project toward the development of a nonmetallic temperature probe that uses a small optical sensor positioned at the end of a fiberoptic bundle. Important biologic applications of such a nonperturbing temperature probe include the monitoring of microwave biohazards, microwave thawing of organs and blood, microwave-induced hyperthermia, and other applications where conventional metallic probes perturb the fields and cause temperature errors. Both the optical etalon type of sensor and a newly-developed semiconductor band edge sensor have proven capable of temperature measurements in the laboratory with the range and accuracy required for biologic studies. The semiconductor sensor is especially suited for small diameter (<0.25 mm) probes. Some additional effort is needed in integrating these probes into thermometry systems that are optically and electronically stable and have the convenience of direct readout in degrees Celsius. To improve stability, an optical reference channel will be added to the system to cancel optical source variations (the major cause of instability), either by separate photodetection or by optical beam chopping followed by ratioing. To obtain direct readout despite an inherently nonlinear calibration curve, a digital read-only memory programmed with the calibration curve will be used. These improvements, which will be field tested, are intended to make the nonperturbing thermometry system more attractive for wide-spread practical use. (4/78-3/79)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. General Medical Sciences

0368 STUDY OF THE EFFECTS OF MICROWAVE RADIATION ON THE CENTRAL NERVOUS SYSTEM. Albert, E. N. (George Washington Univ., Sch. Medicine & Health Sciences, Dept. of Anatomy, 2121 Eye St., N.W., Washington, DC 20006).

Microwave-induced changes in the cytoplasmic components of the neuron and some of their terminals are being explored, and the effects of microwaves on the blood-brain-barrier and neuronal interconnections are being studied. Two-mo-old Chinese hamsters, acclimatized for 10 days prior to exposure, are divided into three groups receiving 2,450, 1,700, or 3,000 MHz, respectively, continuous wave microwave radiation at power densities of 0, 10, or 25 mW/cm^2, resp., for 30 min, 1, 2, or 3 hr/day, resp. One group of animals in each category is sacrificed immediately after exposure, while another group is sacrificed 1 to 2 wk after exposures. Morphologic evaluations of the entire brain are performed. Emphasis is placed on scrutinizing the structural appearance of the neuron cell body, axonal and dendritic swelling, myelin degeneration, and synaptic endings. A recovery phenomenon is being sought. Acute irradiation of Chinese hamsters with 2,450 MHz microwaves at a power density of 10 mW/cm^2 caused alterations in the permeability of the blood-brain barrier to horseradish peroxidase (HRP) in some vessels. The altered permeability of the microvasculature was not confined to any particular region of the brain. This applied only to molecules of 40,000 molecular weight or less (HRP molecular weight=40,000). Larger molecules were not tested. Whether this pattern will persist for longer or chronic exposures and/or other frequencies cannot be predicted presently. These observations represent data obtained from animals showing a strong positive reaction. Blood vessels showing weak or pale reaction product were not evaluated. It was noted that some vessels from control and experimental animals showed a weak positive reaction that might have been caused by endogenous peroxidase or some other factor. (5/77-4/78)

Supporting Agency:HEW, PHS, FDA, BRH

0369 DETECTION, SURVIVAL AND CONTROL OF PLANT PATHOGENIC BACTERIA ON SEEDS AND PLANT PROPAGATIVE MATERIAL. Ries, S. M. (Univ. Illinois, Agricultural Experiment Station, Dept. Plant Pathology, Urbana IL 61801).

The effect of microwave irradiation on pathogen survival in infested seed and propagative plant parts will be investigated. Several phytobacterial diseases overseason in infected plant parts, frequently in seeds. Hot water dips, prolonged storage, or pesticide treatments of infected seeds have been moderately successful in reducing pathogen numbers in seed sources, but these methods are expensive, time consuming, and involve pesticide usage. The application of microwave heat, a physical treatment, would be extremely quick and very inexpensive. *Pseudomonas glycinea*, infested soybean seed, will be the model for these studies. *P. glycinea* is seed-borne in all soybean cultivars. Although probably present in a hypobiotic state, there may be a moisture differential between the moisture content of the seed and the bacterium. This moisture differential will be exploited by irradiating with microwaves. Selective death of the pathogen should occur before seed death, if the pathogen has a higher moisture content than the seed. Infected seed will be adjusted to a selected moisture content, irradiated for varying periods, and assayed for germinability and for *P. glycinea*. Preliminary evidence suggests that soybean seed at 6% moisture can be irradiated for 2 min with a complete destruction of *P. glycinea* and without reducing seed germinability. (10/77-9/78.

Supporting Agency:U.S. Dept. Agriculture, Cooperative State Res. Service, IL

0370 A NEW TECHNIQUE FOR ELIMINATION OF CELLS CAUSING DEATH IN BONE MARROW TRANSPLANT PATIENTS. Kessler, S.; Scher, I. (U.S. Navy, Immunopathology Div., Bethesda, MD 20014).

A technique for isolating large numbers of cells belonging to B- or T-lymphocyte subpopulations will be developed. Analysis of the functional and morphologic characteristics of such subpopulations has been hindered by the difficulty in their isolation. However, such analysis is critical to the understanding of the fundamental mechanisms underlying

the rejection of allogeneic transplanted tissues, which is the major obstacle to successful bone marrow transplantation in lethally-irradiated military personnel. The development of these isolation procedures will allow for the depletion of subpopulations of cells involved in graft rejection, without influencing other cellular populations necessary for successful engraftment. Uniform-sized latex (acrylic) microspheres containing colloidal iron will be synthesized. The chemical composition of these microspheres is such that they can be easily complexed with molecules such as specific immunoglobulins, and/or fluorescent dyes. Initial studies will be designed to test the overall feasibility of this approach by separation of B- from T-lymphocytes using anti-Ig as the functional probe of the microspheres. A powerful magnetic field will then be used to separate lymphocytes with microspheres attached (B-cells) from unassociated lymphocytes (T-cells). Later studies will utilize reagents prepared to isolate lymphocyte subpopulations known to influence graft rejection. (10/77-9/78)

Supporting Agency: U.S. Dept. Defense, Navy

0371 FREEZING AND ELECTROMAGNETIC THAWING OF PLATELETS. Popovic, V. P.; Schaffer, R. E.; Popovic, P.; Stein, S. F.; Cain, F. L. (Emory Univ., Sch. Medicine, Dept. Physiology, 1364 Clifton Rd. N.E., Atlanta, GA 30322).

The best method for cryopreservation of platelets is being sought. It is known that human platelets can be frozen and water-bath thawed with a recovery of one-half of cells. After freezing and thawing, the survival time of platelets is shorter than that of fresh cells. Using a rat model to assess recovery and survival of platelets, freezing rate and thawing rate of platelets is varied to determine the most effective technique for supercooling, freezing, storing, and thawing of platelets. The investigators are attempting to improve the quality of frozen platelets by using electromagnetic devices and much faster thawing rates than were previously possible. (4/78-3/79)

Supporting Agency:HEW, PHS, NIH, Natl. Heart Lung & Blood Inst.

0372 ELECTROMAGNETIC RADIATION AND BIOLOGICAL SYSTEMS. Adey, W. R.; Bawin, S. M.; Sheppard, A.; Sagan, P. M. (U.S. Veterans Admin. Hosp., 11201 Benton St., Loma Linda, CA 92357).

The interactions between weak ultra-high-frequency (450 MHz) electromagnetic fields and the central nervous system will be studied. The investigation will continue research that has disclosed power windows and modulation frequency windows for these interactions. Studies of interactions between weak electromagnetic fields and calcium ion binding in the central nervous system will be continued and will serve as reference for experiments involving amino acids and other putative neurotransmitters. Chick and cat cerebral tissues will be compared in their response to field stimulation. Performances of neonate chicks and ducklings exposed to 450 MHz fields will be compared in a series of behavioral measurements ranging from free behavior to sophisticated behavioral tasks, including variation of an interresponse time schedule. Schedule-controlled behavior in monkeys will be tested under similar field conditions. There will be continued collaboration with the Bureau of Radiological Health in measurements of field gradients in tissue as correlates of neurochemical responses. Recent developments in theoretic physics will be applied in modeling non-linear responses of the central nervous system to weak perturbations of the extracellular environment. (3/78-2/79)

Supporting Agency:HEW, PHS, FDA, BRH

0373 LOCALIZED RADIOFREQUENCY HYPERTHERMIA FOR TREATING LUNG CANCER. Wolf, G. L. (U.S. Veterans Admin. Hosp., 4101 Woolworth Ave., Omaha, NB 68105).

The use of local hyperthermia plus radiation, versus radiation alone, is being compared in the treatment of lung cancer. Qualifying patients are randomly assigned to one of the treatment groups. Localized hyperthermia is obtained with a radiofrequency device. Both subjective and objective responses to therapy are monitored throughout the study. (2/78-1/79)

Supporting Agency:U.S. Veterans Admin.

0374 A STUDY TO DETERMINE THE RF PARAMETERS THAT AFFECT THE BRAIN AND BEHAVIOR AT LOW POWER DENSITY. Frey, A. H. (Randomline, Inc., Huntingdon Valley, PA 19006).

The effects of exposure to electromagnetic energy on irritability, aggression, and motor coordination are being studied. In one experiment, irritability and aggression in male Sprague-Dawley rats as affected by electromagnetic energy (EM) exposure was investigated by placing animals in a pain-induced aggression situation by intermittent pinching of their tails. In a second experiment, the motor coordination or balances of male Sprague-Dawley rats as affected by EM exposure was investigated by measuring the ability of animals to stay on a rotating rod during rotation at various speeds and directions. Experiment I showed a clean cut "docility" effect of exposure to EM energy in rats undergoing the stress of pain-induced aggression

procedure. The exact nature of the effect and the appropriate label for the effect remain to be defined. The effect occurs at low power levels as defined in biologic investigations of EM energy effects. The power levels used, however, were above those generally found in the environment. The threshold for the EM energy parameters used was a peak power between 0.05 mW/cm^2 and 0.1 mW/cm^2. The measurements given, although exact, were considered to be correct within an order of magnitude because of the perturbing effect of the animal and any apparatus in the EM field. Experiment II showed that pulsed modulated EM energy had an adverse effect on motor coordination or balance as defined by use of the rotating rod test. The effect occurred at low power densities usually defined in biologic experiments. The threshold for the effect with the energy parameters used was a peak power between 0.4 mW/cm^2 and 2.8 mW/cm^2. The measurements given, although exact, were considered to be correct within an order of magnitude because of the perturbing effect of the animal and any apparatus in the EM field. (2/77-5/78)

Supporting Agency:HEW, PHS, FDA, BRH

0375 MAPPING OF MICROWAVE FIELDS SURROUNDING HUMAN SUBJECTS UNDER DIATHERMY TREATMENT. Lehmann, J. F. (Univ. Washington, Medical Rehabilitation & Training Center, 15th Ave. N.E., Seattle, WA 98105).

The contours of equal field intensity around human subjects will be measured and plotted while the subjects are irradiated with electromagnetic energy by microwave diathermy equipment operating at 915 and 2,450 MHz. All measurements will be performed in an anechoic chamber to allow precise field intensity levels around the subject. Human volunteers will be placed in the anechoic chamber in a position that is typical of diathermy treatments. The position of the subject will depend on the area to be treated. Selected areas of the body that are frequently treated with diathermy will be used—tight joints, anterior and posterior shoulder, contractor of the biceps, the lower back, and contractors of the thighs. The selected area will be treated with microwave applicator operating at 915 and 2,450 MHz. An X-Y-A coordinate tracking system with a National Bureau of Standards (NBS) energy density probe attached will be shielded and placed in the anechoic chamber. The device will be computer-controlled to follow isobars of power densities with limit switches to set the area that is to be scanned. The computer will position the probe and also plot the field intensity levels in relation to distance from the diathermy applicator. The facility will allow many short-period measurements, which will reduce the time of microwave exposure. Instrumentation will include a NBS power meter, which measures the power density in an electromagnetic field and a commercially available X-Y-Z tracking system. The power meter operates at a frequency of 10-3,000 MHz accurate to 1.0 dB. The NBS probe is attached to this system so that it can be moved in any of three coordinates. A zero point is set by the operator, and this is placed in the computer. A grid is then set up, and the computer directs the tracking system to move in the increments defined, 1 cm-2 cm, etc. The computer than moves the probe throughout this grid while recording the power density measurements at each point. Thermistor power meters will be used to monitor the incident and reflected power going to the applicator. (10/76-9/77)

Supporting Agency:HEW, Office Human Development Services, Rehabilitation Services Admin.

0376 MEASUREMENT OF MUSCULATURE BLOOD FLOW INDUCED BY MICROWAVE DIATHERMY. Lehmann, J. F. (Univ. Washington, Medical Rehabilitation Res. & Training Center, 15th Ave. N.E., Seattle, WA 98105).

The quantitative relationship between doses of microwave diathermy and deep musculature blood flow increase and rate change will be determined. The disappearance rate of ^{125}I injected into deep musculature will be monitored by a scintillation counter before and after heating by microwave radiation. By comparing resting levels of blood flow and the increase in blood caused by the microwave heating, the rate of change in blood flow due to the temperature increase will be calculated. The values will then be related to the amount of power required to cause the increase and also the rate at which this energy was delivered to the tissue. In a 20-min preliminary session the subject will be familiarized with the general procedures to be followed during the measurement session. One or two x-rays of the front part of the thigh will be taken to determine the position of certain structures (muscle-fat boundary, femur) that will underlie the diathermy applicator. Areas that are particularly sensitive to x-rays (gonads) will be protected by a lead apron. During the experimental session, 0.05 ml (one drop) of a radioisotopically labeled iodine-antipyrine compound will be injected into a forearm (or thigh muscle) through an extremely fine (1/100 inch thick, 27 gauge) needle. Since only one injection per individual will be allowed, this experiment will be divided into two parts. Some subjects will participate in Part I and some, Part II. In Part I, injection of isotope will be in a resting forearm or thigh. In Part II, injection of the isotope will be made into a forearm or thigh muscle over which is strapped a small, light weight isotope counting probe. (10/76-9/77)

Supporting Agency:HEW, Office Human Development Services, Rehabilitation Services Admin.

0377 CELLULAR INJURY AS INDICATED BY ULTRASTRUCTURAL ALTERATIONS (MICE). Stephens,

R. J. (Stanford Res. Inst. Internatl., 333 Ravenswood Ave., Menlo Park, CA 94025).

No descriptive information is available. (6/77-5/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. General Medical Sciences

5674 MICROWAVE MAGIC. *(Eng.)* Bateman, J. B. (Office Naval Res., Branch Office, London, England, FPO New York, NY 09510). 29 pp.; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A048060]. (13 refs)

A critical review of a symposium on the results of current French research on the biological effects of microwaves is presented. The symposium covered the following topics: microwave research in the United States and France; microwave dosimetry and physical measurement; the biological effects of a black box device, invented by A. Priore, that reportedly causes implanted animal tumors to regress and prevents the development of fatal disease in rodents infected with trypanosomes; biological research on the effects of microwaves relating to yeast growth, insect metamorphosis and morphogenesis, lipid metabolism, the reticuloendothelial system, and plasma coagulation; medical applications of microwaves relating to radiometry of tumors, selective tumor heating, the fixation of radiotherapeutic substances by tumors, and the thawing of blood pellets; and industrial applications involving food thawing and food sterilization. In general, French research was seen to be empiric with little regard for fundamental mechanisms. Little attention was given to the reporting of details about the physical equipment used and especially to dosimetry and thermometry.

5675 THE INFLUENCE OF ELECTROSTATIC AND MAGNETIC FIELDS ON MUTATION IN *DROSOPHILA MELANOGASTER* SPERMATOZOA. *(Eng.)* Diebolt, J. R. (Dept. Biology, Univ. North Carolina at Charlotte, Charlotte, NC 28223). *Mutat Res* 57(2): 169-174; 1978. (23 refs)

Wild-type *Drosophila melanogaster* males, 4-6 days of age, were exposed to a inhomogeneous (- or + polarity) electrostatic field (0.3 kV/cm) or to a homogeneous magnetic field (0.9266 tesla) for 24 hr to determine the effect of weak electrostatic and moderately strong magnetic fields on the production of sex-linked recessive lethal mutations in mature sperm. After treatment the males were left with females for 48 hr. Since a recently inseminated female is reluctant to mate a second time within a 24-hr interval, it is considered that the males mated with the females only two or possibly three times. Thus, it is considered that only mature sperm were sampled in the study. Neither the electrostatic nor the magnetic field significantly increased the sex-linked recessive lethal mutation frequency in mature sperm.

5676 REGENERATIVE REACTIONS OF RAT ORGANISM FOLLOWING MICROWAVE IRRADIATION (2,400 MHz). *(Rus.)* Tikhonchuk, V. S. (Inst. Biophysics, USSR Acad. Sciences, Moscow, USSR). *Biull Eksp Biol Med* 85(2): 170-171; 1978. (4 refs)

At intervals ranging from 2 to 30 min, 736 mongrel male rats were exposed to a microwave field (2,400 MHz, power density 100-800 mW/cm^2, 2x). At constant power density, the survival rate of the animals increased with the interval between the two irradiations; this relationship was described by a logistic curve. The survival rates were 2%, after exposure to 100 mW/cm^2 for 14.3 min; 2.5%, after 4.1-min exposure to 200 mW/cm^2; 2%, after 2.5-min exposure to 300 mW/cm^2; 5%, after 1.8-min exposure to 500 mW/cm^2; and 1%, after 1.2-min exposure to 800 mW/cm^2. The rate of the regenerative processes was found to be inversely proportional to the power density of the field. At constant regeneration level, the relationship between the power density and the interval between the irradiation was described by a linear function. The findings indicate the constant rate of the regenerative reactions at a given effect level.

5677 LOCAL HIGH-FREQUENCY HYPERTHERMIA OF THE BROWN-PIERCE CARCINOMA IN THE URINARY BLADDER OF RABBITS. *(Ger.)* Harzmann, R. (Lehrstuhl und Abteilung fur Urologie, Universitat Tubingen, Calwer Strasse 7, D-7400 Tubingen, W. Germany); Bichler, K. H.; Gericke, D.; Altenahr, E.; Dietzel, F.; Erdmann, D. *Urologe* [*A*] 17(2): 130-134; 1978. (19 refs)

The effect of local inductive high-frequency hyperthermia (500 kHz, wavelength 600 m, 30-300 W, temperature 43 C for 30 minutes) on Brown-Pierce carcinoma of the urinary bladder was studied in 47 rabbits. The hyperthermic treatment caused a temperature increase of 6.7 C in the center of the tumor compared with the lumen of the urinary bladder. The average survival time of the heat-treated animals was significantly longer than that of the untreated controls (28-38 days versus 82-120 days). After the transplantation, the take rate was 91-93.8% of untreated carcinomas but only 33.3% in the case of in vivo heat-treated tumors. The findings indicate the therapeutic effectiveness of inductive hyperthermia in the treatment of Brown-Pierce carcinoma.

5678 ELECTROMAGNETIC FIELDS AND VENTRICULAR-INHIBITED PACEMAKERS. *(Fre.)* Birmann, L. (Service de Medecine et de Cardiologie, Centre Medico-Chirurgical et Obstetrical, Strasbourg-Schiltigheim, France); Friedrici, R.; Sacrez, A. *Bull Soc Sci Med Grand Duche Luxemb* 114(1): 5-10; 1977.

Electrical and electromagnetic fields capable of interfering with the proper function of ventricular-inhibited pacemakers, which detect spontaneous depolarization complexes of the cardiac activity are reviewed. The filters with which such pacemakers are equipped offer relatively efficient protection against most electromagnetic fields. Parasitic signals, whose frequency is identical with or close to that of the QRS, may cause functional disturbances. Muscular potentials generated by the contraction of skeletal muscles near the pacemaker may also interfere with the proper function of the latter. Electromagnetic fields of high energy and

at frequencies over 100 MHz, such as, those generated by the ignition system of automobiles, may also cause interferences. Such high-frequency radiation is, however, effectively absorbed by the tissues, and the pacemaker is protected against them by its capsule.

5679 ELECTROMAGNETIC SYRINGE. *(Eng.)* Taylor, L. S. (Dept. Electrical Engineering, Univ. Maryland, College Park, MD 20742). *IEEE Trans Biomed Eng* 25(3): 303-304; 1978. (0 refs)

A hyperdermic syringe for directly injecting radio frequency and microwave fields into deep tissues in vivo is described. The syringe consists of a subminiature rigid coaxial waveguide, which connects to the generator at one end and terminates in a needle-like configuration that radiates the field at the other end. The radiator is obtained simply by open-ending the outer conductor and having the inner conductor extend out beyond for the proper length. A needle radiator was constructed that effected a voltage standing wave ratio of less than 1.1:1 at a frequency of 2,450 MHz when the radiator was embedded in a phantom material, which had the same dielectric permittivity and loss tangent as human muscle tissue. Thermographs of heating in phantom material injected with 25 W of microwave power for 30 sec using a syringe with an outside diameter of 0.76 mm demonstrated the feasibility of this type of device for a variety of applications and experimental uses. Waveguides of the type used here are commercially available with diameters down to 0.20 mm, presenting the possibility for microwave injection into very delicate tissues. The device has possible applications in diathermy and in experiments investigating the effect of electromagnetic fields on biologic systems.

5680 CARCINOGENIC PROPERTIES OF IONIZING AND NON-IONIZING RADIATION: VOLUME II -- MICROWAVE AND RADIOFREQUENCY RADIATION. *(Eng.)* Dwyer, M. J.; Leeper, D. B. (Biomedical Resources, The Franklin Inst. Res. Lab., Science Information Services, Philadelphia, Pa). NIOSH Contract No. 210-76-0145, 39 pp.; 1978. [available through the Superintendent of Documents, U.S. Government Printing Office, Washington, CD 20402, DHEW (NIOSH) Publication No. 78-134] (84 refs)

A review of the literature dealing with the carcinogenic properties of microwave (MW) and radio frequency (RF) radiation is presented. In general, there is little scientific or medical literature relating to actual or possible carcinogenic effects of RF or MW radiation. The strongest evidence comes from a recent WHO study, the North Karelian Project. The evidence is circumstantial, consisting of little more than a possible correlation between an RF/MW-induced increase in cardiovascular disease and a rise in the incidence of cancer. There have been unconfirmed and unscientifically reported allegations of RF/MW-induced cancer in one incident at Philco-Ford, at the United States Embassy in Moscow, and at the Boeing Corporation. An increased incidence of leucosis and leukemia in chronically irradiated Swiss albino mice has also been reported, but without follow-up. The biomedical literature, on the other hand, reports a variety of other problems including behavioral, neurologic, biochemical, hematologic, genetic, developmental, and degenerative disorders and cellular transformations. Although these latter effects do not directly relate to cancer, the possibility of carcinogenicity at very high cumulative doses and the possible enhancement of already carcinogenic or potentially carcinogenic situations by occupational exposure to RF/MW radiation should be closely examined.

5681 AN ABSOLUTE REACTION RATE MODEL FOR THE RESPONSE OF *B. SUBTILIS* TO MICROWAVE RADIATION. *(Eng.)* Wayland, J. R.; Brannen, J. P. (Sandia Lab., Albuquerque, NM 87115). 4 pp.; 1977. [available through U.S. Energy Research and Development Admin., Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830, Document No. SAND 76-9301C]. (8 refs)

A theoretic foundation for the study of biologic responses to electric and magnetic fields was developed. Absolute reaction rate theory is used to predict the response of spores of *Bacillus subtilis niger* in a microwave field. An arrhenius plot for the inactivation of the spores in a microwave electrical field reveals qualitative agreement between the theoretical predictions and experimental observations. The data suggest that temperature and electric effects are interdependent. This information is important in understanding the problems associated with the classification of biologic responses as thermal or nonthermal.

5682 USE OF LOCAL ELECTROMAGNETIC HYPERTHERMIA IN ONCOLOGY. *(Rus.)* Aleksandrov, N. N. (Scientific Res. Inst. Oncology Medical Radiology, Belorussian SSR Ministry of Public Health, USSR; Savchenko, N. E.; Fradkin, S. Z.; Zhavrid, E. A. *Vopr Onkol* 23(5): 3-13; 1977. (95 refs)

Studies on the possible uses and action mechanisms of local high-frequency electromagnetic hyperthermia in cancer therapy are reviewed. Electromagnetic local hyperthermia increases the blood flow, capillary pressure, the permeability of the cell membranes, and the intensity of metabolic processes. High frequency electromagnetic therapy is assumed to intensify the immune response of the body. The frequencies commonly used range from 915 to 2,450 MHz. It was reported that local hyperthermia (43-43.5 C for 45-60 min) caused complete disappearance of anaplastic breast carcinoma in 20-25% of the treated mice. Local electromagnetic hyperthermia (42.8 C for 60 min) was given to 17 patients with malignant tumors of the limbs in conjunction with normothermal or slightly hypothermal perfusion with reduced doses of chemotherapeutic drugs and thermosensitizing and acidifying agents. Complete disappearance of the tumor was seen in six patients after the treatment. In another report, considerable re-

duction of tumor size was achieved in most of the 70 patients with malignant tumors of the skin, soft tissues, and breast who underwent combination therapy with X-ray, telegammatherapy, and electromagnetic local hyperthermia. Destructive changes were seen also in radioresistant tumors.

5683 MAMMALIAN AUDITORY RESPONSES TO 3.0 GHZ MICROWAVE PULSES. *(Eng.)* Cain, C. A. (Dept. Electrical Engineering, Bioacoustics Res. Lab., Urbana, IL 61801); Rissmann, W. J. *IEEE Trans Biomed Eng* 25(3): 288-293; 1978. (16 refs)

Experiments involving the exposure of cats, dogs, chinchillas, and human subjects to short microwave pulses (less than 20 μsec) at a frequency of 3.0 GHz were performed to assess the effect of such exposure on auditory sensation. In agreement with results obtained at different microwave frequencies by other investigators, the threshold energy density per pulse for the small animals remained relatively constant as pulse width and peak power were varied. The energy density per pulse needed to evoke auditory responses in cats ranged from 8.7 $\mu J/cm^2$ to 14 $\mu J/cm^2$. Chinchilla thresholds were similar and ranged from a low of 7.5 $\mu J/cm^2$ to a high of 20 $\mu J/cm^2$. The average of the thresholds for beagle dogs was 5.0 $\mu J/cm^2$. The average threshold energy density of microwave pulses that could be heard by human subjects was 10.6 $\mu J/cm^2$. However, three out of eight subjects could not hear pulses below 20 μsec in width at maximum peak power settings. Inability to hear microwave pulses was correlated with hearing losses at frequencies beyond 8 kHz.

5684 ACTIVATION OF ENZYME PREPARATIONS IN SUPER-HIGH FREQUENCY ELECTROMAGNETIC FIELD. *(Rus.)* Popadich, I. A. (Dept. Analytical Chemistry, Moscow Inst. Food Industry, Moscow, USSR); Gubiev, Iu. K.; Kulikova, L. S. *Pishch Tekhnol* (2): 112-114; 1978. (2 refs)

The effect of high-frequency electromagnetic field (2,450 MHz, length of exposure 5-20 sec) on the amylolytic activity of a 0.01% aqueous solution of Amylosubtilin G10X was studied in the temperature range of 20-65 C. The treatment caused an average increase of 70% in the amylolytic activity of the preparation compared with that of the unexposed control and with the 20-25% increase caused by convective heat treatment. The increase was a function of the length of the treatment and of the applied high-frequency energy. Longer treatment with reduced high-frequency energy caused a slight reduction in the amylolytic activity compared with the control. Maximum effect was achieved when the rate of heat-up did not exceed 1.8-2 C/sec.

5685 EFFECT OF UHF FIELD ON IMMUNOGENESIS OF MICE WITH NORMAL REACTIVITY AND IMMUNOSUPPRESSION INDUCED BY RUBOMYCIN. *(Rus.)* Lopatin, V. F. (Scientific Res. Inst. Medical Radiology of USSR Acad. Medical Sciences, Obninsk, USSR); Vatin, A. E.; Dedenkov, A. N. *Antibiotiki* 23(4): 358-361; 1978. (12 refs)

The effect of whole-body irradiation with ultra-high-frequency radiowaves (15 W, 30 min) on the normal and rubomycin-depressed (10 mg/kg) immune response was studied in male CBA mice immunized with sheep erythrocytes. The animals were irradiated at different dates before or after immunization and after immunization and rubomycin treatment. The immunologic parameters studied were the weight of the thymus and spleen, the karyocyte count in the spleen, and the number of antibody-forming cells in the spleen per 10^6 karyocytes. Irradiation, applied 24 hr before, on the day of, or 48 or 72 hr after immunization as well as irradiation applied 48 hr after immunization and 24 hr after rubomycin treatment caused significant ($p<0.05$) increase in the number of antibody-producing cells. The increase in the antibody-producing cells in the spleen of the mice with normal immune response was at least 3-fold, and the exposure caused about 1.8-fold increase in the antibody-producing cell count in the spleen following immunosuppression with rubomycin. There were no significant changes in the other parameters.

5686 EFFECT OF ELECTROMAGNETIC FIELD ON THE GROWTH AND DEVELOPMENT OF PLANTS. *(Rus.)* Bel'skii, A. I. (Kostroma, USSR). *Elektron Obrab Mater* (6): 69-71; 1978. (5 refs)

The effect of electromagnetic field generated by high-voltage electric transmission lines on the growth, development, and crop yield of cherry trees, and tomato, pepper, and corn plants was studied in model experiments. The electromagnetic field (parameters and exposure time not given) caused about 1/3 reduction in the longitudinal growth of the plants compared with the untreated control, and the yearly growth of the exposed plants was also smaller than that of the controls. The cherry trees developed fruit 2-3 yr after planting, but the control trees required 4-5 yr. The crop yield of the exposed cherry trees was 15-20.7 kg versus 12-18 kg of the controls. The exposure also increased the crop yields of the tomato, pepper, and corn plants. The exposed plants were more resistant to fungi and insects than were the controls. Exposure to excessively intense electromagnetic field caused stunted and deformed growth of the plants.

5687 HIGH-FREQUENCY CURRENTS: INDICATIONS AND CONTRAINDICATIONS. *(Fre.)* Chantraine, A. (Division de Medecine Physique et de Reeducation, Hopital cantonal (Beau-Sejour), Universite de Geneve, Geneva, Switzerland). *Z Unfallmed Berufskr* 70(4): 202-208; 1977. (0 refs)

The indications and contraindications of short-wave electrotherapy are presented. Treatment with high-frequency electrical fields is indicated during the subacute stage of various inflammatory (post-traumatic, metabolic) reactions, in chronic inflam-

mation, gonarthrosis, sinusitis, and adnexitis. The treatment improves the supply of nutrients indispensable to tissue repair, facilitates the elimination of certain metabolites, and has sedative effect. The length of one session is usually 15-20 min but only 3-6 min in subacute sinusitis and adnexitis. The dose should be low initially (50 W) and increased to 150-200 W later. The treatment is contraindicated in sclerosis and other conditions accompanied by impaired heat dissipation, in pregnancy, and in patients with foreign bodies, especially metallic ones, in their bodies. The treatment of tumors may cause the spread of tumor cells.

5688 EFFECT OF SUPER-HIGH FREQUENCY ENERGY ON MATTER. *(Rus.)* Tereschenko, A. I. (No affiliation given). *Radiotekhnika* (1): 4-15; 1978. (27 refs)

Studies on the uses and effects of microwave energy on matter are reviewed. Microwave ovens are used increasingly for the preparation and and warm-up of meals; such treatment has no harmful effect on the meal, and it sometimes improves the nutrient value of the food. Microwave radiation is highly effective in the sterilization and pasteurization of foods, in disinfection, and in therapy. When used as therapy, microwave radiation increases the capillary pressure, the permeability of cell membranes, and intensifies metabolic processes in the irradiated tissues.

5689 HAZARD AT A DISTANCE: EFFECTS OF EXPOSURE TO THE ELECTRIC AND MAGNETIC FIELDS OF HIGH VOLTAGE TRANSMISSION LINES. *(Eng.)* Marino, A. A. (Veterans Admin. Hosp., Irving Ave. and Univ. Pl., Syracuse, NY 13210); Becker, R. O. *Med Res Eng* 12(5): 6-9; 1977. (31 refs)

Possible hazards associated with high voltage overhead electrical transmission lines are discussed. It is shown that for a proposed 765-kV transmission line, electric fields ranging from 48-90 V/cm are present within 100 feet from the center line. Individuals who live near high voltage transmission lines undergo chronic exposure to fields of comparable intensity to those which have been found to produce biologic effects in laboratory studies. In one study, rats developed bone tumors when exposed to electric fields of 70 V/cm, and in another study, electric fields of about 4 V/cm were found to interfere with the growth pattern of flatworms. Extremely low frequency fields of 35 V/cm have been found to depress the growth rate of chicks. An electric field of 6,000 V/cm has been reported to kill mammalian cells in cell culture. Electric fields of 0.04 V/cm have been shown to affect human reaction time performance. Based on these and other experiments, it is concluded that high voltage overhead electrical transmission lines probably cause biologic effects in individuals living near such lines. The EPA published a notice in the *Federal Register* in March of 1975 requesting data on the health hazards of high voltage transmission lines but has not yet begun to analyze the information submitted. In the Soviet Union, nationwide rules and regulations governing the nature and extent of permissible exposure to high voltage transmission lines were promulgated in 1970. According to these rules, working conditions are not limited or controlled where the electric field is less than or equal to 50 V/cm. If the electric field is greater than 250 V/cm, all workers must wear protective clothing or employ some protective device. For electric fields between the two values, the permissible duration of exposure without protective measures is limited.

5690 MICROWAVE APPLICATORS FOR LOCALIZED HYPERTHERMIA TREATMENT OF MALIGNANT TUMORS. *(Eng.)* Mendecki, J. (Montefiore Hosp. and Medical Center, Albert Einstein Coll. Medicine, Bronx, NY 10467); Friedenthal, E.; Botstein, C.; Sterzer, F.; Paglione, R.; Nowogrodzki, M.; Beck, E. *J Bioeng* 1(5/6): 511-518; 1977. (3 refs)

The design and performance of small microwave applicators used in conjunction with 915- and 2,450-MHz generators for inducing hyperthermia in malignant tumors are described. One particular applicator consists of a tapered waveguide loaded with a low-loss high-dielectric-constant ceramic. When such an applicator is in direct contact with tissue, the voltage standing wave ratio is typically less than 2.25:1 (more than 85% of the power fed into the applicator penetrates into the tissue). When this applicator was placed on the surface of a mouse mammary adenocarcinoma approximately 10 mm in diameter, the temperature in the center of the tumor was raised to about 43 C in 90 sec using 1.25 W of power at 2,450 MHz. This applicator has been successfully used in preliminary clinical studies of patients with basal cell carcinoma, skin metastases from breast cancer, and malignant melanoma. In a 66-yr-old female with basal cell carcinoma of the left posterior neck, one part of the lesion was exposed to hyperthermia (43 C, 45 min) using the applicator immediately followed by a radiotherapy dose of 300 rad, while another part of the lesion was treated with the same dose of radiotherapy alone. Both parts were treated three times weekly. Following six sessions (1,800 rad), the tumor part treated with combined therapy disappeared completely, while the rest of the tumor required a cumulative radiation dose of 6,000 rad to achieve total eradication. Another type of applicator described is a coaxial type that can be readily inserted into natural body cavities, suggesting possible use in the treatment of cancers of the rectum, colon, bladder, vagina, and esophagus. Another potential application of coaxial applicators is their use as interstitial implants into tumors. Of particular interest may be applicators having geometries that more closely conform to the shape of the areas to be treated and that have deliberate changes in the power distribution across the treatment area. Also of interest are coaxial units equipped with directive reflectors so that a particular area within a body cavity

can be raised to the treatment temperature with the other areas remaining cool. Preliminary in vivo measurements with an applicator of this type have recently been reported.

5691 TISSUE REACTIONS TO LONG-TERM ELECTRICAL STIMULATION OF THE CEREBELLUM IN MONKEYS. *(Eng.)* Brown, W. J. (Div. Neuropathology and Neurological Surgery and Brain Res. Inst., UCLA Center for the Health Sciences, Los Angeles, CA); Babb, T. L.; Soper, H. V.; Lieb, J. P.; Ottino, C. A.; Crandall, P. H. *J Neurosurg* 47: 366-379; 1977. (13 refs)

Light and electron microscopic observations of the cerebellar histopathology and neural damage found in rhesus monkey brains *(Macaca mulatta)* that had stimulated and unstimulated electrodes implanted on the cerebella for 2 mo are reported. Electrode pairs were placed bilaterally over the paravermal cortices in six monkeys. Charges of 0.5, 2.4, 4.8, 10, and 22 μcoulombs (C)/phase (ph) were delivered for 205 hr by a commercially available neurostimulator with stimulation parameters used in clinical trials (1-msec charge-balanced asymmetrically-biphasic pulses at 10 pulses/sec). In every monkey, the leptomeninges overlying the electrodes were thickened. The meningeal reaction, however, was usually markedly greater around stimulated electrodes than around the corresponding unstimulated electrode, and the intensity of the reaction was directly related to the charge delivered. The only charge that did not result in detectable ultrastructural changes was 0.5 μC/ph or approximately 7.35 $\mu C/cm^2$/ph. Since it has been shown that a charge as low as 0.1 μC/ph is sufficient to activate cerebellar efferent activity, the finding that a charge of 0.5 μC/ph does not injure the cerebellum indicates that it may be possible to use a physiologically effective stimulus to the cerebellum for long periods of time without producing cerebellar damage or raising the threshold for effective stimulation. In all of the above monkeys, injury such as severe molecular layer attenuation, Purkinje cell destruction, gliosis, myelinated axon degeneration, collagen intrusion, and increased local polysaccharide levels never was found more than 1-2 mm from the edges of the electrode arrays.

5692 POTENTIAL GENETIC RISKS FROM STATIONARY MAGNETIC FIELD. *(Eng.)* Roessner, P. (Inst. Hygiene and Epidemiology, 100 42 Prague 10, Srobarova 48, Czechoslovakia); Matejka, M. *J Hyg Epidemiol Microbiol Immunol* 21(4): 465-467; 1977. (6 refs)

The mutagenic effect of a stationary magnetic field (SMF) alone or in combination with the mutagen tris(1-aziridinyl)phosphine oxide (TEPA) on a pseudodiploid Dede line of Chinese hamster cells was studied. After formation of a continuous layer (48 hr of cultivation), the cells were exposed for 15 min to a 1,500-G SMF. In combination experiments, TEPA at a concentration of 10^{-6} molar was applied to the cell medium 24 hr before SMF exposure. When the cells were fixed 8 hr after exposure to SMF alone, the percentage of aberrant cells was 4.0% compared with a control value of 0.5%. Cells exposed to SMF and TEPA and fixed 8 hr later showed an aberration percentage of 13.5%, suggesting an additive effect produced by SMF and TEPA, since TEPA alone resulted in an 8.0% aberration frequency. Cells fixed 48 hr after exposure to SMF and TEPA also showed an additive effect (14.0% aberrant cells). These results support the hypothesis that exposure to SMF may induce aberrations in Dede cell lines, and it is suggested that SMF is one environmental factor that might contribute to the induction of genetic changes in mammals as well.

5693 HYPERTHERMIA AS AN ADJUNCT TO CANCER THERAPY. *(Eng.)* Robinson, J. E. (Univ. Maryland, Sch. Medicine, Baltimore, MD 21201). *J Bioeng* 1(5/6):467-469; 1977. (0 refs)

The role of hyperthermia in cancer therapy is discussed, and reference is made to the potential usefulness of microwave technology in such therapy. There is evidence that hyperthermia may increase the effectiveness of both radiation treatment and some chemotherapeutic drugs. Hyperthermia appears to offer a therapeutic advantage in cancer patients by increasing tumor damage while protecting critical normal tissues. This therapeutic advantage is supported by data which indicate the following: the thermal sensitivity of tumor cells is greater than that of normal cells; the hyperthermal radiosensitization of some tumors is greater than that of the normal tissues; in contrast to radiation sensitivity, the thermal sensitivities at normal temperatures of poorly oxygenated cells is as great or greater than that of well oxygenated cells; and the poor blood flow associated with many tumors may yield differential tumor heating. The role of microwave technology in such therapy is in producing and controlling the thermal fields necessary for the treatment. There is also a need for the development of noninvasive techniques for determining thermal patterns produced by microwave irradiation or other heating sources. Noninvasive temperature measurement by microwave thermography is in the beginning stage of development.

5694 MICROWAVE ENZYME INACTIVATION SYSTEM: ELECTRONIC CONTROL TO REDUCE DOSE VARIABILITY. *(Eng.)* Brown, P. V. (Dept. Microwave Res. and Medical Neurosciences, Div. Neuropsychiatry, Walter Reed Army Medical Center, Washington, DC 20012); Lenox, R. H.; Meyerhoff, J. L. *IEEE Trans Biomed Eng* 25(2): 205-208; 1978. (14 refs)

Electronic circuitry for reducing the dose variability of typical 2,450-MHz microwave enzyme inactivation systems is described. The length of microwave exposure is regulated by a timing circuit, which counts the number of energy pulses that the load receives. Output power is controlled by a leveler circuit, which uses a feedback loop that varies the magnet current of the tube to keep the delivered power at a fixed value. The control

electronics has the additional capacity to operate in an integrating mode. The circuit integrates the energy delivered; when the total energy delivered reaches a preset level, the triac drive and thus the magnetron is shut off. The circuits described are able to maintain output power within 2% of a set point and the exposure time to within 3 msec of the desired value. Without electronic control, the exposure time typically varies by 50 msec and the output power by 15%. The electronics are compatible with any 220 V single phase commercial microwave power source.

5695 INCREASE IN X-RAY SENSITIVITY OF CANCER AFTER EXPOSURE TO 434-MHZ ELECTROMAGNETIC RADIATION. *(Eng.)* Holt, J. A. G. (Inst. Radiotherapy and Oncology, Western Australia, 21 McCourt St., Leederville, W. A. 6007). *J Bioeng* 1(5/6): 479-485; 1977. (7 refs)

The use of 434-MHz electromagnetic radiation to increase the X-ray sensitivity of tumors is reported. The study involved three groups of 52 patients suffering from ear, nose, or throat cancer. One group received X-ray treatment alone at a total dose of 6,000 rad. A second group received X-irradiation (total of 3,500-3,600 rad) under 3 atmospheres of hyperbaric oxygen at 37 C. The third group of patients received 20 min of 434-MHz radiation followed by a 15-min waiting period prior to X-irradiation (total dose of 5,400 rad). The calculated dose required to reduce tumor cell survival by 63% on the exponential part of the survival curve (D_o) was 140 rad for patients treated with X-rays only, 51 rad for the hyperbaric group, and only 8 rad for patients receiving 434-MHz radiation in addition to X-rays. The rate of clinical clearance of the primary tumor and lymph nodes was 81% for patients receiving 434-MHz radiation in combination with X-rays compared with only 32% for patients receiving X-radiation only and 61% for patients X-irradiated under hyperbaric conditions. In additional experiments, 13 patients received whole-body hyperthermia by a hot wax bath method at 41.8 C, and the calculated D_o value for these patients was 50-60 rad. Four patients treated with 7-MHz radiation had D_o values greater than 60 rad. The increased radiation sensitivity induced by 434-MHz radiation appeared to be partly thermal and partly nonthermal in origin. The nonthermal origin is evidenced by the fact that the induced sensitivity of the tumor to X-rays persisted for up to 30 min after 434-MHz irradiation, even when the cancer was at normal temperature.

5696 MODELS OF MEMBRANES OF CEREBRAL CELLS AS SUBSTRATES FOR INFORMATION STORAGE. *(Eng.)* Adey, W. R. (Dept. Anatomy and Physiology, Brain Res. Inst., Univ. California, Los Angeles, CA 90024). *BioSystems* 8: 163-178; 1977. (52 refs)

The interaction of extremely low frequency and very-high-frequency electric fields with brain tissue is discussed with particular emphasis on the effects of such fields on calcium efflux and the process of recall. The exposure of freshly isolated chicken cerebral hemispheres to a 147-MHz field at 0.8 mW/cm^2 has been shown to result in an increased calcium efflux of more than 15% at amplitude modulation frequencies between 9 and 20 Hz. In contrast, the exposure of chicken and cat cerebral hemispheres to frequencies below 30 Hz has been shown to result in decreased calcium efflux. Studies of electroencephalogram (EEG) interactions in cats exposed to low level 147-MHz radio fields amplitude modulated at biologic frequencies between 0.5 and 30 Hz were conducted in which spontaneously occurring brief trains of EEG waves were first identified in cortical and subcortical structures. Each train had a characteristic frequency or signature which the cats were trained to produce in response to a light flash. Failure to produce the EEG rhythm pattern was punished by stimulation of the cortical frontal eye field. The effects of the modulated radio field were then tested during both training and extinction of the response. The radio field was modulated at the same frequency as the EEG rhythm signature in a specific brain structure. In the training tests, when the modulated radio field was present, the level of correct performances was higher than in the absence of fields. In extinction trials, the correct response declined slowly over 45-60 days, even though there was no punishment for failure to respond. In the absence of the fields, extinction of the learned response occurred within 1 or 2 days. The EEG changes were anatomically localized, highly specific in frequency, and occurred as transient patterns. It is suggested that the components of such electric fields running through the extracellular spaces and at cell surfaces in cerebral tissue can exercise a relatively specific influence on the process of recall, despite their miniscule amplitudes in comparison with transmembrane electric gradients.

5697 NONINTRUSIVE ACOUSTIC TEMPERATURE TOMOGRAPHY FOR MEASUREMENT OF MICROWAVE AND ULTRASOUND-INDUCED HYPERTHERMIA. *(Eng.)* Johnson, S. A. (Mayo Clinic, Rochester, MN 55901; Christensen, D. A.; Baxter, B.; Greenleaf, J. F.; Rajagopalan, B. *J Bioeng* 1(5/6): 555-570; 1977. (20 refs)

The measurement of microwave- and ultrasound-induced hyperthermia by nonintrusive ultrasound temperature tomography is discussed in terms of theory and experimental evidence to support the theory. Microwave heating and ultrasound heating are the candidates of choice for the application of hyperthermia in such areas as cancer therapy because of the short response time of milliseconds or less, localization of heating effects (microwaves can be applied to areas of several square centimeters or larger with controlled depth of penetration), and ease of regulation by an electronic control system using ultrasound and point probe thermometry. The theory and experimental evidence on ultrasound reconstruction methods for determining temperature indicate that the temperature of homogeneous materials of known composition

(with temperature coefficients similar to water) may be measured to an accuracy of less than 0.5 C in a 1 cm^3 volume when a time resolution of 1 nsec is used in measuring the ultrasound propogation time through the material. Proportionally smaller temperature changes may be measured by increasing the linear dimensions of the measurement region, by increasing the resolution of propagation time measurements, or by imaging materials of larger temperature coefficient. At present, ultrasound reconstruction methods for determining temperature depend on theories developed for analysis of transmission data, and these theories limit the use of temperature reconstruction to those areas of the body, such as the breast, where reflection and absorption effects are minimal. The development of ultrasound reflection thermometry techniques would enable more accurate control of hyperthermia therapy in other areas of the body where bone or air are present.

5698 APPLICATIONS OF THE ABSOLUTE REACTION RATE THEORY TO BIOLOGICAL RESPONSES IN ELECTRIC AND MAGNETIC FIELDS. *(Eng.)* Brannen, J. P.; Wayland, J. R. (Sandia Lab., Albuquerque, NM 87115). 29 pp; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. SAND76-0057]. (41 refs)

A theoretic foundation for the study of biologic responses to electric and/or magnetic fields is presented. The formulation is based on absolute reaction rate theory and the effects of fields on reaction rates. Derivations that expand the theory to include field-effect are given, and the theory is applied to observations of the spores of *Bacillus subtilis niger* in a microwave field. The theoretic results are in qualitative agreement with experimental observations, and a preliminary analysis of the microwave data suggests that absolute reaction rate theory is applicable to electric field effects. It is suggested that there is no reason to suspect that magnetic fields will be an exception.

5699 IN VIVO BIOELECTROCHEMICAL CHANGES ASSOCIATED WITH EXPOSURE TO EXTREMELY LOW FREQUENCY ELECTRIC FIELDS. *(Eng.)* Marino, A. A. (Veterans Admin. Hosp., Syracuse, NY 13210); Berger, T. J.; Austin, B. P.; Becker, R. O.; Hart, F. X. *Physiol Chem Phys* 9(4/5): 433-441; 1977. (16 refs)

Male Sprague-Dawley rats, 21-24-days old, were continuously exposed to a 60-Hz electric field of 150 V/cm intensity for 1 mo to determine the generalized effect of such exposures. Data from 10 separate experiments indicated that the following changes were produced in at least some of the experiments: depressed water consumption, depressed body weight, increased adrenal and pituitary weights, and altered serum concentrations of albumin, hydroxycorticosterone, and glutamic oxaloacetic transaminase. The observed changes are consistent with, but do not categorically establish, the hypothesis that a power frequency electric field is a biologic stressor. To establish the nonthermal nature of the above effects, the induced current in the rats was measured; it was found that 0.68 μA was induced at 150 V/cm with a corresponding current density of about 11.1 mμA/cm^2. Assuming the rat to be a uniform mass with a resistivity of 100 ohm/cm, then the total power dissipated is about 2.3×10^{-12} W, which is too low to produce heating.

5700 A NEW NON-PERTURBING TEMPERATURE PROBE USING SEMICONDUCTOR BAND EDGE SHIFT. *(Eng.)* Christensen, D. A. (Dept. Bioengineering and Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112). *J Bioeng* 1(5/6): 541-545; 1977. (9 refs)

A nonperturbing temperature probe that can be used in applications involving microwave-induced hyperthermia is described. The temperature probe uses a small 0.250 mm gallium-arsenic semiconductor sensor affixed to the distal end of a fiber bundle and relies on the wavelength-dependent absorption of light whose wavelength matches the band gap energy of the semiconductor. One or two fibers of the bundle transmit .905-micron light from a pulsed light-emitting diode and narrowband filter combination to the sensor where it is transmitted through the gallium-arsenic and reflected back into one or two receiving fibers for detection by a silicon photodiode and digital display. Changes in the sensor temperature are observed as changes in received light intensity, which may be related to temperature by a calibration curve. A temperature test of a prototype probe was performed with a calibrated water bath and thermocouple monitor, and it was determined that the probe had a range of at least 33-47 C (limited by the testing apparatus) with several more degrees of range expected with improved testing conditions. Instabilities and scatter in the displayed intensity corresponded to about ± 0.1 C and appeared to be due primarily to short-term variations in the source intensity. A technique for cancelling source fluctuations, which involves a reference channel and electronic ratioing before the display, is being developed to improve the accuracy of the probe to better than 0.1 C. The small tip size of the probe and its inherent sensor stability make the probe useful for temperature monitoring in biologic experiments.

5701 RF DIELECTRIC PROPERTIES MEASUREMENT SYSTEM: HUMAN AND ANIMAL DATA. *(Eng.)* Toler, J.; Seals, J. (Biomedical Res. Group, Electromagnetic Effectiveness Div., Systems and Techniques Lab., Engineering Experiment Station, Georgia Inst. Technology, Atlanta, GA 30332). 87 pp.; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. PB-274 776]. (21 refs)

An in vivo probe measurement system for accurately measuring the electrical properties (relative dielectric constant and conductivity) of a wide variety of sample materials, such as standard liq-

uids, phantom modeling materials, and in vivo tissue is described. The system is based on relating the impedance of a short monopole antenna in air to its impedance in dielectric media. The applicable frequency range of the system is 10-100 MHz, which can be scanned on either a discrete or swept frequency basis. The in vivo probe-network analyzer system provides relative dielectric constant and conductivity data that compare within ± 5% of available reference data. With the aid of the above system, phantom modeling materials can be mixed such that the electrical characteristics of living biologic systems will be duplicated, making these materials useful for studies examining the effects of absorbed radiation on biologic systems.

5702 THE VISCOMETRIC THERMOMETER: A NON-PERTURBING INSTRUMENT FOR MEASURING TEMPERATURE IN TISSUES UNDER ELECTROMAGNETIC RADIATION. *(Eng.)* Chen, M. M. (Univ. Illinois at Urbana-Champaign, Urbana, IL 61801; Cain, C. A.; Lam, K. L.; Mullin, J. *J Bioeng* 1(5/6): 547-554; 1977. (14 refs)

A non-perturbing viscometric thermometer probe for measuring temperature in biologic tissues exposed to electromagnetic radiation is described. The viscometric thermometer is based on the measurement of temperature-dependent viscosity of a fluid flowing slowly through a small capillary at the tip of the thermometer probe. For sufficiently low velocities, the flow resistance is directly proportional to the viscosity. Several prototypes of the viscometric thermometer probe were constructed and tested to verify the practicality of the concept. The finished probes had outer diameters of 1.2-2.0 mm and lengths of about 50 mm. A number of fluids, including distilled water, castor oil, mineral oil, and ethylene glycol, were used as the sensing media; flow rates varied from 3×10^{-4} to 2×10^{-3} ml/sec. Relative to water, mineral oil did not absorb microwave energy; whereas, ethylene glycol was highly absorbing. A mixture of two or three fluids could be used to obtain any desired loss characteristics. The sensitivity of the probe could be varied over very wide ranges depending on the capillary diameter, the working fluid, and the flow rate. Advantages of the probe include its simplicity and thermal and mechanical ruggedness. Frequent recalibration is not necessary, and the probe should be autoclavable. Another advantage of the probe is that the probe body material and sensing fluid can be chosen so that their electrical and thermal properties match closely those of the tissue, thus minimizing any electrical and thermal perturbations.

5703 EXTREMELY LOW FREQUENCY VERTICAL, 45-HZ ELECTRIC FIELD EXPOSURE OF RATS: A SEARCH FOR GROWTH, FOOD, AND WATER CONSUMPTION, BLOOD METABOLITE, HEMATOLOGICAL, AND PATHOLOGICAL CHANGES. *(Eng.)* Mathewson, N. S.; Oosta, G. M.; Levin, S. G.; Diamond, S. S.; Ekstrom, M. E. (Armed Forces Radiobiology Res. Inst., Defense Nuclear Agency, Bethesda, MD 20014). 59 pp; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A045417]. (21 refs)

Several experiments were performed in which young male Sprague-Dawley rats were exposed for 28 days to sinusoidal 45-Hz vertical electric fields in nonmetallic cages at field strengths of 0, 2, 10, 20, 50, and 100 V/m (root mean square) to verify the existence of lowered growth rates for rats exposed to such fields and to determine if food and water consumption, serum metabolite concentrations, or parameters of a complete blood count were perturbed. No biologically important differences were found for any of the variables studied. No statistically significant differences were observed in any experiment where six groups of 16 animals were exposed to the above field strengths for the following variables: water consumption, serum or plasma cholesterol, serum or plasma triglycerides, white blood bount, segmented neutrophils, lymphocytes, adrenal weights, and spleen weights. Histopathological analyses also failed to reveal any significant differences between rats exposed to the above field strengths. The most unequivocal results were obtained from an experiment in which 48 animals were used in both control and 20 V/m-exposed groups. No significant differences were observed for any of the variables and no dose relationships were found for any of the above variables.

5704 HYPERTHERMIA IN ANIMAL AND HUMAN BODIES INDUCED BY ELECTROMAGNETIC FIELDS. *(Eng.)* Chen, K. M. (Dept. Electrical Engineering and Systems Science, Michigan State Univ., E. Lansing, MI 48824); Rukspollmaung, S. *J Bioeng* 1(5/6): 531-539; 1977. (6 refs)

Methods of inducing hyperthermia in tumors embedded in simulated animal and human bodies using electromagnetic fields were investigated. The body was considered to be homogeneous with certain electrical properties, and the tumor was assumed to be a local region with a conductivity that differs from that of the surrounding tissue. Electric fields of 1 V/m at various frequencies were used to produce hyperthermia. It was shown that part-body irradiation with high-frequency 15-MHz electric fields was effective for internal tumors, especially those with lower conductivities; however, this scheme of irradiation was not capable of heating surface tumors selectively. Whole-body irradiation with the same high-frequency field did not produce a local heating effect at the tumor. At the microwave (2,450 MHz) and ultra-high-frequency (600 MHz) frequency ranges, it was found that the application of a focalized electromagnetic radiation at the tumor may create hot spots at various locations away from the tumor instead of heating the tumor. A scheme for locally heating a surface tumor with a nonuniform electromagnetic wave of 500 MHz is proposed in which the incident electric field in the cells directly above and under the tumor is directed in the opposite direction of the incident

electric field at the tumor in order to create a concentrated induced field in the tumor. This type of nonuniform electromagnetic field can be synthesized by an array of aperture radiators.

5705 THERMAL RESPONSE IN *MACACA MULATTA* EXPOSED TO 15- AND 20-MHZ RADIOFREQUENCY RADIATION. *(Eng.)* Krupp, J. H. (Radiation Physics Branch, Radiation Sciences Div., USAF Sch. Aerospace Medicine, Aerospace Medical Div., Brooks Air Force Base, TX 78235). 13 pp; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A045508]. (5 refs)

Rhesus monkeys *(Macaca mulatta)* were exposed to 15- and 20-MHz radio frequency radiation for 3 hr at power levels approximating 15-25 times the maximum permissible exposure limits for man to evaluate the effect of such exposures on body core temperature. The 20-MHz exposures were performed at incident power densities of 1,270 and 760 mW/cm^2, and the 15-MHz exposures were done at 1,025 and 775 mW/cm^2. At all four irradiation conditions, mean rectal temperatures rose quickly during the first 30 min of exposure, then leveled off, and then fluctuated slightly or continued a slow rise for a time as thermoregulatory mechanisms were brought into play. A comparison of all four irradiation conditions with respect to temperature rise indicated some frequency times time interaction. There was a suggestion that the higher frequency increased the body temperature more during the first hour and then maintained the higher level throughout the 3-hr exposure period. For example, monkeys exposed to 20-MHz fields at a power density of 760 mW/cm^2 showed a mean rectal temperature rise of from 38.46 to 39.28 C during the first 60 min of exposure, and their mean rectal temperature at the end of the 180-min exposure period was 39.46 C. Monkeys exposed to 15-MHz fields at a power density of 775 mW/cm^2 showed a mean rectal rise of from 38.56 to 39.01 C during the first 60 min of exposure, and their mean rectal temperature at the end of the 180-min exposure was 39.06 C. These observations conform to the concept of a thermal burden based on absorbed power, which has been shown to be frequency dependent.

5706 COMPARISON OF THE HEATING PATTERNS OF SMALL MICROWAVE (2450 MHZ) APPLICATORS. *(Eng.)* Magin, R. L. (Lab. Chemical Pharmacology, DTP, DCT, Natl. Cancer Inst., Natl. Inst. Health, Bethesda, MD 20014); Kantor, G. *J Bioeng* 1(5/6): 493-509; 1977. (15 refs)

Heating patterns of typical circular, rectangular, and slab-loaded 2,450-MHz microwave applicators were studied in planar dielectric phantoms, tumor models, and actual mouse tumors to determine the effective volume heated by such applicators. It is concluded that a simple consideration of applicator size and tissue penetration depth is not sufficient to predict the temperature distributions within small animal tumors. The half-power widths and depths of heating give a better estimate of the effective heating volume, but factors such as tumor size, shape, and blood flow greatly influence the steady state temperature distribution. Small microwave applicators concentrate their heating within the tumor, but the deposition of energy is not uniform as seen by uneven steady state temperature distributions within live tumors. The nonuniform deposition of microwave energy and the large tumor-to-ambient air temperature gradient are suspected reasons for the relatively poor intratumor temperature uniformity. Careful consideration of the characteristics of the applicator, tumor, and temperature-sensing methods is necessary to generate temperatures within small animal tumors, which are uniform enough for meaningful biologic results to be obtained.

5707 KIDNEY MODEL FOR STUDY OF ELECTROMAGNETIC THAWING. *(Eng.)* Burdette, E. C. (Electromagnetic Effectiveness Div., Engineering Experiment Station, Georgia Inst. Technology, Atlanta, GA 30332); Karow, A. M. *Cryobiology* 15(2): 142-151; 1978. (36 refs)

The use of electromagnetic heating, such as 2,450-MHz microwaves, for thawing large organs after cryopreservation is discussed. In contrast to other techniques of thawing, this technique has been shown to yield functioning dog kidneys that had been frozen at temperatures of -20 C to -80 C. In one particular experiment, 9 of 17 dogs survived from 2-14 mo on a single kidney that had been treated with 1.4 molar dimethylsulfoxide, held at -80 C for 15 min, and thawed in a microwave oven. From a theoretic standpoint, the Method of Moments has been applied to determine the electromagnetic field distribution within whole organs; this method is capable of predicting the locations of any potential regions of nonuniform heating in the material for realistic geometric models with varied and arbitrary contours. At the present time a computer program based on the Method of Moments is being used to predict the field intensity within sample models represented by circular and elliptical cylinders with a plane electromagnetic wave incident on the sample.

5708 EFFECTS OF ELECTROMAGNETIC FIELDS ON ISOLATED NERVE AND MUSCLE PREPARATIONS. *(Eng.)* Chou, C. K. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine RJ-30, Univ. Washington Sch. Medicine, Seattle, WA 98195); Guy, A. W. *IEEE Trans Microwave Theory Tech* 26(3): 141-147; 1978. (25 refs)

Isolated frog sciatic nerves, cat saphenous nerves, rabbit vagus nerves, superior cervical ganglia, and rat diaphragm muscles (maintained at a constant temperature by Ringer's solution) were exposed in an S-band waveguide either parallel or perpendicular to a 2,450-MHz microwave field to investigate the effect of the field on nerve action potential and muscle contractile tension. As long as the temperature of the nerves or muscles was kept constant, no changes in amplitude or conduction characteristics

or in contraction were observed over continuous wave specific absorption rates (SAR) of 0.3-1,500 W/kg and pulsed peak SAR of 0.3-220 kW/kg. Changes observed at the highest power levels were due to associated increases in temperature and were duplicated by increasing the solution temperature. No direct electric field stimulation of nerve axons, ganglia, or muscles was observed during microwave irradiation.

5709 EXPERIMENTS WITH A 915 MHZ HYPERTHERMIA SYSTEM FOR CANCER TREATMENT. *(Eng.)* Johnson, C. C. (Dept. Bioengineering, Univ. Utah, Salt Lake City, UT 84112); Durney, C. H.; Plenk, H. P. *J Bioeng* 1(5/6): 519-529; 1977. (24 refs)

Experiments involving the use of 915-MHz radiation for the induction of hyperthermia in animal and human tumors are reported. Preliminary experiments with a dog showed the necessity of providing surface cooling to avoid unacceptably high skin temperatures. Using a system with surface temperature control, a cat with a salivary gland tumor was given six treatments. The 8 cm by 4 cm tumor was treated with the surface temperature not exceeding 43 C. Midtumor temperature rose as high as 46 C, and the back surface of the tumor was typically raised to 39-41 C. After the sixth treatment, the tumor was almost completely necrosed, but there was also considerable skin necrosis. When the same system was applied to a Saint Bernard dog with a 10-cm diameter tumor in the left front wrist, the surface temperature was again controlled to about 43 C; however, the back surface of the tumor could not be raised higher than about 39 C. Considerable tumor necrosis was observed, followed by apparent healing. However, the tumor later regrew. A series of five treatments were administered to a human subject who had several subsurface tumors resulting from bladder tumor metastasis. The treatments consisted of raising the surface temperature to about 43 C for 45 min. One tumor that was treated by 915-MHz microwave hyperthermia plus X-ray irradiation regressed completely; whereas, another tumor, treated with X-ray alone, regressed substantially but not completely.

5710 CYTOLOGICAL EFFECTS OF 2450 MHZ CW MICROWAVE RADIATION. *(Eng.)* Lin, J. C. (Dept. Electrical Engineering and Physical Medicine and Rehabilitation, Wayne State Univ., Detroit, MI 48202); Peterson, W. D. *J Bioeng* 1(5/6): 471-478; 1977. (26 refs)

Cultured human skin fibroblasts and lymphoblasts were exposed to 2,450-MHz continuous wave microwave radiation in a constant temperature waveguide exposure chamber to investigate the effect of irradiation on the growth and viability of these cells in the absence of a measurable temperature rise. At incident power densities ranging from 10-500 mW/cm^2, which corresponded to energy absorption rates of 235-1,200 mW/g, a 15-min exposure of the cells to radiation did not alter either growth or viability in comparison with unirradiated controls. These results suggest that previously reported observations to the contrary may have been due to selective heating of a fraction of the cells in flasks and vials used as sample holders during the irradiation process.

5711 HYPERTHERMIA DOSE DEFINITION. *(Eng.)* Atkinson, E. R. (Natl. Cancer Inst., Div. Cancer Treatment, Bethesda, MD 20014). *J Bioeng* 1(5/6): 487-492; 1977. (17 refs)

Fractional unit of cell kill (F), calculated from time, temperature, and somewhat arbitrary assumptions regarding cytotoxicity and chemical reaction kinetics is proposed as a unit of hyperthermia dosage. This hyperthermia dose unit definition incorporates a nonlinear weighting factor in the procedure that is already in use for computing hyperthermia exposure in degree-hours above an arbitrary temperature. It may loosely be interpreted as the percentage of cells killed by such a treatment applied to in vitro tissue culture. Without the nonlinear temperature-dependent weighting factor, the degree-hour figure is simply proportional to the total energy transferred or confined to the patient during treatment.. The absence of a nonlinear weighting factor makes long exposure to low temperatures entirely equivalent to brief exposures to high temperatures in direct contradiction to experience. It must be recognized that the dose defined by F will not generally be linearly cumulative over times comparable to cell cycle duration and will be strictly interpretable as a surviving fraction only for the cell subpopulation and under the growth conditions for which the numeric values of cytotoxicity are determined. Although the simple assumptions of chemical reaction kinetics used in arriving at the expression for F ignore more sophisticated considerations of cell kinetics, it is felt that in a typical clinical situation insufficient data will be available to incorporate these refinements, while the functional form of F will remain unchanged over sufficiently narrow ranges of applicability. If more refined data are available, the proposed model may be easily modified accordingly.

5712 ELECTRICAL STIMULATION OF SOFT TISSUE GROWTH (LETTER TO EDITOR). *(Eng.)* Howes, R. M. (The Johns Hopkins Hosp., Dept. Surgery, Baltimore, MD 21205); Lipson, S. D.; Hoopes, J. E. *South Med J* 71(4): 484; 1978. (5 refs)

Electrical stimulation of soft tissue growth in a 73-yr-old woman treated for postherpetic neuralgia involving the right hemithorax is reported. Treatment was begun with fluphenazine hydrochloride and amitriptyline as well as with transcutaneous electrical stimulation (parameters not specified). Relief of symptoms was dramatic; however, 4 mo after the initiation of therapy, the patient became aware of an increase in the size of her right breast and pain associated with the use of the stimulator. Physical examination at 7 mo revealed a right breast slightly larger than the left (20.3

cm from the suprasternal notch to the nipple on the right compared with 19.7 cm on the left). Excisional biopsy of a 2 by 1 cm soft, not freely movable mass just above the right areola revealed ductal ectasia. This case raises the question as to the feasibility of electrical stimulation of soft tissue growth. Although the growth of tissue in this case could perhaps be partially explained on an iatrogenic basis, it seems more reasonable that the unilateral breast enlargement, which occurred at the stimulation electrode site, was secondary to the externally applied electrical current. More importantly, this case provides interesting speculations concerning the effects of bioelectric fields on human growth processes.

5713 MICROWAVE IRRADIATION FIXATION FOR STUDIES OF POLYPHOSPHOINOSITIDE METABOLISM IN BRAIN. (Eng.) Soukup, J. F. (Dept. Physiology and Pharmacology, Duke Univ. Medical Center, Durham, NC 27710); Friedel, R. O.; Shanberg, S. M. *J Neurochem* 30(3): 635-637; 1978. (32 refs)

The efficacy of microwave irradiation fixation for analyzing polyphosphoinositide (PPI) metabolism in rat brain was investigated by comparing recoveries of PPI and PPI incorporated ^{32}P-orthophosphate from unfixed brains, frozen brains, and microwave-irradiated brains of male Sprague-Dawley rats. Microwave fixation was achieved by irradiation of the whole animal in a microwave oven delivering 1,300 W at a frequency of 2,450 MHz for 30-45 sec. Recovery of triphosphoinositide (TPI: 441 ± 16 to 550 ± 10 nmoles/g) and TPI-incorporated ^{32}P (53 ± 5 to 84 ± 4 ncuries/g) from irradiated brains was equal to or greater than recoveries from frozen brains, and both of these fixation techniques produced greater recoveries than that obtained from unfixed brains. The recovery of diphosphoinositide from irradiated brains was comparable to that from frozen brains. In irradiated brains, TPI losses never exceeded 10% from any region at any age; DPI losses were greater from the brainstem than cerebellum or cerebral cortex and generally were greater than TPI losses (20-25%). There were no significant differences in the percentage of PPI loss and the percentage of PPI-incorporated ^{32}P-orthophosphate loss. These results indicate that microwave irradiation fixation is more effective in preventing postmortem degradation of PPI than fixation by freezing. Also, using the microwave fixation technique, it was demonstrated that activation of brain neurotransmitter receptors results in an increased turnover of PPI polar group moieties; these effects were not demonstrated in similar studies using freeze fixation techniques.

5714 THE EFFECT OF ELECTRIC FIELDS ON OSTEOPOROSIS OF DISUSE. *(Eng.)* Martin, R. B. (West Virginia Univ. Medical Center, Morgantown, WV 26506); Gutman, W. *Calcif Tissue Res* 25(1): 23-27; 1978. (18 refs)

The effect of electrical stimulation on osteoporosis of disuse was studied in male Sprague-Dawley rats. The right thigh and leg of 35 evaluable rats were placed in a plaster cast to achieve disuse of the limb. Electrical stimulation of the immobilized limb was performed in 16 of these 35 rats and was achieved by applying a 200-V peak-to-peak 30-Hz signal to the limb via insulated electrodes. One group of nine electrically-stimulated rats received the treatment for 1 hr in the morning and 1 hr in the afternoon; the stimulation was reduced to 1 hr/day on weekends. Another group of seven electrically stimulated rats was treated for 8 hr/weekday and 1 hr/weekend day. In control rats, immobilization produced significant atrophy of bone mass. However, osteoporosis did not occur in the immobilized limbs of electrically stimulated rats. Also, femoral shafts electrically stimulated for 8 hr/day for an average of 23 days were larger and heavier than those treated for 2 hr/day for an average of 33 days. No tumors or other malformations were observed either by gross examination of the electrically stimulated femurs or in histologic sections. The results confirm previous findings indicating that a noninvasive electrical field can offset the effects of disuse osteoporosis in rats but fail to produce any evidence of previously reported electrically-induced bone tumors.

5715 MW INTERFEROMETERS FOR BIOLOGICAL STUDIES. *(Eng.)* Griffin, D. W. (Univ. Adelaide, Adelaide, South Australia). *Microwave J* 21(5): 69-72; 1978. (5 refs)

The use of microwave interferometers for recording small surface movements in biologic subjects is discussed. Both magic tee hybrid and three-port circulator designs are covered; the latter design is more sensitive for a given source power. The microwave generator can be a simple klystron or a relatively elaborate signal generator. Square wave amplitude modulation at a repetition frequency of 1 kHz is required so that a selective amplifier type standing wave indicator can be used as a receiver to drive an x-y plotter. The amplitude of movement of a test subject that can be accurately recorded is a small fraction (about 1/10) of the operating wavelength of the interferometer. An interferometer of the three-port circulator design operating at a frequency of 9.3 GHz was used to measure chest movement and various hand and foot movements of a test subject in an ordinary room. The recorded results demonstrate accurate detail in the movement associated with various physiologic functions and the potential for more advanced studies involving correlation with recordings of other effects.

5716 RADIATION PROTECTION ACTIVITIES - 1976. *(Eng.)* Office of Radiation Programs (Environmental Protection Agency, Washington, DC 20460). 186 pp; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. PB-273 469]. (173 refs)

Radiation protection activities of several Federal agencies are reviewed in an annual report. With

regard to nonionizing radiation, only the Environmental Protection Agency's Office of Radiation Programs and the Food & Drug Administration's Bureau of Radiological Health (BRH) activities are discussed in detail. The BRH began the process of generating a draft performance standard for microwave diathermy applicators, and several major compliance actions were taken. Studies by the EPA relating to microwaves and radio frequency (RF) radiation included urban area environmental measurements, measurements of RF levels in buildings, source distribution analysis for both RF and microwaves, and population exposure studies, as well as experiments on the biologic effects of nonionizing radiation. The BRH studies involved marine radar exposure, theoretic dosimetry, and a miniature microwave field probe. The EPA prepared to let a contract to evaluate and summarize 6,000 pages of comments in response to its request for information on the health and environmental effects of extra-high voltage power transmission lines.

5717 RF RADIATION ABSORPTION PATTERNS: HUMAN AND ANIMAL MODELING DATA. *(Eng.)* Guy, A. W.; Webb, M. D.; McDougall, J. A. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine RJ-30, Univ. Washington Sch. Medicine, Seattle, WA 98195). 77 pp; 1977. [available through Dept. Health, Education, and Welfare, National Inst. Occupational Safety and Health, Div. Biomedical & Behavioral Sci., Cincinnati, OH 45226, Publication No. 77-183. (11 refs)

A technique for modeling radio frequency (RF:10-300 MHz) radiation absorption patterns in animals and humans is reported. Various models of animals and humans were exposed to RF fields produced by different sources. Power absorption patterns and the rate of power absorption at specific anatomical locations within the models were thermographically recorded. These parameters were recorded under simulated RF industrial exposure conditions using a near-field synthesizer. The results of the modeling research demonstrated the validity of this technique for predicting the magnitude and distribution of RF-induced power absorption in humans and animals. The utility of the technique for the extrapolation of animal data to human RF exposure thresholds was also firmly established.

5718 RESEARCH NEEDS FOR ESTABLISHING AN ENVIRONMENTAL MICROWAVE RADIATION SAFETY STANDARD. *(Eng.)* Elder, J. A. (Experimental Biology Div., Health Effects Res. Lab., Environmental Protection Agency, Research Triangle Park, NC 27711). 13 pp; 1976. [available through National Technical Information Services, Springfield, VA 22161 Document No. PB 273 232]. (12 refs)

Research needs for establishing an environmental microwave radiation safety standard are outlined. It is recommended that epidemiologic and clinical investigations be performed on groups of workers and others exposed to both high and low power densities of microwave radiation. Special emphasis should be placed on potentially heat-sensitive civilian sub-populations. In particular, behavioral, immunologic, and teratologic effects should be investigated. Chronic low-level studies of animals exposed to power densities approximating the present occupational exposure guide of 10 mW/cm^2 are also recommended. Emphasis should be placed on possible sensitive test systems, such as, the developing embryo, immune defense system, central nervous system, chromosomes, eye lens, and male reproductive organs. Research is also needed to determine the basic mechanisms of radio frequency effects on molecular and cellular components and the loci of interaction as a function of power density and frequency. Biologic systems, such as, the brain, heart, ear, and lymphocyte as well as model studies including anthropomorphic models should be emphasized. Support should be continued for surveys to systematically evaluate the frequencies and intensities of electromagnetic radiation in the environment, and the results should be incorporated into the design of laboratory bioeffects studies, particularly chronic studies. Means must also be taken to assure that biologic effects, including negative effects, be related to quantitative measurements of absorbed power so that the data can be extrapolated to man.

5719 ENVIRONMENTAL IMPACT OF ELECTRICITY TRANSMISSION. *(Ger.)* Moeller, K. (Institut fur Allgemeine Elektrotechnik und Hochspannungstechnik, RWTH, Aachen, W. Germany). *Elektrizitaetswirtschft* 77(1): 26-31; 1978. (25 refs)

Studies on the biological effects of electric and electromagnetic fields are reviewed. Electric fields with potentials of up to 20 kV/m had no marked effect on the reaction time, pulse rate, and blood pressure of test persons. The exposure even delayed somewhat the normal increase of the reaction time, i.e., it had a slight stimulating effect. Slight but significant increase in heart rate but no significant changes in respiration rate and blood pressure were seen in rats exposed to an electric field of 80 kV/m for 2x 4 hr during a 16-hr period. The changes observed in test persons exposed simultaneously to electric field (20 kV/m) and magnetic field (induction 0.3 mtesla) were the same as those seen during exposure to the electric field alone. The findings do not support evidence of health hazards from electric and magnetic fields generated by power transmission lines.

5720 RADIOLOGICAL SAFETY BY DESIGN—I A U.S. VIEWPOINT. *(Eng.)* Gundaker, W. E. (Bureau Radiological Health, Food and Drug Admin., Rockville, MD). *Ann Occup Hyg* 20(3): 305-311; 1977. (4 refs)

The development of product performance standards under the Radiation Control for Health and Safety Act is described along with administrative procedures by which the standards are enforced. Under the Act, the Food & Drug Administration may prescribe performance standards for products emitting

both ionizing and nonionizing electromagnetic and particulate radiation as well as sonic, infrasonic, and ultrasonic waves. Types of products that fall within the definitions of equipment covered by the act include x-ray machines, television receivers, accelerators, diathermy units, laser products, microwave ovens, and ultrasonic cleaners. The provisions of a performance standard may include a definition of the maximum level of radiation emission permissible from an electronic product and a procedure for testing the product and measuring the emitted radiation. At present six performance standards have been promulgated, with two of them applying to nonionizing radiation sources. A microwave oven standard, which is applicable to all ovens manufactured after October 6, 1971, limits radiation leakage from an oven at 5 cm from the external surface to 1 mW/cm^2 at the time of manufacture and to 5 mW/cm^2 during the lifetime of the oven. The act also contains a mechanism for ensuring that all radiation safety defects in products are appropriately corrected. Between October 1968 and February 1977, there were 189 compliance actions involving defective and noncompliant products. Of these compliance actions, 26 involved microwave ovens.

5721 WHERE DOES SPACE BEGIN? MAY SOLAR ENERGY BE USED WITHOUT RESTRICTION? *(Ger.)* Panzram, H. (Feuerbachstr. 10, 6000 Frankfurt/M., W. Germany). *Naturwiss Rundsch* 31(4): 148-150; 1978. (0 refs)

A country's legal jurisdiction of the upper part of the atmosphere is discussed. A study was performed in the US on satellite solar stations. Celesium cell reflectors were positioned so that solar energy was continuously absorbed and reflected to earth through microwaves. It is theorized that if the energy was too concentrated, deaths, bodily injury, property damage, and possible damage to the environment may result.

5722 BIOLOGICAL AND MEDICAL PROBLEMS OF THE USE OF RADAR WAVES. II. MEDICAL PROBLEMS (PROTECTION AND SURVEILLANCE OF THE EXPOSED PERSONNEL). *(Fre.)* Delahaye, R. P. (Service de Radiologie, Hopital Begin, 69, avenue de Paris, 94160 Saint-Mande, France). *Radioprotection* 12(4): 359-377; 1977. (104 refs)

Studies on the effects of radar waves on exposed personnel and general problems of radiation protection are reviewed. Medical examinations of 226 persons exposed to radar waves with a peak intensity of 1 mW for 3-13 yr failed to reveal significant pathologic changes, but 25% of the personnel had subjective complaints that could be related to the exposure (sensation of heat in the face and hands, tinnitus, abnormal fatigue, headache and pain in the eyeballs). Neurovegetative disorders (asthenic syndrome, cardiovascular dystonia, and diencephalic syndrome, somnolence, insomnia, sensory disturbances, and EEG changes) were reported in the USSR to occur in persons exposed to microwaves with intensities below 10 mW/cm^2. Other investigators observed mild hypothyroidism accompanied by thyroid hyperplasia and increased adrenocorticotropic hormone secretion by the pituitary gland. Cataracts of the eye were found in a man subjected to a radiation intensity of 100 mW/cm^2 (frequency 2,000-3,000 MHz) and in another after 2 mo exposure to 10-12-cm microwaves. The literature indicates the need for regular medical checkups of personnel exposed to microwaves.

5723 THE BIOLOGICAL EFFECTS OF MICROWAVES. *(Fre.)* Berteaud, A. J. (No affiliation given). *La Recherche* 9(85): 65-66; 1978. (3 refs)

State-of-art report on the biologic effects of microwaves based on studies presented at the International Symposium on the Biological Effects of Electromagnetic Waves held in Airlie, Virginia, in the fall of 1977 is discussed. In a wide range of frequencies, electromagnetic waves have biologic effects other than thermal. Microwaves were found to increase the permeability of the hematoencephalic barrier due to the increased formation of intercellular bridges. Microwaves were also reported to interfere with interferon formation and lymphocyte and macrophage stimulation (no specific data given). Hormonal effects of microwaves were observed during long-term exposure of *Drosophila* and certain other larvae. The effects of microwaves are reversible; irreversible effects can be produced only by other factors, e.g., x-rays acting simultaneously with microwaves. The increased radiation and drug sensitivity of tumor cells heated to 41-42 C indicates the potential value of microwave hyperthermia as an adjuvant method in cancer therapy.

5724 EXPERIENCE WITH DECIMETER-WAVE THERAPY IN THE COMPLEX TREATMENT OF PATIENTS WITH PEPTIC ULCER. *(Rus.)* Zhgun, A. A. (N. N. Burdenko Principal Clinical Hosp., Moscow, USSR); Ushakov, A. A.; Aloiants, G. A.; Rebrov, V. G. *Vopr Kurortol Fizioter Lech Fiz Kult* (3): 38-41; 1977. (3 refs)

Complex treatment that included local decimeter-wave therapy (20 and 40 W, 10-15 min/session, 8-12 sessions) was given to 113 patients with ulcers of the duodenal bulb, to 23 with gastric ulcer, and to 3 with gastroduodenitis. The bioelectric activity of the stomach was investigated in 91 patients. Of these, 48 were treated with 20 W and 43, with 40 W. Significant inhibition of the motor activity of the stomach was observed in 62 patients during or immediately after irradiation; the bioelectric activity returned to the original level immediately after the session in six of these patients. The inhibitory effect was most marked in patients with hypermotoric dyskinesia of the stomach. The initial gastric pH was 1-8.4. After treatment, reduction of the gastric acidity was seen in 28 patients in the corpus of the stomach and in 25 patients in the antral part, while the acidity of the corpus and antral part increased

in 5 and 7 patients, respectively. The findings indicate the great value of decimeter wave therapy in the complex treatment of ulcer patients with pronounced motor and secretory disorders of the stomach and duodenum.

5725 EFFECT OF UHF MAGNETIC FIELD ON THE DEVELOPMENT OF COLLATERAL ARTERIES AND LYMPHATICS (AN EXPERIMENTAL STUDY). *(Rus.)* Pas, A. I. (Dept. Normal Anatomy, I. P. Pavlov First Leningrad Medical Inst., Leningrad, USSR). *Vopr Kurortol Fizioter Lech Fiz Kult* (4): 65-68; 1977. (8 refs)

The effect of a therapy course with ultra-high-frequency magnetic field (15 or 30 W) on the development of collateral arteries and lymphatics was studied in 216 albino rats. The treatment was initiated 3-4 days after the dissection of the femoral artery or removal of the popliteal lymph nodes. Compared with the non-irradiated controls, the magnetic field accelerated the development of the collateral arteries, improved their structure, and facilitated lymph drainage through collateral lymphatics and reserve lymphatic vessels. The magnetic field of 15 W had more favorable effect (better structure of arteries, more marked and prolonged effect on lymph flow through superficial lymphatics) than the magnetic field with 30 W. (Parameters of field, duration and number of sessions not given.)

5726 CYTOLOGICAL EFFECTS OF MICROWAVE RADIATION IN CHINESE HAMSTER CELLS IN VITRO. *(Eng.)* Alam, M. T. (Direction des Laboratoires, Ministere des Affaires Sociales, 20045 Chemin Ste-Marie ouest, Ste-Anne de Bellevue, Quebec, Canada, H9X 3L2); Barthakur, N.; Lambert, N. G.; Kasatiya, S. S. *Can J Genet Cytol* 20(1): 23-30; 1978. (14 refs)

The cytologic effects of exposing a CHO-KI subclone of parental Chinese hamster ovary cells to 2,450-MHz microwave radiation at power levels of 25-200 W for 30 min under both temperature-controlled and uncontrolled conditions were investigated. Cells irradiated under hypothermic conditions (29 C) at power levels of 75-200 W showed no significant increase in the mean number of chromosomal breakages per cell in comparison with control cells. In contrast, cells irradiated with only 25 W under uncontrolled temperature conditions (49 C) showed significant increases in chromosome breakages over control cells. In addition to chromosomal breakage, these cells also exhibited nuclear vacuoles and pycnotic and decondensed chromosomes. These changes can be directly attributed to temperature elevation which also resulted in partial cell death (6% as determined by trypan blue test).

5727 A METHOD FOR THE EXPOSURE OF MINIATURE SWINE TO VERTICAL 60 HZ ELECTRIC FIELDS. *(Eng.)* Kaune, W. T.; Phillips, R. D.; Hjeresen, D. L.; Richardson, R. L.; Beamer, J. L. *IEEE Trans Biomed Eng* 25(3): 276-283; 1978. (9 refs)

A clear Plexiglas exposure system for subjecting Hanford miniature swine to vertical 60-Hz single-phase electric fields is described. Each pig was placed on a metal ground plane, and the impedance between the pig's body and the metal ground plane was 2-3 kohms with all four feet on the ground. The normalized swine short circuit current was 6.9 μA/(kV/m), which made the root mean square voltage of the pig's body about 17 mV/(kV/m). Even at a high exposure field strength of 30 kV/m, the potential difference between the pig's body and ground (or a grounded watering system) would be less than 0.5 V. With a grounded anesthetized pig supported in a standing position by a nonconducting holder, the electric potential at 7.5 cm above the back of the pig was 1,200 V relative to ground at 2.9 kV/m unperturbed field strength; this corresponds to an average field strength of 16 kV/m. The threshold field strength for shocks and corona discharge in the system was greater than 55 kV/m unperturbed field strength and for hair stimulation about 40 kV/m. Behavioral tests indicated that there was some field perception, via an unknown mechanism, at unperturbed field strengths of as low as 30 kV/m. During measurements of the sensitivity of swine to small 60-Hz mouth-to-drinking nozzle currents, a significant increase in the perception threshold was found as the open-circuit nozzle voltage was reduced from 35-V peak to 2.5-V peak. This unexpected result suggests that swine respond to transient discharges from sources with rather low open-circuit voltages and illustrates the importance of designing electric field exposure systems so that such transient discharges cannot occur.

5728 A SEQUENTIAL STIMULATOR FOR ELECTRICAL RESTORATION OF THE MICTURITION REFLEX. *(Eng.)* Naumann, S. (Dept. Electrical Engineering, McMaster Univ., Hamilton, Ontario, Canada); Milner, M. *IEEE Trans Biomed Eng* 25(3): 307-311; 1978. (25 refs)

A sequential vesical stimulator for the electrical restoration of the micturition reflex is described. The stimulator is designed to deliver 4 W to an impedance of 100 ohms at a separation of 12 mm edge to edge between the transmitting and receiving coil systems which are inductively coupled. Sequential pulsing is achieved by using three carrier frequencies of 190, 160, and 130 kHz. The stimulator was implanted in a normal sow anesthetized with sodium thiopentone. The sow voided well while under anaesthetic, and there were no visible signs of current spread. The sow was also stimulated 2 days postoperatively while conscious, and no evidence of pain or current spread was observed. Further clinical trials are required to fully assess the device.

5729 NEW INTERFERENCE SENSING DEMAND PACEMAKER FUNCTIONS. *(Eng.)* Brownlee, R. R. (Dept. Electrical Engineering, Pennsylvania State Univ., University Park, PA 16802); Tyers, G. F.; Neff, P. H.; Hughes, H. C. *IEEE Trans Biomed Eng* 25(3): 264-269; 1978. (19 refs)