DETERMINATION OF ENERGY ABSORPTION
IN A MIXED FLUX OF FAST NEUTRONS AND $\gamma$-RAYS
BY AN IONIZATION METHOD

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The possibility of separate determinations of the energy absorption of fast neutrons and $\gamma$-rays in the mixed radiation flux from a reactor has been studied with ionization chambers. Three chambers with different hydrogenous fillers were used: polyethylene with an ethylene filler; graphite with a CO$_2$ filler and a chamber made from aerion, a conducting plastic, which was filled with a mixture of ethylene and CO$_2$. Calculations have been carried out to ascertain the sensitivity of these chambers to neutrons with energies ranging from 0.2-8 Mev. Variation of the neutron spectrum over wide limits has no effect on the accuracy in the determination of the absorbed dose in the hydrogenous substrates. A calculation shows that the error in the determination of the absorbed energy for fast neutrons is approximately 15% and is a weak function of the relative doses of neutrons and $\gamma$-rays.

One of the basic problems of present-day ionizing-radiation dosimetry is the determination of the energy transferred by the radiation to a unit mass of matter. There is available a great deal of data concerning $\gamma$-radiation; these data allow us to determine accurately the absorbed dose (in rads) for various energies of the $\gamma$-radiation and various source-object configurations.

The determination of the absorbed dose for a neutron flux has not been as nearly widely studied [1]. The great bulk of the work on fast and intermediate neutron fluxes is of theoretical nature and has been carried out for monoenergetic neutron fluxes [2-4]. The use of these data requires a knowledge of the neutron spectrum; hence, the accuracy in the determination of the absorbed dose is very low under most conditions. If the neutron flux is accompanied by $\gamma$-radiation, the determination of the absorbed dose becomes still more difficult. For a small $\gamma$-background and absorbed dose $D_\gamma$ (10-15% of the absorbed fast-neutrons dose $D_n$), the quantity $D_\gamma$ can be determined by a photographic-emulsion technique. This method has been used by a number of authors [7, 8], in conjunction with the uniform thimble chamber [5, 6] (the composition of the walls and the gas is the same).

When the background due to $\gamma$-radiation is significant and $D_\gamma$ is comparable with $D_n$, the use of the photographic technique in conjunction with an ionization technique can lead to large errors in the determination of the neutron absorption dose because of the low accuracy of the first technique.

Separation of the $\gamma$ and neutron components by means of chemical methods has not been used widely because these methods are characterized by low accuracy. The use of threshold detectors in neutron dosimetry is also very limited, because of the difficulty involved in the measurements. These considerations apply especially in measurements in dummies, in which case one must determine the absorbed dose at various points of an object. Furthermore, the threshold-detector method requires additional measurements of the accompanying $\gamma$-radiation, in which connection differential measurements with ionization chambers become important; these chambers are made from materials with different hydrogenous content.
Neutron reactors are being more widely used as sources in radiobiological than in neutron experiments. The experiments can be carried out with both thermal and fast neutrons. In this case, the background \( \gamma \)-radiation can become very large, so that the absorbed dose of \( \gamma \)-radiation may become comparable with the absorbed dose of thermal or fast neutrons [9].

In the present work we present the results of an experimental determination of the absorbed dose in biological objects which was carried out by means of uniform thimble chambers in mixed neutron-gamma fluxes.

In principle, having two chambers with different hydrogenous contents in the walls, we should be able to separate the neutron component from the \( \gamma \)-component [10, 11]. In order to carry out these experiments, it is important that the chambers be truly uniform, that is to say the chemical composition of the walls must be identical with the chemical composition of the gas used in the chamber. Under these conditions the true absorption coefficient and bulk stopping power of the walls are the same as those of the gas.

The radiation energy transferred to one gram of chamber wall material per unit time consists of two components in the case of a mixed neutron and \( \gamma \)-flux. 1) The energy \( D^\gamma_1 \) absorbed by the chamber walls by virtue of the interaction with the \( \gamma \)-ray flux and 2) the energy \( D^\gamma_n \) absorbed by the chamber walls by virtue of the interaction with the neutron flux. For two chambers we have

\[
D^\gamma_1 + D^\gamma_2 = D^\gamma;
\]

\[
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\]

where \( D^\gamma_1 \) and \( D^\gamma_2 \) represent the total energy transferred to one gram of wall material per unit time in the first and second chambers, respectively.

we use the symbols \( D^\gamma \) and \( D^n \) to denote the energy transferred by the \( \gamma \)-radiation and the neutron flux, respectively, to one gram of biological tissue. Then

\[
D^\gamma_1 = a_1 D^\gamma; \]

\[
D^\gamma_2 = a_2 D^\gamma.
\]

The coefficients \( a_1 \) and \( a_2 \) are equal to the ratio of the true bulk absorption coefficients for \( \gamma \)-rays in the wall material in the first and second chambers to the true bulk absorption coefficient for tissue. Similar equations hold for the neutrons:

\[
D^n_1 = b_1 D^n; \]

\[
D^n_2 = b_2 D^n,
\]

where \( b_1 \) and \( b_2 \) are equal to the ratio of the energy absorbed by one gram of wall material in the first and second chambers to the energy absorbed by one gram of tissue.