Heating of Biological Tissue in the Induction Field of VHF Portable Radio Transmitters

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Abstract—The results of a research project on the heating of simulated human tissue in the induction field of portable radios at VHF are summarized. The investigation was initiated because measurements made with commercially available field probes indicated that, in some cases, apparent power levels higher than 10 mW/cm^2 are incident on the operator. Two phantom models have been built for RF heating tests. The first is a parallelepiped of simulated muscle material 26 in long, 9 in wide, and 6.5 in high, topped by a 0.5 in layer of fat and bone composition. The other phantom is a human-size head and shoulders. This "dummy" is a 1/3-in thick shell of bone composition containing simulated brain material. The measurements of temperature increment due to radiation were performed with a digital thermometer having a sensitivity of 0.01°C. Temperature measurements on the parallelepipedal phantom have shown that the penetrating power densities in the simulated tissue are substantially lower than what could be expected from an incident plane wave with the same *E*-field intensity. The physical reason for this apparent discrepancy is that the strong fields of static nature emanating from a VHF helical antenna (commonly used with portable radios) are normally rather than tangentially directed to the surface of the phantom. These fields practically collapse at the air-body interface because of the high complex dielectric constant of human flesh. The results of the measurements performed on the head phantom have shown that a 6-W portable radio with a helical antenna held at 0.2 in from the operator's mouth causes very little heating of the simulated biological tissue (less than 0.1°C is highest temperature increase for one minute exposure). The maximum power density penetrating the dummy is less than 1 mW/cm^2 in the middle forehead. No detectable temperature increase is present in the immediate eye area. This is because in normal use, the eyes of the operator are exposed to the relatively low fields at the base of the antenna. A health hazard is present if the user places the tip of the antenna in the immediate vicinity of the eye (less than a 0.2-in distance) and then operates the transmitter. In this case, the possibility of damage is greatly reduced by a thick insulating cap at the tip of the antenna.

INTRODUCTION

THE HEATING OF biological tissue due to exposure to RF fields has been the topic of a large number of papers [1]-[6]. The research effort, so far, has been directed mainly to the investigation, theoretical and experimental, of the heating patterns induced by incident plane waves. The work performed by Guy [7], [8], [11] in the analysis of diathermy applicators addresses the problem of the heating patterns due to RF fields in the vicinity of the source. These RF fields, however, are transverse electric (TE) in nature and analogous to a plane wave at skewed incidence except for edge effects at the boundary of the applicator. To date, no literature has treated the problem on RF heating of tissue by the induction fields of VHF radio antennas.

A research project has been conducted in this somewhat unexplored area to gain knowledge of the heating of simulated human tissue in the induction field of a portable radio antenna at VHF. The investigation was initiated because of the growing use of portable transmitters of higher powers. Recent measurements made with field strength probes calibrated in terms of plane waves indicated that apparent power densities could in some cases exceed the 10 mW/cm^2 level, which is part of current safety standards. Previous work led to the conclusion that the actual energy transfer had to be significantly lower than indicated by such a meter due to the low total energy and very high field impedances involved. However, no substantiating measurements were available, and so this project was begun to provide both analytic and experimental data.

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EXPERIMENTAL METHOD

The phantom models of human tissue have been built with the materials suggested by Guy [9]. To simulate muscle and fat at VHF (≅150 MHz), the following compositions were used (percentages are in weight):

Muscle		Fat and Bone	
H_2O	77.24 percent	Laminac 4110	85.20 percent
NaCl	.82 percent	Aluminum Powder	14.51 percent
Polyethylene Powder	13.3 percent	Acetylene Black	0.28 percent
Super Stuff[1]	8.65 percent	MEK Peroxide	7cc/2Kg

The flat surface phantom, shown in Fig. 1, is a parallelepiped of muscle material 26 in long, 9 in wide and 6.5 in high. The muscle material is topped by a layer of fat and bone composition 0.5 in thick. A simulated human head and torso, shown in Fig. 2, has been built to imitate the geometry of the human body in the immediate vicinity of the radiator. The "dummy" head has a 1/3 in thick shell of fat and bone material, which contains the simulated brain material, whose composition is similar to the muscle compound.

The measurement of temperature increment due to radiation was performed by using a digital thermometer with two thermoelectric probes (Bailey Instruments, BAT-8), as shown in Fig. 2. The instrument has a sensitivity of 0.01°C for differen-

[1] A jelling agent, product of Whamo Manufacturing Co.