CORONA TRIODE WITHOUT ANODE POWER SUPPLY

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Abstract

A design of corona triode without anode power supply of the output tube is described. That corona triode works in the system of potential stabilization of electrostatic accelerator conductor. The output tube is placed within a screen of corona triode in order to reduce the capacity of anode circuit to a minimum and to increase the operation speed of stabilization system. Under these conditions an anode voltage at the output tube arises as the result of a current flow through the internal resistance of electron tube. That is, the conductor of electrostatic accelerator is the source of the anode voltage. The speed of operation that stabilization system is more than by an order of magnitude better than in the case of system with the source of anode voltage.

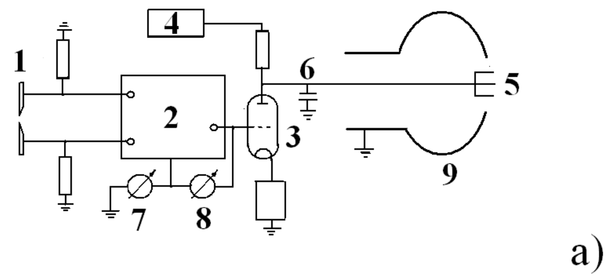
1 INTRODUCTION

The system of stabilization the potential of conductor at the electrostatic accelerator EG-8 (Institute of Nuclear Physics, Moscow State University) incorporates from 1997 the corona triode without the source of anode voltage; the output tube is placed within the corona triode screen.

2 ELECTRICAL SCHEME OF THE STABILIZATION SYSTEM

Formerly the system of conductor potential stabilization was fitted with a slit transducer (see Fig.1a); this device was mounted at the exit of the 90° electromagnetic analyzer. Differential signal from the slit device was transmitted over short (0.5 m) cables to the input of dc differential amplifier with controlled gain factor (up to 10^3) and the band width up to 10^4 Hz.

Band width of amplifier has to be equal to 100 Hz. Extension of the band practically has no effect on the voltage stability of the electrostatic generator. Contraction of the band to < 100 Hz gives rise to decline of stability, that testifies to speed of operation of the stabilization system. Differential signal from the amplifier output transmits on the grid of high-voltage triode loaded to the impedance of 30 MOhm. 10 kV rectifier had been used as the source of the tube anode voltage. The tube anode was connected to the corona points by the short (1m) high-voltage cable. For the measurement of the corona triode current the frame of amplifier was isolated and grounded through the micro ammeter. The ammeter and the device for measurement an output voltage had been mounted on the control panel of the accelerator.



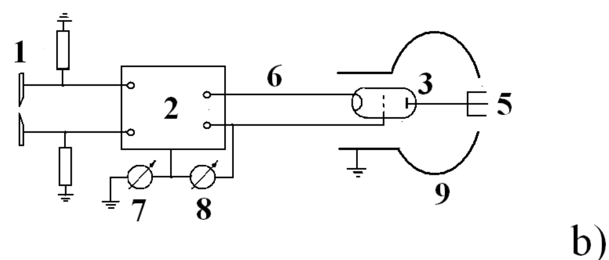


Figure 1: Scheme of the stabilization system with anode power supply – a) and without it – b). 1 – slit device; 2 – differential amplifier; 3 – high voltage triode; 4 – rectifier; 5 - corona points; 6 - high-voltage cable; 7 – micro ammeter; 8 – device for measurement of output voltage.

The accelerator EG-8 is located in the basement. It results in elevated humidity during hot months and, consequently, in leakage from the elements under high voltage. In such moments the leakages distort the ammeter indications of corona current and cause a malfunction in the system of stabilization. At turning-off the 10 kV anode power supply the stabilization system responded to the beam deflection, but worked badly, and the beam is frequently separated from the slits. Decrease of the stabilization system's operation speed at de-energization of the source of anode voltage led practically to the system's inserviceability.

The speed of response may be estimated in the following way. At blocking the triode by a signal of the dc amplifier the capacity of anode is charged only by current of corona

I (about 10 μA). Capacity of the anode circuit C consists of the capacity of the high-voltage cable (several hundreds pF) and capacity of the tube anode (< 10 pF). For efficient changing the corona current a potential of the corona points U has to be changed by approximately 1 kV. Then the time constant τ of the anode circuit will be $\tau = U \cdot C/I$, that amounts to tens milliseconds and is comparable with time of the ion drift in the corona discharge [1].
For minimizing the capacity down to 10 pF the tube was incorporated in the corona triode screen (see Fig. 1b). Such an arrangement results in increasing the operation speed of the scheme without anode power supply more than by an order, and in obtaining the same stabilization of the conductor potential, as in the case of the scheme with use of the anode voltage source.

3 CONSTRUCTION OF THE CORONA TRIODE WITHOUT ANODE POWER SUPPLY

The anode of the output tube in the corona triode without anode power supply is inserted in the disk, whereon the corona points are mounted (see Fig. 2). It

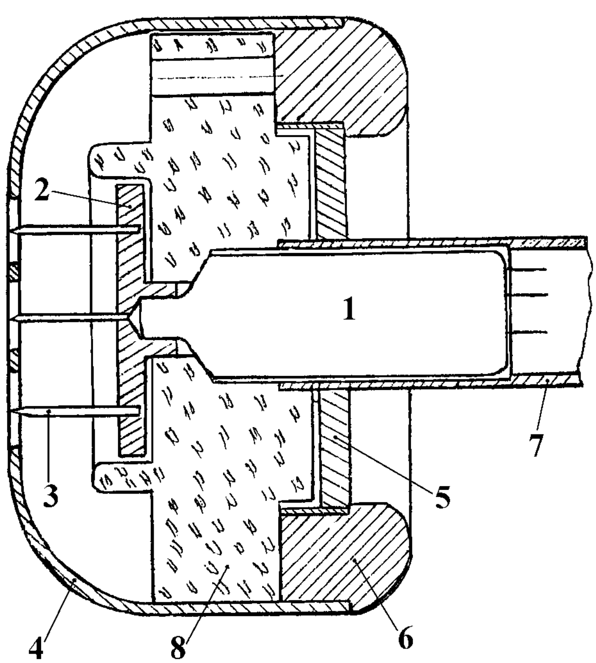


Figure 2: Construction of the corona triode without anode power supply: 1 – output tube; 2 – disk; 3 – corona points; 4 – screen; 5 – flange of the rod; 6 – foot; 7 – rod; 8 – isolator.

results in minimization of the anode circuit capacity. The cavity for a tube is packed with two gaskets. Corona points may be moved relative to the screen by the rotation of screen on the flange of rod with fixation through 90°. Originally the corona points extend above the screen surface on 0.5 mm.

The former construction had the mechanism of displacement of points relative to the screen mounted at the exterior side of tank [2]. In a new construction such mechanism is absent. So for adjusting the position of points as they are burning, corona triode has to be removed from the tank. The necessity of adjusting arises once during 2-3 years of the accelerator's work. It should be noted that the normal operation of the corona triode is kept even at pronounced shortening of the points in comparison with their original length [3].

4 RESULTS

Passing the corona current through the internal resistance of tube brings out anode voltage on the output tube in the corona triode without power supply. In other words, in a new scheme the conductor of electrostatic accelerator is the source of anode voltage. Dependence of corona current on the voltage on the corona points at definite potential of conductor is the same for both schemes (see Fig. 3). On the base of this dependence and the family of grid-drive characteristics one may obtain the dependence

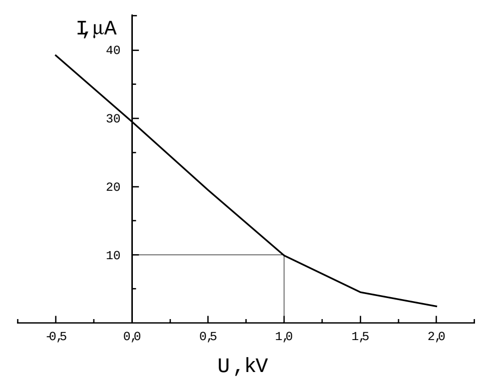


Figure 3: Volt-ampere characteristic of the corona triode. A voltage at the conductor is equal 1.8 MV and a pressure of nitrogen is equal 6 atm.

of corona current on the potential of grid of the corona triode without anode power supply (Fig. 4). Applying 1 V negative bias to the grid of tube ensures the initial current of corona triode of 10 μA. It is achieved by the offset of the amplifier's zero and without use of the special source of bias voltage. At such negative bias and 10 μA current of the corona triode a beam is passing through a center of the slit device. If the accelerator works in a normal regime the fluctuations of the triode grid potential are within the limits ±0.5 V of the initial set-up. At changing an average potential of grid (by the change of corona triode position or by varying the charging current) the beam is shifted from a center of the slit device. It is noticeable very good at 5 m base from the slit device.

Operators are using this phenomenon for correction the beam position along the vertical, because the stabilization system maintains stability in the range of the average tube potentials up to 10 V.

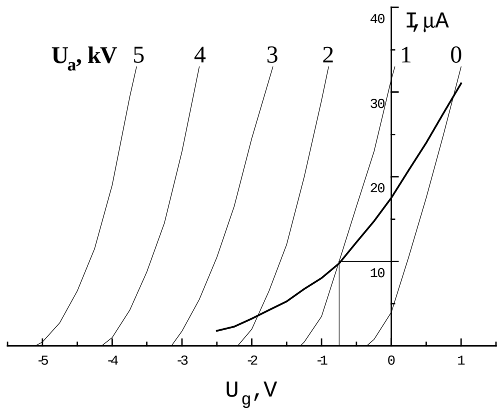


Figure 4: Family of grid-drive characteristics of output tube 6C40П - thin lines and dependence of the current corona triode without anode power supply on the potential of grid of output tube - thick line.

Under two-year service of the corona triode without anode power supply there was no necessity in adjusting or repair of the stabilization system. The increasing of the current-voltage curve’s steepness could increase the system’s operation speed. For this it is necessary to decrease the size of screen’s aperture with corresponding increasing of point’s number, that permits to keep the point’s service life. However the results of service showed that increasing of the system’s operation speed is unnecessary.

ACKNOWLEDGEMENTS

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