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A METHOD OF MEASURING RF ABSORPTION OF WHOLE ANIMALS AND BODIES OF PROLATE SPHEROIDAL SHAPES*

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ABSTRACT

RF absorption of brain-phantom prolate spheroidal bodies of different aspect ratios is measured to 4000 MHz using a parallel plate waveguide and correlated with results for mice and rats. Absorption more than an order of magnitude greater is observed at resonance for waves polarized along the long dimension.

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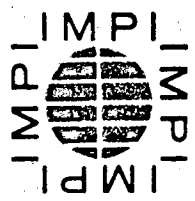

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A METHOD OF MEASURING RF ABSORPTION OF WHOLE ANIMALS AND BODIES OF PROLATE SPHEROIDAL SHAPES

This paper addresses itself to the following questions:

1. How does the RF absorption of whole animals vary with frequency?
2. Does the power absorbed in the body vary with the polarization of the electric field?
3. Can one extrapolate to predict the frequency region/s of most interest from the point of maximum absorption for humans?

Toward the above objective, a parallel plate waveguide (WG) is used as a medium for plane waves. The WG offers the capability to work over wide-bands, including measurements down to megacycle frequencies. The WG dimensions are designed such that the bodies to be measured fill between 10 to 30 percent of the cross section. This gives an insertion loss on the order of 1 dB or more which helps to reduce, by comparison, the measurement errors. To conduct measurements with mice and rats as test animals and prolate spheroids with various aspect (a/b) ratios up to and including 5.75, (the value taken for humans), the WG was designed with a cross section of 6.35 x 15.9 cm^2 with the lower plate having a slightly larger width of 20.3 cm. Using the empty WG for the "connect through" in the calibration of the network analyzers HP8745A/8743A, the base attenuation and reflection is cancelled from subsequent measurements. For empty WG the field intensity is measured to be uniform over 80 percent of the cross-sectional area.

The validity of this approach is checked by running absorption characteristics of nine spheres of brain-phantom material of diameter (2a) varying from 3.3 to 5.6 cm. The frequencies of peak absorption varying

from 1610 to 974 MHz correspond for each of the spheres to a value of ka ≈ 0.55 to 0.59 in good correlation with 0.50 to 0.54 obtained from Mie theory.[1,2] Also in reasonable agreement with the theory is the $k^{4.75}\, a^{6.1}$ dependence of the below-resonance power absorption. It is found that bodies of prolate spheroidal shape absorb considerably more in the vertical* than in the horizontal configuration**, with longitudinal orientation giving a value only slightly larger than that for horizontal configuration. Peak absorption in the vertical configuration occurs at a frequency such that ka ≈ 0.75 to 1.0. Maximum absorption for longitudinal and horizontal orientations occurs at successively higher frequencies with ka for these configurations on the order of a/2b. The observed values of ka for resonance in the different orientations are approximately obtained by requiring that, as for sphere,[1-3] the shortest circumference for the lossy creeping waves launched at the center of the shadow plane be 0.5 λ.

The results of the measurements of a rectangular-parallelepiped-shaped body sustain the above observations. The measurements on mice and rats agree with the observed resonances of the prolate spheroids of aspect ratios similar to these animals. RF absorption larger by an order of magnitude or more is found to occur in such bodies at resonance for vertical than for other orientations. Confirmatory experiments of heating/lethality by plane waves are described. For prolate spheroids of aspect

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* The nomenclature vertical, horizontal, and longitudinal is used to denote the orientation of the major length (2a) of the body along $\vec{E}$, $\vec{H}$, and $\vec{k}$, respectively, these quantities denoting, in turn, the electric and magnetic fields and the propagation vector of the waves.

** For below-resonance regions this result is in qualitative agreement with the small-ka theory of C. H. Durney and C. C. Johnson (to be published).

ratio 5.75, a temperature increase of 10 times as much is found for exposure to microwaves in the vertical as compared to the horizontal configuration. Important frequencies for maximum absorption for humans are derived by extrapolation as 40 to 55 MHz for vertical and 135 to 165 MHz for the other two configurations.

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