In recent years, semiconductor detectors of charged particles have been finding ever increasing use in physical experiments and in dosimetry. This is explained by the existence of a whole series of advantages in comparison with previously known detectors: fast charge carrier collection time, high resolution, small dimensions, insensitivity to strong magnetic fields, a pulse height independent of ionization density along the track of the detected particle. Especially convenient is the use of semiconductor detectors for the measurement of the energy of short-range particles ($\alpha$-particles, fission fragments), when it is permissible to use silicon with comparatively low resistivity.

It is reasonable to expect that semiconductor detectors prove to be useful in detecting weak $\alpha$-spectra lines located close to high intensity lines. However, it was noted [1] that the pulse-height distribution from monochromatic $\alpha$-particles had a low-energy "tail" extending to zero with little decrease. The total count in the tail was approximately 1%, therefore it was impossible to observe even the well-known weak lines in the $^{238}$U spectrum. The authors of [1] concluded that there were "traps" in the depletion region of a (p-n) junction which caused a reduction in pulse height when they intersected the track of a particle.

The presence of such properties in semiconductor detectors leads to considerable complications not only in the field of $\alpha$-spectrometry, but also, for example, to complications in the investigation of the fission of slightly excited heavy nuclei in the symmetric region of mass distribution. It is only natural to expect that, because of increased specific ionization, the traps will distort the fission fragment energy spectrum to an even greater degree, and the reduced pulses of the light fragments of a highly asymmetric fission will be attributed erroneously to symmetric fission. Thus, a measurement of fission characteristics requires, in the first place, more precise knowledge of the nature of the reduced pulses and of their quantitative evaluation.

Investigation of reduced pulses from $\alpha$-particles and fission fragments. The most likely reasons for reduction in pulse height might be: particle reflection by target backing, reflection and escape of particles outside the limits of the sensitive region of the detector (for example, the existence of local regions with considerably higher energy in the ionization process). All measurements in this work were made with semiconductor surface barrier detectors, 5 x 5 mm in size, with a resistivity of 150 $\Omega \cdot$ cm, which were developed at the A. F. Ioffe Physico-Technical Institute of the USSR Academy of Science located in Leningrad. A voltage of 20 V was applied to the detectors.

The $^{241}$Am $\alpha$-particle energy spectrum is shown in Fig. 1 together with the low-energy tail which amounts to 0.7% of the recorded pulses. The americium was electrolytically deposited on polished platinum and placed 7 mm from the detector. With such a geometry, reflected and detected particles could escape from the target at an angle of not less than 45° to the surface. Calculations using Rutherford's formula gave an amount of reflection from platinum and silicon somewhat less than that observed. A practical verification of the fact that the amount of reflection is unimportant was obtained by a measurement of the $\alpha$-particle spectrum from $^{233}$U deposited on a collodion film 15 $\mu$g/cm$^2$ thick. In this situation, reflection from the backing was completely eliminated, but the magnitude of the low-energy tail was not changed.

Reflection from the silicon was checked by counting the coincidence pulses from two detectors located close by on different sides of a $^{235}$U $\alpha$-particle source on a 15 $\mu$g/cm$^2$ thick film. The number of coincidences corresponded exactly to the number of accidental coincidences which limited the effect of reflection to an amount less than 0.05% of the total number of pulses.
Fig. 1. Am\(^{241}\) α-particle energy spectrum: a) main peak; b) spectrum of the low-energy tail for a 100-fold increase in the number of recorded pulses (5 \times 10^5 pulses); c) spectrum of the low-energy tail for the same number of recorded pulses and a 2.5 times increase in the ratio of detector perimeter to operating area.

Fig. 2. Single-sided spectrum of U\(^{235}\) fission fragments; low-energy region scale increased by a factor of 10.

In order to exclude the possibility of detector inhomogeneity, the edges of the detector were covered by aluminum foil 0.05 mm thick (approximately twice the α-particle range). However, even in this case, the edge effect can appear because of oblique penetration of the edge of the aluminum foil by the α-particles and the recording of their residual energy by the detector. A rough calculation indicated that it was impossible to neglect this effect for a small detector surface (5 \times 5 mm). A comparison of the size of the tails for different ratios of working area and detector perimeter could serve as a most conclusive experimental check of this. For this purpose two α-particle spectrum measurements were carried out for a source-detector distance of 7 mm: one with an ordinary detector; the other with the same detector, but with the working surface covered by two narrow strips of aluminum foil which increased the ratio of detector perimeter to working area by 2.5 times (see Fig. 1). The increased number of pulses with reduced amplitude corresponded precisely to the changed ratio of perimeter to detector working area.

Spectral measurements and a quantitative determination of the amount of tail were done in the same geometry for pulses from fission fragments. The one-sided spectrum for fragments from thermal neutron fission of U\(^{235}\) (thickness of the U\(^{235}\) layer, 40 \(\mu\)g/cm\(^2\)) is shown in Fig. 2. The pulses in analyzer channels 3-27 can only be explained by a reduced energy of some of the light and heavy fragments. The total amount of the tail in proportion to the total amount of detected fragments turned out to be somewhat less than that for α-particles. From the point of view of the influence of the edge effect, this difference is understandable since the fragments, on the average, have a shorter range than α-particles do.

Measurements in this work and in [1] were made with detectors having the same working area; the shape of the reduced pulse spectra and the total count in these spectra (≈1% of the count in the main peak) also are in agreement, and are qualitatively explained by the edge effect as is obvious from the remarks above. Therefore, it is possible to consider that the detecting zone of the (p-n) junction in the detectors used contains no local regions which significantly reduce pulse height, within limits of a fraction of a percent.

Kinetic energy of the fragments from thermal neutron fission of U\(^{235}\). Taking into account the corrections for the contribution of the low energy tails in the symmetric fission region, the dependence of total kinetic energy and of the half-width of its distribution on fragment mass ratio was determined (Fig. 3). A layer of uranium \(\sim 40 \mu\)g/cm\(^2\) thick was deposited by vacuum evaporation of UF\(_4\) onto a collodion film 15 \(\mu\)g/cm\(^2\) thick and then placed between detectors at a distance which assured 45° collimation. Amplified coincidence pulses from two fragments were recorded by an analyzer based on an oscilloscope tube with simultaneous displacement of the beam along mutually perpendicular axes.