and pulse repetition rate up to 50 Hz. At present time the electron source is operated at the complex VEPP-5 preinjector.
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To generate electron bunches in the complex VEPP-5 preinjector electron beam source with the following parameters is required:

Electron energy	200 keV
Beam current (peak)	10 A
Pulse duration (at halfheight)	2-3 ns
Pulse repetition rate	50 Hz
Emittance, no more than	0.01 π cm rad
Synchronization instability	100 ps
Energy spread	<1 %

At the initial stage the DC power supply based on a high voltage cascade generator [1] was used. Operation of such a source over a long period of time showed that vacuum isolation breakdowns forced to decrease operation voltage from 200 kV to 130-140 kV. Therefore to provide required energy the high-voltage pulse generator on the base of pulse transformer [2] was developed.

1 HIGH VOLTAGE GENERATOR CIRCUIT

Fig. 1 represents the simplified generator circuit. The charging of the primary circuit storage C1 comes from high voltage adjustable power supply with a voltage up to 10 kV.

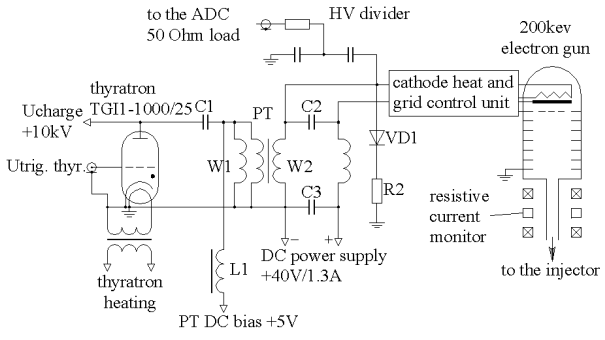

Fig. 1. Simplified circuit of the electron beam source.

After triggering the thyratron TGI1-1000/25 the capacitance C1 discharges through PT primary winding to the secondary circuit capacitance consisting of PT distributed capacitance (~80 pF), electron gun and gun control unit capacitances (~120 pF). For complete energy transfer from C1 to the secondary contour reduced values of primary and secondary circuits capacitances should be equal therefore capacitance C1 was chosen about 100 nF. To obtain a pulse rise time on the gun no more then 0.5 mcs the total primary circuit inductance and reduced PT leackage inductance were chosen no more then 300 nH. The pulse fall time generation is provided by PT core saturation. Both PT core section and number of turns as well as a reset current are chosen so that the induction in the core is average out to the saturation induction in a moment of pulse top. A circuit formed of the resistor R2 and diode VD1 placed in parallel to the load is used to limit the subsequent inverse overvoltage on a load.

2 PULSE ELECTRON SOURCE DESIGN

The sketch of the source is shown in Fig. 2. A gun, a beam focusing system, a gun control unit and a high voltage pulse generator are located on a rack. The cathode grid unit 6 is fixed on a sectioned metall-ceramic transfer isolator 7 made from UF-46 ceramics, which is similar to one used in ELV series industrial accelerators. The length of the isolator is 20 cm. All components wich are located under high voltage – gun isolator 7, control unit 8, pulse transformer 12 – are arranged inside common tank 9. SF_6 gas under pressure of 1.7 atm is used as an insulation.

The basic part of the high voltage pulse generator is PT. Structurally PT is carried out similarly [3]. The core is of continuous type and carried out from a tape of 50NP permalloy by thickness of 10 microns that allows to reduce magnetization losses in PT to a minimum. The PT secondary winding is carried out from two symmetric parallel parts. The high-voltage edges of windings adjoin each other, therefore the electrical field between windings is practically homogeneous in such design. Using two parallel branches of a secondary winding allows to use them for the cathode filament and grid control power supply. For reduction of leakage inductance the secondary winding is of cone type in a radial direction. The absence of a skeleton on an internal generating line of the secondary winding excludes an opportunity of breakdowns along the surface.

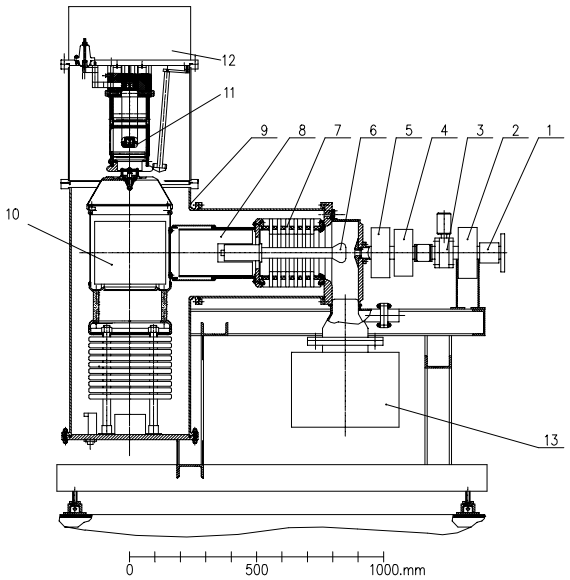

Fig. 2. Electron source sketch: 1 – corrector coil, 2 – second magnetic lens, 3 - vacuum valve, 4 – wall current monitor, 5 – first magnetic lens, 6 – cathode grid unit, 7 – sectioned isolator, 8 – gun control unit, 9 – tank, 10 – gun control unit power supply, 11 – pulse transformer, 12 – thyratron and primary storage unit, 13 – high vacuum pump NMD-0.4.

3 ELECTRON GUN

GS-34 lamp cathode grid unit with oxide cathode of 12 mm diameter is used in electron gun. Low grid voltage values required for this unit simplify the task of forming short control pulse and provide beam with low emmitance. In rated mode the gun gives close to parallel beam (divergence angle is about 50 mrad for a 10 A beam) at the output.

Beam focusing system comprises two magnetic lenses 5, 2 (Fig. 2) and beam position corrector 1. Valve 3 providing cut off the gun from the injector and resistive wall current monitor 4 are located between lenses. Estimations show that beam size at the subharmonic buncher input does not exceed 10 mm during the whole pulse. Vacuum in the gun is provided by vacuum pump of NMD-0.4 type.

4 GUN CONTROL UNIT

One of the complex block of the source – gun control unit, forming pulse voltage between grid and cathode. To decrease the breakdown influence on reliability of the unit the scheme with "grounded" grid is utilized. This unit solves two tasks – forming of beam current pulse of required amplitude and duration and at the same time providing synchronism of gun triggering from the complex control system. The pulse current amplitude can be regulated from 0 up to 10 A by bias voltage variation.

The unit is made of transistors and integral circuits, its block-scheme is shown in Fig. 3. Special unit with resolution of 100 ps was developed to control the pulse of current time correlation. Synchronization pulses are fed to the unit by fiber cable.

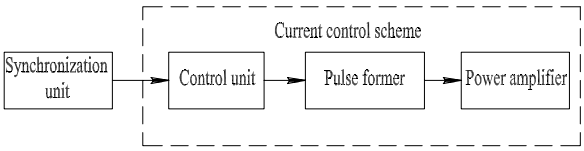

Fig. 3. Block-scheme of gun current control.

5 TEST RESULTS

To the present days breakdown free electrical tests on a voltage 230 kV, pulse repetition rate 50 Hz was carried out. The source is used for test and tuning experiments of preinjector complex. Electron gun voltage and beam current waveforms are shown in Fig. 4.

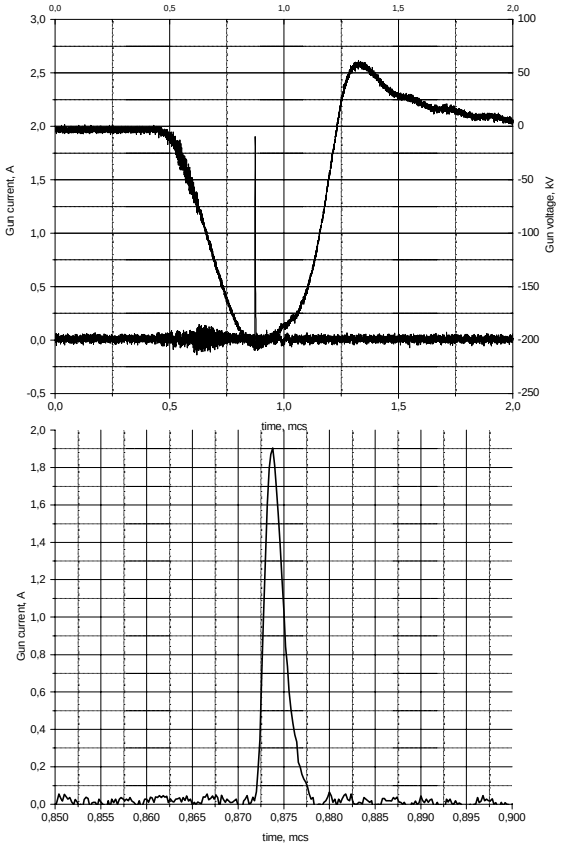

Fig. 4. Beam current and gun voltage oscillogramms.

In the conclusion it is necessary to note that A.Goncharov, A.Sharapa, A.Shemyakin took part in the developing of the electron gun at the design stage. Designing of the first version of the source was done by B.Smirnov.

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