HIGH VOLTAGE EQUIPMENT OF POLARIZED PROTON PREACCELERATOR

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Introduction

Since 1980, a polarized proton preaccelerator has been built as a three-year project at KEK. A new building was made adjacent to the operating pre-accelerator room. An 800 kV Cockcroft-Walton generator (CW), a high voltage terminal (HVT) and an insulating motor-generator have been installed in it. The ion source and its power supplies are being moved into the HVT.

High Voltage Generator

A symmetric CW generator was made to supply an accelerating voltage to the HVT (Figs. 1 and 2). Its rated voltage is 800 kV with a stability of ± 0.2 % and the maximum available current is 5 mA. The voltage drop ΔV and ripple δV (p-p) are denoted approximately by

$$\Delta V = \frac{I}{fC}\frac{N}{3}\left(\frac{N^2}{2}+1\right) \quad \text{and} \quad \delta V = \frac{I}{fC}\frac{N}{2} \quad ,$$

where N is the number of stages, f is the frequency of the driving voltage, C is the capacitance of the capacitors and I is an output current supplied to a load. For the new generator, N = 4, f = 350 Hz, and C = 0.01 μF. The control system and the 350 Hz generator are similar to those of the old CW so that they can work with the new and the old CWs.

16 rectifiers were assembled at KEK. Commercially available Si diode stacks (Fuji Electric RBHB24-288D24) were put into a glass tube, then the tube was filled with oil (Toray Silicone SH200-50EG), evacuated to remove air bubbles and enclosed with flanges (Fig. 3). Deterioration of the oil and the diodes can be observed by visual inspection. No corona discharge is observed up to 800 kV in a low humidity atmosphere. The voltage drift and fluctuation are within ± 0.04 % of an output voltage of 760 kV for 24 hours. The ripple of a single stage was measured directly with a 2000:1 probe for an 80 kV output. The observed ripple of 28 V (p-p) corresponds to 1.4×10^{-3} of the single stage voltage or 20 kV for a load of 0.2 mA. This agrees well with the calculated value of 0.143 %. As δV is proportional to N, the ripple of 760 kV can be estimated by a simple calculation.

High Voltage Terminal

The HVT has a space 3.75 m long, 4 m wide, and 3.2 m high for the polarized ion source. It is supported by 4 straight porcelain tubes of 60 cm in diameter and 3.9 m long as shown in Fig. 4. A 10 MΩ limiting resistor protects the Si rectifiers of the CW generator from damage from arcing of the accelerating column, and it serves as a ripple filter with the stray capacitance of the HVT. The ripple of the accelerating voltage is reduced to less than 1/10 of the CW ripple. No problems were found up to 795 kV.

Insulating Motor-generator

A 80 kVA generator supplies electric power to the ion source and its auxiliary equipment in the HVT. It is in a small room attached to the HVT and is mounted on a separate support to isolate the ion source from mechanical vibrations caused by the generator. The support consists of three 49 cm diameter fiber reenforced plastic (FRP) pipes. The generator is driven by three 10 cm diameter FRP shafts which are connected with diaphragm couplings. (Eagle industry 65E308-250-ED) The shafts are driven by a 90 kW motor. About 300 μm-vibrations are detected on the surface of the middle FRP pipe when some 50 kW is fed from the generator to the magnet power supplies in the HVT. It is reduced to less than 1/10 by resonant dampers which consist of massive iron donuts and supports of appropriate stiffness.

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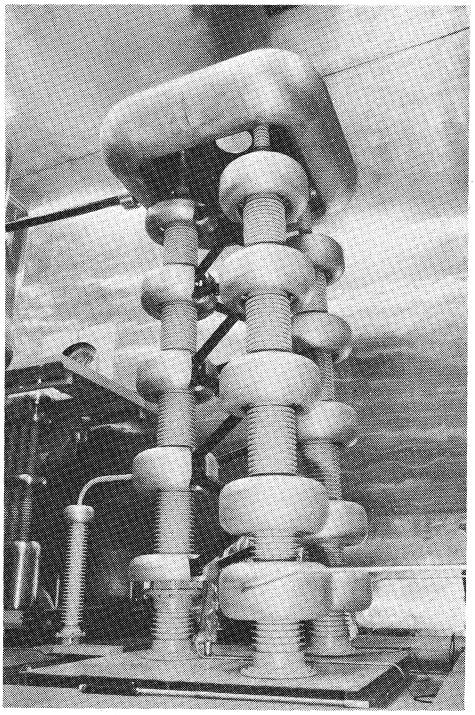

Fig. 1 800 KV symmetric Cockcroft-Wlaton generator.

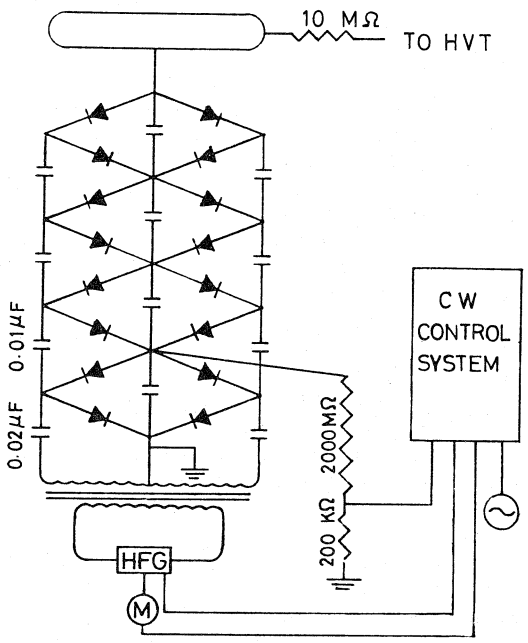

Fig. 2 Schematic Diagram of the CW generator.

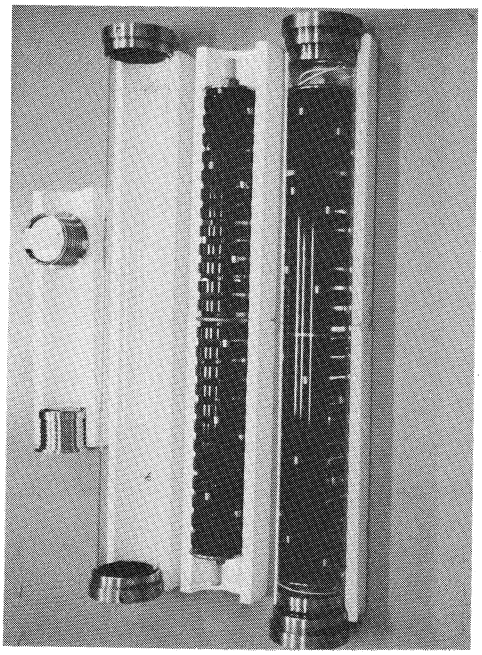

Fig. 3 Silicon rectifier and its components.

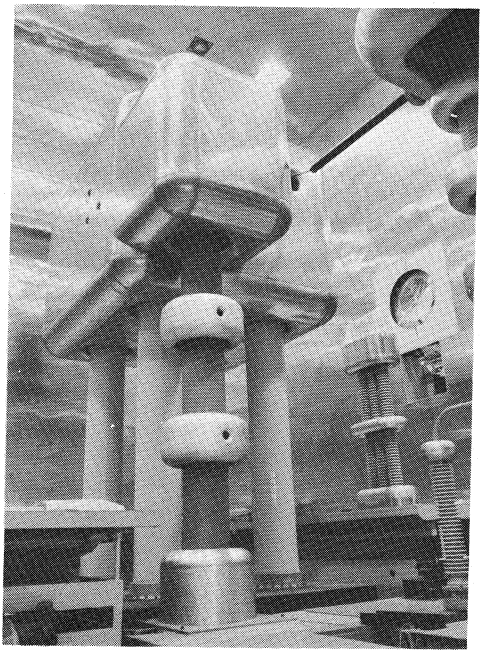

Fig. 4 High voltage terminal with insulating motor-generator.