and a 7.0 cm radius spherical head exposed to 918 MHz plane wave are shown in Figures 1 and 2. The plane wave impinges from the negative z direction and is polarized in the x-direction. Note that in both cases the absorbed energy along the three coordinate axes exhibits characteristic oscillations along the outer portion of the spherical head and reaches a maximum near the center.

Although the detailed absorption along the three axes is not the same, there are enough general similarities to justify the assumption of a spherically symmetric absorption pattern. It is therefore reasonable to approximate the absorbed energy distribution inside the head by the spherically symmetric function

$$W(r,t) = I_o \operatorname{Sin} \left(\frac{N\pi r}{a}\right) / \left(\frac{N\pi r}{a}\right) + I_1 \tag{3}$$

where I_o is the peak absorbed energy per unit volume, r is the radial variable, and a is the radius of the spherical head. The parameter N specifies the number of oscillations in the approximated spatial dependence of the absorbed energy. I_1 is a constant included to account for the uniform component of the absorbed energy distribution. Figure 3 shows the approximated energy absorption pattern for N = 6 and is particularly suited to the cases shown in Figures 1 and 2.

INDUCED TEMPERATURE RISE

We take advantage of the symmetry of the absorbed energy pattern by expressing the heat conduction equation as a function of r alone [14]. That is,

$$\frac{1}{r^2} \frac{\partial}{\partial r} r^2 \frac{\partial v}{\partial r} - \frac{1}{\kappa} \frac{\partial v}{\partial t} = \frac{W(r,t)}{K} \tag{4}$$

where v is temperature, κ and K are, respectively, the thermal diffusivity and conductivity of brain material, and W is the heat production rate which equals the absorbed microwave energy pattern and is assumed for the moment independent of time.

Equation (4) may be solved to obtain the change in temperature by setting the initial and ambient temperatures equal to zero [14]. Thus,

$$\begin{aligned} v(r,t) &= \frac{I_o}{K} \left(\frac{a}{N\pi}\right)^2 \left[1 - \exp\left(-\frac{\kappa N^2 \pi^2 t}{a^2}\right)\right] \sin\left(\frac{N\pi r}{a}\right) / \left(\frac{N\pi r}{2}\right) \\ &+ \frac{\kappa I_1 t}{K} - \frac{4\kappa I_1 at}{Kr} \sum_{n=o}^{\infty} \left\{ i^2 \operatorname{erfc}\left[\frac{(2n+1)a-r}{2(\kappa t)^{1/2}}\right] - i^2 \operatorname{erfc}\left[\frac{(2n+1)a+r}{2(\kappa t)^{1/2}}\right] \right\} \end{aligned} \tag{5}$$

where

$$i^n \operatorname{erfc}(x) = \int_x^{\infty} i^{n-1} \operatorname{erfc}(x')dx'$$

is the integral of the complementary error function. Note that the second and third terms of equation (5) are related only to the uniform heat production rate I_1. Since I_1 is small compared with I_o, and microwave absorption occurs in very short time intervals ($\sim$ microseconds), equation (5) can be approximated by