The results of measurements on time distribution and energy spectrum of $\gamma$-rays from an instantaneous point source in a uniform wood medium are described. Delayed coincidence technique and the Co$^{60}$ $\gamma$-pair were used for the measurements. For an average $\gamma$-ray energy of 0.8 Mev, the half-width of the time distribution was about 7 nsec at 200 cm from the source. An intensity build-up factor of 10.4 was obtained from calculations based on the measurements.

In published theoretical and experimental papers on the investigation of $\gamma$-ray penetration through thick layers of matter [1-5], the spectral and angular characteristics of $\gamma$-radiation have been studied, as well as the increase in intensity because of multiple scattering.

The problem of the time distribution of $\gamma$-radiation from an instantaneous point source at various positions within a homogeneous medium is of interest. However, the amount of published data on this problem is quite small [6, 7].

The authors of this paper measured the time distribution of $\gamma$-radiation in a homogeneous wood medium at a point 200 cm from a $\gamma$-ray source.

The method of measurement was the following. A 0.12 mC Co$^{60}$ source was placed in a homogeneous wood medium. Near it was placed scintillation detector 1 which recorded the departure of $\gamma$-quanta from the source, sending an electrical impulse over one of the inputs of the time analyzer. Scintillation detector 2, located 200 cm from the source and connected to the second time analyzer input, recorded the arrival of $\gamma$-quanta at the detector after penetrating the wood. The distribution of the time interval between the times of arrival at the first and second detectors corresponded to the time distribution of $\gamma$-radiation from an instantaneous source with an average $\gamma$-energy of about 1.25 Mev. A time analyzer [8] with a time resolution $2\tau = 2.3$ nsec was used for the measurements. The material for the investigation of time distribution was so chosen that the mean delay time because of $\gamma$-quantum multiple scattering path length in the medium was not less than the resolving time of the analyzer. Assuming that the average path length in matter is of the order of several mean free paths, $\lambda$ of the primary radiation, it is necessary to satisfy the condition $\lambda \geq c\tau = 30$ cm, where $c$ is the speed of light. Of the available materials, dry wood satisfies such a condition.

The time distribution of $\gamma$-radiation at an arbitrary point in a medium depends on the relations between the cross sections for Compton scattering, photo-effect, and pair production over the complete spectral distribution of the $\gamma$-radiation in the medium. Therefore, it is possible to assume that, for materials with neighboring atomic numbers, the time distributions will differ only by time scales whose ratios are determined by the ratios of the electron densities of the materials. This makes it possible to determine the time distribution for any other light material from the results for wood.

Instrumentation and Experimental Geometry

The arrangement of detectors relative to the material investigated is shown schematically in Fig. 1. Pine boards with an average density of 0.41 $\text{g/cm}^3$ (taking into account the density of stacking) were used. For this density, the mean free path of Co$^{60} \gamma$-radiation is 42 cm. Parallelepipeds $a$ and $b$ were $3.4 \times 4 \times 2$ m and $3.4 \times 4 \times 1$ m, respectively, and rested on a concrete floor. Parallelepiped $c$ with dimensions $2 \times 2 \times 1$ m, was raised above the floor. All the specified dimensions were chosen so as to create a good representation of an infinite
It was shown that a reflector which simulated the half-space behind the source exhibited no significant effect on the results. This follows from the fact that the $\gamma$-quantum albedo is insignificant [9, 10], and the energy after reflection is small.

Plastic scintillators (60 mm in diameter and height in the case of detector 1, 78 mm in diameter and 80 mm in height in the case of detector 2) were used with FEU-33 photomultipliers for $\gamma$-ray detection.

A block diagram of the measuring equipment is shown in Fig. 2. The operation of the various units of the system, the methods for their adjustment and calibration when used in an investigation of the $\gamma$-radiations from fast neutron interactions are described in [11]. For recording the $\gamma$-spectrum, pulses from the 12th dynode of detector 2 photomultiplier were fed to the pulse height analyzer through the linear amplifier and gating circuit. In this way, the gating circuit passed pulses from the time analyzer which corresponded to $\gamma$-$\gamma$ coincidences.

**Experimental Results**

The time distribution of $\gamma$-rays which arrived at detector 2 is shown in Fig. 3 (curve 1). The chance coincidence background, represented by curve 3, was measured under the same conditions with an introduced delay $\Delta t = 75$ nsec. The zero of the analyzer time scale was determined from the position of the mean of the ($\gamma$-$\gamma$)-coincidence curve 2 which was obtained with a Co$^{60}$ source, without wood, and for the same distance between detectors. (The rise in curve 2 in the 10-16 nsec region is explained by the effect of $\gamma$-quanta scattered from walls, floor, and wood.)

It is obvious from Fig. 3 (curve 1) that the time distribution of $\gamma$-radiation in wood at 200 cm from an instantaneous point source took up a time interval of approximately 20 nsec. The maximum intensity of the time distribution was shifted by approximately 1.6 nsec relative to zero time which corresponds to a path length of approximately 1.5 mean free paths for the $\gamma$-quanta. The average $\gamma$-ray delay time was about 6 nsec. The half-width of the time distribution was 7 nsec. The energy threshold of the recording apparatus was $\sim 50$ kev for the measurement of time distribution. It was demonstrated that reduction of $\gamma$-quanta energy down to 200 kev did not lead to instrumental broadening and shift of ($\gamma$-$\gamma$)-coincidence lines.

The time distribution obtained was not corrected for change in $\gamma$-ray detection efficiency because of spectrum moderation at increased delay times. In Fig. 3 (curve 4), there is shown the shape of a time distribution that was obtained on the assumption that the average quantum energy was approximately 100 kev for the largest time delay and 0.8 Mev for the most probable delay. The actual time distribution will occupy a position between curves 1 and 4.

* This assumption is based on data for the spectral and angular distribution of $\gamma$-radiation in homogeneous media [1, 12].