Bock et al. [1] present data on the use of direct charge detectors (DCD) with a cobalt emitter to measure the neutron flux density in a pulsed reactor. There are two types of DCD’s: an activation type using β particles produced in the $^{241}\text{Am}(n, \gamma)^{242}\text{Am}^\beta$ reaction, and a Compton type using Compton electrons and photoelectrons produced in the interaction of gamma rays from the $(n, \gamma)$ reaction with the emitter. Compton electrons also contribute to the current in an activation type DCD.

The basic equation for an activation type DCD in the one-group approximation is

$$i + \frac{1}{\lambda} \frac{di}{dt} = (f + \alpha) \Phi + \frac{\Sigma}{\lambda} \frac{d\Phi}{dt},$$

where $i$ is the DCD current, $\lambda$ is the decay constant of the β-active isotope responsible for the induced activity, $t$ is the time, $e$ is the charge of the electron, $\Phi$ is the neutron flux density, $\Sigma$ is the macroscopic activation cross section, $f$ is a factor taking account of the perturbation of the characteristics of the neutron distribution introduced by the detector and the decrease in current due to the incomplete utilization of β particles as a consequence of their absorption in the emitter and the insulator, and $\alpha$ is an analogous factor for Compton electrons and photoelectrons.

The basic DCD equation relates the detector current to the neutron flux, and permits the determination of the neutron flux in a nonstationary regime, as was shown experimentally in [2].

Fig. 1. Oscillogram of response of a rhodium detector compared with recording of pulse by a regular instrument with an organic scintillator.

Fig. 2. Oscillogram of response of a gadolinium detector compared with recording of pulse by a regular instrument with an organic scintillator.

Fig. 3. Experimental data normalized to the integrated responses of a rhodium DCD and a regular instrument.

Fig. 4. Experimental data normalized to the integrated responses of a gadolinium DCD and a regular instrument.

It is easy to show that for sufficiently short pulses the contribution of activation currents to the total DCD current can be neglected, and any DCD can be regarded as a Compton type which is inertialess with respect to the basic current generating process. The effect of the activation current can be neglected when \( t \ll \alpha/\lambda f \).

Table 1 lists values of \( t \) calculated under the assumption that the contribution of the activation current does not exceed 1% of the Compton current.

Figures 1 and 2 show oscillograms of the responses of rhodium and gadolinium detectors. These figures also show the pulse recorded by a regular instrument with an organic scintillator. The recording instrument was a type S-1-18 oscilloscope with a shunted input \( (l = 1 k\Omega) \) ensuring a time constant of \( 10^{-6} \) sec. The traces were photographed with a "Zenith" type camera. It is clear from the oscillograms that there is good agreement between the DCD response and that of the regular instrument.

Figures 3 and 4 show experimental data normalized to the value of \( \int i \, dt \), where \( i \) is the response of the DCD or the regular instrument. The build up of the neutron flux pulse front as measured by the DCD clearly lags that recorded by the regular instrument. The pulse width at half maximum is 0.2 msec less for the DCD than for the regular instrument. At the same time the shapes of the neutron pulse recorded by the rhodium and gadolinium DCD's practically coincide as can be seen from Fig. 5 where the curves are superposed and normalized at the maximum reading.

In discussing the experimental data it should be taken into account that the counting efficiency of organic scintillators is considerably higher for gamma rays than for neutrons [3]. The experimentally observed differences in the readings of the DCD's and regular instruments are explained by the kinetics of neutron transmission through the detector region, and are determined by the neutron slowing down time and the time of transmission to the detector.

Thermal neutrons propagate much more slowly than gamma rays. Only fast neutrons contribute initially to the rise of the pulse front in the detector response. As slower neutrons reach the detector its response shows contribution from neutrons of a broader range of energies. The cross section for the absorption of neutrons by the emitter material increases with decreasing neutron energy. Hence it follows that there is a lag in the build up of the front of the DCD response curve in comparison with the regular instrument, and also a sharper rise.