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A Nanosecond Pulsed Electron Gun System for BEPC

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Abstract

A nanosecond pulsed electron gun has been installed at IHEP in Beijing. Two types of pulser have been tested for our fast pulsed gun. Instead of the hybrid fast pulser , a new transistor avalanche pulser was developed. 1.1 Amp beam pulse current from the gun has already been obtained. Preliminary test and details of the gun system are presented in this paper.

Introduction

The nanosecond pulsed electron gun is the electron sousce of BEPC injector. The main parameters of the electron gun required by the machine are: Beam pulse width 2.5 ns; beam pulse current 1 Amp. In order to shorten the injection time of the positron to the collider, higher beam pulse current of the electron gun is required. These technical requirements are similar to the gun for PEP beam injection at SLAC. According to Chinese technological conditions, we designed our fast pulse gun system with reference to the gun.[1]

At the beginning, we obtained first ns beam current from our fast gun with a hybrid fast pulser. In order to further increase beam pulse current, we have developed a new transistor avalanche pulser which is made of Chinese silicon transistor. Now a higher beam pulse current is delivered by this fast gun.

Description

Gun Development

In the past, microsecond pulsed electron gun was generally used on electron linear accelerators in China. We have investigated and compared projects of several ns fast pulsed gun systems used in the world. We consider the project of SLAC PEP Gun is more suitable for the technical requirements. Therefore, in designing, we also used a cathode-grid assembly Y646B which is supplied by Varian Co, its structure is the same as small UHF planar triode. The transconductance of the structure is about 10 millimhos, the grid cutoff voltage is -30 volts at anode potential 80 KV. The grid drive voltage is about 150 volts. It is convenient to make small type pulser which can be mounted directly within the cone of the gun, so that decrease lead inductance and stray capacitance. Thus it is easy to obtain ns pulse beam from the fast gun. The vacuum seal structure allows easy replacement of cathode-grid assembly without demounting the gun envelope. The cathode is a dispenser cathode which can be let up to air several times, and can still be put in operation . We designed a ceramic insulator envelop outside the gun electrodes. It can undergo 100 KV in air. Fig. 1 shows a cross-section of our fast gun.

According to the electrode geometry of the present electron gun. We calculated the beam shape and other characteristics with the aid of the electron trajectory computer program. The results are shown in the following.

V = 80 KV I = 1 Amp
P = 0.044 Microperv ε = 2.6 cm mrad

Pulser Development

The first pulser used in our fast gun is the hybrid fast pulse amplifier board consisted of a quad transistor IC amplifier, a V-MOS transistor, a snap diode , a small ceramic UHF planar triode and a clip line etc. Because of the restriction of the maximum drain-source voltage and the maximum pulsed drain current of the V-MOS transistor, and more current loss divided by clip line, the hybrid pulser could not deliver enough driving voltage and current for the fast gun. So the beam pulse current is within the limits of 600 milliamperes.

Fig.2 shows our gun, transistor avalanche pulser and power supply electronics in place as a test facility. Fig.3 shows a picture of our transistor avalanche pulser board with a cathode-grid assembly in place, it consists of a set of three transistor avalanche pulser and a 50 ohm coaxial inversion transformer driving the gun cathode-grid gap.

Fig. 1, BEPC Electron Gun

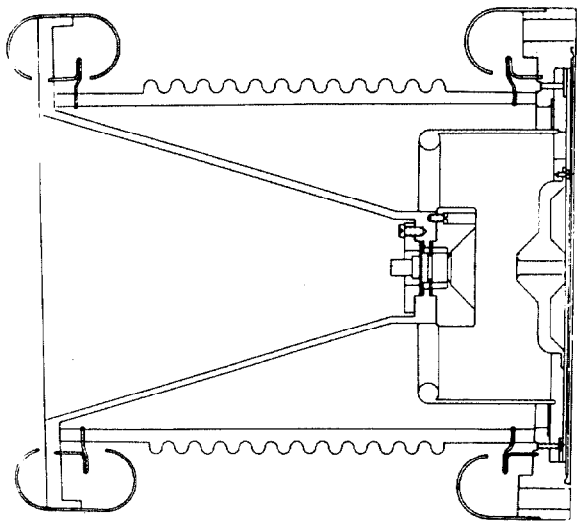

Fig.2 Gun, Pulser and Power Supply

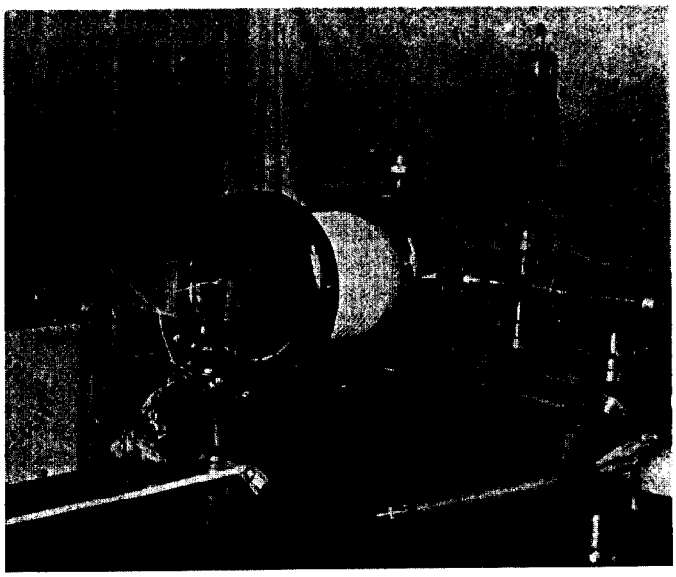

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Fig. 3, Transistor Avalanche Pulser

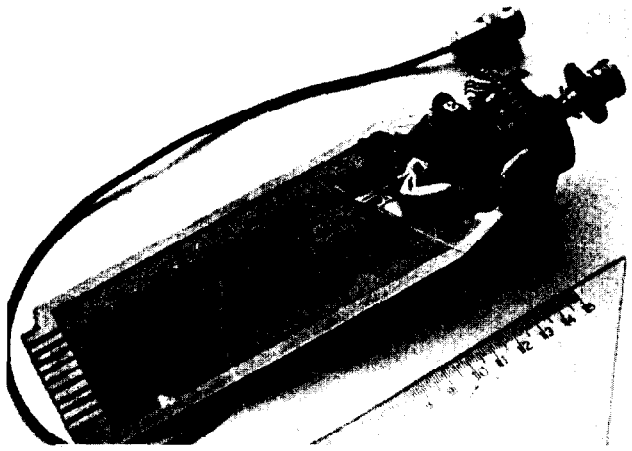


Fig. 4 shows a block diagram of our transistor avalanche type pulser used in our fast gun.[2]

The trigger pulses are generated and amplified to about 10 volts with a pulse width of 10 ns in low level electronics. Then delivered to the pulser board on the high voltage gun grid potential through a fast balum-type pulse isolation transformer. The amplitude of the trigger pulses at the base of the avalanche transistor is about 3 volts which results in the avalanche breakdown process of the transistor. In order to increase the output pulse, three avalanche transistors in series are used. When the negative pulse is applied, the base of an avalanche transistor is opened, the collector-emitter breakdown voltage abruptly drops to lower voltage. From the load (50 ohm) we can get a fast output pulse about 200 volts. So the fast gun drived by the new pulser has delivered the beam pulse current about 1.1 Amps. For our fast gun, the drive voltage is so high that the cathode-grid assembly always operates on the over-drive situation. The beam current delivered from the gun is dependent on the space charge effect limit between anode and grid.

DC High Voltage Power Supply and Pulser Supply

The 80 KV DC high voltage power supply consists of the inverter operating at 3 KHz and the voltage multiplier rectifier. The high voltage is supplied to the grid of the electron gun through a restrictive resistance.

On the 80 KV DC high voltage level there is a pulser power supply for which the A.C. power is derived from H. V. isolation transformer. It supplies a 400 volts DC voltage for the transistor avalanche pulser and supplies the filament and grid bias voltages for the cathode-grid assembly. The filament voltage, the grid bias voltage and the avalanche transistor voltage can be adjusted by three long insulation rod.

Vacuum System

There is a set of high vacuum system in our gun test facility. An ion pump and a turbomolecular pump are equiped. After baking electron gun body and vacuum system as well as conversion of the cathode, the vacuum of electron gun system reached down to 10^{-9} Torr. It assured that the high voltage processing was carried out without a hitch.

Fast Pulse Beam Monitor

A faraday cup has been designed to measure the fast pulse beam current. Its structure must preserve the high frequency components of the electrical signal generated by the fast pulse beam. The major problem is designing a uniform impedance coaxial structure capable of transmitting the high frequency components without distortion. Its impedance is designed as 50 ohms. Faraday cup is used to collect the beam current on the center conductor of a coaxial structure, the electrical signal produced by the collected current is transmitted down the structure to a coaxial cable and then to the fast oscilloscope.

Fig.4

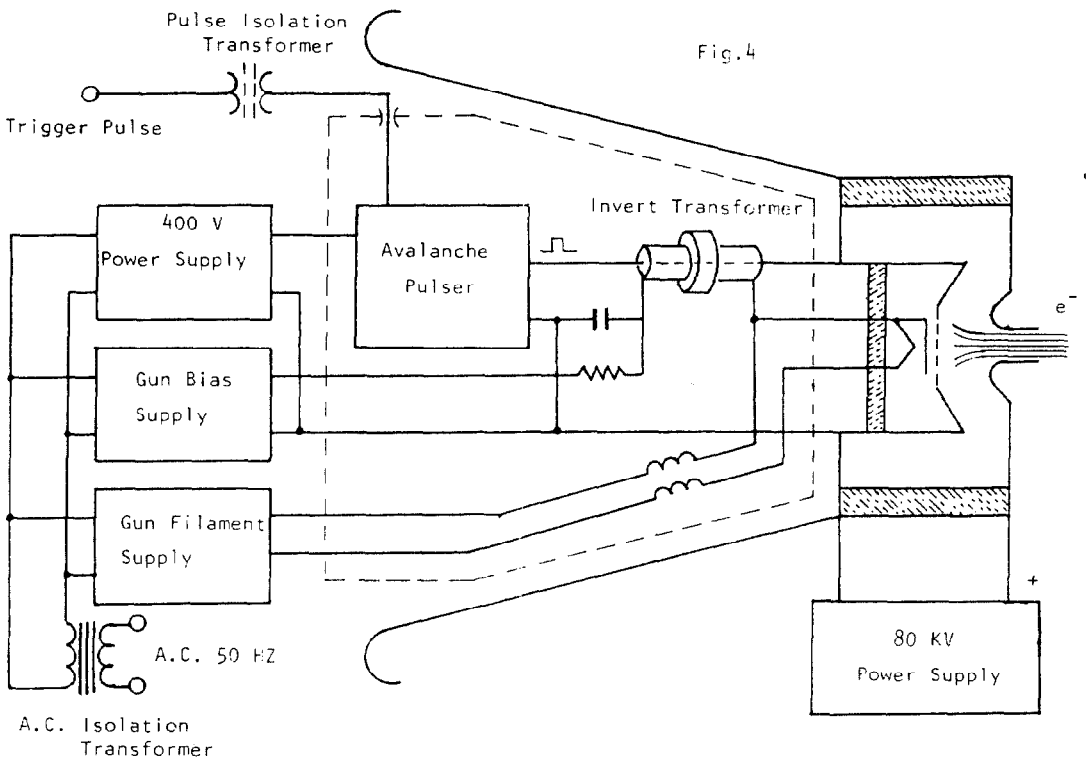
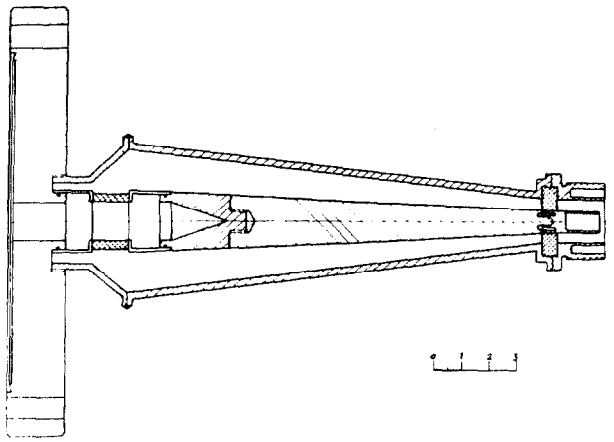


Fig. 5, Faraday Cup



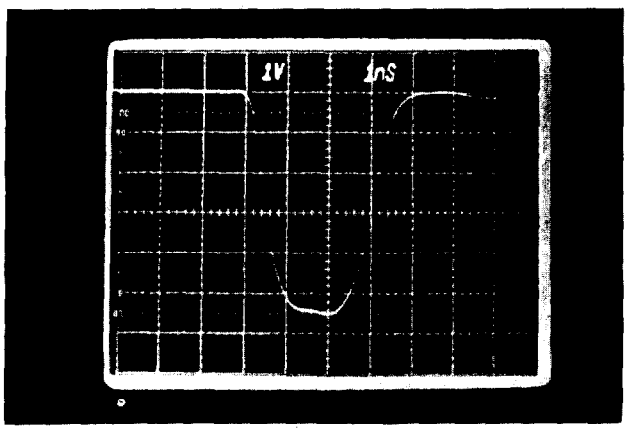
The faraday cup is shown in Fig. 5. Tektronix 485 or 7104 oscilloscope is used to display the pulse wave shape of the fast pulse beam and to measure the pulse current of electron beam.

Experimental Results

We started our fast gun experiment with the hybrid fast pulser at first.[3] The pulse beam current delivered by the gun is limited to about 600 milliamperes within the range of the required pulse width. Furthermore. The degradation of the emission capability of the triode GE16231 caused a decreasing of the pulse current delivered from the pulser.

We have now switched to the new transistor avalanche pulser for grid driving of our fast gun. The pulse beam current delivered by the gun is doubled to 1.1 Amps at 75 KV. The measured perveance of our gun is about 0.053 microperv. Fig. 6 shows a scope photograph of the resulting electron beam pulse taken on a Tektronix 7104 scope. The rise time is about 700 picosecond. The full width of half maximum pulse is about 2.5 nanosecond. The pulse repetition rate is 2 KHz for display purpose. The emittance has not been measured as yet. We plan to further measure characteristics of our fast gun.

Fig. 6, Electron Beam Pulse



Conclusion

We intend to develop a new gun which can deliver higher beam pulse current. A new type of cathode-grid assembly would be developed. The gun electrode geometry must be slightly modificed with the aid of electron trajectory computer program. So long as the new gun would be combined with the transistor avalanche pulser. The new fast gun will deliver higher beam pulse current to fulfil the requirement of the positron injection.

Acknowledgement

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