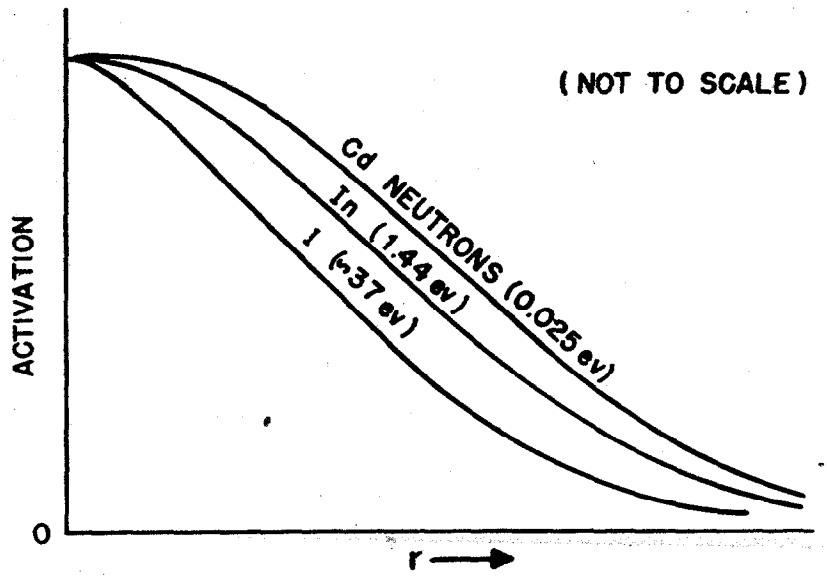

Figure 34. Neutron source in water.

6.3 DISTRIBUTION OF NEUTRONS FROM POINT SOURCE - CALCULATION OF r^2_{av}

Consider a point source of neutrons of energy E_o located in an infinite homogeneous medium. The neutrons are slowed down by collisions after leaving the source. Consider all the neutrons of energy E. How far away from the source are they on the average? What is the average of the square of the distance from the source r^2_{av}?

If a neutron from a source S undergoes successive collisions (Figure 35), with successive displacements of $\vec{l}_1, \vec{l}_2, \vec{l}_3, \vec{l}_4, \ldots \vec{l}_n$, then the resultant displacement is:

$$\vec{r} = \vec{l}_1 + \vec{l}_2 + \vec{l}_3 + \ldots + \vec{l}_n$$

and the square of the displacement $(\vec{r} \cdot \vec{r})$ is:

$$r^2 = l_1^2 + l_2^2 + l_3^2 + \ldots . l_n^2 + 2(\vec{l}_1 \cdot \vec{l}_2 + \vec{l}_1 \cdot \vec{l}_3 + \ldots + \vec{l}_2 \cdot \vec{l}_3 + \ldots .)$$

To obtain the average of the foregoing expression, we break the averaging into three steps (Figure 36). First, we average over the azimuthal angle ψ keeping ϕ, the angle of scattering in the laboratory system, and the lengths l constant. Then we average over l and finally over ϕ. The average over ψ is accomplished by use of the theorem:

$$[\cos(1, 4)]_{\psi av} = \cos(1, 2) \cos(2, 3) \cos(3,4) \qquad (6\text{-}8)$$

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