magnetic field. These results indicate that the magnetic field has a normalizing effect, i.e. the field eliminates those structural changes in the hemoglobin molecule which result from tumor development. (8 references)

0687 A SUMMARY OF THE ERMAC WORK SESSION ON NERVOUS SYSTEM AND BEHAVIORAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATIONS. *(E.)* Galloway, D. (BRH, FDA, PHS, Washington, D.C.), S. M. Bawin, J. Frazer, W. Stavinoha, A. Guy, R. Lovely, D. Hawkins, J. Schrot, J. R. Thomas, D. R. Justesen, E. L. Hunt, A. Frey, R. Seaman, and M. DeSantis. *J. Microwave Power* 10(2):127-140, 1975.

On October 31 and November 1, 1974, an Electromagnetic Radiation Management Advisory Council (ERMAC) work session took place in Washington, D.C., to review research and progress pertaining to possible nervous system and behavioral effects of NIR and to assess the biological effects of these radiations. The participants described their current research efforts, after which a summary and set of recommendations were drawn up. It was noted that a large amount of material is emerging with commonality, especially with regard to biochemical, endocrine, and neuroendocrine effects. There remains a need to build up a greater base of information without precluding new or innovative approaches. Liaison and communication between laboratories and agencies should also be improved. In the neural/behavioral field, indications of nervous system and behavioral effects warrant further investigation, particularly in terms of specific exposure conditions and health conditions. Difficulties in determining doses and distribution of absorbed energy remain and the importance of characterizing power density and absorbed energy in a uniform manner was emphasized. Measurement guidelines should be published. Discrepancies between studies in which performance effects were observed only during irradiation and those in which they were observed following exposure were noted and a hypothesis for a possible mechanism was suggested which could account for this. The difference between pulsed and CW radiation effects should be studied with associated neurochemical and mechanism studies. The use of RF as a tool for understanding brain function was noted. Areas requiring more emphasis included: chronic exposure; separation of E and H fields; CW *vs* PW effects, parallel efforts to investigate mechanisms; more work at the biophysical, membrane, and neurochemical levels; and uniformity of measurement to allow extrapolation between animals and man. The levels of funding for this research are inadequate and multi-year funding was particularly stressed. (No references)

0688 FLAVOR AND CHEMICAL CHARACTERISTICS OF CONVENTIONALLY AND MICROWAVE REHEATED PORK. *(E.)* Penner, K. K. (Dep. Foods Nutr., Kansas State Univ., Manhattan) and J. A. Bowers. *J. Food Sci.* 38 (1973):553-555, 1974.

Flavor and aroma of MW and conventionally reheated and stored pork were compared with that of fresh conventionally cooked pork, and the relation of flavor and aroma to various chemical characteristics of the heat treated meat was studied. Most aroma and flavor components of freshly cooked and reheated pork were similar. No significant differences were found between freshly cooked and MW reheated pork, but some differences were noted between conventionally reheated muscle and that of the other treatments. MW reheated muscle is more like freshly cooked muscle than is conventionally reheated muscle. Total ninhydrin-reactive compounds and amount of protein in various tissue extracts were not affected significantly by the heating treatments. (20 references)

0689 EXPERIMENTAL MODELS FOR THE EVALUATION OF MICROWAVE BIOLOGICAL EFFECTS. *(E.)* Czerski, P. (Dep. Hum. Genet., Natl. Res. Inst. Mother Child, Warsaw, Poland). *Proc. IEEE* 63(11):1540-1544, 1975.

Biological organisms are self regulating systems equipped with interdependent homeostatic mechanisms. Absorption of radiant energy creates a disturbance which activates these mechanisms. Biological effects resulting from exposure should be considered as a chain of events initiated by the primary interaction of radiation with living matter and may be classified as early (immediate) direct effects, early (immediate) indirect (secondary) effects, or late (delayed) effects. This approach should serve in experimental design and interpretation of results obtained in MW experimentation. The term primary interaction should refer to the mechanisms of radiation energy absorption and direct interference with biophysical, biochemical, and bioelectrical mechanisms or phenomena in the living system. The present knowledge of biophysics of complex living systems is insufficient to predict the whole range of modes of the primary interaction of MWs with such systems. Assessing the biological significance of the phenomena produced is also difficult. Empirical observations should be included in the knowledge forming the basis for further experimental approaches and used for verification of the validity of theoretical predictions. The most investigated primary interaction of MWs with living systems is the transformation of absorbed energy into increased kinetic energy of the absorbing molecules. Its physiological consequences are insufficiently taken into account in experimental design. The internal distribution of fields within the irradiated object is nonuniform and is a function of frequency, exposure conditions, tissue geometry and dielectric properties. An increase in temperature changes metabolic rate and magnitude of blood flow (early direct biologic effects) and these changes influence metabolism and transport of metabolites. These local changes may influence the function of the whole organism (secondary early biological effects). It becomes obvious that research on MW biological effects is a highly interdisciplinary domain which requires a team consisting of a physiologist, cytologist, biochemist, biophysicist, and electronics engineer. In future research, thermal balance characteristics of animals exposed to MWs should be studied; physiological and pharmacological methods should be used to discriminate between early immediate and secondary biological effects; the possibilities for developing biological MW dosimetric indices should be examined;

and effects on growth and development should be urgently investigated under carefully controlled conditions. (55 references)

0690 EVALUATION OF POSSIBLE MICROWAVE-INDUCED LENS CHANGES IN THE UNITED STATES AIR FORCE. *(E.)* Shacklett, D. E. (U.S. Air Force Sch. Aerosp. Med., Brooks Air Force Base, Tex.), T. J. Tredici, and D. L. Epstein. *Aviat., Space, Environ. Med.* 46(11):1403-1406, 1975.

A Joint Service Ad Hoc Committee on Microwave Ocular Effects was formed to research MW effects in terms of lens changes using an epidemiologic approach. If significant ocular effects occurred from exposure to MWs, a difference between control and study groups could be statistically determined. The presence or absence of effects was recorded qualitatively using three diagnostic signs: opacities, vacuoles, and posterior subcapsular iridesence. Subjects (477) and age matched controls (340) were examined at 8 different Air Force bases over a 3 yr period. The subjects had known histories of having worked around MW generating equipment. Controls had no known MW exposure. Examination included a detailed work history, past medical history, and family history. The distant visual acuity was measured for each eye individually and pupils were dilated. In a double-blind study the subjects were examined for the 3 lenticular criteria and given an external ocular examination and direct ophthalmoscopic fundus examination. The groups were broken into age decades and compared. No significant differences were seen between the 2 groups: 60% of the controls and 56% of the study subjects had lenticular opacities; 41% of each group had vacuoles; and 62% of the controls and 60% of the study subjects had posterior subcapsular iridescence. An expected increased incidence of lens changes with age was seen. This study does not support the contention that MW exposure causes human cataracts at levels permitted by U.S. safety standards. (18 references)

0691 ELECTROMAGNETIC FIELD EFFECTS IN NERVE TISSUE. *(E.)* Sandler, S. S. (Northeastern Univ., Boston, Mass.), G. S. Smith, and E. N. Albert. *Aviat., Space, Environ. Med.* 46(11):1414-1417, 1975.

An attempt was made to correlate morphological alterations in nerve tissue from the bullfrog with specific local electric fields in the tissue. A train of high intensity, short duration pulses was used to produce a high electric field intensity with negligible thermal heating. The peak electric field was 1.3×10^5 V/m with a pulse repetition rate of 250 Hz. The nerve tissue of freshly dissected sections of the spinal cord and brainstem of bullfrogs was irradiated and the large motor neurons were used for histological study. The tissue was fixed, cut, and stained with thionin or hematoxylin. No significant histological differences were seen between control and exposed tissue, suggesting that previous findings may have resulted from appreciable amounts of thermal heating. (7 references)

0692 MICROWAVES CHALLENGE TODAY'S HEAT PROCESSING. *(E.)* Schiffmann, R. F. (Bedrosian Assoc., Alpine, N.J.). *Food Eng.* 47(11):72-76, 1975.

Industrial MW heating is becoming a more important food processing tool due to economic and/or product quality benefits. Foods are processed faster, cheaper, and with less labor. Increased production, increased yield, and reductions in processing time pay for the initial investment. MW tempering of meat shortens tempering time, reduces drip loss, and improves sanitation. The MW doughnut proofer heats dough uniformly to 45.5 C in just 4 min from cutter to fryer. It provides speed and better control of production and product quality. The MW fryer yields a product which never before existed: a coreless doughnut which is larger and less chewy. A MW dryer is used to produce uniformly dried pasta at lower capital costs and process times, with lower requirements for space. Internal heating by MWs drives the water to the surface very efficiently to avoid hardening. To thaw fish, new thawing tunnels use refrigerated air (-30 C) in the MW system. The production of kw-hr of MW power is more costly when thawing than when tempering, but not any higher than present methods. Some potential commercial uses of MW include freeze drying and/or vacuum drying. Though still being researched, the process is presently used commercially in Europe to make natural color extracts and to dry tea leaves. MW baking hopes to make use of domestic soft wheat flour as a partial replacement for imported hard wheat. Continued use of MWs in the puffing, drying, and blanching of foods awaits further investigations. *(No references)*

0693 MEASURE OF ENZYMATIC ACTIVITY COINCIDENT WITH 2450 MHz MICROWAVE EXPOSURE. *(E.)* Ward, T. R. (Exp. Biol. Lab., Natl. Environ. Res. Cent., EPA, Research Triangle Park, N.C.), J. W. Allis, and J. A. Elder. *J. Microwave Power* 10(3):315-320, 1975.

A dual beam Cary 15 spectrophotometer was fitted with a waveguide tuner and applicator so that a sample could be irradiated at 2450 MHz while being spectrophotometrically compared to an unirradiated reference solution. The CW beam was perpendicular to the light path and irradiated the sample through the top of the open cuvette. Enzymatic activities were determined at 25 C. Temperatures in both reference and sample solutions were measured continuously with microthermocouples, as enzymatic activity is temperature sensitive. To maintain 25 C during irradiation the sample was regulated at 19.8 C without radiation. Total irradiation time was about 5 min. Human and Torula yeast glucose 6-phosphate dehydrogenase were assayed for enzymatic activity by following the change in absorbance at 340 nm. Adenylate kinase from rat liver mitochondria and rabbit muscle were determined at 340 nm by the method of Schnaitman and Greenawalt. NADPH cytochrome c reductase was assayed at 550 nm. No differences were seen in specific activities of unirradiated and MW irradiated preparations ($p \leq 0.05$). An absorbed dose rate of 42 ± 4 W/kg was calculated from temperature differences before and during irradiation. These results are relevant to the use of a 2450 MHz MW blood warmer to raise the temperature of refrigerated bank blood

to body temperature prior to transfusion. The lack of a difference between control and sample NADPH cytochrome c reductase, which is membrane bound to the endoplasmic reticulum, is important in regard to the hypothesis that MW interactions can occur with biologic membranes. If membrane interaction does occur, it is not detectable as a change in enzymatic activity. (40 references)

0694 OXYGEN COMSUMPTION AND RESPIRATORY QUOTIENT IN FIVE ANIMAL POPULATIONS NATURALLY EXPOSED TO SANGUINE ELECTROMAGNETIC FIELDS. *(E.)* Greenberg, B. (Dep. Biol. Sci., Univ. Illinois, Chicago Circle). *Res. Rep.*, Contract No. N00039-73-0030, 16p, 1975.

A study was made to determine if or how ELF EM fields have biological effects. Specimens taken in September from the Sanguine experimental antennae in Wisconsin were tested. At this time mating and reproduction are over and day length is diminished. The animals tested included the wood louse, earthworm, redworm, slug, and redbacked salamander. These animals undergo a seasonal change in metabolic rate related to reproduction and general activity cycles so it was of interest to determine whether the fall populations responsed differently to Sanguine EMFs because of their different physiologic states. Exposed and control animals, grouped for uniformity of size, were tested simultaneously. Oxygen consumption was measured in a closed manometric system. The electric and magnetic fields were measured at each collecting site. No significant difference was found in O_2 consumption or respiratory quotient between test and control groups of fall animals. As all the species collected have limited mobility it is reasonable to assume that they are the third or later generation of animals that have been exposed to Sanguine-generated fields for 5 years. After 5 yr of Sanguine operation, metabolic rate, behavior, habitat selection and external features are not altered. (14 references)

0695 OVICIDAL LEVELS OF 2.45 GHz ELECTROMAGNETIC ENERGY FOR THE SOUTHERN CORN ROOTWORM. *(E.)* Fanslow, G. E. (Dep. Electr. Eng., Eng. Res. Inst., Iowa State Univ., Ames), J. J. Tollefson and J. C. Owens. *J. Microwave Power* 10(3):321-325, 1975.

To use EM energy as a nonpulluting means of controlling insects, it is necessary to determine the energy level required to produce a specific effect on a given insect. This study describes the determination of the threshold energy levels required to produce an ovicidal effect on the southern corn rootworm. The eggs of southern corn rootworm were subjected to EM energy at 2.45 GHz in slotted waveguide applicators. The effect of the EM energy was determined by comparing the average number of hatched eggs/treatment with the average number of hatched eggs/control. By comparing treatments with controls, the effect of EM energy can be separated from normal egg mortality. IR measurements of temperature changes were made with a scanning system. The temperature changes found were very large, suggesting that the ovicidal mechanism is thermal. The most effective MW treatment occurs when a high power is applied for a short time. When a low MW power is applied for a longer time, the sample has time to cool, and it takes a larger amount of power to produce the ovicidal effect. (2 references)

0696 A THEORETICAL INVESTIGATION OF MICROWAVE IRRADIATION OF SEEDS IN SOIL. *(E.)* Olsen, R. G. (Dep. Electr. Eng., Washington State Univ., Pullman). *J. Microwave Power* 10(3):281-286, 1975.

Seeds in soil are exposed to MW radiation in an attempt to prevent germination. MW energy absorbed by the seed and soil is converted into heat resulting in lethal temperature rises. The larger the temperature rise, the larger the probability of lethal effects is. The seed can be heated to a significantly higher temperature than its soil environment and this can lead to a saving in the energy necessary to produce germination control. The amount of energy absorbed by seeds irradiated from above is not only a function of the dielectric field intensity and the exposure time, but also depends upon the reflection of the radiation from the surface and the geometry of the seed. Maximum power absorption occurs from frequencies in the range of 1 GHz for seeds buried at 2.5 cm. For seeds closer to the surface, higher frequencies will result in greater power absorption. For seeds buried more deeply, a lower frequency is desirable. The temperature rise of the seed is a function of the power dissipated in the seed, the duration of irradiation, and the heat capacity and mass of the seed. The soil type is an important factor in determining the effect of the exposure. For seeds buried in a mineral soil, the required energy density for germination control is in excess of 800 J/cm. The greater the thermal conductivity of the soil, the faster the decay in soil temparature is. (17 references)

0697 CONDITIONS OF STRONGEST ELECTROMAGNETIC POWER DEPOSITION IN MAN AND ANIMALS. *(E.)* Gandhi, O. P. (Dep. Electr. Eng., Univ. Utah, Salt Lake City). *IEEE Trans. Microwave Theory Tech.* MTT-23(12):1021-1029, 1975.

The strongest whole body absorption for biological bodies was found for EMFs polarized with the electric field along the long dimensions of the bodies. The major length is approximately 0.4 times the wavelength of radiation for bodies in free space. EM power absorption was measured for bodies of fixed size at various frequencies using a parallel-plate waveguide as a transmission medium of plane waves. Bodies scaled down in all dimensions result in peak absorption frequencies scaled up by the same factor and vice versa. Experiments with biological phantom figurines show a high power deposition in the neck region. Initial experiments with anesthesized and

dead rats have shown a higher power deposition in the neck region than in the core of the animals. The frequencies of maximum absorption for adult humans is projected to be on the order of 65-75 MHz for free space conditions and about half as much in the presence of ground effects. (12 references)

0698 MUTAGENESIS BY RADIOWAVES IN ANTIRRHINUM MAJUS L. *(E.)* Harte, C. (Inst. Dev. Physiol., Univ. Cologne, West Germany). *Mutat. Res.* 29(1):71-75, 1975.

The pollen of *Antirrhinum majus* L. Sippe 50 was irradiated (λ = 1.5 m; field strength = 1.5 V/m) for 4, 12 and 43 3/4 hr to test the mutagenic effect in the progenies. The irradiated pollen was crossed onto styles of emasculated flowers of plants in the greenhouse. The only difference between experimental pollen and the controls was the exposure to radiowaves. The frequency of progenies with a high percentage of empty seeds shows a correlation with the duration of the pollen treatment. Abnormalities were only counted as mutations when several seedlings of the same progeny showed the same character. The mutagenic effect was confirmed by the increase in embryonic lethality after selfing the M_1 plants and the increase in relative frequency of segregating progenies with seedling anomalies. (9 references)

0699 THE DISTRIBUTION OF HEATING POTENTIAL INSIDE LOSSY SPHERES. *(E.)* Kritikos, H. N. (Dep. Bioeng., Moore Sch. Electr. Eng., Univ. Pennsylvania, Philadelphia) and H. P. Schwan. *IEEE Trans. Biomed. Eng.* BME-22(6):457-463, 1975.

One mechanism which contributes to the effects of EMFs on biological tissues is the process by which the heating potential is distributed inside the test objects. A nonuniform distribution implies the possibility of nonuniform temperature rise or the creation of hot spots. This study was designed to establish the conditions under which the heating potential peaks inside the test object and to determine the exact size and shape of these potential hot spots. Biological tissues are lossy dielectrics providing Joules heat when subject to EMFs. For this study, the dielectric properties of brain tissue in a homogenous sphere was chosen. In no case was the heating found to be uniformly distributed throughout the sphere. The type of nonuniformity was dependent on the radius of the sphere and frequency of the radiation. Two regions could be distinguished: one where heating takes place primarily at the front surface and a second where maximum heating takes place inside the sphere. The magnitude of the maximum heating potential was substantially different from values calculated by traditional methods, with maximum discrepancy (larger by a factor of 10) taking place in the region where hot spots occur. Hot spots occur only for small spheres and are therefore pertinent to heads of small animals and infants. Only the heating potential was calculated; the resulting temperature rise is reduced by heat diffusion and heat convection due to blood flow. (7 references)

0700 CONFORMATION CHANGES IN rRNA INDUCED BY ELECTRIC IMPULSES. *(E.)* Revzin, A. (Max Planck Inst. Biophys. Chem., D-34 Gottingen, West Germany) and E. Neumann. *Biophys. Chem.* 2(2):144-150, 1974.

Electric impulse experiments were performed with a high power pulse generator equipped with a fast spectrophotometric detection system and polarization optics. The light intensity emerging through crossed polarizers is increased in the presence of the field while the intensity emerging through parallel polarizers is decreased. The time course of changes in UV absorbance and electric dichroism can be resolved into contributions from orientational and conformational changes. Results of experiments show a field induced effect and not an artifact form, e.g., cell distortion. The results of a typical electric dichroism experiment show that the fast changes when the rectangular pulse starts are due to (partial) rotation of double helical arms into the field direction. The slower part (relaxation times in the msec and μsec range) is shown to be due to changes in orientation of the entire rRNA molecule, concomitant with electric induced helix coil transitions of oligomeric base paired regions. The study indicates that such electro-optical studies may be complicated by conformational changes which occur in addition to orientation, especially for long impulses of high field intensity in solutions of low ionic strength. Conversely, possible orientation of molecules should be considered when analyzing optical changes in temperature jump experiments, since a large electric field is present as the capacitor is discharged during the jump. (33 references)

0701 DORSAL COLUMN STIMULATION. ITS EFFECT ON THE SOMATOSENSORY EVOKED RESPONSE. *(E.)* Blair, R. D. G. (Div. Neurol. Neurosurg., Toronto Western Hosp., Ontario, Canada), R. G. Lee, and G. Vanderlinden. *Arch. Neurol.* 32(12):826-829, 1975.

The physiological mechanisms by which dorsal column stimulation (DCS) relieves pain are not known. The effects of varying frequency, duration, and intensity of DCS in the individual components of the somatosensory evoked response (SER) are investigated. Six patients had been selected to receive implantation of a dorsal column stimulator to relieve chronic pain. The SER obtained by stimulating the tibial nerve at the ankle consisted of a series of positive and negative deflections beginning approximately 30 msec after the stimulus and lasting for more than 400 msec. Four subjects showed well defined responses of this type. During DCS there was a consistent reduction in amplitude of the late components of the SER. When the intensity of DCS was maintained at levels adequate to relieve pain, little change in the early components of the SER occurred during the first 100 msec. With higher voltage

levels of DCS, there was some suppression of all components of the response. Most patients reported best relief with DCS at frequencies around 100 Hz. The relief lasted several hours after a period of DCS. (11 references)

0702 MICROWAVE DRYING OF MICROORGANISMS: I. INFLUENCE OF THE MICROWAVE ENERGY AND OF THE SAMPLE THICKNESS ON THE DRYING OF YEAST. *(E.)* Gomes, A. M. F. (Dep. Chem. Eng., Sch. Eng. Mauá, Sao Paulo, Brazil), G. F. Leonhardt, M. Torloni, and W. Borzani. *J. Microwave Power* 10(3):265-270, 1975.

The study was made to ascertain whether MW heating could be used to dry yeast cells. A Microvac-2000, 2450 MHz MW oven, with an input power varying from 1.2 to 4.2 kW, was used in the experiments. Commercial pressed yeast in 500 g tablets was used in the drying tests. The moisture content of the pressed yeast was determined by drying 1.5 g of the sample in a conventional oven at 100-105 C for 5 hr. Drying time needed to achieve a final moisture content of 0.05 g of water/g of dry yeast and drying rate during constant rate period are provided. There was a good linear correlation between the power input and the drying rate calculated during the constant rate period. Sample thickness on the drying rate indicated that for a sample larger than 2.0 cm there is no significant variation of the constant drying rate. The results indicate a real possibility of using MW energy for drying single cell protein. (3 references)

0703 EVIDENCE FOR COOPERATIVE MECHANISMS IN THE SUSCEPTIBILITY OF CEREBRAL TISSUE TO ENVIRONMENTAL AND INTRINSIC ELECTRIC FIELDS. *(E.)* Adey, W. R. (No affil.). *Functional Linkage in Biomolecular Systems*, ed. F. O. Schmitt, D. M. Schneider, and D. M. Crothers (New York: Raven Press, 1975), pp. 325-342.

Information processing in brain tissue no longer is considered to involve only the nerve cells. There are strong physiological interactions between nervous and surrounding neuroglial cells. Surface regions may have other quite special functions in the detection and transduction of weak chemical and electrical events at the membrane surface. The characteristic phenomenon of overlapping dendritic fields in the palisades of cells that characterize all vertebrate cerebral ganglia may be associated with the concurrent development of a rhythmic electric wave process. This dendritic organization appears to constitute a specific arrangement in cerebral tissue. The possibility that brain tissue may be sensitive to field potentials in the environment of the neuron, including the intrinsic fields of the EEG, is discussed. Experiments involving monkeys are described which involve the effects of low level, low frequency electric fields on EEG and behavior. There was a decided trend to shorter interresponse times in the presence of the fields. To add to the evidence that membrane surface might transduce weak extracellular fields as a step in the excitation process, the effects of VHF electromagnetic fields, amplitude modulated at EEG frequencies, was studied. Unequivocal interactions have been demonstrated between the brain tissue of mammals and birds and a variety of electric and EM fields. Behavioral effects from these studies occur with very low tissue electric gradients. Calcium ion appears to have an essential role in these interactions, and evidence points to a functional role for intrinsic electric gradients. (65 references)

0704 NONIONIZING RADIATION. *(E.)* Sliney, D. H. (No affil.) and D. L. Conover. *Industrial Environmental Health; The Worker and the Community*, ed. L. V. Cralley and P. R. Atkins (New York: Academic Press, 1975), pp. 157-177.

A review of the standards concerning physiologic effects of NIR, with an emphasis on new exposure criteria, is given. Mention is made of national consensus standards and federal rules which are near publication for several types of NIR, including lasers and MW exposure. The ANSI C95.1 standard was modified to include the specification of the TLVs in the equivalent free space electric field strength (200 V/m) and the magnetic field strength (0.5 A/m) for CW fields and in electric field strength squared (40,000 V^2/m^2) for modulated fields. This revision was primarily the result of a growing realization that separate electric and magnetic field strength measurements were mandatory for meaningful and accurate characterization of RF fields below approximately 300 MHz. (63 references)

0705 FREQUENCY AND ORIENTATION EFFECTS ON WHOLE ANIMAL ABSORPTION OF ELECTROMAGNETIC WAVES. *(E.)* Gandhi, O. P. (Dep. Electr. Eng., Univ. Utah, Salt Lake City). *IEEE Trans. Biomed. Eng.* BME-22(6): 536-542, 1975.

Studies were carried out to determine whether the total power absorbed in a whole animal body varies with frequency, what the frequency regions of most absorption for various polarizations are, what percentage of incident power is absorbed at such frequencies, and whether extrapolations to humans are possible. Using a parallel plate waveguide with a 6.35 x 15.9 cm^2 cross section, RF absorption of 96, 158, 261, and 390 g anesthesized Wistar rats was measured. The animals were placed on a styrofoam sheet to separate them from the waveguide plates as observed characteristics were independent of placement as long as the bodies were 2-3 mm from the plates. It was found that there is a definite frequency region of peak absorption and the frequency for maximum absorption reduces as $W^{-1/3}$ with weight W of the animals. For frequencies below resonance, the power absorbed varies as $f^{4.75}$. At the absorption peak, the power absorbed varies as $W^{2/3}$, which is essentially an absorption cross section proportional to the shadow cross section of the animal. Above resonance, absorption reduces monotonically with increasing frequency. The effect of the tail on whole body absorption was minimal. The RF power deposition varied significantly with orientation and frequency, with the strongest absorption for waves polarized along the long dimension of the body at frequencies such that the major length is approximately $\lambda/4$ wavelength of radiation in the presence of ground caused image. The highest whole body absorption for humans is predicted to be 40-50 MHz by extrapolation. (6 references)

0706 INDUSTRIAL AND SCIENTIFIC APPLICATIONS OF DOPPLER RADAR. *(E.)* Whetton, C. P. (Br. Rail Board, London, England). *Microwave J.* 18(11): 39-42, 1975.

The principal advantages of Doppler radar over other methods of speed measurement are the lack of any need of physical contact with the system and the ability of MWs to be directed into areas which are normally inaccessible. The MW hardware is usually very simple, ranging from single cavity devices to arrangements in which the oscillator power is transferred to the mixer by a coupler and a circulator is used to allow single antenna working. A physiological application of Doppler radar is its use to monitor the respiration rate of humans and animals. The radar is directed at the subject's chest and respiration rate is inferred from the periodic changes in Doppler shift frequency which occur as the chest wall moves. It is a great advantage that the radar needs no contact with the patient. The device causes no discomfort and, at 2.5 mW, presents no biological hazard. The same principle is used to form a respiration monitor in a polygraph system. (21 references)

0707 CLINICAL APPLICATION OF EM METHOD ON THE CENTRAL AND PERIPHERAL ARTERIES. *(Jap.)* Wanibuchi, Y. (Mitsui Mem. Hosp., Japan), H. Ijima, F. Sano, M. Nakanishi, A. Nishimura, and S. Okino. *Kokyu To Junkan* 22(7-8):605-610, 1974.

The application of the electromagnetic method to measure human blood flow is presented with examples of measurements in large arteries. The flow measurement results for the aorta and pulmonary artery in both pre- and post-operations of ASD indicated the same blood flow volume in the aorta and pulmonary artery upon the disappearance of the left-right shunt. The arterial blood flow wave of a patient with aortic insufficiency indicated that the disappearance of the back current of blood could be seen after an operation to install an artificial valve. The quantitative diagnosis of heart rate and back current could be determined from the pulmonary artery blood flow wave for a patient with Fallot's tetralogy. The EM blood flow measurement can be used for the selection of an effective drug for enlarging peripheral arteries. The blood inflow wave measured at the upper arm of a patient indicated an increase in the blood inflow rate from 40 ml/min to 262 ml/min after arterial injection of 5 ml Priscoline. The EM measurement of blood flow was limited to its use in animal experiments until a few years ago; however, the technique has been applied in human surgical cases, and the comparable accuracy of the blood flow measurement obtainable in animal experiments is possible in human applications. (17 references)

0708 ECOLOGICAL INFLUENCE OF ELECTRIC FIELDS. *(E.)* Bankoske, J. W. (Westinghouse Electr. Corp., East Pittsburgh, Pa.) and G. McKee. *Res. Rep.* No. EPRI 129, 20p, 1975.

This project was initiated to study effects of electric fields on plants, animals, and soils in the vicinity of high voltage transmission lines. It was necessary to determine the nature of electric fields in the vicinity of actual transmission lines, including the calculation of the magnitude of fields at ground level, several meters above ground, and the lateral profile of the gradients in a direction perpendicular to transmission lines. The maximum gradients that were calculated were used to set reasonable limits on the fields. The electric field intensity can be minimized by using a triangular configuration for line voltage. The number, size, and spacing of the phase sub-conductors have a minor effect on the gradient, with the gradient increasing as the apparent size of the phase conductor is increased. The steps taken to reduce corona and RIV tend to increase the voltage gradients at ground level. The maximum electric field intensity increases as plant height increases beneath a prototype 1100 kV transmission line. This increase is caused by raising the effective ground plane for the transmission line. The project will involve tests made on the germination rate of seeds and morphological changes at the cellular level. Plants will be grown through several life cycles under different electrical fields to assess effects on pollen tube growth, pollen viability, meiosis, and mitosis. (20 references)

0709 ORIENTATION BEHAVIOR OF RING-BILLED GULL CHICKS (LARUS DELAWARENSIS) EXPOSED TO PROJECT SANGUINE'S ELECTRIC AND MAGNETIC FIELDS. *(E.)* Southern, W. E. (Dep. Biol. Sci., Northern Illinois Univ., DeKalb). *Res. Rep.*, Office of Naval Research, Contract No. N00014-72-A-0050-0002, 32p., 1973.

A study of possible Sanguine impact on avian migrational orientation was conducted during the summer of 1973. Ring-billed Gull chicks were used to determine if the magnetic and electric fields produced by the energized antenna had an effect on their direction finding ability. Experimental trials were conducted with either north-south or east-west antenna energized with 260 or 300 A at 45 or 76 Hz of CW or modulated signal. Trials serving as controls were conducted when the entire system was shut down. All trials were conducted during low intensity disturbances in the geomagnetic field. The 255 controls showed mean headings ranging between 145.93° and 154.28° which are consistent with the headings predicted for the population sampled. Analysis of the 1133 experimental trials conducted with the buried antenna energized did not produce such clear cut results although a detrimental effect was evident. Frequency, amperage, and mode of transmission did not noticably modify the birds' responses during trials. The AC magnetic field produced by the energized antenna and superimposed on the geomagnetic field is responsible for the recorded disorientation. These effects were recorded at ground level where the Sanguine field was at its maximum intensity. Birds subjected to short term exposure to the Sanguine fields responded similarly to those given larger exposure. It is possible that the fields estimated to occur at even 1000 ft above the operating system may be sufficient to cause disorientation of juvenile Ring-billed Gulls. (13 references)

0710 ELECTRICAL ENHANCEMENT OF HEALING IN COMBAT INJURIES TO HARD AND SOFT TISSUES. *(E.)*

Savara, B. S. (Health Sci. Cent., Univ. Oregon, Portland), R. W. Fields, R. T. Tacke, and M. H. Bartley. *Res. Rep.*, U.S. Army Med. Res. Dev. Command, Contract No. DADA-17-72-C-2185, 26p., 1974.

Experiments are being conducted to establish quantitative relationships between application of electric current and the reparative process in hard and soft tissue. *In vivo* dog calvarium models were used in conjunction with tetracycline hydrochloride labeling techniques to determine whether the reparative process in hard tissue is enhanced or accelerated. *In vivo* studies of the soft tissue of rats and *in vitro* studies of tissue and cell cultures were conducted to determine the effects of current levels, waveforms, and electrode materials. Dogs (23-35 lb) from a defined genetic pool were utilized. Four circumscribed defects, 4 mm square, were cut through the cortical and spongy bone into the marrow of each parietal bone using a dental handpiece. Electrodes were implanted on each side of the defect and a constant direct current of 0.10, 1.0, or 10 μA was applied. Daily physical examinations and weekly hematological and serum chemical evaluations were reported. Tetracycline hydrochloride was administered i.v. (10 mg/kg total body wt) at 1, 3, and 5 wk post operatively. On the 42nd day post operative, the animal was sacrificed and a complete autopsy was performed. All defects of the animals that had received current were in a more advanced state of repair than those of animals that had not received current. Those defects receiving current in the earlier stages (1-3 wk) of the reparative process showed slightly more advanced repairs than those in the later stages (4-6 wk) and controls. In soft tissue repair, observations correspond to the results found in the hard tissue *in vivo*. *In vitro* cell and tissue culture studies of primate fibroblasts grown in suspension and in monolayer cultures showed that cultures receiving 0.1 and 1.0 μA direct current exhibit slightly increased cell counts when compared to controls, but no significant change in cell viability was seen. Under microscopic examination of the monolayer culture, an uneven distribution of mitotic figures which are more numerous in the area of the cathode are seen. Cultures receiving 10 μA current show a definite decrease in total cell count with no significant difference in the viability count. This work is continuing. (45 references)

CURRENT RESEARCH

0200 INFLUENCES OF VERY WEAK EXTRA-PHOTIC ELECTROMAGNETIC FIELDS. Brown, F. A. (Sch. Arts Sci., Northwestern Univ., Evanston, Ill.).

See CR 0112, Volume II(1), for description of this research. (Renewed 7/75-6/76)

Supporting Agency:U.S. Natl. Sci. Found., Div. Biol. Med. Sci.

0201 OCULAR PATHOLOGY FROM ELECTROMAGNETIC RADIATIONS. Fine, B. S.; Hirsch, S. E.; Tso, M. O. (Univ. Assoc. Res. Educ., Bethesda, Md.).

It is known that damage to ocular tissues may occur by exposure to various wavelengths of the EM spectrum. Damage is dependent on the amount of energy absorbed. With development in recent years of a wide variety of sources of powerful EMRs, some of which are, in addition, coherent (i.e., masers and lasers) the potential grows for accidental injury to the eye. This research proposes to evaluate the sequence of morphologic events produced in ocular tissues by such devices in both the visible and invisible portions of the spectrum. Current methods of light and electron microscopy will be applied to these studies. This project consists of two parts: (1) an evaluation of two important regions of the invisible spectrum using (a) an ultraviolet laser to determine effects on cornea, lens, and possibly the retina in short (days, weeks) and medium term (months, year) experiments and (b) determination of the effects of MW radiation on the lens in short, medium and long term experiments, and (2) an evaluation of damage to the primate fovea by coherent visible light using a CW laser (Argon). The proposed studies are currently of great clinical importance in the matter of evaluating the potential for accidental injury and determination of standards of safety. (6/75-5/76)

Supporting Agency:HEW, PHS, FDA.

0202 THE EFFECTS OF LOW POWER DENSITY ELECTROMAGNETIC ENERGY ON BIOLOGICAL SYSTEMS. Flanigan, W. F.; Ridgway, S. H. (Biosyst. Res. Dep., U.S. Navy, San Diego, Calif.).

The objective of this project is to study the electrophysiology (i.e., brain wave activity, heart rate) and behavior of reptiles (turtles) exposed to low power density ($\leq$ 10 mW/cm^2) EMR at a number of frequencies within a range of 0.1 to 10 GHz. Nonmetallic electrodes will be developed to enable both EEGs and ECGs to be recorded from the brain and heart, resp., of acute and chronically implanted animals. All field exposure experiments will be conducted in air. Acutely implanted turtles will be anesthetized or partially anesthetized and restrained. EEGs and ECGs will be simultaneously recorded. Chronically implanted animals will be prepared using a standardized procedure. Each animal will serve as its own control. Baseline recordings prior to any field exposure will be compared with those obtained when an animal is exposed to EMR. Cumulative effects of recurring field exposure will be investigated by comparing baseline recordings to recovery recordings made between periods of irradiation as well as by comparing subsequent field exposure recordings with prior field exposure recordings. Baseline field exposure recovery recordings will range from a fraction of a second to hours for acute preparations and minutes to days for chronically implanted animals. Electrophysiological techniques will be employed including spectral analyses of EEGs and averaged cortical evoked potentials using a computer of averaged transients to determine sensitivity to EMR. (7/74-6/75)

Supporting Agency:U.S. Dep. Def., Navy.

0203 FLUID SHEAR OR MAGNETIC ALIGNMENT OF BLOOD COMPONENTS. Gardner, R. A.; Joist, J. H.; Sutera, S. P.; Barnothy, M. F.; Barothy, J. M. (Sch. Eng. Appl. Sci., Washington Univ., St. Louis, Mo.).

The objective of this project is to identify quantitatively field mechanisms of interaction in blood due to either fluid flow (rate-of-shear) or externally applied fields (electric or magnetic). Two such effects that have been documented recently are the delay of *in vitro* thrombus formation due to either increasing rate of shear in the flow or the application of an external magnetic field. The efforts of this research will be focused on the working hypothesis that the mechanism which results in these effects is the preferential alignment of one or more of the macromolecular participants in the *in vitro* thrombus formation process. Fresh whole blood (wb) or platelet-rich-plasma (prp) from fasted dogs will be used to produce coagula under the controlled *in vitro* flow conditions of a modified Chandler rotating loop system. The effects to be studied include the dependence of thrombus-formation time in prp and wb on field strength and rate-of-shear and the dependence of thrombus structure in wb and prp on field strength and rate-of-shear. The reduced sedimentation of erythrocytes in whole blood or single protein solutions in a transverse field will be examined theoretically and experimentally in order to identify orientation effects. Solutions of single blood proteins will be examined using the optical techniques of spectrophotometry, spectropolarimetry and birefringence to quantify their orientation in a transverse magnetic field. (6/75-5/76)

Supporting Agency:HEW, PHS, NIH.

0204 DEVELOPMENT OF A HIGHT POWER MICROWAVE FOCUSED OVEN. Guidotti, A.; Cheney, D. L.; Costa, E.; Wang, C. (Lab. Preclin. Pharmacol., Natl. Inst. Ment. Health, Bethesda, Md.)

See CR 0079, Volume I(3), for description of this research. (Renewed 7/74-6/75)

Supporting Agency:HEW, PHS, Natl. Inst. Ment. Health

PRECEDING PAGE BLANK-NOT FILMED

0205 PRE- AND POSTNATAL EFFECTS OF MICROWAVE IRRADIATION. Jensh, R. P.; Brent, R. L.; Weinberg, I.; Vogel, W. (Sch. Med., Thomas Jefferson Univ., Philadelphia, Pa.).

There are three objectives of this investigation. Techniques and instrumentation will be developed further for the determination of exposure and dosimetric parameters at 915 and 2450 MHz, and for the determination of the influence of pulsed exposure, continuous exposure, peak power, and average power (pulsed irradiation). The dosage and monitoring procedures will be refined through polishing of techniques and instrumentation for quantitative measurement of modulated and pulsed transmission of 2450 and 915 MHz and power ranges at or near those currently considered acceptable. The effects of low dose chronic prenatal MW irradiation and (1) embryonic and fetal development in the rat, (2) postnatal development in the rat, (3) reproductive capacity of the rat, and (4) CNS of the exposed adult offspring will be determined. The procedure will include three power ranges at two transmissions and two frequencies (2450 and 915 MHz) and four time periods in the rat pregnancy plus paired controls. (6/75-5/76)

Supporting Agency:HEW, PHS, NIH

0206 VESTIBULO-COCHLEAR EFFECTS OF UHF-MICROWAVE RADIATION. Lebovitz, R. M.; Seaman, R. (Sch. Med., Univ. Texas, Dallas).

This research concerns the experimental examination of the neural activity in the vestibular system of animals subject to acute, cranial MW radiation. This work will proceed initially on mongrel cats and progress to monkeys as techniques are refined. With the animal immobilized in a stereotaxic frame, MW radiation will be applied to the cranium at an incident frequency of 915 MHz, using power densities in the range of 5 to 100 mW/cm^2. The relevant data include gross field and single cell electrical activity in the vestibular nerve and associated nuclei. Interspike intervals are analyzed by computer for average rate and interval statistics and correlated with the MW radiation. As a control, known but weak cranial acceleration is applied before and during MW exposure to classify the unit and field response pattern. Other controls include vestibular nerve section, intracranial temperature monitoring and histological verification of electrode sites. Particular attention is paid to the suppression of MW induced field artifacts in electrodes and to the calibration of absorbed energy. A secondary aim of this work will be to examine the effects of MW radiation unit activity in the auditory pathway. (5/75-4/76)

Supporting Agency:HEW, PHS, FDA

0207 BIOLOGICAL EFFECTS OF MICROWAVE RADIATION. McAfee, R. D.; Cazenavette, L. L.; Holland, M. G.; Robinette, C. D. (VA Hosp., New Orleans, La.).

In order to determine if MW radiation can produce cataracts in primates, the face and eyes of operantly trained unfettered rhesus monkeys have been irradiated during their operation of a manipulandum. The operant conditioning apparatus has been built and the MW irradiation equipment is in use. Power densities (500 mW/cm^2) and durations (15-20 min) of x-band pulsed MW irradiation to the face, which produces ocular and skin injury in anesthetized animals, have been found to be readily tolerated by unanesthetized rhesus monkeys for a rewarding drink presented in 0.25 ml increments on a variable schedule (25%). A long term study of possible latent effects of chronic exposure to 9.31 GHz pulsed MW irradiation is in progress with eight experimental and eight control unfettered rhesus monkeys. The original pilot study is being enlarged to a full scale investigation of electronic technicians who may have been exposed to MW radiation. It will be their task to obtain the names and addresses of selected groups of veterans to whom the shadowgraph device will be mailed. The data obtained will be statistically interpreted. (7/75-6/76)

Supporting Agency:U.S. Veterans Adm.

0208 MINIMALLY-INVASIVE STIMULATION WITH IMPLANTED DIODE. Schuder, J. C.; Stoeckle, H.; Almond, C. H.; Stephenson, H. E. (Sch. Med., Univ. Missouri, Columbia).

Electrical stimulation of biological tissues is currently used or under active consideration for use in the treatment of a variety of clinical problems. While the possibility of selective electrical stimulation of a localized region within the body by completely noninvasive means has been postulated on theoretical grounds, such stimulation has yet to be demonstrated experimentally. However, the selective stimulation of a localized region within the body can be achieved by implanting a very small diode at the desired site and then applying a pulsed RF field by means of electrodes or a coil on or near the surface of the body. Reasonably complete theoretical descriptions of the two systems have been derived on the basis of an idealized model in which circular electrodes or the coil are placed on the surface of a semi-infinite homogeneous medium. The direct current component of diode current is related to the power input to the electrode pair or to the coil and to the geometry of the system. The two systems are being currently evaluated for the cardiac pacing of dogs and the study will be extended to cover other stimulation applications. Input power-diode current relationships will be derived for more complex models.

Supporting Agency:HEW, PHS, NIH

0209 MECHANICAL PROPERTIES AND ENERGY PROPAGATION CHARACTERISTICS OF TISSUES. Ware, R.; McCutcheon, E.; Knapp, C.; Bhagat, C. (VA Hosp., Lexington, Ky.).

The objective of this research is to investigate the

correlation of classical mechanical properties of various kinds of human and animal tissue in correlation with the tissue propagation characteristics for US and EM energy. Investigation of transmission spectra of the full range of infrared energy for dog blood and design of US test range and instrumentation systems are already underway. The goal for the first year is to complete design and fabrication of the test range and instrumentation system and to obtain preliminary data using animal (dog and rabbit) tissues. (7/73-6/74)

Supporting Agency:U.S. Veterans Adm.

0210 BIOELECTRIC PHENOMENA CONTROLLING BONE GROWTH. Bassett, C. A.; Pawluk, R. J.; Chokshi, H. R.; Park, I.; Bogoshian, A. (Sch. Med., Columbia Univ., New York, N.Y.).

The objective of this project is to develop a highly effective surgically noninvasive method to increase the rate and frequency of fracture repair. Capacitively coupled electric and inductively coupled EM fields already have been shown to have the ability to influence osteogenesis and other biological processes. The coupling efficiency of present fields, however, is not capable of provoking osteogenic stimulation of a magnitude already shown possible with a potent biochemical osteogenic factor. Since the biological system has a demonstrated capacity to respond on a scale heretofore thought impossible, it appears important to develop electric pertubations which can trigger responses of this magnitude. As an initial step to increase the effectiveness of these modalities, an attempt will be made to study mechanisms by which pulsing electric and EM fields interact with nonexcitable cells to alter their behavior. Primary emphasis is to be focused on effects at the plasma membrane-glycocalyx interface and the capacity of this structure to complex or release cations such as Ca^{+2} and K^{+1}. Results will be correlated with altered patterns and rates of collagen and DNA synthesis by connective tissue cells *in vitro*. The relationships established by these studies will be used to screen pulse characteristics, such as amplitude frequency, shape, and width, for maximal perturbation of cell function. Data arising from these basic studies will be applied in fracture and pseudarthrosis models in animals. (12/74-3/75)

Supporting Agency:HEW, PHS, NIH

0211 ACCELERATION OF FRACTURE HEALING BY ELECTRICAL FIELDS. Brighton, C. T.; Friedenberg, Z. B.; Black, J.; Korostoff, E.; Heppenstall, R. B. (Sch. Med., Univ. Pennsylvania, Philadelphia).

See CR 0134, Volume II(2), for description of this research. (Renewed 9/75-8/76)

Supporting Agency:HEW, PHS, NIH

0212 EFFECTS OF LOW INTENSITY MICROWAVE RADIATION ON MAMMALIAN SERUM PROTEINS. Cleary, S. F.; Berry, E. R. (Sch. Med., Virginia Commonw. Univ., Richmond).

See CR 0136, Volume II(2), for preliminary description of this research. This ongoing project is designed to synthesize *cis* and *trans* isomers of β-mercaptoethylamine and γ-mercaptoprophylamine for studies to determine their radio protective properties. Careful studies have been made to determine modes of synthesis of the proposed compounds. The general approach will be to follow the routes of synthesis so as to make sufficient quantities of the compounds for testing. (Renewed 7/75-6/76)

Supporting Agency:U.S. Dep. Def., Army

0213 BEHAVIORAL AND BIOLOGICAL EFFECTS OF RESONANT ELECTROMAGNETIC POWER ABSORPTION IN RATS. Gandhi, O. P.; Johnson, C. C. (Sch. Eng., Univ. Utah, Salt Lake City).

See CR 0080, Volume I(3) and CR 0148, Volume II(2), for descriptions of this research. (Renewed 7/75-6/76)

Supporting Agency:U.S. Dep. Def., Army

0214 MECHANISMS OF MICROWAVE INTERACTION WITH HUMAN AUDITORY SYSTEMS. Lin, J. C.; Yu, F. T. (Wayne State Univ., Detroit, Mich.).

This research will investigate, through theory and experiment, the mechanism of interaction of pulsed MWs with living tissues. This involves analytic studies of the stress and forces induced by the incident MW energy, optical measurement of vibrations in models of human and animal heads exposed to pulsed MWs, and theoretical and experimental investigations of the frequency behavior of the induced vibrations which may be used to isolate the precise mechanism involved in the auditory phenomenon. The results of this research will advance the existing knowledge on the quantitative effects of MW energy on living organisms and provide some urgently needed scientific information in determining human tolerance to MW radiation. (8/75-7/76)

Supporting Agency:Natl. Sci. Found., Div. Eng

0215 ANALYSIS AND PREPARATIONS OF AVAILABLE WORLD LITERATURE ON BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION. Lindberg, R.; Larrimore, J. (Mead Corp., Dayton, Ohio).

See CR 0103, Volume II(1), for description of this research. (Renewed 7/75-6/76)

Supporting Agency: Office Telecomm. Pol.

0216 THE ROLE OF CYCLIC AMP AND CYCLIC GMP IN THE CENTRAL NERVOUS SYSTEM. Lust, W. D.; Passonneau, J. V.; Kupperberg, H. J.; Yonekawa, W. D. (HEW, PHS, NIH, Bethesda, Md.).

The reactions of cyclic AMP and cyclic GMP to induce alterations experimentally in brain metabolism were investigated *in vivo*. Cyclic GMP in the cerebellum increased following electroconvulsive shock (ECS) and after the administration of either CNS stimulants or convulsants. The levels of cyclic GMP were decreased following the injection of a number of CNS depressants and anti-convulsants. While cyclic AMP also increased following ECS, this cyclic nucleotide is pharmacologically unresponsive. Most of the anti-convulsants tested to date decreased the cyclic GMP levels by greater than 50%. The relationship of cerebellar cyclic GMP to both electrically and chemically induced seizures is currently being investigated. (7/74-6/75)

Supporting Agency:HEW, PHS, NIH

0217 INVESTIGATION OF OCULAR EFFECTS OF CHRONIC EXPOSURE OF PRIMATES TO MICROWAVE RADIATION AT 2.45 GHz. Polson, P. (Stanford Res. Inst., Menlo Park, Calif.).

See CR 0102, Volume II(1), for description of this research. (Renewed 7/75-6/76)

Supporting Agency:U.S. Dep. Def., Army

0218 BIOLOGICAL EFFECTS AND HAZARDS OF MICROWAVE RADIATION. Hunt, E. L.; Larsen, L. E.; Jacobi, J. H. (Walter Reed Army Inst. Res., Washington, D.C.).

See CR 0117, Volume II(1), for description of this research. (Renewed 7/75-6/76).

Supporting Agency:U.S. Dep. Def., Army

AUTHORS OF CURRENT LITERATURE INDEX

ADEY, W.R.
644, 703
ALBERT, E.N.
691
ALLIS, J.W.
693
ANDERSON, J.
627
APISTARKHOV, V.M.
686
BAKER, R.E.
637
BANKOSKE, J.W.
708
BARTLEY, M.H.
710
BATTOCLETTI, J.H.
631
BAWIN, S.M.
644, 687
BEAL, J.B.
632, 653
BELLOSSI, A.
667, 668, 669, 670
BELLOSSI, G.
667
BERRYER, P.
665
BIGU DEL BLANCO, J.
640
BLAIR, R.D.G.
701
BLAKEMORE, R.
659
BOCCALON, H.
665
BORZANI, W.
702
BOWERS, J.A.
683
BRENT, P.L.
629
BRIDGES, D.F.
649
BROOKS, M.E.
630
BURTON, C.
650
BUSH, D.
623
CASTETS
670
CHENEY, D.L.
679
CHOU, C-K.
678
COLE, F.E.
641
CONOVER, D.L.
704
COURTNEY, K.R.
678
CZERSKI, P.
689
DE CERTAINES, J.
668
DELATEUR, B.J.
681
DEMAILLE, J.
669
DESANTIS, M.
687
DORDEVIC, Z.
672
DOTEUCHI, M.
679
DUCLOS, M.
667, 668
DWIVEDI, R.S.
662
ELDER, J.A.
693
ENGLE, R.P.
661
EPSTEIN, D.L.
690
FANSLOW, G.E.
695
FERRIS, C.D.
645
FIELDS, R.W.
710
FRANKLIN, D.L.
653
FRAZER, J.
687
FREY, A.
687
FRIEDMAN, H.
651
GALLOWAY, D.
687
GANDHI, O.P.
697, 705
GAVALAS-MEDICI, R.J.
644
GOBAN, V.L.
682
GOMES, A.M.F.
702
GOODMAN, E.M.
628
GRAF, E.R.
641
GREENBERG, B.
694
GREENEBAUM, B.
628
GUIDOTTI, A.
679
GUY, A.W.
658, 678, 687
HAFFNER, J.D.
642
HAKES, S.D.
645
HAMI, D.
629
HARTE, C.
698
HAUBER, M.E.T.
621
HAWKINS, D.
687
HAWKINS, R.A.
679
HEPPNER, F.H.
642
HUNT, E.L.
687
IADA, H.
624
IJIMA, H.
707
JOHNSON, C.C.
663
JUSTESEN, D.R.
687
KAHN, A.R.
654
KAPPEL, D.A.
652
KAUFMAN, G.E.
634
KETCHUM, L.D.
652
KLEPSCH, I.
622
KLIMOVSKAYA, L.D.
680
KOBAYASHI, T.
625
KOLODUB, F.A.
675
KRASNOBAEV, P.E.
682
KRITIKOS, H.N.
699
KROGER, W.S.
648
KRUMPE, P.E.
639
KUCHERENKO, A.E.
685
LANGRANJAN, I.
622
LAJN, H.M.
621
LEE, R.G.
701
LEHMANN, J.F.
681
LEONHARDT, G.F.
702
LIN, J.C.
656, 664, 678
LLAURADO, J.G.
631
LOVELY, R.
687
LOWE, J.F.
626
LUCZAK, M.
677
MAICANESCU, M.
622
MAMIYA, D.
625
MARRON, M.
628
MAURER, D.
650

MCCLEOD, W.
662
MICHAELSON, S.M.
634
MILLER, B.F.
684
MILLER, D.A.
635, 654
MISHCHENKO, L.I.
675
MITTLER, S.
657
MURASHOV, B.F.
682
MURAWSKI, B.J.
661
NAHAS, G.G.
665
NAKANISHI, M.
707
NEUMANN, E.
700
NIEVEL, J.G.
627
NISHIMURA, A.
707
OGUNWUYI, S.
662
OKINO, S.
707
OLSEN, R.G.
696
OSIPOV, P.P.
671
OSTROVSKAYA, I.S.
674
OWENS, J.C.
695
PAUL, R.
676
PAVLOVICH, S.A.
671
PENNER, K.K.
688
PIRUZIAN, L.A.
686
POLK, C.
633
POPESCU, H.I.
622
POSTOW, E.
654
PRIETO, A., JR.
647
RAFAILA, E.
622
REGESTEIN, Q.R.
661
REMOND, A.
655
REVZIN, A.
700
ROBINSON, N.
627
ROHL, D.
621
ROMANOV, I.V.
673
ROMANUSHKO, V.A.
682
ROMERO-SIERRA, C.
640
ROSENTHAL, S.H.
649
ROZZELL, T.C.
638
SANCES, A., JR.
631
SANDLER, S.S.
691
SANO, F.
707
SASAKI, K.
625
SAVARA, B.S.
710
SCHIFFMANN, R.F.
692
SCHROT, J.
687
SCHWAN, H.P.
699
SEAMAN, R.
687
SHACKLETT, D.E.
690
SHEALY, C.N.
647, 655, 660
SHEVCHUK, V.I.
685
SLINEY, D.H.
704
SMIRNOV, IU.V.
673
SMIRNOVA, N.P.
680
SMITH, G.S.
691
SOLAKOVA, S.
683
SOUTHERN, W.E.
709
STAUNCH, M.
621
STAVINOHA, W.
687
STEFANOV, B.
683
STONEBRIDGE, J.B.
681
SUGIYAMA, S.
646
SZMIGIELSKI, S.
677
TACKE, R.T.
710
TAFLOVE, A.
630
TAMIYA, H.
625
TEOTIA, J.S.
684
THOMAS, J.R.
687
TOCKMAN, M.S.
639
TOFILO, P.P.
671
TOLLEFSON, J.J.
695
TORLONI, M.
702
TRABOULAY, E.A., JR.
666
TRABUCCHI, M.
679
TREDICI, T.J.
690
TSYBYSHEV, V.P.
686
ULYANOV, M.IU.
673
VALENTINO, A.R.
643
VANDERLINDEN, G.
701
VARMA, M.M.
666
VOIGT, H.
621
VORONKINA, M.I.
671
WAGNER, B.
665
WANG, C.
679
WANIBUCHI, Y.
707
WARD, T.R.
693
WARNKE, U.
676
WHETTON, C.P.
706
WILLIAMS, T.
651
WILSON, A.S.
636
YAMANE, A.
625
YASHINA, L.N.
674
YEVTUSHENKO, G.I.
674
YOSHIDA, S.
625
ZILBER, S.
652

GPO 911-462