

DIRECT CURRENT STABILIZATION OF SCINTILLATION COUNTERS USED WITH PULSED ACCELERATORS

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A simple system is described for the gain stabilization of the photomultiplier of a scintillation counter. Use is made of a

constant light source. The stabilization factor of the system amounts to $S = 200$.

1. Introduction

Gain stabilization of photomultipliers may be necessary in high resolution scintillation spectroscopy. If the pulse spectrum contains a high intensity narrow line the circuit developed by de Waard¹⁾ may be used. The difference in counting rates of two channels, set on the two halves of the line, is fed back to regulate the voltage on the multiplier. In the more sophisticated circuit of de Waard one channel is modulated across the line. In many scintillation counter experiments, however, the pulse spectrum does not contain a high intensity narrow line, and it may be difficult or impossible to introduce such a line artificially. In the present paper a simple circuit is described which operates on a different principle and which can be used for the gain stabilization of scintillation counters detecting radiation or particles produced by pulsed accelerators.

The new system uses a constant light source illuminating the multiplier photo-cathode. The deviation of the d.c. anode current from a preset value is amplified and fed back to regulate the multiplier voltage. The multiplier anode current is diverted during the burst of the machine to prevent the d.c. component of the scintillation pulses from influencing the stabilization. The system has proved very reliable during experiments on the elastic and inelastic scattering of 90 MeV positive pions produced with the CERN synchro-cyclotron in Geneva. Scattered pions

were completely stopped in large plastic scintillation counters. The height of the resulting pulse was used to distinguish elastic from inelastic scattering.

2. Stabilizer Design

Sufficiently constant illumination of the photo-cathode was obtained from a commercial 10 W, 230 V incandescent lamp. This lamp was mounted inside the multiplier shielding near the base of the multiplier. The light arrived from below, through the glass envelope of the multiplier, at the photo-cathode. The lamp was fed from a 300 V stabilized power supply through a variable resistor, reducing the voltage to about 40 V. The variation in light output was below 1% for changes in the ambient temperature up to 50°C. After several days of burning in at 230 V the light output has not changed measurably over a period of one month. To prevent fatigue of the photomultiplier the anode current must be kept low. With RCA 7046 multipliers the decrease in gain caused by fatigue was less than 5% for constant anode currents up to 1 μ A.

The electronic circuit consists of two separate units (fig. 1). The first unit is placed near the scintillation counter in the cyclotron experimental hall. It contains the circuit to suppress the multiplier current during the machine burst, and a cathode follower, feeding the signal through a 150 m screened cable to the counting room. The second unit, placed in the counting room

¹⁾ H. de Waard, *Nucleonics* 13, no. 7 (1955) 36.

together with the power supply of the multipliers consists of a d.c. differential amplifier with a cathode-follower output. Neither side of the

block with an amplitude of 30 V is derived from the high-frequency system of the synchro-cyclotron. The repetition frequency of the ma-

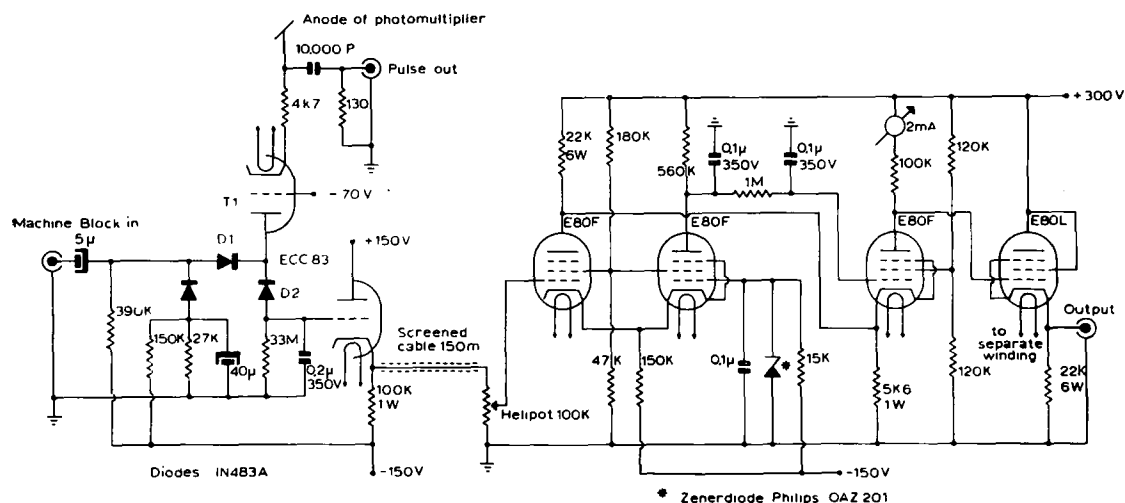


Fig. 1. Stabilization circuit. The error signal, produced in the left hand part of the circuit (placed in the cyclotron experimental hall) is fed through 150 m screened cable to the difference amplifier in the right hand part of the circuit (placed in the cyclotron counting room). The amplifier output regulates the multiplier power supply.

photomultiplier high voltage power supply is grounded, but the positive bus is connected with the amplifier output and the negative bus with the multiplier photo-cathode, via the high-voltage cable to the experimental hall. A change in input of the amplifier varies the output voltage and consequently the voltage on the multiplier, correcting the variations of the anode current of the multiplier.

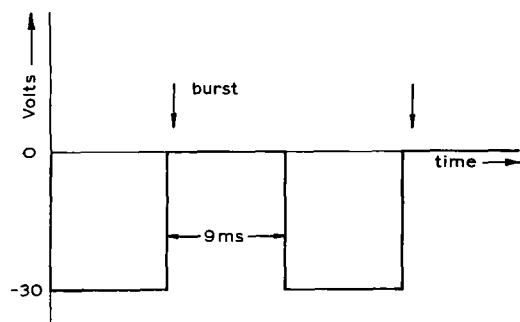


Fig. 2. Voltage at the anode of D1. The machine burst started about 0.5 ms after the fast rise of the block.

The suppression of the anode current during the burst of the machine is performed by the diode circuit in the first unit. A symmetrical

chine is 54 Hz. The timing of this block with respect to the machine burst, and also the d.c. level at the anode of the diode D1 is shown in fig. 2. This block causes the diodes D1 and D2 (both IN483A) to conduct alternately. When the machine block is in its negative half-period, D1 is switched off and the anode current has to go through the resistor of 33 M Ω . The voltage built up over this resistor is then about -15 V for an anode current of $1\mu\text{A}$. The diodes have a very high back resistance. For -50 V the inverse current is less than 10^{-8} A. But at $1\mu\text{A}$ the forward resistance also is rather high. Therefore it was necessary to install T1, as otherwise the RC-time of the multiplier anode would be too long. A number of different tubes were measured to select the type with the highest mutual conductance. The best proved to be the type ECC83, which has a mutual conductance of $6\mu\text{A/V}$ at $i_a = 1\mu\text{A}$. With an effective capacity of the multiplier anode of 10^4 pF this gives a RC-time of 1.6 ms, which is sufficiently short compared to 9 ms (see fig. 2).

The current going through the resistor of 33 M Ω is not exactly half the multiplier anode

current, but about 10% less. The reason is that when D2 is switched into conduction, the voltage at the anode of T1 is reduced from 0 V to -15 V. Therefore, at that moment the cathode of T1, together with the condenser at the anode of the multiplier, also has to drop about 0.2 V in voltage. Consequently, during the first milliseconds of that half period a part of the multiplier anode current is used for charging the condenser.

In the amplifier the signal voltage is compared with the voltage on the Zener diode, which was -8.3 V. The gain of the amplifier is 4000. Its output can vary from 120 V to 280 V.

The desired gain of the photomultiplier is set roughly with the light intensity of the lamp. Fine regulation is done with the helipot at the input of the amplifier. The meter in the amplifier serves to indicate if the circuit is working in its stabilizing region.

3. Fluctuations

The noise of the anode current of the photomultiplier gives an increase in the statistical fluctuations of the pulse height measured. This effect can be calculated from the fluctuations in the number of photoelectrons due to the d.c. current, in a time interval equal, roughly speaking, to the pulse length. In first approxima-

tion the relative increase of the peak width amounts to $(\tau i \sigma^2)/(2eg)$, where τ is the pulse length, i the anode current, σ the pulse height relative standard deviation, e the electron charge and g the current amplification of the multiplier. In our experiment the pulse length was 20 ns. For e.g. $\sigma = 0.1$, $g = 10^5$ the increase is completely negligible.

4. Stabilization Factor

For the stabilization factor of the system one finds $S = \alpha VG/E$, where V is the voltage of the Zener-diode, G the gain of the amplifier, E the voltage over the photomultiplier, and α the relative variation of the gain of the multiplier with the voltage, $\alpha = (dg/g)/(dE/E)$. In the present case the stabilization factor amounted to $S = 200$.

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