A COORDINATE PROPORTIONAL COUNTER

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Results are presented of investigation of a 30 × 30 cm multifilament proportional counter suitable for measuring the coordinates of the point of passage of a charged particle.

PROPORTIONAL counters have recently gained a second lease on life. The point is that besides their known advantages, such as short dead time, good energy resolution, relatively large output-signal amplitude, continuous operation, and wide choice of working gases, there has been added one important quality, namely the possibility of measuring, with good accuracy, the coordinate of the point of passage of a charged particle. Such counters can be very useful in experiments both on low-energy physics and for high-energy physics and cosmic rays.

It has been shown in the case of multifilament proportional counters of large area[1] that even when the distance between filaments is 0.1 cm, each filament operates as a separate independent counter. Therefore, the possibility of determining the coordinates of the point of passage of a charged particle is determined by the method of interconnection of the filaments (see Fig. 1). Thus, if they are interconnected by resistors, the coordinates x and y of the particle can be determined by comparing the amplitudes of the signals A–D at the output of the corresponding networks: $A/(A + B) \sim kx + l$, $C/(C + D) \sim my + n$.

If the wires are interconnected by inductances, then, in conjunction with the distributed capacitance of the wiring, the entire system constitutes a line with lumped constants. Then, the coordinates of the particle can be determined from the differences of the time of arrival of the signals at the two ends of the line:

$$x \sim \{t(A) - t(B)\}, \quad y \sim \{t(C) - t(D)\}.$$

In the investigation described below, we studied one more possible construction of a coordinate counter. A single working filament, made of material with large resistivity, is mounted in zig-zag fashion over the entire working area of the counter (Fig. 2; the second electrode of the counter is not indicated). In fact, the resistors interconnecting the wires are replaced here by the distributed resistance of the wire itself. Therefore, as before, the coordinates of the particles are determined by the ratios $A/(A + B)$ and $C/(C + D)$.

The proposed scheme is simple and quite easy to construct. It is free of a number of structural complications typical of counters with many individual filaments.

It should be noted that in this case it is not advisable to connect voltage amplifiers to the output of the counter. Otherwise, in order to make the picked off pulse as large as possible, the load resistance of the counter would have to be large, and in order to retain the coordinate sensitivity of the counter, it would be necessary to increase the resistance of the working filament. Then the distribution of the primary current due to the passage of the particle would be determined not only by the resistance of the corresponding sections of the circuit, but also by the capacitances between the wires and the installation. This complicates the procedure of determining the coordinate of the particle. The use of current amplifiers, which have very small input resistances, eliminates the difficulty connected with the wire capacitances. In addition, the coordinate of the particle turns out to be simply proportional to the ratio $A/(A + B)$. If the input resistance of the amplifier is 1 ohm, the total resistance of the wire can be 100 ohms.

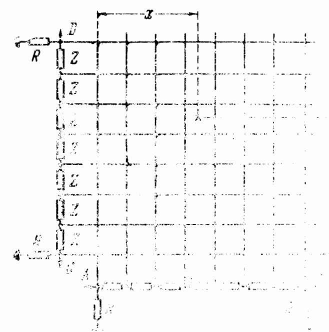

FIG. 1

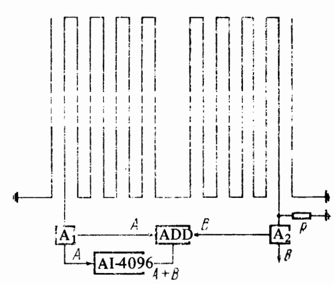

FIG. 2

FIG. 1. Diagram of multiwire coordinate proportional counter.

FIG. 2. Schematic diagram of setup with coordinate proportional counter. A_1 and A_2 – current amplifiers, ADD – adder, AI-4096 – 4096-channel pulse analyzer.

CONSTRUCTION

The counter wire was stretched on a Plexiglas frame with inside dimensions 30 × 30 cm, the distance between the parallel working sections of the filament being 0.7 cm (see Fig. 3). The total resistance of the working filament, made of nichrome with d = 0.01 cm, was 2 kohm, and the capacitance of the wire relative to the housing of the counter was 150 pF.

The upper high-voltage electrode was made in the form of a duraluminum frame, on which a wire was stretched (nichrome, d = 0.02 cm, distance between wires 0.2 cm). The lower high-voltage electrode, to simplify the construction, was made of a duraluminum sheet. The electrodes were located parallel to the

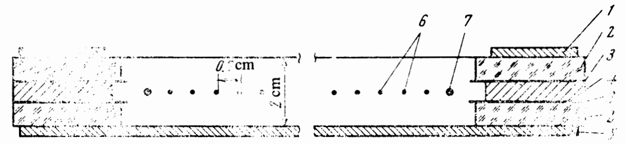

FIG. 3. Section through body of counter. 1 – High voltage electrode (frame with wires stretched in parallel); 2 – insulator (glass); 3 – guard frames; 4 – frame with stretched working wire; 5 – high voltage electrode (plate), 6 – working filaments; 7 – wires bounding the working volume.

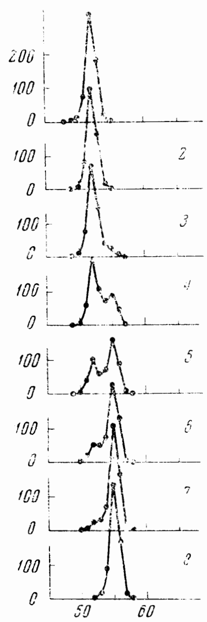

FIG. 4

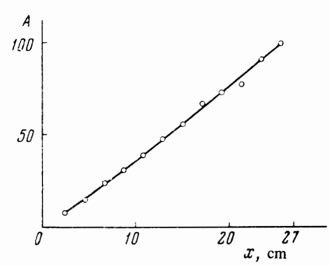

FIG. 5

FIG. 4. Pulse spectrum obtained when the source moves over the working volume of the counter in steps of 0.1 cm (two-dimensional analysis).

FIG. 5. Results of measurement of the coordinates of an α-particle source moving over the entire area of the counter in steps of 2.1 cm.

plane of the working filaments at a distance 1 cm above and below this plane. The guard electrodes, serving the usual purpose, were thin metallic frames and located on both sides of the frame with the working wire. The insulators were glass frames and teflon sleeves.

A collimated α source (Am^{241}, $E_\alpha = 4.8$ MeV) is located over the upper "transparent" electrode in such a way that the particle beam passes perpendicular to the plane of the filaments. With the aid of a simple device, the source can be moved in a direction perpendicular to the working filaments. For the experiments, the counter was placed in a vacuum chamber, with leads for the corresponding electric circuits and for the source-motion mechanism passing through the walls of this chamber. The chamber was filled with methane to a pressure of 170 Torr.

THE CIRCUIT

The characteristics of the coordinate proportional counter described above were investigated with the aid of a collimated source and an AI-4096 analyzer. The schematic diagram of the setup is shown in Fig. 2. Before the start of the measurements, the gains of the current amplifiers were equalized accurate to ~1.5%. In the analyzer memory, 128 channels were allotted to the measurement of the pulse amplitude A from one output of the counter, and 32 channels were allotted to the measurement of the amplitude of the summary signal (A + B). An expander was used in the summary-signal channel (A + B), so that the 20th channel of the analyzer was equivalent to the 150th channel of the total scale. With such a subdivision of the analyzer memory, the lost counts were few, since the center of gravity of the (A + B) peak depends in practice little on the position of the α source, and the energy scatter of the α particles was 20% in our case.

RESULTS

Figure 4 shows the results of measurements of the coordinates of the α particles, with the source moved in steps of 0.1 cm in the front part of the counter (over the centers of the wires). This is the dependence of the quantity A on the position of the source at a chosen and fixed (A + B). The spectrum 1 corresponds to the position of the source over one filament, and the spectrum 8 corresponds to the position over the neighboring one. The doubled peaks in the intermediate spectra 2–7 are due to the finite width of the α-particle beam (~0.5 cm) from the source. This confirms, in particular, that each counter filament operates independently of the others. With further motion of the source, the picture repeats itself identically.

Notice should be taken also of a shortcoming of the proposed method of winding the filament: the accuracy with which the coordinate is measured varies over the area of the counter. Whereas in the central part it equals the distance between filaments, near the edges of the filaments the accuracy drops to double the distance between filaments.

Figure 5 shows results of the measurements of the coordinates of particles when the α source is moved in steps of 2.1 cm in the central part of the counter over the entire area (A at fixed A + B). The small deviation from the straight line at the center is due to the influence of the distributed capacitance of the working filaments.

The foregoing results pertain to a counter with a total wire resistance 2 kΩ. Similar results were obtained for filaments with a resistance of 100 Ω. However, while using the same amplifiers as in the first case, the corresponding spectra turned out to be worse (broader peaks), this being apparently due to the unstable operation of two current amplifiers coupled by a small load.

[1] G. Charpak, R. Bouclier, T. Bressani, J. Favier, and C. Zupancic, Nucl. Instr. and Meth. 62, 262 (1968).

[2] E. Epple and D. Decker, Nucl. Instr. and Meth. 66, 77 (1968).

Translated by J. G. Adashko
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