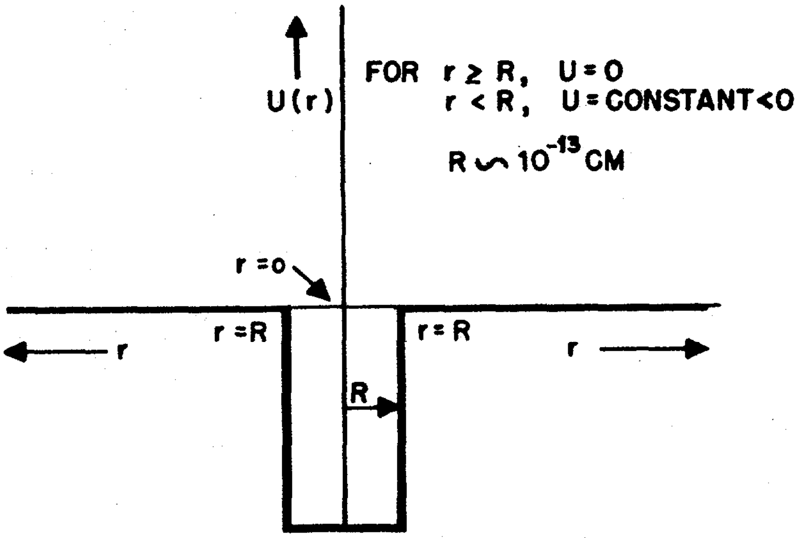

Figure 19. Potential Well Representation of Neutron-Nucleus Interaction.

Figure 19 shows the general shape of the potential well. The wave function ψ of the incident particle satisfies the Schroedinger equation:

$$\nabla^2\psi + (2m/\hbar^2)[E - U(r)]\,\psi = 0 \qquad (5\text{-}6)$$

Where E is the incident particle energy and U the nuclear potential. Considering only s scattering (zero angular momentum), the Schroedinger equation reduces to the radial equation:

$$\frac{1}{r^2}\frac{d}{dr}\,r^2\frac{d\psi}{dr} + \frac{2m}{\hbar^2}\,[E - U(r)]\,\psi = 0$$

or

$$u'' + (2m/\hbar^2)(E - U)u = 0 \qquad (5\text{-}7)$$

with

$$u = r\psi \text{ and } u'' = d^2u/dr^2$$

The latter simplified form is derived from the relations $u'' = (r\psi)'' = (r\psi' + \psi)' = r\psi'' + 2\psi' = (1/r)(r\psi')'$ where the primes indicate differentiation with respect to r.

Now in the scattering problem at hand, equation (5-7) must be solved for the particular form of U(r) chosen to represent the nucleus with the boundary conditions $\psi=0$ at $r = \infty$ and ψ finite elsewhere. Inspection of (5-7) shows that whenever $E - U>0$, the curvature of u is negative (u curves toward r axis), that is, $u''/u = -(2m/\hbar^2)(E - U)<0$. For $E - U<0$, the curvature $u''/u>0$, and for $E - U = 0$, it follows that $u''/u = 0$. Referring to Figure 19, it is apparent that there are three cases to consider: (a) $E>0$, in which case $E - U>0$ for all r, (b) $E = 0$, for which $E - U>0$ within the nucleus and $E - U = 0$ outside (c) $E<0$, in which case $E - U>0$ inside the nucleus and $E - U<0$ outside. The solutions for the three classes of values of $(E - U)$ can be readily determined to be:

a-93-4