Fyz. čas. SAV 22 (1972), No. 4

NOISE EFFECT AFTER FILLING A COUNTER

JÁN CHRAPAN*, Bratislava

We describe the mechanism responsible for noise effects arising after filling a proportional or Geiger—Müller counter.

I. INTRODUCTION

When measuring low activities by a gas-filled counter it is often useful to increase the sensitivity of the system by introducing the measured specimen (in gaseous form) into the effective volume of the counter. During the measurement of radioactivity of the counting gas we often come across the following situation: the characteristics of the counter do not show the plateau shortly after the counter was filled but later the characteristics get by themselves into the standard shape. The intermediate non-equilibrium state may last some dozen of minutes [1]. By routine measurements this may be considered as an effect induced by electrophilic admixtures in the working volume [2]. The measurements take more time if the counter is cleaned and — what is frequently more important — the measured specimen in the filling gets lost. The occurence of the effect is rather irregular and it is easily misinterpreted as a result of the memory effect of the counter.

In what follows we shall refer to this effect as to the „noise effect after filling a counter" or as to the „P-effect".

II. EXPERIMENTAL OBSERVATIONS

We have observed the P-effect on cylindrical gas counters of the Oeschger type, working in the proportional and Geiger regions by measuring the radiocarbon in the form of CO_2 [3].

The experimental results can be summarized as follows:

1. The effect depends on the counter's geometry and it is proportional to the distance between the counter's electrodes.

* Katedra jadrovej fyziky Prírodovedeckej fakulty UK, BRATISLAVA, Šmeralova 2a.

2. The effect does not occur regularly, it depends on how the counter was filled.

3. After a counter's filling with the counting gas $CO_2 + CH_4$, at a preasure of 760 torr and an input sensitivity of 5 mV, fast snapped counting characteristics had the form showed in Fig. 1.

4. The counting rate (fixed voltage and the same specification as those in 3.), decreased with time according to Fig. 2.

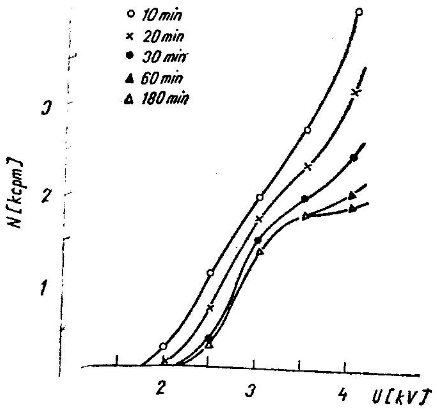

Fig. 1.

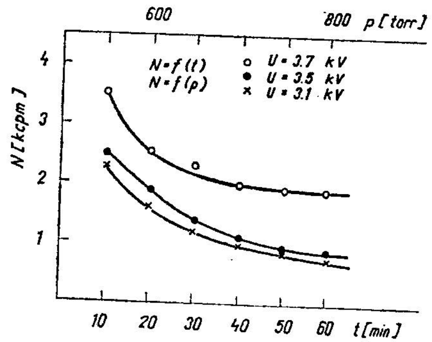

Fig. 2.

III. AN ATTEMPT TO EXPLAIN THE EFFECT

The amplitude (denoted as U) of a pulse in a gaseous counter is given by the following relation:

$$U = M \frac{q}{C}, \tag{1}$$

here q denotes the charge, caused by the ionization, C is the equivalent capacity of the counter, M is the coefficient of the total gaseous amplification. We can keep M constant and given as

$$M = \frac{m}{1 - \gamma m}, \tag{2}$$

where m is the coefficient of gaseous amplification:

$$m = \exp \left\{ \int_{r_a}^{r} \alpha(r) \, dr \right\} \tag{3}$$

here r_a is the anode's radius, r is the distance of the spot where ionization occurred from the anode and α is the coefficient of ionization. The following holds

$$\alpha = ap \exp (bE/p), \tag{4}$$

where a, b are constants, characteristic for filling, p is the pressure of the filling and E is the intensity of the electric field.

The coefficient γ in equation (2) is the surface ionization coefficient:

$$\gamma = \frac{N}{N_0'}, \tag{5}$$

where N is the number of electrons, released by a surface ionization, N_0' is the number of ions which reach the surface, exposed to surface ionization.

If N_0 is the multitude of ions near the anode, then in the surface ionization N_0' ions will participate:

$$N_0' = N_0 - \varrho n_+ n_- T. \tag{6}$$

Here $\varrho \in (10^{-8}, 10^{-10})$ cm^3 s^{-1} is the coefficient of recombination, n_+, n_- the concentration of ions and electrons, T is the time of recombination.

Subsequently with decreasing the time of recombination, less ions have been recombined. Time T is given by

$$T = t_0 \left[\left(\frac{r_k}{r_a} \right)^2 - 1 \right], \tag{7}$$

where $t_0 \sim 10^{-7}$ s, r_k is the radius of the cathode.

The amplitude of a noise pulse can according to (1), at a sufficiently short time T, by (6), (5) and (2) exceed the input sensitivity and the pulse can be registered.

According to (7) T can be shortened by diminishing r_k. Let us consider, that r_k is the distance, which an ion must cross, in order to evoke a surface ionization. T can be shortened by inserting some obstacles into a counter's sensitive volume. Such obstacles are small parts of dust, which stay after a counter's filling for some time in the counter's sensitive volume.

IV. COMMENTS AND CONCLUSIONS

The mechanism suggested above explains in a natural way the feature of the P-effect listed in section II.

i. Note that according to the eqs. (1) and (7) the intensity of the P-effect depends on the geometry of the counter.

ii. The phenomenon depends on how the counter is filled, since the amount of the dust depends on that.

iii. The dust contained in the counter gradually settles. This explains items 3. and 4. listed in sec. II.

The behaviour of the counting rate, analogous to that occurring in the P-effect, is also obtained by increasing the pressure of the counter's filling (see Fig. 2.). If we assume a specific heat of the counter's gaseous filling and walls of the counter (its ratio is $\sim 10^{-4}$), we can neglect the increase of the pressure as a consequence of the temperature's stability.

The effect described plays an important role in routine measurements requiring frequent changes of the filling in surroundings which cannot guarantee a permanent absence of dust [4].

If the effect increases to such an extent as to seriously disturb the measurement, the counter has to be dismantled and the dust removed by washing.

REFERENCES

[1] Renk H., Chrapan J., Kopiczyński T., ACTA F. R. N. Univ. Comen., Physica *IX* (1969), 77.

[2] Starčuk Z., Cupák M., Radioisotopy *2* (1966), 7, 339.

[3] Schmidt Z., Chrapan J., *Slovenský kras VIII.* Zborník MSK, Osveta Martin 1970, 69.

[4] Chrapan J., *Dissertation.* Katedra jadrovej fyziky PFUK, Bratislava 1971.

Received March 11th, 1971