THE MODIFIED 200 keV PULSED ELECTRON BEAM SOURCE FOR THE VEPP-5 INJECTION COMPLEX

A.V. Akimov, V.E. Akimov, P.A. Bak, I.V. Kazarezov, A.A. Korepanov, Ya.V. Kulenko, T.V. Ribitskaia, G.I. Kuznetsov, A.A. Pachkov, M.A. Tiunov
The Budker Institute of Nuclear Physics, Novosibirsk, Russia

The modified pulsed electron beam source on voltage 200 kV and current 10 A with half-height pulse duration 2.5 ns and repetition rate 50 Hz is described. The source gun has been performed on the base of impregnated cathode with 20 mm diameter. The cathode pulse voltage is formed by storage capacitance discharge through IGBT switch and pulse transformer. The gun control unit located at the high voltage potential produces cathode heat voltage and control grid voltage. The source test results are presented.

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1. INTRODUCTION

In the Budker Institute of Nuclear Physics SB RAS a construction of the VEPP-5 injection complex is continued. Electron bunches for preinjector are formed by an electron gun operating at a stable mode of 200 kV, 2 A current amplitude [1]. The 12.5 mm in diameter oxide cathode-grid unit from GS-34B valve is used as electrons emitter. This cathode does not provide a required current and also is not durable enough. To provide the complex project parameters the electron gun with parameters listed below was designed:

electron energy……………………..200 keV;
bunch current amplitude…………...10 A;
pulse duration (at half height)……...2…3 ns;
pulse repetition rate………………..50 Hz;
beam emittance less than……..0.01 π cm rad;
the cathode life-time…………..more than 10^4 hours.

The results of electron source (electron gun with control unit, high voltage modulator, electron-optic line) tests and also its parameters measurement results are presented.

2. ELECTRON SOURCE DESIGN

The electron source design is shown in Fig.1. The accelerating tube (11) along with the gun control unit (GCU) (12) installed on it, the pulse transformer (PT) (3) and the modulator parts (the IGBT module (1) and the primary storage unit (13)) are placed in the common SF_6 filled tank (2) under pressure 0.17 MPa.

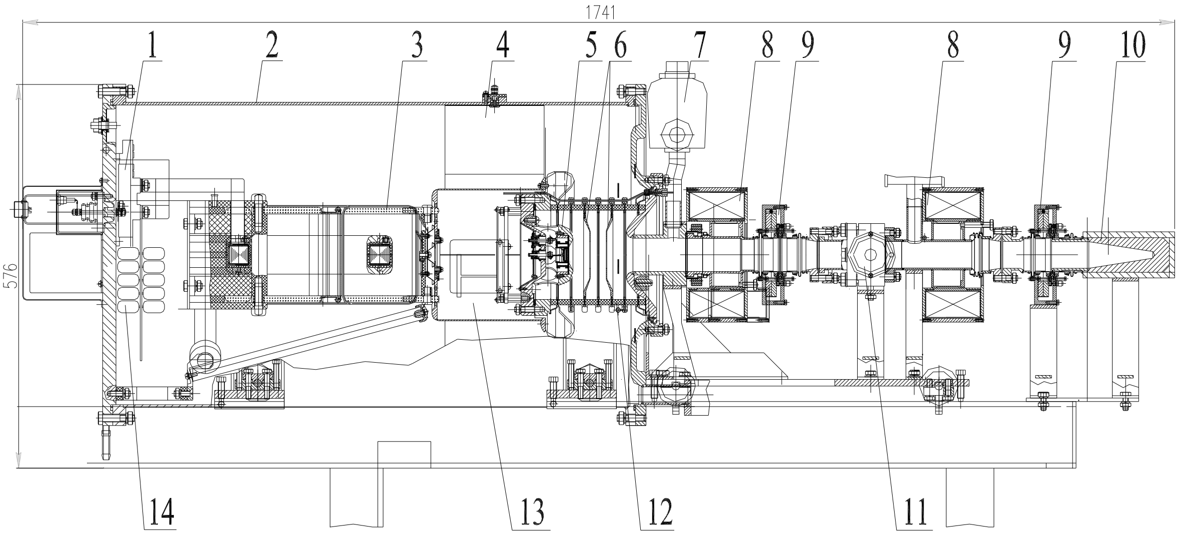

Fig.1. 200 kV and pulse modulator design.
1 – IGBT module; 2 – SF6 filled tank; 3 – PT; 4 – capacitive divider; 5 – cathode-grid unit with focusing electrode; 6 – electrodes; 7 – ion pump; 8 – magnetic lenses; 9 – beam current resistive monitors; 10 – collector; 11 – gate; 12 – accelerating tube; 13 – gun control unit; 14 – primary circuit capacitive unit

Fig. 2. 200 kV gun and pulse modulator design.
1 – IGBT module, 2 – SF6 filled tank, 3 – PT, 4 – capacitive divider, 5 – cathode-grid unit with focusing electrode, 6 – electrodes, 7 – ion pump, 8 – magnetic lenses, 9 – beam current resistive monitors, 10 – collector, 11 – gate, 12 – accelerating tube, 13 – gun control unit, 14 – primary circuit capacitive storage unit

In a design like this all modulator pulse elements are shielded by a metal tank, therefore, an electromagnetic striking is reduced to minimum [2]. A high-voltage pulse former is based on the resonant charge of secondary capacitance through the step up pulse transformer and subsequent discharge to the primary storage capacitance back.

The pulse former circuit is presented in Fig.2. At the expense of small overall dimensions of the high voltage elements (accelerating tube, gun control unit) and modified electron-optical scheme it is succeeded to reduce the electron source total capacitance more than 2 times (down to ~50 pF) as compared with old variant of the gun [1]. Therefore, negative consequences of high voltage discharges were strongly decreased.

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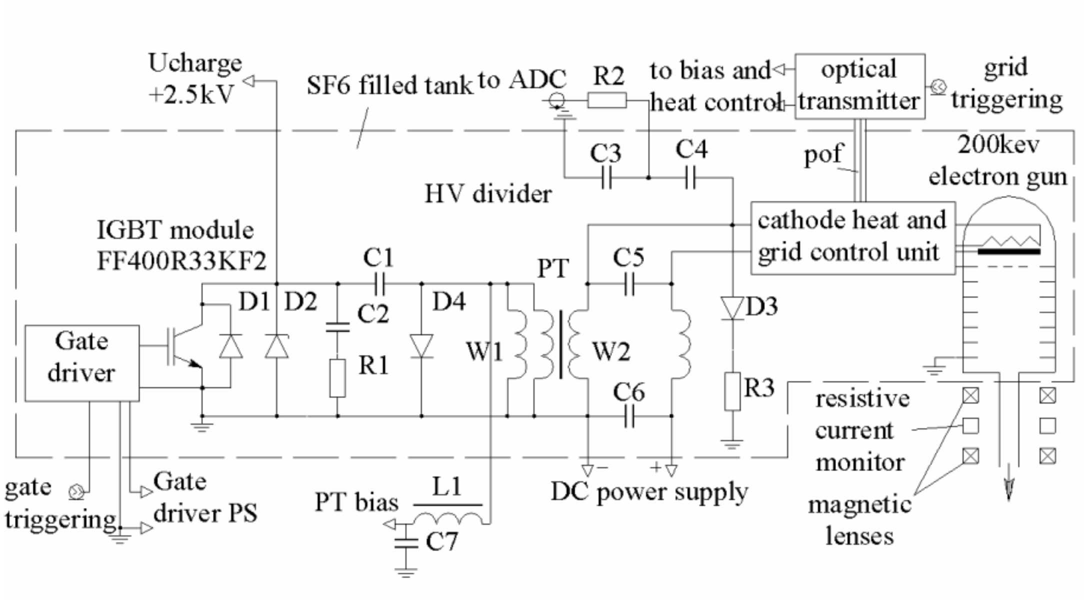

Fig.2. The pulse former circuit

An electron-optical system of the gun is described in [3]. A cathode-grid unit with a focusing electrode is manufactured on the flange as one spear unit (5) (Fig.1). To decrease the breakdown influence on the GCU reliability the scheme with "grounded" grid is utilized. A dispenser spherical cathode unit 20 mm in diameter produced in "Thorium", Moscow, is used as an electron emitter. The cathode allows 4–5 disassemblies of the gun and exposure on the air without its emission degradation. The control grid has spherical radius 100 mm, cell size 0.4×0.4 mm, width of crosspieces 0.06 mm and is made of 100 mkm molybdenum. The distance between grid and cathode is equal to 0.5 mm and is decreased down to 0.4 mm when the unit is heated. The measured grid transparency is 0.685. The accelerating tube consists of 6 welded alumino-oxide ceramic 22HS rings with outer and inner diameters 150 mm and 135 mm, respectively. The accelerating electrodes, which along with the focusing electrode and anode are forming the electron-optical system, are fixed into the tube electrode recesses.

The beam transportation and its matching to the linear accelerator input are performed by means of two magnetic lenses (7,9). Nanosecond resistive wall current monitors (8) allow measuring an amplitude and a shape of the current pulses with required precision. The vacuum gate (10) installed between the gun and the linear accelerator permits one to fix on the preinjector the operational gun previously prepared and tested on the separated facility.

The primary storage capacitance is charged from special charging unit which allowed stabilization of output voltage with precision better than ±0.25%.

The specially designed compact gun pulser generates voltage pulses of up to 290 V amplitude and pulse duration at halfheight ~3 ns. To disable current and to regulate extraction voltage the unit forms constant bias voltage on the cathode in the range 10…200 V. The same unit supplies the cathode filament. Pulse former triggering is realized using plastic optic fiber cables. The double secondary winding of the PT is used to supply the GCU.

3. TEST RESULTS

At present time the electron source operation is tested on a test bench. A collector is used as a beam receiver. In such design the source worked for several dozens of hours in nominal mode (200 kV, 50 Hz). The shape of beam current at the first current monitor at the electrons energy 200 keV is shown in Fig.3.

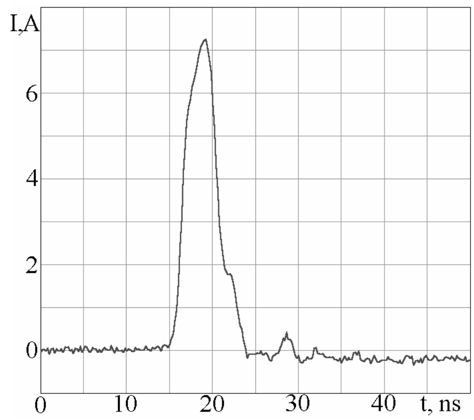

Fig.3. The shape of beam current at the first monitor

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МОДИФИЦИРОВАННЫЙ 200 кэВ ИМПУЛЬСНЫЙ ИСТОЧНИК ЭЛЕКТРОННОГО ПУЧКА ДЛЯ ФОРИНЖЕКТОРА КОМПЛЕКСА ВЭПП-5

А.В. Акимов, В.Е. Акимов, П.А. Бак, И.В. Казарезов, А.А. Корепанов, Я.В. Куленко, Т.В. Рыбицкая, Г.И. Кузнецов, А.А. Пачков, М.А. Тиунов

Описан модифицированный источник электронного пучка на напряжение 200 кВ, импульсный ток до 10 А, длительность импульса на полувысоте 2,5 нс при частоте следования 50 Гц. Источник выполнен на базе импрегнированного катода диаметром 20 мм. Импульсное напряжение на катоде пушки формируется путем разряда накопительной емкости через IGBT-ключ и импульсный трансформатор. Блок управления пушкой, расположенный под высоким потенциалом, формирует напряжение накала и сеточное напряжение. Приведены результаты испытаний источника.

МОДИФІКОВАНЕ 200 кеВ ІМПУЛЬСНЕ ДЖЕРЕЛО ЕЛЕКТРОННОГО ПУЧКА ДЛЯ ФОРІНЖЕКТОРА КОМПЛЕКСУ ВЕПП-5

А.В. Акимов, В.Є. Акімов, П.А. Бак, І.В. Казарезов, А.А. Корепанов, Я.В. Куленко, Т.В. Рибицька, Г.І. Кузнецов, А.А. Пачков, М.А. Тіунов

Описано модифіковане джерело електронного пучка на напругу 200 кВ, імпульсний струм до 10 А, тривалість імпульсу на напіввисоті 2,5 нс при частоті проходження 50 Гц. Джерело виконане на базі імпрегнуваного катоду діаметром 20 мм. Імпульсна напруга на катоді гармати формується шляхом розряду накопичувальної ємності через IGBT-ключ і імпульсний трансформатор. Блок керування гарматою, розташований під високим потенціалом, формує напругу накалу і сіткову напругу. Наведено результати випробувань джерела.