CHARACTERISTIC OF BÉU-6 CHANNEL ELECTRON MULTIPLIERS IN DETECTION OF NEUTRAL PARTICLES

M. A. Gruntman and A. P. Kalinin

UDC 621.374.4

A BÉU-6 is used to measure zone characteristics, pulse-height spectra, the effect of a load, fatigue characteristics, and characteristics as functions of the type of particles during detection of neutral fluxes with an energy of 0.6-2 keV [1].

In performing the measurements we used an arrangement [2] in which a neutral beam was produced by recharging He⁺, N₂⁺, and H⁺ ions. The cross section of the collimated beam was trapezoidal and had a half-width of 0.2 mm. In comparison with the characteristic dimensions of the BÉU-6 (entrance cone diameter 3 mm and channel diameter 1.5 mm), the cross section could be considered as a point. The BÉU-6, which was mounted on a moving platform, moved in a plane perpendicular to the beam axis. A negative voltage, U_m, was applied to the input of the channel emitter connected to the grid whereas the multiplier output was grounded. This kind of circuit is typical of the detection of slow charged particles when preacceleration by the input voltage is employed. The anode signal was fed into the amplifier and then to a PP9-2M scaler or AI-1024-4 pulse-height analyzer. The pulse-height spectrum was recorded by an X-Y recorder (PDS-021M). The pulse distributions were normalized by area, i.e., by the total pulse count.

It was established that the pulse-height distribution does not depend on the type of particle detected for beams of He, N₂, and H with an energy of E_b = 1200 eV. Therefore, the characteristics obtained for He atoms are given below.

Zone characteristics are of interest for a channel electron multiplier (CEM) with an entrance cone. Figure 1a gives results of measurements of the counting rate as a function of the point of impact of the beam at various voltages U_m. The modulation of the measured functions corresponds to the grid pitch. In contrast to the case when electrons, ultra-soft x-rays, and ultraviolet radiation are detected [3, 4], the counting rate for neutral particles does not increase when the beam enters the center of the entrance cone. The dip seen in Fig. 1a is caused by a specific feature of the interaction of slow charged particles with the grid, which is typical of a channel electron multiplier.

![Fig. 1. Counting rate as function of distance to cone center: 1) U_m = 2.6 kV; 2) U_m = 2.2 kV; 3) U_m = 2 kV, E_b = 600 eV; b) relative gain as function of distance to center of cone: 1) U_m = 2.5 kV, E_b = 2 keV; 2) U_m = 3.5 kV; E_b = 600 eV; 3) U_m = 2.5 kV; E_b = 600 eV.](image)

Fig. 2. a) Gain as function of voltage $U_m$. Distance to center of cone: 1) $r = 3$ mm; 2) $r = 0$; $E_b = 600$ eV; b) counting rate as function of voltage $U_m$. Distance to center of cone: 1) $r = 0$; 2) $r = 2$ mm; $E_b = 600$ eV.

Fig. 3. Pulse-height distributions: a) as a function of beam energy: 1) $E_b = 600$ eV; 2) $E_b = 2$ keV; $U_m = 3.5$ kV; $r = 0$; b) as a function of the distance to the center of the cone: 1) $r = 0$; 2) $r = 2.5$ mm; $U_m = 3.5$ kV; $E_b = 600$ eV; c) as a function of the load: 1) 120,000 pulses/sec; 2) $I = 40,000$ pulses/sec; 3) $I = 4000$ pulses/sec; $U_m = 2.5$ kV; $E_b = 600$ eV, $r = 0$.

For $U_m < 2.4$ kV is due to the decrease in the CEM gain both when the beam is displaced from the periphery of the cone to the center and when $U_m$ decreases. Consequently, the pulse height drops below the scaler discriminating level which is usually set at a background level of $N < 0.1$ pulse/sec.

The most probable pulse height was used for the relative gain $K_m$ of the multiplier [3]. Figure 1b shows $K_m$ plotted as a function of the distance to the center of the cone for two values of $U_m$ and $E_b$. It is seen from this figure that when $E_b = 600$ eV, $K_m$ decreases as the center of the cone is approached, as is the case for electrons [3]. If the beam energy is increased to 2 keV, $K_m$ becomes the same over the entire area of the cone. The empirical plots of $K_m$ as a function of the multiplier voltage for various points on the cone are shown in Fig. 2a. These plots are straight lines whose slopes increase with the distance from the point of beam impact to the center of the cone.

Figure 2b plots the counting rate $I$ against the voltage $U_m$ for a fixed discriminating level at the PP9-2M input for two incidence points of the beam. The curves obtained are of a complex nature and do not reach a plateau in the region of voltages $U_m$ studied but instead have a tendency to rise as $U_m$ grows. Note that for the cone center when $U_m > 2.4$ kV the increase in $I(U_m)$ is $\approx 10\%$ per 300 V. Similar results were obtained when ultraviolet radiation was recorded [5] with a Mullard B419BL channel electron multiplier.

The pulse-height distributions obtained for various BEU-6 operating conditions are shown in Fig. 3. It is especially interesting that at low beam energies $U_m > 3$ kV, the pulse-height distribution displays two peaks (Figs. 3a and b) more and more distinctly as the cone center is approached. For $E_b = 600$ eV and $U_m = 3.5$ kV, the height of the second peak is 30% of that of the first.

In various types of measurements the dependence of $K_m$ on the load on the CEM is of great importance. Figure 3c shows typical distributions for the center of the cone. It is seen that $K_m$ decreases by a factor of two when the beam intensity rises from 4000 to 120,000 pulses/sec. It turned out that in the range of intensities from 100 to 4000 pulses/sec the gain $K_m$ does not depend on the load. A distinctive feature of the BEU-6 is that $K_m$ increases with the beam energy (Fig. 3a).
To study the fatigue characteristics the ЄПУ-6 was subjected to the action of a beam with an intensity of $10^6$ pulses/sec for three hours. It was found that $V_m$ decreases tenfold during the accumulation of a total count of $10^6$ pulses.

**LITERATURE CITED**


**COMPACT HCN LASER**

D. N. Yundev

UDC 621.373.8

A cw HCN laser is described and the results of its optimization are presented. The laser is 1 m long, operates at a wavelength of 0.337 mm, has a radiated power of 1 MW, in a stability of $\pm 5\%$/h, and a period of continuous operation of up to 300 h.

Because of the active media in common use, HCN lasers have a length of several meters. Reduction of the dimensions to 0.6–1.0 m still allows generation to be observed [1] but small lasers have not as yet been used in practical applications. The desirability of building a more compact HCN laser has been noted on many occasions. Reduction of the laser size makes it possible to decrease the high voltage needed, thus easing the requirements placed on the power supply. Although a decrease in the discharging current generally leads to a drop in radiated power the lifetime of the discharge tube is extended because of the reduced rate at which it is eroded by the products of chemical reactions in the discharge.

Optimization of the radiated power takes on particular importance in the construction of a laser [2]. To carry out optimization it is necessary to study the principal laser characteristics, including the stability of the radiated power, as a function of the operating parameters and to choose the optimal conditions for the laser operation. Thus far various authors have studied only individual characteristics of a laser and the optimization has been of a limited nature.

![Diagram of cyanide laser](image)

**Fig. 1. Arrangement of cyanide laser: 11) anode; 16) vacuum gasket seal.**


This material is protected by copyright registered in the name of Plenum Publishing Corporation, 227 West 17th Street, New York, N.Y. 10011. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, microfilming, recording or otherwise, without written permission of the publisher. A copy of this article is available from the publisher for $7.50.