Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 47; 1978. (0 refs)

As part of a series of experiments, 10 male Sprague-Dawley rats were exposed to a 20 kV/m, 60-Hz vertical electric field. After 4 mo of 24 hr exposure, their visual evoked responses (VERs) were measured and analyzed. The analyzed results were then compared with those of 10 sham-control rats. By superimposing the averaged evoked responses of each group it was found that the 2 averaged VERs differed only in their downward deflection at a latency of 40 msec. To determine whether such a difference is indicative of physiopathologic changes, a series of experiments is currently underway involving periodic measurements of the VER throughout the developmental stage of the second generation of rats. The results of these experiments are presented.

5888 EFFECTS OF 60 Hz ELECTRIC FIELDS ON THE BEHAVIOR OF RATS (MEETING ABSTRACT). *(Eng.)* Hjeresen, D. L.; Chandon, J. H.; Phillips, R. D. (Biology Dept., Battelle, Pacific Northwest Lab., Richland, WA 99352). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 48; 1978. (0 refs)

The position and activity levels of 39 male Sprague-Dawley rats, confined to a visually symmetrical shuttlebox, were investigated. Following 23.5-hr sessions with field strengths of 0, 25, 50, 75, and 100 kV/m, no difference between groups was seen in activity levels, which followed a predictable diurnal pattern corresponding to the light cycle used (7 a.m. on, 7 p.m. off). Rats spent significantly ($p<0.01$) more time shielded from fields of strengths 75 and 100 kV/m than did 0-kV/m controls, particularly during the light-on periods. During the same periods, however, rats showed a preference for the exposed portion of the box at field strengths of 25 and 50 kV/m.

5889 EFFECTS OF HIGH STRENGTH 60-Hz ELECTRIC FIELDS ON GENERAL AND REPORDUCTIVE ENDOCRINOLOGY OF MALE RATS. (MEETING ABSTRACT). *(Eng.)* Free, M. J.; Smith, L. G.; Jaffee, R. A.; Kaune, W. T.; Phillips, R. D. (Biology Dept., Battelle, Pacific Northwest Lab., Richland, WA 99352). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 49; 1978. (0 refs)

Adult male rats were exposed (N=20) or sham-exposed (N=20) to 100 kV/m for 30 days in a system that eliminated secondary effects to examine the effects of electric fields on general and reproductive endocrinology. Plasma blood was assayed for testosterone, follicle stimulating hormone, luteinizing hormone, and thyroxine. Weights of body, thymus, thyroid, pituitary, adrenals, testes, seminal vesicles, coagulating glands, and epididymis were recorded, but no statistically significant differences between exposed and sham-exposed animals were found in any of these parameters. Additional exposed (N=10) and sham-exposed (N=8) rats were anesthetized and heparinized, and one testis was exposed and maintained at 33 C, while testicular vein blood samples (200 µl) were taken. Plasma from these samples was assayed for androgens. Immediately following testicular vein sampling, 10µ or 50µ labeled microspheres were injected into the left ventricle, while a reference blood sample was withdrawn at a known rate from the femoral artery. After 3 min, both testicles, epididymis, and vasa deferens were excised, and tissues and reference blood were assayed for radioactivity. Blood flow to each organ, calculated by comparing intraorgan radioactivity with reference blood, did not differ between exposed and sham-exposed animals. Likewise, testosterone secretion rate and testicular vein concentrations of testosterone, dihydrotestosterone, 5α androstan 3α, 17β-diol, 5α-androstan-3β, 17β-diol and dehydroepiandrosterone were unaffected by the electric field. It was concluded that major systemic and reproductive hormones and blood flow to the reproductive tract of adult male rats are unaffected by 30 days exposure to 60-Hz electric fields (100 kV/m) when secondary effects are eliminated.

5890 THE EFFECTS OF CHRONIC EXPOSURE TO A 60-Hz ELECTRIC FIELD ON SYNAPTIC TRANSMISSION IN THE MAMMALIAN NERVOUS SYSTEM (MEETING ABSTRACT). *(Eng.)* Jaffe, R. A.; Kaune, W. T.; Phillips, R. D. (Biology Dept., Battele, Pacific Northwest Lab., Richland WA 99352). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 51; 1978. (0 refs)

The effects of chronic (30-day) exposure to a 60-Hz, 100 kV/m electric field on synaptic transmission were investigated in rats. Superior cervical sympathetic ganglia were removed from anesthetized rats placed in a temperature-controlled chamber, and continuously superfused with a modified mammalian Ringer's solution. Several parameters and tests were used to characterize synaptic transmission through the ganglion. These included amplitude, area, and configuration of the postsynaptic compound action potential; conduction velocity and synaptic delay; conditioning-test response; frequency response; post-tetanic response; and high-frequency-induced fatigue. To date, the results of all the neurophysiologic tests and measurements indicate that synaptic transmission is not significantly affected by chronic (30-day) exposure to a 60-Hz, high voltage electric field.

5891 ELECTROMAGNETIC MEDIATED HORMONAL EFFECTS: THEORETICAL CONSIDERATIONS AND EXPERIMENTATION (MEETING ABSTRACT). *(Eng.)* Hsieh, S.; Weissfield, D.; Koltun, D.; Lymangrover, J.; Seto, Y. (Electroscience and Biophysics Res. Lab., Tulane Univ., New Orleans, LA 70118). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 52; 1978. (0 refs)

A theoretic model for the study of electromagnetic mediated hormal regulation is proposed. Analysis based on this model includes the effect of an external electromagnetic field on the diffusional process of some hormones. Perturbation of the secretion and the target site of the hormones is examined. Experiments were performed with adult male Sprague-Dawley rats. The rats, after living in a 60-Hz electric field of strength 20 kV/m for 3 mo, were examined for endocrine changes. Weights of the testes, pituitary, adrenal, and thyroid glands were measured and compared with those from an identical group of animals not exposed to the field. In addition, a set of experiments was designed to examine the integrity of the pituitary-adrenal axis by testing the ability of the adrenal cortex to respond to adrenocorticotropic hormone stimulation. The results of this experimental work are compared with the theory.

5892 MONITORING OF ARTERIAL WALL MOVEMENTS BY MICROWAVE DOPPLER RADAR (MEETING ABSTRACT). *(Eng.)* Stuchly, S. S.; Goldbert, M.; Thansandote, A. (Univ. Ottawa, Faculty Science and Engineering, Electrical Engineering, Ottawa, Ontario, Canada). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada); p. 54; 1978. (0 refs)

A new technique for monitoring arterial wall movement by microwave Doppler radar is proposed. Preliminary experimental results, performed using a low power Doppler transceiver operating at a frequency of 10.525 GHz, indicate that the technique is feasible and in many respects seems to be complementary to ultrasonic techniques used in studies of arterial wall movements.

5893 USE OF MICROWAVE POWER IN NEONATAL CARDIAC SURGERY (MEETING ABSTRACT). *(Eng.)* Johnson, C. C.; Durney, C. H.; Wong, K. W.; Westenskow, D. R. (Dept. Bioengineering, Univ. Utah, Salt Lake City, UT 84112). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 55; 1978. (0 refs)

The use of 915 MHz power, applied directly to the heart, is described as an improved method for warming in neonatal cardiac surgery. Very rapid restoration of heart and blood pressure has been observed in animals. Restoration of mean blood pressure from 50 mm Hg, after 1 hr of arrest at 20 C, to 130 mm Hg in 18 min has been observed. Since the heart is warmed first and the circulatory capability is restored before warming peripheral tissue, it is suggested that microwave heating is preferred to conventional warming techniques. The design of the microwave hardware and results of animal experiments are presented.

5894 LOCAL MICROWAVE-INDUCED HYPERTHERMIA FOR CANCER THERAPY (MEETING ABSTRACT). *(Eng.)* Bowers, E. D.; Walsh, J. E.; Douple, E. B.; Strohbehn, J. W.; Gibson, R. (Thayer Sch. Engineering, Dartmouth Coll., Hanover, NH 03755). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 56; 1978. (0 refs)

Results of experiments that have investigated the delivery of heat directly into mouse tumors using a microwave antenna are reported. A quarter-wave length antenna, consisting of a rigid coaxial cable with an inner conductor and insulator exposed in length that corresponds to 1/4 of the wavelength in the medium, and less than 0.5 mm in diameter was employed. Operating in the GHz range, thermal distributions produced by this microwave system have been measured in saline solutions, bologna, and transplantable mouse tumors using thermistor probes and a fiberoptic thermometry system. It is proposed that this approach may overcome some of the problems associated with other systems, which use external radiation sources.

5895 HEATING PATTERNS OF A NEW MICROWAVE HYPERTHERMIA APPLICATOR (MEETING ABSTRACT). *(Eng.)* Sandhu, T. S.; Johnson, R. J.; Kantor, G.; Kowal, H. S. (Dept. Radiation Medicine, Roswell Park Memorial Inst., Buffalo, NY 14263). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 57; 1978. (0 refs)

Heating patterns produced in tissue equivalent materials by a new dielectric loaded waveguide applicator excited simultaneously in the TE_{10} and TE_{01} modes at a frequency of 915 MHz are compared with those of a similar applicator excited in the TE_{10} mode alone. Studies were performed on phantom materials simulating the electromagnetic properties of various tissue types, and heating patterns were recorded using a thermograph camera. The results show that the applicator excited in the

TE_{10} mode alone produces an asymmetric heating pattern. This drawback is overcome in the new design. This feature is very important in clinical use of these applications in the evaluation of thermal enhancement of the therapeutic ratio of ionizing radiation in the treatment of cancer. Also, if needed, an asymmetric heating pattern of a desired shape can be obtained by changing the relative power input levels of the TE_{10} and TE_{01} modes.

5896 A NEW 915 MHz DIRECT CONTACT APPLICATOR WITH REDUCED LEAKAGE (MEETING ABSTRACT). *(Eng.)* Kantor, G.; Witters, D. M. (Div. Electronic Products, Bur. Radiological Health, FDA, 5600 Fishers Lane, Rockville, MD 20857). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 58; 1978. (0 refs)

A new commercially-developed direct contact applicator for microwave diathermy, operating at 915 MHz, was evaluated by investigating thermographic heating patterns in phantoms and associated leakage. The main features are a quadridge circular waveguide to obtain circular polarization and a choke around the waveguide to minimize unwanted leakage. Two similar prototypes with outside diameters of 15 cm and 25 cm were developed. The smaller one has an annular choke, while the larger one has three such concentric chokes. The four forward ridges in each applicator were adjusted to optimize polarization. An axial ratio of about two in the far field was measured. Heating patterns on the exposed surface of muscle phantoms and inside fat-muscle phantoms are spatially similar for both designs. Muscle heating, in a plane parallel to the fat-muscle interface at a temperature of half the maximum temperature, covers an area of about 45 cm^2. The ratios of free space longitudinal and transverse components of the total electric field (squared) in front of the center of the apertures were obtained for each applicator. For the 15-cm aperture and the 25-cm aperture, the ratios are respectively 0.03 and 0.05. Effective heating (specific absorption rate [SAR] of 235 W/kg) required 55 W and 40 W of net power to be applied to the large and small applicators, respectively, while typically corresponding leakage level of less than 0.25 mW/cm^2 and 10 mW/cm^2 equivalent plane wave power density were observed for these two units.

5897 THE EFFECT OF LOCAL TUMOR HYPERTHERMIA ON THE GROWTH OF SOLID TUMORS IN MICE (MEETING ABSTRACT). *(Eng.)* Magin, R. L. (Lab. Chemical Pharmacology, DTP, DCT, National Cancer Inst., NIH, Bethesda, MD 20014). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 59; 1978. (0 refs)

A single treatment with local microwave (2,450 MHz) tumor hyperthermia (43 C, 60 min) retarded the growth of small solid mouse tumors but did not result in cures. The microwave power was automatically regulated to maintain the center of the tumor at a constant temperature. The steady state intratumor temperature, monitored by implanted thermocouples, was measured to be less than 2.0 C when the tumor was encapsulated with a bolus of muscle-equivalent dielectric phantom material. No significant whole body hyperthermia occurred during treatment. Eight different subcutaneously implanted mouse tumors (B16 melanoma, Lewis lung carcinoma, Glioma 26, Ovarian carcinoma M5076, Colon adenocarcinoma No. 38, adenocarcinoma No. 26, Barrett mammary adenocarcinoma, and Mammary adenocarcinoma Line 16C) were tested. Groups of eight mice with tumor volumes in the range 100-150 mm^3 were selected for the control and local heat treatment groups. Both groups were anesthetized, and the treatment group subjected to 60 min of local tumor hyperthermia at 43 C. Tumor volumes and body weights were recorded twice weekly following treatment. A single local hyperthermia treatment reduced the size and retarded the growth of each of the treated tumors compared with the controls. A difference in the sensitivity of the different tumors to local hyperthermia treatment was observed. Short growth delays (1-5 days) and moderate size reduction (20-50%) were observed in five of the treated tumors, while longer growth delays, greater size reduction, and a few cures were seen in Colon adenocarcinoma 38 (13 days, 71%), Glioma 26 (7 days, 67%, 1 cure) and Ovary M5076 (9 days, 71%, 1 cure). Three sequential treatments of the Colon adenocarcinoma 38 at approximately 1-wk intervals increased the growth delay to 19 days, and the tumor size was significantly inhibited.

5898 RADIOFREQUENCY (0.5 & 3.3 MHz) CURRENT INDUCTION OF LOCALIZED HYPERTHERMIA IN TISSUES: SOME EXAMPLES (MEETING ABSTRACT). *(Eng.)* Cetas, T. C.; Connor, W. G.; Cooper, D. H.; Miller, R. C.; Roth, H. B. (Health Sciences Center, Univ. Arizona, Tucson, AZ 85724). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 60; 1978. (0 refs)

Physical aspects of clinical trials of localized hyperthermia are discussed. Heating is primarily by radio frequency (0.5 and 3.3 MHz) currents in direct resistive contact with the tissue to be heated. Various electrode geometries have been used effectively including interstitial needle electrodes, surface plate electrodes (usually water cooled), and central obturator electrodes for rectal and vaginal tumor heating. Water baths and microwaves (2.45 GHz) are used for heating shallow surface lesions. Thermographic studies with phantom, and occasionally, animal models are used in treatment planning. Temperature measurements during

human treatments are often limited by clinical constraints to one or two subcutaneous or intratumor probes. Thermographic monitoring of exposed surfaces of the heated field gives dosimetric data for the normal skin tissue and provides valuable, if only semiquantitative, information on the uniformity of the heating. The techniques discussed clearly represent early stages of development, but the clinical efficacy provides strong stimulus for continued efforts.

5899 FINITE-ELEMENT CALCULATIONS OF ELECTROMAGNETIC ABSORPTION BY BIOLOGICAL BODIES (MEETING ABSTRACT). *(Eng.)* Barber, P. W.; Johnson, C. C.; Yeh, C. (Dept. Bioengineering, Univ. Utah, Salt Lake City, UT 84112). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 63; 1978. (0 refs)

To better quantify the absorption characteristics of realistic inhomogeneous models of man and animals, the unimoment formulation of the finite-element method was used to make calculations. The unimoment approach surrounds the object under consideration by a sphere. The interior region is discretized into a mesh of triangular subregions. Relationships between the fields in the sub-regions are developed by the finite-element method and assembled into a system of linear equations that govern the entire interior region. The fields outside the sphere are expanded in the usual spherical harmonic wave functions. The interior and exterior problems are solved separately and later coupled on the spherical surface by enforcing continuity on the tangential electric and magnetic fields. The finite-element method is also used to calculate the total power absorption and power distribution in realistic models of mice and rats. The results show the dependence of the absorption characteristics on the size and location of internal inhomogeneities. Particular problems associated with applying the finite-element method to man model calculations are considered.

5900 HEAD RESONANCE: NUMERICAL SOLUTIONS AND EXPERIMENTAL RESULTS (MEETING ABSTRACT). *(Eng.)* Hagmann, J.; Gandhi, O. P.; D'Andrea, J. A.; Chatterjee, I. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 64; 1978. (0 refs)

New numeric results are presented for a 312-cell model of man, which differs from previous models in that 144 cells are used in the head region to provide greater detail regarding the distribution of energy deposition. Preliminary tests were conducted with anesthetized 450 ± 30 g Long Evans rats at 2,450 MHz, and a value of head specific absorption rate (SAR), which is approximately 2.2 times the whole-body average was observed. Experimental data are presented for head resonance in the laboratory rat with both $\vec{E}||\hat{L}$ and $\vec{K}||\hat{L}$ orientations. The measurements of whole-body average SAR and the absorption cross section of the head for phantom models of man at frequencies near head resonance with both $\vec{E}||\hat{L}$ and $\vec{K}||\hat{L}$ orientations are presented and compared with numeric solutions.

5901 SURFACE INTEGRAL EQUATION SOLUTIONS FOR FIELDS IN BIOLOGICAL BODIES OF REVOLUTION (MEETING ABSTRACT). *(Eng.)* Wu, T. K. (Dept. Electrical Engineering, Univ. Mississippi, University, MS 38677). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 65; 1978 (0 refs)

Internal fields and power absorption in biologic bodies of revolution are evaluated using the surface integral equation method. The method yields moment method solution for the induced current densities on the body surface. The interior fields to the body are then evaluated via the reciprocity theorem and the measurement matrix concept. The bulk body power deposition is obtained by the integration of the surface Poynting vector. The method applies for a wide range of dielectric parameters in the resonance region.

5902 THERMOGRAPHIC COMPARISON OF TEMPERATURE PROBES USED IN MICROWAVE DOSIMETRY STUDIES (MEETING ABSTRACT). *(Eng.)* Olsen, R.; Hammer, W. (No affiliation given). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): pp. 66-67; 1978. (0 refs)

Temperature probes were compared for accuracy and for perturbation of the energy absorption pattern in a sphere of tissue equivalent material. A two-part styrofoam mold was filled with muscle phantom material. Double layer gauze was used to partition the hemispheres. The gauze was very light weight, and it allowed virtually continuous contact of the phantom material across the interface. The various temperature probes entered the spherical phantom along the partition plane with the measuring tip either at the center or at a measured depth. Two anechoic chambers were used in this study; at 1.7 GHz, overhead irradiation from a low-gain waveguide horn was used to illuminate the phantom. At 5.95 GHz, a wall-mounted standard gain horn (Narda) in a smaller chamber provided the radio frequency feed. In both instances, the phantom sphere was located in the far zone of the horn. Temperature probes used in this comparison in-

cluded a typical rectal thermistor (YSI Type 401), a liquid crystal optical fiber device (Ramel Inc.), a fine wire thermocouple made of copper and constantan, a non-metallic thermocouple developed at NBS, and a four-lead device using high-resistance lead material. By recording the thermographic scan at 4-sec intervals, the surface cooling process was utilized to construct cooling curves for the various locations of observed temperature maxima on the scanned surface. With an individual probe tip inserted into the phantom during irradiation, the probe output was monitored and compared with the formerly deduced change in temperature. Immediately following the microwave exposure, the phantom was opened and scanned thermographically. The resulting image was then compared with the heating pattern obtained for the unperturbed sphere. Initial results of this study showed a very large perturbation for all metallic probes when oriented parallel with the electric field. The field distortion was much smaller yet still visible for probes with non-metallic (but conducting) leads.

5903 TRANSMISSION COEFFICIENT OF NEAR ZONE MICROWAVES INTO PLANAR BIOLOGICAL TISSUES: HORIZONTAL DIPOLES (MEETING ABSTRACT). *(Eng.)* Kamal, A. A.; Al Badwaihy, K.; Hashish, E. (Electronic Dept. Faculty of Engineering, Cairo Univ., Giza-Cairo, Egypt). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 68; 1978. (0 refs)

The transmission coefficient of near zone fields may have higher values than in the case of normally incident plane waves. An upper limit is computed for the coefficient of transmission of microwave fields into living tissues. The source is an elementary horizontal electric or magnetic dipole located in the free space region above the biologic half space.

5904 TEMPERATURE RISE IN TISSUE SPHERES INDUCED BY MICROWAVE RADIATION: A GREENS FUNCTION APPROACH (MEETING ABSTRACT). *(Eng.)* Kritikos, H. N.; Foster, K. R.; Schwan, H. P. (Dept. Electrical Engineering, Univ. Pennsylvania, Philadelphia, PA 19104). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 69; 1978. (0 refs)

To find the steady state temperature increases throughout living tissue, exposed to microwave radiation, a simple thermal model for tissue, including a scalar term representing blood flow in the head transport equation, and including the (physiologically complicated) transfer of heat from the tissue surface into space as an appropriate boundary condition was investigated. The Greens function solution for the heat transport equation is presented for several cases; a "false color" computer display is used to present the results. For relatively low microwave frequencies (where the wavelength in the tissue is much less than the tissue diameter) the specific absorption rate (SAR) can be analytically expressed in terms of a multipole expansion. For the first three terms, the Greens function solution is analytically evaluated; the resulting steady state temperature profile clearly shows the electric and magnetic dipole heating contributions from the microwave field. For higher microwave frequencies, the Greens function solution must be evaluated numerically. In a four-layer tissue sphere of 5-cm radius exposed to a 1-GHz field, the SAR (from a previous study) shows a "hot spot" near the sphere's center. The calculated steady state temperature profile for this complicated heating pattern closely resembles the steady state temperature distribution produced by a uniform "hot spot" embedded in a much larger uniform volume of tissue. For values of blood flow appropriate for human brain tissue, the maximum calculated tissue temperature rise is about 0.6 C at an incident microwave intensity of 10 mW/cm^2. The thermal model and results are discussed in terms of the physiology of temperature regulation.

5905 IMPLICATIONS OF THE RADIOFREQUENCY RADIATION DOSIMETRY HANDBOOK (SECOND EDITION) (MEETING ABSTRACT). *(Eng.)* Allen, S. J.; Durney, C. H.; Johnson, C. C. (Radiation Sciences Div., USAF Sch. Aerospace Medicine, Brooks AFB, TX 78235). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 70; 1978. (0 refs)

The second edition of the *Radiofrequency Radiation (RFR) Dosimetry Handbook* includes predictions of specific absorption rate for frequencies from 10 MHz to 100 GHz utilizing human and experimental animal models. These data, which extend well above resonance, should prove valuable in establishing more meaningful experimental protocols and interpreting RFR bioeffects research in terms of predicted effects on man.

5906 NUMERICAL MODELING OF THREE-DIMENSIONAL ARBITRARILY-SHAPED HETEROGENEOUS BIOLOGICAL BODIES UNDER COMPLEX EXCITATIONS (MEETING ABSTRACT). *(Eng.)* Wang, J. J. H.; Cain, F. L.; Burdette, E. C. (Engineering Experiment Station, Georgia Inst. Technology, Atlanta, GA 30332). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 71; 1978. (0 refs)

A generalized numeric model or a composite, arbitrarily-shaped, heterogeneous three-dimensional biologic body under complex excitation has been

developed and validated. The model employs the method of moments to solve a pair of integral equations for the unknown equivalent volume electric and magnetic currents. Pulse functions are used as basis functions, and delta functions are used for testing. The excitation can be a plane wave, the near-field of an antenna, or that due to an enclosing coil. The biologic body must be electrically small and have ferromagnetic seeds to produce hyperthermia for the treatment of cancerous tumors. The computer program was validated, and numeric tests, such as, convergence and conservation of energy tests were also conducted. In the most demanding case of coil excitation and magnetic heating, gross agreements between measurements and calculations established two important aspects of the process. First, the effectiveness of magnetic heating to generate hyperthermia was verified by the heating patterns. Secondly, the adjustment of hyperthermia patterns by varying the frequency was achieved using ferrites with a magnetic loss tangent, which rapidly increased for frequencies from 5 to 20 MHz. Therefore, the feasibility of controlling magnetic heating between 5 and 20 MHz has been demonstrated in both analysis and experiments.

5907 NUMERICAL CALCULATION OF MICROWAVE ABSORPTION IN ARBITRARY GEOMETRY WITH APPLICATION TO A MODEL OF MAN (MEETING ABSTRACT). *(Eng.)* Neuder, S. (Bureau Radiological Health, HEW/FDA, Rockville, MD). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 72; 1978. (0 refs)

A recently developed numeric approximation technique for calculating induced electromagnetic fields and absorbed power density in multiregion, arbitrary, biologic systems has been applied to a model of the human body. The associated computer program, FEMS (A Fortran Program for Microwave Scattering - to be published), provides approximate solutions in irregularly-shaped lossy dielectric media. To formulate the FEMS equations, the reduced Maxwell's equations are written in the weak form. A homogeneous model of the human body, 175 cm high, was chosen, and exposed to a linearly polarized plane wave in the MHz frequency range. Isoparametric finite elements followed curved contours of the body model so that improved accuracy was achieved. Quantities calculated were the induced field and the distribution of absorbed power densities in the body during exposure at various frequencies. Preliminary results of these calculations were presented.

5908 THERMAL ANALYSIS OF HUMAN PHANTOM MODELS EXPOSED TO EMISSION FROM A MICROWAVE OVEN (MEETING ABSTRACT). *(Eng.)* Prucha, R. V.; Belsen, L. H. (General Electric Co., Appliance Park, Louisville, KY 40225). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 73; 1978. (0 refs)

A series of thermographic measurements were performed on full size phantom models exposed to energy from a microwave oven. Specific emphasis was directed toward determining the maximum specific absorption rate into the lower abdomen of a female phantom model and the head of a child phantom model. To understand the model variables, several different conditions were adjusted (i.e., single material model, multilayer model, and different parting plane material). A thermal time history of the models was also evaluated to better understand the effect of material properties, parting plane material, and exposure time. The results from these measurements were used as the basis for heat input and temperature rise calculations in thermal models of humans. Both worst case and typical case calculations based on movement patterns were made, and the results compared with those produced by other heating means, such as, changes in metabolic rate (deep heating) and exposure to normal sunlight (surface heating). Results also were compared with medical diathermy practice. These results show the conservative nature of the current microwave oven emission standards.

5909 AN EMPIRICAL FORMULA FOR CALCULATING THE SAR OF PROLATE SPHEROIDAL MODELS OF HUMANS AND ANIMALS IRRADIATED BY PLANE-WAVES (MEETING ABSTRACT). *(Eng.)* Durney, C. H.; Iskander, M. F.; Massoudi, H.; Johnson, C. C. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 74; 1978. (0 refs)

An empiric relation that allows the calculation of approximate values of the average specific absorption rate (SAR) over a broad frequency range for any prolate spheroid model is derived for E-polarized incident plane waves. The formula satisfied the f^2 SAR behavior at lower frequencies, the resonance characteristic at intermediate frequencies, the 1/f behavior past resonance, and the dielectric constant dependence at the geometric optics limits. An expression for the resonance frequency F_o in terms of the dimensions of the model was also derived. The unknown coefficients in the empiric relations were determined by curve fitting all the data available in the second edition of the *Radiofrequency Radiation Dosimetry Handbook.* Since the empiric formula is a nonlinear function of these coefficients, the method of differential corrections together with Newton's iterative method were used. Numeric results obtained from the empiric relations for prolate spheroid models of a variety of sizes are presented graphically

and compared with available data calculated by other techniques. The results obtained from the empiric relations were generally very close to those calculated by other means, differing at most by about 15% in some models at some frequencies. For those models where neither the resonance frequency nor the SAR at resonance were previously known, the results from the empirical formulas were found to be in good agreement with those obtained using other empiric relations particularly developed for frequencies near resonance. This empiric formula is intended to complement the specific data available in the *Radiofrequency Radiation Dosimetry Handbook.*

5910 APPROXIMATE ANALYSIS OF PLANEWAVE IRRADIATION OF MAN NEAR A GROUND PLANE (MEETING ABSTRACT). *(Eng.)* Iskander, M. F.; Durney, C. H.; Massoudi, H.; Johnson, C. C. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112). *In: Abstracts of Scientific Papers: 1978 Symposium on Electromagnetic Fields in Biological Systems held June 27-30, 1978 in Ottawa, Canada.* Sponsored by Internat'l Microwave Power Inst. and Inst. of Electrical & Electronic Engineers. (Edmonton, Canada): p. 75; 1978. (0 refs)

An approximate analysis for calculating the average specific absorption rate (SAR) of a model of man exposed near or on a ground plane is presented. The analysis involved two approaches, namely, the antenna approach, which utilized the equivalent circuit of a receiving antenna, and a combination of circuit theory and curve-fitting procedures. In the former, the antenna input impedance was obtained by calculating the internal impedance of a finite cylinder, while the field impedance was calculated by extrapolating available data for a cylindrical antenna. In both cases, the introduction of a separation between the man's feet and the earth (rubber sole or shoe) was taken into account by introducing a lossy capacitor in the equivalent circuit. Numeric results showed that the effect of the ground plane on the average SAR values was primarily important at lower frequencies, diminishing as the frequency increases. Furthermore, it was found that such an effect decreases rapidly with increasing gap width. For the worst case of a barefoot man placed at a distance from a wet earth, it was found that for separation distances of 7.5 cm or more, the SAR was the same as that for freespace irradiation. Results for both cases of lossy and lossless capacitive gaps are presented graphically.

AUTHOR OF CURRENT LITERATURE INDEX

[Entry numbers followed by an asterisk indicate primary authors]

ADEY, W.R.
05845*
AHMED, A.
05788
AL BADWAIHY, K.
05903
ALAVI, A.
05810
ALBANESE, R.A.
05873*
ALBERT, E.
05861
ALLEN, S.J.
05780, 05905*
ANONYMOUS
05785
ARAI, S.
05815
ARENDSE, M.C.
05804*
ARKAD'YEV, V.
05805*
ASSENHEIM, H.M.
05862
ASTLE, L.
05879
BACHURIN, V.I.
05811*, 05813*
BAHL, I.J.
05827
BAKER, R.J.
05859*
BARABOI, V.A.
05796*
BARBER, P.W.
05780, 05899*
BELMAN, S.
05851
BELSEN, L.H.
05908
BICHER, H.I.
05848*
BINI, M.
05783*
BOAN, R.T.
05831*
BONE, S.
05791*
BOTTOMLEY, P.A.
05824*
BOURKE, D.L.
05839
BOVEY, R.W.
05826
BOWERS, E.D.
05894*
BRAINARD, G.
05861*
BRAITSEV, A.V.
05799*
BRIGHTON, C.T.
05810
BRUGNOLOTTI, P.L.
05874
BUCZYNSKI, A.Z.
05820
BURDETTE, E.C.
05906
BURNY, F., ED.
05835*
CAIN, F.L.
05906
CAIRNIE, A.B.
05872*
CALLAGHAN, M.
05840*
CAMICI, G.
05783
CARPENTER, R.L.
05866*
CARROLL, D.
05881*
CASSEDAY, J.H.
05864
CETAS, T.C.
05898*
CHANDON, J.H.
05888
CHATTERJEE, I.
05900
CHECCUCCI, A.
05783
CHERNOVETZ, M.E.
05876*
CLEARY, S.F.
05834*, 05846*
COHOON, D.K.
05873
CONNOR, W.G.
05853*, 05898
CONOVER, D.L.
05878*
COOPER, D.H.
05898
CURTIS, L.
05839
CZERSKI, P.
05788
D'AGOSTINO, L.
05848
D'ANDREA, J.A.
05879*, 05900
DALINKA, M.K.
05810
DAVIDOVS'KA, T.L.
05812*
DE LORGE, J.
05883*
DESANTIS, M.
05861
DICKSON, J.A.
05778, 05837
DIETZEL, F.
05830
DOCTOR, S.R.
05882
DODGE, C.H.
05828*
DOUPLE, E.B.
05894
DOWNES, E.M.
05802
DUBROV, A.P.
05842*
DUMA-DRZEWINSKA, A.
05820*
DURNEY, C.H.
05780*, 05879, 05893, 05905, 05909*, 05910
DUTTA, S.K.
05871*
ECKERT, E.E.
05794*
ETHERIDGE, J.D.
05786*
FAITEL'BERG-BLANK, V.R.
05777*, 05795*
FERRI, E.S.
05868*
FESENKO, L.D.
05821, 05823
FISCHER, G.
05819*
FISHBURN, R.I.
05847
FOLEY, E.D.
05878
FORSTED, D.L.
05810*
FOSTER, K.R.
05904
FOTI, M.E.G.
05868
FRANCOIS, H.
05789*
FREE, M.J.
05889*
FROEHLICH, H.
05801*
GABOVICH, R.D.
05821*
GALAKTIONOVA, G.V.
05776
GANDHI, O.P.
05879, 05900
GASCOYNE, P.R.
05791
GERICKE, D.
05830*
GIBSON, R.
05894
GLASER, Z.R.
05828
GOLDBERT, M.
05892
GOLDBLUM, R.D.
05857*
GRACHEV, IU.I.
05799
GUERRERO, A.H.
05781

GUILLET, R.
05809
GUPTA, K.C.
05827*
GUY, A.W.
05817, 05844*, 05867, 05877, 05880
HAGMANN, J.
05900*
HAHN, E.W.
05807
HAHN, G.M.
05870
HAMMER, W.
05902
HARDING, R.K.
05872
HARRIS, C.
05867
HASHISH, E.
05903
HEGGENESS, F.W.
05809
HERBST, E., ED.
05835
HETZEL, F.
05849
HETZEL, F.W.
05848
HINDS, W.T.
05817
HINSENKAMP, M., ED.
05835
HJERESEN, D.L.
05817, 05882*, 05888*
HORIKAWA, A.
05790
HOSOYA, E.
05790
HOSSAIN, M.A.
05871
HSIEH, S.
05891*
HUNGATE, F.P.
05852*
IGNESTI, A.
05783
IIDA, N.
05790
ISKANDER, M.F.
05780, 05909, 05910*
JAFFE, R.A.
05890*
JAFFEE, R.A.
05889
JOHNSON, C.C.
05780, 05879, 05893*, 05899, 05905, 05909, 05910
JOHNSON, R.B.
05877*, 05880
JOHNSON, R.J.
05822, 05848, 05849, 05850, 05895
JOINES, W.I.
05847
JOINES, W.T.
05864
JUSTESEN, D.R.
05817*, 05876
KAMAL, A.A.
05903*
KANT, G.J.
05836
KANTOR, G.
05895, 05896*
KARCHES, G.J.
05787
KAUNE, W.T.
05889, 05890
KENNER, G.H.
05825
KHAFIZOV, R.Z.
05797
KIM, J.H.
05807*
KINN, J.B.
05874
KLIMOVSKAIA, L.D.
05775
KNAPP, E.
05819
KOCHETKOV, V.D.
05799
KOLTUN, D.
05891
KOLTUN, D.M.
05886*, 05887
KOSTINSKY, H.
05832*
KOTOVA-KHROMENKO, L.K.
05777
KOWAL, H.
05849
KOWAL, H.S.
05822, 05850, 05895
KOZIARIN, I.P.
05821, 05823*
KRAMAR, P.O.
05867*
KRITIKOS, H.N.
05904*
LARY, J.M.
05878
LEACH, K.E.
05872
LEACH, W.M.
05788
LEHMANN, E.J.
05792*
LENOX, R.H.
05836
LEVINSON, D.M.
05876, 05881
LI, G.C.
05870*
LIBURDY, R.P.
05875*
LIN, J.C.
05841*
LIVINGSTON, G.K.
05869
LLOBERA, O.
05781
LOBANOVA, E.A.
05816*
LORDS, J.L.
05780, 05879
LOTZ, W.G.
05863*
LOVELY, R.H.
05877, 05880*
LYMANGROVER, J.
05891
MACNICHOLS, G.
05869
MAGIN, R.L.
05897*
MANAO, G.
05783
MARUYAMA, Y.
05790*
MASSOUDI, H.
05780, 05909, 05910
MATHEWS, M.
05880
MCKELVIE, D.H.
05853
MCREE, D.I.
05869*
MESSITE, J.
05787
MEYERHOFF, J.L.
05836*
MICHAELSON, S.M.
05781, 05809*
MIKHALIUK, I.A.
05821, 05823
MILLANTA, L.
05783
MILLER, L.S.
05847
MILLER, R.C.
05898
MISHRA, R.K.
05808
MITCHELL, E.
05810
MITCHELL, J.C.
05780
MIZUMORI, S.
05877
MOORE, R.R.
05825
MOREVA, E.V.
05774
MOROJI, T.
05815*
MOSINA, I.V.
05774
MOSKVITINA, L.T.
05798*

MOSS, C.E.
05787*
MOTUZKOV, I.N.
05796
MURRAY, W.E.
05787
MYERS, B.R.
05825
NEELAKANTASWAMY, P.S.
05803*
NELSON, S.O.
05826*
NEUDER, S.
05907*
NEUDER, S.M.
05814*
NIKUL'CHEVA, N.G.
05774
NOELL, K.T.
05847
NUSSBAUM, G.H.
05855*, 05856
NYQUIST, J.K.
05840
O'HARA, M.
05848
OGURA, K.
05815
OLCERST, R.B.
05851*
OLSEN, R.
05902*
ONARAL, B.
05865
OREL, V.E.
05796
OSEPCHUK, J.M.
05784*
OVCHINNIKOV, V.I.
05799
OZINKOVSKII, V.V.
05779
PARK, J.B.
05825
PARKER, J.
05861
PARR, W.H.
05787
PARSADANIAN, A.SH.
05797*
PEREVALOV, G.M.
05795
PEREZ, J.C.
05781
PEREZ, R.J.
05781
PETHIG, R.
05791
PHILLIPS, R.D.
05817, 05843*, 05888, 05889, 05890
PLATASH, V.I.
05813
PLATONOVA, A.T.
05798
PORTELA, A.
05781*
POSTOW, E.
05861
PRESTON, E.
05862*
PRUCHA, R.V.
05908*
PRUD'HOMME-LALONDE, L.E.
05872
RABINOWITZ, J.R.
05851
RAGAN, H.A.
05817
RAMAKRISHNAN, K.P.
05803
RAMPONI, G.
05783
RAYMOND, U.
05847*
RICHARDSON, R.L.
05852
RIDDLE, M.M.
05874
RODGERS, J.E.
05855, 05856*
RODRIGUEZ, C.A.
05781
ROGERS, L.E.
05817
ROSENBERG, M.
05839*
ROTH, H.B.
05853, 05898
RUBINO, N.
05783
RYSER, D.K.
05780
RYZHENKOV, V.E.
05774
SANDHU, T.S.
05822*, 05849, 05850*, 05895*
SAUER, B.W.
05825
SBIRNAIA, A.F.
05796
SCHAEFER, H.
05793*
SCHWAN, H.P.
05860*, 05865, 05904
SEAMAN, R.L.
05782*
SEGERSON, D.A.
05858*
SELL, K.W.
05788
SETO, J.M.
05886
SETO, Y.
05891
SETO, Y.J.
05886, 05887
SHAH, S.A.
05778*, 05837*
SHARWELL, W.G.
05833*
SHELDON, R.L.
05882
SHUTENKO, O.I.
05796
SILNY, J.
05793
SIMONIS, R.
05800*
SINITSYNA, T.A.
05774
SMIALOWICZ, R.J.
05874*
SMIRNOVA, N.P.
05775*
SMITH, L.G.
05889
SMITH, V.
05854*
STERNBACH, R.A.
05840
STETSON, L.E.
05826
STEWART, P.A.
05781
STROHBEHN, J.W.
05894
STRZHIZHIVSKII, A.D.
05776*
STUCHLY, M.A.
05818*, 05829*
STUCHLY, S.S.
05892*
SUBJECK, J.R.
05849*
SUD, V.K.
05808*
SURI, P.K.
05808
TAKAHASHI, K.
05815
TAKASHIMA, S.
05865*
TATSII, IU.A.
05796
TELL, R.A.
05885*
THANSANDOTE, A.
05892
TIGRANIAN, R.E.
05797
TIMMERMANS, G.
05840
TOISHI, T.
05815
TOKITA, N.
05807
TSYGANOV, A.I.
05779*

UDERMANN, H.
05819
USSR ACAD SCI INTERKOS COUN
05806*
VAN KERSEN, I.
05870
VAVASOUR, E.J.
05862
VOSKRESENSKAIA, G.A.
05799
WACHTEL, H.
05782
WALKER, C.
05887*
WALSH, J.E.
05894
WANG, J.J.H.
05906*
WARD, T.R.
05874
WATSON, J.
05802*
WEISSFELD, D.M.
05886, 05887, 05891
WESTENSKOW, D.R.
05893
WHITE, K.A.
05870
WIKTOR-JEDRZEJCZAK, W.
05788*
WILLIAMS, W.
05884*
WILSON, B.S.
05864*
WITTERS, D.M.
05896
WONG, K.W.
05893
WOODWARD, K.T.
05847
WORDE, B.T.
05847
WU, T.K.
05901*
YANCHINSKI, S.
05838*
YEH, C.
05899
YOUNG, S.O.
05825*
ZAVODSKAIA, I.S.
05774*
ZOOK, J.M.
05864

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)

Franklin Research Center
Science Information Services Organization
Philadelphia, PA 19103

AD59870

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3. REPORT TITLE

Biological Effects of Nonionizing Electromagnetic Radiation

4. DESCRIPTIVE NOTES (Type of report and, inclusive dates)

Quarterly Report: September, 1978-December, 1978

5. AUTHOR(S) (First name, middle initial, last name)

Bruce H. Kleinstein, Ph.D., J.D., Project Manager
Elena P. Saboe, Managing Editor

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO OF REFS
December, 1978	54	

8a. CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S)
HO-A01-78-1157 New b. PROJECT NO	80G-C5003-01 See A059870 same
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT

Previous issues of the digest can be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161. The accession numbers for these issues are listed below.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

This quarterly digest presents current awareness information on the biological effects of nonionizing electromagnetic radiation (microwave and radio frequency) in the range of 0 Hz to 100 GHz. The effects of magnetic and electric fields (static and alternating) are also covered. Each issue contains abstracts of English and foreign current literature, summaries of ongoing research investigations, news items, and a directory of meetings and conferences.

Accession Numbers

AD-A034926 I(1-2): June-Sept., 1974
AD-A034423 I(3): Dec., 1974
AD-A034893 II(1): Mar., 1975
AD-A034426 II(2): Jun., 1975
AD-A034429 II(3): Sep., 1975
AD-A034430 II(4): Dec., 1975
AD-A034166 I(1): Oct., 1976
AD-A034895 I(2): Jan., 1977
AD-A039956 I(3): Apr., 1977
AD-A040681 I(4): Jun., 1977
AD-A043458 II(1): Sep., 1977
AD-A047647 II(2): Dec., 1977
AD-A052779 II(3): Mar., 1978
AD-A055569 II(4): Jun., 1978
AD-A059870 III(1): Sep., 1978

DD FORM 1 NOV 65 1473 (PAGE 1)

S/N 0102-014-6700

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
biologic effects						
electric fields						
electromagnetic						
magnetic field						
microwaves						
nonionizing radiation						
radio frequency						