end of the counter. It was found that the predicted temperature was highly insensitive to large changes in these parameters. Of the 10% standard deviation given for the neutron temperature, 9% was due to counting statistics, while only 1% was due to an assumed factor of two uncertainty in the mosaic spread.

The effect of total reflection at the collimator walls is very large at low energies. For example, the beam intensity from our collimator was raised by a factor of 5 at 0.005 ev due to this effect. Taylor (*5*) neglected total reflection in analyzing his data, and reported that a Maxwellian with a neutron temperature equal to the moderator temperature provided a good fit at wavelengths shorter than 2 A. Similar results were obtained here, as shown by the crosses in Fig. 1, representing data analyzed without correction for mirror reflection. This result must be regarded as fortuitous, since the presence of totally reflected neutrons in our beam was definitely established by the following experiment. The counter aperture was stopped down with a cadmium slit, an angular scan of the direct beam was made, and the total cross section of indium was measured as a function of the scanning angle. The beam was considerably wider than would be predicted by line-of-sight calculations, and the indium cross section rose rapidly in the "wings," indicating the presence of neutrons of increasingly lower energy at larger angular divergencies.

The observed count rate spectrum showed sharp intensity variations, which have been ascribed to secondary, or multiple, Bragg scattering in the crystal (*6*). The effect of these deviations upon the predicted spectrum were studied by analyzing the data in three ways: (1) a smooth curve was drawn through the peaks of the original data, and points at equally spaced angles were chosen to be analyzed; (2) the data were first analyzed, after which the smooth curve was drawn through the peaks and representative points chosen to be fit; (3) the complete set of unsmoothed data was analyzed and fit. It was found that the temperatures predicted by the three methods were identical to within the quoted experimental uncertainty.

The presence of secondary scattering precludes the observation of spectral details. Since the process is a purely geometrical one, crystals of similar structure will exhibit the effect at equal Bragg angles but not at equal wavelengths. It had been hoped that the results obtained using several crystals could be superimposed in order to "wash out" this effect, but it was found that there was enough deviation between the various crystals used so that this could not be done with any accuracy.

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Total Cross Sections of Hydrocarbons and Tissue*

The total neutron cross section of several organic materials has been measured in the energy region 0.015 ev$<E<$0.2 ev. The object of these measurements was to obtain data which would assist in the application of the medical therapy facility at the MIT Research Reactor. Neutron penetration into organic material is of critical importance in the medical application of neutrons. Substances whose neutron cross section were studied include formic, acetic, propionic, and butyric acids, ethyl, propyl, and butyl alcohols, methyl-ethyl ketone, and human muscle, brain, and bone.

The measurements were made using the transmission method with the crystal spectrometer described in the preceding letter, with Ge(111) as a monochromator. Liquid samples were contained in an aluminum cell with aluminum foil windows. The cell was calibrated by measuring the

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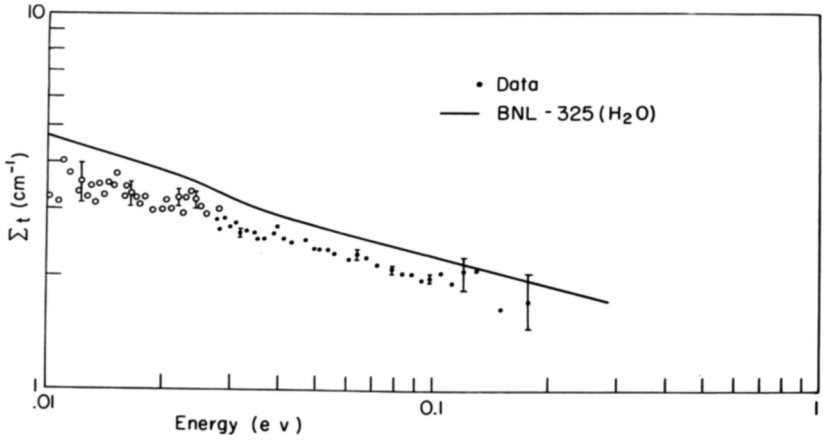

Fig. 1. Total macroscopic cross section of *n*-Butyl alcohol, compared to that for water.

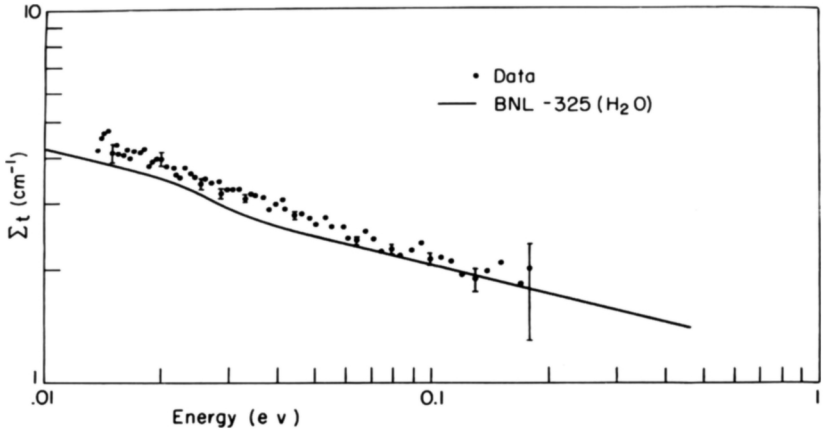

FIG. 2. Total macroscopic cross section for muscle tissue, compared to that for water.

transmission of a distilled water sample, and normalizing the data to the curve given in BNL-325 (*1*). Tissue samples were autopsy specimens which were sealed in polyethylene film to prevent dehydration, and were kept under refrigeration until used. The data were not corrected for the effects of instrumental resolution, higher order contamination of the beam, or thermal motion of the target nuclei (*2*) all of which were small. In several of the runs, a quartz filter (*3*) was used at low energy to reduce the higher order contamination further.

Figure 1 shows the total macroscopic cross section, Σ_t, in cm^{-1}, for *n*-Butyl alcohol. The points and open circles show data obtained without and with the quartz filter, respectively. The solid line has been drawn using the curve in BNL-325 for H_2O. Results for all the other organic liquids closely resembled this, except for a scale factor due to density differences.

An alternate method of presenting the results is in terms of cross section per hydrogen atom, derived by converting the results to microscopic cross section, and subtracting the contributions of carbon and oxygen. If this is done two dissimilar regions can be distinguished, separated by the "break" in the water cross section in the neighborhood of 0.03 ev. At higher energies, all the liquids gave the same value of barns per hydrogen atom, the values for H_2O and formic acid being approximately 10% higher than for the others. However, at lower energies, the water result rose above the others. If the break in the water curve is attributed to the action of intermolecular bonding, such a result would be expected since the hydrocarbons are less polar than water.

Figure 2 shows Σ_t for muscle tissue. Σ_t for brain tissue was almost identical, while that for bone was 15% lower.

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